

OPERATING MANUAL

AEOLUS

WUS30F

Ultrasonic anemometer



EN

V1.1



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1 Introduction

AEOLUS WUS30F... is a 3-axis ultrasonic static anemometer. In addition to the measurement of wind speed and direction, the anemometer also provides the U-V-W Cartesian components of wind speed and the Wind Gust values.

Equipped with heating which prevents the whole detection area from the accumulation of snow and ice formation, allowing accurate measurements in all environmental conditions.

The **AISI 316 housing** allows the instrument to be used even in a particularly aggressive atmosphere (e.g., marine environment).

The anemometer integrates a barometric pressure sensor and a tilt/roll sensor for continuously monitoring a possible misalignment with respect to the vertical axis.

Available outputs:

- **RS232, RS485** and **RS422** isolated outputs, with **NMEA, Modbus-RTU** and ASCII proprietary protocols.
- **SDI-12** isolated output.
- Three analog outputs, for wind speed and direction or for wind U-V-W cartesian components. The type of analog output depends on model.

Mounting on a $\varnothing 40$ mm mast.

The high immunity to electromagnetic disturbances makes the anemometer suitable for measurements in electrically noisy environments (e.g., industrial environments, wind farms, etc.).

All instrument sensors are factory-calibrated and do not require additional interventions of the user (field calibration is not required).

The absence of moving parts minimizes the instrument maintenance.

The anemometer satisfies the requirements of the following standards:

- **MIL-STD-810G Method 509.6** and **EN ISO 9227:2017** (salt fog anti-corrosion test)
- **MIL-STD-810F Method 521.2** (anti-icing/freezing rain test)
- **EN 60068-2-6:2008 / IEC 60068-2-6:2007** (vibration resistance test)

MODELS

The different models differ in the type of analog output:

Model	Analog output			
	0...20 mA 4...20 mA	0...1 V	0...5 V	0...10 V
WUS30FA	√			
WUS30FW		√		
WUS30FX			√	
WUS30FY				√

2 Technical specifications

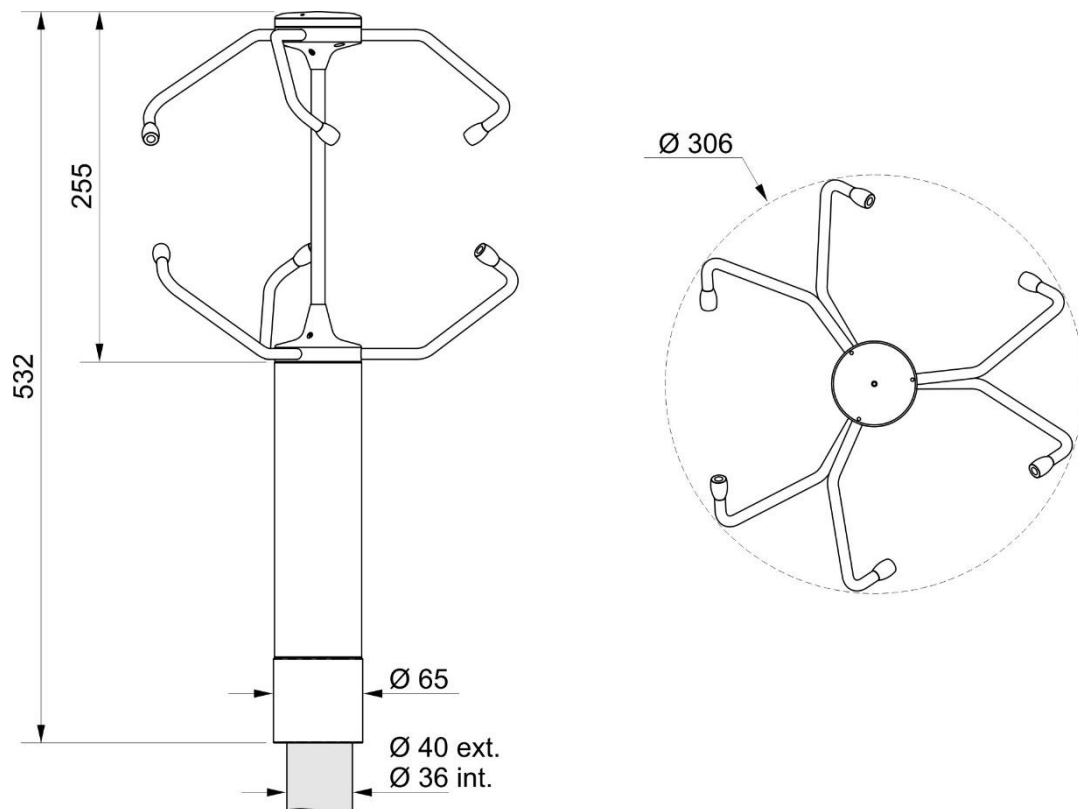
Wind speed	
Sensor	Ultrasounds
Measuring range	0...85 m/s
Resolution	0.01 m/s
Accuracy	± 0.2 m/s or $\pm 2\%$ of measure, the greatest (0...65 m/s) $\pm 3\%$ of measure (> 65 m/s)
Wind direction	
Sensor	Ultrasounds
Measuring range	0...360° (Azimuth) $\pm 60^\circ$ (Elevation)
Resolution	0.1°
Accuracy	$\pm 2^\circ$ RMSE (2 m/s < wind speed < 65 m/s) $\pm 3^\circ$ RMSE (wind speed > 65 m/s)
Sonic temperature	
Sensor	Calculated quantity
Measuring range	-40...+60 °C
Resolution	0.1 °C
Accuracy	± 1 °C
Barometric Pressure	
Sensor	Piezoresistive
Measuring range	300...1100 hPa
Resolution	0.1 hPa
Accuracy	± 0.5 hPa (700...1100 hPa) @ 20 °C ± 1 hPa (500...1100 hPa) / ± 1.5 hPa (300...500 hPa) @ T=0...60 °C
Tilt angles	
Resolution	0.05°
Accuracy	$\pm 1^\circ$
General features	
Instrument power supply (*)	12...30 Vdc (15...30 Vdc for 0...10 V output) / < 8 W
Heating power supply (**)	24 Vdc $\pm 10\%$ / 105 W
Serial outputs	Isolated RS232, RS485, RS422 and SDI-12
Communication protocols	NMEA, Modbus-RTU, SDI-12, ASCII proprietary
Analog outputs	3 isolated analog outputs, for wind speed and direction or for speed U-V-W cartesian components. Output type: 0/4...20 mA, 0...1 V, 0...5 V or 0...10 V depend- ing on model. Load: max. 500 Ω for current output, min 10 k Ω for voltage output. Analog outputs updating rate 4 Hz.

Measurement interval	From 1 to 4 Hz (measurements/s)
Wind speed averaging interval	Configurable from 1 s to 10 min
Wind Gust calculation interval	Configurable from 1 s to 10 min
Electrical connection	19-pole M23 male connector
Operating temperature	-40...+70 °C
Protection degree	IP 67 (EN 60529)
Anti-corrosion test	MIL-STD-810G Method 509.6 (48 hours of exposure + 48 hours of drying) EN ISO 9227:2017
Anti-icing/freezing rain test	MIL-STD-810F Method 521.2
Vibration resistance test	EN 60068-2-6:2008 / IEC 60068-2-6:2007
Survival speed	100 m/s
Weight	2.6 kg approx.
Housing	AISI 316
Installation	on mast \varnothing 40 mm external and \varnothing 36 mm internal

(*) The main power supply of the instrument also powers the sensors heating, which cannot be disabled. The max. consumption occurs when the sensor heating is on.

(**) Heating of sensor support arms is independent of the main instrument power supply and can be disabled.

Dimensions (mm)



3 Wind speed and direction measurement

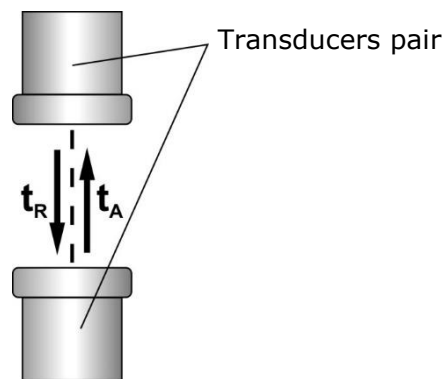
Wind speed and direction are determined by measuring the time taken by ultrasonic pulses to cover the distance from the transducer that generates the pulse to the receiving transducer.

The instrument uses 3 pairs of transducers oriented along orthogonal axes. Detecting the wind speed along the various axes allows determining not only the intensity but also the wind direction.

The instrument measures the travel time of the ultrasonic pulse between the two transducers of the same pair in both directions. The travel times in the two opposed directions are defined as t_A (forward direction time) and t_R (reverse direction time).

If wind speed is zero, t_A and t_R values are the same. In the presence of wind, one of the two time values is greater than the other and the comparison between the two time values allows determining wind intensity and direction.

Measuring the travel time in both directions allows cancelling the dependence of the transmission speed of ultrasounds in the air from the environmental conditions of temperature, humidity and barometric pressure.



The travel times of the ultrasonic pulses are given by:

$$t_A = \frac{D}{C + v_n} \quad t_R = \frac{D}{C - v_n}$$

Where:

D = Distance between the two transducers of the same pair

C = Sound speed

v_n = Component of wind speed along the measurement axis

Measuring the two travel times allows determining the wind speed component:

$$v_n = \frac{D}{2} \left(\frac{1}{t_A} - \frac{1}{t_R} \right)$$

The wind speed components are given by convention along Cartesian axes called **U**, **V** and **W**. The U axis is the axis from West to East, the V axis is the axis from South to North, the W axis is the vertical component.

It is defined **elevation angle** the angle formed by the wind speed vector with respect to the horizontal plane. The angle is positive above the horizontal plane.

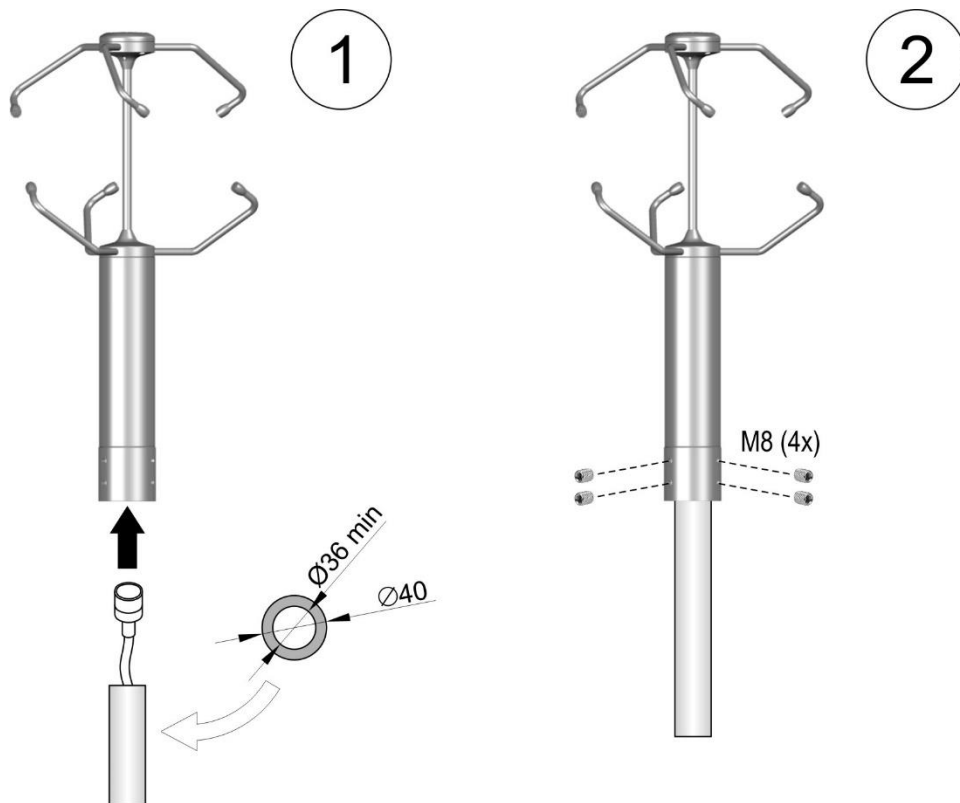
It is defined **Azimuth** the angle formed by the projection of the wind speed vector in the horizontal plane with respect to the direction of geographic North (considered the 0° reference). The angle is positive proceeding from North clockwise (toward East).

4 Installation

The instrument is supplied with 4 bird spikes, which can be screwed into the holes on the head of the instrument. **Be careful not to get hurt by sharp spikes.**

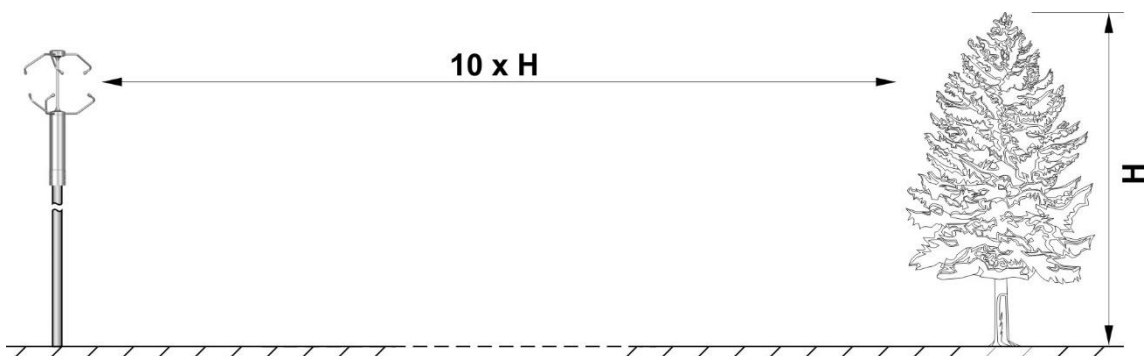
To install the instrument, pass the connection cable inside the support mast and connect the 19-pole M23 female connector of the cable to the 19-pole M23 male connector situated at the bottom of the instrument. Ensure connection stability by tightening the connector external nut.

Slide the instrument completely into the support mast and align it (see par. 4.1), then fix it to the mast by tightening the four M8 grub screws at the bottom of the instrument (fix the upper grub screws first).



The support mast, having 40 mm max. outer diameter and 36 mm min. inner diameter, must be positioned on a stable surface and electrically connected to ground.

The instrument should be installed vertically (check the tilt angles provided by the instrument) and in an open area, far from obstructions located in the vicinity that might alter the natural air flow. Any close objects (such as buildings, trees, pylons, etc.) should be at a distance equal to at least ten times their height.



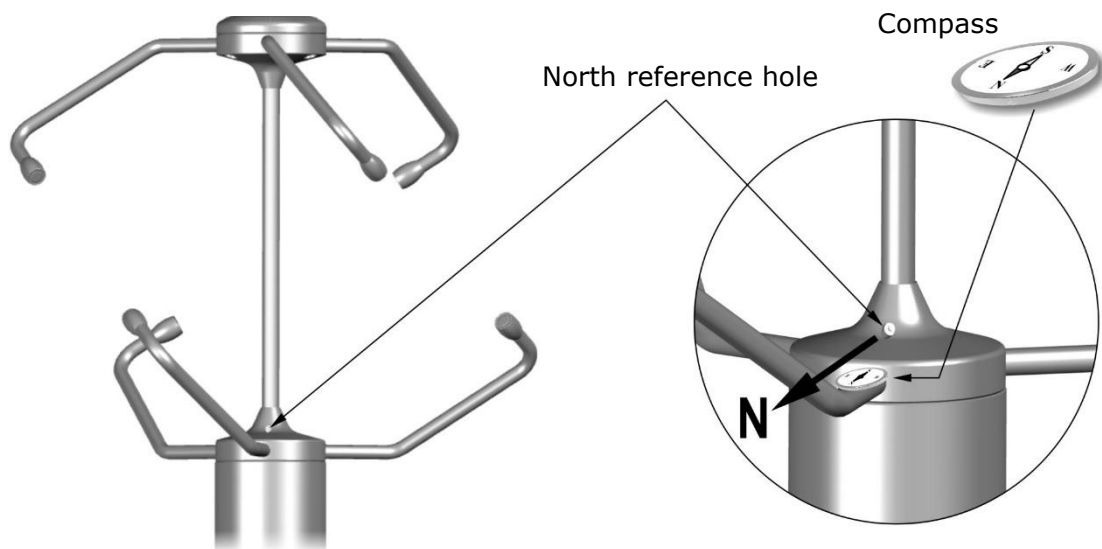
In presence of close objects, it is advisable to place the instrument at a height of 10 m. If the instrument is installed on a building, the height of the instrument should be at least 1.5 times the minimum value between the height of the building and the roof longest diagonal.

4.1 Alignment of the instrument

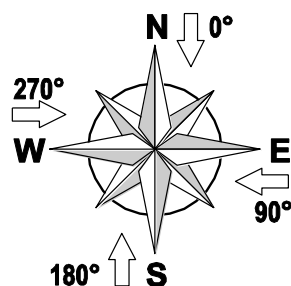
The instrument measures the wind direction with respect to a reference on the housing: the hole on the support disk of the lower arms. The reference must be aligned with the **geographical North**.

A magnetic compass placed on the lower part of the arm coming out at the reference hole can be used for alignment, taking into account the **magnetic declination** (angular difference between geographical north and magnetic north) of the place where the instrument is installed.

It is possible to align the instrument with the **magnetic North** and set in the instrument a magnetic declination value (serial command **cxd**), allowing the measurements to be referred to geographical North.



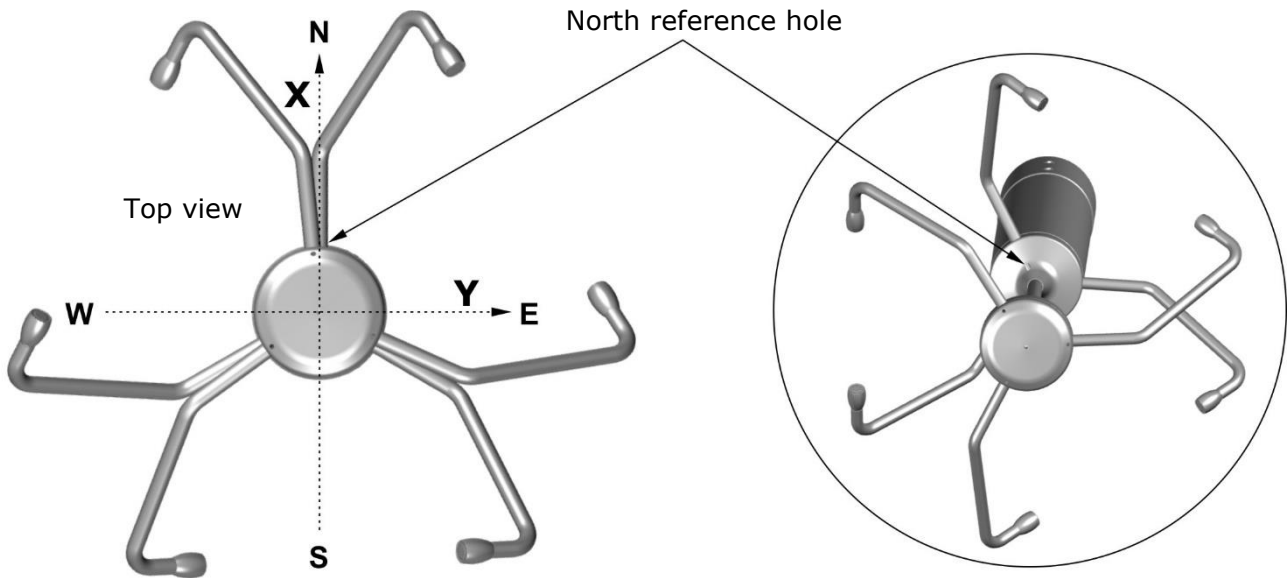
If wind speed and direction (Azimuth) values are given in polar coordinates, 0° angle corresponds to a wind coming from North.



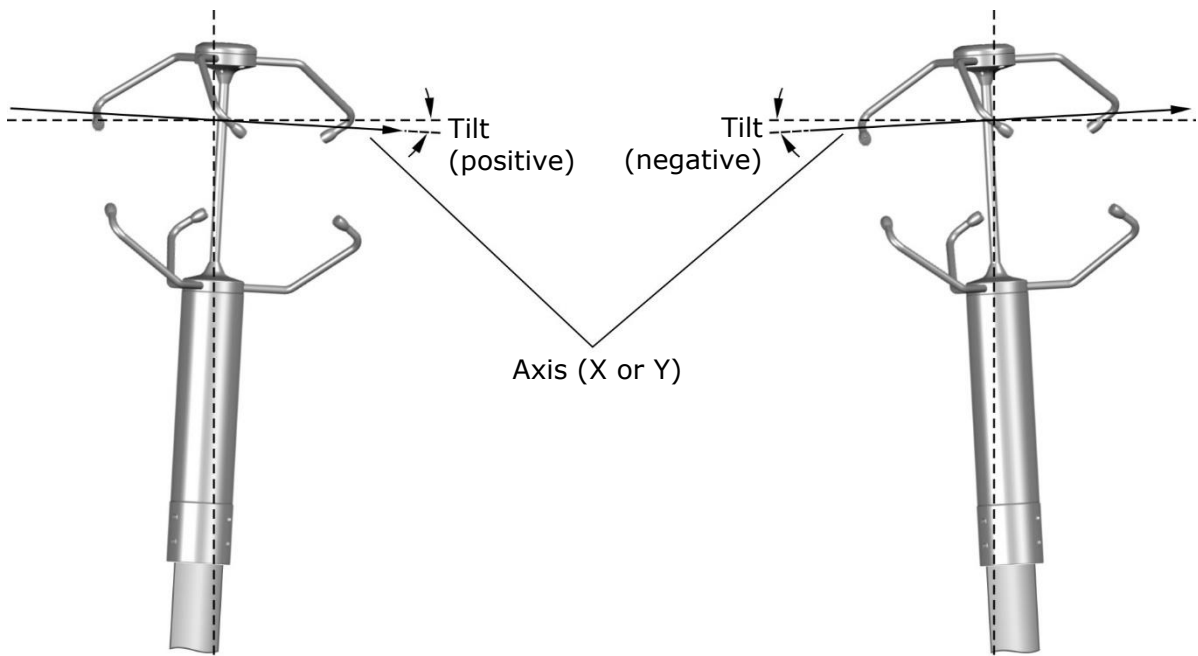
4.2 Tilt angles

For an accurate measurement, the anemometer must be installed in an exactly vertical position. Alignment with respect to the vertical axis can be verified by means of the tilt angles provided by the instrument.

The instrument detects two tilt angles: **Tilt_X**, tilt of the X axis, and **Tilt_Y**, tilt of the Y axis.

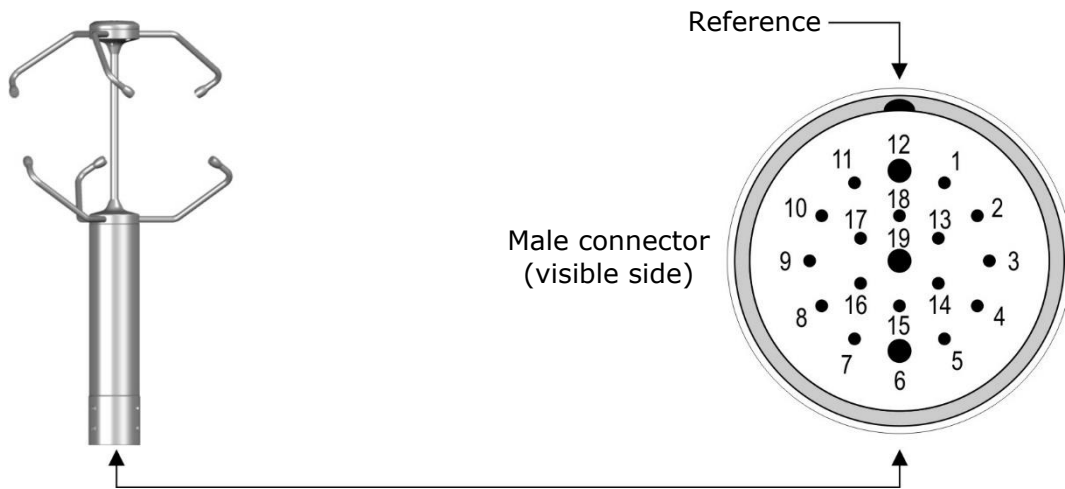


The tilts are considered with respect to a plane parallel to the ground.



4.3 Electrical connections

The instrument has 19-pole M23 male connector. Below are the numbering and function of the connector pins and the color correspondence with the wires of the optional **CPM23-19.x** cable.



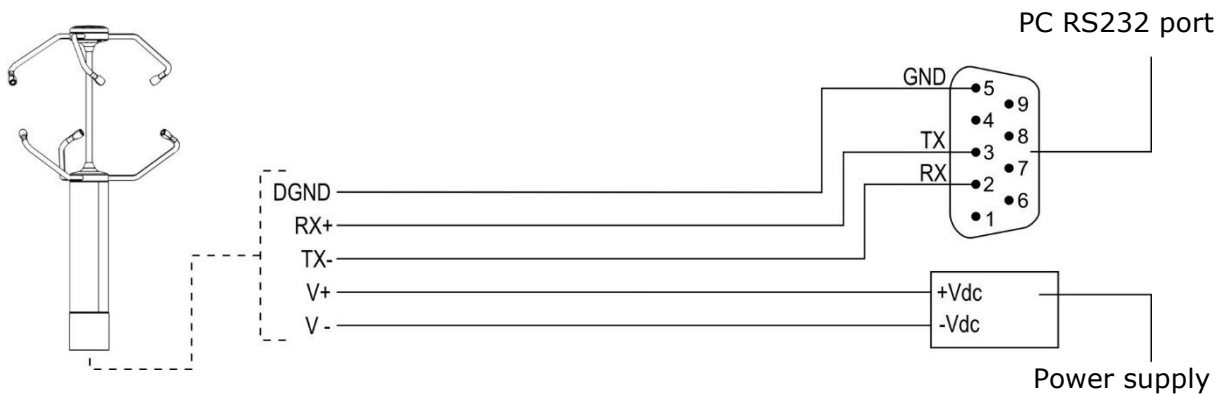
Connector pin number	CPM23-19.x wire color	Symbol	Description
1	White/Red	AOUT3	Analog output 3 positive
2	White/Grey	SDI-12	SDI-12 output
3	Yellow/Brown	RX+	Serial receive (input) positive
4	Brown/Green	HEAT-	Arms heating power supply negative
5	Violet	HEAT+	Arms heating power supply positive
6	Brown	HEAT-	Arms heating power supply negative
7	Grey/Brown	HEAT+	Arms heating power supply positive
8	Yellow	DGND	Digital ground (isolated from V -) (*)
9	Grey	TX-	Serial transmission (output) negative "DATA -" main RS485 output
10	White/Yellow	AUX_B	"DATA +" auxiliary RS485 output (D+)
11	White	AUX_A	"DATA -" auxiliary RS485 output (D-)
12	Black	V-	Instrument power supply negative
13	Green	RX-	Serial receive (input) negative
14	Pink/Brown	AOUT1	Analog output 1 positive
15	Blue	AGND	Analog ground (isolated from V -) (*)
16	Red/Blue	AOUT2	Analog output 2 positive
17	White/Green	TX+	Serial transmission (output) positive "DATA +" main RS485 output
18	--		Not connected
19	Red	V+	Instrument power supply positive
--	Grey/Red	SHIELD	Cable shield / Connector shell / Anemometer housing

(*) DGND and AGND are internally shorted.

Warning!

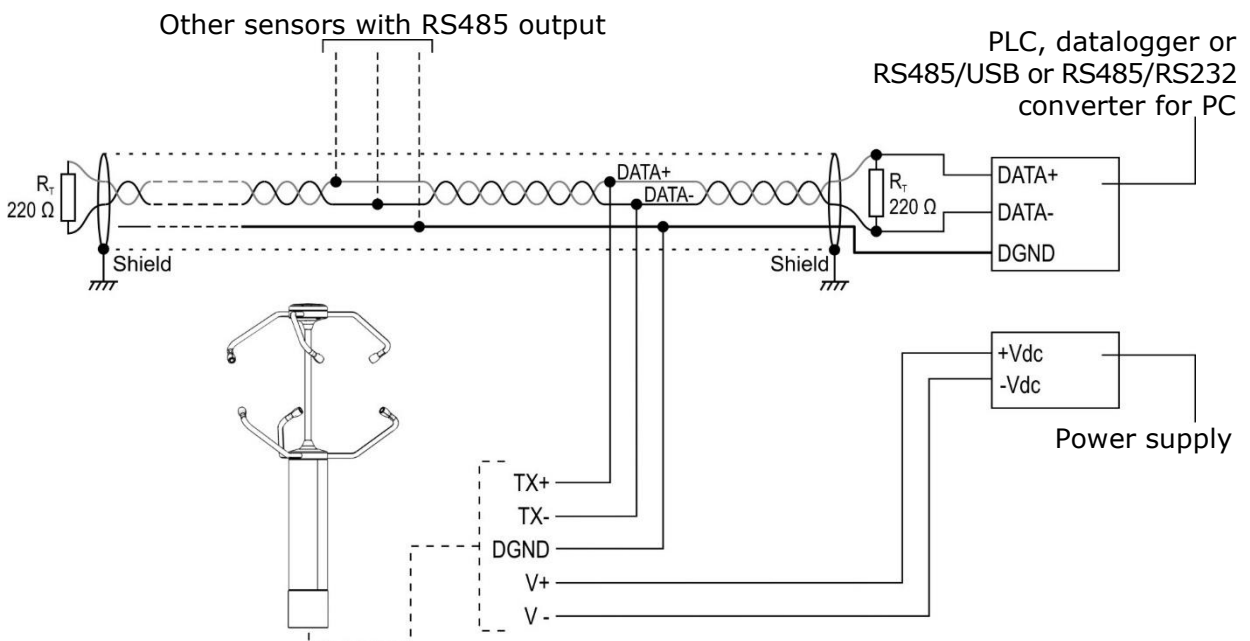
The metallic housing of the anemometer should be grounded locally, via the support mast. The CPM23-19.x cable shield is connected to the connector shell and then to the metallic housing of the anemometer. Do not connect the gray/red wire (cable shield) to ground, unless it is not possible to ground the anemometer metallic housing locally via the support mast.

4.3.1 RS232 connection



The maximum length of the RS232 connection is typically 15 m.

4.3.2 RS485 connection

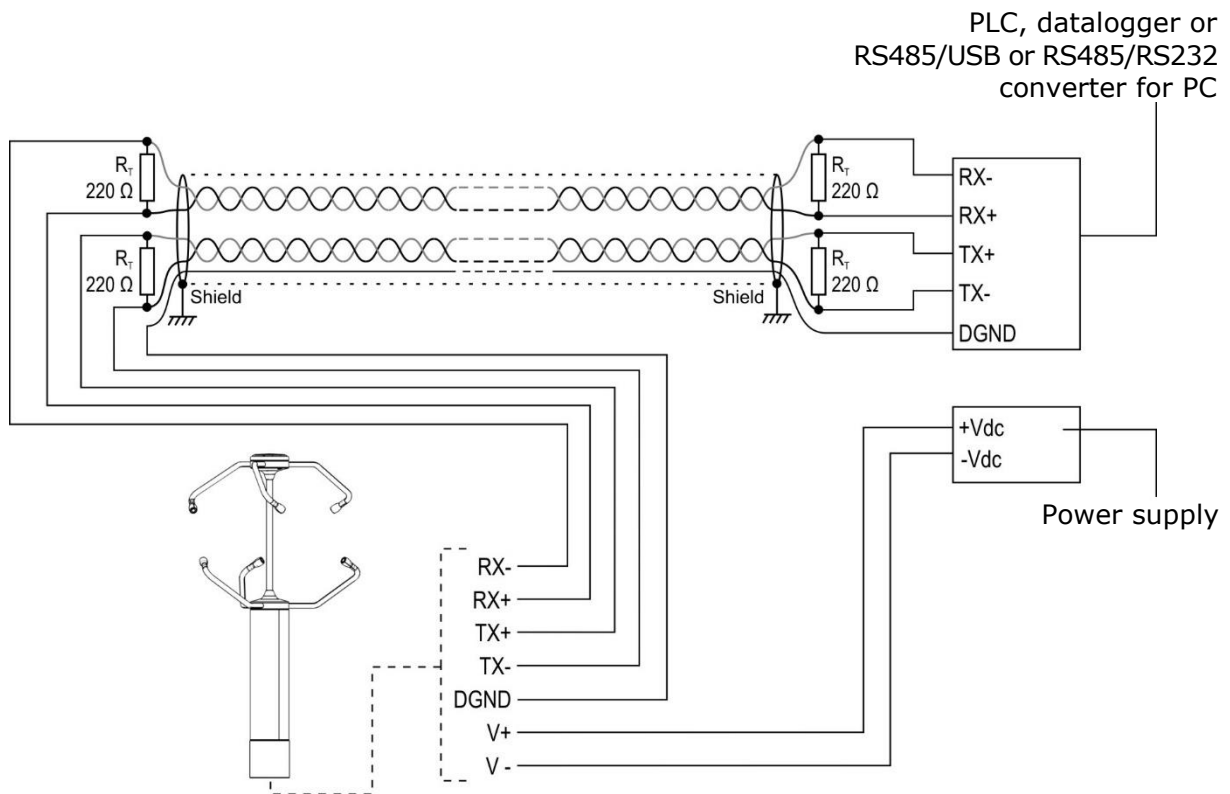


Multiple sensors can be connected in sequence through a twisted-pair shielded cable for signals and a third wire for ground.

The maximum RS485 bus length depends on baud rate and cable characteristics. Typically, using a specific RS485 cable, the maximum length is 1200 m.

Before connecting the anemometer to the network, set the address and the communication parameters, if different from the factory preset (see chapter 5).

4.3.3 RS422 connection

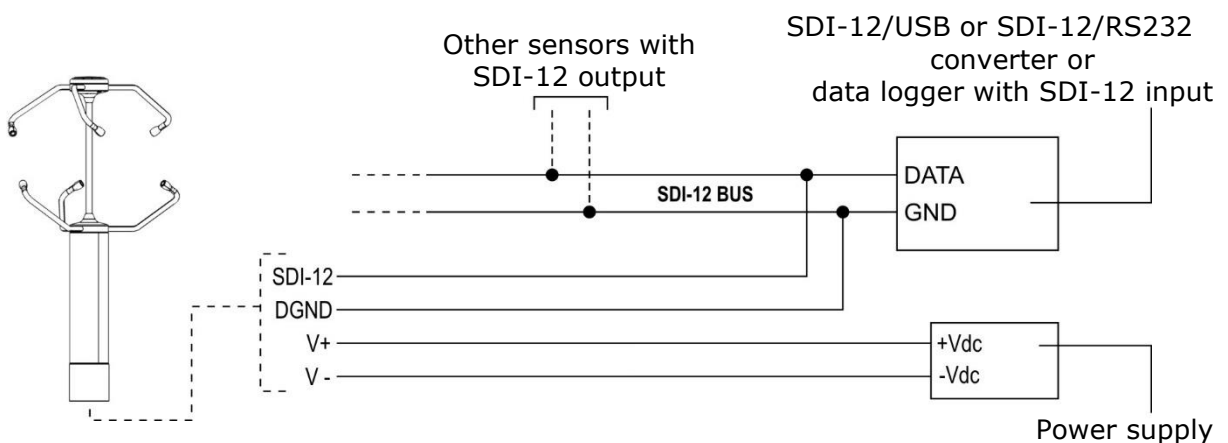


RS422 standard is used for point-to-point connection on long distances, via a shielded cable with two twisted pairs for signals and an additional wire for ground.

The maximum connection length depends on baud rate and cable characteristics. Typically, using a specific RS422 cable, the maximum length is 1200 m.

Before connecting the anemometer to the network, set the address and the communication parameters, if different from the factory preset (see chapter 5).

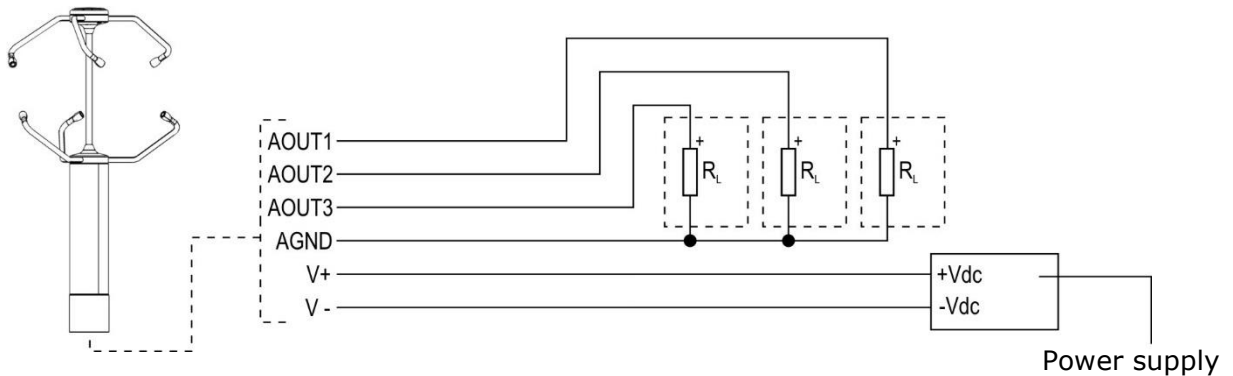
4.3.4 SDI-12 connection



More sensors can be connected in parallel. The baud rate is 1200. The SDI-12 bus maximum length is 60 m.

The instrument should be configured to operate in SDI-12 mode. Set the address (see chapter 5) before connecting the instrument to the network.

4.3.5 Analog outputs connection



The anemometer power supply and the load resistance vary according to the type of analog output:

Analog output	Power supply required	Load resistance
0...20 mA	12...30 Vdc	$\leq 500 \Omega$
4...20 mA	12...30 Vdc	$\leq 500 \Omega$
0...1 V	12...30 Vdc	$\geq 10 \text{ k}\Omega$
0...5 V	12...30 Vdc	$\geq 10 \text{ k}\Omega$
0...10 V	15...30 Vdc	$\geq 10 \text{ k}\Omega$

For associating the outputs with the various available parameters, see chapter 5.

4.3.6 Heating connection

The sensors heating is powered by the main instrument power supply, while the sensor support arms heating power supply is independent (HEAT- e HEAT+).

Due to the power required by the heating, it is recommended to connect both HEAT- and both HEAT+ wires, so as to halve the current in each wire.

The heating system is switched on below +5 °C. After switching on, the heating is switched off when the temperature exceeds +15 °C.

4.3.7 Auxiliary RS485 output connection

The auxiliary RS485 output can be used as an alternative to the main serial output for connecting the instrument to the PC, for the configuration of the instrument. The output does not support the operating protocols (NMEA, Modbus-RTU and ASCII proprietary).

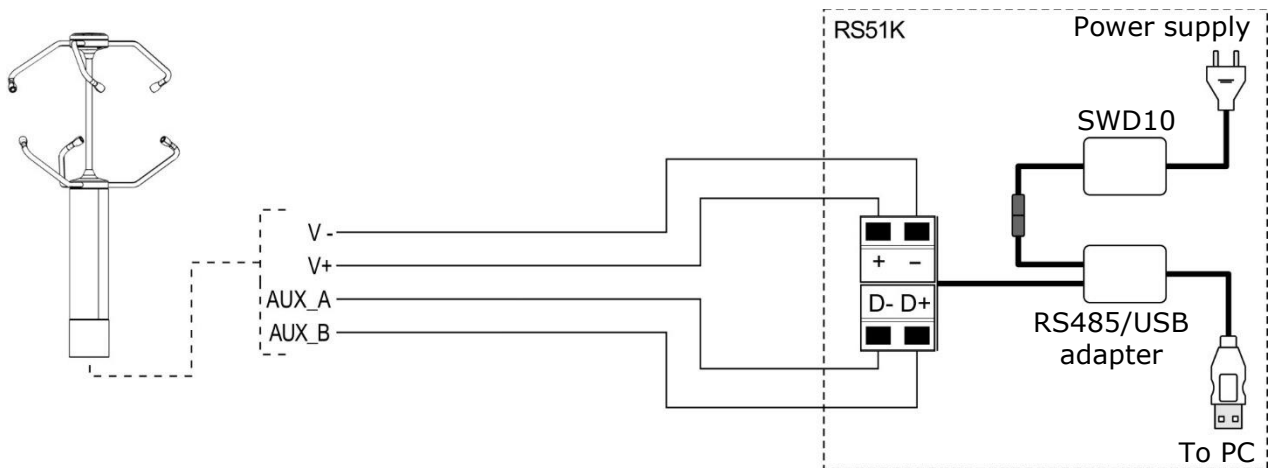
The auxiliary RS485 output can be used for the configuration of the instrument and the communication with the **HD52.3D-S** application software in case the main serial output is busy with one of the operating protocols.

Warning!

The auxiliary RS485 output is not available if the SDI-12 operating mode is set in the instrument.

For connecting the auxiliary RS485 output to the PC, the optional **RS51K** kit can be used. The kit includes the SWD10 power supply and the RS485/USB adapter with:

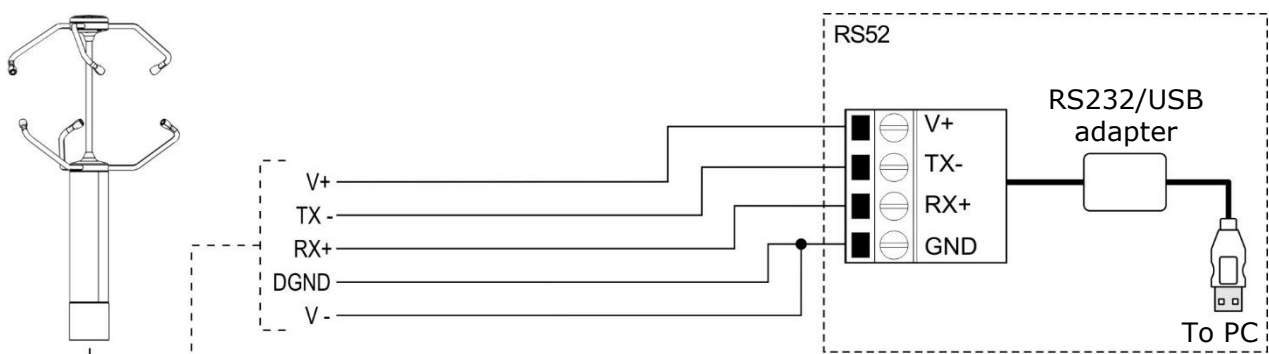
- screw terminals for the connection to the CPM23-19... cable (not included);
- USB connector for the connection to the PC;
- jack connector for connecting the SWD10 power supply.



To use the RS51K kit, the USB drivers included in the HD52.3D-S software package should be installed in the PC.

4.3.8 RS52 cable connection

The **RS52** optional cable, equipped with RS232/USB converter, allows connecting the instrument main serial output to a PC USB port.



To use the RS52 cable, the USB drivers included in the HD52.3D-S software package should be installed in the PC.

The instrument is powered directly from the USB port of the PC.

4.4 Serial output protocol

Unless otherwise requested, at the first power up the instrument main serial output starts in configuration mode and waits to receive the commands for setting the operating parameters (see chapter 5) or the connection with the **HD52.3D-S** application software.

In this case, in order to activate an operating protocol (NMEA, Modbus-RTU or ASCII proprietary) it is necessary to set it with the appropriate serial command (CUMn, see chapter 5) or with the aid of the **HD52.3D-S** application software.

If the instrument is set up to work with an operating protocol, the protocol becomes active 10 seconds after power on (in the first 10 seconds the instrument waits for a possible command to enter configuration mode, as explained in chapter 5).

The auxiliary RS485 output is always in configuration mode.

5 Configuration

Configuration mode allows reading the instrument general info (firmware version, serial number, ...) and to set the instrument operation mode and operation parameters. The configuration of the instrument can be done:

- With the aid of **HD52.3D-S** application software (see the software online help), downloadable from the website.
- By sending serial commands (listed in paragraph 5.1) via a standard communication program, setting the following parameters in the program: 115200 (baud rate), 8N2, flow control none.

For the configuration, the instrument can be connected to the PC:

- Via **auxiliary RS485** (see paragraph 4.3.7 for the connection).
The auxiliary RS485 serial output is always in configuration mode and therefore it is always available to receive commands from the PC.
- Via **RS232** (see paragraphs 0 and 4.3.8 for the connection).
The instrument can receive commands from the PC via RS232 only if it is in configuration mode (factory setting, unless otherwise requested).
If the instrument is not set in in configuration mode but in one of the available operating modes (NMEA, Modbus-RTU or ASCII proprietary), to enter configuration mode it is necessary to send **within 10 seconds from power on** (if the instrument is already powered, disconnect and reconnect the power supply) the serial command @, if a standard communication program is used, or the request of connection with the **HD52.3D-S** software.

5.1 Serial commands

Instrument information:

Command	Reply	Description
G1	&VPnn.nn yyyy/mm/dd	Version and date of firmware
RGS	&nnnnnnnn	Serial number of instrument
RGI	&ccc...ccc	User code
CGIc...c	&	Sets user code to c...c (max. 34 char.)

Instrument control:

Command	Reply	Description
@	&	Allows entering configuration mode if the instrument is set up in an operating mode. It must be sent within 10 s from power on.
#	<i>Info on operating mode</i>	Exits from the configuration mode activated with the command @.

Operating Mode:

Command	Reply	Description
CUMn	&	Sets instrument in mode: <ul style="list-style-type: none"> ▪ Configuration if n=0 (<i>default</i>) ▪ RS485 ASCII proprietary if n=1 ▪ RS232 ASCII proprietary if n=2 ▪ SDI-12 if n=3 ▪ NMEA if n=4 ▪ Modbus-RTU if n=5

Command	Reply	Description
RUM	& n	Reads mode set in the instrument.

Note 1: after sending the CUMn command, the instrument remains in configuration mode. Power cycle the instrument to activate the set operating mode.

Parameters for RS232 and RS485 ASCII proprietary modes:

Command	Reply	Description
CU1Ac	&	Sets the address for RS485 ASCII proprietary mode to c value. The address is an alphanumeric character ranging within 0...9, a...z, A...Z. Default=0.
RU1A	& c	Reads the address for RS485 ASCII proprietary mode set in the instrument.
CU1Bn	&	Sets Baud Rate for RS485 ASCII proprietary mode to: <ul style="list-style-type: none"> ▪ 9600 if n=3 ▪ 19200 if n=4 ▪ 38400 if n=5 ▪ 57600 if n=6 ▪ 115200 if n=7 (<i>default</i>)
RU1B	& n	Reads Baud Rate setting for RS485 ASCII proprietary mode.
CU2Bn	&	Sets Baud Rate for RS232 ASCII proprietary mode to: <ul style="list-style-type: none"> ▪ 9600 if n=3 ▪ 19200 if n=4 ▪ 38400 if n=5 ▪ 57600 if n=6 ▪ 115200 if n=7 (<i>default</i>)
RU2B	& n	Reads Baud Rate setting for RS232 ASCII proprietary mode.
CU2In	&	Sets interface for ASCII mode to: <ul style="list-style-type: none"> ▪ RS232 if n=0 ▪ RS485 if n=1 (<i>default</i>) ▪ RS422 if n=2
RU2I	& n	Reads interface setting for ASCII mode.
CU2Mn	&	Sets parity and stop bits (data bits = 8 fixed) for ASCII mode to: <ul style="list-style-type: none"> ▪ 8N1 if n=0 ▪ 8N2 if n=1 (<i>default</i>) ▪ 8E1 if n=2 ▪ 8E2 if n=3 ▪ 8O1 if n=4 ▪ 8O2 if n=5
RU2M	& n	Reads current setting of parity and stop bits for ASCII mode.

Command	Reply	Description
CU1Dc...c	&	Sets measurements order in the string sent in ASCII proprietary mode. In the sequence c...c, each character identifies a measurement according to the following correspondence: 0 ⇒ Barometric Pressure 5 ⇒ Instant speed U,V,W coordinates 6 ⇒ Instant speed intensity in the U,V plane 7 ⇒ Wind speed average intensity 8 ⇒ Wind average direction (Azimuth) 9 ⇒ Elevation angle G ⇒ Wind Gust (intensity and direction) S ⇒ Sound speed T ⇒ Sonic Temperature C ⇒ Tilt_Y, Tilt_X E ⇒ Errors Default=78TE (see Note 2)
RU1D	& c...c	Reads measurements order in the string sent in ASCII proprietary mode.
CU2Rnnnn	&	Sets transmission interval of string with measurements in ASCII proprietary mode to nnnn seconds. The interval should range within 1 and 3600 seconds. Default=1 second.
RU2R	& nnnn	Reads transmission interval of string with measurements in ASCII proprietary mode.

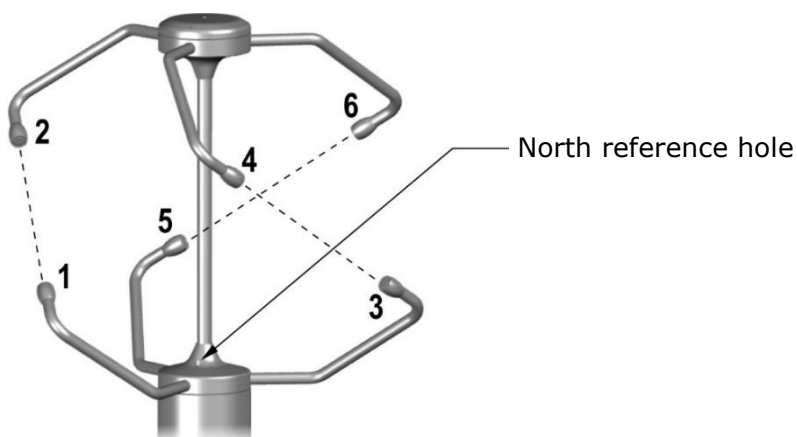
NOTE 2: MEASUREMENTS ORDER

In the measurement string sent by the instrument in ASCII proprietary mode, the measurements can be ordered arbitrarily; simply indicate the desired order in the sequence of characters "c...c" sent by the command CU1D. The sequence of characters "c...c" can have a variable length up to a maximum of 16 characters.

If information on error conditions is requested (E character), three numbers with the following meaning will appear in the data string sent by the instrument:

1. *First number* = error code identifying the transducers and the type of error.

The number consists of two digits. The first digit indicates the transducer that presents the error, according to the numbering indicated in the figure below. Zero indicates no error.



The second digit indicates the type of error: **0** = no errors; **5** = transducer broken, electric interruption, path obstruction; **Other** = codes reserved to technical service.

2. *Second number* = heating status: **0** = off, **1** = arms heating is on, **2** = arms heating and transducers heating are both on.
3. *Third number* = number of invalid measurements.

Parameters for NMEA mode:

Command	Reply	Description
CU4Bn	&	Sets Baud Rate for NMEA mode to: <ul style="list-style-type: none"> ▪ 2400 if n=1 ▪ 4800 if n=2 (<i>default</i>) ▪ 9600 if n=3 ▪ 19200 if n=4 ▪ 38400 if n=5 ▪ 57600 if n=6 ▪ 115200 if n=7
RU4B	& n	Reads Baud Rate setting for NMEA mode.
CU4In	&	Sets interface for NMEA mode to: <ul style="list-style-type: none"> ▪ RS232 if n=0 ▪ RS485 if n=1 (<i>default</i>) ▪ RS422 if n=2
RU4I	& n	Reads interface setting for NMEA mode.
CU4Mn	&	Sets parity and stop bits (data bits = 8 fixed) for NMEA mode to: <ul style="list-style-type: none"> ▪ 8N1 if n=0 (<i>default</i>) ▪ 8N2 if n=1 ▪ 8E1 if n=2 ▪ 8E2 if n=3 ▪ 8O1 if n=4 ▪ 8O2 if n=5
RU4M	& n	Reads current setting of parity and stop bits for NMEA mode.
CU4Rnnn	&	Sets transmission interval of string with measurements in NMEA mode to nnn seconds. The interval should range within 1 and 255 seconds. Default=1 second.
RU4R	& nnn	Reads setting of transmission interval of string with measurements in NMEA mode.

Parameters for Modbus-RTU mode:

Command	Reply	Description
CU5Annn	&	Sets Modbus address to nnn. The address should range within 1 and 247. Default=1.
RU5A	& nnn	Reads the Modbus address setting.
CU5Bn	&	Sets the Baud Rate for Modbus mode to: <ul style="list-style-type: none"> ▪ 9600 if n=3 ▪ 19200 if n=4 (<i>default</i>) ▪ 38400 if n=5 ▪ 57600 if n=6 ▪ 115200 if n=7
RU5B	& n	Reads Baud Rate setting for Modbus mode.
CU5In	&	Sets interface for MODBUS mode to: <ul style="list-style-type: none"> ▪ RS232 if n=0 ▪ RS485 if n=1 (<i>default</i>) ▪ RS422 if n=2
RU5I	& n	Reads interface setting for Modbus mode.
CU5Mn	&	Sets parity and stop bits (data bits = 8 fixed) for Modbus mode to: <ul style="list-style-type: none"> ▪ 8N1 if n=0 ▪ 8N2 if n=1 ▪ 8E1 if n=2 (<i>default</i>) ▪ 8E2 if n=3 ▪ 8O1 if n=4 8O2 if n=5
RU5M	& n	Reads the setting of parity and stop bits for Modbus mode.
CU5Wn	&	Sets waiting time after transmission in Modbus mode to: <ul style="list-style-type: none"> ▪ Immediate reception if n=0 (violates protocol) ▪ Waiting 3.5 characters if n=1 (respects protocol, <i>default</i>)
RU5W	& n	Reads current setting of waiting time after transmission in Modbus mode.

Parameters for SDI-12 mode:

Command	Reply	Description
CU3Ac	&	Sets the SDI-12 address to c value The address is an alphanumeric character ranging within 0...9, a...z, A...Z. Default=0.
RU3A	& c	Reads the SDI-12 address.

Units of measurement:

Command	Reply	Description
CGUVn	&	Sets wind speed unit of measurement: <ul style="list-style-type: none"> ▪ m/s if n=1 (<i>default</i>) ▪ cm/s if n=2 ▪ km/h if n=3 ▪ knot if n=4 ▪ mph if n=5
RGUV	n	Reads the wind speed unit of measurement.
CGUTn	&	Sets temperature unit of measurement: <ul style="list-style-type: none"> ▪ °C if n=1 (<i>default</i>) ▪ °F if n=2
RGUT	n	Reads the temperature unit of measurement.
CGUPn	&	Sets pressure unit of measurement: <ul style="list-style-type: none"> ▪ hPa (mbar) if n=1 (<i>default</i>) ▪ mmHg if n=2 ▪ inchHg if n=3 ▪ mmH₂O if n=4 ▪ inchH₂O if n=5 ▪ atm if n=6
RGUP	n	Reads the pressure unit of measurement.

Sensor support arms heating:

Command	Reply	Description
CGHn	&	Enables/disables heating: <ul style="list-style-type: none"> ▪ Disables if n=0 ▪ Enables if n=1 (<i>default</i>)
RGH	n	Enabling status of the heating.

Note: the sensors heating cannot be disabled.

Measurement parameters:

Command	Reply	Description
CWCnnnn	&	Sets wind speed threshold to nnnn value, in hundredths of m/s. Value should range within 0 and 100 hundredths of m/s (= 0...1 m/s). Default=20 (= 0.2 m/s). (see Note 3)
RWC	& nnnn	Reads the wind speed threshold value, in hundredths of m/s.
CWaLnnn	&	Sets time interval for averaging speed and direction to nnn value. Value should range within 1 and 600 s. Default=1 s.
RWaL	& nnn	Reads the time interval for averaging speed and direction.
CWaMn	&	Sets the method for averaging speed and direction: <ul style="list-style-type: none"> ▪ Scalar average if n=0 ▪ Vector average if n=1 (<i>default</i>) (see Note 4)

Command	Reply	Description
RWaM	& n	Reads the method for averaging speed and direction.
CWgLnnn	&	Sets time interval for the calculation of averages in Wind Gust measurement to nnn value. Value should range within 1 and 100 s. Default=3 s (standard WMO value). (see Note 6)
RWgL	& nnn	Reads the time interval for the calculation of averages in Wind Gust measurement.
CWgMn	&	Sets the method for the calculation of averages in Wind Gust measurement: <ul style="list-style-type: none"> ▪ Scalar average if n=0 ▪ Vector average if n=1 (<i>default</i>) (see Note 4)
RWgM	& n	Reads the method for the calculation of averages in Wind Gust measurement.
CWgOnnn	&	Sets time interval for detecting the maximum of the averages in Wind Gust measurement to nnn value. Value should range within 1 and 600 s. Default=60 s. (see Note 6)
RWgO	& nnn	Reads the time interval for detecting the maximum of the averages in Wind Gust measurement.
cxd nn.n	cxd	Sets the magnetic declination to nn.n°. Value should range within -90.0 and +90.0, and it is used to compensate the measurement and refer it to the geographical North. Default=0.
rxd	Direction offset to N mark nn.n°	Reads the set magnetic declination.
cor n	cor	Sets the measurement rate to n Hz (measurements per second). Value should range within 1 and 4. Default=4.
ror	n samples per second	Reads the set measurement rate.

NOTE 3: WIND SPEED THRESHOLD VALUE

If the wind speed is very low, the determination of the direction can result inaccurate. The instrument allows setting the threshold value of speed below which the direction value is frozen on the last acquired value.

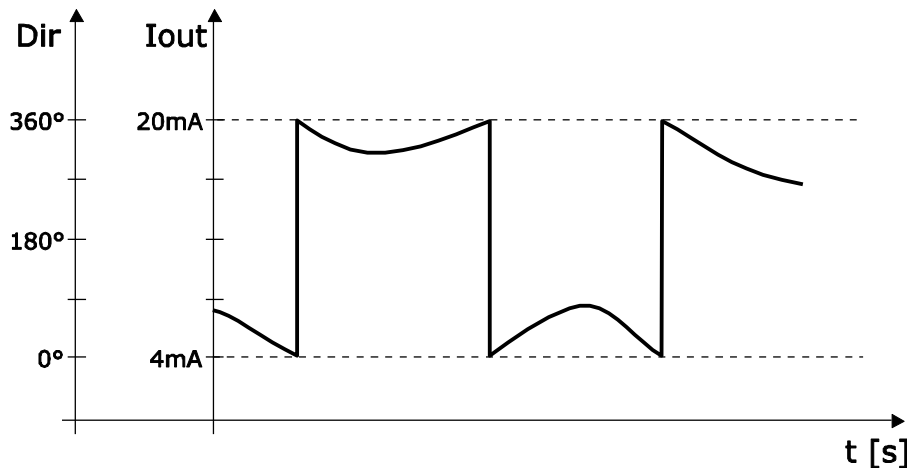
NOTE 4: SCALAR AVERAGE AND VECTOR AVERAGE

Scalar average: the average intensity is calculated as average of intensities. For the calculation of the average direction, also called "prevailing direction", the velocity **versor** (unit vector having the same direction of the velocity vector) is considered for each measurement, and the versor coordinates along the measurement axes are calculated, then the average of the coordinates along each axis is calculated. The average coordinates determine the average versor and therefore the average direction. The average direction is expressed according to the extended characteristic for the analog output (see **Note 5**).

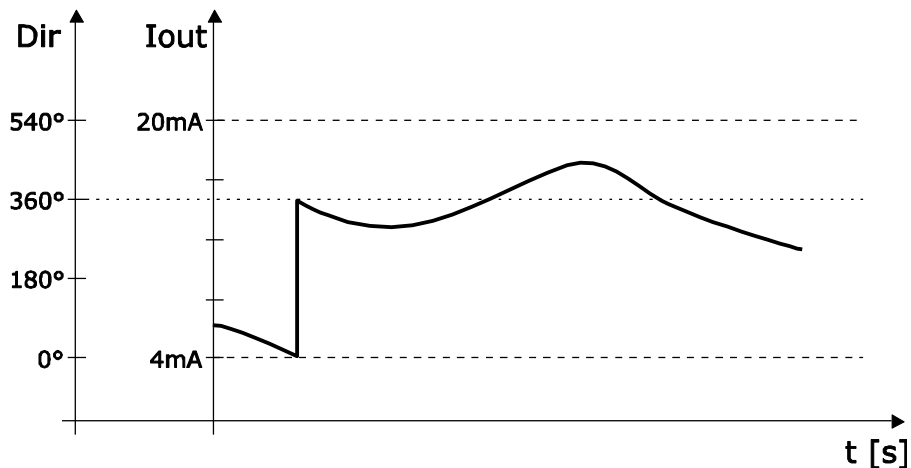
Vector average: for each measurement, the coordinates of the velocity vector along the measurement axes are calculated and then the average of the coordinates along each axis is calculated. The average intensity and the average direction are those determined by the average coordinates.

NOTE 5: WIND DIRECTION EXTENDED CHARACTERISTIC

With 0÷360° wind direction measuring range, the analog output continues to oscillate between maximum and minimum scale if the direction continues to slightly fluctuate around 0°:



This effect can be reduced through the extended ("wrap-around") characteristic of direction. In this mode, the wind direction is considered as corresponding to 0÷540° range instead of 0÷360°. The wide output fluctuation occurs the first time that the wind direction goes from 0 to 359.9°; if later the "physical" direction goes back to 0°, the analog output will always remain around 360°. Using the extended characteristic, the behavior of the above graph changes into the following:



If 540° is exceeded in extended mode, the output goes to the value corresponding to 180°. The table below shows the correspondence between the value of the analog output and the direction of the wind in the two modes.

Wind direction	4...20mA output		0...1V output		0...5V output		0...10V output	
	standard	extended	standard	extended	standard	extended	standard	extended
0°	4.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00
180°	12.00	9.33	0.50	0.33	2.50	1.67	5.00	3.33
360°	20.00	14.67	1.00	0.67	5.00	3.33	10.00	6.67
540°	--	20.00	--	1.00	--	5.00	--	10.00

NOTE 6: WIND GUST MEASUREMENT

The Wind Gust measurement is determined as follows:

- the wind speed averages (according to the method set with the **CWgM** command, by default vector averages) in a time interval equal to that set with the **CWgL** command (by default 3 seconds) are calculated continuously;
- the maximum value of the averages calculated in the previous point is detected over a time interval equal to that set with the **CWgO** command (by default 60 seconds); the maximum value detected is the measure of Wind Gust.

Analog outputs:

Command	Reply	Description
RAT	& n	Reads the analog output type: <ul style="list-style-type: none"> ▪ 4...20/0...20 mA if n=0 ▪ 0...1 V if n=1 ▪ 0...5 V if n=2 ▪ 0...10 V if n=3
CAFxnn	&	Sets offset and direction of the analog output x (x=1, 2 or 3) to: <ul style="list-style-type: none"> ▪ Standard if nn=00 (<i>default</i>) [ex. 4...20 mA, 0...1 V, 0...5 V, 0...10 V] ▪ Without offset if nn=01 [ex. 0...20 mA] ▪ With offset if nn=02 [ex. 0.2...1 V, 1...5 V, 2...10 V] ▪ Inverted if nn=04 [ex. 20...4 mA, 1...0 V, 5...0 V, 10...0 V] ▪ Inverted without offset if nn=05 [ex. 20...0 mA] ▪ Inverted with offset if nn=06 [ex. 1...0.2 V, 5...1 V, 10...2 V]
RAFx	& nn	Reads offset and direction setting of the analog output x (x=1, 2 or 3).
CAMn	&	Association of the analog outputs: <ul style="list-style-type: none"> ▪ If n= 0 (<i>default</i>): Output 1 = Mean wind speed. Output 2 = Mean wind direction (with extended characteristic if average is scalar). Output 3 = Not used. ▪ If n= 1 (see Note 7): Output 1 = Instant wind speed component along V-axis. Output 2 = Instant wind speed component along U-axis. Output 3 = Instant wind speed component along W-axis. ▪ If n= 2 (Tunnel mode, see Note 8): Output 1 = Instant wind speed component along the direction indicated by the reference on the instrument housing. Output 2 = Instant wind direction referred to the direction indicated by the reference on the instrument housing. Output 3 = Not used.

Command	Reply	Description
RAM	& n	Reads the association of analog outputs.
CAHn	&	Associates full scale of wind speed analog output to: <ul style="list-style-type: none"> ▪ 5 m/s if n=0 ▪ 10 m/s if n=1 ▪ 15 m/s if n=2 ▪ 20 m/s if n=3 ▪ 25 m/s if n=4 ▪ 30 m/s if n=5 ▪ 35 m/s if n=6 ▪ 40 m/s if n=7 ▪ 45 m/s if n=8 ▪ 50 m/s if n=9 ▪ 55 m/s if n=10 ▪ 60 m/s if n=11 ▪ 65 m/s if n=12 ▪ 70 m/s if n=13 ▪ 75 m/s if n=14 (<i>default</i>) ▪ 80 m/s if n=15 ▪ 85 m/s if n=16 ▪ 90 m/s if n=17
RAH	& n	Reads the value corresponding to the wind speed analog output full scale.

NOTA 7: U, V, W COMPONENTS

By selecting the U, V, W components, the speed value associated to the initial scale of the analog outputs is equal to the opposite of the speed value associated to the full scale of the outputs (e.g., -75 m/s if f.s.=75 m/s).

NOTA 8: TUNNEL MODE

The reference on the instrument housing should be aligned with the direction of the tunnel. The output 2 is set to full scale value if the wind blows in the direction pointed by the reference, and to initial scale value if the wind blows in the opposite direction. The initial scale of output 1 is associated to the speed value opposite to that associated to the output full scale.

6 RS232 ASCII proprietary mode

In RS232 ASCII proprietary mode, the instrument sends automatically the acquired measurements at regular intervals. The interval is factory-set to 1 second and is configurable from 1 to 3600 seconds. To change the interval, enter configuration mode and send the command **CU2Rnnnn**, where nnnn indicates the interval value in seconds (see chapter 5).

By default, the communication parameters are 115200, 8N2 and can be changed by using the appropriate commands of the configuration mode.

The instrument sends measurements in the following format:

<M1><M2>...<Mn><CR><LF>

with <M1><M2>...<Mn> = values of the first, second, ..., nth measurement

<CR> = ASCII character *Carriage Return*

<LF> = ASCII character *Line Feed*

The fields <M1><M2>....<Mn> consist of 8 characters each (spaces are possibly added before the values to get to 8 characters). The sequence of the measurements is configurable (command **CU1Dc...c**, see chapter 5).

7 RS485 ASCII proprietary mode

In RS485 ASCII proprietary mode, the instrument sends the acquired measurements only if requested by the PC.

To use this mode, you must connect to a RS485 or RS422 serial port.

By default, the communication parameters are 115200, 8N2 and can be changed by using the appropriate commands of the configuration mode.

The instrument is requested to send measurements by generating a *Break Signal* (*) on the serial line for at least 2 ms, and then sending the following command, consisting of 4 ASCII characters:

M<Address><x>G

with <Address> = address of the instrument measurements are requested to
<x> = any ASCII character, except G

The instrument answers with the following string:

IIIIIM<Address>I<M1><M2>....<Mn><SP>&AAAM<Address><CS><CR>

with <Address> = address of the instrument sending measurements
<M1><M2>....<Mn> = values of the first, second,...., nth measurement
<SP> = space
<CS> = checksum (8-bit hex value equal to the sum of all previous characters)
<CR> = ASCII character Carriage Return

The fields <M1><M2>....<Mn> consist of 8 characters each (spaces are possibly added before the values to get to 8 characters). The sequence of the measurements is configurable (command **CU1Dc...c**, see chapter 5).

A minimum time interval should elapse between two commands, depending on the Baud Rate setting:

Baud Rate	Minimum interval between two commands
9600	200 ms
19200	100 ms
38400	70 ms
57600	40 ms
115200	25 ms

(*) The **Break Signal** is an interruption of the serial communication for a given time interval. It is used to inform the devices connected to the network that a command is going to be sent.

8 NMEA mode

The instrument is compatible with NMEA 0183 V4.00 protocol. In NMEA mode, the instrument sends automatically the acquired measurements at regular intervals. The interval is factory-set to 1 second and can be configured within 1 and 255 seconds. To change the interval, enter configuration mode and send **CU4Rnnn** command, where nnn indicates the interval value in seconds (see chapter 5).

By default, the communication parameters are 4800, 8N1 and can be changed by using the appropriate commands of the configuration mode.

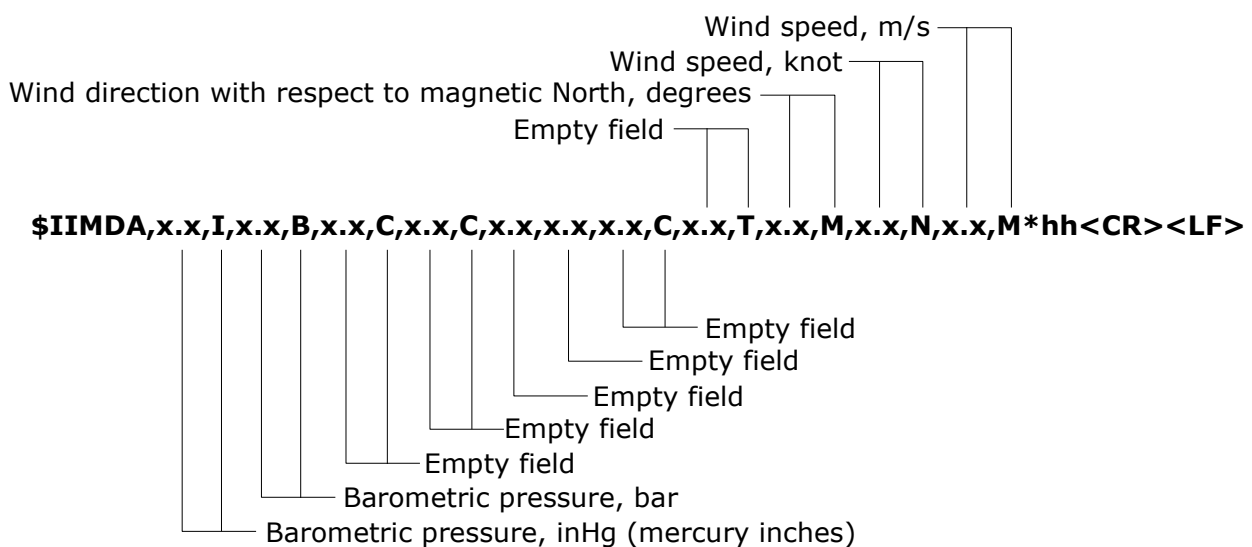
The protocol establishes that data are sent in the following format:

\$<Prefix>,<Data>*<hh><CR><LF>

with <Prefix> = field consisting in 5 alphanumeric characters: the first two indicate the type of transmitting device, the other three indicate the type of transmitted data
 <Data> = values measured by the instrument, separated by commas
 <hh> = checksum, consisting in two hexadecimal characters
 <CR> = character ASCII Carriage Return
 <LF> = character ASCII Line Feed

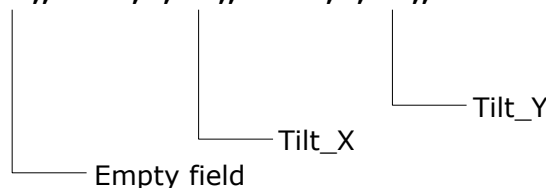
The checksum is calculated as exclusive OR of all characters between \$ and * symbols. The 4 most significant bits and the 4 less significant bits of the result are converted in hexadecimal and the value corresponding to the most significant bits is transmitted first.

The instrument regularly sends a string in the following general format:



The previous string is followed by a second string (\$IIXDR...) including the tilt angles:

\$IIXDR,G,x.x,,PYRA,G,x.x,,TILTX,G,x.x,,TILTY*hh<CR><LF>



The fields related to quantities not measured by the instrument are empty (multiple consecutive commas appear to indicate the missing fields).

For additional information regarding the protocol, visit the website "www.nmea.org".

9 MODBUS-RTU mode

By default, the Modbus address is **1** and the communication parameters are 19200, 8E1. The address and the communication parameters can be changed by using the appropriate commands of the configuration mode.

Below is the list of registers.

Input Registers

Address	Description	Format
0	Instantaneous wind speed (x100)	unsigned 16 bits
1	Instantaneous wind direction (Azimuth) in degrees (x10)	unsigned 16 bits
2	Instantaneous elevation angle (x10)	16 bits
3	Average elevation angle (x10)	16 bits
4	Average of the three sonic temperatures measured by the three transducers pairs (x10)	16 bits
7	Barometric pressure (x1000 if the unit of measurement is atm, x10 in the other cases)	unsigned 16 bits
10	Average wind speed (x100)	unsigned 16 bits
11	Average wind direction (Azimuth) in degrees (x10)	unsigned 16 bits
14	Instantaneous wind direction (Azimuth) in degrees (x10) with extended feature (see page 23)	unsigned 16 bits
15	Instantaneous wind speed (x100) along V-axis	16 bits
16	Instantaneous wind speed (x100) along U-axis	16 bits
17	Instantaneous wind speed (x100) along W-axis	16 bits
18	Wind speed unit of measurement: 0=m/s, 1=cm/s, 2=km/h, 3=knot, 4=mph	unsigned 16 bits
19	Temperature unit of measurement: 0=°C, 1=°F	unsigned 16 bits
20	Barometric pressure unit of measurement: 0=hPa, 1=mmHg, 2=inchHg, 3=mmH ₂ O, 4=inchH ₂ O, 5=atm	unsigned 16 bits
21	Wind Gust intensity (x100)	unsigned 16 bits
22	Wind Gust direction (Azimuth) in degrees (x10)	unsigned 16 bits
23	Average wind speed (x100) in the U,V plane	unsigned 16 bits
24	Tilt_Y in degrees (x10)	16 bits
25	Tilt_X in degrees (x10)	16 bits

For quantities with configurable unit of measurement, the measurement value is expressed in the unit set in the instrument.

For additional information regarding the protocol, visit the website "www.modbus.org".

10 SDI-12 mode

The instrument is compatible with V1.3 version of the protocol. To use this mode, an SDI-12 serial connection should be performed. The communication parameters are 1200, 7E1.

By default, the SDI-12 address is **0** and can be changed by using the appropriate command of the configuration or SDI-12 mode.

Communication with the instrument is performed by sending a command in the following format:

<Address><Command>!

with <Address> = address of the instrument the command is sent to.

<Command> = type of operation requested to the instrument.

The instrument reply is as follows:

<Address><Data><CR><LF>

with <Address> = address of the replying instrument

<Data> = information sent by the instrument

<CR> = ASCII character *Carriage Return*

<LF> = ASCII character *Line Feed*

Below is the list of SDI-12 commands. To comply with the SDI-12 standard, the instrument address is indicated in the table with the letter **a**.

SDI-12 COMMANDS

Command	Reply	Description
a!	a<CR><LF>	Checks for the presence of the instrument.
aI!	allccccccmmmmmmvvvx...x<CR><LF> where: a = address of the instrument (1 character) ll = compatible SDI-12 version (2 characters) ccccccc = manufacturer (8 characters) mmmmm = instrument model (6 characters) vvv = firmware version (3 characters) x...x = instrument version (up to 13 characters)	Request for instrument information.
aAb! where: b = new address	b<CR><LF> Note: if character b is not an acceptable address, the instrument answers with a in the place of b.	Change of instrument address.
?!	a<CR><LF>	Request for instrument address. If more than a sensor is connected to the bus, a conflict will occur.

Type M (start measurement) commands

Command	Reply	Description
Wind speed and direction, barometric pressure		
aM!	attn<CR><LF> where: a = address of the instrument (1 character) ttn = number of seconds needed by the instrument to make measurements available (3 characters) n = number of detected quantities (1 character) Note: ttn = 000 means data immediately available.	Request to detect the measurements.
aD0! aD1! aD2!	a<WS><WD><NU><CR><LF> <i>Parameters not used</i> a<P><WUV><NU><CR><LF> where: a = address of the instrument <WS> = wind speed <WD> = wind direction in degrees <P> = barometric pressure <WUV> = average wind speed in the U,V plane <NU> = <i>parameter not used</i>	Request for measured values.
Average wind speed and direction, wind gust, elevation angle, U,V,W coordinates		
aM1!	attn<CR><LF> where: a = address of the instrument (1 character) ttn = number of seconds needed by the instrument to make measurements available (3 characters) n = number of detected quantities (1 character) Note: ttn = 000 means data immediately available.	Request to detect the measurements.
aD0! aD1! aD2! aD3!	a<WSa><WDa><CR><LF> a<WGS><WGD><CR><LF> a<WE><WEa><CR><LF> a<WV><WU><WW><CR><LF> where: a = address of the instrument <WSa> = average wind speed <WDa> = average wind direction in degrees <WGS> = wind Gust intensity <WGD> = wind Gust direction in degrees <WE> = instantaneous elevation angle <WEa> = average elevation angle <WV> = wind speed V coordinate <WU> = wind speed U coordinate <WW> = wind speed W coordinate	Request for measured values.

Type R (continuous measurements) commands

Command	Reply	Description
aR0!	a<WS><WD><NU><CR><LF>	Request for measured values.
aR1!	<i>Parameters not used</i>	
aR2!	a<P><WUV><NU><CR><LF>	
aR3!	a<WSa><WDa><CR><LF>	
aR4!	a<WGS><WGD><CR><LF>	
aR5!	a<WE><WEa><CR><LF>	
aR6!	a<WV><WU><WW><CR><LF>	
	where: a = address of the instrument <WS> = wind speed <WD> = wind direction in degrees <P> = barometric pressure <WUV> = average wind speed in the U,V plane <WSa> = mean wind speed <WDa> = mean wind direction in degrees <WGS> = wind Gust intensity <WGD> = wind Gust direction in degrees <WE> = instantaneous elevation angle <WEa> = average elevation angle <WV> = wind speed V coordinate <WU> = wind speed U coordinate <WW> = wind speed W coordinate <NU> = <i>parameter not used</i>	

Notes:

- 1) The positive values are always preceded by a + sign to identify the beginning of the measurement value.
- 2) The values of the quantities with configurable unit of measurement are expressed in the unit set in the instrument.
- 3) If a quantity measurement is in error condition, a negative value consisting in a series of 9 is sent.
- 4) The fields corresponding to parameters not measured (NU) are always present: a negative value consisting in a series of 9 is sent.
- 5) The Wind Gust measurement is determined by continuously calculating the wind speed averages in a time interval equal to 3 seconds, and detecting the maximum value of the calculated averages over the time elapsed between the current reading command and the previous reading command (the Wind Gust measurement is reset after each reading command).

For additional information regarding the protocol, visit the website "www.sdi-12.org".

11 Maintenance

Wind speed sensors does not generally require maintenance.

In case abnormal measures are detected, verify the cleanliness of the ultrasonic sensors. For cleaning, use a moistened soft cloth. The sensors should be wiped gently: **do not brush or twist the sensors.**

12 Instrument storage

Instrument storage conditions:

- Temperature: -40...+70 °C.
- Humidity: less than 90 %RH no condensation.
- In storing, avoid locations where:
 - There is a high humidity level.
 - The instrument is exposed to direct sunlight.
 - The instrument is exposed to a high temperature source.
 - There are high vibration levels.
 - There is presence of vapor, salt and/or corrosive gas.

13 Safety instructions

The instrument proper operation and operating safety can be ensured only in the climatic conditions specified in this manual and if all standard safety measures as well as the specific measures described in this manual are followed.

Do not use the instrument in places where there are:

- Corrosive or flammable gases.
- Direct vibrations or shocks to the instrument.
- High-intensity electromagnetic fields, static electricity.

User obligations

The instrument operator shall follow the directives and regulations below that refer to the treatment of dangerous materials:

- EU directives on workplace safety.
- National law regulations on workplace safety.
- Accident prevention regulations.

14 Accessories ordering codes

The anemometer is supplied with M23 female free connector (only if the optional cable is not ordered), bird spikes and HD52.3D-S PC application software downloadable from the website.

The cable must be ordered separately.

CPM23-19... Cable with 19-pole M23 connector on one end, open wires on the other end. Length 5 m (CPM23-19.5) or 10 m (CPM23-19.10).

RS51K Kit for connecting the anemometer RS485 auxiliary output to a PC. It includes SWD10 power supply and a RS485/USB adapter with screw terminals for the connection to the CPM23-19... cable (not included), USB connector for the connection to the PC and jack connector for connecting SWD10 power supply.

WARRANTY

The manufacturer is required to respond to the "factory warranty" only in those cases provided by Legislative Decree 6 September 2005 - n. 206. Each instrument is sold after rigorous inspections; if any manufacturing defect is found, it is necessary to contact the distributor where the instrument was purchased from. During the warranty period (24 months from the date of invoice) any manufacturing defects found will be repaired free of charge. Misuse, wear, neglect, lack or inefficient maintenance as well as theft and damage during transport are excluded. Warranty does not apply if changes, tampering or unauthorized repairs are made on the product. Solutions, probes, electrodes and microphones are not guaranteed as the improper use, even for a few minutes, may cause irreparable damages.

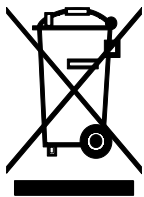
The manufacturer repairs the products that show defects of construction in accordance with the terms and conditions of warranty included in the manual of the product. For any dispute, the competent court is the Court of Padua. The Italian law and the "Convention on Contracts for the International Sales of Goods" apply.

TECHNICAL INFORMATION

The quality level of our instruments is the result of the continuous product development. This may lead to differences between the information reported in the manual and the instrument you have purchased.

We reserve the right to change technical specifications and dimensions to fit the product requirements without prior notice.

DISPOSAL INFORMATION



Electrical and electronic equipment marked with specific symbol in compliance with 2012/19/EU Directive must be disposed of separately from household waste. European users can hand them over to the dealer or to the manufacturer when purchasing a new electrical and electronic equipment, or to a WEEE collection point designated by local authorities. Illegal disposal is punished by law.

Disposing of electrical and electronic equipment separately from normal waste helps to preserve natural resources and allows materials to be recycled in an environmentally friendly way without risks to human health.



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