3.4 Meteorological Sensors

3.4.1 Atmospheric Pressure Sensor

Barometer and weather are usually understood as being strongly related to each other. The exact measurement of the atmospheric pressure is, for example, very important for the weather forecast and for aviation where it is used as a scale of height. The unit for the atmospheric pressure is millibar (mbar) or hectopascal (hPa).

$$1\text{mbar} = 10^2\text{N/m}^2 = 10^2\ \text{Pa} = 1\ \text{hPa} = 10^3\text{dyn/cm}^2 = 10.2\ \text{Kp/m}^2$$

(N = Newton, Pa = Pascal, hPa = hectopascal).

The following relation is applicable for the formerly used units torr and mm mercury column:

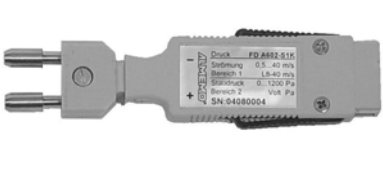
$$1\ \text{mbar} = 0.750\ \text{torr} = 0.7500\ \text{mm Hg}$$

The physical atmosphere (mean atmospheric pressure on the earth, reduced to sea level) is defined as:

$$1\ \text{atm} = 1013\ \text{mbar} = 760\ \text{torr}$$

ALMEMO® Atmospheric pressure measuring module / connector

For measuring the barometric pressure the ALMEMO® sensor range provides the piezoelectric pressure measurement module FDA612 MA and pressure measurement connector FDA612SA.



The pressure measuring module and connector are designed and constructed in such a way that they can be plugged directly onto the measuring instruments.

The measuring module may, despite its highly compact design, conceal access to certain other input sockets. Different extension cables ZA 9060-VKx, with 5m maximum length, are available from our range of accessories to allow a use of all input sockets, or allow the module to be directly installed at the measuring location.

Meas.variable	Meas. range	Resol.	Dim	Range	Factor	Exp.
Atm. pressure	0 - 1050 mbar	0.1	mb	d2600	-1.0000	+ 3

Technical Data:

Measuring range:	700 to 1050 mbar (total range 0 to 1050 mbar)
Accuracy:	± 0.5% (typically ± 0.1%) of full scale value
Nominal temperature:	22°C ± 3K
Overload capacity:	2x measuring range at maximum
Humidity:	10 to 90% non-condensing
Temperature drift:	at maximum 1% of full scale value (typically ± 0.6%)
Dimensions:	Messuring module: 37 x 36 x 22 mm Messuring connector: 90 x 20 x 7,6 mm
Hose connection:	Ø 5mm, 12 mm long

3.4.2 Wind Velocity Sensor

The following units are used to indicate the wind velocity:
Meter per second (m/s), kilometer per hour (km/h) or knots with 1 knot equalling 1 nautic mile per hour.
The following conversions are applicable for the units:

1 m/s	= 3.6 km/h	= 1.9 knots
1 km/h	= 0.54 knots	= 0.28 m/s
1 knot	= 0.52 m/s	= 1.86 km/h

Table m/s to km/h and wind force, wind force designation

m/s	km/h	Wind Force	Designation
0.3 to 1.5	1 to 5	1	light air
1.6 to 3.3	6 to 11	2	light breeze
3.4 to 5.4	12 to 19	3	gentle breeze
5.5 to 7.9	20 to 28	4	moderate breeze
8.0 to 10.7	29 to 38	5	fresh breeze
10.8 to 13.8	39 to 49	6	strong breeze
13.9 to 17.1	50 to 61	7	moderate gale
17.2 to 20.7	62 to 74	8	fresh gale
20.8 to 24.4	75 to 88	9	strong gale
24.5 to 28.4	89 to 102	10	whole gale
28.5 to 32.6	103 to 117	11	storm
more than 32.7	more than 118	12	hurricane

Measuring Principle

A large number of different methods can be used for measuring the wind velocity. In meteorology it is mainly the rotating cup anemometer being used.
It consists of a three or four prong star (cup) that rotates around a vertical shaft. A hemisphere is attached to each prong of the star. These are arranged so that the wind always, simultaneously, encounters one concave and one

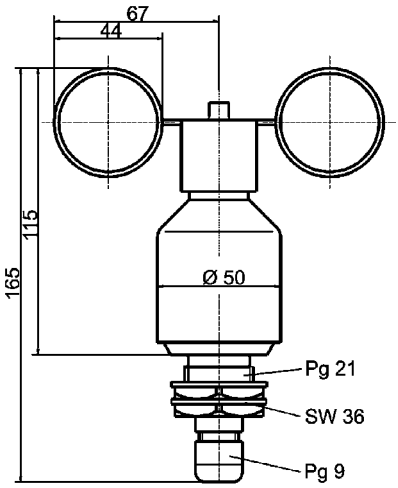
convex hemisphere. The concave surface provides a significantly higher aerodynamic resistance to the wind than the convex surface. As a result, the wind applies a higher force to the prong of the concave hemisphere than to the prong of the convex hemisphere. Consequently, the star starts to turn and rotate, becoming faster as the wind becomes stronger. The advantage of this measuring principle is that it works independent from the wind direction.
Due to the unavoidable friction effects in the bearings, the wind velocity pick-up will only work from a certain minimum wind velocity and is characterised by a certain 'sluggishness'. In case of a sudden wind gust the cup needs a short acceleration time until it has reached the rotational speed that corresponds to the wind gust. However, it still runs for a certain time when the wind has already decreased. This leads to a smoothing of the wind recording - velocity peaks are smoothed. As the cup adjusts faster with increasing wind velocities than with decreasing wind velocities, the indicated mean value will be higher than the true value.

ALMEMO® Wind Velocity Sensor

For measuring the wind velocity the ALMEMO® range of sensors includes the wind velocity sensor FV A615-2.

Applications

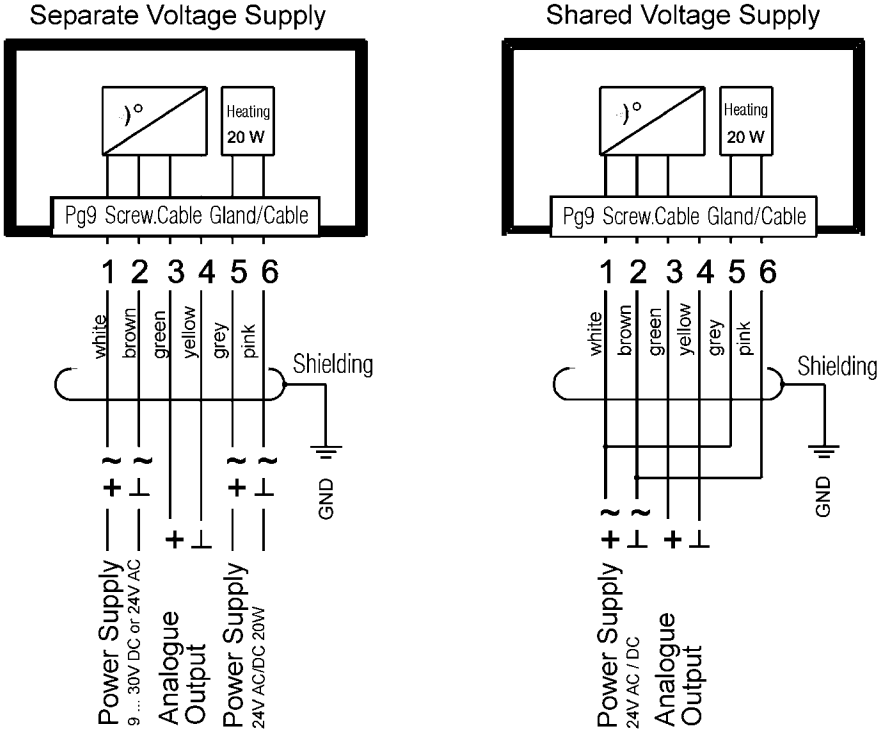
The wind velocity sensor can be used for measuring the horizontal wind velocity. The measured values are provided as electrical analogue current or voltage signals, e.g. for wind power stations.
All devices are equipped with electronically controlled heating for winter operation to prevent ball bearings and external rotational parts from freezing. The electrical power supply for the heating of the wind velocity sensor must be provided by the customer, e.g. by using an external power supply unit.
If fastening adapters are used (angles, tie-bars) the possible influence caused by turbulences must be considered.



Technical Data

Measuring range	0.5 ... 50m/s
Measuring accuracy	± 0.5m/s or ± 3% of measured value
Resolution	< 0.1m/s
Measuring principle	optoelectronically (slotted disk)
Operating voltage	9 - 30 VDC or 24 VAC/DC
for 0 -10V output	13 - 30 VDC
Heating	24 VAC/DC max. 20W
Ambient temperature	-30 ... +70°C
Cable	12m long LiYCY 6 x 0.25mm^2
Installation	e.g. pole tube with holding thread PG21 or drill hole Ø 29mm
Weight	0.75kg

Connection Diagrams



Preparation for Operation
Selection of the place of installation
Generally, instruments for measuring wind data should detect the wind conditions in the widest possible range. The place of installation should be located at a height of 10m above an even, undisturbed area to obtain comparable values when determining the ground wind. An undisturbed area means that the distance between the wind sensor and an obstruction should be, at minimum, ten times the height of the obstruction (see also VDI 3786). If this regulation cannot be met the wind sensor should be installed at a height where local obstructions, if possible, will not influence the measured values (approx. 6-10m higher than the disturbance level). On flat roofs the wind sensor should be mounted in the centre of the roof rather than the edge of the roof to avoid any predominant directions.

Installation
The installation can, for example, be performed on a central pole tube with a holding thread PG 21 or on brackets or similar devices with a Ø 29mm drill hole. Obstructions must be considered that could tamper the air flow and corrupt the measured value. The flexible control line LiYCY is guided through the drilled hole and the wind sensor must be fixed with the hexagon nut (jaw span SW36). The electrical connection must be performed according to the connection diagram shown on page 3-4-4.

Note: Storage, installation and operation, when exposed to weather conditions, must only be carried out in a vertical position as otherwise water can penetrate into the device.

Maintenance
If correctly mounted, the device will work maintenance-free. Heavy environmental pollution can lead to clogging of the slit between the rotating and fixed parts of the wind velocity sensor. The slit must always be kept clean.

3.4.3 Wind Direction Sensor

The wind direction is specified either corresponding to the point of the compass or to a scale with a 360 or, sometimes, a 36 graduation.
In meteorological data acquisition the wind-T is usually used to determine the wind direction.

ALMEMO® Wind Direction Sensor

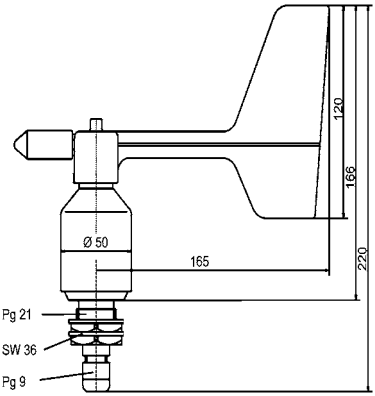
For determining the wind direction the ALMEMO® range of sensors includes the wind direction sensor FV A614.

Applications

The wind direction sensor can be used for measuring the horizontal wind direction. The measured values are provided as electrical analogue current or voltage signals, e.g. for wind power stations.

All devices are equipped with electronically controlled heating for winter operation to prevent ball bearings and external rotational parts from freezing. The electrical power supply for the heating of the wind velocity sensor must be provided by the customer, e.g. by using an external power supply unit.

If fastening adapters are used (angles, tie-bars) the possible influence caused by turbulences must be considered.



Technical Data

Measuring range	0 ... 360 °
Measuring accuracy	± 5 °
Resolution	11.25 ° (5 bit Graycode)
Measuring principle	optoelectronically
Operating voltage	9 - 30VDC or 24 VAC/DC
for 0 -10V output	13 - 30VDC
Heating	24 VAC/DC max. 20W
Ambient temperature	-30 ... +70°C
Cable	12m long LiYCY 6 x 0.25mm^2
Installation	e.g. pole tube with holding thread PG21 or drill hole Ø 29mm
Weight	1.10kg

For connection diagrams please see page 3-4-4.

Preparation for Operation

Selection of the place of installation

Generally, instruments for measuring wind data should detect the wind conditions in the widest possible range. The place of installation should be located at a height of 10m above an even, undisturbed area to obtain comparable values when determining the ground wind. An undisturbed area means that the distance between the wind sensor and an obstruction should be, at minimum, ten times the height of the obstruction (see also VDI 3786). If this regulation cannot be met the wind sensor should be installed at a height where local obstructions, if possible, will not influence the measured values (approx. 6-10m higher than the disturbance level). On flat roofs the wind sensor should be mounted in the centre of the roof rather than the edge of the roof to avoid any predominant directions.

Installation

The installation can, for example, be performed on a central pole tube with a holding thread PG 21 or on brackets or similar devices with a Ø 29mm drill hole. (e.g. tie-bar compact, Order No. ZB 9015TC)

The flexible control line LiYCY is guided through the drilled hole and, after it has been aligned to north, the wind sensor must be fixed with the hexagon nut (jaw span SW36). The electrical connection must be performed according to the connection diagram shown on page 3-4-4.

Note: Storage, installation and operation, when exposed to weather conditions, must only be carried out in a vertical position as otherwise water can penetrate into the device.

Alignment to North

The markings on the shaft and at the protective cap must be turned over each other until they are congruent. A compass can be used to determine a landmark (tree, building or similar), which is located in the north direction. The wind-T is used to aim at the landmark and, when conforming, the sensor is fiexed with the screw (the north mark must point to the north direction).

Maintenance

If correctly mounted, the device will work maintenance-free. Heavy environmental pollution can lead to clogging of the slit between the rotating and fixed parts of the wind velocity sensor. The slit must always be kept clean.

3.4.4 Rainfall Sensor

The rainfall is specified in mm depth of rainfall or just mm. It is assumed that the fallen rain neither seeps away nor evaporates, but that it forms a sea. Its depth in mm leads to the unit mm depth of rainfall. 1mm equals 1l/m² or 10 m³/ha.

Measuring Principle

To not only measure the amount of rainfall but also to determine the time slope of the rainfall intensity, the rainfall sensor must have a recording unit.

For recording the rainfall, the measuring system is equipped with a tipping scale. At a specified amount of liquid the scale tips and one half of the tipping scale is emptied while the other half is filling. This process is repeated continuously. The content of both halves of the tipping scale is constant. The number of tip processes is a measure for the amount of rainfall. The tipping actions are electronically counted and converted into the amount of rainfall.

ALMEMO® Rainfall Sensor

For rainfall measurements the ALMEMO® sensor range provides the rainfall sensor FR A916 with sieve bar for protection against insects and similar contaminations.

Meas. Variable	Meas. Range	Resol.	Dim	Range	Factor	Exp.
Rainfall amount	0.2 mm/pulse	0.2	mm	PULS	2.0000	- 1

Technical Data

Measuring range:	0.2 mm/pulse, resolution 0.2 mm
Capture cross section:	400 cm²
Operating range:	0 to +50°C, with heating –30 to +50°C
Heating:	24V DC max. 30W
Material:	housing: corrosion-resistant metal, tipping scale: weather-resistant plastic
Dimensions:	280 mm high, 240 mm Ø
Weight:	2.4 kg

3.4.4.1 Precipitation detector

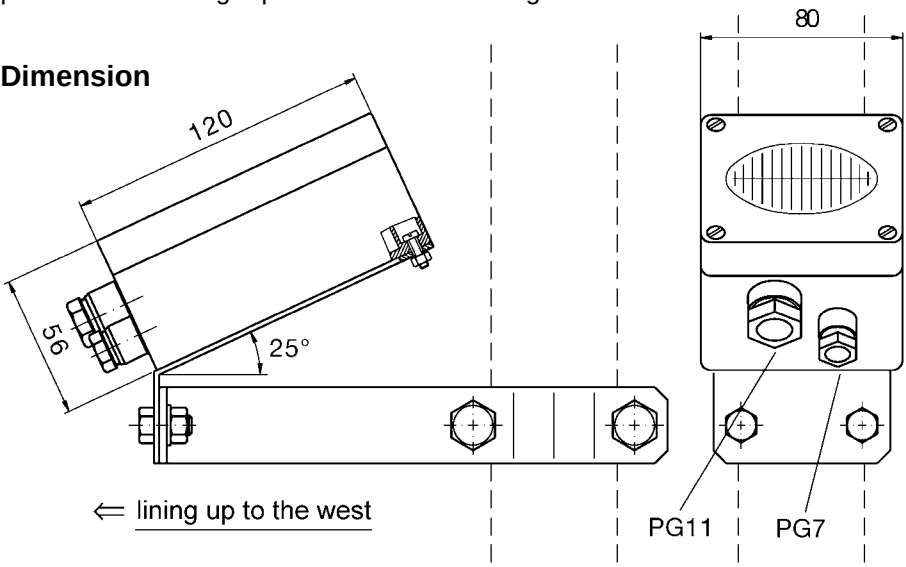
Description

- The sensor reacts to precipitation in the form of either rain or snow within just a few seconds.
- It detects even very slight precipitation.
- The precipitation detector reacts by switching a relay. It does not provide a continuous measuring signal; it operates with a step function :
  If it detects precipitation,
  display in ALMEMO® measuring instrument : 1.0000,
  if it does not detect precipitation,
  display in ALMEMO® measuring instrument : 0.0000.
- The precipitation detector is designed for use for example in automatic ventilation or shading systems, or in automatically controlled greenhouses, etc.

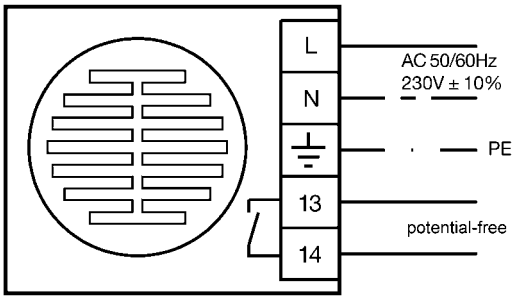
Function

As soon as the response threshold is exceeded, an integrated relay is triggered. This switches the integrated sensor heating system full on. As soon as the sensor surface has sufficiently dried (value dropping back below the limit value plus hysteresis) the automatic reset delay starts to run. This delay is fixed at approx. 5 minutes. In the period from activation of the automatic reset delay until the moment when “rain“ is reported again the sensor heating system operates at approx. 25 percent of full power. This preheating phase helps to prevent “rain” being reported as a result of e.g. mist or dew.

Dimension



Connection



Technical data

Voltage connection:	230V AC ±10% 6VA (50/60 Hz) optional 24V AC
Power draw:	
Elektronics:	3 VA
Preheating:	1 VA
Total heating:	3 VA
Admissible ambient temperature.:	-30 ... +60 °C
Storage temperature:	-30 ... +70 °C
Relative humidity:	0 ... 100 %
Relay drop-out delay:	5 minutes ± 15%
Test voltage:	
Terminals L or N → Electronics :	1,5kV
Electronics → Relay contacts:	1,5kV
Electromagnetic compatibility:	EN50081-1; EN50082-2; EN61010-1
Relay output:	250V AC, max. 4A, 300VA inductive.
Duty classificationt:	approx. 1 million operations
Housing:	
Material:	polycarbonate, gray
Protection system:	IP65
Mounting system:	Tubular steel pole, diameter approx. 25 to 50 mm
Weight:	approx 0,8 kg (incl. mounting materials)
Connection	
FR8616D:	with connecting terminals
FRA616D:	with ALMEMO® connector and 12-meter connection cable

Product overview

Option:

Precipitation detector designed for connection to 24 V AC	Order no. OR8616U6
Precipitation sensor including mounting materials	Order no. FR8616D
Precipitation sensor including mounting materials, ALMEMO® connector, and 12-meter cable	Order no. FRA616D

3.4.5 Global Radiation Pyranometer

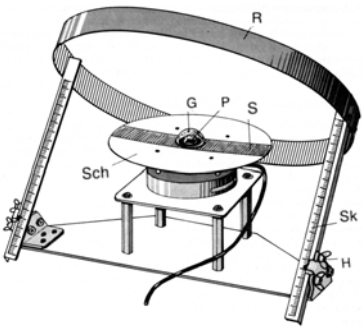
The global radiation is the radiation from the upper hemisphere to a horizontal surface in a wave length range of the solar spectrum from 0.3 to 3 µm. It is the sum of the direct solar and the diffuse sky radiation and is specified in Watt per m² (W/m²).

Measuring Principle

The measurement of the intensity of radiation (radiant intensity) is performed indirectly via the temperature difference between black and white areas. By this, an influence from the ambient temperature is avoided.

At star pyranometers, 12 circular arranged small copper plates, alternating black and white, are used as radiation-sensitive surfaces. On irradiation the black surfaces heat up more than the white surfaces. This temperature difference is measured using a thermoelectric pile attached to the underside of the surfaces.

Measurement of the Sky Radiation Component



In principle, pyranometers only measure the short-wave radiation as the cover hoods are too opaque for the long-wave spectral range. However, the sky radiation component can also be measured separately by using special constructions. For this purpose, a shade ring (R) is mounted above the device so that the direct sun radiation is kept away from the measuring element. The seasonal variation of the sun elevation is considered by a height adjustment (H) that can be performed by means of a scale (SK).

Determining the Intensity of the Sun Radiation

If a shaded and a free pyranometer are used together, the difference between their measured values allows for calculating the intensity of the sun radiation.

Measurement of the Short-wave Radiation Balance

A pair of pyranometers, with one device directed upwards and the other device directed downwards, allows for a measurement of the short-wave radiation balance. The radiation detected by the downward-directed sensor surface is just the radiation reflected by the earth. This also allows for calculating the albedo (reflecting ability) of the ground surface.

ALMEMO® Global Radiation Sensor

For measuring the global radiation, the sky radiation and the short-wave radiation the ALMEMO® sensor range provides the star pyranometer, according to Dirmhirn, FL A628-S. The sensor surfaces are shielded from environmental effects by a cut precision glass cupola.

Meas. Variable	Meas. Range	Resol.	Dim	Range	Factor	Exp.
Global radiation	0 - 1500.0 W/m²	0.1	Wm	d26	-	2

Calibration

Each device is supplied with a calibration certificate. The calibration values are stored in the ALMEMO® connector plug and are locked. They must **not** be modified.

Pyranometers that are used in continuous operation should be calibrated every quarter of a year or at minimum every six months.

Maintenance and Service

If star pyranometers are used in continuous operation, the glass cupola should be cleaned and dried at least once per day. The levelling should be checked daily. It can be easily adjusted by 3 setting screws and an integrated bubble.

For measurements during the winter months, ventilation and heating for the device has been integrated to prevent the glass from becoming covered with moisture (rain, snow, ice). Ice formation must be very carefully removed by using a de-icing spray. The removable dry tank is screwed to the underside of the star pyranometer and contains silica gel crystals as dry substance to avoid condensing effects. The dry substance should always be blue (never pink) and should be replaced or regenerated (by heat-up to approximately 80°C) every two weeks.

The radiation-sensitive surfaces must always be black and white. In case of damages or irregularities to the radiation-sensitive surfaces the device must be inspected in our factory. Scratching of the radiation-sensitive surfaces and the glass cupola must be absolutely avoided.

Technical Data

Measuring range:	0 to 1500 W/m^2, resolution 0.1 W/m^2
Spectral range:	0.3 to 3 µm
Output:	approx. 15µV/Wm^{-2}
Impedance:	approx. 35 ohm
Operating range:	–40 to +60°C
Cosine effect:	< 3% of measured value 0 to 80°
Inclination azimuth effect:	< 3% of measured value
Temperature influence:	< 1% of meas. value from –20 to +40°C
Accuracy:	cosine effect + azimuth effect + temp. influence
Nominal temperature:	22°C ±2°C
Linearity:	<0.5% in range 0.5 to 1330 W/m^2
Stability:	<1% of meas. range per year at occasional operation
Settling time:	25 s (t_{95})
Dimensions:	housing: 160 mm Ø, 75 mm high bolt circle: 134 mm Ø bore holes: 8 mm Ø
Weight:	1 kg
Cable length:	3 m with ALMEMO® connector and programmed calibration value

3.4.6 Temperature/Humidity Sensor in All-Weather Housing

ALMEMO® Temperature/Humidity Sensor
For measuring the temperature and humidity in outdoor areas the ALMEMO® sensor range provides the sensor FH A646 AG.

It includes a 'dew-proof' humidity sensor with a capacitive thin-film sensor (see 3.3.2) and a high-precision NTC sensor and is integrated in all-weather housing.
ALMEMO® devices can, in addition to the relative humidity and temperature, also indicate the dew point temperature and the mixture ratio in g/kg.

Technical Data

Humidity sensor:	capacitive thin-film sensor
Measuring range:	5 to 98% rH (total range 0 to 100% rH)
Accuracy:	± 2% at nominal temperature
Reproducibility:	± 1%
Nominal temperature:	25°C ±3°C
Temperature sensor:	NTC type N (10kΩ at 25 °C)
Measuring range:	–20 to +80°C
Accuracy:	–20 to 0°C: ±0.4 °C 0 to 70°C: ±0.1 °C above 70°C: ±0.2 °C
Nominal temperature:	25°C ± 3°C
Operating range:	–20 to +80°C
Protective housing:	85 mm Ø, 100 mm high