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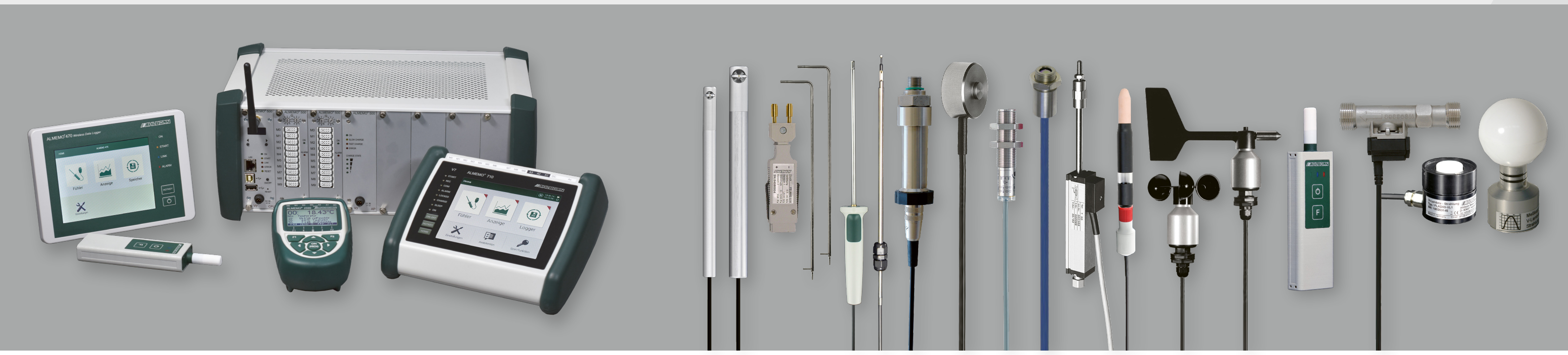
ALMEMO® Manual

for all ALMEMO® measuring instruments and sensors

- Sensor programming
- Operating instructions for sensors
- Metrological basics



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ALMEMO® Manual
For all ALMEMO® measuring instruments and sensors

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1 Introduction to ALMEMO® technology

The ALMEMO® System consists of an ALMEMO® measuring device and intelligent ALMEMO® connectors for the corresponding sensors. A wide variety of versions are available, from 1-channel transmitters to measurement data acquisition systems with more than 1000 measuring points. Most of the ALMEMO® measuring instruments differ only in their design (hand-held device, desktop device, 19" system, panel-mounted device, transmitter...), in the number of measuring inputs, in the display, output and operating elements, as well as in the power supply. The intelligent ALMEMO® connector allows the devices to be completely programmed, except for the time sequence control, when standard sensors and interface cables are connected. They have a uniform functional scope with configurable options. All parameters are accessible via the interface and can be changed at will, as the data carriers in the connectors can be overwritten again and again. All units have the same measuring input circuit. More than 60 standard measuring ranges are available for cross-sector applications. Averaging of measured values can be performed in three different ways. Averaging can be done via several manual measurement point queries, via all measured values within a cycle or via all measured values from the beginning to the end of a measurement. If limit values are to be monitored, this can be done by programming max/min values into the ALMEMO® connector.

The devices are equipped with a high-resolution AD converter, digital linearization and digital calibration. An optimal reference junction compensation is guaranteed by precision thermistors in the socket spring. Measuring inputs, power supply and interfaces are galvanically isolated from each other. The internal memory of ALMEMO® data loggers is externally expandable and can be configured as linear or ring buffer. The memory can be read out selectively by time and number. The switching of the measuring points is done galvanically isolated with absolutely wear-free solid state relays.

Measuring and output cycles can be selected independently. There is also an output or storage of measured and average values, as well as minimum and maximum values available. The start and end of a measurement point enquiry can be controlled variably (via keyboard or interface, via time and date, by limit values or external signal). All measuring devices can be addressed via the interface and are therefore networkable. Up to 100 devices can be networked via cable or wirelessly.

Maximum individuality

ALMEMO® devices can be used in completely different applications. The measuring instruments automatically recognize the characteristics of the connected sensor. Certain functions are only activated with the corresponding connector, interface cable or module. When humidity sensors are plugged in, e.g. dew point, mixing ratio, vapor pressure and enthalpy are calculated automatically. With attached psychrometers, dynamic pressure probes and probes for dissolved oxygen, the current air pressure can be entered or automatically compensated by pressure sensors. When measuring dynamic pressure, pH, humidity, dissolved oxygen and conductivity, the influence of temperature can be compensated. For flow probes, the cross-section can be entered for volume flow measurements. For special sensors there are connectors with integrated adaptation electronics.

Only one measuring device for all sensors

The intelligent ALMEMO® input connector makes every measuring arrangement an extremely flexible measuring system. Instead of using the pre-assembled ALMEMO® sensors, it is also possible to use your own, already existing transducers. For this purpose, pre-programmed ALMEMO® connectors with the necessary sensor parameters and the appropriate measuring range are available. The connectors have six screw terminals and can be easily connected. It is possible to assign a designation to each measuring point on all devices and plugs. This individual sensor designation makes the measurement setup clear and prevents mix-ups. In addition, sensor signal and dimension can be scaled and the measured value can be corrected in zero and slope. Some measuring instruments with ALMEMO® connectors offer the possibility to store multi-point calibrations in the connector or to program own linearizations with up to 30 points in the connector (simple interpolation point input with setpoint and actual value table via ALMEMO® Control software, any special measuring ranges programmed in the connector). Calibration dates can be managed in the connector and displayed with an automatic message. The possibility of correcting sensor errors in the connector turns simple sensors into precise measurement sensors. Their function and accuracy is increased by ALMEMO® measurement technology. Standard signals can be displayed in their original size. For multiple sensors, e.g. temperature and humidity, only one connector is required. Programming is easily done via the device keypad, via terminal or software and can be protected by a staggered locking system. All settings and programming can be carried out using the Windows configuration software ALMEMO® Control included in the scope of delivery.

ALMEMO® digital technology

Via digital ALMEMO® D6 and D7 connectors, numerous analog sensors and measured variables can be digitized. Thus, the ALMEMO® System is open for any extensions of measurement parameters, measurement functions and applications. New measuring ranges and linearizations are stored in the digital ALMEMO® D6 or D7 connector independently of the ALMEMO® measuring device. The overall accuracy of the digitized ALMEMO® sensor remains independent of the device and connected extension cables. The complete measuring chain, consisting of the sensor and the connected ALMEMO® D6 or D7 connector (with its own AD-converter), is calibrated (DAkkS / factory) and can be replaced or exchanged at will. Pluggable, digital extension cables offer a high transmission security.

Important! ALMEMO® D7 connectors can only be connected to the current ALMEMO® instruments of version V7 (e.g. ALMEMO® 500, ALMEMO® 710, ALMEMO® 809, ALMEMO® 202/204, ALMEMO® 470).

Digital ALMEMO® D7 connectors enable high measuring speeds and high precision. They can be used for a wide variety of measuring tasks. Dynamic processes are measured by the ALMEMO® D7 connector with a fast conversion rate (range: fast measurement). If high resolutions and stable values are required, e.g. for precision transducers, the ALMEMO® D7 connector works with a reduced conversion rate (range: high resolution). The digital ALMEMO® D7 connector has its own built-in AD-converter. The measuring rate is solely determined by the AD-converter. On the ALMEMO® V7 measuring device all D7 connectors work in parallel with their own measuring rate. Thus high measuring speeds are achieved.

Open to every periphery

Sensors with analog or digital output signals can be connected to the inputs of ALMEMO® measuring instruments via various connectors or cables.

Depending on the requirements, various adapters can be plugged into the outputs of the measuring instruments, e.g: analog outputs, various interfaces (USB, RS232, RS485, WLAN, fiber optic, Ethernet, Bluetooth), alarm transmitters or trigger inputs. For remote enquiries, the data can also be transmitted via Internet or mobile radio modem.

Suitable output formats are available for spreadsheets. Various software packages are available for the graphical display and evaluation of the measured data.

2 ALMEMO® Measuring instruments

Measuring principle

As already described in chapter 1, the ALMEMO® System consists of an ALMEMO® measuring device and intelligent ALMEMO® connectors for the corresponding sensors. The ALMEMO® devices automatically adapt the characteristic data of the connected sensor stored in the sensor plug and are completely programmed, except for the time sequence control.

Properties of the measuring instruments

Equipment

Measurement inputs

While smaller ALMEMO® measuring instruments are equipped with one, two or four measuring inputs, the large data acquisition systems offer 190 measuring inputs or more. The measurement inputs on the measuring devices are specially designed for ALMEMO® connectors.

Fig. 2.1 Measuring inputs on ALMEMO® 500

Plug-in cards for miniature thermal plugs and for 10-way plugs are also available for the data acquisition systems.

Display

Some portable measuring devices are equipped with a simple LC display.

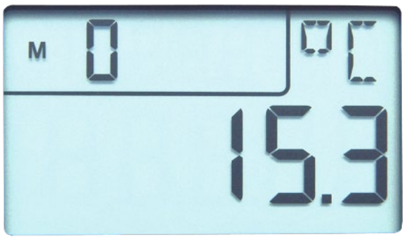


Fig. 2.2 Simple LC display

More comfort is offered by measuring instruments with a graphic display, which has great advantages in terms of clarity and programming options.

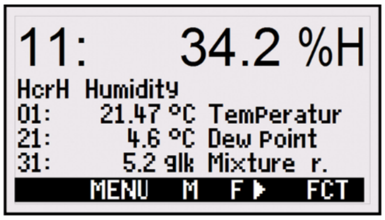


Fig. 2.3 Graphic display

The data logger ALMEMO® 710 has a touch display that shows the settings of the device and connectors as well as measured values in table or diagram form.

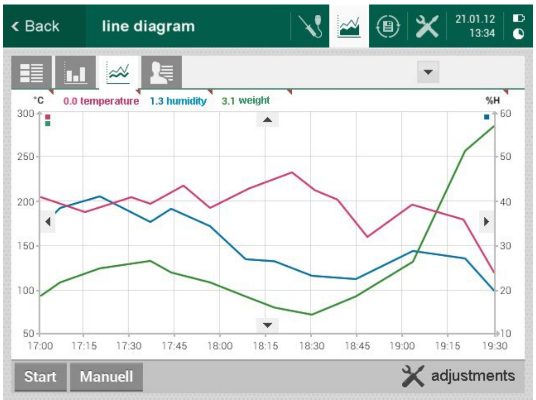


Fig. 2.4 Screen ALMEMO® 710

The data acquisition system ALMEMO® 500 uses a tablet with app for instrument operation and display. The app is available for Android, Windows and Apple IOS.

Fig. 2.5 Tablet with app for ALMEMO® 500

Data logger function

Most ALMEMO® measuring instruments have a data logger function, i.e. they can automatically write data into a memory.

While most measuring instruments are equipped with internal memory, there are also measuring instruments whose data logger function is activated when an external memory is plugged in. To use them as data loggers, they must be operated with the ZA1904SD memory plug.

Memory

The memory of the simpler devices can hold up to 100,000 measured values in an internal flash memory. In contrast, the ALMEMO® 500 data acquisition system is equipped with an internal, SD-based memory that can hold up to approx. 600 million measured values.

Interfaces

ALMEMO® socket A1

Digital interface:	Baud rates: up to 921 kBaud, data 8-bit serial, 1 start bit, 1 stop bit, no parity
	ALMEMO® Data connection via USB, RS232, Ethernet, wireless with Bluetooth, WLAN, mobile radio, cloud See chapter Network technology
Analog output:	ALMEMO® Analog cable and analog interface, see chapter Output modules

ALMEMO® socket A2

Networking:	ALMEMO® Network cable or wireless with Bluetooth See chapter Network technology
Data storage:	ALMEMO® Memory connector with memory card See chapter General accessories
Analog output:	ALMEMO® Analog cable and analog interface, see chapter Output modules
Trigger input:	ALMEMO® Trigger cable and trigger interface, see chapter Output modules
Relay output:	ALMEMO® Relay cable and relay interface, see chapter Output modules

Power supply

The power supply of the devices can be done on the one hand by carefully selected power units, on the other hand most of the devices can be supplied by batteries or rechargeable batteries which can be charged in the devices. The MA500 data acquisition system can be equipped with rechargeable battery inserts (charge quantity up to approx. 14 Ah).

Versions

	Measuring inputs	Expansions	Display	Graphics display	Data logger function	Integrated memory	Interface / outputs	Precision class	Measuring rate (mops) max.	Measuring ranges	Multi-point adjustment	Portable device	Desktop device	Fitted device	Catalog page
Compact measuring instrument															
ALMEMO® 2450-1L	1		✔					C	2.5	35		✔			01.16
Basic measuring instrument															
ALMEMO® 2490-1A	1		✔				✔	B	10	65		✔			01.18
ALMEMO® 2490-2A	2		✔				✔	B	10	65		✔			01.18
Professional measuring instrument															
ALMEMO® 470 V7 wireless		10		✔	✔	✔	✔						✔		01.12
ALMEMO® 202 V7	2			✔	✔		✔		1000		opt.	✔			01.20
ALMEMO® 204 V7	4			✔	✔	✔	✔		1000		opt.	✔			01.xx
ALMEMO® 2470-1S/-SCRH	1	✔			✔	✔	A	10	65		✔			01.22	
ALMEMO® 2470-2S	2		✔		✔	✔	✔	A	10	65		✔			01.22
ALMEMO® 2470-2	2		✔				✔	A	10	65		✔			01.22
ALMEMO® 2590-2A	2			✔	✔		✔	A	10	65		✔			01.25
ALMEMO® 2590-4AS	4			✔	✔	✔	✔	A	10	65		✔			01.25
Precision measuring instrument															
ALMEMO® 2690-8A	5			✔	✔	✔	✔	AA	100	66	opt.	✔			01.28
ALMEMO® 2890-9	9			✔	✔	✔	✔	AA	100	66	opt.	✔			01.30
ALMEMO® 710 V7	10			✔	✔	✔	✔	AA	2000	66	opt.	✔			01.32
ALMEMO® 8590-9	9				✔	opt.	✔	AA	100	66	opt.		✔		01.36
ALMEMO® 8690-9A	9				✔	opt.	✔	AA	100	66	opt.		✔		01.36
ALMEMO® 809 V7	9				✔	✔	✔	AA	2000	66	opt.		✔		01.38
ALMEMO® 5690-1M09	9	opt.			✔	opt.	✔	AA	100	66	opt.		✔		01.40
ALMEMO® 5690-2M09	9	opt.		✔	✔	✔	✔	AA	100	66	opt.		✔		01.40
ALMEMO® 5690-1CPU		opt.			✔	✔	✔	AA	100	66	opt.		✔		01.48
ALMEMO® 5690-2CPU		opt.		✔	✔	✔	✔	AA	100	66	opt.		✔		01.48
ALMEMO® 500 CPU V7	20	opt.		✔	✔	✔	✔	AA	4000	66	opt.		✔	✔	01.54
ALMEMO® 4390-2	1		✔		✔	✔	✔	AA	100	66				✔	01.60
Basic device (transmitter)															
ALMEMO® 2490-1R02U	1		✔				✔	B	10	65				✔	01.58
ALMEMO® 2490-2R02U	2		✔				✔	B	10	65				✔	01.58
Reference measuring instrument															
ALMEMO® 1020-2 X6	2			✔	✔		✔	AS	1.25	4	✔	✔			01.62
ALMEMO® 1030-2 X6	2			✔	✔		✔	AS	1.25	1	✔	✔			01.65
ALMEMO® 1033-2 X6	2			✔	✔		✔	AS	2.5	2	✔	✔			01.xx
ALMEMO® 1036-2 X6	2			✔	✔		✔	AS	1.25	7	✔	✔			01.67
ALMEMO® 8036 X6	9				✔		✔	AS	1.25	7	✔		✔		01.69

ALMEMO® measuring instruments are available as portable devices, desktop devices and built-in devices:

Type	Example
Portable device	
Desktop device	
Built-in device	

Possible measuring ranges of ALMEMO® 2450, 2490, 2470 and all other ALMEMO® devices

Sensors	Item number	2450	2490	2470	All other devices
Temperature					
Thermocouple sensors:					
NiCr-Ni Type K (NiCr)	FTA xxx	×	×	×	×
NiCroSil-NiSil Type N (NiSi)		×	×	×	×
Fe-CuNi Type L/J (FeCo/IrCo)		×	×	×	×
Cu-CuNi Type U/T (CuCo/CoCo)		×	×	×	×
PtRh10-Pt Type S (Pt10)		×	×	×	×
PtRh13-Pt Type R (Pt13)		Range	×	×	×
PtRh30-PtRh6 Type B (EL18)		Range	×	×	×
AuFe-Cr (AuFe)		Range	×	×	×
Resistance temperature sensors:					
Pt100/1000 (P104, P204)	FPA xxx	Range	×	×	×
Ni100/1000 (N104)		Range	×	×	×
NTC Type N (NTC)	FNA xxx	×	×	×	×
Heat flow					
Heat flow	FQA xxx, FQADxx	×	×	×	×

Sensors	Item number	2450	2490	2470	All other devices
Rel. humidity					
Capacitive with NTC	FHA 646 xxx	×	×	×	×
Digital humidity-/temperature sensor	FHAD 46x	×	×	×	×
Digital humidity-/temperature sensor	FHAD 36 Rx	×	×	×	×
Psychrometric with NTC	FNA 846	Range	Function	Function	×
Psychrometric with Pt100 (2 connectors)	FPA 8363	Range	Function	Function	×
Digital psychrometer	FNAD 46, FNAD 463	×	×	×	×
Dew point					
Digital dew point sensor	FHA 646 DTC1	×	×	×	×
Condensation detector	FHA 9461	×	×	×	×
Material moisture					
Water detector probe	FHA 936 WD	×	×	×	×
Material moisture sensor	FHA 696 MF	Function	Function	×	×
Wood moisture sensor	FHA 636 MFx, FHA 696 MFS1	×	×	×	×
Moisture sensor for granules	FHA 696 GF1	×	×	×	×
Soil moisture, tensiometer	FDA 602 TM	×	×	×	×
Airflow					
Vane anemometer for air	FVAD 15 Sxxx, FVAD 15 MA1	× *	× *	× **	×
Differential pressure for pitot tube measurement	FDA 602 S1K, FDA 602 S6K	Range	× *	× **	×
Thermoanemometer	FVAD 35 THxx	× *	× *	× **	×
Thermoelectric flow sensor	FVA 605 TAxx	× *	× *	× **	×
* No average value channel for flow measurement possible (no start of a continuous or cyclic measurement)					
** Damping for 1 measuring channel possible					
Pressure					
Pressure transducer for liquids and gas	FDA 602 Lxx	×	×	×	×
Temperature compensated pressure transducer	FD 8214	×	×	×	×
Differential transmitter	FDA 602 D	×	×	×	×
Digital pressure transducer	FDAD 33, FDAD 35M	×	×	×	×
Pressure transducer for wall mounting	FD 8612 DPS / APS / DPT	×	×	×	×
Atmospheric pressure	FDA 612 SA	Range	×	×	×
Digital atmospheric pressure	FDAD 12 SA	×	×	×	×
Pressure measuring connector for differential pressure	FDA6 12 SR, FDA 602 SxK	Range	×	×	×
Force					
Tension and pressure force	FKA xxx	× *	× *	× *	×
* Only temporary zero setting possible (no end value adjustment)					
Speed sensor					
Speed sensor	FUA 9192	×	×	×	×

Sensors	Item number	2450	2490	2470	All other devices
Displacement					
Displacement transducer, potentiometric	FWA xxx T	× *	× *	× *	×
Displacement transducer, spring loaded	FWA xxx TR	× *	× *	× *	×
* Only temporary zero setting possible (no end value adjustment)					
Flow rate					
Axial or turbine flowmeter for liquids	FVA 915 VTHxxx	×	×	×	×
Flow sensor with temperature	FVA 645 GVx	×	×	×	×
Electrical variables					
Clamp current transformer for alternating current	FEA 6042, FEA 604 MN, FEA 6044 N	×	×	×	×
ALMEMO® Meas. module					
DC voltage, direct current	ZA 9900 ABx, ZA 9901 ABx	×	×	×	×
AC voltage, AC current	ZA 9903 ABx, ZA 9904 ABx	×	×	×	×
Meteorology					
Meteo-multi sensor (2 connect.)	FMA 510, FMA 510H	Function	×	×	×
Wind speed sensor	FVA 615-2	×	×	×	×
Wind direction sensor	FVA 614	×	×	×	×
Precipitation sensor	FRA 916, FRA 916 H	Function	Function	× *	×
Rain detector	FRA 616 D	×	×	×	×
Radiation measuring sensor	FLA 613 x	×	×	×	×
Star pyranometer	FLA 628 S	×	×	×	×
* For ALMEMO® 2470-2: Missing functions					
Room climate					
Globe thermometer	FPA 805 GTS	Range	×	×	×
Optical radiation					
Radiation sensor	FLA 603 x	×	×	×	×
Radiation sensor	FLA 613 x	×	×	×	×
Radiation sensor	FLA 623 x	×	×	×	×
Digital colour temperature sensor	FLAD 23 CCTx	×	×	×	×
Water analysis					
pH combination electrode	FY 96 PH x	Adjustment	×	×	×
Redox combination electrode	FY 96 RXEK	Adjustment	×	×	×
Conductivity probe	FYA 641 LF xxx	Range	×	×	×
Oxygen sensor	FYA 640 O2	Adjustment	×	×	×
Gas concentration in air					
Portable digital carbon dioxide sensor	FYAD 00 CO2	×	×	×	×
Carbon dioxide probe	FYA 600 CO2	Range	×	×	×
Carbon monoxide probe	FYA 600 CO	×	×	×	×
Oxygen probe	FYA 600 O2	Adjustment	×	×	×

Sensors	Item number	2450	2490	2470	All other devices
Ozone transmitter	FYA 600 O3	×	×	×	×
Gas probes	FYA 600 Ax	×	×	×	×
Infrared temp. measurement					
ALMEMO® infrared measuring head	FIA 844	×	×	×	×
Infrared measuring head	MR 7838, MR 7842	×	×	×	×
Infrared handheld device	MR 781420 SB	×	×	×	×
Digital infrared temp. sensor	FIAD 43	× *	× *	× *	×
* Emissivity not changeable					

Restrictions in functionality:

- Range: Missing or limited measuring range → Measured value cannot be displayed
- Function: Missing function to display sensor-specific measurement data (e.g.: average value/cycle) or to carry out necessary programming
- Adjustment: No measured value adjustment of the sensor possible (pressure, force, displacement, O2, pH, conductivity)

Programming

The programming of ALMEMO® measuring instruments is described in detail in chapter 6.2 of this manual.

All measuring ranges supported by ALMEMO® devices are listed in chapter 7.4.1

Technical Data

Inputs:

Channel switching between the input sockets for analog sensors	4-pole with Photo-MOS relays: Electrical isolation: max. 50 V (Measuring module with higher electrical isolation see chapter 4) Offset voltage: < 5 µV
Reference junction compensation:	Active in the range from –30 to +100°C , accuracy: ±0.2 K ±0.01 K/°C
Nominal temperature:	22°C ±2 K
Sensor power supply:	6 V to 12 V, depending on power supply
Self calibration:	Automatic zero point correction, measuring current calibration
Control functions:	Automatic sensor and sensor break recognition

Precision classes of the ALMEMO® devices

			Basic meas. devices	Professional meas. devices	Precision measuring devices			Reference measuring devices	
Precision class		C	B	A	AA			A+	
ALMEMO® Device series	**Devices older than V6 series**	**2450, 2420**	**2490**	**2470, 2790, 2590A**	**4390**	**500, 710, 809, 2690A, 2890, 5690, 8590, 8690**	**D7 Connector**	**1020**	**1030/1036, 8036**
Input current	< 50 nA	0.5 nA, (2 nA OP)	100 pA, ex 1 V: 10 nA	100 pA	500 pA, 2 V: 500 nA	100 pA	100 pA	500 pA	500 pA
Input range	-4 to +4 V	-0.26 to 2.6V	-2 to +5V	-1.9 to +2.9 V	2.6 V: -3 to +3 V otherwise: -2.3 to +1.3 V	-1.9 to +2.9V	-1.9 to +2.6V	-2 to +1.7 V	
Max. Overload	±5 V	-4 to +5 V	-2 to +5 V	-2 to +5 V	±12 V	±12 V	±2.8 V	±3.3 V	
System accuracy	0.05% ± 4 Dig.	0.1% ± 4 Dig.	0.03% ± 4 Dig.	0.03% ± 3 Dig.	0.02% ± 2 Dig.			0.1 K ± 1 Dig.	0.010 K ± 1 Dig.
Measuring current	Pt100: 1 mA Pt1000: 0.1 mA		Pt100/1000: 0.3 mA	Pt100: 1 mA, Pt1000: 0.1 mA	Pt100: 1 mA, Pt1000: 0.1 mA	Pt100: 1 mA, Pt1000: 0.1 mA	Pt100: ca. 1 mA, Pt1000: ca. 0.1 mA		Pt100: ca. 1 mA
TC	100 ppm/K	100 ppm/K	50 ppm/K	30 ppm/K	30 ppm/K			10 ppm/K	2 ppm/K
Measuring rates in Measurements/s	2.5 to 10 M/s	2.5 M/s	2.5 to 10M/s	2.5 to 10M/s	2.5 to 100 M/s Option 400 M/s*	Option 500 M/s*	2.5 to 1000 M/s	1.25 M/s	

*Measuring rate 400 Measurements/s (Option SA0000Q4)
*Measuring rate 500 Measurements/s (Option SA0000Q5)

Condition for high conversion rate

In addition to the standard conversion rates, the conversion rate can be set to 400 or 500 measurements/sec. This allows a selected measuring channel to be stored with a measuring rate of 400 or 500 measurements/sec. This is only possible with NTC sensors and sensors with voltage or current measuring range. It is not possible to change channels during the measurement.

Resolution, accuracy and sensitivity to mains hum or electromagnetic interference are comparable to a measurement at the conversion rate of 50 measurements/sec when using these options. Care must be taken to ensure an interference-free environment and short sensor cables!

Data output is only possible on a micro SD card: accessory ZA1904SD, memory plug with micro SD. The data are stored in table format (separated by semicolons) with a time stamp with a resolution of 0.001 seconds. The WinControl software can process this format from version 6.1.1.6.

Use

Preparation

The electronics contained in the plugs can be destroyed by voltage spikes that can occur when the plugs are plugged into a switched-on device. Therefore, ALMEMO® connectors should always be connected with the measuring instrument switched off.

Protection of the measuring instruments

The working and storage temperatures specified in the data sheets of the measuring instruments must be observed, which also contain information on the range of humidity in which the measuring instruments can be operated. Special care must be taken to ensure that no moisture condenses on the boards of the measuring instruments in the event of a sudden drop in temperature.

Maintenance

To maintain the reliability and measuring accuracy of the instruments, it is recommended to have them serviced at regular intervals.

3 ALMEMO® sensors

With the help of approx. 65 measuring ranges, a large number of transducers can be directly connected to the ALMEMO® measuring instruments and the exact measured values can be read off immediately without having to make any adjustments to the instrument. All sensors with ALMEMO® connector are generally programmed with measuring range, dimension and the possibly required scaling in an EEPROM. The corresponding measuring channels are automatically activated and set accordingly by the sensor. A mechanical coding ensures that sensors and output modules can only be plugged into the correct sockets in the correct position. The handling of the sensors and the connection of own sensors is described in detail in the following chapters.

3.1 Different types of ALMEMO® sensors

3.1.1 ALMEMO® standard sensors

With analogue sensors, the electrical signal is recorded and evaluated in the device according to the measuring range. There are also digital sensors, mostly for digital signals with the measuring range 'DIGI'. They contain their own microcontroller in the connector, which processes the measured values and transmits them digitally to the measuring device via the I2C bus.

All ALMEMO® sensors are adjustable, i.e. correction values of the sensor can be permanently stored in the connection plug (see chapter 6.3.10). If they have an enlarged EEPROM in the connector (E4), multi-point corrections are also possible (see chapter 6.3.13). With DAkkS (Ilac) or factory calibrations, the deviations can be immediately stored as correction values in the connector.

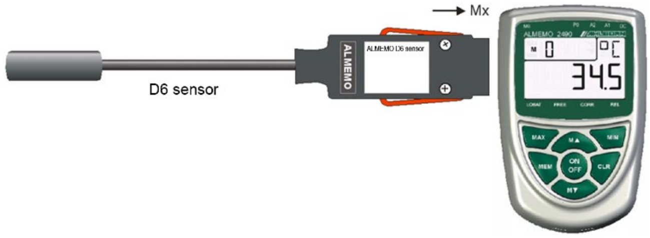
3.1.2 Digital ALMEMO® D6 sensors

The digital ALMEMO® D6 sensors are characterized by highest accuracy and flexibility. The digitalization of the measuring signal is done in the connector of the D6 sensors, which has several advantages (see chapter 4, 'Basics'). In addition to the I2C interface of the standard sensors they are equipped with a second serial interface (UART). Thus, they can be used for measurements on ALMEMO® devices (V5 and higher, update if necessary), while programming is carried out via the UART interface on V7 devices or on the PC directly via a special cable. In this way, new functions and areas that are not supported by the ALMEMO® devices themselves can be configured and used with the ALMEMO® Control software via a menu stored in the sensor. As before, various functions for adjustment, correction and multi-point adjustment are available for the measured values. As a new function an internal measured value damping can be programmed for each D6 sensor (see below).

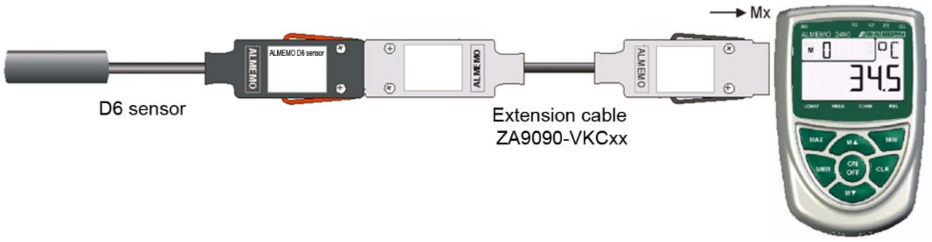
Operation as sensor at any ALMEMO® measuring instrument

The ALMEMO® D6 sensor supplies digital measured values of 1 to 4 measuring channels over the measuring range 'DIGI' to the ALMEMO® device, where they are processed as usual. Hidden channels (marked with ~) can be activated via the ALMEMO® device, just as any other channel can be switched off or deactivated and also reactivated. Certain function channels can also be programmed and used. The sensor is supplied by the measuring instrument.

Without extension



With extension



The universal extension cables ZA9090-VKCxx are used to extend the probes on the device. The measured values and connector programming are transmitted serially and interference-free via RS485 drivers (maximum 100m).

For operation in sleep mode, a sleep extension must be programmed for some probes.

Atmospheric pressure measurement and compensation

Some measured variables, which are marked 'CP' in the measuring range list (see chapter 7.4.1), depend on the atmospheric pressure, i.e. without its consideration, considerable measuring errors may occur. For this reason, these D6 sensors are equipped with an atmospheric pressure sensor in the ALMEMO® connector as standard or as an option, which automatically always serves for atmospheric pressure compensation (CP), even when the channel is deactivated. However, this sensor-internal atmospheric pressure compensation cannot be displayed in the device with the abbreviation CP as usual. The measured value of atmospheric pressure is also programmed as a climate variable by default.

Measured value correction

For the primary measuring channels, adjustment values or a multi-point adjustment can be stored in the D6 sensor. If correction values (zero point, slope, base, factor) have been programmed in the ALMEMO® connector, they are processed normally by the ALMEMO® device.

Operation on PC via serial interface

Operating a D6 sensor via the serial interface is used to configure the sensor (see below). Depending on the operating mode - on the ALMEMO® measuring instrument or directly on the PC via serial interface (USB, RS422) - different configurations can be carried out:

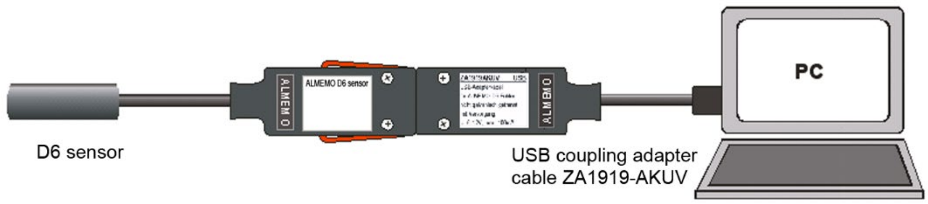
Functional comparison	Operating mode	
	On ALMEMO® device	**Direct on PC**, via USB coupling adapter ZA1919AKUV, see below
Deactivate measuring channel	Yes*	Yes
Activate measuring channel (without changing range)	Yes*	Yes
Change D6 measuring range	No	Yes
Change or use V6 functional channels	Yes*	No
Define atmospheric pressure as reference for ALMEMO® devices	Yes*	Yes
Program atmospheric pressure to a fixed value	No	Yes
Programming damping	No	Yes (see below)
Correction value, zero point, slope, base, factor programming	Yes*	Yes*
Multipoint adjustment	Yes**	No

* See operating instructions of device or ALMEMO® manual

** Only with ALMEMO® devices including option KL

Connection to the PC via USB coupling adapter cable

The ALMEMO® D6 sensor can be connected directly to the PC with the USB coupling adapter cable ZA1919-AKUV. A microcontroller in the adapter cable automatically sets the necessary power supply as well as the baud rate and device address of the sensor (see below, Interface).



Configuration on PC

Via the additional serial interface, the D6 sensors offer the possibility to configure new measuring ranges and sensor-specific functions with the PC using the ALMEMO® Control software (from v. 5.14.0.330) and then to operate the D6 sensor on any ALMEMO® measuring instrument.

The individual 'Sensor menu' can be found in the measuring point list under 'Edit'. Primarily the 4 measuring points with the special D6 measuring ranges of the D6 sensor can be programmed here. The measuring ranges appear on the interface with new meaningful abbreviations, while only the 'DIGI' range can be used via the measuring instruments. In addition to the range, a 2-digit dimension and a comment are automatically programmed and then the channel is locked with 5.

Functional channels* are either parameters of the ALMEMO® device or they are calculated by the device. In most cases they cannot be provided by the sensor. Therefore they cannot be programmed from the PC and cannot be used. If they have been programmed from the instrument, the range but no measured value appears on the interface and the message ´!unusable´ appears as comment.

Primary channels do not necessarily have to be activated if they are not to be corrected by the device. To delete ranges from the list, select ´- - - -´.

In addition, other parameters (such as atmospheric pressure compensation or temperature compensation) can be set depending on the sensor type.

Atmospheric pressure compensation

For sensors with integrated atmospheric pressure sensor, the compensation is set to 'Sensor' as standard, i.e. the current measured value is displayed in the sensor menu under 'Value'. However, if a certain value (sea level, weather report, channel) is to be used, this value can be programmed in the menu item 'Value'. In order to use the measured value of the atmospheric pressure for compensation of other sensors on the ALMEMO® device, simply click on the item 'Reference'. This will program the abbreviation '*P' into the commentary of the measuring channel 'D AP', so that the measured value is also permanently available in the ALMEMO® device for atmospheric pressure compensation (see chapter 6.2.5).

Averaging time (damping)

All measured values of the primary channels are continuously queried internally at the individual refresh rate. If these values are too unstable due to the measurement conditions, an averaging time can be entered automatically for both primary channels in the menu. This dampens the measured values by means of a sliding averaging.

Interfaces

USB coupling adapter cable ZA1919-AKUV is always operated with 115.2 kBd on the PC side. The sensors themselves also work with 115.2 kBd as standard. The following table shows the supported commands for configuration and polling of the sensors during operation on the PC.

Interface commands

Supported standard commands see chapter 7, Identification: D6

New commands of D6 modules:

Outputs:	**Commands**
Infolist: Range, baud rate	P60
Configuration menu	P61
Internal: Adjustment, averaging time, range	P69
Inputs:	
Query of programming:	P15
New initialisation:	f1 C19
Fixed programming of atmospheric pressure:	gxxxxx
Switch back to built-in sensor:	g00000

To activate the serial interface, addressing with the command Gxx or G-00 is required in any case.

The CRC mode is supported.

Adapted sensors to D6 connectors

ALMEMO®-D6 Atmospheric pressure sensor with temperature compensation	FDAD12-SA
ALMEMO®-D6 Temperature/humidity sensor, pluggable sensor element	FHAD46-C
ALMEMO®-D6 Temperature/humidity sensor, pressure tight to 16 bar	FHAD46-C7
ALMEMO®-D6 Temperature/humidity sensor with atmosph. pressure compensation	FHAD36-R
ALMEMO®-D6 NTC psychrometer with atmospheric pressure compensation	FNAD46
ALMEMO®-D6 Infrared temperature sensor	FIAD43
ALMEMO®-D6 NTC temperature sensor	ZAD040-FS/FS2
ALMEMO®-D6 Thermoanemometer 2 m/s with atmospheric pressure compensation	FVAD35
ALMEMO®-D6 Omnidirectional thermoanemometer	FVAD05-TOK
ALMEMO®-D6 Vane anemometer	FVAD15
ALMEMO®-D6 Vane anemometer	FVAD15-H
ALMEMO®-D6 Heat flow board with temperature compensation	FQADxx
ALMEMO®-D6 CO2 sensor with atmospheric pressure compensation	FYAD00-CO2
ALMEMO®-D6 Precision pressure sensor	FDAD33/35
ALMEMO®-D6 Colour temperature sensor	FLAD23-CCT
ALMEMO®-D6 V-lambda radiation sensor	FLAD03-VL1

Accessories:

Intelligent ALMEMO® extension cable for sensors (xx = length in m)	ZA9090-VKCxx
USB adapter cable with coupling 6..12V, 200mA, baud rate 115.2kBd	ZA1919-AKUV

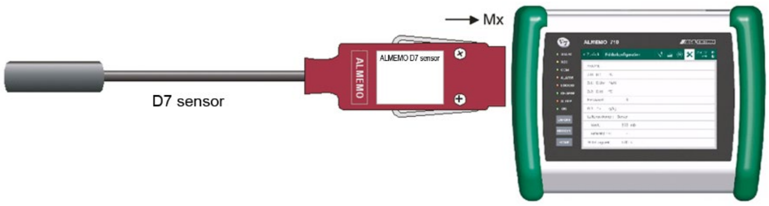
3.1.3 Digital ALMEMO® D7 sensors

The new digital ALMEMO® D7 sensors offer significant advantages due to additional measured variables, higher speed, extended measuring range and a higher number of channels per sensor. At the same time, efficient measurement of fast and slow sensors with any range of measured values is possible. New measuring functions and ranges that are not supported by the ALMEMO® devices themselves can be configured and used via a menu, stored in the sensor. This makes the new ALMEMO® D7 system flexible and future-proof. Communication from sensor to measuring device is generally done via a serial interface. Thus, the D7 sensors can only be plugged into new ALMEMO® V7 devices. For up to 4 primary channels a floating averaging can be configured internally.

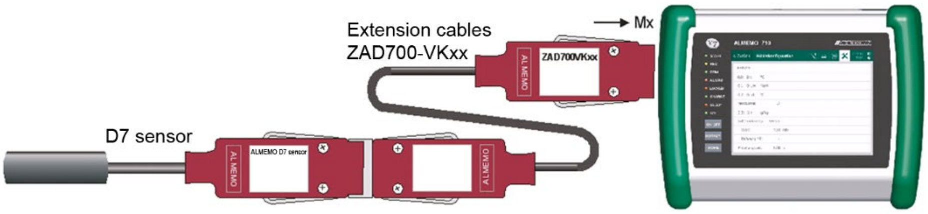
3.1.3.1 Operation as sensor on ALMEMO® V7 devices

ALMEMO® D7 sensors deliver their final digital measured values of 1 to 10 measuring channels to the ALMEMO® V7 device via the serial interface almost simultaneously. The measured values are only stored or output there. Function channels can only be programmed and used by the device. If a measuring channel should not be displayed, the measuring range can be switched off or deactivated and also reactivated as usual via the ALMEMO® device. The sensor is powered by the measuring device.

Without extension



With extension



The ZAD700-VKxx extension cables are used to extend the probes on the device. The measured values and the connector programming are transmitted serially via RS422 drivers without interference. A small ZAD700-GT adapter cable is also available for electrical isolation.

Measured value correction

For the primary measuring channels, adjustment values or a multi-point adjustment can be stored in the D7 sensor (ex works or via V7 measuring instrument with option KL). Correction values (zero point, slope, base, factor) are already processed in the sensor.

Sensor menu

In order to maintain the future viability of the new ALMEMO® V7 measuring system for many years without changing the measuring device, an individual sensor menu is stored in each D7 sensor, which can be downloaded via the serial interface. Thus it is possible to configure measuring ranges, averaging time for measurement damping or other specific sensor functions. A new ALMEMO® V7 measuring instrument or a PC can be used as an operating device.

3.1.3.2 Configuration on PC via USB adapter cable

The ALMEMO® D7 sensor is directly connected to the PC using the USB coupling adapter cable ZA1919-AKUV with a baud rate of 115.2 kBd. A microcontroller in the adapter cable automatically sets the necessary power supply as well as the baud rate and device address of the sensor.

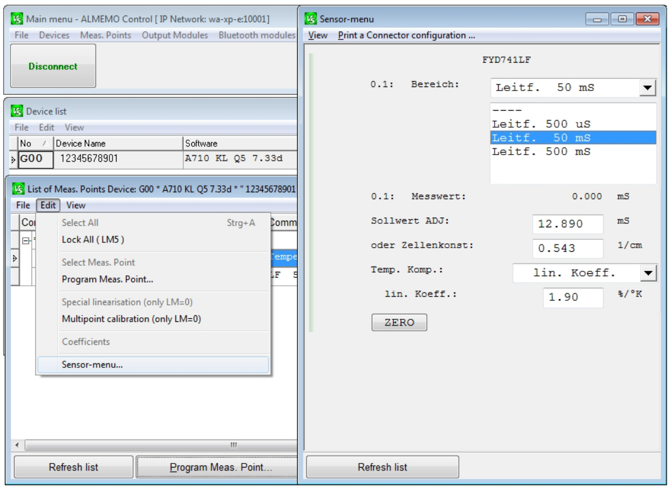
The ALMEMO® Control (from v. 5.14.0.330) is used to operate the sensor menu with a PC. In the measurement loop list under 'Edit' you will find the 'Sensor menu'. Primarily up to 10 measuring points with the specific D7 measuring ranges of the D7 sensor and other settings can be programmed here. The measuring ranges appear on the interface with new meaningful abbreviations. In addition to the range, a dimension of up to 6 digits and a comment are automatically programmed and then the channel is locked with 5.

To delete ranges from the list, select '- - - -'.

Function channels are either parameters of the device or are calculated by the device. Therefore they can only be programmed and used by the device. The following function channels are available:

Batt, Meas, Alrm, Diff, Max, Min, M(t), n(t), M(n), Flow, Time

They cannot be used when connected directly to the PC. The commentary then contains the note '!unusable'.



Depending on the sensor type, further parameters such as setpoint adjustment, atmospheric pressure or temperature compensation can be set.

Atmospheric pressure compensation

For sensors with integrated atmospheric pressure sensor, the compensation is set to 'Sensor' as standard, i.e. the current measured value is displayed in the sensor menu under 'Value'. However, if a certain value (sea level, weather report, channel) is to be used, this value can be programmed in the menu item 'Value'. In order to use the measured value of the atmospheric pressure for compensation of other sensors on the ALMEMO® device, simply click on the item 'Reference'. This will program the abbreviation '*P' into the commentary of the measuring channel 'D AP', so that the measured value is also permanently available in the ALMEMO® device for atmospheric pressure compensation (see chapter 6.2.5).

Averaging time (damping)

All measured values of the primary channels are continuously queried internally at the individual refresh rate. If these values are too unstable due to the measurement conditions, an averaging time can be entered automatically for both primary channels in the menu. This dampens the measured values by means of a sliding averaging.

D7 connector and sensors adapted to D7 connectors

ALMEMO®-D7 Measuring plug ±64 mV, ±250 mV, ±2 V, ±20 V, ±60 V, 20 mA	ZED700/1/2-FS(2)
ALMEMO®-D7 Pt100 connector	ZPD70x-FS
ALMEMO®-D7 Potentiometer connector	ZWD700-FS
ALMEMO®-D7 Bridge connector	ZKD700-FS
ALMEMO®-D7 Traction and force sensor	FK0xx + ZKD712-FS
ALMEMO®-D7 Precision pressure sensor	FD8214xx + ZDD714-AK
ALMEMO®-D7 Pressure sensor	FD0602Lxx + ZDD702-AKL
ALMEMO®-D7 Conductivity sensor	FYD741-LF
ALMEMO®-D7 Multifunctional meteo sensor	FMD760/770
ALMEMO®-D7 GPS sensor	FGD701
ALMEMO®-D7 Thermocouple connector	ZTD700-FS
ALMEMO®-D7 Pt1000 connector	ZPD710-FS
ALMEMO®-D7 PH- and Redox connector	ZYD7x0-AK

Accessories:

Intelligent ALMEMO® extension cable for sensors (xx = length in m)	ZA9090-VKCxx
USB adapter cable with coupling 6..12V, 200mA, baud rate 115.2kBd	ZA1919-AKUV

3.1.4 Sensor overview (Table from page 21 to page 34)

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
Temperature sensors, see chapter 3.2										
Resistance temperature sensors:										
Pt100-1 4-lead	FPAxxx	-200.0...	+850.0	°C	ZA9030FS1	Normal	±0.05 K ± 0.05 % of meas. val.	P104		B01
Pt100-2 4-lead	FPAxxx	-200.00...	+400.00*	°C	ZA9030FS2	Normal	± 0.05 K	P204		B03
Pt100-2 4-lead	FPA923-Lx	-200.00...	+850.00	°C		X6°	-	P214		B69
Pt100-2 4-lead	FPAxxx	-200.00...	+850.00	°C	ZPD700FS	D7	-		DPO4	B-01
Pt100-2 3-lead	FPAxxx	-200.00...	+850,00	°C	ZPD703FS	D7	-		DPO3	B-01
Pt100-3 4-lead *	FPAxxx	-8.000...	+65.000	°C	ZA9030FS7	Normal	± 0.002 K	P304		B00
Pt100-3 4-lead	FPA923-Lx	-200.000...	+560.000	°C		X6°	-	P314		B96
Pt1000-1 4-lead with ElFlg1	FPAxxx	-200.0...	+850.0	°C	ZA9030FS4	Normal	±0.05 K ± 0.05 % of meas. val.	P104		B01
Pt1000-2 4-lead with ElFlg1	FPAxxx	-200.00...	+400.00*	°C	ZA9030FS5	Normal	± 0.05 K	P204		B03
Pt1000-2 4-lead	FPAxxx	-200,00...	+850,00	°C	ZPD710FS	D7	-		DP14	B-01
Ni100 4-lead		-60.0...	+240.0	°C	ZA9030FS3	Normal	± 0.05 K	N104		B63
Ni1000 4-lead with ElFlg1		-60.0...	+240.0	°C	ZA9030FS6	Normal	± 0.05 K	N104		B63
NTC Type N	FNAxxx	-50.00...	+125.00	°C	ZA9040FS	Normal	± 0.05 K	Ntc		B09
NTC Type N 2 times	FNAxxx	-50.00...	+125.00	°C	ZA9040FS2	Normal	± 0.05 K	Ntc		B09
NTC Type N	FNAxxx	5.000...	+46.000	°C	ZA9040SS3	Normal	± 0.005 K	Ntc3		B99
NTC Type N	FNAxxx	-50.00...	+125.00	°C	ZAD040FS	D6	-	DIGI	DNtc	B-01
NTC Type N	FNAxxx	-20.000...	+65.000	°C	ZAD040FS3	D6	-	DIGI	DNt3	B-03
KTY 84 *		-40.0...	+200.0	°C	ZA9040SS4	Normal	± 0.1 K	KTY		B99
YSI 400 *		-40.0...	+130.0	°C	ZA9641SS	Normal	0..50°C:± 0.05K; else:±0.1K	NtcY		B99

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
Thermocouples:										
NiCr-Ni (K)	FTAxxx	-200.0...	+1370.0	°C	ZA9020FS	Thermo	± 0.05 K ± 0.05 % of meas.val.	NiCr		B04
NiCr-Ni (K)	FTAxxx	-100.0...	+500.0	°C	ZA9020SS2	Thermo	± 0.025 K	NiC2		B99
NiCr-Ni (K) with galv. isol. 1kV		-200.0...	+1370.0	°C	ZAD950ABK	Module	± 0.05 K ± 0.05 % of meas.val.	DIGI		B55
NiCr-Ni (K)		-200,0…	+1370,0	°C	ZTD700FS	D7	-		NiCrNi	B-01
NiCr-Ni (K)		-200,00…	+1370,00	°C	ZTD700FS	D7	-		NiCrNi	B-09
NiCrSi-Nisi (N)		-200.0...	+1300.0	°C	ZA9021FSN	Thermo	± 0.05 K ± 0.05 % of meas.val..	NiSi		B34
NiCrSi-Nisi (N)	FTAN926L0500P2	-200.00...	+1300.00	°C	ZA9400FSN	X6+	-	T N2		B92
NiCrSi-Nisi (N)		-200,0…	+1300,0	°C	ZTD700FS	D7	-		NiSil	B-02
Fe-CuNi (L)		-200.0...	+900.0	°C	ZA9021FSL	Thermo	± 0.05 K ± 0.05 % of meas.val.	FeCo		B05
Fe-CuNi (J)		-200.0...	+1000.0	°C	ZA9021FSJ	Thermo	± 0.05 K ± 0.05 % of meas.val.	IrCo		B35
Fe-CuNi (J)		-210,0…	+1100,0	°C	ZTD700FS	D7	-		IrCo	B-03
NiCr-CuNi (E)		-270,0…	+800,0	°C	ZTD700FS	D7	-		NiCrCu	B-04
Cu-CuNi (U)		-200.0...	+600.0	°C	ZA9000FSU	Normal	± 0.05 K ± 0.05 % of meas.val.	CuCo		B06
Cu-CuNi (T)		-200.0...	+400.0	°C	ZA9021FST	Thermo	± 0.05 K ± 0.05 % of meas.val.	CoCo		B36
Cu-CuNi (T)		-200,0…	+400,0	°C	ZTD700FS	D7	-		CoCoT	B-05
PtRh10-Pt (S)		0.0...	+1760.0	°C	ZA9000FSS	Normal	± 0.3 K	Pt10		B07
PtRh10-Pt (S)	FTAS9xxLxxxxP2	0.00...	+1760.00	°C	ZA9400FSSP2	X6+	-	T S2		B93
PtRh10-Pt (S)		-50,0…	+1760,0	°C	ZTD700FS	D7	-		PtRh10	B-06
PtRh13-Pt (R)		0.0...	+1760.0	°C	ZA9000FSR	Normal	± 0.3 K	Pt13		B37
PtRh13-Pt (R)		0.00...	+1760.00	°C	ZA9400FSRP2	X6+	-	T R2		B94
PtRh13-Pt (R)		-50,0…	+1760,0	°C	ZTD700FS	D7	-		PtRh13	B-07
PtRh30-PtRh6 (B)		+400.0...	+1800.0	°C	ZA9000FSB	Normal	± 0.3 K	EL18		B08
PtRh30-PtRh6 (B)		+400.00...	+1800.00	°C	ZA9400FSBP2	X6+	-	T B2		B95
PtRh30-PtRh6 (B)		+250,0…	+1820,0	°C	ZTD700FS	D7	-		El18	B-08
AuFe-Cr		-270.0...	+60.0	°C	ZA9000FSA	Normal	± 0.1 K	AuFe		B38
W5Re - W26Re (C)		0.0...	2320.0	°C	ZA9000SSC	Normal	± 0.25 K	Wr26		B99

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Comma nd
Heat flow W/m²	FQAxxx	-2000.0..	+2000.0	W/m²	ZA9007FS	Normal	-	mV 2		B28
1. Heat flow W/m²	FQADxx	-2000.0..	+2000.0	W/m²		D6	-	DIGI	D q	B-01
2. Temperature	"	-40.00...	+80.00	°C		D6	-	DIGI	D t	B-02
Infrared 1. object temperature	FIAD43	-40.0...	+600.0	°C		D6	-	DIGI	D to	B-01
2. Ambient temperature	"	-10.0...	+120.0	°C		D6	-	DIGI	D ta	B-02
Voltage, see chapter 4										
Millivolt DC		-10.000...	+55.000	mV	ZA9000FS0	Normal	-	mV		B10
Millivolt 1 DC		-26.000...	+26.000	mV	ZA9000FS1	Normal	-	mV 1		B27
Millivolt 2 DC		-260.00...	+260.00	mV	ZA9000FS2	Normal	-	mV 2		B28
Volt DC		-2.6000...	+2.6000*	V	ZA9000FS3	Normal	-	Volt		B11
26 Volt DC		-26.000...	+26.000	V	ZA9602FS	Divider	-	mV 2		B28
2 x 26 Volt DC		-26.000...	+26.000	V	ZA9602FS2	Divider	-	mV 2		B28
Voltage differential measurement with sensor supply from the ALMEMO® device										
Diff.-Millivolt DC		-10.000...	+55.000	mV	ZA9000FS0D	Normal	-	D 55		B50
Diff.-Millivolt1 DC		-26.000...	+26.000	mV	ZA9000FS1D	Normal	-	D 26		B51
Diff.-Millivolt2 DC		-260.00...	+260.00	mV	ZA9000FS2D	Normal	-	D260		B52
Diff.-Volt DC		-2.6000...	+2.6000*	V	ZA9000FS3D	Normal	-	D2.6		B53
2 Volt DC 5M/s		-2.20000...	+2.20000	V	ZED700FS	D7	-		D U25	B-01
2,2 Volt DC 500M/s		-2.2000...	+2.2000	V	ZED700FS	D7	-		D U24	B-02
2,2 Volt DC 1000M/s		-2.200...	+2.200	V	ZED700FS	D7	-		D U23	B-03
250 Millivolt DC 5M/s		-250,000…	+250,000	mV	ZED700FS2	D7	-		D U254	B-01
64 Millivolt DC 5M/s		-64,000…	+64,000	mV	ZED700FS2	D7	-		D U643	B-02
20 Volt DC 5M/s		-20.0000...	+20.0000	V	ZED702FS	D7	-		D U204	B-01
20 Volt DC 500M/s		-20.000...	+20.000	V	ZED702FS	D7	-		D U203	B-02
20 Volt DC 1000M/s		-20.00…	+20,00	V	ZED702FS	D7	-		D U202	B-03

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
60 Volt DC 5M/s		-60,000…	+60,000	V	ZED702FS2	D7	-		D U603	B-01
60 Volt DC 500M/s		-60,00…	+60,00	V	ZED702FS2	D7	-		D U602	B-02
60 Volt DC 1000M/s		-60,00…	+60,00	V	ZED702FS2	D7	-		D U612	B-03
Voltage differential measurement with sensor supply 12V										
Diff.-Millivolt DC		-10.000...	+55.000	mV	ZA9600FS0V12	V12	-	D 55		B50
Diff.-Millivolt1 DC		-26.000...	+26.000	mV	ZA9600FS1V12	V12	-	D 26		B51
Diff.-Millivolt2 DC		-260.00...	+260.00	mV	ZA9600FS2V12	V12	-	D260		B52
Diff.-Volt DC		-2.6000...	+2.6000*	V	ZA9600FS3V12	V12	-	D2.6		B53
Diff.-26Volt DC		-26.000...	+26.000	V	ZA9602FS3V12	V12 Divider	-	D260		B53
Plug for measuring bridges with 5V- supply										
Diff.-Millivolt DC		-10.000...	+55.000	mV	ZA9105FS0	Bridge	-	D 55		B50
Diff.-Millivolt1 DC		-26.000...	+26.000	mV	ZA9105FS1	Bridge		D 26		B51
Diff.-Millivolt2 DC		-260.00...	+260.00	mV	ZA9105FS2	Bridge		D260		B52
Diff.-Millivolt DC 10M/s		-29.600...	+29.600	mV	ZKD700FS	D7	-		DMS1	B-01
Diff.-Millivolt DC 1000M/s		-29.600...	+29.600	mV	ZKD700FS	D7	-		DMS2	B-02
Force sensor 1000M/s	FK0x			N	ZKD712FS	D7	-		DMS2	B-02
Connector for potentiometer										
2,6V DC Difference	FWAxxx	-2,6000…	+2,6000*	V	ZA9025FS3	Normal	-	D2.6		B53
Potentiometer		0,00…	100,00	%	ZWD700FS	D7	-		D U24	B-01
Fast overload-proof DC measuring module with galvanic isolation 1kV:										
2.0 Volt DC 1000M/s		-2.000...	+2.000	V	ZA9900AB2	Module	-	DIGI		B55
20 Volt DC 1000M/s		-20.00...	+20.00	V	ZA9900AB3	Module	-	DIGI		B55
200 Volt DC 1000M/s		-200.0...	+200.0	V	ZA9900AB4	Module	-	DIGI		B55
400 Volt DC 1000M/s		-400.0...	+400.0	V	ZA9900AB5	Module	-	DIGI		B55

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
DC current, see chapter 4										
Milliampere DC		-32.000...	+32.000*	mA	ZA9601FS1	Shunt	-	mA		B12
Percent (4-20mA)		0.00...	100.00	%	ZA9601FS2	Shunt	-	%		B13
DC current differential measurement: Sensor supply 7..9V										
Differential 32mA		-32.000...	+32.000*	mA	ZA9601FS5	Shunt	-	mA		B12
Differential percent		0.00...	100.00	%	ZA9601FS6	Shunt	-	%		B13
20 mA DC 5M/s		-20.0000...	+20.0000	mA	ZED701FS	D7	-		D I204	B-01
20 mA DC 500M/s		-20.000...	+20.000	mA	ZED701FS	D7	-		D I203	B-02
20 mA DC 1000M/s		-20,00…	+20,00	mA	ZED701FS	D7	-		D I202	B-03
Differential measurement: Sensor supply 12V										
Differential 32mA		-32.000...	+32.000*	mA	ZA9601FS5V12	ShuntV12	-	mA		B12
Differential % (4 - 20mA)		0.00...	100.00	%	ZA9601FS6V12	ShuntV12	-	%		B13
Fast overload-proof DC measuring module with galvanic isolation 1kV:										
20 mA DC 1000M/s		-20.00...	+20.00	mA	ZA9901AB1	Module	-	DIGI		B55
200 mA DC 1000M/s		-200.0...	+200.0	mA	ZA9901AB2	Module	-	DIGI		B55
2 A DC 1000M/s		-2.000...	+2.000	A	ZA9901AB3	Module	-	DIGI		B55
10 A DC 1000M/s		-10.00...	+10.00	A	ZA9901AB4	Module	-	DIGI		B55
AC voltage, see chapter 4										
260 mV AC without galv. isol.		-260.0...	+260.0	mV	ZA9603AK1	Cable	-	mV 2		B28
2.6 Volt AC without galv. isol.		-2.600...	+2.600	V	ZA9603AK2	Cable	-	Volt		B11
26 Volt AC without galv. isol.		-26.00...	+26.00	V	ZA9603AK3	Cable	-	Volt		B11
Fast overload-proof AC measuring module with electrical isolation 1kV:										
130 Millivolt AC TRMS		0.0...	+130.0	mV	ZA9903AB1	Module	-	DIGI		B55
1.3 Volt AC TRMS		0.000...	+1.300	V	ZA9903AB2	Module	-	DIGI		B55
13 Volt AC TRMS		0.00...	+13.00	V	ZA9903AB3	Module	-	DIGI		B55

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
130 Volt AC TRMS		0.0...	+130.0	V	ZA9903AB4	Module	-	DIGI		B55
400 Volt AC TRMS		0. ...	+400.	V	ZA9903AB5	Module	-	DIGI		B55
AC current, see chapter 4										
1 A AC TRMS		0.000...	+1.000	A	ZA9904AB1	Module	-	DIGI		B55
10 A AC TRMS		0.00...	+10.00	A	ZA9904AB2	Module	-	DIGI		B55
Resistance, see chapter 4										
500 Ohm *		0.00...	500.00	Ω	ZA9003FS	Normal	-	Ohm		B15
5000 Ohm with ElFlg1 *		0.00...	5000.0	Ω	ZA9003FS2	Normal	-	Ohm		B15
50 Ohm *		0.00...	50.00	Ω	ZA9003SS3	Normal	-	Ohm1		B99
110 kOhm		0.00...	110.00	Ω	ZA9003SS4	Normal	± 0.2 % of meas. val. ± 0.02KW	Ohm4		B99
Potentiometer		0.00...	+100.00	%	ZA9025FS3	Normal	-	D2.6		B53
Potentiometer		0.00...	+100.00	%	ZWD700FS	D7	-		D U24	B-01
Digital signals, see chapter 4.6										
Frequency		0 ...	15000	Hz	ZA9909AK1U	Cable	-	Freq		B29
Speed		8 ...	32000	UpM	ZA9909AK4U	Cable	-	Freq		B29
Pulse count / measurement cycle		0 ...	65000		ZA9909AK2U	Cable	-	PULS		B54
Digital input		0.00 ...	100.00	%	ZA9000EK2	Cable	-	Inp		B70
Digital interface		-65000...	65000		ZAD919AKxx	Cable	-	DIGI		B55
Humidity sensors, see chapter 3.4										
Capacitive humidity sensors, analog:										
1. Temperature NTC Type N	FHA646	-50.00...	+125.00	°C	ZA9000FS	Normal	± 0.05 K	Ntc		B09
2. Rel. humidity	"	-5.0 ...	98.0	%H	"	Normal	-	% rH		B16
x. Dew point temperature	"	-25.0 ...	100.0	°C	"	Normal	± 0.2 K	H DT	H td	B44
x. Mixture ratio., AC	"	0.0 ...	500.0	g/kg	"	Normal	± 0.5 % of meas. val.	H AH	H r	B43
x. Abs. humidity AH, d_v	"	0.0 ...	596.3	g/m^3	"	Normal		D dv	D dv	B87

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
x. Partial vapour pressure	"	0.0 ...	1013.2	mbar	"	Normal	±0.1mbar ± 0.1% of meas. v.	H VP	H e	B59
x. Enthalpy with AC	"	0.0 ...	400.0	kJ/kg	"	Normal	± 0.5 % of meas. value	H En	H h	B58
1. Temperature NTC Type N	FHA646C	-50.00...	+125.00	°C	ZA9000FS	Normal	± 0.05 K	Ntc		B09
2. Rel. humidity with TC	"	5.0 ...	98.0	%H	"	Normal	± 0.5 %	HcrH		B42
1. Temperature NTC Type N	FHA646R	-50.00...	+125.00	°C		Cable	± 0.05 K	Ntc		B09
2. Rel. humidity with TC Ø 5mm	"	5.0 ...	98.0	%H		Cable	± 0.5 %	H rH		B56
Psychrometer, analog:										
1. Dry temperature TT, t	FNA846	0.0 ...	90.0	°C	ZA9846-AK	Cable	± 0.05 K	Ntc		B09
2. Humid temperature HT, t_w	"	0.0 ...	90.0	°C	"	Cable	± 0.05 K	P HT		B45
3. Rel. humidity RH, U_w, with AC	"	0.0 ...	100.0	%H	"	Cable	± 1.0 %H	P rH	P Uw	B46
x. Dew point temp. DT, t_d, with AC	"	-64.8 ...	100.0	°C	"	Cable	± 0.2 K	P DT	P td	B48
x. Mixture ratio MH, r, AC	"	0.0 ...	500.0	g/k	"	Cable	± 0.5 % of meas. value	P AH	P r	B47
x. Abs. humidity AH, d_v, with AC	"	0.0 ...	596.3	g/m^3	"	Cable			D dv	B87
x. Partial vapour pressure VP, e, AC	"	0.0 ...	1100.0	mb	"	Cable	±0.1mbar ± 0.1% of meas. v.	P VP	P e	B49
x. Enthalpy En, h with AC	"	0.0 ...	400.0	kJ/kg	"	Cable	± 0.5 % of meas. value	P En	P h	B57
x. Rel. humidity from t and t_d	"	0.0 ...	100.0	%H	"	Cable			tdUw	B68
Capacitive humidity sensor, digital:										
FHAD46:										
1. Temperature	FHAD46	-20.00 ...	+100.00	°C		D6		DIGI	D t	B-01
2. Rel. humidity RH, U_w	"	0.0 ...	+100.0	%H		D6		DIGI	D Uw	B-02
3. Dew point temperature DT, t_d	"	-64.8 ...	+100.0	°C		D6		DIGI	D td	B-03
4. Atmospheric pressure	"	300.0...	1100.0	mb		D6		DIGI	D p	B-08
x. Mixture ratio MH, r, AC	"	0.0 ...	6500.0	gk		D6		DIGI	D r	B-04
x. Abs. humidity AH, d_v	"	0.0 ...	596.3	gm		D6		DIGI	D dv	B-05
x. Partial vapour pressure VP, e	"	0.0 ...	1100.0	mb		D6		DIGI	D e	B-06
x. Enthalpy En, h with AC	"	0.0 ...	6500.0	kJ		D6		DIGI	D h	B-07

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
FHAD36:										
1. Temperature	FHAD36	-100.00 ...	+200.00	°C		D6		DIGI	D t	B-01
2. Rel. humidity RH, U_w	"	0.0 ...	+100.0	%H		D6		DIGI	D Uw	B-02
3. Dew point temperature DT, t_d	"	-64.8 ...	+100.0	°C		D6		DIGI	D td	B-03
4. Atmospheric pressure	"	300.0...	1100.0	mb		D6		DIGI	D p	B-08
x. Mixture ratio MH, r, AC	"	0.0 ...	6500.0	gk		D6		DIGI	D r	B-04
x. Abs. humidity AH, d_v	"	0.0 ...	596.3	gm		D6		DIGI	D dv	B-05
x. Partial vapour pressure VP, e	"	0.0 ...	1100.0	mb		D6		DIGI	D e	B-06
x. Enthalpy En, h with AC	"	0.0 ...	6500.0	kJ		D6		DIGI	D h	B-07
Psychrometer, digital:										
1. Dry temperature TT, t	FNAD46	0.0 ...	90.0	°C		D6		DIGI	D t	B-01
2. Humid temperature HT, t_w	"	0.0 ...	90.0	°C		D6		DIGI	D tw	B-09
3. Rel. humidity RH, U_w, with AC	"	0.0 ...	100.0	%H		D6		DIGI	D Uw	B-02
4. Atmospheric pressure AP, p	"	300.0...	1100.0	mb		D6		DIGI	D p	B-03
x. Dew point temperature DT, t_d, with AC	"	-64.8 ...	100.0	°C		D6		DIGI	D td	B-08
x. Mixture ratio MH, r, AC	"	0.0 ...	6500.0	g/k		D6		DIGI	D r	B-04
x. Abs. humidity AH, d_v, with AC	"	0.0 ...	596.3	g/m^3		D6		DIGI	D dv	B-05
x. Partial vapour pressure VP, e, AC	"	0.0 ...	1100.0	mb		D6		DIGI	D e	B-06
x. Enthalpy En, h with AC	"	0.0 ...	6500.0	kJ/kg		D6		DIGI	D h	B-07
Moisture sensor										
1. Moisture building materials	FHA696MF	0.0 ...	20.0	B%		Normal		D2.6		B53
2. Moisture wood	"	0.0 ...	50.0	H%		Normal		D2.6		B53
x. Moisture paper	"	0.0 ...	20.0	P%		Normal		D2.6		B53

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
Flow, see chapter 3.7										
Vane anemometer mini, D6 mn20	FVAD15H120	0...	22.50	m/s		D6		DIGI		B-05
Vane anemometer mini, D6 mn40	FVAD15H140 FVAD15H25xxx	0 ...	45.00	m/s		D6		DIGI		B-06
Vane anemometer micro, D6 mc20	FVAD15H220	0.60 ...	22,50	m/s		D6		DIGI		B-01
Vane anemometer micro, D6 mc40	FVAD15H240 FVAD15H16xxx	0 ...	44.00	m/s		D6		DIGI		B-02
Vane anemometer frequency Hz	FVAD15Hxxx	0 …	65000	Hz		D6		DIGI		B-13
Vane anemometer frequency 0,1 Hz	FVAD15Hxxx	0 …	6500,0	Hz		D6		DIGI		B-14
Vane anemometer frequency 0,01Hz	FVAD15Hxxx	0 …	650,00	Hz		D6		DIGI		B-15
Vane anemometer speed	FVAD15Hxxx	8…	65000	U/min		D6		DIGI		B-16
Vane anemometer macro	FVAD15SMA1	0.20 ...	20.00	m/s		D6		DIGI	D420	B-05
Vane anemometer frequency Hz	FVAD15SMA1	0. ...	65000	Hz		D6		DIGI	D f0	B-07
Vane anemometer frequency 0.1 Hz	FVAD15SMA1	0.0 ...	6500.0	Hz		D6		DIGI	D f1	B-08
Vane anemometer frequency 0.0 Hz	FVAD15SMA1	0.00 ...	650.00	Hz		D6		DIGI	D f2	B-09
Vane anemometer speed	FVAD15SMA1	0. ...	65000	UpM		D6		DIGI	Drpm	B-10
Turbine flow meter	FVA915Vx			m/s		Counter		Freq		B29
Thermoanemometer										
FVAD35THx										
1. Temperature	FVAD35THx	-20.00...	70.00	°C		D6		DIGI	D t	B-01
2. Flow	FVAD35TH4	0.08...	2.000	m/s		D6		DIGI	D v	B-02
2. Flow	FVAD35TH5	0.20...	20.00	m/s		D6		DIGI	D v	B-02
3. Atmopspheric pressure AP, p	FVAD35THx	300.0...	1100.0	mb		D6		DIGI	D p	B-03
FVAD05TOKx										
1. Flow, v 2,5 m/s	FVAD05TOKx	0,050...	2,500	m/s		D6		DIGI		B-01
2. Flow, v 1,0 m/s	FVAD05TOKx	0,050...	1,000	m/s		D6		DIGI		B-02
2. Atmospheric pressure AP, p	FVAD05TOKx	300,0...	1100,0	mbar		D6		DIGI		B-03
3. Voltage Volt	FVAD05TOKx	0,000...	10,000	V		D6		DIGI		B-04

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Comman d
Thermal sensor SS20	<SS 20.21>	0.50...	+20.00	m/s	ZA9602SSS	Divider	± 0.02 m/s	L920		B99
Dynamic pressure sensor										
Dynamic pressure 250 Pa	FDA602S2K	-250.0 ...	+250.0	Pa		Pressure	-	D2.6		B53
1. Flow 40m/s, TC and AC	FDA602S1K	0.5 ...	40.0	m/s		Pressure	± 0.1 m/s	L84O		B40
2. Dynamic pressure 1250 Pa	"	-1250.0 ...	1250.0	Pa		Pressure	-	D2.6		B53
1. Flow 90m/s, TC and AC	FDA602S6K	1.8 ...	90.0	m/s		Pressure	± 0.1 m/s	L89O		B41
2. Dynamic pressure 6800 Pa	"	-6800. ...	6800	Pa		Pressure	-	D2.6		B53
Weather station, see chapter 3.6										
Wind direction min	FMD760/770	0. ...	359.	°		D7			D Dmin	B-01
Wind direction averaged	"	0. ...	359.	°		D7			D Davg	B-02
Wind direction max	"	0. ...	359.	°		D7			D Dmax	B-03
Wind speed min	"	0.0 ...	60.0	m/s		D7			D vmin	B-04
Wind speed averaged	"	0.0 ...	60.0	m/s		D7			D vavg	B-05
Wind speed max	"	0.0 ...	60.0	m/s		D7			D vmax	B-06
Current air temperature	"	-52.0 ...	+60.0	°C		D7			D t	B-07
Air temperature min	"	-52.0 ...	+60.0	°C		D7			D tmin	B-08
Air temperature averaged	"	-52.0 ...	+60.0	°C		D7			D tavg	B-09
Air temperature max	"	-52.0 ...	+60.0	°C		D7			D tmax	B-10
Current rel. humidity	"	0.0 ...	100.0	%H		D7			D Uw	B-11
Current atmospheric pressure	"	600.0 ...	1100.0	mbar		D7			D p	B-12
Rainfall	"	0.00 ...	999.99	mm		D7			D R	B-13
Rain intensity	"	0. ...	200,0	mm/h		D7			D Ri	B-14
Snow-/hail	"	0 ...	999,99	mm		D7			D H	B-15
Snow-/hail intensity	"	0 ...	200,0	mm/h		D7			D Hi	B-16
Wind direction code	"	0. ...	+359	°		D7			D Dtxt	B-17
Radiation, only at FMD770	FMD770	0 …	2000,0	W/m 2		D7			D GR	B-18

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
Sensors for mechanical quantities, see chapter 3.8										
Barometer	FDAD12SA	300.0...	1100.0	mb		D6		DIGI	D p	B-01
Pressure sensor	FD8214	2,5...	100	bar	ZA8214AK	Cable		D2.6		B53
1. Pressure sensor	FDA602LxAK	0.000...	50.000	bar		Normal		D2.6		B53
2. Temperature refrigerant R22, t	Dew pressure 0..36 bar	-90.0...	+79.0	°C	Device option R2*	Normal	<-24°C:± 0.2K; >-24°C:±0.1K	R 22		B20
3. Refrigerant R23, t	Dew pressure 0..49 bar	-100.0...	+26.0	°C	"	Normal	<-24°C:± 0.2K; >-24°C:±0.1K	R 23		B19
4. Refrigerant R134a, t	Dew press. 0..40.5 bar	-75.0...	+101.0	°C	"	Normal	<-16°C:± 0.2K; >-16°C:±0.1K	R134		B21
x. Refrigerant R404A, t"	Boiling press. 0..32 bar	-60.0...	+65.0	°C	"	Normal	± 0.1 K	R4O4		B22
x. Refrigerant '404A, t'	Dew pressure 0..32 bar	-60.0...	+65.0	°C	"	Normal	± 0.1 K	'4O4		B17
x. Refrigerant R407C, t"	Boiling press. 0..46 bar	-50.0...	+86.0	°C	"	Normal	<-30°C:± 0.2K; >-30°C:±0.1K	R4O7		B23
x. Refrigerant '407C, t'	Dew pressure 0..46 bar	-50.0...	+86.0	°C	"	Normal	<-30°C:± 0.2K; >-30°C:±0.1K	'4O7		B62
x. Refrigerant R410, t	Dew pressure 0..49 bar	-70.0...	+70.0	°C	"	Normal	<-30°C:± 0.2K; >-30°C:±0.1K	R41O		B25
x. Refrigerant R417, t	Dew pressure 0..27 bar	-50.0...	+70.0	°C	On request	Normal	<-35°C:± 0.2K; >-35°C:±0.1K	R417		B26
x. Refrigerant R507, t	Dew pressure 0..37 bar	-70.0...	+70.0	°C	"	Normal	<-30°C:± 0.2K; >-30°C:±0.1K	R5O7		B18
x. Refrigerant R717, t	Dew pressure 0..65 bar	-46.0...	+102.0	°C	"	Normal	± 0.1 K	R717		
x. Refrigerant R290, t	Dew pressure 0..37 bar	-90.0...	+90.0	°C	"	Normal	± 0.1 K	R29O		
x. Refrigerant R600A, t	Dew pressure 0..36 bar	-50.0...	+134.0	°C	"	Normal	± 0.1 K	R6OO		

Type of sensor	Sensor name	Measuring range	Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
1. Pressure sensor 200M/s	FDAD33/35		bar		D6		DIGI	D p	B-01
2. Max. value	"		bar		D6		DIGI	DMax	B-02
3. Min. value	"		bar		D6		DIGI	DMin	B-03
4. Average value	"		bar		D6		DIGI	DAvg	B-04
Pressure sensor 500M/s 50000Dig	FD0602L		bar	ZDD702AKL	D7			D U24	B-02
Pressure sensor 5M/s 200000Dig	FD0602L		bar	ZDD702AKL	D7			D U25	B-01
Pressure sensor 500M/s 50000Dig	FD8214		bar	ZDD714AK	D7			D U24	B-02
Pressure sensor 5M/s 200000Dig	FD8214		bar	ZDD714AK	D7			D U25	B-01
Speed sensor digital	FUA919-2	8... 30000	UpM		Counter		Freq		B29
GPS sensors									
1. Longitude	FGD701	-180. ... +180.	°		D7			D LG_G	B-02
2. Latitude	"	-90. ... +90.	°		D7			D BG_G	B-04
3. Height above geoid	"	0.0 ... +9999.9	m		D7			D HGeo	B-06
4. Speed	"	0.0 ... +9999.9	km/h		D7			D vkmh	B-09
5. Direction of movement	"	0.0 ... 359.0	°		D7			D °	B-11
Light sensors, see also chapter 3.10									
1. 26000 Lux	FLA613VL	0. ... 26000	Lux		Normal		D26O		B52
2. 260 kLux	"	0.00. 260.00	kLux		Normal		D26O		B52
1. Colour temperature	FLAD23CCT	0. ... 30000	K		D6		DIGI	DCCT	B-01
2. Light intensity	"	0. ... 65000	Lux		D6		DIGI	kEv0	B-02
3. Light intensity	"	0.00 ... 170.00	kLux		D6		DIGI	kEv2	B-03
Sensors for water analysis, see chapter 3.11									
pH/Redox sensors:									
pH sensor									
1. Temperature NTC Type N	FY96PHxx	-50.00... +125.00	°C	ZA9640AKY4	Cable	± 0.05 K	Ntc		B09

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
2. pH sensor with TC	"	0.00...	14.00	pH	"	Cable		D2.6		B53
Redox sensor	FY96RXxx	-1000.0...	+1000.0	mV	ZA9610AKY5	Cable		D2.6		B53
Conductivity sensors										
Conductivity sensor 2L with TC	FYA641LF/2/3	0.0 ...	20.000	mS		Conductivity	± 0.2 % of meas. value		LF	B60
Conductivity sensor 4L with TC	FYD741LF	-5.00 ...	+70.00	°C		D7			D t	B-01
	"	0.00 ...	500.00	uS		D7			DLF1	B-02
	"	0.000 ...	50.000	mS		D7			DLF2	B-03
	"	0.00 ...	500.00	mS		D7			DLF3	B-04
O_2 sensor for dissolved oxygen in water										
1. NTC type N	FYA640O2	-50.00...	+125.00	°C		Normal	± 0.05 K	Ntc		B09
2. O_2 saturation with TC, AC	"	0 ...	260	%		Normal	-	O2-S		B55
3. O_2 concentration with TC	"	0.0 ...	40.0	mg/l		Normal	± 0.2 mg/l	O2-C		B66
O_2 sensor for gas	FYA600O2	1.00 ...	100.00	%		Normal	-	mV 2		B28
CO_2 sensor for gas	FYA600CO2	0.0 ...	25.00	%		Normal	± 0.2 % of meas. value	CO2		B64
1. CO_2 concentration	FYAD00CO2	0. ...	10000	%		D6	-	DIGI	DCO2	B-01
2. Atmospheric pressure	"	300.0...	1100.0	mb		D6	-	DIGI	D p	B-02
Sensors for gas analysis, see chapter 3.12										
Function channels:	Function/Reference									
Difference	(Mb1-Mb2)						-	Diff		B71
Max. value	(Mb1)						-	Max		B72
Min. value	(Mb1)						-	Min		B73
Average value over time	(Mb1)						-	M(t)		B74
Average value over meas. channels	(Mb2...Bb1)						-	M(n)		B75
Sum over measuring channels	(Mb1)	0 ...	65000				-	S(n)		B76
Total number of pulses	(Mb1)	0 ...	65000		ZA9909AK2U		-	S(t)		B77
Number of pulses / printing cycle	(Mb1)	0...	65000		ZA9909AK2U		-	S(P)		B78

Type of sensor	Sensor name	Measuring range		Dim	Connector name	Con. type	Linearisation accuracy	Code	V6/V7	Command
Alarm value	(Mb1)	0.0...	100.00	%			-	Alrm		B79
Heat flow coefficient	M(q) / M(DT)			W/m^2K			-	q/dt		B80
Wet bulb globe temp.	0.1TT+0.7HT+0.2GT			°C			-	WBGT		B02
Battery voltage		0,00...	26.00	V			-	Batt		B14
Measuring value *	(Mb1)						-	Meas		B81
Reference junction temp. *		-30.00...	+100.00	°C			± 0.05 K	CJ		B82
Number of averaged values *	(Mb1)	0...	65000				-	n(t)		B83
Flow rate *	$\bar{M}$(Mb1) * Q	0...	65000	m^3/h			-	Flow		B84
Timer 1s *		0...	60000	s			-	Time		B85
Timer 0.1s * Exp=-1		0...	6000.0	s			-	Time		B85
Atmospheric pressure * device internal		300.0...	1100.0	mb			-	AP		B86

TC = With temperature compensation, AC = With air pressure compensation, Mbx = Reference channels
Probes type D6 can only be configured with V7 devices or with USB cable ZA1919-AKUV, display with range DIGI
Sensors type D7 can only be used with V7 devices or with USB cable ZA1919-AKUV
Probes type X6° can only be used with reference encoders 1030-2, 1036-2 or 8036, type X6+ only with reference encoder 1020-2
* Range available depending on type and version of the device, some data may differ (see device manual)

3.2 Temperature sensors

Selection

The type of temperature sensor depends on the measuring task. Basically, thermocouples, resistance sensors (Pt100 and NTC) and radiation thermometers (infrared sensors) are available.

Base of the selection:

1. Thermocouple sensors measure quite fast and offer a wide measuring range.
2. Pt100 sensors are more slow but offer a high accuracy.
3. NTC sensors measure fast and very accurate, but the measuring range is limited.
4. Infrared sensors do not touch the measuring object, have very small time constants, but the measurement depends on the emissivity.
5. The larger the measuring range, the more universal the application possibilities.

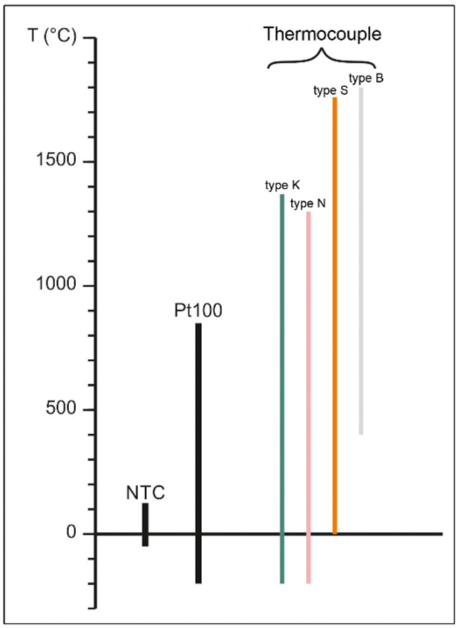


Fig. 3.2.1
Measuring range of various temperature sensors

Selection criteria:

Selection of temperature sensors suitable for the measuring task according to the following criteria:

- Measuring range
- Accuracy
- Response time
- Durability
- Type

Type versions:

- Surface sensors for good heat conductors
- Surface sensor for poor heat conductors
- Immersion sensor for liquids
- Immersion sensors for air and gases
- Piercing probe
- High temperature sensor
- Infrared sensor for non-contact measurements
- Sword probes for paper, cardboard, tobacco, textiles

3.2.1 Thermocouples

Measuring principal

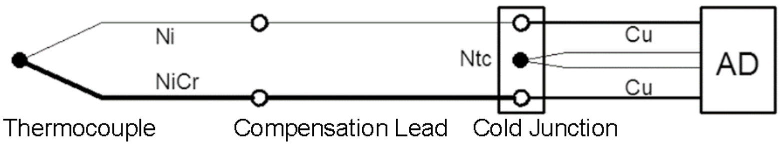


Fig. 3.2.2
Thermocouple with compensation cable and reference junction

Thermocouples consist of two spot-welded wires of different metals and metal alloys. During temperature measurement, the so-called thermoelectric effect is used at the contact surface. It causes a relatively small thermoelectric voltage, which depends on the temperature difference between the measuring point and the reference junction.

Basics

Reference junction

With thermocouples, the absolute temperature can only be determined if the terminal temperature is kept at a known temperature (e.g. with ice water or thermostat) or the reference junction temperature is measured continuously.

In ALMEMO® devices, a miniature NTC temperature sensor is located in the ALMEMO® socket in the contact in order to measure the temperature of the transition point from thermocouple to copper as accurately as possible. Since every temperature difference between the transition point and the temperature sensor is noticeable as a measuring error, ALMEMO® connectors with pins made of thermo-material are available for thermocouples of types K, N, J and T, so that the transition point is actually in the immediate vicinity of the NTC temperature sensor (ZA 902x-FSx).

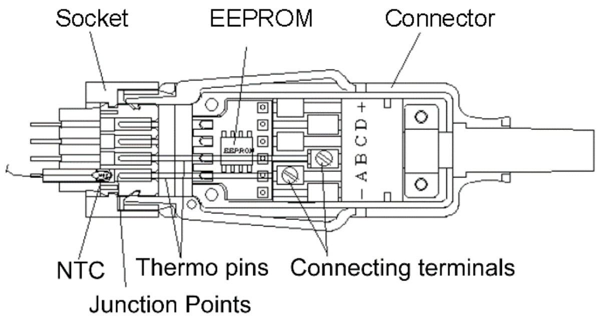


Fig. 3.2.3
ALMEMO® connector ZA 902x-FSx for thermocouples with pins made of thermo-material

The characteristic curves of the thermocouples are not linear. For this reason, the temperature of the reference junction must not be added to the measuring temperature to calculate the absolute temperature. The voltage which must correspond to the respective reference junction temperature must be added to the measuring voltage.

Examples for thermocouples type K (NiCr-Ni):

	Voltage		Temperature	
Measuring value	**24.902 mV**	→	**600.0°C**	
Reference junction temperature	**1.000 mV**	←	**25.0°C**	
Corrected measuring value	**25.902 mV**	→	**623.5°C**	**not 625°C!**

The calculations are performed in the ALMEMO® measuring device. When measuring with an external reference junction (see chapter 6.7.3) it is very helpful for the user to understand the relationships.

Selection, product overview

There are a number of thermocouples that differ in temperature range, sensitivity and above all in compatibility with the measured medium.

Basic values of the thermoelectric voltages according to IEC 584-1:1995 (ITS90)

Temperature [°C]	NiCr-Ni Type K U [mV]	NiCroSil-NiSil Type N U [mV]	Fe-CuNi Type J U [mV]	Cu-CuNi Type T U [mV]	PtRh10-Pt Type S U [mV]	PtRh30-PtRh6 Type B U [mV]
-270	-	-4.345	-	-6.258	-	-
-200	-5.891	-3.990	-7.890	-5.603	-	-
-100	-3.554	-2.407	-4.633	-3.379	-	-
0	0	0	0	0	0	0
100	+4.096	+2.774	+5.269	+4.279	+0.646	+0.033
200	+8.138	+5.913	+10.779	+9.288	+1.441	+0.178
300	+12.209	+9.341	+16.327	+14.862	+2.323	+0.431
400	+16.397	+12.974	+21.848	+20.872	+3.259	+0.787
500	+20.644	+16.748	+27.393		+4.233	+1.242
600	+24.905	+20.613	+33.102		+5.239	+1.792
700	+29.129	+24.527	+39.132		+6.275	+2.431
800	+33.275	+28.455	+45.494		+7.345	+3.154
900	+37.326	+32.371	+51.877		+8.449	+3.957
1000	+41.276	+36.256	+57.953		+9.587	+4.834
1100	+45.119	+40.087	+63.792		+10.757	+5.780
1200	+48.838	+43.846	+69.553		+11.951	+6.786
1300	+52.410	+47.513			+13.159	+7.848
1400					+14.373	+8.956
1500					+15.582	+10.099
1600					+16.777	+11.263
1700					+17.947	+12.433
1800						+13.591

Features of the individual thermocouples

Type K, NiCr-Ni

Thermocouples type K can be used in a wide temperature range (-270°C to +1372°C). They are recommended for use in clean, oxidizing (air) and neutral atmosphere (inert gases).

In the temperature range between 250°C and 600°C, type K thermocouples are not suitable for accurate measurements at faster temperature changes due to a rearrangement effect in the crystal structure.

Most frequently used thermocouple.

Type N, NiCrSi-NiSi

Thermocouples type N are best suited for applications in clean, oxidizing (air) or neutral atmosphere (inert gases) in the temperature range of approx. 300°C to 1260°C. They offer high thermal stability in air above 1000°C and a higher resistance to oxidation than type E, J, K or T thermocouples.

Compared to the alloyed similar type K thermocouples, they have a better thermoelectric stability over the whole temperature range and are better suited for use under changing temperatures.

This type of thermocouple is often used in low-temperature applications, although it should be noted that the good thermal conductivity of both legs favours measuring errors.

Type J, Fe-CuNi

Besides type K one of the most frequently used thermocouples. The use of the thermocouple should be limited to temperatures between 0 and 750°C. Above 750°C the oxidation rate of both thermocouple legs increases on the one hand, on the other hand at the Curie temperature of iron (768°C) there is a change in the magnetic state and at about 910°C there is a change in the crystal structure, both of which can lead to considerable irreversible changes in the characteristic curve. In a humid environment the iron leg can become rusty and brittle.

Type T, Cu-CuNi

Thermocouples type T are recommended for applications in the temperature range from -200°C to +370°C in vacuum or oxidizing, reducing or inert atmosphere (inert gases). Above 370°C the positive branch of the thermocouple wires type T oxidizes very fast. Even in a hydrogen atmosphere it is not recommended to use above approx. 370°C because the positive branch of the thermocouple becomes brittle. The positive leg of the thermocouple has a high thermal conductivity.

Type S, PtRh10-Pt

Type S thermocouples can be used from -50°C to about +1300°C in continuous operation. Their characteristic curve has good reproducibility, stability and resistance. Their stability is highest in a clean oxidizing atmosphere (air). For a short time they can also be used in inert gas atmospheres or in vacuum. Use in reducing atmospheres is not recommended.

Type B, PtRh30-PtRh6

Thermocouple for high temperatures. It can be exposed to temperatures up to 1700°C for several hundred hours. It is most resistant to clean, oxidizing atmosphere (air), but can also be used in inert gas atmospheres or in vacuum.

Compensation leads

For the extension of thermocouples, often cheaper and easier to handle compensating cables are used, but their thermoelectric voltage may differ from that of the thermocouple. In order to keep the measuring errors within narrow limits, care should be taken to ensure that the contact points to the thermocouple and to the measuring instrument have the same temperature, if possible.

Even greater errors occur if the type of compensating cable does not match the thermocouple or if the compensating cable is incorrectly polarized. This must be avoided at all costs.

Fields of application

Due to their low mass, thermocouple sensors have a high display speed. Therefore they are particularly suitable for control measurements in production, test field and laboratory. Jacketed thermocouples with diameters below 0.5 mm are very advantageous, as they are internally insulated and thus do not form an electrical connection to the measured object. They are bendable and can even be soldered in.

3.2.1.1 Thermocouple sensors FTA xxx

Sensor characteristics

Features

For the sensor connection cables, thermoelectric cable (stranded wire, thermoelectric cable class 2) is used for many sensor types (instead of the usual compensating cable). The transition point from the measuring element (sensor tip) to the connecting cable (in the cable transition sleeve or in the handle) thus does not cause a temperature error in a wide temperature range up to 200°C; the usual measuring errors (due to temperature differences at the transition point) are avoided when using a compensating cable (no thermoelectric cable).

For a few sensor types and for extension cables, compensating cable is used as before. The compensating cables usually correspond to class 2 according to DIN 43722. For type K the application temperature range of the compensating cable is 0 to 150°C.

Types

Jacketed thermocouples

Since the thermocouples, as described above, corrode easily under certain conditions, they are often used in an Inconel tube as jacketed thermocouples. Inconel is a corrosion-resistant nickel alloy, which is also suitable for use in extreme environments and at high temperatures.

Jacketed thermocouples are available in various lengths and diameters. There are several thermocouple types available, for example NiCr-Ni, type K, with operating temperatures from -40 to +900°C or NiCrSi-NiSi, type N, with operating temperatures from -200 to +1150°C.

Inconel tubes can be bent. The cable transition sleeve is made of brass (hexagon, L = 65 mm, corner dimension = 9.1 mm, operating temperature -40 to +160°C).

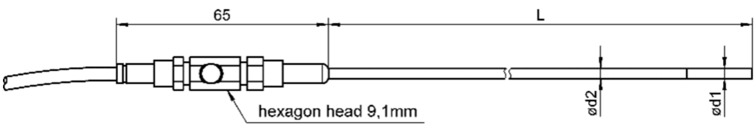


Fig. 3.2.4
Jacketed thermocouple sensor

Standard cable: 1.5m FEP/silicone thermoelectric cable (stranded wire, operating temperature -50 to +200°C, no temperature influence at the transition from measuring element to cable.

Sensors for surface and immersion measurements

These probes have a handle and have different tips that make the probes suitable for surface or immersion measurements.

Examples:

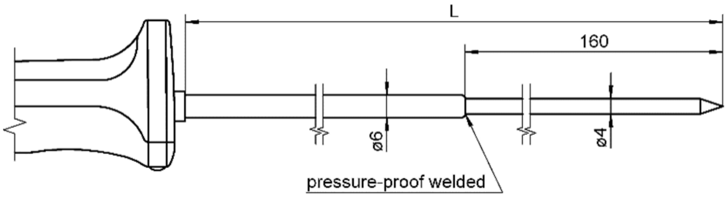


Fig. 3.2.5 FTA 1231-LxxxxH for immersion measurement in plastic or pasty media

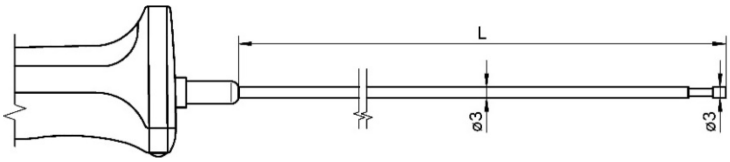


Fig. 3.2.6 FTA 122-LxxxxH for surface and immersion measurement

Thermo wire

Types:

Type	Isolation	Operating temperature	Wire diameter	External diameter
T 190-0	**Glass silk**	**-25 to +400°C**	**0.5 mm**	**ca. 1.3 x 2.1 mm**
T 190-1	**Glass silk**	**-25 to +400°C**	**0.2 mm**	**ca. 0.6 x 1.0 mm**
T 190-2	**PVC**	**-10 to +105°C**	**0.5 mm**	**ca. 2.2 x 3.4 mm**
T 190-3	**Silicone**	**-45 to +200°C**	**0.5 mm**	**ca. 4 mm**
T 190-7	**Ceramic fibre**	**-40 to +1200°C**	**0.8 mm**	**ca. 3 x 4 mm**
T 190-10	**FEP**	**-200 to +205°C**	**0.5 mm**	**ca. 1.5 x 2.5 mm**
T 190-11	**FEP**	**-200 to +205°C**	**0.2 mm**	**ca. 1.3 x 2.0 mm**

Thermo wires can be connected to ALMEMO® devices via ALMEMO® connectors (ZA 9020-FS, ZA 9021-FSx, ZA 9000-FSx, ZA 5690-MU) or via miniature flat connectors (ZK 9029-FS, type K).

Measurements with bare, non-insulated thermowire sensors are only recommended in air or in/on electrically insulating materials (e.g. plastics). For measurements on electrically conductive materials with (high) electrical potential, insulated jacketed thermocouple probes should preferably be used. Alternatively, thermocouple wire sensors can be connected electrically isolated via the ZAD 950-ABx measuring module (available for types K, J and T) (see section 4.5.3).

Technical data

The basic values of the thermoelectric voltages and the permissible tolerances of thermocouples are defined in DIN/IEC 584.

Three accuracy classes are defined for thermocouples according to DIN/IEC 584-2. Ahlborn offers thermocouple sensors in two of these accuracy classes.

The following limits apply for type K:

	Area of validity	Limit deviation (the larger value applies in each case)
Class 1:	-40 to 1000°C	±1.5 K or ±0.004 • | t | K
Class 2:	-40 to 1200°C	±2.5 K or ±0.0075 • | t | K

The T_{max} values given in the technical data refer to the sensor tip. The sensor handles and cables are generally resistant up to 80°C, for higher ambient temperatures heat-resistant cables are also available.

Probes age depending on the operating conditions. As a result, their accuracy may vary over time from the accuracy class in which they were delivered. The temperature limits specified for the accuracy classes are not necessarily the recommended limits of the application temperature (in the voltage series, the thermoelectric voltages are given for considerably wider temperature ranges.) Outside these temperature limits, however, no limit deviations are defined.

Use

Increase of measuring accuracy

The immersion depth of the thermocouple sensors should be selected sufficiently large. If the sensor is not immersed deep enough, the non-immersed part of the sensor sheath influences the temperature measured at the tip by thermal conduction.

The minimum immersion depth can be determined by immersing the sensor as deeply as possible, then slowly pulling it out and observing when the displayed measured value changes. Shortly before this happens, the sensor has the minimum immersion depth.

The immersion depth depends not only on the sensor, but also on the surrounding medium and especially on the circulation/movement of the medium.

The length of the jacketed thermocouples should be at least 10 cm, better 25 cm, otherwise the temperature of the cable transition sleeve will influence the measuring result.

Sensor protection

Thermocouple sensors must not be subjected to sudden temperature changes, neither positive nor negative. If, for example, the temperature in an oven is to be measured, the sensor should be heated up together with the oven and also cooled down again. Sudden changes in temperature can significantly reduce the accuracy of the sensor due to changes in the material of the sensor element.

Excessive mechanical loads should also be avoided with thermocouples, because structural changes can affect the characteristic curve. The radius of curvature of Inconel tubes must not be too small (at least 10 times the diameter).

3.2.2 Pt100 resistance sensors

Measuring principal

When measuring temperature with Pt100 sensors, their resistance increase is utilized with increasing temperature. The measuring resistor is supplied with a constant current and the voltage drop across the resistor is measured as a function of temperature. Due to the small change in resistance (0.3-0.4 Ω/°C), the 4-wire circuit should always be used to exclude the influence of the lead wires.

Basics

Wire measuring resistors

The Pt100 resistor consists of a platinum wire, which is melted in many turns into a glass rod or embedded in a ceramic mass. Wound sensors are preferably used for higher temperatures.

Coated measuring resistors

Here, the platinum is applied to a carrier material in a meandering pattern using thin-film technology and then coated to protect it from chemical influences. Thin-film sensors are preferred nowadays because of their rational manufacturing process.

3.2.2.1 Pt100 resistance sensors FPA xxx

Sensor characteristics

Features

Analog connectors

As standard, the Pt100 sensors are equipped with a plug (ZA 9030-FS1, see chapter 4.1.2.1), which processes the signal analogously.

Following measuring ranges are possible:

Range	-200 to +850°C	Resolution 0.1 K
Range	-200 to +400°C	Resolution 0.01 K
Range	-8 to +65°C	Resolution 0.001 K

Digital connector

Pt100 sensors can also be equipped with digitally operating D7 connectors (ZPD700FSx, see section 4.1.2.3).

Range -200 to +850°C Resolution 0.01 K

This digital ALMEMO® D7 measuring connector works with its own built-in 24-bit AD-converter. The linearization of the Pt100 characteristic is calculated without errors according to DIN IEC 751 (no approximation method). Since the overall accuracy of the sensor with a D7 connector does not depend on an evaluation device, the sensor can also be calibrated and even multi-point adjusted on its own. For sensor identification, a comment of up to 20 digits can be programmed in the ALMEMO® D7 measuring connector.

Types

Jacketed resistance sensor

Operating temperatures of standard Pt100 jacketed resistance sensors range are from -40 to +500°C.

They are surrounded by a stainless steel tube and have a cable transition sleeve (see chapter 3.2.1.1). The stainless steel tubes can be bent with a radius of up to 10 x Ø. Pt100 jacketed sensors should not be bent for the first 30 mm from the tip.

Jacketed sensors are available in various lengths and diameters. In some types, the sensor tip and sheathed cable have different diameters (sensor tip reinforced). These types are therefore not suitable for mounting with compression fittings.

Standard cable: 1.5m FEP/silicone-insulated cable, operating temperature -50 to +200°C.

Sensors for surface and immersion measurement

With handle and various tips that make the probes suitable for surface or immersion measurements (see examples in section 3.2.1.1)

Cable sensors

Rigid protection tube made of stainless steel, available in different lengths and diameters. There is no cable transition sleeve. The cable diameter is always smaller or equal to the protection tube diameter.

Cable probes are also available for use in autoclaves, sterilizers and other superheated steam applications, in vacuum applications and freeze drying systems (FPA 30K20-L0020), as well as for temperature measurement in climatic and heating chambers at high humidity (FPA 40ST0050S01K-L0xxx).

Programming

Analog connectors

Pt100 sensors FPAxxx are supplied with the connector ZA 9030-FS1 with the measuring range Pt100-1 (resolution 0.1 K) as standard. The range Pt100-2 (resolution 0.01 K) can be programmed alternatively on the 1st or additionally on the 2nd channel.

On V6 instruments (2690-8A and larger) the measuring range Pt100-3 (resolution 0.001K) can be programmed with these plugs.

Type	Command	Acronym	Measuring range	Resolution
Pt100-1	**B01**	**P104**	**-200 to +850°C**	**0.1 K**
Pt100-2	**B03**	**P204**	**-200 to +400°C**	**0.01 K**
Pt100-3	**B00**	**P304**	**0 to +65°C**	**0.001 K**

Digital connectors

Connector/designation	Command	Acronym	Measuring rate	Measuring range	Resolution
ZPD700-FS 4-leads Pt100	**B-01**	**DPO4**	**10 M/s**	**-200 to +850°C**	**0.01 K**
ZPD703-FS 3-leads Pt100	**B-01**	**DPO3**	**10 M/s**	**-200 to +850°C**	**0.01 K**

Technical data

Pt100 sensors are used as standard with class B measuring resistors according to DIN/IEC 751 (class A or 1/5 DIN class B at extra charge). The T_{max} values given in the technical data refer to the sensor tip. The sensor handles and cables are resistant up to 80°C, for higher ambient temperatures heat-resistant cables are also available.

Accuracy classes of Pt100 sensors

Class	Area of validity		Limit deviation
	Wire measuring resistor	Coated measuring resistor	
B	-196 to +600°C	-50 to +500°C	± (0.3 + 0.005 |t|) K
A	-100 to +450°C	-30 to +300°C	± (0.15 + 0.002 |t|) K

Examples for Pt100 limit deviations

Temperature	Limit deviation		
	DIN Class B	DIN Class A	1/5 DIN Class B*
At 0°C	±0.3 K	±0.15 K	±0.06 K
At 100°C	±0.8 K	±0.35 K	±0.16 K
At 200°C	±1.3 K	±0.55 K	±0.26 K
At 300°C	±1.8 K	±0.75 K	±0.36 K

* Validity range probe-specific

Indication of accuracy for digital Pt100 connectors ZPD700-FS and ZPD703-FS

When using digital D7 connectors, not the system accuracy of the encoder but that of the connector is added to the limit deviation given above:

System accuracy: ± 0.07 K ± 2 digit

Temperature drift: Max. 30 ppm/K

Nominal temperature: 22°C ± 2 K

Reference measuring instruments

Reference measuring instruments with a resolution of 0.001K are available for use in calibration laboratories and quality control. They can only be used together with special wire-wound Pt100 sensors of class 1/10 B (DIN EN 60751), whose accuracy has been further improved by a multi-point adjustment (SP10302D).

Use

Increase of measuring accuracy

The immersion depth of the Pt100 sensors should be selected sufficiently large. If the sensor is not immersed deep enough, the non-immersed part of the sensor casing influences the temperature, measured at the tip by heat conduction.

The minimum immersion depth can be determined by immersing the sensor as deeply as possible, then slowly pulling it out and observing when the displayed measured value changes. Shortly before this happens, the sensor has the minimum immersion depth.

The immersion depth depends not only on the sensor, but also on the surrounding medium and especially on the circulation/movement of the medium.

The length of the jacketed sensor should be at least 10 cm, better 25 cm, otherwise the temperature of the cable transition sleeve has too great an influence on the measurement result.

Sensor protection

Pt100 jacketed sensors with a diameter of 1 mm at the tip must not be exposed to vibrations. They must be handled with extreme care, otherwise the sensor element in the tip of the probe will break.

Jacketed sensors with a diameter of 2 mm are still very sensitive in this respect. Probes with a larger diameter are somewhat more robust.

Pt100 temperature sensors must also not be subjected to sudden temperature changes, neither positive nor negative. If, for example, the temperature is to be measured in an oven, the sensor should be heated up together with the oven and also cooled down again. Sudden changes in temperature can significantly reduce the accuracy of the sensor due to changes in the material of the sensor element.

3.2.3 NTC resistance sensors

Measuring principal

NTC sensors (thermistors) have a much higher resistance than Pt100 sensors and a negative temperature coefficient, i.e. the resistance decreases with increasing temperature.

Temperature °C	Pt100 (ITS90) R [Ω]	Temperature °C	NTC (N) R [Ω]
-200	18.52	-50	670100
-150	40.00	-40	336500
-100	60.26	-30	177000
-50	80.31	-20	97080
0	100.00	-10	55330
50	119.40	0	32650
100	138.51	10	19900
150	157.33	20	12490
200	175.86	25	10000
250	194.10	30	8057
300	212.05	40	5327
350	229.72	50	3603
400	247.09	60	2488
450	264.18	70	1752

Temperature °C	Pt100 (ITS90) R [Ω]	Temperature °C	NTC (N) R [Ω]
500	280.98	80	1255
550	297.49	90	915.3
600	313.71	100	678.3
650	329.64	110	510.3
700	345.28	120	389.3
750	360.64	130	300.93
800	375.70	140	235.27
850	390.48	150	185.97

Notes on measurement

For temperature measurements with NTC sensors, extensions cause additional deviations depending on the measured temperature and the cable length:

Temperature NTC sensor °C	Resistance NTC sensor Ohm	Error at 5 m °C	Error at 10 m °C	Error at 50 m °C	Error at 100 m °C
-20	97 080	0	0	0	0
0	32 650	0	0	0.01	0.02
25	10 000	0	0.01	0.03	0.06
50	3 603	0.01	0.02	0.09	0.18
70	1 752	0.02	0.04	0.21	0.42
100	678.3	0.06	0.13	0.65	1.3

The specified values are typical deviations for cables with a wire cross-section of 0.14 mm². For a cable length of 100 m this corresponds to a typical loop resistance of approx. 25 Ohm (= 2 cores).

3.2.3.1 NTC resistance sensor FNA xxx

Sensor characteristics

Features

Analog connectors

The NTC sensors are equipped as standard with an analogue connector (ZA9040FS, see section 4.1.3.1):

Measuring range -50 to +125°C, resolution 0.01 K

Digital connector

NTC sensors can also be equipped with a digital D6 connector (ZAD040FS, see chapter 4.1.3.2):

Measuring range -50 to +125°C, resolution 0.01 K

Measuring range -20 to +65°C, resolution 0.001 K

This digital ALMEMO® D6 measuring connector works with its own built-in 24-bit AD-converter. The linearization of the NTC characteristic is calculated without errors using ‚Steinhart Hart' coefficients (no approximation method).

The high precision of a temperature sensor with digital connector is independent of the processing of the signal in the ALMEMO® device and subsequent extension cables.

Types

Jacketed sensors

Operating temperatures of jacketed, standard NTC resistance sensors are from 0 to typical +70°C.

They are surrounded by a stainless steel tube and have a cable transition sleeve (see chapter 3.2.1.1). The stainless steel tubes can be bent with a radius of up to 10 x Ø. Jacketed NTC sensors should not be bent for the first 30 mm from the tip.

Jacketed sensors are available in various lengths and diameters. In some types, the sensor tip and sheathed cable have different diameters (sensor tip reinforced). These types are therefore not suitable for mounting with compression fittings.

Standard cable: 1.5m cable PVC/PVC insulated, operating temperature -20 to +105°C.

Sensors for surface and immersion measurements

With handle and various tips that make the probes suitable for surface or immersion measurements (see examples in section 3.2.1.1.)

Programming

Analog connectors

NTC sensors FN Axxx are supplied with the connector ZA 9040-FSx with the measuring range NTC type N (resolution 0.01 K) as standard.

Type	Command	Acronym	Measuring range	Resolution
NTC Typ N	**B09**	**Ntc**	**-50 to +125°C**	**0.01 K**

Digital connector

Measuring ranges on delivery

Type	Command	Acronym	Exp	Measuring range	Resolution
Ntc, t	**B-01**	**DIGI**	**-2**	**-50 to +125°C**	**0.01 K**

Configuration via sensor menu

It is possible to connect two NTC probes via this connector (second probe terminal Ntc2-Gnd). Only for the probe connected to terminal Ntc-Gnd, the Ntc3 range can be programmed with a resolution of 0.001 K.

Configurable measuring ranges

Type	Connection	Command	Acronym	Exp	Measuring range	Resolution
Ntc, t	**Clamp Ntc-Gnd**	**B-01**	**DIGI**	**-2**	**-50 to +125°C**	**0.01 K**
Ntc2, t	**Clamp Ntc2-Gnd**	**B-02**	**DIGI**	**-2**	**-50 to +125°C**	**0.01 K**
Ntc3, t	**Clamp Ntc-Gnd**	**B-03**	**DIGI**	**-3**	**-20 to +65°C**	**0.001 K**

Technical data

The accuracy specifications for the standardised NTC sensors are based on information provided by suppliers. The sensor element is installed in a sensor and equipped with a connecting cable and ALMEMO® connector. Processing, transition and clamping points and the connecting cable have an influence on the accuracy of the temperature sensor.

The T_{max} values given in the technical data refer to the sensor tip. The sensor handles and cables are resistant up to 80°C, for higher ambient temperatures heat-resistant cables are also available.

Accuracy specifications for NTC sensor elements

Type	Range of validity	Limit deviation
NTC element	**–20 to < 0 °C**	**±0.4 K**
(10 K at 25 °C)	**0 to 70 °C**	**±0.2 K**
	> 70 to 125 °C	**±0.6 K**

Accuracy data for the digital NTC connector ZAD040FS

When using digital D6 plugs, the system accuracy of the encoder is added to the limit deviation specified above, not the system accuracy of the encoder, but that of the plug.

Measuring range	Type	System accuracy
-50.00 to +125.00 °C	**Ntc/Ntc2 (see above)**	**±0.05 K at -50 to +100 °C**
-20.000 to +65.000 °C	**Nt3**	**±0.02 K at -20 to +65 °C**

Temperature drift: 40 ppm/K
Nominal temperature: 23 °C ± 2 K

Use

Increase of measuring accuracy

The same instructions apply as for the Pt100 sensors (see chapter 3.2.2.1.)

Sensor protection

NTC temperature sensors are much less sensitive to vibrations than Pt100 sensors.

3.2.4 Wet bulb globe temperature measurement

The wet bulb globe temperature (WBGT) is the decisive parameter for evaluating the work load at hot workplaces and the associated operating and cooling times. Temperature, radiation, relative humidity and air velocity are determined by measuring the drying temperature TT, the natural humid temperature HTN of a psychrometer and the radiation temperature GT of a globe thermometer and summarized as WBGT.

To measure TT and HTN, a psychrometer with a motor that can be switched off (FNA 846-WB) must be connected to socket M0, which is programmed with the measuring ranges Ntc and P HT. To maintain the natural humid temperature HTN, the plexiglass cover of the psychrometer must be removed during measurement and the fan motor must be switched off with the slide switch.

A globe thermometer (Pt100) (FPA 805-GTS) with measuring ranges P204 and WBGT is required at socket M1.

To calculate the wet bulb globe temperature (WBGT) there is the function channel WBGT, which displays the wet bulb globe temperature when the correct probes are connected.

Arrangement and programming of the WBGT sensors:

Sensor	Socket/Channel	Range	Dimension	Explanation
Psychrometer	**M0, channel 0**	**Ntc**	**TT**	**Dry temperature in air (°C)**
	M0, channel 1	**P HT**	**HTN**	**Natural humid temperature in air**
Pt100 globe thermometer	**M1, channel 0**	**P204**	**GT**	**Globe temperature (°C)**
	M1, channel 1	**WBGT**	**WBGT**	**0.1 TT + 0.7 HT + 0.2 GT**

To obtain current values, a continuous or cyclical measuring point query must be running.

3.2.5 ALMEMO® infrared sensor

Basics

In order to achieve satisfactory results with infrared measurement technology, it is important to observe the basic relationships and influences of emissivity, ambient radiation and radiation path (measuring field).

Temperature radiation

Every body emits electromagnetic radiation above absolute zero. According to Planck's radiation laws, there is a fixed relationship between the emitted radiation and the temperature of a body.

Total radiation**:** $S = \sigma \cdot T^4$ (Law of Stefan-Boltzmann) (1)

However, this law only applies to so-called "black emitters", which emit all their radiation. Real bodies are "grey emitters" that emit only a part of the radiation. The ratio of the individual radiation S_O of any temperature radiator to the radiation of a black radiator S_S is called emissivity:

Emissivity**:** $\varepsilon = S_O / S_S$ (2)

The emissivity plays an important role in non-contact temperature measurement. Since infrared measuring instruments are calibrated on "black emitters", it is necessary to take into account the emissivity of the surface to be measured when measuring. The radiation thermometer measures a radiation S_M, which is composed of the intrinsic radiation of the target S_O and the radiation S_U reflected from the environment. This applies to objects with zero transmission (not transparent). The object radiation S_O has the emissivity ε, the ambient radiation S_U the reflectance ρ:

Measuring radiation: $S_M = \varepsilon \cdot S_O + \rho \cdot S_U$ (3)

With the relation $\varepsilon + \rho = 1$ (Transmission = 0) the object radiation can finally be determined to:

Object radiation: $S_O = 1/\varepsilon \cdot (S_M - S_U) + S_U$ (4)

In particular: $S_O \approx 1/\varepsilon \cdot S_M$ (Object temperature much higher than environment)

$S_O \approx S_U$ (Object temperature same as environment)

The influence of ambient radiation can be neglected for objects whose temperature is far above the ambient temperature.

Sensors

As transducers there are photoelectric radiation receivers with high sensitivity and particularly short response time, as well as thermal detectors with slightly higher inertia.

Radiation paths and measuring spot

In order to obtain correct measured values, not only the emissivity but also the radiation path of the sensor must be taken into account. Depending on the optics, a certain measuring spot diameter results depending on the distance. This relationship is shown in the measuring field diagram. The measuring spot diameter must always be smaller than the measured object or the measuring point of interest.

Table of emissivity

The following table is intended as a guide for estimating the emissivity of various materials.

Please note that the emissivity can vary greatly, especially for metals, depending on surface condition, oxidation, rust or the presence of dirt, water or oil.

Material	ε	Material	ε	Material	ε
Bare aluminium	**0.1**	**Spring steel**	**0.87**	**Monel oxidized**	**0.4**
Oxidized aluminium	**0.2 - 0.4**	**Plaster**	**0.8 - 0.9**	**Nickel not oxidized**	**0.15**
Alu.-oxidized	**0.42 - 0.26**	**Glass**	**0.85 - 0.95**	**Nickel oxidized**	**0.2 - 0.5**
Asbestos	**0.96**	**Rubber**	**0.95**	**Paper**	**0.95**
Asphalt	**0.95**	**Graphite**	**0.7 - 0.8**	**Render**	**0.91**
Basalt	**0.7**	**Cast iron not oxidized**	**0.2**	**Mercury**	**0.1 - 0.12**
Concrete	**0.95**	**Cast iron oxidized**	**0.6 - 0.95**	**Soot**	**1**
Lead oxidized	**0.2 - 0.6**	**Cast iron overtwisted**	**0.45**	**Sand**	**0.9**
Bitumen	**1**	**Skin**	**0.99**	**Fire clay**	**0.75**
Bread	**0.88**	**Hardboard**	**0.95**	**Snow**	**0.9**
Roofing felt	**0.94**	**Radiator**	**0.8**	**Sheet steel with rolling skin**	**0.75**
Iron not oxidized	**0.1 - 0.2**	**Wood**	**0.9 - 0.95**	**Bare sheet steel**	**0.65**
Iron oxidized	**0.5 - 0.9**	**Limestone**	**0.95**	**Blank steel swivel**	**0.3**
Iron rusted	**0.5 - 0.7**	**Ceramic**	**0.95**	**Textile**	**0.95**
Stainless steel	**0.1 - 0.8**	**Carbon**	**0.8 - 0.9**	**Clay**	**0.95**
Ice	**0.98**	**Copper oxidized**	**0.4 - 0.9**	**Water**	**0.93**
Enamel	**0.9**	**Plastic**	**0.9**	**Cement**	**0.9**
Colour matt	**0.95**	**Leather**	**0.94**	**Rough bricks**	**0.93**
Colour shining	**0.9**	**Marbel**	**0.93**	**Glazed bricks**	**0.75**
Aluminium colour	**0.52**	**Brass oxidized**	**0.5**	**Zinc oxidized**	**0.1**

Spectral dependence of emissivity

The infrared measurement is mainly limited to the wave ranges between approx. 0.5 and 20 µm. Also in this range the emissivity is partly strongly dependent on the wavelength. Therefore, in certain cases, appropriate filters are necessary.

Selection, product overview

Three different infrared sensor versions are available for connection to ALMEMO® measuring instruments:

Compact infrared sensor FIA 844:

Analogue sensor, temperature range -20 to +500 °C, fixed emissivity 0.95 for matt, black surfaces, optical resolution 13:1 or 9:1.

Digital infrared sensor FIAD 43-32:

Digital ALMEMO® D6 probe, miniature measuring head, temperature range -40 to +600 °C, emissivity programmable, optical resolution 10:1 or sharp point optics with spot diameter 1 mm.

AMiR 7838 infrared sensor head:

Industrial version with current output 4 to 20 mA, available with ALMEMO® connection cable, different spectral ranges/versions for temperatures from -18 to +2000 °C, emissivity adjustable, different optical resolutions or sharp point optics.

Fields of application

Infrared sensors detect the heat radiation of objects without contact and display the temperature in °C. This measuring method also allows the surface temperature to be recorded at measuring points that would not be possible with conventional contact sensors. Surfaces of materials with low heat conduction and surfaces of bodies with low heat capacity can be measured without influencing the measurement object and with high response speed. Measurement on moving, inaccessible or live parts is also possible.

Infrared sensors are suitable for non-contact temperature measurement on surfaces in numerous industrial applications. Typical applications are: Measurements on paper or textile webs, in painting lines, coatings, drying processes. Special applications arise in the field of electrics/electronics, e.g. in the search for hot spots on circuit boards, contacts. Surface comparison measurements using a contact temperature sensor allow the emissivity to be determined.

Application notes

With polished or shiny metals, as well as with transparent targets, the emissivity is too low for a meaningful measurement. A blackened measuring point has an emissivity of 0.9 to 1.0 and is therefore easily measurable.

We recommend to treat the measuring point with matt black lacquer or similar or to use emissivity stickers.

Emissivity paint up to 200°C, article number ZX 1070-EL2

Emissivity paint up to 450°C, article number ZX 1070-EL4

Emissivity sticker up to 300°C, article number ZR 7000-EK

3.2.5.1 Compact infrared sensor FIA 844

Sensor characteristics

Features

Fig. 3.2.7
Infrared sensor FIA 844
with ALMEMO® connector

The electronics are integrated in the measuring head. The LED on the back of the measuring head signals the respective operating status of the instrument.

The infrared sensor operates with the fixed set emissivity 0.95.

The following accessories are available: mounting bracket and air blow attachment.

The measuring head has a permanently connected cable with mounted ALMEMO® connector. Two different cable lengths can be supplied: length 1 m or length 3 m. For greater distances between the measuring head and the ALMEMO® measuring device, pluggable ALMEMO® extension cables can be used: Series ZA 9060-VKx up to 4 m, Series ZA 9090-VKCx up to 100 m.

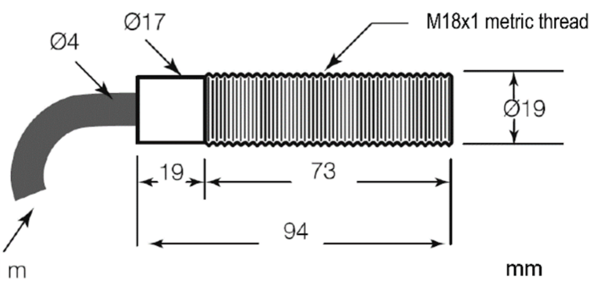
Programming

The ALMEMO® connector is delivered fully programmed: Range D2.6, scaled for the measuring range of the sensor, sensor supply via the ALMEMO® connector.

Technical data

Temperature range	**-20 to +500 °C**
Spectral sensitivity	**8 to 14 µm**
Optical resolution (90% energy)	**13:1 (11.5 mm at 150 mm distance), far field 9:1**
Accuracy	**±1.5% of meas. value or ±2 K, the higher value is valid** **±3.5 K for meas. values < 0 °C**
Reproducability	**±0.5% of meas. value or ±1 K, the higher value is valid**
Nominal conditions	**23 °C ±5 K, degree of emissivity 0.95**
Temperature resolution	**0.1 K**
Response time	**150 ms (95%)**
Emissivity factor	**0.95 fixed**
Voltage supply	**Via ALMEMO® connector (12 V DC)**
Protection class	**IP65**
Ambient temperature	**-10 to +70 °C**
Storage temperature	**-20 to +85 °C**
Relative humidity	**10 to 95% non condensing**
Housing	**Stainless steel**
Dimensions:	**Length 94 mm, thread M18x1**
Connection cable:	**Fixed, 1 m or 3 m, -30 to +105 °C** **incl. programmed ALMEMO® connector**
Weight:	**About 160 g (1 m cable)**

Dimensions



Use

Preparation

Distance and size of measuring spot

The measuring field diagram indicates the diameter of the measuring field that is detected by the infrared sensor for measurement. The diameter is dependent on the distance between the measuring head and the surface of the target.

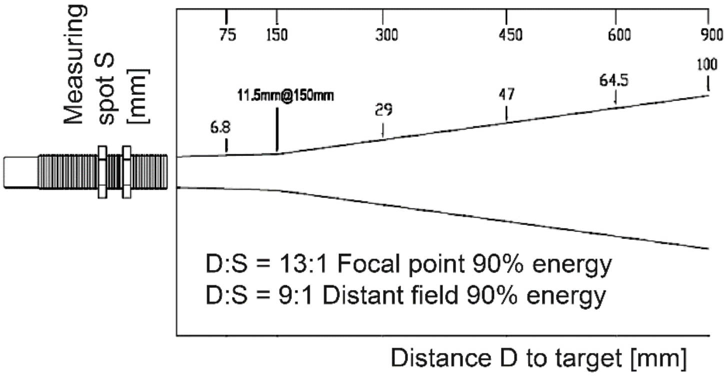


Fig. 3.2.8
Infrared sensor FIA 844
diagram of meas. field

The desired spot size on the target determines the maximum distance between the measuring head and the surface. The measuring spot size is shown in the measuring field diagram as a function of the distance. To avoid faulty measurements, the measurement object must fill the entire field of view of the sensor optics.

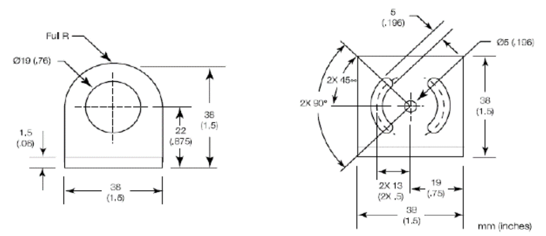
Ambient temperature

The measuring head must be operated within the ambient temperature range specified in the technical data.

The installation location of the sensor head is selected so that the ambient temperature of the sensor head is constant (stationary) during the measurement. A fluctuating ambient temperature must be avoided at all costs. Fluctuations would directly affect the display of the measured surface temperature.

Mounting

The measuring head is mounted via its thread. A rigid or adjustable mounting bracket is available as an accessory.



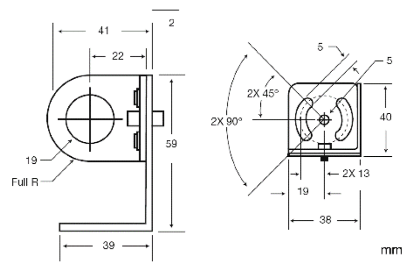


Fig. 3.2.9 Rigid mounting angle

Adjustable mounting angle

Mount the measuring head as perpendicular as possible to the surface of the object! In general, the mounting angle should not exceed 30° to keep the proportion of radiation reflected from the surface low. Reflections from surrounding temperature sources should also be minimized by shielding the object.

Air purity

To avoid incorrect measurements and damage to the lens, it should always be protected from dust, smoke, haze and other contaminants. In environments with dust or high humidity, an air blowing attachment (accessory) is recommended.

Air blow attachment

The air blow attachment is designed to keep dust, moisture, airborne particles and steam away from the lense. It can be mounted in front of or behind the mounting bracket. It has a quick connector for connecting the purge air. It is recommended to use a 4 mm plastic hose to connect the purge air to the connector. The air flows through the connector into the air blowing attachment and out of the opening at the front. The air pressure should be between 0.6 and 1 bar. Oil-free, technically clean air must be used.

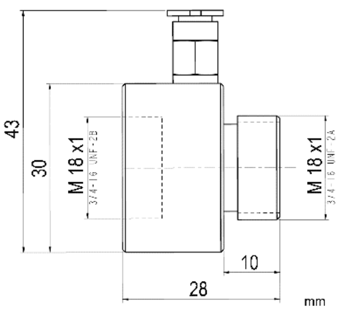


Fig. 3.2.10 Air blow attachment

Measuring

The infrared sensor operates with a fixed emissivity of 0.95. This means that only targets with a matt black surface can be measured with sufficient accuracy. If the surface is shiny/mirrored, emissivity varnish or emissivity stickers can be used.

The measuring head is completely mounted with the required accessories, fixed at a fixed distance from the target and aligned with the surface of the target.

The ALMEMO® plug of the infrared sensor is plugged into the measuring input of an ALMEMO® measuring device, the measuring device is switched on and the measured value is read and processed further.

LED display showing the status of the measuring head

The measuring head status is indicated by different flashing modes of the LED on the back of the measuring head:

Status	LED
Normal	✳✳✳✳✳✳✳✳✳○✳✳✳✳✳✳
Out of measuring range	✳○✳○○○○○✳○✳○○○○○✳
Unstable	✳○○○✳○○○✳○○○✳○○○✳○○○
Alarm / malfunction	✳✳✳✳✳✳✳✳✳✳✳✳✳✳✳

The unstable status is typically caused by the warm-up phase or by thermal shock events.

Maintenance

Cleaning of measuring window

Always ensure that the measuring window is clean. Foreign bodies impair the measuring accuracy. The measurement window must be cleaned with care. The following procedure is recommended:

1. Blow away loose particles with clean air.

2. Remove remaining particles very carefully with a microfiber cloth (for optical devices).

3. Remove heavier contaminants with a clean, soft cloth moistened with distilled water. In any case avoid scratches on the lense surface!

If silicones, which are contained in hand creams, for example, get onto the optics, carefully clean the surface with hexane. Then let the measurement window air-dry.

To remove fingerprints or grease, spirit or technical alcohol or Kodak lense cleaner can be used:

Apply one of the above mentioned products to the optics. Gently wipe with a soft clean cloth until colours are visible on the surface. Then air-dry the surface. Do not rub the surface dry - it could be scratched!

Do not use ammonia or ammonia-containing cleaners for cleaning. This could lead to permanent damage to the surface!

3.2.5.2 Digital infrared sensor FIAD 43

Sensor characteristics

Features

Fig. 3.2.11
Digital infrared sensor FIAD 43
with ALMEMO® connector

The ALMEMO® D6 sensor FIAD 43 is a digital sensor. The complete electronics is integrated in the sensor head. All sensor data and adjustment values are stored in the measuring head. The emissivity of the measured object (material-dependent) is adjustable. The measured value is transmitted digitally to the ALMEMO® connector. Thus, the measured value is, among other things, independent of bending or movement of the sensor cable.

The following options are available (only ex works): air cooling housing, air blow attachment and deflecting mirror.

The following accessories are available: mounting bracket, sharp-point attachment lense and protective window.

The measuring head has a permanently connected cable with mounted digital ALMEMO® D6 connector. Two different cable lengths can be supplied: length 1 m or length 3 m. For greater distances between the measuring head and ALMEMO® measuring device, pluggable ALMEMO® extension cables can be used: Series ZA 9060-VKx up to 4 m, series ZA 9090-VKCx up to 100 m.

Programming

The ALMEMO® connector is delivered fully programmed. The sensor is supplied via the ALMEMO® connector.

Measuring range on delivery

Designation	Command	Range	Exp	Measuring range	Dim	Resolution
Object temperature t_o	**B-01**	**DIGI**	**-1**	**-40 to +600**	**°C**	**0.1 °C**

Configurable measuring ranges

The measuring ranges are configured in the sensor menu of an ALMEMO® V7 measuring instrument or directly on the PC (via the connecting cable ZA 1919-DKUV) in the ALMEMO® Control software. On the 2nd channel, the ambient temperature of the sensor can be activated or a 2nd temperature channel can be used to additionally display the measured values in another dimension, for example.

Designation	Command	Range	Exp	Measuring range	Dim	Resolution
1. * Object temperature t_o	**B-01**	**DIGI**	**-1**	**-40 to +600**	**°C**	**0.1 °C**
2. ~ Ambient temperature t_a	**B-02**	**DIGI**	**-1**	**-10 to +120**	**°C**	**0.1 °C**

*Delivery status
~ Range can also be activated via ALMEMO® devices.

Configuration on PC with help of the software ALMEMO® Control, via sensor menu

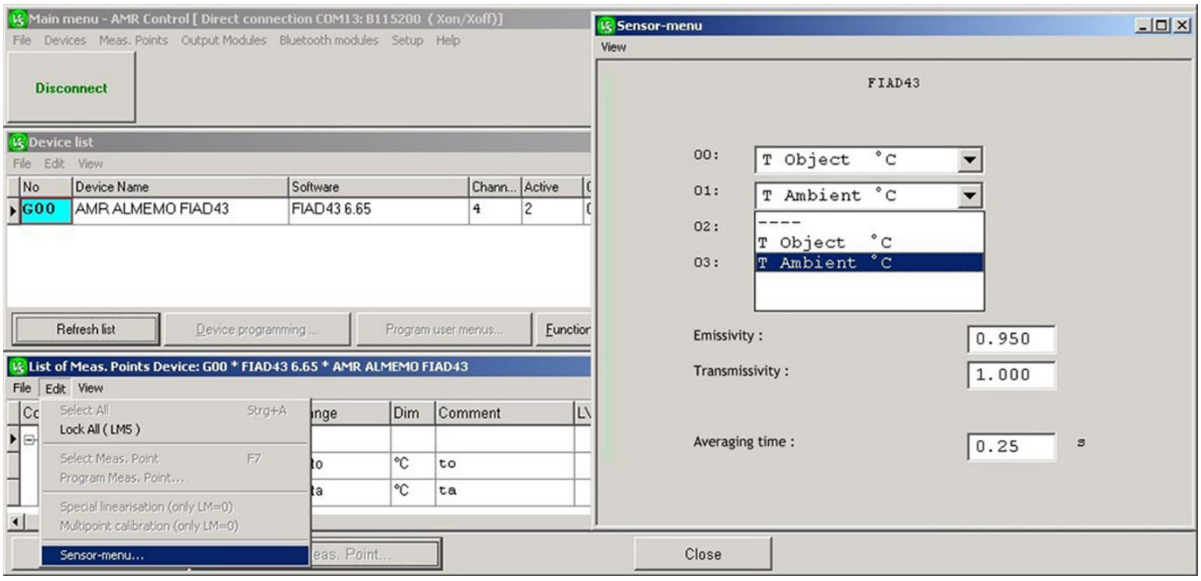


Fig. 3.2.12 Configuration on PC with help of the software ALMEMO® Control, via sensor menu

Emissivity

The emissivity of the measured object (material-dependent) can be set in the sensor menu (see figure 3.2.13).

If the sensor is operated on an ALMEMO® V6 device, the emissivity can also be set in the normal V6 sensor programming. If the infrared sensor is connected, the parameter 'Slope correction' is replaced by the parameter 'Emission', so that the emissivity can be programmed here.

When delivered from the factory, the emissivity factor is set to 0.95, i.e. for matt, black surfaces.

Transmittance of the sharp-point attachment lense or protective window

When using the sharp-point attachment lense or a protective window, it is necessary to consider the transmittance of the sharp-point attachment lense or protective window. This setting is only possible in the sensor menu (see figure 3.2.13).

When delivered from the factory, the transmittance is set to 1.00, i.e. for operation without attachment lense or protective window.

Technical data

Temperature measuring range	**-40 to +600 °C**
Spectral sensitivity	**8 to 14 µm**
Optical resolution (90% energy)	**10:1 with sharp-point attachment lense: 1 mm at distance of 10 mm, programming of degree of transmission to 0.75 (see above, ‚Programming‘)**
Accuracy	**±1 % of meas. value or ±1 K, the higher value is valid, ±2 K for meas. vales < 20 °C**
Reproducibility	**±0.5 % of meas. value or ±0.5 K, the higher value is valid**
Nominal conditions	**23 °C ± 5 K, emissivity factor 1**
Temperature coefficient	**±0.05 K/K or ±0.05%/K of meas. value, the higher value is valid**
Temperature resolution	**0.1 K**
Response time	**130 ms (90%)**
Emissivity factor	**0.95 (programmed ex works), in the range of 0.1 to 1.0 at actual ALMEMO® devices V6 programming via the device (just partly via interface).**
Degree of transmissions of the sharp-point attachment lense or protection window	**1.0 (programmed ex works), in the range of 0.01 to 1.0 direct programming on PC with USB-adapter cable ZA1919AKUV**
Protection class	**IP65 (NEMA 4)**
Ambient temperature	**-10 to +120 °C, with air cooling housing: -10 to +200 °C**
Storage temperature	**-20 to +120 °C**
Relative humidity	**10 to 95% non-condensing**
Housing	**Stainless steel**
Dimensions	**Measuring head: L 28 x Ø 14 mm, thread M12 x 1**
Weight	**Measuring head: 50 g with 1 m cable**
Connection cable	**Fixed, PUR, length see above at ‚Features‘, with ALMEMO® D6 connector**
ALMEMO® D6 connector	**Refreshment time: 0.25 sec. for all channels** **Voltage supply: 6 to 13 V DC** **Power consumption: 4 mA**

Dimensions

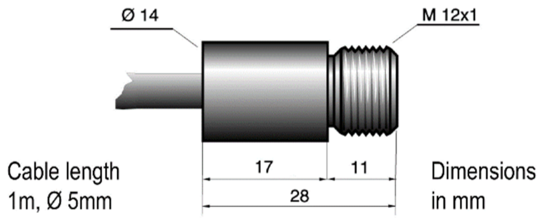


Fig. 3.2.13
Digital infrared sensor FIAD 43 dimensions

Use

Preparation

Distance and size of measuring spot

The measuring field diagram indicates the diameter of the measuring field that is detected by the infrared sensor for measurement. The diameter is dependent on the distance between the measuring head and the surface of the target.

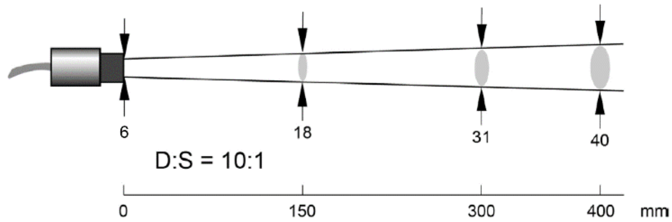


Fig. 3.2.14
Measuring field diagram

The desired spot size on the target determines the maximum distance between the measuring head and the surface. The measuring spot size is shown in the measuring field diagram as a function of the distance. To avoid faulty measurements, the measurement object must fill the entire field of view of the sensor optics.

Sharp-point attachment lense

The sharp-point attachment lense is used to achieve a very small measuring spot of up to 1 mm.

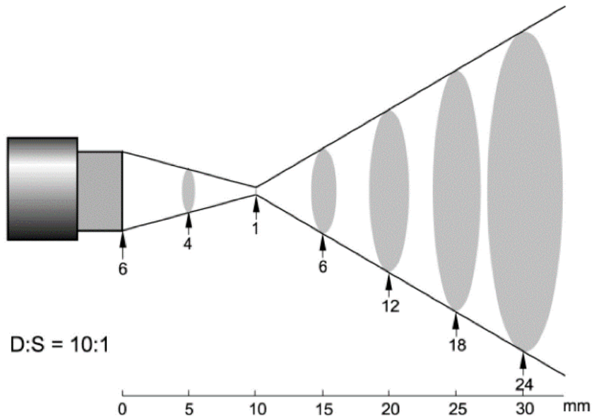


Fig. 3.2.15
Measuring field diagram with sharp point attachement lense

Important: When using the sharp-point attachment lense, the transmission factor of the sharp-point attachment lense must be set in the ALMEMO® D6 sensor menu, see above under 'Programming'.

Ambient temperature

The measuring head must be operated within the ambient temperature range specified in the technical data.

Air-cooling housing (option, only possible when mounted ex works)

The measuring head can be operated at an ambient temperature of up to 200°C when using air cooling. The air cooling system consists of a T-adapter including 0.8 m (alternatively 2.8 m) air hose, insulation and air blow attachment.

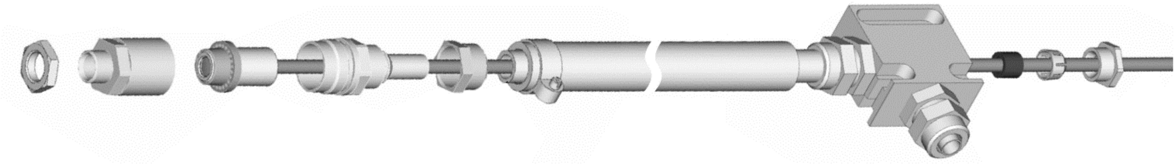


Fig. 3.2.16 Air cooling with T-adapter, air hose, insulation and air blow attachment

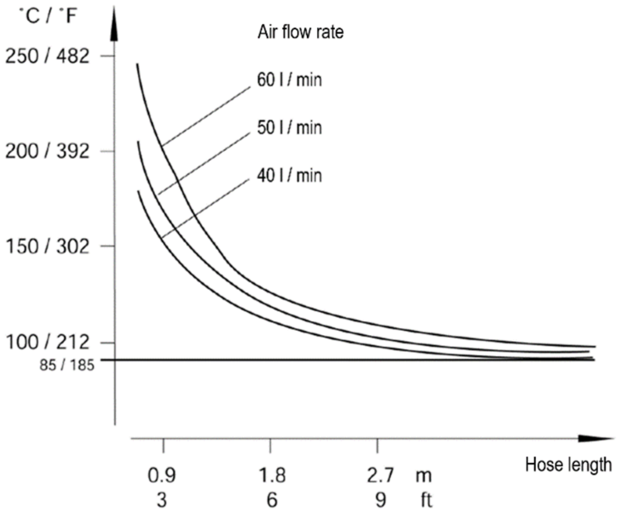


Fig. 3.2.17 Max. ambient temperature depending on air flow rate and hose length. Note: "Hose length" is the length of the hose section exposed to the higher ambient temperature.

The installation location of the measuring head is selected so that the ambient temperature of the measuring head is constant (stationary) during the measurement. A fluctuating ambient temperature must be avoided at all costs. Fluctuations would directly affect the display of the measured surface temperature.

Mounting

The measuring head is mounted via its thread. A rigid or adjustable mounting bracket is available as an accessory.

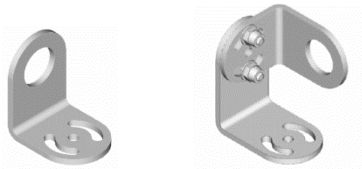


Fig. 3.2.18 Rigid and adjustable mounting bracket

Mount the measuring head as perpendicular as possible to the surface of the object! In general, the mounting angle should not exceed 30° to keep the proportion of radiation reflected from the surface low. Reflections from surrounding temperature sources should also be minimized by shielding the object.

Air purity

To avoid incorrect measurements and damage to the lense, it should always be protected from dust, smoke, haze and other contaminants. In environments with dust or high humidity, an air blow attachment (optional) is recommended.

Air blow attachment (option, mounted ex works)

The air blowing attachment is designed to keep dust, moisture, airborne particles and steam away from the lense.

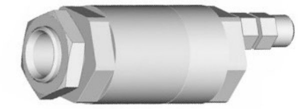


Fig. 3.2.19 Air blow attachment

The air blow attachment has a screw-in connector for connecting the purge air. It is recommended to use a plastic hose with an inner diameter of 3 mm and an outer diameter of 5 mm. The air flows through the connector into the air blow attachment and out of the opening at the front. The air pressure must not exceed 5 bar. Oil-free, technically clean air must be used.

Deflecting mirror with integrated air blow attachment (option, mounted ex works).

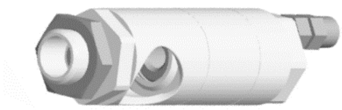


Fig. 3.2.20 Deflecting mirros with integrated air blow attachment

For special installation situations, a 90° deflecting mirror can be used (ambient temperature max. 180°C). The length of the infrared beam within the deflecting mirror is 18 mm. This must be taken into account when calculating the measurement spot size.

Sharp-point attachment lense

The sharp-point attachment lense has an outer diameter of 17 mm. The lense can be screwed directly onto the measuring head. During operation, the measuring head and the auxiliary lense must have the same temperature.

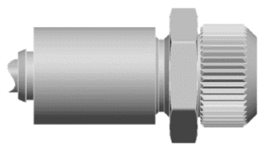


Fig. 3.2.21 Measuring head with mounted sharp point attachment lense

Technical data

Material of holder	Stainless steel
Material of window	Silicon (non-transparent, domed)
Degree of transmission	0.75 ± 0.05
Maximum ambient temperature	+180 °C

Important: When using the sharp-point attachment lense, the transmission factor of the sharp-point attachment lense must be set in the ALMEMO® D6 sensor menu, see above under 'Programming'.

Protection window

Protective windows are used to protect the optics of the measuring head from external dirt influences. The protective window has an outer diameter of 17 mm. It can be screwed directly onto the measuring head. During operation, the measuring head and attachment lense must have the same temperature.

Fig. 3.2.22 Protection window

Technical data

Material of holder	Stainless steel
Material of window	Zinc sulphide (non-transparent, flat)
Degree of transmission	0.75 ± 0.05
Maximum ambient temperature	+180 °C

Important: When using the protection window, the transmission factor of the protection window must be set in the ALMEMO® D6 sensor menu, see above under 'Programming'.

Measuring

The measuring head is completely mounted with the required accessories, mounted stationary at a fixed distance to the measuring object and aligned to the surface of the measuring object.

The probe is configured ready with the emissivity of the target and, if a sharp-point attachment lense or protective window is used, with the corresponding transmittance.

The ALMEMO® plug of the infrared sensor is plugged into the measuring input of an ALMEMO® measuring device, the measuring device is switched on and the measured value is read and further processed.

Maintenance

Cleaning of protective window

The measurement window must be cleaned with care. The following procedure is recommended:

1. Blow away loose particles with clean air.

2. Remove remaining particles very carefully with a microfiber cloth (for optical devices).

3. Remove more severe contamination with a clean, soft cloth moistened with distilled water. In any case avoid scratches on the lense surface!

If silicones, which are contained in hand creams, for example, get onto the optics, carefully clean the surface with hexane. Then let the measurement window air-dry.

To remove fingerprints or grease, spirit or technical alcohol or Kodak lense cleaner can be used. After one of these agents has been applied to the optics, wipe gently with a soft clean cloth until colours are visible on the surface. Then let the surface air-dry. Do not rub the surface dry - it could be scratched!

Do not use ammonia or ammonia-containing cleaners for cleaning. This could lead to permanent damage to the surface!

3.2.5.3 Infrared measuring head AMiR 7838

Sensor characteristics

Features

Fig. 3.2.23 Infrared measuring head AMiR 7838

The infrared measuring head AMiR 7838 is an independent device in industrial design with 2-wire current output 4 to 20 mA. A complete operating manual is included in the delivery.

In the following, the operation of the measuring head on an ALMEMO® universal measuring instrument is described in addition to this operating manual.

The infrared measuring head AMiR 7838 with current output 4 to 20 mA (2-wire circuit) can be supplied with an ALMEMO® connecting cable ZA 7838-AK (accessory).

The cable is firmly clamped in the measuring head. The ALMEMO® connector supplies 12 V DC for the measuring head and measures the signal current via the shunt (2 Ohm) built into the ALMEMO® connector.

Programming

Range D2.6, scaled for the measuring range of the sensor, sensor supply via the ALMEMO® connector.

Scaling in ALMEMO® connector

The scaling of the current signal is programmed according to the temperature measuring range of the infrared measuring head in the ALMEMO® connector: Range % (4-20 mA, multiplexer C-), scaled ex works for the measuring range of the measuring head (can be changed by the user). After plugging in, the ALMEMO® measuring device immediately displays the measured value in °C.

Emissivity

The emissivity of the measuring object (material-dependent) is set at the measuring head: With the standard model via 2 rotary switches under the cover cap on the back, with the programmable Smart model via the software. See operating instructions of the measuring head. When delivered ex works, the emissivity is set to 0.95, i.e. for matt black surfaces.

Transmission factor of the protective window

When using a protective window, it is necessary to consider the transmittance of the protective window. This setting is made on the measuring head (see operating manual of the measuring head). When delivered ex works, the transmission factor 1.00 is taken into account, i.e. for operation without protective window.

Technical data

The infrared measuring head AMiR 7838 is supplied in different versions with different spectral ranges for temperatures from -18 to +2000 °C and with different optical resolutions or sharp point optics (see operating manual of the measuring head).

Use

Mounting

The installation of the measuring head and accessories is described in the operating manual of the measuring head.

Measuring

The measuring head is completely mounted with the required accessories, mounted at a fixed distance to the measuring object and aligned to the surface of the measuring object.

The emissivity of the measurement object is set on the measuring head and the transmittance of the protective window is taken into account when using a protective window.

The ALMEMO® plug of the ALMEMO® connecting cable is plugged into the measuring input of an ALMEMO® measuring device, the measuring device is switched on, and the measured value is read and further processed.

Maintenance

Maintenance of the measuring head is described in the operating manual of the measuring head.

3.3 Heat flow boards for building physics

Basics

The heat transfer of a component is characterised by complex relationships and depends, among other things, on the thermal conductivity of the materials used, their layer thicknesses, the geometry of the component (flat wall, cylindrically curved pipe wall, etc.) and the transition conditions at the component surfaces.

Heat transfer coefficient (U):

The heat transfer coefficient (U) [U-value, formerly k-value] describes the amount of heat through a single- or multi-layer material layer, which flows through an area of 1 m² in one second, if the air temperatures on both sides differ by 1 K.

In contrast to the heat transmission coefficient (Λ), the U-value takes into account the transition coefficients (α_i; α_a), i.e. the intensities of heat transfer at the internal and external surfaces.

The heat transfer coefficient (U) is the reciprocal value of the heat transfer resistance (RK), which is made up of the sum of the heat transmission resistances (R) of the individual successive layers of the building component and the heat transition resistances (R_i; R_a) to the surrounding layers (air etc.) on the two surfaces:

$$U = \frac{1}{R_k} = \frac{1}{(R_i + R + R_a)} = \frac{1}{\left(\frac{1}{\alpha_i} + \frac{1}{\Lambda} + \frac{1}{\alpha_a}\right)}$$

U = Heat transfer coefficient in [W/m^{2}K]
R_k = Total heat transfer resistance in [m^{2}K/W]
R_i = Heat transition resistance on the inside of the component in [m^{2}K/W]
R_a = Heat transition resistance on the outside of the component in [m^{2}K/W]
R = Heat transmission resistance in [m^{2}K/W] (of the individual layers)
α_i = Heat transition coefficient inside in [W/m^{2}K]
α_a = Heat transition coefficient outside in [W/m^{2}K]
Λ = Heat transmission coefficient [W/m^{2}K]

Heat transfer resistance	=	Heat transmission resistance of the individual layers + heat transition resistance	$R_k = R + R_i + R_a$
Heat transmission resistance	=	1 / Heat transmission coefficient	$R = 1 / \Lambda$
Heat transition resistance	=	1 / Heat transition coefficient	$R_i = 1 / \alpha_i$, $R_a = 1 / \alpha_a$
Heat transfer resistance	=	1 / Heat transfer coefficient	$R_k = 1 / U$

Heat flux density (q)

In a state of equilibrium, a heat flow with density q flows through an external component, on one side of which internal air with temperature (T_{Li}) and on the other side of which external air with temperature (T_{La}) is adjacent. The heat flow density is calculated according to the following formula:

$$q = U(T_{Li} - T_{La})$$

U = Heat transfer coefficient in [W/m^{2}K]
q = Heat flux density in [W/m^2]
T_{Li} , T_{La} = Air temperature inside, air temperature outside in [°C]

Measuring principal

Determination of heat coefficients

The measuring principle for the quantitative detection of heat transfer losses on partition walls, such as house walls, heating systems, etc., is based on the so-called auxiliary wall method, in which a measuring sensor (heat flow plate) is inserted directly into the heat transfer. Based on the known thermal properties of the sensor and the thermoelectrically measured temperature difference, the density (q) of the heat flow loss is determined.

If the surface temperatures and the air temperatures in the transition area of a component are additionally measured on both sides, all relevant heat coefficients can be calculated.

Wall with attached heat flow plate (auxiliary wall):

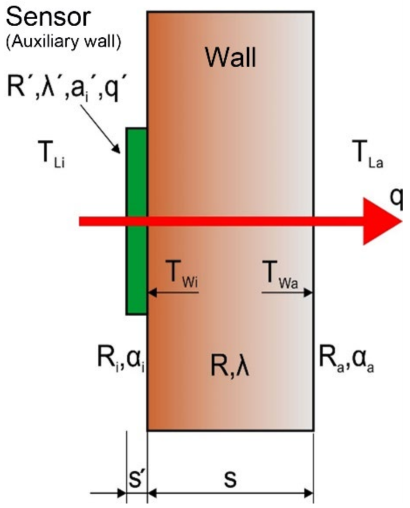


Fig. 3.3.1 Wall with attached heat flow plate

T_{Li} = Air temperature inside in [°C]
T_{La} = Air temperature outside in [°C]
T_{Wi} = Wall surface temperature inside in [°C]
T_{Wa} = Wall surface temperatures outside in [°C]
q = Heat flux density in [W/m^2]
R = Heat transmission resistance of the wall layers in [m^{2}K/W]
R_i = Heat transition resistance on the inside in [m^{2}K/W]
R_a = Heat transition resistance on the outside in [m^{2}K/W]
α_i = Heat transfer coefficient inside in [W/m^{2}K]
α_a = Heat transfer coefficient outside in [W/m^{2}K]
λ = Thermal conductivity of the wall layers in [W/m K]
s = Thickness of the wall layers in [m]
R´ = Heat transmission resistance of the heat flow board in [m^{2}K/W]
q´ = Heat flux density of the heat flow board in [W/m^2]
λ´ = Thermal conductivity of the heat flow board in [W/m K]
α_i´ = Heat transition coefficient of the heat flow board inside in [W/m^{2}K]
s´ = Thickness of the heat flow board in [m]

Practically, the application of the formulas encounters difficulties, as they are only valid in a state of equilibrium (i.e. temperature conditions that are constant over time, the wall emits just as much heat as it absorbs, the heat storage capacity of the wall does not matter).

Furthermore the temperatures must be defined exactly.

Therefore the calculation is based on the cyclical acquisition of the average temperature values and the average values of the heat flow density.

If the measuring time is long enough, the influence of the heat capacity of the component on the calculation, e.g. the U-value, becomes negligible and the average value reaches the actual U-value, e.g. of the wall.

Depending on the location of the temperature sensors, the quotient $q/(T_1-T_0)$ corresponds to the heat transfer coefficient (α_i; α_a), the heat transmission coefficient (Λ) or the heat transfer coefficient (U) or their reciprocal values (see table above in 'Basics'):

$$\text{Heat transition coefficient } \alpha_i = \left(\frac{\text{Heat flux density q}}{(\text{Wall temperature inside } T_{Wi} - \text{ Air temperature inside } T_{Li})}\right)$$

$$\text{Heat transition coefficient } \alpha_a = \left(\frac{\text{Heat flux density q}}{(\text{Wall temperature inside } T_{Wa} - \text{Air temperature outside } T_{La})}\right)$$

$$\text{Heat transmission coefficient } \Lambda = \left(\frac{\text{Heat flux density q}}{(\text{Wall temperature inside } T_{Wi} - \text{Wall temperature outside } T_{Wa})}\right)$$

Experimental U-value:

$$\text{Heat transfer coefficient } U = \left(\frac{\text{Heat flux density q}}{(\text{Air temperature inside } T_{Li} - \text{Air temperature outside } T_{La})} \right)$$

Example 1:

It is possible to determine the heat transmission resistance (R), which is decisive for the thermal insulation properties of a wall, from measurements of the internal and external surface temperatures and the heat flow density (q):

$$q = \frac{1}{R}(T_{Wi} - T_{Wa})$$

Example 2:

If the U value is known or measured, the heat transmission resistance (R) can be calculated from the U value:

$$R = \frac{1}{U} - \frac{1}{\alpha_i} - \frac{1}{\alpha_a}$$

In this case the heat transition coefficient (α_i; α_a) must be known, or the values from DIN are used:

α_i = 7.69 [W/m^{2}K]; α_a = 25 [W/m^{2}K]

Standardization

The calculation of the heat transfer coefficient is defined internationally in the ISO 6946 standard.

There is no standardized measurement specification for determining the U-value. The practical measurement is based on the calculation formulas of DIN 4108, thermal insulation in building construction. The measuring principle described above is therefore based on DIN 4108, but not according to DIN 4108.

3.3.1 ALMEMO® Heat flow boards

Measuring principle

Heat flow boards are sensitive sensors that enable precise measurement of heat flow densities (q) [energy per time and area].

If the heat flow board is placed on the measuring point to be tested, it represents a thermal resistance in the way of the heat flow. As the heat flow passes through the thickness of the plate, a temperature gradient is formed which is proportional to the density of the heat flow.

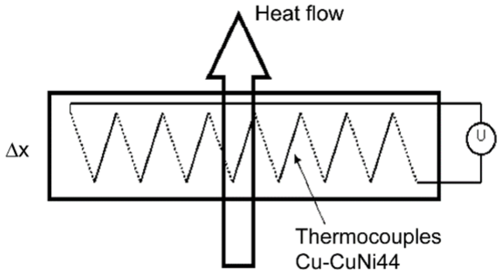


Fig. 3.3.2 Measuring principle of a heat flow board

Heat flow boards consist of a meander of many thermocouples connected against each other and embedded in a carrier material.

With thick carrier material, the plates are constructed in such a way that there is a sufficient edge zone (protective ring) next to the meander to prevent the heat flow from circulating laterally. The heat flows always refer to the surface covered by the meander and form its average value.

These active sensors provide easily evaluated signals in the millivolt range.

The sought-after heat flux density (q) is obtained by multiplying the measured DC voltage (U_{th}) by an individually determined calibration constant (C), usually determined using a single-plate apparatus according to the relationship:

$q = CU_{th}$

q = Heat flow density in [W/m^2], C = Calibration constant in [W/m^2 • mV], U_{th} = Measuring voltage in [mV]

Basics

Notice

A high thermal insulation value is achieved by a high heat transmission resistance and low thermal conductivity.

The higher the heat transfer coefficient, the greater the heat loss through the wall.

The higher the heat transfer resistance, the better the thermal insulation properties.

Fields of application

Heat flow boards are used in many areas of science and technology:

1. Determination of heat losses through walls of buildings, pipelines, cold stores, heat accumulators
2. Calorimetry and measurement of thermal properties
3. Technical applications where a temperature difference serves as the controlled variable

Notes on measurement

Use of the measuring method for U-value determination

An important parameter is the heat transfer coefficient (U) in the building industry, where it is used to determine the transmission heat losses through building components.

The transmission heat loss describes the energetic quality of the thermal envelope (insulation of roof, outer walls, windows and floor) of a building. For each residential building, a maximum permissible value is specified in accordance with the Energy Saving Ordinance (EnEV) in its current version, depending on the enclosure area and its volume.

Due to the phase shift between the measured heat flux density and the temperature differences, the measurement should only be carried out under the following conditions:

1. The temperature difference between indoor and outdoor air must be sufficiently large (standard value for normal insulation $\Delta T > 10$ K, standard value for large insulation $\Delta T > 20$ K).
2. The fluctuations of these temperatures (including day/night) should be as small as possible during the measurement period.
3. The measured values must be recorded on site over a sufficiently long period (approx. 2 to several days) and then calculated using average values.
4. Measurement only when the inside temperature of the building is balanced (approximate value approx. 20°C).
5. As little influence as possible of the dependencies listed in figure 3.3.1 such as direct sunlight and humidity (e.g. measurement at night, measurement in dry weather and on dry surfaces).

Measurement setup on site for measuring the U-value

The heat flow plate is preferably attached to the inner wall. The underside should be connected as homogeneously as possible to the measuring point (wall surface), e.g. by fixing to the edge of the plate with adhesive tape or mechanical retaining elements. Avoid radiator proximity and window recesses if possible.

Bare thermowire sensors of type FT A390-0 with different lengths welded at the tip are suitable as temperature sensors.

For measuring the air temperature inside (T_{Li}), the measuring tip should be placed at least 10 cm above the heat flow plate and project approx. 10 cm into the room (angled).

For measuring the air temperature outside (T_{Wa}), the measuring tip is also fixed approx. 10 cm from the outside wall by means of a suitable wall or window bushing.

Measurement setup on site for measuring additional heat coefficients

If further heat coefficients are to be determined, the wall surface temperatures inside and outside must also be measured.

Bare FT A390-0 thermowire sensors welded at the tip with different lengths are also suitable as temperature sensors.

For the measurement of the wall surface temperature inside (T_{Wi}) the measuring tip is fixed with suitable adhesive tape directly next to the heat flow plate.

For the measurement of the wall surface temperature outside (T_{Wa}) the measuring tip is fixed to the outer wall surface by a suitable wall or window feed-through with suitable adhesive tape.

To minimise disturbing influences, the temperature sensors can be protected externally by a baffle plate mounted in front (protection against direct sunlight or moisture).

For the measuring systems you will find a compilation of the required components in the AHLBORN catalogue in the chapter building physics.

Measurement and calculation of the U-value in the ALMEMO® device

Arrangement and programming of the probes

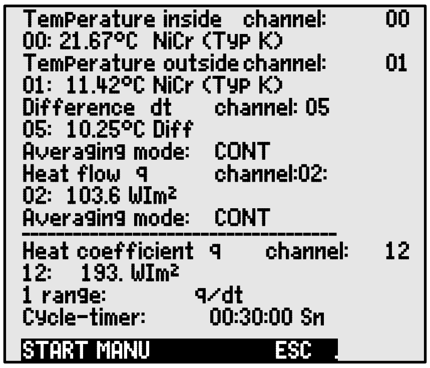
In the ALMEMO® devices MA2690-8A, MA2890-9 and MA710, a wizard menu is available, with the help of which a heat coefficient is calculated from a long-term measurement series depending on how the temperature sensors are viewed (device instructions, keyword 'heat coefficient').

If the internal and external air temperatures are recorded in addition to the heat flux density, the heat coefficient calculated in the device is the U value.

Example ALMEMO® 2690-8A with heat flow board FQA 0xx

To determine the heat coefficient $\overline{q}/\overline{(T1-T0)}$, the two temperature sensors are connected to input M0 and M1 and the heat flow plate to M2, depending on the task. The temperature difference T(M1)-T(M0) is automatically measured on channel M05. Only the following programming must be carried out for measurement:

Averaging mode of channel M05: CONT
Averaging mode of channel M02: CONT
Range of channel M12: q/dt
Program cycle with: Cycle-timer
Start measurement with: <START>
Stop measurement with: <STOP>



Note: The dimension of the thermal coefficient is shown in the MA2690-8A display as W/m² instead of W/m²K for space reasons.

Measurement and calculation of the U-value and other heat coefficients with the software WinControl

Arrangement and programming of the probes

To calculate the measured values recorded with an ALMEMO® instrument, a U-value assistant is available in the software WinControl, which was developed for measurements with ALMEMO® instruments (see Ahlborn catalogue, chapter Software and chapter Building Physics). This assistant takes over the calculation and graphical representation of the U-value.

With this method there is no need to assign an averaging mode to the sensors, as averaging and calculation is done by the software.

Also the channel arrangement of the sensors for heat flux density and inside and outside air temperature on the ALMEMO® device can be chosen at will. The correct assignment of the sensors is also queried in the U-Value Assistant.

All ALMEMO® devices with internal or external memory are suitable for measuring and recording, e.g. V6 devices ALMEMO® 2590, 2690, 2890, 8590, 8690, 5690 and V7 devices ALMEMO® 710, 809, 500. In addition, the U-Value Assistant can also be used to calculate a different heat coefficient depending on the assignment of the temperature sensors (air or surface temperature) (for definition see 'Measuring principle' in chapter 3.3). It must be taken into account that this is then no longer the U-value.

Maintenance

Calibration

Calibration is performed at a temperature of 23°C and a heat flux density of approx. 100 W/m². The sensor is embedded between two foam rubber plates.

Schematic construction of the plate apparatus:

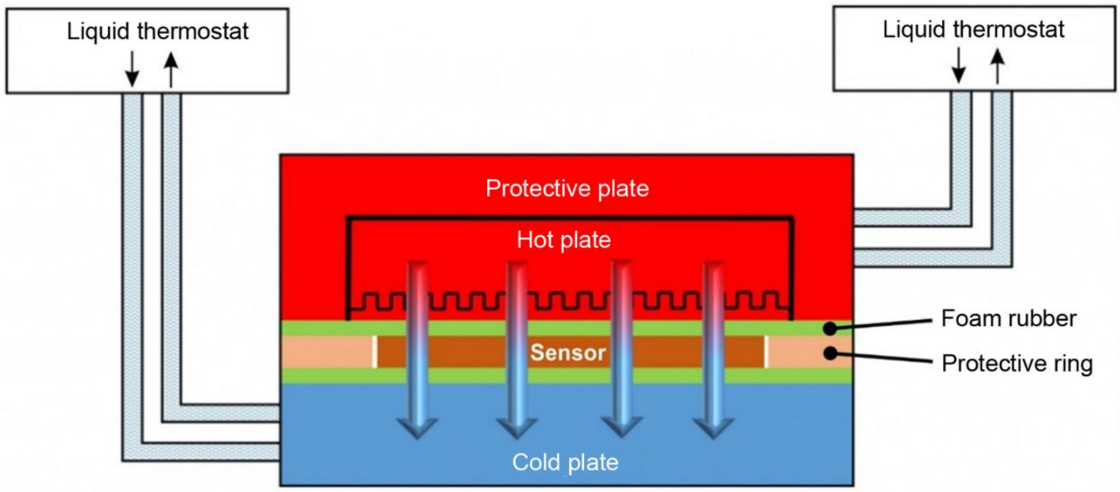


Fig. 3.3.3 Calibration of heat flow boards

The reproducibility of the calibration performed is better than 1%. For the uncertainty of the calibration value of the sensors a value of 5% is guaranteed for the duration of one year.

Since the calibration values can be influenced by ageing, thermal stress and by the diffusion of harmful gases and water, it is recommended to recalibrate the sensors at regular intervals (approx. 1 year).

The result of the calibration is documented in a test report and is included in the scope of delivery of a new heat flow board.

3.3.1.1 ALMEMO® heat flow board FQA 0xx

Sensor characteristics

Features

ALMEMO® heat flow boards FQA 0xx are supplied ready for connection with ALMEMO® connector. The calibration value is already stored in the ALMEMO® connector at the factory, so that the current heat flux density is immediately displayed in W/m².

Fig. 3.3.4
Heat flow board FQA 017C

Programming

The selection of the measuring range and the scaling with the calibration value can also be done by the user according to the following table:

Max. measuring range heat flow density [W/m^2]	Calibration value [W/m^2•mV]	Measuring range	Factor	Exp.
0.0 to 5200.0	1.0 to 20.0	260 mV	0.100 to 2.000	1
0.0 to 5200.0	10.0 to 200.0	26 mV	0.100 to 2.000	2

Use

See ‚Notes on measurement‘ in chapter 3.3.1.

3.3.1.2 Digital heat flow board ALMEMO® D6, type FQAD xx

Sensor characteristics

Features

The FQAD xx sensor uses its own AD converter to measure the output voltage of the heat flow plate and the temperature of a precise NTC sensor. This temperature is used for active temperature compensation of the heat flow plate. The temperature coefficient and the calibration value (adjustment factor) for the heat flux density can be programmed via the sensor menu.

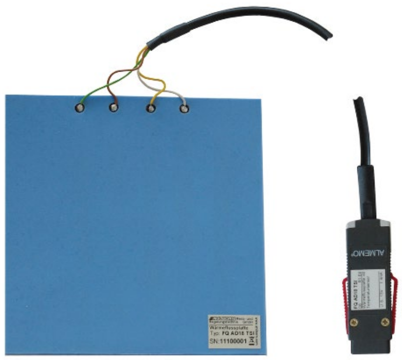


Fig. 3.3.5
Heat flow board FQAD 18T

Programming

Measuring ranges on delivery

Type	Command	Range	Exp	Measuring range	Dim	Resolution
1. Heat flow φ_q	B-02	DIGI	-1	-2000 to +2000	Wm	0.1 W/m^2
2. ~Temperature T, t	B-01	DIGI	-2	-40 to +80	°C	0.01 K

~ Range can also be activated via ALMEMO® device.

If a measuring range should not be displayed, it can be switched off or deactivated and also reactivated as usual via the ALMEMO® device.

Configuration via sensor menu on PC

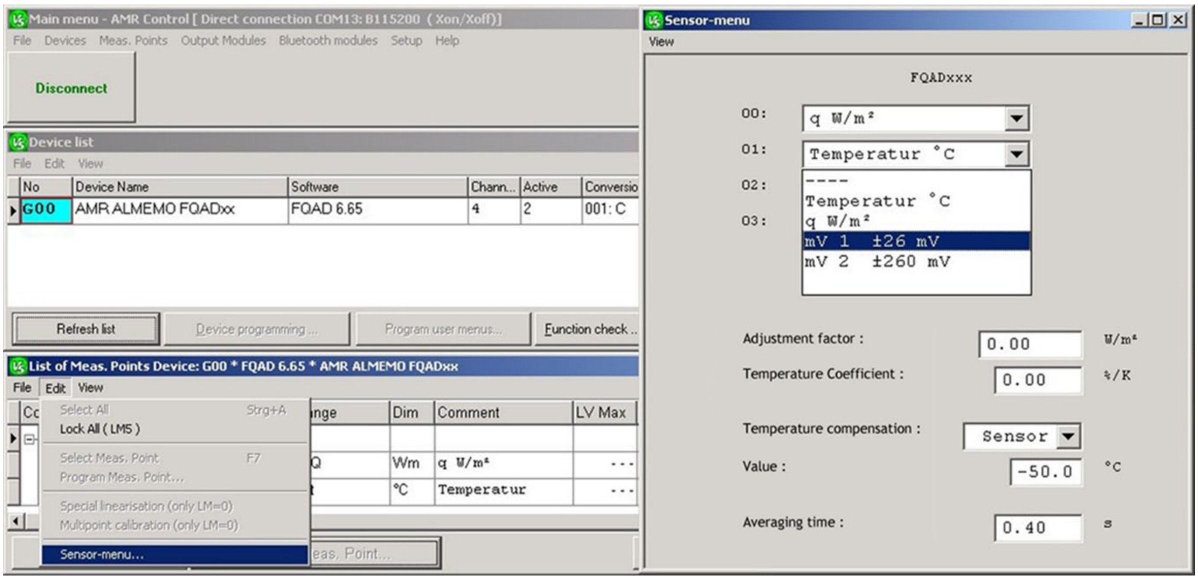


Fig. 3.3.6 Configuration on PC via sensor menu

The measuring ranges of the 4 possible measuring channels are selected from a list of 4 ranges:

Configurable measuring ranges

Type	Command	Range	Exp	Measuring range	Dim	Resolution
1. Heat flow φ_q	B-02	DIGI	-1	-2000 to +2000	Wm	0.1 W/m^2
2. Temperature T, t	B-01	DIGI	-2	-40 to +80	°C	0.01 K
3. Voltage U 26 mV	B-03	DIGI	-3	-26 to +26	mV	0.001 mV
4. Voltage U 260 mV	B-04	DIGI	-2	-260 to +260	mV	0.01 mV

Heat flow coefficient

Two voltage measurement ranges 0 to 26 mV and 0 to 260 mV are available for recording the heat flux density. To scale the voltage in heat flux density, the heat flux coefficient must be programmed in the sensor menu as 'Adjustment factor'. This can be found in the sensor protocol of the heat flow plate manufacturer. If the measuring module is delivered complete with heat flow plate, the factor is already programmed ex works. The voltage measuring range is switched automatically based on the programmed heat flow coefficient.

Temperature measurement and temperature compensation

The heat flow coefficient is also temperature dependent. The sensors are therefore equipped with a temperature sensor as standard. The temperature coefficient of ALMEMO® heat flow plates is at:

Silicone plates: -0.17 %/K

Plastic sheets: -0.12 %/K

This coefficient is also already entered in the sensor menu, but can be changed at any time.

The nominal temperature is 23°C.

If the heat flow plate has no temperature sensor, the plate temperature can also be entered manually in the sensor menu.

Technical data

Heat flow board	
Range of application	-40 to +80 °C
Heat flow sensor	Acccuracy of calibration value 5% at 23 °C
Temperature sensor	Miniature NTC type N, accuracy ±0.5 K at 0 to 80 °C
AD converter in ALMEMO® D6 connector	
Measuring ranges	Temperature NTC: -50 to 125 °C Accuracy: ±0.05 K (-50 to 100 °C) Temperature drift 0.004 %/K (40 ppm) Heat flow: 0 to 26.000 mV or 0 to 260.00 mV Accuracy: ±0.02% of meas. value ± 2 digit Temperature drift 0.003 %/K (30 ppm)
Nominal temperature	23 °C ± 2 K
Refresh rate	0.4 seconds for all channels
Connector colours	Two-coloured light grey and dark grey, red levers
Power supply	6 to 13 V DC
Power consumption	4 mA

Pin assignment

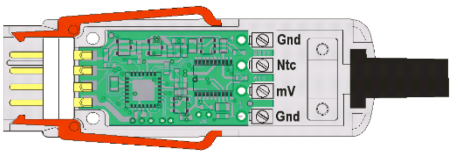


Fig. 3.3.7 ALMEMO® D6 connector

The two sensors for heat flow (mV) and temperature (NTC) are connected to the corresponding terminals mV-Gnd and Ntc-Gnd.

Use

See ‚Notes on measurement‘ in chapter 3.3.1.

3.4 Humidity sensors

Basics

Humidity measurement quantities, their formula symbols and description

Humidity measurement quantities	Formula symbol	Dim	Description
Gas pressure	p	Pa	Total pressure, which is the sum of the partial pressure of the gaseous components
Gas temperature	t, T	°C, K	Temperature of a gas or gas mixture
Saturation vapour pressure in gas above water	e_w'	Pa	Vapour pressure in a real gas or gas mixture at saturation above water
Water vapour partial pressure in a real gas	e'	Pa	Partial pressure of the gaseous phase of water in a given volume of a real gas or gas mixture
Dew point temperature	t_d	°C	The temperature at which the actual water vapour partial pressure is equal to the saturation vapour pressure and starts condensation
Relative humidity in reference to water	U_w	%	Ratio, expressed as a percentage, of the water vapour partial pressure to the saturation vapour pressure at saturation above water and at the same total pressure and temperature
Water vapour density, also absolute humidity	d_v	kg/m3	The absolute humidity indicates the weight of water vapour contained in a m^3 air-water vapour mixture
Mixing ratio	r	kg/kg	Ratio of the mass of water vapour to the mass of dry gas
Specific enthalpy	h	J/kg	State variable of the moist gas, which is composed of the specific enthalpies of the components of the mixture and is related to the mass fraction of the dry gas
Humid temperature	t_w	°C	Temperature at the interface of a humidified surface and a gas flowing past
Enhancement factor for water	f_W		The enhancement factor considers the interactions between water and gas in the real system

Humidity measurement quantities, their unit and formula

Humidity measurement quantities	Dim	Formula
Gas temperature	°C	$t = (T - 273.15\ K) \cdot \frac{°C}{K}$
Saturation vapour pressure in gas above water	Pa	$e'_w = f_w \cdot e_w$ $\ln e_w\ (T_s) = 21.2409642 - \frac{6096.9385}{T_s} - 0.02711193 \cdot T_s + 1.673952\, e^{-5} \cdot T_s^2 + 2.433502 \cdot \ln T_s$ T_s: Saturation temperature in K $e_w(T_s)$: Corresponding saturation vapour pressure in clean phase above water in Pa e'_w: $f_w \cdot e_w$, saturation vapour pressure in gas above water in Pa f_w: Enhancement factor
Water vapour partial pressure in a real gas	Pa	$e' = x_V \cdot p$
Dew point	°C	$e' = e_w'(p, t_d)$
Relative humidity in relation to water	%	$U_W = \frac{e'}{e_w(t) \cdot f_w(p,t)} \cdot 100$
Water vapour density, also absolute humidity	kg/m³	$d_v = 0.0021667 \cdot \frac{1}{Z_{mix}} \cdot \frac{e'}{T}$
Mixing ratio	kg/kg	$r = 0.62198 \cdot \frac{e'}{(p - e')}$
Specific enthalpy	J/kg	$h = c_{pa} \cdot t + (l_w + c_{pv} \cdot t) \cdot r$ c_{pa}: Specific heat capacity of the dry gas c_{pv}: Specific heat capacity of water vapour at constant pressure l_w: Specific latent heat (heat of evaporation of water)

3.4.1 Capacitive humidity sensors

Measuring principle

In capacitive humidity sensors, a moisture-sensitive polymer layer is applied between two electrodes on a substrate. By absorbing water vapor according to the relative humidity, the dielectric constant changes and thus the capacity of the thin-film capacitor. The measurement signal is directly proportional to the relative humidity.

In order to determine other humidity variables such as absolute humidity, mixture, vapour pressure and enthalpy from the relative humidity measured in this way, temperature and ambient pressure (gas pressure) are also required, which are therefore recorded in the sensors simultaneously with the relative humidity.

Analog sensors (e.g. FHA 646-R, see chapter 3.4.1.4) use approximation methods for the determination of the calculated variables, which are carried out by ALMEMO® measuring instruments. In the ALMEMO® connectors of the digital sensors (D6) the formulas according to Dr. Sonntag are used for the calculation, taking into account the enhancement factor according to W. Bögel (correction factor fw(t,p) for real mixed gas systems).

Selection, product overview

Humidity sensors

	Operating range humidity	Operating range temperature at sensor element	Accuracy
FHAD 46-C4x	5 to 98% rH	-40 to +85°C	Humidity: ±2.0% rH in the range of 10 to 90% rH ±4.0%rH in the range of 5 to 98 %rH (at 23°C ± 5 K) Temperature: Typ. ±0.2 K at 50 to 60°C Max. ±0.4 K at 5 to 60°C Max. ±0.7 K at -20 to 80°C
FHAD 46-C2	5 to 98% rH	-20 to +60°C	See FHAD 46-C4x
FHAD 46-C0	5 to 98% rH	-20 to +80°C	See FHAD 46-C4x
FHAD 46-C7 Pressure tight with thread	5 to 98% rH	-20 to +80°C	See FHAD 46-C4x
FHAD 36-RASx	0 to 100% rH	-50 to +90°C	Humidity: ±1.3% rH (at 23°C ± 5 K) Temperature: ±0.2 K (at 23°C ± 5 K)
FHAD 36-RICx	0 to 100% rH	-100 to +170°C	See FHAD 36-RASx
FHAD 36-RHKx	0 to 100% rH	-100 to +150°C, or 170°C	See FHAD 36-RASx
FHA 646-R Analog sensor	5 to 98% rH	-30 to +100°C	Humidity: ±2.0% rH in the range of < 90% rH (at 23°C ± 3 K) Temperature: -20 to 0°C: ±0.4 K 0 to 70°C: ±0.2 K 70 to 100°C: ±0.6 K

Selection criteria for filter (sensor protection)

Material	Max. temp.	Notes on use
Polyethylene	100°C	Recommended filter material for all applications below 100°C. Good reaction and good protection against fine dust particles. No water absorption or storage.
PTFE	200°C	Good protection against fine dust particles and salt (marine environments). Moderately slowed reaction.
Stainless steel wire mesh DIN 1.4401 (V4A)	200°C	Offers fastest response time. Not recommended in environments with fine dust particles (clogging) and in bioactive environments.
Stainless steel sinter filter DIN 1.4401 (V4A)	200°C	Good reaction at low humidity values. Do not use at high humidity levels. Offers best protection against abrasive* particles.

* Abrasive wear: the removal of surfaces by abrasive media

Application range

FHAD 46-C4x, -C2, -C0 and FHAD 36-RSx
Climate measurement, heating-ventilation-climate, food storage, healthcare (blood donation services, hospitals), climate in warehouses, building automation, paper, textile and pharmaceutical industry.

FHAD 36-RICx
Process measurement in industry and research, also fixed mounting.

FHAD 36-RHKx
Control measurements in air ducts, dryers, climate chambers and ovens

FHAD 46-C7
Pressure-tight sensor, e.g. measurements in compressed air lines.

FHA 646-R
Measurements between printed circuit boards, in housings, in walls and ceilings, as well as insulation in building technology and monument protection.

Notes on measurement

Guidelines for measurements with hand probes

Humidity sensors must be in a steady state (stationary) with their surroundings during the measurements with regard to humidity and temperature.

At the beginning of the measurement or if the sensor has been moved to another location in the measurement setup, it must be given sufficient time to adapt to the environment to be measured.

If the sensor is colder than the environment, condensation may form on the sensor elements. If this happens during a measurement, the sensor no longer provides reliable measured values. The measurement should be stopped and the sensor element dried with the filter removed. Calibrations of the sensors are still valid after this.

Standing air is an excellent insulator. If the air does not move, even at small intervals, larger differences in temperature and humidity can occur. Therefore, sufficient ventilation should be provided during measurements.

Guidelines for measurements at fixed installations

Install the sensor in a location where the humidity, temperature and pressure conditions are representative of the environment to be measured.

The following should be avoided:

- Sensor too close to heating element, cooling coil, cold or warm wall, direct sunlight etc.
- Sensor too close to steam injector, humidifier, or exposed to direct precipitation.
- Unstable pressure conditions with large air turbulence.

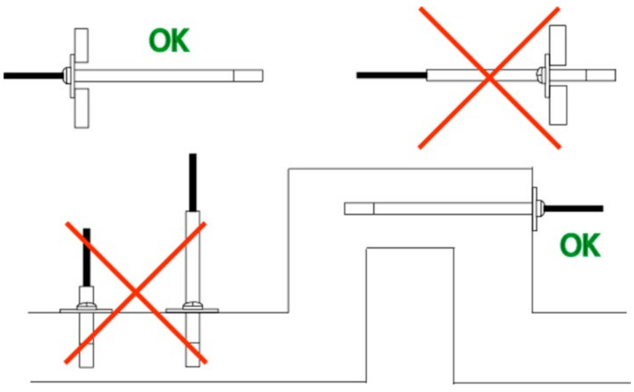


Fig. 3.4.1 Mounting of a sensor

If the sensor is permanently mounted, do not mount it directly above a heat generating element of the measuring device such as a transmitter or Ethernet adapter (rising warm air).

If possible, choose a location where good air movement is provided at the sensor: an air velocity of at least 1 m/s accelerates and facilitates the adaptation of the sensor to changing temperatures.

When mounting the sensor through a wall, immerse the sensor as far as possible in the environment to be measured.

Arrange the sensor in such a way that no condensation water can collect in the area of the sensor connection lines. Install the sensor so that the tip of the sensor points downwards. If this is not possible, install it in a horizontal position.

Depending on the sensor model, a sensor holder (mounting flange with a conical screw connection) can facilitate wall through installation.

Maintenance work can be simplified if a maintenance opening is prepared next to the sensor. During maintenance, a reference sensor (calibrator) can thus be easily inserted. The opening should be the same size as the one used to install the sensor. A holder for the reference sensor can be mounted.

Maintenance

Adjustment and inspection

For maximum accuracy, the adjustment of a probe should be checked every 6 to 12 months. Applications that may contaminate the sensor require more frequent checks. Likewise, if the measured values are not plausible, it is recommended that the sensor be checked at the factory.

Calibrations of humidity sensors can be carried out independently of the connecting cable and ALMEMO® measuring instrument, since all calibration and sensor data of the sensors are stored in the sensor module.

Dust protection filter

Observe the following instructions:

When used in dusty air the filters become dirty. Replace dirty filters in good time, otherwise the response times become longer and longer and measured values may be falsified.

CAUTION when opening the protective cap!

Never touch the humidity sensor! If the humidity sensor is mechanically destroyed, no warranty claim can be made.

Condensation

If you use the sensor for a longer period of time at high humidity (>90% rH) and condensed water condenses, then you must expect incorrect measured values or even measuring range overruns.

In such a case, allow the sensor to dry for several hours at the lowest possible humidity and with moving air.

3.4.1.1 FHAD 46-C4xAx, -C2, -C0

Sensor characteristics

Features

Miniature multisensor module

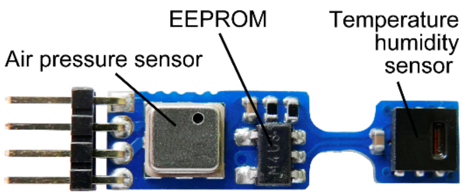


Fig. 3.4.2 Miniature multisensor module FH0D 46-C

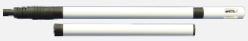
All D6 temperature humidity sensors FHAD46Cxx are based on the fully calibrated sensor module FH0D 46-C, which consists of a digital capacitive temperature-humidity sensor, a digital barometric air pressure sensor and an EEPROM data carrier (see figure 3.4.2).

The sensor module is fully calibrated. All adjustment and sensor data are stored in the data carrier of the sensor module. When readjusting the individual sensors, the values of the adjustment are saved directly in the data carrier of the sensor module.

Each sensor module has a unique serial number which is stored in the humidity sensor. The serial number is displayed in the sensor menu on the measuring instrument or in the ALMEMO® Control software. Calibrated sensor modules are thus clearly assigned to the calibration certificate.

The sensor module can be plugged in and thus easily exchanged. Even after replacement, the humidity sensors still have the specified accuracy. ALMEMO® connecting cables and ALMEMO® measuring instruments have no influence on the calibration.

Types

Image	Reference Nr.	Description	Characteristics
	FHAD46C4xAx	Digital sensor for air humidity, temperature and air pressure, stainless steel version, with slotted filter cap, with ALMEMO® D6 plug	
	FH0D46C	Digital replacement multisensor module	Can be plugged in, calibrated
	FHAD46C2x	Digital sensor for air humidity, temperature, air pressure, with pluggable, digital sensor element in slotted sensor cap with ALMEMO® D6 connector	Compact design, short response time
	FHAD46C2L00	Digital probe on cable stub	Length incl. sensor cap about = 80 mm
	FH0D46C2	Spare multi-sensor module for FHAD 46-C2, in slotted sensor cap	Calibrated, sensor cap Ø 8 mm, length 36 mm plug connection Ø ca. 9 mm
	ZB0D462VR	Extension tube for FHAD 46-2	Ø 8mm, length 97 mm, can be plugged
	FHAD46C0x	Digital sensor for air humidity, temperature, air pressure, exposed multisensor module, with ALMEMO® D6 connector	Exposed sensor element: smallest design, short response time
	FH0D46C0	Replacement sensor element for FHAD 46-C0	Digital, calibrated

Filter for FHAD 46-C4xAx

The multisensor module can be protected with a filter cap.
Dimensions: Diameter 12 mm, length about 33 mm

Filter cap	Pore size	Max. temp.	Typical application	Reference Nr.
Slotted, open cap without filter	Open	100°C	Short response time, no contamination	ZB9600SK10
Metal grille filter in polycarbonate housing	100 µm	120°C	Universal, for medium contamination, also moisture of wood	ZB9600SK7
PTFE sinter filter	50 µm	180°C	High chemical resistance	ZB9600SK6
Stainless steel sinter filter	10 µm	180°C	High mechanical stress, high contamination, high air flow	ZB9600SK8

Programming

Measuring ranges on delivery

Designation	Command	Range	Exp	Measuring range	Dim	Resolution
1. Temperature T, t	B-01	DIGI	-2	-20 to +80*	°C	0.01 K
2. Rel. humidity RH, U_w	B-02	DIGI	-1	5 to 98	%H	0.1% rH
3. Dew point DT, t_d	B-03	DIGI	-1		°C	0.1 K
4. Atmosph. pressure AP, p	B-08	DIGI	-1	700 to 1100	mb	0.1 mbar

* Measuring range depending on sensor type (see technical data)

FHAD 46-Cxx humidity sensors are delivered with the measuring ranges shown above. This programming can be changed, i.e. for example, the absolute humidity can be displayed instead of the dew point in channel 3.

ALMEMO® V7 measuring instruments, ZA 1919-AKUV

The programming is changed via the sensor menu (see chapter 3.1.3.1), which can be accessed via the ALMEMO® Control software. For this purpose, the sensors can either be plugged into a ALMEMO® V7 device or directly connected to the computer via the cable ZA1919AKUV. With ALMEMO® 710 the sensor menu is directly accessible via the touch display.

ALMEMO® V6 measuring instruments

If the humidity sensors are operated on a ALMEMO® V6 device, there is no access to the sensor menu. The sensors can be programmed in devices with a larger range of functions (at least ALMEMO® 2590) and the latest revision level. To do this, go to the sensor programming in the menus of the devices. Here you can change the ranges of the humidity sensors: The abbreviation 'H DT' corresponds to 'dew point', 'H AH' to 'mixture', 'H VP' to 'partial vapour pressure', 'H En' to 'enthalpy'. Ranges for the absolute humidity and the atmospheric pressure measured in the humidity sensor plug cannot be selected in the 'sensor programming' of the ALMEMO® V6 device. If the humidity sensor is normally operated on a V6 device and the 'Absolute humidity' range is to be programmed on one of its channels, this can only be done via a ALMEMO® V7 device or a ZA1919AKUV cable (see above).

Configurable measuring ranges

The measuring ranges of the 4 measuring channels can be configured from a list of 8 ranges (* Delivery status):

Designation	Command	Range	Exp	Measuring range	Dim	Resolution
1. Temperature T, t	B-01	DIGI	-2	-20 to +80*	°C	0.01 K
2. Rel. humidity RH, U_w	B-02	DIGI	-1	5 to 98	%H	0.1% rH
3. Dewpoint DT, t_d	B-03	DIGI	-1		°C	0.1 K
4. Mixture MH, r with LK	B-04	DIGI	-1		gk	0.1 g/kg
5. Abs. humidity AH, d_v	B-05	DIGI	-1		gm	0.1 g/m^3
6. Vapour pressure VP, e	B-06	DIGI	-1		mb	0.1 mbar
7. Enthalpy En, h with LK	B-07	DIGI	-1		kJ	0.1 kJ/kg
8. Atmosph. pressure AP, p	B-08	DIGI	-1	700 to 1100	mb	0.1 mbar

* Measuring range depending on sensor type (see technical data)

In addition to the range, a two-digit dimension and a comment are automatically programmed, consisting of the previously common abbreviations of the tables of the German Weather Service and the newer formula symbols according to VDI/VDE 3514.

Technical data

Operating range	
FHAD 46-C4xAx	-40 to +85°C/ 5 to 98% rH
FHAD 46-C2	-20 to +60°C/ 5 to 98% rH
FHAD 46-C0	-20 to +80°C/ 5 to 98% rH
Humidity	
Measuring range	5 to 98% rH
Sensor	CMOSens® technology
Accuracy	±2.0% rH in the range of 10 to 90% rH at nominal temperature ±4.0% rH in the range of 5 to 98% rH at nominal temperature
Hystereses	Typ. ±1% rH
Nominal temperature	23°C ± 5 K
Sensor operating pressure	Atmospheric pressure
Response time T_{63}	Typical 8 s at 25°C, 1 m/s without filter
Temperature	
Measuring range	-20 to +80°C
Sensor	CMOSens® technology
Accuracy	Typ. ±0.2 K at 5 to 60°C, Max. ±0.4 K at 5 to 60°C, max. ±0.7 K at -20 to 80°C,
Reproducibility	Typ. ±0.1 K
Response time T_{63}	Typ. 20 s without filter
ALMEMO® connection cable	At FHAD 46-C4xAx silicone, at FHAD 46-C2 and FHAD 46-C0 PVC, Length see below under 'Dimensions', with ALMEMO® D6 connector
Digital atmospheric pressure sensor (on multisensor module)	
Measuring range	700 to 1100 mbar
Accuracy	± 2.5 mbar at 23°C ± 5 K
ALMEMO® D6 connector	
Refresh rate	1 sec. for all 4 channels
Power supply	6 to 13 V DC
Power consumption	3 mA

Temperature operating range of the various parts of the sensor

FHAD 46-C41A

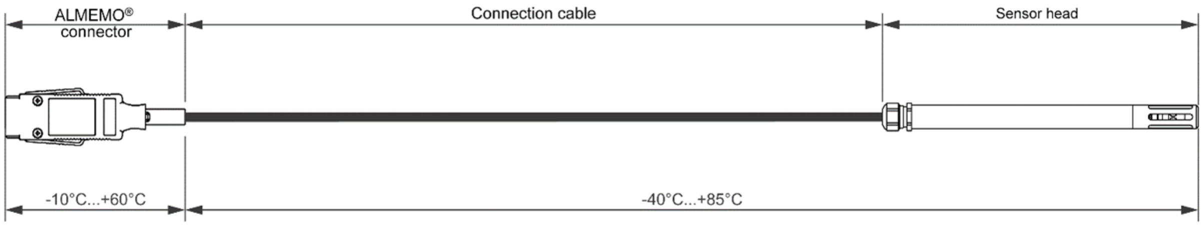


Fig. 3.4.3
Temperature operating range of FHAD 46-C41A

Dimensions

Reference number	Sensor length	Cable length
FHAD 46-C4xAx	160, 270 and 530 mm	2, 5 and 10 m
FHAD 46-C2x	Sensor cap: Ø 8 mm, length 36 mm, plug connection: Ø ca. 9 mm	2, 5 and 10 m
FHAD 46-C2L00	Incl. sensor cap about 80 mm	-
FHAD 46-C0x	Multisensor module (over all) ca. 6 mm x 23 mm x 3 mm, plug connection: width about 7 mm	2, 5 and 10 m

Use

Measuring

For long-term measurements it is possible to operate some devices in sleep mode (see chapter 6.9.2.1). This requires a 1 second sleep delay for the humidity sensors described in this chapter. For this reason, the sensor in sleep mode can only be operated with units where a sleep delay is possible!

Sensor protection

In case of an increased dust concentration, the sensor element must be protected by a suitable filter. Even a sensor protected by a filter must not come into contact with oil mist or finely atomized solvents.

3.4.1.2 FHAD 46-C7

Sensor characteristics

Features

The FHAD 46-C7 humidity sensor is a compact sensor made of stainless steel, pressure-tight and with screw-in thread. It largely corresponds to type FHAD 46-C41x (see section 3.4.1.1), but is designed for use in compressed air lines up to 16 bar.

The sensor element is protected as standard by the PTFE sinter filter ZB9600S6K (see section 3.4.1.1). A connection adapter for compressed air lines ZB96467AP is available.

The sensor is available with a cable length of 2, 5 or 10 m.

Programming

Measuring ranges on delivery

Designation	Command	Range	Exp	Measuring range	Dim	Resolution
1. Temperature T, t	B-01	DIGI	-2	-20 to +80	°C	0.01 K
2. Rel. humidity RH, U_w	B-02	DIGI	-1	5 to 98	%H	0.1% rH
3. Dewpoint DT, t_d	B-03	DIGI	-1		°C	0.1 K

The FHAD 46-C7 sensor can be used up to a pressure of 16 bar. Since the measuring range of the pressure sensor in its multi-sensor module only extends to 1100 mbar, it fails at high pressures.

If an atmospheric pressure-dependent variable is to be used, an atmospheric pressure up to 16 bar can be entered in the measuring instrument for atmospheric pressure compensation. This pressure can also be displayed as a channel with range 'D Cp' ('correction pressure') (see table 'Configurable ranges' below).

The FHAD 46-C7xx humidity sensors are delivered with the measuring ranges shown above. This programming can be changed, i.e. for example, the absolute humidity can be displayed instead of the dew point in channel 3.

The programming of the sensor on V6 and V7 devices and the cable ZA1919AKUV is described in the subchapter 'Programming' in chapter 3.4.1.1.

Configurable measuring ranges

The measuring ranges of the 4 measuring channels can be configured from a list of 8 ranges:

Designation	Command	Range	Exp	Measuring range	Dim	Resolution
1. Temperature T, t	B-01	DIGI	-2	-20 to +80	°C	0.01 K
2. Rel. humidity RH, U_w	B-02	DIGI	-1	5 to 98	%H	0.1% rH
3. Dew point DT, t_d	B-03	DIGI	-1		°C	0.1 K
4. Mixture MH, r with LK	B-04	DIGI	-1		gk	0.1 g/kg
5. Abs. humidity AH, d_v	B-05	DIGI	-1		gm	0.1 g/m^3
6. Vapour pressure VP, e	B-06	DIGI	-1		mb	0.1 mbar
7. Enthalpy En, h with LK	B-07	DIGI	-1		kJ	0.1 kJ/kg
8. Atmosph. pressure AP, p	B-08	DIGI	-1	700 to 1100	mb	0.1 mbar
9. Atmosph. pressure CP, p	B-09	DIGI	0		mb	1 mbar

In addition to the area, a two-digit dimension and a comment are automatically programmed, consisting of the previously common abbreviations of the tables of the German Weather Service and the more recent formula symbols according to VDI/VDE 3514.

Technical data

Operating range	-20 to +80°C / 5 to 98% rH
Digital humidity / temperature sensor	(incl. AD converter)
Humidity	
Measuring range	5.0 to 98.0% rH
Sensor	CMOSens® technology
Accuracy	±2.0% rH in the range of 10 to 90% rH ±4.0% rH in the range of 5 to 98% rH At nominal temperature
Hystereses	Typ. ±1% rH
Nominal temperature	23°C ± 5K
Sensor operating pressure	To 16 bar
Temperature	
Measuring range	-20 to 80°C
Sensor	CMOSens® technology
Accuracy	Typ. ±0.2 K at 5 to 60°C Max. ±0.4 K at 5 to 60°C Max. ±0.7 K at -20 to 80°C
Reproducibility	Typ. ±0.1 K
ALMEMO® connection cable	PVC, in length 2, 5 and 10 m, with ALMEMO® D6 connector
ALMEMO® D6 connector	
Refresh time	1 sec. for all 4 channels
Power supply	6 to 13 V DC
Power consumption	3 mA
Mechanical version	
Sensor	Stainless steel
Filter cap	PTFE sinter filter SK6
Cable gland	Splash-proof

Dimensions

Reference number	Sensor	Process connection
FHAD46C7xxx	Diameter 12 mm, total length about 77 mm	External thread G ½“, mounting length 48 mm, wrench size 27

Use

See chapter 3.4.1.1.

3.4.1.3 Humidity- /temperature sensor FHAD 36-x

Sensor characteristics

Features

These digital capacitive humidity sensors have an integrated signal processor for the calculation of the humidity values that are not directly measured. All adjustment and sensor data are stored in the humidity sensor.

All versions of this humidity sensor type are delivered with manufacturer's test certificate.

Types

Image	Reference number	Description	Characteristics
	**FHAD36RAS**	Humidity/temperature, standard type, sensor incl. connection cable with ALMEMO® D6 connector	
	**FHAD36RAICx**	Humidity/temperature sensor, industrial type, with filter carrier, high temperature sensor cable and plug connetion incl. connection cable with ALMEMO® D6 connector	For high temperatures
	**FHAD36RHKx**	High temperature portable sensor with filter carrier, 2 m sensor cable and plug connection with ALMEMO® D 6 connector	Portable sensor for high temperatures

Filter for type FHAD 36-RASx

To protect the humidity polymer and the temperature sensor, a filter cap is used, consisting of a screwable polycarbonate filter carrier and various filter inserts with different specifications.

Filter cap	Application, characteristics	Reference number
Filter carrier polycarbonate with filter insert polyethylene	For standard applications, good reaction time, good protection against fine dust particles	ZB9636APE
Filter carrier Polycarbonate with filter insert stainless steel wire mesh	Fastest response time, not for environments with fine dust particles (clogging) and in bioactive environments	ZB9636AWM
Filter carrier polycarbonate with filter insert PTFE	Good protection against fine dust particles and salt (marine environment), slow reaction time	ZB9636APTFE

Fig. 3.4.4 Filter cap ZB9636APE, with which the FHAD 36 humidity sensor is delivered as standard

The FHAD 36-RAS type sensors are supplied with a filter cap consisting of a polycarbonate filter carrier with polyethylene (ZB9636APE) filter insert.

Filter for type FHAD 36-RAICx

Filter cap	Application, characteristics	Reference number
Stainless steel wire mesh filter	Fastest reaction time, not for environments with fine dust particles (clogging) and in bioactive environments	ZB9636AIWM
Stainless steel sinter filter	Best protection at high particle load, good reaction time for low humidity (do not use for high humidity)	ZB9636AISSS
PTFE filter	Good protection against fine dust particles and salt (marine environment), slower reaction time	ZB9636AIPTFE

The sensors type FHAD 36-RAICx are delivered with stainless steel wire mesh filter.

Filter for FHAD 36-RHKx

To protect the humidity polymer and the temperature sensor, a filter is used, consisting of a screwable filter carrier (nickel-plated brass slotted sleeve) and a replaceable filter insert with different specifications. The filter insert is pushed over the filter carrier, fixed with a washer and secured with a locking screw.

Filter insert	Applications, characteristics	Reference number
Stainless steel wire mesh filter insert	Fastest response time, not for environments with fine dust particles (clogging) and in bioactive environments	ZB9636M15
Stainless steel sinter filter insert	Best protection at high particle load, good reaction time for low humidity (do not use for high humidity)	ZB9636S15
PTFE filter insert	Good protection against fine dust particles and salt (marine environment), slower reaction time	ZB9636T15

Fig. 3.4.5 Humidity sensor FHAD 36-RHKx with filter carrier

The sensors type FHAD 36-RHKx are delivered with filter carrier and stainless steel wire mesh filter insert.

Programming

The FHAD 36-R is based on a fully calibrated digital capacitive sensor that can be exchanged at any time without loss of accuracy. For automatic atmospheric pressure compensation, an atmospheric pressure sensor is installed as standard.

The measured atmospheric pressure can also be used as reference atmospheric pressure in the ALMEMO® measuring instrument (see chapter 6.2.5 and 6.2.6).

Measuring ranges on delivery

Designation	Command	Range	Exp	Measuring range	Dim	Resolution
1. Temperature T, t	B-01	DIGI	-2	-100 to +170*	°C	0.01 K
2. Rel. humidity RH, U_w	B-02	DIGI	-1	0 to 100	%H	0.1% rH
3. Dewpoint DT, t_d	B-03	DIGI	-1	-64.8 to +100	°C	0.1 K
4. Atmosph. pressure AP, p	B-08	DIGI	-1	700 to 1100	mb	0.1 mbar

* Measuring range depends on sensor type (see technical data)

The FHAD 36-x humidity sensors are delivered with the measuring ranges shown above. This programming can be changed, i.e. for example the absolute humidity can be displayed instead of the dew point in channel 3.

The programming of the sensor on V6 and V7 devices and the cable ZA1919AKUV is described in the subchapter 'Programming' in chapter 3.4.1.1.

Configurable measuring ranges

The measuring ranges of the 4 measuring channels can be configured from a list of 8 ranges (* Delivery status):

Designation	Command	Range	Exp	Measuring range	Dim	Resolution
1. Temperature T, t	B-01	DIGI	-2	-100 to +200*	°C	0.01 K
2. Rel. humidity RH, U_w	B-02	DIGI	-1	0 to 100	%H	0.1% rH
3. Dew point DT, t_d	B-03	DIGI	-1	-64.8 to +100	°C	0.1 K
4. Atmsoph. pressure AP, p	B-08	DIGI	-1	700 to 1100	mb	0.1 mbar
5. Mixture MH, r with LK	B-04	DIGI	-1	0 to 6500	gk	0.1 g/kg
6. Abs. humidity AH, d_v	B-05	DIGI	-1	0 to 596.3	gm	0.1 g/m^3
7. Vapour pressure VP, e	B-06	DIGI	-1	0 to 1100	mb	0.1 mbar
8. Enthalpy En, h with LK	B-07	DIGI	-1	0 to 6500	kJ	0.1 kJ/kg

* Measuring range depends on sensor type (see technical data)

In addition to the range, a two-digit dimension and a comment are automatically programmed, consisting of the previously common abbreviations of the tables of the German Weather Service and the more recent formula symbols according to VDI/VDE 3514.

Technical data

Operating range	Depending on sensor type, see below and also chapter 3.4.1 under 'Selection, product overview'
Humidity	
Sensor	Capacitive
Measuring range	0 to 100 % rH
Adjusted	At 23°C and 10%, 35%, 80% rH
Accuracy	±1.3% rH (at 23°C ± 5K)
Reproducibility	0.3% rH
Temperature	
Sensor	Pt100 class A
Measuring range	-100 to 170°C, observe operating range, depending on sensor type
Accuracy	±0.2 K (at 23°C ± 5K)
Repeatability	Typical 0.05°C
Digital atmosph. pressure sensor	(Built-in in ALMEMO© D6 connector)
Measuring range	700 to 1100 mbar
Accuracy	±2.5 mbar (in the range of 700 to 1100mbar) at 23°C±5K
Atmosph. pressure compensation	0 to 6500 mbar (programmable)
Sensor connection	Plug connection between sensor head and coupling (FHAD 36-RS), between sensor connection and connection cable (FHAD 36-RIC, FHAD 36-RHK), see below Material: Alu-Anticorodal, anodized, IP65
ALMEMO® Connection cable	Material TPU, with ALMEMO® D6 connector
ALMEMO® D6 connector	
Refresh rate	1 second for all 4 channels
Power supply	6 to 13 V DC
Power consumption	12 mA
Sleepmode of device	Possible (with extension delay 1s necessary)

FHAD 36-RASx:

Material of sensor housing	Polycarbonate
Filter carrier	Polycarbonate
Filter	Polyethylene
Response time T_{63}	< 15 s at typ. 1 m/s

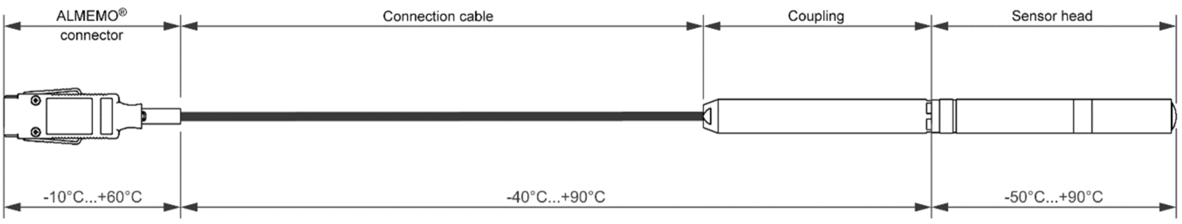
FHAD 36-RAICx:

Sensor material	PPS
Filter carrier	Stainless steel 1.4301
Filter	Stainless steel wire mesh filter
Response time T_{63}	< 10 s at typ. 1 m/s without filter

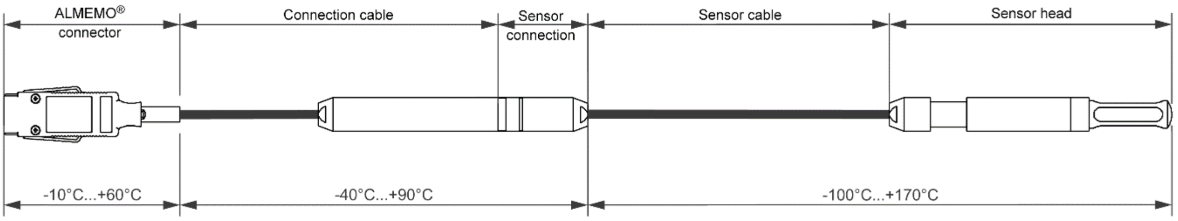
FHAD 36-RHKx:

Material of sensor housing	Shaft: PPS, handle: POM
Filter carrier	Nickel-plated brass
Filter	Stainless steel wire mesh
Response time T_{63}	< 10 s at typ. 1 m/s without filter

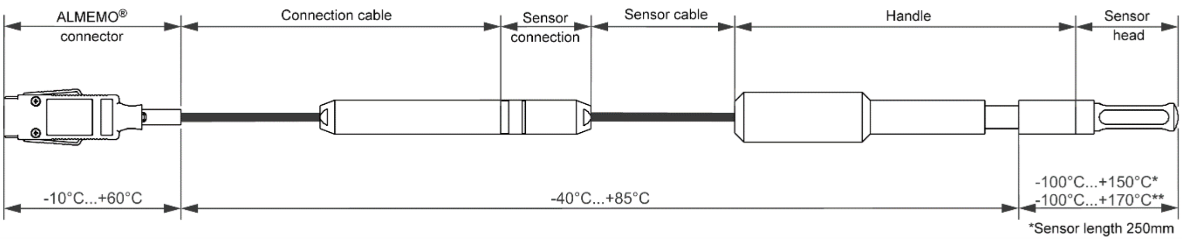
Operating temperature of the various sensor parts



FHAD 36-RAS

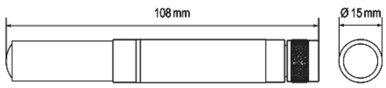
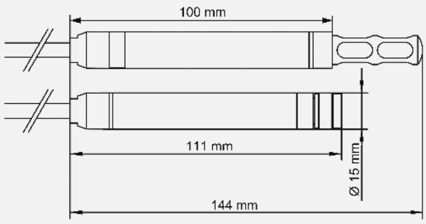
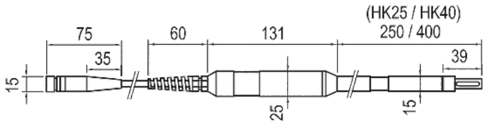


FHAD 36-RAIC



FHAD 36-RHK

Dimensions

Reference number	Sensor length/dimensional drawings	Sensor cable	Connection cable
FHAD36RAS		-	2 and 5 m
FHAD36RAIC	 Sensor length 144 mm incl. filter, 294 mm on demand	2 and 5 m	2 and 5 m
FHAD36RHK	 Sensor length FHAD 36-RHK25 250 mm Sensor length FHAD 36-RHK40 400 mm	2 m	0.3 m

Use

Measurement

For long-term measurements it is possible to operate some devices in sleep mode (see chapter 6.9.2.1). This requires a 1 second sleep delay for the probes described in this chapter. For this reason, the sensor can only be operated in sleep mode with devices for which a sleep delay is possible!

Sensor protection

In case of an increased dust concentration, the sensor element must be protected by a suitable filter. Even a sensor protected by a filter must not come into contact with oil mist or finely atomized solvents.

3.4.1.4 Analog capacitive humidity sensor FHA 646-R

Sensor characteristics

Technical data

Operating range	-30 to +100°C / 5 to 98% rH
Humidity	
Measuring range	5.0 to 100.0% rH
Sensor	Capacitive
Accuracy	±2.0% rH in the range < 90% rH at nominal temperature

Reproducibility	< 1% rH at nominal temperature
Nominal temperature	25°C ± 3°C
Response time T_{63}	About 10 s at 1 m/s
Temperature	
Sensor	NTC Type N
Accuracy	-20 to 0°C: ±0.4 K 0 to 70°C: ±0.2 K 70 to 100°C: ±0.6 K
Reproducibility	0.1 K
Mechanical version	
Sensor tube	Nickel plated
Protection cap	None
Cable	High temperature cable (to 100°C), with ALMEMO® connector

Dimensions

Length of sensor tube 50 mm, diameter 5 mm Ø
Cable length 2 m

3.4.1.5 Analog capacitive humidity sensors FHA 646-Ex, FHA 646-AG, FHA 646-1/-6

Sensor characteristics

Features

Cable

The capacitive humidity sensors are usually delivered with 1.5 m sensor cable. Depending on the type, a longer sensor cable (for FHA 646-Ex, FHA 646-AG up to 30m) can also be supplied ex works.

Filter caps

The humidity sensors are protected by a protective cap against mechanical damage and against dirt/dust. Depending on the application, different filter types are optionally available:

Type	Designation	Pore size	Max. temperature	Application
ZB9600SK7	Metal grid filter in PC housing	100 µm	120°C	Universal, for medium dirt load, also high humidity
ZB9600SK6	PTFE sinter filter	50 µm	180°C	High chemical resistance
ZB9600SK8	Stainless steel sinter filter	10 µm	180°C	For heavy mechanical load, high dirt load, high air flow

Programming

The variables air temperature T, relative humidity U_W, dew point temperature td and mixing ratio r are already programmed on 4 channels for ready-made sensors. The measured variables T and U_W are fixed to the first two channels, the calculation variables e', td, r and h can be assigned to the 3rd and 4th channel. If a calculation variable is selected, temperature and humidity are measured continuously to update the displayed value.

Designation	Command	Range	Measuring range	Dim.	Resolution
Air temperature T, t	B09	Ntc	-50 to 100	°C	0.01 K
Relative humidity RH, U_W	B16	% rH	0 to 100	%H	0.1% rH
Rel. humidity FHA 646-xC	B42	HcrH	0 to 100	%H	0.1% rH
Rel. humidity FHA 646-R	B56	H rH	0 to 100	%H	0.1% rH
Dew point DT, t_d	B44	H DT	-25 to 100	°C	0.1 K
Mixture MH, r	B43	H AH	0 to 500	gk	0.1 g/kg
Partial vapour pressure VP, e	B59	H VP	0 to 1050	mb	0.1 mbar
Enthalpy En, h	B58	H En	0 to 400	kJ/kg	0.1 kJ

Cable extension for capacitive humidity sensors

Extensions up to 4 m are made for all types FHA 646 with the passive extension cables ZA 9060-VK.

Extensions up to 100 m are made with the intelligent ALMEMO® extension cables ZA 9090-VKC (see chapter 3.13). These cables are suitable for type FHA 646-ExC (range "HcrH") and also for type FHA 646-E1 in current version (range "% rH" with multiplexer M4 C-B). Older FHA 646-x sensors with range "% rH" can also be used if the multiplexer is programmed to position M4 C-B in the connector EEPROM (via software AMR-Control, Measuring Points Programming, multiplexer).

With the intelligent ALMEMO® extension cables the humidity adjustment values of the sensor plug are automatically transmitted to the ALMEMO® instrument. Thus the sensor can be easily exchanged and calibrated (on site with a short cable).

Sensors with a multi-point adjustment on V6 units can be connected to the intelligent extension cable from revision R2E4 on.

The accuracy of the humidity measurement is not affected by the extension. For temperature measurement (with the built-in NTC sensor), the extension may cause additional deviations which depend on the measured temperature and the cable length (see chapter 3.2.3 under 'Notes on measurement‘)

3.4.2 Psychrometer

Measuring principle

The psychrometer is a sensor with the help of which the gas humidity can be determined with the corresponding characteristic values.

The psychrometer contains two temperature sensors. One of these sensors measures the ambient temperature (dry sensor). The other temperature sensor (humidity sensor) is wrapped in moist material (e.g. moistened cotton fabric).

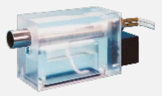
The drier the gas, the faster the water evaporates, which creates more evaporative cooling, resulting in a greater temperature difference between the two temperature sensors.

The built-in fan ensures a sufficient flow around the humid temperature sensor and prevents the water vapour that has already formed from hindering evaporation.

The temperature difference and other parameters can be used to determine the gas humidity and humidity characteristics. The VDI/VDE guideline 3514 serves as the basis for calculation.

The psychrometric measuring principle is one of the most accurate methods for determining gas humidity and is therefore used in systems where accurate measurements are required or in reference instruments. A prerequisite for accurate measurement is that the wet bulb temperature sensor is always sufficiently humidified.

Selection

Image	Reference number	Description	Operating temperature
	**FNAD 46**	Portable psychrometer with 2 NTC sensors	0 to 60°C
	**FAND 46-3**	Stationary psychrometer with 2 NTC sensors	0 to 90°C
	**FPA 836-3**	Stationary psychrometer with 2 Pt100 sensors	0 to 90°C

Notes on measurement

The proper handling of the psychrometer is very important. Therefore, please observe the following instructions:

1. The stabilization of the measured value may take a few seconds after the fan has started, during which time the wet bulb temperature sensor must be cooled down by the air flow.
2. Make sure that the humidity sensor is always sufficiently humidified. If in doubt, check the humidification of the cotton stocking or wick by visual inspection. Always use distilled water to moisten the wick. Otherwise the wick could calcify.
3. With the hand psychrometer: When measuring, hold the psychrometer if possible so that the water tank is below the sensor and no additional drops of water form on the wick. Water drops on the dry sensor or in the suction tube would falsify the measurement result.
4. If the wick no longer accepts water (contamination or drying out), it must be replaced.
5. Sufficient air speed at the intake opening must be ensured. Therefore, make sure that the air intake is not obstructed.

6. Only on the hand psychrometer: When the BAT - sign appears in the display, the supply voltage of the fan is no longer sufficient. Sufficient ventilation is no longer available, which can lead to incorrect measurements. Replace the batteries of the instrument.
7. Avoid heating up the psychrometer by external heat sources or your own body.

3.4.2.1 Portable psychrometer FNAD 46

Sensor characteristics

Features

The digital probe FNAD 46 uses NTC sensors with an accuracy of 0.2 K, which can be exchanged without loss of accuracy. The temperatures are measured with a dedicated 24-bit AD converter. An atmospheric pressure sensor is fitted as standard for automatic atmospheric pressure compensation.

The determination of the humidity variables is carried out from the primary measuring channels (real measured variables), dry and wet bulb temperature and atmospheric pressure on the basis of the formulas according to Dr. Sonntag under consideration of the enhancement factor (correction factor fw(t,p) for real mixed gas systems) according to W. Bögel.

Measuring range and accuracy are thus considerably increased compared to older sensors. The measured atmospheric pressure can also be used as reference atmospheric pressure in the ALMEMO® measuring instrument.

Programming

Measuring ranges on delivery

Designation	Command	Range	Exp.	Measuring range	Dim.	Resolution
1. Dry temperature TT, t	B-01	DIGI	-2	0 to 90	°C	0.01 K
2. Humid temperature HT, t_w	B-09	DIGI	-2	0 to 90	°C	0.01 K
3. Rel. humidity RH, U_w with PC	B-02	DIGI	-1	10 to 100	%H	0.1% rH
4. Atmospheric pressure AP, p	B-08	DIGI	-1	700 to 1100	mb	0.1 mbar

The FNAD 46 psychrometers are delivered with the measuring ranges shown above. This programming can be changed, i.e. for example, instead of the dew point in channel 3, the absolute humidity can be displayed.

The programming of the sensor on V6 and V7 instruments and the cable ZA1919AKUV is described in the subchapter 'Programming' in chapter 3.4.1.1.

Configurable measuring ranges

The measuring ranges of the 4 measuring channels can be configured as desired from the list of 9 ranges. PC: Atmospheric pressure compensation

Designation	Command	Range	Exp.	Measuring range	Dim.	Resolution
1. Dry temperature TT, t	B-01	DIGI	-2	0 to 90	°C	0.01 K
2. Humid temperature HT, t_w	B-09	DIGI	-2	0 to 90	°C	0.01 K

Designation	Command	Range	Exp.	Measuring range	Dim.	Resolution
3. Rel. humidity RH, U_w with PC	B-02	DIGI	-1	10 to 100	%H	0.1% rH
4. Atmospheric pressure AP, p	B-08	DIGI	-1	700 to 1100	mb	0.1 mbar
Designation	**Command**	**Range**	**Exp.**	**Measuring range**	**Dim.**	**Resolution**
5. Dew point DT, t_d with PC	B-03	DIGI	-1	-64.8 to +100	°C	0.1 K
6. Mixture MH, r with PC	B-04	DIGI	-1	0 to 6500	gk	0.1 g/kg
7. Abs. humidity AH, d_v with PC	B-05	DIGI	-1	0 to 596.3	gm	0.1 g/m^3
8. Vapour pressure VP, e with PC	B-06	DIGI	-1	0 to 1100	mb	0.1 mbar
9. Enthalpy En, h with PC	B-07	DIGI	-1	0 to 6500	kJ	0.1 kJ/kg

In addition to the area, a two-digit dimension and a comment are automatically programmed, consisting of the previously used abbreviations of the tables of the German Weather Service and the more recent formula symbols according to VDI/VDE 3514.

Technical data

Operating temperature range	0 to 60 °C (no ice)
Humidity	
Measuring range	10 to 100% rH
Accuracy at nominal conditions	±1 % rH
Nominal conditions	25°C ± 3 K, 1013 mbar, 50% rH
Accuracy full range	Typ. ±1% rH at 25°C ± 3 K, 1013 mbar, 10 to 100% rH
Temperature	
Temperature sensor	2 x NTC Type N
Accuracy	± 0.2 K at 0 to 60°C
Atmospheric pressure	
Digital atmospheric pressure sensor	Built-in to ALMEMO® D6 connector
Measuring range	700 to 1100 mbar
Accuracy	±2.5 mbar (at 23°C ± 5 K)
AD converter in ALMEMO® D6 connector	
Inputs	2 NTC sensors (soldered to board in plug)
Resolution	0.01 K
Linearisation	Error-free calculation method according to Galway Steinhart (no approximation method)
Accuracy	±0.05 K
Nominal temperature	23°C ± 2 K
Temperature drift	0.004% /K (40 ppm)
Humidity calculated value	Analytical equation (no approximation method)
Refresh rate	0.4 seconds for all 4 channels
Housing, cable, motor	
Power supply of fan	Via ALMEMO® D6 connector
Housing	Plastics
Weight	About 300 g
Sensor connection	Built-in connector
ALMEMO® connection cable	Coupling, 1.5 m PVC cable, with ALMEMO® D6 connector
Power supply	9 to 13 V DC
Power consumption	20 mA

Dimensions

Housing: Ø 50 mm, length 245 mm

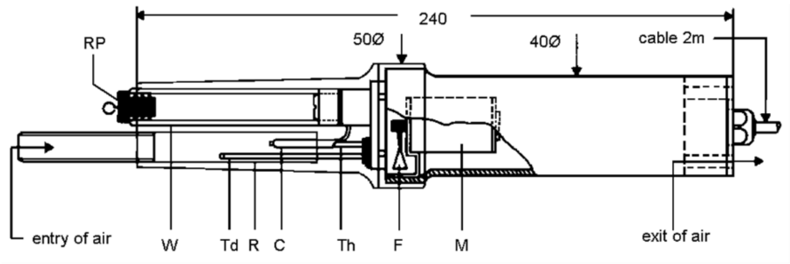


Fig. 3.4.6
Portable psychrometer

Portable psychrometer FNAD 46

M	= Motor	B	= Cotton wick
V	= Wings of van	S	= Radiation protection
TT	= Dry temperature sensor	W	= Water tank
TF	= Humid temperature sensor	St	= Stopper with pressure mandrel

Use

Preparation

Fill water tank for portable psychrometer

A water tank is installed in psychrometers for humidifying the wet bulb. It is filled differently depending on the model.

1. Remove the rubber plug (St) and pour in distilled water.
2. Close water tank with plug (wire removed).
3. Pull off the plexiglass cover and bring the psychrometer into a position where the water tank is above the temperature sensors.
4. Turn the water tank to the left (approx. 2-3 mm), which starts the water supply to the cotton stocking. If the cotton stocking has a darker and slightly shiny appearance, turn the water tank 1 to 2 mm to the right, thereby reducing the water supply.
5. Put the psychrometer in a vertical position and observe whether a drop of water forms. If this is the case, dab the water drop off. If another drop of water forms, turn the water tank a little to the right again.
6. Put the plastic cover back on and take the measurement.
7. After the measurements, insert the wire into the plug and turn the water tank 1 to 2 mm to the right to reduce the water supply to the cotton stocking.

Maintenance

Under certain conditions, the growth of germs in the water of the tank can occur, which is why an inspection and regular cleaning is necessary. The tank should be emptied during longer breaks in operation or for transport.

Wick change for portable psychrometer

A dirty or encrusted wick is no longer soaked through. Depending on the purity of the air and water, it must therefore be changed sufficiently often.

1. Remove the cap (Plexiglass) from the psychrometer.
2. Unscrew the water tank.
3. Remove the cotton wick with rubber and plastic disc from the bottom of the water tank.
4. Thread a new cotton wick with the open end through the holes in the rubber and plastic disc.
5. Insert the tip of the short probe through the hole 3 cm before the end so that it is firmly attached to the set area. Then place the cotton stocking together with the threaded discs on the bottom of the water container.
6. Screw on the water container.

3.4.2.2 Stationary psychrometer FNAD 46-3

Sensor characteristics

Features

The digital probe FNAD46-3 uses NTC sensors with an accuracy of 0.1 K, which can be exchanged without loss of accuracy. The temperatures are measured with a dedicated 24-bit AD converter. An air pressure sensor is fitted as standard for automatic air pressure compensation.

The determination of the humidity variables is carried out from the primary measuring channels (real measured variables), dry, wet temperature and air pressure on the basis of the formulas according to Dr. Sonntag, taking into account the enhancement factor (correction factor fw(t,p) for real mixed gas systems) according to W. Bögel.

Measuring range and accuracy are thus considerably increased compared to older sensors. The measured air pressure can also be used as reference air pressure in the ALMEMO® measuring instrument.

This psychrometer is an optimized version for long-term measurements.

Programming

See chapter 3.4.2.1.

Sensor connection

With the stationary psychrometer FNAD46-3 the two NTC sensors for dry temperature TT and wet temperature HT are screwed into the corresponding terminals TT-Gnd and HT-Gnd.

For the handheld psychrometer FNAD46 the sensors and the power supply via the ALMEMO® device are soldered to the board of the connector.

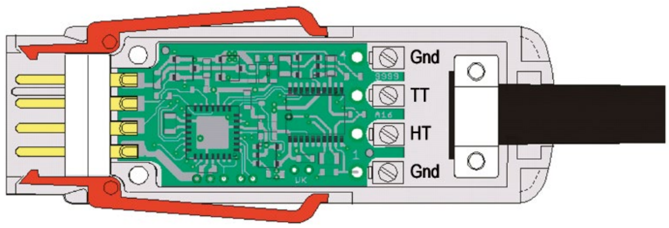


Fig. 3.4.7
Connector of stationary psychrometer FNAD846-3

Technical data

Operating temperature range	0 to 90°C (no ice)
Humidity	
Measuring range	10 to 100% rH
Accuracy at nominal conditions	±1% rH
Nominal conditions	25°C ± 3 K, 1013 mbar, 50% rH
Accuracy over full measuring range	Typ. ±1% rH at 25°C ± 3 K, 1013 mbar, 10 to 100% rH
Temperature	
Temperature sensor	2 x NTC Type N
Accuracy	± 0.2 K at 0 to 70 °C ± 0.4 K at 70 to 90 °C
Atmospheric pressure	
Digital atmospheric pressure sensor	Built-in to ALMEMO® D6 connector
Measuring range	700 to 1100 mbar
Accuracy	±2.5 mbar (at 23°C ± 5 K)
AD converter in ALMEMO® D6 connector	
Inputs	2 NTC probe (terminal connections in the connector)
Resolution	0.01 K
Linearisation	Error-free calculation method according to Galway Steinhart (no approximation method)
Accuracy	±0.05 K
Nominal temperature	23°C ± 2 K
Temperature drift	0.004%/K (40 ppm)
Humidity calculated value	Analytical equation (no approximation method)
Refresh rate	0.4 seconds for all 4 channels
Housing, cable, motor	
Power supply of the fan	12 V DC via mains adapter, cable about 1.5 m (included in delivery)
Housing	Plastics: PMMA
Weight	About 890 g
Sensor connection	Built-in connector
ALMEMO® connection cable	Cable FEP/silicone, 5 m, with ALMEMO® D6 connector
Power supply	9 to 13 V DC
Power consumption	4 mA

Dimensions

Length 175 mm,
Width 50 mm
Height 75 mm

Use

Preparation

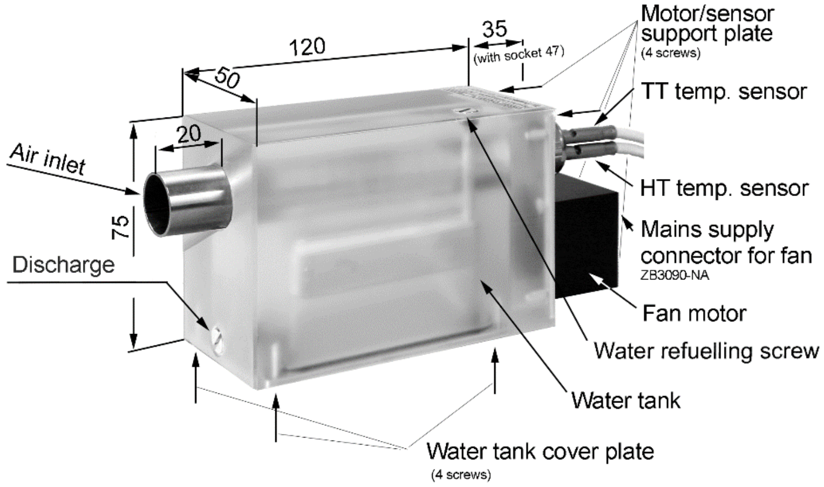


Fig. 3.4.8
Stationary psychrometer
FNAD46-3

Fill water tank for stationary psychrometer:

1. Open water refill screw
2. Pour distilled water into the water tank using the spray bottle provided.
3. Screw the refill screw back in and carry out the measurement.

Maintenance

Under certain conditions the growth of germs in the water of the tank can occur. Therefore the tank must be cleaned every 6 weeks. The tank should be emptied during longer breaks in operation or for transport.

Wick change for stationary psychrometer

A soiled or encrusted cotton wick is no longer properly soaked and falsifies the measured value. Depending on the purity of the air and water, it must therefore be replaced regularly.

1. Empty the water tank (see above)
2. Unscrew the water tank cover plate
3. Unscrew the motor / sensor holding plate and remove the old wick from the HT sensor
4. Insert a new wick into the pipe of the psychrometer on the water tank side and pull it over the HT sensor
5. Screw on the motor / sensor holding plate
6. Pull the wick tight from the water tank side, screw on the water tank cover plate and fill the water tank

3.4.2.3 Stationary psychrometer FPA 836-3

Sensor characteristics

Features

Adjusted Pt100 probes are used to measure the dry and wet bulb temperature. The stationary psychrometer is equipped with a water tank, which guarantees an automatic humidification of the wick over a longer period of time.

Programming

A psychrometer with Pt100 sensors for wet and dry temperature can be connected to any ALMEMO® measuring instrument with at least 2 input sockets. All calculation channels for the determination of humidity parameters are supported. The two Pt100 sensors must be arranged one behind the other and have the range P204, the humidity variables must be programmed in the second sensor on the 2nd to 4th channel:

Sensor	Measuring channel		Range	Dim.	Designation
Pt100	Mx:		P204	HT, t_w	Humid temperature in °C *
Pt100	Mx+1:	**1. Channel**	P204	TT, t	Dry temperature in °C *
		2. Channel to 4. Channel	P rH	RH, U_W	Rel. humidity in %H
			P dT	DT, t_D	Dew point temperature in °C
			P AH	MH, r	Mixture ratio in g/kg
			P UP	VP, e	Partial vapour pressure in mbar
			P En	En, h	Enthalpy in kJ

* Humid and dry temperature sensors must not be interchanged.

Technical data

Operating temperature	0 to 90°C
Humidity	
Humidity measuring range	About 10 to 100% rH
Type of measurement	Psychrometric
Accuracy of nominal conditions	±1% rH at nominal conditions with ALMEMO® 710 (new humidity calculation)
Nominal condition	25°C ± 3°C, 1013 mbar, 50% rH
Accuracy over full measuring range	Typ. ±1% rH at 25°C ± 3 K, 1013 mbar, 10 to 100% rH
Temperature	
Temperature sensor	2 x Pt100 film resistance
Accuracy	Class B, ALMEMO® justed
Housing, cable, motor	
Power supply of van	12 V DC via mains adapter, cable about. 1.5 m (included in delivery)
Housing	Plastics: PMMA
Weight	About 890 g
Cable	FEP / silicone, 5 m with ALMEMO® connector 2 cables / 2 connector

Dimensions

Length 175 mm,
Width 50 mm,
Height 75 mm

Use

Preparation

See 'Use/Preparation' in chapter 3.4.2.2.

Increase measuring accuracy

The prevailing ambient pressure sometimes has a considerable influence on the amount of the gas humidity parameters. Unlike the FNAD46 and FNAD46-3, the FPA836-3 is not equipped with an atmospheric pressure sensor in the connector. In order to still include the atmospheric pressure in the calculation of the humidity parameters, the atmospheric pressure compensation of the ALMEMO® measuring instruments can be used. The atmospheric pressure can be measured by a pressure sensor or entered manually into the ALMEMO® measuring instrument.

The precision measuring instrument ALMEMO® 710 is particularly suitable for this purpose. The ALMEMO® 710 calculates the moisture-related parameters based on the formulas of Dr. Sonntag and the enhancement factor according to W. Bögel (correction factor fw (t,p) for real mixing systems). The calculated variables are determined from the three primary measuring channels (real measured variables) dry temperature (°C, t), wet temperature (°C, tw) and atmospheric pressure (Pa, p).

When measuring the air humidity with the FPA 836-3 at the ALMEMO® 710, a considerably higher accuracy for the humidity-related variables calculated from the primary measuring channels and a larger measuring range is achieved. The digital atmospheric pressure sensor for compensation is built into the measuring instrument.

Various variables can be selected: Relative humidity (%, Uw), dew point temperature (°C, td), mixing ratio (kg/kg, r), absolute humidity (kg/m3, dv), water vapour partial pressure (Pa, e'), specific enthalpy (J/kg, h).

Maintenance

See 'Maintenance' in chapter 3.4.2.2.

3.4.3 Dew point sensors

Measuring principle

The following methods are commonly used to detect the dew point:

Dew point mirror method

An optically monitored mirror is mounted on a cascaded Peltier element. A control circuit is connected downstream of each sensor unit, with which the operating current of the cooling element is controlled in such a way that a defined condensate is produced. The resulting dew point temperature is measured directly in the sensor and output in evaluable form.

CCC dew point principle according to Heinze

Instead of the cooled mirror, the integrated sensor chip contains a cooled stray field capacitor with capacitive condensate detection (Condensate Controlled Capacitance), which is mounted on a miniature cooling element. The active sensor surface in contact with the measuring medium is a hygroscopically neutral wear-resistant and chemically resistant insulating layer under which the stray field capacitor is located. The capacitance increases almost abruptly when water condensation forms.

A control circuit is connected downstream of each sensor unit, with which the operating current of the cooling element is controlled in such a way that a defined condensate is formed. The resulting dew point temperature (the actual measured variable is the sensor surface temperature) is measured with an integrated temperature sensor and output in evaluable form.

Capacitive humidity measurement

In capacitive humidity sensors, a moisture-sensitive polymer layer is applied between two electrodes on a substrate. By absorbing water vapor according to the relative humidity, the dielectric constant changes and thus the capacity of the thin-film capacitor. The measurement signal is directly proportional to the relative humidity. The dew point can be calculated from the relative humidity and the temperature.

3.4.3.1 Dew point sensor FHA 646-DTC1 and dew point transmitter MT 8716-DTC1

Measuring principle

The dew point sensor FHA 646-DTC1 uses capacitive humidity measurement to determine the dew point.

Sensor characteristics

Features

Fig. 3.4.9
Dew point sensor FHA 646-DTC1 / Dew point transmitter MT 8716-DTC1

To protect the sensor element, the sensor is supplied with a stainless steel sinter filter.

The dew point sensor can be ordered in two different versions, as ALMEMO® dew point sensor with 1.5 m connection cable and ALMEMO® plug and as dew point transmitter with current output including connection plug.

For both, a screw-on measuring chamber for connecting a dew point sensor to compressed air lines via a ball valve is available (ZB 9646-DTCK).

Versions

Reference number	Version	Measuring range	Output	Connection
FHA 646-DTC1	ALMEMO® dew point sensor	-80°C to +20°C DT dew point temperature	ALMEMO® digital	ALMEMO® connector
MT 8716-DTC1	Dew point transmitter	-80°C to +20°C DT dew point temperature	4 to 20 mA/ -80 to +20°C DT, 2 wire	Transmitter connector

Both versions are available with the option OA 9646-DTCP for process pressure up to 350 bar.

Programming

Just for FHA 646-DTC1

Channel	Designation	Measuring range	Range	Dimension
1	Temperature	-20.0 to +70.0°C	DIGI	°C
2	Relative humidity	0 to 98.0% rH	DIGI	%H
3	Dew point	-80.0 to +20.0°C DT	DIGI	°C

Technical data

Measuring range	-80°C to +20°C DT dew point temperature
Measuring accuracy	± 0.5°C of -10 to +20°C DT
	Typical ± 2°C DT at -40°C DT
Measuring channels (just FHA 646-DTC1):	
Temperature	-20.0 to +70.0°C
Relative humidity	0 to 98.0% rH
Dew point	-80.00 to +20.0°C DT
Operating temperature	-20 to +70°C
Process connection	Screw-in thread G1/2" stainless steel
Protection cap	Stainless steel sinter filter
Pressure range	-1 to 50 bar standard
Storage temperature	-40 to 80°C
FHA 646-DTC1:	
Output	ALMEMO® digital
Power supply	Via ALMEMO® connector, 5 mA
Connection	1.5 m with ALMEMO® connector
MT 8716 DTC1:	
Output	4 to 20 mA / -80 to +20°C as 2 wire technology
Power supply	10 to 30 V DC, load < 500 Ohm
Connection	Transmitter connector
Housing:	Material: Polycarbonat
Protection type	IP65

Dimensions

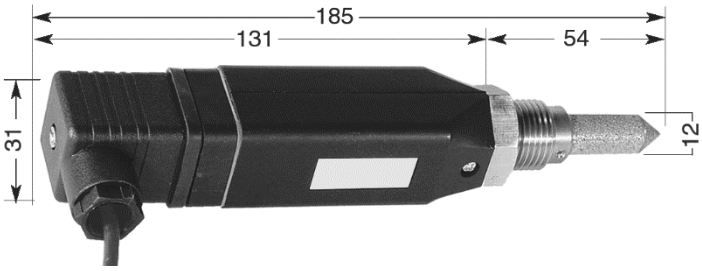


Fig. 3.4.10 Dimensions dew point sensor FHA 646-DTC1 / dew point transmitter MT 8716-DTC1

Use

Preparation

The dew point sensors can be installed directly in the air flow. However, we generally recommend using a screw-on measuring chamber. This ensures a fast measurement without installation effort.

Directly in the compressed air network

Screw the sensor with the G 1/2" thread pressure-tight into the centre or top of the compressed air line to be measured. Make sure that the measurement is taken close to the compressed air flow. With bagged lines and non-flowing compressed air, very long reaction times for the moisture measurement value result. It is recommended to carry out the installation after drying the compressed air and all bypass lines or even with critical compressed air consumers.

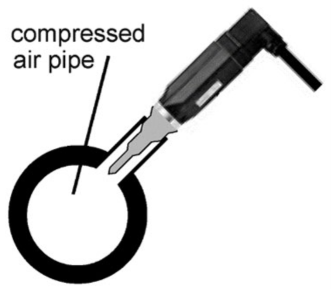
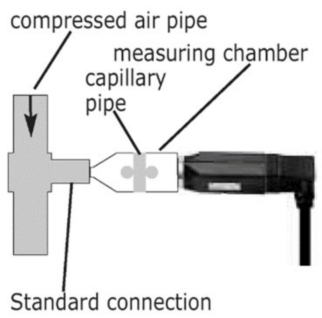


Fig. 3.4.11 Dew point sensor directly in the compressed air network

Indirectly in the compressed air network



Screw the probe with the G 1/2" thread into the measuring chamber. Connect the measuring chamber to the compressed air line via a ball valve and, if necessary, a diffusion-tight connecting line (max. 5 m). If the compressed air contains oil or dirt, install a 40 µm prefilter upstream of the measuring chamber. A small amount of compressed air continuously flows out through the capillary line of the measuring chamber (at 7 bar approx. 1 l/min expanded). The reaction times for the measured humidity value are shorter than with direct mounting.

Advantage: easy mounting and dismounting of the sensor, fast reaction time

Fig. 3.4.12 Dew point sensor in measuring chamber

For particularly critical and cost-intensive productions, we recommend installing a second measuring device for safety reasons and monitoring it with the switching contact option.

Measurement

In general, the humidity can be measured in all non-corrosive gases. For corrosive gases information on the use of the dew point sensor can be obtained from Ahlborn Mess- und Regelungstechnik.

For precise measurements in the low dew point range (-30...-80 °C td) the measuring temperature of the gas should be at room temperature (20 to 35 °C) if possible. Often, e.g. in pellet dryers or other applications, the temperature of the sample gas is higher, e.g. 80 to 120 °C.

In this case we recommend to install a "cooling section" made of moisture-impermeable material in front of the screw-on measuring chamber. Ideally suited here is a PTFE line or a copper line, in which the hot gas is ideally cooled to ambient temperature by approx. 2 to 5 m due to the length of the line.

Normal plastic hoses must not be used.

The dew point temperature in °C td does not change during cooling, since it is an absolute humidity value which, like other measured variables, e.g. g/m3, is independent of temperature.

Sensor protection

Safety instructions

Read before commissioning!

Attention: Do not exceed pressure of 50 bar for standard version. For special version up to 350 bar.

Observe measuring ranges of the sensor!

Overheating will destroy the sensors.

Observe the permissible storage and transport temperature as well as the permissible operating temperature (e.g. protect the measuring instrument from direct sunlight).

Opening the device, improper handling or use of force will invalidate the warranty!

Adjustment and calibration work may only be carried out by qualified personnel from the measurement and control technology department.

Important: Before installation, briefly allow compressed air to flow out to remove condensate and particles (prevents soiling of the sensor).

Standing air leads to long measuring times.

3.5 Material moisture

Basics

The material moisture plays an important role in the processing of building materials, wood and paper as well as in the assessment of soil quality.

It can be determined with many different moisture measurement methods. The most important ones are listed below.

Direct measurement methods:	Indirect measurement methods:
• Gravimetric method (Darr-method) • Calcium carbide method (analytic) • Karl-Fischer method	• Micro wave method • Infrared reflection/-absorption • Humidity compensation method • Humidity measurement with TDR • Wave propagation speed • Tensiometer (soil moisture, capillary forces in the soil) • Capacitive methods • Conductivity measurement method

Capacitive and conductivity measuring methods are particularly suitable for fast comparison measurements. Humidity differences can be determined non-destructively and problem areas can be quickly detected.

However, the measured values depend on various factors. In particular, density fluctuations, different ingredients, variations in salt concentration or layer thickness influence the measurement result. The measured values should therefore normally not be interpreted as absolute values, unless the same material is always used and a reference measurement is carried out for calibration.

The material moisture can be represented by various characteristic values:

Moisture content or water content

… is the ratio of the mass of water contained in the substance to the mass of the anhydrous substance.

$$u_m = \frac{m_w}{m_{tr}} = \frac{(m - m_{tr})}{(m - m_w)}$$

If the moisture content is to be expressed in %, the value of u_m must be multiplied by 100.

Moisture content by volume

… is the ratio of the volume of the water contained in the substance to the volume of the anhydrous substance.

$$u_V = \frac{V_w}{V_{tr}} = \frac{m_w}{\rho_w \cdot V_{tr}} = \frac{u_m \cdot m_{tr}}{\rho_w \cdot V_{tr}} = u_m \cdot \frac{\rho_{tr}}{\rho_w}$$

The density of water is ρ_w= 1000 kg/m^3.

Moisture proportion or water proportion

… is the ratio of the mass of water contained in the substance to the total mass of the substance.

$$\psi_m = \frac{m_w}{m} = \frac{(m - m_{tr})}{(m_w + m_{tr})}$$

Moisture proportion by volume

… is the ratio of the volume of water contained in the substance to the total volume of the substance.

$$\psi_V = \frac{V_w}{V} = \frac{m_w}{V \cdot \rho_w} = \frac{\psi_m \cdot m}{\rho_w \cdot V} = \psi_m \cdot \frac{\rho}{\rho_w}$$

The density of water is ρ_w= 1000 kg/m^3.

Dry matter proportion

… is the ratio of dry matter to total mass.

$$T = \frac{m_{tr}}{(m_{tr} + m_w)} = \frac{1}{1 + \frac{m_w}{m_{tr}}} = \frac{1}{1 + u_m} \approx 1 - u_m$$

for $u_m < 1$

m_w	= Mass of water in kg
m_{tr}	= Mass of water free substance (mass of dry material) in kg
m	= Total mass of the sample (mass of humid material) in kg
V_w	= Volume of water in m^3
V_{tr}	= Volume of water free substance (volume of dry material) in m^3
V	= Total volume of the sample in m^3
ρ	= Density of the sample in kg/m^3
ρ_{tr}	= Density of the water free sample in kg/m^3
ρ_w	= Density of water (1000 kg/m^3)

Standardisation

For absolutely accurate measurements the drying oven or Darr-method is essential. In this method, a material sample is taken, weighed and dried in the drying oven until no change in weight can be detected. From the difference in weight, the moisture content can now be precisely calculated.

Definition of the raw density:

The variable raw density is used to indicate the density of a porous material. Density is calculated from the ratio of the mass of a material to its volume. In the case of raw density, the volume of the substance also includes the volume of its own or cell pores.

Raw density is one of the important parameters for assessing the strength, thermal conductivity and water permeability of building materials, among others.

3.5.1 Capacitive moisture sensor

Measuring principle

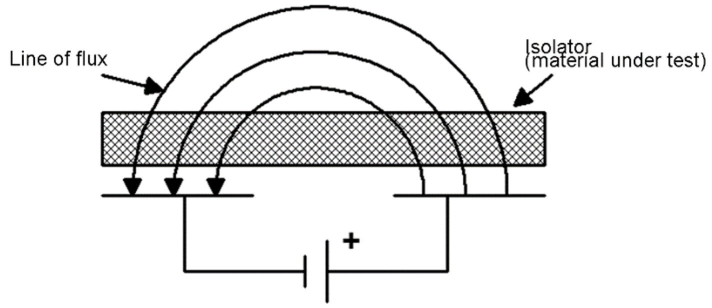


Fig. 3.5.1
Illustration of the function of a capacitive material moisture sensor

The capacitive moisture sensors work like an open (unfolded) capacitor (see figure 3.5.1).

A high-frequency electric field penetrates the material to be measured and generates a voltage signal.

The capacitance of the capacitor and thus the voltage signal generated by this field depends on the dielectric constant of the material between the plates.

Since water has a relatively high dielectric constant compared to other materials (water: $\varepsilon_r = 80$, air: $\varepsilon_r = 1$, paper: $\varepsilon_r = 3.7$), the voltage signal can be used to determine the water content of a moist material.

Selection, product overview

Type	Measuring range	Material	Version
FHA 696-MF	0 to 50% humidity	Mineral building materials, wood, paper and cardboard	Portable sensor with handle
FHA 696-MFS1	0 to 50% humidity	Wood	For stationary use
FHA 696-GF1	0.0 to 99.9% water content in weight percent H_2O	Granulates such as wood chips, pellets, sawdust, grain	Portable sensor

Application range

The capacitive determination of the material moisture is a simple and fast measuring technique, which is also possible in long-term use and enables non-destructive contact measurement.

FHA 696-MF	Manual measurement of moisture in mineral building materials, wood and cardboard
FHA 696-MFS1	Stationary installation and long-term measurements, e.g. of wooden building constructions, roof constructions (among others with laminated beams)
FHA 696-GF1	Determination of moisture in wood chips, wood pellets, sawdust, grain and other water absorbing granules

3.5.1.1 Moisture sensor FHA 696-MF

Sensor characteristics

Features

Fig. 3.5.2
Moisture sensor FHA 696-MF

The sensor has three different display ranges for mineral building materials, wood and paper.

It is equipped with a 1.5 m long cable with ALMEMO® connector. Two test blocks for adjustment are available.

Types

Reference number	Measuring range	Resolution	Operating range	Version
FHA 696-MF	0 to 50% moisture content of wood, by mass	0.1%	0 to + 60°C	Portable sensor

Programming

3 measuring channels are set up for the material types mineral building materials, wood types, paper and cardboard. They are individually adjusted and provided with a characteristic dimension.

Measuring channel	Range	Res.	Dim	Exp.	Base value
1. Mineral building materials	d2600	0.1%	B%	3	Can be adjusted according to the material, see Use / Preparation
2. Wood sepcies	d2600	0.1%	H%	3	
3. Paper and cardboard	d2600	0.1%	P%	3	

Technical data

Measurement procedure	Capacitive
Resolution	0.1%
Measuring range	0 to 50% moisture, by mass
Display range	Mineral building material: 0 to 20% moisture content Woods: 0 to 50% moisture content Papers: 0 to 20% moisture content
Nominal temperature	15 to 25°C
Operating range	0 to +60°C
Storage temperature	-20 to +80°C
Housing	Plastic handle
Terminal block	Aluminium/plastics
Measuring comb	Stainless springsteel
Weight	260 g
Signal output	0 to 2 V
Power supply	8 to 12 V
Power consumption	About 7 mA

Dimensions

Housing	40 mm Ø, 130 mm long
Terminal block	20 x 25 x 70 mm,
Measuring comb	0.5 mm, 70 x 35 mm

Use

Increase measuring accuracy

For the material types mineral building materials, wood types, paper and cardboard, three measuring channels are set up as shown under 'Programming'.

According to the material to be measured (e.g. wood) the correct channel is selected. For the different materials within a group (in case of wood e.g. balsa, spruce, poplar, maple...) a material specific correction value can be set to increase the accuracy.

This correction value consists of an offset, which is programmed into the base value of the corresponding channel in the ALMEMO® connector. In the case of woods of group H8 (ebony, snakewood, ...) a value is added to this offset, which has to be written into the pitch.

Mineral building materials

Group	Material	Base value
B1	Ytong	0.0
B2	Brick, plaster, wall tiles	2.5
B3	Sand, cement, eternit slabs, floor slabs, anhydrite screed	5.0
B4	Cement screed, concrete	6.0
B5	Marble	7.0

Wood types

Group	Material	Base value
H1	Balsa	0.0
H2	Abachi, Samba	1.0
H3	Spruce, Gabon, Ilomba, Lauan, Meranti light, Oregon, Poplar, Red Pine, Fir	2.0
H4	Carolinapine, Pine, Limba, Linden, Horse chestnut, White willow, Cedar	3.0
H5	Maple, Birch, Beech, Ash, Cherry, Nut, Pitch-pine, Red oak, Ramin, Sipo, Teak, Elm	4.0
H6	Apple, Pear, Sessile and Sessile oak, Zebrano, Dark meranti, Merbau, Padouk, Hornbeam	5.0
H7	Hardboard, Jarrach, Keruing, Macore, Mahagony, Red Balau, Wenge	6.0
H8	Bongossi, Cocobolo, Ebony, Snakewood In this group, in addition to the base value, the slope must also be changed to 0.9!	7.0

Paper and cardboard:

Group	Material	Base value
P1	Filter paper, tissue paper	2.0
P2	Semi-chemical pulp, crepe paper, bogus paper, testliner	2.5
P3	Packaging paper, corrugated paper	3.5
P4	Kraft paper	4.5
P5	Offset paper	5.5

Programming the base value

The programming can be done as follows:

1. Use the measuring point selection button to select one of the three channels for the desired material type (e.g. channel 2 with H% for wood)
2. Select the BASE function.
3. Program the desired base value. The input of a gradient correction is done in the same way (necessary e.g. for group H8, see above).

Zero point correction

Since the ambient conditions strongly influence the capacitive measurement of the material moisture, the zero point should be checked before each measurement and corrected if necessary.

1. Hold the probe freely in the air. The meter must display the set BASIC VALUE as a negative reading.
2. If this is not the case, press the ENTER, ± keys in succession to correct the measured value.

Review

There are 2 adjustment modules for checking the sensor calibration:

- ZB 9696-PE05 for the building material duct

- ZB 9696-PE30 for the wood and paper duct

They consist of a plastic whose dielectric properties remain constant for years at 0°C to 30°C.

Testing conditions

The sensor with the adjustment module should be checked in a closed room at a room temperature between 15°C and 25°C. The measuring device, connected sensor and adjustment module must be stored in this room for at least 1 hour before the test can be performed. The sensor must be clean and dry.

Adjustment instructions

1. Delete programmed basic values.
2. Place the adjustment module on a table with the aluminium side facing down.
3. Hold the probe in the air to measure the zero point. The corresponding output voltage is measured. If the meter displays a value other than zero, press the ENTER, ± keys in succession to correct the measured value.
4. Press the probe on the adjustment module as shown in the figure (contact pressure approx. 10 N). (See instructions in 'Measuring' below).
5. The output voltage now occurring, minus the determined zero point value, is a measure of the sensitivity of the sensor.
6. If the base value is deleted, the following control values must be displayed when the probe is placed on the instrument:

   In the 1st channel mineral building materials on test block PE05: 9.0 B%

   In 2nd channel wood species on test block PE30: 12.0 H%

   In 3rd channel paper and cardboard on test block PE30: 8.5 P%
7. If the control value deviates roughly from the setpoint, the correction factor can be entered with the Slope correction (SK) function, or the calibration can be renewed at the factory.

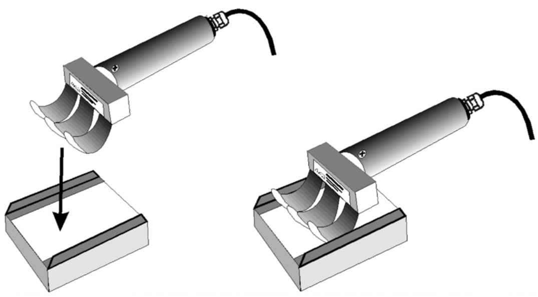


Fig. 3.5.3
Moisture sensor FHA 696-MF with terminal block

Measurement

1. Switch on the measuring instrument.
2. Set the material type building materials B%, wood H% or paper P% with the measuring point changeover key
3. To change the material group BASIC VALUE, if necessary enter the slope correction accordingly.
4. Check zero point and correct if necessary.
5. Place the probe with the sensor on the material so that the measurement is transverse to the structure of the material (e.g. grain of the wood).
6. Grasp the plastic handle at the rear end for measurement. To avoid influencing the measurement, the hand should not come near the sensor head or touch it.

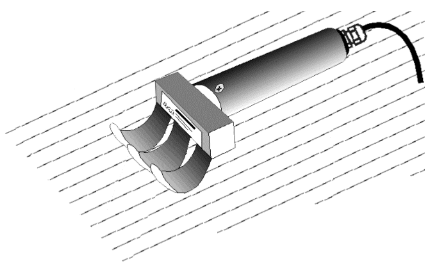


Fig. 3.5.4 Positioning of FHA 696-MF in relation to the wood grain

7. Read the measured value, the MAX VALUE function of the measuring instrument can be useful to record the maximum value.

Penetration depth of the measuring field

The penetration depth of the measuring field into the material to be measured is approx. 25 mm, whereby the moisture of deeper lying layers is also detected.

For materials thinner than 25 mm (plywood, sheetrock, paper), the sensitivity of the probe is too low (i.e. the measured value is too low), but you can make comparative measurements. To accurately determine moisture in thin material, measurements must be taken on the stack or roll. Metal plates should be avoided as supports, otherwise the measured value will be distorted by the depth effect.

Since material factors such as layer thickness, material density, drying conditions are different for each application, it is generally not possible to accurately determine the actual moisture content of a material over a large area.

Due to a wide variety of conditions on site, which we do not know, no liability claim against us can be derived from consequential damage.

3.5.1.2 Moisture sensor for wood FHA 696-MFS1

Sensor characteristics

Features

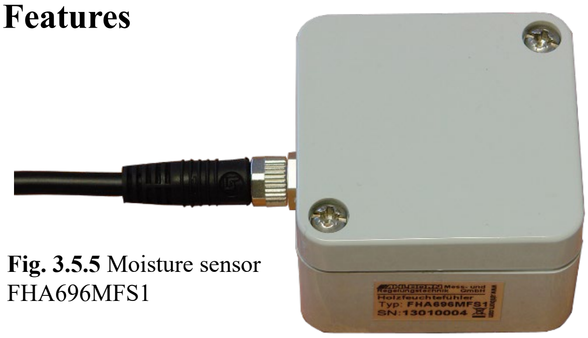


Fig. 3.5.5 Moisture sensor FHA696MFS1

The capacitive sensor element together with its measurement technology is completely integrated in a moisture-protected sensor housing. The sensor housing can be easily mounted on a wooden surface.

An ALMEMO® connection cable can be plugged into the housing. In its ALMEMO® connector a linearization curve is stored, on the basis of which the ALMEMO® device determines the material moisture.

Types

Reference number	Measuring range	Resolution	Operating range	Version
FHA 696-MFS1	0 to 50% moisture content of wood, by mass	0.1% moisture content	0 to 80°C, rel. humidity 0 to 90% rH	Stationary

Technical data

Measurement procedure	Capacitive
Measuring range	0 to 50% moisture of wood, by mass (at 23°C)
Resolution	0.1% moisture content
Repeatability	±1% moisture content
Nominal temperature	23°C ± 2 K
Operating conditions	0 to 80°C, rel. humidity 0 to 90% rH (non-condensing, no ice)
Storage temperature	-20 to 80°C
Housing	Plastics
Signal connection	Built-in connector
Protection type	Housing and plug connection: IP64
ALMEMO® connection cable	Coupling, PVC cable 5 m
ALMEMO® connector	Linearisation for wood, stored in ALMEMO® connector, for current ALMEMO® devices from version 6
Power supply	Via ALMEMO® connector (5 V)
Power consumption	About 7 mA

Dimensions

Housing: L 51 x W 53 x H 36 mm

Use

Measurement

The penetration depth of the measuring field into the material to be measured is approx. 25 mm, whereby the moisture of deeper layers is also recorded.

The sensor is suitable for stationary installation and long-term measurements. It can be used for data logger operation in power-saving sleep mode (interval operation).

3.5.1.3 Moisture sensor FHA 696-GF1 for determination of water content of granules

Measuring principle

The sensor element of the device contacts the material to be measured so that a high-frequency electric field can penetrate the material. A microprocessor receives the measuring signals and determines the average percentage water content from the measured value, taking into account the set material curve.

Basics

There are a number of methods for measuring the material moisture or the water content of granulates more or less accurately, such as the hygroscopic method, the distillation method or the Karl Fischer titration method.

Moisture of wood and water content

The so-called kiln-drying method (Darr method) also allows a very precise determination:

A sample of wood is taken and weighed. It is then dried at a temperature of 103 ± 2°C, if possible in a ventilated oven, until the weight is constant. By determining the loss of weight caused by drying, the amount of water originally present in the wood body is determined.

Of practical relevance are the electrical wood moisture measuring methods, which make use of either the ohmic resistance or the dielectric properties of the material, e.g. water (ε_r = 80) and wood (ε_r = 1 to 7). The density of the wood to be measured must be taken into account. In addition, the course of the fibres between the electrodes or the penetration depth of the electrodes influence the measurement results in both methods.

Definition of wood moisture

$$u = \frac{m_{\text{mass of water in wood}}}{m_{\text{dry mass of wood}}}$$

To calculate the wood moisture in %, the value of u must be multiplied by 100.

With fresh or wet wood, the wood moisture content can be well over 100% (see example 2).

Example 1:

From a wood sample with a mass ('weight') of 100 g, 40 g of water are extracted. The wood sample then weighs only 60 g. The ratio of 40 g of water removed to 60 g of residual weight of wood is therefore 40 g.

According to the formula

$$u = \frac{m_{\text{ mass of water in wood}}}{m_{\text{dry mass of wood}}} = \frac{40}{60} = 0{,}6667$$

the moisture content of this wood sample is 66,67 %.

Example 2:

From a wood sample with a mass (weight) of 100 g, 60 g of water are extracted. The wood sample then weighs only 40 g. The ratio of 60 g of water removed to 40 g of residual weight of wood is therefore 60 g.

According to the formula

$$u = \frac{m_{\text{mass of water in wood}}}{m_{\text{dry mass of wood}}} = \frac{60}{40} = 1.5$$

the moisture content of this wood sample is 150 %.

Definition of water content

$$w = \frac{m_{\text{mass of water in wood}}}{m_{\text{total mass of wood moisture}}}$$

To calculate the water content in %, the value of w must be multiplied by 100.

The percentage water content, in contrast to the percentage wood moisture content, can only ever have a value of < 100%.

Different importance of wood moisture and water content

In practice, the wood moisture must not be confused with the water content or even equated with it. While wood moisture refers to kiln-dry weight (absolutely dry wood), water content is based on the ratio of water content to wet weight of the wood (total mass of wet wood).

With simple formulas, the water content can be calculated from the wood moisture content and vice versa.

Water content w from wood moisture u:

$$w = \frac{u}{1 + u}$$

Or water content in % (w%), from wood moisture in % (u%):

$$w_{\%} = \frac{u_{\%}}{100 + u_{\%}} \cdot 100$$

Wood moisture u from water content w:

$$u = \frac{w}{1 - w}$$

Or wood moisture in % (u%), from water content in % (w%)

$$u = \frac{w_{\%}}{100 + w_{\%}} \cdot 100$$

Standardisation

The kiln-drying method (Darr method) is the only method that is standardised (DIN 52 183) and is therefore also used as a calibration method for the other methods.

An EU standard has been in force since 2011, which ensures uniform regulation of pellet qualities. The EU standard 'Pellets EN 14961-2' replaces the DIN standards, Austrian standards and individual regulations on the individual pellet markets throughout Europe.

Heating value

The heating value of wood results from the heating value of the dry matter contained in it, from which the energy required to evaporate the water content must be subtracted. This is 0.63 kilowatt hours per kg of water.

Physical units of energy (calorific value)

1 MJ/kg = 1000 kJ/kg; 1 MJ = 0.27778 kWh or 1kWh = 3.6MJ

Sensor characteristics

Fig. 3.5.6
Moisture sensor FHA 696-GF1
for granule

Features

The sensor consists of a sensor head, three extensions for screwing on, an end piece and a connection cable of 2 m length with ALMEMO® plug.

A transport case is included in the delivery.

Versions

Reference number	Measuring range	Resolution	Operating temperature	Measuring radius
FHA696GF1	0.0 to 99.9% water content in percent by weight H_2O	0.1% moisture content	5 to 40°C	About 10 cm around the sensor

Programming

The FHA 696-GF1 sensor is supplied with a programming for wood chips. However, programming for measurements with pellets is also possible on customer request.

	Channel	Designation	Range	Dim.	Comment	Factor	Base	Exp.
Wood chips	1	Moisture	D2.6	%	Wood 3	0.1833	-27.3	3
Pellets	1	Moisture	D2.6	%	Pellets	0.0905	-11	3

Technical data

Measuring principle	Capacitive
Measuring range	0.0 to 99.9% water content in weight % H_2O, by mass
Resolution	0.1%
Measuring radius / penetration depth	About 10 cm around the sensor
Material temperature	5 to 40°C
Operating temperature	5 to 40°C
Storage temperature	-20 to 70°C
Weight	300 g
Signal output	ALMEMO® (voltage)
Power supply	5 V from ALMEMO® device
Power consumption	About 5 mA
Cable connection	Built-in connector on sensor head
Cable	PVC, length = 2 m, with ALMEMO® connector, the cable is led through the extension tubes and the end piece

Dimension

Sensor head d = 22 mm, l = 200 mm, rounded tip
Extension, screw-on d = 18 mm, l = 300 mm
End plastics d = 22 mm, l = 30 mm

Use

Review

A check of the sensor seems to be useful:

- In case of mechanical damage
- After use under extreme conditions (e.g. high temperatures)
- For implausible measurement results

The ZB 9696-PE22 test block is available for checking the sensor calibration.

Measurement

Fig. 3.5.7
Measurement with sensor FHA 696-GF1

When measuring, make sure that the measuring radius or the penetration depth of the sensor is approx. 10 cm.

The material to be measured should be optimally compacted (shaken). For reproducible results, the penetration depth should always be the same.

Sensor protection

- Observe operating instructions.
- Use the sensor exclusively in accordance with its intended use.
- Avoid contact of the sensor with live and energized parts.
- Protect the sensor from moisture.
- Protect the sensor from shock.
- Protect the sensor from heat sources.
- Repair and maintenance only by a qualified specialist.
- Protect the sensor against electrostatic discharge.

Damage caused by disregarding the above-mentioned instructions is excluded from the warranty.

3.5.2 Moisture sensor, operating on the conductance principle

Measuring principle

When measuring with these probes, the moisture dependence of the electrical resistance is used to determine the material moisture. Metal probes inserted into the wood are used to measure the electrical resistance and relate it to the moisture content of the material.

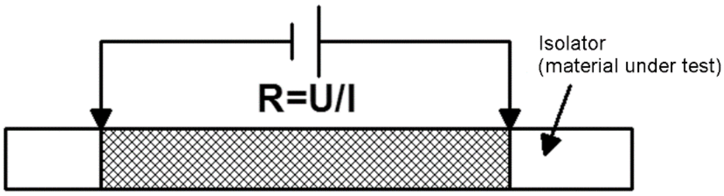


Fig. 3.5.8
Functioning of a material moisture sensor working according to the conductance principle

Selection, product overview

Type	Measuring range	Materials	Version
FHA 636-MF	7 to 30% moisture content, by mass	Wood	Portable sensor with handle
FHA 636-MFS1	5 to 50% moisture content, by mass	Wood	For stationary use
FHA 636-WD	< 10% no water available, > 10% water available	Different materials, for detection of unbound water	Portable sensor with handle

Application range

FHA 636-MF Manual measurement of moisture in wood

FHA 636-MFS1 Stationary installation and long-term measurements, e.g. of wooden building constructions, roof constructions (among others with laminated beams)

FHA 636-WD Especially suitable for use in the building trade for control measurements in hidden places, e.g. at sealing joints, under screed, etc.

3.5.2.1 Conductivity sensor for wood moisture FHA 636-MF

Sensor characteristics

Fig. 3.5.9
Conductivity sensor for wood moisture

FHA 636-MF

Features

A microprocessor is built into the sensor handle, which calculates the material moisture in weight percent from the measuring signal.

The sensor consists of a round black plastic housing to which 2 collets are attached.

Types

Reference number	Measuring range	Operating temperature	Version
FHA636MF	7 to 30% moisture content, by mass	0 to 60°C	Portable sensor with handle

Programming

Measured variable	Measuring range	Resolution	Range	Dimension	Exponent
Wood moisture	7.0 to 30.0	0.1%	d2600	%	3

Technical data

Measuring principle	Conductivity principle
Measuring range	7 to 30% moisture content, by mass
Repeatability	± 1%
Nominal temperature	23°C ± 2°C
Operating temperature	0 to +60°C
Storage temperature	-20 to +80°C
Measuring tip	Stainless steel, not isolated
Housing	Plastic handle
Weight	260 g
Signal output	0 to 2V
Power supply	7.5 to 12 V
Power consumption	Max. 10 mA

Dimensions

Housing: Ø 40 mm, length 130 mm
Measuring tip: Ø 3 mm, length 50 mm

Use

Preparation

Replacing the electrodes

If the electrodes have become bent or PTFE insulated electrodes are to be used due to surface moisture on the wood, they can be replaced as described below:

The chuck of the electrode measuring tips should be held with an open-ended spanner (span 7 mm). The clamping nut can now be loosened with a second wrench (spanner width 7 mm). This prevents the chuck from twisting and damage to the sensor handle.

The electrode can now be replaced. When retightening the clamping nut, make sure again that the chuck does not rotate in the housing.

Increase measuring accuracy

Adjustment of the sensor

1. Hold the probe in the air (no material on the electrodes) and determine the control value. The target value for measurements in air is 7.0 %.
2. Connect calibration resistor with 1 GΩ and determine control value. The nominal value with reference resistor is 12.0 %.
3. If the control value deviates roughly from the setpoint, the correction factor can be entered with the function INCLINE CORRECTION (SK) or the adjustment can be renewed at the factory.

PTFE-insulated measuring tips for use with surface moisture

PTFE-insulated measuring tips are available to prevent incorrect measurements in case of surface moisture:

1 piece ZB 9636-MFST (2 pieces are required per probe)

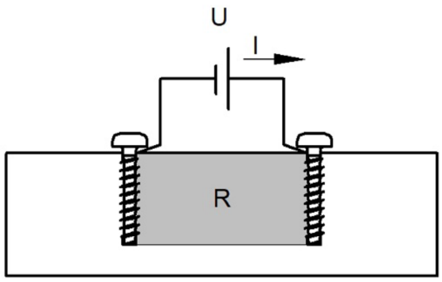
Measurement

When measuring, care must be taken to ensure that the electrodes are pressed into the material to be measured during the measurement.

1. Press the electrodes of the probe into the material so that the measurement is transverse to the structure of the material (wood grain).
2. Switch on the measuring instrument.
3. Read the measured value. The MAX VALUE function of the measuring instrument can be useful for recording the maximum value.

3.5.2.2 Wood moisture sensor for long term measurement FHA 636-MFS1

Measuring principle



The ALMEMO® wood moisture sensor works according to the conductivity principle. The moisture dependence of the electrical resistance is used to determine the moisture content of the material.

The stainless steel hanger bolts included in the delivery are screwed into the wood and the electrical resistance between them is measured. The microprocessor built into the electronics housing calculates the moisture content of the wood in percent by weight.

Fig. 3.5.10 Measuring principle wood moisture sensor

Sensor characteristics

Fig. 3.5.11
Wood moisture sensor for stationary use FHA 636-MFS1

Features

The sensor is delivered with two hanger bolts and two measuring lines. An ALMEMO® connecting cable can be plugged into the housing.

The conductivity is temperature-dependent. With the built-in temperature sensor the displayed humidity value is automatically temperature compensated.

Types

Reference number	Measuring range	Resolution	Operating temperature	Version
FHA636MFS1	5 to 50% moisture content, by mass	0.2% moisture content	0 to 80°C	Sensor for stationary use

Technical data

Measuring principle	Conductivity principle
Measuring range	5 to 50% moisture content of wood, by mass (at 23°C)
Resolution	0.2% moisture content
Repeatability	±1% moisture content
Nominal temperature	23°C ± 2 K
Temperature sensor	NTC, built into sensor housing
Temperature compensation	In the range of 0 to 80°C
Operating conditions	0 to 80°C, humidity 0 to 90% rH (non-condensing, no ice)
Storage temperature	-20 to +80°C
Housing	Plastics
Measuring input	2 input sockets 4 mm with cross hole
Measuring leads	2 leads, PTFE isolated Length = 0.5 m With ring cable lug 4 mm
Measuring tips	2 stainles steel hanger bolts M4, total length = 60 mm, incl. 4 stainless steel nuts, 2 stainless steel spring washers
Mounting distance	2.5 cm crosswise to the wood grain direction
Signal connection	Built-in connector
Protection type	Housing incl. connections: IP63
ALMEMO® connection cable	Couple, PVC cable 5 m
ALMEMO® connector	Linearisation for wood, stored in ALMEMO® connector for current ALMEMO® devices from version 6
Power supply	Via ALMEMO® connector (5 V)
Power consumption	About 5 mA

Dimensions

Housing: L 51 x W 53 x H 36 mm

Use

Preparation

The two stainless steel M4 hanger bolts are screwed into the wood at a distance of 2.5 cm transverse to the direction of the wood grain and connected to the measuring electronics in the moisture-protected sensor housing via the measuring leads.

The sensor housing with the built-in temperature sensor is also fixed to the wood surface.

Measurement

The data logger must be operated in sleep mode (interval operation) to prevent salination or drying out of the wood.

3.5.2.3 Water detector sensor FHA 936-WD

Sensor characteristics

Fig. 3.5.12
Water detector sensor FHA 936-WD

Features

The probe consists of a round black plastic housing, on which two collets are mounted for easy exchange of the electrodes.

The water detector probe is supplied with electrodes in three different versions to suit the respective application (see also 'Dimensions' below):

- Stainless steel, rounded
- Stainless steel, sharp tip
- Spring steel strip

Types

Measuring variable	Measuring range	Operating temperature	Resolution
FHA936WD	< 10%: No water available > 10%: Water available	0 to 60°C	Portable sensor with handle

Programming

Measuring range	Range	Resolution	Dimension	Exponent
No water <10% Water >10%	d2600	0.1%	%	3

Technical data

Measuring principle	Detection of water
Measuring values	<10% No water available >10% Water available
Housing	Plastic handle
Electrodes	Stainless steel, 3 versions, see ‚Dimensions‘
Weight	260 g
Nominal temperature	23°C ± 2°C
Operating temperature	0 to +60°C
Storage temperature	-20 to +80°C
Signal output	ALMEMO® (About 0 to 2V)
Power supply	7.5 to 15 V
Power consumption	Max. 10 mA

Dimensions

Housing: Ø 40 mm, length 130 mm

Electrodes in 3 versions:

- Stainles steel length 200 mm, diameter 3 mm, rounded
- Stainless steel length 50 mm, diameter 3 mm, sharp tip
- Spring steel strip length 200 mm, width 6 mm, thickness 0.5 mm

Use

Preparations

Replacing the electrodes

When changing the electrodes, the chuck must be held with an open-ended spanner (span 7 mm). The clamping nut can now be loosened with a second wrench (spanner width 7 mm). This prevents the chuck from twisting and damaging the handle of the probe.

When retightening the clamping nut, make sure again that the chuck does not rotate in the housing. After changing the electrode no new adjustment is necessary.

Control

Before starting the measurement, the probe should be subjected to a functional test. For this purpose the electrodes are held in a water bath. The measuring instrument should then display the value 100%. If the control value deviates roughly from the target value, the probe must be returned to the factory to renew the calibration.

Measurement

During the measurement itself, care must be taken to ensure that, depending on the application, the electrodes either rest firmly on the material to be measured or are penetrated into the material to be measured.

1. Press the electrodes of the probe onto the material.
2. Switch on the measuring instrument.
3. Read the measured value. The MAX VALUE function of the meter can be useful to record the maximum value.

If the probe is held in the air, a negative value is displayed because necessary correction values are programmed in the connector.

3.5.3 Soil moisture tensiometer

Measuring principle

Depending on the saturation state of the soil (or groundwater level), water is sucked through the ceramic (Al2O3 sintered material), which is considered to be an idealized semi-permeable membrane, by the otherwise hermetically sealed tensiometer according to the water tension prevailing in the soil.

The resulting atmospheric underpressure in the tensiometer tube is - neglecting the above mentioned potentials - minus the vertical tensiometer length equal to the water tension in the soil. This value can be displayed with a manometer or electronically processed by means of a pressure sensor.

Basics

Suction tension measurement

With the water tension measurement (suction tension) as a direct measure of the water availability of soils for plants, the sum of the water holding forces in the soil (except osmotic potential, differential pressure and gravitational potential) is measured.

Physical unit of suction tension

The suction tension physically designates a negative pressure with the unit:

1 mbar = 1 hPa = 1 cm water column

The measured negative pressure is used for the evaluation of the soil/substrate moisture and is described as a transmittable quantity for these with positive numbers.

Typical suction stress values

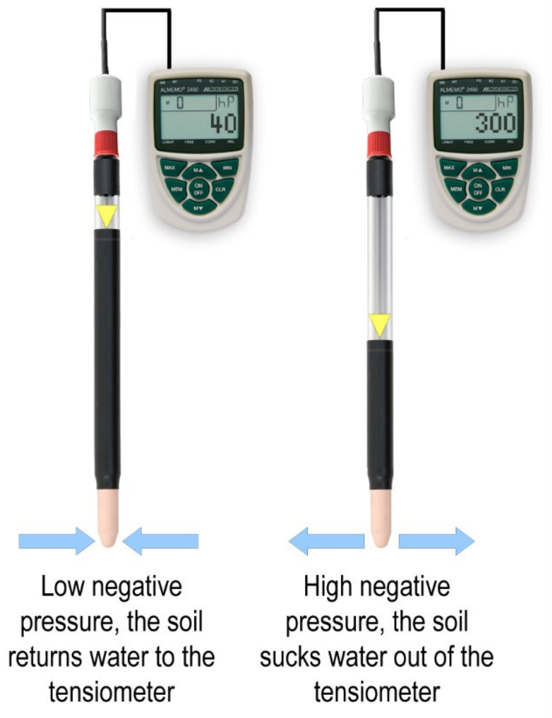


Fig. 3.5.13
Measurement with Tensiometers at low and high negative pressure in the soil

Typical suction stress values in pot substrates in hPa

30 to 40	Very moist
50 to 120	Moist
150 to 200	Dried
> 200	Dry

Typical suction stress values in outdoor soil (medium soil type)

< 50	Saturated
100 to 150	Wet to moist
> 200	Dried
200 to 500	Watering

Advantages and disadvantages of suction voltage measurement

Advantages	Disadvantages
Measurement of the direct availability of soil water for the plants on site	Punctual measurement
Measurement not directly dependent on soil conditions (measurement in coarse-grained and very loose substrates possible)	Year-round measurements only possible at frost-proof depths or with the addition of substances such as polyethylene glycol
Measurement is carried out independently of the salt content (e.g. by fertiliser salts) in the soil or plant substrate	No statement on water content in Vol % (must be determined separately for each soil type)

Application ranges

In soil physics investigations, the water balance in the soil can be continuously measured at different depths using tensiometers. In agriculture and horticulture tensiometers are used for the automation of irrigation systems. Here the water quantity can be controlled in such a way that the plants are optimally supplied with water without water and nutrients being washed out into the subsoil.

Notes on measurement

An increase of the ambient temperature causes a temporary reduction of the suction tension in the tensiometer tube, which is reduced more or less quickly depending on the porosity of the tensiometer cell. The influence of temperature is all the greater, the greater the current air volume in the tensiometer tube. For accurate measurements deaerate the tensiometer at an early stage (see 'Use' in chapter 3.5.3.1) and avoid exposing the tensiometer to direct sunlight.

For measurements with long tensiometers it is necessary to calculate the vertical water column in the tensiometer tube, as this creates additional pressure. However, as the measured value is of interest to the ceramic cell, the water column in cm must be subtracted from the displayed value.

The correction is made according to the formula:

"Suction tension at the clay body"= "Measured value in hPa"- "Height of the water column in cm"

Example for a tensiometer with 20 cm water column:

Measured value in hPa	150 hPa
Minus water column in cm	20 hPa (20 cm water column)
Actual measured value	130 hPa

3.5.3.1 Tensiometer FDA 602-TM2

Sensor characteristics

Features

The Tensiometer consists of two parts:

Lower part

The lower part consists of the Tensiometer tube and the ceramic. It is available as a plug-in or surface tensiometer.

The plug-in tensiometer is the tensiometer tube with an elongated clay cell that can be easily inserted into the soil.

The area tensiometer has a much smaller tensiometer tube and a clay base, which is suitable for measurements on thin substrate layers or surfaces.

Upper part

The lower part is screwed into an upper part, which consists of the electronics of the tensiometer (pressure sensor), a cable and an ALMEMO® connector.

The ALMEMO® connector with voltage divider and sensor supply 5 V can be used to operate the sensor with all ALMEMO® instruments that have the range 'Diff-Millivolt2 DC (± 260 mV)' (see instrument manuals). The parameters for scaling and dimension are stored in the ALMEMO® connector so that the measured value is displayed directly in hPa suction voltage.

By means of the ALMEMO® Relay Trigger Adapters ZA 8006-RTA3/4, ES 5690-RTA5 or the output modules ZA 1006-EKG/ETG or ZA 1006-GK with relay adapter ZB 2280-RA the ALMEMO® system can also be used for irrigation control (see chapter 5, ALMEMO® Output Modules).

Labelling

The labelling of a Tensiometer contains the following data:

The individual test number Txxxxxxx

The maximum suction capacity of the tensiometer cell 700-800-900 hPa

The suck-back factor as a measure for the tensiometer reaction 0.1-0.2-0.3 min

Types

Parts	Reference number		
Tensiometer electronic	**FDA602TM2**	Upper part	
Connectable tensiometer L2	**ZB9602TML2**	Lower part	
Connectable tensiometer LKV2	**ZB9602TMKV2**	Lower part	
Area tensiometer FO	**ZB9602TMFO**	Lower part	

Parts	**Reference number**		
Area tensiometer FV	**ZB9602TMFV**	Lower part	

Technical data

Tensiometer electronic		
Type	**FD A602-TM2**	
Measuring range	0 to -1000 hPa relative (negative pressure)	
Output signal	0.5 to 4.5 V / linear	
Power supply	5 V DC via ALMEMO® connector	
Mounting situation	Preferably vertical	
Temperature range	-20 to +85°C	
Protection type	IP54	
Connection cable	Sensor with fixed cable, length = 5 m with ALMEMO® connector	
Connectable tensiometer		
Type	**ZB 9602-TML2**	**ZB 9602-TMKV2**
Measuring range	0 to 900 hPa	0 to 900 hPa
Clay cell	Cylindrical with tip Ø 20 mm Length 65 mm	Cylindrical with tip Ø 15 mm Length 40 mm
Total length	About 340 mm	About 160 mm
Insertion depth	Typical 250 mm	Typical 70 mm
Area tensiometer		
Type	**ZB 9602-TMFO**	**ZB 9602-TMFV**
Measuring range	0 to 900 hPa	0 to 900 hPa
Clay foot	Ø 70 mm	Ø 70 mm
Total height	65 mm	65 mm
Insertion depth	About 30-60 mm	

Use

Preparation

Water for one day

The dry clay body must first be watered for one day. In order to allow the air to escape from all pores, it is best if the water is first drawn in on one side for a few hours, i.e. the pipe is first filled before the entire clay body is immersed in the water (overnight). Trapped air can significantly affect the tensiometer performance at the beginning.

Filling

The Tensiometer tube is filled to the brim. Clean tap water, that is not too hard, is suitable for this purpose (without added fertiliser). Distilled water is not absolutely necessary, although it prevents deposits and early algae growth. In oxygen-rich water, numerous air bubbles can form at the beginning with increasing negative pressure, but these do not indicate leakage. Boiled water offers a remedy here.

Closing and opening

Only slightly unscrew the cap!

Attention! The upper edge (sealing surface) of plastic threads can be damaged with a hard object and cause leaks - do not hit it!

Do not screw the sensor cap on too tightly! Too hard screwing damages the seals! After the first slight resistance, tighten by only about 1/4 turn! To open, first push up the cap after screwing it on, then lift the sealing grommet sideways and pull it off. Before closing the cap again, always clean the sealing surface or 0-ring and the upper edge of the threaded connection!

General plugging in

Good contact with the substrate or soil is a prerequisite for the clay body to release water properly and quickly. In addition, there must be a residual moisture, because if the substrate or soil is absolutely dry the Tensiometer function will not start working or start only with difficulty.

In potted plants and substrate layers

Clay cone must be completely covered by substrate!

If the substrate is loose, the plug-in tensiometer is inserted directly without pre-drilling, especially types with the short clay cone. If necessary, the substrate can be pressed slightly to the side of the Tensiometer to achieve a firm stand. The tensiometer tube should not be wobbled later on, so that no hollow space is created at the clay cone. For long clay cones of type L it is recommended to prick the hole thinly to avoid unnecessary stress on the cones - no lateral pressure, otherwise danger of breakage!

The insertion depth depends on the desired measuring depth. In any case, the insertion depth must be such that the clay cone is covered.

In soil cultures

Plug in as deep as possible!

To insert longer tensiometers with long clay cones, usually pre-drill a hole, for example with a drill stick (sampler), Ø 25 mm. If the ground is soft, the clay cone can be inserted the last piece directly (only press vertically, otherwise danger of breakage!), otherwise it has to be grouted, but the upper part of the borehole is only loosely filled.

The insertion depth depends on the desired measuring depth, possibly depending on the root zone. The Tensiometer should only protrude from the soil to a point where the water column can be checked. If the tensiometer tube protrudes too long, temperature fluctuations have an unfavourable effect (measuring errors, higher water consumption).

Venting

Deaerate the tensiometer regularly!

Tensiometers of the present design consume some water, because the suction tension is created by water release with low losses when sucking back, especially with increasing air volume in the tube. The larger air volume also causes a slower tensiometer reaction. Tensiometers should therefore be checked regularly and occasionally deaerated, even if the sluggish reaction rarely has a significant effect in irrigation practice. This is a recommendation:

A longer connectable tensiometer for soil measurements should be refilled at an air column of approx. 10 cm. Leakages are evident by rapid water loss after 1-2 days with a simultaneous drop in suction tension. Then first check the screw connection and threaded connection for dirt and damage before suspecting the cause at the clay cell or a glued joint.

Plug-in tensiometer KV 2 (for potted plants): Due to the short design, venting and refilling during a growing season is hardly necessary, provided that these tensiometers are used in the normal moisture range (up to approx. 120 hPa). A balance between water filling and air volume is formed.

Control

A regular check is advisable, which is done by carefully pulling out (turning) and tilting the Tensiometer. The inspection window directly under the cap indicates whether water is still present. When reinserting the Tensiometer a new position can be selected or loose substrate can be filled into the old insertion hole, so that the Tensiometer cell has better substrate contact again.

Maintenance

If the Tensiometer tube is soiled or covered with algae, it is best to clean it mechanically with a spout brush (max. Ø 20 mm). Stubborn contamination can also be removed with a one percent citric acid solution. The clay surface can be cleaned and refreshed with finest sandpaper (grain 320), but only when dry.

Attention! Greasy and oily substances or paints that penetrate the pores must be kept away from the clay surface!

When not in use, Tensiometers can be stored either dry or the clay body can be stored in distilled water for a not too short time. The latter serves to regenerate the permeability. Observations have shown that the permeability of the clay body occasionally decreases, especially in connection with intensive fertilization.

The Tensiometer can also remain in the soil during winter, but the screw cap should be opened to allow the remaining water to seep through.

Sensor protection

Attention must also be paid to the humidity at the place of use. After intensive wetting, a sensor must be able to dry off again!

Constant use in very high humidity (> 95%) is not recommended.

Immersion must be avoided at all costs, as moisture inside the housing can cause damage.

3.6 Meteorological sensors

Basics

Small glossary of important technical terms

Starting value	The wind speed at which a cup star or wind vane begins to move.
Barometer	Device for measuring atmpospheric pressure.
Atm. pressure	Pascal [Pa] = Newton per square meter [N/m^2]; 1 hPa = 1 mbar; 1 bar =10^5 Pa
Beaufort	Classification for specific wind speed ranges:

bft	m/s	bft	m/s	bft	m/s	bft	m/s	bft	m/s	bft	m/s
0	0-0.2	1	0.3-1.5	2	1.6-3.3	3	3.4-5.4	4	5.5-7.9	5	8.0-10.7
6	10.8-13.8	7	13.9-17.1	8	17.2-20.7	9	20.8-24.4	10	24.5-28.4	11	28.5-32.6
12	32.7-36.9	13	37.0-41.4	14	41.5-46.1	15	46.2-50.9	16	51.0-56.0	17	56.1-61.2

Damping ratio	Measure for the damping of wind vanes. It is the ratio of the successive damped deflection amplitudes (e.g. 3rd to 1st amplitude) in one direction.
Distance constant	It is the distance covered by the wind, which is reached when the speed has reached 63% of its final value after a sudden change in wind speed.
Gray-Code	Single-level digital code for the wind direction.
Altitude formula	Mathematical reduction of the atmospheric pressure to a reference altitude, usually sea level (QFF). Example: for every 8 m increase in altitude the pressure decreases by about 1 hPa.
Limit of detecion	The lowest value of wind speed and wind direction at which a stable measured value is obtained.
Normal pressure	The barometric standard pressure (1013.25 hPa) defined according to DIN ISO 2533, which is used as the basic value for the terms high pressure or low pressure.
QFE	The atmospheric pressure reduced to the runway of an airfield.
QFF	A term commonly used in aviation for the atmospheric pressure reduced to sea level (0 m). It also serves as a common basis for the atmospheric pressure comparison of different weather stations with different station heights and is the basis for the representation of the isobars in the weather charts.
QNH	A term commonly used in aviation for the atmospheric pressure that must be entered as an initial value for an altimeter to indicate the altitude above sea level.
Station altitude	The altitude of the measuring station where the barometer is installed above sea level.
Variation	It is the area where the wind direction has changed in the last 10 minutes (according to ICAO).
Wind speed	Common units are: 1 m/s = 3.6 km/h = 1.9455 knots
Wind direction	Indicates the direction from which the wind is coming. The indication is clockwise from north to east (90°), south (180°) and west (270°) to north (360°).
Wind distance	It is the distance covered by the wind for a certain period of time.

3.6.1 Mobile weather stations

Basics

Different sensors for measuring meteorological parameters are combined in one weather station. The following measured variables can be used to describe the weather:

- Air temperature
- Relative humidity
- Atmospheric pressure
- Precipitation
- Wind direction
- Wind speed

All sensors of weather stations are located in one housing to protect them from solar radiation and weather. Analogue and digital weather stations are in use.

Weather stations allow weather observations at a specific location. Together with other weather stations their results contribute to weather forecasts and climate research.

Application ranges

- Building automation (heating, ventilation, shading)
- Photovoltaic monitoring
- Monitoring of industrial emissions
- Civil protection (tracking of gas clouds etc.)
- Sporting events
- Agricultural experiments
- Information systems for road weather
- Smoothing alarm systems
- Vehicle test tracks

3.6.1.1 Meteorological sensor FMD 760 / FMD 770

Measuring principle

Wind

The wind measurement is carried out via 4 ultrasonic sensors (4 cardinal points). The wind speed in m/s and the wind direction in degrees are calculated from the running time differences. For winter operation the ultrasonic sensors are heated if necessary.

Precipitation

The precipitation is recorded with radar technology. A Doppler radar measures the drop speed of the individual drops (rain/snow). Based on the correlation of drop size and speed, the precipitation quantity is calculated in mm and the precipitation intensity in mm/h. The type of precipitation (rain/snow) is determined by the different fall velocity. For winter operation the precipitation sensor is heated if required.

Air temperature and relative humidity

The air temperature in °C is measured with a highly accurate NTC resistance sensor and the relative humidity in % rH with a capacitive humidity sensor.

The sensors are located in a forced-ventilated radiation shield to minimize external influences (solar radiation, etc.). Thus considerably more accurate measuring results are achieved with high radiation power. At the same time, the ventilation improves the response behaviour after condensation.

Global radiation

Global radiation is measured (only in FMD770) with an integrated pyranometer, which works with a thermopile.

Measuring values

The sensors of the meteorological transmitter continuously determine the current measured values with their internal measuring rate. In the ALMEMO® D7 connector minimum, maximum, and average values or quantities (over the output cycle of the ALMEMO® V7 device) are calculated for various measurement types.

Sensor characteristics

Features

The FMD760 mobile weather station is equipped with sensors for wind, precipitation, air temperature, humidity and atmospheric pressure.

It has a ventilated radiation protection and has a built-in heater. Mounting brackets for mast mounting are included.

The weather station has a built-in plug including sensor connection cable (length = 10 m, mounted in the connection box). Both the supplied power supply unit 24 V ZB 1024-NA2 and the ALMEMO® connection cable (length = 2 m, with ALMEMO® D7 plug) are mounted in the connection box (see below, 'Use, Preparation').

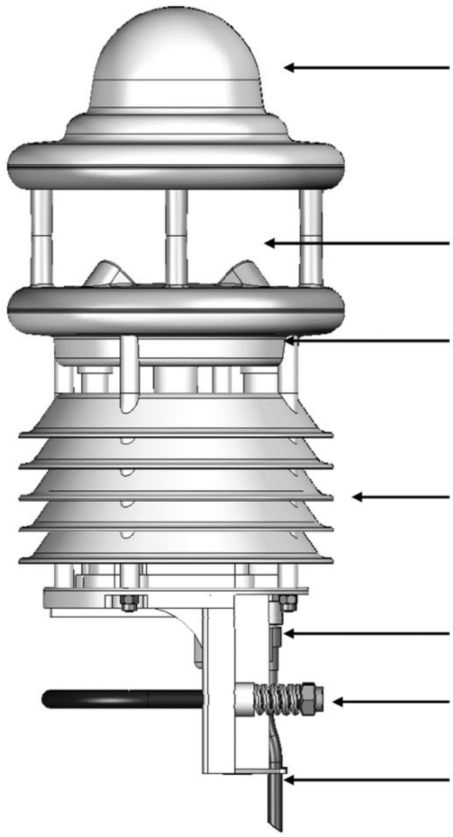


Fig. 3.6.1 Structure of the sensors of meteorological device FMD 760

Accessories

Reference number	Part	Characteristics
ZB9760ST	Mobile tripod	Telescopic up to about 4.4 m
ZB9760AK100	Sensor connection cable	Free ends, length = 100 m
ZB9760AK20	Sensor connection cable	Free ends, length = 20 m
FLA613GS	Measuring head for global radiation	Up to 1200 W/m², see chapter 3.10.5.2
FLA613VLM	Measuring head for illuminance	Up to 170 kLux, see chapter 3.10.1.3
FLA613PSM	Measuring head for quantum radiation	Up to 3000 µmol/m²s
FLA613UVA	Measuring head for UVA radiation	Up to 3 mW/cm², see chapter 3.10.2.2
FLA613UVB	Measuring head for UVB radiation	Up to 50 µW/cm², see chapter 3.10.3.2
ZB9510MH	Measuring head holder for tripod	Length about 0.5 m, for 1 radiation measuring head FLA613xxx

Types

Version/reference number	Measured variable	Measuring range	Measurement principle
Mobile weather station FMD 760 / FMD 770	Wind speed	0 to 75 m/s	Ultrasonic
	Wind direction	0 – 359.9°	Ultrasonic
	Precipitation	Drop size 0.3 to 5.0 mm	Radar sensor
	Air temperature	-50°C to +60°C	NTC
	Relative humidity	0 to 100% rH	Capacitive
	Atmospheric pressure	300 to 1200 hPa	MEMS sensor capacitive
	Global radiation (just FMD 770)	0 to 2000 W/m²	Pyranometer with thermopile
Digital sensor FMD 720	Wind speed	0 to 75 m/s	Ultrasonic
	Wind direction	0 – 359.9°	Ultrasonic

Programming

For FMD760:

Measuring ranges on delivery

Measured value	Command	Range	Exp	Measuring range	Dimension	Resolution
1. Wind direction averaged	B-02	DIGI	0	0 to +359	°	1°
2. Wind speed averaged	B-05	DIGI	0	0 to 75	m/s	0.1 m/s
3. Wind speed maximum	B-06	DIGI	0	0 to 75	m/s	0.1 m/s
4. Atmospheric pressure	B-12	DIGI	0	300 to 1200	mbar	0.1 mbar
5. Temperature at present	B-09	DIGI	0	-50 to +60	°C	0.1 K
6. Relative humidity	B-11	DIGI	0	0 to 100	% rH	0.1% rH
7. Rainfall	B-13	DIGI	0	0 to 999.99	mm	0.01 mm
8. Rain intensity	B-14	DIGI	0	0 to 200	mm/h	0.1 mm/h

Configurable measuring ranges

Measured value	Command	Range	Exp	Meas. range	Dimension	Resolution
1. Wind direction min.	B-01	DIGI	0	0 to +359	°	1°
2. * Wind direction averaged	B-02	DIGI	0	0 to +359	°	1°
3. Wind direction max.	B-03	DIGI	0	0 to +359	°	1°
4. Wind speed min.	B-04	DIGI	0	0 to 75	m/s	0.1 m/s
5. Wind speed averaged	B-05	DIGI	0	0 to 75	m/s	0.1 m/s
6. Wind speed max.	B-06	DIGI	0	0 to 75	m/s	0.1 m/s
7. Temperature min.	B-07	DIGI	0	-50 to +60	°C	0.1 K
8. Temperature averaged	B-08	DIGI	0	-50 to +60	°C	0.1 K
9. Temperature at present	B-09	DIGI	0	-50 to +60	°C	0.1 K
10.Temperature max.	B-10	DIGI	0	-50 to +60	°C	0.1 K
11. Relative humidity	B-11	DIGI	0	0 to 100	% rH	0.1% rH
12. Atmospheric pressure	B-12	DIGI	0	300 to 1200	mbar	0.1 mbar
13. Rainfall	B-13	DIGI	0	0 to 999.99	mm	0.01 mm
14. Rain intensity	B-14	DIGI	0	0 to 200	mm/h	0.1 mm/h
15. Quantity of snow/hail	B-15	DIGI	0	0 to 999.99	mm	0.01 mm
16. Intensity of snow/hail	B-16	DIGI	0	0 to 200	mm/h	0.1 mm/h
17. Wind direction abbreviation	B-17	DIGI	0	0 to +359	°	0.1°
18. Global radiation (just FMD770)	B-18	DIGI	0	0 to 2000	W/m²	0.1 W/m²

Technical data

Wind speed	
Measuring range	0 to 75 m/s
Resolution	0.1 m/s
Accuracy	±0.3 m/s or ±3% (0 to 35 m/s) ±5% (>35 m/s) RMS
Response threshold	0.3 m/s
Measuring rate	10 seconds
Wind direction	
Measuring range	0 – 359.9°
Resolution	0.1°
Accuracy	< 3° (> 1 m/s)
Response threshold	0.3 m/s
Measuring rate	10 sec
Precipitation	
Measuring range	Drop size 0.3 mm to 5.0 mm
Resolution	Liquid precipitation 0.01 mm
Type of precipitation	Rain, snow
Reproducability	Typical > 90%

Response threshold	0.002 mm
Measuring rate	Event-dependent when the response threshold is reached
Intensity of precipitation	0 to 200 mm/h; measuring rate 1 minute
Air temperature	
Measuring range	-50°C to +60°C
Resolution	0.1 K (-20°C to +50°C), otherwise 0.2 K
Sensor accuracy	±0.2 K (-20°C to +50°C), otherwise ±0.5 K (> -30°C)
Measuring rate	1 minute
Relative humidity	
Measuring range	0 to 100% rH
Resolution	0.1% rH
Accuracy	±2% rH
Measuring rate	1 minute
Atmospheric pressure	
Measuring range	300 to 1200 hPa
Resolution	0.1 hPa
Accuracy	±0.5 hPa (0 to 40°C)
Measuring rate	1 minute
Global radiation (just FMD770)	
Measuring range	0 to 2000 W/m²
Resolution	0.1 W/m²
Spectral range	300 to 1100 nm
Measuring rate	10 seconds (with energy saving mode switched on: 1 minute)
Operating conditions	
Temperature	-50 to +60°C (with heating)
Relative humidity	0 to 100% rH
Weight	About 1.5 kg (with mounting device, without sensor connection cable)
Housing	Plastics, type of protection IP66
Mounting	Pole mounting device, stainless steel, for Ø 60 to 76 mm
Sensor connection	Built-in connector
Sensor connection cable	Mounted in connection box, length see above or ‚Accessories‘
Connection box	Clamp connection for sensor connection cable and ALMEMO® connection cable, plug connection for power supply cable for heating supply, 3 cable glands
Heating	
Power supply	24 V DC
Power consumption	1.7 A (40 W) Via external mains adapter ZB1024NA2 (included in delivery), 100 to 240 V AC / 24 V DC, 4.17A With hollow connector, mounted in connection box
ALMEMO® connection cable	Mounted in connection box, length 2 m
ALMEMO® D7 connector	
Refresh rate	2 seconds for all current values, average, max., min. value and with output cycle (minimal 2 seconds, maximum 24 hours) of ALMEMO® V7 devices
Power supply with mains adapter 24 V (standard)	All functions available 24 V from the mains adapter, max. 1.8 A 12 V from the ALMEMO® device, typical 10 mA
Power supply without mains adapter 24 V (mobile operation)	Fan and heating deactivated 12 V from the ALMEMO® device, typ. 130 mA with rain radar in continuous operation Operation in energy saving mode 1: Typ. 25 mA, no rain test / no rain, typ. 130 mA for 2 s/min with rain test, typ. 130 mA, when it rains

Dimensions

Weather station, with mounting device:

Height	343 mm (FMD760), 344 mm (FMD770)
Diameter	150 mm
Connection box:	80 x 82 x 55 mm

Use

Preparation

Selection of the installation site

Wind speed measurement

- Mount the sensor at least 2 m above the ground.
- Surrounding area of the sensor free from objects

Precipitation measurement with radar

- The sensor should be positioned at least 4.5 m above the ground. If there are no moving objects in the immediate vicinity of the sensor, a lower installation height can be considered.
- Distance to roads at least 1 m
- Distance to moving objects (trees, bushes, even bridges) should be at least 5 m at the height of the sensor.
- A distance of 8 m should be maintained to other sensors that measure precipitation with radar.

Radiation measurement (global, UV or others)

While a pyranometer for measuring global radiation is integrated in the FMD770 weather station, an additional measuring head for measuring radiation can be attached to the stand (see above, 'Features, Accessories') for the FMD760 weather station.

In both cases the following must be observed for radiation measurements:

- Installation site should be free of shade. The distance of the sensor to objects casting shadows such as trees or buildings should be 10 times the difference between the mounting height of the sensor and the object height.
- If possible, 360° free view of the horizon at the height of the sensor

Mounting the weather station on the mounting pole

The mounting bracket of the weather station is made for mounting poles with tube diameters from 60 to 76 mm.

To mount the weather station on the mounting pole you need

- Fork or ring spanner SW13
- A compass to orient the wind sensor to north

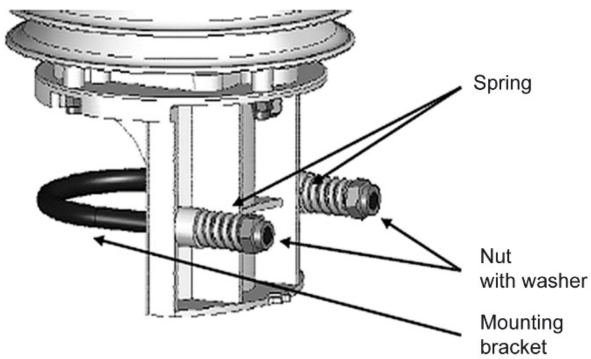


Fig. 3.6.2 Bracket at the bottom of the weather station

Installation procedure:

1. Loosen nuts.
2. Push the weather station from above onto the mast.
3. Tighten the nuts evenly until contact is made with the springs, but the sensor can still be moved easily.

4. Align the sensor to north (see figure 3.5.3).
5. Tighten the nuts by three more turns.

Orientation to the north

In order for the wind direction to be displayed correctly, the sensor must be aligned exactly north. A number of arrows are attached to the sensor for this purpose.

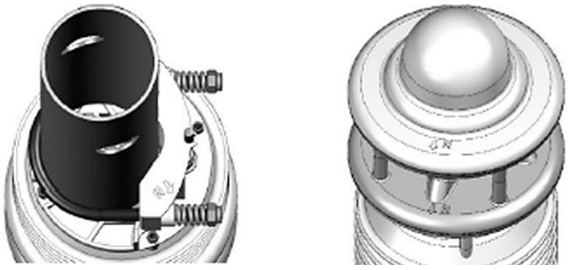


Fig. 3.6.3 Arrows on the weather station to align the sensor to north

Procedure:

1. If the weather station is already installed on the mast, loosen the nuts evenly so that the weather station can be turned.
2. Using a compass to determine where 'North' is and a corresponding reference point on the horizon.
3. The weather station must now be rotated so that the southern and northern wind sensors are aligned with this reference point on the horizon.
4. After that the nuts are screwed tight again by three rotations.

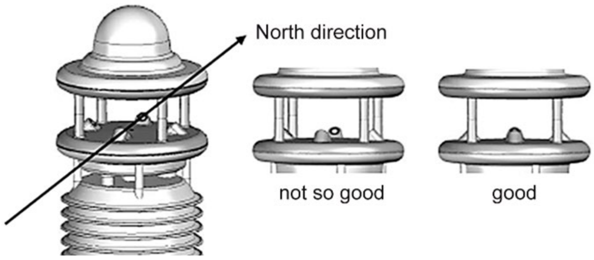


Fig. 3.6.4 Alignment of the wind sensor of the weather station in north/south direction

The compass shows the magnetic north pole. As this is not always the same as the geographic North Pole, information about the local deviation should be obtained and appropriate corrections made before mounting the wind sensor of the weather station.

If the weather station is mounted on a mast, it must be taken into account that the material of the mast will change the compass display. Aluminium masts are best suited in this respect.

Connecting the weather station to the power supply and the ALMEMO® device

The following steps must be carried out to start up the weather station. A connection overview is shown below.

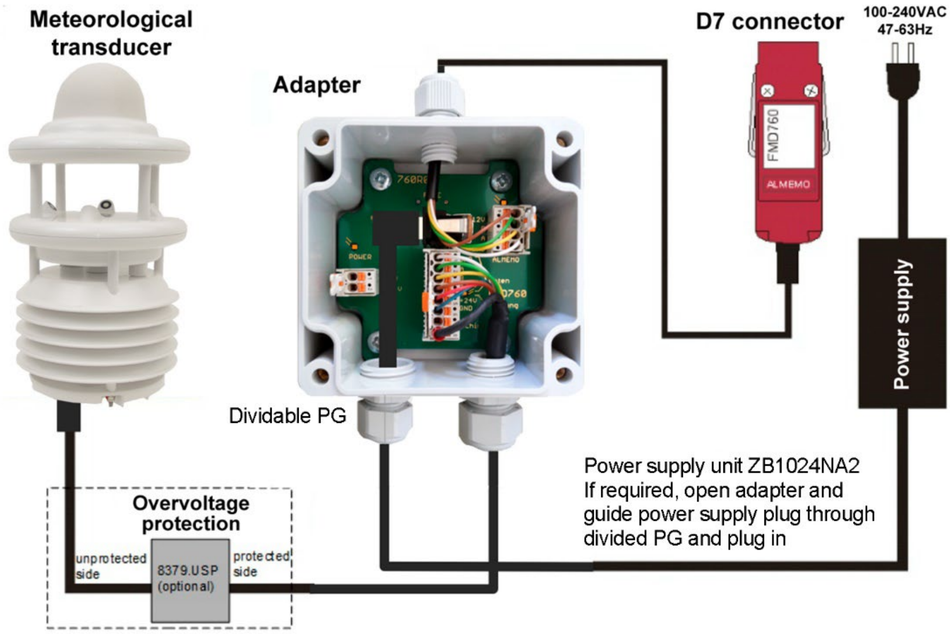


Fig. 3.6.5
Connection overview of the meteorological sensor FMD760

1. Establishing the cabling between ALMEMO® connector and sensor
2. On demand supply for heating and fan via external power supply unit (via power supply connector or WAGO terminal block)
3. Installation of surge protection (optional)
4. Plugging the ALMEMO® connector onto the measuring instrument after completion of the wiring
5. Check the signal LEDs in the adapter. The meaning of the LEDs is listed in the following table.

LED	Description
POWER	Signals the status of the external supply voltage. LED active: external supply voltage applied LED inactive: no or defective external supply
ALMEMO	Signals the status of the ALMEMO® supply voltage from the measuring device. LED active: ALMEMO® supply voltage active LED inactive: ALMEMO® supply defective
FMD760	Signals the status of the sensor supply. LED active: Sensor is supplied with 12 V or 24 V LED inactive: Sensor is not supplied with power (possible causes: Measuring instrument, power supply unit or sensor defect, fuse in the adapter blown)

Settings of the device heating

In the delivery state, the heater is configured to 'Auto'. This is the recommended operating mode of the heating system for 'Intelligent Weather Sensor Technology'. The following operating modes can be set via the sensor menu (see chapter 3.1.3.2) of the FMA760 (see also the table Operating modes/settings below).

Auto: In this operating mode, the unit is kept at a constant control temperature in order to generally prevent impairment by snow and ice.

Off: In the 'Off' operating mode, the heating is completely deactivated. Winter operation is not possible in this operating mode, as possible icing can prevent the rain sensor or wind meter from functioning properly.

Fan settings

In the delivery state, the fan is configured to 'Auto'. The following operating modes can be set via the sensor menu (see chapter 3.1.3.2) of the FMA760 (see also table Operating modes/settings below).

Auto: Automatic mode, fan is switched on cyclically.

Off: The fan can be switched off to reduce power consumption.

Note: When the fan is switched off, the heaters are also switched off (energy saving mode 1)! When the fan is switched off, the temperature and humidity measurement may vary in sunlight (see chapter 'Energy Saving Mode' below). If the Weather Station is powered directly from the measuring device, the fan is disabled regardless of the 'Auto Off' setting (see chapter 'Measuring' below).

With the 'Auto' setting, the weather station will not switch to Energy Saving mode 1.

Energy saving mode 1

Energy saving mode 1 is determined by the following measures:

- The ventilation of the temperature / humidity unit is switched off.

- All heaters are switched off.

- The radar rain sensor is not operated continuously; per minute the sensor is only activated for one second; if precipitation is then detected, it remains activated until the end of the event; otherwise it is deactivated again after the one second.

- The compass measurement is performed only once after power-up. For this measurement the fan, which is otherwise deactivated, is switched on for a short time.

This operating mode has the following limitations:

- When the fan is switched off, the temperature and humidity measurement may be different in sunlight.

- In this operating mode, only limited winter operation is possible, as possible icing can prevent the rain sensor or wind meter from functioning properly.

- The rain detection can be delayed up to 2 minutes. Short events may not be detected. As a result, deviations in the accuracy of the precipitation quantity are also possible.

	Power supply	Heating	Fan	Rain radar
24/1	24 V via mains adapter **State on delivery**	Adjustment: AUTO Function: Heating active	Adjustment: AUTO Function: Fan active	Function: Permanent operation
24/2	24 V via mains adapter	Adjustment: OFF Function: Heating deactivated	Adjustment: AUTO Function: Fan active	Function: Permanent operation
24/3	24 V via mains adapter	Adjustment: OFF* Function: Heating deactivated (Energy saving mode 1)	Adjustment: OFF* Function: Fan deactivated (Energy saving mode 1)	Function: Rain test Every minute, continuously active after rain detection (Energy saving mode 1)
12/1	<12 V via ALMEMO® device, consumption: 130 mA	Adjustment: AUTO Function: Heating deactivated (because no 24 V supply)	Adjustment: AUTO Function: Fan deactivated (because power supply < 12 V)	Function: Permanent operation
12/2	<12 V via ALMEMO® device, consumption: 130 mA	Adjustment: OFF Function: Heating deactivated	Adjustment: AUTO Function: Fan deactivated (because power supply < 12 V)	Function: Permanent operation
12/3	<12 V via ALMEMO® device, consumption: 25 mA: no rain test/no rain 130 mA: 2 s/min. by rain test 130 mA: permanent by rain test	Adjustment: OFF* Function: Heating deactivated (Energy saving mode 1)	Adjustment: OFF* Function: Fan deactivated (Energy saving mode 1)	Function: Rain test Every minute, permanent active when rain detection (Energy saving mode 1)

*The adjustment Heating AUTO is automatically set to Heating OFF when the fan is turned OFF.

Note: The status of the sensor heating is not stored in the ALMEMO® connector. If the weather sensor is not connected, the status "OFF" is always signaled. After connecting the sensor, the value stored in the sensor is read out and displayed.

Increase measuring accuracy

Wind speed measurement

Buildings, bridges, embankments and trees can influence the wind measurements. Even traffic on roads can falsify the measurement by sudden gusts of wind.

Precipitation measurement

Falling or moving objects, e.g. falling leaves or leaves swirling in the wind, can cause false readings and/or precipitation types to be measured.

The accuracy of the precipitation measurement can be affected by strong winds. The weather station should not be installed in places where air turbulence is expected, such as buildings.

The weather station must not be operated near other devices that also operate at 24 GHz. These could be, for example, sensors for traffic counting, which are mounted on gantries.

Measurement

The wind speed is indicated from 0 m/s. The response threshold is 0.3 m/s. At wind speeds below 0.5 m/s, no measured values for the wind direction are indicated.

With the aid of the function channels Xmax, Xmin, Xavg and the sensor-internal cycle of 2 sec. the corresponding max., min. and average values of the individual variables are continuously calculated. To query these values, a desired output cycle (2s to 24h) must be programmed in the device.

To save energy, the humidity fan can be switched off in the sensor menu and thus the weather station on the ALMEMO® device can be operated with 12V in energy saving mode 1 (approx. 25mA). The rain radar is then only tested every minute and the fan is switched off (see chapter 'Energy Saving Mode 1' above). With a connected 24V power supply and set Auto mode the heating, fan and radar are switched on automatically when required. The sensor supply voltage is displayed for control purposes.

If the meteo multi sensor is operated without external supply voltage, i.e. with an operating voltage below 12 V DC, the fan will not be switched on, regardless of the setting of the fan operating mode. This can affect the accuracy of the temperature and humidity measurement when exposed to sunlight.

It is not possible to operate the FMD760 weather station in the sleep mode of ALMEMO® devices.

Sensor protection

The operational safety and function can no longer be guaranteed in the event of modifications or conversions.

Maintenance

The weather station is basically maintenance-free.

However, an annual basic inspection of the weather station is recommended:

- Removal of visible soiling
- Checking the sensors by measured value enquiry
- Check the function of the fan (running noise present?)

We also recommend an annual check of the humidity sensor inside the housing by the manufacturer. The humidity sensor cannot be replaced by the customer.

If a radiation sensor is used with the weather station, care must be taken that its dome is cleaned at appropriate intervals.

3.6.2 Atmospheric pressure sensors

Measuring principle

In the atmospheric pressure sensors there is a chamber which is sealed with a membrane. The outer side of the membrane is in contact with the atmosphere, i.e. the atmospheric pressure is on the outside of the membrane. Depending on the level of the atmospheric pressure, the membrane is stretched more or less.

Electrical resistances are vapour-deposited on the diaphragm, which change their resistance when stretched. The voltage that falls across these resistors is related to the atmospheric pressure.

Basics

Barometer and weather are generally perceived as closely related. Thus, the accurate measurement of atmospheric pressure plays a decisive role in weather forecasting and aviation, which uses it as a measure of altitude.

Physical units

1 mbar = 10^2 N/m² = 10^2 Pa = 1 hPa = 10^3 dyn/cm² = 10.2 Kp/m²

N = Newton
Pa = Pascal
hPa = Hectopascal

The following relationship applies between the previously frequently used units Torr and mm mercury:

1 mbar = 0.750 Torr = 0.7500 mm Hg

Selection, product overview

Reference number	Measuring range	Accuracy	Features
FDAD12SA	300 to 1100 mbar	± 2.5 mbar	Without pressure connection piece
FDA612SA	700 to 1050 mbar	± 0.5% of final value	With pressure connection piece

Notes on measurement

Due to their compact design, the atmospheric pressure measuring connectors can be plugged directly onto the measuring instruments.

3.6.2.1 Digital sensor FDAD 12-SA for atmospheric pressure

Sensor characteristics

Features

Fig. 3.6.6 Digital atmosp. pressure sensor FDAD 12 SA

The atmospheric pressure sensor is based on a digital fully calibrated and temperature compensated absolute pressure sensor.

For this atmospheric pressure sensor, a pressure sensor element was installed in an ALMEMO® D6 connector, so that it can be plugged directly onto the measuring instrument as a compact sensor. As pressure sensor for barometric pressure a pressure connection piece was omitted.

Programming

The measured value "atmospheric pressure" can be used to compensate other sensors on the ALMEMO® device (programming comment: *P).

Measuring ranges on delivery

Measured value	Command	Range	Exp	Measuring range	Dim	Resolution
1. Atmosp. pressure AP, p	B-01	DIGI	-1	300 to 1100	mb	0.1 mb

Configurable measuring ranges

The measuring ranges of the measuring channels can be configured from a list of 2 ranges (see table below).

D6 connectors provide 4 channels. If necessary, atmospheric pressure and temperature can be reconfigured on two channels and additionally on the 2 remaining channels the same ranges can be reconfigured to display the measured values e.g. in other dimensions.

Measured value	Command	Range	Exp	Measuring range	Dim	Resolution
1. Atmospheric pressure AP, p	B-01	DIGI	-1	300 to 1100	mb	0.1 mb
2. Temperature T, t	B-02	DIGI	-1	-10.0 to +60.0	°C	0.1 K

The atmospheric pressure measured by the probe is displayed in the sensor menu. It can be used to compensate other sensors on the ALMEMO® instrument by clicking on 'Reference' below this display.

Technical data

Sensor type	Digital atmospheric pressure sensor (integrated in ALMEMO® D6 connector)
Measuring range	300 to 1100 mbar
Accuracy	±2.5 mbar (in the range from 700 to 1100 mbar at 23°C ± 5 K)
Range of operation	-10.0 to +60.0°C 10 to 90% rH non-condensing

ALMEMO® D6	
connector	1 second for all channels
Refresh rate	6 to 13 V DC
Power supply	4 mA
Power consumption	

Dimensions

62 x 20 x 7.6 mm

Measurement

A measurement in the sleep mode of the device is possible with this sensor. However, a sleep delay of 1 s is necessary for an extension.

3.6.2.2 Measuring connector for atmospheric pressure FDA 612-SA

Sensor characteristics

Fig. 3.6.7 Atmospheric pressure connector FDA 612 SA

Features

For this atmospheric pressure sensor, a pressure sensor element was installed in an ALMEMO® connector, so that it can be plugged directly onto the measuring instrument as a compact sensor. It is equipped with a pressure connection piece.

Programming

Measured value	Measuring range	Resolution	Dim	Programmable range	Factor	Exp.
Atmospheric pressure	700 to 1050 mbar	0.1	mb	D2.6	-1.0000	3

Technical data:

Measuring range	700 to 1050 mbar (total range from 0 to 1050 mbar)
Overload capacity	Maximum 1.5 times of final value
Accuracy	±0.5% of final value
Nominal temperature	25°C
Temperature drift	< ±1% of final value at 0 to 70°C
Tube connections	Ø 5 mm, 12 mm long
Sensor material	Aluminium, nylon, silicone, silicone gel, brass
Range of operation	–10 to +60°C, 10 to 90% rH non-condensing

Dimensions

Length: 90 mm, width: 20 mm, height: 7.6 mm

3.6.3 Wind speed sensors

3.6.3.1 Wind speed sensor FVA 615 2

Measuring principle

Fig. 3.6.8 Wind speed sensor FVA 615 2

A whole range of different methods is available for measuring wind speed. In meteorological practice, the rotating cup cross anemometer is mainly used.

It consists of a three- or four-pointed star (shell cross), which can rotate around a vertical axis. At each point of the star there is a hemisphere. These are arranged so that the wind always hits a concave and a convex hemisphere at the same time. The concave surface opposes the wind with a considerably higher flow resistance than the convex one.

The wind therefore exerts a greater force on the points with the concave hemisphere than on those with the convex one. The result is that the star begins to rotate and the stronger the wind, the faster it rotates. The great advantage of this measuring principle is that it works independently of the wind direction.

The wind sensor is used to record the horizontal wind speed. The measured values are output as electrical analog current or voltage signals, e.g. for controlling wind turbines.

Basics

The following units of measurement are commonly used to indicate wind speed:

Meters per second (m/s),

kilometers per hour (km/h) or

knots, where one knot corresponds to one nautical mile per hour.

The following conversions apply between the units:

1 m/s	= 3.6 km/h	= 1.9 knots
1 km/h	= 0.54 knots	= 0.28 m/s
1 knots	= 0.52 m/s	= 1.86 km/h

Table Beaufort scale

m/s	km/h	Wind force	Wind designation
0.3 to 1.5	1 to 5	1	Soft breeze
1.6 to 3.3	6 to 11	2	Gentle breeze
3.4 to 5.4	12 to 19	3	Weak breeze
5.5 to 7.9	20 to 28	4	Moderate breeze
8.0 to 10.7	29 to 38	5	Fresh breeze

m/s	km/h	Wind force	Wind designation
10.8 to 13.8	39 to 49	6	Strong breeze
13.9 to 17.1	50 to 61	7	Stiff wind
17.2 to 20.7	62 to 74	8	Stormy wind
20.8 to 24.4	75 to 88	9	Storm
24.5 to 28.4	89 to 102	10	Heavy storm
28.5 to 32.6	103 to 117	11	Violant storm
More than 32.7	More than 118	12	Hurricane

Sensor characteristics

Features

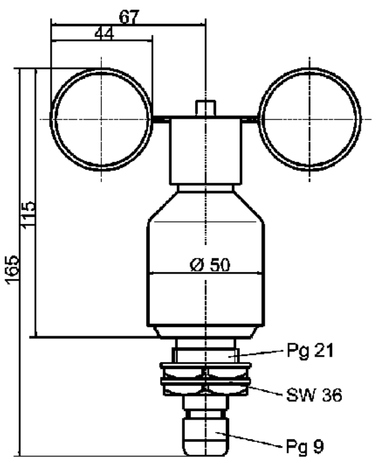
For winter operation, all units are equipped with an electronically controlled heater to prevent freezing of the ball bearings and the outer rotating parts.

Technical data

Measuring range	0.5 to 50 m/s
Measuring accuracy	± 0.5 m/s ± 3% of meas. value
Resolution	< 0.1 m/s
Measuring principle	Opto-electronic (slotted disc)
Operating voltage	9 - 30 V DC or 24 V AC / DC
for 0 - 10 V output	13 - 30 V DC
Heating	24 V AC / DC max. 20 W
Ambient temperature	-30 to +70°C
Cable	Length 12 m LiYCY 6 x 0.25 mm^2
Mounting	E.g. mast tube with mounting thread Pg21/bore Ø 29 mm
Weight	0.75 kg

Dimensions

Specified in mm



Use

Preparation

Selection of installation place

In general, wind measuring instruments are intended to record the wind conditions of a wide radius. In order to obtain comparable values when determining the ground wind, measurements should be taken at a height of 10 meters above level, undisturbed terrain.

Undisturbed terrain means that the distance between wind meter and obstacle should be at least ten times the height of the obstacle (see VDI 3786). If this regulation cannot be complied with, the anemometer should be installed at a height at which the measured values are not influenced by local obstacles (approx. 6-10 m above the level of the obstacle).

On flat roofs, the anemometer should be placed in the middle of the roof instead of at its edge to avoid any preferential directions.

Wiring diagram

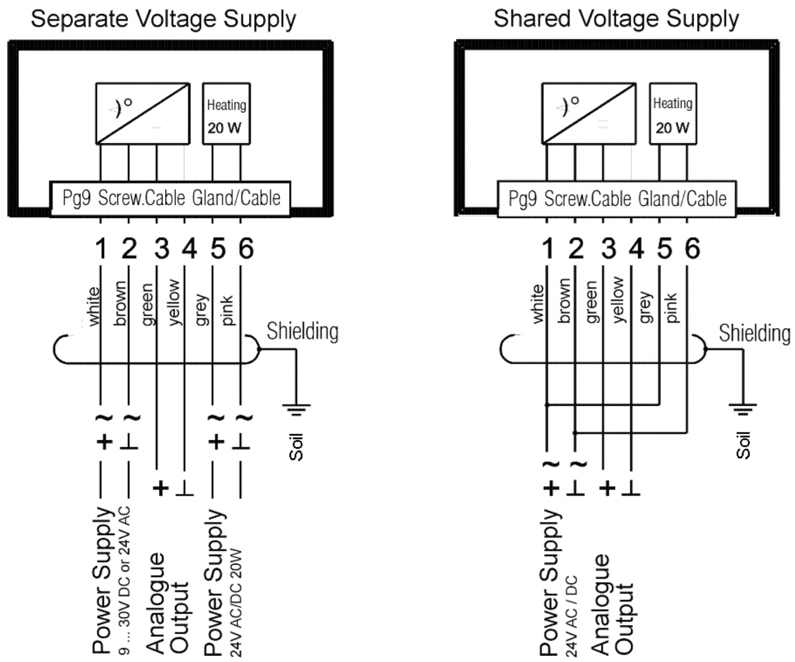


Fig. 3.6.9 Pin assignment

Mounting

It can be mounted, for example, on a central mast tube with a PG 21 holding thread or on brackets or similar with a bore of Ø 29 mm. Attention must be paid to obstacles which distort the air flow and influence the measured value.

The flexible control cable LiYCY is led through the bore and the wind sensor is fixed with the hexagon nut (SW 36). The electrical connection is made according to the connection diagram above.

Heating

The heating of the wind sensor (see chapter 'Features') must be supplied electrically via an external power supply unit (not included in the scope of delivery of the FVA 615 2).

Increase measuring accuracy

When using mounting adapters (angle, traverse, etc.), the possible influence of turbulence must be taken into account.

Measurement

Due to the unavoidable friction in the bearings, the wind speed sensor only starts up at a certain minimum wind speed and has a certain inertia. In the event of a sudden gust of wind, the shell cross needs a short acceleration time until it has reached the rotation speed corresponding to the gust. On the other hand, it continues to run for a while after the gust has died down.

This leads to a smoothing of the wind registration: speed peaks are ground down. Since the shell cross adapts faster with increasing wind speed than with decreasing wind speed, the displayed mean value is then higher than the actual.

Sensor protection

Storage, installation and operation under weather conditions is only permitted in vertical position, otherwise water can penetrate into the device.

Maintenance

When installed correctly, the device operates maintenance-free.

The slot between the rotating and stationary parts can be clogged by driven dust or dirt. It must always be kept clean.

3.6.4 Wind direction sensors

3.6.4.1 Wind direction sensor FVA 614

Basics

The wind direction is indicated either by the direction of the heavens or by a 360-, sometimes also 36-part scale.

In meteorological data acquisition, the wind vane is mainly used to determine the wind direction. The measured values are output as electrical analog current or voltage signals, e.g. for the control of wind turbines.

Fig. 3.6.10 Wind direction sensor FVA 614

Sensor characteristics

Features

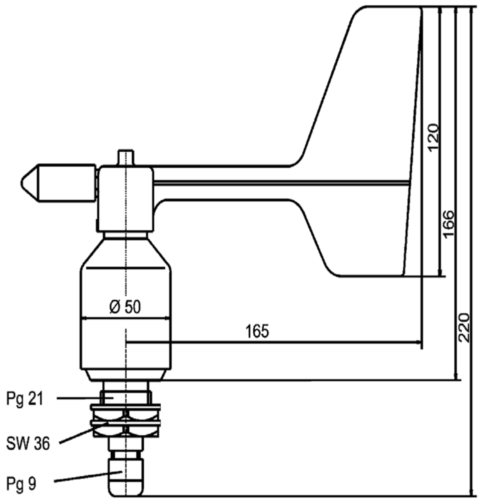
For winter operation, all units are equipped with an electronically controlled heater to prevent freezing of the ball bearings and the outer rotating parts.

Technical data

Measuring range	0 to 360°
Measuring accuracy	± 5°
Resolution	11.25° (5-Bit-Gray-Code)
Measuring principle	Opto-electronic
Operating voltage	9 - 30 V DC or 24 V AC / DC
for 0 - 10 V output	13 - 30 V DC
Heating	24 V AC / DC max. 20 W
Ambient temperature	-30 to +70°C
Cable	Length 12 m LiYCY 6 x 0.25 mm^2
Mounting	E.g. mast tube with mounting thread Pg21 or bore Ø 29 mm
Weight	1.10 kg

Dimensions

Specified in mm



Use

Preparation

Selection of installation place

In general, wind measuring instruments are intended to record the wind conditions of a wide radius. In order to obtain comparable values when determining the ground wind, measurements should be taken at a height of 10 meters above level, undisturbed terrain. Undisturbed terrain means that the distance between wind meter and obstacle should be at least ten times the height of the obstacle (see VDI 3786).

If this regulation cannot be complied with, the anemometer should be set up at a height at which the measured values are as unaffected as possible by local obstacles (approx. 6-10 m above the level of the obstacle). On flat roofs, the anemometer should be placed in the middle of the roof instead of at its edge to avoid any preferential directions.

When using mounting adapters (angle, crossbar, etc.), please note the possible influence of turbulence.

Mounting

Mounting can be carried out e.g. on a central mast tube with a PG 21 mounting thread or on brackets or similar with a bore of Ø 29 mm (e.g. traverse compact, article number ZB 9015TC)

The flexible control cable LiYCY is led through the hole and the wind direction transmitter is fixed with the hexagon nut (SW 36) after the north alignment. The electrical connection is carried out according to the connection diagram (see chapter wind speed sensor) analogous to the wind speed sensor.

Heating

The heating of the wind sensor (see chapter 'Features') must be supplied electrically via an external power supply unit (not included in the scope of delivery of the FVA 614), for connection diagrams see chapter 3.6.3.1, 'Use‘.

North alignment

The housing markings on the shaft and on the protective cap are turned over each other so that they are congruent. Then a prominent point of the landscape (tree, building, etc.) in north direction is determined with the help of a compass. The wind vane is used to find this point and the compass is screwed on when the sensors match (the north marking must point to the north).

Sensor protection

Storage, installation and operation under weather conditions is only permitted in vertical position, otherwise water can penetrate into the device.

Maintenance

When installed correctly, the device operates maintenance-free.

The slot between the rotating and stationary parts can be clogged by driven dust or dirt. It must always be kept clean.

3.6.5 Optical sensors

Selection, product overview

Reference number	Measured value	Measuring range	Spectral sensitivity
FLA 628 S	Global radiation pyranometer	0 to 1500 W/m^2	300 nm to 3000 nm
FLA 613 GS	Global radiation sensor	0 to ca. 1200 W/m^2	400 nm to 1100 nm
FLA 613 VLM	Light intensity sensor	0 to 170 kLux	360 nm to 760 nm
FLA 613 UVA	UVA sensor	0 to about 3 mW/cm^2	310 nm to 400 nm
FLA 613 UVB	UVB sensor	0 to about 50 µW/cm^2	265 nm to 315 nm

While global radiation pyranometer FLA 628 S is described here (see below, chapter 3.6.5.1), the other four optical probes for outdoor use are documented under 'Probes for measuring optical quantities' (see chapter 3.10).

3.6.5.1 Global radiation pyranometer FLA 628 S

Measuring principle

The radiation intensity (radiation current density) is measured indirectly via the difference temperature between white and black surfaces. This avoids any influence of the ambient temperature.

In star pyranometers, 12 circularly arranged copper plates, alternately painted black and white, serve as radiation-sensitive surfaces. During irradiation the black surfaces heat up more than the white ones. This temperature difference is measured with a thermopile attached to the bottom of the surfaces.

Measurement of the sky radiation component

Pyranometers initially only measure short-wave radiation because the covers are opaque for the long-wave spectral range. With the help of special designs, the sky radiation component alone can also be measured. For this purpose, a shadow band is mounted over the sensor in such a way that direct solar radiation is kept away from the measuring element. The seasonal variation of the sun's height is taken into account by adjusting the height using a scale.

Determination of the intensity of solar radiation

Using a shaded and a free pyranometer side by side, the intensity of the solar radiation can be calculated from the difference of their measured values.

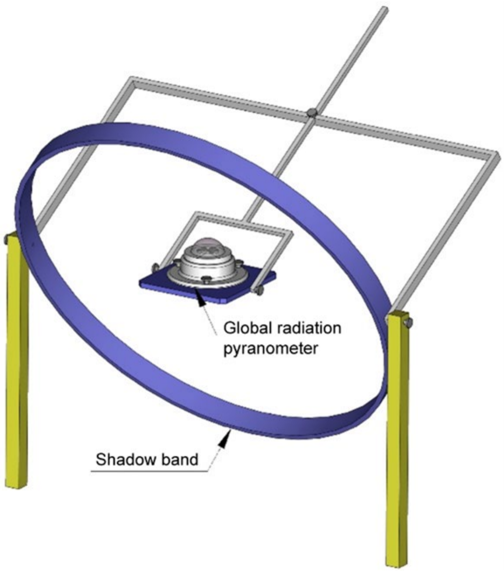


Fig. 3.6.11 Global radiation pyranometer with shadow band

Measurement of the short-wave radiation balance

A pair of pyranometers, one pointing upwards and the other downwards, allows the determination of the short-wave radiation balance, because what the lower receiver surface picks up is nothing more than the reflected radiation of the ground. From this, the albedo (reflectivity) of the ground surface can be calculated.

Basics

Global radiation is the radiation in the wavelength range of the solar spectrum from 0.3 - 3 µm falling from the upper half space onto a horizontal surface. It is the sum of direct solar and diffuse sky radiation and is given in watts per m² (W/m²).

Sensor characteristics

Features

The ALMEMO® sensor program includes the star pyranometer according to Dirmhirn FL A628-S for the measurement of global radiation, sky radiation and short-wave reflected radiation. Environmental influences are shielded from the sensor surfaces by a ground precision glass dome.

Fig. 3.6.12 Global Radiation Pyranometer FLA 628 S

Programming

Measured value	Measuring range	Resolution	Dim	Range	Factor	Exp.
Global radiation	0 - 1500 W/m^2	0.1	Wm	d26	-	2

Technical data

Measuring range	0 to 1500 W/m^2, resolution 0.1 W/m^2
Spectral range	0.3 to 3 µm
Output	About 15 µV/Wm^2
Impedance	About 35 Ω
Operating range	–40 to +60°C
Cosine effect	< 3% of meas. value from 0 to 80° slope
Slope Azimuth effect	< 3% of meas. value
Temperature influence	< 1% of meas. value from –20 to +40°C
Accuracy	Cosine effect + Azimuth effect + temperature influence
Nominal temperature	22°C ± 2 K
Linearity	< 0.5% in the range 0.5 to 1330 W/m^2
Stability	< 1% of the measuring range per year for case-by-case use
Setting time	25 s (T_{95})
Weight	1 kg
Cable length	3 m with ALMEMO® connector and programmed calibration value

Dimensions

Housing:	160 mm Ø, 75 mm high
Bolt circle:	134 mm Ø
Bearings:	8 mm Ø

Use

Increase measuring accuracy

Each instrument is supplied with a calibration certificate. The calibration values are stored and locked as correction values in the ALMEMO® connector plug. They must not be changed.

Pyranometers in continuous operation should be calibrated quarterly, but at least every six months.

If star pyranometers are in continuous use, the glass dome should be wiped clean and dry at least once a day. The levelling should be checked daily if possible. This can be easily done with 3 set screws and a built-in level indicator.

When measuring during the winter months, a ventilation and heating of the instrument is advisable to avoid fogging of the glass by precipitation. Ice coating must be removed very carefully, possibly with the help of de-icing spray.

At the bottom of the star pyranometer there is the unscrewable drying container to avoid condensation effects, which contains silica gel as dry substance. This should always be red and should be replaced or regenerated every 2 weeks (heat up to approx. 80°C).

The receiver surfaces must always be black and white. In case of damage or irregularities on the receiver surfaces, an inspection in our factory is inevitable. Scratching of the receiver surfaces and the glass dome must be avoided at all costs.

3.6.6 Combined meteorological sensors

3.6.6.1 Digital sensor for humidity, temperature, atmospheric pressure FHAD 46-C4AG in weather protection housing

Measuring principle

In capacitive humidity sensors, a moisture-sensitive polymer layer is applied between two electrodes on a substrate. By absorbing water vapor according to the relative humidity, the dielectric constant changes and thus the capacity of the thin-film capacitor. The measurement signal is directly proportional to the relative humidity.

In order to determine other humidity variables such as absolute humidity, mixture, vapour pressure and enthalpy from the relative humidity measured in this way, temperature and ambient pressure (gas pressure) are also required, which are therefore measured in the sensors simultaneously with the relative humidity.

In the ALMEMO® connectors of the digital sensors (D6), the formulas according to Dr. Sonntag are used for the determination of the calculated variables, taking into account the enhancement factor according to W. Bögel (correction factor $f_w(t,p)$ for real mixed gas systems).

Fig. 3.6.13 FHAD 46-C4AG

Sensor characteristics

Features

The sensor operates with a miniature multisensor module (see subchapter 'Features' in chapter 3.4.1.1).

Cable lengths

Cable lengths are possible in gradations up to 100 m (5 m, 10 m, 20 m, 40 m, 100 m).

Programming

Measuring ranges on delivery

Measured value	Command	Range	Exp	Meas. range	Dim	Resolution
1. Temperature T, t	B-01	DIGI	-2	-20 to +80⁺	°C	0.01 K
2. Rel. humidity RH, U_w	B-02	DIGI	-1	5 to 98	%H	0.1% rH
3. Dew point DT, t_d	B-03	DIGI	-1		°C	0.1 K
4. Atmosp. pressure AP, p	B-08	DIGI	-1	700 to 1100	mb	0.1 mb

⁺ Measuring range depending on sensor type (see 'Technical data')

The FHAD46Cxx humidity sensors are delivered with the measuring ranges shown above. This programming can be changed, i.e. instead of the dew point in channel 3 the absolute humidity can be displayed.

The programming of the sensor on V6 and V7 devices and the cable ZA1919AKUV is described in the subchapter 'Programming' in chapter 3.4.1.1.

Configurable measuring ranges

The measuring ranges of the 4 measuring channels can be configured from a list of 8 ranges (*delivery status):

Measured value	Command	Range	Exp	Meas. range	Dim	Resolution
1. Temperature T, t	B-01	DIGI	-2	-20 to +80+	°C	0.01 K
2. Rel. humidity RH, U_w	B-02	DIGI	-1	5 to 98	%H	0.1 % rH
3. Dew point DT, t_d	B-03	DIGI	-1		°C	0.1 K
4. Mixture MH, r with LK	B-04	DIGI	-1		gk	0.1 g/kg
5. Abs. humidity AH, d_v	B-05	DIGI	-1		gm	0.1 g/m^3
6. Vapour pressure VP, e	B-06	DIGI	-1		mb	0.1 mb
7. Enthalpy En, h with LK	B-07	DIGI	-1		kJ	0.1 kJ/kg
8. Atmosp. pressure AP, p	B-08	DIGI	-1	700 to 1100	mb	0.1 mb

+ Measuring range depending on sensor type (see data sheet)

In addition to the area, a two-digit dimension and a comment are automatically programmed, consisting of the previously used abbreviations of the tables of the German Weather Service and the newer formula symbols according to VDI/VDE 3514.

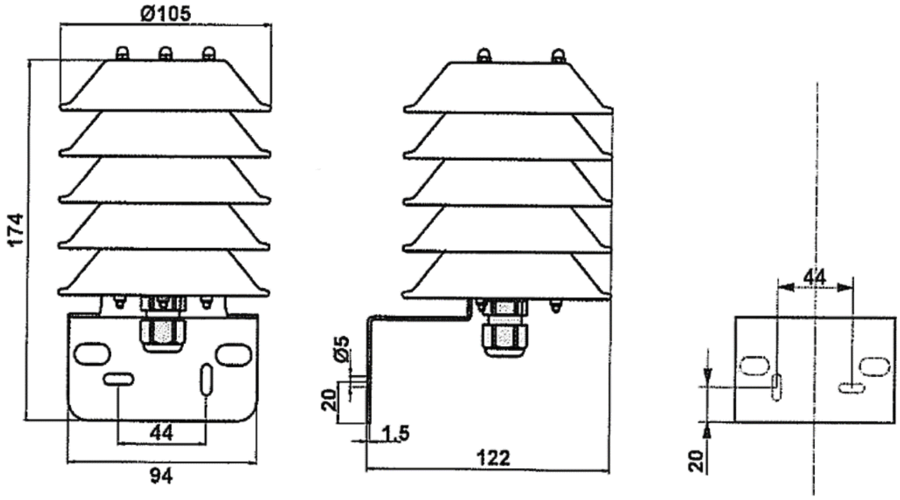
Technical data

Operating range	-30 to +60°C / 5 to 98% rH
Sensor type	Digital humidity/temperature sensor (incl. AD converter)
Humidity	
Measuring range	5 to 98% rH
Sensor	CMOSens® technology
Accuracy	±2.0% rH in the range of 10 to 90% rH ±4.0% rH in the range of 5 to 98% rH at nominal temperature
Hystereses	Typ. ±1% rH
Nominal temperature	23 °C ± 5K
Sensor operating pressure	Atmospheric pressure
Temperature	
Sensor	CMOSens® technology
Accuracy	Typ. ±0.2 K at 5 to 60°C Max. ±0.4 K at 5 to 60°C Max. ±0.7 K at -20 to 80°C
Reproducability	Typ. ±0.1 K
Digital Atmospheric Pressure (on multi sensor module)	
Measuring range	700 to 1100 mbar
Accuracy	±2.5 mbar (at 23°C ± 5 K)
ALMEMO® connection cable	PVC, lengths 5 m, 10 m, 20 m, 40 m, 100 m with ALMEMO® connector
ALMEMO® connector	
Refresh time	1 sec. for all 4 channels
Power supply	6 to 13 V DC
Power consumption	12 mA
Mechanical version	
Sensor tube	Plastic, diameter 12 mm

Filter cap	PTFE – sintered filter SK6
Weather protection	Ø 105 mm, height ca. 110 mm
Terminal box	51 x 53 x 36 mm
Compression fitting	Splash proof

Dimensions

Specified in mm



Use

Preparation

Mounting

The sensor cable is connected via screw terminals, so it can be removed and reattached for mounting.

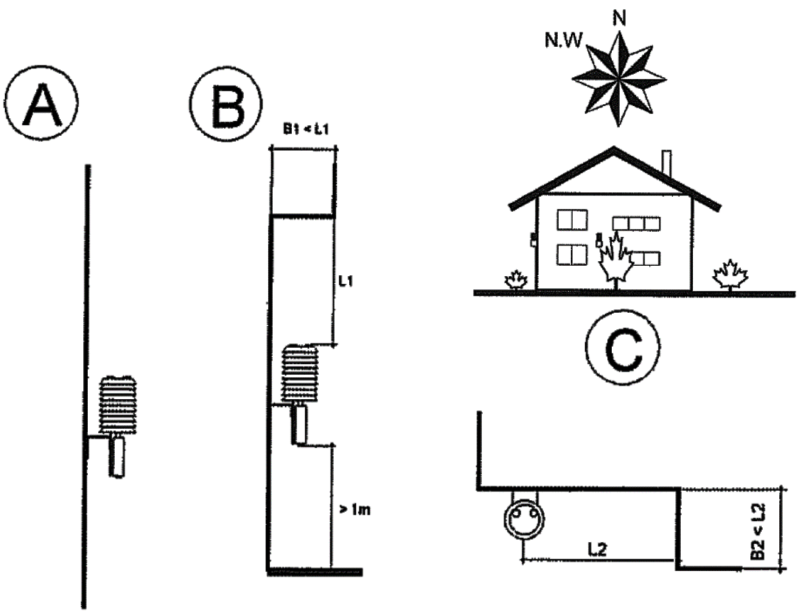


Fig. 3.6.14 Mounting

Unfavourable mounting places:

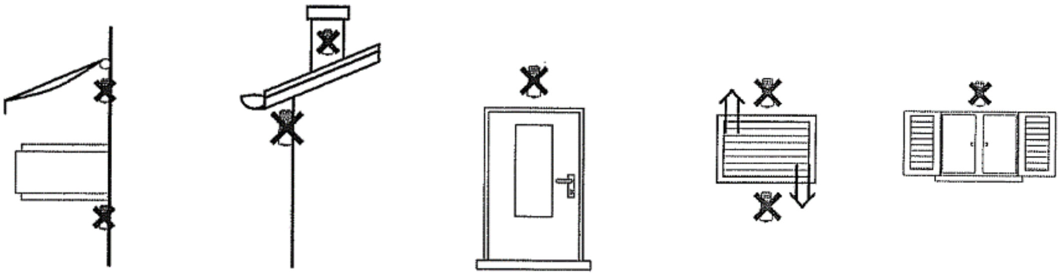


Fig. 3.6.15 Unfavourable mounting places

Wall and mast mounting

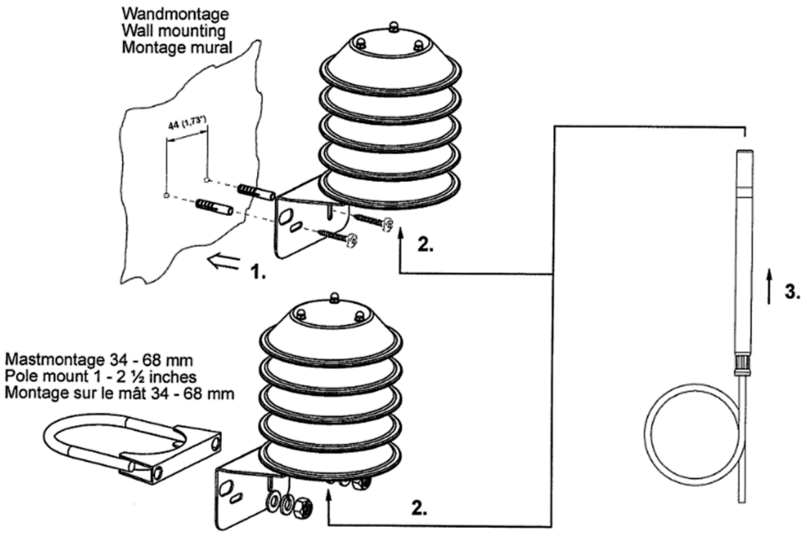


Fig. 3.6.16
Wall and mast mounting

3.7 Airflow sensors

Selection, field of operation

In the ALMEMO® sensor program thermoanemometer sensors, pitot tubes and vane anemometers are available for the measurement of flow velocities.

The application range of the flow velocity and the operating temperature are important selection criteria before purchasing an airflow sensor:

Sensor	Flow velocity	Operating temperature
Thermoanemometer	0.1 to 20 m/s	to 50°C
Vane anemometer	0.2 to 40 m/s	to 140°C
Pitot tubes	ca. 7 to 90 m/s	to 600°C

The following properties of the different sensor types further limit the selection:

Thermoanemometer Measurements of very low air flows (e.g. draught measurement) are possible. With certain thermoanemometers, directional measurements can be carried out. Thermoanemometers should only be used in pure air and should be handled with great care.

Vane anemometer Has high accuracy at medium flow velocities and medium ambient temperatures, insensitive to turbulent flows.

Pitot tubes Suitable for high flow speeds and rough operating conditions, high ambient temperatures possible, easy to clean.

Notes on measurement

General information on the installation of flow sensors

The accurate and reliable determination of the air velocity depends on the correct positioning of the sensor.

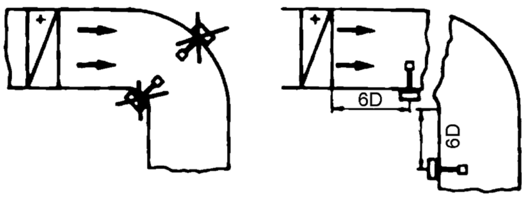
Accurate measurements are only possible if the sensors are positioned far enough away from places with turbulent flow. Turbulent flows occur after pipe bends, branches, behind dampers, fans or cross-sectional changes.

The calming distance is a function of the pipe diameter D.

The following applies to rectangular pipes: $D = \frac{2\,a\,b}{a + b}$

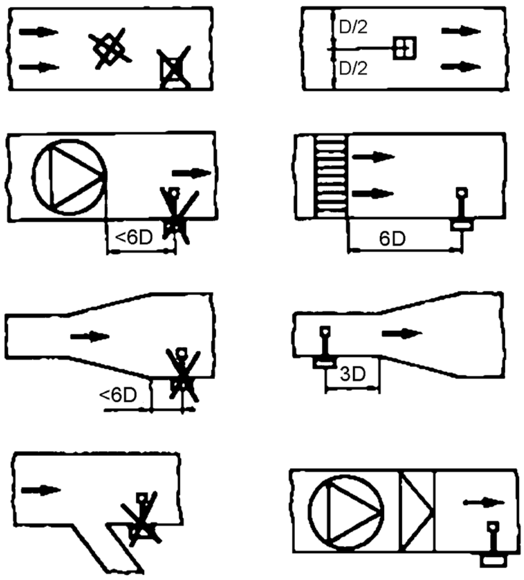
a, b: Sides of the tube cross section

The following pictures should help when installing an air velocity sensor.



Exact measured values can be obtained if, when installing after pipe bends, branches, behind dampers, fans or cross-sectional changes, the calming distances are taken into account according to the above formula.

Fig. 3.7.1 Positioning of airflow sensors



Mount the sensor in the middle of the duct.

Optimal is the placement behind filters and rectifiers, because there is no twist.

Place sensor in front of diffusers and confusers.

Filters or coolers calm the flow.

Fig. 3.7.2 Positioning of airflow sensors

3.7.1 Thermoanemometer

Measuring principle

The measuring probes contain a temperature-dependent semiconductor (NTC or thin-film sensor), which is heated by a current to a constant temperature that is higher than the ambient temperature.

As soon as the heated semiconductor is exposed to an air flow, energy is extracted from it. The temperature of the element is kept constant by a control circuit. The control current is proportional to the heat extraction, the heat extraction thus serves as a measure for the air speed.

Since this measurement is strongly dependent on the ambient temperature, the ambient temperature is measured and automatically compensated for by another precision NTC resistor.

Fields of application

Thermistors and hot-wire or hot-film probes are highly sensitive transducers, particularly suitable for very low air velocities and confined spaces. They are suitable for use in all areas of air conditioning and ventilation technology, as well as in the field of building services and for assessing workplaces (draughts).

The volume flow rate can be easily calculated and displayed from the average flow velocity by specifying the cross-sectional area.

3.7.1.1 Thermoanemometer FVAD35THx

Sensor characteristics

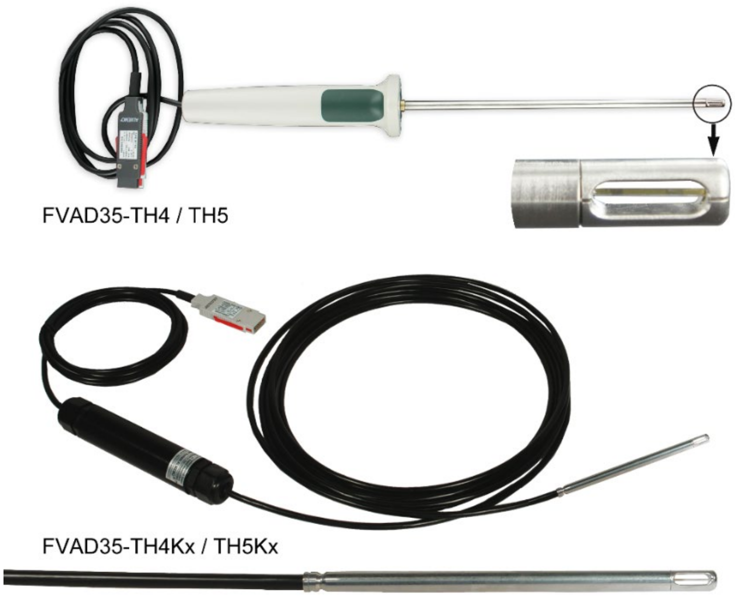


Fig. 3.7.3 Airflow sensors FVAD35TH4/TH5 and FVAD35TH4Kx/TH5Kx

Features

The thermoanemometers of type FVAD35x are equipped with a digital ALMEMO® D6 sensor, which has flow, temperature and atmospheric pressure as primary measuring channels (measured variables). The flow velocity is temperature-compensated in the range of 0 to 50°C and is also air pressure-compensated by an atmospheric pressure sensor which is serially installed in the ALMEMO® connector.

The value of the flow velocity measured by thermoanemometers is inversely proportional to the atmospheric pressure ($v = vm \cdot 1013/pm$), i.e. already 10% deviation (912 mbar) from the normal pressure 1013 mbar causes a measurement error of 10%. For this reason, the D6 sensors are equipped as standard with an atmospheric pressure sensor in the ALMEMO® connector, which automatically always serves to compensate the air pressure (LK) of the flow, even if the channel is deactivated (see chapter 3.1.3.1). The measured atmospheric pressure can also be used as a reference air pressure for other sensors in the ALMEMO® measuring instrument (see chapter 6.3.6).

Programming

Measuring ranges on delivery

Designation	Command	Code	Exp	Measuring range	Resolution
Temperature T, t	B-01	DIGI	-1	-20 to +70°C	0.1 K
Flow, v with LK (TH4)	B-02	DIGI	-3	0.08 to 2 m/s*	0.001 m/s
Flow, v with LK (TH5)	B-02	DIGI	-2	0.2 to 20 m/s*	0.01 m/s
Atmospheric pressure AP, p	B-03	DIGI	-1	300 to 1100 mbar	0.1 mbar

* Measuring ranges and resolution depending on sensor type

Configuration on PC via the sensor menu

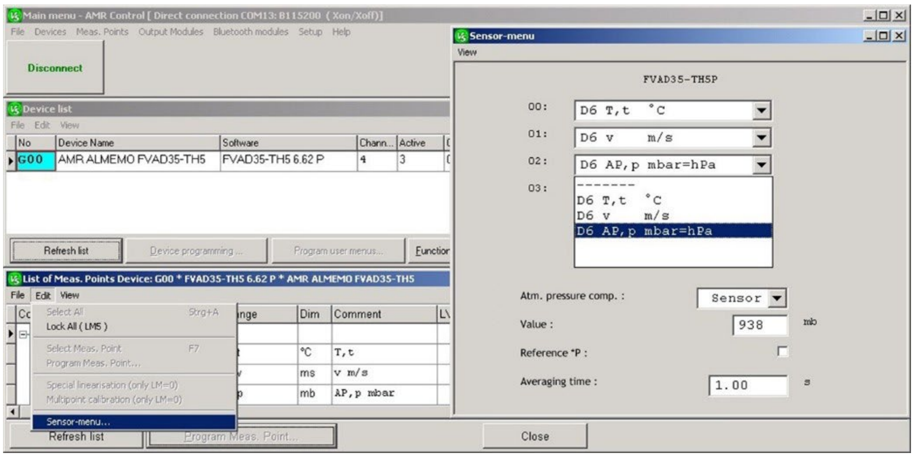


Fig. 3.7.4 Sensor menu in software ALMEMO® Control

In the sensor menu, the connector of the sensor can be programmed via the computer (see section 3.1.3.1).

Configurable measuring ranges

Designation	Command	Code	Exp	Measuring range	Resolution
Temperature T, t	B-01	DIGI	-1	-20 to + 70.0°C	0.1 K
Flow, v with LK (TH4)	B-02	DIGI	-3	0.08 to 2 m/s*	0.001 m/s
Flow, v with LK (TH5)	B-02	DIGI	-2	0.2 to 20 m/s*	0.01 m/s
Atmospheric pressure AP, p	B-03	DIGI	-1	300 to 1100 mbar	0.1 mbar

* Measuring range and resolution depending on sensor type

Technical Data

Flow	
Measuring range	
FVAD35TH4 / TH4Kx	0.08 to 2 m/s
FVAD35 TH5 / TH5Kx	0.2 to 20 m/s
Resolution	
FVAD35TH4 / TH4Kx	0.001 m/s
FVAD35 TH5 / TH5Kx	0.01 m/s
Response time	< 1.5 s
Accuracy	
FVAD35TH4 / TH4Kx	± (0.04 m/s + 1% of meas. value)
FVAD35 TH5 / TH5Kx	± (0.2 m/s + 2% of meas. value)
Nominal conditions	22°C ± 2K, 45% rH ±10% rH, 1013 mbar
Temperature compensation	0 to 50 °C
Temperature influence	
FVAD35TH4 / TH4Kx	±0.5% v MW/°C (0.3 to 2 m/s)
FVAD35 TH5 / TH5Kx	±0.3% v MW/°C (0.3 to 20 m/s)
Flow direction	Bidirectional
Angle dependence	< 3% of meas. value when twisted < 15°
Pressure range	Ambient pressure
Atmos. pressure compens.	Automatic in the range from 700 to 1100 mbar
Temperature	
Measuring range	-20 to +70°C
Resolution	0.1°C
Accuracy	±0.7°C at 0 to 50°C, v > 0.5 m/s
Response time t_{90}	Typical 10 s
Digital atmos. pressure sensor	Built into ALMEMO® D6 connector
Measuring range	700 to 1100 mbar
Accuracy	±2.5 mbar at 23°C ± 5K
ALMEMO® D6 connector	
Refresh rate	0.5 sec. for all 3 channels
Power supply	6 to 13 V DC
Power consumption	40 mA

Dimensions

Sensor diameter: 6 mm
Flow opening: ca. 10 x 3 mm

FVAD35TH4/TH5: Sensor with handle
Sensor length: 210 mm (plus handle), ALMEMO® cable: 1.5 m

FVAD35TH4Kx/TH5Kx: Sensor with seperate electronic in cable housing
Sensor length: THxK180 mm / THxK2 300 mm
Sensor cable: 5 m to electronic, ALMEMO® cable: 1.5 m

Maintenance

The air velocity probes FVAD35TH4/5 contain no moving parts and are therefore wear-free. As they operate on the principle of the hot film anemometer, the sensors are largely insensitive to dirt and dust, so that no maintenance is required under normal conditions.

For heavy duty applications we recommend periodic cleaning with isopropyl alcohol. Then let the element dry in the air. The use of mechanical aids should be avoided.

3.7.1.2 Omnidirectional thermoanemometer FVAD 05- TOKx

Sensor characteristics

General

The FVAD 05-TOKx thermoanemometer has an omnidirectionally sensitive tip with an exposed heat-ball sensor. Due to the stable construction of the sensor tip it is also suitable for mobile applications. Thermoanemometers are particularly suitable for detecting low air flows even in confined spaces.

The digital ALMEMO® D6 sensor has the primary measuring channels (measured variables) flow and atmospheric pressure. The flow velocity is compensated by a standard atmospheric pressure sensor (installed in the ALMEMO® connector). This results in an excellent overall accuracy of the sensor. The measured atmospheric pressure can also be used as reference air pressure in the ALMEMO® measuring instrument (see chapter 3.1.2).

The flow velocity of thermoanemometers is inversely proportional to the atmospheric pressure (v = vm · 1013/pm), i.e. even a 10% deviation (912 mbar) from the normal pressure 1013 mbar causes a measurement error of 10%. For this reason the D6 sensors are equipped as standard with an atmospheric pressure sensor in the ALMEMO® connector, which automatically always serves to compensate for the air pressure (LK) of the flow, even if the channel is deactivated (see chapter 3.1.2). Alternatively the atmospheric pressure can be entered manually in the sensor menu and used as compensation pressure by switching from 'Sensor' to 'Manual'.

Programming

Measuring ranges on delivery

Designation	Command	Code	Exp	Measuring range	Resolution
Flow, v 1.0 m/s	B-01	DIGI	-3	0.05 to 2.5 m/s	0.001 m/s
Atmospheric pressure AP, p	B-03	DIGI	-1	300 to 1100 mbar	0.1 mbar

Configuration via sensor menu

Selectable in the sensor menu:

- Assignment of the four channels of the D6 connector with the ranges given below

- Type of air pressure compensation

- Manual input of the atmospheric pressure

- The atmospheric pressure sensor of the thermoanemometer can be defined as the reference air pressure for the measuring instrument (*P).

- Averaging time

Configurable measuring ranges

Designation	Command	Code	Exp	Measuring range	Resolution
Flow, v 2.5 m/s	B-01	DIGI	-3	0.05 to 2.5 m/s	0.001 m/s
Flow, v 1.0 m/s	B-02	DIGI	-3	0.05 to 1 m/s	0.001 m/s
Atmospheric pressure AP, p	B-03	DIGI	-1	300 to 1100 mbar	0.1 mbar
Voltage volt	B-04	DIGI	-3	0 to 10 V	0.001 V

If the flow measuring range in the ALMEMO® connector is changed, the corresponding measuring range must also be changed in the sensor (transmitter electronics). The procedure can be found in the enclosed sensor documentation.

Technical data

Flow sensor	
Measuring range	0.05 to 1 m/s or 2.5 m/s
Resolution	0.001 m/s
Accuracy	± (3% of meas. value + 1% of final value + 2 Digit)
Nominal conditions	23°C ± 3 K, 50% rH, 1013 mbar
Temperature compensation	Effective in the range from 0 to 60°C
Temperature influence	0.5% of meas. value/K
Output time constant	0.1 s (selectable in the range from 0.05 to 10 seconds)
Flow direction	Omnidirectional
Pressure range	Ambient pressure
Atmos. pressure comp.	Automatic in the range from 700 to 1100 mbar
Sensor cable	5 m
Transmitter electronic	
Operating temperature	0 to 60°C
Power supply	12 V DC
Power consumption	Max. 350 mA
Power supply connection	Cable 0.2 m with 3 pole connection for power supply ZB1212NA10
ALMEMO® connection	Cable 2 m with ALMEMO® D6 connector
Digital atmos. pressure sensor	Built into ALMEMO® D6 connector
Measuring range	700 to 1100 mbar
Accuracy	±2.5 mbar (at 23°C ± 5 K)
AD converter	In ALMEMO® D6 connector
Refresh rate	0.1 s for all 2 channels
Power supply	Via ALMEMO® instrument (6 to 13 V DC)
Power consumption	8 mA

Dimensions

Flow sensor

Tip length:	32 mm
Sensor diameter:	6.4 mm
Sensor length:	300 mm tip included

Transmitter electronic

Length:	126 mm
Width:	80 mm
Height:	60 mm

Use

Preparation

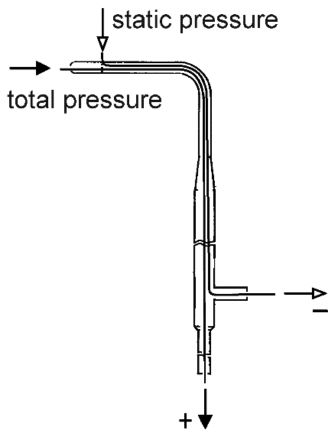
The sensor must be firmly attached before use. When mounted in a shaft or pipe, it must be located either 7.5 shaft diameters upstream or 3 shaft diameters downstream of objects that may cause turbulence. The directional point of the probe must point against the flow direction.

Maintenance

Dust and dirt can settle on the sensor. If necessary, clean the sensor carefully with a soft brush and a mild cleaning solution such as isopropyl alcohol.

3.7.2 Differential pressure measuring modules and pitot tubes

Measuring principle



The air speed is determined by the dynamic pressure. When a Prandtl pitot tube is held in an air flow, the total pressure of dynamic pressure and static pressure hits the pitot tube opening and is transmitted to the connection (+) of the pressure measuring module.

The static pressure is absorbed via the lateral slots and is applied to the connection (-) of the pressure measuring module.

The pressure difference, the dynamic pressure, is a measure of the flow velocity. This is evaluated and displayed.

Fig 3.7.5 Pitot tube with dynamic and static pressure

Basics

The dynamic pressure is related to air speed as follows:

1. Density of air:

$$\rho = \rho_0 \frac{273}{273 + t}$$

with ρ_0 = 1.292 kg/m^3 (density at 0 °C), t = air temperature in °C

2. Airflow (valid up to about 40 m/s):

$$v = \sqrt{\frac{2p}{(k\rho)}}$$

with p = dynamic pressure in Pa
k = side value of the sensor
Prandt pitot tube: k = 1
Cylinder sensor: k = 1.7

3. Air velocity taking into account the compressibility of the air (also valid above 40 m/s):

$$v = \sqrt{\frac{p}{\frac{\varrho}{2} + \frac{p}{4\,c^2}}}$$

at the speed of sound in air $c = \left(331 + 0.6 \cdot \frac{t}{°C}\right) \cdot \frac{m}{s}$

The formulas show the influence of the air temperature on the air density and thus on the measurement result of the dynamic pressure measurement. In addition, the deviation of the atmospheric pressure Pa from the normal pressure 1013 mbar is included in the result. The following factor can be used to correct the speed:

$K = \sqrt{\frac{1013\ \text{mbar}}{P_a}}$ $\qquad$ $K \approx 1 + \left(1013 - \frac{P_a}{\text{mbar}}\right) \cdot 0.0005$ (in the first approximation)

Air flow for selected dynamic pressures (Prandtl pitot tube, t = 22 °C)

Dynamic pressure [Pa]	Dynamic pressure [mmWS]	Air flow [m/s]
1	0.1	1.29
2	0.2	1.83
3	0.3	2.24
4	0.41	2.59
5	0.51	2.89
10	1.02	4.09
20	2.04	5.78
30	3.06	7.08
40	4.08	8.18
50	5.1	9.14
100	10.2	12.93

Correction factors to account for temperature and atmospheric pressure:

The actual air speed depends on air temperature and atmospheric pressure. Therefore, for accurate air velocity measurements, the reading must be corrected according to the table below.

Example:
Air speed 50 m/s, air temperature 80°C, atmospheric pressure 960 mbar. The measured value must be multiplied by the correction factor 1.123 (see below). The air speed is thus 56.1 m/s.

If you measure with ALMEMO® plugs and instruments, this correction is made in the instrument, so that the value in the display is already the corrected air speed.

However, atmospheric pressure and temperature must be programmed in the instrument or measured with additional sensors, see chapter 6.2.5.

The table below refers to 1013 mbar atmospheric pressure and 22°C, so that the correction value is equal to 1 under these conditions.

Air temperature	940 mbar	960 mbar	980 mbar	1000 mbar	1020 mbar	1040 mbar
- 30 °C	0.942	0.932	0.922	0.913	0.904	0.895
- 20 °C	0.961	0.951	0.941	0.932	0.923	0.914
- 10 °C	0.980	0.970	0.960	0.950	0.941	0.931
0 °C	0.998	0.988	0.978	0.968	0.958	0.949
10 °C	1.016	1.005	0.995	0.985	0.975	0.966
20 °C	1.035	1.024	1.013	1.003	0.993	0.983
30 °C	1.051	1.040	1.029	1.019	1.009	0.999
40 °C	1.069	1.057	1.047	1.036	1.026	1.016
50 °C	1.085	1.074	1.063	1.052	1.042	1.031
60 °C	1.102	1.090	1.079	1.068	1.057	1.047
70 °C	1.118	1.106	1.095	1.084	1.073	1.063
80 °C	1.135	1.123	1.111	1.100	1.089	1.078
90 °C	1.151	1.139	1.127	1.116	1.105	1.094
100 °C	1.167	1.154	1.142	1.131	1.120	1.109
150 °C	1.242	1.229	1.216	1.204	1.192	1.180
200 °C	1.314	1.300	1.287	1.274	1.261	1.249
250 °C	1.381	1.367	1.353	1.339	1.326	1.313
300 °C	1.446	1.431	1.416	1.402	1.388	1.375
400 °C	1.567	1.550	1.534	1.519	1.504	1.489
500 °C	1.680	1.663	1.646	1.629	1.613	1.597
600 °C	1.784	1.766	1.748	1.730	1.713	1.696
700 °C	1.884	1.865	1.846	1.827	1.809	1.791

3.7.2.1 ALMEMO® Differential pressure measuring connector FDA602-SxK, Pitot tubes FD9912xxx

Measuring principle

For flow measurement Prandtl pitot tubes are connected via hoses to the differential pressure measuring connector FDA602-SxK.

The differential pressure measuring connector has a measuring chamber which is divided by a membrane. The two hose connections are each connected to one of the two parts of the measuring chamber. If different pressures are applied to both hose connections, the membrane is stretched. The pressure difference results from this stretching.

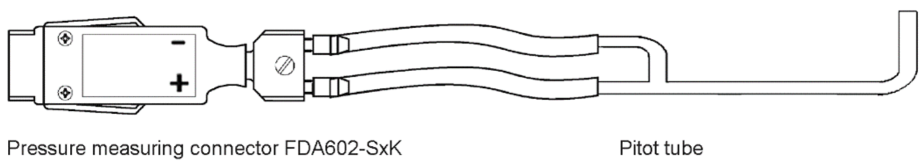


Fig. 3.7.6
Differential pressure measuring connector with pitot tube

Basics

Cylindrical probes can also be used instead of Prandtl tubes if the specific coefficient of the probe (1.7) is taken into account by programming a factor of $1/\sqrt{1.7} = 0.767$.

Overload capacity

The difference in pressure at the two hose connections of the differential pressure measuring connector must not exceed a certain value, which is called "overload capacity" (see below, 'Technical Data'). If this value is exceeded, the membrane in the measuring chamber would be irreversibly altered by excessive stretching.

Common mode pressure

The common mode pressure is equal to the lower of the two pressures applied to the hose connections. It must also not exceed a certain value (see below, Technical Data). Damage to the measuring chamber (e.g. the walls) could be caused.

Sensor characteristics

Types

Differential pressure measuring connector

Designation	Measuring range differential pressure	Measuring range airflow	Recommended range of operation
FDA602S1K	±1250 Pa	1 to 40 m/s	1 to 40 m/s
FDA602S6K	±6800 Pa	2 to 90 m/s	2 to 90 m/s

Pitot tubes

Pitot tubes made of nickel-plated brass can be used up to temperatures of 350°C, pitot tubes made of chrome-nickel steel up to 500°C. They are available in lengths from 300 mm to 2000 mm.

The Prandtl pitot tubes have a hemispherical head. The diameters for the head diameter range from 3 to 20 mm. The permissible dust load increases with the thickness of the pitot tube.

Programming

The measured variables dynamic pressure and air velocity are programmed in the ALMEMO® pressure measuring connector on two measuring channels.

Designation	Channel	Measuring range	Dim	Code	Factor	Exp
FD A602 S1K:	1.Channel:	1 to 40 m/s	ms	L840	-	-
	2.Channel:	± 1250 Pa	Pa	D2.6	-	3
FD A602 S6K:	1.Channel:	2 to 90 m/s	ms	L890	-	-
	2.Channel:	± 6800 Pa	Pa	D2.6	0.4	4

Technical Data

Diff. pressure meas. connector:	
Overload:	Maximum 3 x final value
Max. common mode pressure:	700 mbar
Accuracy (zero point aligned):	±0.5% of final value in the range from 0 to positive final value
Nominal temperature:	25°C
Temperature drift:	< ±1.5% of final value
Compensated temperature range:	0 to 70°C
Operating range:	–10 to +60°C, 10 to 90% rH non-condensing
Hose connections:	Ø 5mm, length 12mm
Sensor material:	Aluminium, nylon, silicone, silicone gel, brass

Dimensions

Differential pressure measuring connector: 74 x 20 x 8.8 mm

Note for use with ALMEMO® 2890, 5690, 5790, 8590, 8690, 500, 809:

The pressure measuring connector FDA602SxK has a slightly greater height (8.8mm) than other ALMEMO® connectors. Therefore the adjacent input socket of the ALMEMO® instrument can be partially covered. The 1st input socket can be used without restrictions. Alternatively, the pressure measuring plug can be connected to any input socket with the connecting cable ZA9060AK1.

Pitot tube:

To measure the dynamic pressure, there is an opening of 0.3 d at the tip of the pitot tube. To measure the static pressure, a total of 12 holes with a diameter of 0.1 d are arranged at a distance of 3 d.

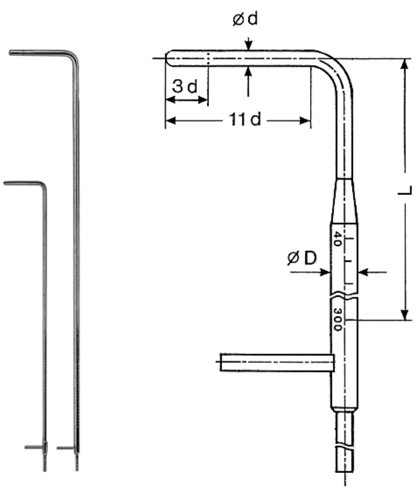


Fig. 3.7.7
Dimensions pitot tubes

Length	300 to 2000 mm
Head diameter	3 to 20 mm

Use

Control

Make sure that the pitot tube is connected correctly. Mixing up the pressure connections leads to incorrect measurements.

Increase measuring accuracy

The zero point of the pressure transducers can shift due to changes in position and temperature. Therefore it is useful to adjust the zero point before each measurement. For the adjustment the pressure hoses must be disconnected or the pitot tube must be removed from the flow channel. When the measured value has stabilized, the zero point can be adjusted. This 'zero adjustment' is described in the operating manual of the respective instrument under 'Sensor Zero Adjustment' (for interface command see chapter 6.4.2.).

The zero point adjustment must be carried out separately for each active channel (m/s, Pa).

This adjustment is lost when switching off. Therefore, you must carry out a new adjustment with the next measurement.

Temperature compensation for airflow

If the measuring temperature deviates significantly from the reference temperature of 25°C or fluctuates strongly, the temperature influence (range -50.0 to +700.0°C) is best compensated by measuring with a NiCr-Ni (type K) temperature sensor. For all ALMEMO® instruments from generation V5 on, any suitable temperature sensor (resolution 0.1°C) can be used for compensation by means of the reference channel (see chapter 6.3.4).

Sensor protection

The pressure transducers contain very sensitive load cells.

Observe the permissible maximum pressures, they must not be exceeded!

Be careful when disconnecting the hoses! Avoid harmful negative pressures!

Do not compress the hoses, do not step on them accidentally.

Avoid too strong vibrations!

Do not allow aggressive gases to reach the diaphragm of the pressure cans, which would destroy them!

3.7.3 Vane Anemometers

3.7.3.1 Digital vane anemometer FVAD15-Hxxx

Measuring principle

The vane assumes a speed proportional to the airflow v of the fluid (e.g. air or water) in which it is immersed. The speed of rotation is almost independent of the density, pressure and temperature of the medium to be measured.

The vane wheel speed is detected by an inductive proximity switch. The installation of a further inductive proximity switch allows the detection of the vane rotation and thus the detection of the ± direction of inflow.

This type of speed detection is carried out without any braking effect on the vane wheel. Due to the low weight of the vane, it adapts its speed to increases in speed within milliseconds. The changed speed is then detected with a refresh rate of 0.5 s in the D6 ALMEMO® connector.

Sensor characteristics

Features

Fig. 3.7.8 Head of vane anemometer FVAD 15-H

The vane anemometers FVAD15-H are equipped with an ALMEMO® D6 connector. It measures the frequency signal of the vane with high resolution. The robust design of this probe is suitable for mobile as well as stationary measurements. The sensor head has a flow-optimized shape and is mounted in a protected position.

Each vane anemometer of the FVAD15-H16x and FVAD15-H25x versions is individually adjusted. The multi-point adjustment is stored in the ALMEMO® D6 connector.

Extensions of the vane shaft are available for all vane anemometer types.

Extension of the vane anemometer shaft

Reference number vane anemometer	Extension	Features
FVAD15-H120 / -H140	Extension set ZV9915VR3 + Threaded adapter ZV9915M22	The extension set (Ø 15 mm, 4 x 255 mm) can be attached to the vane anemometer by the customer using the threaded adapter (M22x1.5).
FVAD15-H220 / -H240	Extension set ZV9915VR3 + Threaded adapter ZV9915M14	The extension set (Ø 15 mm, 4 x 255 mm) can be attached to the vane anemometer by the customer using the threaded adapter (M14x1.5).
FVAD15-H16GFAMC40	Extension rod OV9915HVS16A	Aluminium, Ø 16 mm, length 350 mm, mounted on vane anemometer ex works, not removable.
FVAD15-H25GAMN40 FVAD15-H25RGAMN40	Extension rod OV9915HVS25A	Aluminium, Ø 25 mm, length 350 mm, mounted on vane anemometer ex works, not removable.
FVAD15-H25GEMN40T2	Extension rod OV9915HVS25E	Stainless steel, Ø 25 mm, length 350 mm, temperature resistance -20 to +240°C (VITON O-ring), mounted on vane anemometer ex works, not removable.

Types

Reference number	Measuring range	Ø of meas. head	Operating temperature	**Particular suitability**
FVAD15-H120	0.3 to 20 m/s	25 mm	-20 to +125°C	
FVAD15-H140	0.4 to 40 m/s	25 mm	-20 to +125°C	
FVAD15-H220	0.6 to 20 m/s	16 mm	-20 to +125°C	
FVAD15-H240	0.7 to 40 m/s	16 mm	-20 to +125°C	
FVAD15-H16GFAMC40	0.6 to 40 m/s in gas 0.06 to 10 m/s in liquids	16 mm	-20 to +100°C	Measurement of gas and liquids
FVAD15-H25GAMN40	0.4 to 40 m/s	25 mm	-20 to +125°C	
FVAD15-H25RGAMN40	±0.4 to ±40 m/s	25 mm	-20 to +125°C	With direction recognition
FVAD15-H25GEMN40T2	0.5 to 40 m/s	25 mm	-40 to +260°C	Use in wide temperature range, stainless steel, high temperature cable

Programming

A measuring channel is programmed ex works: Flow velocity v [m/s]. Further measuring channels, which can be selected via the sensor menu, are also available.

The measuring range for the air flow is configured according to the connected vane anemometer.

Configurable measuring ranges

Designation	Command	Range	Meas. range	Dim	Resolution
D6 mc20, v	B-01	DIGI	0 to 22.5	m/s	0.01 m/s
D6 mc40, v	B-02	DIGI	0 to 45	m/s	0.01 m/s
D6 mc80, v	B-03	DIGI	0 to 90	m/s	0.01 m/s
D6 mc120, v	B-04	DIGI	0 to 135	m/s	0.01 m/s
D6 mn20, v	B-05	DIGI	0 to 22.5	m/s	0.01 m/s
D6 mn40, v	B-06	DIGI	0 to 45	m/s	0.01 m/s
D6 mn80, v	B-07	DIGI	0 to 90	m/s	0.01 m/s
D6 mn120, v	B-08	DIGI	0 to 135	m/s	0.01 m/s
D6 md20, v	B-09	DIGI	0 to 22.5	m/s	0.01 m/s
D6 md40, v	B-10	DIGI	0 to 45	m/s	0.01 m/s
D6 md80, v	B-11	DIGI	0 to 90	m/s	0.01 m/s
D6 md120, v	B-12	DIGI	0 to 135	m/s	0.01 m/s
D6 f 1Hz	B-13	DIGI	0 to 65000	Hz	1 Hz
D6 f 0.1 Hz	B-14	DIGI	0 to 6500	Hz	0.1 Hz
D6 f 0.01 Hz	B-15	DIGI	0 to 650	Hz	0.01 Hz
D6 rpm	B-16	DIGI	8 to 65000	U/min	1 U/min

Measuring ranges for different vane anemometer types

Vane anemometer	Measuring range
FVAD 15-H120	D6 mn20
FVAD 15-H140	D6 mn40
FVAD 15-H220	D6 mc20
FVAD 15-H240	D6 mc40
FVAD 15-H16GFAMC40	D6 mc40
FVAD 15-H25GAMN40	D6 mn40
FVAD 15-H25RGAMN40	D6 mn40
FVAD 15-H25GEMN40T2	D6 mn40

Sensor menu

Points in the sensor menu	Options	Remarks	Standard adjustment
Range of first channel	See above, 'Configurable measuring ranges'		See above, 'Measuring ranges for different vane anemometer types'
Range of second channel	See above, 'Configurable measuring ranges'		----
Direction	Unidirectional Bidirectional	'Bidirectional' selectable for FVAD 15-H25RGAMN40, for all other probes only 'Unidirectional'	Unidirectional
Medium	Gases Liquids	'Liquids' can be selected for FVAD 15-H16GFAMC40, for all other sensors only 'Gases'	Gases
Density	0.0500 to 6.5000 kg/m^3	Density correction is only effective for measurements in gases	1.2040 kg/m^3 (Air at 20°C and sea level)
Averaging time	2.0 to 100.0 s		2.0 s

Technical data

Common technical data

Max. resolution	0.01 m/s
Nominal temperature	22°C ± 2 K
ALMEMO® D6 connector	
Frequency measurement	Resolution 0.01 Hz
Multipoint adjustment	Sensor specific, stored in ALMEMO® D6 connector
Refresh rate	0.5 seconds for all channels
Averaging time	2 seconds, programmable from 2 to 100 s
Power supply	6 to 13 V DC
Power consumption	8 mA

FVAD 15-H120 / -H140

Version	Mini, aluminium
Measured medium	Air / gas
Operating range	-20 to +125°C (incl. cable)
Pressure resistance	Up to 6 bar positive pressure
Measuring range	

FVAD15-H120	0.3 to 20 m/s
FVAD15-H140	0.4 to 40 m/s
Accuracy	± (0.5% of final value + 1.0% of meas. value)
Measuring head	
FVAD15-H120	MN20GA, aluminium
FVAD15-H140	MN40GA, aluminium
Sensor shaft	Aluminium
Cable outlet	Thread M 22 x 1.5
Connection cable	Fixed cable, 2 m, with Lemo connector
ALMEMO® adapter cable	Lemo coupling, cable 0.2 m, with ALMEMO® D6 connector

FVAD 15-H220 / -H240

Version	Micro, aluminium
Measured medium	Air / gas
Operating range	-20 to +125°C (incl. cable)
Pressure resistance	Up to 3 bar positive pressure
Measuring range	
FVAD15-H120	0.6 to 20 m/s
FVAD15-H140	0.7 to 40 m/s
Accuracy	± (0.5% of final value + 1.0% of meas. value)
Measuring head	
FVAD15-H220	MC20GA, aluminium
FVAD15-H240	MC40GA, aluminium
Sensor shaft	Aluminium
Cable outlet	Dimension IG thread M 14 x 1.5
Connection cable	Fixed cable, 2 m, with Lemo connector
ALMEMO® adapter cable	Lemo coupling, cable 0.2 m, with ALMEMO® D6 connector

FVAD 15-H16GFAMC40

Version	Micro, aluminium, also for liquids
Measured medium	Air / gas or liquids (requirement: No cavitation)
Operating range	-20 to +100°C (incl. cable)
Pressure resistance	Up to 3 bar positive pressure
Measuring range	In air: 0.6 to 40 m/s or in liquids: 0.06 to10 m/s Indicate desired medium
Accuracy	± (0.5% v.E. + 1.0% of meas. value) for the specified medium, sensor-specific multi-point adjustment
Vane anemometer type	MC40GFA, aluminium
Measuring head	Aluminium
Sensor shaft	Aluminium
Cable outlet	Thread M 14 x 1.5 (Dimension IG)
Connection cable	Fixed cable, with ALMEMO® D6 connector
Cable length	2 m

FVAD 15-H25GAMN40 b

Version	Mini, aluminium
Measured medium	Air / gas
Operating range	-20 to +125°C (incl. cable)

Pressure resistance	Up to 6 bar positive pressure
Measuring range	0.4 to 40 m/s
Accuracy	± (0.5% of final value + 1.0% of meas. value), sensor-specific multi-point adjustment
Vane anemometer type	MN40GA, aluminium
Measuring head	Aluminium
Sensor shaft	Aluminium
Cable outlet	Thread M 22 x 1.5
Connection cable	Fixed cable, with ALMEMO® D6 connector
Cable length	2 m

FVAD 15-H25RGAMN40

Version	Mini, aluminium, with direction recognition
Measured medium	Air / gas
Operating range	-20 to +125°C (incl. cable)
Pressure resistance	Up to 6 bar positive pressure
Measuring range	±0.4 to ±40 m/s with direction recognition
Accuracy	± (0.5% of final value + 1.0% of meas. value), sensor-specific multi-point adjustment
Vane anemometer type	MN40GA, aluminium
Measured head	Aluminium
Sensor shaft	Aluminium
Cable outlet	Thread M 22 x 1.5
Connection cable	Fixed cable, with ALMEMO® D6 connector
Cable length	2 m

FVAD 15-H25GEMN40T2

Version	Mini, stainless steel, high temperature up to 260°C
Measured medium	Air / gas
Operating range	-40 to +260°C (incl. high temperature cable)
Pressure resistance	Up to10 bar positive pressure
Measuring range	0.5 to 40 m/s
Accuracy	± (0.5% of final value + 1.0% of meas. value), sensor-specific multi-point adjustment
Vane anemometer type	MN40GE, stainless steel
Measuring head	Stainless steel
Sensor shaft	Stainless steel
Cable outlet	Thread M 22 x 1.5
Connection cable	Fixed cable, with ALMEMO® D6 connector
Cable length	2 m high temperature cable (up to 260°C), cable amplifier (-30 to 125°C), 1.5 m cable (up to 125°C)

Dimensions

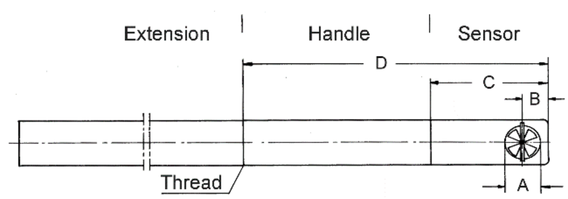
Vane anemometer	Measuring head	Sensor shaft	Sensor length
FVAD 15-H120 /-H140 See below,	Ø 25 mm Dimension C 60 mm	Ø 25 mm	170 mm

Fig. 1	Dimension A Ø 18.2 mm Dimension B 13.4 mm		(Dimension D)*
FVAD 15-H220 /-H240 See below, Fig. 2	Ø 16 mm (Dim. ØK) Dimension LK 53 mm Dimension B 10.65 mm	Ø 16 mm (Dimension ØS)	163 mm (Dimension C)*
FVAD 15-H16GFAMC40 See below, Fig. 2	Ø 16 mm (Dim. ØK) Dimension LK 53 mm Dimension B 10.65 mm	Ø 16 mm (Dimension ØS)	163 mm (Dimension C)*

Vane anemometer	Measuring head	Sensor shaft	Sensor length
FVAD 25-H25GAMN40 See below, Fig. 1	Ø 25 mm Dimension C 60 mm Dimension A Ø 18.2 mm Dimension B 13.4 mm	Ø 25 mm	170 mm (Dimension D)*
FVAD 15-H25RGAMN40 See below, Fig. 1	Ø 25 mm Dimension C 66 mm Dimension A Ø 18.2 mm Dimension B 13 mm	Ø 25 mm	166 mm (Dimension D)*
FVAD 15-H25GEMN40T2 See below, Fig. 1 and 3	Ø 25 mm Dimension C 81 mm Dimension A Ø 18.2 mm Dimension B 14 mm	Ø 25 mm	170 mm (Dimension D)*

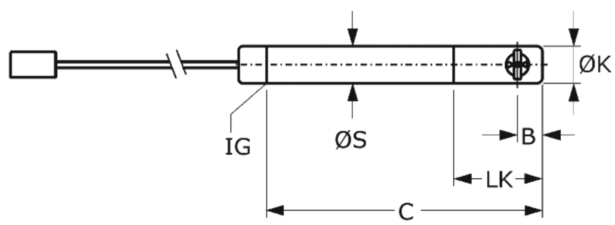
* Optionally, a longer sensor length is possible with extension rods (see above, features).

Fig. 1



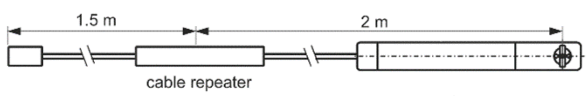
FVAD 15-H120 / -H140 as well as FVAD 25-H25GAMN40 and FVAD 15-H25RGAMN40

Fig. 2



FVAD 15-H220 / -H240 as well as FVAD 15-H16GFAMC40

Fig. 3



FVAD 15-H25GEMN40T2

Use

Preparation

Inlet / outlet sections

When measuring in a measuring section, e.g. a pipe, with an inside diameter D_i, it must be ensured that the optimum measuring accuracy can only be achieved when converting the local/point velocity vP to the average velocity vm = vP · PF (PF = profile factor) if there is a swirl-free flow on the inlet / outlet side and additionally the condition

20 D_i straight, undisturbed inlet section
10 D_i straight, undisturbed outlet section

is fulfilled.

If a sufficiently long, straight pipe section is not available, the measuring cross section must be arranged so that 2/3 of the straight pipe section is in front of and 1/3 behind the measuring cross section.

Increase measuring accuracy

Consideration of the density of the measuring medium

In practice, measurement in air/gas is largely independent of environmental parameters such as pressure, temperature and humidity.

Both the measured value of the vane anemometer and the initial value of the measuring range depend to a small extent on the density.

Dependence of the initial value of the measuring range on the density

Vane anemometers do not start up in gases until the measuring medium reaches a certain speed, which is due to the friction of the axles in the bearings and the inertia of the vanes. Therefore, vane anemometers operated in gases have a measuring range whose initial value is greater than 0, e.g. 0.5 m/s to 40 m/s.

The initial value for the measuring range specified in the 'Technical Data' for measurements in air/gases is 1.2 kg/m³ for a medium density $\rho \approx 1.2$ kg/m³. This initial value v0 increases/reduces only slightly even with a considerably different medium density than 1.2 kg/m³ and follows the relationship

$$v_{0,real} \cong v_{0,spec}\sqrt{\frac{1.2\ \mathrm{kg/m^3}}{\rho_{real}}}$$

Dependence of the characteristic curve on the density

It is assumed that with the initial value the whole characteristic curve is also increased by the difference
v0, spec - v0, real = Δv shifted.
Output measured values are too large by the amount Δv when measured in gases with a medium density ρ_{real} > 1.2 kg/m³, too small by the amount Δv when measured in gases with a medium density ρ_{real} < 1.2 kg/m³. If the density of the measuring medium is entered in the sensor menu (see above, chapter 'Programming'), the measured value output by the measuring instrument is already corrected by the corresponding amount Δv:

1. Select 'Gases' in the sensor menu.
2. Enter the density of the medium to be measured.

Measurement in liquids

Depending on the order, the vane anemometers are adjusted ex works in air or in water (FVAD 15-H16GFAMC40).

When measuring in liquids with a viscosity greater than 10 cSt or less than 1 cSt, measurement uncertainties must be expected which are no longer covered by the standard specification of measurement uncertainty.

Average velocity in pipes

If the average velocity v_m is to be calculated from the local/point measured velocity v_p in a pipe, it can be multiplied by a profile factor PF.

$v_m = v_p \cdot PF$

For measurements with cylindrical probes with circular measuring cross-sections with an internal diameter D_i, the following values must be observed for

- Tube-centered positioning of the sensor
- Swirl-free flow
- Formed flow profile (measuring cross section selected so that 20 D_i straight, undisturbed inlet section, 10 D_i straight, undisturbed outlet section)

to be based on the following profile factors.

D_i	Sensor diameter 16 mm FVAD 15-H220 FVAD 15-H240 FVAD 15-H16xx	Sensor diameter 25 mm FVAD 15-H120 FVAD 15-H140 FVAD 15-H25xx
40	0.914	-
50	0.933	0.735
60	0.950	0.760
70	0.964	0.784
80	0.976	0.807
90	0.987	0.829
100	0.994	0.849
120	1.004	0.882
170	1.008	0.935
180	1.008	0.945
220	1.008	0.955
…	1.008	0.955

Sensor protection

Compatibility material / Measuring medium

It must be ensured that the materials of the sensor that come into contact with the measured medium are compatible with it under operating conditions.

Solid loaded gases / liquids

Contamination of the flowing medium to a small extent, in particular the usual dust content of the air, has only a minor effect on the long-term stability.

For measurements in gases or liquids which are more heavily loaded with solids, a reduction in the long-term stability of the vane tips must be expected, depending on the type and content of the solids. The solids must under no circumstances have an abrasive effect.

The sensor should be cleaned at regular intervals when used in such applications. The length of the time intervals depends on the type and concentration of the particles.

Humidity

Moisture in measuring gases does not cause any disadvantages as long as no condensation occurs at the measuring head. If there is little condensation on the vane wheel, a self-cleaning effect can be expected, provided the velocities are greater than 10% of the full scale value.

Drops must not hit the vane wheel.

3.7.4 Flow rate measurement

To determine the flow rate VS in ventilation ducts, the average flow velocity is multiplied by the cross-sectional area F:

$VS = v_M \cdot F \cdot 0.36$

VS = Flow rate in m^3/h
F = Cross-sectional area in cm^2
v_M = Average flow velocity in m/s

Air volume measurement with attachment funnel

For air volume measurement at ventilation outlets (e.g. poppet valves) up to 200 mm diameter, the ZV 9915-LM attachment funnel is available as an accessory for the FVAD 15 MA1 macro vane anemometer. By scaling the air velocity with the factor 1.3762, exponent +1 and dimension mh, the air volume in m^3/h is obtained. A correction factor for the forced flow through the vane anemometer is already taken into account. The measured variable volume flow can also be programmed as a 2nd channel.

Channel	Function	Measuring range	Dim	Range	Factor	Exp
1. Channel:	Air flow	0.2 to 20.00 m/s	ms	L420	-	-
2. Channel:	Flow rate	1.0 to 275.0 m^3/h	mh	L420	1.3762	+1

Flow rate measurement with midpoint sensor

For an approximate flow rate measurement it is sufficient to attach a flow probe in the centre of the duct. The average flow velocity is approx. $0.8 \cdot v$ (see below network measurement centre point method). By scaling the velocity with the factor $(0.8 \cdot F \cdot 0.36)$, the current volume flow can be displayed continuously in m^3/h. In addition to the factor, exponent and dimension may also have to be programmed.

Determination of flow rate from average value and cross-section

In order to obtain the most accurate measurement values possible, the flow velocity must be integrated or averaged over the entire surface. It is possible to enter the cross-sectional area directly via the keyboard of the instruments in function QF as area F with max. 32000 cm^2 or in function DN via the diameter with max. 2000 mm. To do this, connect the sensor and select the Assistant / Function menus. There is either a direct menu item 'Flow rate' or the help for flow rate measurement can be found under the menu items 'Averaging'. The volume flow VS can then be read off directly in a function channel 'Flow' as product average (of the flow velocity) x area in m^3/h. The function channel 'n(t)' is available to document the number of measurements (see chapter 6.3.3 or the unit instructions chapter 'Flow rate measurements').

Determination of the average air flow

The most important parameter for flow rate measurement is the average flow velocity v_M. Since the velocity in each duct is highest in the middle and much lower at the walls, it must be averaged over the cross-section using one of the following methods.

Averaging over time

When measuring flow rate at ventilation grilles, you can determine the average flow velocity by a temporal averaging:

1. Set the averaging mode for averaging over time.
2. Place the vane anemometer at one end and start averaging.
3. Run the entire cross section evenly.
4. When you reach the other end, stop averaging again.

Network measurements

For flow measurements within the scope of acceptance measurements in accordance with the VDI/VDE 2640 guidelines, the average flow velocity is determined in a network of individual measuring points in the measuring cross section lying perpendicular to the line axis. For these network measurements, use averaging over individual measurements (see instrument manual). The average value of the individual measurements v_M must be corrected with the correction factor k depending on the measurement method: $v=k \cdot v_M$

k = 0.8 for the mid-point method for tubes with a round or rectangular cross-section and a diameter or side length of less than 250 mm.

Realisation

If you carry out the measurements according to the VDI/VDE 2640 guidelines, observe the following instructions:

- Depending on the design of the ventilation system, turbulence may occur even at low flow velocities.
- Carry out the measurements in a quiet section of a ventilation system where as little turbulence as possible occurs.
- Select the measuring point in such a way that the greatest possible safety distances exist in front of and behind the measuring point. The safety distance N is the distance from a possible turbulence point to the measuring point. Turbulence occurs, for example, after fans, bends, reductions, control dampers, rectifiers, heating units or filters, etc.
- Select the safety distance N1=L1/D before the measuring point so that it is equal to or greater than 6 and the safety distance N2=L2/D after the measuring point so that it is equal to or greater than 2.

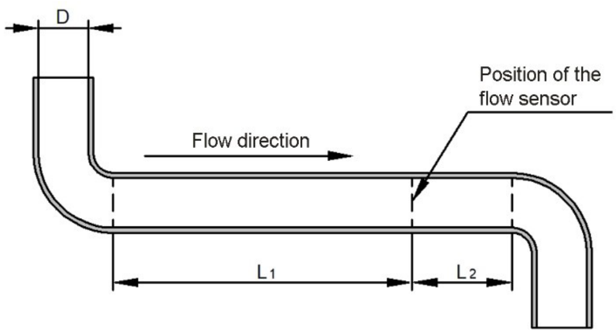


Fig. 3.7.9 Position of flow sensor

- If you only have short, straight parts of a pipeline system available for measurement, you can select a smaller safety distance N by using a higher number of measuring points for averaging. N1=L1/D must be at least 2.5.

3.8 Sensors for measuring mechanical quantities

3.8.1 Pressure sensors

Measuring principle

The central element of a pressure sensor is a membrane with the medium whose pressure is to be measured on one side. The membrane is stretched by the applied pressure and this stretching is converted into an electrical signal. In most cases two strain gauges are attached to the membrane, one of which is stretched and the other is compressed. Their resistance changes are evaluated in a bridge circuit. The resulting signal is either used directly (mV) or provided as a standard signal (voltage or current).

Basics

For the production of pressure sensors different methods are common, which are adapted to the respective application purpose.

Thick-film sensors

The strain-sensitive elements are applied to a stainless steel membrane using screen printing technology.

Thin-film sensors

In a complex manufacturing process, the strain measurement resistances are directly generated on a passivated stainless steel membrane by a chemical vapor deposition process.

Piezoresistive sensors

A silicon membrane serves as pressure-sensitive element, into which the strain-sensitive resistors are diffused. Since silicon would limit the use of the sensor with regard to its compatibility with media, a pressure transmission system consisting of a filling fluid and a stainless steel membrane is installed upstream. The pressure measuring cell is temperature-compensated and is manufactured in complex vacuum processes.

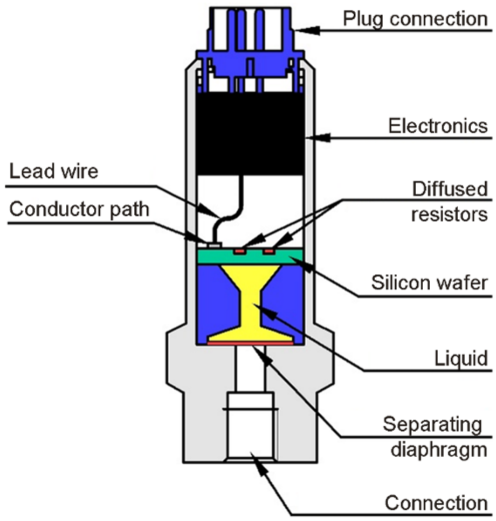


Fig. 3.8.1 Piezoresistive sensor with silicon membrane

Sensor	Features
Thick-film sensor	Compact design, especially suitable for use in simple monitoring and control circuits, temperature application range limited, measured values subject to a certain long-term fluctuation
Thin-film sensor	Very compact and homogeneous design, high long-term stability and dynamic load capacity, especially suitable for robust industrial applications in the medium and high relative pressure range
Piezoresistive sensor	High accuracy in a wide temperature field, especially suitable for use in high-quality measurement and control tasks, especially for the absolute pressure range and the low to medium relative pressure range

Selection, product overview

Different types of pressure sensors

Relative pressure	Pressure related to ambient pressure
Absolute pressure	Pressure related to vacuum (0 bar)
Over pressure	Pressure related to atmospheric pressure during manufacturing (abaout 1 bar)
Differential pressure	Pressure related to a second variable pressure

Industrial pressure sensors for permanent installation

For liquid and gaseous media, with piezoresistive measuring cell

Reference number	Application	Relative pressure	Absolute pressure	Over pressure
		All sensors are available with different measuring ranges, the widest measuring range for the respective sensor type is indicated, for more detailed information see below.		
FDA 602 L	Pressure sensor for permanent installation	0 to 10 bar	0 to 10 bar	0 to 500 bar
FDAD 33/35M	Pressure sensor for permanent installation	0 to 30 bar	0 to 30 bar	0 to 1000 bar
FD8214	Pressure sensor for permanent installation	0 to 10 bar	0 to 10 bar	0 to 1000 bar
FDA602 LxAK	For temperature measurement of refrigerants	-	0 to 50 bar	-

Differential pressure

100 Pa correspond to 1 mbar.

Reference number	Features	Medium	Differential pressure	Absolute pressure
FDA 602 D	Also for use in pressure lines	Liquid and gaseous media	0 to 300 bar (this is the widest measuring range, sensors with different measuring ranges available, see chapter 3.8.1.5)	0 to 300 bar (this is the widest measuring range, sensors with different measuring ranges available, see chapter 3.8.1.5)
FDA612SR	ALMEMO® connector with hose connections	Gases	±1000 mbar	-
FDA602S1K	ALMEMO® connector with hose connections	Gases	±1250 Pa	-
FDA602S2K	ALMEMO® connector with hose connections	Gases	±250 Pa	-
FDA602S6K	ALMEMO® connector with hose connections	Gases	±6800 Pa	-

Pressure sensors for atmospheric pressure

Reference number	Features	Measuring range
FDAD12SA	Compact design without pressure connection	300 to 1100 mbar
FDA612SA	ALMEMO® connector with hose connections	700 to 1050 mbar

The pressure sensors for atmospheric pressure are described in chapter 3.6.2.

Pressure sensors for wall mounting

Reference number	Features	Measuring range
FD8612DPS	Transmitter, output: Pressure proportional voltage signal from 0 to 2 V	Relative and differential pressure 0 to 1000 mbar, widest measuring range specified, sensors with different measuring ranges available, see chapter 3.8.1.6
FD8612APS	Transmitter, output: Pressure proportional voltage signal from 0 to 2 V	Absolute pressure 0 to 1000 mbar or 900 to 1100 mbar or 800 to 1200 mbar

Application fields

FDA 602 L, FDAD 33/35M, FD 8214, FDA 602 LxAK	These ALMEMO® pressure transducers are suitable for measurement in liquid and gaseous media in a wide range of industrial applications, e.g: medical technology, air conditioning systems, hydraulic controls, robotics, process engineering, motor controls, test benches.
FD 8612DPS/APS	Suitable for use in the laboratory, but also under harsh industrial conditions, e.g. in heating/ventilation/air conditioning technology, clean room technology, medical technology, filter technology and fine draft technology.

Notes on measurements

All ALMEMO® sensors can be adjusted, i.e. correction values for the sensor can be stored in the connector plug. This increases the measuring accuracy considerably.

During the DAkkS and factory calibrations performed by Ahlborn, the correction values are recorded, stored in the sensor connector and locked if required. The adjustment can be performed in 2 points (zero point, slope) or in more than 30 points as multi-point adjustment. Thus, smallest deviations are achieved at the calibrated temperature points.

Measurement of pressure peaks and rapid pressure changes with digital ALMEMO® D7 sensors

The pressure sensors are supplied with analog connectors as standard. However, if pressure peaks and fast pressure changes are to be measured with a very high temporal resolution, the analog connectors can be replaced by new ALMEMO® D7 connectors.

The ALMEMO® D7 measuring connector ZED 700-FS works with an AD converter built into the connector and a measuring rate of up to 1000 measurements/s (1 ms per measurement). Together with the ALMEMO® V7 measuring device, e.g. ALMEMO® 710, pressure peaks and rapid pressure changes can be recorded. In the software WinControl the measured values can be evaluated as a table or line graph.

Another advantage of the ALMEMO® V7 measuring system is that the overall accuracy of the measurement is determined only by the pressure sensor with the connected ALMEMO® D7 measuring plug, independent of the ALMEMO® display device/data logger and any extension cables used.

The complete measuring chain consisting of the pressure sensor and the connected ALMEMO® D7 measuring connector can be calibrated. Increased accuracy is achieved during calibration by multi-point adjustment of the sensor.

Measurement with higher resolution for digital ALMEMO® D7 sensors

The ALMEMO® D7 measuring connector allows not only fast measurements but also measurements with higher resolution. The measuring connector works with a reduced conversion rate. This way, stable measuring values with high resolution are achieved with precision sensors.

The configuration of the ALMEMO® connector is easily done by the user on the ALMEMO® V7 measuring device.

3.8.1.1 Pressure sensor for fixed installation FDA602Lx

Measuring principle

In ALMEMO® built-in pressure sensors the piezoresistive measuring cell is suspended in an oil-filled, fully welded stainless steel housing. Since all parts in contact with the medium are made of stainless steel, they are also suitable for use in chemically aggressive media.

Sensor characteristics

Features

Fig. 3.8.2 Pressure sensor FDA602Lx

Due to the stable mechanical construction, the measuring cell is reliably protected against the measuring medium and insensitive to pressure peaks and vibrations.

For direct connection to ALMEMO® instruments, the pressure transducers are equipped with an ALMEMO® connection cable as standard (length 1.5 m, other lengths on request).

If pressure peaks and rapid pressure changes are to be measured, the standard connector can be replaced by the digital ALMEMO® D7 measuring connector ZDD702AKL.

Types

Type	Reference number	Measuring range
Relative pressure	FDA602L3R FDA602L4R FDA602L5R	Up to 2.5 bar Up to 5 bar Up to 10 bar
Absolute pressure	FDA602L3A FDA602L4A FDA602L5A	Up to 2.5 bar Up to 5 bar Up to 10 bar
Over pressure	FDA602L2U FDA602L3U FDA602L4U FDA602L6U	Up to 25 bar Up to 50 bar Up to 100 bar Up to 500 bar

Accesories

Reference number	Description
ZB9000TB	PTFE sealing tape, -200 to +260°C, width 10 mm, thickness 0.1 mm, roll with 12 m
ZB9602N5	Quick coupling NW 5, up to 35 bar, connection G1/4" inside, brass
ZB9602N7	Quick coupling NW 7.2, up to 35 bar, connection G1/4" inside, brass

Programming

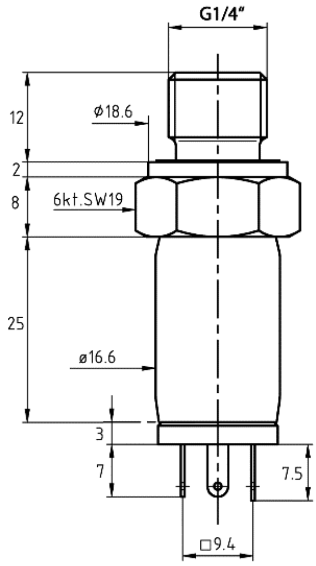
The ALMEMO® connector of the connecting cable already contains important parameters such as measuring range and scaling, so that the output values of the pressure transducer are already displayed as pressure in bar.

Technical data

Overload	Double end value
Output signal	0.2 to 2.2 V
Class of accuracy	±0.5% of end value (linearity + hystereses + reproduceability)
Total error band	0 to 50°C: ±1.0 % of end value -10 to 80°C: ±1.5 % of end value (Linearity + hystereses + reproduceability + temperature coefficiant + zero pont + tolerance of masuring range)
Response time (0 to 99%)	< 5 ms
Nominal conditions	22°C ± 2 K, 10 to 90% rH non-condensing
Power supply	6 to 15 V DC, consumption < 4 mA, via ALMEMO® connector
Operating temperature	–40 to +100°C
Pressure connection	External thread G1/4", internal membrane
Material in contact with the medium	Stainless steel DIN 1.4404/1.1135 Viton outer seal
Weight	About 50 g
Protection type	IP 65

Dimensions

Data in mm



Use

Sensor protection

Since the pressure is transmitted to the pressure diaphragm through a small hole in the threaded part, liquids should not have a tendency to crystallize and gases should not be heavily contaminated with dust.

3.8.1.2 High precision pressure sensor for fixed installation FDAD 33/35M

Measuring principle

The FDAD33/35M is a piezoresistive sensor with integrated AD converter and signal processor.

By mathematically compensating temperature dependencies and nonlinearities of the sensor, it offers highest accuracy over a wide temperature range.

Sensor characteristics

Fig. 3.8.3
Pressure sensor FDAD33/35M

General

The FDAD33/35 is suitable for liquid and gaseous media.

To detect rapid pressure fluctuations or pressure peaks, the ALMEMO® D6 connector can calculate the maximum, minimum and average values from the current values and output them in 3 function channels.

Types

Pressure range	Resolution	Overload	Item number internal membrane	Item number front flush membrane
Relative pressure				
0 to 1 bar	0.0001 bar	2 bar	FDAD3301R	FDAD35M01R
0 to 3 bar	0.0001 bar	5 bar	FDAD3302R	FDAD35M02R
0 to 10 bar	0.001 bar	20 bar	FDAD3303R	FDAD35M03R
0 to 30 bar	0.001 bar	60 bar	FDAD3304R	FDAD35M04R
Special range -1 to 1 / 3 / 10 bar on request				
Over pressure				
0 to 100 bar	0.01 bar	200 bar	FDAD3305U	FDAD35M05U
0 to 300 bar	0.01 bar	400 bar	FDAD3306U	FDAD35M06U
0 to 700 bar	0.1 bar	1000 bar	FDAD3307U	FDAD35M07U
0 to 1000 bar	0.1 bar	1000 bar	FDAD3308U	FDAD35M08U

Pressure range	Resolution	Overload	Item number internal membrane	Item number front flush membrane
Absolute pressure				
0.8 to 1.2 bar	0.0001 bar	2 bar	FDAD3300A	FDAD35M00A
0 to 1 bar	0.0001 bar	2 bar	FDAD3301A	FDAD35M01A
0 to 3 bar	0.0001 bar	5 bar	FDAD3302A	FDAD35M02A
0 to 10 bar	0.001 bar	20 bar	FDAD3303A	FDAD35M03A
0 to 30 bar	0.001 bar	60 bar	FDAD3304A	FDAD35M04A

Programming

Measuring range on delivery

Designation	Command	Range	Exp	Meas. range	Dim	Resolution
Pressure, p	B-01	DIGI	-3	0 to +1.000+	br	0.001 br

+ Measuring range and resolution depending on type (see above, 'Types')

Configureable measuring ranges

Designation	Command	Range	Exp	Meas. range	Dim	Resolution
1. Pressure, p	B-01	DIGI	-3	+	br	+ br
2. *Maximum value	B-02	DIGI	+	+	br	+ br
3. *Minimum value	B-03	DIGI	+	+	br	+ br
4. *Average value	B-04	DIGI	+	+	br	+ br
5. Temperature	B-05	DIGI	-2		°C	0.01

+ Measuring range, resolution and exponent depending on type (see above, 'Types')

*Range can also be activated via ALMEMO® device.

The D6 connector is configured on the ALMEMO® V7 measuring device or directly on the PC with the USB adapter cable ZA1919AKUV.

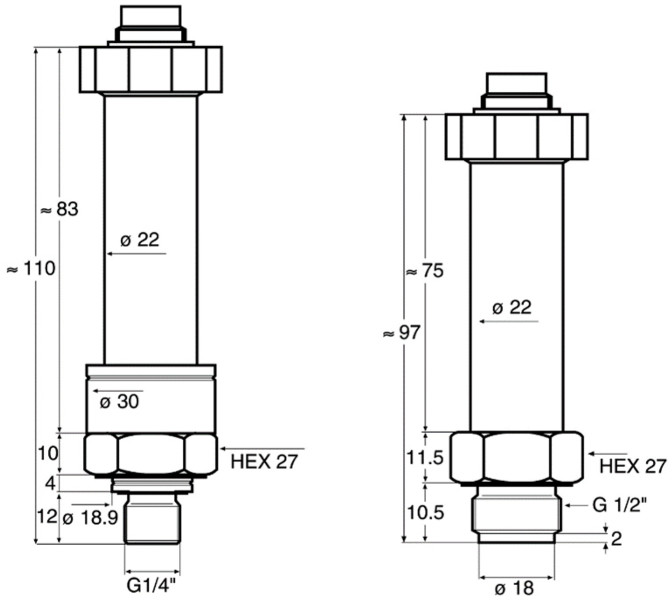
Technical data

Digital pressure sensor (incl. AD converter)	
Pressure range	1 to 1000 bar, see under 'Types'
Pressure connection	G ¼" External thread, internal diaphragm
FDAD33	Flush diaphragm, G ½" external thread
FDAD35M	For pressure range 700 bar / 1000 bar: G ¾" external thread
Storage and operating temperature	-40 to 120°C
Accuracy	Error band* at -10 to 40°C: 0.05% of final value Error band* at -10 to 80°C: 0.1% of final value *Linearity, hysteresis, reproducibility, temperature coefficients, zero point
Internal meas. rate	200 Hz
Material in media contact	Stainless steel AISI 316L, Viton

Type of protection	IP65
Sensor connection	Built-in connector
ALMEMO® conection cable	Coupling, 2 m PVC-cable, ALMEMO® D6 connector
ALMEMO® D6 connector	
Refresh time	0.005 sec for all channels
Settling time	0.6 s
Sleep delay	1 s
Power supply	6 to 13 V DC
Power consumption	About 11 mA

Dimension

Data in mm



FDAD 33 FDAD 35M

Use

Sensor protection

Since the pressure is transmitted to the pressure diaphragm through a small hole in the threaded part, liquids should not have a tendency to crystallize and gases should not be heavily contaminated with dust.

3.8.1.3 Pressure sensor for fixed installation FD 8214

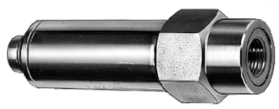
Sensor characteristics

Features

The pressure sensor FD8214 has a piezoresistive measuring cell with temperature compensation and is suitable for liquid and gaseous media.

Pressure diaphragm and housing are made of stainless steel.

Types

Image	Type	Thread
	Standard version FD 8214, internal diaphragm	G ¼“ internal thread
	FD 8214 M, flush diaphragm, welded with threaded end, easily sterilizable	G ½“ external thread
	FD 8214 + OR8214T2: Version with cooling fins for use with high media temperatures up to 150°C, with internal diaphragm (but also available with flush diaphragm)	G ¼“ internal thread

Range	Reference number		Range	Reference number	
	G1/4“ intenal	G1/2“ external		G1/4“ internal	G1/2“ external
Relative pressure:			Over pressure:		
0 to 100 mbar	FD821401R	FD8214M01R	0 to 10 bar	FD821412U	FD8214M12U
0 to 160 mbar	FD821402R	FD8214M02R	0 to 16 bar	FD821413U	FD8214M13U
0 to 250 mbar	FD821403R	FD8214M03R	0 to 25 bar	FD821414U	FD8214M14U
0 to 400 mbar	FD821404R	FD8214M04R	0 to 40 bar	FD821415U	FD8214M15U
0 to 600 mbar	FD821405R	FD8214M05R	0 to 60 bar	FD821416U	FD8214M16U
0 to 800 mbar	FD821406R	FD8214M06R	0 to 100 bar	FD821417U	FD8214M17U

Range	Reference number		Range	Reference number	
	G1/4“ internal	G1/2“ external		G1/4“ internal	G1/2“ external
0 to 1 bar	FD821407R	FD8214M07R	0 to 160 bar	FD821418U	FD8214M18U
0 to 1.6 bar	FD821408R	FD8214M08R	0 to 250 bar	FD821419U	FD8214M19U
0 to 2.5 bar	FD821409R	FD8214M09R	0 to 400 bar	FD821420U	FD8214M20U
0 to 4 bar	FD821410R	FD8214M10R	0 to 600 bar	FD821421U	FD8214M21U
0 to 6 bar	FD821411R	FD8214M11R	0 to 1000 bar	FD821422U	FD8214M22U
0 to 10 bar	FD821412R	FD8214M12R			

Range	Reference number		Range	Reference number	
	G1/4“ internal	G1/2“ external		G1/4“ internal	G1/2“ external
Absolute pressure:			Absolute pressure:		
0 to 1 bar	FD821407A	FD8214M07A	0 to 4 bar	FD821410A	FD8214M10A
0 to 1.6 bar	FD821408A	FD8214M08A	0 to 6 bar	FD821411A	FD8214M11A
0 to 2.5 bar	FD821409A	FD8214M09A	0 to 10 bar	FD821412A	FD8214M12A

Other measuring ranges on request, versions in relative pressure and overpressure also available with negative pressure.

Options/accessories

Options (depending on type) + Accessories		Reference number
Linearity 0.1%, (for ranges: > 1 bar to 600 bar)		OR8214G1
Media temperature -25 to +100°C		OR8214T1
Media temperature -25 to +150°C (version with cooling fins)		OR8214T2
Process connection small flange (for FD8214xxA absolute pressure)	KF16 KF25	OR8214KF16 OR8214KF25
Food safe execution with vegetable oil Anderol Food		OR8214ML
Throttle against pressure peak		OR8214DS
Output 0 to 10 V		OR8214V
Output 0 to 20 mA		OR8214A
Output 4 to 20 mA		OR8214R4
PTFE sealing tape, -200 to +260°C, width 10 mm, thickness 0.1 mm, roll with 12 m		ZB9000TB

Quick coupling NW 5, up to 35 bar, connection G1/4" outside, brass	ZB8214N5
Quick coupling NW 7.2 to 35 bar, connection G1/4" outside, brass	ZB8214N7

For use in the food and pharmaceutical industries, the pressure transducers are optionally available with Anderol Food filling (see option OR8214ML).

Cable

An ALMEMO® connecting cable (ZA8214AK) is available for direct connection to ALMEMO® devices.

Reference number	Feature
ZA8214AK	Coupling socket with 2 m, cable and ALMEMO® plug (other cable lengths on request)
ZB9030RB	Coupling socket 6 pin, straight version, without cable and ALMEMO® plug
ZB9030RBW	Coupling socket 6-pin, angle version, without cable and ALMEMO® plug

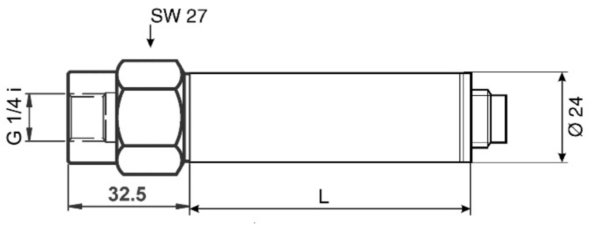
The ALMEMO® plug of the connecting cable ZA8214AK already contains important parameters like measuring range and scaling, so that the output values of the pressure sensor are already displayed as pressure in mbar or bar.

Technical data

Measuring cell	Piezoresistive
Overload	Ranges 0 to 600 bar: 1.5 times the final value (min. 3 bar, max. 850 bar) Ranges > 600 bar: 1500 bar
Output signal/power supply	
Standard 0 to 2 V	Power supply 6.5 to 13 V (from ALMEMO® device), current < 4 mA
Option 0 to 10 V	Supply 15 to 30 V, load > 10 kOhm, current < 4 mA
Option 0 to 20 mA	Supply 9 to 33 V (> 18 V with load 500 Ohm), current < 25 mA
Option 4 to 20 mA, 2 conductors	Supply 9 to 33 V (>18 V with load 500 Ohm), current < 25 mA
Response time	< 1.5 ms / 10 to 90% nominal pressure
Linearity	Standard ±0.25% of full scale Option ±0.1% of full scale for ranges 1 bar and up to 600 bar
Media temperature	0 to +80°C, temperature comp.: 0 to +70°C
optional	-25 to +100°C, temperature comp.: -25 to +85°C -25 to +150°C, temperature comp.: -25 to +85°C
Temperature drift	Zero point < ±0.04% of final value/°C for ranges > 0.5 bar Span < ±0.02% of final value/°C for all ranges
Nominal temperature	22°C ± 2 K, 10 to 90% rH non-condensing
Material	Housing, pressure connection, membrane: stainless steel 1.4435
Protection type	IP 67
Dimensions	See 'Dimensions' below
Connection thread	Type 8214: Internal thread G1/4", wrench SW 27 Option for absolute pressure: small flange KF16 or KF25 Type 8214 M: External thread G1/2", key SW 27 Other threads on request
Electrical connection	Installation plug Binder 723 5-pin
Weight	About 180 g

Dimensions

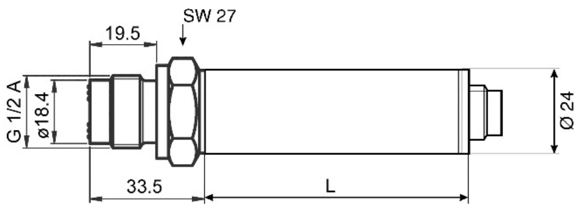
Type FD 8214



Standard version with G ¼" internal thread

L = 45 mm (L = 72 mm with option media temperature up to 150°C with cooling fins)

Type FD 8214 M



Flush diaphragm (welded with thread end), external thread G ½", easily sterilizable

L = 45 mm (L = 72 mm with option media temperature up to 150°C with cooling fins)

Use

Sensor protetion

Since the pressure is transmitted to the pressure diaphragm through a small hole in the threaded part, liquids should not tend to crystallize and gases should not be heavily contaminated with dust. For critical applications there is the sensor with flush diaphragm.

3.8.1.4 Pressure sensor for temperature measurement with refrigerant, absolute pressure FDA 602 LxAK

Basics

ALMEMO® device option SB0000R2 (temperature measuring ranges for refrigerant)

ALMEMO® devices from version V6 on can be equipped with the SB0000R2 option and thus be used for continuous refrigerant temperature measurement with absolute pressure sensors (resolution 0.001 bar mandatory). Pressure and temperature are measured simultaneously.

In each measuring device there are specific measuring ranges for the measurement with different sensors. The device option SB0000-R2 adds 10 new measuring ranges to the already existing ones. Each of these measuring ranges, together with an absolute pressure sensor, enables the device to take temperature measurements on a specific refrigerant in addition to pressure measurements.

The dew point pressure or boiling point pressure is used to determine the temperature.

Sensor chracteristics

General

The FDA 602 LxAK is suitable for industrial applications in liquid and gaseous media.

Fig. 3.8.4 Type FD A602LxAK:
Standard version with 7/16" external thread,
membrane inside

Features

The pressure transducer FDA 602 LxAK has a piezoresistive, flexibly suspended silicon measuring cell in an oil-filled, fully welded stainless steel housing.

Due to the stable mechanical construction the measuring cell is reliably protected against the measuring medium and insensitive to pressure peaks and vibrations.

For direct connection to ALMEMO® instruments, the pressure transducers are equipped with an ALMEMO® connection cable (length 1.5 m, other lengths on request) as standard.

Types

The FDA 602 LxAK is only available as an absolute pressure sensor, with a resolution of 0.001 bar.

Reference number	Range
FDA602L5AK	Up to 10 bar
FDA602L6AK	Up to 30 bar
FDA602L7AK	Up to 50 bar

Programming

The ALMEMO® plug of the connecting cable already contains important parameters such as measuring range and scaling, so that the output values of the pressure transducer are already displayed as pressure in bar with a resolution of 0.001 bar.

In addition, a customer-selectable measuring channel for the temperature of the refrigerant is programmed ex works as a function channel in the ALMEMO® connector. The refrigerant temperature is displayed in °C with a resolution of 0.1 K.

Technical data

Sensor

Overload	Double end value
Output signal	0.2 to 2.2 V
Pressure resolution	0.001 bar (programmed)
Class of accuracy	±0.5% of final value (Linearity + hystereses + reproduceability)
Total error band	0 to 50°C: ±1.0% of final value -10 to 80°C: ±1.5% of final value (Linearity + hystereses + reproduceability + temperature coefficiant+ zero point + tolerance of range)
Response time (0 to 99%)	< 5 ms
Nominal conditions	22°C ± 2 K, 10 to 90% rH non-condensing
Power supply	6.5 to 15 V DC, consumption < 4 mA, via ALMEMO® connector
Operating temperature	–40 to +100°C
Pressure connection	External thread 7/16“, membrane inside
Material in contact to media	Stainless steel DIN 1.4404/1.1135, Viton external sealing
Weight	About 50 g
Type of protection	IP 65

Refrigerant

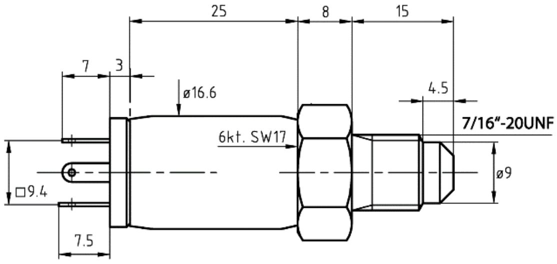
Refrigerant	R22	R23	R134a	R404a	R404a
Pressure range	0 to 36 bar	0 to 49 bar	0 to 40.5 bar	0 to 32 bar	0 to 32 bar
Operating point	Dew point	Dew point	Dew point	Dew point	Boiling point
Temperature range	-90 to +79°C	-100 to +26°C	-75 to +101°C	-60 to +65°C	-60 to +65°C
Resolution	0.1 K	0.1 K	0.1 K	0.1 K	0.1 K
Linearisation	< -24°C: 0.2 K	< -24°C: 0.2 K	< -16°C: 0.2 K	0.1 K	0.1 K
Accuracy	> -24°C: 0.1 K	> -24°C: 0.1 K	> -16°C: 0.1 K		
Abbreviation	R22	R23	R134	R404	'404
V24 command	B20	B19	B21	B22	B17

Refrigerant	R407C	R407C	R410A	R417A	R507
Pressure range	0 to 46 bar	0 to 46 bar	0 to 49 bar	0 to 27 bar	0 to 37 bar
Operating point	Dew point	Boiling point	Dew point	Dew point	Dew point
Temperature range	-50 to +86°C	-50 to +86°C	-70 to +70°C	-50 to +70°C	-70 to +70°C
Resolution	0.1 K	0.1 K	0.1 K	0.1 K	0.1 K
Linearisation	< -30°C: 0.2 K	< -30°C: 0.2 K	< -30°C: 0.2 K	< -35°C: 0.2K	< -30°C: 0.2 K
Accuracy	> -30°C: 0.1 K	> -30°C: 0.1 K	> -30°C: 0.1 K	> -35°C: 0.1K	> -30°C: 0.1 K
Abbreviation	R407	'407	R410	R417	R507
V24 command	B23	B62	B25	B26	B18

The final value of the temperature range is derived from the available data of the refrigerants. For pressure transmitters with smaller pressure ranges only the measurable final temperature is reduced.

Dimensions

Dimensions in mm



Use

Preparation

To calculate the refrigerant temperature from the measured absolute pressure, the measuring instrument must be equipped with the ALMEMO® instrument option SB0000R2 (temperature measuring ranges for refrigerant).

As already mentioned under 'Programming', the FDA 602 LxAK pressure sensor is programmed ex works with a customer-selectable measuring channel for the temperature of a refrigerant as a function channel in the ALMEMO® connector.

If a pressure sensor other than the FDA 602 LxAK with an ALMEMO® connector is to be connected in order to measure temperatures of refrigerants, the measuring ranges for the refrigerants can also be programmed into the connector as function channels. The correspondingly scaled pressure measuring range with a resolution of 0.001 bar must then be available as reference channel.

If the temperature measuring ranges are to be programmed manually, the corresponding abbreviations 'Rxxx' for the refrigerant measuring ranges appear under 'Range' between 'DIGI' and 'S120'.

Since the FDA 602 LxAK has a standard connector with four channels, three additional channels are available in addition to the measuring channel for absolute pressure. The ranges for one to three refrigerants can be programmed on these channels. If different refrigerants are used alternately, these ranges can be called up by selecting the appropriate channel.

If a measuring device has the option SB0000R2, the ranges 'Ir 1' to 'Ir 6' and 'L605' are deleted from the list of measuring ranges.

3.8.1.5 ALMEMO® module for differential pressure measurement FDA 602 D

Measuring principle

The measuring module for differential pressure FDA 602 D is equipped with two absolute pressure sensors. From the two measured pressures, the differential pressure is calculated directly in the sensor with the help of a microprocessor.

All reproducible errors of the pressure sensors, such as non-linearities and temperature dependencies, are completely eliminated with mathematical error compensation.

Due to the two separate absolute pressure sensors in the FDA 602 D, the sensor is more robust in case of a sudden one-sided pressure drop, as it can happen, for example, if one of the two connections on pressure-carrying lines breaks.

Sensor charactersitics

General

The FDA 602 D is suitable for liquid and gaseous media.

Fig. 3.8.5
Module for differential pressure measurement
FDA 602 D

Features

For direct connection to ALMEMO® instruments, the pressure transducers are equipped with an ALMEMO® connection cable (length 2 m, other lengths on request) as standard.

The ALMEMO® plug of the connecting cable already contains important parameters such as measuring range and scaling, so that the output values of the pressure transmitter are displayed as differential pressure in mbar or bar.

Types

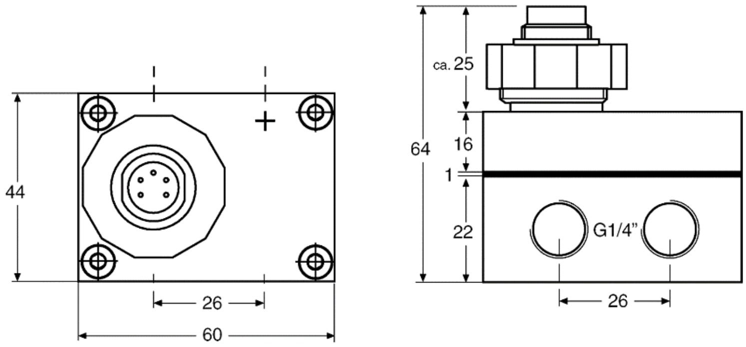
Standard pressure range **Absolute pressure**	**Overload**	**Differential pressure range** **Please indicate final value**	**Reference number**
Low pressure version:			
0 to 3 bar	10 bar	0 to 0.2 … 3 bar	FDA602D01
0 to 10 bar	20 bar	0 to 0.5 … 10 bar	FDA602D02
0 to 25 bar	30 bar	0 to 1.25 … 25 bar	FDA602D03
Medium pressure version:			
0 to 100 bar	200 bar	0 to 5 … 100 bar	FDA602D10
0 to 300 bar	450 bar	0 to 15 … 300 bar	FDA602D11

Technical data

Standard pressure range (Maximum measurable pressure per pressure connection), overload, differential pressure range	See ‚Types‘ above
Storage / operating temperature	-40 to +100°C
Compensated standard range	-10 to +80°C
Error band	≤ 0.05 % typical ≤ 0.1 % Maximum of the end value of the standard print area (Linearity + hysteresis + reproducibility + temperature error)
Pressure connection	G ¼ inside (2 per pressure side)
Material in contact to media	Stainless steel 316L, DIN 1.4435
Power supply	6 to 15 V DC, via ALMEMO® connector

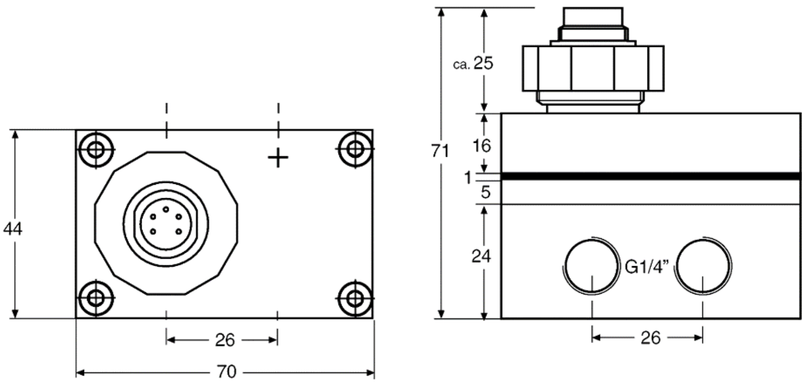
Output	0 to 2 V
Electrical connection	Binder connector incl. 2 m ALMEMO® connetcion cable
CE conformity	EN61000-6-1 to 4 with shielded cable
Protection type	IP65
Weight	
Low pressure version	475 g
Medium pressure version	750 g

Dimensions



Low pressure version

Dimensions in mm



Medium pressure version

Dimensions in mm

Use

Increase measuring accuracy

The differential pressure range should be at least 5% of the standard pressure range.

3.8.1.6 Differential pressure sensor for wall mounting FD 8612 DPS / APS

Measuring principle

The pressure is measured via a CuBe membrane that is sensitive to the pressure range. The membrane system is scanned inductively without any force.

A temperature drift is reduced to a minimum by specific compensation of the sensors.

Sensor characteristics

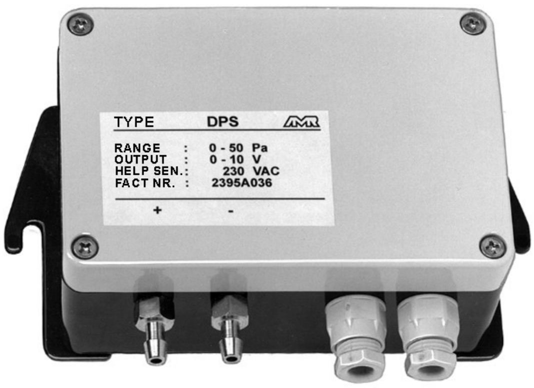


Fig. 3.8.6
Differential pressure sensor for wall mounting

General

The pressure sensor type DPS is used to detect very low pressures and differential pressures. The solid mechanics guarantees long-term stability, linearity and good reproducibility. An almost maintenance-free operation is guaranteed by the wear-free, inductive measuring system.

The pressure sensor is suitable for non-aggressive gases in the laboratory, but can also be used under harsh industrial conditions, e.g. in heating-ventilation air conditioning, clean room technology, medical technology, filter technology and fine draft technology.

The integrated electronics provides a pressure-proportional voltage signal of 0 to 2 V as output as standard.

Types

Reference number	Measuring range
FD8612DPS	Relative and differential pressure 0 to 2.5 mbar … 1000 mbar, please specify measuring range when ordering With option OD8612P10: 1 mbar (100Pa) With option OD8612P05: 0.5 mbar (50 Pa)
FD8612APS	Absolute pressure 0 to 1000 mbar 900 to 1100 mbar 800 to 1200 mbar

Options

Reference number	Features
OD8612L2	Linearity 0.2% (DPS of final value/APS of range span), with DPS only for ≥ 2.5mbar, for APS only with range span ≤ 100 mbar
OD8612L5	Linearity 0.5% (DPS of final value/APS of range span), with DPS only for areas ≥ 1mbar, for APS only with range span ≤ 200 mbar
OD8612N	Power supply 230 V
OD8612R2	Output 0 to 10 V (Power supply 19 – 31 V DC)
OD8612R3	Output 0 to 20 mA (Power supply 19 – 31 V DC)
OD8612R4	Output 4 to 20 mA (Power supply 19 – 31 V DC)

Accessoires

Reference number	Features
ZB2295S	1 set of silicone hoses 2 m, black/colorless
ZB2295SSL	Silicone tube black, surcharge per m
ZB2295SFL	Silicone tube colorless, surcharge per m

Connection cable to ALMEMO® devices

For direct connection to ALMEMO® devices, a factory-installed ALMEMO® connection cable is available with the following features.

Reference number	Features
ZA8612AK2	Connection cable 2 m long, mounted with plug for connection to ALMEMO® devices (other cable lengths on request)

Programming

The ALMEMO® connector of the connecting cable already contains important parameters such as measuring range and scaling, so that the output values of the pressure sensor (pressure proportional voltage signal from 0 to 2 V) are displayed as difference or relative pressure in Pa (Pascal) or mbar.

Technical data

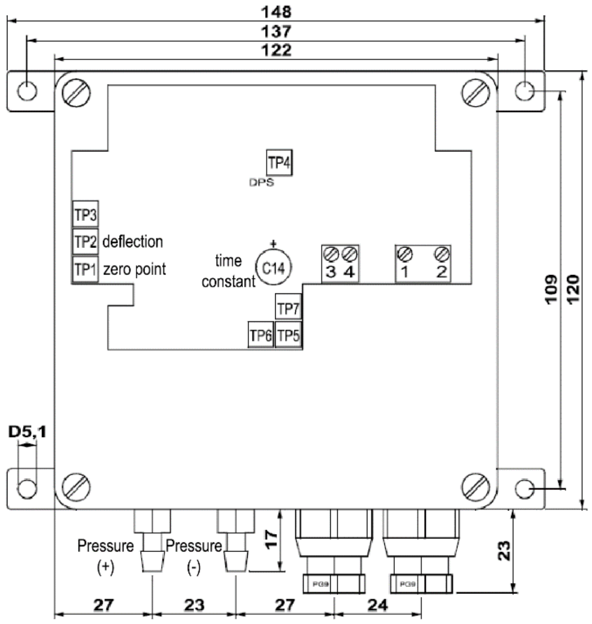
Linearity	±1% of final value, option: ±0.2% or ±0.5%
Hystereses	±0.1% of final value
Nominal temperature	23°C
Overloadability	To 400 mbar: 5 times, from 500 mbar: 2 times
Maximum common mode pressure	1 bar (at differential measurements)
Power supply	6 to 12 V DC, option: 230 V 50/60 Hz
Power consumption	About 3.5 mA
Output	0 to 2 V, Option: 0 to10 V / 0(4) to 20 mA

Connection	Electrical: Screw terminals, cable gland PG 7 Pressure: 6.5 mm hose connection
Rise time	T_{90} about 0.02 s
Temperature drift	Zero point 0.03% of final value / K, span 0.03% of final value / K
Operating range	10 to 50°C, humidity10 to 90%, non-condensing
Storage temperature	–10 to +70°C
Housing	Material ABS, 120 x 80 x 55 mm (L x W x D) at DC supply
Class of protection	0
Protection type	IP 54
Weight	About 300 g
Sensor volume	About 3 ml
Growth in volume	About 0.2 ml at nominal pressure

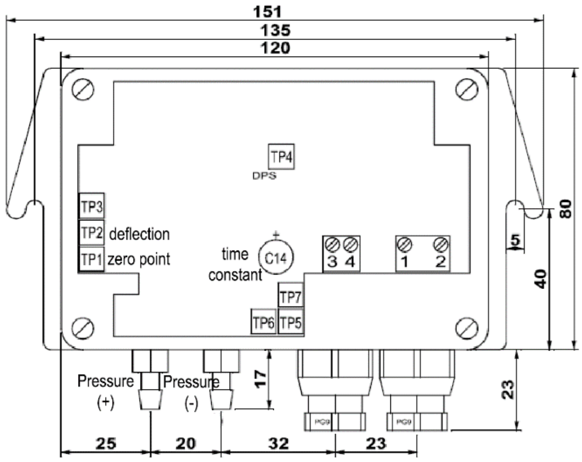
Dimensions

Information on connecting the measuring and supply cables is shown in the drawing below.

AC supply



DC supply



Use

Preparation

Installation

The pressure sensors are fixed with the help of the two lateral tabs. The immediate vicinity of sources of interference (transformers, transmitters, motors) and heat sources must be avoided.

Shocks or vibrations of the mounting location can cause a distorted output signal.

The appropriate installation is carried out in vertical position, i.e. the pressure connections point downwards. The sensors are factory calibrated in this mounting position. This mounting method also prevents any condensate from entering the sensor via the pressure lines.

Commissioning

For commissioning, remove the housing cover of the sensor. The electrical connection is made via connection terminals (see drawing above in 'Dimensions').

When applying the supply voltage make sure that it is not connected to the output terminals. The devices with DC power supply have a reverse polarity protection. The output signal of the sensors is short-circuit proof.

Pin assignment four-wire

AC power supply,

supply range see name plate on the device:

Supply	Output
Clamp 1 = N	Clamp 2 = L1
Clamp 3 = 0	Clamp 4 = Output A, current or voltage

Pin assignment three-wire

DC power supply,

Supply range see name plate on the device:

Supply	Output
Clamp 1 = 0	Clamp 2 = VDC
Clamp 3 = 0	Clamp 4 = Output A, current or voltage

Increase measuring accuracy

After applying the supply voltage, you can measure the output signal. If there is a deviation of the output signal, two things must be considered:

1. The run-in time of the sensor is about 1 hour. After this time the sensor signal must be zero at differential pressure and stable at constant ambient temperature.

2. At small measuring ranges a noticeable, physically caused zero point shift is caused by the position influence.

However, this error can be adjusted at the zero point potentiometer after the running-in time of the sensor (set the output signal of the sensor to zero with open pressure inputs).

Adjustment

The pressure sensors are factory adjusted. With fine pressure sensors there is an increased risk of damage. Therefore they should be checked at regular intervals at the factory.

Sensor protection

Do not blow into the pressure connections. Measuring cells up to 100 hPa can be damaged or destroyed by lung pressure.

3.8.1.7 ALMEMO® pressure measuring connector for differential pressure FDA 612 SR, FDA 602 SxK

Sensor characteristics

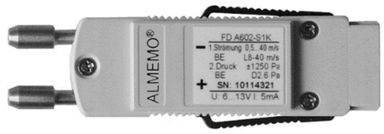


Fig. 3.8.7
Pressure measuring connector for differential pressure FD A602 S1K

General

In the ALMEMO® program there are piezoresistive pressure measuring plugs with two connecting pieces for relative or differential pressure measurement of gases (see also chapter 3.7.2.1). They can be plugged directly onto the measuring instruments. Such a connector is also available for air pressure measurement (see chapter 3.6).

Features

The sensor is delivered with a manufacturer's test certificate and a set of silicone tubes (length 2 m).

Versions

Reference number	Range
FDA612SR	±1000 mbar
FDA602S2K	± 250 Pa (independent of position)
FDA602S1K (see chapter 3.7.2.1)	±1250 Pa (independent of position)
FDA602S6K (see chapter 3.7.2.1)	±6800 Pa (independent of position)

Accessories

Reference number	Description
ZA9060AK1	Conection cable, 0.2 m
ZA9060VK2	Prolongation cable, 2 m long
ZA9060VK4	Prolongation cable, 4 m long

Technical data

Pressure measuring connector FDA 612 SR, FDA 602 S2K:

Measuring range	See above, ‚Types‘
Overloadability	
FDA 612 SR	Maximum 1.5 times final value
FDA 602 S2K	Maximum 250 mbar
Accuracy	±0.5% from end value in range 0 to positive end value

(Zero point aligned)	
Common mode pressure	FDA 602 S2K: Max. 700 mbar FDA 612 SR: Max. 3 bar
Nominal temperature	25°C
Temperature drift	
FDA 612 SR	< ±1.5% of final value, compensated temperature range: 0 to 70°C
FDA 602 S2K	< ±2% of final value, compensated temperature range: -25 to +85°C
Operating range	–10 to +60°C, 10 to 90% rH non condensing
Hose connection	Ø 5 mm, 12 mm long
Sensor material	Aluminum, nylon, silicone, silicone gel, brass

Dimensions

Length 74 mm
Width 20 mm
Height 8.8 mm

Due to the height of the plug, the adjacent input socket of the ALMEMO® 2890, 5690, 5790, 8590, 8690 devices can be partially covered. The 1st input socket can be used without restrictions. Alternatively, the ALMEMO® pressure measuring plug can be connected to any input socket with the connecting cable ZA9060AK1.

3.8.2 Force sensors

Measuring principle

The measuring chain of a force sensor consists of a mechanical-electrical converter, e.g. a Wheatstone bridge of strain gauges and a measuring amplifier for signal standardization.

The strain gauges (SG) are arranged in a full bridge circuit in 4-wire technology, i.e. the strain gauges are fed via 2 supply lines and the measuring signal is tapped via 2 further lines.

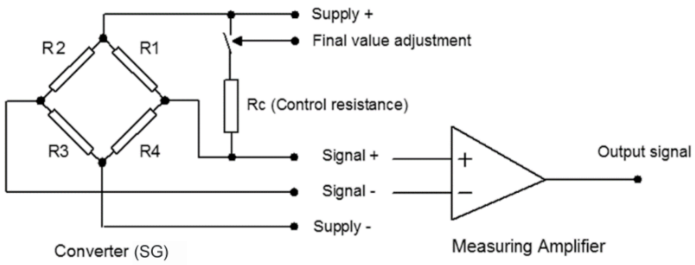


Fig. 3.8.8 Full bridge circuit in 4-wire technology with control resistance

For the final adjustment of the measuring range, the force sensors can be equipped with a corresponding control resistor, which enables checking and readjustment.

Basics

The technical characteristics of the force sensors are largely defined by the VDI/VDE guideline 2637. The most important terms are explained below.

Term	Description
Measuring range	The load range within which the guaranteed error limits are not exceeded.
Nominal load	The nominal load is the upper limit of the measuring range. Depending on the sensor, the nominal load can be a tensile or compressive load.
Working load	The working load is the load with which the sensor may be loaded beyond the nominal load without changing the specified characteristics. The working load range should only be used in exceptional cases.
Limit load	The limit load is the maximum permissible load on the load cell, at which no destruction of the measuring system is to be expected. At this load, the specific error limits no longer apply.
Breaking load	The breaking load is the load at which a permanent change or destruction occurs.
Max. dynamic load	Vibration amplitude of a sinusoidally changing force in the direction of the measuring axis of the sensor, related to the nominal force. At a load of 107 cycles, the sensor does not experience any significant change in its metrological properties when reused up to the nominal force.
Creep error	The creep error is the maximum permissible change in the output signal of the sensor over the specified time under constant load and stable ambient conditions.

Physical units and conversions

A force is the cause for the acceleration of a body. The SI-unit of force is the Newton [N]. 1 Newton is equal to the force that gives a body of mass 1 kg the acceleration 1 m/s^2.

Selection, product overview

The ALMEMO® program includes force sensors in 3 versions:

Type of force	Reference number	Measuring range
Compressive force	FKA 022	100 N, 200 N, 500 N, 1000 N, 2000 N
	FKA 613	0.5 kN, 1 kN, 2 kN, 5 kN, 10 kN, 20 kN, (50 kN on request)
Tension and compressive force		
	FKA 0251	0.02 kN, 0.05 kN, 0.1 kN, 0.2 kN, 0.5 kN,1 kN, 2 kN, 5 kN, 10 kN
	FKA 0252	20 kN
	FKA 0255	50 kN

The ALMEMO® connector of the connecting cable already contains important parameters such as measuring range and scaling, so that the output values of ALMEMO® force sensors are displayed as tensile or compressive force in N (Newton).

All measuring ranges specified in N are also available in kg ranges. As an option, ALMEMO® devices can display the measured values with both dimensions one after the other.

Reference number	Options for all force sensors
OK9000K	Measured value display for ALMEMO® instruments in kg
OK9000NK	Measured value display for ALMEMO® instruments in N and kg

ALMEMO® input connectors for force sensors

Reference number	Connector type	Sampling rate	Switch for control resistance	Description
ZA9612FS	Standard, analog	≤ 100/s (depending on instrument)	Available	See below
ZKD712FS	D7, digital	Up to 1000/s	Available	See below
ZA9105FSx	Standard, analog	≤ 100/s (depending on instrument)	None	See chapter 4.4.3.1
ZKD700FS	D7, digital	Up to 1000/s	None	See chapter 4.4.3.2

ALMEMO® force sensors are always equipped with a control resistor and are therefore normally delivered with the connector ZA9612FS or, on request, with the connector ZKD712FS. The latter can only be used on V7 devices.

The connectors ZA9105FSx and ZKD700FS can be used to connect force sensors without control resistor (see chapter 4.4.3.1 and 4.4.3.2).

ZA 9612-FS

This connector has a built-in precision differential amplifier (gain 10) and provides a stable bridge voltage supply of 5 V DC (0.5%, typ. 20 ppm/K). Input signal: 26 mV, due to the 10-fold amplification the ALMEMO® measuring range 260 mV is used.

An electronic switch is built into the measuring amplifier module of the connector, which makes it possible to switch on the rolling resistance in the force sensor from the device.

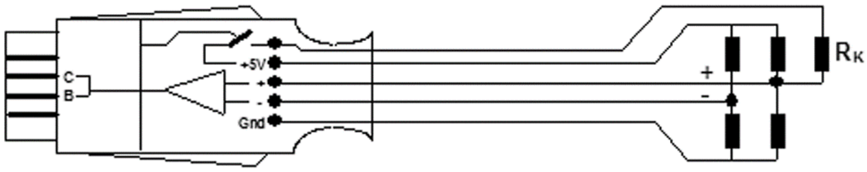


Fig. 3.8.9
Analog input connector ZA 9612-FS for force transducer with calibration resistor RK

ZKD712-FS

As an alternative to the ZA 9612-FS connector, the force sensors can be supplied with the digital ALMEMO® D7 connector ZKD712-FS on request.

The four-wire full bridge of strain gauges (see above, 'Measuring Principle') is fed by a 5V bridge supply via the electronics in the ZKD712FS connector and evaluated by a fast 24-bit AD converter.

This makes it possible to record dynamic force changes alternatively with 2 different conversion rates of 10 or 1000 measurements/second. For the adjustment of the final value the sensors have an internal control resistor, which can be switched on in the sensor menu if necessary.

Programming

of connector ZKD712-FS

Type	Command	Range
Force 10 M/s	B-01	DMS1
Force 1000 M/s	B-02	DMS2

If force sensors are supplied with a ZKD712FS connector, they are set to the strain gauge2 range at 1000 M/s. After changing the range, the force sensor adjustment (zero point and end value, see below, chapter 'Notes on measurement') must be repeated.

The technical data of the connector are the same as those of the ZKD700FS (see chapter 4.4.3.2).

Connection of force sensors without control resistance

The connectors ZA9105-FS (standard, analog) and ZKD700FS (digital) are available for connecting force sensors without control resistor (see chapter 4.4.3.1 and chapter 4.4.3.2).

Notes on measurement

Zero point adjustment

For all weight and force measurements, the zero point should be adjusted before each measurement. This sets the measured value to zero in case of a preload or a zero point error.

Zero point adjustment for type ZA9612FS:

In all ALMEMO® instruments it is possible to carry out a zero point adjustment (tare function) (see instrument manuals). The value output by the unloaded force sensor is written into the BASIC of the connector programming (see function BASIC VALUE chapter 6.3.11).

To use the zero point adjustment of the instruments, the locking mode of the measuring channel must be set to 4.

Zero point adjustment for ZKD712FS:

For the ZKD712FS, the zero point adjustment can be carried out in the device as for the connector ZA9612FS (see above and the respective device instructions).

Furthermore, it is possible to adjust the zero point in the sensor menu. The sensor menu is accessible via V7 devices (see operating instructions) or via the interface of the devices to the PC using the ALMEMO® Control software.

Click on the 'ZERO' button to carry out the zero point adjustment (see illustration of the sensor menu below).

Force sensor adjustment (two-point adjustment)

ALMEMO® force sensors are supplied fully calibrated with connectors. However, if the calibration is to be renewed or if the customer wishes to connect a force sensor himself, not only must a zero point calibration be carried out, but the sensor must also be calibrated at another point (two-point calibration). For this purpose it is assumed that the sensor behaves linear. While a value is written into the BASIC of the connector programming when the zero point is calibrated, a value is also written into the FACTOR for the two-point calibration.

A decimal point shift and dimension input may be required for complete scaling (see chapter 6.3.11 and 6.3.5).

For all new instruments, the adjustment via keys is described in the respective operating instructions under 'Setpoint input', the adjustment via the interface in chapter 6.4.2. The locking mode of the measuring channel must be set to 4.

Force transducer adjustment for ZA9612FS:

1. Zero point adjustment:
   Unload load cell.
   Perform zero point adjustment with function 'Zeroing measured value'.
   The zero point error is stored as BASE and the measured value shows 0000.
2. Set final value:
   Switch on end value control resistance.
   The final value is displayed.
3. Final value adjustment:
   Enter setpoint and adjust with function 'Setpoint input'.
   The slope error is stored as FACTOR and the measured value shows the setpoint.
   If necessary, repeat point 3.
4. Finish adjustment:
   Remove nominal load, if necessary.
   Exit the calibration function.
   The control resistance is now switched off.
   The measured value shows 00000 again.

For units without setpoint input, the factor (setpoint/actual value) itself can be calculated and programmed (see chapter 6.3.11).

Force sensor adjustment for ZKD712FS:

If a force sensor is connected to the digital connector ZKD712FS, the force sensor calibration can be performed in the same way as the zero point calibration in the sensor menu (see below). In the case of the ZKD712FS, force sensor calibration from the device is not possible.

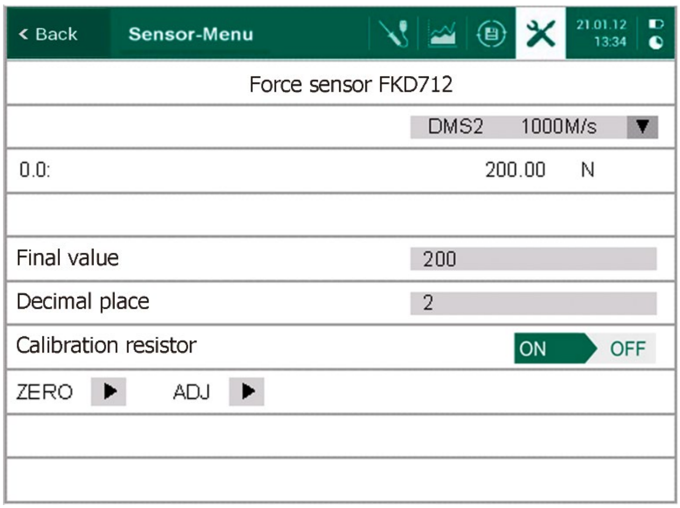


Fig. 3.8.10
Adjustment force sensor,
adjustment for ZKD712FS sensor menu of the ALMEMO® 710 measuring instrument

The sensor menu can be accessed in the device (see operating instructions of the devices) or via the interface to the computer with the ALMEMO® Control software.

1. Zero point adjustment:
   Unload load cell.
   Perform zero point adjustment by clicking on 'ZERO'.
   The measured value shows 0.
2. Set final value:
   First enter the desired decimal place in the sensor menu.
   Then enter the final value of the force sensor.
3. Final value adjustment:
   Click on 'Calibration resistance'.
   Click on 'ADJ'.
   The final value is now displayed as measured value.
4. Finish adjustment:
   Click on 'Calibration resistance'.
   Exit sensor menu.
   The measured value displays 0 again.

3.8.2.1 Pressure force sensors FKA 022, FKA 613

Sensor characteristics

Features

The sensors measure via strain gauges, which are connected in a four-wire full bridge. They are equipped with a control resistor for the final adjustment of the measuring range.

Fig. 3.8.11
Pressure force sensor FKA 022

Types

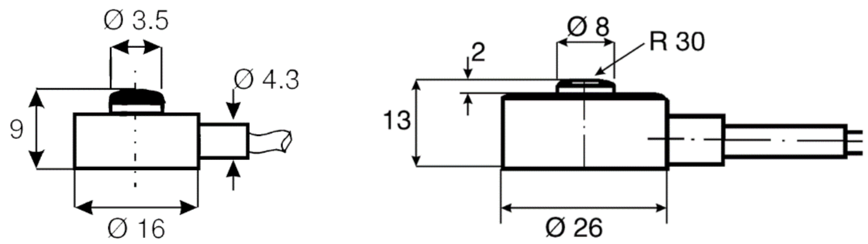
All measuring ranges given in Newton are also available in kg ranges.

Technical data

Measuring range	
FKA 022	100 N, 200 N, 500 N, 1000 N, 2000 N
FKA 613	0.5 kN, 1 kN, 2 kN,5 kN, 10 kN, 20 kN (50 kN on request)
Max. limit load	150% of final value
Max. dynamic load	70% of final value
Reference temperature	23°C
Accuracy	< ±0.5% of final value
Nominal measuring path	< 0.2 mm
Operating range	–10 to +50°C
Creep error under continuous load	< ±0.1% per 30 min
Protection type	IP 65
Material	Stainless steel
Cable	Radial, 3 m length with ALMEMO® connector

Dimensions

Left: FKA 022
Right: FKA 613



3.8.2.2 Tension and compression force sensors FKA 0251, FKA 0252, FKA 0255

Sensor characteristics

Features

The sensors measure via strain gauges, which are connected in a four-wire full bridge. They are equipped with a control resistor for the final adjustment of the measuring range.

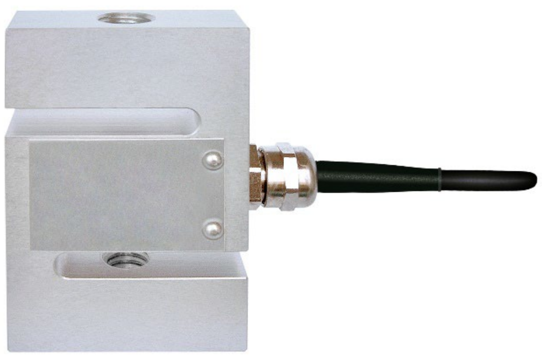


Fig. 3.8.12
Tension and compression force FKA 025x

Accessories for FKA 025

Reference number	Type
ZB902512	Hinge eyes with external thread M 12 (2 pieces)
ZB902524	Hinge eyes with external thread M 24 x 2 (2 pieces)

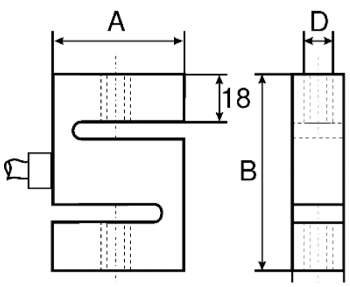
Types

All measuring ranges given in Newton are also available in kg ranges.

Technical data

Measuring ranges	
FKA0251	0.02 kN, 0.05 kN, 0.1 kN, 0.2 kN, 0.5 kN, 1 kN, 2 kN, 5 kN, 10 kN
FKA0252	20 kN
FKA0255	50 kN
Max. limit load	150% of final value
Max. dynamic load	70% of final value
Reference temperature	23°C
Cable	3 m length with ALMEMO® connector axial
Accuracy for tension	< ±0.1% of final value
Accuracy for tension and pressure	< ±0.2% of final value
Nominal measuring path	< 0.15 mm
Operating range	–10 to +70°C
Creep error under continuous load	< 0.07% per 30 min
Permissible lateral forces	±60% of final value
Protection type: up to 1 kN	IP 65, from 2 kN: IP 67
Material	Up to 1 kN: aluminium, 2 to 50 kN: stainless steel

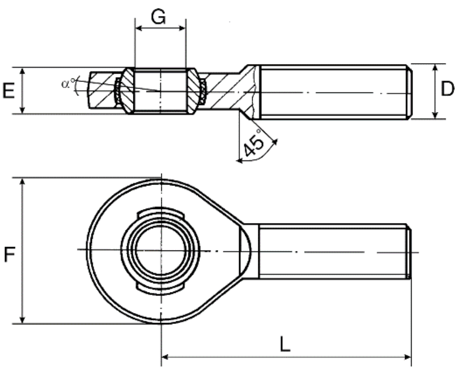
Dimensions



Tension and compression force sensor FKA25

Up to 10 kN (in mm): A=50, B=75, C=20, D=M12

Up to 20 kN, 50 kN (in mm): A=65, B=85, C=40, D=M24 x2



Dimensions hinge eyes

External thread M 12 (in mm):

D = M 12, E = 16, F = 32, G = 12, L = 54)

External thread M 24 (in mm):

D = M 24 x 2, E = 26, F = 62, G = 25, L = 94)

3.8.3 Displacement and position sensors

Measuring principle

ALMEMO® displacement transducers function according to the principle of conductive plastic potentiometers.

On the basis of a voltage divider with a resistive element made of conductive plastic, the wiper voltage is picked up without load by an operational amplifier connected as a voltage follower.

Basics

The range of applications for displacement transducers and displacement sensors is very diverse. Not every application can be recognized as displacement measurement from the beginning. Often it is a completely different measured variable, but it can be traced back to a displacement or distance variable.

Displacement sensor

These sensors are suitable for the direct, precise measurement of paths in control, regulation and measurement technology. The displacement is measured via a drawbar with ball coupling. This enables a backlash and lateral force-free operation even with angular offset of sensor and measuring direction.

Position sensor

These sensors are suitable for direct displacement measurement without positive connection, for position determination with fixed targets, for tolerance measurements, as well as for continuous contour scanning. The push rod, which is supported on both sides, can absorb transverse forces, such as those that occur during continuous scanning of curves and wedge strips. An end stop on the rear side is used for simple mechanical coupling of automatic retraction devices, such as pneumatic cylinders or electromagnets.

Selection, product overview

Reference number displacment sensor	Reference number position sensor	Range	Resolution
FWA 025 T	FWA 025 TR	25 mm	0.001 mm
FWA 050 T	FWA 050 TR	50 mm	0.01 mm
FWA 075 T	FWA 075 TR	75 mm	0.01 mm
FWA 100 T	FWA 100 TR	100 mm	0.01 mm
FWA 150 T		150 mm	0.01 mm

Application fields

FWA xxx T	Displacements in control, regulation and measurement technology
FWA xxx TR	Direct displacement measurement without form-fit connection, for determining the position of fixed targets, for tolerance measurements, and for continuous contour scanning

Notes on measurement

The potentiometers are connected via connector ZA9025FS3 with a stable 2.5 V supply (see chapter 4.4.2.1). This results in a measuring range of 0 to 2.5 V for the total distance. A pre-adjustment is made by means of the correction values in the factory.

The exact adjustment must be carried out by the customer on site after installation with gauge blocks.

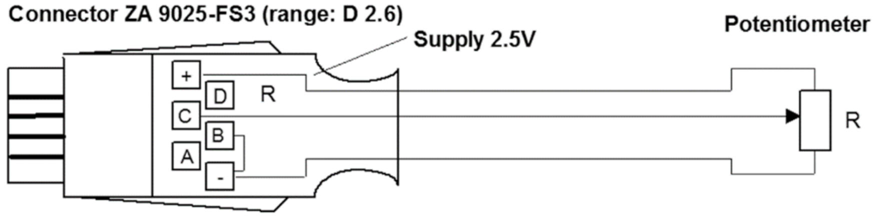


Fig. 3.8.13
Connector ZA9025FS3
with stable 2.5 V supply

3.8.3.1 Displacement sensor FWA xxx T

Sensor characteristics

Features

The distance is taken up by a drawbar with ball coupling. This enables a backlash and transverse force-free actuation even with parallel and angular displacement of transducer and measuring direction.

The sensor is equipped with an elastomer-damped, independently sprung multi-finger precious metal wiper for reliable contact even at high adjustment speed (up to 10 m/s), shock and vibration. Its drawbar is supported by two bearings.

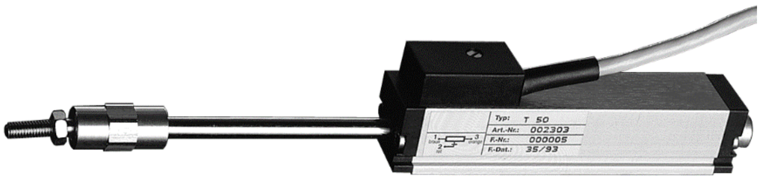


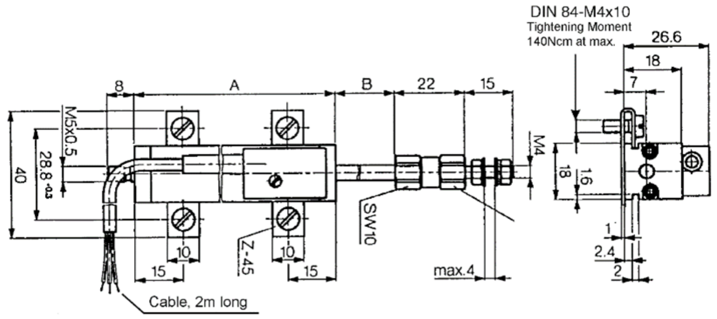
Fig. 3.8.14
Distance sensor FWA xxx T

Technical data

Distance sensors T	T25	T50	T75	T100	T150
Independent linearity	±0.2%	±0.15%	±0.1%	±0.075%	±0.075%
Housing length in mm (Dimension A + 1 mm)	63	88	113	138	188
Mechanical stroke in mm (Dimension B ±1.5 mm)	30	55	80	105	155
Total weight in g (Incl. 2 m cable)	140	160	170	190	220
Mass of the drawbar with coupling and slider block in g	35	43	52	58	74
Mobility of the ball coupling	±1 mm parallel offset, ±2.5° angular offset				
Actuating force (horizontal)	≤ 0.30 N				
Repeating accuracy	0.002 mm				
Insulation resistance	≥ 10 MΩ (at 500 V DC, 1 bar, 2 s)				
Dielectric strength	≤ 1 mA (at 50 Hz, 2s, 1 bar, 500 V AC)				
Max. permissible tightening torque of the fixing screws	140 Ncm				
Temperature range	-30 to +100°C				
Temperature coefficient of the voltage divider ratio	Typical 5 ppm/°C				
Vibrations	5 to 2000 Hz, A_{max} = 0.75 mm, a_{max} = 20 g				

Joint	50 g / 11 ms
Life time	> 100 x 10^6 strokes
Protection type	IP 40

Dimensions



3.8.3.2 Position sensor FWA xxx TR

Sensor characteristics

Features

The resistor and collector tracks of the sensor are made of conductive plastic. The push rod, which is supported on both sides, can absorb transverse forces, such as those that occur during continuous scanning of curves and wedge strips.

The rear end stop is used for simple mechanical coupling of automatic retraction devices, such as pneumatic cylinders or electromagnets.

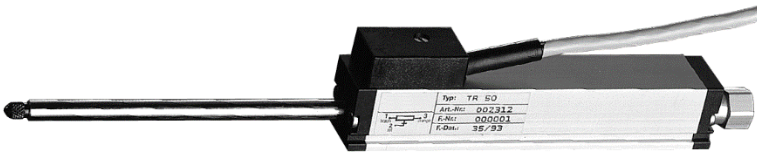


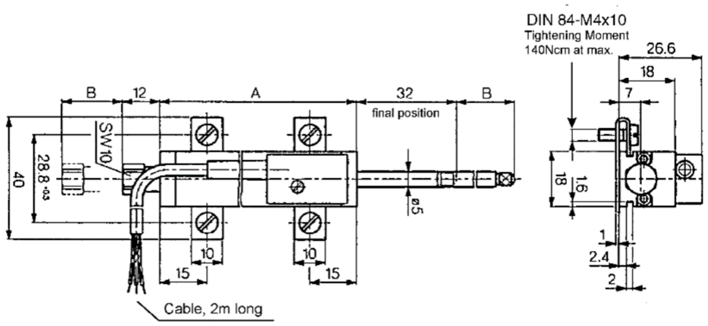
Fig. 3.8.15
Position sensor FWA xxx TR

Technical data

Position sensor TR	TR25	TR50	TR75	TR100
Independent linearitiy	±0.2%	±0.15%	±0.1%	±0.075%
Housing length in mm (Dimensions A + 1 mm)	63	94.4	134.4	166
Mechanical stroke in mm (Dimensions B ±1.5 mm)	30	55	80	105
Total weight in g (Incl. 2 m cable):	120	150	180	200
Mass of the drawbar with coupling and slider block in g	25	36	48	57
Actuation frequency max (for most critical application "Probe tip up")	18 Hz	14 Hz	11 Hz	10 Hz
Actuating force (horizontal)	≤ 5 N			

Repeatability Insulation resistance Dielectric strength	0.002 mm ≥ 10 MΩ (at 500 V DC, 1 bar, 2 s) ≤ 1 mA (at 50 Hz, 2s, 1 bar, 500 V AC)
Max. permissible tightening torque of the fixing screws	140 Ncm
Temperature range	-30 to +100°C
Temperature coefficient of the voltage divider ratio	Typical 5 ppm/°C
Vibrations Joint Life time Protection type	5 to 2000 Hz/A_{max} = 0.75 mm / a_{max} = 20 g 50 g / 11 ms > 100 x 10^6 strokes IP 40

Dimensions



3.8.4 Sensors for measuring flow

Measuring principle

Three types of flow sensors for liquids are offered:

1. Turbine flow sensor
2. Magnetic inductive flow sensors
3. Vortex flow sensors

Turbine flow sensor

In the sensor there is a wing or paddle wheel, which is set in rotation by the flow. The rotational speed is proportional to the average flow velocity and thus to the respective flow rate. Compared to optical scanning, this principle is also suitable for turbid, non-transparent liquids.

The electrical output signal can be generated in two different ways.

1. Hall sensor:

The rotor is equipped with permanent magnets that act on a Hall sensor located in the sensor. The integrated electronics converts the Hall signal into an electronic pulse signal at the output.

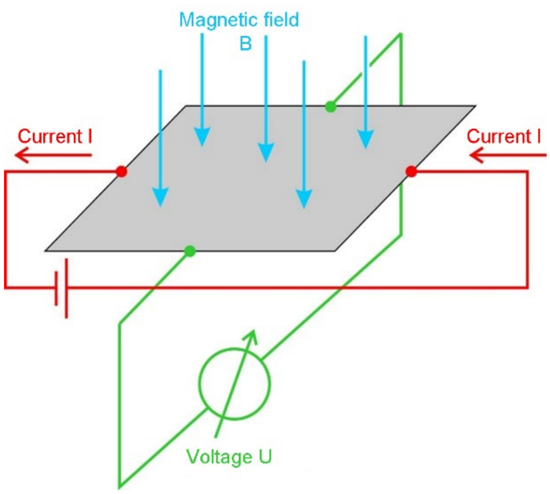


Fig. 3.8.16 Hall effect

2. Inductive proximity switch:

The rotor blades are fitted with stainless steel caps, so that the inductance of the sensor is changed by the approach of the rotor blades to the sensor and a pulse-shaped output signal is generated.

Calibration:

The K-factor (calibration factor) of the turbine flow meter expresses the sensor-specific average pulse rate. The sensors are calibrated to determine the K-factor for water.

The following equation applies to the flow rate:

$$Q = f \cdot \left(\frac{60}{K}\right)$$

Q = Flow in l/min
f = Frequency in Hz
K = K-factor in pulses/l

Magnetic inductive flow sensor

An electrically conductive liquid, whose flow rate is to be determined, flows through the measuring tube of the sensor. This is located in a magnetic field, whereby the charges in the liquid are deflected at right angles to the magnetic field. A voltage is generated in the medium which is proportional to the average flow velocity and is tapped by two electrodes.

Vortex flow sensor

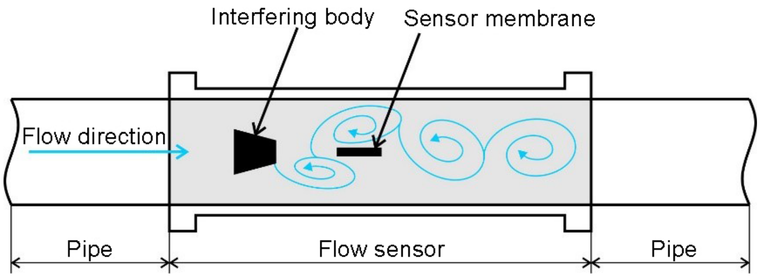


Fig. 3.8.17
Kármán whirl street

The physical effect of the Kármán vortex street is used in the vortex flow measurement by introducing an interfering body into the flow sensor, behind which the named vortex street is formed.

Since the vortices run in opposite directions and offset to each other, local pressure differences are formed. The sensor determines the so-called vortex frequency by counting the occurring pressure pulses per time unit. As the flow velocity increases, the vortex frequency also increases.

The frequency of the pressure pulsations is a measure of the flow velocity and, together with the defined cross section of the measuring section, results in a measuring signal proportional to the flow rate, which is made available in the sensor as an electrical output signal.

Basics

The term flow describes a measurand that describes the quantity of a flowing or streaming medium.

A volume flow is the volume of a medium moving through a cross-section within a unit of time and is defined as follows:

$$Q = \frac{(\delta V)}{(\delta t)}$$

Q = Volume flow in [m³/s], [l/min], [m³/h]
V = Volume in [cm³], [dm³], [m³]
t = Time in [s], [min], [h],

Furthermore for fluids like gases and liquids the relation applies:

$$Q = v_m * A$$

Q = Volume flow in [m³/s]
v_m = Average flow speed in [m/s]
A = Cross-sectional area at the measuring point in [m²]

If the flow velocity has been measured, the volume flow can be calculated with this formula for known cross-sectional areas (pipes, channels).

Since the flow velocity is not constant over the cross-section of a pipe, the average flow velocity v_m is determined by integration.

Flow sensor (also flowmeter) is a collective term for all sensors that measure the flow of a gas or liquid through a pipe.

Selection, product overview

Sensors	Measuring ranges	Measuring principle	Notes, conditions
FVA915VTHM FVA915VTH25 FVA915VTH40	2 to 40 l/min 4 to 160 l/min 6.7 to 417 l/min	With turbine	Also for turbid liquids
FVA915VMZ030 FVA915VMZ081 FVA915VMZ082 FVA915VMZ153 FVA915VMZ204 FVA915VMZ205 FVA915VMZ256	0.1 to 2 l/min 0.25 to 5 l/min 1 to 20 l/min 2.5 to 50 l/min 5 to 100 l/min 10 to 200 l/min 12.5 to 250 l/min	Magnetic inductive	Conductivity of at least 20 µS/cm required, without moving parts
FVA645GV12QT FVA645GV40QT FVA645GV100QT FVA645GV200QT	1 to 12 l/min 2 to 40 l/min 5 to 100 l/min 10 to 200 l/min	Kármán whirl street	No air inclusions, no suspended particles

Application fields

FVA915VTH	Cooling water measurement, medical technology, plastics industry, solar systems, bakery machines, machine tools, canteen kitchen equipment, photo lab equipment, dispensing systems, dosing devices, cooling devices, heating applications, heat quantity measurement
FVA645GV	Petrochemistry, power engineering, heat supply, pharmacy, paint production, agrochemistry, cosmetics production, food industry in particular: - Water, solar and brine circuits (water-glycol) for system optimization or for determining the heat quantity - Heat quantity measurement in heating and cooling systems

3.8.4.1 Axial-turbine flow sensor FVA 915 VTHM

Sensor characteristics

Features

The sensor is supplied with a 6 m long connection cable with ALMEMO® connector.

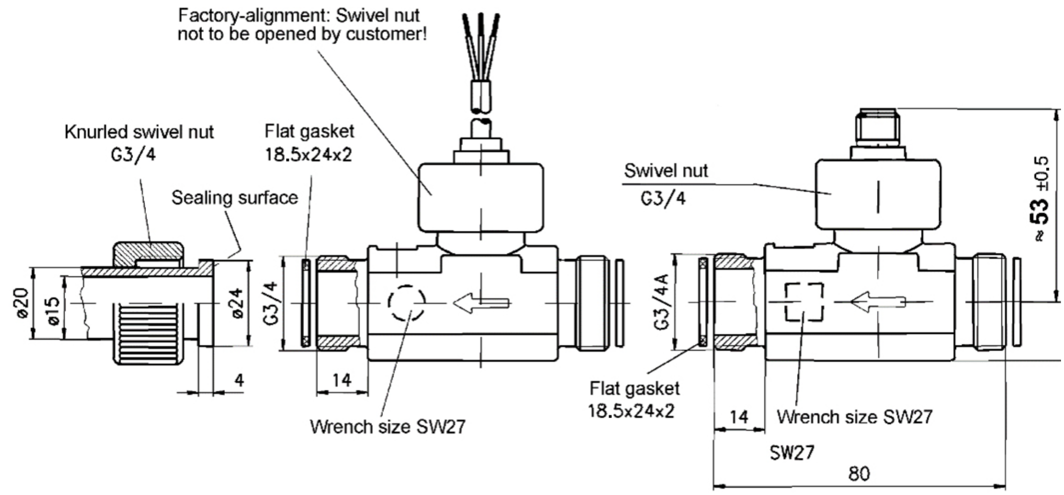
Types

Sensor	Measuring range	Measuring principle	Material turbine body
FVA915VTHM	2 to 40 l/min	Axial-turbine flow sensor	Brass

Technical data

Pipe section material	Brass
Nominal diameter	DN 15
Measuring range	2 to 40 l/min, continous load max. 20 l/min
Measurement accuracy	± 1% of final value
Reproducibility	± 0.2%
Signal output	From 0.3 l/min
Max. size of the particles in the medium	0.5 mm
Max. temperature of the medium	85°C
Nominal pressure	PN10
Process connection	G ¾" External thread and union nuts
Pressure loss in bar	Dp = 0.00145 x Q^2 (Q in l/min) About 0.6 bar at 20 l/min Ca. 2.3 bar at 40 l/min
Protection type	IP 54
Output signal	
Pulse rate / K-factor	940 pulse/liter
Resolution	1.1 ml/pulse
Signal shape	Square wave signal NPN open collector
Measuring sensor	Hall effect sensor
Supply voltage	4.5 to 24 V DC (from ALMEMO® instrument)
Electrical connection	4 pin connector M12x1 Incl. PVC leads, (T_{max} = 70°C) with ALMEMO® connector
Materials	
Pipe section	Brass CuZn36Pb2As
Flat gasket	NBR
Turbine cage	PEI ULTEM
Impeller	PEI ULTEM
Vane wheel equipment	Hard Ferrite Magnets
Axle / bearing	Arcap AP1D axis with carbide pins in sapphire bearings
Stockist	Arcap AP1D
Transducer	PPO Noryl GFN3
O-ring	NBR
Union nut	PA GF 30 (not in contact with medium)

Dimensions



Dimensions in mm

Use

Preparation

Notes on construction

Before installation, check whether the materials of the flow sensor are suitable for the medium to be measured.

The flow meter VTHM is not suitable for the measurement of oils due to the materials used. The strengths of the used plastic parts would be reduced decisively.

1. The flow sensor can be installed in any position. Installation in horizontal pipelines and an upright housing facilitate venting. For installation in vertical pipes, the flow direction from bottom to top is preferred. A free outlet must be avoided.
2. The arrow on the flow sensor (→) indicates the only possible flow direction.
3. The medium to be measured should contain as few solids as possible. Possibly existing particles must not be larger than 0.5 mm, if necessary install a filter.
4. In front of the flow sensor, a "straight" inlet section of min. 10 x DN, e.g. 15 cm for DN15, should be maintained. Behind the flow sensor a "straight" outlet distance of 5 x DN, e.g. 7.5 cm for DN15, should be considered. The inner diameter of the inlet and outlet sections must correspond to that of the flow sensor, e.g. 15 mm for DN15. Before and after this, the pipe may be constricted or widened.

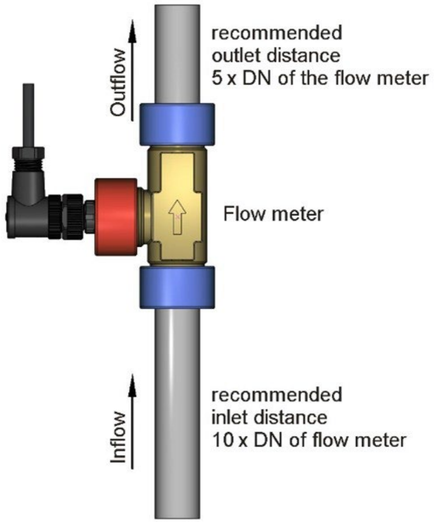


Fig. 3.8.18
Installation of a flow sensor in a pipe

5. To clean the flow sensor from contamination, a flush should be carried out against flow direction.

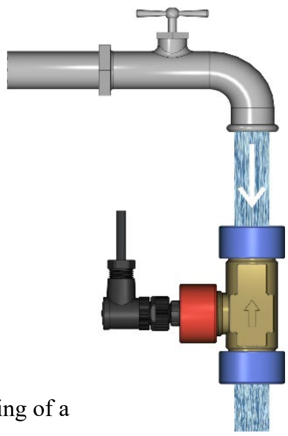


Fig. 3.8.19 Cleaning of a flow sensor

The pipeline to be connected must have a "collar" (see drawing above under 'Dimensions'). The front side of the collar serves as a sealing surface and is pressed against the flat gasket using the knurled union nuts supplied. If the external thread is to be sealed, it is essential to ensure that no fibrous sealing material (hemp or PTFE tape) enters the flow.

Tightening torque:

Plastic union nuts max. 8 Nm
Brass union nuts max. 30 Nm

Fig. 3.8.20 Flow sensor with arrow, the flow direction

Measurement

The ALMEMO® connector of the connecting cable already contains important parameters such as measuring range and scaling, so that the measured value is displayed in l/min.

In ALMEMO® devices the pulse signal of the sensor is measured in the range "Frequency". From the flow rate equation (see above, 'Measuring principle') the term (60/K) corresponds to the respective scaling value.

The flow signal is linear in the specified measuring range within the scope of the measuring accuracy. For flow control applications, e.g. constant flow with clogging filter, the sensor can also be operated in the non-linear range, since here also a sufficient repeatability is given.

The measurement of liquids with higher viscosity is possible with deviation from the above mentioned 'Technical Data'.

Sensor protection

The union screw at the cable outlet is sealed.

If it is opened anyway, the fixation of the turbine system is loosened and there is a risk of damage. A factory repair becomes necessary.

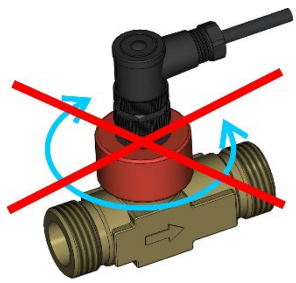
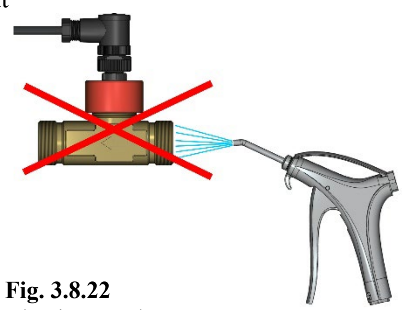


Fig. 3.8.21 The screw cap at the cable outlet must not be opened.

If the unit is blown out with compressed air, it may only be blown out against the direction of flow.



As already mentioned under 'Preparation', the sensor must not be used to measure the flow of oil.

Fig. 3.8.22
Blowing out the sensor

3.8.4.2 Axial-turbine flow sensor FVA 915 VTH 25M

Sensor chracteristics

Features

The sensor is supplied with a 6 m long connection cable with ALMEMO® connector.

Types

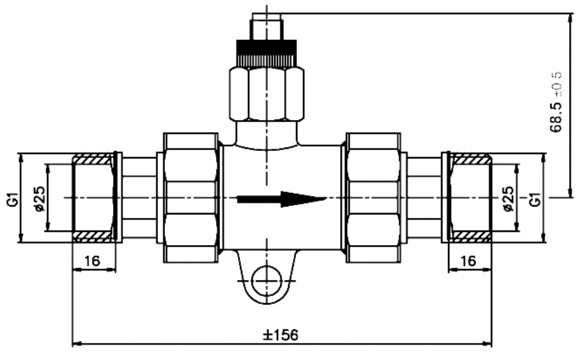
Sensor	Measuring range	Measuring principle	Material turbine body
FVA915VTH25M	4 to 160 l/min	Axial turbine flow sensor	Brass

Technical data

Nominal diameter	DN 25
Measuring range	4 to 160 l/min, continous load max. 80 l/min
Measurement accuracy	± 5% of measuring value (to 5 l/min ± 7% of measuring value)
Reproducibility	± 0.5%
Signal output from	< 1 l/min
max. size of the particles i. medium	0.63 mm
max. temperature of the medium	85°C
Nominal pressure	PN10
Process connection	G 1¼" External thread incl. connection adapter to R 1" (mandatory)
Pressure loss	About 0.1 bar at 80 l/min About 0.45 bar at 160 l/min
Protection type	IP 54
Output signal	
Pulse rate / K-factor	65 pulse/liter
Resolution	15 ml/pulse
Form of signal	NPN open collector
Measuring sensor	Hall effect sensor
Supply voltage	4.5 to 24 V DC (from ALMEMO® instrument)
Electrical connection	4 pin connector M12x1 incl. PVC leads, (T_{max} = 70°C) with ALMEMO® connector
Materials	
Pipe section	Brass CW602N
Turbine cage	PPO Noryl GFN 1630V
Impeller	PPO Noryl GFN 1520V
Vane wheel equipment	Hard Ferrite Magnets
Axle / bearing	Stainless steel 1.4539 / sapphire, PA
Transducer sleeve	PPO Noryl GFN 1630V
O-ring	EPDM

Dimensions

Dimensions in mm



Use

Preparation

Installation instructions

See chapter 3.8.4.1 (FVA915VTHM)

Installation in the piping system

First, the connection adapters are sealed into the pipeline. It must be ensured that no fibrous sealing materials (hemp or PTFE tape) enter the turbine during this process.

The actual turbine is then installed using the union nut and the flat gaskets supplied.

Measurement

See chapter 3.8.4.1 (FVA915VTHM)

Sensor protection

The union screw at the cable outlet is sealed.

If it is opened anyway, the fixation of the turbine system is loosened and there is a risk of damage. A factory repair becomes necessary.

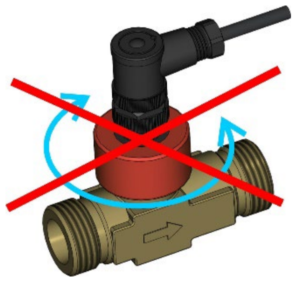


Fig. 3.8.23 The screw cap at the cable outlet must not be opened.

The flow sensor must not be blown out with compressed air. Damage to the bearing of the turbine may occur.

3.8.4.3 Magnetic inductive flow sensor FVA915VMZx

Sensor characteristics

Features

The sensor is supplied with a 6 m long connection cable with ALMEMO® connector.

Types

Sensor	Measuring range	Nominal width	Thread	Signal output	Max. flow
FVA915VMZ030	0.1 to 2 l/min	DN 3	G3/8 B external	0.05 l/min	2.5 l/min
FVA915VMZ081	0.25 to 5 l/min	DN 8	G1/2 B external	0.1 l/min	6 l/min
FVA915VMZ082	1 to 20 l/min	DN 8	G1/2 B extenal	0.25 l/min	25 l/min
FVA915VMZ153	2.5 to 50 l/min	DN 15	G3/4 B external	1 l/min	60 l/min
FVA915VMZ204	5 to 100 l/min	DN 20	G 1 B external	2 l/min	120 l/min
FVA915VMZ205	10 to 200 l/min	DN 20	G 1 B external	4 l/min	240 l/min
FVA915VMZ256	12.5 to 250 l/min	DN 25	G 1 1/4 B external	5 l/min	300 l/min

Technical data

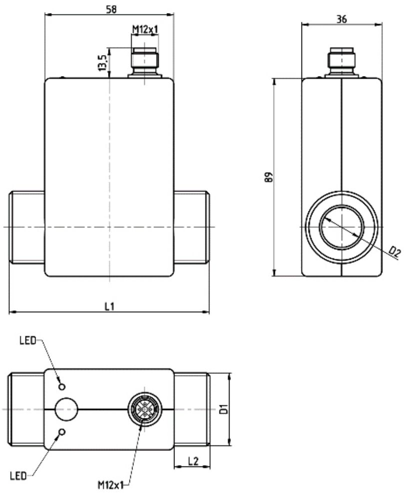
Nominal widths	See above 'Types'
Measuring ranges	See above 'Types'
Measurement accuracy	1% of measured value (test conditions: water 23°C)
Reproducibility	1%
Response time	< 100 ms
Signal output from	See above 'Types'
max. flow	See above 'Types'
Measuring medium	Water and other conductive liquids
Min. Conductivity of the measuring medium	20 µS
Media temperature	-10 to +60°C (not freezing)
Ambient temperature	5 to 60°C
Max. operating pressure	10 bar at 20°C 8 bar at 40°C 6 bar at 60°C
Flow display	LED red = power supply, LED green = flow rate
Protection type	IP65 (with plugged on coupling socket)
Materials	
Electrodes and grounding rings	316L stainless steel
Measuring tube and process connections	POM or PVDF
O-rings	EPDM
Housing	ABS

Dimensions

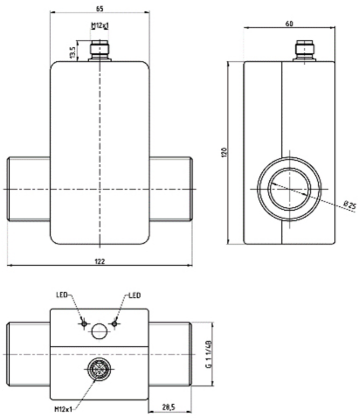
FVA915VMZ03/08/15/20

Dimensions in mm

Refernce number	L1	L2	D1	D2
FVA915VMZ030	85	13.3	G 3/8 B	Ø 3
FVA915VMZ081	85	13.3	G ½ B	Ø 8
FVA915VMZ082	85	13.3	G ½ B	Ø 8
FVA915VMZ153	90	16	G ¾ B	Ø 14
FVA915VMZ204	90	16	G 1 B	Ø 18
FVA915VMZ205	90	16	G 1 B	Ø 18



FVA915VMZ25



Use

Measurement

The minimum conductivity of the medium must be 20 µS. The medium must not contain any moving parts.

The measuring tube must always be completely filled (no air bubbles etc.).

The recommended installation position is horizontal.

3.8.4.4 Vertox flow sensor FV A645 GVx

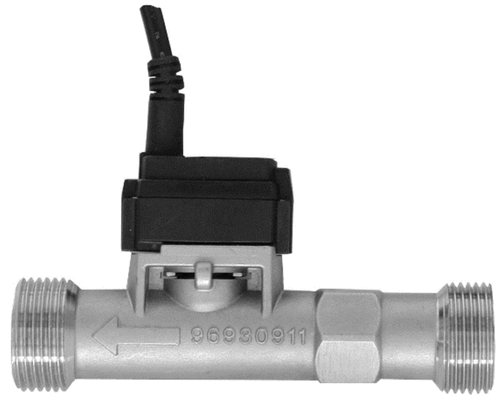


Fig. 3.8.24
Vertox flow sensor FVA 645 GVx

Measuring principle

The ALMEMO® vortex flow sensor consists of a measuring section, sensor element and a triangular vortex element, on which the vortices detach on both sides. A piezoresistor serves as the sensor element for detecting the fine pressure pulsations. The piezoresistor detects the change in electrical resistance due to pressure and is arranged in a Wheatstone bridge.

The temperature sensor, which is still integrated on the sensor chip, is required for compensation of the measurement signal, but the recorded temperature value is also made available as a measurement signal at the output of the sensor. The direct contact with the medium allows very low response speeds for flow and temperature measurement in an application range from 0°C to 100°C.

Basics

In fluid mechanics, vortices (also called vortexes) are circular flows of a fluid. When observing the physical behavior of liquids and gases, a phenomenon arose in which counter-rotating vortices form behind a body around which a flow is passing. These vortices alternately detach themselves from the left and right side of the body and have opposite flow directions.

The character of the vortex formation is essentially determined by the Reynolds number Re. It represents the ratio of inertial to viscous forces and is calculated from the flow velocity, the diameter of the body being flowed around and the viscosity. The frequency of vortex shedding is characterized by the Strouhal number. Since both numbers represent physical constants, the calculation ultimately results in a linear relationship between separation frequency and flow velocity and thus the volume flow.

The so-called vortex streets were first proven and calculated in 1911/12 by the engineer Theodore von Kármán and form the basis for today's measuring technology.

Sensor characteristics

Features

The sensor measures the flow rate as well as the temperature.

Types

Reference number	Range	Resolution	Process connection thread	Construction length	Dyn. viscosity of media*
FVA645GV12QT	1 to 12 l/min	0.06 l/min	G 3/4“ external	About 110 mm	< 4 mm²/s
FVA645GV40QT	2 to 40 l/min	0.2 l/min	G 3/4“ external	About 110 mm	< 4 mm²/s
FVA645GV100QT	5 to 100 l/min	0.5 l/min	G 1“ external	About 129 mm	< 2 mm²/s
FVA645GV200QT	10 to 200 l/min	1.0 l/min	G 1 1/4“ external	About 137.5 mm	< 2 mm²/s

* Conversion: 1 St = 1 cm²/s, 1 St = 10^{-4} m²/s, 1 cSt = 1 mm²/s

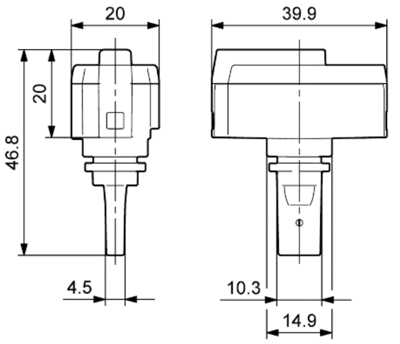
Technical data

Flow	
Measuring principle	Pressure pulsation, Kármán's whirl street
Measuring range	See above ‚Types‘
Accuracy	±1.5 % of final value from 0 to 100°C with medium water
FVA 645 GV12QT/40QT	With medium water-glycol (42%), 30 to 100°C (viscosity about 4 mm²/s: ±5% of final value)
Resolution	See above ‚Types‘
Response time (63%)	< 1 s (< 3 s for FVA 645 GV12QT)
Temperature	
Measuring range	0 to 100°C
Accuracy	±1 K at 25 to 80°C ±2 K at 0 to 100°C
Resolution	0.5 K
Response time (63%)	<1 s at flow, 50% of final value
Process connection	2 x external thread, see above ‚Types‘
Pressure	10 bar (burst pressure > 16 bar)
Pressure loss	Typ. 0.1 bar at flow 50% of final value
Operating conditions	
Medium	Water Water-glycol (max. 42% Glykol) FVA 645 GV12QT/40QT with viscosity < 4 mm²/s FVA 645 GV100QT/200QT with viscosity < 2 mm²/s
Medium temperature	0 to 100°C
Ambient temperature	-25 to +60°C
Ambient humidity	Up to 95% rH, non-condensing
Electrical connection	
Output signal	2 x 0.5 to 3.5 V
Supply	5 V DC (±5%), <10 mA, via ALMEMO® connector
Connection	Sensor with 2.9 m connection cable and ALMEMO® connector
Construction length	See above ‚Types‘
Material (in contact with media)	Corrosion resistant coating, EPDM, PPS, PPA 40-GF
Pipe section	Stainless steel 1.4408, (inner tube: PPA 40-GF)

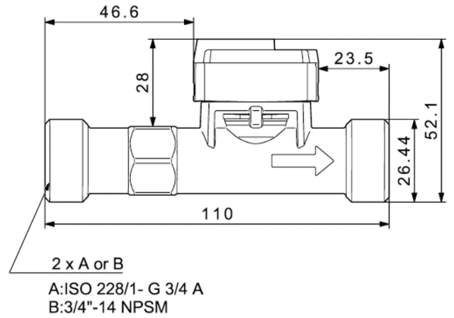
Dimensions

Dimensions in mm

Sensor element
FVA 645 GV12QT
FVA 645 GV40QT
FVA 645 GV100QT
FVA 645 GV200QT

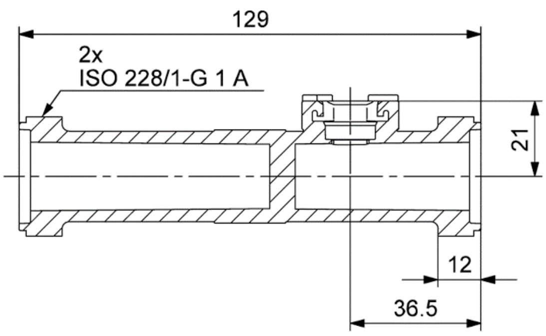


Turbine body
FVA 645 GV12QT
FVA 645 GV40QT



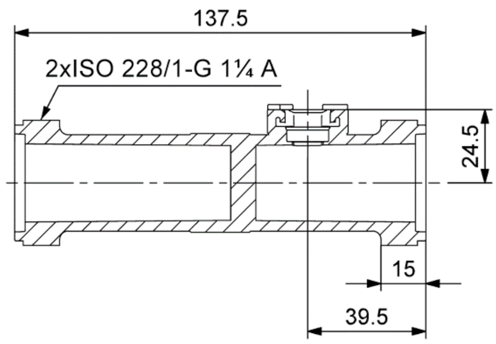
Turbine body

FVA 645 GV100QT



Turbine body

FVA 645 GV200QT



Use

Preparation

The green/yellow ground cable must be connected to the metal part of the sensor.

Measurement

The ALMEMO® connector of the connecting cable already contains important parameters such as measuring range and scaling, so that the output voltage values of the flow sensor and the temperature sensor are already displayed in l/min and °C, respectively.

Sensor protection

The medium flowing through the sensor must not contain any solid parts.

There is a sensitive membrane inside the flow meter. To protect it, sudden pressure surges must be avoided (e.g. snapping of a valve).

3.8.5 Sensor for measuring speed

Measuring principle

For speed measurement on shafts, wheels, fans, etc., the optical reflex method is recommended, for which practically every measuring object can be provided with the corresponding reflex marks.

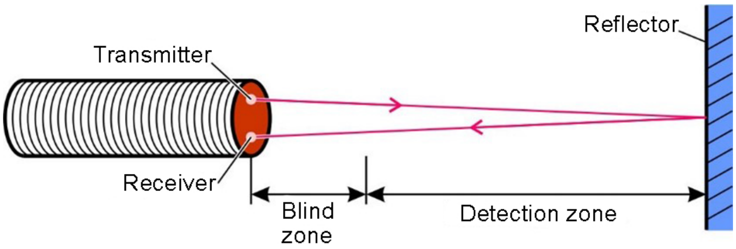


Fig. 3.8.25 Reflection light barrier

With diffuse sensors, the transmitter and receiver form a single unit. The light coming from the emitter is reflected back to the receiver by an opposite object. The sensor switches if the reflected amount of light at the receiver exceeds a certain adjustable threshold.

This amount of light in turn depends on the size and reflection properties of the object. To increase the range and to improve the signal-to-noise ratio, special reflex foils should be used for speed measurement.

Basics

Optical reflection processes include the diffuse reflection light scanner and the photoelectric reflex switch.

Measurement procedure	Characteristic properties
Reflection light barrier (DIN EN 60947: Type D)	Detects only opaque objects. The detection range depends on the reflectivity of the object, i.e. on surface condition and color. Sensitive to dirt and to changes in the reflective properties of the object. These influences can be compensated (within limits) with a controller for sensitivity. Low installation effort, since the sensor consists of one unit and a rough alignment is usually sufficient.
Reflection light barrier (DIN EN 60947: Type R)	The use of retro reflectors achieves long ranges and a better signal-to-noise ratio. Less susceptible to interference, therefore well suited for use under difficult conditions, e.g. outdoor applications or in dirty environments.

3.8.5.1 Speed sensor FUA 9192

Sensor characteristics

Features

The speed probe FUA 9192 works as a diffuse sensor, whose sensitivity can be adjusted with a potentiometer to increase the functional safety.

For pulse evaluation, the speed probe is equipped with a special frequency measuring module that calculates the revolutions per minute from the time between two pulses (see section 4.6.1). A stable display is achieved by averaging over at least 500 ms.

The sensor is equipped with a 1.5 m cable and ALMEMO® connector. The delivery includes five reflective strips.

Types

Sensor	Measuring range	Measuring principle
FUA9192	8 to max. 30000 UpM	Diffuse reflection light scanner

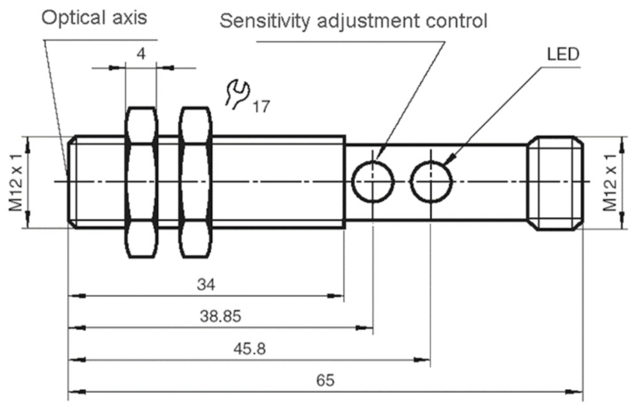
The same probe can also be used with another frequency measurement module as a light barrier for counting or similar purposes.

Technical data

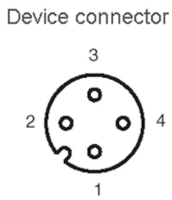
Measuring range	8 to 30000 UpM (maximum)
Light scanning time	> 1 ms
Resolution	1 UpM
Accuracy	Up to 15000 UpM: ± 0.02 % of M. v. ± 1 digit Up to 30000 UpM: ± 0.05 % of M. v. ± 1 digit
Coverage area	20 to 200 mm (depending on reflector)
Sensitivity adjustment	With potentiometer
Recognizable object	Opaque or reflector
Distance hysteresis	≤ 10%
Display switching status	LED yellow
Light type	Red light 660 nm
External light limit	Sun light: ≤ 20000 Lux Halogen light: ≤ 5000 Lux
Ambient temperature	-25°C to + 55°C
Storage temperature	-40°C to +70°C
Protection class	IP 67 (according EN 60529)
Optics	2- lens system PC
Permissible shock load	b ≤ 30 g, T ≤ 1ms
Permissible vibration stress	f ≤ 55 Hz, a ≤ 1 mm
Idle current	≤ 20 mA
Power supply	> 8.5 V DC from meas. instrument, mains adapter recommended
Connection	Instrument connector M12x1 Incl. cable socket M12x1 angled Incl. 1.5 m cable and ALMEMO® connector
Material	Housing: brass, nickel plated Light emission: PMMA
Dimensions	Diameter: M12 x 1 mm Length: 55 mm
Weight	15g
Meets standard	EN 60 947-5-2

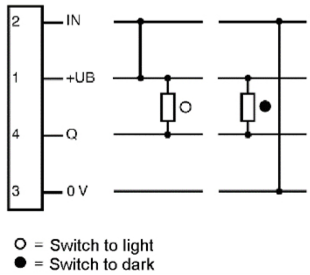
Dimensions

Dimensions in mm



Electric connection:





Use

Preparation

Reflective adhesive tape

The measuring object must show a clear light-dark contrast at its circumference. If several bright sections (e.g. rotor blades) are present, the speed is determined to be correspondingly too high.

The moving part is provided with a reflective adhesive strip and the probe is aligned to it. For function control, a yellow signal lamp lights up on the back of the probe when the reflective tape is detected.

The reflective adhesive strip must be large enough, especially at higher speeds. Otherwise it can easily happen that it cannot be seen by the sensor for a sufficiently long time.

Adjustment and sensitivity

To adjust the sensitivity of the speed sensor, the potentiometer is first turned all the way back and then slowly turned up until the control LED flashes evenly and a stable display appears on the measuring device.

Distance to object

Even if the distance of the sensor from the object to be measured is too small or too large, it can be difficult to detect the light reflected by the reflex adhesive tape. Different distances should be tried.

Measurement

The upper measuring range limit depends on the duty cycle light to dark. At a duty cycle of 1:1 (50%) 30000 rpm are reached, at 1:10 (10%) correspondingly less, i.e. only 6000 rpm.

3.9 Electrical quantities

3.9.1 Clamp current transformer

Measuring principle

Current transformers are used to detect high alternating currents without contact and without interrupting the circuit. In principle they consist of two separate transformer windings (B1 = primary winding with N1 turns, B2 = secondary winding with N2 turns) on a common iron core (closed magnetic circuit).

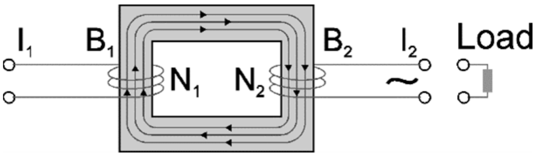


Fig. 3.9.1
Illustration of the meas. principle of a clamp current transformer

If an alternating current I1 flows through winding B1, a current I2 is excited in winding B2, which depends on the winding ratio N1 to N2. In contrast to fixed panel-mounted current transformers, pincer current transformers have a cut open magnetic circuit to be able to enclose a conductor. In practice, the primary winding B1 thus consists of only one turn of the cable through which the current to be measured flows.

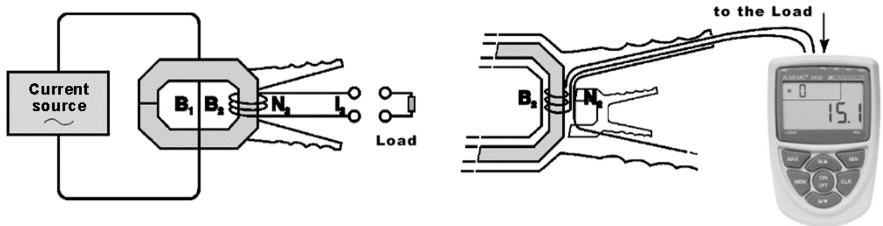


Fig. 3.9.2
Design and function of a clamp current transformer

The following applies to the transmission ratio of a current transformer: $I_1 \cdot N_1 = I_2 \cdot N_2$

Example:
I1 = 100 A N1= 1 winding N2 = 1000 windings
I2 = (I1 x N1) / N2 = 100 x 1 / 1000 = 0.1 A
The transmission ratio is therefore: N2/N1 = I1 / I2 = 100 A / 0.1 A = 1000.

In the multimeter display, each mA AC is therefore equal to 1 A AC (primary current).

Selection, product overview

Reference number	Measuring range	Frequency range	Containment capacity
FEA6049	1 A to 150 A AC	48 Hz to 500 Hz	Cable Ø 10 mm
FEA604MN	0.5 A to 200 A AC	40 Hz to 10 kHz	Cable Ø 20 mm Rail 20 x 5 mm
FEA6044N	2 A to 500 A AC	40 Hz to 1 kHz	Cable Ø 30 mm Rail 30 x 63 mm

Other current clamps with AC voltage output than those offered here can be connected to ALMEMO® devices via the AC voltage module ZA 9603-AKx (see chapter 4.2.2.1).

Application fields

FEA 604-9	Application-oriented design, especially suitable for measurement in narrow wiring. Ideal for measurement of residual currents or measurements on devices with low current consumption.
FEA 604-MN	Asymmetrical shape of the pliers jaws, particularly suitable for enclosing cables and rails. Ideal for measurements in systems with low power.
FEA 604-4N	Asymmetrical shape of the pliers jaws, particularly suitable for enclosing cables and rails. Ideal for measurements in systems with low power.

Notes on measurements

If a very small current is to be measured, it is helpful to lead the cable several times through the opening of the clamp current transformer and then divide the measured current by the number of windings.

3.9.1.1 Clamp current transformer for alternating current Chauvin Arnoux Type Mini 09

Sensor characteristics

Fig. 3.9.3
Clamp current transformer FEA 604-9

Features

The FEA 604-9 has integrated rectification and is equipped with an ALMEMO® connection cable.

Technical data

Measuring range	1 A to 150 A AC	
Measuring accuracy at 50/60 Hz	40 to 150 A: ± 4%	15 to 40 A: ± 3% ± 0.2 A
	5 to 15 A: ± 6% ± 0.2 A	1 to 5 A: ±10% ± 0.2 A
Containment capacity	Cable Ø 10 mm	
Transmission ratio	100 mV DC/1 A AC	
Output signal	15 V DC	
Operating frequency	48 to 500 Hz	
Safety norms	EN 61010-2-032 (version 2/2003)	
Permissible voltage	300 V Cat. IV or 600 V Cat. III	
Weight	About 180 g	
Nominal conditions	25°C ±3 K, 1013 mbar, 20 to 75% rH	
Ambient conditions		
Operating temperature	–10 to +50°C	
Relative humidity	10 to 85% rH	
Storage temperature	–40 to +80°C	

Connection cable	Cable 1.5 m with safety laboratory plugs, incl. safety connection coupling, incl. 1.5 m ALMEMO® connection cable with banana plugs

Dimensions

Length130 mm, Height 37 mm, Width 25 mm

3.9.1.2 Clamp current transformer for alternating current Chauvin Arnoux Type MN 88

Sensor characteristics

Fig. 3.9.4
Clamp current transformer FEA 604-MN

Features

The FEA 604-MN has integrated rectification and is equipped with an ALMEMO® connection cable.

Due to the asymmetrical shape of the pliers jaws, it is particularly suitable for enclosing cables and rails.

Technical data

Measuring range	0.5 A to 200 A AC (The higher value corresponds to 120% of max. nominal value.)
Measuring accuracy at 50 Hz	±3% of measured value ±0.5 A
Containment capacity	Cable Ø 20 mm Rail 20 x 5 mm
Transmission ratio	100 mV DC/1 A AC
Output signal	20 V DC
Operating frequency	40 Hz to 10 kHz
Safety norms	IEC 1010-1
Overvoltage protection	Category III
Weight	About 180 g
Nominal conditions	25°C ±3 K, 1013 mbar
Ambient conditions	
Operating temperature	–10 to +55°C
Relative humidity	0% to 90% rH at max. 40°C
Storage temperature	–40 to +70°C
Connection cable	Built-in banana sockets, incl. 1.5 m ALMEMO® connection cable with banana plugs

Dimensions

Length: 135 mm, Height: 50 mm, Width: 30 mm

3.9.1.3 Clamp current transformer for alternating current Chauvin Arnoux Type Y4N

Sensor characteristics

Fig. 3.9.5
Clamp current transformer FEA 604-4N

Features

The FEA 604-4N has integrated rectification and is equipped with an ALMEMO® connection cable.

Due to the asymmetrical shape of the pliers jaws, it is particularly suitable for enclosing cables and rails.

Technical data

Measuring range	2 A to 500 A AC (The higher value corresponds to 120% of max. nominal value)
Measuring accuracy at 50 Hz	±3% of measured value ±0.5 A
Containment capacity	Cable Ø 30 mm Rail 30 x 63 mm
Transmission ratio	1 mV DC/1 A AC
Output signal	0.5 V DC
Operating frequency	40 Hz to 1 kHz
Safety norms	IEC 348, IEC 1010-2-032
Overvoltage protection	None
Weight	About 420 g
Nominal conditions	25°C ±3 K, 1013 mbar
Ambient conditions	
Operating temperature	–10 to +55°C
Relative humidity	0% to 90% at max. 40°C
Storage temperature	–40 to +70°C
Connection cable	Cable 1.5 m with safety laboratory plugs, incl. safety connection coupling, incl. 1.5 m ALMEMO® connection cable with banana plugs

Dimensions

Length: 215 mm, Height: 66 mm, Width: 34 mm

3.10 Sensors for measuring optical quantities

Basics

What is optical radiation?

Electromagnetic radiation in the wavelength range from 100 nm to 1 mm is called optical radiation. However, the limits of the wavelength range are not sharp and are binding for all applications.

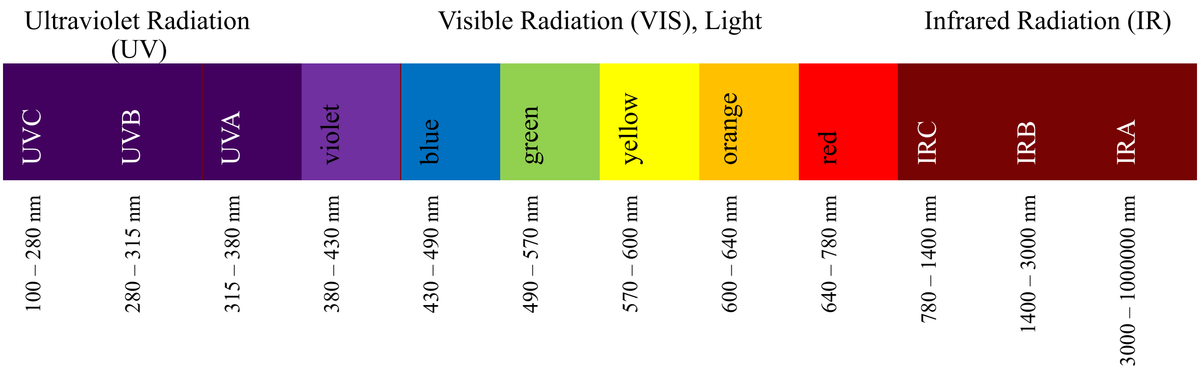


Fig. 3.10.1 Wavelength of optical radiation

Optical radiation can be measured e.g. in radiation physical (radiometric), light technical (photometric), photo-biological or plant physiological parameters.

Comparison of optical quantities in lighting technology and radiation physics

Each photometric quantity corresponds to a radiometric quantity for which the same relationships apply. The differentiation of the quantities is made by index v (visual) and index e (energetic).

Lighting technology			**Radiation physics**		
Quantity	Formula sign	Dimension	Quantity	Formula sign	Dimension
Luminous flux	Φ_V	Lumen lm = cd · sr	Radiant power	Φ_e	W
Light intensity	I_V	Candela cd	Radiant intensity	I_e	W/sr
Luminance	L_V	cd/m²	Radiance	L_e	W/(sr · m²)
Illuminance	E_V	lux lx = lm/m²	Irradiance	E_e	W/m²
Amount of light Exposure	Q_V H_V	Lumen secund lm · s lx · s	Radiant energy Irradiation	Q_e H_e	Ws Ws/m²

Lighting technology / Photometry		Radiation physics / Radiometry	
Photometry	Limited to the range of the optical spectrum (light) visible to the human eye. An essential feature of photometry is the evaluation of the brightness sensation with the spectral brightness sensitivity function of the eye for daytime vision or in rare cases for night vision (DIN 5031). For this reason, radiation detectors for photometric measurement tasks must exhibit one of these spectral sensitivity curves.	Radiometry	Metrological evaluation of optical radiation. The essential feature of radiometry is the wavelength-independent consideration of radiation intensity. Thus, radiometry differs from the weighted measurement quantities used in photometry, photobiology, plant physiology, etc..
Luminous flux	The light output of a light source (lamp, light emitting diode, etc.). Since lamps usually do not emit a parallel light beam, measuring geometries are used to measure the luminous flux. These geometries measure the luminous flux independently of its spatial distribution. These are primarily integrating spheres or goniometers.	Radiant power	The amount of energy per time transported by electromagnetic waves.
Light intensity	The part of a luminous flux that radiates in a certain direction. Luminous intensity is an important parameter for calculating the efficiency and quality of lighting equipment. It is measured by detectors with a defined field of view at distances in which the light source can be considered a point light source.	Radiant intensity	The quotient of the radiant power emitted by a light source in a certain direction and the solid angle irradiated. The radiant intensity serves to measure the spatial distribution of the radiant power.
Luminance	The impression of brightness that an illuminated or luminous surface gives the eye. In many cases, luminance has a much greater significance for the quality of an illumination than illuminance. To measure luminance, measuring heads with a defined measuring field angle are used.	Radiance	The radiance is used for the evaluation of surface emitters. It is the radiant power passing through a surface in a certain direction divided by the solid angle and by the projection of the surface on a plane perpendicular to the considered direction. As measuring geometry special tubes for radiance or telescope attachments are used.

Lighting technology / Photometry		Radiation physics / Radiometry	
Illuminance	The luminous flux that is emitted by one or more light sources horizontally or vertically onto a given surface. In the case of non-parallel incidence of light, which is the rule in practical light measurement technology, a cosine diffuser must be used as the measurement geometry.	Irradiance	The quotient of the radiant power impinging on a surface and the illuminated surface. For the measurement of irradiance, the spatial evaluation of the incident radiation is of great importance, which is why a cosine-corrected field of view function is given.

The spectral evaluation function

The relative spectral sensitivity of the human eye is given for the light-adapted eye (day vision) and for the dark-adapted eye (night vision) with different functions. Because of the individual differences, these data are only average values, but are sufficient for most technical purposes. The detailed data of the spectral sensitivity curves are listed as table in DIN 5031.

The two different spectral effect functions result from the different "sensor types" of the eye. The spectral brightness level for daytime vision (cone, > 10 cd/m^2) is described with the function V(λ) and is the most frequently used function. The spectral luminosity for night vision (rods, < 0.001 cd/m^2) is described with the V'(λ) function and is rarely used in practice.

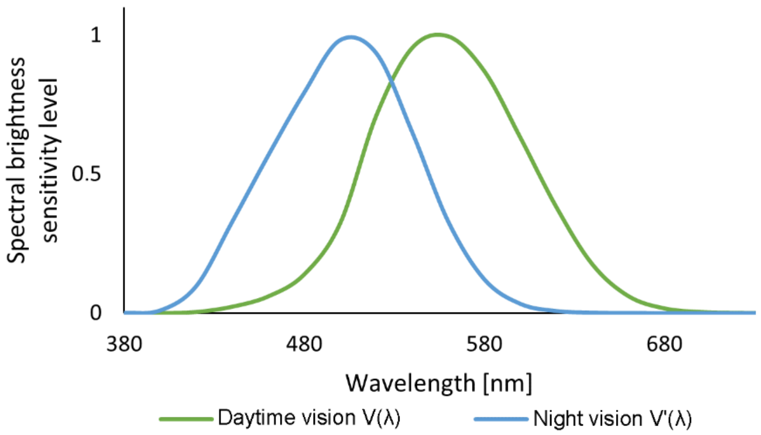


Fig. 3.10.2 Sensitivity of cones and rods in the eye as a function of the wavelength of light, values taken from table 2, DIN 5031, 3rd part

Determination of photometric characteristics

There are internationally recognized recommendations for the metrological evaluation of the properties of materials with regard to their reflection, transmission and absorption as well as the stray light of lenses.

These are primarily CIE 130-1998 "Practical methods for the measurements of reflectance and transmittance", DIN 5036 Part 3 "Radiation physics and photometric properties of materials", DIN 67507 "Light transmittance of glazing, DIN 58186 "Determination of scattered light in optical imaging systems“.

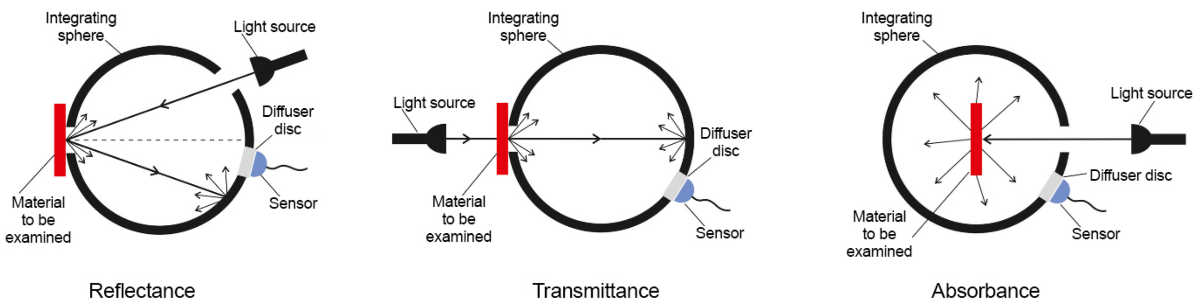


Fig. 3.10.3 Light measurements with integrating sphere

The human eye perceives the different wavelengths of light as colors. The spectral sensitivity of the eye to the different colors depends on the wavelength.

However, light is only the visible part of the electromagnetic spectrum. Ultraviolet radiation in the short wave range and infrared radiation in the long wave range also affect the human organism.

Illuminance:

Humans are used to illuminance levels of daylight. On a cloudy winter day these are values of about 5000 lux, on a sunny summer day about 100000 lux, and with artificial lighting usually only between 100 and 1000 lux are reached.

However, sufficient light is an essential component for the well-being of people. Symptoms of fatigue caused by too little light do not so much affect the eye itself, but rather the entire body.

For this reason, the DIN 5035/2 standard contains guideline values for the illuminance of workplaces to protect health. These are legally stipulated in the guideline ASR 7/3 and must be observed.

The following nominal illuminances apply in closed rooms:

Offices	Office space Writing and drawing places	300 Lux 750 Lux
Factories	Visual work in the production process	1000 Lux
Hotels	Common rooms, reception, cash desk	200 Lux
Stores	Front side of shop windows	1500 - 2500 Lux
Hospitals	Hospital room Emergency rooms	100 - 150 Lux 500 Lux
Schools	Lecture halls, gymnasiums	300 Lux

Irradiance:

For radiometric radiation the term irradiance is used instead of illuminance (only for visible light, photometry).

Global radiation :

Global radiation is an important measure in environmental research and represents the total diffuse and direct solar radiation incident on the earth's surface. The spectral range extends from the short-wave range at 300 nm (UV-B) to the long-wave range at 5000 nm (IR).

UVA radiation:

The long-wave UV radiation (over 313 nm) reaches the earth's surface almost unfiltered, tans the human skin and strengthens the immune system. In solariums, the biological effect of the UVA spectrum is used in combination with other spectral ranges as a trigger for direct pigmentation (melanin coloration). Excessive irradiation promotes damage to connective tissue and skin aging.

UVB radiation:

The short-wave UV range (below 313 nm) can cause irreversible damage. The CIE recommendation summarizes all spectral functions that can have an unfavorable effect on the human skin. This recommendation is described in DIN 5050 and is considered a guideline. A popular measure of sunburn sensitivity is the UV index "UVI" determined by the German Weather Service. The measurement results provide information about medically and biologically relevant correlations directly or in comparison with other spectral ranges.

UV-Index

The UV index is an internationally established measurement. The erythema-effective irradiance (corresponds to the sunburn effectiveness) of the UV radiation E(λ) of a horizontal surface is weighted and integrated with the effect spectrum ser(λ) defined by the CIE (Commission Internationale de l'Eclairage → International Commission on Illumination).

$$E_{CIE} = \int s_{er}(\lambda) \cdot E(\lambda) d\lambda$$

In order to obtain the UV index as a dimensionless value, the UV index is divided by 25 mW/m^2.

The maximum UV index of a day suitable for warnings is defined as the highest 30-minute average value. The weighting function ser (λ) takes into account the damaging effect of radiation, which is strongly dependent on the wavelength.

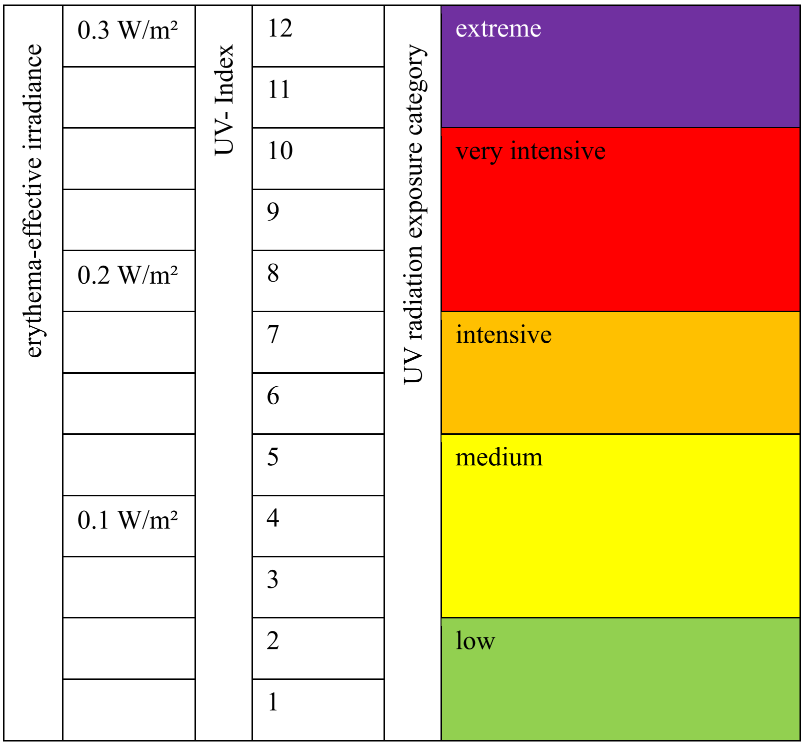


Fig. 3.10.4
Irradiance and UV index

Selection, application fields

Measuring heads for measuring a specific spectral range

Type of radiation	Measured spectral range	Application/Sensor type
V-Lambda radiation	Visible light, according to the sensitivity of the human eye	Interior, FLA623 Outdoor area, FLA633 High resolution, FLA 603
UVA radiation	Long wave UV radiation (tanning effect on the human skin)	Interior, FLA623 Outdoor area, FLA633 High resolution, FLA 603
UVB radiation	Short wave UV radiation	Interior, FLA623 Outdoor area, FLA633
UVC radiation	UVC radiation, e.g. Hg-line at 256 nm	Interior, FLA623
Global radiation	Solar spectrum in the visible range and in the short-wave IR range	Interior, FLA623 Outdoor area, FLA633
IR radiation	Solar spectrum in the short-wave IR range (without visible range)	Interior, FLA623
Quantum radiation	Visible light absorbed by the chlorophyll of plants during photosynthesis	Interior, FLA623 Outdoor area, FLA633 High resolution, FLA 603

Special measuring heads

Quantity	Reference number
Luminance	FLA 603 LDM2
Luminous flux	FLA 603 LSM4
Color temperature	FLAD 23 CCT
Irradiance, Radiometric measuring head	FLA 603 RW4

Sensor type

Image	Reference number	Features
	**FLA623**	For indoor applications
 	**FLA633,** **FLA613**	For outdoor measurements Sensors with dome (FLA633) or plastic ball (FLA613) For direction-independent measurements
	**FLA603**	Optical sensors with high resolution

3.10.1 Measuring heads for V-lambda radiation

Basics

V-lambda radiation is the spectral range of visible light, which corresponds to the sensitivity of the human eye. The measured value is a measure for the perceived brightness.

The wavelength range extends from the end of the UV range at 400 nm to the beginning of the IR range at 720 nm with the maximum at 555 nm. The determined illuminance in 'LUX' can be converted directly into the irradiance 'W/m²'.

Measurements in this area have great importance for workplace design and lighting projects.

Selection, product overview

Sensor type	Spectral sensitivity	Maximum	Measuring range
FLAD03VL1	380 to 720 nm	555 nm	1 lx to 200 klx
FLA623VL	380 to 720 nm	555 nm	0.05 to about 170 klx
FLA633VLM	360 to 760 nm	550 nm	0.05 to about 170 klx
FLA613VLK	360 to 760 nm	555 nm	0 to about 50 klx
FLA603VL2			0.05 to about 9600 lx
FLA603VL4			1 to about 190 klx

Application fields

FLAD03VL1 Can be used in medical biological research, agriculture and automotive industry or for measuring artificial lighting.

FLA623VL For indoor use. For the evaluation of lighting conditions e.g. at the workplace, use in agriculture, the automotive industry.

FLA633VLM Especially suitable for outdoor measurements, e.g. in medical, biological and climate research, in weather information and forecasting systems, in agriculture and for general population information.

FLA613VLK Universally applicable, also outdoors, e.g. for photostability testing according to various international standards and ICH guidelines.

FLA603VL2 In lighting technology. All applications where DIN recommends the use of a class B luxmeter.

FLA603VL4 In sunlight. All applications where DIN recommends the use of a class B luxmeter.

3.10.1.1 Digital measuring head for illuminance (V-Lambda) FLAD 03-VL1

Measuring principle

In nature, radiation always acts on flat surfaces. Accordingly, the receiving characteristic of a radiation measuring receiver should correspond to that of a plane and the angle dependence of the received signal should have a cos-function.

Since the photoelectric converter is often housed in a case protected against environmental influences, devices must restore the original characteristic. New materials, e.g. PTFE, have good scattering properties today and with a suitable empirically determined shape extremely good cosine characteristics can be achieved.

Therefore, after passing through the light entrance window (dome or flat glass) of the sensor, the electromagnetic radiation first hits a diffuser material.

The scattered light is then sorted according to the desired wavelength spectrum using glass filters (optical filter glass).

The remaining electromagnetic radiation hits a chip consisting mainly of silicon and generates a small current flow in its PN junction.

The amount of current flow is equivalent to the irradiance and is brought to the level of the desired output signal by an amplifier unit (operational amplifier). The operational amplifier is also used to calibrate the irradiance to the output voltage, which can then be recorded by a data logger.

Sensor characteristics

Fig. 3.10.5
V-Lamda radiation sensor FLAD03VL1

Features

The measuring head works with its own AD converter. Used extension cables and the measuring device have no influence on the accuracy of the measurement.

The spectral sensitivity is very well adapted to the sensitivity of the human eye and corresponds to device class B according to DIN 5032.

The ALMEMO® D6 sensor has 4 sensor channels, one for the kilolux range and 3 additional channels with different resolutions for the lux range.

This sensor head is equipped with a D6 connector and is therefore particularly suitable for measuring low illuminances.

The measuring head FLAD 03 VL1 has a black anodized aluminium housing and is equipped with a 1.5 m long cable. The measurement is cos-corrected. The measuring head is only suitable for indoor use.

Programming

Measuring range on delivery

Designition	Command	Range	Exp	ALMEMO® measuring range	Dim	Resolution
1. Ev kLux	B-01	DIGI	-2	to 200	kL	0.01 klx
2. Ev Lux0	B-02	DIGI	0	to 65000	Lx	1 lx
3. Ev Lux1	B-03	DIGI	-1	to 6500	Lx	0.1 lx
4. Ev Lux2	B-04	DIGI	-2	to 650	Lx	0.01 lx

Configurable measuring ranges

Designition	Command	Range	Exp	ALMEMO® measuring range	Dim	Resolution
1. Ev kLux	B-01	DIGI	-2	to 200	kL	0.01 klx
2. Ev Lux0	B-02	DIGI	0	to 65000	Lx	1 lx
3. Ev Lux1	B-03	DIGI	-1	to 6500	Lx	0.1 lx
4. Ev Lux2	B-04	DIGI	-2	to 650	Lx	0.01 lx

The measuring ranges of the measuring channels can be configured from a list of ranges in the sensor menu.

Technical data

Measuring range V-Lambda	1 lx to 200 klx
ALMEMO® measuring ranges	MR1: 0.00 to 200.00 klx MR2: 0 to 65000 lx MR3: 0.0 to 6500.0 lx MR4: 0.00 to 650.00 lx
Sensor system	Si / interf. filter
Amplifier IC	8 levels with automatic adjustment
Spectral sensitivity	380 nm to 720 nm, maximum at 555 nm
Minimum resolution	0.02 lx
Diffuser	PTFE
Cos-correction	Error f2 < 2,0%
Linearity	< 1%
Absolute error	< 5%
V-Lambda adjustment	< 3%
Working temperature	-20°C to +60°C
Standard conditions	23°C ± 3 K, 0 to 90% rH (non-condensing)
Signal output	I^2C
Switch-on time	< 1 s
Switch-off time	< 1 s
Measuring time	< 3 s
Refresh rate	1.5 seconds for all channels
Settling time	3 s
Sleep delay	3 s
Energy supply	6 to 13 V DC from the ALMEMO® device
Power consumption	Approx. 4 mA

Cable routing	Lateral, fixed cable, 1.5 m long
Housing	Aluminium, black anodized
Plug colors	Two-colored, light and dark gray, red Lever
Baud rate Standard	115.2 kBd (1200 Bd to 921 kBd selectable)
Mounting	2 screws M3
Weight	Approx. 50 g
ALMEMO® D6 connector	
Refresh rate	1.5 s for all channels
Settling time	3 s (For data logger operation in sleep mode a sleep delay must be programmed)
Supply voltage	From 6 V from the ALMEMO® device
Power consumption	Approx. 4 mA

Spectral sensitivity

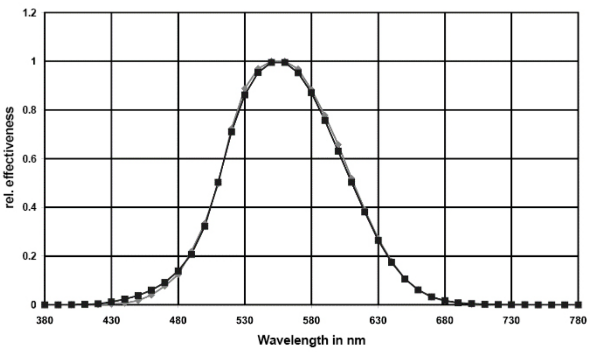
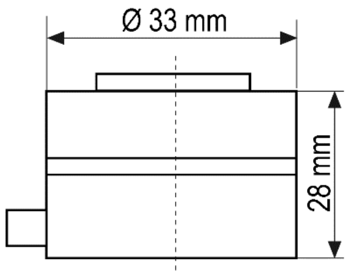


Fig. 3.10.6 Spectral sensitivity of FLAD03VL1

Dimensions

Diameter 33 mm

Height about 29 mm



3.10.1.2 Illuminance measuring head FLA 623 VL

Measuring principle

See chapter 3.10.1.1.

Sensor chracteristics

Fig. 3.10.7
Illuminance measuring head FLA 623 VL

Features

This housing series is suitable for indoor applications. The aluminium housing is scratch-resistant black anodized for long-term use and is equipped with a laterally arranged built-in plug for connecting the ALMEMO® connection cable.

It has a flat light entry window made of Teflon (PTFE). The material is UV-permeable and long-term stable against radiation and environmental influences.

The measuring heads are supplied with a pluggable connection cable (length 2 m) with ALMEMO® connector. The connection cable is also available in lengths of 5 and 10 m.

The ALMEMO® connector of the connection cable already contains important parameters such as measuring range, scaling and physical dimension. The output voltage of the sensor (0 to 2V) is displayed in 2 measuring channels with different resolutions as illuminance in lx (lux) and in klx (kilolux).

The sensor is delivered with a factory test certificate.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Illuminance up to about 20000 lx	1 lx
2. channel	Illuminance up to about 170 klx	0.01 klx

Technical data

Measuring range	0.05 to about 170 klx
Measuring channel	1. channel: up to 20000 lx 2. channel: up to 170 klx
Spectral sensitivity	380 nm to 720 nm, maximum at 555 nm
Diffuser	PTFE
Cos-correction	Error f2 < 3
Linearity	< 1 %
Absolute error	< 5 %
V-Lambda adjustment	< 3 %
Nominal temperature	22°C ±2 K
Working temperature	-20°C to +60°C
Signal output	0 to 2 V
Switch-on time	< 1 s
Energy supply	via ALMEMO® connector (5 to 15 V DC)
Electrical connection	Built-in connector, lateral
Connection cable	PVC cable, pluggable, with ALMEMO® connector
Housing	Aluminium, black anodized
Mounting	2 M2 screws in the base plate
Weight	Approx. 50 g (without cable)

The sensor corresponds to device class B according to DIN 5032.

Spectral sensitivity

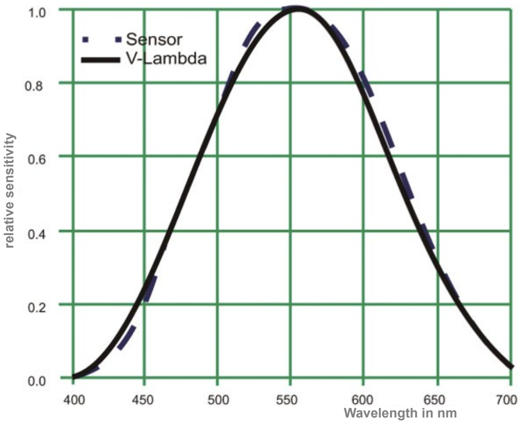
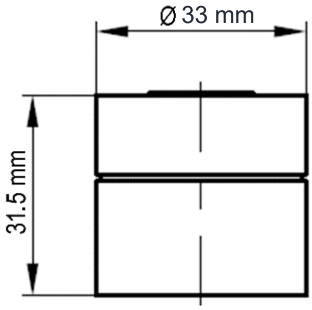


Fig. 3.10.8 Spectral sensitivity of FLA 623 VL

Dimensions

Diameter 33 mm

Height about 32 mm



Use

Increase measurement accuracy

Dark correction

Any dark signal that may occur should be subsequently corrected by dark adjustment in the BASIC VALUE function.

Proceed as follows:

1 Set the locking mode to 4.

2. Place the sensor in a dark room (radiant intensity/illuminance = 0)

3. Perform zero point adjustment. (Press ENTER, DELETE keys)

4. Set the locking mode back to 5.

When entering programming values, please also observe the operating instructions of your measuring device.

Sensor protection

Avoid soiling or scratching the measuring surface (diffuser)!

Calibration

Our optical sensors are calibrated ex works. The calibration values are stored and locked as correction values in the ALMEMO® connector plug.

The calibration values must not be changed!

Never open the sensor! Otherwise the validity of the sensor calibration is no longer guaranteed.

3.10.1.3 Illuminance measuring head FLA 633 VLM

Measuring principle

See chapter 3.10.1.1.

Basics

The irradiance in W/m² measured with this sensor can be converted directly into the illuminance 'Lux'.

Sensor characteristics

Fig. 3.10.9
Illuminance measuring head FLA 633 VLM

Features

This housing series is suitable for outdoor applications. The measuring heads have an anodized aluminium housing, which is scratch-resistant anodized for long-term outdoor applications. Its natural metal color prevents overheating during intense sunlight.

The sensors are equipped with a plastic dome made of polymethylmetacrylate (PMMA). The material is UV-permeable and long-term stable against radiation and environmental influences. It is therefore also used as a viewing window in aircraft cockpits and submarines. The reception characteristics have been tested and proven with great care.

The system is protected against rain and splash water. Silicone-bonded housing parts keep the interior absolutely air and dust free. Inside there is an additional desiccant to prevent fogging of the dome from the inside.

The measuring heads are supplied with a connection cable (length 1.5 m) with ALMEMO® plug for connection to an ALMEMO® device. They are also available with a connection cable of 5 m length.

The ALMEMO® connector of the connection cable already contains important parameters such as measuring range, scaling and physical dimension. The output voltage of the sensor (0 to 2V) is available as a display value for irradiance in W/cm² as well as in kLux.

The sensor is delivered with a test report.

Programming

Measuring channel	Range	ALMEMO® measuring range	Resolution
1. channel	D2.6	Illuminance up to 170 kLux	0.01 kLux
2. channel	D2.6	Illuminance up to about 250 W/cm²	0.01 W/cm²

Technical data

Measuring range	1. channel: 0.05 up to 170 klx 2. channel: 0.07 up to 250 W/cm^2
Spectral sensitivity	360 nm to 760 nm
Max. spectral sensitivity	550 nm
Diffuser	PTFE
Cos-correction	Error f2 < 3%
Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ± 2°C
Working temperature	-20°C to +60°C
Signal output	0 V to 2 V
Residual voltage	(E = 0) < 10 mV
Energy supply	5 V to 15 V
Cable routing	Down
Housing	Anodized aluminium
Dome	PMMA
Mounting	2 screws M4, in base plate
Weight	Approx. 300 g

Spectral sensitivity

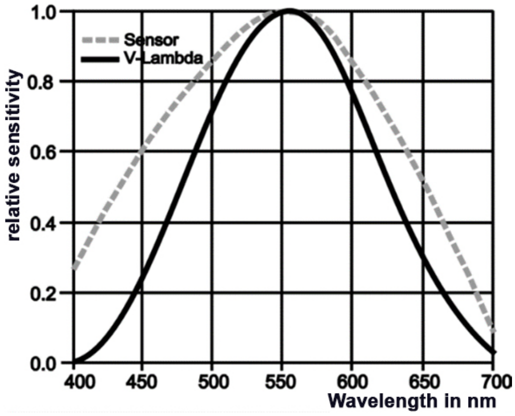
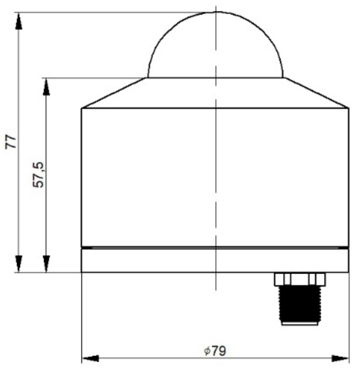


Fig. 3.10.10 Spectral sensitivity of FLA 633 VLM

Dimensions

Dome:	Ø 40 mm
Housing:	Ø 79 mm
Height:	77 mm



Use

Preparation

Screw the measuring head to a suitable holder (e.g. aluminium box profile) using 2 M4 screws. It must be aligned as exactly horizontal as possible. The installation location must be selected so that the measuring head can be exposed to sunlight all day long. The measuring head must have a free horizon in all directions. Installation near houses and trees can falsify the measured value.

Sensor protection

The plastic dome is very sensitive to knocks and scratches. The assembly must be carried out with extreme care.

Damage caused by improper handling and glass breakage are not covered by the warranty.

Calibration

Our optical sensors are calibrated ex works. The calibration values are stored and locked as correction values in the ALMEMO® connector plug.

The calibration values must not be changed!

Never open the sensor! Otherwise the validity of the calibration of the sensor is no longer guaranteed.

Maintenance

The electronic-optical part of the measuring head is maintenance-free, but should be calibrated regularly.

The plastic dome as well as the housing must be cleaned at least twice a year with a soft damp cloth or, if heavily soiled, with clear water or, if necessary, dishwashing detergent, depending on the installation location.

Never use liquid cleaning agents with added abrasive agents or solvents for external cleaning.

3.10.1.4 Omnidirectional illuminance measuring head FLA 613 VLK

Measuring principle

See chapter 3.10.1.1.

Sensor characteristics

Fig. 3.10.11
Illuminance measuring head FLA 613 VLK

Features

This housing series is particularly suitable for non-directional measurements due to the omnidirectional characteristic of the measuring head.

The probes are equipped with a spherical plastic body made of polymethylmetacrylate (PMMA). The material is long-term stable against radiation and environmental influences. The receiving characteristics have been tested and proven with great care.

The measuring heads have an anodized aluminium housing, which is scratch-resistant anodized for long-term outdoor applications. Its natural metal color prevents overheating during intense sunlight.

Zero-ring seals between the housing parts keep the interior absolutely air and dust free. Its humidity is reduced with a desiccant to prevent misting.

For connection to ALMEMO® devices the illuminance measuring head is equipped with an ALMEMO® connection cable (length 1.5 m) as standard. The ALMEMO® plug of the connection cable already contains important parameters such as measuring range, scaling and physical dimension. The output voltage of the sensor (0 to 2V) is available as a display value for illuminance in kLux.

The sensor is delivered with a test report.

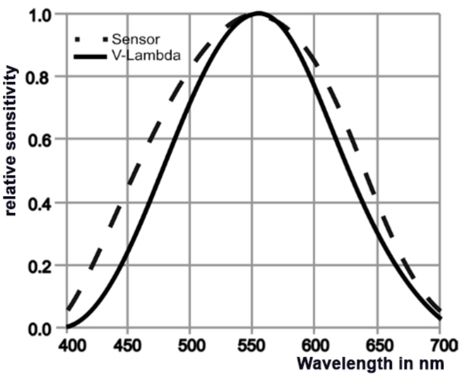
Programming

Measuring channel	Range	ALMEMO® measuring range	Resolution
1. channel	D2.6	Illuminance 0 to 50 kLux	0.01 kLux

Technical data

Measuring range	0 to 50 kLux
Spectral sensitivity	360 nm to 760 nm
Max. spectral sensitivity	555 nm
Diffuser	Plastics
Polar pattern	See diagram below
Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ± 2K
Working temperature	-20°C to +60°C
Signal output	0 V to 2 V
Switch-on time	< 1 s
Energy supply	Via ALMEMO® connector 5 to 15 V
Cable routing	To the side
Sphere	Plastics
Housing	Anodized aluminium
Mounting	2 screws M4, in base plate
Weight	Approx. 100 g

Spectral sensitivity and directional characteristic



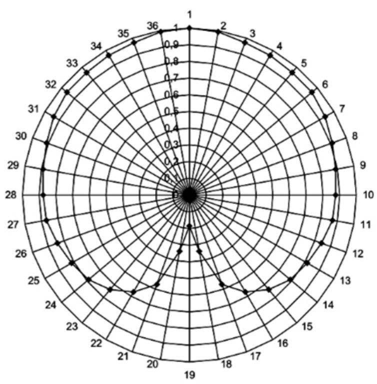
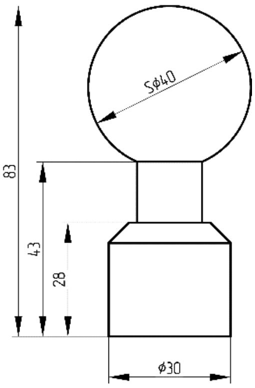


Fig. 3.10.12
Spectral sensitivity and directivity of the FLA 613 VLK

Dimensions

Head: Ø 40 mm

Height: 83 mm



Use

Preparation

See chapter 3.10.1.3.

Sensor protection

See chapter 3.10.1.3.

Maintenance

See chapter 3.10.1.3.

3.10.1.5 Illuminance measuring head FLA 603 VLx according to DIN class B

Measuring principle

High-quality measuring head for determining illuminance, whose spectral adaptation is approximated to the photometric evaluation function V(λ) for daytime vision (DIN quality class B, better 5%)

Sensor characteristics

Fig. 3.10.13
Illuminance measuring head FLA 603 VLx

Features

For direct connection to ALMEMO® devices the illuminance measuring head is equipped with an ALMEMO® connection cable as standard (length approx. 1.5 m, other lengths on request).

The ALMEMO® plug of the connection cable already contains important parameters such as measuring range, scaling and physical dimension, so that the output signal of the sensor is available as a display value of illuminance in lx (Lux).

The sensor is delivered with a factory calibration certificate in lx.

Types

Sensor type	Measuring range
FLA603VL2	0.05 lx to about 9600 lx
FLA603VL4	1 lx to about 190 klx

Programming

FLA603VL2

Measuring channel	Range	ALMEMO® measuring range	Resolution
1. channel	D26	Illuminance	0.01 lx
2. channel	D260	Illuminance	0.1 lx
3. channel	D2.6	Illuminance	0.001 klx

FLA603VL4

Measuring channel	Range	ALMEMO® measuring range	Resolution
1. channel	D26	Illuminance	0.1 lx
2. channel	D260	Illuminance	1 lx
3. channel	D2.6	Illuminance	0.01 klx

Technical data

Measuring range	
FLA603VL2	0.05 lx to about 9600 lx
FLA603VL4	1 lx to about 190 klx
Sensitivity	About 20 pA/lx
Spectral matching	Approximated to photometric evaluation functions V(λ) for daytime vision, class B, better 5
Max. cos-deviation	Class B, < 3%
Nominal temperature	24 °C ± 2K
Working / storage temperature	0 to 60°C / -10 to +80°C
Humidity range	10 to 90% non-condensing

The photometric sensitivity and cosine field of view function corresponds to DIN-5032 part 7 quality class B.

Spectral sensitivity

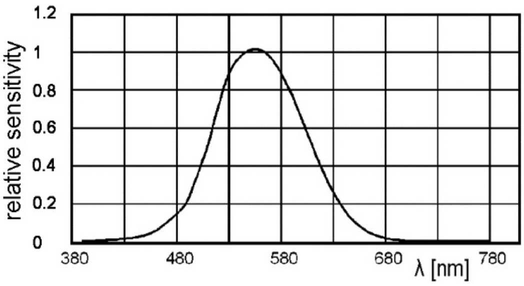
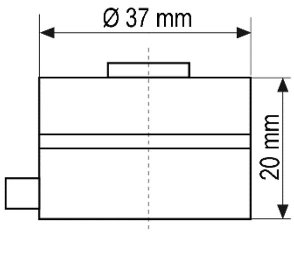


Fig. 3.10.14
Spectral sensitivity of FLA 603 VLx

Dimensions

Diameter:	37 mm
Height:	20 mm
Cos-Diffuser:	Ø 7 mm



3.10.2 Measuring heads for UVA radiation

Basics

UVA radiation has wavelengths in the range from 315 to 380 nm. This long-wave ultraviolet radiation has a tanning effect on the human skin.

Selection, product overview

Sensor type	Spectral sensitivity	Maximum	Measuring range
FLA623UVA	310 to 400 nm	335 nm	0.02 to about 50 W/m^2
FLA633UVA	310 to 400 nm	335 nm	0.001 to about 3 mW/cm^2
FLA613UVAK	310 to 400 nm	355 nm	0 to about 50 W/m^2
FLA603UV12	315 to 400 nm	see Fig. 3.10.22	0.00002 to about 3.8 mW/cm^2
FLA603UV14	315 to 400 nm	see Fig. 3.10.22	0.0004 to about 70 mW/cm^2
FLA603UV22	320 to 400 nm	see Fig. 3.10.24	0.00002 to about 3.8 mW/cm^2
FLA603UV24	320 to 400 nm	see Fig. 3.10.24	0.0004 to about 100 mW/cm^2

Application fields

FLA623UVA	Especially suitable for outdoor measurements, e.g. in medical, biological and climate research, in weather information and forecasting systems, in agriculture and for general population information.
FLA613UVAK	Universally applicable e.g. for photostability testing according to various international standards and ICH guidelines.
FLA 603 UV12	Examinations in occupational medicine
FLA 603 UV14	Measurements in industrial plants
FLA 603 UV22	Examinations in medical therapy
FLA 603 UV24	Industrial measurements of UV radiation curing

3.10.2.1 Illuminance measuring head FLA 623 UVA

Measuring principle

See chapter 3.10.1.1.

The spectral sensitivity is weighted according to the global solar radiation.

Sensor characteristics

Fig. 3.10.15
Illuminance measuring head FLA 623 UVA

Features

This housing series is suitable for indoor applications. The aluminium housing is scratch-resistant black anodized for long-term use and is equipped with a laterally arranged built-in plug for connecting the ALMEMO® connection cable.

It has a flat light entry window made of Teflon (PTFE). The material is UV-permeable and long-term stable against radiation and environmental influences.

For direct connection to ALMEMO® devices the UVA measuring head is equipped with a pluggable ALMEMO® connection cable (length 2 m, optional 5 m and 10 m) as standard.

The ALMEMO® plug of the connection cable already contains important parameters such as measuring range, scaling, and physical dimension, so that the output voltage of the sensor (0 to 2V) is available as a display value for irradiance UVA in W/m^2.

The sensor is delivered with a factory test certificate.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Illuminance up to 50 W/m^2	0.01 W/m^2

Technical data

Measuring range	0.02 to approx. 50 W/m²
Spectral sensitivity	310 to 400 nm, maximum at 335 nm
Diffuser	PTFE
Cos-correction	Error f2 < 3%
Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ± 2 K
Working temperature	-20°C to +60°C
Signal output	0 to 2 V
Switch-on time	< 1 s
Energy supply	Via ALMEMO® connector, (5 to 15 V DC)
Electrical connection	Built-in connector, lateral
Connection cable	PVC cable, pluggable, with ALMEMO® connector
Housing	Aluminium, black anodized
Mounting	2 M2 screws in the base plate
Weight	Approx. 50 g (without cable)

Spectral sensitivity

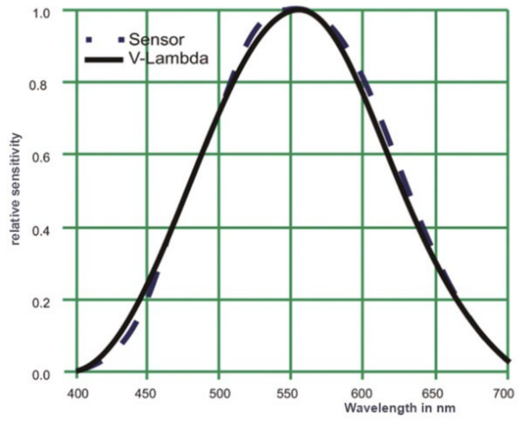
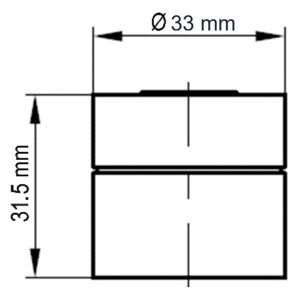


Fig. 3.10.16 Spectral sensitivty of FLA 623 UVA

Dimension

Diameter 33 mm

Height about 32 mm



Use

Increase measuring accuracy

See chapter 3.10.1.2.

Sensor protection

See chapter 3.10.1.2.

3.10.2.2 Illuminance measuring head FLA 633 UVA

Measuring principle

See chapter 3.10.1.1.

The spectral sensitivity is weighted according to the global solar radiation.

Sensor characteristics

Fig. 3.10.17
Illuminance measuring head FLA 633 UVA

Features

This housing series is suitable for outdoor applications. The measuring heads have an anodized aluminium housing, which is scratch-resistant anodized for long-term outdoor applications. Its natural metal color prevents overheating during intense sunlight.

The sensors are equipped with a plastic dome made of polymethylmetacrylate (PMMA). The material is UV-permeable and long-term stable against radiation and environmental influences. It is therefore also used as a viewing window in aircraft cockpits and submarines.

The system is rain- and splash-proof. Silicone-bonded housing parts keep the interior absolutely air and dust free. Inside there is an additional desiccant to prevent fogging of the dome from the inside.

The measuring heads are supplied with a connection cable (length 1.5 m) with ALMEMO® plug for connection to an ALMEMO® device. They are also available with a connection cable of 5 m length.

The ALMEMO® connector of the connection cable already contains important parameters such as measuring range, scaling and physical dimension. The output voltage of the sensor (0 to 2V) is available as a display value for irradiance in mW/cm^2.

The sensor is delivered with a test report.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Illuminance up to 3 mW/cm^2	1 $\mu W/cm^2$

Technical data

Measuring range	0.001 to approx. 3 mW/cm²
Spectral sensitivity	310 nm to 400 nm
Max. spectral sensitivity	335 nm
Diffuser	PTFE
Cos-correction	Error f2 < 3%
Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ± 2K
Working temperature	-20°C to +60°C
Signal output	0 V to 2 V
Residual voltage	(E = 0) < 10 mV
Energy supply	5 V to 15 V, via ALMEMO® connector
Cable routing	Down
Housing	Anodized aluminium
Dome	PMMA (UV-permeable)
Mounting	2 screws M4 in base plate
Weight	Approx. 300 g

Spectral sensitivity

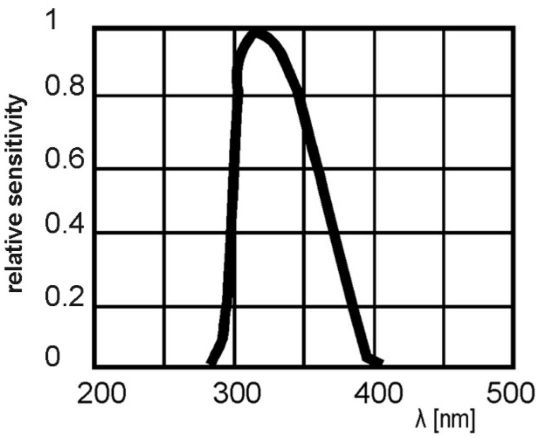
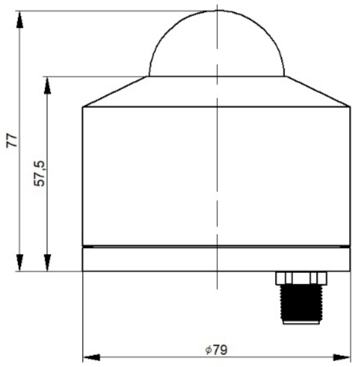


Fig. 3.10.18 Spectral sensitivity of FLA 633 UVA

Dimensions

Dome: Ø 40 mm
Housing: Ø 79 mm
Height: 77 mm



Use

See chapter 3.10.1.3.

Maintenance

See chapter 3.10.1.3.

3.10.2.3 Omnidirectional UVA measuring head FLA 613 UVAK

Measuring principle

See chapter 3.10.1.1.

Sensor characteristics

Fig. 3.10.19
UVA measuring head FLA 613 UVAK

Features

This housing series is particularly suitable for non-directional measurements due to the omnidirectional characteristic of the measuring head.

The probes are equipped with a spherical plastic body made of polymethylmetacrylate (PMMA). The material is long-term stable against radiation and environmental influences. The receiving characteristics have been tested and proven with great care.

The measuring heads have an anodized aluminium housing, which is scratch-resistant anodized for long-term outdoor applications. Its natural metal color prevents overheating during intense sunlight.

Zero-ring seals between the housing parts keep the interior absolutely air and dust free. Its humidity is reduced with a desiccant to prevent misting.

For connection to ALMEMO® devices the illuminance measuring head is equipped with an ALMEMO® connection cable (length 1.5 m) as standard. The ALMEMO® plug of the connection cable already contains important parameters such as measuring range, scaling and physical dimension. The output voltage of the sensor (0 to 2V) is available as a display value for illuminance in W/m^2.

The sensor is delivered with a test report.

Programming

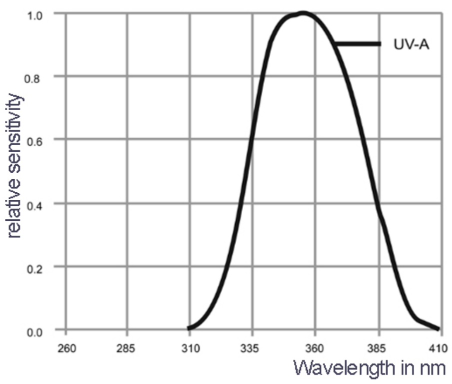
Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Illuminance 0 to 50 W/m²	0.01 W/m²

Technical data

Measuring range	0 to approx. 50 W/m^2
Spectral sensitivity	310 nm to 400 nm
Max. spectral sensitivity	355 nm
Diffuser	PMMA
Polar pattern	See diagram below

Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ± 2K
Working temperature	-20°C to +60°C
Signal output	0 V to 2 V
Switch-on time	< 1 s
Energy supply	Via ALMEMO® connector 5 to 15 V
Cable routing	To the side
Housing	Anodized aluminium
Sphere	PMMA (UV-permeable)
Mounting	2 screws M4, in base plate
Weight	Approx. 100 g

Spectral sensitivity



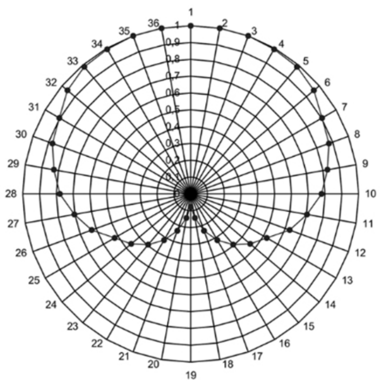
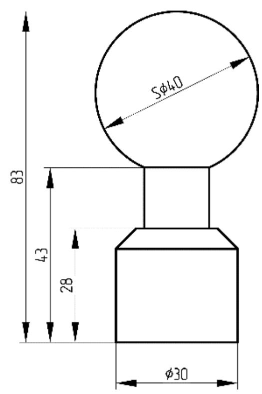


Fig. 3.10.20
Spectral sensitivity and directional characteristic

Dimensions

Head diameter: 40 mm

Total height: 83 mm



Use

Preparation

See chapter 3.10.1.3.

Sensor protection

See chapter 3.10.1.3.

Maintenance

See chapter 3.10.1.3.

3.10.2.4 UVA irradiance measuring head FLA 603 UV12/14

Sensor characteristics

Fig. 3.10.21
UVA irradiance measuring head FLA 603 UV12/14

Features

For direct connection to ALMEMO® devices the UVA irradiance measuring head is equipped with an ALMEMO® connection cable (length approx. 1.5 m, other lengths on request) as standard.

The ALMEMO® connector of the connection cable already contains important parameters such as measuring range, scaling and physical dimension, so that the output signal of the sensor is available as an irradiance display value in mW/cm^2.

The measured values can be distributed to different ALMEMO® measuring channels with different sensitivity.

Measuring geometry with cosine diffuser instead of a simple diffusing plate.

The sensor is delivered with a factory calibration certificate.

Types

Sensor type	Measuring range	Spectral sensitivity
FLA603UV12	0.00002 to 3.8 mW/cm^2	315 to 400 nm
FLA603UV14	0.0004 to 70 mW/cm^2	315 to 400 nm

Programming

For FLA603UV12

Measuring channel	ALMEMO® measuring range	Resolution
1. to 3. channel	Irradiance divided 0.00002 to 3.8 mW/cm^2	Smallest resolution 20 nW/cm^2

For FLA603UV14

Measuirng channel	ALMEMO® measuring range	Resolution
1. to 3. channel	Irradiance devided 0.0004 to 70 mW/cm^2	Smallest resolution 100 nW/cm^2

Technical data

Measuring range	
FLA603UV12	0.00002 to 3.8 mW/cm^2
FLA603UV14	0.0004 to 70 mW/cm^2
Spectral sensitivity	315 to 400 nm
Max. cos-deviation	< 5%
Nominal temperature	24 °C ± 2K
Operating / storage temperature	0 to 60°C / -10 to +80°C
Humidity range	10 to 90% non-condensing

Spectral sensitivity

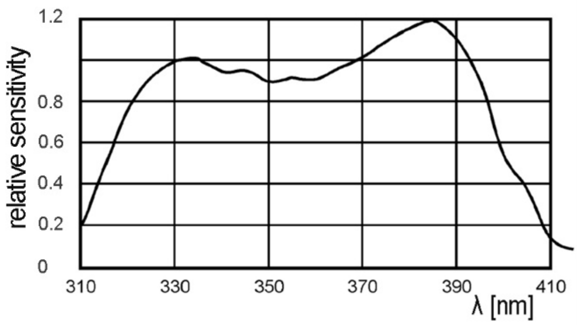


Fig. 3.10.22 Spectral sensitivity of FLA 603 UV12/14

Dimensions

Diameter	37 mm
Height	ca. 32 mm
Cos-diffuser	Ø 15 mm

3.10.2.5 UVA irradiance measuring head FLA 603 UV 22/ 24

Sensor characteristics

Fig. 3.10.23
UVA irradiance measuring head FLA 603 UV 22/24

Features

For direct connection to ALMEMO® devices the UVA irradiance measuring head is equipped with an ALMEMO® connection cable (length approx. 1.5 m, other lengths on request) as standard.

The ALMEMO® connector of the connection cable already contains important parameters such as measuring range, scaling and physical dimension, so that the output signal of the sensor is available as an irradiance display value in mW/cm^2.

The measured values can be distributed to different ALMEMO® measuring channels with different sensitivity.

Measuring geometry with cosine diffuser instead of a simple diffusing plate.

The probe is supplied with a factory calibration certificate.

Types

Sensor type	Measuring range	Spectral sensitivity
FLA603UV22	0.00002 to 3.8 mW/cm^2	320 to 400 nm
FLA603UV24	0.0004 to 70 mW/cm^2	320 to 400 nm

Programming

For FLA603UV22

Measuring channel	ALMEMO® measuing range	Resolution
1. to 3. channel	Irradiance devided 0.00002 to 3.8 mW/cm^2	Smallest resolution 20 nW/cm^2

For FLA603UV24

Measuring channel	ALMEMO® measuring range	Resolution
1. to 3. channel	Irradiance devided 0.0004 to 70 mW/cm^2	Smallest resolution 100 nW/cm^2

Technical data

Measuring range	
FLA603UV22	0.00002 to 3.8 mW/cm^2
FLA603UV24	0.0004 to 70 mW/cm^2
Spectral sensitivity	320 to 400 nm
Max. cos-deviation	< 5 %
Nominal temperature	24 °C ± 2K
Operating- / storage temperature	0 to 60°C / -10 to +80°C
Range of humidity	10 to 90% non condensing

Spectral sensitivity

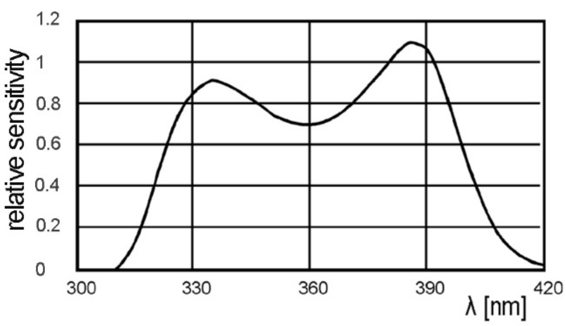


Fig. 3.10.24 Spectral sensitivity of FLA 603 UV 22/24

Dimensions

Diameter	37 mm
Height	ca. 32 mm
Cos-diffuser	Ø 15 mm

3.10.3 Measuring heads for UVB radiation

Measuring principle

UVB radiation is in the range of 280 to 315 nm (wavelengths shorter than UVA radiation).

Selection, product overview

Sensor type	Spectral sensitivity	Maximum	Measuring range
FLA623UVB	265 to 315 nm	297 nm	0.002 to about 5 W/m^2
FLA633UVB	265 to 315 nm	297 nm	0.02 to about 50 $\mu W/cm^2$

Application fields

FLA623UVB Determination of the UV index

FLA633UVB Particularly suitable for outdoor measurements, e.g. in medical, biological and climate research, in weather information and forecasting systems, in agriculture and for general population information.

3.10.3.1 UVB Irradiance measuring head FLA 623 UVB

Measuring principle

See chapter 3.10.1.1.

The spectral sensitivity is weighted according to the global solar erythema radiation (sunburn-producing) according to the recommendation of the CIE (Commission Internationale de l'Eclairage). The UV index can be determined.

Sensor characteristics

Fig. 3.10.25
UVB Irradiance measuring head FLA 623 UVB

Features

This housing series is suitable for indoor applications. The aluminium housing has a scratch-resistant black anodized finish for long-term use and is equipped with a side-mounted connector for plugging in the ALMEMO® connection cable.

It has a flat light entry window made of Teflon (PTFE). The material is UV-permeable and long-term stable against radiation and environmental influences.

For direct connection to ALMEMO® instruments, the UVA measuring head is equipped as standard with a pluggable ALMEMO® connection cable (length 2 m, optionally 5 m and 10 m).

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output voltage of the sensor (0 to 2V) is available as display value irradiance UVB in W/m².

The sensor is delivered with a factory test certificate.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Irradiance to about 5 W/m²	0.001 W/m²

Technical data

Measuring range	0.002 to about 5 W/m²
Spectral sensitivity	265 nm to 315 nm, maximum at 297 nm
Diffusor	PTFE
Cos-correction	Error f2 < 3 %
Linearity	< 1 %
Absolute error	< 10 %
Nominal temperature	22°C ± 2 K
Operating temperature	-20°C to +60°C
Signal output	0 to 2 V
Switch-on time	< 1 s
Power supply	Via ALMEMO® connector, (5 to 15 V DC)
Electrical connection	Built-in connector, lateral
Connection-cable	PVC-cable, connectable, with ALMEMO® connector
Housing	Aluminium, black anodized
Mounting	2 screws M2 in the base plate
Weight	ca. 50 g (without cable)

Spectral sensitivity

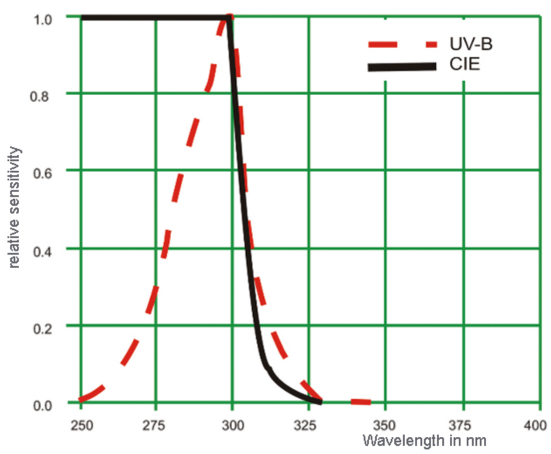
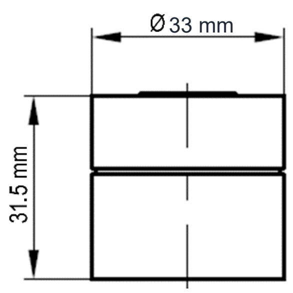


Fig. 3.10.26 Spectral sensitivity of FLA 623 UVB

Dimensions

Diameter 33 mm

Height about 32 mm



Use

Increase measuring accuracy

See chapter 3.10.1.2.

Sensor protection

See chapter 3.10.1.2.

3.10.3.2 UVB measuring head FLA 633 UVB

Measuring principle

See chapter 3.10.1.1.

The relative spectral sensitivity of the sensor is specially adapted to the erythema curve according to DIN 5050.

The erythema sensor precisely detects the skin-damaging components from this spectral range.

Sensor characteristics

Fig. 3.10.27
UVB measuring head FLA 633 UVB

Features

This housing series is suitable for outdoor applications. The measuring heads have an anodized aluminium housing, which is scratch-resistant anodized for long-term outdoor applications. Its natural metal color prevents excessive heating in intense sunlight.

The probes are equipped with a plastic dome made of polymethylmetacrylate (PMMA). The material is UV-transparent and has long-term stability against radiation and environmental influences. It is therefore also used in aircraft cockpits and submarines as a viewing window. The reception characteristics have been tested and proven with great care.

The system is rain and splash proof. Silicon bonded housing parts keep the interior absolutely free of air and dust. Inside there is an additional desiccant to prevent fogging of the dome from the inside.

The measuring heads are supplied with a connection cable (length 1.5 m) that can be plugged into the sensor and has an ALMEMO® plug for connection to an ALMEMO® device. They are also available with a 5 m connection cable.

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output voltage of the sensor (0 to 2V) is available as display value irradiance in $\mu W/cm^2$.

The sensor is supplied with a test protocol.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Irradiance 0 to about 50 µW/cm²	0.01 µW/cm²

Technical data

Measuring range	0 to ca. 50 µW/cm²
Spectral sensitivity	265 nm to 315 nm
Max. spectral sensitivity	297 nm
Diffusor	PTFE
Cos-correction	Error f2 < 3%
Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ± 2K
Operating temperature	–20°C to +60°C
Signal output	0 V to 2 V
Residual voltage (E=0)	< 10 mV
Power supply	5 V to 15 V, via ALMEMO® connector
Cable routing	Down
Housing	Anodized aluminium
Dome	PMMA (UV- permeable)
Mounting	2 screws M4 in the base plate
Weight	About 300 g

Spectral sensitivity

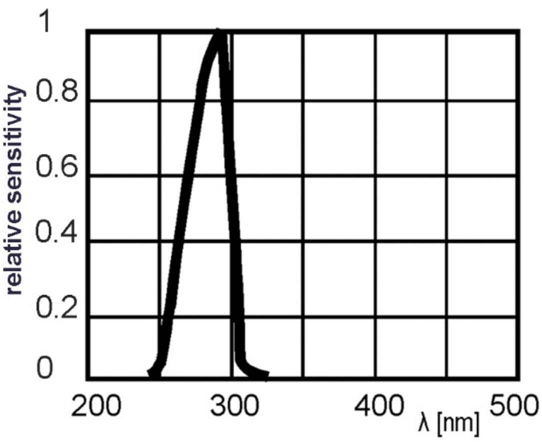
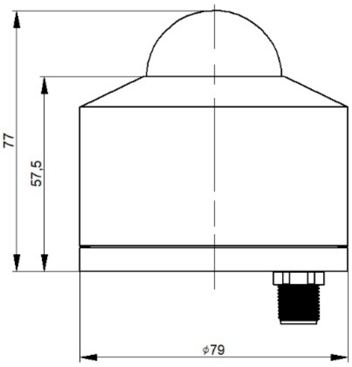


Fig. 3.10.28 Spectral sensitivity of FLA 633 UVB

Dimensions

Dome:	Ø 40 mm
Housing:	Ø 79 mm
Height:	77 mm



Use

Preparation

See chapter 3.10.1.3.

Sensor protection

See chapter 3.10.1.3.

Maintenance

See chapter 3.10.1.3.

3.10.4 Measuring heads for UVC radiation

Selection, product overview

Sensor type	Spectral sensitivity	Maximum	Measuring range
FLA623UVC	220 to 280 nm	265 nm	1 to about 1990 mW/m^2

Application fields

FLA623UVC Measurement of UVC radiation, e.g. Hg line at 256 nm.

The measuring head can be used in water disinfection plants, among others.

3.10.4.1 Irradiance measuring head FLA 623 UVC

Measuring principle

See chapter 3.10.1.1.

Sensor chracteristics

Fig. 3.10.29
Irradiance measuring head FLA 623

Features

This housing series is suitable for indoor applications. The aluminium housing has a scratch-resistant black anodized finish for long-term use and is equipped with a side-mounted plug for plugging in the ALMEMO® connection cable.

It has a flat light entry window made of Teflon (PTFE). The material is UV-permeable and long-term stable against radiation and environmental influences.

For direct connection to ALMEMO® instruments, the UVA measuring head is equipped as standard with a pluggable ALMEMO® connection cable (length 2 m, optionally 5 m and 10 m).

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output voltage of the sensor (0 to 2V) is available as display value irradiance UVC in mW/m².

The sensor is delivered with a factory test certificate.

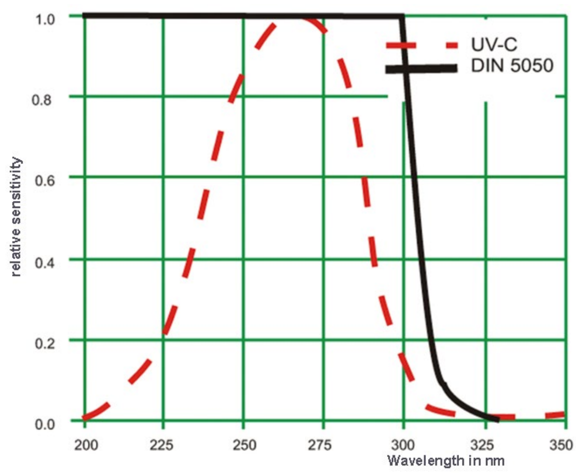
Programming

Measuring channel	ALMEMO® Measuring range	Resolution
1. channel	Irradiance up to about 1990 mW/m²	0.1 mW/m²

Technical data

Measuring range	1 to about 1990 mW/m²
Spectral sensitivity	220 nm to 280 nm, maximum at 265 nm
Diffusor	PTFE
Cos-correction	Error f2 < 3%
Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ± 2 K
Operating temperature	-20°C to +60°C
Signal output	0 to 2 V
Switch-on time	< 1 s
Power supply	Via ALMEMO® connector, (5 to 15 V DC)
Electrical connection	Built-in connector, lateral
Connection cable	PVC-cable, connectable, with ALMEMO® connector
Housing	Aluminium, black anodized
Mounting	2 screws M2 in the base plate
Weight	About 50 g (without cable)

Spectral sensitivity



Dimensions

Diameter 33 mm

Heigth about 32 mm

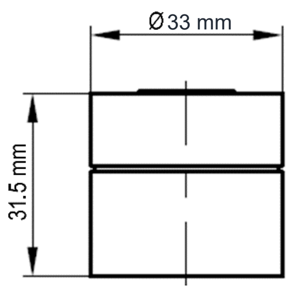


Fig. 3.10.30 Spectral sensitivity of measuring head FLA 623 UVC

Use

Increase measuring accuracy and sensor protection

See chapter 3.10.1.2.

3.10.5 Measuring heads for global radiation

Basics

Global radiation comprises the visible and the short-wave IR range of the solar spectrum. It is composed of the diffuse and direct solar radiation.

Selection, product overview

Sensor type	Spectral sensitivity	Maximum	Measuring range
FLA623GS	400 to 1100 nm	780 nm	0.4 to about 1300 W/m^2
FLA633GS	400 to 1100 nm	780 nm	0.4 to about 1200 W/cm^2

Application fields

FLA633GS Particularly suitable for outdoor measurements, e.g. in medical and biological research, in climate research, in weather information and forecasting systems, in agriculture and for general population information.

3.10.5.1 Irradiance measuring head FLA 623 GS

Measuring principle

See chapter 3.10.1.1.

Sensor characteristics

Fig. 3.10.31
Irradiance measuring head FLA 623 GS

Features

This housing series is suitable for indoor applications. The aluminium housing has a scratch-resistant black anodized finish for long-term use and is equipped with a side-mounted plug for plugging in the ALMEMO® connection cable.

It has a flat light entry window made of Teflon (PTFE). The material is UV-permeable and long-term stable against radiation and environmental influences.

For direct connection to ALMEMO® instruments, the UVA measuring head is equipped as standard with a pluggable ALMEMO® connection cable (length 2 m, optionally 5 m and 10 m).

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output voltage of the sensor (0 to 2V) is available as display value irradiance in W/m².

The sensor is delivered with a factory test certificate.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Global radiation up to 1300 W/m²	0.1 W/m²

Technical data

Measuring range	0.4 up to 1300 W/m²
Spectral sensitivity	400 nm to 1100 nm, maximum at 780 nm
Diffusor	PTFE
Cos-correction	Error f2 < 3%
Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ± 2 K
Operating temperature	-20°C to +60°C
Signal output	0 to 2 V
Switch-on time	< 1 s
Power supply	Via ALMEMO® connector (5 to 15 V DC)
Electrical connection	Built-in connector, lateral
Connection cable	PVC cable, connectable, with ALMEMO® connector
Housing	Aluminium, black anodized
Mounting	2 screws M2 in the base plate
Weight	About 50 g (without cable)

Spectral sensitivity

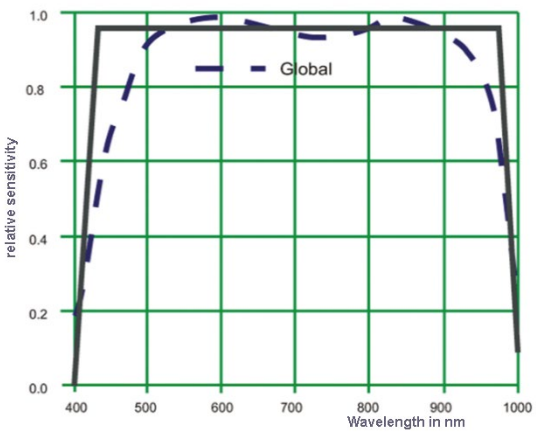
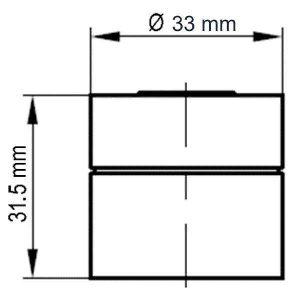


Fig. 3.10.32 Spectral sensitivity of measuring head FLA 623 GS

Dimensions

Diameter	33 mm
Height	about 32 mm



Use

Increase measuring accuracy

See chapter 3.10.1.2.

Sensor protection

See chapter 3.10.1.2.

3.10.5.2 Irradiance measuring head FLA 633 GS

Measuring principle

See chapter 3.10.1.1.

The measuring head detects almost 90% of the solar spectrum in the range from 400 nm to 1100 nm and thus captures VIS (visible light) and part of the short-wave IR range.

Sensor characteristics

Fig. 3.10.33
Irradiance measuring head FLA 633 GS

Features

This housing series is suitable for outdoor applications. The measuring heads have an anodized aluminium housing, which is scratch-resistant anodized for long-term outdoor applications. Its natural metal color prevents excessive heating in intense sunlight.

The probes are equipped with a plastic dome made of polymethylmetacrylate (PMMA). The material is UV-transparent and has long-term stability against radiation and environmental influences. It is therefore also used in aircraft cockpits and submarines as a viewing window. The reception characteristics have been tested and proven with great care.

The system is rain and splash proof. Silicon bonded housing parts keep the interior absolutely free of air and dust. Inside there is an additional desiccant to prevent fogging of the dome from the inside.

The measuring heads are supplied with a connection cable (length 1.5 m) that can be plugged into the sensor and has an ALMEMO® plug for connection to an ALMEMO® device. They are also available with a 5 m connection cable.

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output voltage of the sensor (0 to 2V) is available as display value irradiance in W/cm².

The sensor is delivered with a test protocol.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Irradiance 0 to about 1200 W/cm²	1 W/cm²

Technical data

Measuring range	0 up to 1200 W/cm²
Spectral sensitivity	400 nm to 1100 nm
Max. spectral sensitivity	780 nm
Diffusor	PTFE
Cos-correction	Error f2 < 3%
Linearity	< 1%
Absolute Error	< 10%
Nominal temperature	22°C ± 2 K
Operating temperature	–20°C to +60°C
Signal output	0 V to 2 V
Residual voltage	(E = 0) < 10 mV
Power supply	5 V to 15 V, via ALMEMO® connector
Cable routing	Down
Housing	Anodized aluminium
Dome	PMMA
Mounting	2 screws M4, in base plate
Weight	About 300 g

Spectral sensitivity

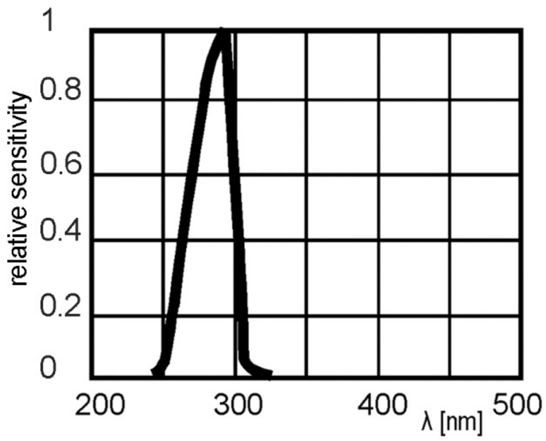
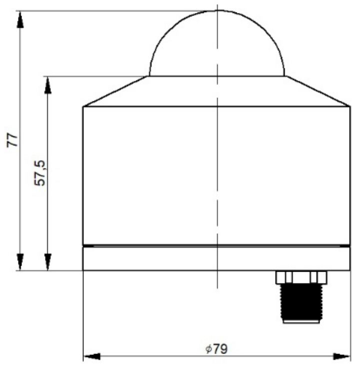


Fig. 3.10.34 Spectral sensitivity of measuring head FLA 633 GS

Dimensions

Dome: Ø 40 mm
Housing: Ø 79 mm
Height: 77 mm



3.10.6 Measuring heads for infrared radiation

Selection, product overview

Sensor type	Spectral sensitivity	Maximum	Measuring range
FLA623IR	800 to 1100 nm	950 nm	0.1 to about 400 W/m^2

Application fields

FLA623IR The measuring head measures in the short-wave infrared range. It is therefore particularly suitable for measuring the infrared portion of the solar spectrum.

3.10.6.1 Irradiance measuring head FLA 623 IR

Measuring principle

See chapter 3.10.1.1.

Sensor characteristics

Fig. 3.10.35
Irradiance measuring head FLA 623 IR

Features

This housing series is suitable for indoor applications. The aluminium housing has a scratch-resistant black anodized finish for long-term use and is equipped with a side-mounted plug for plugging in the ALMEMO® connection cable.

It has a flat light entry window made of Teflon (PTFE). The material is UV-permeable and long-term stable against radiation and environmental influences.

For direct connection to ALMEMO® instruments, the UVA measuring head is equipped as standard with a pluggable ALMEMO® connection cable (length 2 m, optionally 5 m and 10 m).

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output voltage of the sensor (0 to 2V) is available as display value irradiance in W/m².

The sensor is delivered with a factory test certificate.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Infrared radiation up to about 400 W/m²	0.01 W/m²

Technical data

Measuring range	0.1 to about 400 W/m²
Spectral sensitivity	800 nm to 1100 nm, maximum at 950 nm
Diffusor	PTFE
Cos-correction	Error f2 < 3%
Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ± 2 K
Operating temperature	-20°C to +60°C
Signal output	0 to 2 V
Switch-on time	< 1 s
Power supply	Via ALMEMO® connector, (5 to 15 V DC)
Electrical connection	Built-in connector, lateral
Connection cable	PVC cable, connectable, with ALMEMO® connector
Housing	Aluminium, black anodized
Mounting	2 screws M2 in the base plate
Weight	About 50 g (without cable)

Spectral sensitivity

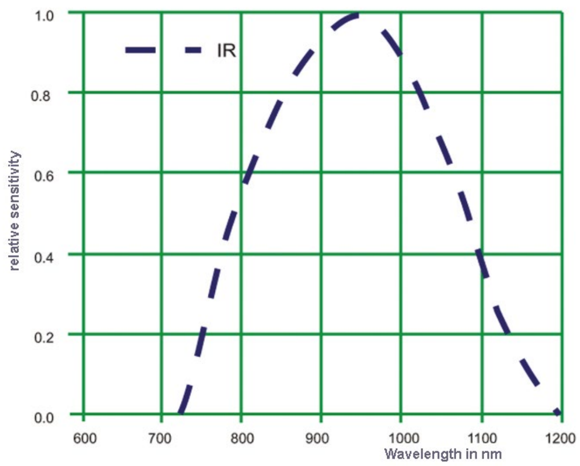
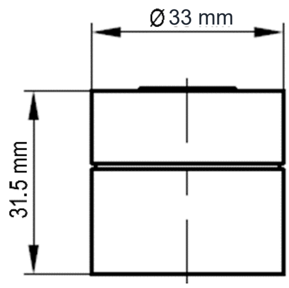


Fig. 3.10.36 Spectral sensitivity of measuring head FLA 623 IR

Dimensions

Diameter	33 mm
Height	about 32 mm



Use

Increase measuring accuracy

See chapter 3.10.1.2.

Sensor protection

See chapter 3.10.1.2.

3.10.7 Measuring heads for quantum radiation

Basics

Quantum radiation is the part of visible light that is absorbed by the chlorophyll of plants. The number of absorbed photons is decisive for the productivity of photosynthesis. Therefore, it is not the irradiance that is measured in W/m^2, but the photon flux density in $\mu mol/m^2s$.

Selection, product overview

Sensor type	Spectral sensitivity	Maximum	Measuring range
FLA623PS	380 to 720 nm	420 and 700 nm	1 to about 3000 $\mu mol/m^2s$
FLA603PS4	400 to 700 nm	see Fig. 3.10.40	0.0002 to 3.8 $\mu mol/m^2s$
FLA603PS5	400 to 700 nm	see Fig. 3.10.40	0.2 $\mu mol/m^2s$ to 7 $mmol/m^2s$

Application fields

FLA623PS	To assess the development conditions of plants in the open field and greenhouse.
FLA603PS4/PS4WG	Measurement of photosynthetically effective irradiances. Measurement of residual light (twilight, artificial lighting).
FLA603PS5/PS5WG	Measurement of photosynthetically effective irradiances. Measurement in the greenhouse area in daylight.

3.10.7.1 Quantum radiation measuring head FLA 623 PS

Measuring principle

See chapter 3.10.1.1.

Sensor characteristics

Fig. 3.10.37
Quantum radiation measuring head FLA 623 PS

Features

This housing series is suitable for indoor applications. The aluminium housing has a scratch-resistant black anodized finish for long-term use and is equipped with a side-mounted plug for plugging in the ALMEMO® connection cable.

It has a flat light entry window made of Teflon (PTFE). The material is UV-permeable and long-term stable against radiation and environmental influences.

For direct connection to ALMEMO® instruments, the UVA measuring head is equipped as standard with a pluggable ALMEMO® connection cable (length 2 m, optionally 5 m and 10 m).

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output voltage of the sensor (0 to 2V) is available as a display value the photon current density in µmol/m²s.

The sensor is delivered with a factory test certificate.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Quantum radiation up to 3000 µmol/m²s	0.1 µmol/m²s

Technical data

Measuring range	1 to about 3000 µmol/m²s
Spectral sensitivity	380 nm to 720 nm, maximum to 420 and 700 nm
Diffusor	PTFE
Cos-correction	Error f2 < 3%
Linearity	< 1%
Absolute error	< 10%
Nominal temperature	22°C ±2 K
Operating temperature	-20°C to +60°C
Signal output	0 to 2 V
Switch-on time	< 1 s
Power supply	Via ALMEMO® connector, (5 to 15 V DC)
Electrical connection	Built-in connector, lateral
Connection cable	PVC cable, connectable, with ALMEMO® connector
Housing	Aluminium, black anodized
Mounting	2 screws M2 in the base plate
Weight	About 50 g (without cable)

Spectral sensitivity

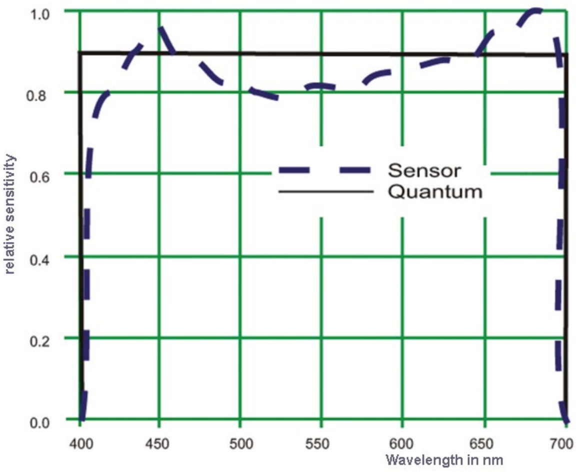
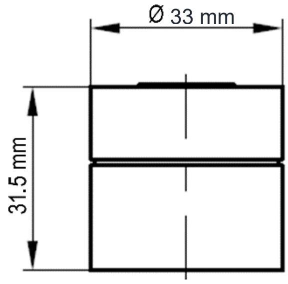


Fig. 3.10.38 Spectral sensitivity of FLA 623 PS

Dimensions

Diameter 33 mm

Height about 32 mm



Use

Increase measuring accuracy

See chapter 3.10.1.2.

Sensor protection

See chapter 3.10.1.2.

3.10.7.2 Photosynthesis measuring head FLA 603 PS4/ PS4WG/ PS5/ PS5WG

Sensor characteristics

Fig. 3.10.39
Photosynthesis measuring head FLA 603 PSxxx

Features

For direct connection to ALMEMO® devices, the UVA irradiance measuring head is equipped with an ALMEMO® connection cable (length approx. 1.5 m, other lengths on request) as standard.

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output signal of the sensor is available as a display value photon current density in µmol/m²s.

The measured values can be divided among different ALMEMO® measuring channels with different sensitivities.

Measuring geometry with cosine diffuser instead of simple diffusing disk for highest quality requirements.

Waterproof versions of this probe with transparent quartz dome (see figure 3.10.39) are available.

The probe is delivered with a factory calibration certificate.

Types

Sensor type	Measuring range	Spectral sensitivity	Type of radiation
FLA603PS4	0.2 nmol/m²s to 3.8 µmol/m²s	400 to 700 nm	Photosynthetically active radiation
FLA603PS4WG	0.2 nmol/m²s to 3.8 µmol/m²s	400 to 700 nm	Photosynthetically active radiation, waterproof version with transparent quartz dome
FLA603PS5	200 nmol/m²s to 7 mmol/m²s	400 to 700 nm	Photosynthetically active radiation
FLA603PS5WG	200 nmol/m²s to 7 mmol/m²s	400 to 700 nm	Photosynthetically active radiation, waterproof version with transparent quartz dome

Programming

For FLA603PS4 / PS4WG

Measuring channel	ALMEMO® measuring range	Resolution
1. to 3. channel	Photosynthetic irradiance divided 0.2 nmol/m²s to 3.8 µmol/m²s	Smallest resolution 0.2 nmol/m²s

For FLA603PS5 /PS5WG

Measuring channel	ALMEMO® measuring range	Resolution
1. to 3. channel	Photosynthetic irradiance divided 0.2 µmol/m²s to 7 mmol/m²s	Smallest resolution 0.1 µmol/m²s

Technical data

Measuring range	
FLA603PS4	0.2 nmol/m²s to 3.8 µmol/m²s
FLA603PS4WG	0.2 nmol/m²s to 3.8 µmol/m²s
FLA603PS5	200 nmol/m²s to 7 mmol/m²s
FLA603PS5WG	200 nmol/m²s to 7 mmol/m²s
Spectral sensitivity	400 to 700 nm
Max. cos-deviation	< 5%
Cos-Diffusor	Ø 15 mm
Operating-/storage temperature	0 to 60°C / -10 to +80°C
Range of humidity	10 to 90% non condensing

Spectral sensitivity

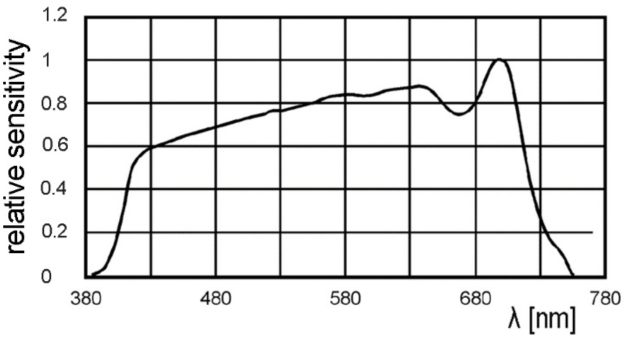


Fig. 3.10.40 Spectral sensitivity of FLA 603 PSxxx

Dimensions

Diameter: 37 mm

Heigth: about 35 mm

3.10.8 Measuring heads for luminance

Selection, product overview

Sensor type	Measuring range
FLA603LDM2	Luminance devided 0.04 cd/m^2 to 6400 cd/m^2

Application fields

FLA603LDM2 Self-luminous surfaces such as color monitors, alphanumeric displays, information signs and illuminated panels.

Reflective surfaces such as walls and equipment at the workplace, projection surfaces, traffic and information signs as well as roadways and taxiways.

3.10.8.1 Luminance measuring head FLA 603 LDM2 according DIN-class B

Sensor chracteristics

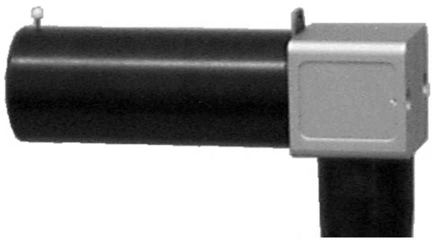


Fig. 3.10.41
Luminance measuring head FLA 603 LDM2

Features

The luminance measuring head with 1° field of view is equipped with achromatically corrected low-stray light optics and a high-quality V(λ) detector according to DIN Class B.

The external sighting device allows an exact aiming of the measuring point at a working distance of 1 m, therefore the sensor is particularly suitable for the evaluation of the luminance for service and constancy tests.

For direct connection to ALMEMO® devices, the luminance measuring head is equipped with an ALMEMO® connection cable as standard (length approx. 1.5 m, other lengths on request). The measured values can be distributed to different ALMEMO® measuring channels with different sensitivities. Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output signal of the sensor is available as a display value luminance in cd/cm².

The sensor is supplied with a factory calibration certificate.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. to 3. channel	Luminance devided 0.04 cd/m^2 to 6400 cd/m^2	Smallest resolution 10 mcd/m^2

Technical data

Range of display	0.04 cd/m² to 6400 cd/m²
Smallest resolution	10 mcd/m²
Field of view	1°
Field of view diameter	About 30 mm at 0.5 m distance About 40 mm at 1 m distance About 120 mm at 5 m distance
Spectral matching	Approximated to photometric Evaluation functions V(λ) for day vision, class B, better 6%
Nominal temperature	24°C ± 2K
Operating-/storage temperature	0 to 60°C / -10 to +80°C
Humidity range	10 to 90% non condensing
Measuring surface	21 x 21 mm at 1 m operating distance
Standards met	IEC 61223-2-5, DIN 5032-T.7

Dimensions

Diameter	30 mm
Length	150 mm

3.10.9 Measuring heads for luminous flux

Selection, product overview

Sensor type	Measuring range
FLA603LSM4	Luminous flux 0.0002 lm to 38 lm

Application fields

FLA603LSM4 Suitable for cold light sources, lamps with high color temperature and virtually monochromatic radiation like that of light emitting diodes, furthermore endoscopes, fiber optic bundles, light emitting diodes.

3.10.9.1 Luminous flux measuring head FLA 603 LSM4 according DIN class B

Sensor chracteristics

Fig. 3.10.42
Luminous flux measuring head FLA 603 LSM4

Features

The FLA 603 LSM4 is a measuring head for luminous flux measurement with integrating sphere. The coating of the sphere with BaSO4 ensures diffuse reflectivity and spectrally neutral reflection behavior.

It meets the requirements of DIN quality class B.

For direct connection to ALMEMO® instruments, the measuring head is equipped with an ALMEMO® connection cable as standard (length approx. 2 m, other lengths on request).

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output signal of the sensor is available as the display value luminous flux in lm (lumen).

The sensor is supplied with a factory calibration certificate.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. channel	Luminous flux 0.0002 lm to 38 lm	Smallest resolution 0.001 lm

Technical data

Range of display	0.0002 lm to ca. 38 lm
Smallest resolution	0.001 lm
Sensitivity	20 nA/lm
Acceptance angle	To 90°
Accuracy	DIN grade B
Nominal temperature	24°C ± 2K
Operating-/storage temperature	0 to 60°C / -10 to +80°C
Application temperature	Max. 100°C inside the sphere
Range of humidity	10 to 90% non condensing

Spectral sensitivity

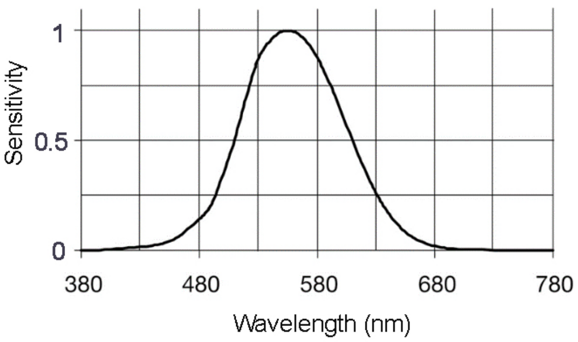
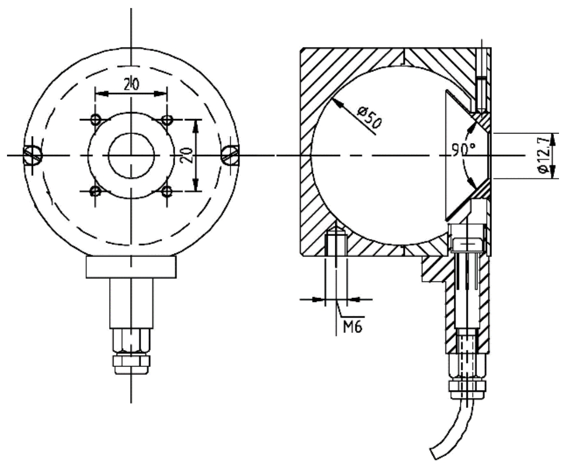


Fig. 3.10.43 Spectral sensitivity of FLA 603 LSM4

Dimensions

Sphere diameter: 50 mm

Measuring hole: 12.7 mm



3.10.10 Measuring heads for color temperature

Measuring principle

The main component of the color temperature sensor is a silicon diode chip with a diameter of about 3 mm.

The chip has a honeycomb structure with many receiver tripletts.

The light entering through a diffuser is split by optical filters on the triplets into the RGB colors (red, green, blue) needed to calculate the color temperature. The diffuser is used to generate the directional characteristic according to DIN.

The light generates three RGB-equivalent electrical currents in the diodes. These currents are measured by a microprocessor and calculated with each other using a formula.

The calculation results in the color point in the RGB color space with the coordinates X and Y and the corresponding color temperature (Correlated Color Temperature CCT in Kelvin). Since the color used, G = green, has the spectral sensitivity of the human eye, its signal can be used to determine the illuminance in lux and also show it on the display.

Selection, product overview

Sensor type	Spectral sensitivity	Measuring range
FLAD23CCT	380 to 720 nm	**Color temperature**: 54 K to 30000 K (at 120 lx to 170 klx) **V-Lambda:** MB1: 10 to 65000 lx MB2: 0.05 to 170.00 klx

Application fields

FLAD23CCT Determination of color temperature and illuminance for measurement and evaluation of lighting systems.

3.10.10.1 Measuring head for color temperature and Illuminance FLAD 23 CCT

Sensor chracteristics

Fig. 3.10.44
Measuring head for color temperature and illuminance FLAD 23 CCT with ALMEMO® connector

Features

The D6 color temperature sensor FLAD23CCT is equipped with a TrueColor sensor chip and integrated signal processor. The three color sensors are adapted to the standard spectral curves according to CIE or DIN.

The sensor is supplied with a manufacturer's test certificate.

For direct connection to ALMEMO® instruments, the measuring head is equipped with an ALMEMO® connection cable (length approx. 1.5 m) as standard.

Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output signal of the sensor is available as a display value color temperature in Kelvin and illuminance in Lux.

Programming

Measuring ranges on delivery

Designation	Command	Range	Exp	Meas. range	Dim	Resolution
Color temperature (CCT)	B-01	DIGI	0	to 30000	K	1 K
Illuminance (Illumin.)	B-02	DIGI	0	to 65000	Lx	1 lx

Configurable measuring ranges

Designation	Command	Range	Exp	Meas. range	Dim	Resolution
Color temperature (CCT)	B-01	DIGI	0	to 30000	K	1 K
Illuminance (Illumin.)	B-02	DIGI	0	to 65000	Lx	1 lx
Illuminance (Illumin.)	B-03	DIGI	-2	to 170.00	kL	0.01 klx
X-value	B-04	DIGI	-4	to 1.0000	X	0.0001
Y-value	B-05	DIGI	-4	to 1.0000	Y	0.0001

Technical data

Spectral sensitivity	380 nm to 720 nm
Sensor system	TrueColor (MAZET), 3 sensors on 1 chip
Amplifier-IC	8 levels with automatic adjustment
Meas. range color temperature CCT	54 K to 30000 K (at 120 lx to 170 klx)
Accuracy	< 10% (in the range 1600 K to 17000 K)
Coordinate resolution (dx, dy)	< 0.005
Measuring range V-Lambda	MB1: 10 to 65000 lx (factory setting) MB2: 0.05 to 170.00 klx
Accuracy	< 10% (in the range 120 lx to 170 klx)
Cos-correction	8 mm diffusing lens
Cos-error	< 3%
Measuring time	< 3 s
Nominal conditions	23°C ± 3 K, 0 to 90% rH (non condensing)
Operating temperature	-10°C to +40°C
ALMEMO® connection cable	Fixed cable 1.5 m with ALMEMO® D6 connector
ALMEMO® D6 connector	
Refresh rate	1.5 s for all channels
Settling time	3 s (a sleep delay of 3 s must be programmed for data logger operation in sleep mode)
Power supply	6 to 13 V DC
Power consumption	About 4 mA

Spectral sensitivity

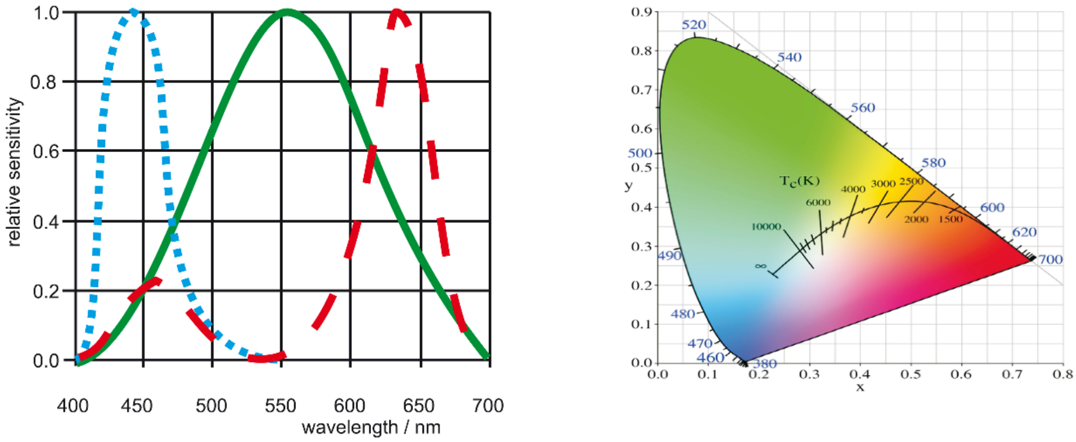
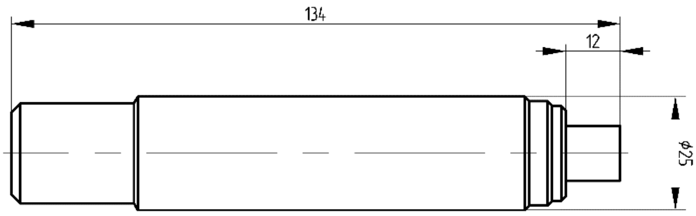


Fig. 3.10.45 Spectral sensitivity (left). On the right the measured values x and y and the color determined from them.

Dimensions

Diameter: 25 mm

Length: 134 mm



3.10.11 Radiometric measuring heads

Selection, product overview

Sensor type	Spectral sensitivity	Measuring range
FLA603RW4	400 to 800 nm	40 nW/cm^2 to 7 mW/cm^2

3.10.11.1 Radiometric measuring head FLA 603 RW4 for measuring the irradiance

Sensor characteristics

Features

The FLA 603 RW4 measuring head has a measuring geometry with cosine diffuser instead of a simple diffusing disc.

For direct connection to ALMEMO® devices, it is equipped with an ALMEMO® connection cable as standard (length approx. 1.5 m, other lengths on request).

The measured values can be divided among various ALMEMO® measuring channels with different sensitivities. Important parameters such as measuring range, scaling and physical dimension are already stored in the ALMEMO® connector of the connection cable, so that the output signal of the sensor is available as display value irradiance in mW/cm^2.

The sensor is delivered with a factory calibration certificate.

Programming

Measuring channel	ALMEMO® measuring range	Resolution
1. to 3. channel	Irradiance devided 40 nW/cm^2 to 7 mW/cm^2	Smallest resolution 10 nW/cm^2

Technical data

Measuring range	40 nW/cm^2 to 7 mW/cm^2
Spectral sensitivity	400 to 800 nm
Max. cos-deviation	< 5%
Cos-diffuser	Ø 15 mm
Operating-/storage temperature	0° to +60°C / -10° to +80°C
Humidity range	10 to 90% non condensing

Spectral sensitivity

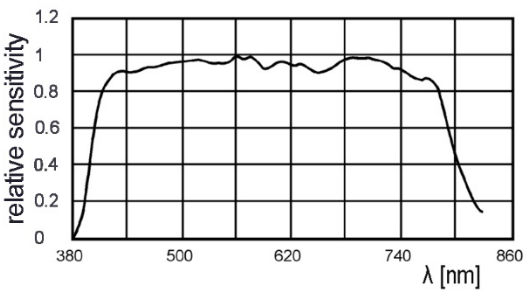


Fig. 3.10.46 Spectral sensitivity of FLA 603 RW4

Dimensions

Diameter: 37 mm

Height: 50 mm

3.11 Water analysis - pH, redox, conductivity, oxygen

Selection, application

pH electrodes	The pH value is a logarithmic measure of the concentration of H+ ions in an aqueous solution and thus describes in numerical values whether it reacts acidically, neutrally or alkaline. The pH scale ranges from pH 0 to pH 14, pH 7 is neutral. The further the pH value deviates from 7, the more aggressive the sample. Per pH unit, the acidic or basic effect increases by a factor of 10.
Redox electrodes	The level of the redox potential (measured in mV) indicates how strongly the test solution oxidizes or reduces. A negative voltage value means that the solution is reducing compared to a normal hydrogen electrode. A positive value indicates that the solution is oxidizing. Since the killing of microorganisms (disinfection) is directly related to the oxidizing power (of e.g. chlorine), the redox potential is successfully used to monitor disinfection processes, e.g. in baths. Redox measurements are also used to control the denitrification of wastewater (redox kink point determination), for detoxification in electroplating operations and to monitor a wide range of chemical processes (e.g. cyanide oxidation or chromate reduction).
Conductivity electrodes	Conductivity (unit S/m = Siemens/meter) is a measure of the ion concentration in a test sample. The more salt, acid or base a measuring solution contains, the higher the conductivity. Ultrapure waters have a conductivity of about 0.05 µS/cm (at 25°C), natural waters about 100 - 1000 µS/cm, some bases (e.g. potassium hydroxide solutions) up to just over 1000 mS/cm. In practice, conductivity measurement is used to monitor plants, to produce ultrapure water or to determine the salinity of seawater.
Electrode for measurement of dissolved oxygen	Oxygen is not only a component of air, but also occurs dissolved in water and practically every liquid. For example, at a temperature of 20°C and an air pressure of 1013 mbar, water contains about 9 mg/l oxygen in its saturated state. Every liquid absorbs as much oxygen as necessary until the partial pressure of the oxygen in the liquid and the air in contact with it are equal. The actual oxygen concentration increases with increasing air pressure and decreasing temperature. Electrodes for measuring dissolved oxygen are used, for example, to record oxygen consumption during microbiological degradation processes or oxygen production, e.g. by algae growth. The oxygen concentration is of decisive importance for animals and organisms living in the water and for the biological clarification of municipal and industrial wastewater. Corrosion processes in pipes and the shelf life of beverages also depend on the dissolved oxygen in the liquid.

3.11.1 Measuring the pH value

Measuring principle

When measuring the pH value and the redox potential, the chain voltage between two electrodes is determined by potentiometric measurement.

Basics

The pH value is a logarithmic measure of the concentration of H+ ions in an aqueous solution and thus describes in numerical values whether it reacts acidically, neutrally or alkaline. The pH scale ranges from pH 0 to pH 14, pH 7 is neutral. Some examples of pH values of everyday substances:

Examples for pH values of different liquids

Measured material			pH value
Water	Mineral water	Altmühltaler, without gas	7.3
	Mineral water	Astorda Elitess, with gas	5.2
	Tap water		7.4
Beverages, without alcohol	Green tea	1. Infusion	6.9
	Green tea	2. Infusion	7.6
	Espresso		5.5
	Apple spritzer	Comet	3.4
Beer	Weltenburger		4.5
Wine	Pinot Grigio	Valdadigo 2006	3.4
	Cabernet Sauvignion	Pinotage 2006	3.6
Fruits	Nectarine		3.9
	Kiwi		4.0
	Pineaple		3.7
	Plum		5.2
Others	Wellness apple vinaigre	Elderberry	2.9

pH electrode

A pH electrode for pH measurement always consists of a measuring electrode and a reference electrode, either in the form of a separate two-rod electrode (two individual electrodes) or in the form of the easier-to-handle single-rod electrode (see below, Fig. 3.11.1).

The actual pH-sensitive sensor part is the glass membrane of the measuring electrode. A potentiometric difference occurring here corresponds to the pH value difference between the inside and outside.

Inside the measuring electrode is the internal electrolyte buffered to pH7 and the internal discharge. The reference electrode consists of a reference electrolyte, the outer discharge line and a diaphragm, which represents the electrolytically conductive connection between the reference electrolyte and the measuring solution.

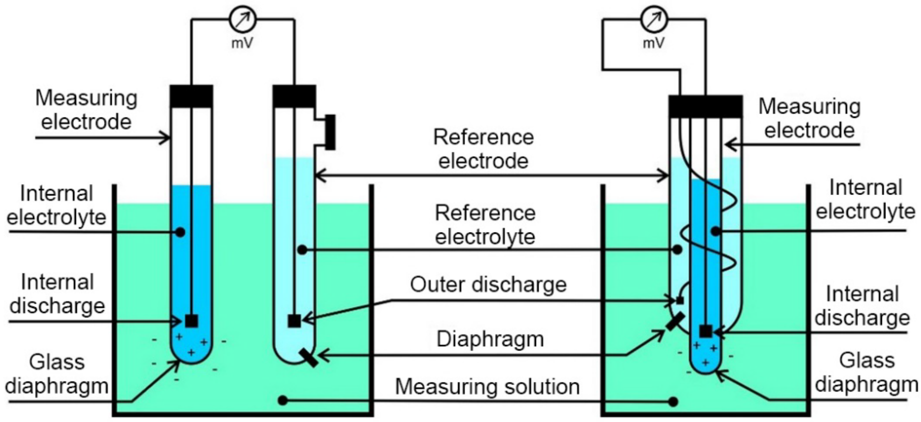


Fig. 3.11.1 Drawing explaining single- and dual-rod electrodes

Measuring signal

The pH measuring signal of a pH electrode has its theoretical zero point at pH 7 and changes by 59.2 mV at 25°C when the pH value of the measuring solution changes by one pH. The voltage is positive for acidic solutions (pH0 to pH7) and negative for alkaline solutions (pH7 to pH14). The slope increases by 0.2 mV/K with increasing temperatures and decreases accordingly with decreasing temperatures.

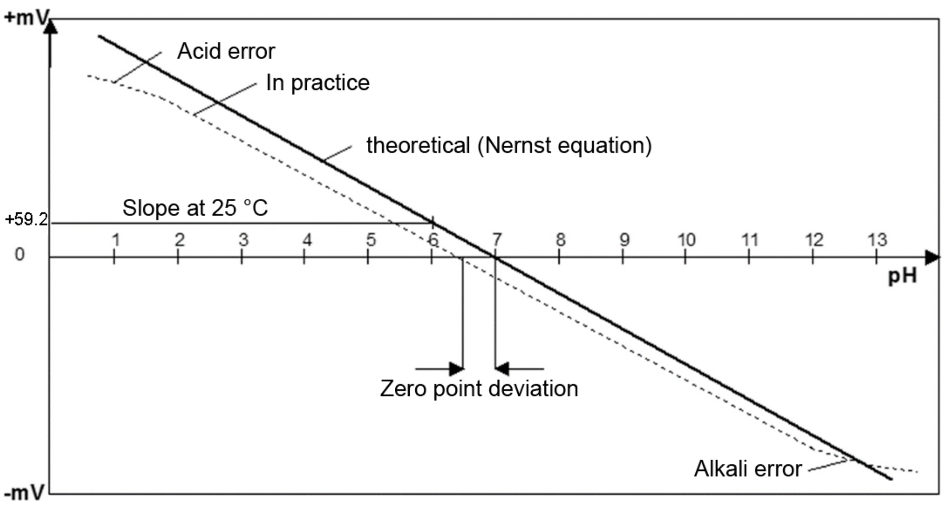


Fig. 3.11.2 Measurement signal of a pH electrode in practice and theoretically calculated via the Nernst equation

In practice, the measurement signal of a pH electrode deviates more or less from the so-called Nernst equation:

1. The real zero point is slightly shifted compared to the theoretical pH7.

2. The slope may be lower than the theoretical value due to age.

3. The slope may decrease at very high pH values. This is commonly referred to as alkali error and depends on the glass type of the membrane glass.

4. At very low pH values, the so-called acid error can occur, i.e. the slope also decreases slightly here.

5. Depending on the conditions of use, the measuring signal can be falsified by many other influences, e.g. aging, penetration of measuring solution into the reference electrode, deposits on the glass membrane.

Due to the manufacturing tolerances and the many possible influences, each electrode must be adjusted with buffer solutions with a defined pH value at the specified temperatures.

Selection, product overview

pH electrodes

Sensor type	Meas. range	Application range	Conductivity	Diaphragma	Refillable
FY96PHEK	pH 1 … 12	pH 0 … 13 / 0 … 60°C	> 150 µS / cm	Fiberglass	–
FY96PHER	pH 1 … 12	pH 0 … 13 / 0 … 80°C	> 50 µS / cm	PTFE	–
FY96PHEN	pH 0 … 12	pH 0 … 13 / 0 … 80°C	> 150 µS / cm	Ceramic	x
FY96PHEE	pH 1 … 12	pH 0 … 13 / 0 … 60°C		Ceramic	x

ALMEMO® Connection cable with transducer

Reference number	Programmed for	Connection socket	Connector	See also …
ZA 9610-AKY4	pH electrode	S7/SN6	Standard connector	
ZA 9610-AKY6	pH- or Redox electrode	S7/SN6	Standard connector	
ZA 9640-AKY8	pH electrode with built-in temperature sensor NTC (30 kΩ at 25°C)	SMEK	Standard connector	
ZA 9610-AKY8	pH electrode	SMEK	Standard connector	
ZYD7 10-AK4	pH electrode	S7/SN6	D7 connector	Chapter 4.7.2.2
ZYD7 40-AK4	pH electrode	S7/SN6	D7 connector, temperature sensor NTC	Chapter 4.7.2.2

Plug head S7/SN6: Coaxial plug with screw connection.
All connection cables are available in lengths of 2 or 5 m.

Solutions for refilling and adjusting the pH electrodes

KCl solution, 3-molar	ZB 98PH-NL
Buffer solution pH 4.0	ZB 98PH-PL4
Buffer solution pH 7.0	ZB 98PH-PL7
Buffer solution pH 10.0	ZB 98PH-PL10

Application fields

FY96PHEK	Manual measurements e.g. swimming pool, drinking water
FY96PHER	Municipal and industrial wastewater, drinking and process water, chemicals, paper production, food industry
FY96PHEN	Hand measurement in the laboratory
FY96PHEE	pH measurements in semi-solid or pasty media, e.g. foods such as meat, cheese

Notes on the measurement

Make sure that no moisture gets into the plug connection when screwing both the pH and the redox electrode into the connection head because of the high-impedance signal.

Galvanic isolation

For connection cables with standard plugs (see table above) the following applies:
Measurements with more than one pH electrode must not be carried out simultaneously in one bath due to the lack of galvanic isolation. The same applies to redox electrodes and conductivity probes. However, the sensors are designed in such a way that measurements can be taken simultaneously with both a pH electrode and a redox electrode as well as a conductivity probe in one bath.

For connection cables with D7 connector (see table above) the following applies:
There is galvanic isolation from the ALMEMO® V7 meter. Therefore, several pH probes can be operated in the same sample solution on one measuring instrument without influencing each other.

Adjustment for ALMEMO® connection cable with standard connector (ZA 96x0-AKYx)

After connecting the ALMEMO® plug to the measuring instrument, the measuring system is ready for use. However, the sensor should be readjusted at regular intervals according to the conditions of use. To adjust the pH electrodes, we offer three buffer solutions as accessories. The measuring accuracy is ultimately also determined by the accuracy and purity of the buffer solution.

- ZB 98 PHPL4: pH 4 (±0.05pH at 25°C)
- ZB 98 PHPL7: pH 7 (±0.05pH at 25°C)
- ZB 98 PHPL10: pH 10 (±0.05pH at 25°C)

The buffer solution with pH7 is used for zero point correction.

On delivery, the dimension 'PH' or 'pH' is stored in the connectors of the sensors. This specification means that not only an automatic zero point correction, but also an automatic slope correction is possible. During adjustment, the locking mode for the correction values must not be set higher than 3. Afterwards, the locking mode should be reset to 5.

In order to get easily into the adjustment mode and to carry out the adjustment, there are different key combinations for the individual instruments (see instrument operating instructions chapter 'Sensor adjustment' or manual chapter 6.4.2).

First, the zero point correction is always carried out with the buffer solution pH7.

Zero point correction:

1. Hold pH electrode in buffer solution pH 7.
2. Wait for the measured value to stabilize.
3. Perform zero point adjustment (see operating manual of the respective measuring instrument). The zero point error is automatically stored in the connector. The instrument displays exactly "7.00 PH".
4. If possible, rinse the sensor with distilled water.
5. Dab the sensor with a soft, lint-free paper towel.

Do NOT rub the sensor! This can otherwise lead to electrostatic charges and thus to falsification of the measured values.

Gradient correction:

1. Hold pH electrode in buffer solution pH4 for acidic or pH10 for basic test solutions.
2. Wait for the measured value to stabilize.
3. Perform a slope adjustment (see operating manual of the respective measuring instrument). The slope is recalculated and saved, the sensor is now exactly calibrated.
4. Rinse and dab the sensor (see above).

If incorrect buffer solutions or used sensors are used, the adjustment may no longer provide correct correction values. In this case, the standard values (slope correction -0.1689, base value -7.00) can be restored with the function 'Reset measured value' (see device operating manual).

Adjustment for ALMEMO® connection cable with D7 connector (ZAD7 x0-AK4)

The adjustment can be made via the sensor menu, see chapter 4.7.2.2.

Measurement

1. Immerse the sensor in the test sample and swirl it slightly. The electrode must be immersed so far that at least the diaphragm is covered with test sample.
2. When a stable measured value is reached, read off and record the value.
3. Rinse the sensor and store it moist in KCL solution.

Temperature compensation for ALMEMO® connection cable with standard connector (ZA 96x0-AKYx)

The calculation of the pH value is based on the electrode slope at 25°C or, after adjustment, on the slope at the buffer solution temperature. If the temperature of the measured medium deviates strongly from the reference temperature, then temperature compensation is possible with all ALMEMO® instruments. With the aid of the reference channel, any temperature sensor with a resolution of 0.01°C (Ntc or P204) can be used for compensation (see section 6.3.4). However, for continuous measurements, a measuring point query (cyclic or continuous) must be used to ensure that the measured temperature value is continuously updated.

With most instruments, the compensation temperature (see operating manual of the instruments) can also be entered manually. The pH value is then compensated with the entered temperature. The programming is described in the operating manual of the respective device.

Temperature compensation for ALMEMO® connection cable with D7 connector (ZAD7 x0-AK)

The temperature compensation can be done via the sensor menu, see chapter 4.7.2.2. Either a temperature value can be entered manually for compensation or reference can be made to an external Ntc sensor.

Maintenance

Storage of pH and redox electrodes

The pH and redox combination electrodes must only be stored moist. To do this, pour some 3-molar KCl solution into the protective caps and slide them onto the sensor.

Life time

The sensors are subject to natural aging even when handled properly. Depending on the intended use, a service life of between half a year and a maximum of three years can be specified. In individual cases, especially under extreme operating conditions, the service life may be reduced to days.

Cleaning and care

The sensors should be visually inspected regularly (approx. once a month) and cleaned if necessary. If the contamination on the glass membrane cannot be removed with a damp cloth, the following cleaning agents may be used:

Deposit type	Detergent	Duration of exposure
General deposits	Non-abrasive household cleaners	
Lime or metal hydroxides	Diluted hydrochloric acid (about 0.1% - 3%)	1-5 min.
Oils, fats	Solvents, such as alcohol or acetone	
Biological coatings	Solution of diluted hydrochloric acid and pepsin	Several hours

In principle, sufficient rinsing must be carried out after each cleaning operation.

3.11.1.1 FY96PHEK

Sensor characteristics

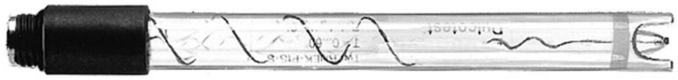


Fig. 3.11.3
pH electrode FY96PHEK

Features

Gel-filled, non-refillable pH electrode with plastic shaft and glass fiber diaphragm.

ZA9610AKY4 or ZYD7x0AK4 measuring transducer cables (see chapter 'Selection, product overview' above) are available for all common electrodes with coaxial connector. In order to prevent the measuring signal from being distorted by the measuring device, an extremely high-impedance measuring amplifier (>500 GΩ) is integrated in the ALMEMO® connector of the connection cable in the case of pH measuring chains.

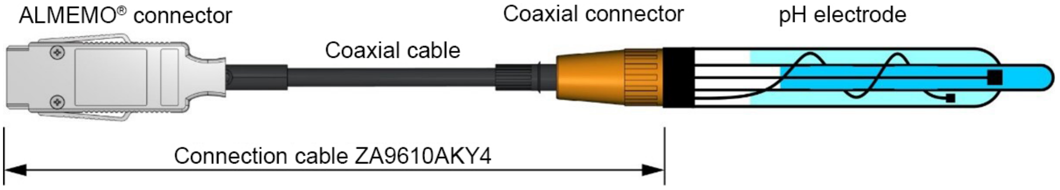


Fig. 3.11.4 pH electrode with connection cable ZA 9610-AKY4

Programming

Connection cable ZA9610AKY4

In order to achieve a representation of the pH value with two decimal places according to the Nernst equation with a measuring range of 2.6000 V, the connector of the ZA9610AKY4 connection cable is programmed as follows as standard.

Range	Dimension	Gradient correction	Base value	Exponent	Locking mode
d2600	PH	-0.1689 100 (1.00pH): 592 (59.2mV)	- 7.00	2	5

Programming connection cable ZYD7x0AK4

See chapter 4.7.2.2.

Technical data

pH electrode FY96PHEK

Measuring range	pH 1 to 12
Application range	pH 0 to 13 / 0° to 60°C
Max. pressure	Unpressurized operation
Conductivity	> 150 µS/cm
Diaphragm	Fiberglass
Reference	Ag/AgCl (3mol KCl / Gel)
Head of electrode	Plug-in head SN6

Measuring transducer in the ALMEMO® connection cable ZA9610AKY4

Measuring range	pH 0.00 to 14.00
Input resistance	> 500 GΩ
Amplification	1
Potential of the reference electrode with respect to GND	< 2 V
Power consumption	< 1 mA
Line length	< 100 m

Technical data ALMEMO® connection cable ZYD7x0AK4

Measuring range	
pH	0.00 to 14.00 pH
Redox	-1100.00 to +1100.00 mV
Temperature	-50.00 to +125.00°C
AD converter	Delta-Sigma
Accuracy	
pH/Redox	0.02% from M. v. ± 2 Digit
Temperature	±0.05 K in the range of -50.00 to +100.00°C
Temperature drift	Max. 40 ppm/K
Nominal temperature	23°C ± 2 K
Application range	-10 to +60°C 10% to 90% rH (non condensing)
Refresh rate	0.8 s
Power supply	6, 9, 12 V from ALMEMO® measuring device
Power consumption	ca. 8 mA
Connector colors	Housing ruby red, black lever

Dimensions

Shaft length 125 ± 3 mm

Plastic shaft diameter 12 mm (material Polycarbonate)

3.11.1.2 FY96PHER

Sensor characteristics

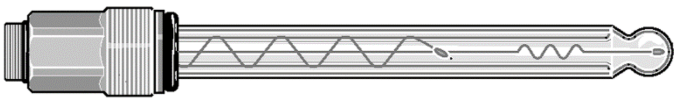


Fig. 3.11.5 pH electrode FY96PHER

Features

Polymer-filled, non-refillable pH electrode with glass shaft, PTFE ring diaphragm and screw-in thread PG 13.5.

Connection cable see chapter 3.11.1.1.

Programming

See chapter 3.11.1.1.

Technical data

pH electrode FY96PHER

Measuring range	pH 1 to 12
Application range	pH 0 to 13 / 0° to 80°C
Max. pressure	6 bar
Conductivity	> 50 µS / cm
Diaphragm	PTFE ring diaphragm
Reference	Ag with AgCl stock (3 mol KCl / Polymer)
Head of electrode	Plug-in head SN6

Technical data of the measuring transducer in the ALMEMO® connection cable ZA9610AKY4

See chapter 3.11.1.1.

Technical data of ALMEMO® connection cable ZYD7x0AK4

See chapter 4.7.2.2.

Dimensions

Installation length 120 ± 3 mm

Diameter 12 mm (material glass)

Screw-in thread PG 13.5

Use

Sensor protection

Not suitable for media containing chlorine / fluoride or measurements with frequent temperature fluctuations.

3.11.1.3 FY96PHEN

Sensor characteristics

Fig. 3.11.6 pH electrode FY96PHEN

Features

KCl refillable pH electrode with glass shaft, refill nozzle, ceramic diaphragm.

Connectrion cable see chapter 3.11.1.1.

Programming

See chapter 3.11.1.1.

Technical data

pH electrode FY96PHEN

Measuring range	pH 0 to 12
Application range	pH 0 to 13 / 0° to 80°C
Max. pressure	Unpressurized operation
Conductivity	> 150 µS/cm
Diaphragm	Ceramics - Diaphragm
Reference	Ag/AgCl – stock (3mol KCl / licquid) KCl electrolyte refillable
Head of electrode	Plug-in head SN6

Technical data of the measuring transducer in the ALMEMO® connection cable ZA9610AKY4

See chapter 3.11.1.1.

Technical data of ALMEMO® connection cable ZYD7x0AK4

See chapter 4.7.2.2.

Dimensions

Shaft length 160 ± 3 mm

Diameter 12 mm (material glass)

3.11.1.4 FY96PHEE

Sensor characteristics

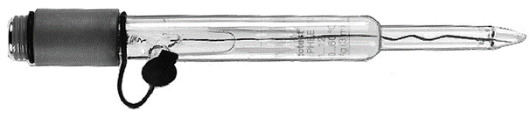


Fig. 3.11.7 pH electrode FY96PHEE

Features

KCL refillable pH insertion electrode with glass shaft, ceramic diaphragm

Connection cable see chapter 3.11.1.1.

Programming

See chapter 3.11.1.1.

Technical data

pH electrode FY96PHEE

Measuring range	pH 1 to 12
Application range	pH 0 to 13 / 0° to 60°C
Max. pressure	Unpressurized operation
Diaphragm	3 ceramic diaphragm
Reference	Ag/AgCl – stock (3mol KCl / liquid) KCl electrolyte refillable
Head of electrode	Plug-in head SN6

Technical data of the measuring transducer in the ALMEMO® connection cable ZA9610AKY4

See chapter 3.11.1.1.

Technical data of ALMEMO® connection cable ZYD7x0AK4

See chapter 4.7.2.2.

Dimensions

Shaft lenght 120 ± 3 mm

Grooving tip about 45 mm, Ø 6 to 8 mm

3.11.2 Measurement of the redox potential

Basics

The level of the redox potential (measured in mV) is a measure of how strongly the test sample oxidizes or reduces. Thus, a wealth of chemical processes (e.g. cyanide oxidation or chromate reduction) can be monitored. Since the killing of microorganisms (disinfection) is directly related to the oxidizing power (of e.g. chlorine), the redox potential is successfully used to monitor disinfection processes.

For measurement, the potential of a precious metal electrode (platinum or gold) is recorded against a reference electrode. Instead of two-rod electrodes, the easier-to-handle combination electrodes are usually used.

Selection, product overview

Sensor type	Meas. range	Appl. range	Conductivity	Diaphragm	Metal electrode
FY96RXEK	±1000 mV	0 to 60°C	> 150 µS/cm	Fiberglass	Platinum

ALMEMO® Connection cable with transducer

For sensors with plug-in head S7/SN6 (Coaxial plug with screw connection):
Programming for redox electrodes ZA 9610-AKY5, ZYD7 10-AK5 (see chapter 4.7.2.2)
Programming for pH or redox electrodes ZA 9610-AKY6 (see chapter 3.11.1)

Solutions for refilling and adjusting redox electrodes

KCl-solution, 3-molar	ZB 98PH-NL
Redox-buffer solution Redox 220 mV against Pt-Ag/AgCl	ZB 98RX-PL2

Application fields

FY96RXEK	Manual measurements e.g. swimming pool, drinking water

Notes on measurements

When screwing the redox electrode into the connection head, make sure that no moisture gets into the plug connection because of the high-impedance signal.

Galvanic isolation

The following applies to connection cables with standard plug (ZA 9610-AKYx):

Measurements with more than one redox electrode must not be carried out simultaneously in one bath due to the lack of galvanic isolation. The same applies to pH electrodes and conductivity probes. However, the sensors are designed in such a way that measurements can be made simultaneously with both a pH electrode and a redox electrode as well as a conductivity probe in one bath.

For connection cables with D7 connector (ZYD7 10-AK5) the following applies:
There is galvanic isolation from the ALMEMO® V7 measuring instrument. Therefore, several ORP probes can be operated in the same sample solution on one measuring device without influencing each other.

Review

After connecting the sensor to the measuring device, it is immersed in a redox buffer solution, e.g. 220 mV (order no.: ZB 98RXPL2). Within max. 30 seconds the value of the buffer solution should be reached or exceeded. If the value is only reached very sluggishly or if it falls below the value by more than 20 mV, the sensor must be cleaned (see below and Chapter 3.11.1, 'Maintenance'). If this is not successful, the sensor must be replaced.

Maintenance

See chapter 3.11.1.

The metal surfaces of redox electrodes can additionally be cleaned by grinding and polishing. If the side-mounted ceramic diaphragm of the reference system is blocked, this can be cleaned in the same way as the glass membrane and additionally by careful scraping with a fingernail, a razor blade or a fine file. The glass diaphragm must not be scratched during cleaning.

3.11.2.1 Redox combination electrode Type FY96RXEK

Sensor characteristics

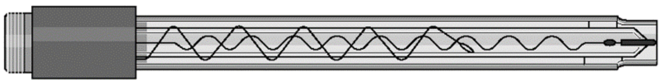


Fig. 3.11.8 pH-electrode FY96RXEK

Features

Non-refillable redox electrode with plastic shaft and glass fiber diaphragm.

ZA9610AKY5 and ZYD710AK5 measuring transducer cables are available for all common electrodes with coaxial connector. In order to prevent the measuring signal from being distorted by the measuring device, an extremely high-impedance measuring amplifier (>500 GΩ) is integrated in the ALMEMO® connector of the connection cable for redox measuring chains.

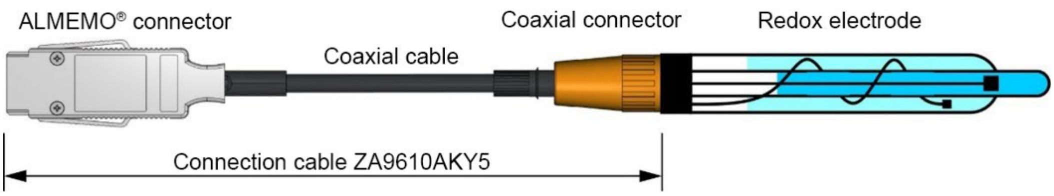


Fig. 3.11.9 Redox-electrode with connection cable ZA 9610-AKY5

Programming

Since only voltages in the range ±1000 mV are measured, the programming of the connectors is as follows.

Range	Dimension	Exponent	Locking mode
D2600	mV	3	5

Programming of connection cable ZYD710AK5

See chapter 4.7.2.2.

Technical data

Measuring range	±1000 mV
Operating range	0 to 60°C
Max. pressure	Pressureless operation
Conductivity	> 150 µS/cm
Diaphragma	Fiberglass
Metal electrode	Platinum
Head of electrode	Plug-in head SN6

Technical data of the measuring transducer in the ALMEMO® connection cable ZA9610AKY5

Input resistance	> 500 GΩ
Amplification	1
Potential of the reference electrode with respect to GND	< 2 V
Power consumption	< 1 mA
Cable length	< 100 m

Technical data for ALMEMO® connection cable ZYD710AK5

See chapter 4.7.2.2.

Dimensions

Shaft lenght 125 ± 3 mm

Diameter 12 mm (plastic material)

3.11.3 Conductivity

Measuring principle

The conductivity in electrolytes is measured by means of an electrochemical resistance measurement using a 2-electrode or a 4-electrode measuring cell. A sinusoidal voltage with a frequency of approx. 1 kHz is applied to the measuring electrodes. The current flowing through the measuring object is converted into a voltage. In the case of probes with standard connectors (FYA641), this is phase-synchronously rectified, smoothed and then displayed as a measured value. For the probes with digital D7 connectors (FYD741), the voltage is rectified via a TRMS converter, smoothed and then fed to an 18-bit AD converter.

Basics

The conductivity (unit S/m = Siemens/meter) is a measure of the ion concentration of a test sample. The more salt, acid or base a measuring solution contains, the greater its conductivity. Ultrapure waters have a conductivity of about 0.05 µS/cm (at 25°C), natural waters about 100 - 1000 µS/cm, some bases (e.g. potassium hydroxide solutions) up to just over 1200 mS/cm. The diagram on the right shows further examples of metrologically relevant aqueous solutions.

Temperature compensation

The conductivity κT is a temperature-dependent quantity. For most dilute aqueous salt solutions and natural waters, an approximately linear dependence of the conductivity on the temperature T:

$$\kappa_T = \kappa_{25}\left(1 + \alpha\frac{(T - 25°C)}{100}\right)$$

The conductivity κ25 referred to 25°C is calculated as follows:

$$\kappa_{25} = \frac{\kappa_T}{1 + \alpha\frac{(T - 25°C)}{100}}$$

The temperature coefficient describes the relative change in conductivity with a change in temperature compared to the reference temperature of 25°C.

Definition of α [%/K]:

Change in conductivity in % when the temperature is increased by one Kelvin, based on the reference temperature of 25°C.

$$\alpha = \left(\frac{\kappa_T - \kappa_{25}}{T - 25°C}\right) \cdot \frac{1}{\kappa_{25}} \cdot 100$$

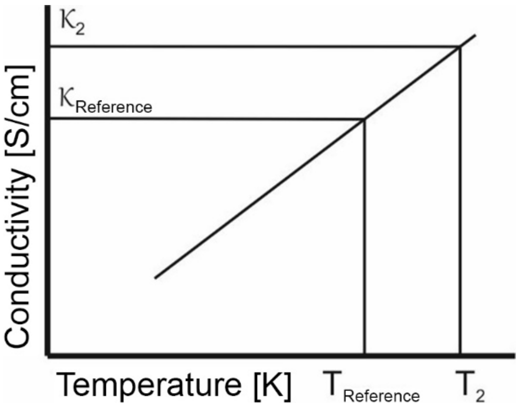


Fig. 3.11.10 Determination of the conductivity at any temperature from the known conductivity at a reference temperature.

The temperature coefficient α itself depends on:

- Chemical composition of the solution
- Concentration of electrolyte
- Temperature, especially for small conductivities < 1 µS and very high conductivity

If the temperature coefficient of a sample is not known, an experimental determination of α helps. Electrical conductivity values are determined at (25 ± 0.1) °C and at a known temperature (T2 ± 0.1) °C and used in the above equation.

If the measurement is not temperature-compensated, the conductivity measured at a known temperature can be converted to the conductivity at 25°C using the temperature coefficient.

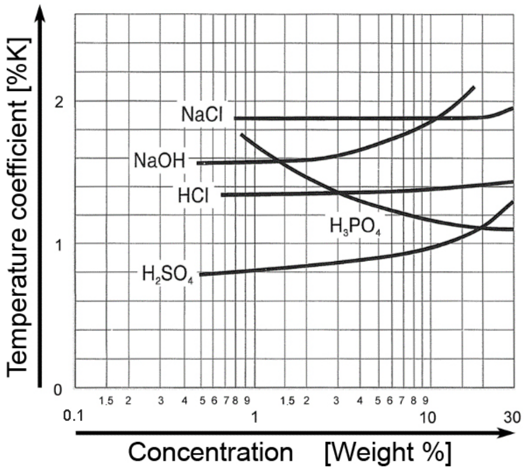


Fig. 3.11.11 Dependence of the temperature coefficient on the concentration of various substances in water

Examples for typical conductivity

Distilled water	< 5 µS/cm
Rain water	50-100 µS/cm
Drinking water	500 µS/cm
Mineral water	> 1000 µS/cm
Industrial waste water	5 mS/cm
Sea water	50 mS/cm
1 mol/L NaCl	85 mS/cm
1 mol/L HCl	332 mS/cm

Selection, product overview

Reference number	Measuring range	Connector
FYA641LFP1	0.01 to 20 mS/cm	Standard
FYA641LFL1	0.01 to 10 mS/cm	Standard
FYA641LFP2	10 to 200 µS/cm	Standard
FYA641LFL2	10 to 200 µS/cm	Standard
FYA641LFP3	0 to 200 mS/cm	Standard
FYD741LFP	Range DLF1: to 500.00 µS/cm Range DLF2: to 50.000 mS/cm Range DLF3: to 200.00 mS/cm	Digital D7 connector
FYD741LFE01	Range DLF1: to 500.00 µS/cm Range DLF2: to 50.000 mS/cm Range DLF3: to 500.00 mS/cm	Digital D7 connector

Application fields

FYA641LFP1, FYA641LFL1, FYA641LFP3	Concentrated wastewater, aggressive waters, general aqueous and semi-aqueous media, beer, emulsions, electroplating, waters, concentrated acids and alkalis, corrosive acids and alkalis, varnishes and paints, protein-containing media, soaps, detergents, suspensions, titrations in organic media, environmental analysis
FYA641LFP2, FYA641LFL2	Low-salt wastewater, general aqueous and semi-aqueous media, aquariums, emulsions, desalination/ion exchangers, beverages, waters, cooling/boiler feed water, varnishes and paints, milk, low ionic strength samples, protein-containing media, ultrapure water, soaps, detergents, suspensions, drinking water, environmental analysis

Notes on measurement

During measurement, the conductivity electrode must be immersed at least 30 mm so that the electrodes are completely surrounded by liquid.

Maintenance

Minor soiling can be removed with a soft brush. In the case of intensive cleaning of heavily soiled electrodes, the electrode distances may change slightly and influence the measurement result.

3.11.3.1 Conductivity probe Type FYA641LFP1 / LFL1

Sensor characteristics

Features

The probes are equipped with an NTC bead for automatic temperature compensation. While the FYA641LFL1 probe is used as a laboratory probe, FYA641LFP1 has a thread for installation.

Both probes are supplied with 1.5 m cable and ALMEMO® connector. A manufacturer's test certificate is enclosed.

Types

Reference number	Measuring range	Application	Thread	Max. pressure	Shaft lenght/-diameter
FYA641LFP1	0.01 to 20 mS/cm	Built-in	G ¾“	16 bar	130 mm / 20 mm
FYA641LFL1	0.01 to 10 mS/cm	Laboratory probe	–	Ambient pressure (pressureless)	130 mm / 10 mm

Programming

Two channels each are programmed in the connector for the two measured variables temperature and conductivity:

Probe	Chan	Meas. size	Measuring range	Res.	Dim	Range	Factor	Exp
FYA 641 LFP1	1	Temperature T	-5 to 70 °C	0.01	°C	Ntc	-	0
	2	Conductivity κ	0.01 to 20 mS/cm	0.01	mS	LF	0.1	1
FYA 641 LFL1	1	Temperature T	-5 to 70 °C	0.01	°C	Ntc	-	0
	2	Conductivity κ	0.01 to 10 mS/cm	0.01	mS	LF	0.1	1

Dimension and exponent must not be changed in the ALMEMO® connector, since they are used to identify internal device calculation functions!

Technical data

Measuring range	
FYA 641 LFP1	0.01 to 20 mS/cm
FYA 641 LFL1	0.01 to 10 mS/cm
Temperature sensor	NTC, Type N (10 kΩ at 25°C)
Temperature compensation	0 to 70°C, automatic
Compensation coefficient	1.9 linear
Cell constant	ca. 1 cm^{-1}
Accuracy	± 3% of Meas. value ± 0.1 mS/cm
Nominal temperature	25°C ± 3°C
Operating temperature	-5 to 70°C
Minimum immersion depth	30 mm
Electrode material	Special carbon
Shaft material	PVC – C
Max. pressure	
FYA 641 LFP1	16 bar at 25°C
FYA 641 LFL1	Pressurelesss
Cable lenght	1.5 m
Power supply	8 to 12 V from device
Power consumption	About 3 mA

Standardization

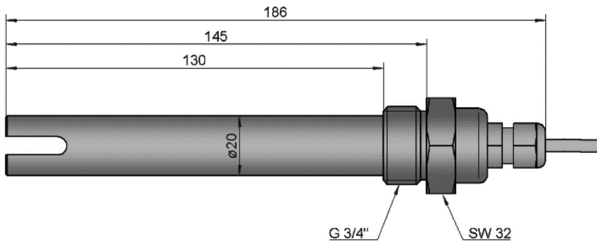
The determination of the electrical conductivity of water is anchored in DIN EN 27 888.

Dimensions

FYA 641 LFP1

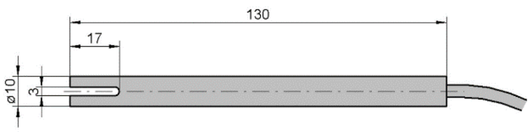
Shaft length/-diameter: 130 mm / 20 mm

Built-in lenght/thread: 145 mm / G 3/4"



FYA 641 LFL1

Shaft length/-diameter:
130 mm / 10 mm



Use

Review

A check of the probe seems reasonable:

- When changing the geometry (electrode gap)
- After use under extreme conditions (e.g. high temperatures)
- In case of non-plausible measurement results

Increase measuring accuracy

During adjustment, the solution temperature must be kept constant at ±0.1°C!

The automatic adjustment of the conductivity probe takes place in two measuring points:

1. At 0 mS/cm in the dry state,
2. At 2.77 mS/cm - 0.02 mol KCl reference solution at (25 ± 0.1) °C

   or at 147 µS/cm - 0.001 mol KCl reference solution at (25 ± 0.1) °C

The correction is carried out in both points (zero point and slope) with the same procedure 'Sensor calibration' (see instrument operating manual chapter 'Sensor calibration' or manual chapter 6.3.10).

Measurement

The probe is fully calibrated upon delivery.

Regardless of the actual temperature of the measured medium, the instrument displays the conductivity at 25°C, $\kappa 25$. It is calculated using the continuously measured temperature T of the medium and the temperature coefficient of the probe $\alpha 25 = 1.9\%$ /K.

3.11.3.2 Conductivity probe Type FYA641LFP2 / LFL2

Features

The probes are equipped with an NTC bead for automatic temperature compensation. While the FYA641LFL2 probe is used as a laboratory probe, FYA641LFP2 has a thread for installation.

Both probes are supplied with 1.5 m cable and ALMEMO® connector. A manufacturer's test certificate is en-closed.

Sensor characteristics

Types

Reference number	Measuring range	Application	Winding	Max. pressure	Shaft lenght/-diameter
FYA641LFP2	10 to 200 µS/cm	Buit-in probe	G ¾“	16 bar	130 mm / 20 mm
FYA641LFL2	10 to 200 µS/cm	Laboratory probe	–	Ambient pressure (pressureless)	130 mm / 10 mm

Programming

Two channels each are programmed in the connector for the two measured variables temperature and conductivity:

Probe	Chan	Measur. size	Meas. range	Res.	Dim	Range	Factor	Exp
FY A641 FP2	1	Temperature T	-5 to 70 °C	0.01	°C	Ntc	-	0
	2	Conductivity κ	10 to 200 µS/cm	0.1	µS	LF	0.1	2
FY A641 FL2	1	Temperature T	-5 to 70 °C	0.01	°C	Ntc	-	0
	2	Conductivity κ	10 to 200 µS/cm	0.1	µS	LF	0.1	2

Dimension and exponent must not be changed in the ALMEMO® connector, since they are used to identify internal device calculation functions!

Technical data

Measuring range	
FYA 641 LFP2	10 to 200 µS/cm
FYA 641 LFL2	10 to 200 µS/cm
Temperature sensor	NTC, Type N (10 kΩ at 25°C)
Temperature compensation	0 to 70 °C, automatic
Compensation coefficient	1.9 linear
Cell constant	ca. 1 cm^{-1}
Accuracy	± 3% of meas. value ± 1 µS/cm
Nominal temperature	25°C ± 3°C
Operating temperature	-5° to +70°C
Minimum immersion depth	30 mm
Electrode material	Special carbon
Shaft material	PVC – C
Max. pressure	
FYA 641 LFP2	16 bar at 25°C
FYA 641 LFL2	Pressureless
Cable lenght	1.5 m
Power supply	8 to 12 V from device
Power consumption	About 3 mA

Standardization

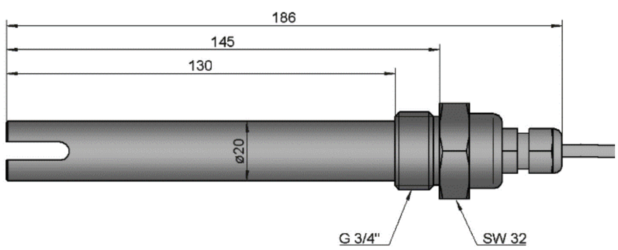
The determination of the electrical conductivity of water is anchored in DIN EN 27 888.

Dimensions

FYA 641 LFP2

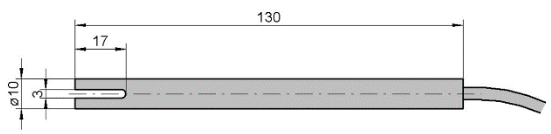
Shaft lenght /diameter: 130 mm / 20 mm

Built-in lenght/thread: 145 mm / G3/4"



FYA 641 LFL2

Shaft lenght /diameter: 130 mm / 10 mm



Use

Review

A check of the probe seems reasonable:

- When changing the geometry (electrode gap)
- After use under extreme conditions (e.g. high temperatures)
- In case of non-plausible measurement results

Increase measuring accuracy

During adjustment, the solution temperature must be kept constant at ±0.1°C!

The automatic adjustment of the conductivity probe takes place in two measuring points:

1. At 0 mS/cm in the dry state,
2. At 2.77 mS/cm - 0.02 mol KCl reference solution at (25 ± 0.1) °C

   or at 147 µS/cm - 0.001 mol KCl reference solution at (25 ± 0.1) °C

The correction is carried out in both points (zero point and slope) with the same procedure 'Sensor calibration' (see instrument operating manual chapter 'Sensor calibration' or manual chapter 6.3.10).

Measurment

The probe is fully calibrated upon delivery.

Regardless of the actual temperature of the measured medium, the instrument displays the conductivity at 25°C, $\kappa 25$. It is calculated using the continuously measured temperature T of the medium and the temperature coefficient of the probe $\alpha 25 = 1.9\%$ /K.

3.11.3.3 Conductivity probe Type FYA641LFP3

Sensor characteristics

Features

The FYA641LFP3 probe has a thread for installation. It is supplied with 1.5 m cable and ALMEMO® connector. A manufacturer's test certificate is enclosed.

Types

Reference number	Measuring range	Application	Winding	Max. pressure	Shaft lenght/-diameter
FYA641LFP3	0 to 200 mS/cm	Built-in probe	G ¾“	16 bar	130 mm / 20 mm

Programming

Two channels each are programmed in the connector for the two measured variables temperature and conductivity.

Probe	Chan	Meas. size	Meas. range	Res.	Dim	Range	Factor	Exp
FY A641 LFP3	1	Temperature T	-5 to 70°C	0.01	°C	Ntc	-	0
	2	Conductivity κ	0 to 200 mS/cm	0.1	mS	LF	0.1	2

Dimension and exponent must not be changed in the ALMEMO® connector, since they are used to identify internal device calculation functions!

Technical data

Measuring range	
FYA 641 LFP3	0 to 200 mS/cm
Temperature sensor	NTC, Typ N (10 kΩ to 25°C)
Cell constant	About 1 cm^{-1}
Accuracy	± 3% from M. v. ± 1 mS/cm
Nominal temperature	25°C ± 3°C
Operating temperature	0 to 70°C
Minimum immersion depth	30 mm
Electrode material	4 electrode from special carbon
Shaft material	PVC - C
Max. pressure	16 bar at 25°C
Cable lenght	1.5 m
Power supply	8 to 12 V from device
Power consumption	About 15 mA

Standardization

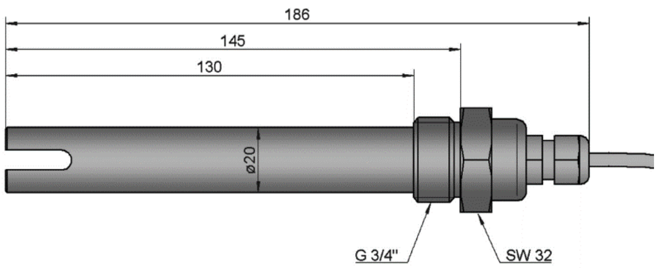
The determination of the electrical conductivity of water is anchored in DIN EN 27 888.

Dimensions

FYA 641 LFP3

Shaft lenght /-diameter: 130 mm / 20 mm

Built-in lenght/thread: 145 mm / G ¾"



Use

Review

A check of the probe seems reasonable:

- When changing the geometry (electrode gap)
- After use under extreme conditions (e.g. high temperatures)
- If the measurement results are not plausible

Increase measuring accuracy

Adjustment of the probe at standard conditions (25 ± 0,1) °C

The conductivity probe is adjusted at two measuring points:

1. At 0 mS/cm in the dry state,
2. At 111.8 mS/cm - 1 mol KCl reference solution at (25 ± 0.1) °C.

Under standard conditions (25 ± 0.1) °C, the correction in both points is carried out with the same procedure 'Sensor calibration' (see instrument operating manual chapter 'Sensor calibration' or manual chapter 6.3.10). When using the automatic adjustment, the standard conditions (25 ± 0.1) °C must be observed!

Adjustment of the probe outside the standard conditions

If the adjustments of this probe are to be performed outside the standard conditions of (25 ± 0.1) °C, the following instructions apply:

Zero adjustment is performed as for automatic adjustment.

For slope adjustment, the value of the reference solution at a known solution temperature (see table below) is compared with the deviating value determined on site and entered manually as a correction value under 'Slope correction (SK)' in the ALMEMO® connector (see instrument operating manual chapter 'Correction values' or manual chapter 6.3.10).

Example for the adjustment of the probe FYA 641 LFP3 with 1 mol KCl reference solution at measured solution temperature of 20.0°C:

Value of the reference solution at solution temperature 20.0°C: 102.09 mS/cm (table below)

measured value at solution temperature 20.0°C: 98.72 mS/cm.

$$\mathrm{SK} = \frac{\text{"Value reference solution at solution temperature" 20°C}}{\text{"measured value at solution temperature" 20°C}} = \frac{102.09}{98.72} = 1.034$$

Electrical conductivity κ in mS/cm of KCL standard solutions as a function of temperature t and concentration:

t in °C	κ in mS/cm 0.001 mol/l	κ in mS/cm 0.01 mol/l	κ in mS/cm 0.02 mol/l	κ in mS/cm 1.00 mol/l
0		0.776	1.521	65.41
1		0.800	1.566	67.13
5		0.896	1.752	74.14
10		1.020	1.994	83.19
15		1.147	2.243	92.52
16		1.173	2.294	94.41
17		1.199	2.345	96.31
18	0.127	1.225	2.397	98.24
19	0.130	1.251	2.449	100.16
20	0.133	1.278	2.501	102.09
21	0.136	1.305	2.553	104.02
22	0.138	1.332	2.606	105.54
23	0.141	1.358	2.659	107.89
24	0.144	1.386	2.712	109.84
25	0.147	1.413	2.765	111.8

The reference solutions are available as accessories for the respective conductivity probe.

Measure

The probe is fully calibrated on delivery.

The FYA 641-LFP3 conductivity probe with measuring range 0 to 200.0 mS is not temperature compensated because the temperature coefficient can be very different at high conductivities (see Fundamentals).

It therefore displays the conductivity at the respective temperature of the medium and not the conductivity at 25°C like the other probes described in the chapter 'Conductivity'.

If the electrical conductivity is measured outside the standard conditions of 25°C ± 1°C, the result will be less accurate than at standard conditions. This fact is independent of the type of temperature compensation.

For routine field work, it may not be necessary to convert the values measured at the prevailing temperature to 25°C. However, such measured values are to be interpreted with reservation and comparison with other values is difficult or not possible.

3.11.3.4 D7-Conductivity probe FYD 741-LF

Sensor characteristics

Fig. 3.11.12 Digital probe for conductivity FYD 741-LFP

FYD 741-LFE01

Features

The probes are equipped with an NTC bead for possible automatic temperature compensation. While the FYA 741-LFE01 probe is used as a laboratory probe, FYA 741-LFP has a thread for installation.

Both probes are supplied with cable and ALMEMO® connector. A manufacturer's test certificate is enclosed.

Types

Reference number	Measuring range	Application	Thread	Max. pressure	Shaft lenght/-diameter
FYD 741 LFP	10 µS/cm to 200 mS/cm	Installation probe	G ¾“	16 bar	130 mm / 20 mm
FYA 741 LFE01	10 µS/cm to 200 mS/cm, on request to 500 mS/cm	Laboratory probe	–	Ambient pressure (without pressure)	120 mm / 12 mm

Programming

Measuring ranges on delivery

Probes	Designation	Range	Chan	Measuring range	Resolution	Dim
FYD 741 LFE01	Temperature	DIGI	1	-5 to 80°C	0.01	°C
	Conductivity LF2	DIGI	2	0 to 50 mS/cm	0.001	mS
FYA 741 LFP	Temperature	DIGI	1	-5 to 70°C	0.01	°C
	Conductivity LF2	DIGI	2	0 to 50 mS/cm	0.001	mS

The probe is fully calibrated on delivery. The temperature compensation is set to a linear characteristic with a temperature coefficient of 1.90 %/K.

Configuration via the sensor menu

The sensor parameters (measuring range, temperature compensation and adjustment of the sensor) can be configured via the sensor menu (see chapter 3.1.3.1) in a V7 measuring device or on the PC with the ALMEMO® Control software (from version 5.14.0.330).

Configurable measuring ranges

In the D7 sensor, in addition to the temperature range on the first measuring channel, one of three conductivity ranges on the second measuring channel can be configured from the following list (* delivery state):

Designation	Command	Range	Measuring range	Resolution	Dim
1. Conductivity LF1	B-01	DIGI	0 to 500 µS/cm	0.01	µS
2. * Conductivity LF2	B-02	DIGI	0 to 50 mS/cm	0.001	mS
3. Conductivity LF3	B-03	DIGI	0 to 500 mS/cm	0.01	mS

Changing the range is only possible when the sensor lock (level 0) is removed.

Technical data

Conductivity probe	FYD741LFE01	FYD741LFP
4-pole conductance probe	Laboratory electrode	Process electrode
Measuring range: Conductivity	10 µS to 500 mS	10 µS to 200 mS
Accuracy at nominal conditions	±2% of av. ±0.2% of final value	±3% of av. ±0.2% of final value
Temperature sensor	Ntc sensor 30 kΩ	Ntc sensor 10 kΩ
Temperature	0 to 80°C	0 to 70°C
Accuracy	0.2°C	0.2°C
Temperature compensation	Automatic / non compensated	
Temperature coefficient	Natural waters or linear in the range of 0.00 to 9.99	
Cell constant	About 0.5 cm^{-1}	About 0.5 cm^{-1}
Electrode material	Special carbon	Special carbon
Nominal temperature	25°C ± 2°C	25°C ± 2°C
Operating temperature	0 to 80°C	0 to 70°C
Minimum insertion depth	30 mm	30 mm
Shaft material	PC (+ABS)	PVC - C
Max. pressure	Pressureless	16 bar at 25°C
Connector	ALMEMO® D7	
Cable lenght	1.0 m	1.5 m
Power supply	6 to 13 V DC from ALMEMO® device (sensor power supply)	
Power consumption	About 10 mA	
Conector colours	Housing ruby red, black levers	
Refresh rate	2.5 sec.	
AD converter	Delta-Sigma 18 bit resolution	
Sleepmode of device	Possible with delay 5 s	

Dimensions

FYD741LFE01: Shaft length /-diameter: 120 mm / 12 mm

FYD741LFP: Shaft length /-diameter: 130 mm / 20 mm
Construction lenght/thread: 145 mm / G ¾"

Use

Increase measuring accuracy

The sensor menu helps with temperature compensation and adjustment of the FYD741LF:

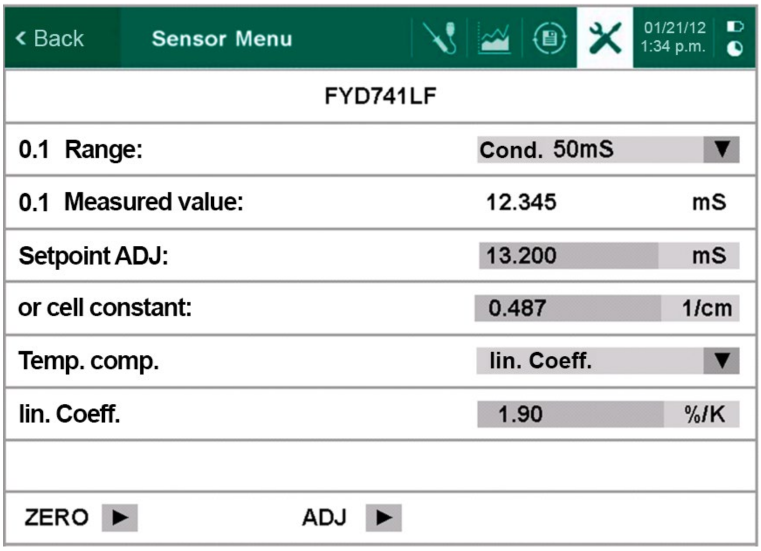


Fig. 3.11.13
Configuration via sensor menu

The 'ZERO' and 'ADJ' keys are only enabled when the sensor interlock is released (level 0).

The following options are available for adjusting the conductivity electrodes:

Adjustment via input of a newly determined cell constant

The cell constant is the characteristic value of conductivity measuring cells, which is determined by the size and geometrical arrangement of the measuring electrodes. It is practically invariable. If the electrode surfaces are clean and without insulating coatings, then adjustment is generally not necessary.

However, after cleaning, repair or replacement of the sensor, it may be necessary to correct the cell constant. It can then be redetermined during an adjustment with reference solutions. The cell constant is preconfigured to the following values.

1. FYD741LFP: 0.500
2. FYD741LFE01: 0.550

Note: The cell constant can only be entered when the sensor interlock is released (level 0).

Adjustment by two-point calibration

Better than adjusting the probe by entering the cell constant is usually the adjustment of the measuring ranges with a reference solution.

The adjustment of the probe is only possible when the sensor lock (level 0) is released. During adjustment, the solution temperature must be kept constant at (25 ± 0.1) °C.

The conductivity probe is adjusted at two measuring points:

1. **In dry state** at 0 mS/cm. Sensor calibration by pressing the 'ZERO' key in the sensor menu.
2. **In reference solutions** according to the measuring range e.g. 147 µS/cm - 0.001 mol KCl reference solution at (25 ± 0.1) °C in measuring range 500 µS or 12.88 mS/cm - 0.1 mol KCl reference solution at (25 ± 0.1) °C in the measuring range 50 mS.

3. **Input of the setpoint** (reference value) in function 'Setpoint' (see sensor menu Fig. 3.11.15),
4. **Sensor calibration** by pressing the key 'ADJ'.

The adjustment of the probe can also be carried out outside the standard conditions of (25 ± 0.1) °C:

The zero point adjustment is carried out as described above. For the slope adjustment, the value of the reference solution at a known solution temperature (see table in section 3.11.3.3) is compared with the deviating value determined on site and entered manually as a correction value under 'Slope correction (SK)' in the ALMEMO® connector.

Example for the adjustment of the probe with 1 mol KCl reference solution at measured solution temperature of 20.0 °C:

Value reference solution at solution temperature 20.0°C: 102.09 mS/cm (table in chapter 3.11.3.3)

Measured value at solution temperature 20.0°C: 98.72 mS/cm

$$\mathrm{SK} = \frac{\text{"Value reference solution at solution temperature 20°C"}}{\text{"Measured value at solution temperature 20°C"}} = \frac{102.09}{98.72} = 1.034$$

Reference solution

They are available as accessories for the respective conductivity ranges.

Solutions for adjusting conductivity probes are unbuffered systems. Their conductivity values are not stable and are already affected by minor impurities or dilution (e.g. water drops on the sensor). This applies in particular to low conductivities.

Clean measuring cells

Before adjustment, make sure that the sensor is clean. Residues should be rinsed off with distilled water. Afterwards, it is recommended to dry the sensor and rinse it with the intended adjustment solution.

Temperature compensation

For the present sensor, three different settings are provided in the sensor menu under menu item „Temp. comp.“:

Off: No temperature compensation for low or very high conductance values.

Nat. water: Temperature compensation with non-linear characteristic for natural water and ultrapure water.

Lin. characteristic: Temperature compensation with linear characteristic and adjustable temperature coefficient.

If temperature compensation by a linear temperature coefficient is selected, a temperature coefficient must be entered in the line below, in the case of the FYD741LF it is 1.90 %/K.

If the temperature coefficient of a sample is not known, an experimental determination of α helps. In this case, the electrical conductivity κ25 is determined at (25 ± 0.1) °C and κT at a known temperature (T2 ± 0.1) °C and entered into the equation α = (κT - κ25) -100 / κ25 (T2-25).

If the measurement is not temperature-compensated, the conductivity measured at a known temperature can be converted to 25°C using a correction factor.

Measuring

During the measurement, the probe must be immersed at least 30 mm so that the electrodes are completely surrounded by liquid.

3.11.4 Dissolved oxygen concentration in water

Measuring principle

For the determination of dissolved oxygen, membrane-covered amperometric sensors based on the Clark principle have proven their worth in the laboratory and in process control. These sensors operate according to the principle of polarography.

In simple terms, a constant polarization voltage is applied to two electrodes and the current that occurs is measured. This is proportional to the concentration of the respective measurement ion. The selectivity of the respective reaction depends on the half-step potentials of competing partners present. When a defined voltage is applied, it is thus possible to selectively measure different substances.

In the case of the determination of dissolved oxygen with the membrane-covered Clark cell, the working electrode acting as a cathode is made of platinum and the counter or reference electrode is made of silver/silver chloride. The two electrodes are immersed in a chloride-containing electrolyte solution, which is separated from the measuring solution by an O2-permeable PTFE membrane. The thin PTFE membrane allows the dissolved oxygen gas to pass through, but not dissolved ions or other foreign substances.

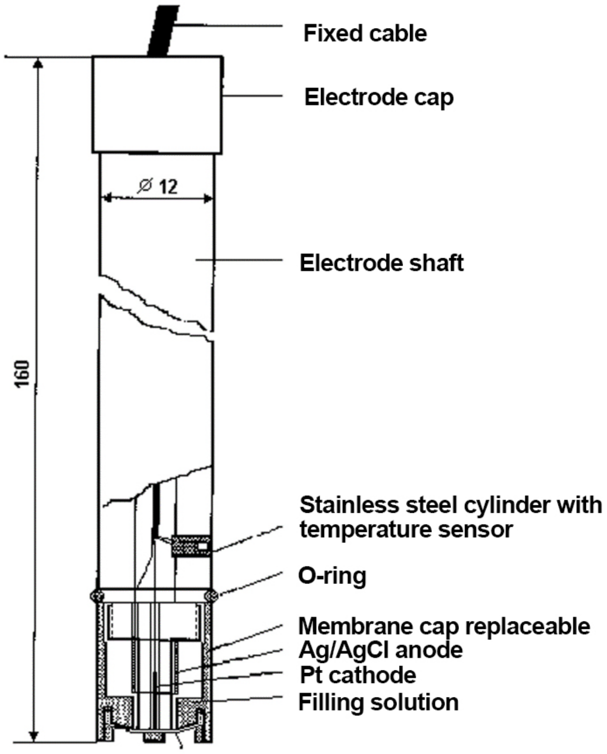


Fig. 3.11.14
Construction of a probe for the measurement of dissolved oxygen in water

In this oxygen measurement method, the oxygen dissolved in the water diffuses through the PTFE membrane to the surface of a highly polished platinum electrode acting as a working electrode and is electrochemically reduced to OH ions (base). Electrons are released equivalently at the silver counter-electrode connected as anode and the resulting silver ions react with the chloride ions of the filling electrolyte to form silver chloride, which is deposited on the silver electrode.

The reactions taking place in detail are described by the following equations:

Cathode: $O_2 + 2\ H_2O + 4$ electrons $\rightarrow 4\ OH^-$
($U_{Ag/AgCl} = +611$ mV)

Anode: $4\ Ag + 4\ Cl^- \rightarrow 4\ AgCl \downarrow + 4$ electrons

These reactions do not occur voluntarily, but must be forced by applying a polarization voltage of at least +611 mV to the platinum cathode and the silver anode. The current flowing in this process is measured and is a measure of the concentration of discharged oxygen.

To prevent other reactions from occurring, the polarization voltage must be kept relatively constant. A polarization voltage of +650 mV is applied to the oxygen electrode.

The reaction products of the operating oxygen electrode are poorly soluble silver chloride on the silver anode and a base (OH-ions) in the inner electrolyte. After prolonged use of the oxygen electrodes (several months), the silver salt must be removed by means of sodium thiosulfate or ammonia solution or mechanically and the used electrolyte must be renewed.

Basics

Basics of oxygen measurement in water

Oxygen is not only a component of air, but also occurs dissolved in water. Here it is of crucial importance for animals and organisms living in water and for the biological purification of municipal and industrial wastewater. The dissolved content increases with increasing air pressure and decreasing temperature.

An equilibrium for oxygen is established between the air and the water. The saturation state (air-saturated water) is reached when the partial pressure of the oxygen physically dissolved in the water [pO_2(water)] is equal to the partial pressure of the oxygen in the air [pO_2(air)].

$$p\,O_2\,(\text{water}) = p\,O_2\,(\text{air})$$

Since in the air, in addition to oxygen (20.9%), there are also nitrogen (78.1%), noble gases (0.96%), carbon dioxide (0.03%) and water vapor, the following equation applies to the partial pressure of oxygen in air saturated with water vapor [p'O2 (air)]:

$$p'O_2\,(\text{air}) = X\,O_2\,(p_L - p_W)$$

$X\,O_2$ = Mole fraction of oxygen in air (0.2095)
p_L = Atmospheric pressure p_W = water vapor pressure

The oxygen partial pressure in water vapor-saturated air corresponds to the oxygen partial pressure in air-saturated water at equilibrium.

This is of particular practical importance in the adjustment of oxygen sensors.

For the evaluation of the oxygen saturation state it is usual to determine the oxygen saturation O2S in % or the direct concentration O2C in mg/l instead of the oxygen partial pressure. The value O_2S in % indicates the dissolved oxygen concentration O_2C in the water as a percentage of the saturation value O_2C_S.

$$\mathrm{O_2S} = \frac{\mathrm{O_2C}}{\mathrm{O_2C}_S} \cdot 100$$

Calculation of oxygen saturation in the meter

The oxygen saturation is influenced by the water temperature and the air pressure. Therefore, these two parameters must be taken into account when calculating the degree of saturation. The temperature sensor for temperature compensation is integrated in the sensor. A sensor for air pressure can be additionally plugged in. If the conditions are constant, the air pressure can also be entered. The reference point is 1013 mbar (normal pressure).

The oxygen concentration is calculated from the saturation and the temperature using the Wagner tables. It is not dependent on air pressure.

Calculation formulas:

The meter uses the following formulas to calculate the degree of saturation and the absolute amount of oxygen in mg/l from the O_2 reading and the temperature.

O_2- saturation corrected: $O_2S\,[\%] = O_2m \cdot SK \cdot Tk\,(Tm) \cdot Pn/Pm$

Measuring signal O_2m = O_2-saturation measured
Gradient correction SK = $100 / (O_2c \cdot Tk\,(Tc) \cdot Pn/Pc)$

O_2c = O_2-Saturation during adjustment
Tc = Temperature during adjustment
Pc = Atmospheric pressure during adjustment

Temperature compensation Tk(T) = exp(k1/(Tm+T0)) /k0
(in the range of 5 to50°C) k0=4840, k1=2530, T0=273.15
Tm = Temperature measured

Atmospheric pressure compensation Pn = Normal atmospheric pressure 1013 mbar
Pm = Atmospheric pressure during measurement

O_2-concentration: O_2C[mg/l] = $O_2m \cdot SK/100 \cdot Tk(Tm) \cdot O_2C_S(Tm)$
O_2C_S = O_2-Saturation concentration according Wagner

Selection, product overview

Sensor type	Measuring range
FYA640O2	Temperature, O_2 Saturation, O_2 Concentration

Applications fields

- Determination of living conditions for fish and microorganisms in water bodies and aquaria
- Biological treatment of municipal and industrial wastewater
- Storage of organic liquids
- Drinking water analysis
- Control of corrosion processes in pipes of heating systems
- Testing of the shelf life of beverages

3.11.4.1 Probe for oxygen concentration in aqueous solutions FYA 640-O2

Sensor characteristics

Fig. 3.11.15 Sensor for oxygen FYA 640 O2

Features

For O_2 measurement in water, the ALMEMO® O_2 probe FY A640-O2 contains a Clark cell with measuring amplifier and an NTC temperature sensor.

It is delivered with connection cable (1.5 m long) and ALMEMO® plug.

Accessories

Article	Article number
Adjustment set: 25 g sodium sulfite in 20 ml PE bottle for the production of the zero solution Vessel for saturation adjustment	ZB9640AS
25 g sodium sulfite in 20 ml PE bottle	ZB9640NS
20 ml filling solution in PE bottle for O_2 probe	ZB9640NL
Spare membrane cap with protection (2 pieces)	ZB9640EM

Programming

Chan	Meas. parameter	Meas. range	Resolution	Dim	Range
1	Temperature T	-5 to 50°C	0.01	°C	Ntc
2	O_2 Saturation	0 to 260%	1	%	O2-S
3	O_2 Concentration	0.0 to 40.0 mg/l	0.1	mg	O2-C

Technical data

Measuring range	
Temperature range	-5.0 to 50°C
O_2 Saturation	0 to 260% Saturation
O_2 Concentration	0.0 to 40 mg/l (5 to 40°C)
Measuring principle	Clark
Working electrode (Cathode)	Pt
Reference electrode (Counter electrode)	Ag/AgCl
Membrane	PTFE
Response time ($t_{90\%}$)	ca. 10-15 s
Zero current at 0% saturation	< 5 nA
Measuring current at 100% saturation	ca. 700 nA
Oxygen measurement accuracy	< ± 1% of the measured value
Inflow velocity	ca. 10 cm/s
Storage temperature	-10 to 50°C
Depth of immersion	40 mm
Filling volume (electrolyte)	0.6 ml
Temperature probe	NTC Type N (10 kΩ at 25°C)
Temperature measurement accuracy	-20 to 0°C: ±0.4°C, 0 to 70°C: ±0.1°C (at nominal conditions)
Nominal conditions	25°C ± 3°C/1013 mbar
Shaft material	PVC, black
Membrane cap	Interchangeable (Spare part)
Connection cable	1.5 m long with ALMEMO® connector
Polarization voltage	650 mV
Service life (with one electrolyte filling)	Several months
Total service life (Life time)	Several years

Dimensions

Diameter 12 mm, length 145 mm

Use

Increase measuring accuracy

Air pressure compensation:

For the calculation of the oxygen saturation, an air pressure compensation is required (see 'Basics'), which can be done in three different ways:

1. Manual input in mb function
2. Interface input with command: g 0xxxx [mbar] (see chapter 6.2.5)
3. Measurement with additional sensor for air pressure FDA612SA (see chapter 6.7.2)

Adjustment

In order to achieve the most accurate measured values, the oxygen probe can be adjusted in zero point and slope. Before adjusting, please polarize the electrode sufficiently. To do this, connect the electrode to the measuring instrument and switch it on. Especially if the electrode has not been in operation for a long time, the polarization time can be up to 30 min. A sufficiently polarized and intact electrode shows a stable, non-drifting measured value.

Oxygen electrodes are adjusted at 0% oxygen saturation (adjustment point 1) and 101% oxygen saturation (adjustment point 2).

Produce zero solution for adjustment point 1:

A sodium sulfite salt solution ("zero solution") is used as the oxygen-free liquid (0% saturation). This is created by dissolving sodium sulfite (Na2SO3) in water (accessory ZB 9640-NS). Either distilled (deionized) or tap water can be used. The amount of sodium sulfite required depends on the water used. Distilled water or even stale water usually contains less dissolved oxygen than fresh water from the tap, so the sodium sulfite requirement is correspondingly lower. As a guide value, 1 g of sodium sulfite per 100 ml of water can be assumed.

The zero solution absorbs some oxygen from the air again if it is stored for a longer period of time. You should therefore check the zero solution regularly before you start to adjust it.

If you measure saturation values > 0% with your measuring instrument in the zero solution, please first add some sodium sulfite to the solution. The dissolved oxygen will be bound and the measured value for oxygen saturation will decrease. Only when further salt additions do not cause a decrease in the saturation value (stable measured value) do you have a true "zero solution" and you can begin with the adjustment.

Alignment for adjustment point 1:

1. Immerse the oxygen probe so deeply in the zero solution that the integrated temperature probe (stainless steel insert in the shaft) sits securely in the solution.
2. Wait for an adjustment time of ca. 2 to 3 min (display < 50).
3. Select the LOCK MODE function.
4. Unlock plug (if possible only momentarily, see instrument instructions or manual chapter 6.3.12).
5. Select the MEASUREMENT function.
6. Carry out zero point adjustment (see instrument instructions or manual chapter 6.4.2).
7. Afterwards, rinse the sensor thoroughly with water to remove all residues of the sodium sulfite solution.

8. Dab the membrane cap dry carefully (e.g. with a cellulose cloth) before starting the adjustment in water vapor saturated air.

Water drops on the membrane can lead to distortion of the adjustment.

Preparation for adjustment point 2:

Water vapor saturated air is used instead of air-saturated water. For this purpose, a moistened sponge is placed in an adjustment vessel (accessory ZB 9640-AS). After ca. 5 to 10 minutes, the air it contains is saturated with water vapor. When adjusting with water vapor saturated air, however, even with sufficient water vapor saturation, there are slight differences (about 2%) compared to sensors in air-saturated water due to the membrane properties. Despite the inflow, an unstirred diffusion layer remains in the water, which leads to a reduction in the measured value. For this reason, ALMEMO® measuring instruments are set to the saturation value 101% at calibration point 2 in order to measure the saturation value in water correctly.

Alignment for adjustment point 2:

1. Place the carefully cleaned and dried sensor in the adjustment vessel with water vapor saturated air (100% O_2).
2. Add about 2 ml of water to the vessel and check that the receiving tube is correctly seated in the vessel (marking). The electrode must not sit on the water-soaked foam material, a distance > 1 cm must be ensured.
3. Wait a few minutes until equilibrium is reached (stable display). Select the MEASUREMENT function.
4. Carry out slope alignment in the same way as zero point alignment (see instrument instructions or manual section 6.4.2).
5. Restore the locking (not necessary with momentary unlocking).

Maintenance

Storage

To prevent the electrolyte from evaporating and to protect the membrane, the oxygen electrode should always be stored with the protective cap on.

Clean electrode

For cleaning in daily use, please only rinse and carefully dab the electrode, avoid damaging the membrane.

Renew electrolyte filling

If larger air bubbles have formed in the electrolyte chamber due to evaporation or if it is only filled to ca. 80%, the electrolyte filling must be renewed:

1. Place the electrode vertically.
2. Unscrew the membrane cap downwards.
3. Empty the membrane cap and fill it to the brim with electrolyte.
4. Screw the membrane cap back onto the vertical electrode so that as few air bubbles as possible are trapped.

Replace the membrane cap:

If the PTFE membrane is damaged, the entire membrane cap must be replaced.

Leakage of the membrane can be recognized by the formation of small water droplets on the membrane surface as well as by the "overflow" of the measured values. The cap replacement is handled in the same way as the electrolyte replacement.

Clean electrode surfaces:

If the silver anode has turned black after several months of measuring use, the electrode surfaces should be cleaned.

1. Unscrew the cap with the gas-permeable membrane.
2. Immerse the probe head to a depth of about 2 cm in a sodium thiosulfate cleaning solution for ca. 30 minutes.
3. Rinse the probe head thoroughly with distilled water.
4. Rub the silver anode vigorously with cellulose or polishing cloth.
5. Apply new filling solution to the electrode cap and screw it back onto the oxygen electrode.
6. Approximately 30 minutes after switching on (polarization time), the electrode is ready for use again.

3.12 Sensors for measuring the concentration of gases

Basics

Insufficient indoor air quality (e.g. in offices) can lead to fatigue, poor concentration and even illness in humans. The indicator of indoor air quality is the concentration of certain gases in the air.

The most imortant are:

- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Oxygen (O_2)
- Ozone (O_3)

Carbon dioxide (CO_2)	An important criteria for assessing indoor air quality is the CO_2 concentration. A too high CO_2 concentration due to insufficient ventilation is perceived as bad or stale air.
Carbon monoxide (CO)	CO is formed from incompletely burned carbon (fuel). It is very dangerous to humans because it is highly toxic, but invisible and odorless. Causes of its formation during combustion processes: • Lack of air • Too much excess air • Too early cooling of the flame
Oxygen (O_2)	About one fifth of the air we breathe consists of oxygen, which is essential for life. Oxygen is necessary for all oxidation processes, for combustion processes as well as for silent oxidations. These include, for example, the rusting of iron, oxidations that occur during life processes or the decomposition of organic material. In addition, all energy-giving combustion processes need this gas, from heaters to aircraft engines. However, oxygen is also bound up in all kinds of damaging fires, such as forest and steppe fires. Oxygen is constantly formed from carbon dioxide by the assimilation or photosynthesis process that constantly takes place in green plants when they are exposed to sunlight. The balance between oxygen consumption and oxygen production is one-sidedly stressed by the constantly increasing combustion of fossil fuels.
Ozone (O_3)	The ozone present in the earth's atmosphere is formed at altitudes of around 30 km and acts as a protective shield around the earth, blocking a good half of the solar UV radiation, in particular the short-wave component that is dangerous to living organisms. However, ozone is a toxic, extremely aggressive trace gas that can cause severe burns to the mucous membranes of humans if inhaled in high concentrations.

Physical units for the concentration

The most important unit in the measurement of gases is the volume fraction in percent, or in parts per million, abbreviated "ppm". Actually, the designation "ppm" no longer corresponds to the valid standards. Exactly it should be "ml/m^3" or "mg/kg", which in principle means the same. The following table illustrates the proportion of the gases to be determined in the ambient air for the individual concentration units:

1 percent (%) is one part in one hundred parts	10 grams per kilogram	10 g/kg

1 per mille (‰) is one part in a thousand parts	1 gram per kilogram	1g/kg
1 part per million (ppm) is one part of one million	1 milligram per kilogram	0.001g/kg
1 part per billion (ppb) is one part of one billion parts	1 microgram per kilogram	0.000 001g/kg

Selection, application

ALMEMO® gas probes find a wide range of applications in the industrial and environmental sectors:

1. Workplace monitoring
   - Room air monitoring for MAK values (Maximum Workplace Concentration)
   - Monitoring of laboratories and engine test benches
2. Emission/immission measurement
   - Measurement, control and warning in e.g. underground garages
   - Power stations
   - Monitoring of outside air or protective air in houses and large shelters
3. Process control
   - Bioreactors
   - Chemical industry

Each of these measurement tasks places specific demands on the instruments and sensors used. Workplace measurements often require long measurement times with summation and evaluation of the measured values to assess the health hazard. Since many substances are harmful to the human organism even in low concentrations, the sensors must detect low concentrations as accurately as possible.

3.12.1 Measuring the gas concentration with infrared

Basics

The CO_2 concentration is used as an indicator for assessing indoor air quality. A CO_2 concentration in the room air that is too high (limit value 1000 ppm) is perceived as "bad or stale" air.

The graph shows the spectrum of CO_2 concentrations relevant to humans.

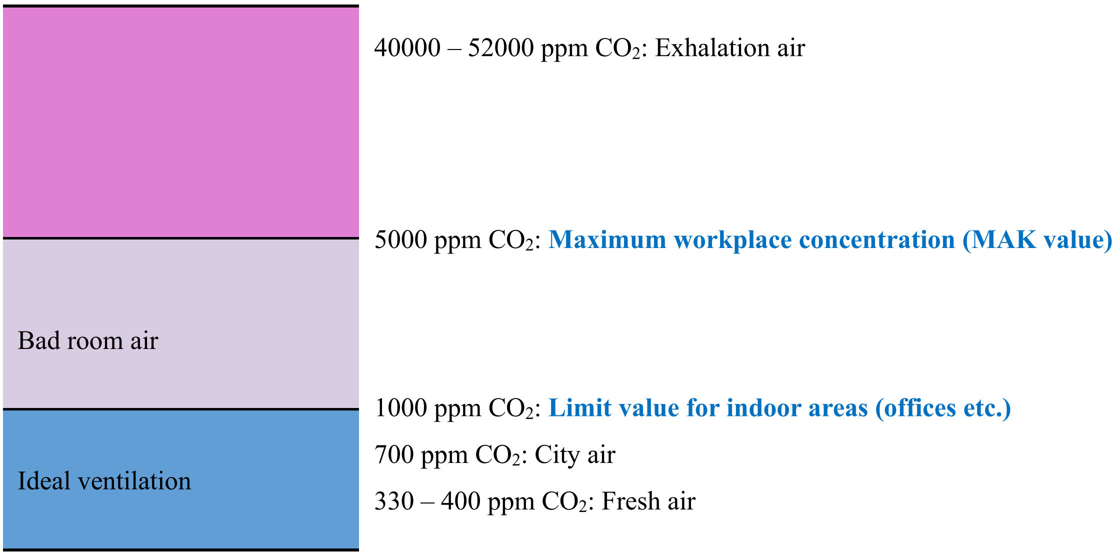


Fig. 3.12.1 CO_2 concentrations relevant for humans

Selection, product overview

Sensor type	Measuring range	Type
FYAD00CO2	0 to 10000 ppm 0 to 5000 ppm	With handle
FYA600CO2	Nominal (% CO_2) 0 to 2.5% 0 to 10% 0 to 25%	For wall mounting

3.12.1.1 Digital carbon dioxide probe FYAD 00-CO2

Measuring principle

The FYAD00CO2 probe detects CO_2 concentrations from 0 to 10000 ppm with a 2-beam infrared cell. The air pressure dependence of the CO_2 measurement is compensated by a built-in air pressure sensor element.

All calibration and sensor data are stored in the carbon dioxide probe. Aging effects are compensated automatically (without fresh air supply) by an auto-calibration procedure.

Sensor characteristics

Fig. 3.12.2
Digital carbon dioxide probe FYAD 00-CO2

Features

The digital carbon dioxide probe has an integrated signal processor. The sensor element is protected from contamination by a replaceable PTFE filter cap.

The digital air pressure sensor element for automatic air pressure compensation is built into the handle of the sensor.

Types

Sensor type	Measuring range	Accuracy
FYAD00CO2B10	0 to 10000 ppm	± (100 ppm + 5% of measured value)
FYAD00CO2B05	0 to 5000 ppm	± (50 ppm + 3% of measured value)

Programming

Measuring ranges at delivery

Designation	Comm	Range	Exp	Meas. range	Dim	Resolution
1. CO_2 concentration with LK	B-01	DIGI	0	0 to 10000	pp	1 ppm
2. Air pressure	B-02	DIGI	-1	300.0 to 1100.0	mb	0.1 mb

Configurable measuring ranges

The measuring ranges of the measuring channels can be configured out of a list of ranges in the sensor menu.

Designation	Comm	Range	Exp	Meas. range	Dim	Resolution
1. CO_2 ppm avg	B-01	DIGI	0	0 to 10000	pp	1 ppm
2. Air pressure AP, p	B-02	DIGI	-1	300 to 1100.0	mb	0.1 mb
3. CO_2 ppm*	B-03	DIGI	0	0 to 10000	pp	1 ppm
4. Temperature Tp,t*	B-04	DIGI	-1	-40.0 to +60.0	°C	0.1 K

* Range can also be activated via ALMEMO® instrument.

The standard CO_2 range (1. CO_2 ppm avg) is averaged over 11 measured values of the primary value (3. CO_2 ppm, measuring time 15 s) (measuring time 165 s).

Technical data

Gas	Carbon dioxide, CO_2
Measuring principle	Non-dispersive infrared technology (NDIR)
Sensor element	2-beam infrared cell
Measuring range:	
FYAD 00-CO2B10	0 to 10 000 ppm
FYAD 00-CO2B05	0 to 5 000 ppm
Accuracy:	
FYAD 00-CO2B10	± (100 ppm + 5% of measured value)
FYAD 00-CO2B05	± (50 ppm + 3% of measured value)
Nominal conditions	25°C, 1013 mbar
Temperature dependence	Typ. 2 ppm CO_2 / K in the range 0 to 50°C
Setting time	< 195 s
Operating range	-40 to +60°C, 0 to 95% rH (non-condensing)
Measuring interval	Moving average 165 s (= 11 momentary values 15 s)
Filter cap	PTFE
Sensor connection	Plug-in connection
Handle	With socket, built-in electronics
ALMEMO® connection cable	Fixed cable 2 m with ALMEMO® D6 connector
Digital air pressure sensor element	
built into the handle	
Measuring range	300 to 1100 mbar
Accuracy	± 2.5 mbar (23°C ± 5K)
ALMEMO® D6 connector	
Refresh rate	1 second for all 4 channels
Supply voltage	6 to 13 V DC
Current consumption	25 mA

Dimensions

Diameter 20 mm
Total length incl. sensor element 245 mm
Filter cap: Diameter ca. 18 mm, length ca. 41 mm

Use

Review

Before measuring, please make sure that the probe tip is firmly attached to the probe handle with the bayonet lock.

Measurement

Long-term measurements in sleep mode are possible, but only for current instrument types with a sleep delay of 180 s. This sleep delay is necessary to obtain a safe average value.

Sensor protection

The sensor may only be connected to the switched-off measuring instrument.

In case of damage or contamination, the filter cap of the sensor can be reordered (article number: ZB9600CO2SK).

3.12.1.2 Carbon dioxide probe FYA 600-CO2

Measuring principle

The carbon dioxide gas probe FYA 600-CO2 operates on an infrared-optical basis and uses the light absorption of CO_2 in a narrow wavelength range of infrared radiation.

The correlation between the output signal of the module and the CO_2 concentration is essentially determined by the Lambert-Beer absorption law. Due to further effects, the correlation is not simply logarithmic. The gas is supplied by free convection, especially for air conditioning. The sensor does not use any mechanically moving parts.

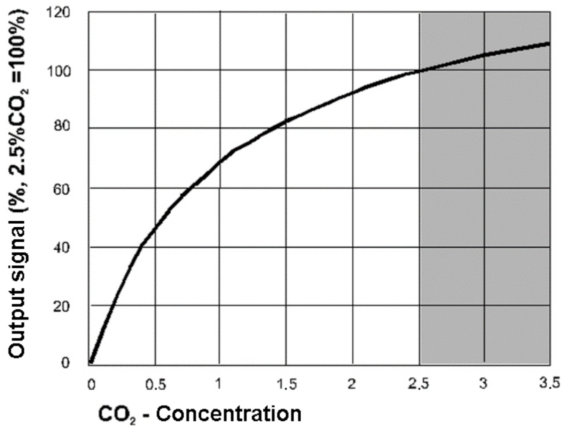


Fig. 3.12.3 Dependence of the output signal on the CO_2 concentration

The output signal of the FYA 600-CO2 carbon dioxide probe is a voltage of 0 to 2 volts. 0 volts is output in the absence of CO_2. 2 volts is referred to the final value of the respective measuring range.

The end values can be selected from 0.5% to 25% CO_2, so that the sensor can be used universally. The output signal is temperature compensated as standard in the present version of the sensor.

Sensor characteristics

Fig. 3.12.4 Carbon dioxide probe FYA 600-CO2

Types

Sensor type	Measuring range nominal (% CO_2)	
FYA600CO2	0 to 2.5% 0 to 10% 0 to 25%	Measuring ranges must be specified when ordering.

Technical data

Gas	Carbon dioxide, CO_2
Measuring principle	IR-optical
Measuring ranges nominal (% CO_2)	0 to 2.5%, 0 to 10%, 0 to 25%
Accuracy	±2% of final value
Reproducibility	±1% of final value
Resolution, dep. on measuring range	< 200 ppm to 2.5%
Voltage output	0 to 2 V on ALMEMO® connector Linearization in ALMEMO® instrument
Voltage supply	6.5 to 12V DC from ALMEMO® instrument, operation with plug-in power supply recommended
Current consumption	Eff. 50 mA / max. 70 mA
Setting time t90	< 60 s
Temperature coefficient	Typical -0.4% Signal / K
Temperature range	5 to 40°C
Relative humidity	0 to 95% non-condensing
Weight	241 g
Connection cable	1.5 m with ALMEMO® connector

Dimensions

Width 96 mm x Height 36 mm x Debth 64 mm

Use

Preparation

The setting time is essentially determined by the flow/purge rate of the interior of the sensor. The CO_2 gas has a greater specific weight than air, so that it is "at the bottom". The recommended installation position of the sensor is therefore upright (vertical). The sensor has mounting holes for screws for wall mounting.

When operating more than one CO_2 sensor on one ALMEMO® unit, an external power supply for the CO_2 sensors is required. Depending on the specific measurement setup, different power supply variants are available.

Review

The zero point can be checked with sufficient accuracy in ambient air. The CO_2 content of fresh, unpolluted ambient air is on average 330 - 370 ppm (approx. 0.03%). However, this value can also be exceeded locally, e.g. in urban or industrial areas.

Increase measurement accuracy

If the sensor has lost accuracy, it is usually sufficient to correct the zero point (on the CO_2 sensor: Offset).

If a complete recalibration is necessary, the zero point (Offset) and gain (SPAN) can be adjusted on the CO_2 sensor. This requires CO_2-free synthetic air and a test gas with a defined CO_2 concentration. A volume flow of at least 1l/min must be set.

Measurement

The CO_2 sensor is calibrated to the corresponding range upon delivery and is immediately ready for operation.

Operation in SLEEP mode of the ALMEMO® instruments is not possible.

Sensor protection

Gas probes are very sensitive measuring installations. They must not be subjected to shocks or abrupt movements. A mechanical load could lead to the sensor needing to be readjusted.

3.12.2 Electrochemical measurement of the gas concentration

Measuring principle

Redox processes are decisive for the function of electrochemical sensors. During the chemical reaction of two substances, electrons are usually transferred between the substances. One reaction partner is oxidized, i.e. it releases electrons, the other is reduced, i.e. it receives electrons.

If oxidation and reduction can be separated spatially in so-called half cells (anode, cathode) in such a way that the exchange of electrons does not take place directly between the molecules but via an external current circuit, the electron current can be used as a measure of the intensity of the reaction.

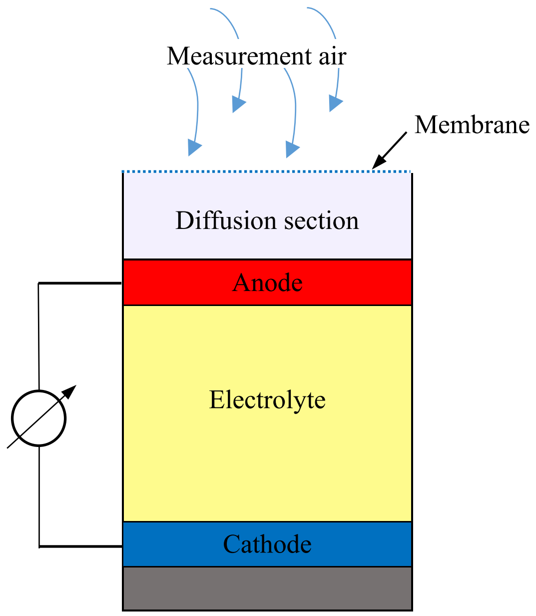
Technically, this is implemented in such a way that the processes take place at electrodes immersed in an electrolyte by which ion exchange is possible.

To illustrate the electrode reactions of a CO probe and an H_2S probe, the following are representative examples:

Reaction	H_2S probe (Hydrogen sulfide)	CO probe (Carbon monoxide)
Oxidation anode	$H_2S + 4\ H_2O \rightarrow H_2SO_4 + 8\ H^+ + 8\ e^-$	$CO + H_2O \rightarrow CO_2 + 2\ H^+ + 2e^-$
Reduction cathode	$2\ O_2 + 8\ H^+ + 8\ e^- \rightarrow 4\ H_2O$	$½\ O_2 + 2\ H^+ + 2\ e^- \rightarrow H_2O$

An electrochemical sensor consists of a housing, usually referred to as a measuring cell, whose front sides are sealed with gas-permeable membranes. The housing contains an electrolyte, the measuring electrode (anode) and the counter electrode (cathode). The electrolyte itself can be liquid or in gel form. Sometimes a porous solid is also impregnated with electrolyte. The electrolyte consists of a strong alkaline or acidic solution whose components are present in ionized form.

The gas mixture to be measured diffuses through the membrane into the electrolyte of the measuring cell. At the counter electrode, the released H+ ions and the electrons are converted into water, H_2O, in a cathode reaction with oxygen. The current generated between anode and cathode is directly proportional to the gas concentration in the measured gas mixture.



Selection, product overview

Sensor type	Measured gas	Types	Measuring range
FYA600CO	Carbon monoxide CO	FYA600COB1 FYA600COB2 FYA600COB3 FYA600COB4	0 to 150 ppm 0 to 300 ppm 0 to 5000 ppm 0 to 5 Vol. %
FYA600O2	Oxygen O_2	FYA600O2	1 to 100% O_2, linear
FYA600O3	Ozone O_3	FYA600O3	0 to 300 ppb
FYA600A	Ammonia NH_3 Nitrogen dioxide NO_2 Nitrogen oxide NO Chlorine gas Cl_2 Sulfur dioxide SO_2 Hydrogen sulfide H_2S Ethylene oxide C_2H_4O	FYA600ANH3 FYA600ANO2 FYA600ANO FYA600ACL2 FYA600ASO2B1 FYA600ASO2B2 FYA600ASO2B3 FYA600AH2SB2 FYA600AH2SB3 FYA600AC2H4OB1 FYA600AC2H4OB2 FYA600AC2H4OB4	0 to 250 ppm 0 to 30 ppm 0 to 50 ppm 0 to 50 ppm 0 to 20 ppm 0 to 50 ppm 0 to 250 ppm 0 to 50 ppm 0 to 250 ppm 0 to 20 ppm 0 to 50 ppm 0 to 100 ppm

Application fields

Carbon monoxide probe FYA600COBX

- For measuring, controlling and warning in garages
- For room air monitoring for maximum workplace concentration (MAK value, e.g. in laboratories or engine test stands)
- For monitoring outdoor air or protective air in houses and large shelters

Oxygen probe FYA600O2

- Measurement in air conditioners, air purifiers, oxygen rectifiers, greenhouses, oxygen incubators
- Approved by PTB and for exhaust emission tests in the automotive industry

Ozone probe FYA600O3

Ozone is a toxic trace gas that can cause severe mucous membrane burns in humans if inhaled in high concentrations. Control measurements of the ozone content of the air are therefore necessary in many areas, e. g.:

- Search for leaks in industry
- In occupational safety
- For mobile air quality measurements
- Obtaining data on the environment

Notes on the measurement

Due to the strongly alkaline or acidic components of the electrolytes, special care must be taken when handling leaking measuring cells to avoid burns to the skin and mucous membranes.

3.12.2.1 Carbon monoxide probe FYA 600-CO

Basics

Effect of CO in ambient air on the human body:

CO Concentration		Inhalation time and effects
30 ppm	0.003%	MAK value (maximum concentration at the workplace during 8 hours working time) for Germany
200 ppm	0.02%	Mild headache within 2 - 3 hours
400 ppm	0.04%	Headache in the forehead area within 1 - 2 hours, spreads to the whole head area
800 ppm	0.08%	Dizziness, nausea and limb twitching within 45 minutes, unconsciousness within 2 hours
1600 ppm	0.16%	Headache, nausea, dizziness within 20 minutes, death within 2 hours
3200 ppm	0.32%	Headache, nausea, dizziness within 5 - 10 minutes, Death within 30 minutes
6400 ppm	0.64%	Headache and dizziness within 1 - 2 minutes, death within 10 - 15 minutes
12800 ppm	1.28%	Death within 1 - 3 minutes

Sensor characteristics

Technical data

Gas	Carbon monoxide, CO
Measuring principle	Electrochemical reaction
Measuring range	
FYA600COB1	0 to 150 ppm
FYA600COB2	0 to 300 ppm
FYA600COB3	0 to 5000 ppm
FYA600COB4	0 to 5 vol. %
Zero point error	< 10 ppm CO
Level value unsteadiness	< 3 ppm CO
Measured value error	±3% of measuring range end value
Zero point drift	< 2% (1 year)
Repeatability	< 2% (1 year)
Linearity	< 2% of measuring range end value
Setting time t90	< 60 s
Cross sensitivities	< 2% due to integrated filter
Output	4 to 20 mA on ALMEMO® connector
Supply voltage	Via ALMEMO® instrument
Ambient temperature	-10 to +40°C, sensor in temperature compensated range
Humidity	0 to 90% non-condensing
Life time of the measuring cell	Ca. 2 years typical
Weight	600 g
Connection cable	1.5 m with ALMEMO® connector

Dimensions

Measuring head dimensions: Ø 80 mm, height 80 mm

Use

Increase measuring accuracy

A new adjustment is recommended every two years.

When the sensor is sent in, it will receive a new measuring cell and an adjustment with a factory test certificate after ordering the ZB9600COD service package.

Measurement

Operation in SLEEP mode of the ALMEMO® instruments is not possible.

3.12.2.2 Oxygen probe FYA 600-O2

Measuring principle

The oxygen probe contains a lead-oxygen cell consisting of a lead anode and a gold cathode using a special acid electrolyte. The oxygen molecules of the gas mixture diffuse through a non-porous membrane into the electrochemical cell where they are absorbed by the gold electrode.

The chemical processes are described by the following reaction equations:

O_2- Reduction at the cathode:	$O_2 + 2\ H_2O + 4e- \rightarrow 4\ OH^-$
Oxidation at the lead anode:	$2\ Pb + 4\ OH^- \rightarrow 2\ PbO + 2\ H_2O + 4\ e^-$
Reaction in the measuring cell:	$2\ Pb + O_2 \rightarrow 2\ PbO$

Output signal

The current flow between the electrodes is proportional to the oxygen concentration in the gas mixture to be measured. The signal is measured as a voltage drop across both a resistor and an NTC (for temperature compensation).

The change in output voltage is proportional to the concentration of oxygen, provided that its penetration into the sensor element is limited by diffusion alone. A plastic film serves as the diffusion membrane.

At higher gas pressures, the diffusion rate of the molecules increases. Thus, the output signal is directly proportional to the oxygen partial pressure, ensuring a linear response over all concentrations.

Cross-sensitivity

Only minor cross-sensitivities occur in typical gas mixtures:

Gas mixture	Output signal change
16% CO_2 / N_2-Equilibrium	< 0.01% O_2
5% H_2 / N_2-Equilibrium	< 0.001% O_2
2000 ppm n-Hexane / N_2-Equilibrium	< 0.01% O_2
6% CO / N_2-Equilibrium	< 0.002% O_2
3000 ppm NO / N_2-Equilibrium	< 0.002% O_2

Even if the sensor is used in such gas mixtures over a longer period of time, its output characteristics remain unaffected:

Gas mixture	Time
14.4% CO_2 / 3.6% CO / 2050 ppm Propane / N_2-Equilibrium	16 weeks
8% CO_2 / 10% O_2 / N_2-Equilibrium	72 hours
50% CO_2 / 10% O_2 / N_2-Equilibrium	18 hours

Although the concentration measurement is based on a capillary diffusion membrane, there is neither an increased CO_2 mass flow nor does a gas carrier effect occur. This means that the output signal of the oxygen probe is solely dependent on the oxygen partial pressure.

Sensor characteristics

Features

The O_2 probe contains a small circuit board on which the measuring resistor and the electronics for temperature compensation are located. The response of the sensor is optimized by a compensating auxiliary probe.

The temperature compensation (NTC close to the sensor electrode) stabilizes the output signal of the sensor and is effective in the range -10°C to +40°C.

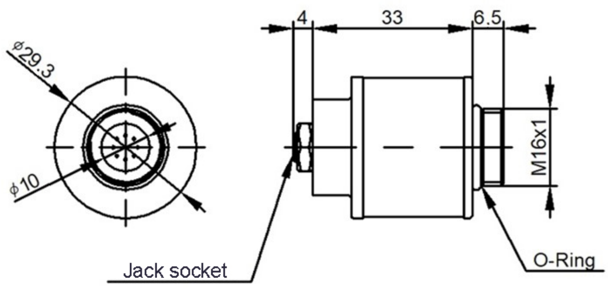
The sensor is connected to the ALMEMO® measuring instruments via a standard jack socket (3.5mm) using the ZA 9600-AKO2 adapter cable.

Technical data

Gas	Oxygen, O_2
Measuring principle	Electrochemical cell
Measuring range	1 to 100% O_2, linear
Accuracy	1% O_2
Resolution	0.01% O_2
Response time	< 40 s
Signal drift	< 2% signal/month (typically < 5% over lifetime)
Offset voltage at 20°C	< 20 µV
Operating time	2 years, when operating in 20.9% O_2
Nominal conditions	20°C, 50% rH, 1013 mbar
Temperature range	-20 to +50°C
Temperature compensation	Effective in the range -10 to +40°C
Pressure range	Air pressure ±10%
Relative humidity	0 to 99% non-condensing
Connection cable	Adapter cable 1.5m long

Dimensions

Height: 43 mm
Diameter: 29.3 mm



Use

Review

As a result of the electrochemical processes, the sensors are subject to natural aging. Therefore, the setpoint should be checked before each measurement or at regular intervals and corrected if necessary. In fresh air, the sensor must indicate 20.9% O_2. If the measured value deviates from this setpoint, the sensor must be readjusted by programming a correction factor.

Increase measuring accuracy

To compensate for the natural aging of the sensors, a correction value can be stored in the ALMEMO® connector so that an optimum output characteristic is guaranteed for the entire operating time.

Most ALMEMO® display instruments are equipped with an automatic setpoint programming function. The set-point value is entered, the correction factor is automatically calculated and stored as FACTOR in the EEPROM of the connector. For all new instruments, the adjustment via keys is described in the respective operating manual under section 'Setpoint input', the adjustment via the interface in chapter 6.4.2. For this purpose, the locking mode must be set to 4.

In principle, the following procedure is to be carried out:

1. Bring the probe into fresh air.
2. Set connector to locking mode 4.
3. Enter setpoint 20.9% and adjust. The correction factor is stored as FACTOR and the measured value now shows 20.9%.
4. Set the connector to locking mode 5.

For the instruments without setpoint input, the factor (setpoint/actual value) can be calculated and programmed by yourself (see chapter 6.3.11).

Sensor protection

Operating time

The operating time of the sensor depends on the lead mass available for the oxygen reaction and its oxidation rate. High oxygen partial pressures and high temperatures increase the output signal of the sensor and thus shorten the operating time. At their end, the sensor signal quickly collapses to 0 mV in air.

By screwing on the protective cap when not in use, you prevent oxidation and thus increase the service life.

3.12.2.3 Ozone transmitter FYA 600-O3

Measuring principle

The FYA 600-O3 ozone transmitter is based on an electrochemical three-electrode sensor. A membrane pump integrated in the housing of the sensor with a typical suction rate of 500 ml/min is used for air sampling. To increase the pump service life, the outside air is sucked in during interval operation and measured during the second half of the suction phase.

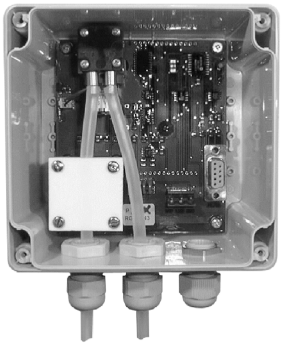


Fig. 3.12.6
Open ozone transmitter

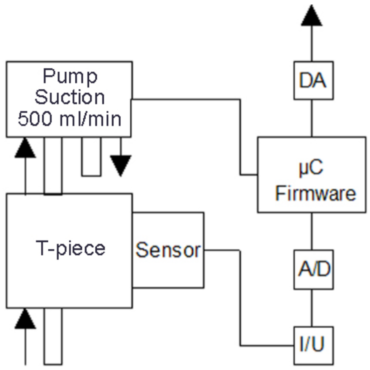


Fig. 3.12.7
Structure of the ozone transmitter

Basics

Conversion formula

The following applies to the ozone concentration at a temperature of 20°C and a pressure of 1013 mbar:

$$1\ \text{ppb} = 2.00 \cdot \frac{\mu g}{m^3}$$

ppb: Represents the volume mixing ratio here (1 to 109 volume fractions).

Sensor characteristics

Features

Each ozone probe is supplied with a test certificate. Due to the high long-term stability, only low maintenance costs are incurred.

Types

As can also be seen in the 'Technical data', the pump is switched on for 5 minutes and switched off for 10 minutes in each measuring interval. During these 10 minutes, the ozone in the measuring cell is completely consumed. When there is no more ozone in the measuring cell, the ozone probe automatically performs a zero adjustment. After this, the measuring cell is pumped full again for 5 minutes in the next measuring interval.

Interval operation of the pump extends the service life of the ozone sensor, while the zero adjustment increases the accuracy of the measurements.

However, if the sensor is used in personal protection, for example, and an alarm is to be issued in the event of a sudden increase in ozone, the pump should run in continuous operation to avoid delays (option OY9600O3D).

Technical data

Gas	Ozone, O_3
Measuring principle	Electrochemical three-electrode sensor
Measuring range	0 to 300 ppb
Detection limit	20 ppb
Accuracy	Typ. 5% of final value at nominal conditions (for interval operation)
Long-term accuracy	After 12 months at nominal conditions typ. 5% of final value (for interval operation)
Exposure time	Until reaching the specification at least 2 h (at 200 ppb); the instrument has been in an ozone-free environment for a longer period of time
Measuring interval	Pump on: 5 min Pump off: 10 min Option: OY9600 O3 Pump in continuous operation (factory setting)
Pump flow rate	500 ml/min
Signal output	0 to 2V, load resistance > 100 kΩ
Voltage supply	6 to 14 V, stable
Current consumption	Pump on: 50 mA typ. Pump off: 25 mA typ. Pump blocked: 180 mA typ.
Overload capacity	1 ppm
Life expectancy	Sensor element typ. 24 months (at 20 °C) Pump typ. 6000 h
Nominal conditions	20°C, 30% rH, 1013 mbar, no contamination of contact surfaces
Operating range	-20 to +40°C / 30% to 80% rH
Storage temperature	0 to 20°C at 30% to 80% rH, non-condensing
Connection cable	1.5 m long with ALMEMO® connector, programmed in ppb

Dimensions

Length: 180 mm, Width: 125 mm, Height: 90 mm

Use

Preparation

Installation notes

1. You achieve the highest measuring accuracy at a constant ambient temperature of approx. 20°C. We recommend mounting the ozone transmitter in the building at a height of at least 3 m with a suction hose (PTFE hose) led to the outside.
2. The opening of the suction hose must be at least 20 cm away from walls or other objects and point downwards.
3. If indoor mounting is not possible, the ozone transmitter must be mounted in 24-hour shade (north side). However, due to the greater temperature fluctuations, lower measuring accuracy must be expected. For outdoor installation, install the ozone sensor protected from precipitation, e.g. on a balcony, under a canopy or a protective hood.
4. Install the ozone probe so that it remains accessible for ongoing maintenance.
5. Install the ozone probe in a place that is well ventilated so that the ozone does not decompose due to lack of convection.

Connection plan

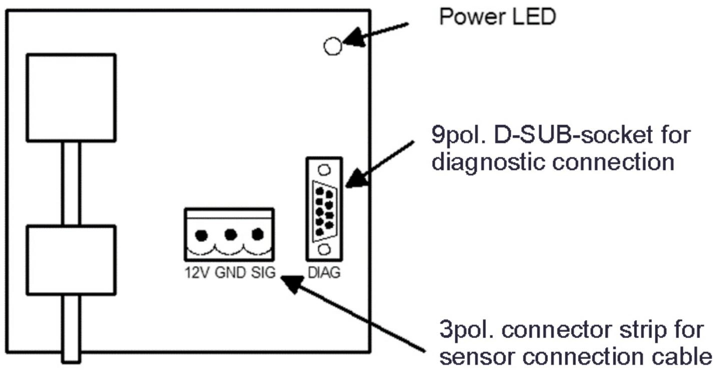


Fig. 3.12.8 Connection plan of FYA 600-O3

Measurement

If the ozone probe has been stored in an ozone-free environment for an extended period of time, it will take time for it to reach full sensitivity. At 200 ppb this is at least 2 hours, at lower concentrations it takes longer.

Unlike temperature, ozone spreads out in clouds, i.e. there is a strong local and temporal distribution. In addition, the measurement is carried out in interval mode. Therefore, it is possible that the ozone values can fluctuate by up to 50% within a short period of time.

Sensor protection

It is recommended to operate the sensor without filters, as these quickly become dirty in practice, e.g. when pollen is present, and lead to falsification of the measurement results.

Maintenance

For outdoor measurements, maintenance should be performed annually in the spring to ensure the highest measurement accuracy during the ozone season. For non-seasonal measurements, we recommend maintenance every 24 months.

Maintenance package ZB9600O3S: new electrochemical measuring cell, pump exchange, readjustment including test certificate.

Unusual weather conditions, such as a hot dry summer, strong pollen count, or foreign substances (e.g. varnish), lead to a premature deterioration of the sensor's characteristics. A shorter maintenance interval may be necessary.

3.12.2.4 Gas probes for different gases FYA 600-A

Sensor characteristics

Types

The ALMEMO® FYA600A gas probes are suitable for continuous measurement of toxic gas concentrations in air in the range from 0 to 250 ppm. Different electrochemical types are available.

Article number	Gas	Range
FYA600ANH3	Ammonia NH_3	0 to 250 ppm
FYA600ANO2	Nitrogen dioxide NO_2	0 to 30 ppm
FYA600ANO	Nitrogen oxide NO	0 to 50 ppm
FYA600ACL2	Chlorine gas Cl_2	0 to 50 ppm
FYA600ASO2B1	Sulfur dioxide SO_2	0 to 20 ppm
FYA600ASO2B2	Sulfur dioxide SO_2	0 to 50 ppm
FYA600ASO2B3	Sulfur dioxide SO_2	0 to 250 ppm
FYA600AH2SB2	Hydrogen sulfide H_2S	0 to 50 ppm
FYA600AH2SB3	Hydrogen sulfide H_2S	0 to 250 ppm
FYA600AC2H4OB1	Ethylene oxide C_2H_4O	0 to 20 ppm
FYA600AC2H4OB2	Ethylene oxide C_2H_4O	0 to 50 ppm
FYA600AC2H4OB4	Ethylene oxide C_2H_4O	0 to 100 ppm

Technical data

Gas	See above under 'Types'
Measuring principle	Electrochemical reaction
Measuring range	See above under 'Types'
Measured value error	±3% of measuring range end value
Zero point drift	< 2% (1 year)
Repeatability	< 2% (1 year)
Linearity	< 2% of measuring range end value
Setting time t90	< 60 s
Cross sensitivities	< 2% due to integrated filter
Output	4 to 20 mA on ALMEMO® connector
Supply voltage	Via ALMEMO® instrument
Ambient temperature	-10 to +40°C, sensor temperature compensated in this range
Humidity	0 to 90%, non-condensing
Lifetime of the measuring cell	Ca. 2 years typical
Weight	600g
Connection cable	1.5 m with ALMEMO® connector

Dimensions

Diameter: 80 mm
Height: 80 mm

Use

Increase measuring accuracy

A new adjustment is recommended every two years.

Measurement

The current of the sensor element is amplified and output via a 2-wire 4-20mA interface at the sensor. Important parameters such as measuring range and scale are already stored in the ALMEMO® connector of the connection cable, so that the measured value is displayed in ppm of the respective sample gas.

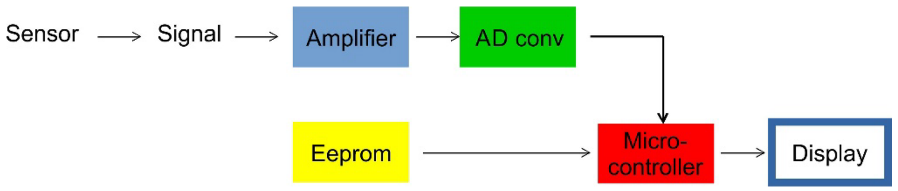
Operation in SLEEP mode of the ALMEMO® instruments is not possible.

4 Connection of foreign sensors and electrical signals to the ALMEMO® system

Basics

Appropriate ALMEMO® connectors are available for connecting foreign sensors or electrical signals to the ALMEMO® system.

Signal processing from sensor to display, general

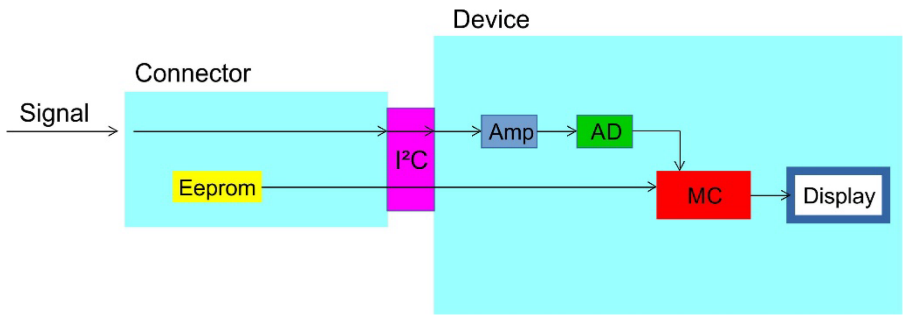


The analog signal coming from the sensor is transferred via an amplifier to an AD converter. After the converter has digitized the signal, it passes it on to a microcontroller, which prepares it for display or storage. For this purpose, it needs certain information, e.g. about the

- Linearization
- Scaling
- Dimension
- Zero adjustment
- Multipoint adjustment

It gets this information from a memory module, an EEPROM.

Signal processing in analog ALMEMO® standard connectors

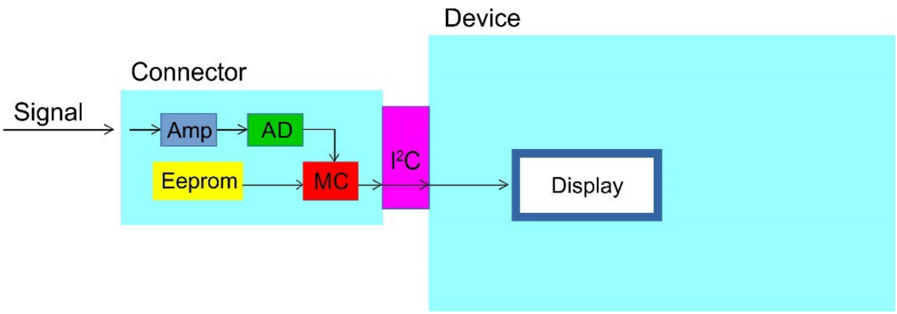


Analog ALMEMO® standard connectors are connected to the measuring devices via an I²C interface. The signal passes the connector unchanged and meets the amplifier, the AD converter and the microcontroller only in the device. The microcontroller obtains the necessary information for processing the signal from the EEPROM in the analog standard connector.

As the EEPROM is located in the connector and not in the device, each connector contains the specific information about the measurement signal of its sensor. In this way, a wide variety of sensors can be connected to the same measuring device.

The query in the measuring device is done with the conversion rate.

Signal processing in ALMEMO® D6 connectors



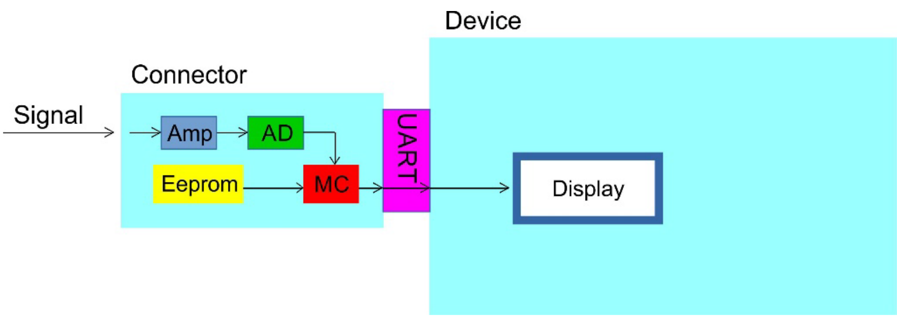
In addition to the EEPROM, each D6 connector has its own amplifier, an AD converter and a microcontroller. The device receives the finished, digital measured value from the connector and therefore only needs the display and possibly a memory for the measured data.

The query in the measuring device is done with the conversion rate of the measuring device together with the analog measuring signals.

Advantages:

- The signal is digitized in the connector, which is why the signal transmission to the instrument is insensitive to electrical interference, even when extensions are used.
- For calibrations, the sensor with its connector is sent to the calibration laboratory without the measuring device.

Signal processing in ALMEMO® D7 connectors



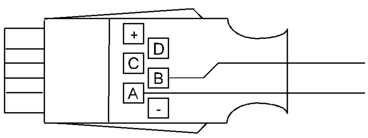
Here, as well, the amplifier, the AD converter and the microcontroller are located in the connector in addition to the EEPROM. However, the interface between the connector and the device is a UART interface. This new interface together with a more advanced amplifier, AD converter and V7 devices allows sampling up to 1000 measurements per second.

The new AD converter delivers 24-bit signals in contrast to the previous 16-bit signals. This allows measured values to be displayed with significantly higher resolution than before.

Query is performed with the query cycle, which is significantly faster than the conversion rate. Several connectors can work simultaneously with a high sampling rate on one device.

Structure of the analog ALMEMO® standard connectors

The analog ALMEMO® standard connectors have 6 screw terminals inside with the measuring inputs A, B, C and D, as well as 2 power supply connections + and - .



Many of these analog standard connectors are based on a non-programmed connector, the ZA9000 FS. All analog standard connectors that have the same hardware as this connector belong to the connector type 'Normal'. By programming its memory, the EEPROM, this connector type can be used to measure different voltages. The ZA9000FS0 and ZA9000FS3 connectors are examples of analog standard connectors 'Normal' with special programming.

Examples

Article number	Measuring range	Abbreviation of the measuring range	Connection (multiplexer)
ZA9000FS0	-10 to +55 mV	mV	AB
ZA9000FS3	-2.6 to +2.6 V	Volt	AC

Since the hardware of all analog standard connectors 'Normal' is the same, they can be converted into each other by changing the programmed range. It must be noted that different ranges may require the lines to be connected to different screw terminals.

Analog ALMEMO® standard connectors can be programmed using the ' ALMEMO® Control' software (download at www.ahlborn.com). In some cases, programming is also possible via the ALMEMO® device display.

Structure of the ALMEMO® D6 and D7 connectors

The digital ALMEMO® D6 and D7 connectors are very complex and specially tailored to their respective tasks. Digital connectors for connecting external sensors or electrical signals have marked screw terminals inside. Certain changes in the programming of the connectors can be made in the sensor menu (see chapter 3.1.3.1).

Extension of the analog standard connector 'Normal' with special hardware

Sensors supply various measuring signals, which can be voltages or currents, for example. If these measuring signals are not within the measuring range of up to ±2.6 V covered by the analog standard connector type 'Normal', it must be extended by various hardware parts:

- For large voltage signals (e.g. 26 volts) it is equipped with a voltage divider (connector type 'divider', see chapter 3.1.4).
- For sensors with current signals, the signal is converted into a voltage signal with a shunt between the measuring inputs (connector type 'shunt').

When measuring with base metal thermocouples, the reference temperature must be measured at the interface between the legs of the thermocouple and the copper lines of the measuring circuit. This can be achieved in two different ways:

- The signal lines are replaced in the connector by the respective thermal material, so that the transition to copper lines only occurs in the measuring device (connector type 'Thermo'). There are one or two temperature sensors for reference junction measurements in each device.
- The reference junction is located in the connector and its temperature is also measured there.

Examples

Connector type	**Special hardware**	**Article number**	**Measuring range of the connector**	**Signal actually seen by the measuring device**
Voltage	Voltage divider 1:100	ZA9602FS	-26 to +26 Volt	-260 to +260 mV
Current	Shunt (2Ω) between A and B	ZA9601FS1	-32 to +32 mA	-64 to +64 mV
Thermocouple Type K	Thermal line	ZA9020FS	-200 to +1370°C	at 1000°C: 41.269 mV
Thermocouple Type J	RJC in the connector	ZA9400FSJ	-200 to +1000°C	at 1000°C: 57.942 mV

Sensor current supply

The operating voltage of the device (usually 9V with battery or 12V with mains adapter) is available for the sensor current supply of the analog standard connector type 'Normal'. For the larger devices such as the MA2690-8A, MA2890-9 or MA710, the voltage for the sensor supply is programmable (6 V, 9 V, 12V).

For other sensor supply voltages there are special connectors available.

Supply voltage	**Article number**	**Load capacity**	**Type of connector / usage**
6 to 12 Volt	ZA9000 FS	100 mA	Analog standard connector ‚Normal', without programming
2.5 Volt stable	ZA9025 FS3	100 mA	Potentiometer
5 Volt stable	ZA9105 FS	100 mA	Measuring bridges
5 Volt	ZA9602FS5V05	50 mA at U_G= 9 to 12 V	Voltage connector with divider, measuring range -1 to +5.5 V
12 Volt	ZA960xFSxV12	100 mA at U_G= 9 to 12 V	Voltage / current connector
15 Volt	ZA960x FSxV15	Max. 80 mA at U_G= 12 V	Voltage / current connector
24 Volt	ZA960x FSxV24	Max. 30 mA at U_G= 9 to 12 V	Voltage / current connector

Some of the digital connectors also provide sensor supplies, e.g. the D7 connector for DC voltage ZED702FS, which provides a voltage of 6/9/12 V via screw terminals. It is also available in the versions ZED702FSV15 with a sensor supply of 15 Volt or ZED702FSV24 with 24 Volt.

Differential measurements with sensors supplied from the measuring device

If the sensor is supplied from the measuring device, differential connectors (e.g. ZA9600FS2V12) should be used. Here, the measurement is not mass-related and thus a measurement error due to the supply current is excluded.

The supply lines of the sensors are connected to '-' and '+', the signal lines to B and C.

ZA9xxx-SS connector with special measuring ranges

For sensors with special or non-linear signals, connectors with special measuring ranges can be supplied on request. These connectors cannot be changed in their programming.

4.1 Connectors for connection of temperature sensors

4.1.1 Connection of thermocouples

Basics

See chapter 3.2.1.

Selection, product overview

Article number	Types	Special feature	Connector type
ZA9000FSx	U, L, S, R, B, A	-	Analog standard connector
ZA9020FS	K	With thermal material in the connector	Analog standard connector
ZA9021FSx	N, J, T	With thermal material in the connector	Analog standard connector
ZA9400FSx	K, N, L, J, T, U, S	NTC bead for measuring the reference junction temperature	Analog standard connector
ZTD700FS	K, N, J, E, T, S, R, B	NTC bead in the connector	D7 connector
ZAD950ABx	K, J, T	Galvanically isolated measuring module	Module, see chapter 4.5.3.

4.1.1.1 Analog standard connector ZA9000FS for thermocouples type U, L, S, R, B, A

Characteristics of the connectors

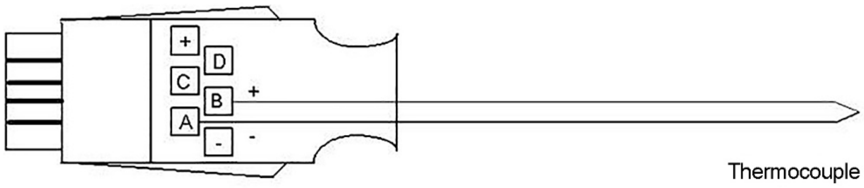
Features

The analog standard connector type 'Normal' ZA 9000-FS can be used with appropriate programming to connect thermocouples type U, L, S, R, B, A, because in these no electromotive force (EMF) is generated in the ambient temperature range.

Types

Article number	Type	Measuring range	Resolution	Programmed range
ZA9000FSU	U (Cu-CuNi)	-200 to +600°C	0.1 K	CuCo
ZA9000FSL	L (Fe-CuNi)	-200 to +900°C	0.1 K	FeCo
ZA9000FSS	S (PtRh10-Pt)	0 to +1760°C	0.1 K	Pt10
ZA9000FSR	R (PtRh13-Pt)	0 to +1760°C	0.1 K	Pt13
ZA9000FSB	B (PtRh30-PtRh6)	+400 to +1800°C	0.1 K	El18
ZA9000FSA	A (AuFe-Cr)	-270 to +60°C	0.1 K	AuFe

Connection assignment



4.1.1.2 Analog standard connectors ZA9020FS / ZA9021FSx for thermocouples type K, N, J, T

Characteristics of the connectors

Features

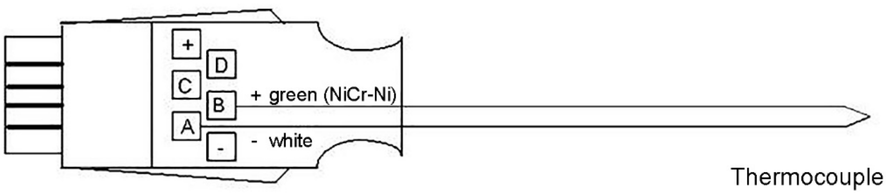
In the basic connector, the wires between the screw terminals in the connector and the socket of the measuring device are made of copper. If it were used unchanged, a measurement error would occur with base metal thermocouples in the event of a temperature difference between the terminals and the socket, since the reference junction temperature is measured just behind the socket inside the measuring devices. For this reason, there are special thermopower-free connectors made of thermal material for the K, N, J and T thermocouples.

Types

Article number	Type	Measuring range	Resolution	Programmed range
ZA9020FS	K (NiCr-Ni)	-200 to +1370°C	0.1 K	NiCr
ZA9021FSN	N (NiCroSil-NiSil)	-200 to +1300°C	0.1 K	NiSi
ZA9021FSJ	J (Fe-CuNi)	-200 to +1000°C	0.1 K	IrCo
ZA9021FST	T (Cu-CuNi)	-200 to +400°C	0.1 K	CoCo

Connection assignment

Example ZA9020FS



4.1.1.3 Analog standard connector ZA9400- FSx with built-in reference junction sensor for all thermocouples

Characteristics of the connectors

Features

For particularly accurate measurements with multiple sensors under unfavorable conditions (e.g. thermal radiation), there are ALMEMO® ZA 9400-FSx connectors with built-in temperature sensors for reference junction compensation.

The connector is suitable for all thermocouple types, but requires 2 channels:

- The first one shows the reference temperature measured with the NTC bead in the connector.
- The second is occupied by the programming for the temperature measured with the thermocouple.

In the comment of the first channel (thermocouple), a '#J' must be programmed on the first 2 digits so that the built-in temperature sensor is used for reference junction compensation.

Types

Article number	Type	Measuring range	Resolution	Programmed range
ZA9400FSK	K (NiCr-Ni)	-200 to +1370°C	0.1 K	NiCr
ZA9400FSN	N (NiCroSil-NiSil)	-200 to +1300°C	0.1 K	NiSi
ZA9400FSL	L (Fe-CuNi)	-200 to +900°C	0.1 K	FeCo
ZA9400FSJ	J (Fe-CuNi)	-200 to +1000°C	0.1 K	IrCo
ZA9400FST	T (Cu-CuNi)	-200 to +400°C	0.1 K	CoCo
ZA9400FSU	U (Cu-CuNi)	-200 to +600°C	0.1 K	CuCo
ZA9400FSS	S (PtRh10-Pt)	0 to +1760°C	0.1 K	Pt10

Connection assignment

See chapter 4.1.1.2.

4.1.1.4 D7 connector ZTD700FS for various thermocouples

Characteristics of the connector

Features

The ZTD700-FS D7 thermocouple connector uses its own 24-bit AD converter to record the thermoelectric voltage of a thermocouple with the highest precision at four selectable speeds (up to 100 measurements per second). A selection of nine different thermocouples is available for the measuring range, i.e. different thermocouple types can be programmed with one connector.

The linearization of the thermocouple characteristics is calculated error-free according to DIN IEC 584 (no approximation method). Since the overall accuracy of the sensor does not depend on an evaluation device, the sensor can be calibrated and even multi-point adjusted on its own.

For ultra-low temperature applications, the connector can be programmed for measurements with thermocouple type E by selecting the appropriate range in the measuring device (sensor menu).

The thermocouple is connected via two screw terminals in the connector.

Each connector has its own temperature sensor built directly into the terminals for measurement and automatic compensation of the reference junction temperature.

The input of the ALMEMO® D7 measuring connector is galvanically isolated from the ALMEMO® V7 measuring device. In this way, the connected thermocouple sensor is also galvanically isolated from the other connected ALMEMO® sensors.

Programming

Designation	Command	Programmed range	Measuring range	Dim	Resolution
1. * Type K	B-01	NiCrNi	-200 to +1370	°C	0.1 K
2. Type N	B-02	NiSil	-200 to +1300	°C	0.1 K
3. Type J	B-03	IrCo	-210 to +1100	°C	0.1 K
4. Type E	B-04	NiCrCu	-270 to +800	°C	0.1 K
5. Type T	B-05	CoCoT	-200 to +400	°C	0.1 K
6. Type S	B-06	PtRh10	-50 to +1760	°C	0.1 K
7. Type R	B-07	PtRh13	-50 to +1760	°C	0.1 K
8. Type B	B-08	El18	+250 to +1820	°C	0.1 K
9. Type K2	B-09	NiCrNi	-200 to +1370	°C	0.01 K
10. Millivolt U643	B-10	U643	-10 to +64	mV	0.001 mV
11. Millivolt U324	B-11	U324	-10 to +32	mV	0.0001 mV
12. Fixed value 10mV	B-12	U10D	+10	mV	0.0001 mV
13. Cold junction	B-13	CJ	-30 to +100	°C	0.01 K

*State on delivery

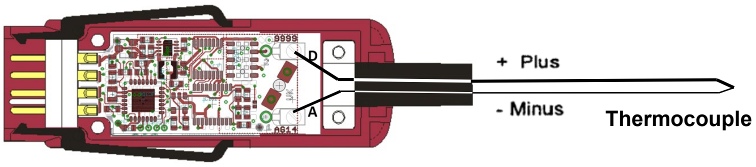
Technical data

Application range	Temperature depending on sensor type	
Measuring input	Galvanically isolated, voltage strength 50 V	
Measuring ranges temperature	Type K: -200.0 to +1370.0°C	
	Type N: -200.0 to +1300.0°C	
	Type J: -210.0 to +1100.0°C	
	Type E: -270.0 to +800.0°C	
	Type T: -200.0 to +400.0°C	
	Type S: -50.0 to +1760.0°C	
	Type R: -50.0 to +1760.0°C	
	Type B: +250.0 to +1820.0°C	
	Type K2: -200.00 to +1370.00°C	
	Reference junction compensation: -30.00 to +100.00°C	
Measuring ranges voltage	U643 -10.000 to +64.000 mV	
	U324 -10.0000 to +32.0000 mV	
Resolution	0.1 K* resp. 0.01 K at measuring range K2	
AD converter	Delta-Sigma	
Accuracy at 10 M/s	Thermocouples:	±0.2 K ± 0.02% (Type K, K2, N, J, T)
		±1.0 K ± 0.02% (Type E)
		±0.8 K ± 0.02% (Type R, S, B)
	Voltage:	±8 Digit ± 0.02% (U324, U643)

Temperature drift	Max. 30 ppm/K
RJC sensor	NTC 10 K at 25°C
Reference junction compensation	Effective in the range of -10 to +60°C Accuracy: ±0.2 K ± 0.01 K/°C
Nominal temperature	23°C ± 2 K
Application range	-10 to +60°C 10% to 90% rH (non condensing)
Refresh rate	* 400 ms (2.5 M/s), 100 ms (10 M/s), 20 ms (50 M/s), 10 ms (100 M/s)
Supply voltage	6, 9, 12 from the ALMEMO® measuring device
Current consumption	Ca. 5 mA
Connector colors	Housing ruby red, black levers

*State on delivery

Connection assignment



4.1.2 Connection of resistance sensors for temperature measurement

Basics

See chapter 3.2.2

Selection, product overview

Article number	Type	Connection	Measuring range	Connector type
ZA9030FS1	Pt100	4-wire	-200 to +850°C	Analog
ZA9030FS2	Pt100	4-wire	-200 to +400°C	Analog
ZA9030FS4	Pt1000	4-wire	-200 to +850°C	Analog
ZA9030FS5	Pt1000	4-wire	-200 to +400°C	Analog
ZPD700FS	Pt100	4-wire	-200 to +850°C	D7
ZPD703FS	Pt100	3-wire	-200 to +850°C	D7
ZPD710FS	Pt1000	4-wire	-200 to +850°C	D7
ZA9030FS3	Ni100	4-wire	-60 to +240°C	Analog
ZA9030FS6	Ni1000	4-wire	-60 to +240°C	Analog

4.1.2.1 Analog standard connector ZA9030-FSx for Pt100 and Pt1000 sensors

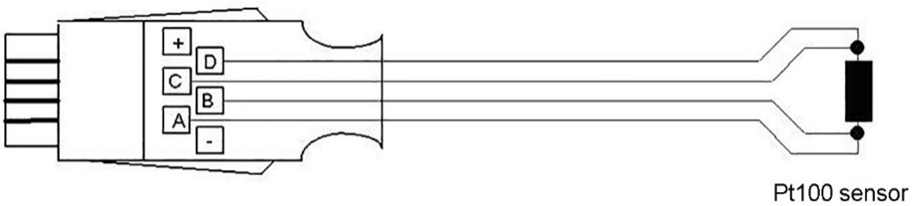
Characteristics of the connectors

Types

Article number	Type	Measuring range	Resolution	Programmed range
ZA9030FS1	Pt100 4-wire	-200 to +850°C	0.1 K	P104
ZA9030FS2	Pt100 4-wire	-200 to +400°C	0.01 K	P204
ZA9030FS4	Pt1000 4-wire	-200 to +850°C	0.1 K	P104, Element flag 01:I2*
ZA9030FS5	Pt1000 4-wire	-200 to +400°C	0.01K	P204, Element flag 01:I2*

* Switching to 1/10 measuring current with element flag, see chap. 6.10.3

Connection assignment



4.1.2.2 D7 connector ZPD70xFS for Pt100 sensors

Characteristics of the connectors

Features

The D7-Pt100 connector ZPD700-FS records the temperature of the sensor with a resolution of 0.01K in the entire measuring range from -200.00 to +850.00°C with its own 24-bit AD converter. The linearization of the Pt100 characteristic is calculated error-free according to DIN EN 60751 (no approximation method).

Since the overall accuracy of the sensor does not depend on an evaluation device, the sensor can also be calibrated and even multi-point adjusted on its own.

Types

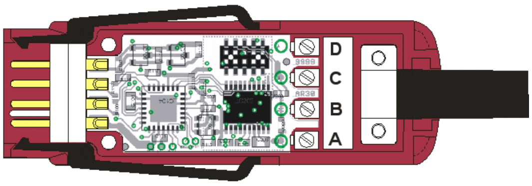
Article number	Type	Measuring range	Dimension	Resolution	Command	Programmed range	Sampling
ZPD700FS	Pt100 4-wire	-200 to +850°C	°C	0.01 K	B-01	DP04	10 M/s
ZPD703FS*	Pt100 3-wire	-200 to +850°C	°C	0.01 K	B-01	DP03	10 M/s

* For 3-wire connection there is the connector ZPD703-FS. The accuracy in this case depends on the difference of the wire resistances.

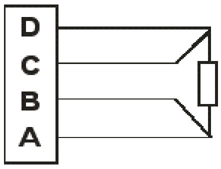
Technical data

Application range	Temperature depending on sensor type
Temperature sensor	ZPD700-FS: Pt100 4-wire ZPD703-FS: Pt100 3-wire
Measuring input	Galvanically connected to the voltage supply (mass of the ALMEMO® device)
Measuring ranges	-200.00 to 850.00°C
Conversion rate	10 Measurements/s
Measuring current	Pt100: ca. 1 mA
Resolution	0.01 K
AD converter	Delta-Sigma
System accuracy	0.07 K ± 2 Digit
Temperature drift	Max. 30ppm/K
Nominal temperature	22°C ± 2 K
Refresh rate	0.1 sec
Self-calibration	12.8 sec
Supply voltage	6 to 13 V DC
Power consumption	Ca. 8.5 mA
Connector colors	Housing ruby red, black levers

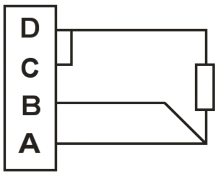
Connection assignment



4-wire connection



3-wire connection



4.1.2.3 D7 connector ZPD710-FS for Pt1000 sensors

Characteristics of the connector

Features

The D7-Pt1000 connector ZPD710-FS records the temperature of the sensor with a resolution of 0.01K in the entire measuring range from -200.00 to +850.00°C with its own 24-bit AD converter. The linearization of the Pt1000 characteristic is calculated error-free according to DIN IEC 751 (no approximation method).

Since the overall accuracy of the sensor does not depend on an evaluation device, the sensor can also be calibrated and multi-point adjusted on its own.

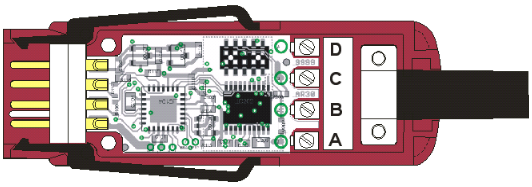
Type

Article number	Type	Measuring range	Dimension	Resolution	Command	Programmed range	Sampling
ZPD710FS	Pt1000 4-wire	-200 to +850°C	°C	0.01 K	B-01	DP14	10 M/s

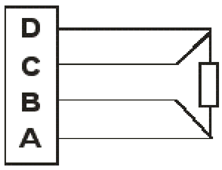
Technical data

Temperature sensor	ZPD710-FS: Pt1000 4-wire
Measuring input	Galvanically connected to the voltage supply (mass of the ALMEMO® device)
Measuring ranges	-200.00 to 850.00°C
Conversion rate	10 Measurements/s
Measuring current	Pt1000: ca. 0.1 mA
Resolution	0.01 K
AD converter	Delta-Sigma
System accuracy	0.07 K ± 2 Digit
Temperature drift	Max. 30ppm/K
Nominal temperature	22°C ± 2 K
Refresh rate	0.1 sec
Self-calibration	12.8 sec
Supply voltage	6, 9, 12 V DC from the ALMEMO® measuring device
Current consumption	Ca. 8 mA
Connector colors	Housing ruby red, black levers

Connection assignment



4-wire connection



4.1.2.4 Analog standard connectors ZA9030-FSx for Ni100 and Ni1000 sensors

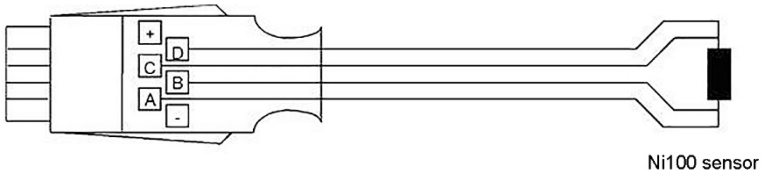
Characteristics of the connectors

Types

Article number	Type	Measuring range	Resolution	Programmed range
ZA9030FS3	Ni100 4-wire	-60 to +240°C	0.1 K	N104
ZA9030FS6	Ni1000 4-wire*	-60 to +240°C	0.1 K	N104, Element flag 01:I2 *

* Switching to 1/10 measuring current with element flag, see chap. 6.10.3

Connection assignment



4.1.3 Connection of NTC and PTC sensors for temperature measurement

Selection, product overview

Article number	Type	Measuring range	Resolution	Connector type
ZA9040FS	Ntc Type N	-50 to +125°C	0.01 K	Analog
ZA9040FS2	2 x Ntc Type N	-50 to +125°C	0.01 K	Analog
ZAD040FS	Ntc Type N	-50 to +125°C	0.01 K	D6
ZAD040FS2	2 x Ntc Type N	-50 to +125°C	0.01 K	D6
ZAD040FS3	Ntc Type N	-20 to +65°C	0.001 K	D6

4.1.3.1 Analog standard connector ZA9040FS for NTC sensors

Characteristics of the connectors

General

The ZA9040FS analog standard connectors are used for the ALMEMO® FNAxxx NTC sensors (see chapter 3.2.3).

Types

Article number	Type	Measuring range	Resolution	Programmed range
ZA9040FS	NTC Type N	-50 to +125°C	0.01 K	Ntc
ZA9040FS2*	2 x NTC Type N	-50 to +125°C	0.01 K	1. Channel: Ntc 2. Channel: Ntc, multiplexer C-A

* No galvanic isolation

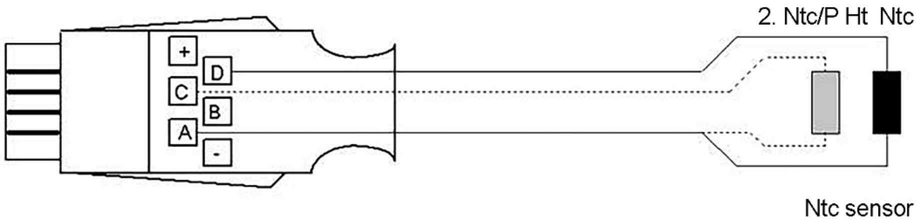
The programming given here is the delivery state. If it is lost, the second channel of the ZA9040FS2 can be reprogrammed to the 'Ntc' range and the multiplexer set to C-A (see chapter 6.10.2).

Special types

The linearization is stored in the ALMEMO® connector.

Article number	Type	Measuring range	Resolution	Programmed range	Connector type
ZA9040SS3	Ntc Type N	+5 to +46	0.001 K	Ntc3	Standard, analog
ZA9040SS4	KTY 84	-40 to +200	0.1 K	KTY	Standard, analog
ZA9641SS	YSI 400	-40 to +130	0.1 K	NtcY	Standard, analog

Connection assignment



4.1.3.2 D6 connectors ZAD040FS for NTC sensors

Characteristics of the connectors

General

The digital ALMEMO® D6 measuring connector operates with its own built-in 24-bit AD converter. The linearization of the NTC characteristic curve is calculated error-free using the Steinhart-Hart coefficients (no approximation method). Up to two NTC sensors can be detected with a resolution of 0.01 K or one sensor with a resolution of 0.001K.

Since the overall accuracy of the sensor does not depend on an evaluation device, the sensor can also be multipoint adjusted and calibrated separately.

The ZAD040FS connector can be used to connect customer-specific NTC sensors to the ALMEMO® system after configuring the corresponding Steinhart-Hart coefficients via the sensor menu (see chapter 3.1.2) (see below, chapter 'Use, Increase measuring accuracy').

Types

Article number	Number of inputs	Measuring range	Dimension	Resolution
ZAD040FS	1	-50 to +125°C	°C	0.01 K
ZAD040FS2	2	-50 to +125°C	°C	0.01 K
ZAD040FS3	1	-20 to +65°C	°C	0.001 K

Programming

Measuring ranges on delivery

Article number	Designation	Terminal	Command	Range	Exp
ZAD040-FS	1. Temperature T, t	Ntc-Gnd	B-01	DIGI	-2
ZAD040-FS2 1. Channel	1. Temperature T, t (Ntc)	Ntc-Gnd	B-01	DNtc	-2
ZAD040-FS2 2. Channel	2. Temperature T, t (Ntc2)	Ntc2-Gnd	B-02	DNt2	-2
ZAD040-FS3	Temperature T, t (Ntc3)	Ntc-Gnd	B-03	DNt3	-3

Configuration on the PC via the sensor menu

In addition to the first Ntc range, a second one can be activated or a range with higher resolution can be selected on the ZAD040-FS connector via the sensor menu in the measuring instrument or in the ALMEMO® Control software, if required:

Configurable measuring ranges

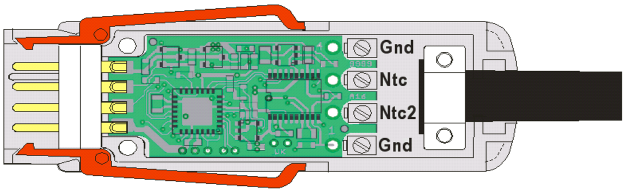
Designation	Terminal	Command	Range	Exp	Measuring range	Dim	Resolution
1. Temperature T, t (Ntc)	Ntc-Gnd	B-01	DNtc	-2	-50 to +125	°C	0.01 K
2. Temperature T, t (Ntc2)	Ntc2-Gnd	B-02	DNt2	-2	-50 to +125	°C	0.01 K
3. Temperature T, t (Ntc3)	Ntc-Gnd	B-03	DNt3	-3	-20 to +65	°C	0.001 K

Technical data

Application area	Temperature depending on sensor type
Temperature sensor	NTC Type N, accuracy: ± 0.1 K (0 to 70°C)
Measuring input	Galvanically connected to the voltage supply (mass of the ALMEMO® device)
Measuring ranges	-50.00 to 125.00°C, accuracy: ± 0.05 K (-50 to 100°C), DNtc/DNt2 -20.000 to 65.000°C, accuracy: ± 0.02 K (-20 to 65°C), DNt3
Temperature drift	40 ppm/K
Nominal temperature	23°C ± 2 K
Precision class	AA
Refresh rate	0.3 sec. for up to 2 channels
Linearisation	Error-free calculation method (no approximation method)
Connector colors	Two-toned light and dark gray, red levers
Application area	-10 to 60°C, 10 to 90% rH (non condensing)
Baud rate standard	115.2 kBd (1200 Bd to 921 kBd selectable)
Supply voltage	6, 9, 12 V DC from the ALMEMO® device (sensor supply)
Current consumption	Ca. 4 mA

Connection assignment

The NTC sensors are screwed into the corresponding terminals Ntc-Gnd and Ntc2-Gnd.



Use

Increase measuring accuracy

Configuration of Steinhart-Hart coefficients

On the second page of the sensor menu, the Steinhart-Hart coefficients A (coeff. A), B (coeff. B) and C (coeff. C) can be configured for connecting customer-specific NTC sensors. For this purpose, the channel interlock must be reduced to level 0.

The following formula is used as the basis for the calculation:

$$\frac{1}{T} = A + B \ln R + C(\ln R)^3$$

Via the check mark **Coeff. normalized R/R25** the formula can be calculated optionally with R as well as with R/R25.

The field **Reference R25** is used to also enable the connection of NTC sensors with R25 ≠ 10 kΩ. However, this requires a new adjustment of the connector, which can only be performed at the factory.

Individual range limits can be entered via the **T Min** and **T Max** input fields.

The **RESET** key cancels all settings and restores the factory Steinhart-Hart coefficients and range limits.

4.2 Connector for voltage measurements

4.2.1 DC voltage

4.2.1.1 Voltage measurements with sensors that do not have to be supplied from the device

Characteristics of the connectors

Features

The connectors are based on the standard analog connector 'Normal' ZA9000FS (see 'Basics' at the beginning of chapter 4) and are adjusted to the respective measuring range by programming different ranges.

ZA9602FS4, ZA9602FS have a divider 100:1 built in, which adapts the signal to the measuring input. They are programmed with respect to the divider with corresponding decimal point.

For two signals with common mass there is the connector ZA9602FS2. It is equipped with two dividers 100:1. The two signals are not galvanically isolated from each other.

The connectors with divider have an accuracy of ± 0.1% of the meas. value and an input resistance of 100 kΩ.

Types

Analog standard connectors

Article number	Measuring range	Resolution	Connection on screw terminals	Special element in connector	Programmed range
ZA9000FS0	-10 to +55 mV	1 µV	AB	-	mV
ZA9000FS1	-26 to +26 mV	1 µV	AB	-	mV1
ZA9000FS2	-260 to +260 mV	10 µV	AB	-	mV2
ZA9000FS3	-2.6 to +2.6 V	0.1 mV	AC	-	Volt
ZA9602FS4	-1 to +5.5 V	0.1 mV	AC	Divider 100:1	D55
ZA9602FS	-26 to +26 V	1 mV	AC	Divider 100:1	D260
ZA9602FS2	-26 to +26 V	1 mV	AB/AC	2 x divider 100:1 no galv. isolation	mV2

D7 connector **(see chapter 4.2.1.2)**

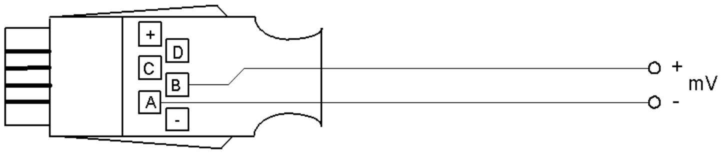
Technical data

ZA9602FS4, ZA9602FS, ZA9602FS2

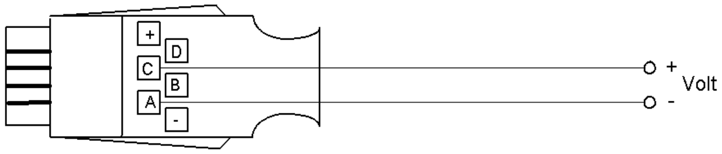
Accuracy divider	±0.1% of meas. value
Temperature coefficient divider	<10 ppm/K
Nominal temperature divider	23°C ± 2 K
Input resistance	100 kΩ

Connection assignment

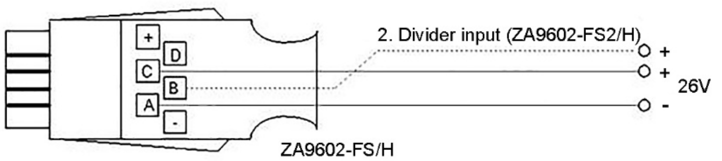
ZA9000FS0, ZA9000FS1, ZA9000FS2



ZA9000FS3, ZA9602FS4



ZA9602FS, ZA9602FS2



4.2.1.2 Connector for DC voltage with sensor supply from the device

Basics

Sensors that need electrical supply can get it from the ALMEMO® measuring instruments. Their supply lines are connected to '-' and '+' in the connectors.

The voltage applied to '-' and '+' in the connectors depends on the type of device and can be found in the data sheets. For the larger devices, it can be set to either 6 V, 9 V or 12 V.

Especially for sensors or transmitters (e.g. pressure sensors), which are supplied from the device, a differential voltage measurement is advisable to eliminate the voltage drop UL on the mass line. The transmitter is connected with the connectors in 4-wire circuit and the output signal UM is tapped directly with the differential input pin C and pin B. The output signal UM can be measured with the connectors of this subchapter.

The connectors of this subchapter pass the supply voltage directly from the device, i.e. unchanged, to the sensor.

Characteristics of the connectors

Features

Analog standard connectors

The connectors are based on the basic ZA9000FS connector (see 'Basics' at the beginning of chapter 4) and are adjusted to the respective measuring range by programming different ranges.

ZA9602FS3 has a 100:1 divider built in, which reduces the voltage to the measuring instrument. It is programmed with respect to the divider with corresponding decimal point and has an accuracy of ± 0.1% of the meas. value and an input resistance of 100 kΩ.

D7 connector

The digital ALMEMO® D7 measuring connector works with its own built-in 24-bit delta-sigma AD converter.

One can select two or three different ranges for each connector, which differ in terms of their resolution and sampling rate. Thus, at 5 measurements/second, 200,000 digits are achieved; at 500 measurements/second, 20,000 digits; and at 1000 measurements/second, 2,000 digits.

If a sensor supply is required, it can be tapped on U+ and Gnd and set to 6, 9 or 12V via the instrument. The four-wire circuit prevents measurement errors due to a voltage drop on supply and ground lines.

For galvanic isolation, the pluggable cable, length 0.2 m, ZAD700GT is available for the D7 connectors.

Types

Analog standard connectors

Article number	Measuring range	Resolution	Connection on screw terminals	Special element in connector	Programmed range
ZA9000FS0D	-10 to +55 mV	1 µV	BC	-	D55
ZA9000FS1D	-26 to +26 mV	1 µV	BC	-	D26
ZA9000FS2D	-260 to +260 mV	10 µV	BC	-	D260
ZA9000FS3D	-2.6 to +2.6 V	0.1 mV	BC	-	D2.6
ZA9602FS3	-26 to +26 V	1 mV	BC	Divider 100:1	D260

D7 connectors

Article Nr.	Designation	Measuring range	Resolution	Command	Range	M/s
ZED700-FS	1. * U2.00000	-2.2 to +2.2 V	0.01 mV	B-01	D U25	5
	2. U2.0000	-2.2 to +2.2 V	0.1 mV	B-02	D U24	500
	3. U2.000	-2.2 to +2.2 V	1 mV	B-03	D U23	1000
ZED700-FS2	1. * U250.000	-250 to +250 mV	1 µV	B-01	D U254	5
	2. U64.000	-64 to +64 mV	1 µV	B-02	D U643	5
ZED702-FS	1. * U20.0000	-20 to +20 V	0.1 mV	B-01	D U204	5
	2. U20.000	-20 to +20 V	1 mV	B-02	D U203	500
	3. U20.00	-20 to +20 V	10 mV	B-03	D U202	1000
ZED702-FS2	1. *U60.000	-60 to +60 V	1 mV	B-01	D U603	5
	2. U60.00	-60 to +60 V	10 mV	B-02	D U602	500
	3. U60.00	-60 to +60 V	10 mV	B-03	D U612	1000

The preset measuring ranges are marked with an *.

Technical data

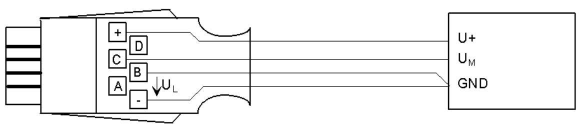
ZA9602FS3

Accuracy divider	±0.1% of meas. value
Temperature coefficient divider	<10 ppm/K
Nominal temperature divider	23°C ± 2 K
Input resistance	100 kΩ

D7 connector ZED700FS, ZED700FS2, ZED702FS, ZED702FS2

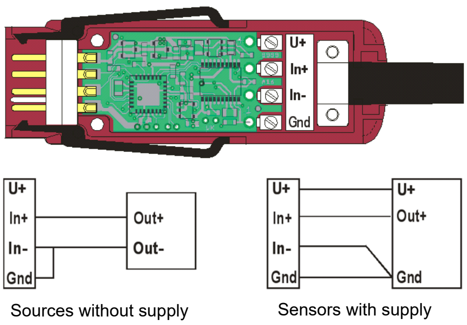
Measuring range	See Types
Sampling rate, resolution	See Types
Input resistance	ZED700FS and ZED702FS: 110 kΩ ZED700FS2: 5 GΩ ZED702FS2: 103 kΩ
Overload	ZED700FS: ±3 V ZED700FS2: ±2.8 V ZED702FS: ±30 V ZED702FS2: ±60 V
Input current	100 pA
Measuring input	Galvanically connected to the voltage supply (mass of the ALMEMO® device)
AD converter	Delta-Sigma
System accuracy	0.02% ± 2 Digit at 5 M/s
Temperature drift	Max. 30 ppm/K
Nominal temperature	22°C ± 2 K
Application area	-10 to +60°C, 10 to 90% rH (non condensing)
Refresh rate	200 ms (5 M/s), 2 ms (500 M/s)
Supply voltage	6 / 9 / 12 V from the ALMEMO® device (sensor supply)
Current requirement	Ca. 7.5 mA (5 M/s), ca. 9.5 mA (500 M/s)
Connector colors	Housing ruby red, black levers

Connection assignment



ZA9000FS0D, ZA9000FS1D, ZA9000FS2D, ZA9000FS3D, ZA9602FS3

ZED700FS, ZED700FS2, ZED702FS, ZED702FS2



4.2.1.3 Connectors for DC voltage with voltage converters for specific supplies

Basics

The connectors listed in this chapter contain a voltage converter that steps up or down the voltage received from the instrument to the voltage required to supply the sensor.

These connectors are suitable, for example, for sensors or transmitters that require a supply of at least 12 V DC but are operated with a device that provides a sensor supply of 9 V DC. The differential evaluation eliminates the line voltage drop.

Characteristics of the connectors

Features

Analog standard connectors

The connectors are based on the basic ZA9000FS connector, but have a voltage converter for supplying the sensors with certain voltages.

ZA9602FS3V12 has a built-in 100:1 divider, which reduces the voltage to the device. It is programmed with respect to the divider with an appropriate decimal point.

For sensors that require a particularly stable supply of 5 V DC, there is the ZA9602FS5V05. The connectors with divider have an accuracy of ± 0.1% of the meas. value and an input resistance of 100 kΩ.

D7 connectors

See chapter 4.2.1.2

Types

Analog standard connectors

Article number	Measuring range	Resolution	Connection on screw terminals	Special element in the connector	Programmed range	Supply voltage
ZA9600FS0V12	-10 to +55 mV	1 µV	BC	Voltage converter	D55	12 V
ZA9600FS1V12	-26 to +26 mV	1 µV	BC	Voltage converter	D26	12 V
ZA9600FS2V12	-260 to +260 mV	10 µV	BC	Voltage converter	D260	12 V
ZA9600FS3V12	-2.6 to +2.6 V	0.1 mV	BC	Voltage converter	D2.6	12 V
ZA9602FS3V12	-26 to +26 V	1 mV	BC	Voltage converter, divider 100:1	D260	12 V
ZA9602FS5V05	-1 to +5.5 V	0.1 mV	BC	Voltage converter, divider 100:1	D55	5 V

D7 connectors

Article number	Designation	Measuring range	Resolution	Command	Range	M/s	Supply voltage
ZED702-FSV15 / ZED702-FSV24	1. * U20.0000	-20 to +20 V	0.1 mV	B-01	D U204	5	15 V/ 24 V
	2. U20.000	-20 to +20 V	1 mV	B-02	D U203	500	15 V/ 24 V
	3. U20.00	-20 to +20 V	10 mV	B-03	D U202	1000	15 V/ 24 V

The preset measuring ranges are marked with an *.

Technical data

Analog standard connectors

ZA9600FS0V12, ZA9600FS1V12, ZA9600FS2V12, ZA9600FS3V12, ZA9602FS3V12

Device voltage U_G	8 to 12 V
Sensor supply voltage U_F	12.2 V to 12.5 V (15 V / 24 V on request)
Output current	100 mA at U_G = 9 to 12 V

ZA9602FS5V05

Device voltage U_G	8 to 12 V
Sensor supply voltage U_F	5 V ± 2% (max.)
Output current	50 mA at U_G=9 to 12 V

Divider of ZA9602FS3V12 and ZA9602FS5V05

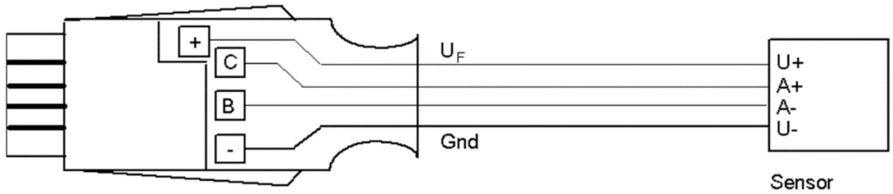
Accuracy divider	±0.1% of meas. value
Temperature coefficient divider	<10 ppm/K
Nominal temperature divider	23°C ± 2 K
Input resistance	100 kΩ

D7 connectors ZED702FSV15, ZED702FSV24

Measuring range	See Types
Sampling rate, resolution	See Types
Input resistance	110 kΩ
Overload	±30 V
Input current	100 pA
Measuring input	Galvanically connected to the voltage supply (mass of the ALMEMO® device)
AD converter	Delta-Sigma
Accuracy (at 5 M/s)	0.02% ±2 Digit
Temperature drift	Max. 30 ppm/K
Nominal temperature	22°C ± 2 K
Application area	-10 to +60°C, 10 to 90% rH (non condensing)
Refresh rate	200 ms (5 M/s), 2 ms (500 M/s)
Sensor supply	ZED702FSV15: 15 V, max. 50 mA at device voltage 12 V ZED702FSV24: 24 V, max. 30 mA at device voltage 12 V
Current requirement	Depending on the sensor
Connector colors	Housing ruby red, black levers

Connection assignment

ZA9600FS0V12, ZA9600FS1V12, ZA9600FS2V12, ZA9600FS3V12, ZA9602FS3V12, ZA9602FS5V05 ZED702FSV15, ZED702FSV24



See chapter 4.2.1.2.

4.2.1.4 ALMEMO® Adapter cable ZA 9000-AK

Characteristics of the adapter cable

Features

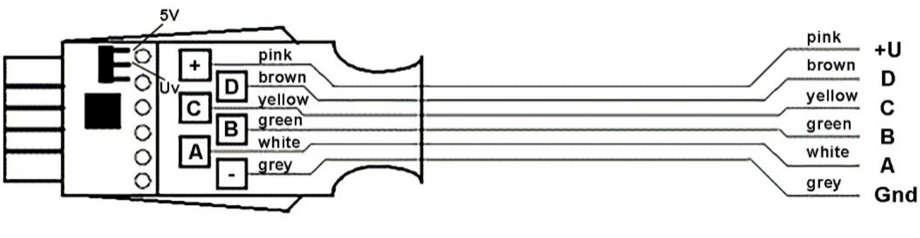
As explained at the beginning of chapter 4 in 'Basics', there is a non-programmed ALMEMO® basic connector, ZA 9000-FS, on which many standard analog connectors are based.

This connector, which is also suitable for voltage measurements, is also available with a connection cable and free ends as adapter cable ZA 9000-AK.

The sensor supply voltage provided by the ALMEMO® device is connected to terminal U+ (sensor supply voltage 5 V stabilized, load capacity max. 50 mA, on request).

Characteristics of the connection cable: 8-core, 8 x 0.14 mm^2 black, length 1.5 m

The connection diagram and the color coding of the cores are uniform for all ALMEMO® sensors and cables, so that each connection assignment can be identified immediately.



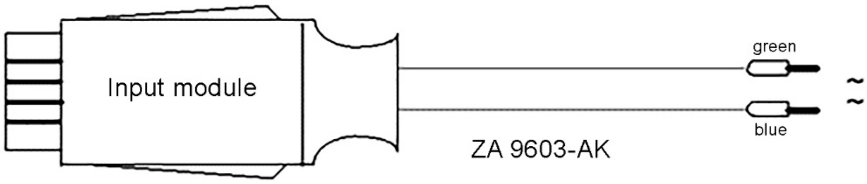
4.2.2 AC Voltage

4.2.2.1 ALMEMO® Adapter cable ZA9603-AKx for AC voltage

Characteristics of the adapter cable

Features

ZA 9603-AK adapter cable operates with a True-RMS-converter.



Types

Article number	Measuring range	Resolution	Internal resistance
ZA9603AK1	5 to 260 mV_{eff}	0.1 mV	R_i = 100 kΩ
ZA9603AK2	0.05 to 2.6 V_{eff}	0.001 V	R_i = 1 MΩ
ZA9603AK3	0.5 to 26 V_{eff}	0.01 V	R_i = 10 MΩ

Technical data

Measuring range	See Types
Resolution	See Types
Internal resistance	See Types
Frequency range	50 Hz to 10 kHz
Accuracy	± 0.2 % of end value ± 0.5% of meas. value (40 Hz to 2 kHz Sinus)
Crest factor	3 (additional error 0.7%)
	5 (additional error 2.5%)
Current consumption	Ca. 5 mA

Use

Measuring

The True RMS converter located in the connector is supplied galvanically isolated via a built-in DC/DC converter, so that several of these modules can be connected to a measuring device at the same time, even if signals with different potentials are applied to them. The potential difference must not exceed 50 V.

If the channel of one of these connectors is selected, there is a galvanic connection from the measuring input to the mass of the measuring instrument. Voltages above 50 V must therefore not be applied under any circumstances (danger to life!).

The use in sleep mode is not provided by default because of the settling time of the electronics.

4.3 Connectors for current measurements

4.3.1 DC current

4.3.1.1 Current measurements for sensors that do not have to be supplied from the device

Characteristics of the connectors

Features

For current measurements, a ZA9601-FS1 connector is available in the ± 32 mA range, or a ZA9601-FS2 connector with a built-in 2 Ohm shunt is available in the 0-100% (4-20mA) range.

If two current signals have a common mass, both can be measured with a ZA 9601-FS3 or -FS4 connector.

Types

Analog standard connectors

Article number	Measuring range	Resolution	Connection on screw terminals	Special element in connector	Programmed range
ZA9601FS1	-32 to +32 mA	1 µA	AB	Shunt	mA
ZA9601FS2	0 to 100% (4 to 20 mA)	0.01%	AB	Shunt	%
ZA9601FS3*	-32 to +32 mA (2x)	1 µA	AB/AC	2 x Shunt	mA
ZA9601FS4*	0 to 100% (2x) (4 to 20 mA)	0.01%	AB/AC	2 x Shunt	%

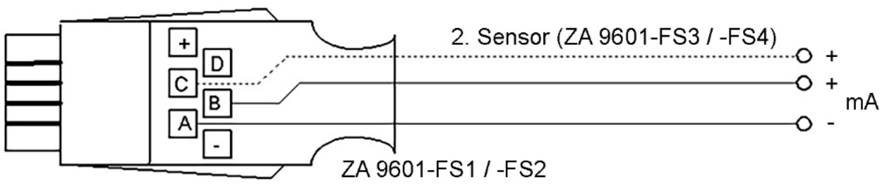
* No galvanic isolation

D7 connectors see 4.3.1.2

Technical data

Shunt accuracy	±0.1% of meas. value
Shunt temperature coefficient	< 25 ppm/K
Shunt nominal temperature	23°C ± 2 K

Connection assignment



Use

Measuring

If two current signals are connected to the ZA9601FS3 and ZA9601FS4 connectors, they have a common mass, i.e. there is no galvanic isolation.

4.3.1.2 Connectors for DC current with supply directly from the device

Basics

See chapter 4.2.1.2.

Characteristics of the connectors

Features

Analog standard connectors

If sensors with current output are supplied from the device, the problem of voltage drop on the mass line is even more noticeable than with sensors with voltage output (see chapter 4.2.1.3). It can be solved in a similar way, but requires a ZA9601-FS5 or -FS6 connector with shunt between C and B and with change of multiplex setting to C-B (see chapter 6.10.2).

D7 connectors

The digital ALMEMO® D7 measuring connector works with its own built-in 24-bit delta-sigma AD converter.

One can select three different ranges on the ZED701FS connector, which differ in terms of their resolution and sampling rate. Thus, at 5 measurements/second 200,000 digits are achieved, at 500 measurements/second 20,000 digits and at 1000 measurements/second 2,000 digits.

If a sensor supply is required, it can be tapped on U+ and Gnd and set to 6, 9 or 12V via the instrument. The four-wire circuit prevents measurement errors due to a voltage drop on the Gnd line.

For galvanic isolation at the D7 connectors, the pluggable cable, length 0.2 m, ZAD700GT is available.

Types

Analog standard connectors

Article number	Measuring range	Resolution	Connection on screw terminals	Special element in connector	Programmed range
ZA9601FS5	-32 to +32 mA	1 µA	BC	Shunt	mA
ZA9601FS6	0 to 100% (4 to 20 mA)	0.01%	BC	Shunt	%

D7 connector

Article number	Designation	Measuring range	Resolution	Command	Range	M/s
ZED701FS	1. * I20.0000	-20 to +20 mA	0.1 µA	B-01	D I204	5
	2. I20.000	-20 to +20 mA	1 µA	B-02	D I203	500
	3. I20.00	-20 to +20 mA	10 µA	B-03	D I202	1000

The preset measuring ranges are marked with an *.

Technical data

Analog standard connectors

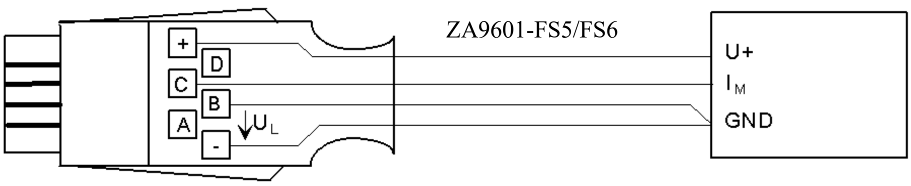
Shunt accuracy	±0.1% of meas. value
Shunt temperature coefficient	< 25 ppm/K
Shunt nominal temperature	23°C ± 2 K

D7 connector ZED701FS

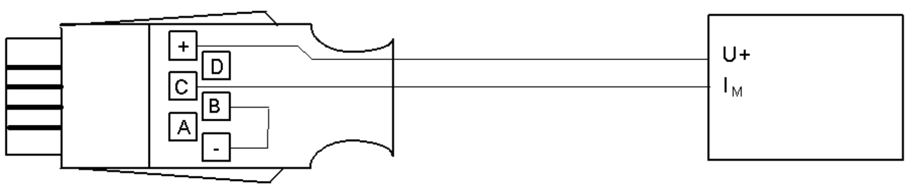
Measuring range	See Types
Sampling rate, resolution	See Types
Input resistance	100 Ω
Overload	±28 mA
Input current	100 pA
Measuring input	Galvanically connected to the voltage supply (mass of the ALMEMO® device)
AD converter	Delta-Sigma
Accuracy (at 5 M/s)	0.02% ±2 Digit
Temperature drift	Max. 30 ppm/K
Nominal temperature	22°C ± 2 K
Refresh rate	200 ms (5 M/s), 2 ms (500 M/s)
Range of application	-10 to +60°C, 10 to 90% rH (non condensing)
Power supply	6 / 9 / 12 V from the ALMEMO® measuring device
Current consumption	Ca. 7.5 mA (5 M/s), ca. 9.5 mA (500 M/s)
Connector colors	Housing ruby red, black levers

Connection assignment

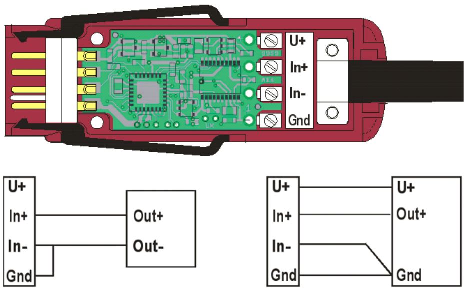
ZA9601FS5, ZA9601FS6



2-wire transmitters can also be connected (bridge between - and B):



ZED701FS



Sources without supply Sensors with supply

4.3.1.3 Connectors for DC current with voltage converters for specific supplies

Basics

See chapter 4.2.1.3.

Characteristics of the connectors

Types

Analog standard connectors

Article number	Measuring range	Resolution	Connection on screw terminals	Special element in connector	Programmed range	Supply voltage
ZA9601FS5V12	-32 to +32 mA	1 µA	BC	Voltage converter, Shunt	mA	12 V
ZA9601FS6V12	0 to 100% (4 to 20 mA)	0.01%	BC	Voltage converter, Shunt	%	12 V

D7 connectors

Article number	Designation	Measuring range	Resolution	Command	Range	M/s	Supply voltage
ZED701-FSV15 / ZED701-FSV24	1. * I20.0000	-20 to +20 mA	0.1 µA	B-01	D I204	5	15 V/24 V
	2. I20.000	-20 to +20 mA	1 µA	B-02	D I203	500	15 V/24V
	3. I20.00	-20 to +20 mA	10 µA	B-03	D I202	1000	15 V/24V

The preset measuring ranges are marked with an *.

Technical data

Analog standard connectors

ZA9601FS5V12, ZA9601FS6V12

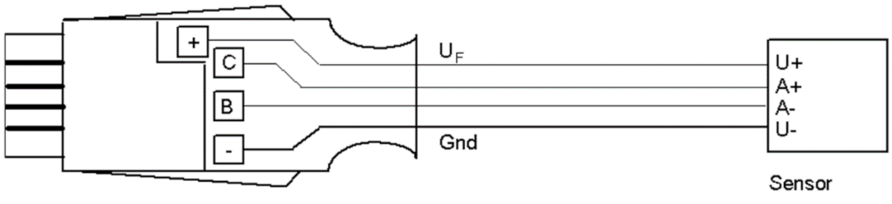
Device voltage U_G	8 to 12 V
Sensor supply voltage U_F	12.2 V to 12.5 V (15 V / 24 V on request)
Output current	100 mA at U_G = 9 to 12 V
Input resistance	2 kΩ
Shunt accuracy	±0.1% of meas. value
Shunt temperature coefficient	< 25 ppm/K
Shunt nominal temperature	23°C ± 2 K

D7 connectors ZED701FSV15, ZED701FSV24

Measuring range	See Types
Sampling rate, resolution	See Types
Input resistance	100 Ω
Overload	±28 mA
Input current	100 pA
Measuring input	Galvanically connected to the voltage supply (mass of the ALMEMO® device)
AD converter	Delta-Sigma
Accuracy (at 5 M/s)	0.02% ±2 Digit
Temperature drift	Max. 30 ppm/K
Nominal temperature	22°C ± 2 K
Refresh rate	200 ms (5 M/s), 2 ms (500 M/s)
Range of application	-10 to +60°C, 10 to 90% rH (non condensing)
Sensor supply	ZED701FSV15: 15 V, max. 50 mA at device voltage 12 V ZED701FSV24: 24 V, max. 30 mA at device voltage 12 V
Current consumption	Depending on sensor
Connector colors	Housing ruby red, black levers

Connection assignment

ZA9601FS5V12, ZA9601FS6V12, ZED701FSV15, ZED701FSV24



See chapter 4.3.1.2.

4.4 Connectors for measuring resistances and measuring bridges

4.4.1 Connectors for resistance

4.4.1.1 Connectors ZA9003xxx for resistance

Characteristics of the connectors

Types

Article number	Measuring range	Resolution	Signal on terminals	Special element in connector	Programmed range
ZA9003FS	0 to 500 Ω	0.01 Ω	BC	-	Ohm
ZA9003FS2	0 to 5000 Ω	0.1 Ω	BC	-	Ohm, Element flag 01:I2*

* Switchover to 1/10 measuring current with element flag, see chap. 6.10.3

Special types

Connectors with measuring ranges up to 50Ω or up to 100kΩ can be realized as special connectors on request.

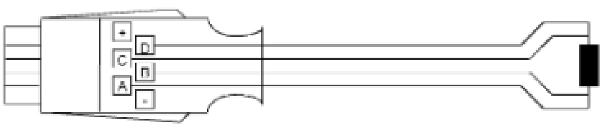
Article number	Measuring range	Resolution	Signal on terminals	Special element in connector	Programmed range
ZA9003SS3	0 to 50 Ω	0.01 Ω	BC	-	DIGI, Linearization in the connector
ZA9003SS4	0 to 110 kΩ	0.01 kΩ	BC	-	DIGI, Linearization in the connector

Technical data

Only for ZA9003SS4

Linearization accuracy	±0.2% ± 0.02 kΩ

Connection assignment



Use

Measuring

The connectors for measuring resistances should be connected in a four-wire circuit. If this is not possible, a two-wire circuit with bridges A-B and C-D can also be used. The error caused by the connecting cables must be taken into account here.

All ALMEMO® measuring instruments can be used for measurement with the ZA9003FSx resistor connectors except the MA2450-1.

4.4.2 Connectors for potentiometer sensors

4.4.2.1 Analog standard connector ZA9025FS3 for potentiometers

Measuring principle

Potentiometer sensors for length and angle measurements can be evaluated with the ZA 9025-FS3 connector. The potentiometer is connected to an internal supply voltage of 2.5 V (max. 50 ppm/K) and the pickup is recorded in the 2.6 V measuring range.

Characteristics of the connector

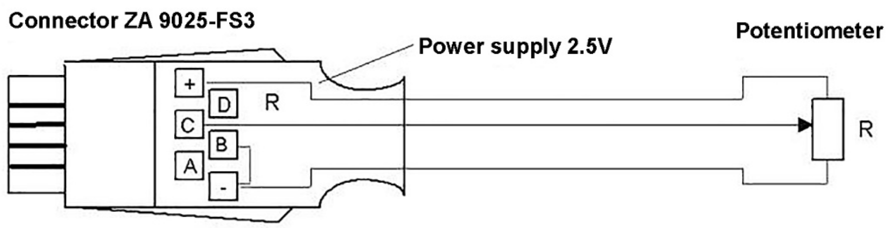
Types

Article number	Measuring range	Resolution	Signal on terminals	Special element in connector	Programmed range	Supply voltage
ZA9025FS3	-2.6 to +2.6 V	0.1 mV	BC	-	D2.6	2.5 V

Technical data

Sensor supply	2.5 V
Temperature coefficient	< 50 ppm/K

Connection assignment



4.4.2.2 D7 connector ZWD700FS for potentiometers

Characteristics of the connector

Features

The D7 potentiometer connector ZWD700-FS uses its own 24-bit AD converter and 100 measurements/second to detect the voltage drop across a potentiometer sensor fed by the 2V reference voltage of the AD converter.

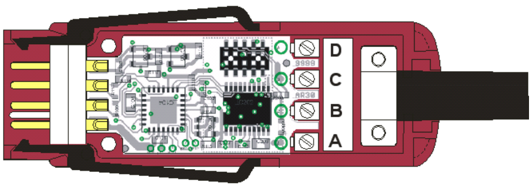
Types

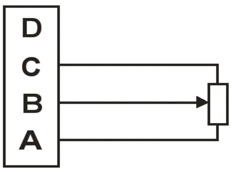
Article number	Designation	Measuring range	Resolution	Command	Range	M/s	Supply voltage
ZWD700FS	Poti	0 to 100%	0.01%	B-01	D U24	100	2 V from AD converter

Technical data

Measuring range	00.00 to 100.00%
Measuring input	Galvanically connected to the voltage supply (mass of the ALMEMO® device)
Input range	-2 to +2 Volt
Resolution	0.01 %
Conversion rate	100 Measurements/s
Reference voltage	2 V
AD converter	Delta-Sigma
System accuracy	0.02 % ± 2 Digit
Temperature drift	Max. 30 ppm/K
Nominal temperature	22°C ± 2 K
Refresh rate	0.01 seconds
Supply voltage	6 to 13 V DC
Current consumption	Ca. 8 mA (without sensor)
Connector colors	Housing ruby red, black levers
Range of application	-10 to 60 °C, 10 to 90% rH (non condensing)

Connection assignment





Use

Preparation

The scaling of the sensor to the physical quantity (e.g. displacement in mm) is done via the ALMEMO® V7 device (device operation or in the ALMEMO® Control software): adjustment of the zero point and adjustment of the final value.

4.4.3 Connectors for measuring bridges

4.4.3.1 Analog standard connectors ZA9105FSx for measuring bridges

Characteristics of the connectors

Features

The ZA9105-FSx connectors provide a zero-point symmetrical voltage supply of ± 2.5V, which is stabilized in the ALMEMO® connector.

In addition, the supply is switched off when the measuring point is not selected. This makes it possible to operate many measuring bridges on one measuring device in a power-saving way.

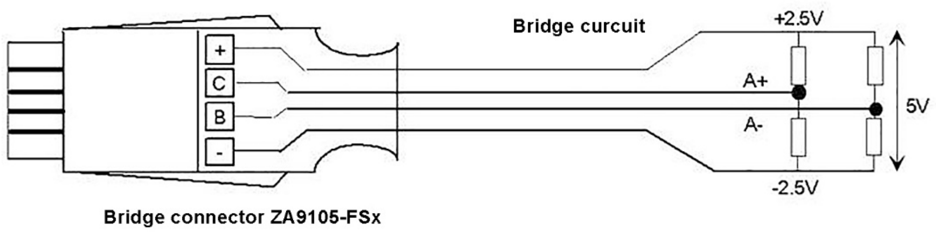
Types

Article number	Measuring range	Resolution	Signal on terminals	Special element in connector	Programmed range	Supply voltage
ZA9105FS0	-10 to +55 mV	1 µV	BC	-	D55	5V, symm.
ZA9105FS1	-26 to +26 mV	1 µV	BC	-	D26	5V, symm.
ZA9105FS2	-260 to +260 mV	10 µV	BC	-	D260	5V, symm.
ZA9105FS3	-2.6 to +2.6 V	0.1 mV	BC	-	D2.6	5V, symm.

Technical data

Sensor supply	
Voltage U_F	5 V ± 0.05 V
Temperature coefficient	< 50 ppm/°C
Output current	25 mA at U_G = 12 V 30 mA at U_G = 9 V 50 mA at U_G = 6 V
Closed current	Ca. 3 mA
Power saving circuit	The bridge voltage is switched off when the measuring point is not selected.

Connection assignment



4.4.3.2 D7 connector ZKD700-FS for measuring bridges

Characteristics of the connector

Features

The D7 bridge connector ZKD700-FS records the output voltage of a four-wire full bridge with 5V supply (5V, Gnd) with a fast 24-bit AD converter.

This makes it possible to record dynamic force changes with strain gauges alternatively with 2 different conversion rates of 10 or 1000 measurements/sec. The connection is made via 4 screw terminals.

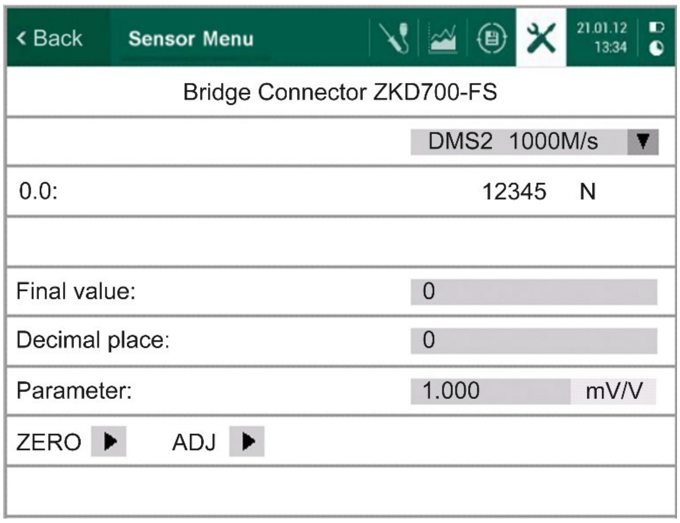
Types

Article number	Designation	Measuring range	Dim	Resolution	Command	Range	End value	M/s
ZKD700 FS	1. * Force	± 50 000 Digit	N	1 N	B-02	DMS2	50000	1000
	2. Force	± 200 000 Digit	N	1 N	B-01	DMS1	200000	10

The preset measuring ranges are marked with an *.

Programming

The adjustment is carried out via internal precision resistors each time the device is switched on, plugged in or the range is changed. Depending on the characteristic data of the strain gauges, the measuring channel must be programmed with the desired dimension. The scaling is done in the sensor menu of the V7 measuring instrument or on the PC.

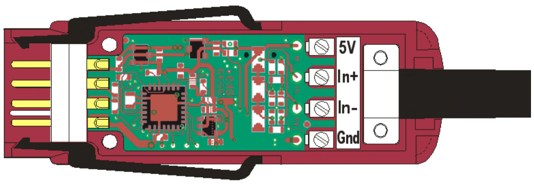


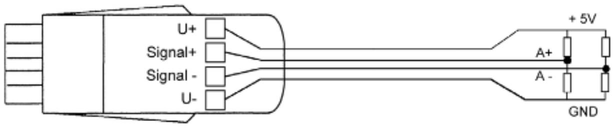
Technical data

Sensor type	Full bridge, 4-wire
Measuring input	Galvanically connected to the voltage supply (mass of the ALMEMO® device)
Input range	-29.3 to +29.3 mV (terminals In + and In -)
Display range	0 to ±200.000 (range DMS1 with 10 measurements/sec.) 0 to ±50.000 (range DMS2 with 1000 measurements/sec.)

Bridge supply	5 V, self-calibration with divider chain Accuracy 0.01%, Temperature drift 10 ppm/K
AD converter	Delta-sigma ratiometric (bridge voltage = reference)
Common mode range	0.25 V to 4.75 V
System accuracy	0.02% ± 2 Digit (at 10 measurements/s)
Nominal temperature	22°C ± 2 K
Temperature drift	Max. 30 ppm/K
Range of application	-10 to +60°C, 10 to 90% rH (non condensing)
Supply voltage	From 6 V from the ALMEMO® device (sensor supply)
Current consumption	Ca. 15.5 mA
Self-calibration	When switching on and plugging in
Refresh rate	DMS1: 100ms, DMS2: 1ms
Connector colors	Housing ruby red, black levers

Connection assignment





Use

Preparation

Sensor adjustment and scaling

The two measuring ranges offer 2 different conversion rates and correspondingly different measuring ranges and resolutions. The maximum end values are to be kept in each case including decimal places.

For zero adjustment the key 'ZERO' is provided.

For the configuration of the individual slope and scaling of the sensor there are 2 possible procedures:

1. If the sensor was delivered with a specific 'parameter' in mV/V, you can simply enter it in the sensor menu and scale it with the final value and decimal place.
2. Alternatively, the parameter is deleted and the sensor is loaded with a force that corresponds to the final value. The final value and the decimal place are used again for scaling. With the key 'ADJ' the slope is adjusted accordingly.

The standard function 'Zeroing' of the measured value is used for taring in the ALMEMO® measuring instrument.

4.5 Galvanically isolated high-voltage measuring modules for AC and DC signals and thermocouples

Notes on the measurement

Safety instructions

If the measuring module is used as intended, the safety of the device and operator is guaranteed. However, safety cannot be guaranteed in case of improper operation. Therefore, please read the following safety rules completely to avoid injury to the operator, fire and damage to the measuring module or measuring device. When handling voltages above 50V, the personnel must be appropriately instructed about the dangers, especially due to mains voltages.

- Switch off the measuring device when connecting the measuring modules.
- Depending on the type, the measuring modules are suitable for measuring voltages, currents or thermocouples at potentials above 50V. During operation and especially when connecting the measuring module, care must be taken that no high-voltage parts are touched.
- In the case of the measuring module for thermocouples, the operating voltages of the devices involved must be switched off in order to connect the temperature sensor.
- For the measuring modules for AC/DC signals, use the supplied or equivalent touch-protected test cables.
- For the measuring modules for thermocouples, do not use cables insulated with glass silk for reasons of insulation.
- The measuring module for DC signals may only be operated with DC voltage or DC current according to the measuring range marked on the type plate.
- Pay special attention that the current modules are always connected in series to the consumer, i.e. in a supply line, and must not be connected directly to the voltage source.
- The measuring device and measuring module must not be operated in a wet or damp environment.
- The plastic housing must be protected from open fire and hot surfaces (e.g. hotplates).
- The measuring module may no longer be used if it is externally damaged or possibly no longer functions after an incorrect connection.
- If the measuring module is misused or operated wrongly, no liability can be accepted for any damage.

Safety symbols:

Attention: It is imperative that you observe all correspondingly marked instructions in the manual in order to avoid injury and danger to life and limb, as well as damage to the device.

Warning: There is a risk of electric shock from touching high-voltage connections. Do not touch exposed parts or connections during operation to avoid electric shock.

4.5.1 Fast ALMEMO® DC measuring module

Measuring principle

The ALMEMO® ZA 9900/1-AB measuring module records the instantaneous, maximum, minimum and average values of a DC voltage or DC current signal at a sampling rate of 1 kHz and transfers these four values to the ALMEMO® device for each measuring point query.

The transmission of the data to the measuring device is purely digital. The connection in the module is permanently galvanically isolated with 1kV and overvoltage protected. The measuring module can thus be connected to any ALMEMO® measuring input, i.e. even several to one ALMEMO® device.

The maximum assignment of the ALMEMO® device must be considered.

Selection, product overview

Article number	Measuring range	Resolution	Overload	Internal resistance
DC voltage:				
ZA9900AB2	±2 V	0.001 V	±400 V	800 kΩ
ZA9900AB3	±20 V	0.01 V	±500 V	1 MΩ
ZA9900AB4	±200 V	0.1 V	±500 V	1 MΩ
ZA9900AB5	±400 V	1 V	±1000 V	4 MΩ
DC current:				
ZA9901AB1	±20 mA	0.01 mA	±0.1 A*	10 Ω
ZA9901AB2	±200 mA	0.1 mA	±1 A*	1 Ω
ZA9901AB3	±2 A	0.001 A	±10 A*	0.1 Ω
ZA9901AB4	±10 A	0.01 A	±20 A*	0.01 Ω
ZA9901AB5	±20 A	0.1 A	±30 A*	0.002 Ω
* Without safety fuse, only max. 1 min overloadable				
DC current via external shunt:				
ZA9900AB1	±200 mV	0.1 mV	±40 V	6 kΩ

All measuring modules are supplied including contact-protected connection cable.

Notes on the measurement

Connection of the measuring module

When connecting the measuring module, pay attention to the measuring range marked on the type plate.

Switch off the measuring device when plugging in the measuring modules.

Connecting the measuring module to an ALMEMO® device

The ALMEMO® connector of the measuring module can be plugged into any sensor socket Mxx of any ALMEMO® measuring device. The power supply of the measuring module is provided by the ALMEMO® measuring device via a DC/DC converter (insulation voltage min. 4kV/1sec., permanently 1kV). The power supply of the measuring device is thus loaded with approx. 40 mA, i.e. a power supply unit is required for long-term operation. The data are transmitted opto-isolated digitally to the measuring device with a refresh rate every 0.1 seconds.

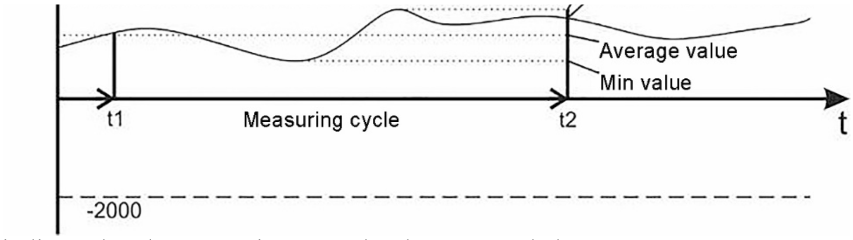
Measured value acquisition

The measuring signal is continuously sampled with 1 kHz and from this the maximum value, the minimum value and the average value are calculated. With each measuring point query (with V6 devices, MA710, MA809 and MA500 also with the conversion rate, note refresh rate), the max, min and average values since the last measuring point query are output via the 4 channels of the ALMEMO® connector in addition to the current measured value and then deleted.

If you want to receive the max, min or average values over a longer period of time, you can program the element flag 4 (only cyclic polling, see chapter 6.10.3) and a corresponding cycle on these channels. In this way, instantaneous values can be recorded with the conversion rate and the max, min or average values with manual or cyclic queries.

If more than 100 measured values are outside the measuring range in succession, the measured value flashes to

Fig. 4.1 Current/voltage displayed against time. Illustration of the measured value, as well as the maximum, minimum and average value.



indicate that the measuring range has been exceeded.

4.5.1.1 Measuring module ZA 9900-AB for DC voltage

Characteristics of the module

Features

The measuring module is supplied with ALMEMO® connection cable, two test cables with touch-proof banana connectors and an operating manual.

Fig. 4.2 Measuring module ZA9900AB for DC voltage

Programming

Programming of the ALMEMO® connector:

Channel	Measuring function	Range	Resolution	Interlock
1. Channel	Measured value	DIGI	1/2000 of meas. range	5
2. Channel	Maximum value	DIGI	1/2000 of meas. range	5
3. Channel	Minimum value	DIGI	1/2000 of meas. range	5
4. Channel	Average value	DIGI	1/20000 of meas. range	5

Technical data

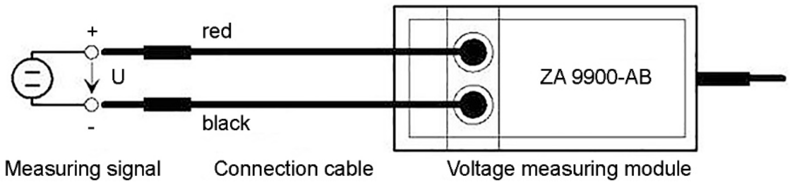
Measuring range	See chapter 4.5.1, Selection, product overview
Resolution	See chapter 4.5.1, Selection, product overview
Accuracy	0.1% of end value ± 2 Digit For DC current 20 A: ±4 Digit
Sampling rate	1 kHz

Resolution	12 bit, ± 2048 Digit
Refresh rate	0.1 s
Measuring cycle maximum	14 h
Galvanic isolation	1 kV continuously, 4 kV for 1 sec.
Nominal conditions	23°C ± 2 K, 10 to 90% rH (non condensing)
Housing	Polystyrene, dimensions L100 x W54 x H31 mm
Sockets	Touch-proof, Ø 4 mm
Operating voltage	6 to 14 V via ALMEMO® device
Current consumption	< 40 mA (connector and module)

Use

Preparation

The input sockets of the measuring module are connected directly to the terminals of the voltage source using the supplied touch-protected connection cables.



Warning! With measuring voltages of more than 50V, it is essential to ensure that the wiring is carried out in a voltage-free state and that the voltage is only switched on afterwards. Do not touch any exposed parts or connections during operation to avoid electric shocks.

Sensor protection

The adjustment of the measuring range is stored in the slope correction. Before setting the interlock under 4, be sure to make a note of the adjustment value so that you can enter it again if it is deleted during programming or incorrect operation.

4.5.1.2 Measuring module ZA 9901-AB for DC current

Characteristics of the module

Features

The measuring module is supplied with ALMEMO® connection cable, two test cables with touch-proof banana connectors and an operating manual.

Programming

See chapter 4.5.1.1.

Technical data

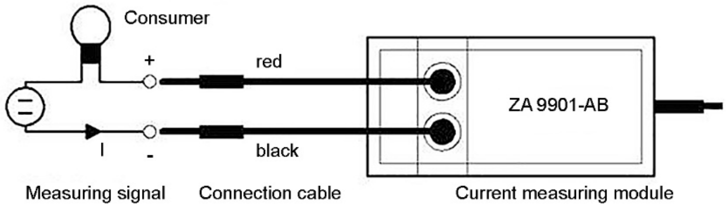
See chapter 4.5.1.1.

Fig. 4.3 Measuring module ZA9901AB for DC current

Use

Preparation

The current measuring module is switched into the connection line of a consumer using the supplied touch-proof connection cables.



Warning! With measuring voltages of more than 50V, it is essential to ensure that the wiring is carried out in a voltage-free state and that the voltage is only switched on afterwards. Do not touch any exposed parts or connections during operation to avoid electric shocks.

Attention! Do not connect the current measurement module directly to the voltage source without a consumer, because this can destroy the module and create a hazard due to overheating. The current ranges can be overloaded for a short time, but they have no protection fuse.

4.5.2 ALMEMO® AC measuring modules for AC voltage and AC current

Measuring principle

The ALMEMO® AC measuring modules ZA 9903-AB and ZA 9904-AB independently acquire the true RMS value of an AC variable fully digitally, i.e. the measuring signal with any waveform is digitized at 1kHz and the true RMS value is calculated.

On the 2nd channel the frequency can be retrieved. The transmission to the measuring device is purely digital. The connection in the module is permanently galvanically isolated with 1kV and overvoltage protected. The measuring module can thus be connected to any measuring input of any ALMEMO® measuring device, i.e. also several to one device. The maximum assignment of the ALMEMO® device must be considered.

Selection, product overview

Article number	Measuring range	Resolution	Peak value	Overload	Internal resistance
AC voltage:	U_{eff} sinus		U_{SS}	U_{SS}	R_i
ZA9903AB1[1)]	130 mV	0.1 mV	±0.2 V	±400 V	0.5 MΩ
ZA9903AB2	1.3 V	1 mV	±2 V	±400 V	0.8 MΩ
ZA9903AB3	13 V	10 mV	±20 V	±500 V	1 MΩ
ZA9903AB4	130 V	0.1 V	±200 V	±500 V	1 MΩ
ZA9903AB5	400 V	1 V	±1000 V	±1000 V	4 MΩ

[1)] When using the measuring module for current measurement with external shunt, the shunt must be looped into the neutral conductor (not into the phase).

Article number	Measuring range	Resolution	Peak value	Overload	Internal resistance
AC current:	I_{eff} sinus		I_{SS}	I_{SS}	R_i
ZA9904AB1	1 A	1 mA[2)]	±2 A	±10 A	0.10 Ω
ZA9904AB2	10 A	10 mA[2)]	±20 A	±20 A	0.01 Ω
ZA9904AB3	20 A	0.1 A[2)]	±30 A	±30 A	0.002 Ω

[2)] Without protection fuse, only max. 1 min overloadable

All measuring modules are supplied including touch-proof connection cable.

Notes on the measurement

Connection of the measuring module

When connecting the measuring module, pay attention to the measuring range marked on the type plate.

Switch off the measuring device when plugging in the measuring modules.

The ALMEMO® connector of the measuring module can be plugged into any sensor socket Mxx of any ALMEMO® measuring device. The data are transmitted opto-isolated digitally to the measuring device every 0.5 seconds.

The power supply of the measuring module is provided by the ALMEMO® measuring device via a DC/DC converter (insulation voltage min. 4kV/1sec., permanently 1kV). The power supply of the measuring device is thus loaded with approx. 40 mA, i.e. a power supply unit is required for long-term operation.

True RMS value measurement

The AC voltage signal is continuously sampled at 1kHz and the total RMS value is calculated from the DC and AC voltage components every 0.5 seconds.

$$U_{\text{eff}} = \sqrt{U_{AC}^2 + U_{DC}^2}$$

With a measuring range of 1300 digit for sinusoidal signals, the total measuring range is ±2000 digit.

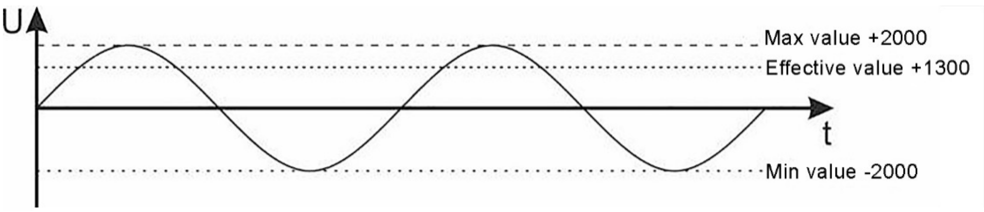


Fig. 4.4 AC voltage displayed against time. Illustration of effective value, maximum and minimum value.

If more than 10 of the 500 measured values are outside the measuring range, the measured value flashes to indicate that the measuring range has been exceeded. To record the frequency, the amplitude must be at least 10% of the final value.

4.5.2.1 Measuring module ZA 9903-AB for AC voltage

Characteristics of the module

Features

The measuring module is supplied with ALMEMO® connection cable and two test cables with touch-proof banana connectors.

Fig. 4.5 Measuring module ZA9903AB for AC voltage

Programming

Programming of the ALMEMO® connector

Channel	Measuring function	Range	Dim.	Resolution	Interlock
1. Channel	AC-RMS value	DIGI	V~	1/1300 of meas. range	5
2. Channel	Frequency	DIGI	Hz	0.1 Hz	5

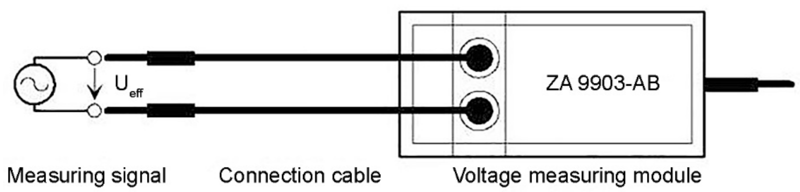
Technical data

Measuring range	See chapter 4.5.2 Selection, product overview	
Resolution	See chapter 4.5.2 Selection, product overview	
	TRMS	**Frequency**
Accuracy	0.1% of end value ± 2 Digit	± 0.1 Hz
Sampling rate	1 kHz	1 kHz
Resolution	12 bit, ± 2048 Digit for U_{ss}	0.1 Hz
Sensitivity	-	10% of end value
Frequency range	20.0 to 250 Hz	20.0 to 250 Hz
Measuring duration / settling time	0.5 s	0.5 s
Galvanic isolation	1 kV continuously, 4 kV for 1 sec.	
Nominal conditions	23°C ± 2 K, 10 to 90% rH (non condensing)	
Housing	Polystyrene, dimensions L100 x W54 x H31 mm	
Sockets	Touch-proof, Ø 4 mm	
Operating voltage	6 to 14 V via ALMEMO® device	
Current consumption	< 40 mA (connector and module)	

Use

Preparation

The input sockets of the measuring module are connected directly to the terminals of the voltage source using the supplied touch-proof connection cables.



Warning! For measuring voltages of more than 50V, it is essential to ensure that the wiring is carried out in a voltage-free state and that the voltage is only switched on afterwards. Do not touch any exposed parts or connections during operation to avoid electric shocks.

Sensor protection

The adjustment of the measuring range is stored in the slope correction. Before setting the interlock under 4, be sure to make a note of the adjustment value so that you can enter it again if it is deleted during programming or incorrect operation.

4.5.2.2 Measuring module ZA 9904-AB for AC current

Characteristics of the module

Features

The measuring module is supplied with ALMEMO® connection cable and two test cables with touch-proof banana connectors.

Fig. 4.6 Measuring module ZA9904AB for AC current

Programming

See chapter 4.5.2.1.

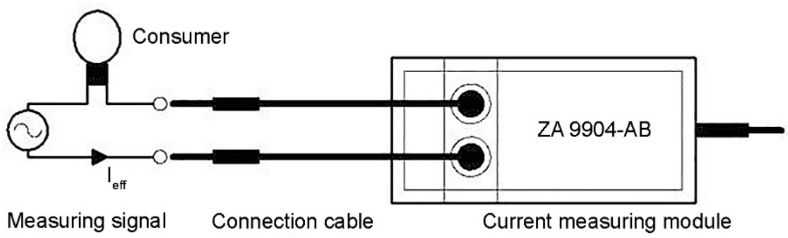
Technical data

See chapter 4.5.2.1.

Use

Preparation

The measuring module is switched into the connection line of a consumer using the supplied touch-proof connection cables.



Warning! For measuring voltages of more than 50V, it is essential to ensure that the wiring is carried out in a voltage-free state and that the voltage is only switched on afterwards. Do not touch any exposed parts or connections during operation to avoid electric shocks.

Attention! Do not connect the current measurement module directly to the voltage source without a load, because this can destroy the module and create a danger due to overheating. The current ranges can be overloaded for a short time, but they have no protection fuse.

Sensor protection

The adjustment of the measuring range is stored in the gradient correction. Before setting the interlock under 4, be sure to make a note of the adjustment value so that you can enter it again if it is deleted during programming or incorrect operation.

4.5.3 Measuring module for thermocouples

Measuring principle

If temperatures at high potential up to 1000V are to be measured, the digital ALMEMO® measuring modules ZAD950-ABK, J, T (type K, J, T) can be used. They record the temperature of a thermocouple galvanically isolated (especially for bare thermocouple wires) and transfer the measured value continuously digitally to the ALMEMO® device. The measuring module can be connected to any ALMEMO® measuring input, i.e. even several to one ALMEMO® device. The maximum assignment of the ALMEMO® device must be considered.

Selection, product overview

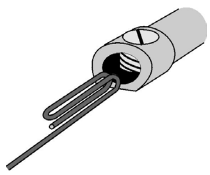
Article number	Measuring range	Resolution
ZAD950ABK	-200 to +1370°C	0.1 K
ZAD950ABJ	-200 to +1000°C	0.1 K
ZAD950ABT	-200 to +400°C	0.1 K

Notes on the measurement

Connection of the measuring module

Caution high voltage!

With potentials of more than 50 V, it is essential to ensure that the wiring is carried out in a voltage-free state and that the voltage is only switched on afterwards. The measuring module may only be operated outside the hazardous area. The user is responsible for safety from the sensor connections onwards.



Make sure that the supplied touch-proof high-voltage connectors are used for sensor connection! With wire thicknesses of less than one millimeter, the wire may have to be bent several times to ensure a secure hold in the screw terminal.

The ALMEMO® connector of the measuring module can be plugged into any sensor socket Mxx of any ALMEMO® measuring device. The data is transmitted opto-isolated digitally to the measuring device at a measuring rate of 2.5 Hz.

The power supply of the measuring module is provided by the ALMEMO® measuring device via a DC/DC converter (insulation voltage min. 4kV/1sec., permanently 1kV). The measuring device must provide a sensor supply of 7 to 12V, approx. 30 mA, i.e. a power supply unit is usually required.

4.5.3.1 Measuring modules ZAD 950 AB for thermocouples, galvanically isolated up to 1000V

Characteristics of the modules

Features

The measuring module has a connection cable with ALMEMO® connector.

Fig. 4.7 Measuring module ZAD950AB for thermocouples, galvanically isolated

Programming

Programming of the ALMEMO® connector

Channel	Measuring function	Range	Dim.	Resolution	Interlock
1. Channel	Temperature	DIGI	°C	0.1 K	5

Technical data

Measuring probe	Thermocouple
Measuring ranges	ZAD 950 ABK: NiCr-Ni (K) -200.0 to 1370.0°C ZAD 950 ABJ: Fe-CuNi (J) -200.0 to 1000.0°C ZAD 950 ABT: Cu-CuNi (T) -200.0 to 400.0°C
Resolution	0.1 K
Measuring rate	2.5 M/s
Linearization accuracy	± 0.05 K ± 0.05% of meas. value
System accuracy	0.1% of meas. value ± 4 Digit, 0.01%/K
Precision class	C see chapter 2
Galvanic isolation	1kV DC/AC continuously, 4 kV for 1 second
Housing	ABS, L127 x W83 x H38 mm
Sensor connection	4 mm safety sockets and connectors (with screw terminals)
Connection cable	1.5 m with ALMEMO® connector
Voltage supply	6 to 13 V DC via ALMEMO® device, power supply unit recommended
Current consumption	Ca. 30 mA

4.6 Frequency / pulses / speed

4.6.1 ALMEMO® adapter cable ZA9909-AKxU for frequency and pulse signals

Measuring principles

The adapter cable for frequency signals ZA 9909-AKxU is used for the acquisition of digital pulses. It counts pulses in the sensor connector with its own small microcontroller and transfers them to the measuring device on command. Since in this way signals are also taken into account if the measuring channel is not selected, even several adapter cables can be connected to one device and acquired via measuring point queries.

Selection, product overview

Article	Type	Measuring range	Resolution	Programmed range
ZA9909-AK1U	Frequency	0 to 15000 Hz or 0 to 3200 Hz	1 Hz 0.1 Hz	Freq
ZA9909-AK2U	Pulse	0 to 65000 Imp	1 Imp	Puls
ZA9909-AK4U	Speed	8 to 32000 UpM		Freq

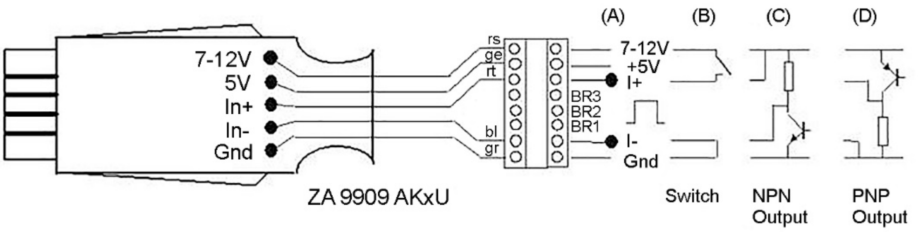
Notes on the measurement

There are four different ways to wire the adapter cable (see figure below):

(A) The adapter cable can be directly driven with active voltage signals from 6 to 40 V and is then connected to 'Input +' and 'Input -". Optocouplers in the input provide galvanic isolation in this case.

(B) Passive potential-free switching contacts can be used to transmit pulses via the supply voltage of the measuring instrument.

(C/D) Turbines or photoelectric pulse generators can be supplied by the adapter cable (max. 50mA). Depending on the output driver, the optocoupler must be wired accordingly (NPN:C) or (PNP:D). If the device voltage is not sufficient, the connector is also available with voltage converter to 13.5V ± 0.5V (option OA9909V12).



By programming the measuring range, either frequency or pulse measurement is possible. For speed measurement, an adapter cable with its own programming is required.

4.6.1.1 Adapter cable ZA9909-AK1U for frequency measurement

Measuring principle

The adapter cable for frequency measurement counts the pulses per second and outputs this frequency value continuously.

Characteristics of the adapter cable

Features

The adapter cable provides a 5 V sensor supply. However, the sensors can also be supplied directly from the device via '7 - 12 V'. Depending on the device voltage (see data sheets of the devices), 6, 9 or 12 volts are then available. If this supply is not sufficient, the adapter cable can be equipped with a supply voltage of 13.5 V on the connection for the device voltage via option OA9909V12.

Technical data

Frequency range	0 to 15000 Hz (Resolution: 1Hz), gate time 4 times 0.5 s
	0 to 3200.0 Hz (0.1Hz), gate time 0.5 s + 1flank
Pulse length	> 50 µs (5ms with contact bounce)
Input voltage range	6 to 40 V rectangle via optocoupler
Cable length	1.5 m
Sensor supply	Directly from the ALMEMO® device (6, 9 or 12V)
Option OA9909V12	
Sensor supply	13.5 V ± 0.5 V
Output current	100 mA with device voltage 12 V
	50 mA with device voltage 9 V
Current consumption	3 mA
Temperature range	-10 to +60°C

Use

Preparation

The adapter cable ZA9909-AK1U is delivered with a resolution of 1 Hz and a measuring range of 0 to 15000 Hz (see above).

If a higher resolution is required, a wire bridge can be attached from terminal BR1 to terminal +5V. This increases the resolution to 0.1 Hz, whereas the measuring range changes to 0 up to 3200.0 Hz. After setting the wire bridge, a decimal point shift must be programmed (exponent: -1).

4.6.1.2 Adapter cable ZA9909-AK2U for pulse measurement

Measuring principle

The adapter cable counts the pulses between two measuring point queries (manually or cyclically) and outputs the pulse count only at the measuring point query.

Characteristics of the adapter cable

Features

See chapter 4.6.1.1.

Technical data

Max. pulse count	65000
Pulse length	> 50 µs (5ms with contact bounce)
Input voltage range	6 to 40 V rectangle via optocoupler
Cable length	1.5 m
Sensor supply	Directly from the ALMEMO® device (6, 9 or 12V)
Option OA9909V12	
Sensor supply	13.5 V ± 0.5 V
Output current	100 mA with device voltage 12 V
	50 mA with device voltage 9 V
Current consumption	3 mA
Temperature range	-10 to +60°C

Use

Preparation

Pulse measurement is intended for signals with a low repetition rate that are to be acquired over a longer period of time. The adapter cable therefore counts the pulses between two measuring point queries (manually or cyclically) and outputs the pulse count only during the measuring point query, i.e. during the cycle the displayed value does not change.

If a measuring cycle of 1 minute is programmed, the number of pulses/minute is displayed every minute. By summation over the pressure cycle with the function channel S(P), the number of pulses over a longer period (e.g. 1 hour) can also be determined.

Bouncing contacts can be suppressed digitally with a time constant of 5ms by connecting terminal BR1, terminal BR2 and terminal +5V with wire bridges.

4.6.1.3 Adapter cable ZA9909-AK4U for speed measurement

Measuring principle

The adapter cable for speed measurement measures the time between two pulses and calculates the speed per minute from that.

Characteristics of the adapter cable

Features

See chapter 4.6.1.1.

Technical data

Speed range	8 to 32000 Upm (Resolution: 1Upm)
Pulse length	> 50 µs (5ms with contact bounce)
Input voltage range	6 to 40 V rectangle
Cable length	1.5 m
Sensor supply	Directly from the ALMEMO® device (6, 9 or 12 V)
Option OA9909V12	
Sensor supply	13.5 V ± 0.5 V
Output current	100 mA with device voltage 12 V
	50 mA with device voltage 9 V
Current consumption	3 mA
Temperature range	-10 to +60°C

4.7 Various connectors and connection cables

4.7.1 Digital input cable

Selection, product overview

Article	Type	Inputs	Characteristics
ZA9000ES2	For potential-free contacts	3 Digital inputs	Potential-free contacts, auxiliary voltage 5 V led out, optocoupler, with 1.5 m long cable
ZA9000EK2	For external voltage 4 to 30 V	4 Digital inputs	Galvanically isolated (optocoupler), with 1.5 m cable

4.7.1.1 ALMEMO® adapter cable ZA9000ES2 for digital input signals

Measuring principle

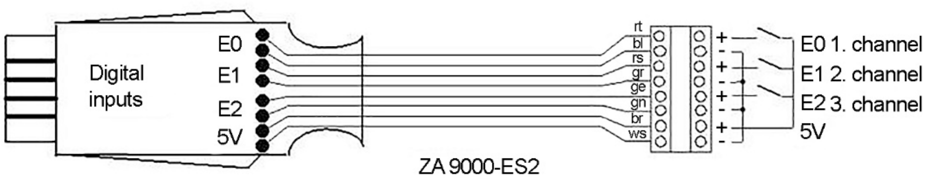
With the ZA 9000-ES2 digital input cable, 3 digital states (potential-free contacts) can be detected and monitored per measuring input.

For potential-free contacts, appropriate external voltages must be provided. The ZA 9000-ES2 digital input cable provides an auxiliary voltage of 5V for this purpose.

Use

Preparation

The contacts must be connected to the 5V according to the circuit diagram so that they drive the optocouplers.



4.7.1.2 ALMEMO® adapter cable ZA9000EK2 for digital input signals

Measuring principle

With the ZA 9000-EK2 digital input cable, 4 digital states (electrical voltage levels) can be recorded and monitored per measuring input of an ALMEMO® measuring device.

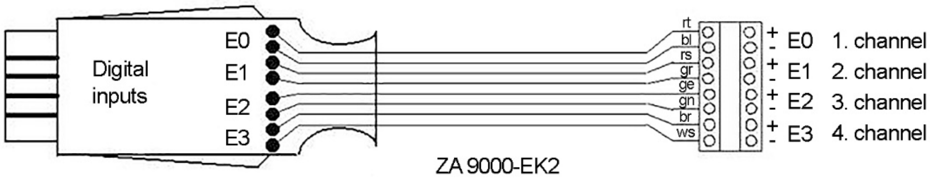
Use

Preparation

Each input is programmed as a channel with the range 'Inp ' and the state appears at each measuring point query in the data output with 0.00% or 100.00%. By entering a limit value of e.g. 50.00%, an output of disturbance values can also be realized.

If the percentage ratio of the on-off state is to be documented over a cyclic period or the entire measurement, this quantity must be recorded via averaging (cyclic or continuous) (see chapter 6.7.4).

The highest resolution is obtained with continuous measuring point query.



The digital inputs are optocouplers that go from the LO state (0% = 0 to 1V DC) to the Hi state (100% = 4 to 30V DC) when a voltage of approximately 4 to 30V DC is applied.

4.7.2 Connectors or cables for adapting special sensors to the ALMEMO® system

4.7.2.1 Interface adapter cable ZAD 919-AKxx for foreign devices

Measuring principle

Many sensors or external measuring devices do not have an analog output but a digital interface. In order to be able to integrate these into the data acquisition with ALMEMO® devices, the interface adapter cable ZAD 919-AKxx is available. The device type protocol is programmed to match the output interface of the external device and its interface cable is fitted with the appropriate ALMEMO® connector.

For interface programming, a detailed description of the output interface of the device to be connected, a suitable cable or connector with assignment diagram must be available. The foreign device to be connected must also be available for testing and checking.

Basics

Areas of application

- Scales and weighing equipment
- Dial gauges and displacement sensors
- Multimeters
- Incremental displacement sensors
- Chemical analysis devices
- Digital sensors

Characteristics of the adapter cable

Features

The interface adapter cable ZAD 919-AKxx allows the integration of max. 4 measured values of any foreign device with serial interface (RS232, RS485, Modbus or similar) into the measured value acquisition of any ALMEMO® device.

The digital connector of the adapter cable provides an galvanically isolated serial interface and contains an interface processor for protocol conversion. Several adapters can be used simultaneously on one ALMEMO® device.

Programming

Range: DIGI

Technical data

Display range	± 65000 Digit
Interface	Asynchronous 7/8 bit data, 1/2 stop bit, galvanically isolated

4.7.2.2 D7 pH and redox connector ZYD7 x0-AKx

Characteristics of the connector

Features

The D7 pH and redox connector ZYD7x0-AKx uses its own 24-bit AD converter to record the voltage of the pH or redox electrode with the highest precision and displays it in the ranges 0.00 to 14.00 pH or -1100.00 to +1100.00 mV (redox).

The connector has an integrated galvanic isolation, which also allows simultaneous measurement with different probes on one measuring device.

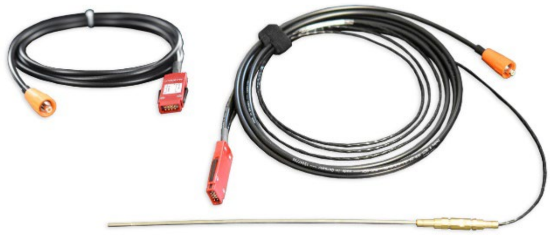


Fig. 4.8 D7 pH and redox cable ZYD710AKx (left) and pH cable with NTC sensor ZYD740AK4 (right)

Types

Article number	Type of probe	With NTC sensor	Available lengths
ZYD710AK4	pH	-	2 and 5 m
ZYD740AK4	pH	×	2 m
ZYD710AK5	Redox	-	2 and 5 m

Programming

Configurable measuring ranges

Designation	Measuring range	Dimension	Resolution	Command	Range
*pH, pH	0 to 14	pH	0.01	B-01	DIGI
Redox, mV	-1100 to +1100	mV	0.1	B-02	DIGI
Temperature, °C	-50 to +125	°C	0.01	B-03	DIGI

* State on delivery

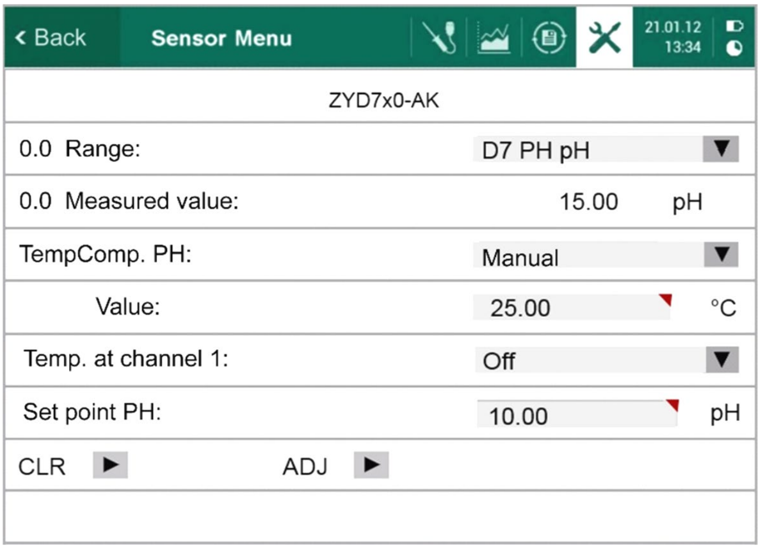
Apart from the range, all sensor-specific parameters, such as dimension, comment, sensor supply and interlocking are programmed automatically.

Technical data

Measuring ranges	
pH	0.00 to 14.00 pH
Redox	-1100.00 to +1100.00 mV
Temperature	-50.00 to +125.00°C
AD converter	Delta-Sigma
Accuracy	
pH/Redox	0.02% of meas. value ± 2 Digit
Temperature	±0.05 K in the range -50.00 to +100.00°C
Temperature drift	Max. 40 ppm/K
Nominal temperature	23°C ± 2 K
Area of application	-10° to +60°C
	10% to 90% rH (non condensing)
Refresh rate	0.8 s
Supply voltage	6, 9, 12 V from the ALMEMO® measuring device
Current consumption	Ca. 8 mA
Connector colors	Housing ruby red, black levers

Use

Increase measuring accuracy



Calibration of pH and redox probes is performed with reference solutions either by manual entry of the setpoint or by automatic recognition at PH 4, 7 or 10 via the sensor menu integrated in the sensor using the ADJ key. For manual calibration, the setpoint must be entered in the 'Setpoint PH' field. Also, the calibration values can be cleared after the connector is unlocked using the CLR key.

In addition, the connector has an external NTC connection option, which allows temperature compensation via the external NTC sensor in addition to manual temperature compensation with a fixed value.

Since the compensation is retained in the ALMEMO® connector, the probe can also be operated on other ALMEMO® devices.

4.7.3 Multiway connector

4.7.3.1 ALMEMO® 10-way MU connector ZA 5690 MU

Characteristics of the connector

Features

The ALMEMO® MA500 and MA5690 measuring systems have various input cards, including the ES5690xMU/ES500MMU input card with a 64-pole socket strip. The connection of sensors to this socket strip is made via the ZA5690-MU multiway connector. It has ten terminal blocks inside, each of which corresponds to individual connectors, i.e. each of these terminal blocks is provided with 4 screw terminals A, B, C and D respectively. However, the U- and U+ terminals present in the standard analog connectors are missing, so that sensors requiring a power supply cannot be connected. Sensors that require electronics for adjustment (such as humidity sensors or impellers) are also unsuitable for this type of multiway connector.

Programming is possible individually for all connected sensors and is stored in a joint EEPROM in the connector.

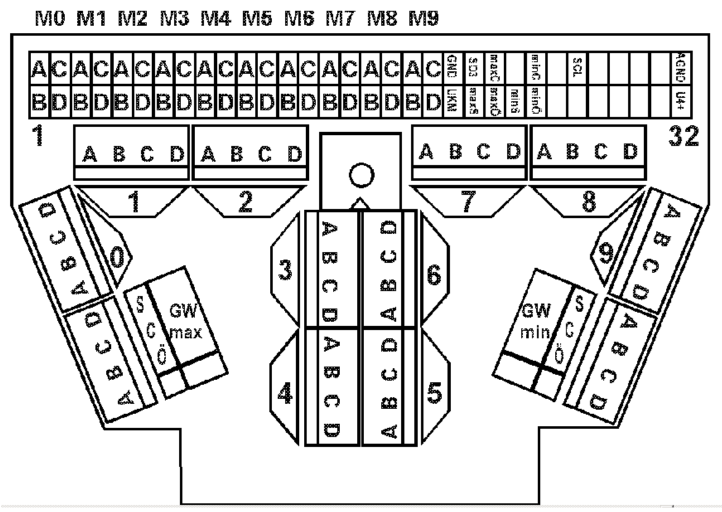
Programming

Programmable ranges (see chapter 7.4) for these connectors:

Physical value	Type of sensors	Programmed ranges
Temperature	Thermocouples	NiCr-Ni, Fe-CuNi (L, J), Cu-CuNi (U, T), PtRh-Pt (S, R, B)
	Pt100 / Ni100	Pt100-1, Pt100-2, Ni100
	Pt1000/Ni1000	Pt100-1, Pt100-2, Ni100, all with element flag 01:I2*
	NTC	Ntc
Voltage		2,6 V, 26 mV, 55 mV, 260 mV
Resistance		Ohm

* Switchover to 1/10 measuring current with element flag, see chapter 6.10.3

Connection assignment



5 ALMEMO® Output modules

Introduction

Measuring devices must be able to communicate with their environment, i.e. transfer their measurement data to analog or digital peripheral devices, execute commands from a computer, trigger alarms or even react to switching pulses. In order to fulfill all possibilities, but to minimize the hardware effort, all necessary interfaces have been built into ALMEMO® output connectors or modules.

Depending on the task, this concept allows the user to choose freely between wire connections (e.g. USB, RS232, RS485, Ethernet), radio (WLAN, Bluetooth) and fiber optics for digital data transmission.

For connecting the modules, almost all ALMEMO® devices have two output sockets A1 and A2, which additionally allow digital networking of the devices. The output modules are automatically recognized like the sensors, so that no programming is required by default.

5.1 Accessories for control and signal transmission

Functionality

For analog output, most ALMEMO® devices output a PWM signal on sockets A1 and A2. For this purpose there are analog output cables or modules which convert the digital signal into analog values 0-2V, 0-10V, 0-20mA.

The output modules RTA3, RTA4 and RTA5 have their own DA converters, so that several analog outputs can be provided. In some cases it is possible to switch the output type to 0-10V or 0-20mA depending on the application. The new modules contain up to 10 interface elements and, in addition to analog outputs, also relays and trigger inputs. All of them are individually configurable in their function.

Selection, application

Modules with the following functions are available for control and signal transmission:

- Relay
- Trigger
- Analog output

Some modules combine two or even all three functions.

5.1.1 Trigger and relay cables

Selection, product overview

Cables with built-in semi-conductor relays are available for alarm messages when limit values are exceeded (see chapter 6.3.9) and for controlling peripheral devices (see chapter 6.10.8). For remote control of the devices (see chapter 6.6.4) there are trigger cables as well as the combination of both.

Type	Article number	Trigger/relay	Characteristics
Trigger cable	ZA1006ET	1 Trigger input	With key
Trigger cable	ZA1006EK2	2 Trigger inputs	For external contacts or voltages, with terminal connector
Trigger/ Relay cable	ZA1006EKG	2 Trigger inputs 2 Normally open contacts	Trigger inputs for external voltages
Trigger/ Relay cable	ZA1006ETG	2 Trigger inputs 2 Normally open contacts	Trigger inputs for external potential-free contacts
Relay cable	ZA1006GK	1 Normally open contact	With two banana connectors

5.1.1.1 ALMEMO® Trigger cable ZA 1006 ET and ZA 1006 EK2

Characteristics

Features

The ZA 1006 EK2 has two trigger inputs each for external potential-free contacts and two trigger inputs for external voltages. They can both be programmed separately, also with macros (see chapter 6.6.4).

The ZA 1006 ET has one trigger input via a key. Trigger variants are programmable.

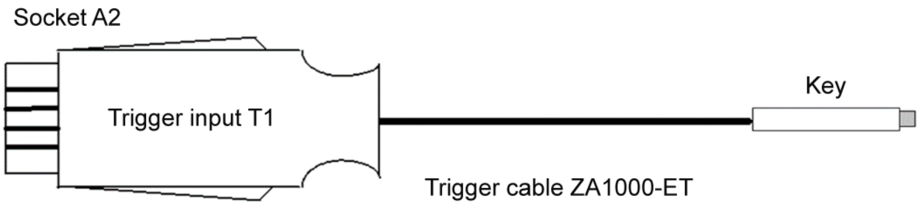


Fig. 5.1 Trigger cable ZA 1000 ET

Technical data

Trigger input	
ZA1006ET	With key, trigger variants programmable
ZA1006EK2	• For external potential-free contact (Ri > 50 kΩ, not galvanically isolated) • For external voltage 4 to 30 V DC (optocoupler), trigger variants programmable
Current consumption	Ca. 3 mA
Cable length	1.5 m
Connection	With terminal connector (ZA1006EK2)

5.1.1.2 ALMEMO® Trigger/Relay cables ZA 1006 EKG/ETG

Characteristics

Features

The trigger/relay cables have two independent trigger inputs, ZA1006EKG for external voltages and ZA1006ETG for external potential-free contacts. They can both be programmed separately, also with macros (see chapter 6.6.4).

Both cables are equipped with two relays each, which can be configured individually (see chapter 6.10.9), e.g. inverse or PC-controlled.

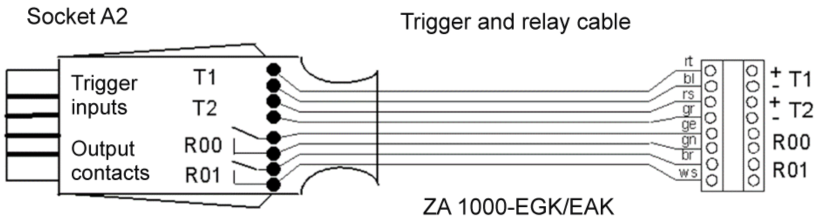


Fig. 5.2 Trigger/Relay cables ZA 1006 EKG/ETG

Technical data

Trigger input	For external potential-free contact (Ri > 50 kΩ, not galvanically isolated) or for external voltage 4 to 30 V DC (optocoupler), trigger variants programmable
Relay	Normally open contact (semi-conductor relay), also inversely programmable, load capacity: 50 V DC, 0.5 A, 1 Ω (without polarity)
Current consumption	Ca. 3 mA
Cable length	1.5 m
Connection	With terminal connector

5.1.1.3 ALMEMO® Relay cable ZA 1006 GK

Characteristics

Features

The relay cable (ZA1000-GK) can be operated with the relay adapter ZB 2280-RA for switching mains operated devices. It is plugged between the socket and the alarm device and controlled by the relay cable (ZA1000-GK), i.e. switched on in the event of an alarm.

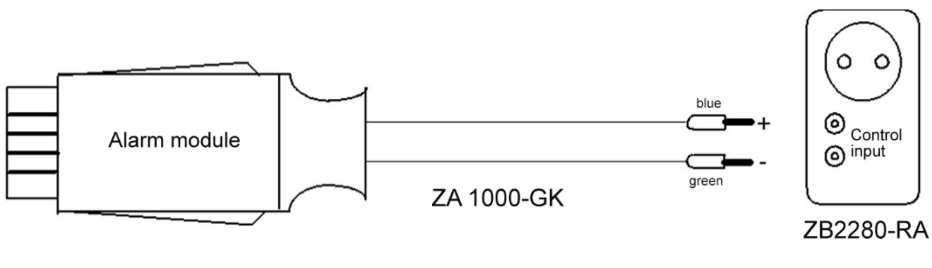


Fig. 5.3 Relay cable ZA1006GK and socket relay adapter ZB2280RA

Technical data

Relay cable ZA1006GK	
Relay	Normally open contact (semi-conductor relay), also inversely programmable, load capacity: 50 V DC, 0.5 A, 1 Ω (without polarity)
Current consumption	Ca. 3 mA
Cable length	1.5 m
Connection	Tuft connector
Socket relay adapter ZB2280RA	
Control input	For optocoupler output or switching contact R < 10 kΩ
Output	Schuko socket, mechanical relay, load capacity: 230 V, 6 A
Switching state	Sleep OFF; Alarm ON

5.1.2 Relay-trigger-analog adapters

Selection, product overview

Article number	Outputs	Characteristics
ZA8006RTA3	Relay, trigger, analog outputs	Pluggable to ALMEMO® devices
ZA8006RTA4	Relay, trigger, analog outputs	Interface module in ALMEMO® network
ES5690RTA5	Relay, trigger, analog outputs	Module for all data acquisition systems MA5690

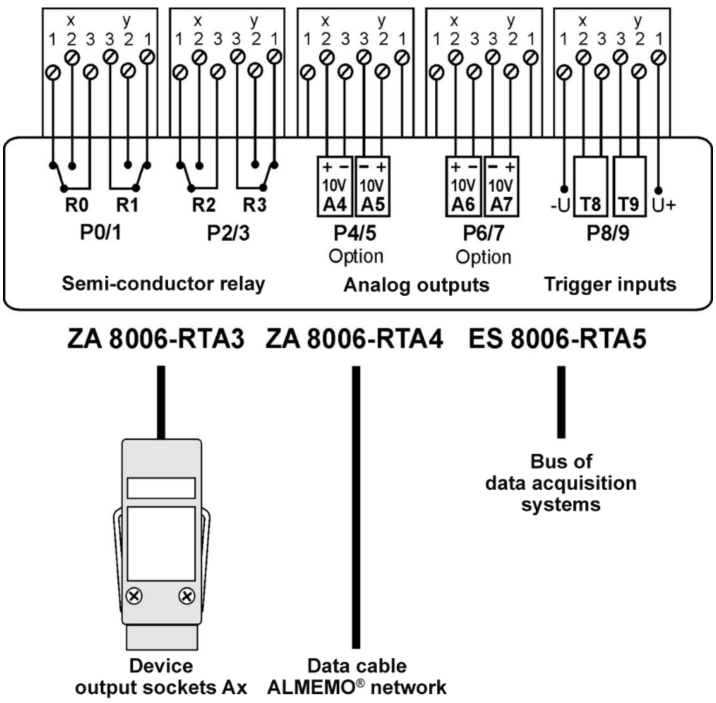


Fig. 5.4 ALMEMO® modules for relay, trigger and analog outputs

Notes on the adapters

All adapters have a maximum of 10 interfaces (semi-conductor relays, analog outputs and trigger inputs). These so-called ports can be addressed and configured individually (see chapter 6.10.9.2). The control of the output relays via the interface is described in chapter 6.10.10, the control of the analog outputs in chapter 6.10.7.

All elements are connected via orange ALMEMO® terminal connectors.

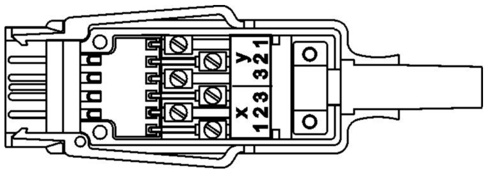


Fig. 5.5 Inside view of the terminal connector for the relay-trigger-analog adapter

The exact equipment, the configuration and the state of the modules can be seen either by the representation on the graphic display or by query via the interface (see chapter 6.10.9.2). More detailed information can be found in the individual instructions.

5.1.2.1 ALMEMO® Trigger output interface ZA 8006 RTA3

Characteristics

Types

Trigger output interface ZA8006RTA3 is an adapter for connection to the output sockets of ALMEMO® devices.

Technical data

Trigger inputs	Optocoupler 4 to 30 V, Ri > 3 kΩ, input current 2 mA
Relay	Semi-conductor relay 1 Ω, load capacity 50 V, 0.5 A
Analog outputs	Can be ordered optionally via option OA 8006-R02
	Double analog output galvanically isolated, max. 50 V
	10 V or 20 mA, programmable
	16 bit DAC
0.0 to 10.0 V	0.5 mV / Digit, load > 100 kΩ
0.0 to 20.0 mA	0.1 mA / Digit, load < 500 Ω
Accuracy	0.1% of meas. value + 0.1% of end value
Temperature drift	10 ppm/K
Time constant	100 µs
Voltage supply	Via ALMEMO® device or
	via power adapter ZA1312NA10 (recommended for analog output option)
Current consumption at	Ca. 10 mA, illumination ca. 15 mA
9V supply	with two analog outputs: ca. 30 mA + 1.6 · I_{Out}
Display	Graphic 128 x 64 (55 x 30 mm)
	Illumination: 2 white LEDs
Keyboard	7 silicone keys (4 softkeys)
Housing	ABS (max. 70°C), 290 g

Dimensions

Length: 127 mm

Width: 83 mm

Height: 42 mm

5.1.2.2 ALMEMO® Trigger output interface ES 5690 RTA5

Characteristics

Types

Trigger output interface ES5690RTA5 is a module for the data acquisition systems ALMEMO® 5690.

Technical data

Trigger inputs	Optocoupler 4 to 30 V, R_i > 3 kΩ, input current 2 mA
Relay	Semi-conductor relay 1 Ω, load capacity 50 V, 0.5 A
Analog outputs	Can be ordered optionally via option OA 8006-R02
	Double analog output galvanically isolated (max. 50 V)
	10 V or 20 mA, programmable
	16 bit DAC
0.0 to 10.0 V	0.5 mV / Digit, load > 100 kΩ
0.0 to 20.0 mA	0.1 mA / Digit, load < 500 Ω
Accuracy	0.1% of meas. value + 0.1% of end value
Temperature drift	10 ppm/K
Time constant	100 µs
Voltage supply	Via ALMEMO® measuring system
Current consumption	Standard: ca. 10 to 20 mA
	with two analog outputs: ca. 15 mA + 1.8 · I_{Out}
Module	19“ 8TE (2 slots)

5.1.3 Analog output cable

5.1.3.1 Analog output cable ZA 1601-RK

Functionality

For measured value registration with a recorder or similar output units, the ZA 1601-RK analog output module can be plugged into socket A1 or A2. A converter is built into the connector which converts the PWM signal from the measuring device into a voltage (-1.25 to +2.0 V) corresponding to the linearized measured value of the selected channel. The output voltage corresponds to 0.1 mV/digit. If a high response speed is to be achieved, a higher conversion rate must be set.

Characteristics

Technical data

Output voltage	-1.250 to 2.000 V not galvanically isolated
Slope	0.1 mV/Digit
Residual ripple	< 2 Digit
Load	> 100 kΩ
Accuracy	± 0.1% ± 6 Digit
Temperature drift	1 Digit / K
Time constant	100 ms
Current consumption	Ca. 3 mA
Cable length	1.5 m

Use

Preparation

The output signal is arbitrarily scalable via analog start and end (see chapter 6.10.7), if the range is more than 100 digit (e.g. 0 - 2 V for -30.0 to 120.0°C).

Measuring

During a cyclic measuring point query, the analog output retains the last value of the selected channel. In the event of a sensor break, the output voltage goes to zero.

In case of real double sensors or continuous measuring point query, two analog output modules can be operated at the two sockets A1 and A2 of the handheld devices and two different channels can be output. Normally this is the 1st channel and the selected measuring channel in one sensor. Instead of the measuring channel, any other channel can be programmed (see chapter 6.10.7).

For a high response speed, a conversion rate of 10 measurements per second can be set in the ALMEMO® device.

5.2 Communication with measuring devices and sensors

5.2.1 Data cables

Selection, product overview

For data transfer from an ALMEMO® device to the computer or to a peripheral device, there are various interface cables/modules that have the necessary interface built into the connector.

Type	Article number	Application	Maximum length	Use
USB data cable	ZA1919DKU	Between device and computer	5 m	Data transmission, transmission of commands, programming of devices and sensors plugged on devices
RS232 data cable	ZA1909DK5	Between device and computer	15 m	
RS232 data cable with fiber optics	ZA1909DKL	Between device and computer	50 m	
Ethernet data cable	ZA1945DK	Between device and company network	1.5 m + max. 100 m extension via Ethernet cable	
USB adapter cable	ZA1919AKUV	Between sensor and computer	1.5 m	Programming of sensors with D6 and D7 connectors
USB adapter cable	ZA1919AKUVW	Between WLAN module and PC	1.5 m	Programming of the WLAN module ZA1719WL

Notes

The interface cables connecting the ALMEMO® device with the PC or the network are plugged into the output socket A1 and recognized by the measuring device fully automatically, since all transmission parameters are stored in the connection plugs.

5.2.1.1 USB data cable ZA 1919 DKU

Characteristics

Features

The USB data cable ZA 1919-DKU contains a converter from USB to RS232. Installation instructions and the necessary Windows driver for the virtual COM interface can be found on the ALMEMO® CD supplied. The cable cannot be extended.

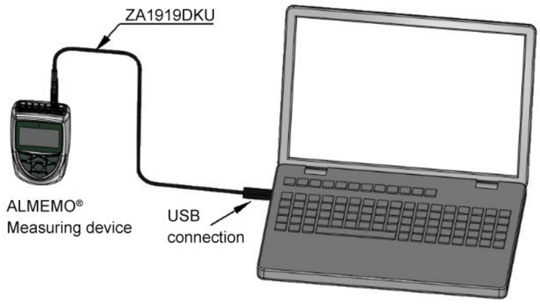


Fig. 5.6 USB data cable ZA1919-DKU

Types

ZA1919DKU with 1.5 m length
ZA1919DKU-05 with 5 m length

Technical data

Electrical characteristics	Galvanically isolated
Max. baud rate	115.2 kBd (for V7 devices 921.6 kBd)

5.2.1.2 RS232 data cable ZA 1909 DK5

Characteristics

General

Computers with 9-pole DSUB socket are connected directly to the measuring instrument via the galvanically isolated ZA 1909-DK5 interface cable.

The current consumption is 1 mA, the maximum baud rate is 115.2 kBd. The hardware handshake is no longer supported, only XON-XOFF.

Types

ZA1909DK5 with 1.5 m length
ZA1909DK5-05/-10/-15 each with 5 m, 10 m or 15 m length

Technical data

Electrical characteristics	Galvanically isolated
Max. baud rate	115.2 kBd
Current consumption	Ca. 1 mA

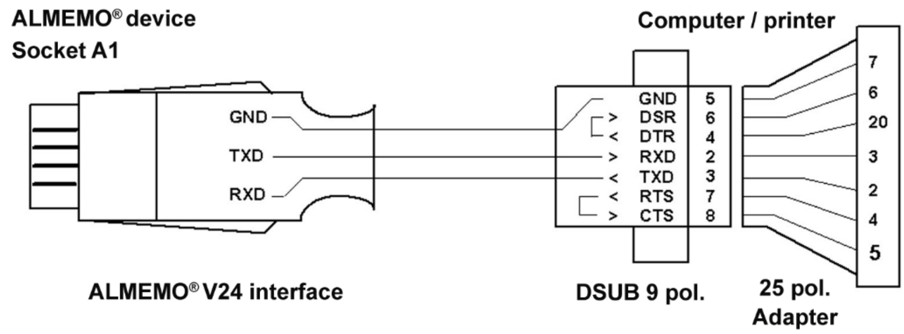


Fig. 5.7 Circuit of the RS232 interface cable ZA 1909-DK5

5.2.1.3 RS232 data cable with fiber optics ZA 1909 DKL

Basics

The transmission of digital data via fiber optics (FO) offers a number of important advantages over wired transmission. There are no EMC problems whatsoever, as electric or magnetic fields do not affect the cabling, i.e. reliable data transmission is possible even in an industrial environment with strong electromagnetic interference. Due to the absolute galvanic isolation of the individual devices, even larger potential differences can be bridged. Even extensive lightning protection is achieved.

Characteristics

General

Corresponding to the RS232 data cable ZA 1909-DK5 there is the fiber optic data cable ZA 1909-DKL. With this cable a transmission over a length of up to 50 m at a baud rate of up to 115.2 kBd is possible (as far as the devices allow this). The hardware handshake is not supported.

Features

The ZA 1909-DKL fiber optic data cable is supplied with a length of 1.5 m, but is also available with a longer fiber optic cable (up to 50 m) for indoor use, duplex plastic 2.2 x 4.3 mm.

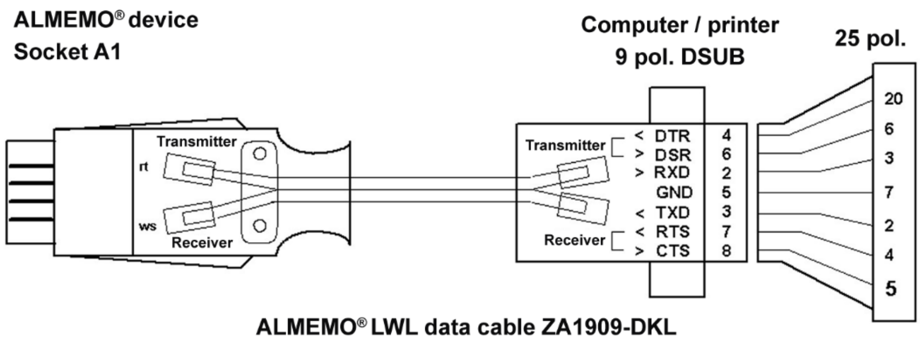


Fig. 5.8 ALMEMO® fiber optic data cable ZA 1909-DKL

Technical data

Electrical characteristics	Galvanically isolated
Max. baud rate	115.2 kBd
Cable length	1.5 m (longer also possible)

5.2.1.4 Ethernet data cable ZA 1945-DK

Characteristics

General

The ZA 1945-DK Ethernet ALMEMO® data cable enables ALMEMO® measuring instruments to be connected directly to an Ethernet network via an RJ45 socket. In this way, a connection to the Internet is also possible.

A measured value acquisition via several Ethernet modules is possible with the WinControl software (version SW5600WC2 or higher).

Technical data

Ethernet	Connection socket RJ45 (10/100BASE-T), automatic switching10/100 Mbit/s
Connection to ALMEMO®	ALMEMO® connector for socket A1, baud rate: standard 9600 Bd, max. 115.2 kBd (change via device installer and browser)
Power supply	12V DC via measuring device (appropriate power supply recommended)
Current consumption	Ca. 60 mA (10 Mbit/s), < 90 mA (100 Mbit/s)

Use

Preparation

Setting the IP address

You can connect the ZA1945DK data cable to a PC via an Ethernet cable directly or via a switch in a company network. For older PCs, a crossover cable may be necessary for the direct connection.

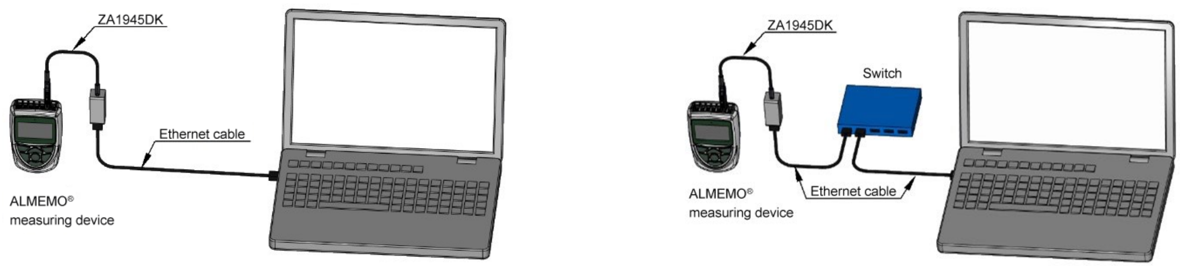


Fig. 5.9 Ethernet data cable ZA 1945-DK

The Ethernet data cable is supplied as a DHCP client. After connecting to a network, the cable is assigned an IP address by the DHCP server. In networks without a DHCP server, it is necessary to manually assign a fixed IP address to the Ethernet data cable.

Verification

Control LEDs

For control of the Ethernet connection there are additionally 2 LEDs available:

Left LED:	Connection	Right LED:	Data transmission
Off:	None	Off:	None
Orange:	10 MHz	Orange:	Half duplex
Green:	100 MHz	Green:	Full duplex

5.2.2 Wireless data connections

Selection, product overview

Type	Article number	Maximum range	Use
Bluetooth	ZA1719BPVU	300 m in free field	Data transmission, transmission of commands, programming of devices and sensors plugged on devices.
WLAN	ZA1719WL	400 m in free field	
Mobile communications modem	ZA1709GPRS	Unlimited	

5.2.2.1 Wireless PC connections with Bluetooth

Basics

Advantages of ALMEMO® connections with Bluetooth compared to other wireless technologies

- Bluetooth wireless technology is defined as an industry standard in accordance with IEEE 802.15.1 and in principle offers high transmission reliability.
- The frequency hopping method used achieves a high level of robustness against interference.
- The Bluetooth participants are uniquely and securely identified by means of a multi-digit PIN code.
- Once configured, connections are (re)established automatically when the system is switched on or when a connection is broken.
- The new high-performance Bluetooth radio modules with built-in active antenna offer a particularly wide range, up to 300 m in free field; additional plug-on antennas are not required.

Characteristics

General

Fig. 5.10 PC connection with Bluetooth

With the Bluetooth USB CPU module ZA 1719-CPU a wireless connection from a PC to ALMEMO® devices is possible.

The Bluetooth connections are delivered paired, i.e. configured ready for operation.

If the Bluetooth connection is interrupted, the USB/COM interface for the software is retained in the PC. This results in high transmission reliability for continuous monitoring. Note: The Bluetooth connections built into laptops/PCs cannot be used here, since the COM interface is deactivated by the operating system after a connection interruption and must always be reactivated manually.

Any ALMEMO® measuring devices with a plug-on Bluetooth slave module can be used.

The plug-on module in the version with 1 m cable between ALMEMO® connector and module (option OA1719BK) can be detached from the measuring device and aligned (with Velcro fastening) to optimize the radio connection.

The complete configuration of all (multi-) connections is easily done via the ALMEMO®-Control software.

The search and selection of all possible Bluetooth slave partners is done simply by entering the corresponding PIN codes.

Types

Article number	Type	
ZA1719BCU	Bluetooth CPU module with USB connection	Pluggable to USB socket of the computer
ZA1719BT1XS	Slave plug-on module	Pluggable to socket A1 of an ALMEMO® device

Articles ZA1719BCU and ZA1719BT1XS are available together configured ready for operation under article number ZA1719BPVU.

Technical data

Bluetooth	Class 1 with active antenna
Protocol	SPP (Encryption 128 bit)
Range	300 m free field (decreases significantly in buildings)
ALMEMO® data rate	1200 Bd to 115.2 kBd
Module housing	Polystyrene (-10° to +70°C)
Cable length	Plug-on module ZA1719-BT1XS: length 0 m, with option OA1719BK: length 1 m ZA1719BCU: length 1.5 m
Voltage supply	
ZA1719BCU	Via USB interface of the PC
ZA1719BT1XS	Via ALMEMO® measuring device, ca. 35 mA (9 V)

Dimensions

Module housing

Length: 61 mm
Width: 30 mm
Height: 12 mm

Use

Preparation

The Bluetooth modules are configured via the PC using the ALMEMO®-Control software.

In the event of interruptions due to power failure or range overrun, the connections are automatically restored after the problems have been eliminated.

Commissioning of the radio connections

Before connecting a USB cable to the computer, install the USB driver with the enclosed CD. Then plug Bluetooth modules onto the corresponding sockets as described above.

If the power supply is OK, the green LEDs of the modules light up. If the radio connection is established, the yellow LEDs of class 1 modules also light up. If the LEDs do not light up or go out, then the range (see Technical data) has been exceeded. It must be noted that the range inside buildings can be greatly reduced by walls or other obstacles. If both modules are brought closer together again, the radio connection is automatically resumed.

The WinControl software is available for recording the measured values of all networked devices. Before starting the measurement, all devices must be set to different addresses.

5.2.2.2 Wireless PC connection with WLAN module ZA 1719-WL

Characteristics

General

The ZA 1719-WL WLAN module with active internal antenna can be plugged onto the A1 socket of any ALMEMO® measuring device instead of a data cable in order to be connected to a local WLAN radio network.

Communication between PC and WLAN module is possible with a range of up to 400 m in free field. Inside buildings, the range decreases significantly.

Power supply and data traffic are indicated by LEDs, and all common encryption modes can be configured.

The module is configured via the ZA 1919-AKUVW USB adapter cable on the PC using special software.

An integration into the data acquisition software WinControl is possible via the Ethernet port.

Fig. 5.11
WLAN module
ZA1719-WL

Features

The following accessories are available for the ZA 1719-WL WLAN module:

Article number	Accessories/Option
ZA 1919-AKUVW	USB adapter cable for configuration of an ALMEMO® WLAN module ZA1719-WL
OA 1719-BK	Cable between ALMEMO® connector and module, length 1 m

Technical data

Standards	WLAN 802,11a/b/g/e/i/h/j
Frequency band	2.4 GHz, channels 1 – 13, (U-NII band 1, 2, 2e, 3)
Output power	100 mW (20dBm)
Flow rate	500 kb/s
Range	400 m free field
Encryption	WPA-PSK, WPA2-PSK, PEAP, LEAP WEP64/128, TKIP, AES (CCMP)
Protocol	TCP/UDP
Ethernet port	10001 (default)
Voltage supply	Via ALMEMO® device
Current consumption	Ca. 70 mA at 9V supply
Module housing	ABS PC GF (-20 to +70°C)
ALMEMO® data rate	1200 Bd to 115.2 kBd

Dimensions

Module housing

Length: 61 mm
Width: 30 mm
Height: 12 mm

5.2.2.3 Mobile communications modem ZA 1709 GPRS

Characteristics

General

The ZA1709-GPRS mobile communications modem is available for remote query and remote configuration of ALMEMO® devices via the mobile Internet. A suitable SIM card and VPN access are required for operation. Both can be obtained from akrobit® software GmbH.

The mobile communications modem can be used throughout Germany, Europe or worldwide. If the modem is used outside Europe, the SIM card must be provided by the customer.

For own direct access, a VPN client software must be installed on the evaluation computer, which is included in the scope of delivery free of charge. For automatic memory readout, the additional module SW5600WCZM9 'Automatic ALMEMO® Memory Readout' is required for the WinControl software.

Alternatively, the measurement data can be obtained via the cloud service of akrobit® software GmbH and also visualized online via a secure Internet access.

Features

The scope of delivery of the ZA 1709-GPRS mobile communications modem includes the following items:

- Mobile communications modem (GPRS/UMTS) incl. data cable ZA1909DK5
- Adapter connector ZA1709AS
- 12V power supply unit 110 to 240 V AC
- Documentation
- Antenna with magnetic base (cable ca. 2.5 m)

Can be ordered additionally:

Article number	Accessories/Option
SW 5600-WCZM9	Additional protocol "Automatic memory readout" for WinControl (SW5600WC1/2/3/4)
ZB 1709EK	Voltage supply cable with connector to the modem and free ends for external voltage 10 to 30 V DC, at least 1.2 A at 12 V DC

Technical data

Frequency range	GPRS: 850/900/1800/1900 MHz UMTS: 800/850/900/1900/2100 MHz
Ports	RS232 (9600 baud, 9-pole, Sub-D socket), FME antenna connection (male), power supply, SIM card reader
Power supply	10 to 30 V, via supplied power supply unit or via cable for external voltage
Current consumption	Max. 1.2 A at 12 V
Operating temperature	-30 to 75°C (power supply unit 0 to 40°C)
Weight	Ca. 110 g
Power supply unit	Input voltage: 110 to 240 V AC, Output voltage: 10.5 to 13.5 V DC, Operating temperature: 0 to 40°C

Dimensions

Module housing

Length:	65 mm
Width:	74 mm
Height:	33 mm

5.3 Networking of measuring instruments with each other

Functionality

Networking of ALMEMO® measuring instruments with each other enables decentralized acquisition of measurement data on site and thus relatively short sensor lines and small modular measuring instruments. The measuring devices are networked via interference-free digital lines and can be evaluated centrally by a computer. This concept minimizes both the wiring effort and EMC-related transmission problems. The use of instrument technology can be flexibly adapted to the respective measuring task.

All ALMEMO® devices are addressable and fully network-compatible (with ALMEMO® Control (all versions) or WinControl (from version 8)). The data lines are looped through in each case, so that another device can be connected to each device with a data cable. In this way, a maximum of 100 devices can be connected to one serial interface of a computer.

Alternatively, interference-free fiber optic cables can be used. For installations over longer distances, however, it is better to use a transmission with RS422/RS485 interfaces. For this purpose, there are separate drivers and galvanically isolated distributors for each device.

The protocol is based on simple ASCII communication, so that the data of each measuring device can be called up in plain text via a terminal. Data flow control is only possible by software handshake (XON/XOFF). Of course, there are also software packages that automate the measuring point query interference-free via CRC in the network, graphically display and evaluate the measured data.

Notes on the measurement

Before each network operation, all measuring devices must be set to different device addresses. For display devices this is done via the keyboard, for transmitters and plug-in units via coding switches (see device instructions). The arrangement of the devices and the order of the addresses are in principle arbitrary, but there must be no gaps.

In network operation, only consecutive addresses between 01 and 99 should be entered so that device 00 is not unjustifiably addressed in the event of a power interruption.

When using connections such as Ethernet, GPRS, WLAN and Bluetooth, not insignificant signal delays may occur. The speed of the connections depends on the quality of the wireless connection, any channel interference and reconnection times after a connection is lost.

Particularly long run times can occur with Bluetooth "network cables". Here the times are multiplied by the cascading and the forward and backward motion. In such cases, responses from different devices could reach the receiver at the same time. To avoid data collisions, appropriate time delays must be provided when switching devices. In the WinControl data acquisition software, the switchover delay parameter is used for this purpose.

5.3.1 Wired networking of measuring devices

Selection, product overview

Article number	Cable	Maximum length	Number of networkable devices	Notes
ZA1999NK5	Four wire cable	50 m	100	Can be self-made with ZA1999FS5 network connectors.
ZA1999NKL	Fiber optics	50 m	10 (at 9600 Bd)	Can be self-made with ZA1999FSL network connectors.

Application areas

ZA1999NK5	Especially suitable for short distances and mobile measurement setups.
ZA1999NKL	Especially suitable for secure data transmission in EMC critical environments.

5.3.1.1 ALMEMO® network interface cable ZA 1999 NK5

Functionality

A ZA1909-DK5 RS232 interface or a ZA1945DK Ethernet interface plugged into socket A1 of the ALMEMO® measuring device can be cascaded with network interface cables (ZA1999NK5) plugged into socket A2 so that up to 99 additional ALMEMO® devices can be connected to the first measuring device.

The commands to the first device are buffered and transmitted to all others. The responses from these are OR-linked on the other hand and therefore also appear at the output of the first device.

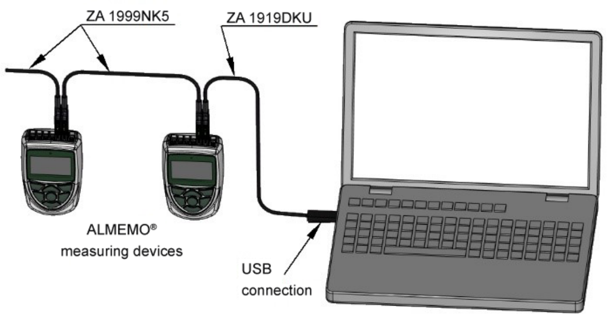


Fig. 5.12 Networking of devices with the ZA1999NK5 network interface cable to each other and to the computer with the ZA1909DK5 data cable.

Characteristics

General

Devices can be easily and quickly plugged together by this cable. Without additional power supply it has a low power consumption (approx. 1 mA).

The ZA1999NK5 network cable can be ordered ready-made or manufactured by the user from individual ZA1999FS5 network connectors (one pair) and a four-wire cable up to 50 m long.

It should be noted that in case of failure of one of the measuring devices, the network is blocked and other peripheral devices such as modules for analog output, alarm relays, etc. cannot be connected due to the assignment of socket A2.

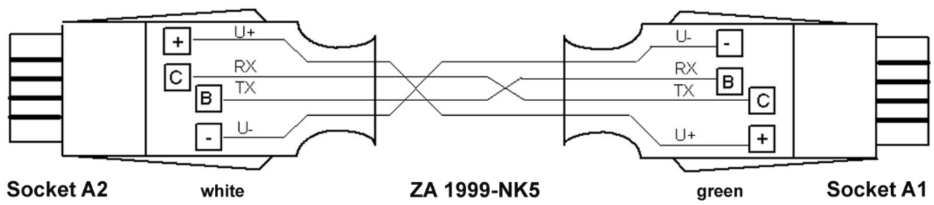


Fig. 5.13 Connection assignment in the network interface cable ZA1999NK5

The ZA1999NK5 network cable is suitable for baud rates up to 115.2 kBd, it is galvanically isolated.

5.3.1.2 Network cable with fiber optic cable

Functionality

The network cable is also available in fiber optic technology as ZA 1999-NKL. It consists of two ALMEMO® fiber optic converters ZA 1999-FSL and 1.5 m duplex plastic fiber optic cable (2.2 x 4.3 mm, can be ordered under LL2243L). The fiber optic cable can take lengths up to 50 m and the transducers can be easily connected by themselves. Power is supplied via the connected devices.

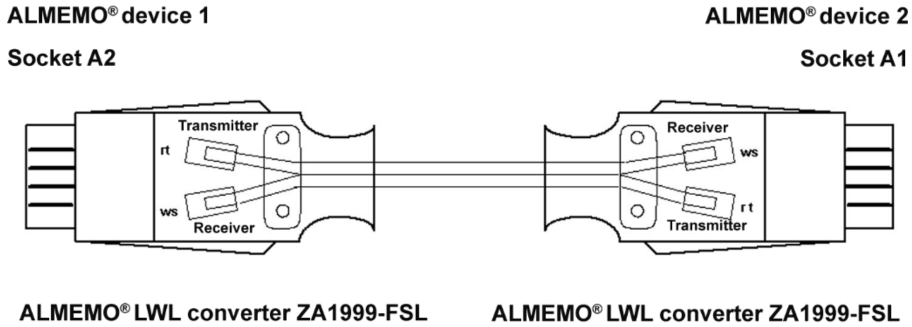


Fig. 5.14 Connection assignment in the network interface cable ZA1999NK5

Characteristics

General

Up to 10 ALMEMO® devices can be networked (at 9600 Bd), double the number at half the transmission rate.

The advantages of this type of device connection are the unproblematic setup of the device network, the high interference immunity and the galvanic isolation of the devices. EMC problems do not occur. An additional voltage supply is not necessary.

Additional peripheral devices such as modules for analog output, alarm relays, etc. cannot be connected.

Use

Preparation

Assembly of the fiber optic cable

To assemble a data cable, the fiber optic cable is cut to the desired length as right-angled as possible with a sharp knife (do not use side cutters). Then the double cable is cut into single wires at both ends over a length of 1 to 2 cm.

In the case of ALMEMO® converters, the two wires are inserted into the two photoelements after removing the cover and secured with the strain relief. When connecting the second converter, make sure that the wires are routed from the transmitter to the receiver in each case. Since the data is transmitted with visible red light, the transmitting wire can be easily identified when data is flowing.

5.3.2 Wireless networking of measuring instruments with each other or sensors with measuring instruments

Selection, product overview

Article number	Maximum length	Maximum number of connections	Notes
ZA1719BNV	300 m (free field)	7	Bluetooth device connection
MA2790BTFV	300 m (free field)	Any number	Bluetooth sensor connection

5.3.2.1 Wireless device connection with Bluetooth module ZA 1719-BNV

Basics

See chapter 5.2.2.1.

Characteristics

General

The Bluetooth connections are delivered paired, i.e. configured ready for operation.

If the Bluetooth connection is interrupted, the USB/COM interface for the software is retained in the PC. This results in high transmission reliability for continuous monitoring. Note: The Bluetooth connections built into laptops/PCs cannot be used here, since the COM interface is deactivated by the operating system after a connection interruption and must always be reactivated manually.

Any ALMEMO® measuring device with an attached Bluetooth slave module can be used.

The search and selection of all possible Bluetooth slave partners is done simply by entering the corresponding PIN codes.

Fig. 5.15 Bluetooth module ZA 1719-BNV

Features

The ZA 1719-BNV wireless device connection consists of two modules, the ZA 1719 BC master module and the ZA 1719 BT1XS slave module. The modules can be networked in two different ways:

1. Star-shaped: one master module ZA 1719 BC is plugged on one ALMEMO® device connected to the computer, while several slave modules ZA 1719 BT1XS are connected to this one master module. One measuring device with Bluetooth CPU can be connected to 1 to 7 ALMEMO® measuring devices with Bluetooth slaves.
2. In series: a ZA 1719 BC master module is placed on an ALMEMO® device connected to the computer, a ZA 1719 BT1XS slave module is placed on a second device (A1 socket), on which in turn a ZA 1719 BC master module is placed on the A2 socket and connected to the slave module of a third device, and so on.

Article number	Function	Position in the network	Socket
ZA1719BC	CPU module, master	Located on the device that is connected to the PC, in the case of devices connected in series, it is located on the device that is closer to the PC.	A2
ZA1719BT1XS	Slave	Located on the device that is further away from the PC in each case.	A1

The complete configuration of all (multi-) connections is easily done via the ALMEMO® Control software.

The plug-on module in the version with 1 m cable between ALMEMO® connector and module (option OA1719BK) can be detached from the measuring device and aligned (with Velcro fastening) to optimize the radio connection.

Technical data

Bluetooth	Class 1 with active antenna
Protocol	SPP (Encryption 128 bit)
Range	300 m free field (decreases significantly in buildings)
ALMEMO® data rate	1200 Bd to 115.2 kBd
Module housing	Polystyrene (-10° to +70°C)
Cable length	For ZA1719-BT1XS plug-on module with OA1719BK option: length 1 m
Voltage supply	
ZA1719BC	Via ALMEMO® measuring device, ca. 20 mA (9 V)
ZA1719BT1XS	Via ALMEMO® measuring device, ca. 35 mA (9 V)

Dimensions

Module housing

Length: 61 mm
Width: 30 mm
Height: 12 mm

Use

See chapter 5.2.2.1.

5.3.2.2 Wireless sensor connection with Bluetooth measuring instrument MA 2790-BTFV

Basics

See chapter 5.2.2.1.

Characteristics

General

An ALMEMO® sensor with a standard or D6 connector (no D7 connector) is plugged onto the MA2790-BTFM measuring device. The ZA 1729 BTFS plug-on module is plugged into the Mxx input socket of any ALMEMO® device. The MA2790-BTFM sends the measured values of the plugged-on sensor to the ZA1729-BTFS plug-on module. This module transfers the measured values to the measuring instrument on which it is plugged. The measuring device displays the measured values or stores them as if the sensor itself were connected to the Mxx input socket. Up to 4 measuring channels per connection can be transmitted. Any number of sensor connections can work in parallel. See also chapter 5.3.2.1

Features

The MA2790-BTFV Bluetooth sensor connection consists of a MA2790BTFM measuring device and a ZA1729BTFS plug-on module.

The MA2790BTFM measuring device has a measuring input for ALMEMO® sensors (with standard or D6 connectors, but not with D7 connectors).

Optionally it is available with a built-in digital sensor for humidity, temperature, air pressure (OA2790RHA). This sensor is pluggable, exchangeable and individually calibratable (without measuring device).

Power is supplied by 3 NiMH mignon rechargeable batteries, battery charging is possible in the device (please order power supply unit separately).

The housing of the MA 2790-BTFM is also suitable for top-hat rail mounting. It has a large two-line static 7/16-segment display.

Air pressure compensation is possible in the device.

MA 2790-BTFM

ALMEMO® 2790
with sensors for humidity,
temperature, atmospheric pressure
option OA 2790-RHA

ZA 1729-BTFS

Fig. 5.16
Sensor connection with Bluetooth measuring device MA 2790-BTFV

Article number	Type	Function
MA2790-BTFM	Measuring device	Has a socket for a sensor, sends data of this sensor to plug-on module ZA1729-BTFS.
ZA1729-BTFS	Plug-on module	Connector with Bluetooth module, passes the received data to the ALMEMO® measuring device on which it is plugged.
MAxxxx (E.g. MA2590, MA2890)	Any ALMEMO® measuring device	Displays and records the data transferred to it by the ZA1729-BTFS plug-on module.

Technical data

MA 2790-BTFM

Measuring input	1 ALMEMO® input socket
AD converter, measuring ranges, features, housing: like ALMEMO® 2490-1, see Ahlborn Product catalog page 01.18, however:	
Sensor supply	6 / 9 / 12 V (depending on programmed minimum sensor supply voltage in ALMEMO® connector), max. 150 mA
Voltage supply	5 to 13 V DC not galvanically isolated
Rechargeable battery	3 NiMH mignon rechargeable batteries, charging circuit built in
Current consumption	Ca. 14 mA with radio (without sensor)
ALMEMO® DC socket	For power supply unit/ interface
Bluetooth connection	Master module built-in

ZA1729-BTFS

Bluetooth	Class 1 with active antenna
Protocol	SPP (Encryption 128 bit)
Range	300 m free field (decreases significantly in buildings)
ALMEMO® data rate	1200 Bd to 115.2 kBd
Module housing	Polystyrene (-10° to +70°C)
Voltage supply	Via ALMEMO® measuring device, ca. 25 mA (9V)
Module housing	ALMEMO® connector, ABS

Dimensions

MA 2790-BTFM
Length: 127 mm
Width: 83 mm
Height: 42 mm

ZA 1729-BTFS
Length: 61 mm
Width: 20 mm
Height: 8 mm

Use

Measuring

The ALMEMO® Bluetooth measuring instrument MA 2790-BTFM and the sensor plug-on module ZA 1729-BTFS are paired at the factory, see operating instructions.

To save power, the MA 2790-BTFM measuring instrument can be operated in sleep mode (memory cycle from 1 minute). The operating time per battery charge is then approx. 240 hours with memory cycle 1 minute or approx. 1 year with memory cycle 1 hour.

6 Operation via serial interface

The serial interface of the ALMEMO® measuring devices can be used to output all measured values individually or automatically, to completely program the device and sensor connector and to query the programming values. The commands can be sent via a terminal or a data communication program. They always consist of a letter, possibly minus sign and 0 to 6 numbers. Only the data and commands having the allowed format are accepted by the measuring device and sent back to the communication device.

A started command is aborted when a new one is entered. Wrong inputs are acknowledged with the message "ERROR". A line feed is automatically appended to each command and each output. Command sequences are shown in this manual separated by blanks, but these should not be entered.

The protocol changes for the new V7 measuring devices can be found in chapter 8.

6.1 Operation via ALMEMO® Control software

The operation and programming of the ALMEMO® devices is made particularly easy and problem-free by the ALMEMO® Control software (previously AMR-Control) for all WINDOWS® versions from 98 onwards. With this software, all device parameters as well as all sensor parameters are clearly displayed and can be changed. In addition, measurement data can be recorded online, the memories of the data loggers can be read out and the measurement data can be stored in files. A terminal is also integrated for online operation of the Ahlborn devices.

6.1.1 Configuration of the interface

1. Start the ALMEMO® Control program.
2. Select "**Interface**" in the input distributor.
3. Select the COM port to which the measuring device is connected.
4. Set the baud rate programmed in the ALMEMO® data cable at "**Baud rate**".
5. Finish configuration with "**OK**". This configuration is saved and will also be used the next time the ALMEMO® Control is started.
6. If you then "**Search for connected devices**", you will reach the "**Main menu**".

6.1.2 Programming and memory readout via menus

All ALMEMO® functions can be conveniently programmed via the "**Device**", "**Measuring points**" and "**Output modules"** menus. In the menu "**Measuring points**" under the item "**Measured values**" current measured values can be read in and edited, in the menu "**Devices**" under the item "**Measured value memory**" it is possible to configure and start a measured data recording completely as well as to read out the stored measured values again later and to write them into a file.

6.1.3 Operation via terminal

A terminal is available in the ALMEMO® Control with which all Ahlborn devices can be operated via interface commands or the outputs of the measuring device can be displayed on the screen.

To do this, click on the "**File**" menu and select the "**Terminal**" menu item. The terminal window is opened.

A list of all possible commands is accessible via the "**Command list**". The commands are simply entered in the terminal window using the keyboard. For easier operation, various command keys are already pre-programmed (labeling and interface commands can be changed at any time with the right mouse button).

All data transferred to the terminal, including e.g. the memory contents of the data logger, can also be saved to a file with the following operation:

Click on the "**File**" menu in the terminal window and select the "**Start terminal recording**" menu item.

In the "**Save terminal recording as:**" window, enter the desired file name, then finish with "**Save**". Now all data, which are generated in the terminal on the screen, are stored in the file above.

If, for example, the memory is to be read out in table format (e.g. for Excel), then:

1. Click on the command key Table format in the terminal window (N2).
2. Click on the "**Memory**" command key (P04).
3. Wait until all data (visible on the screen) have been transferred.

To end saving: Click on the "**File**" menu in the Terminal window, then click on the "**Close terminal recording**" menu item.

Exit the terminal program in the "**File**" menu with "**Exit**".

6.1.4 Read file into spreadsheet

Open the spreadsheet program, e.g. Excel.

1. Click on the "**File**" menu and select the "**Open...**" menu item.
2. Select the saved TXT file.
3. The text conversion wizard appears in Excel.
4. Select file type "separated", then click "**Next**".
5. Set the "Semicolon" separator and the "Text recognition", then click on "**Next**".
6. Select the data format "Standard" and click on "**Finish**".

Now date, time and the measuring points are arranged separately in columns. The line above the measurement data can serve as a legend.

6.2 Device programming

The following describes the operation of all ALMEMO® devices via the serial interface e.g. with a terminal (see chapter 6.1.3).

6.2.1 Selection of a measuring device

In a network, after switching on, the measuring device with the address 00 is active and only the device with the address 00, if available, reacts to all data output commands. The selection of another device is done with the command Gxx.

Command	G01
Response device no. 00	G0
Response device no. 01	1

6.2.2 Output of programming

An overview of **the entire setting of the device** and the connected sensors is best obtained by outputting the programming with the P15 command. In the output format below or next to each other (see chapter 6.5.5) the following picture is obtained:

Command		P15
Response	Print head	ALMEMO 8590-9
	Header	MEAS RANGE LIMIT-MAX LIMIT-MIN BASE D FACTOR EXP AVERAGE DESIGNATION
	Sensor program	01:Ntc +035.00 - - - - - - °C 1.0350 E+0 - - - T external
		02:NiCr - - - +0018.0 - - - °C - - - E+0 - - - T internal
		11:D2.6 - - - - - - - - - V - - - E+0 - - -
	Cycles	MEAS CYCLE: 00:00:00 S S0500.3 F0104.7 A W010 C-SU-
		PRINT CYCLE: 00:00:00 Un 9600 bd

After a line feed, the head with the device designation is output. This designation can be individually configured by the user (see chapter 6.2.3). In the next lines, after a header, the most important parameters of the connected sensors with the active measuring channels appear.

The measuring cycle is no longer available from devices generation V6 onwards. In the case of data loggers, this is followed by the available measured value memory (S...) and the free memory space (F...) in kB, in the case of a memory card in MB. Then follows the setting of the conversion rate and the switches for continuous query. Behind the PRINT CYCLE you can see the memory activation, the output format and the used baud rate.

6.2.3 Individual print head / device designation

An individual print head of max. 40 characters can be programmed via the serial interface. This text appears in the program header instead of the type designation "ALMEMO TYPE-X". When networking several devices, the print head can serve as device identification.

Programming	**Command**	**Response**
Input print head	f4 $ABC test field CR	
Delete print head	f4 $ CR	
Output print head	f1 t0	ABC test field
Output programming	P15	

Printout

```
ABC test field
RANGE LIM.-MAX LIM.-MIN BASE D FACTOR EXP AVERAGE DESIGN.
01:Ntc  +035.00  - - -   - - - °C 1.0350 E+0  - - - T external
02:NiCr  - - -  +0018.0  - - - °C - - -  E+0  - - - T internal
05:D2.6  - - -   - - -   - - -  V - - -  E+0  - - -
MEAS CYCLE:  00:00:30 S  S0500.3 F0130.4 AR  W010 C-SU-
PRINT CYCLE: 00:01:30 U  9600 bd
```

6.2.4 Output of the device configuration

An overview of the current device configuration, settings and output modules can be obtained with the P19 command:

Command `P19`

Response	`DEVICE:      G00 M20 A08 P10/mm/uu`	Address, channels possible, active, primary
	`ATMOSPH. PRESSURE: +01013. mb`	Air pressure see 6.2.5
	`CJ TEMP:     +0023.5 °C`	Cold junction temperature
	`U-SENSOR:    !  12.5 V`	LoBat and sensor voltage
	`HYSTERESIS: 10`	Hysteresis see 6.2.6
	`CONFIG:      FCRDAS-8 -L-- B01`	Configuration see 6.10.13, 6.10.7
	`ALARM:       -1-3`	Alarm status of relays 0..3 see 6.10.8
	`A1:          DK0 Un`	Output module on A1 see 6.10.9
	`A2:          AA`	Output module on A2

In addition to the device address Gxx, the DEVICE line also provides the number of possible measuring channels (Mxx) and the number of currently active ones (Axx).

This is followed by the configuration of the plug-in units for data acquisition systems:

`Ppp/mm/uu:mm/uu/uu.uu,uu;`

`pp` = Primary channels
`mm` = Channels of the measuring circuit card
`uu` = Channels of the switchover cards

After the colon all plug-in units are shown with channel number and type. The type results from the following character:

ALMEMO® sockets	/
10-way MU connector	. (max. 40 channels)
Mini thermal connector	,
Terminal connector	;

Other commands that display the device parameters in detail (see 7.5.1):

	Command
Output of all fixed device parameters:	`f1 P19`
Output of all variable device parameters:	`f2 P19`
Display of all ports of the output modules:	`f3 P19`
Reset to initialize variables:	`f1 C19`
Restoration of the delivery state:	`f2 C19`

6.2.5 Air pressure and temperature compensation

Air pressure compensation

Some measured values depend on the ambient air pressure (see 6.3.3 Measuring range list 'with AC'), so that corresponding measuring errors occur in case of larger deviation from the normal pressure 1013 mbar:

E.g. errors per 100 mbar:		**Compensation range:**
Rel. humidity psychrometer	ca. 2%	500 to 1500 mbar
Mixing ratio cap.	ca. 10%	Vapor pressure VP to 8 bar
Dynamic pressure	ca. 5%	800 to 1250 mbar (error < 2%)
O_2 saturation	ca. 10%	500 to 1500 mbar

The air pressure should therefore be taken into account (approx. -11 mbar/100 m a.s.l.), especially when used at corresponding sea level. It is either programmable or can be measured automatically with a sensor.

Function	Command	Response
Input air pressure in mbar	g xxxxx	
E.g. 1013 mbar	g 01013	
Output air pressure in mbar	P43 or P19	ATM PRESSURE: +01013. mb

For air pressure measurement, an air pressure sensor (e.g. FDAD 12-SA) is defined as a reference by programming the designation to '*P' (see chapter 6.7.2). For automatic queries, the air pressure sensor should be placed before the humidity sensors in the measuring point sequence.

Function	Command
Define air pressure sensor as reference	f2 $*P CR

Temperature compensation

Sensors whose measured value depends strongly on the **temperature** of the measured medium are usually equipped with their own temperature sensor, and the instrument automatically performs temperature compensation (see measuring range list 6.3.3 'with TC'). Dynamic pressure and pH probes are, however, also available without a temperature sensor. If the medium temperature deviates from 25°C, the following measuring errors occur:

E.g. errors per 10°C:		Compensation range:	Sensor:
Dynamic pressure:	ca. 1.6%	-50 to 700°C	NiCr-Ni
pH probe:	ca. 3.3%	0 to 100°C	NTC or Pt100

For compensation, an external temperature sensor can also be defined as reference by programming the designation to '*T' (see chapter 6.3.6) or explicitly the reference channel (see chapter 6.3.4).

However, the compensation temperature can also be entered:

Function	Input compensation temperature in 0.1°C	
Command	f1 gxxxxx	(f1 g02500 = 250.0° C)

6.2.6 Hysteresis

The alarm state in the event of a limit value being exceeded remains until the measured value has fallen below the limit value again by the hysteresis (normally 10 digits) in order to prevent the relays from chattering at the switching point. Depending on the resolution of the measuring range, it is desirable to adjust the hysteresis. The hysteresis of the alarm condition is therefore programmable in a range from 00 to 99 digits:

Function	Command	Response
Input hysteresis in digit	Y xx	
Output hysteresis	P19	HYSTERESIS: 10

6.2.7 Time and date

For logging the measurement time, a clock is built into each ALMEMO® device, which can be set to real time and date. But only in the data loggers the time is battery buffered and remains when the device is switched off. With the other devices, the clock is set to 00:00:00 after switching on and starts with the first measuring point query.

Date	Command	Response
Programming	dddmmyy	
Delete	C13	
Output	P13	DATE: 01.02.05
Time		
Programming	Uhhmmss	
Stop and reset to zero	C10	
Output	P10	TIME: 12:34:00
Measuring time		
Output since start	P46	MEAS. TIME: 01:23:45.67

6.3 Sensor programming

In contrast to conventional measuring devices, all sensor parameters of devices with the ALMEMO® connector system are not stored in the measuring device, but in a data memory of the connector plug. With assembled sensors and factory-programmed connectors, the measuring range and dimension are already stored in the connector and programming is normally not required.

However, there are only some versions of the 10-way connector ZA 5590-MU with programming for 10 identical sensors each, although each measuring point can easily be programmed individually with all the parameters listed here.

When programming correction values, scaling or limit values, it should be noted that parameters programmed ex works are protected against unintentional changes by the locking mode and if a change is desired, the locking level must first be lowered accordingly (see chapter 6.3.12). Otherwise, all parameters can be easily entered or changed, provided that the corresponding sensor connector is plugged in.

The size of the connector memory has been doubled to 4 kbit in the meantime (identifier E4). This supports multipoint calibrations, own linearizations or connectors with special measuring ranges (see chapter 6.3.13).

6.3.1 Select input channel

With the input channel it is possible to program measuring points or to output the measuring and programming values without influencing the selected measuring channel. If a measuring point or an input channel is defined, all subsequent operations refer to the channel defined with it.

Function	Command
Select input channel 2	E02

6.3.2 Output programming

An overview of the programming of the selected channel is obtained with the command P00. As with the printout of the entire programming with P15 (see chapter 6.2.2), the measuring point, range, max. limit, min. limit, base value, dimension, factor, averaging mode and measuring point designation are output:

Command: `P00`

Response: `1:NiCr +0100.0 -0020.0 +0000.0°C 1.0000 E-1 - - -  Design.`

How to query the remaining special parameters of a measuring point can be found in chapter 6.10.1.

6.3.3 Measuring range selection

For each sensor there is a connector programmed with measuring range and dimension. If you want to program the connectors yourself or change the measuring range frequently, then you must pay attention to a special connector design for some sensors (thermo, shunt, divider, frequency, etc.). When programming, the sensor must be plugged in, as all sensor parameters are stored in the connector.

The new stand-alone D6 and D7 sensors can only be configured via a USB interface cable ZA1919-AKUV or a V7 measuring device (see chapter 3.1.2 and 3.1.3).

Range		Connector	Command	Print	Dim
Pt100-1 4wire ITS 90	-200.. 850°C	ZA 9000-FS	B01	P104	°C
Pt100-2 4wire ITS 90	-200.. 400°C / 300°C*	ZA 9000-FS	B03	P204	°C
Pt100-3 4wire ITS 90	-8.. 65.000°C*	ZA 9000-FS	B00	P304	°C
Pt1000-1 4wire with element flag 1	-200.. 850°C	ZA 9000-FS	B01	P104	°C
Pt1000-2 4wire with element flag 1	-200.. 400°C / 300°C*	ZA 9000-FS	B03	P204	°C
Ni100 4wire	-60.. 240°C	ZA 9000-FS	B63	N104	°C
Ni1000 4wire with element flag 1	-60.. 240°C	ZA 9000-FS	B63	N104	°C
NiCr-Ni (K) ITS 90	-200.. 1370°C	ZA 9020-FS	B04	NiCr	°C

Range		Connector	Command	Print	Dim
NiCrSil-NiSil (N) ITS 90	-200.. 1300°C	ZA 9020-FS	B34	NiSi	°C
Fe-CuNi (L)	-200.. 900°C	ZA 9021-FSL	B05	FeCo	°C
Fe-CuNi (J) ITS 90	-200.. 1000°C	ZA 9021-FSJ	B35	IrCo	°C
Cu-CuNi (U)	-200.. 600°C	ZA 9000-FS	B06	CuCo	°C
Cu-CuNi (T) ITS 90	-200.. 400°C	ZA 9021-FST	B36	CoCo	°C
PtRh10-Pt (S) ITS 90	0.. 1760°C	ZA 9000-FS	B07	Pt10	°C
PtRh13-Pt (R) ITS 90	0.. 1760°C	ZA 9000-FS	B37	Pt13	°C
PtRh30-PtRh6 (B) ITS 90	+400.. 1800°C	ZA 9000-FS	B08	El18	°C
AuFe-Cr	-270.. 60°C	ZA 9000-FS	B38	AuFe	°C
Ntc Type N	-50.. 125°C	ZA 9000-FS	B09	Ntc	°C
Millivolt	-10.. 55 mV	ZA 9000-FS	B10	mV	mV
Millivolt 1	-26.. 26 mV	ZA 9000-FS	B27	mV 1	mV
Millivolt 2	-260.. 260 mV	ZA 9000-FS	B28	mV 2	mV
Volt	-2.6.. 2.6 V	ZA 9000-FS	B11	Volt	V
Differential millivolt	-10.. 55 mV	ZA 9000-FS	B50	D 55	mV
Differential millivolt 1	-26.. 26 mV	ZA 9000-FS	B51	D 26	mV
Differential millivolt 2	-260.. 260 mV	ZA 9000-FS	B52	D260	mV
Differential volt	-2.6..2.6V /-2.0..2.6V*	ZA 9000-FS	B53	D2.6	V
Milliampere	-32..32mA/-26..26mA*	ZA 9601-FS	B12	mA	mA
Percent	4-20 mA	ZA 9601-FS	B13	%	%
Battery	0.. 25 V	ZA 9000-FS	B14	Batt	V
Ohm	0.. 500 W	ZA 9000-FS	B15	Ohm	Ω
Ohm with element flag 1	0.. 5000 W	ZA 9000-FS	B15	Ohm	Ω
Frequency	0.. 15000	ZA 9909-AK	B29	Freq	Hz
Impulses	0.. 65000	ZA 9909-AK	B54	Puls	
Digital interface	-65000.. +65000	ZA 9919-AKx	B55	DIGI	
Digital input	0.. 100%	ZA 9000-EK2	B70	Inp	%
Impeller normal	0.3.. 20 m/s	ZA 9915-AK	B30	S120	ms
Impeller normal	0.4.. 40 m/s	ZA 9915-AK	B31	S140	ms
Impeller micro	0.5.. 20 m/s	ZA 9915-AK	B32	S220	ms
Impeller micro	0.6.. 40 m/s	ZA 9915-AK	B33	S240	ms
Impeller macro	0.1.. 20 m/s	ZA 9915-AK	B24	L420	ms
Water turbine micro	0... 5 m/s	ZA 9915-AK	B25	L605	ms
Dynamic pressure 40 m/s TC, AC	0.5.. 40 m/s	ZA 9612-AK	B40	L840	ms
Dynamic pressure 90 m/s TC, AC	0.. 90 m/s	ZA 9612-AK	B41	L890	ms
Rel. humidity cap.	0.. 100%	ZA 9000-FS	B16	% rH	%H
Rel. humidity cap. with TC	0.. 100%	FH A646-C	B42	HcrH	%H
Rel. humidity cap. with TC	0.. 100%	FH A646-R	B56	H rH	%H
Humidity temperature	-30.. 125°C	FN A846	B45	P HT	°C
Conductivity with TC	0.. 20mS	FY A641-LF	B60	LF	mS
CO_2 concentration	0.. 2.5%	FY A600-C02	B64	CO2	%
O_2 saturation with TC and AC	0.. 260%	FY A640-O2	B65	O2-S	%
O_2 concentration with TC	0.. 40 mg/l	FY A640-O2	B66	O2-C	mg
Temperature digital internal*	-20.. +80°C	FH 0D46	B68	D °C	°C
Rel. humidity digital internal*	0.. 100%	FH 0D46	B69	D%H	%H
Function channels					
Mixing ratio cap. with AC	0.. 500 g/kg	FH A646	B43	H AH	gK
Dew point cap.	-25.. 100°C	FH A646	B44	H DT	°C
Vapor pressure cap.	0.. 1050 mbar	FH A646	B59	H VP	mb
Enthalpy cap. with AC	0.. 400 kJ/kg	FH A646	B58	H En	kJ
Rel. humidity psychr. with AC	0.. 100%	FN A846	B46	P RH	%H
Mixing ratio psychr. with AC	0.. 500 g/kg	FN A846	B47	P AH	gK
Dew point psychr. with AC	-25.. 100°C	FN A846	B48	P DT	°C
Vapor pressure psychr. with AC	0.. 1050 mbar	FN A846	B49	P VP	mb
Enthalpy psychr. with AC	0.. 400 kJ/kg	FN A846	B57	P En	kJ
Difference	(Mb1-Mb2)	Arbitrary	B71	Diff	f(Mb1)
Maximum value	(Mb1)	Arbitrary	B72	Max	f(Mb1)
Minimum value	(Mb1)	Arbitrary	B73	Min	f(Mb1)
Average value via time M(t)	(Mb1)	Arbitrary	B74	M(t)	f(Mb1)
Average value via me as. point	(Mb2..Mb1)	Arbitrary	B75	M(n)	f(Mb1)
Sum via meas. point	(Mb2..Mb1)	Arbitrary	B76	S(n)	f(Mb1)
Total pulse count	(Mb1)	ZA 9909-AK2	B77	S(t)	

Range		Connector	Command	Print	Dim
Pulse count/print cycle	(Mb1)_	ZA 9909-AK2	B78	S(P)	
Thermal coefficient*	$\overline{M}$(q)/$\overline{M}$(M01-M00)	ZA 9000-FS	B79	q/dt	Wm
Wet bulb globe temp.*	0.1TT+0.7HT+0.2GT	ZA 9000-FS	B02	WBGT	°C
Alarm value	(Mb1)	Arbitrary	B80	Alrm	%
Measured value*	(Mb1)	Arbitrary	B81	Mess	f(Mb1)
Cold junction temperature*		Arbitrary	B82	CJ	°C
Number of averaged values*	(Mb1)	Arbitrary	B83	n(t)	
Volume flow m^3/h*	$\overline{M}$(Mb1) * Q	Arbitrary	B84	Flow	mh
Timer*	0..60000/6000.0 s	Arbitrary	B85	Time	s
Air pressure in the device * (Option AP)	300..1100 mb	Arbitrary	B86	AP	mb

TC = Temperature compensation, AC = Air pressure compensation, b1/b2 = Reference channels
* Range available depending on device type and version

De-/activate channel	Command
Deactivate programmed measuring channel	`C00`
Activate programmed measuring channel again	`o00`

6.3.4 Function channels

In order to be able to output not only the current measured values of the measured value transmitters in the measuring protocol on the printer or in the computer, but also calculation results, such as humidity variables, max, min, average values or differences of certain channels, the possibility was created to program measuring points with such calculation functions.

All programming values such as limit value, base value, factor and dimension change can be applied to the function channels as well as max, min and average value calculation and measured value storage. The measured values are updated with each measuring point query. One should pay attention to the order of the measuring channels, so that the measured values from which a function is calculated are acquired first.

Selection of the calculation function

The calculation function is programmed exactly like a measuring range in the RANGE function on the 2nd (Mxx_2), 3rd (Mxx_3) or 4th (Mxx_4) channel of a sensor connector. The locking of the 1st channel Mxx1 must be removed for this purpose.

Reference measuring points

By default, the calculation function refers to the 1st channel of the corresponding sensor connector Mxx1 (reference channel b1). The calculation of the difference is done between the 1st channel of the sensor connector (reference channel b1) and the measuring point M00 (reference channel b2), for average value and sum over n measuring points the channels M00 or reference channel b2 to Mxx1 (reference channel b1) are considered. The determination of the wet bulb globe temperature or the heat coefficient requires a very specific sensor configuration (see chapter 3.2.4 and 3.3).

However, the two reference channels Mb1 and Mb2 can also be programmed explicitly, either absolute to a measuring channel Mb1 or relative to the computing channel (e.g. f1 E-01 refers to the previous channel):

Programming	Commands
First select calculation channel	`Exx`
Program calculation function	`Bxx` (Reference channels Mxx_1, M00)
Set reference channel 1 Mb1 absolutely	`f1 E b1`
Set reference channel 1 M-b1 relatively	`f1 E-b1`
Delete reference channel 1 Mb1	`f1 E-00`
Set reference channel 2 Mb2 absolutely	`f2 E b2`
Set reference channel 2 M-b2 relatively	`f2 E-b2`
Delete reference channel 2 Mb2	`f2 E-00`

A temperature sensor for temperature compensation can also be assigned to pH sensors or dynamic pressure transducers via the reference measuring point Mb1. Temperature sensors for pH: Ntc or Pt100 with 0.01°C, for dynamic pressure: NiCr-Ni with 0.1°C!

6.3.5 Dimension change

Any two upper and lower case letters, as well as the special characters [,], %, Ω, ° , -, =, ~ can be used as the dimension.

Programming	Commands
Set input channel	`Exx`
Program dimension ′xy′	`f1 $xy CR`

Conversion of dimensions

°F	By programming the °F dimension, a temperature is automatically converted from °C to °F (°F = °C x 9/5 + 32).
K	To convert °C to abs. temperature K, enter a base value of -273.15.
FM	To convert a flow velocity of m/s with 2 decimal places to feet per minute (FpM = m/s x 3.281 x 60), a factor of 1.9686 with exponent +2 must be programmed.
!C	Switching off the cold junction compensation for thermocouples

6.3.6 Measuring point designation

Via the serial interface it is possible to enter a measuring point designation of 10 characters for the identification of the channels. This name appears in the program header and at measuring point queries as a designation after the measuring range designation.

Set input channel with command `Mxx` or `Exx`.

Function	Command
Enter measuring point designation	`f2 $z.B. Raum1 CR`

Function abbreviation

There are a few abbreviations on the first 2 characters of the designation that cause special functions of the sensor. These must be retained, but the remaining 8 characters may still be used freely:

`*J`	Definition of a temperature sensor for ext. cold junction compensation of all following thermocouples (see chapter 6.7.3)
`#J`	Marking of a thermocouple with its own temperature sensor for cold junction compensation via the reference channel (see chapter 6.7.3)
`#N`	Causes the conversion to standard conditions for a flow sensor (see chapter 6.7.5)
`*P`	Definition of an air pressure sensor for air pressure compensation (see chapter 6.2.5)
`*T`	Definition of a temperature sensor for temp. compensation (see chapter 6.2.5)
. . . . !	A !-sign at the end indicates a special connector with linearization (see chapter 6.3.13).

6.3.7 Averaging mode

For each measuring point an averaging over the measured values of the measuring point queries can be programmed. Depending on the programming, averaging is possible over individual measurements, over the entire measuring time or over the cycle (see chapter 6.7.4). In order to be able to also store average values or output them to the interface, corresponding function channels M(t) must be programmed (see chapter 6.3.4). If only the average value is required instead of the measured value, the output function M(t) (see chapter 6.10.4) can be used. The type of averaging is determined by the averaging mode:

Averaging	Printout	Command
No averaging	- - -	m0
Average value via time or individual measurements	CONT	m1
Average value via the cycle	CYCL	m2

6.3.8 Enter programming values

Programming values are entered after the command letter either with decimal point and RETURN or five-digit with leading zeros and decimal places without decimal point. The position of the decimal point ultimately results from the measuring range and possibly a decimal point shift. The input of a leading sign is only necessary for negative programming values.

Example:

Limit value max.	+100.0 °C	H100 CR	or	H01000
Factor	1.035	F1.035 CR	or	F10350

6.3.9 Limit values

Two limit values (MAX and MIN) can be programmed for each measuring channel. Exceeding the limit values is treated as a malfunction in the same way as exceeding the measuring range limits and sensor breakage.

To activate an alarm circuit, a suitable output cable ZA 1006-GK (see chapter 5.1.1.3) with a semi-conductor relay or the relay adapter ZA 8006-RTA (see chapter 5.1.2.1) can be connected to the output socket A2. The alarm relay is closed when one of the measuring channels is disturbed. The disturbance is only terminated when all measured values have fallen below the limit value by 10 digits (hysteresis). The hysteresis can also be changed if required (see chapter 6.2.6). A selective assignment of relays to limit values is described in chapter 6.10.8.

In addition, actions in the sequence control can be caused by limit value transgressions (see chapter 6.3.3).

Function	Commands	Response
Set channel	Exx	
Limit value max (Hi)		
Program	H-xxxxx	
Delete	C08	
Output	P08	LIMIT VAL. MAX: 01: +0050.0 ° C
Limit value min (Lo)		
Program	L-xxxxx	
Delete	C09	
Output	P09	LIMIT VAL. MIN: 01: +0010.0 ° C

6.3.10 Correction values

Each measured value can be corrected first in zero point and gain with the correction values ZERO POINT and GAIN and then additionally scaled with BASE VALUE and FACTOR. The displayed measured value is calculated as follows:

Corrected measured value = (Measured value - ZERO POINT) x GAIN

Displayed measured value = (Corrected measured value - BASE VALUE) x FACTOR

If no scaling is required, the BASIS and FACTOR functions can also be used for measured value correction (see chapter 6.3.11).

Multipoint calibrations and linearizations in the connector are also possible (see chapter 6.3.13).

Zero point adjustment

Make physical measured value zero (e.g. temperature sensor in ice water, short-circuit voltage or depressurize pressure transducer, etc.).

The displayed measured value must be programmed as a zero correction value. This procedure can be automated by **zeroing** the measured value.

The zero adjustment procedure has a special function with some sensors:

For dynamic pressure flow sensors (range L840 and L890 or dimension Pa), the offset value is entered as a calibration offset before linearization, but is not stored in the EEPROM, i.e. the adjustment is lost when switching off.

For pH probes (dimension pH or PH), conductivity and O_2 probes, both zero adjustment and automatic gain adjustment can be performed with the same command when immersed in the corresponding calibration solutions.

Gain adjustment

Bring physical variable to a precisely defined setpoint (e.g. place temperature sensor in boiling water, apply calibration voltage, etc.).
Determine the actual value in the MEASUREMENT VALUE function.
The correction factor is calculated from the setpoint/actual value.

Function	Commands	Response
Zero point adjustment	`f1 C01`	
Program zero point correction	`f1 O-xxxxx`	
Delete zero point correction	`f1 C06`	
Output zero point correction	`f1 P06`	`ZEROPT: 01: -0001.1 °C`
Program gain correction	`f1 F-xxxxx`	
Delete gain correction	`f1 C07`	
Output gain correction	`f1 P07`	`GAIN: 01: 1.0123`

When the measuring range is changed, the correction values are deleted.

6.3.11 Reference value, scaling, decimal point setting

A useful function is to be able to zero the measured value at certain locations or at certain times in order to then only observe the deviation from this reference value.

Transmitters with standard output (e.g. 0/4-20 mA) almost always require a zero offset and multiplication by a factor for scaling in the physical variable in order to display the actual measured variable correctly.

Displayed value = (corrected measured value - BASE VALUE) x FACTOR (see chapter 6.3.10)

The FACTOR is programmable in the range -2.0000 to +2.0000. For factors above 2.0 or below 0.2, a corresponding decimal point shift must be provided by entering the EXPONENT.

Decimal point shift

When measured values are rescaled, in addition to the correction with the FACTOR, a decimal point shift is often necessary in order to correctly dimension the variables. For this purpose, the FACTOR can be provided with an EXPONENT, which makes the decimal point shiftable as far as it can be represented on the display and printer. An exponential representation of the measured values is not possible.

Decimal point shift by 1 place to the right: EXPONENT = +1

Decimal point shift by 1 place to the left: EXPONENT = -1

If the measured value is already provided with an exponent as standard, then this must be taken into account.

Example:

A temperature transmitter with 4-20mA output signal for the range -100°C to +400°C is to be connected to the measuring instrument and the temperature is to be displayed. With 4-20mA signals one preferably uses the measuring range 'Percent', which first converts the measuring signal into values from 0.00 to 100.00%. The DIMENSION is changed to '°C' according to chapter 6.3.5. The adjustment to the temperature setpoints is done by setting the decimal point with the EXPONENT and calculating the correction values BASE VALUE and FACTOR:

Actual values:	Start A_I = 0.00 %	End E_I = 100.00 %
Nominal values:	Start A_S = -100.0 °C	End E_S = +400.0 °C

It is best to first correct the decimal point according to the desired resolution. In our example the actual values have 2 decimal places, the nominal values only one, therefore the decimal point must be shifted one place to the right with the EXPONENT +1.

After changing the dimension and shifting the decimal point, new actual values result:

	EXPONENT = +1	Dimension = °C
Actual values:	Start A_I = 0.0 °C	End E_I = 1000.0 °C

Now you can easily calculate the scaling values with the following formulas:

$$\text{FACTOR} = \frac{E_S - A_S}{E_I - A_I} = \frac{400.0°C - (-100.0°C)}{1000.0°C} = 0.5000$$

$$\text{BASE VALUE} = \frac{-A_S}{\text{FACTOR}} + A_I = \frac{-(-100.0°C)}{0.5} = 200.0\ °C$$

If a factor of more than 2.0 results, the resolution must be reduced, if it is less than 0.2, it could still be increased.

If the base value including the decimal places is greater than 65000, either a reduction of the resolution helps, or the FACTOR is used as a GAIN CORRECTION (see chapter 6.3.10).

Thus, the BASE VALUE changes to: BASE VALUE = $A_I - A_S$

Function	Commands	Response
Set channel	Exx	
Change dimension	Dx	
Decimal place shift		
1 place to the right	V1	
2 places to the left	V-2	
Base value		
Zero the measured value	C01	
Program	O-xxxxx	
Delete	C06	
Output	P06	BASE VALUE: 01: -0001.1 ° C
Factor		
Program	F-xxxxx	
Delete	C07	
Output	P07	FACTOR: 01: 1.0123

When the measuring range is changed, the scaling values are also deleted.

6.3.12 Sensor locking

If the programmed values are to be protected against unintentional changes, a locking mode can be programmed for each measuring channel, which protects functions against reprogramming up to a certain locking level.

Standard sensors are provided with level 5 ex works, i.e. measuring range, dimension, correction values and scaling are protected, only the limit values can still be changed. With locking level 7, the limit values would also be protected. To change protected functions, the locking mode must be reduced accordingly, to change the measuring range or also to program an additional channel, the locking must be deleted, i.e. set to 0. If the locking mode is provided with a dot, then a change is not possible.

Locking level	Locked functions
0	None
1	Measuring range + Element flags
2	Measuring range + Zero point and gain correction
3	Measuring range + Dimension
4	+ Zero point and gain correction
5	+ Base value, factor, exponent
6	+ Analog output start-end + Temp. zero setting
7	+ Limit values max and min

In the locking mode 5, the zeroing of the measured value is temporarily possible for new devices, i.e. after switching off the device, the original measured value appears again. To prevent the zeroing completely, the locking mode 6 must be programmed.

Functions	Commands	Response
Set channel	`Exx`	
Program locking level x	`f1 kx`	
Query	`f1 P00`	`LOCKING:4`
or	`f1 P15`	See chapter 6.10.1

6.3.13 Special measuring ranges, linearization, multi-point calibration

The following tasks can be realized with the aid of ALMEMO® connectors (identification E4):

1. Provision of special measuring ranges with characteristic curve in the connector (see chapter 2.2)
2. Linearization of voltage, current, resistance or frequency signals by the user
3. Multipoint calibration of all sensors

With the option KL it is possible to convert measuring signals according to a characteristic curve of up to 30 interpolation values into corresponding display values. The interpolation points are programmed into the EEPROM of the ALMEMO® connector via the ALMEMO® Control software. During measurement, the measured values are linearly interpolated in between. When correcting non-linear sensors (e.g. Pt100 or thermocouple sensors), the original characteristic curves are first taken into account and then only the deviations are added linearly interpolated.

Connectors with a characteristic curve can be processed by all ALMEMO® devices from 2390-5 on as standard (2390-5/8 from V6.23, 2690 from V6.21, update possible). Only for programming the characteristic curves, devices from 2690-8 with option KL are required. It should also be noted that only ALMEMO® connectors with a larger EEPROM (identification E4) can be programmed with this.

Programming a multipoint characteristic into the ALMEMO® connector:

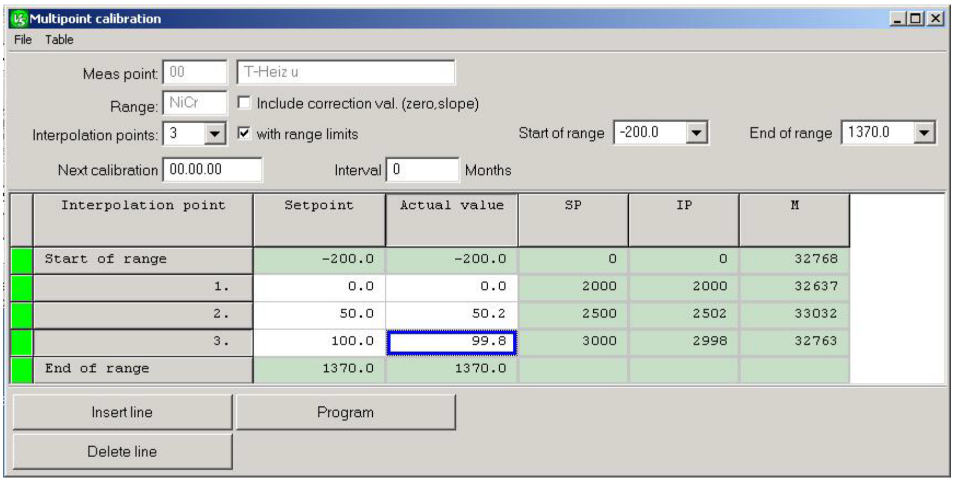
Connect the sensor to an input socket, the data cable to socket A1 of the measuring instrument and to the COM interface of the PC. Open the ALMEMO® Control software (from v. 5.7) on the PC.

Select the desired channel in the 'Measuring points' list and 'Program measuring point'. Under 'Measuring point' you will find the menus '**Multipoint calibration**' and '**Special linearization**'. Both menus are almost the same, the 'Special linearization' only allows additionally a dimension change and a comma shift.

In each case a table appears in which up to 35 actual and nominal values can be entered. The number of interpolation points is selected by a corresponding input field or by adding lines.

Only 1 channel can be provided with a characteristic curve per connector.

The other 3 channels can be used normally.



Measured value processing

Measuring signal
Standard linearisation
Multipoint calibration
Measured value correction s. 6.3.10
Scaling s. 6.3.11
Output

Measuring signal
Standard linearisation
Measured value correction s. 6.3.10
Multipoint calibration (Consider correction values ZC and SC!)
Scaling s. 6.3.11
Output

If sensors have already been corrected with zero point or gain (e.g. DKD calibration), then the correction values can be used by clicking on the option '**Take correction values zero point and gain into account**'. If base or factor should be programmed for scaling, then they can be shifted into zero point or gain, if these are not yet programmed. Attention, if the decimal point of the actual values does not correspond to the measuring range, then the decimal point shift must be considered during the input. However, it is best to create the characteristic curve directly from uncorrected measured values!

The option '**With range limits**' in the menu 'Multipoint calibration' provides a smooth transition to the beginning and end of the measuring range. '**Without range limits**' only the measuring range between first and last interpolation point is available. Outside of this measuring range overflow is signaled.

By clicking the '**Program**' button, the linearization table is written into the EEPROM of the sensor connector.

To read in the new characteristic, either the instrument must be switched off and on again or the connector must be unplugged and plugged in again.

In the **interface protocol** of the 'P15' command there are the following identifications:

1. Devices which can process special characteristics show a '.' after 'DESIGNATION' in the header of the sensor programming.
2. Devices with option KL, which can write special characteristic curves into connectors, show a '!' at the same position.
3. All sensor channels programmed with special characteristics show a '!' at the 10th position of the designation. This identification cannot be influenced by programming the designation.

```
 AMR ALMEMO 2690-8
1. RANGE  LIMIT MAX   LIMIT MIN   BASE   D    FACTOR   EXP    AVERAG.   DESIGN.
2. RANGE  LIMIT MAX   LIMIT MIN   BASE   D    FACTOR   EXP    AVERAG.   DESIGN!
3. 00:NiCr  ---       ---         ---    °C   ---      E+0    ---       Temp.!
```

If a channel with characteristic curve is deactivated or programmed with another range, then the characteristic curve can be reactivated later by restoring the special range 'Lin' via keyboard or with the command 'B99'.

6.4 Acquiring measured values

ALMEMO® devices offer the following options for measured value acquisition:

Continuous measuring point query of all measuring points with adjustable conversion rate with output of the measured values on display and analog output, as well as limit value monitoring and peak value storage.

One-time (manual), cyclic or continuous measured value output to the device memory (option), to a printer or computer.

6.4.1 Selection of a measuring point

With the command Mxx the device switches the channel Mxx to the measuring circuit. The measuring point can be programmed or the current and stored measured values can be queried. The measured value is continuously output to a possibly connected analog output. After a measuring point query of all channels, this measuring point is automatically selected again.

Function	Command	Response
Select measuring point 2	M02	M02

6.4.2 Measured values

The measured values of each channel can also be called up individually. By transferring the measured value to the BASE VALUE (see chapter 6.3.11) or the ZERO POINT CORRECTION (see chapter 6.3.10), the measured value of the selected measuring point can be set to zero.

With the help of a programmable setpoint, the gain can also be adjusted. During adjustment, the correction factor is calculated and stored as FACTOR in the connector.

Function	Command	Response
Output measured value from measuring channel	p	01:+0023.5 °C
Output measured value from input channel	P01	12:34:00 01:+0023.5 °C
Set measured value to zero (base value)	C01	
Calibrate measured value (zero point correction, for pH, LF, O2 also gain correction)	f1 C01	
Switching the calibration resistor on (off)	o(-)01	(see 3.8.2)
Input set value	f2 gxxxxx	
Adjust set point	f2 C01	
Output set value	P45	SETPOINT: 01: 5.000 br

6.4.3 Peak values

From the measured values of each selected measuring point, the highest and the lowest value is continuously determined and stored. The maximum and minimum values of each channel can be output and deleted individually or all as a list. With each change of the measuring range and, if configured, at the start of a measuring point query (see chapter 6.10.13), the peak values are also deleted.

The time and date of the peak values are also recorded and output.

Function		Commands	Response
MAX VALUE	Output	P02	MAX. VALUE: 01: +0020.0 °C
	Delete	C02	
MAX TIME/DATE	Output	P28	MAX. TIME: 01: 12:34 01.02.
MIN VALUE	Output	P03	MIN. VALUE: 01: -0010.0 °C
	Delete	C03	
MIN TIME/DATE	Output	P29	MIN. TIME: 01: 12:34 01.02.

6.4.4 Output measured value list

The current measured, max, min and average values with the number of averaged values of all active measuring channels can be called up and deleted together:

Function	Commands	Response
Measured value list	P18	MS MEAS. VAL. MAX. VAL. MIN. VAL. AVER. VAL. COUNT 00: +0012.0 +0045.1 +0009.0 - - - 00000 01: +0023.0 +0025.0 +0019.0 +0022.1 00025
Delete all measured values	C18	

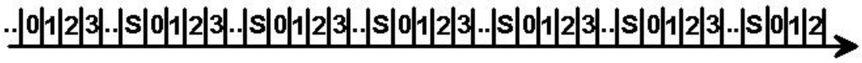
All measured values can also be deleted automatically each time a measuring point query is started (see chapter 6.10.13.1).

6.5 Measuring point query and measured value output

In principle, there are three different types of measuring point query:

Continuous measuring point query

With continuous measuring point query, all measuring points are recorded evenly at the conversion rate by switching the semi-conductor relays, max, min, average values are formed and the limit values are monitored. After each cycle, a special measurement S is inserted for zero point adjustment, cold junction temperature, measuring current calibration or supply voltage measurement.

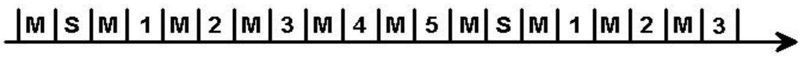


The advantage of this query is the fast and uniform acquisition of all measuring points. The disadvantage with many measuring channels is the possibly low update rate of the selected measuring point. Therefore the semi-continuous query was introduced.

Semi-continuous measuring point query

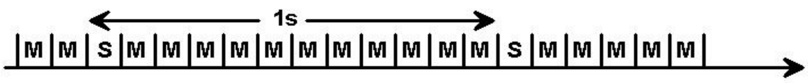
With semi-continuous query (setting 'non-continuous') all measuring points are also queried continuously, but the selected measuring point M is preferred and every 2nd measurement is recorded again. With averaging, attenuation or analog output, a constant measuring rate of half the conversion rate is thus achieved for this channel. The special measurement S is carried out if the interrogation channel X and the selected measuring point M coincide.

M = 0



Special case only 1 active measuring point

If only one measuring point is active, the special measurement is only carried out approx. once a second and the measured value is extrapolated. Thus, practically the full measuring rate is achieved.



Basic setting

Ex works or after a reset, small ALMEMO® devices (less than 5 sockets) are set to semi-continuous, larger ones to continuous measuring point query.

6.5.1 Measured value output/storage

For data acquisition via the interface or into the device memory, the cycle is primarily used. But for a high recording speed also the conversion rate itself can be used.

For conversion rate and cycle it can be defined separately whether the measured values are to be output to the interface or, in the case of data loggers, also stored. The parameters **Memory activation S** for the **cycle** (see chapter 6.5.2) and the **software switches C, S, U** (Continuous, Memory, Interface) for the **conversion rate** (see chapter 6.5.4) are used for this purpose.

The **output format** is used to select the print image for a printer or a table format for reading into spreadsheets.

6.5.1.1 One-time output / storage of all measuring points

In order to record operating states at certain irregular times, one-time measured value outputs are to be performed. These can be triggered via keyboard, interface or external triggering (see chapter 6.6). Computer-controlled queries with their own sequence control, especially in a network, also use the one-time measured value output.

For the interface operation a separate command is available, with key devices mostly the key MANUAL.

Function	One-time measured value output
Command	S1 or s
Output	DATE: 01.02.06
	12:34:00 01: +0008.9 °C NiCr Water.
	02: +0023.4 °C NiCr Air

If an interface cable is connected, then the measured values are generally output in the selected output format. If the measured values are to be saved, the memory activation in the cycle must be switched on.

6.5.1.2 Cyclic output / storage of all measuring points

The cycle is used for cyclic measured value output (see chapter 6.5.2). It enables the output of the measured values to the interface and to the memory, as well as a cyclic max, min, average value calculation and output.

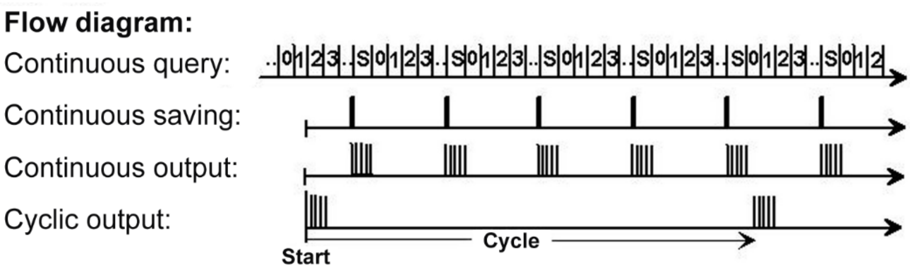
Flow chart and programming see chapter 6.5.1.3.

Function	Start cyclic measured value output
Command	S2
Output	DATE: 01.02.06
	12:34:00 01: +0008.9 ° C NiCr Water.
	02: +0023.4 ° C NiCr Air
	12:44:00 01: +0009.5 ° C NiCr Water.
	02: +0022.1 ° C NiCr Air

6.5.1.3 Continuous measured value output / storage

The continuous measuring point query (see chapter 6.5) with the conversion rate (see chapter 6.5.4) enables the output and/or storage of all measured values at the same time. If only one measuring channel is active, it can be stored or output with the full conversion rate. Otherwise, to determine the measuring rate per measuring point, it must be taken into account that a special measurement is inserted after each measuring point query:

Measuring rate / channel = Conversion rate / Channel number + 1



Continuous measured value output	**WR**	**Cycle**	**AK**
Query continuous, output cyclic	C---	hh:mm:ss	U
Dto. and saving cyclic	C---	hh:mm:ss	S
Measuring point query semi-continuous	----	00:00:00	U
Measuring point query continuous	C---	00:00:00	U
Output continuous	C--U	00:00:00	U
Saving continuous	C-S-	00:00:00	U
Saving and output continuous	C-SU	00:00:00	U
Saving continuous, output in cycle	C-S-	hh:mm:ss	U

Function	Start continuous measured value output
Command	`S2`

Output	`DATE:   01.02.04`
	`12:34:01.00 01: +0008.9 ° C NiCr`
	`12:34:01.10 01: +0008.7 ° C NiCr`
	`12:34:01.20 01: +0008.5 ° C NiCr`

For continuous outputs the time resolution increases to 0.01s (see chapter 6.6.1).

6.5.2 Print cycle

The cycle enables cyclic outputs of the measured values to the interface with the help of the cycle timer. The cycle time can be between 1 s and 59 h, 59 min and 59 s. The cycle timer counts down the time and starts again from zero. If the measuring point query takes longer than the cycle time, the corresponding query fails.

Cycle	Command	Response
Program	`Zhhmmss`	
With memory activation	`I+hhmmss`	
Without memory activation	`I-hhmmss`	
Switch on memory activation	`f1 A4`	
Switch off memory activation	`f1 A-4`	
Stop and delete	`C11`	
Output	`P11`	`PRINT CYCLE: 00:01:30`
Output cycle timer	`f1 P11`	`PRINT TIMER: 00:01:23`
Switch (off) on sleepmode	`o(-)11`	

6.5.3 Measurement cycle

The measurement cycle has been practically replaced by continuous measurement and is no longer supported in today's instruments.

6.5.4 Conversion rate

With the conversion rate and 3 software switches for continuous scan, store and output the continuous measuring point query is configurable. The setting can be called up via the overall programming (see chapter 6.2.2).

Function	Identification	Commands		
Conversion rate 2.5 M/s, switch CSU off	003	f5	k0	
Conversion rate 10 M/s	010	f5	k1	
Conversion rate 50 M/s (depending on type)	050	f5	k7	
Conversion rate 100 M/s (depending on type)	100	f5	k8	
Conversion rate 400 M/s (depending on type, option)	400	f5	k9	
		On		**Off**
Continuous query	C	f5	k2	f5 k-2
Save continuously	S	f5	k4	f5 k-4
Output continuously	U	f5	k5	f5 k-5

Conversion rates above 10 measurements per second

The larger measuring instruments from ALMEMO® 2690-8 onwards are equipped with a fast measuring module as standard, which permits higher conversion rates of 50 and 100 M/s. It should be noted that the measurement quality decreases with increasing measurement rate, while it is highest with lower.

Limitations:

With a conversion rate of more than 10 measurements/second, the following restrictions must be observed due to the shortened evaluation times:

1. Mains hum suppression is in principle no longer possible, so that the accuracy can be impaired by interference in the connecting leads (twist if possible!).
2. Sensor break detection is no longer guaranteed in some cases.
3. 100 M/s can only be recorded with V6 devices using an SD card.

Data transfer to a computer with terminal (e.g. ALMEMO®-Control):

Setting on the ALMEMO® device: e.g. conversion rate 50, continuous scanning and output.

At the conversion rate of 50 M/s with continuous output, the measured values can be written to a file while the measurement is running (e.g. in table format); the file can then be evaluated after the measurement (e.g. in EXCEL).

With the WIN-Control data acquisition software:

Setting on the ALMEMO® device: Conversion rate 50, continuous scanning.

Setting in the WIN-Control: Measuring cycle 00:00, fast data transmission.

At the conversion rate of 50 M/s with the setting 'continuous', the measured values are retrieved without interruption during online measurement with WIN-Control. The WIN-Control achieves approx. 40 to 50 queries per second with one device (depending on computer hardware and baud rate), relatively independent of the number of measuring points. I.e. with one measuring point possibly only 15 measured values are acquired, with 6 measuring points however already approx. 90 measured values per second.

6.5.5 Setting the output form

During a measuring point query, the measured values can be output to the interface in three different formats. The command Nx selects the display mode below each other, side by side or table format (see chapter 6.6.1). The abbreviation for the output format appears in the programming header after the print cycle. Files saved in table format can be read directly by the usual spreadsheet programs (field separation with semicolon, comma as decimal point).

Output form	Abbreviation	Command
Measured values below each other as a list	U	N0
Measured values side by side in column form	Un	N1
Measured values in table format	Ut	N2

6.6 Starting and stopping the measurement

Measurements with cyclic measuring point queries can be started and stopped in many different ways depending on the application. First of all, the START/STOP keys are provided for this purpose. For automatic operation, the serial interface, the real-time clock with start and end time or measuring duration or the limit value overrun of a measuring channel can be used. But also external electrical signals can be used as triggers. All methods can be used alternatively.

6.6.1 Via interface, output protocols

Depending on the selected output format (see chapter 6.5.5), the following output protocols result for the different measuring point queries:

One-time output of all active measuring points:

```
S1          12:34:00        01: +0008.9 °C NiCr Water.   (. for manual)
                            02: +0023.4 °C NiCr Air
```

Start of a cyclic output without output of the header:

```
S2            DATE:         01.02.17
              12:34:00      01:+0008.8 °C NiCr Water
                            06: +0025.0 °C NiCr Air
              12:44:00      01: +0021.0 °C NiCr Water
Sensor break                06:  - - -  °C NiCr Air
```

Start of a cyclic output with output of the header:

```
S3
                      ALMEMO 8590-9
Programming           {SI}MEAS RANGE  LIMIT-MAX  LIMIT-MIN  BASE  D  FACTOR  EXP  AVERAGE  DESIGNATION
                      01:Ntc    +035.00   - - -    - - - °C 1.0350 E+0  - - - T external
                      02:NiCr   - - -    +0018.0  - - - °C - - -  E+0  - - - T internal
                      10:° o H  - - -     - - -    - - - %H - - -  E+0  - - - Humidity
Cycles                {DC2}MEAS CYCLE:  00:00:00 S  S0500.3 F0118.5 AR  W010 C-SU
                      PRINT CYCLE: 00:01:30 U  9600 bd
Start/end             START TIME: 10:30:00
When programmed       END TIME:    18:30:00
                      END DATE:   15.01.98
Number                NUMBER:  12-001
Date                  DATE:   01.02.94
```

{SI} = 0FH = Condensed script, {DC2} = 12H = Normal script (for printer)

1. List format below each other:

```
Cyclic              10:30:00       01: +025.31 °C Ntc  T external
                                   02:!+0016.8 °C NiCr T internal
                                   10: +0039.5 %H ° o H Humidity

Continuous          10:31:30.10    01: +025.31 °C Ntc  T external
1 channel           10:31:30.20    01: +025.47 °C Ntc  T external
Resolution 0.01 s   10:31:30.30    01: +025.87 °C Ntc  T external
```

2. Column format side by side:

```
{SI}10:31:30 01: +025.31°C 02:!+0016.8°C 10:+0039.5 %H       {DC2}
```

3. Table format:

Header	"ALMEMO";"RANGE:";"Ntc ";"NiCr";;;"°o H"
	"5690-2";"DESIGNATION:":"T external";"T internal";;;"Humidity"
	;"LIMIT-MAX:";;35,
	;"LIMIT-MIN:";;;18,
Headline	"DATE:";"TIME:";;M01: °C";"M02: °C";;;"M10 %H"
Measured values	"12.03.16";"10:31:30";+25,31;+16,8;;;39,5
Continuous	"01.10.16";"10:31:30.10";25.8
Resolution 0.01 s	"01.10.16";"10:31:30.20";25.9
	"01.10.16";"10:31:30.30";26.1

One-time query without return of time and date:

s	;;26.1;+16,8;;;39,5

End of cyclic output:

Command: X

6.6.2 Start-end time, measuring duration

A series of measurements can be started and/or stopped automatically at specific times. For this purpose, the start time and date as well as the end time and date can be programmed. If no date is set, the measurement is performed every day in the set period. Alternatively, the measurement can be stopped automatically after a certain measurement period.

The time must already be programmed and started.

	Commands	**Response**
Starting time		
Program	f1 Uhhmmss	
Delete	f1 C10	
Output	f1 P10	START TIME: 12:34:00
End time		
Program	f2 Uhhmmss	
Delete	f2 C10	
Output	f2 P10	END TIME: 12:34:00
Starting date		
Program	f1 dddmmyy	
Delete	f1 C13	
Output	f1 P13	START DATE: 01.02.19
End date		
Program	f2 dddmmyy	
Delete	f2 C13	
Output	f2 P13	END DATE: 01.02.19
Measurement duration		
Program	f2 Ihhmmss	
Output	P47	MEAS DURATION: 02:00:00

6.6.3 Limit value actions

Another possibility to automatically start or stop a measured value recording is triggering by exceeding limit values. In this way, uninteresting measured values can be largely suppressed. With the help of macros (see chapter 6.6.5) also complex sequence controls can be realized. The limit values are to be programmed according to point 6.3.9.

Function	Command	Code
Select channel	`Exx`	
Actions when a limit value Max is exceeded		
START of a measurement	`h1`	`S-`
STOP of a measurement	`h2`	`E-`
Single measurement MANUAL	`h3`	`M-`
Zeroing the 0.1s timer	`h4`	`Z-`
Call up macro 5..9	`h5..9`	`5-..9-`
Delete action and relay assignment	`h0`	`--`
Actions when a limit value Min is exceeded		
START of a measurement	`l1`	`S-`
STOP of a measurement	`l2`	`E-`
Single measurement MANUAL	`l3`	`M-`
Zeroing the 0.1s timer	`l4`	`Z-`
Call up macro 5..9	`l5..9`	`5-..9-`
Delete action and relay assignment	`l0`	`--`

In the sensor programming (see chapter 6.10.1) a composite code for action and alarm relay assignment (see chapter 6.10.8) appears at limit max (AH) and min (AL).

6.6.4 External triggering

In the ALMEMO® accessories there are pure trigger cables (ZA 1006-EK2/ET) for alternately starting and stopping the measurement. The combined input/output cables (ZA 1006-EKG/ETG) additionally enable alarm messages.

Macros can also be programmed as trigger functions (see chapter 6.6.5). Selective programming of the trigger function and the relay function is possible (see chapter 6.10.9). The trigger module is normally connected to the output socket A2 of the ALMEMO® device.

The following trigger functions are programmable (see chapter 6.10.9):

- One-time measuring point query
- Delete max-min values
- Print function
- Zeroing measured value
- Call up macro

6.6.5 Macros

In this chapter it becomes clear that almost all functions of the ALMEMO® measuring instruments can be reached by interface commands. It can be very useful if a number of functions could be executed automatically in case of certain events triggering a trigger signal or in case of limit value exceedings, for example the cycle or the measuring rate can be changed, the continuous storage can be switched on or also different analog values can be output to the analog output.

For these purposes, a series of commands with up to 30 characters can be stored as a macro in the device, a total of 5 macros (key figures 5 to 9). The commands in succession (also leading fx commands) must be separated from each other by the vertical bar '|' (AltGr <). Extending a macro beyond the 30 characters is possible by calling up another one at the end of a macro `(m-5..-9)`.

Enter V24 command xxx in macro 5 (<30Z)	`f-5 $xxx CR`
Enter V24 commands xx and yyyy in macro 6 (<30Z)	`f-6 $xx|yyyy CR`
Enter V24 commands xx and zzz in macro 7 ..9 (<30Z)	`f-7..-9 $xx|zzz CR`
Output macro 5..9	`f-5..-9 P20`
Set macro 5..9 as trigger function of port xx (A2: xx=28)	`ixx f9 k-5..-9`
Assign macro 5..9 to a Max. limit value:	`h5..9`
Assign macro 5..9 to a Min. limit value:	`l5..l9`
Call up macro 5..9 via interface	`m-5..-9`

Through the timer measuring channel even time sequences can be realized.

Example 1: If the limit value is exceeded, the cycle is to be reduced to 5 seconds. If the value falls below the limit value again, a normal cycle of 10 minutes is to be run.

Working steps:

Select measuring channel e.g. M1:	M01
Program Max. limit value to e.g. 70°C:	H70 CR
Program Min. limit value to e.g. 70°C:	L70 CR
Program macro 5 to cycle 5 s:	f-5 $Z000005 CR
Program macro 6 to cycle 10 min:	f-6 $Z001000 CR
Control macro 5:	f-5 P20
Response:	Z000005
Assign the macro1 to the Max. limit value:	h5
Assign the macro2 to the Min. limit value:	l6
Start cycle:	S2

Example 2: If the limit value is exceeded, the measured values are to be stored continuously for 20 seconds with the measuring rate.

Working steps:

Select virtual channel e.g. M5 (2690-8):	M05
Program timer:	B85
Set the Max. limit value of the timer to 20:	H20 CR
Select measuring channel e.g. M1:	M01
Program Max. limit value to e.g. 70°C:	H70 CR
Program macro 5:	f-5 $
Set timer to zero:	f3|C01
Save continuously:	|f5|k4 CR
Program macro 6:	f-6 $
Save continuously off:	f5|k-4 CR
Assign the macro5 to the limit value max. of M1:	M01 h5
Assign the macro6 to the limit value max. of M5:	M05 h6
Start measurement:	S2

Example 3: At each trigger signal the memory is to be output and then deleted:

Macro 7: Output memory, delete	f-7 $P04|C04 CR
Assign macro7 to the trigger signal of port xx:	ixx f9 k-7

6.7 Measurement functions for measuring point queries

There are some measuring tasks and special measuring ranges that require cyclic measuring point queries and defined sensor arrangements.

6.7.1 Pulse measurement, summation

For pulse measurement, the ALMEMO® connector program includes the ZA 9909-AK2U frequency measurement module, which counts the pulses in the sensor connector with its own small microcontroller (see chapter 4.6.1.2). The ZA 9909-AK1U cable for frequency measurement and the ZA 9909-AK2U cable for pulse measurement differ only in the FREQ or PULSE programming.

Pulse measurement in the PULSE measuring range is intended for signals with a low repetition rate that are to be acquired over a longer period of time. The frequency module is only queried and zeroed at all measured value outputs (manual, cyclic or also continuous). In the display the pulse number appears therefore only after the query. If a measuring cycle of 1 minute is programmed, then the number of pulses/minute is displayed every minute.

For the acquisition of the total pulse count or the pulses in cyclic periods there are the function channels Sum over total pulse count S(t) and Sum over pulse count/print cycle S(P) (see chapter 6.3.4). These sums are set to zero at each start or deleted with the command Set measured value to zero.

Function	**Commands**
Set measuring channel	`Mxx`
Set measured value of the measuring channel to zero	`C01`
One-time measuring point query and zero all sums	`f1 s`

6.7.2 Air pressure compensation

The calculation of the partial vapor pressure in the psychrometer, the humidity variables mixing ratio and enthalpy, the dynamic pressure, as well as the O_2 saturation generally depend on the air pressure SP. For compensation, the air pressure is either programmable (see chapter 6.2.5) or can be measured automatically with an air pressure sensor (e.g. FD A612-SA). This is defined as a reference by programming the first 2 characters of the designation to ´*P´ (see chapter 6.3.6). If the reference sensor is removed, the standard value 1013 mbar is automatically used again.

Function:	**Command**
Define air pressure sensor as reference	`f2 $*P CR`

6.7.3 Reference junction temperature measurement with external sensor

In existing measuring systems with thermocouples, the compensating cables are often already merged onto an isothermal reference junction rail in order to reach the measuring device from there with copper cables. In this way, the cost of the expensive thermocouple cables can be limited. An external Pt100 sensor with range 'P204' or an NTC can be used to record the reference junction temperature. It must be placed in front of the thermocouples and programmed with the designation '*J' (see chapter 6.3.6) on the first 2 characters. Several reference junction sensors can also be used. The copper leads of the thermocouples from the reference junction must be connected to the measuring instrument via normal copper connectors (ZA 9000-FS).

Constant reference junction temperature

Often the reference junction temperature is kept at a constant temperature with ice water or a thermostat. In this special case, you can dispense with the real temperature sensor with cable and instead use a dummy connector (e.g. ZA 9000-FS), set the gain correction to zero and program the constant temperature with the negative base value. This measuring point then always displays the constant temperature, which is used as the reference junction.

Reference junction temperature sensor in the connector

For special requirements (e.g. for thermocouples for which there are no connectors made of thermo material or in case of strong heat radiation) there are universal thermocouple connectors (ZA 9400-FSx) with built-in Ntc temperature sensor for reference junction compensation. They can be used without problems for all thermocouples, but require 2 measuring channels each (1. for Ntc, 2. for thermocouple). In the designation of the thermocouple, a '#J' must be programmed on the first 2 digits, so that the built-in temperature sensor is used for reference junction compensation.

6.7.4 Averaging

The **average value** of the measured value is required for a number of applications:

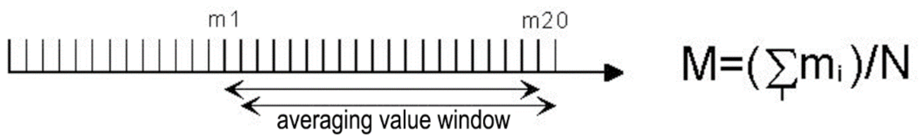
- The average flow velocity in a ventilation duct
- Calming of a strongly fluctuating measured value (wind, pressure etc.)
- Hourly or daily average values of weather values (temp., wind etc.)
- Dto. of consumption values (electricity, water, gas etc.)

The average value of a measured value $\overline{M}$ is obtained by summing up a whole series of measured values M_i and dividing by the number N of measured values:

Average value $\overline{M} = (\sum M_i)/N$

Measured value attenuation through moving averaging

The measured value attenuation function, which calms down the measured values by continuous averaging in the case of unstable measured values, can generally be operated via the interface. However, the measured value attenuation is only possible for the selected channel. The degree of attenuation, which specifies over how many measurements the selected measuring point is to be smoothly averaged, can be set in the range from 0 to 99. The calmed measured value is also valid for all following evaluation functions. For this function, the semi-continuous measuring point query (see 6.5) should be selected, because the measuring rate and thus the filter effect is independent of the number of measuring points.



Function	Commands	Response
Program attenuation (0-99)	`f1 zxx`	
Output (see also chap. 6.10.1)	`P32`	`SMOOTHING: 01: 20`

Averaging with average value mode

Except for the attenuation of the measured value, all averaging is determined by the **average value mode**:

Continuous averaging from start to stop or over single measurements, if not started with:	`C o n t`
Averaging over each cycle with:	`C Y C L`

For averaging, the following applies:

1. Averaging is always performed after a start via the continuous half or continuous measuring point query, as far as an averaging mode is programmed. Therefore, a measuring cycle is no longer necessary for averaging between two outputs.
2. With the semi-continuous measuring point query (standard setting) the selected measuring point is always queried exactly with half the measuring rate.
3. Measurements can now be started and stopped without a cycle for averaging. When stopping, all measured values are now additionally stored, i.e. start-stop averaging can also be realized via the interface with averaging mode ´CONT´.
4. All function values of the averaging can be stored (option S) or output via the interface via the function channels average value 'M(t)', number 'n(t)' and volume flow 'Flow'.

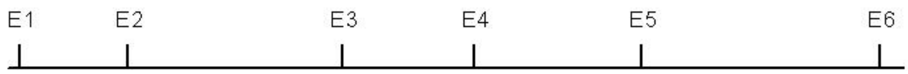
Averaging via measurement series is generally performed for all measurement point queries. It is activated for each measuring point by programming the averaging mode (see chapter 6.3.7). The average value is calculated and stored separately for each measuring point. It can be called up at any time in the 'AVERAGE VALUE' function. In the 'CYCL' mode, the average value is deleted again after one cycle. In order to be able to also store the average values and number or to output them to the interface, corresponding function channels M(t) and n(t) must be programmed (see chapter 6.3.4), which output the average value of the reference channel on a so-called calculation channel. If only the average value is required instead of the measured value, the output function M(t) (see chapter 6.10.4) fulfills this task.

The operating modes listed below can be configured with the following functions:

Functions	Command	Responses
Program averaging mode Cont	`m1`	See chapter 6.3.7
Programming averaging mode CYCL	`m2`	See chapter 6.3.7
Delete averaging mode	`m0`	See chapter 6.3.7
Program function channel average value M(t)	`B74`	See chapter 6.3.4
Program function channel average value M(n)	`B75`	See chapter 6.3.4
Program function channel number n(t)	`B83`	See chapter 6.3.4
Set continuous measuring point query	`f5 k2`	See chapter 6.5.4
Set cycle	`Zhhmmss`	See chapter 6.5.2
Start averaging	`S2`	
Stop averaging	`X`	
Output averaging of a channel	`P14`	`AVERAGE: 01: +0021.3 ° C`
Delete averaging of a channel	`C14`	
Output all max, min, average values	`P18`	See chapter 6.4.4
Delete all max, min, average values	`C18`	See chapter 6.4.4

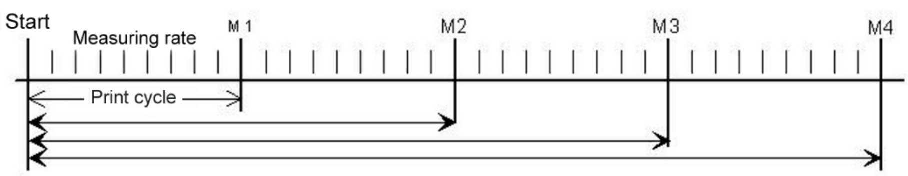
1. Average value via several manual measuring point queries: $\bar{\mathbf{M}} = (\sum \mathbf{E_i})/\mathbf{N}$

Functions		Commands
Measurement:	Stop	`X`
Function channel:	M(t)	`B74`
Averaging mode:	CONT	`m1`
Measuring point queries:	Manual / one time	`S1`
Average value output:	At the end of the measurement with	`P14, P18`



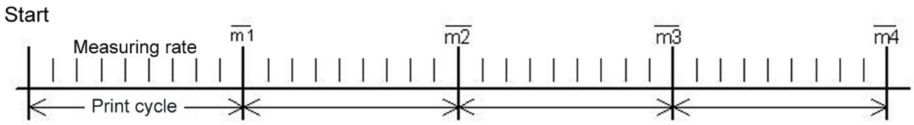
2. Continuous averaging via time: $\bar{\mathbf{M}} = (\sum \mathbf{M_i})/\mathbf{N}$

Averaging mode:	CONT	`m1`
Function channel:	M(t)	`B74`
Measuring point queries:	Continuous	`f5 k2`
Measurement:	Start, stop	`S2, X`
Average value output Mx:	In cycle	`Zhhmmss`
	With function channel M(t) resp. output function M(t)	`P14, P18`
	Total average value at the end of the measurement	



3. Cyclic averaging via the print cycle: $\overline{m_i} = (\sum m_i)/N$

Averaging mode:	CYCL	`m2`
Function channels:	M(t)	`B74`
Measuring point queries:	Continuous	`f5 k2`
Measurement:	Start, stop	`S2, X`
Average value output m_X:	In print cycle	`Zhhmmss`
	With function channel M(t) resp. output function M(t)	



4. Average value via the measured values of several measuring points

Myy to Mxx for each measuring point query: $\bar{M} = (\sum M_i)/n$

Averaging mode:	Not required	
Function channels:	M(n)	`B75`
Reference channels:	From b2=Myy to b1=Mxx (see 6.3.4)	`f1 Eb1, f2 Eb2`
Query measuring points:	All	`Zhhmmss`
Measurement:	Start, stop	`S2, X`
Average value output:	In the print cycle with function channel M(n)	

6.7.5 Volume flow measurement

The principle of volume flow measurement is described in chapter 3.5.5.

In a flow channel, the average velocity M(t) is first recorded by point or time averaging (see chapter 6.7.4).

A function channel ´`Flow`´ is required to represent the volume flow.

Function	Command	Response
E.g. select 2nd channel in flow connector:	`M10`	
Program function channel 'Flow':	`B84`	
Program in this function channel cross section xxxxx of the flow channel in cm^2:	`Qxxxxx`	
Output of the cross section (see chapter 6.10.1)		
Query measured value of the function channel in m^3/h:	`p`	`10:+00834. mh`

Conversion to standard conditions

For all flow sensors a conversion to the standard conditions temperature = 20°C and air pressure=1013mb is possible. The actual measuring conditions are determined with the functions 'Temp.comp.' and 'Air pressure' (see chapter 6.2.5). For conversion, <u>either</u> already in the velocity channel <u>or</u> only in the volumetric flow channel, a '#N' must be programmed in the designation (see chapter 6.3.6), this then automatically results in the standard volume flow.

6.8 Numbering of measurements

For the identification of measurements or measurement series, a number can be entered which will be printed out or saved during the next measurement point query. In this way, stored individual measurements can also be assigned to specific measuring locations or measuring points when they are read out. The number can be entered with 6 digits. In addition to the digits 0 to 9, the characters -, , A, F, N, P can also be used. After entering the number output is activated.

The **printout of the number** is done automatically after each activation of the number once at the next measuring point query. After that the number output is deactivated again.

E.g.
```
NUMBER:       000001
DATE:         01.11.19
08:30:00 01:  +0025.3 ° C NiCr
```

Saving the number is also done at the next measurement point query, if the memory is switched on. When printing the memory, the whole content with the numbering or only measurements with a certain number can be output (see chapter 6.9.3).

Function	Command	Response
Input number and activate ´012001´	n012001	
or with letters ´A1-001´	f3 $A1-001 CR	
Increase number by 1	n+	
Delete number and deactivate	C05	
Output number	P05	NUMBER: A1-001
Output number list	f1 P05	NUMBER: 012001 A1-00..

6.9 Measured value memory

ALMEMO® data loggers offer internally 32kByte up to 2MByte for measured value storage. Per measuring point query once 4 byte for the time and 4 byte for each measured value are needed for storage, i.e. with more than 2 measuring points more than 100.000 measured values can be stored. The storage can be done automatically with the cycle or the conversion rate or manually. Several individual measurements or entire measurement series can be assigned a 6-digit number (memory space 3 bytes) and later selectively read out again. Selection by time and date is also possible.

Attention:
The configuration of the connected sensors is saved at the first start of the recording. If additional sensors are added at the next start, they will be included in the memory configuration. However, no sensors may be exchanged during subsequent measurements, as this would result in incorrect assignments with regard to range, dimension, decimal point and designation. This means that if the sensor configuration is changed, the previous measurement must first be read out and then the memory deleted (except for memory connector with micro SD card, see Chapter 6.9.1).

Functionality of the internal memory:

- Only one sensor configuration possible
- Ring memory recording
- Sleep mode
- Data output in all output formats
- Selective data output via time and date
- Selective data output with number

6.9.1 Data storage in external storage media (ALMEMO® memory connector, micro SD card)

Depending on the type and version, ALMEMO® data loggers also support external storage media. These memories do not require a battery for data retention, they can be removed, possibly sent and evaluated by the computer with a reader, independent of the device. The external memories are automatically recognized and used instead of the internal memory as long as they are plugged in. This is also visible in the memory location display.

ALMEMO® memory connector ZA1904-SD for memory card

Measuring devices:	ALMEMO® 2470, 2590, 2690, 2890, 4390, 8590, 5690
Memory card:	Micro SD flash memory card, Industrial Grade SSD SLC
	Recommended for higher performance, reliability, lifetime
	Capacity: 128MB to 2GB (min. 30000 measured values/MB)

The ZA 1904-SD memory connector with a micro SD memory card also turns devices into data loggers that have no internal memory. The memory card is written with the measurement data in table mode in standard FAT16 format via the memory connector. The memory card can be formatted, read out and deleted via any PC with any card reader (see chapter 6.9.4). The data can be imported into Excel or the Win-Control measured value software. Due to the completely different mode of operation of the memory card, there are restrictions and new possibilities compared to the internal memory.

Functionality of the memory connector with memory card:

- Practically unlimited memory
- A new file is created for each new connector configuration
- No ring buffer recording
- Sleep mode possible
- Data can be evaluated with any reader elsewhere
- Very fast data transfer with reader
- Data recording and output only in table format
- Only the last file can be read out via the ALMEMO® device
- No selective data output via time and date or number

Before the start of each measurement you can enter an 8-digit file name. If this is not done, the default name ´ALMEMO.001´ or the last used name will be used. As long as the connector configuration does not change, you can save several measurements, manually or cyclically, also with numbers in the same file.

For ALMEMO® devices V6, the file name - as long as the connector configuration does not change - also remains unchanged in the following cases:

- Repeated starting and stopping of a measurement
- Switching the measuring device off and on
- Pulling out and re-inserting the micro SD card into the ALMEMO® memory connector (when the measurement is stopped)
- Unplugging the sensor and plugging it into the same input socket

In ALMEMO® devices V7, the file name remains unchanged only when a measurement is repeatedly started and stopped. The file name is automatically changed when the measuring device is switched off and on, when the micro SD card is pulled out and inserted again into the ALMEMO® memory connector while the measurement is stopped, when the sensor is unplugged and plugged into any input socket.

However, if the **connector configuration** has **changed** since the last measurement and no new file name has been programmed, then a new file is always created and the index in the extension is automatically incremented by 1, e.g. ´ALMEMO.002´. If the entered file name already exists, then a new file with the same name but with a new index is also created.

For long-term recordings, it is possible to close the current file and open a new file at each change of day. To activate this function, a file name must be used that begins with the character '&' (e.g. '&Test'). The extention of the file is automatically incremented from '000' to '999' respectively. The complete file names are therefore '&Test.000' to '&Test.999'.

Function	Command
Input file name (max. 8 characters)	`$NAME CR`
File names for automatic day files	`$&NAME CR`

Applies to all ext. storage media:

The memory connectors are plugged into socket A2 for measured value acquisition (trigger and relay cables can also be plugged into socket A1). All measurements must be terminated with <STOP>, because data not completed will not be stored completely or overwritten during the next measurement. Therefore, the external memory must also not be disconnected while the measurement is running!

6.9.2 Measurement data acquisition

To save measurement data, it is sufficient in most cases to enter a cycle (see chapter 6.5.2) and press the start button. In addition, you should only check whether the time and date are set correctly (see chapter 6.2.7).

But to meet even complex requirements, a number of special configurations are possible:

Fast acquisitions
For fast acquisitions, you can alternatively use the conversion rate (see chapter 6.5.4). The various operating modes are described in detail in chapter 6.5.

Start and stop
There are a lot of possibilities to start and stop the automatic saving, which are explained in chapter 6.6.

Query modes
For different applications (long-term recording, stand-alone operation and/or computer query), you can choose from 4 query modes (see chapter 6.9.2.1).

Ring buffer mode
If you are only interested in the most recent past for longer recordings, you can set the ring buffer mode with the operating parameters (see chapter 6.10.13.1).

Number
If you want to better recognize measurements or measurement series or selectively read them out later, you should assign a number to each one (see chapter 6.8).

File name
When using memory cards, you have the option of creating a new file for each measurement and entering a suitable eight-character file name for it.

Memory configuration
The most important parameters of the memory configuration are obtained as follows:

Command:	`f4 P19`	
Response:	`SI:0512.4k R`	Internal memory (R=ring memory)
	`SE:256.00M`	External memory
	`SF:0324.5k`	Free memory
	`SZ:0001.18:20`	Remaining memory time: tttt.hh:mm
	`U3:07:00:00`	Start time of the memory output
	`D3:01.02.16`	Start date of the memory output
	`U4:17:00:00`	End time of the memory output
	`D4:02.02.16`	End date of the memory output
	`DT:FILENEW.001`	File name new file
	`FI:  ALMEMO.001`	File name current file in memory

6.9.2.1 Query modes

There are 4 query modes for stand-alone operation and/or computer query:

Normal:	Internal cycle or cyclic query by the computer
Sleep:	Only internal cycle with switch-off for long-term monitoring
Monitor:	Internal cycle is not disturbed by computer query
Fail-save:	Cyclic query by PC, after failure internal cycle

Sleep mode

For long-term monitoring with larger cycles, it is possible to operate the data loggers from ALMEMO® 2590 in sleep mode. In this power-saving mode, the device is completely switched off after each measuring point query (note for sensors with power supply!) and is only switched on again automatically after the cycle time for the next measuring point query has elapsed. In this way, the runtime is drastically increased in battery operation.

Function	**Command**
Switch on sleep mode	`o11`
Switch off sleep mode	`o-11`

The sleep cycle must be at least 2 minutes.

You can only **end** the sleep recording by switching the device on (off). After that, the measurement must be stopped separately.

Stopping by end time as well as by limit values is not possible in sleep mode and must therefore be switched off.

Sleep delay

There are some sensors, like all impellers, digital humidity or material moisture sensors, chemical sensors etc., which need a certain time after switching on, until a stable measured value is available. So that such sensors can also be operated in sleep mode, a delay of the measurement after switching on in sleep mode has been provided. The input of the delay time is currently only possible via the interface. However, for devices with display, a D appears behind Sleep in the mode display if a delay time is programmed. When waking up from sleep, the display also shows 'SLEEP DELAY' and the delay time is counted down below it.

Input of the delay time xxx in s with command:	`f2 uxxx`
Output of the delay time xxx in s with command:	`f1 P19` (see chapter 7.5) `... SD: xxx s`

When programming the sleep mode, if necessary, the minimum cycle time, i.e. 2 minutes plus delay time is set automatically, cont. outputs are switched off and a measurement is stopped. When operating in sleep mode, the valid measured value acquisition takes place in the measured value memory. The measured value output in the terminal has no defined output format in sleep mode.

Monitor mode:

If a data logger, which is operated cyclically, is to be monitored occasionally by a computer, then the new 'monitor mode' is to be used. The internal cyclic query is not influenced in any way by the software query (switch off 'safe initialization' in Win-Control!).

The internal cycle is started when the software is started, but it can also be started beforehand. During the query by the internal cycle, there is no data output to the interface. To store data, the memory must be activated.

Function	Command
Switch on monitor mode	`f1 A1`
Switch off monitor mode	`f1 A-1`

Fail-save mode:

If, in the case of a pure software query, it is only to be ensured that an internal cyclic query continues to run in the event of a computer failure, then the 'fail-save mode' is appropriate. In this operating mode, a longer cycle must be programmed in the device than for the software query (e.g. device cycle 20s, software cycle 10s). The internal cycle is always reset by the software query, so that it is only used if the software query fails (Switch off 'safe initialization' in Win-Control here too!).

The internal cycle is started at the start with the Win-Control software, but it can also be started before. During the query by the internal cycle, there is no data output to the interface. To save data, the memory must be activated.

Function	Command
Switch on fail-save mode	`f2 A1`
Switch off fail-save mode	`f2 A-1`

6.9.3 Measured data output

In principle, the measured value memory can be output completely or time sections or numbered blocks to the serial interface.

The memory output via the serial interface can be done with different programs (program ALMEMO® Control see chapter 6.1).

6.9.3.1 Memory output to the serial interface

The **output to the serial interface** is possible by the output formats 'list', 'columns' and 'table' with three different output protocols (print image see chapter 6.6.1). After starting, the contents of the memory are output with the same print image as in printer mode, if required also several times and in different output formats. The output can be aborted at any time without erasing the memory.

In the case of **external memory cards**, the measurements are generally stored in table mode, different configurations each in their own files. Therefore, only the complete measurement data of the last used file and only in table mode can be read out from the device. It makes sense to remove the memory card and copy the files directly to the PC via a USB card reader (see chapter 6.9.4). These can be imported into Excel as well as into Win-Control.

6.9.3.2 Selective memory output

Measurements with numbering (not for memory cards)

Measurement series that have been identified by entering a number can be selectively read out by activating the corresponding number. If a number is active, then from the entire memory content only measurements are output, if this number was found in the memory, until another number follows. This can be the data of a certain measuring series or also several single measurements at recurring measuring points with the same numbers.

Time section (not for memory cards)

With the functions memory **start time** and **end time**, as well as **start date** and **end date**, a time section can be determined and output in the entire memory. (**Attention:** The search can take up to approx. 1 min. with 500KB).

Function	Commands	Response
Read out memory completely	P04	MEMORY: 12
(As far as sensor config. unchanged)		DATE: 01.01.17
(Connector number 12, if available)		07:00:00 01: +0123.4 °C NiCr
(In all output formats)		..
Abbreviated table form at 115kB	P04	12.03.19;12:30:00;12,;9,9
Date only if changed, no "		;12:31:00;12,1;9,8
Read out measurement marked with number:		
Output of a list of the	f1 P05	NUMBER:
memory numbers		01-001
		01-002
		02-001
		....
Activate number	n01-001	
Test if available or not	t4	OK or ERROR
Read out measurement with	P04	NUMBER: 01-234
number		17:20:00 01: +0087.5 °C NiCr
(In all output formats)		.....
Read out time section:		
Input starting time	f3 Uhhmmss	
Input starting date	f3 dddmmyy	
Input end time	f4 Uhhmmss	
Input end date	f4 dddmmyy	
Delete starting time	f3 C10	
Delete starting date	f3 C13	
Delete end time	f4 C10	
Delete end date	f4 C13	
Output starting time	f3 P10	START TIME: 07:30:00
Output starting date	f3 P13	START DATE:01.02.16
Output end time	f4 P10	END TIME: 08:00:00
Output end date	f4 P13	END DATE: 01.01.16
Query memory space	f1 P04	MEMORY: S0500.3 F0118.5
Read out section	f3 P04	MEMORY:
(In all output formats)		DATE: 01.02.16
		07:30:00 01: +0123.4 °C NiCr
		.....
Delete memory	C04	

6.9.4 Reading out ext. memory cards with USB reader

A USB reader is supplied with the ZA 1904-SD memory connector for reading memory data from memory cards. However, any other drive for removable media is also suitable. In the case of micro SD cards, it may only be necessary to plug in the corresponding adapter supplied. The measurement files are stored in the standard FAT16 format and can be easily and quickly transferred to the PC's hard disk by copying. The measurement data in table format can be viewed as ASCII data with any editor and easily read into Excel (separated with semicolon separator). With our data acquisition software Win-Control V.6 or higher, the files can also be easily evaluated via 'File Import' (update if necessary).

6.10 Special functions

The ALMEMO® instruments have some additional functions which are rarely needed in routine operation, but are very useful in special applications. However, these functions should only be used by technically experienced users who have correctly understood the mode of operation and consequences. Some programming is only possible with certain devices or requires a defined connector configuration or special hardware. If the input multiplexer does not match the connection assignment or a reference channel is not equipped with the correct sensor, then one usually wonders in vain why no reasonable measured values appear any more.

6.10.1 Output of the extended sensor programming

The special parameters of each measuring point apart from the standard function values (see chapter 6.2.2) can be queried with the command f1 P15. In detail these are:

ZERO-POINT	Zero point correction	see 6.3.10
GAIN	Gain correction	see 6.3.10
LM	Locking mode	see 6.3.12
P	Current comma position incl. exponent	
FUNC	Output function	see 6.10.4
CALOFS	Eich offset	
CALFA	Eich factor	
A-START	Analog output start	see 6.10.7
A-END	Analog output end	see 6.10.7
B1	Reference channel for function channels	see 6.3.4
MX	Input multiplexer	see 6.10.2
EF	Element flags	see 6.10.3
AH	Alarm functions limit value max	see 6.10.8
AL	Alarm functions limit value min	see 6.10.8
CF	Print cycle factor	see 6.10.6
UMIN	Minimal sensor voltage	see 6.10.5

In the output format as list (below each other) or as columns (next to each other) (see chapter 6.5.5) you get the following image:

Commands f1 P15

Response
```
CH  ZERO  GAIN  LM  P  FUNC  CALOFS  CALFA  A-START  A-END  B1  MX  EF  AH  AL  CF  UMIN
01:+0000.0 +1.0000 5.  1 MESS +00000 32000 +0000.0 +1000.0-01 -- -- S2 -0 01 12.0
```

The parameters of each measuring point of the commands P15 and f1 P15 in one line are obtained with the command f2 P15.

Commands f2 P15

Response
```
CH RANGE LV-MAX GAIN LM P FUNC CALOFS CALFA A-START A-END B1 MX EF AH AL CF UMIN
01:NiCr  +0123.4..+1.0000 5.  1 MESS +00000 32000 +0000.0 +1000.0-01 -- -- S2 -0 01
12.0
MEAS. CYCLE:  00:00:00 S  S0500.3 F0130.4 AR  W010 C-SU-
PRINT CYCLE: 00:01:30 U  9600 bd
```

Additional parameters and output commands:

TC	Time constant, attenuation	see 6.7.4
XS	Cross section for volume flow measurement	see 6.7.5
RH	Relay assignment to limit value max	see 6.10.8
RL	Relay assignment to limit value min	see 6.10.8

Commands f3 P15

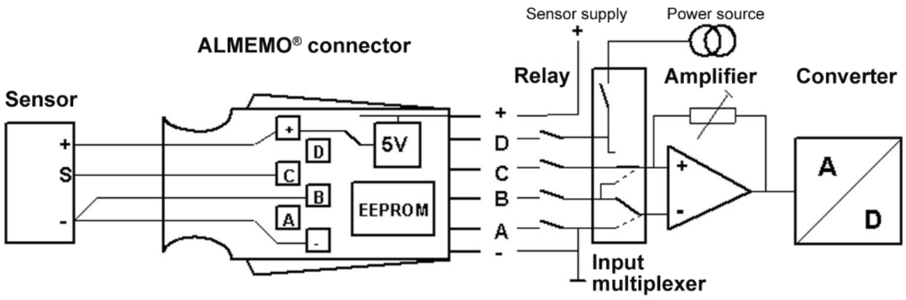
Response
```
MEAS  RANGE  LIMIT-MAX  LIMIT-MIN  BASE  D  FACTOR  EXP  AVERAGE  DESIGN.  TC  XS  RH  RL
01:NiCr +0123.4 -0012.0 +0000.0° C 1.0000 E+0 - - -  Temperat.  10 00078.  20 --
```

With the next command pure connector data can be retrieved:

Commands	`f4 P15`	
Response	`ST SENSOR`	`SERIAL NUMBER CAL-DAT. CY`
	`01:FHA6461.........`	`12345678 01.10.16 12`

6.10.2 Change input multiplexer

For each measuring range, the input multiplexer is normally automatically set correctly depending on the connection assignment. For mass-related signals, the - input of the amplifier is on A, the + input on B (millivolts, thermocouples), on C (volts) or D (NTC). For current supplied sensors (Pt100 or pressure etc.) a currentless sense line is connected from the - pole of the sensor to input B and the differential voltage between C and B is measured.



There are some cases when it is desirable to change the serial multiplex creation:

- Differential voltage measurement for humidity sensors with long cables
- Differential voltage measurement for internally supplied sensors with current output (connector ZA 9601-FS5/6 with differential shunt B-C)
- Double sensors with two equal measuring ranges etc.

The required multiplex creation can be programmed and stored in the connector EEPROM during range selection as follows:

Function	Commands	Code
1. Voltage measurement inputs B-A	`f1 Bxx`	`M1`
2. Voltage measurement inputs C-A	`f2 Bxx`	`M2`
3. Voltage measurement inputs D-A	`f3 Bxx`	`M3`
4. Voltage measurement inputs C-B	`f4 Bxx`	`M4`
5. Voltage measurement inputs D-B	`f5 Bxx`	`M5`

The multiplex creation is indicated in the sensor programming (see chapter 6.10.1) by the above mentioned code, for measuring instruments with 7-segment display it can be checked in the locking mode at the second digit x4xx.

6.10.3 Element flags

In order to be able to optionally activate an additional function for several standard measuring ranges, corresponding flags can be programmed:

	Function	On	Off	Code
1.	Measuring current for resistance sensors 0.1 mA instead of 1 mA	`f2 k1`	`f2 k-1`	`01`
2.	Emission and background temperature for infrared sensors	`f2 k2`	`f2 k-2`	`02`
3.	Activation of measuring bridge switches for end value simulation	`f2 k3`	`f2 k-3`	`04`
4.	Only cyclic query for sensors with DIGI range	`f2 k4`	`f2 k-4`	`08`
5.	Switching off the galvanic isolation in the measuring module *	`f2 k5`	`f2 k-5`	`10`
7.	Switching off the sensor break detection	`f2 k7`	`f2 k-7`	`40`
8.	Analog output 4-20 mA instead of 0-20 mA	`f2 k8`	`f2 k-8`	`80`

* Only 2890-9, 8590-9, 8690-9A, 5690, 710, 809, 500

Explanation:

1. By reducing the measuring current to one tenth, the measuring range of resistance sensors is extended to ten times the resistance value. With the measuring ranges P104, P204, N104 Pt1000 and Ni1000 sensors can be measured instead of Pt100 and Ni100 sensors. The ohmic range extends up to 5000.0 Ω. However, the decimal point must be set accordingly.
2. For infrared radiation transmitters, the emission factor of the measuring object surface and the background temperature are required for the measured value calculation. If the flag 2 is programmed, then the parameters zero point as background temperature and gain as emission factor are used. The standard function for measured value correction is thus no longer available (no longer supported for new devices since 2007).
3. There are built-in calibration resistors in force transducers, which simulate the final value, if they are switched on accordingly. In the bridge voltage measuring module ZA 9612-FS an electronic switch is installed, which is switched on during the final value adjustment, if the flag 3 is activated.
4. Digital sensors partly calculate max-, min-, average values or sums from query to query by themselves (e.g. measuring modules, weather sensors). If you want to receive these values related to the cycle and not to the measuring rate, flag 4 must be set (from ALMEMO® 2490).
5. In the case of devices 2890-9, 8590-9, 8690-9A, 710, 809 and systems 5690 and 500 with galvanic isolation in the measuring module, the isolation can be cancelled with flag 5, i.e. connection A of the selected sensor is connected to the negative pole of the supply via a semiconductor relay. This is necessary for sensors with supply and differential voltage measurement, otherwise the inputs have no reference potential (is usually set automatically).
6. To detect a sensor break, all measuring inputs are periodically pulled to 5V for a short time via high impedance resistors (11MΩ) when the AD converter is not measuring. For all sensors with low impedance output (up to 1kΩ) the measured value is not influenced by this. With high impedance sensors (e.g. chemical cells) or with electronic calibrators, the switching processes can lead to measured value distortions. Therefore this sensor break detection can be switched off with flag 7.
7. The externally pluggable or optional analog outputs can be scaled to the standard values 0-2V, 0-10V or 0-20mA via the parameters analog output start and analog output end. If current outputs are to be set to 4-20mA, then flag 8 must be programmed.

The element flags can be controlled in the sensor programming under the abbreviation EF and for measuring instruments with 7-segment displays in the locking mode at the third digit xx2x.

6.10.4 Change output function

If the actual measured value is not required, but only the max, min average or alarm value, then this function can be programmed as an output function. Limit value monitoring, storage, analog and digital output only consider the corresponding function value.

Examples:

1. If measured values are averaged over the print cycle with the aid of the measuring cycle, then only the average value and not the last measured value is of interest as the output value. This saves memory space in a data logger.
2. The analog measured value of the dew sensor FH A946-1 has no significance. Set the limit value max. to approx. 0.5 V, program the measuring function alarm value and you will only get the values 0.0% for dry and 100.0% for dewy.

Measuring function	Abbreviation	Commands
Measured value	Meas	f1 m0
Difference	Diff	f1 m1
Max value	Max	f1 m2
Min value	Min	f1 m3
Average value	M(t)	f1 m4
Alarm value	Alrm	f1 m5

6.10.5 Minimum sensor supply voltage

The ALMEMO® devices generally monitor the sensor supply voltage, which usually also corresponds to the operating voltage of the measuring device. If the voltage of battery or accumulator devices drops below 6.8V, the LoBat status is indicated in the display, with an LED or in the device configuration (see chapter 6.2.4). However, there are sensors that no longer work at this voltage and therefore no longer provide a usable measured value. To prevent such errors, the minimum required sensor voltage can be entered individually for each sensor in the sensor programming. If this is not reached, the measured value is treated as a sensor break.

Function	Command
Program minimum sensor supply voltage in xx.x V	uxxx

If 00.0 V is entered in the programming (see chapter 6.10.1), then '- -' is displayed and no monitoring is performed.

6.10.6 Print cycle factor

To adapt the data recording to the rate of change of the individual measuring points, it is possible to record some measuring points less often or not at all (i.e. save or output to interface) by programming a print cycle factor between 00 and 99. By default, the print cycle factor of all measuring points is set to 01 (display '- -'), i.e. all activated measuring points are printed out with each print cycle. If another factor is entered, e.g. 10, the corresponding measuring point will only be printed every 10th time, whereas 00 will not be printed at all. With data loggers, this can be used to suppress unnecessary measured values and save memory space. To program the print cycle factor between 00 and 99, the measuring point must be selected beforehand. In the extended sensor programming, the print cycle factor appears under ZF.

Function	Command
Input print cycle factor xx	zxx
Delete print cycle factor	z01

6.10.7 Analog output functions

The analog output modules described in chapter 5 can not only be operated with the specified output signal/digit, but can also be scaled to small partial ranges. With continuous measuring point query, a freely selectable channel can be output analog instead of the measuring channel. Alternatively, it is possible to control the analog output directly via the interface. Several analog outputs are also possible.

Scaling

The output signal of the possible analog outputs (0-2V, 0-10V, 0-20mA, 4-20mA) can be set to any subrange for each sensor, as long as the range is larger than 100 digits (e.g. 0-20mA for -30.0 to 120.0°C).

For this purpose, the values for analog output start and analog output end, as well as the analog output type (0-20mA or 4-20mA), if required, must be programmed for the corresponding measuring channel.

Function	Command	Response
Analog output start		
Program	a-xxxxx	
Delete	C16	
Output	P16	ANALOG START:01: -0030.0 ° C
Analog output end		
Program	e-xxxxx	
Program (4-20mA)	f1 e-xxxxx	
Delete	C17	
Output	P17	ANALOG END: 01: +0120.0 ° C

The flag for switching from 0-20 mA to 4-20 mA can also be queried and programmed via the element flags (see chapter 6.10.3).

Set channel of analog output, second analog output

Normally, the measured value of the selected channel is output on the analog output. In case of continuous measuring point query, however, it is possible to define any channel for the 1st analog output on socket A2 by programming a reference channel. A 2nd analog output on socket A1 simultaneously outputs the measured value of the 1st channel from the selected sensor. The programming of the reference channel can be found in the device configuration (see chapter 6.2.4 `CONFIG:`).

Function	Command
Set reference channel xx for analog output to A2	`f9 Exx`
Switch back to measuring channel	`f9 E-00`
Set reference channel xx for 2nd analog output to A1	`f8 Exx`

The port must be set beforehand (see chapter 6.10.9.2).

Set reference channel xx for analog output on port pp	`ipp f9 Exx`

External control

The analog output can also be controlled via the interface and thus provides a programmable voltage output (-1.2 ... +2.0 V or -6.0 ... +10.0 V) or a current output (0.0 ...20.0 mA). The output value is preset with -12000...+20000 digit (0.1mV, 0.5mV, 1µA depending on the analog output), and is thus intended for the control of peripheral devices (e.g. setpoint setting) by a computer.

Function	Command
Analog output of xxxxx digit	`f9 a±xxxxx`
E.g. Voltage (2V) - 0.5 V	`f9 a-05000`
Voltage (10V) + 6.40 V	`f9 a12800`
Current (20 mA) + 19.0 mA	`f9 a19000`
Switch back to measuring channel	`f9 E-00`
Switch back to last setpoint	`f9 E-01`
Retrieval of reference channel and analog output value via device configuration (see 6.2.4)	`P19` `CONFIG: xxxxxx-- -x-- B-1 a+12345`

The port must be set beforehand (see chapter 6.10.9.2)

Set reference channel xx for analog output on port pp	`ipp f9 Exx`
For outputs DAx switch analog type to 10V	`ipp f9 A1`
For outputs DAx switch analog type to 20mA	`ipp f9 A2`
Analog output of xxxxx digit on port pp	`ipp f9 a±xxxxx`

6.10.8 Assignment of the alarm relays to limit values

By default, both limit values of all measuring points are used for the alarm message (see chapter 6.3.9) and, e.g. with a ZA1006-EGK relay module (see chapter 5.1.1.2), relay 0 is energized if the maximum value is exceeded and relay 1 is energized if the minimum value is not reached.

However, if malfunctions have to be detected and evaluated selectively, then it is possible to assign individual relays to limit values. This mode must be set in the output module as variant 2 (internally assigned) (see chapter 6.10.9).

Several output modules with one function variant each are possible per relay (see chapter 6.10.9.2). Theoretically, up to 100 relays can be controlled in systems:

Function	Command
Assign relays with port address pp to the limit value max of channel yy:	`Eyy f2 Rpp`
Assign relays with port address pp to the limit value min of channel yy:	`Eyy f3 Rpp`
Delete relay assignment of limit value max channel yy:	`Eyy f2 R-pp`
Delete relay assignment of limit value min channel yy:	`Eyy f3 R-pp`

The extended relay assignment can be called up in the extended sensor programming with command f3 P15 (see chapter 6.10.1).

6.10.9 Configuration of the output modules

Various output modules with relays, trigger inputs or analog outputs can be connected to the output sockets A1, A2, etc., and their mode of operation can be configured. Several output modules can be connected. All elements (relay, trigger input or analog output) can be configured individually in their function variant.

The output modules, such as the ZA 8006-RTA3 relay-trigger-analog adapter (see chapter 5.1.3) provide up to 10 relays for controlling peripheral devices. Instead of the relays, trigger inputs and analog outputs are optionally available.

The following should be noted:

- Output cables can be used on all output sockets!
- Output cables have 2 separate trigger inputs.
- Trigger cables can also call up command macros!
- Relay trigger adapters have watchdog control for relays.

Currently the following interface elements are available:

Interface elements:		**Abbreviation**
Relay Normally Open	Semiconductor relay 0.5A	NOO
Relay Normally Closed	Semiconductor relay 0.5A	NCO
Relay Change Over	Semiconductor relay 0.5A	COO
Relay dto.	Relay 2A	xx2
Trigger inputs:		
Deactivated		TR0
With key in output module		TR1
With optocoupler activated when current flows		TR2
With key or optocoupler activated when current flows		TR3
Analog outputs:		
DA converter in module, 10V/20mA switchable:	10V	DA1
	20mA	DA2

The output modules can be plugged to all, even several output sockets. To be able to address all elements, 10 port addresses pp were assigned to each socket:

Socket	**Interface elements**	**Port addresses**
P0	Device-internal elements, connection via socket P0	00..01
A1	Output modules at socket A1	10..19
A2	Output modules at socket A2	20..29
A3	Output modules at socket A3 if available	30..39
A4/B4	Output modules at socket A4 or slot B4	40..49
A5/B5	Etc.	

The operation and status of the individual elements can be queried and programmed as follows:

Output of the output modules and configuration:				f3 P19
Socket P0: Option internal analog output				P0.0A2490R02
DA converter 10V	Applied measuring channel	B10		06:DA1 MOO +08.234V
DA converter 20mA	Controlled by	COM		07:DA2 COM +08.234mA
Socket A1: Data cable USB				A1.ZA1919DKU DKO
Socket A2: Relay trigger analog adapter				A2.ZA8006RTA3
N/O contact 0.5A	Variant 0	passive	Open	20:NOO 0 0 0
N/C contact 0.5A	Variant 8 invers	active	Open	21:NCO-8 1 0
Change over 0.5A	Variant 2	passive	Open	22:COO 2 0 0
Change over 0.5A	Variant 2	active	Closed	23:COO 2 1 C
DA converter 10V	Reference channel	B10		26:DA1 B10 +08.234V
DA converter 20mA	Controlled by	COM		27:DA2 COM +08.234mA

Trigger	Key	Variant 1	Manual	`28:TR1 1`
Trigger	Optoc.	Variant -5	Macro5	`28:TR2-5`

Programming of output modules:		
First set peripheral port pp (A1=1p, A2=2p..)		`ipp`
Set variant x of port address pp		`ipp f9 kx`
Relay variant 0:	Sum alarm	`ipp f9 k0`
Relay variant 2:	Internally assigned	`ipp f9 k2`
Relay variant 3:	Sum alarm max	`ipp f9 k3`
Relay variant 4:	Sum alarm min	`ipp f9 k4`
Relay variant 8:	Externally controlled	`ipp f9 k8`
Relay variant -x:	Dto. inverse control	`ipp f9 k-x`
Switch on (off) watchdog for relay control		`i20 o(-)19`

For the detection of power failure it is advantageous if the relay control is inverted, because without power also the alarm case occurs automatically, i.e. not activated relays are energized, which are de-energized in case of alarm or power failure. For this the function variant can also be entered inverse or negative. With watchdog, relays are de-energized if control fails for 1 min.

Trigger functions:

Trigger variant 0:	Start-Stop	`ipp f9 k0`
Trigger variant 1:	One-time measuring point query	`ipp f9 k1`
Trigger variant 2:	Delete max-min values	`ipp f9 k2`
Trigger variant 3:	Print function	`ipp f9 k3`
Trigger variant 4:	Start-Stop level triggered	`ipp f9 k4`
Trigger variant 8:	Zero the measured value	`ipp f9 k8`
Trigger variant -5..-9:	Macro 5..9 (see chapter 6.6.5)	`ipp f9 k-5..k-9`

6.10.10 Control of output relays

The relays of all output modules can also be controlled via the interface. For this purpose, variant 8 (externally controlled) must be programmed (see chapter 6.10.9).

The output contacts are operated with the following commands:

Function	Commands
Activate relay port address pp (variant 8)	`f1 Rpp`
Deactivate relay port address pp (variant 8)	`f1 R-pp`

The current relay state can be called up (see chapter 6.10.9).

6.10.11 Output of the device version

The ALMEMO® devices are constantly being further developed. Even new devices with completely new hardware and software always receive new functions. In addition, there have always been options and also special versions. When updating and connecting new sensors or peripheral devices, it is therefore very important to know the exact version status. This can be queried by the following command:

Function	Command	Response
Query software version	`t0`	`8590-9KL 6.52`

Options:

- KL Connector linearization
- R Special areas refrigerants

From the answer you can recognize the device ALMEMO® 8590-9 with option connector linearization, the 1st digit of version 6.24 shows that it is a V6 device.

Further commands (serial number, functions etc.) see chapter 7.5

6.10.12 Change baud rate

The baud rate is normally set to 9600 baud in the connectors of the interface cables plugged into the A1 sockets ex works and should not be changed if possible. If cables with different baud rates are used in a network, no communication will be established. High baud rates of 57.6 to 230.4 kB can significantly shorten the readout time of a memory, but are not possible with all data cables, not with every device and not with every computer.

During memory readout with 57.6 kB and higher, a running measured value acquisition is interrupted!

During memory readout with 115.2 kB and higher, the output is shortened in table format (see chapter 6.9.3).

Data format: Unchangeable 8 data bits, no parity, 1- stop bit.

The command via the interface switches all interface cables in a network simultaneously, as far as the connected devices are switched on. Afterwards the baud rate must be changed in the communication device, because otherwise the transmission will be interrupted. A pause of min. 20 ms must be waited until the next command is sent.

Change baud rate	Commands
300 bd	`f1 b1`
600 bd	`f1 b2`
1200 bd	`f1 b3`
2400 bd	`f1 b4`
4800 bd	`f1 b5`
9600 bd	`f1 b6`
57600 bd	`f1 b7`
115200 bd	`f1 b8`
230400 bd	`f1 b9`

6.10.13 Device configuration

There are some device settings (see also chapter 6.2.4) which make earlier options programmable by the user. This configuration, like the already known input of the device designation, is permanently stored in the device EEPROM and is not deleted even during a reset.

6.10.13.1 Operating parameters

The following operating parameters resp. options can be configured by the user:

1. Mains frequency interference suppression

The mains hum, known by humming noises in amplifier systems, is an interference voltage caused by the frequency of the mains voltage. This interference can be minimized in sensitive measuring instruments by the integration time of the AD converter, if this measuring time is exactly one period of the mains frequency. To really achieve the mains frequency interference suppression, the frequency of the mains voltage present at the location must be known and configured via operating parameter 1 (F). The factory setting is always 50 Hz. At measuring rates above 10 measurements/s, the interference suppression is in principle no longer possible.

2. Delete all measured values at the start of a measurement

In many cases it is useful to delete all max, min and average values at the start of a cyclic measurement recording in order to have these parameters available at the end of the measurement. However, if measurements are interrupted and restarted more often, the existing values must not be lost. The configuration flag 2 (C) allows the adaptation to any task.

3. Ring memory for data loggers

The measured value memory of the data loggers is normally organized as a linear memory, which ends the recording and reports 'Memory full' as soon as the entire memory space is occupied. This operating mode is always indicated when the start of the measurement is indispensable. In many other cases, e.g. prophylactic long-term monitoring, it is sufficient to be able to retrieve the history of an event over a limited period of time. This problem can be solved with the configuration parameter 3 (R) by organizing it as a ring memory, i.e. when the memory is full, old data is overwritten, but one can always read out the whole memory up to the present time.

5. Oversampling of the measurement data output

Normally it is possible to query the measurement data more often than they are measured in case of continuous measurement. If the output is to be limited to the measuring rate, then flag 5 must be switched off.

Function	On	Off	Code
1. Mains frequency interference suppression 60Hz instead of 50Hz	f6 k1	f6 k-1	F
2. Delete all measured values at the start of a measurement	f6 k2	f6 k-2	C
3. Ring memory for data loggers	f6 k3	f6 k-3	R
4. Oversampling of the measurement data output	f6 k5	f6 k-5	A
5. Switch off signal generator (for devices with beeper)	f6 k6	f6 k-6	S
6. Date-time in Excel spreadsheet format ´dd.mm.yy hh:mm:ss´	f6 k7	f6 k-7	E

7 Command overview V6 protocol

Function assignment:

	All devices
D6	Also D6 sensors
G	Only devices with graphic display 2590-x, 2690, 2890, 5690-2, 5990-2
*G	Only V6 devices with graphic display 2690, 2890, 5690-2
**	Only higher V6 devices 2690, 2890, 5690, 8590
*K	Only V6 devices with option KL

7.1 Measured value processing

Function		**Command**, ►: Response	**Printout**
D6 Select measuring point xx (incl. input channel)		Mxx	
D6 Only select input channel xx		Exx	
D6 Output measured value from measuring channel (without new query)		p ►01: +0023.5 °C	
D6 Output measured value from input channel (without new query)		P01 ►12:34:00 01: +0023.5 °C	
G Output measured value from input channel (without time, with designation)		P35 ►01: +0023.5 °C Temperature	
D6 **Set measured value to zero** (base value)		C01	
Sensor adjustment (zero-point and gain)	f1	C01	
**Zero-set timer 3 (1s)	f3	C01	
** Zero-set timer 4 (0.1s)	f4	C01	
**Calibration switch (off) / on		o(-)01	
Enter **setpoint	f2	gxxxxx	
**Setpoint adjustment	f2	C01	
**Output setpoint		P45 ►SETPOINT: 01: 1100.0°C	
Enter **temperature compensation** in 0.1°C	f1	gxxxxx	
**Define temperature sensor for TC	f2	$*T .. CR	
Output temperature compensation		P44 ►COMPENSATION 01: 25.0°C	
D6 Enter **atmosph. pressure** in mbar for compensation		g0xxxx	
D6 Define atmospheric pressure sensor as reference	f2	$*P .. CR	
G Output atmospheric pressure		P43 ►ATM. PRESSURE: +01013.mb	
Define temperature sensor as cold junction compensation	f2	$*J .. CR	
Peak values:			
Delete maximum value		C02	
Output maximum value		P02 ►MAX. VALUE: 01: +0020.0 °C	
**Output max time		P28 ►MAX. TIME: 01: 12:32 01.02	
Delete minimum value		C03	
Output minimum value		P03 ►MIN. VALUE: 01: -0010.0 °C	
**Output min time		P29 ►MIN. TIME: 01: 12:32 01.02	
Averaging:			s. P15 **AVERAGE**
Delete averaging mode		m0	- - -
Averaging mode, continuous		m1	CONT
Averaging mode, cyclic		m2	CYCL

Function	Command, ►: Response	Printout
G Output averaging mode	P21	
	►AVERAGE MODE: 01: CONT	
G Output number of average values	P22	
	►AVERAGE NO.:01: 00178.	
Delete average value	C14	
Output average value	P14	
	►AVERAGE VAL.: 01: +0017.8 °C	
Smoothing (number of averaged values xx)	f1 zxx s. f3 P15:	**DG**
Output smoothing	P32	
	►SMOOTHING: 01: 10	
Volume flow measurement:		
Enter cross-section in cm^2 for volume	Qxxxxx s. f3 P15:	**CROSS-SEC**
Output cross-section	P26	
	►CROSS-SECTION: 01: 00078 cm2	
Output diameter	P25	
	►DIAMETER: 01: 00100 mm	
*G Output volume flow	P27	
	►VOLUME FLOW: 01: 00000 m3/h	

7.2 Measuring point queries, measurement data recording and output

7.2.1 Process control

Enter **time**		Uhhmmss		
Delete time		C10		
Output time		P10		
		▶TIME: 12:34:00		
Enter **date**		dddmmyy		
Delete date		C13		
Output date		P13		
		▶DATE: 12:03:06		
Enter **start time of measurement**	f1	Uhhmmss		
Delete start time	f1	C10		
Output start time	f1	P10		
		▶START TIME: 12:00:00		
Enter **end time of measurement**	f2	Uhhmmss		
Delete end time	f2	C10		
Output end time	f2	P10		
		▶END TIME: 18:00:00		
Enter **start date of measurement**	f1	dddmmyy		
Delete start date	f1	C13		
Output start date	f1	P13		
		▶START DATE: 12.03.06		
Enter **end date of measurement**	f2	dddmmyy		
Delete end date	f2	C13		
Output end date	f2	P13		
		▶END DATE: 12.03.06		
Enter **measuring duration**	f2	Ihhmmss		
**Output measuring duration		P47		
		▶DURATION: 06:30:00		
**Output measuring time		P46		
		▶MEAS. TIME: 03:12:45.67		
Enter **cycle**		Zhhmmss		
** Saving in cycle (off) / on	f1	A(-)4		
Delete cycle		C11		
Output cycle		P11		
Memory, format, query mode (see below)		▶PRINT CYCLE: 00:01:30 Sn s		
Cycle timer	f1	P11		
		▶PRINT TIMER: 00:01:23		
Enter **cycle**		Ihhmmss		
With saving		I+hhmmss		
Without saving		I-hhmmss		
Measuring rate and mode:				
Measuring rate 2.5 M/s semi-continuous	f5	k0	s. P15	W003
Measuring rate 10 M/s semi-continuous	f5	k1		W010
**Measuring rate 50 M/s semi-continuous	f5	k7		W050
**Measuring rate 100 M/s semi-continuous	f5	k8		W100
**Measuring rate 400 M/s (option)	f5	k9		W400
Switch continuous query (off) / on	f5	k(-)2		C
Switch continuous saving (off) / on	f5	k(-)4		S
Switch continuous output (off) / on	f5	k(-)5		U
(Do not) allow output more often than measuring rate	f6	k(-)5		
Query mode:				
**Switch sleep mode (off) / on		o(-)11	s. P11	s
Input sleep delay time xxx s:	f2	uxxx		

**Switch monitor mode (off) / on	f1	A(-)1		M
**Switch fail-safe-mode (off) / on	f2	A(-)1		F
Output format: switch (off) / on				
D6 Measured values as a list below each other		N0	s. P15	-
Measured values in column format next to each other		N1		n
D6 Measured values in table format		N2		t
Enter **number**, activate (e.g. 123001)		n123001		
Dto. enter with letters (-, ,A,F,N,P)	f3	$A1-N02		
Increment number		n+		
Output number		P05		
		►NUMBER:	A1-N02	
G Output number		P23		
		►NUMBER:	01-012	
**Enter file name (max. 8 characters)		$Name CR		
**File name for automatic daily files		$&Name CR		

7.2.2 One-time manual measuring point query and output

D6 **Command**		S1
List format		►12:00:00 01: +0012.0 °C Designation
		02: +0009.9 °C Water
Column format		►12:00:00 01: +0012.0 °C 02: +0009.9 °C
Table format		►"12.03.06";"12:30:00";12,;9,9
D6 Dto. without time and date		s
		►;;12,;9,9
Output other modules		G01, G02, G..
		►;;123,4;25,2
Output without query	f1	G01
		►;;123,4;25,2

7.2.3 Start cyclic measuring point query and output

Command	S2
List format	►DATE: 12:03:06
	12:00:00 01: +0012.0 °C
Exceeding limit value	02:!+0009.9 °C
	12:01:30 01: +0012.5 °C
Exceeding measuring range	02:>+0400.0 °C
Column format	►DATE: 12:03:06
	12:00:00 01: +0012.0 °C 02: +0009.9 °C
	12:01:30 01: +0012.5 °C 02: +0010.7 °C
Table format	►"DATE";"TIME";"M01: °C";"M02: °C";;;;
	"12.03.06";"12:00:00";12,;9,9
	"12.03.06";"12:01:30";12,5;10,7

Start and output with program header:

Command S3

Response in list / column format:

```
►AMR ALMEMO 8590-9
  CH RANGE  LIM-MAX  LIM-MIN  BASE  D  FACTOR  EXP  AVG.   COMMENT
  01:NiCr     +0123.4    - - -          - - -   °C  1.0350   E+0  - - -      Designation
  02:NiCr      - - -          +0012.0   - - -   °C  - - -        E+0  CONT   Water
  MEAS. CYCLE:  00:00:00 -  S0500.3 F0312.4 ARS W010 C-SU-
  PRINT CYCLE: 00:01:30 Sn 9600 bd
  DATE:     12:03:06
  12:00:00 01: +0012.0 °C 02: +0009.9 °C
  12:01:30 01: +0012.5 °C 02: +0010.7 °C
```

Response in table format:

```
► "ALMEMO";"RANGE:";"NiCr";"NiCr";;;;;;;
  "8590-9";"COMMENT:";"Designation";"Water";;;;;;
  ;"LIM-MAX:";123,4;;;;;;;;
  "MODUL:00";"LIM-MIN:";;12,;;;;;;;;
  "DATE";"TIME";"M01: °C";"M02: °C";;;;
  "12.03.06";"12:00:00";12,;9,9
  "12.03.06";"12:01:30";12,5;10,7
```

Stop cyclic query X

Output measured values P18
(without new query)

```
►CH MEAS-VAL MAX-VAL MIN-VAL AVERAG-VAL COUNT
  01:+0023.0    +0025.0   +0019.0  +0022.0        99999
```

**Extended measured values f1 P18

```
► CH MEAS-VAL MAX-VAL MIN-VAL AVERAG-VAL COUNT MAX-TIME    MIN-TIME
  01:+0023.0    +0025.0   +0019.0  +0022.0        99999.  12:32 01.02  12:32 01.02
```

7.3 Measured value memory outputs

Output memory capacity	f1	P04
(S=total, F=free)		►MEMORY: S0500.3 F0312.4
G Output function MemoryFree		P33
		►MEMORY: S0512.1 F0324.4
**Output version MMC connector	f4	t0
		►MMC1.04
Output table header	f2	P04 (s. memory output in table format)
Delete memory, format MMC		C04
Delete memory and all measured data	f1	C04
Set start and end of memory output:		
Enter **start time**	f3	Uhhmmss
Delete start time	f3	C10
Output start time	f3	P10
		►START TIME: 14:00:00
Enter **end time**	f4	Uhhmmss
Delete end time	f4	C10
Output end time	f4	P10
		►END TIME: 16:00:00
Enter **start date**	f3	dddmmyy
Delete start date	f3	C13
Output start date	f3	P13
		►START DATE: 12.03.06
Enter **end date**	f4	dddmmyy
Delete end date	f4	C13
Output end date	f4	P13
		►END DATE: 12.03.06
Output **excerpt** start to end	f3	P04
Output **total memory**		P04
Selectively output **memory range with number identification**:		
Enter **number**, activate (e.g. 123001)		n123002
Dto. enter with letters (-, ,A,F,N,P)	f3	$A1-N02
Test if number is in memory		t4
		►OK or ERROR
Output numbers list	f1	P05
		►NUMBER: 11-001 11-002 A1-N02 ....
Output memory after Nr-activation		P04

Response in list / column format:

►MEMORY:
NUMBER: 12-001 — if programmed
DATE: 12:03:06
12:00:00 01: +0012.0 °C 02: +0009.9 °C
12:01:30 01: +0012.5 °C 02: +0010.7 °C

Response in table format:

```
► MEMORY:
  "NUMBER:";"12-001"                  if programmed
  "ALMEMO";"RANGE:";"NiCr";"NiCr";;;;;;;
  "8590-9";"COMMENT:";"Designation";"Water";;;;;;
  "MMC1.04";"LIM-MAX:";123,4;;;;;;;;
  "ALMEMO.001";"LIM-MIN:";;12,;;;;;;;;
  "DATE";"TIME";"M01: °C";"M02: °C";;;;
  "12.03.06";"12:00:00";12,;9,9
  "12.03.06";"12:01:30";12,5;10,7
```

Cancel memory output		X
****Output all memory data:**	f4	P19
Memory capacity internal (R = ring memory)		►SI:0512.4k R
Memory capacity external		SE:256.00M
Free memory		SF:0324.5k
Remaining memory time: dddd.hh:mm		SZ:0001.18:20
Start time for memory output		U3:07:00:00
Start date for memory output		D3:01.02.06
End time for memory output		U4:17:00:00
End date for memory output		D4:02.02.06
File name of new file		DT:FILE NEW.001
File name of current file in the memory		FI: ALMEMO.001

Single value memory:	**Output:**
Saving a measured value:	S-4
Output of the memory data:	P-04

```
► Memory:
  P01: 00: +022.12 °C
  P02: 00: +022.12 °C
  P03: 10: +0039.9 %H
  P04: 10: +0039.9 %H
  P05: 20: +0007.6 °C
  P06: 20: +0007.5 °C
```

Deleting the memory:	C-04

7.4 Sensor programming

Sensor programming		Command	Printout
[D6] Select input channel Exx		Exx	
Reference channel 1 b1 absolute	f1	Eb1	**B1**: b1
Reference channel 1 b1 relative	f1	E-b1	-b1
Reference channel 2 b2 absolute	f2	Eb2	**MX**: b2
Reference channel 2 b2 relative	f2	E-b2	-b2

7.4.1 Measuring ranges:

Measuring range		Command	Abbreviation
Pt100-1 4 wire	-200..850.0 °C	B01	P104
Pt100-2 4 wire	-200..400.00 °C	B03	P204
**Pt100-3 4 wire	-8..65.000 °C	B00	P304
Ni100 4 wire	-60.. 240.0 °C	B63	N104
Ntc Type N	-50..125.00 °C	B09	Ntc
NiCr-Ni (K) with CJC	-200..1370.0 °C	B04	NiCr
NiCrSil-NiSil (N) with CJC	-200..1300.0 °C	B34	NiSi
Fe-CuNi (L) with CJC	-200.. 900.0 °C	B05	FeCo
Fe-CuNi (J) with CJC	-200..1000.0 °C	B35	IrCo
Cu-CuNi (U) with CJC	-200.. 600.0 °C	B06	CuCo
Cu-CuNi (T) with CJC	-200.. 400.0 °C	B36	CoCo
PtRh10-Pt (S) with CJC	0..1760.0 °C	B07	Pt10
PtRh13-Pt (R) with CJC	0..1760.0 °C	B37	Pt13
PtRh30-PtRh6 (B) with CJC	+400..1800.0 °C	B08	El18
AuFe-Cr with CJC	-270... 60.0 °C	B38	AuFe
Millivolt	-10..55.000 mV	B10	mV
Millivolt 1	-26..26.000 mV	B27	mV 1
Millivolt 2	-260..260.00 mV	B28	mV 2
Volt	-2.6..2.6000 V	B11	Volt
Differential millivolt	-10..55.000 mV	B50	D 55
Differential millivolt 1	-26..26.000 mV	B51	D 26
Differential millivolt 2	-260..260.00 mV	B52	D260
Differential volt	-2.6..2.6000 V	B53	D2.6
Milliampere	-32..32.000 mA	B12	mA
Percent	4-20.000 mA	B13	%
Battery	0..25.000 V	B14	Batt
Ohm	0..500.00 W	B15	Ohm
Frequency	0..25000	B29	Freq
Pulses via cycle	0..65000	B54	Puls
[D6] Digital	-65000..+65000	B55	DIGI
Impeller normal	0.3..20.00 m/s	B30	S120
Impeller normal	0.4..40.00 m/s	B31	S140
Impeller micro	0.5..20.00 m/s	B32	S220
Impeller micro	0.6..40.00 m/s	B33	S240
Impeller macro	0.1..20.00 m/s	B24	L420
Water turbine micro	0...5.00 m/s	B25	L605
Dynamic pressure with TC	0.5..40.00 m/s	B40	L840
Dynamic pressure with TC	0..90.00 m/s	B41	L890
Rel. humidity cap.	0..100.0 %	B16	% rH
Rel. humidity cap. with TC	0..100.0 %	B42	HcrH
Rel. humidity cap. with TC	0..100.0 %	B56	H rH
Abs. humidity cap. with PC	0..500.0 g/kg	B43	H AH

Measuring range		Command	Abbreviation
Dew point cap.	-25..100.0 °C	B44	H DT
Vapor pressure cap.	0..1050 mbar	B59	H VP
Enthalpy cap. with PC	0..400.0 kJ/kg	B58	H En
Humid temperature	-50..100.00 °C	B45	P HT
Rel. humidity psychr. with PC	0..100.0 %	B46	P RH
Abs. humidity psychr. with PC	0..500.0 g/kg	B47	P AH
Dew point psychr. with PC	-25..100.0 °C	B48	P DT
Vapor pressure psychr. with PC	0..1050 mbar	B49	P VP
Enthalpy psychr. with PC	0..400.0 kJ/kg	B57	P En
pH probe with TC (Dim=pH/PH)	0..14.00 pH	B53	D2.6
Conductivity with TC	0..20.00 mS	B60	LF
CO_2 concentration	0..25.00 %	B64	CO2
O_2 saturation with TC and PC	0..260 %	B65	O2-S
O_2 concentration with TC	0..40.0 mg/l	B66	O2-C
Temperature digital internal (opt.)	-20..+80 °C	B68	D °C
Rel. humidity digital internal (opt.)	0..100 %	B69	D %H
Digital input	0..100.00 %	B70	Inp
Function channels			
Difference (b1-b2)		B71	Diff
Maximum value (b1)		B72	Max
Minimum value (b1)		B73	Min
Average value via time $\overline{M}$(b1)		B74	M(t)
Average value via meas. points $\overline{M}$(b2..b1)		B75	M(n)
Total via meas. points (b2..b1)		B76	S(n)
Total number of pulses (b1)	0..65000	B77	S(t)
Number of pulses / print cycle (b1)	0..65000	B78	S(P)
Thermal coefficient = $\overline{M}$(b1)/$\overline{M}$(b2)	650.00 W/m^2K	B79	q/dt
WBGT=0.1M(b2)+0.7M(b2+10)+0.2M(b1)	-200..400.00 °C	B02	WBGT
Alarm value (b1)	0..100.00 %	B80	Alrm
Measured value (b1)		B81	Mess
Cold junction temperature	-30..100.0 °C	B82	CJ
Number of averaged values (b1)	0..65000	B83	n(t)
Volume flow m^3/h=M(b1)*CS	m^3/h	B84	Flow
Timer	0..65000 s	B85	Time
Timer with Exp -1	0..6500.0 s	B85	Time
Atmospheric pressure (option AP)	300..1100 mb	B86	AP

CJC=Cold junction compensation, TC=Temperature compensation, PC= Atmospheric pressure compensation

Function	Command
Deactivate programmed measuring point	C00
**Reactivate programmed measuring point	o00

Function		Command		Printout
[G] Output range		P24		
		►RANGE:	01: NiCr	
[D6] Dimension change ´xy´	f1	$xy CR	s. P15:	D
[D6] Measuring point designation ´Name´ (10 Z.)	f2	$NameCR	s. P15:	**COMMENT**

7.4.2 Measured value scaling and correction

D6 Enter base value		O(-)xxxxx s. P15:	**BASE VAL**
D6 Delete base value		C06	
Output base value		P06	
		►BASE VALUE: 01: -0273.0 °C	
D6 Enter factor		Fxxxxx s. P15:	**FACTOR**
D6 Delete factor		C07	
D6 Enter exponent		Vx	
D6 Delete exponent		V0	
Output factor and exponent		P07	
		►FACTOR: 01: +1.0350E-1	
D6 Enter zero-point correction	f1	Oxxxxx s. f1 P15:	**ZEROPNT**
D6 Delete zero-point correction	f1	C06	
Output zero-point correction	f1	P06	
		►ZEROPOINT: 01: -0000.7 °C	
D6 Enter gain correction	f1	Fxxxxx s. f1 P15:	**GAIN**
D6 Delete gain correction	f1	C07	
Output gain correction	f1	P07	
		►GAIN: 01: +1.0013	

7.4.3 Limit values

D6 Enter max. limit value		H(-)xxxxx	
D6 Delete max. limit value		C08	
Output max. limit value		P08	
		►LIMIT MAX: 01: 0100.0 °C	
Action limit value max. alarm only		h0	**AH**: --
Action measuring point query start		h1	S-
Action measuring point query stop		h2	E-
**Action measuring point query manual		h3	M-
**Action zero-set timer		h4	T-
**Action call up macro 5..9		h5..h9	5-
Action control alarm relay x on A2	f1	hx	-x
**Action alarm relay port pp (off) / on	f2	R(-)pp s. f3 P15:	**RH:** pp
D6 Enter min. limit value		L(-)xxxxx	
D6 Delete min. limit value		C09	
Output min. limit value		P09	
		►LIMIT MIN: 01: -0020.0 °C	
Action limit value min. alarm only		l0 s. f1 P15:	**AL**: --
Action measuring point query start		l1	S-
Action measuring point query stop		l2	E-
**Action measuring point query manual		l3	M-
**Action zero-set timer		l4	T-
**Action call up macro 5..9		l5..l9	5-
Action control alarm relay x on A2	f1	lx	-x
**Action alarm relay port pp (off) / on	f3	R(-)pp s. f3 P15:	**RL:** pp

7.4.4 Special functions

D6 **Sensor locking** none	f1	k0	s. f1 P15:	**VM**: 0
Measuring range, element flags	f1	k1		1
Measuring range, zero-point, gain	f1	k2		2
Measuring range, dimension	f1	k3		3
+ Zero-point, gain	f1	k4		4
D6 + Base, factor, exponent	f1	k5		5
+ Analog output start/end	f1	k6		6
+ Limit values	f1	k7		7
Locking sensor permanently	f8	kx		x.
Cancel permanent sensor locking	f-8	kx		
Output locking (see f1 P15)	f1	P00 ►LOCK:5		
G Output locking		P42 ►LOCK:5		
Enter start of **analog output**		a(-)xxxxx	s. f1 P15:	**ANA-START**
Delete start of analog output		C16		
Output start of analog output		P16 ►ANALOG START:01: -0010.0 °C		
Enter end of analog output		e(-)xxxxx	s. f1 P15:	**ANA-END**
Enter end of analog output (4-20mA)	f1	e(-)xxxxx		
Delete end of analog output		C17		
Output end of analog output		P17 ►ANALOG END: 01: +0040.0 °C		
Print cycle factor		zxx	s. f1 P15:	**ZF**
D6 Minimum sensor supply voltage		uxxx	s. f1 P15:	**UMIN**
Set sensor supply voltage	f1	uxxx	s. f2 P19:	**US**
*K Output **serial number** of sensor	f3	t0 ►jjmm1234		
*K Enter **calibration cycle** for sensor (Mon.)	f9	zmm	(only with option KL)	
*KD6 Enter next **calibration date**	f9	dddmmyy		
*K Output next calibration date	f9	P13 ►KF:02.02.06 12		

Function		**Command**		**Printout**
Change multiplexer, inputs for	B-A	f1	Bxx	**MX**: M1
range Bxx	C-A	f2	Bxx	s.f1 P15 M2
	D-A	f3	Bxx	M3
Difference	C-B	f4	Bxx	M4
	D-B	f5	Bxx	M5
Output function	Measured value	f1	m0	**FUNC**:Meas
	Difference	f1	m1	Diff
	Maximum value	f1	m2	Max
	Minimum value	f1	m3	Min
	Average value	f1	m4	M(t)
	Alarm value	f1	m5	Alrm
Set element flags	Meas. current $^1/_{10}$	f2	k(-)1	**EF**: 01
Emission and background temperature	Infrared	f2	k(-)2	02
Activation bridge switch	Bridge	f2	k(-)3	04
**DIGI only cycl. query	DIGI cyclic	f2	k(-)4	08
**Switch off galv. isolation	Iso off	f2	k(-)5	10
Without sensor breakage detection	Sensor breakage	f2	k(-)7	40
Analog output 0/4-20mA	4-20mA	f2	k(-)8	80
Read in sensor programming again			t5	

D6 Output **standard programming**

All active channels with cycles, memory, measuring rate P15

►
```
AMR ALMEMO 8590-9
CH RANGE LIM-MAX LIM-MIN BASE VAL D FACTOR EXP AVERAG. COMMENT
01:NiCr +0123.4 -0012.0 +0000.0 °C 1.0000 E+0 --- Temperature
MEAS CYCLE: 00:00:00 - S0500.3 F0312.4 ARS W010 C-SU
PRINT CYCLE: 00:01:30 Sn 9600 bd
START TIME: 07:00:00 (if programmed)
END TIME: 19:00:00
```

Only input channel P00

► 01:NiCr +0123.4 -0012.0 +0000.0°C 1.0000 E+0 - - - Temperature

D6 **Extended sensor programming:** f1 P15

►
```
AMR ALMEMO 8590-9
CH ZERO PT GAIN CJ K FUNC EOFSET EFAKT ANA-START ANA-END B1 MX EF AH AL ZF UMIN
01:+0000.0 +1.0000 5. 1 MEAS +00000 32000 +0000.0 +1000.0-01 M1 – S- E2 05 12.0
```

D6 **Full standard programming:**

All active channels, cycles, memory, meas. rate f2 P15

►
```
AMR ALMEMO 8590-9
CH RANGE LIM-MAX... CJ K FUNC EOFSET EFAKT ANA-ST ANA-END B1 MX EF AH AL ZF UMIN
01:NiCr +0123.4... 5. 1 MEAS +00000 32000 +0000.0 +1000.0-01 M1 – S- E2 05 12.0
MEAS CYCLE: 00:00:30 S S0500.3 F0312.4 A W010C-SU
PRINT CYCLE: 00:10:00 U 9600 bd
```

Only input channel f2 P00

► 01:NiCr +0123.4... 5. 1 MEAS +00000 32000 +0000.0 +1000.0-01 M1 – S- E2 05 12.0

****New sensor programming:** f3 P15

►
```
CH RANGE LIM-MAX LIM-MIN BASE D FACTOR EXP AVERAG COMMENT DG CROSS-SEC RH RL
01:NiCr +0123.4 -0012.0 +0000.0 °C 1.0000 E+0 --- Temperature 05 01234. 21 22
```

Only input channel f3 P00

► 01:NiCr +0123.4 -0012.0 +0000.0°C 1.0000 E+0 - - - Temperature 05 01234. 21 22

****Connector programming:** f4 P15

►
```
ST SENSOR SERIAL-NO KAL-DAT. ZY
01:FHA6461......... 12345678 01.10.06 12 (only option KL)
```

Only input channel f4 P00

► 01:FHA6461......... 12345678 01.10.06 12 (only option KL)

7.5 Device programming

Device programming	Command		Printout
D6 Select device/module, output measured values		Gxx	After query
Select device/module, output measured values	f1	Gxx	Without query
Software reset, Reinitialization RAM and ports		C19	
D6 Enter device designation (max. 40 characters)	f4	$ Device designation CR	
Output device designation	f1	t0 or GP36	
		► Device designation	
D6 Output device type and version		t0	
		►A8590-9 6.xx	
** Query available functions:		t6	
Memory, connector/MMC, start and end, ring memory,		►S-ARLCK524|2	
sleep,CRC,KL,P15, P18,P19(command number) | version			
**For systems of all modules	f5	t0	
Output type (MF,MU,KS,TH), version, address		►A5690-SL MF 1.10 Adr: 02	
		A5690-SL MU 1.06 Adr: 04	
Output **serial number of device	f2	t0	
		►Hjjmm1234	
*K Enter next **calibration date**	f8	dddmmyy (only with option KL)	
*K Output next calibration date	f8	P13	
A=Notification activated		►KG:02.02.06 -/A	
Enter hysteresis for alarm processing		Yxx	
**Enter language (D=0, E=1, F=2, X=3)		kx	
D6 Change baud rate (6=9.6, 7=57.6, 8=115.2kb)	f1	bx	
Operating parameters:			**CONFIG:**
60Hz hum suppression	f6	k(-)1	F
At start delete max., min. and average value	f6	k(-)2	C
Ring memory	f6	k(-)3	R
Allow oversampling of data output	f6	k(-)5	A
Switch off signal transmitter	f6	k(-)6	S
Date and time in Excel format ´dd.mm.yy hh:mm:ss´	f6	k(-)7	E
**Enter macros 5..9 (max. 30 characters)	f-5...	$bxx|bx CR	
**Output macros 5..9	f-5...	P20	
	-9	►bxx|bx	
**Call up macros 5..9		m-5...-9	
Set **V6 peripheral port pp (A1=1p, A2=2p..)	ipp		
**Switch relay port pp (off) / on		f1	R(-)pp
**Set relay variant x of port pp (- = inverse)	ipp	f9	k(-)x
**Trigger function of port p8 (macro 5..9)	ipp	f9	kx (k-5..k-9)
**Select analog type of pp 1=10V, 2=20mA	ipp	f9	Ax
**Program analog value output of pp	ipp	f9	a(-)xxxxx
**Reference channel of port pp (analog output)	ipp	f9	Exx
**Switch watchdog on / (off)	i20	o(-)19	

7.5.1 Output of device parameters

D6 Output of device parameters	P19
Address, channels possible, active, primary	DEVICE: G00 M20 A08 P10/mm/uu
Atmospheric pressure see 6.2.5	AIR PRESS: +01013. mb
Cold junction temperature	CJ-TEMP: +0023.5 °C
LoBat and sensor voltage	U-SENSOR: ! 12.5 V
Hysteresis see 6.2.6	HYSTERESIS: 10
Configuration see 6.10.13, 6.10.7	CONFIG: FCRDAS-8 -L-- B01
Alarm status of relays 0..3 see 6.10.8	ALARM: -1-3
Output module at A1 see 6.10.9	A1: DK0 Un
Output module at A2	A2: AA

****Output all fixed device parameters:**	f1	P19
Device designation:		►GB:ALMEMO 2690-8
Version, options:		VO.2690-8 RKL
Serial number:		SN.H12345678
Baud rate:		BR:57.6k
Device: Address, total measuring points, active		GE.G00 M40 A08
System: Modules (/=MF !=MU-old .=MU-new ;=KS ,=TH)		G00 M:0 A68 40/10!20.30;10,
Hysteresis:		HY:10
Configuration: 60Hz, CrMv, Ring m, -, U-sampling, signal off		KF:FCR-AS-- --------
Set point:		SW:+1100.0°C
Conversion rate: Output cont, -, memory, V24		WR:010C-SU
Number:		NR:123456
Print cycle: Output channel format, sleep/monitor/fail-safe		Z1:00:10:00 Sn -/s/M/F
Measuring cycle:		Z2:00:00:00
Start time:		U1:07:00:00
Start date:		D1:01.02.06
End time:		U2:17:00:00
End date:		D2:02.02.06
Measuring duration:		MD:00:10:00
Device locking:		GV:M0F0
Next calibration: Date, alarm		KG:01.10.06 -/!
Language:		SP:D
Display: contrast, illumination level, illumination duration		DI:G2 050 2 1
Sleep delay in s (Sleep delay e.g. 123 s)		SD:123 s

****Output all device variables:**	f2	P19
Temperature for compensation:		►TK:+ 25.0°C
Atmospheric pressure for compensation:		LD:+01013.mb
CJ temperature:		CJ.+0023.5 °C
Time:		UZ:12:34:00
Date:		DA:01.02.06
Print timer:		T1.00:01:23
Measuring timer:		T2.00:00:00
Measuring time:		MZ.00:00:00.00
Timer 3		T3. 65000. s
Timer 4		T4. 6500.0 s
U battery:		UB. 3.9 V
U setpoint:		US: 12.0 V
U sensor:		UF.! 12.5 V
Number of rechargeable batteries		AZ.3
Rechargeable battery capacity:		AK:1600mAh
Charging mode:		LM.L1
Charging current:		LS.0500mA
Charging time:		LZ.2.50 h

****Output of output modules:**	f3	P19
Socket DC: Mains adapter ALMEMO® connector		►DC.ZA1312NA8
Voltage 12V, current load capacity 1A		12V 1000mA
Socket P0: Option internal relays		P0.OA2490Rxx
Normally open, 0.5A Variant 0 inverse active Open		00:NO0-0 1 O
Normally open, 0.5A Variant 8 active Closed		01:NO0 8 1 C
Socket A1: Data cable USB		A1.ZA1919-DKU
		DK0
Socket A2: Analog output cable		A2.ZA1601-RK
Analog output, 2V measuring channel M01		RK
Socket A3: Memory card with micro-SD card		A3.ZA1904SD
Socket A4: Relay trigger analog adapter V6		A4.ZA8006RTA3
Normally open, 0.5A Variant 0 passive Open		40:NO0 0 0 O
Normally closed, 0.5A Variant 8 inverse active Open		41:NC0-8 1 O
Changeover, 0.5A Variant 2 active Closed		42:CO0 2 0 C
DA converter, 10V Reference channel M01		46:DA1 B01 +08.234 V
DA converter, 20mA Controlled COM		47:DA2 COM +12.345mA
Trigger Key Variant 0 start / stop		48:TR1 0
Socket A5: Relay trigger cable V6		A5.ZA1006EKA
Normally open 0.5A Variant 2 active Closed		50:NO0 2 1 C

Normally closed 0.5A Variant 2 inverse active Open	51:NC0-2 1 O
Trigger Optoc. Variant 1 Manual	58:TR1 1
Trigger Optoc. Variant -5 Macro5	59:TR2-5
Bus B6..B9:	B6.ES8006RTA5
	60:..69: xx:Function programmable, xx.Function fixed or meas. value

****Memory configuration**	f4	P19
Memory capacity internal (R = ring memory)		SI:0512.4k R
Memory capacity external		SE:256.00M
Memory free		SF:0324.5k
Remaining memory time: dddd.hh:mm		SZ:0001.18:20
Start time of memory output		U3:07:00:00
Start date of memory output		D3:01.02.06
End time of memory output		U4:17:00:00
End date of memory output		D4:02.02.06
File name new file		DT:FILENEW.001
File name current file in the memory		FI: ALMEMO.001

7.5.2 Program simulator:

Program simulator	**Command**
Program on port 01 range V	i01 B11
Program on port 01 range mV	i01 B10
Program on port 01 range TC Type K	i01 B04
Program on port 01 range TC Type N	i01 B34
Program on port 01 range TC Type J	i01 B35
Program on port 01 range TC Type T	i01 B36
Program on port 01 range TC Type S	i01 B07
Program on port 01 range TC Type R	i01 B37
Program on port 01 range TC Type B	i01 B08
Program on port 03 range 4000Hz	i03 B29
Program on port 03 range 10kHz	i03 f1 B29
Program on port 03 range 40kHz	i03 f2 B29
Program on port 03 range 100kHz	i03 f3 B29
Program on port 03 range 99ms	i03 B54
Program on port 03 range 99s	i03 f1 B54
Program CJ temperature in digits e.g. 23.4°C	f1 g00234
Program value of simulator port pp in digits:	ipp f9 a(-)xxxxx

Output programming and status: f3 P19

Pxx	Interface element	Variant	Value	P0.KA7531
00	Pt100 output	Controlled	300.0°C	00:TO0 COM +0300.0°C
01	Analog output 10V	Controlled	10.00 V	01:DA1 COM +10.000 V
01	Analog output 60mV	Controlled	60.00mV	01:DA7 COM +60.000mV
01	Analog output TC Type K	Controlled	1370.0°C	01:TC0 COM +1370.0°C VK:+025.1°C
01	Analog output TC Type N	Controlled	1300.0°C	01:TC1 COM +1300.0°C VK: - - -°C
01	Analog output TC Type J	Controlled	1000.0°C	01:TC2 COM +1000.0°C VK: - - -°C
01	Analog output TC Type T	Controlled	400.0°C	01:TC3 COM +0400.0°C VK: - - -°C
01	Analog output TC Type S	Controlled	1760.0°C	01:TC4 COM +1760.0°C VK:+025.1°C
01	Analog output TC Type R	Controlled	1760.0°C	01:TC5 COM +1760.0°C VK: - - -°C
01	Analog output TC Type B	Controlled	1800.0°C	01:TC6 COM +1800.0°C VK: - - -°C
02	Analog output 20mA	Controlled	20.000mA	02:DA2 COM +20.000mA
03	Frequency output 0.4kHz	Controlled	4000.Hz	03:FO0 COM +04000.Hz
03	Frequency output 10kHz	Controlled	10.00kHz	03:FO1 COM +010.00kH
03	Frequency output 40kHz	Controlled	40.0kHz	03:FO2 COM +0040.0kH
03	Frequency output 100kHz	Controlled	100.kHz	03:FO2 COM +00100.kH
03	Pulse output 99ms	Controlled	99.999ms	03:PO0 COM +99.999ms
03	Pulse output 99 s	Controlled	99.999 s	03:PO1 COM +99.999 s
04	Continuity voltage		1000.mV	04:IN0 +01000.mV

7.5.3 Menu configuration

G Enter designation text 1 (max. 21 characters)	f5	$Designation1 CR
G Enter designation text 2 (max. 21 characters)	f6	$Designation2 CR
G Enter menu title U1 (max. 16 characters)	f7	$Menu title U1 CR
G Enter menu title U2 (max. 16 characters)	f8	$Menu title U2 CR
G Enter menu title U3 (max. 16 characters)	f9	$Menu title U3 CR
G Output designation text 1		P37 ►Designation text 1
G Output designation text 2		P38 ► Designation text 2
G Output menu title U1		P39 ►Menu title U1
G Output menu title U2		P40 ►Menu title U2
G Output menu title U3		P41 ►Menu title U3
G Output empty line		P30 ►
G Output line		P31 ►--------------------

G **Select menu line** xx **ixx**

Selection of menu and function	**Menu U1**	**Menu U2**	**Menu U3**
G Limit value max	f1 o00	f2 o00	f3 o00
G Limit value min	f1 o01	f2 o01	f3 o01
G Base value	f1 o02	f2 o02	f3 o02
G Factor	f1 o03	f2 o03	f3 o03
*G Exponent	f1 o48	f2 o48	f3 o48
G Zero-point correction	f1 o04	f2 o04	f3 o04
G Gain correction	f1 o05	f2 o05	f3 o05
G Analog start	f1 o06	f2 o06	f3 o06
G Analog end	f1 o07	f2 o07	f3 o07
G Range	f1 o08	f2 o08	f3 o08
G Max value	f1 o09	f2 o09	f3 o09
G Min value	f1 o10	f2 o10	f3 o10
G Average value	f1 o11	f2 o11	f3 o11
G Print cycle	f1 o12	f2 o12	f3 o12
G Measuring cycle	f1 o13	f2 o13	f3 o13
G Time, date	f1 o14	f2 o14	f3 o14
G Measured value small	f1 o15	f2 o15	f3 o15
G Measured value medium	f1 o16	f2 o16	f3 o16
G Measured value large	f1 o17	f2 o17	f3 o17
G Measured value bar chart	f1 o34	f2 o34	f3 o34
G Measured value line graphic	f1 o35	f2 o35	f3 o35
G Averaging mode	f1 o18	f2 o18	f3 o18
G Measuring rate	f1 o19	f2 o19	f3 o19
G Print timer	f1 o20	f2 o20	f3 o20
G Measuring timer	f1 o21	f2 o21	f3 o21
G Count	f1 o22	f2 o22	f3 o22
G Number	f1 o23	f2 o23	f3 o23
G Range, designation	f1 o24	f2 o24	f3 o24
G Diameter mm	f1 o25	f2 o25	f3 o25
G Cross-section cm^2	f1 o26	f2 o26	f3 o26
G Volume flow m^3/h	f1 o27	f2 o27	f3 o27
G Max value time / date	f1 o28	f2 o28	f3 o28
G Min value time / date	f1 o29	f2 o29	f3 o29
G Empty line	f1 o30	f2 o30	f3 o30
G Line	f1 o31	f2 o31	f3 o31
G Smoothing	f1 o32	f2 o32	f3 o32
G Memory free	f1 o33	f2 o33	f3 o33
G Device designation	f1 o36	f2 o36	f3 o36

G Designation text 1	f1 o37	f2 o37	f3 o37
G Designation text 2	f1 o38	f2 o38	f3 o38
G Menu title U1	f1 o39	f2 o39	f3 o39
G Menu title U2	f1 o40	f2 o40	f3 o40
G Menu title U3	f1 o41	f2 o41	f3 o41
G Locking	f1 o42	f2 o42	f3 o42
G Atmospheric pressure in mb	f1 o43	f2 o43	f3 o43
G Temperature compensation	f1 o44	f2 o44	f3 o44
G Set point	f1 o45	f2 o45	f3 o45
G Measuring time	f1 o46	f2 o46	f3 o46
*G Measuring duration	f1 o47	f2 o47	f3 o47
*G Exponent	f1 o48	f2 o48	f3 o48
*G File name	f1 o49	f2 o49	f3 o49

G **Output of menu configuration** Ux:	fx P20
Menu title of menu Ux	U1:Menu title U1
In line 00: Function 30 empty line	00:30
In line 01: Function 39 menu title	01:39
In line 02: Function 16 measured value m	02:16
In line 03: Function 24 range, designation	03:24
....	04:30
	05:42
	06:45
	07:44
	08:43
	....

G **Output of the selected menu**	P20
(all functions e.g. measurement correction, see above)	►
Menu title	Meas. correction
Measured value medium	00: +025.67 °C
Range + Designation	Ntc Temperature
Empty line	
Locking	LOCKING:0.
Set point	SETPOINT: 00: +0000.0 °C
Temperature compensation	COMPENSATION: +0025.0 °C
Atmospheric pressure	ATM. PRESSURE: +01013. mb
......	

8 V7 functions and V7 protocol

8.1 ALMEMO® V7 measuring system

Building on the already self-sufficient ALMEMO® D6 connectors with serial interface (see chapter 3.1.2), the possibilities of independence from the measuring device have been consistently further developed and a completely new V7 measuring system has been created. The new generation of intelligent ALMEMO® D7 sensors can now provide completely new measured variables with any control and calculation functions or compensations on up to 10 channels.

All parameters, such as measured value correction, scaling, attenuation and compensations are processed internally and only the final measured value is transferred to the measuring device. The measuring speed can be between 1 millisecond up to minutes, the value range reaches up to 8 digits numerically or also alphanumerically. The special feature is that high-resolution, slow and fast variables can be recorded together in one measurement without any problems due to individual sampling rates.

The new sampling cycle is set to the shortest measuring time of all sensors. Sensors that cannot yet provide a measured value in the short query cycle are omitted, i.e. all measured values are recorded according to the speed of the sensors. Due to the parallel processing of the D7 sensors, a better temporal consistency and a much higher sum sampling rate up to 4 kHz is possible. The parameterization of individual sensor functions is done via a menu stored in the connector.

The D7 sensors only have the serial interface and can therefore in principle no longer be operated on old V6 devices. A new generation of ALMEMO® V7 measuring devices was therefore also required to support the new D7 sensors.

However, in addition to the new D7 sensors, all previously used analog and digital sensors can also be connected and evaluated on the ALMEMO® 710 touchscreen device. For the extension of the D7 sensors there are new interference-free extension cables ZAD700-VKxx with RS422 drivers up to 100m. For galvanic isolation short adapter cables ZAD700-GT are available.

8.2 Improvements and changes of the V7 system

8.2.1 Channel number and numbering of the sensors

The number of possible channels in the D7 sensor has been extended from 4 to 10. For this purpose, the measuring channel numbering is adapted, i.e. first comes the socket number and then the channel follows as an index with '.', so e.g. the first sensor on socket M000 has the channels 000.0 to 000.9, the second on M001 001.0 to 001.9 and so on.

The channels will now be interrogated on a sensor-by-sensor basis, which greatly improves the consistency of the corresponding measured values.

A query and configuration of the sensor programming can only be done when the measured value acquisition is stopped. Plugging and unplugging of sensors during a measurement is not allowed, i.e. it will not be recognized.

Device-internal channels are currently no longer provided.

Function	**Interface command**
Selection of the measuring channels Mxxx.x	Mxxx.x or short Mx.x
Selection of the input channels Exxx.x	Exxx.x or short Ex.x

8.2.2 Measurement speed

Query of the measuring channels

In order to continuously record the measured values of all measuring channels, to store max-min values, to check limit value violations and then to store them in the device, measuring channel queries are required.

All active standard sensors (analog, DIGI or D6) are continuously interrogated one after the other with the conversion rate of the AD converter of the measuring instrument. The conversion rate can be set to 2.5M/s, 10M/s, 50M/s or 100M/s.

Each D7 sensor has its own AD converter with its own conversion rate in its connector. The minimum measuring time resulting from this and other factors is fixed depending on the sensor (1 millisecond to minutes) and stored in the connector.

On the V7 measuring instruments MA710, MA500 and MA809, measurements can be made simultaneously with standard and D7 sensors. For querying all measuring channels of these different sensors, the new query cycle was created, which only records measured values that have been updated since the last query, i.e. in case of a short query cycle, only fast sensors appear for a long time, while the slow ones are added at longer intervals. This method allows the measuring device to adapt to very different sensors without repeatedly outputting or storing the same data.

Output of the measurement results

For all measuring instruments (V6 and V7), the output cycle is available for outputting the measurement results:

Output cycle: The output cycle is an internal cycle of the data logger for saving. It enables, for example, fast measured value acquisition with slow storage of the measured data (e.g. triggering fast limit value actions with slow measured data recording). The output cycle can be set from 1 s to 24 h.

For the V7 measuring instruments, in addition to the output cycle, the following cycles are also available for the output of the measurement results:

D7 Minimum time: The minimum time is selected to record very fast D7 sensors with the maximum speed (total sampling rate up to 4000 measurements per second). If even more measured values occur per second, the query cycle is automatically extended by 1ms each time, i.e. some of the fast measuring points may be dropped out.

D7 Optimal time: The optimal time is the shortest cycle that can always be maintained with the present sensor configuration.

Conversion time: This query cycle corresponds to the conversion rate for the standard connectors (see above), i.e. normally one channel from one standard connector and all D7 channels updated in time with time stamp are acquired each time. However, after a run of the channels of all standard connectors at least one special measurement follows for self-calibration of the AD converter of the ALMEMO® device. If thermocouples are connected, 2 additional internal measurements are performed for cold junction measurements.

Scan time: The scan time is the time required by the measuring instrument to perform a single scan of all measuring channels of the standard sensors. It results from the number of channels to be measured and the set conversion rate. To this must be added the time for a special measurement and, in the case of thermocouples, the time for two cold junction measurements.

D7 Maximum time: This is the shortest query cycle in which all measuring channels were always queried and therefore also appear. It is based on the slowest sensor.

The resolution of the timestamp is always based on the query cycle. For the conversion rate there is a new command independent of the output flags. However, the output in the query cycle is activated as before via the output flags 'save continuously' and 'output continuously'.

The 'semi-continuous measuring channel query' is no longer supported.

Function	Interface command
Conversion rate:	**Wx** (0=2.5, 1=10, 2=50 ... M/s)
Minimum measuring time per sensor in s:	**f1 Txxxx.xxx** (max. 2.7h)
Desired query cycle per sensor in s:	**f2 Txxxx.xxx** (max. 2.7h)
Query cycle of the device in ms:	**Txx.xxx** (max. 99s)
Output query cycle:	**f1 P19 Z3:xx.xxx s ...**
Output suggestions for query cycle:	**P50**
Minimum time	**C1:O.OO2**
Optimal time	**C2:O.OO4**
Conversion time	**C3:O.1**
Scan time	**C4:1.1**
Maximum time	**C5:3**

8.2.3 Range of measured values

The range of measured values has been extended from ±65000 to up to 8 digits plus sign. Also non-numeric characters, times or coordinates can be used. Therefore the output to interface and memory is only possible as ASCII string in table format.

In order to be able to store such measured values also in the internal memory, the table format is also newly introduced there as memory format. The input commands for all corresponding parameters are modified. The number of digits and the number of decimal places are defined in the sensor for each channel. Thus the input commands can be used as before but with suitable number of digits.

Function	Interface command	Abbreviation
Enter number length	**Kx**	**K**
Enter range comma	**f1 Kx**	**1K**
Enter base value	**Oxxxxx.x**	**O**
Enter factor	**Fx.xxxxx**	**F**
Enter zero point	**f1 Oxxxxx.x**	**1O**
Enter gain	**f1 Fx.xxxxx**	**1F**
Enter limit value max	**Hxxxxx.x**	**H**
Enter limit value min	**Lxxxxx.x**	**L**
Enter analog start	**axxxxx.x**	**a**
Enter analog end	**exxxxx.x**	**e**

8.2.4 Measuring ranges

All D7 sensors normally have their own individual digital measuring ranges, which do not belong to the V6 standard ranges. However, the assignment can be called up via serial commands, so that they can be entered normally in the device via the keyboard. Alternatively, they can be programmed via the interface of the measuring instrument or via an adapter cable on the PC. The range abbreviations can be up to 6 digits.

Function	Interface command
Output range list	**P64**
	B\-01$D t ;1$\°C;2$\T,t;1K\2;1H\200;1L\-100
	B\-02$D Uw;1$\%H;2$\RH,Uw;1K\1;1H\100;1L\0
Enter measuring range	**B-xx**

8.2.5 Dimension and designation

Dimensions can now be entered with 6 digits and designations with 20 digits. The commands are unchanged.

Function	Interface command
Enter dimension (max. 6 digits)	**f1 $xxx... CR**
Enter designation (max. 20 digits)	**f2 $xxx... CR**

8.2.6 Configuration of ALMEMO® D7 sensors

The configuration of each D7 sensor with its own previously possibly unknown parameters or ranges is done by an individual sensor menu provided by the sensor. In the measuring device, a separate sensor menu appears in the display for each D7 sensor. The programming of the parameters is done as usual.

Function	Interface command
Output sensor menu	**P61 CR**
Line 00, Instructions..	**iOO_^1O;!$Sensor menu**
Output sensor variables	**P63 CR**
a\Value;b\Value...	**a\1;b\2;c\3;...**
Program variable x to value yy	**vx\yy CR**

8.2.7 Sleep extension

Most sensors are ready for measurement after switching on and initializing the measuring instrument. If the readiness takes longer, especially in the sleep mode you have to wait for a while after switching on until the correct measured values are available, this time is called 'sleep extension'. It is also a characteristic of the sensor and has also been integrated into the measuring channel programming. Thus, the V7 device can also automatically determine the longest sleep extension among all sensors and set it accordingly.

Function	Interface command	Abbreviation
Sleep extension in s of Exxx.x	**Ex.x f3 uxxx**	**3u**

8.2.8 Setpoints

Setpoints used to be a problem because they were only momentarily assigned to one measuring channel in terms of decimal point and dimension. For this reason, the setpoints in V7 devices are integrated into the respective measuring channel programming (also of V6 sensors) and are already programmed with the standard setpoints in many sensors (pressure, pH, conductivity, etc.). The entry SW: xxxxx in the command f1 P19 is omitted.

Function	Interface command	Abbreviation
Enter setpoint of Exxx.x	**Ex.x f2 gxxxxx.x**	**2g**

8.2.9 Alarm relays of limit values

The **f1 hx** and **f1 lx** commands for relay assignment are no longer used.

Instead, there are now the commands f2 Rpp and f3 Rpp for up to 100 relays.

8.2.10 Change input multiplexer

Up to now the multiplexer could only be changed by a new range programming. Thereby all programmed parameters were deleted. Now there is a new command that only influences the multiplexer.

Function		Interface command	Abbreviation
Set multiplexer on	B-A	**f2 m1**	**2m\1**
	C-A	**f2 m2**	**2m\2**
	D-A	**f2 m3**	**2m\3**
	C-B	**f2 m4**	**2m\4**
	D-B	**f2 m5**	**2m\5**

8.2.11 Entering calibration values

The entry of calibration values for V6 sensors was previously only possible via direct EEPROM programming, i.e. they only became effective after the sensor was unplugged and plugged in. Now there are separate commands:

Function	Interface command	Abbreviation
Enter calibration offset	**f2 Oxxxxx**	**2O**
Enter calibration factor	**f2 Fxxxxx**	**2F**

The same commands apply to V7 sensors, but only with selection of the primary channels via a USB data cable ZA1919-AKUV.

8.2.12 Memory

For all V7 devices, the memory format has been changed to table format for both the internal and the external memory (memory connector).

Here, the new configuration is now also saved with a configuration number for each configuration change, as long as no ring memory is set. Only one configuration is supported for the ring memory.

Also new is a designation line for the measurement (max. 64 characters), which appears before the normal header. The list of configurations can be queried in the same way as the numbers list. All configurations, numbers and each date are stored in a separate index list and can therefore be found very quickly. There is a separate command for ending the memory output, so that the measurement is not stopped unintentionally.

Function	Interface command
Enter the memory designation:	f-4 $Designation of the measurement
Output of the configuration list:	f2 P05
	CONFIGLIST:
	$01-000 ...
Select configuration:	$01-000
Cancel memory output only with:	f1 X

8.2.13 Query of the sensor programming

For the output of the new extended sensor parameters, there is the P15 command in table mode, which outputs all programmed values with leading and trailing zero suppression, each with preceding command abbreviation (function number + command character), so that the input command can also be derived from it. Non-programmed values and default values are omitted (factors default=1).

However, in the heading all available functions are listed as abbreviations.

P15 M;B;K;1K;H;L;O;1$;F;V;m;2$;1z;Q;2R;3R;1O;1F;1k;1m;2O;2F;a;e;1E;
2E;2m;2k;h;l;z;u;2K;1T;2T;3K;3u;2g
M\O.O;B\-O1$D Flow;K\5;1K\O;H\5OO;L\3O;1$\ml;2$\Volume;u\6;1T\1

The programming of only one measuring channel is obtained with the command:

POO M\O.O;B\-O1$D Flow;K\5;1K\O;H\5OO;L\3O;1$\ml;2$\Volume;u\6;1T\1

Special features:

The range abbreviation with up to 6 digits follows the range number with separator $ up to the semicolon: e.g.
B\-O1$D Flow;

Some parameters are no longer displayed as a string but only as a number:

Average value mode:	Averaging none	**m\O**	(----)
	Continuous	**m\1**	(CONT)
	Cyclic	**m\2**	(CYCL)
Output function:	Measured value	**1m\O**	(MEAS)
	Difference	**1m\1**	(Diff)
	Max value	**1m\2**	(Max)
	Min value	**1m\3**	(Min)
	Average value	**1m\4**	(M(t))
	Alarm value	**1m\5**	(Alrm)
Multiplexer:	B-A	**2m\1**	(M1)
	C-A	**2m\2**	(M2)
	D-A	**2m\3**	(M3)
	C-B	**2m\4**	(M4)
	D-B	**2m\5**	(M5)
Limit value action:	Only alarm	**h\O**	(-)
	Start	**h\1**	(S)
	Stop	**h\2**	(E)
	Manual	**h\3**	(M)
	Zero-set timer	**h\4**	(T)
	Call up macro 5...9	**h\5**...**9**	(5...9)

Element flags are also specified with their ASCII value, possibly several in a row: e.g. flags 1,5,8
2k\1;2k\5;2k\8

8.2.14 Query of the device programming

In the device programming, the number of possible measuring channels and the active V6 (A) and D7 (D) are displayed as four digits. The query cycle (Z3) is new. The single setpoint (SW) is omitted in this command:

```
f1 P19   ...
         GE.GOO MO1OO AOO18 DOOO5
         ...
         Z3:OO.25O s
         ...
```

8.2.15 Measuring channel query

When starting a cyclic measuring channel query with header, the header is now output as for memory in table mode. Non-numeric measured values are placed in quotation marks.

```
S3        "V7";"RANGE:";"Ntc ";"% rH"
          "8O9";"DESIGNATION:";"Temperature";"Humidity";"GPS"
          ;"LIM-MAX":;3O
          ;"LIM-MIN":;;12
          "DATE";"TIME";"MO.O °C";"MO.1 %H"
          12.O3.O6;12:OO:OO;25,3;39,9;"E011°42.1947"
          ;12:O1:3O;25,5;4O,7;"E011°42.1947"
```

Even when operating with a data acquisition software on the PC, the measuring channel query must be started with:

```
f1 s      "V7";RANGE:";"D °C";"D RH";....
          "71O";"DESIGNATION:";"Temperature";....
          ;"LIM-MAX:";3O;....
          ;"LIM-MIN:";18;....
          ;;"MO.O °C";"MO.1 %H";"M0.2 °C";"MO.3 g/kg"
          ;S;23,5;54,6;-1O,3;5,8          S = Sign for started
          ;X;23,5;54,6;-1O,3;5,8          X = Sign for stopped
```

8.2.16 Measured value list

Also the list of all measured, max, min and average values with number and max and min time/date is now output in table mode.

At the end of each line follow the measurement flags:

O = Overrange
U = Underrange
H = Limit value exceedance
L = Limit value undercut
B = Sensor breakage
F = Sensor voltage low
W = Reference resistance on
R = Relative measurement
M = Averaging

```
f1 P18
CH;MEAS-VALUE;MAX-VALUE;MIN-VALUE;AVERAG-VALUE;COUNT;MAX-TIME;MAX-DATE;MIN-TIME;MIN-DATE
0.0;20,044;150,007;20,038;-;0;02:31;05.01;02:32;05.01;
0.1;26,961;27,017;26,952;-;0;02:33;05.01;02:45;05.01;HM
```

Only 1 measuring channel:
MO.1 P18
0.1;26,961;27,017;26,952;-;0;02:33;05.01;02:45;05.01;HM

8.2.17 Averaging time

As with D6 sensors, most primary channels can be attenuated simultaneously with an averaging time in s, since there is usually no reference to the measuring rate. The input is only possible on the device via the sensor configuration menu.

Interface input only with PC and USB adapter cable ZA1919-AKUV:

Function	Interface command
Select primary channel	**E-xx**
Enter averaging time in s	**f3 Txx.xx**

8.2.18 Compatibility

All old sensors (analog, digital freq, pulse, DIGI, D6) can be used on the V7 device 710 without restrictions.
D7 sensors, on the other hand, cannot be operated on a V6 device.

8.2.19 Extension cable

D7 sensors have only one serial interface, which can be easily extended over long distances using a cable with RS422 drivers. A protocol conversion is not necessary. For galvanic isolation there are corresponding adapter cables ZAD700-GT.

8.2.20 Protocol changes

Due to the extended range of measured values, all parameters are also processed in the corresponding variable. Therefore only the table mode is used for the transmission of these variables. The command output format Nx is omitted. The quotation marks (") are omitted for time and date. Non-numeric measured values are placed in quotation marks ("). Measurement channels are displayed with dot and leading zero suppression (xxx.x). The V6 CRC protocol is retained for compatibility reasons, only differentiation of the k flag with a parameter specifying the configuration change is provided.

Response: gg id Fx k<u>x</u> (x: 1=sensor, 2=device, 4=periphery, 8=memory, oderation = sum resp. decimal value 4+8=12)

8.3 Command overview V7 protocol

8.3.1 Measured value processing

Function assignment

N	New function	D^7	Also D7 sensors
!	Input format changed	D^{7*}	D7 sensor programming to trigger a device function/action
F	Output format changed		

Function		**Command**,	►: Response
! D^7 Select measuring channel xx (incl. input channel)			Mxxx.x
! D^7 Only select input channel xxxx			Exxx.x
! D^7 Select reference channel 1 xxxx		f1	Exxx.x
! D^7 Select reference channel 2 xxxx		f2	Exxx.x
F D^7 Output measured value from measuring channel (without new query)			p ►0.0;23.5;°C
F D^7 Output measured value from input channel (without new query)			P01 ►12:34:00;0.0;23.5;°C
D^7 **Zero measured value** (base value)	Mxxxx		C01
D^7 Zero meas. value temp. (only in RAM)	Mxxxx	f5	C01
D^7 Sensor calibration (zero point and gain)	Mxxxx	f1	C01
Zero-set timer 3 (1s)		f3	C01
Zero-set timer 4 (0.1s)		f4	C01
Calibration switch (off) / on			o(-)01
D^7 Enter **setpoint**	Exxxx	f2	gxxxxx.x
D^7 Setpoint adjustment	Mxxxx	f2	C01
Enter **temperature comp.** in 0.1°C		f1	gxxxxx
Delete temperature compensation (25°C)			C44
D^7 Define temperature sensor for TC		f2	$*T.... CR
D^7 Enter **air pressure** in mbar for comp.			g0xxxx
Delete air pressure (switch to sensor)			C43
D^7 Define air pressure sensor as reference		f2	$*P.... CR
D^7 Define temperature sensor as CJC		f2	$*J.... CR
Peak values:			
Delete maximum value			C02
Delete minimum value			C03
Averaging:			
D^7 Delete average mode			m0
D^7 Average mode continuous			m1
D^7 Average mode cyclic			m2
Delete average value			C14
Attenuation (number of averaged values)		f1	zxx
D^7 **Averaging time** only for D7 sensors	E-xxxx	f3	Txx.xx
Volume flow measurement:			
D^7 Enter cross section in cm^2 for volume			Qxxxxx

8.3.2 Measurement channel queries, measurement data acquisition and output

8.3.2.1 Process control

Enter **time**		Uhhmmss
Delete time		C10
Enter **date**		dddmmyy
Delete date		C13
Enter **start time of the measurement**	f1	Uhhmmss

Enter **start date of the measurement**	f1	dddmmyy	
Delete start time and date	f1	C10	
Enter **end time of the measurement**	f2	Uhhmmss	
Enter **end date of the measurement**	f2	Dddmmyy	
Delete end time and date	f2	C10	
Enter **measuring duration**	f2	Ihhmmss	
Delete measuring duration		C47	
Enter **output cycle**		Zhhmmss	
Switch saving in cycle (off) / on	f1	A(-)4	
Delete cycle		C11	
Conversion rate and mode:			
N Conversion rate 2.5 M/s continuous		W0	W003
N Conversion rate 10 M/s continuous		W1	W010
N Conversion rate 50 M/s continuous		W2	W050
N Conversion rate 100 M/s continuous		W3	W100
N Conversion rate 400 M/s (option)		W4	W400
N Conversion rate 500 M/s (option)		W5	W500
N Enter **query cycle** in s		Txx.xxx	
N Suggestions for query cycle in s		P50	
Minimum time (total D7 minimum times)		C1:0.002	
Optimal time (number of total D7 channels x 1ms)		C2:0.004	
Conversion time (1/conversion rate)		C3:0.1	
Scan time (incl. special measurements, CJC)		C4:1.1	
Maximum time (of D7 sensors or scan time)		C5:3	
Switch continuous saving (off) / on	f5	k(-)4	S
Switch continuous output (off) / on	f5	k(-)5	U
Query mode:			
Switch on normal mode	f1	A0	
Switch on monitor mode	f1	A1	M
Switch fail-safe mode (off) / on	f1	A2	F
Switch on sleep mode	f1	A3	s
Enter **number** numerically (6 dig.)		nxxxxxx	
Enter with letters (-, ,A,F,N,P)	f3	$A1-N02	
Increment number		n+	
Output number		P05	
		►NUMBER: A1-N02	
Enter file name (max. 8 characters)		$Name CR	
File name for automat. daily files		$&Name CR	

8.3.2.2 One-time manual measuring channel query and output

D^7 **Command**	S1
Table format	►01.03.12;12:30:00;23,5;54,6;-10,3;5,8
D^7 dto. without time and date	s
X=stopped, S=started	►;X;23,5;54,6;-10,3;5,8
F With measurement start	f1 s
	►"V7";"RANGE:";"D °C";"D RH";....
	"710";"DESIGNATION:";"Temperature";....
	;"LIM-MAX:";30;....
	;"LIM-MIN:";18;....
	;;"M0.0 °C";"M0.1 %H";"M0.2 °C";"M0.3 g/kg"
	;S;23,5;54,6;-10,3;5,8
S=started	
Output of further modules	G01, G02, G..
	►;;123,4;25,2

8.3.2.3 Start cyclic measuring channel query and output

Command	S2
Table format	►01.03.12;12:00:00;25,3;39,9;"NNO"
Non-numerical values in ""	;12:01:30;25,5;40,7;"NNO"

Start and output with program header:

Command	S3
	►"V7";"RANGE:";"Ntc ";"% rH";"D Ds"
	"809";"DESIGNATION:";"Temperature";...
	;"LIM-MAX:";30
	;"LIM-MIN:";;12
	"DATE";"TIME";"M0.0 °C";"M0.1 %H";"M1.0"
	12.03.06;12:00:00;25,3;39,9;"NNO"
	;12:01:30;25,5;40,7;"NNO"
Stop cycl. query	X

8.3.2.4 Output running measured values

N To **display all measured values** with channel, overflow character, range and designation as a list, there is the command:

	f1 P35
	►0.0;;27,044;°C;P304;HT
	1.0;;26,962;°C;P304;TT
Overflow	1.1;>;100;%H;P2RH;r. Humidity
	2.0;;942,6;mb;AP ;Air pressure
N Only one channel:	Mx.x P35
Limit value exceedance	1.1;!;54,27;%H;P2RH;r. Humidity

Extended measured, max, min, average values with time and date of all channels:

Command f1 P18

F► CH;MEAS-VALUE;MAX-VALUE;MIN-VALUE;AVERAG-VALUE;COUNT;MAX-TIME;MAX-DATE;MIN-TIME;MIN-DATE

0.0;20,044;150,007;20,038;-;0;02:31;05.01;02:32;05.01

1.0;26,961;27,017;26,952;-;0;02:33;05.01;02:45;05.01

N Only one channel: Ex.x P18

1.0;26,961;27,017;26,952;-;0;02:33;05.01;02:45;05.01

8.3.3 Measured value memory outputs

Output memory space	f1	P04
(S=total, F=free, A=start-end, R=ring memory)		►MEMORY: S0500.3 F0312.4
Output version SD connector	f4	t0 ►SD 3.11
Output table header	f2	P04 (s. memory output in table format)
Delete memory, format SD card		C04
Delete memory and all measured data	f1	C04
N Enter designation for measurement:	f-4	$xxxxxxxxxxxxxxxxx (64 characters)
Output **total memory**		P04
Set start and end of memory output:		
Enter **start date**	f3	dddmmyy
Delete start date	f3	C13
Enter **end date**	f4	dddmmyy
Delete end date	f4	C13
Output **section** start to end	f3	P04

Selectively output **memory area with number identification**:		
Enter **number** with letters	f3	$A1-N02
Test if number is in the memory		t4
►OK or ERROR		
Output numbers list	f1	P05 ►NUMBER: 110001 110002 A1-N02 ....
N Output file list	f2	P05 ►FILELIST: $000001 $000002 ...
N Select configuration		$000001
Output memory after activation		P04

F ►MEMORY:

```
"ALMEMO";"K";"Here can be a designation for the measurement"
"V7";"RANGE:";"Ntc";"% rH"
"710";"DESIGNATION:";"Name";"Water"
"SD3.11";LIM-MAX:";"123,4"
"$000001";"LIM-MIN:";;12,
"DATE";"TIME";"M0.1 °C";"M0.2 °C"
"NUMBER:";"012345"                 if programmed
12.03.06;12:00:00;12,;9,9
12.03.06;12:01:30;12,5;10,7
```

N Cancel memory output f1 X

Function		Command
Output all memory data:	f4	P19
Memory space internal (R=ring memory)		►SI:0512.4k R
Memory space external		SE:256.00M
Memory free		SF:0324.5k
Remaining memory time: dddd.hh:mm		SZ:0001.18:20
Start date of the memory output		D3:01.02.06
End date of the memory output		D4:02.02.06
File name new file		DT:FILENEW.001
File name current file in memory		FI: ALMEMO.001
Designation of the measurement (max. 64 Byte)		KO:A Designation A=Active, -=inactive

8.3.4 Sensor programming

Function		Command	
D^7 **N** Select input channel Exx		Exxx.x	(x.x)
D^7 **N** Reference channel 1 b1 absolute	f1	Exxx.x	
N Reference channel 1 b1 relative	f1	E-xxx.x	
D^7 **N** Reference channel 2 b2 absolute	f2	Exxx.x	
N Reference channel 2 b2 relative	f2	E-xxx.x	
D^7 **Dimension change** ´xyz´(≤ 6 Z.)	f1	$xyz CR	
D^7 **Measuring channel name** ´Name´(≤ 20 Z.)	f2	$Name CR	

8.3.4.1 Measuring ranges changed compared to V6 (Dr. Sonntag formula)

Mixture cap. with PC	0..6500.0 g/kg	B43	H r
Dew point cap.	-25..100.0 °C	B44	H td
Vapor pressure cap.	300..1100 mbar	B59	H e
Enthalpy cap. with PC	0..6500.0 kJ/kg	B58	H h
Rel. humidity psychr. with PC	0..100.0 %	B46	P Uw
Mixture psychr. with PC	0..6500.0 g/kg	B47	P r
Dew point psychr. with PC	-25..100.0 °C	B48	P td
Vapor pressure psychr. with PC	0..1050 mbar	B49	P e
Enthalpy psychr. with PC	0..6500.0 kJ/kg	B57	P h
Abs. humidity cap. and psychr.	0..596.3 g/m^{3}3	B87	D dv
Rel. humidity from t and td	0..100.0 %	B68	tdUw

8.3.4.2 Measured value scaling and correction

D^7 **!** Enter base value		O(-)xxxxx.x (acc. to number length)
D^7 Delete base value		C06
D^7 **!** Enter factor		Fx.xxxxx
D^7 Delete factor		C07
D^7 Enter exponent		Vx
D^7 Delete exponent		V0
D^7 **!** Enter zero point correction	f1	O(-)xxxxx.x
D^7 Delete zero point correction	f1	C06
D^7 **!** Enter gain correction	f1	Fx.xxxxx
D^7 Delete gain correction	f1	C07
D^7 **N** Enter number length x characters		Kx
D^7 **N** Enter range comma	f1	Kx

8.3.4.3 Limit values

Function		**Command**
D^{7*} **!** Enter limit value max.		H(-)xxxxx.x
D^{7*} Delete limit value max.		C08
D^{7*} **Action limit value max.** only alarm		h0
D^{7*} Action measuring channel query start		h1
D^{7*} Action measuring channel query stop		h2
D^{7*} Action measuring channel query manual		h3
D^{7*} Action zero-set timer		h4
D^{7*} Action call up macro 5..9		h5..h9
D^{7*} Action limit value relays port pp (off) / on	f2	R(-)pp
D^{7*} **!** Enter limit value min.		L(-)xxxxx
D^{7*} Delete limit value min.		C09
D^{7*} **Action limit value min.** only alarm		l0
D^{7*} Action measuring channel query start		l1
D^{7*} Action measuring channel query stop		l2
D^{7*} Action measuring channel query manual		l3
D^{7*} Action zero-set timer		l4
D^{7*} Action call up macro 5..9		l5..l9
D^{7*} Action limit value relays port pp (off) / on	f3	R(-)pp

8.3.4.4 Special functions

D7 **Sensor locking** none	f1	k0
Measuring range, element flags	f1	k1
Measuring range, zero-point, gain	f1	k2
Measuring range, dimension	f1	k3
+ Zero-point, gain	f1	k4
+ Base, factor, exponent	f1	k5
+ Analog output start-end	f1	k6
+ Limit values	f1	k7
D7 completely	f1	kx (x>0)
Lock sensor permanently	f8	kx
Cancel permanent lock	f-8	kx
D7* **!** Enter **analog output** start		a(-)xxxxx.x
Delete analog output start		C16
D7* **!** Enter analog output end		e(-)xxxxx.x
Enter analog output end (4-20mA)	f1	e(-)xxxxx.x
Delete analog output end		C17
Print cycle factor		zxx
D7 Minimum sensor supply voltage		uxxx
D7 Enter sleep delay xxx in s	f3	uxxx
D7 Enter min. query time per sensor in s	f1	Txxxx.xxx (max. 2.7h)
D7 Enter desired query time per sensor in s	f2	Txxxx.xxx (max. 2.7h)
Output **serial number** of sensor	f3	t0 ►yymm1234
D7 Enter sensor **calibration cycle** (Mon.)	f9	zmm
D7 Enter next sensor **calibration date**	f9	dddmmyy

Function		**Command**	
N Change multiplexer	B-A	f2	m1
	C-A	f2	m2
	D-A	f2	m3
Difference	C-B	f2	m4
	D-B	f2	m5
D7* **Output function**	Measured value	f1	m0
	Difference	f1	m1
	Max value	f1	m2
	Min value	f1	m3
	Average value	f1	m4
	Alarm value	f1	m5
Reset/set element flags	Meas. current 1/10	f2	k(-)1
Activation bridge switch	Bridge	f2	k(-)3
DIGI only cycl. query	DIGI cyclic	f2	k(-)4
Switch off galv. isolation	Iso off	f2	k(-)5
Without sensor break detection	Sensor break	f2	k(-)7
Analog output 0/4-20mA	4-20mA	f2	k(-)8
Delete all element flags		f2	k0
D7* **N Reset/set additional flags**			
Cold junction comp. in output	1=CJC	f2	K(-)1
Temp. compensation in output	2=TC	f2	K(-)2
Air pressure compensation in the output	3=PC	f2	K(-)3
Transfer ext. temp. compensation	4=TCE	f2	K(-)4
Transfer ext. air pressure compensation	5=PCE	f2	K(-)5
Measuring range with non-numerical data	6=TXT	f2	K(-)6
Delete all additional flags		f2	K0
Read in sensor programming again			t5

8.3.4.5 Output of the sensor programming

D7 **N V7 Measuring channel programming** P15
►M;B;K;1K;H;L;O;1$;F;V;m;2$;1z;Q;2R;3R;1O;1F;1k;1m;2O;2F;a;e;1E;2E;2m;
2k;h;l;z;u;2K;1T;3K;3u;2g
M\0.1;B\-01$D °C;**K\5;1K\1**;H\123,4;L\12;1$\°C;m\2;2$\Temperature;1z\10;
Q\78;2R\20;1k\5;2F\32000;e\1000;1E\-0.1;2m\1;h\1;l\2;z\5;u\12**;1T\.1;3K\2**
M\0.2....
D7 **N** Only input channel P00
►M\0.1;B\-01$D °C;**K\5;1K\1**;H\123,4;L\12;1$\°C;m\2;2$\Temperature;1z\10;
Q\78;2R\20;1k\5;2F\32000;e\1000;1E\-0.1;2m\1;h\1;l\2;z\5;u\12**;1T\.1;3K\2**

N Sensor programming f4 P15
► ST;SENSOR;SERIALNR;CAL-DAT;ZY
0;FHA6461;12345678;01.10.12;12;! (!=Calibration date exceeded)
1;F....
D7 **N** Only one sensor Ex.0 f4 P00
► 0;FHA6461;12345678;01.10.12;12;-
D7 Read in the entire connector programming again t5

8.3.4.6 Direct access to the D7 sensors, resp. via V7 device:

D7 N Output sensor configuration: P61
i00 _^10;!$FHAD46P
M00
i01 !$1.:_2;?a\T\---- |T,t °C |RH,Uw %H |DT,td °C |MH,r g/kg |AH,dv g/m3 |VP,e mbar |En,h kJ/kg
M01
i02 !$2.:_2;?b\T\---- |T,t °C |RH,Uw %H |DT,td °C |MH,r g/kg |AH,dv g/m3 |VP,e mbar |En,h kJ/kg
M02
i03 !$3.:_2;?c\T\---- |T,t °C |RH,Uw %H |DT,td °C |MH,r g/kg |AH,dv g/m3 |VP,e mbar |En,h kJ/kg
M03
i04 !$4.:_2;?d\T\---- |T,t °C |RH,Uw %H |DT,td °C |MH,r g/kg |AH,dv g/m3 |VP,e mbar |En,h kJ/kg
i06 !$Airpressurecomp.:;_>17;?e\T\Manual|Sensor
i07 _1;!$Value:;_>17;?f\N\4.0|L300|H6500;_18;!$mb
i08 _1;!$Reference *P:;_>17;?g\Y\0
i10 !$Timeconstant:;_>17;?h\N\4.2|L100|H9999;_18;!$s
D7 N Output of the sensor variables: P63
a\1;b\2;c\3;d\8;e\1;f\934;g\0;h\1

D7 N Input parameters of the variables x:
Enter numbers a=12.3 va\12.3 CR
Enter text b=Text vb\Text CR
Enter logical c=1 (1, yes etc.) vc\1 CR
Enter softkey conditions key 0 (F1)=1 vK0\1 CR

D7 **N Possible D7 and D6 range numbers**
With range abbreviation, dimension,
designation, comma and range limits: P64
B\-01$D t ;1$\°C;2$\T,t;1K\2;1H\200;1L\-100
B\-02$D Uw;1$\%H;2$\RH,Uw;1K\1;1H\100;1L\0
B\-03$D td;1$\°C;2$\DT,td;1K\1;1H\6500;1L\-100
B\-04$D r ;1$\gk;2$\MH,r g/kg;1K\1;1H\6500;1L\0
B\-05$D dv;1$\gm;2$\AH,dv g/m3;1K\1;1H\6500;1L\0
B\-06$D e ;1$\mb;2$\VP,e mbar;1K\1;1H\6500;1L\0
B\-07$D h ;1$\kJ;2$\En,h kJ/kg;1K\1;1H\6500;1L\0
B\-08$D p ;1$\mb;2$\AP,p mbar;1K\1;1H\6500;1L\300

D[7] N **Ranges of all channels** (deleted: B\-00):

```
P65
M\0.0;B\-01
M\0.1;B\-02
M\0.2;B\-03
M\0.3;B\-04
M\0.4;B\-00
M\0.5;B\-06
M\0.6;B\-08
M\0.7;B\14
```

D[7] N **Primary meas. channels**, range numbers and display of a multipoint linearization

```
f1 P65
E\-00;B\-01;L\!
E\-01;B\-02
E\-02;B\-08;L\!
```

D[7] **N Output info list** (only sensor directly)

P60

Info list

B14	Batt
B71	Diff
B72	Max
B73	Min
B74	M(t)
B75	M(n)
B80	Alrm
B81	Meas
B83	n(t)
B85	Time
B-01	D t
B-02	D Uw
B-03	D td
B-04	D r
B-05	D dv
B-06	D e
B-07	D h
B-08	D p
f1 b6	9600 bd
f1 b7	57600 bd
f1 b8	115200 bd
f1 b9	230400 bd
f1 b0	460800 bd
f1 b1	921600 bd

D[7] **N General parameters, primary channels, calibration values, time constant, ranges resp. designations (only sensor directly)**

```
P69
Minimum sensor voltage  : 6.0 Volt
Refresh time            : 2.0 s

Primary channel         : E-00
Range                   : T,t
Time constant           : 2.00 s
Calibration factor      :  1,0000
Calibration offset      : +    0, Digit

Primary channel         : E-01
Range                   : RH,Uw
Time constant           : 2.00 s
Calibration factor      :  1,0000
Calibration offset      : +    0, Digit

Primary channel         : E-02
Range                   : AP,p mbar
Time constant           : 0.00 s
Calibration factor      :  1,0000
Calibration offset      : +    0, Digit

Primary channel         : E-03
Range                   : Tp,t
Time constant           : 0.00 s
Calibration factor      :  1,0000
Calibration offset      : +    0, Digit

1.  M00 :T,t
2.  M01 :RH,Uw
3.  M02 :DT,td
4.  M03 :AP,p mbar...
```

8.3.5 Device programming

	Command		**Printout**
D[7] Select device/module, output measured values		Gxx	After query
Select device/module, output measured values		j	Without query
D[7] Program module address of <u>one</u> sensor	f9	Gxx	
D[7] Software reset, EEPROM, RAM and ports	f1	C19	
D[7] Reinitialization delivery state	f2	C19	
D[7] Enter device designation (max. 40 characters)	f4	$Device designation CR	
D[7] Output device designation	f1	t0 ►Device designation	
D[7] Output device type and version		t0 ►A8590-9 6.xx	
Query available functions: Memory, connector/MMC, start-end, ring memory, sleep, CRC, KL | Version		t6 ►S-ARLCK|7	
Query sensor type, channel number, linearization sensor, type, analog / digital channels, linearization	**f1**	**t7** **►O;T\V6;A\3;L\!** **1;T\D7;D\5**	
D[7] Output **serial number** of device	f2	t0 ►Hyymm1234	
Enter next **calibration date**	f8	dddmmyy	
Enter hysteresis for alarm processing		Yxx	
Enter language (D=0, E=1, F=2, X=3)		kx	
D[7] Change baud rate (6=9.6, 7=57.6, 8=115.2kb)	f1	bx	
D[7] Set sensor supply voltage	f1	uxxx	
Enter sleep delay xxx in s	f2	uxxx	
Operating parameters:			**CONFIG:**
60Hz Hum suppression	f6	k(-)1	F
Delete max, min, average values at start	f6	k(-)2	C
Ring memory	f6	k(-)3	R
Allow oversampling of measured value query	f6	k(-)5	A
Switch off signal transmitter	f6	k(-)6	S
Enter macros 5..9 (max. 30 characters)	f-5	$bx1|bx2 CR	
Call up macros 5..9	...-9	m-5...-9	

	Command		Printout
Output all macros 5..9	f5	P19 ►M5:bx1|bx2 M6:bx...	
Set **V6 peripheral port** pp (A1=1p, A2=2p..)	ipp		
Switch relay port pp (off) / on		f1 R(-)pp	
Set relay variant x of port pp (- = inverse)	ipp	f9 k(-)x	
Trigger function of port p8 (macro 5..9)	ipp	f9 kx (k-5..k-9)	
Select analog type of pp 1=10V, 2=20mA	ipp	f9 Ax	
Program analog value output of pp	ipp	f9 a(-)xxxxx	
Reference channel of port pp (analog output)	ipp	f9 Exxx.x	
Switch watchdog on / (off)	i20	o(-)19	

8.3.5.1 Output of the device parameters

D^7 **V5 output**	P19
F Address, channels possible, active V6, D7	DEVICE: G00 M0020 A0008 D0005
Air pressure see chapter 6.2.5	AIR PRESSURE: +01013. mb
Cold junction temperature	CJ TEMP: +0023.5 °C
LoBat and sensor voltage	U-SENSOR: ! 12.5 V
Hysteresis see chapter 6.2.6	HYSTERESIS: 10
Configuration see chapter 6.10.13, 6.10.7	CONFIG: FCRDAS-8 -L-- B01 ax.
Alarm status of the relays 0..3 see chapter 6.10.8	ALARM: -1-3
Output module on A1 see chapter 6.10.9	A1: DK0 U
Output module on A2	A2: AA

Output all fixed device parameters:	f1	P19
Device designation:		►GB:AMR ALMEMO 710
Version, options:		VO.710 KL 7.16
Serial number:		SN.H12345678
Baud rate:		BR:57.6kbd
Device: Address, total **m**easuring channels, **a**ctive V6, **d**igital D7		GE.G00 M0100 A0008 D0005
System: Modules (/=MF !=MU-old .=MU-new ;=KS ,=TH)		
Hysteresis:		HY:10
Configuration: 60Hz, ClrMv, ring memory, -, oversampling, signal off		KF:FCR--S-- --------
Conversion rate: Output Cont, -, memory, V24		WR:010C-SU
Number:		NR:123456
Cycle: Output channel, sleep/monitor/fail-safe		Z1:00:10:00 St -/s/M/F
N Query cycle:		Z3:00.250 s
Start time:		U1:07:00:00
Start date:		D1:01.02.06
End time:		U2:17:00:00
End date:		D2:02.02.06
Measuring duration:		MD:00:10:00
Device locking:		GV:M0F0
Next calibration: date, alarm		KG:01.10.06-/!
Language:		SP:D
Display: contrast, illumination level, illumination duration		DI:G3 100 2 1
Sleep delay in s (sleep delay e.g. 123 s)		SD:123 s

Output of all device variables:	f2	P19
Temperature for compensation:		►TK:+ 25.0°C
Air pressure for compensation:		LD:+01013.mb
CJC temperature:		CJ.+023.51 °C
Time:		UZ:12:34:00
Date:		DA:01.02.12
Print timer:		T1.00:01:23
Query timer:		T2.00:00:00

Measuring time:	MZ.00:00:00.00
Timer 3	T3. 65000. s
Timer 4	T4. 6500.0 s
Accumulator voltage:	UB. 3.9 V
Sensor voltage setpoint:	US: 12.0 V
Actual sensor voltage:	UF.! 12.5 V
Accumulator temperature:	AT:+ 53.1 °C
Accumulator capacity:	AK: 13.80 Ah
Residual capacity:	RK: 5.78 Ah
Charging mode:	LM.-
Charge-discharge current:	LS.+ 3.20 A
Charging time:	LZ.0:10/0:10h

8.3.5.2 Output of the output modules

Output of the output modules	f3 P19
Socket DC: Mains adapter ALMEMO® connector	►DC.ZA1312NA8
Voltage 12V Current load capacity 1A	12V 2.5A
Socket P0: Option relay internal	P0.OA2490Rxx
Normally open, 0.5A variant 0 inverse active Open	00:NO0-0 1 O
Normally open, 0.5A variant 8 active Closed	01:NO0 8 1 C
Socket A1: Data cable USB	A1.ZA1919-DKU
RS232 Output interface baud rate 115.2kB	DK0 115.2kB
Socket A2: Analog output cable	A2.ZA1601-RK
N V5 Analog output 2V Measuring channel **M**0.1	RK;M;**O.1;+O1.234 V**
V5 Analog output 2V Reference channel **B**1.0	RK;**B;1.O;+O1.234 V**
V5 Analog output 2V Controlled **C**OM	RK;**C;;+O1.234 V**
V5 Relay cable, RTA Relay condition	EA2 0123
Socket A3: Memory card with micro SD card	A3.ZA1904-SD
	SM 256.00M
>**Socket A4:** Relay trigger analog adapter V6	A4.ZA8006RTA3
Normally open, 0.5A variant 0 passive Open	40:NO0 0 0 O
Normally closed, 0.5A variant 8 inverse active Open	41:NC0-8 1 O
Changeover 0.5A variant 2 active Closed	42:CO0 2 0 C
DA converter 10V measuring channel **M**xx0.1	46:DA1;M;0.1;+08.234 V
DA converter 10V reference channel **B**xx1.0	46:DA1;B;1.0;+08.234 V
DA converter 20mA controlled **C**OM	47:DA2;C;;+12.345mA
Trigger key variant 0 start-stop	48:TR1 0
>**Socket A5:** Relay trigger cable V6	A5.ZA1006EKA
Normally open 0.5A variant 2 active Closed	50:NO0 2 1 C
Normally closed 0.5A variant 2 inverse active Open	51:NC0-2 1 O
Trigger Optoc. variant 1 manual	58:TR1 1
Trigger Optoc. variant -5 macro5	59:TR2-5
>**Bus B6**..B9:	B6.ES8006RTA5
	60:..69:
	xx:Function programmable,
	xx.Function fixed or measured value

8.3.5.3 Memory configuration

Memory configuration	f4 P19
Memory space internal (R=ring memory)	SI:8048.4k R
Memory space external	SE:512.00M
Memory free	SF:0324.5k
Remaining memory time: dddd.hh:mm	SZ:0001.18:20
Start time of the memory output	U3:07:00:00
Start date of the memory output	D3:01.02.06
End time of the memory output	U4:17:00:00
End date of the memory output	D4:02.02.06
File name new file	DT:FILENEW.001
File name current file in memory	FI: ALMEMO.001
N Designation of the measurement (max. 64 Byte)	KO:A Designation A=Active, -=inactive

8.3.5.4 Output of all macros

Output of all macros f5 P19

►M5:P15|f1|s
M6:P04|C04
M7:Z000005
M8:Z000100
M9:

8.3.5.5 Menu configuration 710

Selecting user menu Ux (1..7)	f3	mx
Enter designation text 1 (max. 21 characters)	f5	$Designation1 CR
Enter designation text 2 (max. 21 characters)	f6	$Designation2 CR
Enter menu title of Ux (max. 16 characters)	f7	$Menu title Ux CR
Enter number of pages of Ux	f3	Sx
Selecting the page x of Ux	f3	Nx
Enter menu format 1=8Z, 2=6Z, 3=4Z	f3	Wx
Selecting the menu line xx	f1	ixx
Selecting the menu channel x.x	f3	Exxx.x or Ex.x
Enter selectable menu channel	f3	E-0.0

Selection of menu page and function	**Field left**	**Field right**
Measured value	f1 o01	f2 o01
Attenuation	f1 o02	f2 o02
Designation	f1 o03	f2 o03
Max value	f1 o04	f2 o04
Min value	f1 o05	f2 o05
Max value time-date	f1 o06	f2 o06
Min value time-date	f1 o07	f2 o07
Average value	f1 o08	f2 o08
Number	f1 o09	f2 o09
Average mode	f1 o10	f2 o10
Air pressure in mb	f1 o11	f2 o11
Temperature compensation	f1 o12	f2 o12
Setpoint	f1 o13	f2 o13
Conversion rate	f1 o14	f2 o14
Query cycle	f1 o15	f2 o15
Output cycle time, date	f1 o16	f2 o16
Cycle factor	f1 o17	f2 o17
Effective cycle	f1 o18	f2 o18
Measuring time	f1 o19	f2 o19
Start time	f1 o20	f2 o20
Stop time	f1 o21	f2 o21

Selection of menu page and function	Field left	Field right
Measuring duration	f1 o22	f2 o22
Locking	f1 o23	f2 o23
Range	f1 o24	f2 o24
Limit value max	f1 o25	f2 o25
Limit value min	f1 o26	f2 o26
Action max	f1 o27	f2 o27
Action min	f1 o28	f2 o28
Base value	f1 o29	f2 o29
Factor	f1 o30	f2 o30
Exponent	f1 o31	f2 o31
Zero point correction	f1 o32	f2 o32
Gain correction	f1 o33	f2 o33
Analog start	f1 o34	f2 o34
Analog end	f1 o35	f2 o35
Number	f1 o36	f2 o36
File name	f1 o37	f2 o37
Memory free	f1 o38	f2 o38
Device designation	f1 o39	f2 o39
Cross section cm^2	f1 o40	f2 o40
Designation text 1	f1 o41	f2 o41
Designation text 2	f1 o42	f2 o42

Output of the menu configuration Ux:	f3 mx P20
V;Version; menu number; total page number; menu title length; designation length	V;0;7;21;16;21
Menu Ux; menu title; designation 1; designation 2; page number y	Ux:Menu title;Text1;;Sy
Page 1; format z	S1:Wz
In line 00: Ex.x measured value, Ex.x average value	00:Ex.x;15;Ex.x;11
In line 01: Ex.x max value, Ex.x min value	01:Ex.x;09;Ex.x;10
In line 02: Ex.x max time, Ex.x min time	02:Ex.x;09;Ex.x;29
In line 03: Ex.x range, Ex.x designation	03:Ex.x;08;Ex.x;24
In line 04:	04:....
Page 2: format z	S2:Wz
In line 00: E0.0 limit value max.	00:E-00;25
In line 01:	01:....

9 Keyword index

G

Z

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