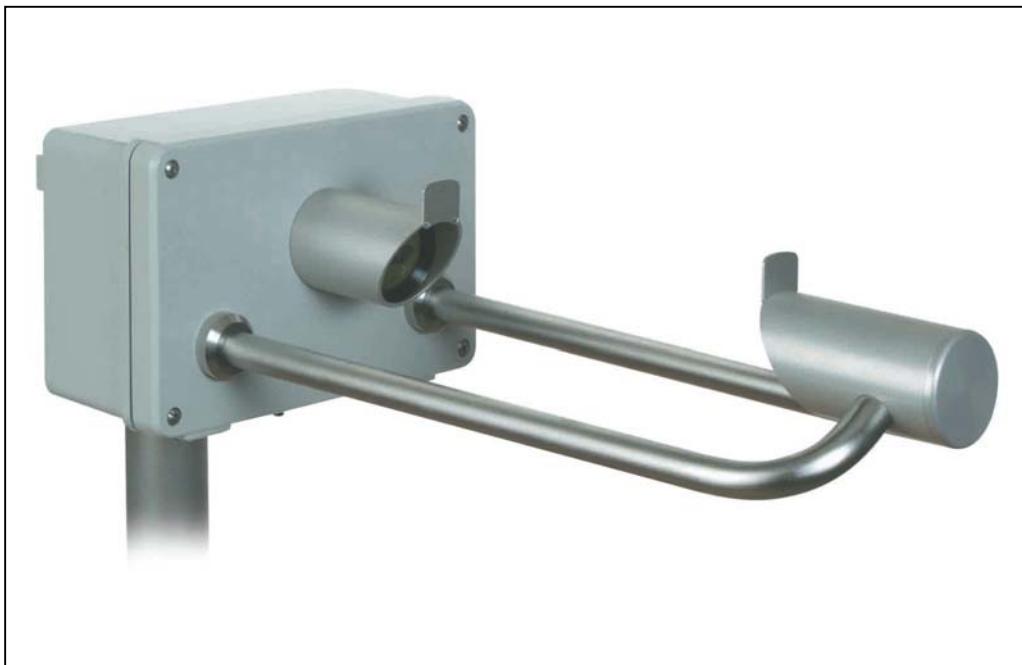


Instruction for Use
021341/07/04

Laser Precipitation Monitor
5.4110.x0.x00



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1 Models

Order-No.	Operating Voltage	Optional Meas. Channel	Electr. Output
5.4110.00.000	24 V AC/DC	no	RS 485/422 u. 2x opto-coupler
5.4110.00.100	115 V AC	no	RS 485/422 u. 2x opto-coupler
5.4110.00.200	230 V AC	no	RS 485/422 u. 2x opto-coupler
5.4110.00.300	12 ... 24 V DC	no	RS 485/422 u. 2x opto-coupler
5.4110.10.000	24 V AC/DC	yes	RS 485/422 u. 2x opto-coupler
5.4110.10.100	115 V AC	yes	RS 485/422 u. 2x opto-coupler
5.4110.10.200	230 V AC	yes	RS 485/422 u. 2x opto-coupler
5.4110.10.300	12 ... 24 V DC	yes	RS 485/422 u. 2x opto-coupler

2 General

The Laser Precipitation Monitor serves as measuring value transmitter, and is well-suited for the measurement and detection of different types of precipitation such as drizzle, rain, hail, snow, and mixed precipitation.

The acquisition comprises the types of precipitation, intensity, and the spectrum. All measuring values are available for the user via an RS 485/422 interface. In addition, the instrument is equipped with two further digital outputs (opto-couplers), which output, for example, pulses and state of precipitation. The optical components are equipped with an integrated heating.

Instruments with „optional measuring channels“ are able to detect temperature, rel. humidity, wind speed, and wind direction in addition. This is possible by connecting respective measuring transmitters. These values are available, as well, via the RS 485/422 interface.

3 Mode of Operation of the Laser Precipitation Monitor

A laser-optical beaming source (laser diode and optics) produces a parallel light-beam (infrared, 780 nm, not visible). A photo diode with a lens is situated on the receiver side in order to measure the optical capacity by transforming it into an electrical signal.

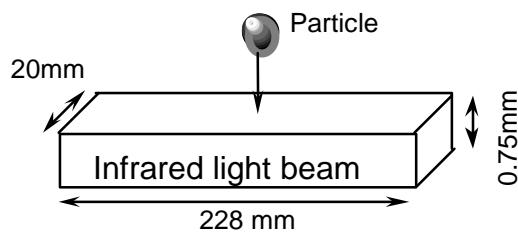


Figure 1: Measurement of the precipitation particle

When a precipitation particle falls through the light beam (measuring area $45,6\text{cm}^2(7\text{inch}^2)$) (fig.1) the receiving signal is reduced. The diameter of the particle is calculated from the amplitude of the reduction. Moreover, the fall speed of the particle is determined from the duration of the reducer signal.



Picture 2: in explanation of the measuring principle

The measured values are processed by a signal processor (DSP), and are checked for plausibility (e.g. edge hits). Calculation comprises the intensity, quantity, and type of precipitation (drizzle, rain, snow, soft hail, hail as well as mixed precipitation), and the particle spectrum (distribution of the particles over the class binning)

The type of precipitation is determined from the statistic proportion of all particles referring to diameter, and velocity. These proportions have been tested scientifically (e.g. Gunn, R., and Kinzer, G.D., 1949, "The terminal velocity of fall for water droplets in stagnant air," *J. of Meteorology*, Vol . 6, pp. 243–248). In addition, temperature is included in order to improve the identification: Precipitations with a temperature of above 9 °C are automatically accepted as liquid (exception: soft hail, and hail), and with a temperature of below –4°C as solid. In the temperature range between, all forms of precipitation might occur.

Diameter [mm]	FALL SPEED[M/S]
0.2 (drizzle)	0.73
0.3 (drizzle)	1.2
0.8 (rain)	3.3
0.9 (rain)	3.7
1.8 (rain)	6.1
2.2 (rain)	6.9
3.2 (rain)	8.3
5.8 (rain)	9.2

Table 1: Example for the speed of liquid particles

The calculated data are memorized over one minute, and are then output via the serial interface.

The instrument is almost maintenance-free. Only the panes of the sensor heads should be cleaned, if necessary. An application all the year round is guaranteed by the integrated pane-heating. For application in areas of extreme weather conditions (for example high mountains) we recommend a model with reinforced heating. The effect of outside light is minimized by the frequency pulse of the light source of 173kHz (so-called „Lock-In“ technology). The effect of aging and temperature on the components as well as the soiling of the glass panes is compensated by controlling the receiving capacity. A watch-dog device controls the signal processor (DSP). The sensor controls its function by measuring and checking the receiving signals for soiling, as well as checking the laser driver for current and temperature. By using a flash-memory the internal software can be updated any time via the serial interface.

The following outputs are available: an electrically isolated serial interface (RS485) as well as two digital outputs (opto-coupler or resp. optional relays). Thanks to the configurable digital outputs this sensor can be used as an alternative for precipitation monitors (e.g. IRSS88 or Thies 5.4103.10.000), and for precipitation sensors (e.g. tipping bucket).

The function of the digital outputs is programmable. For example: output 1

0,1mm or 0,01 resp.. 0,005 mm precipitation per pulse corresponding to the cumulatively measured precipitation quantity. Output 2, for example, as precipitation event monitor, or as additional event output „solid precipitation“ (snow, snow-grains, soft hail, hail) in conjunction with output 1.

In addition, the following sensors can be connected optionally:

temperature (Pt100, not with reinforced heating)

relative humidity (0-1V / 0-100% rel. humidity)

wind speed (frequency 0- 630 Hz for example 4.3519.00.000)

wind direction (serially synchronous for example 4.3129.00.000)

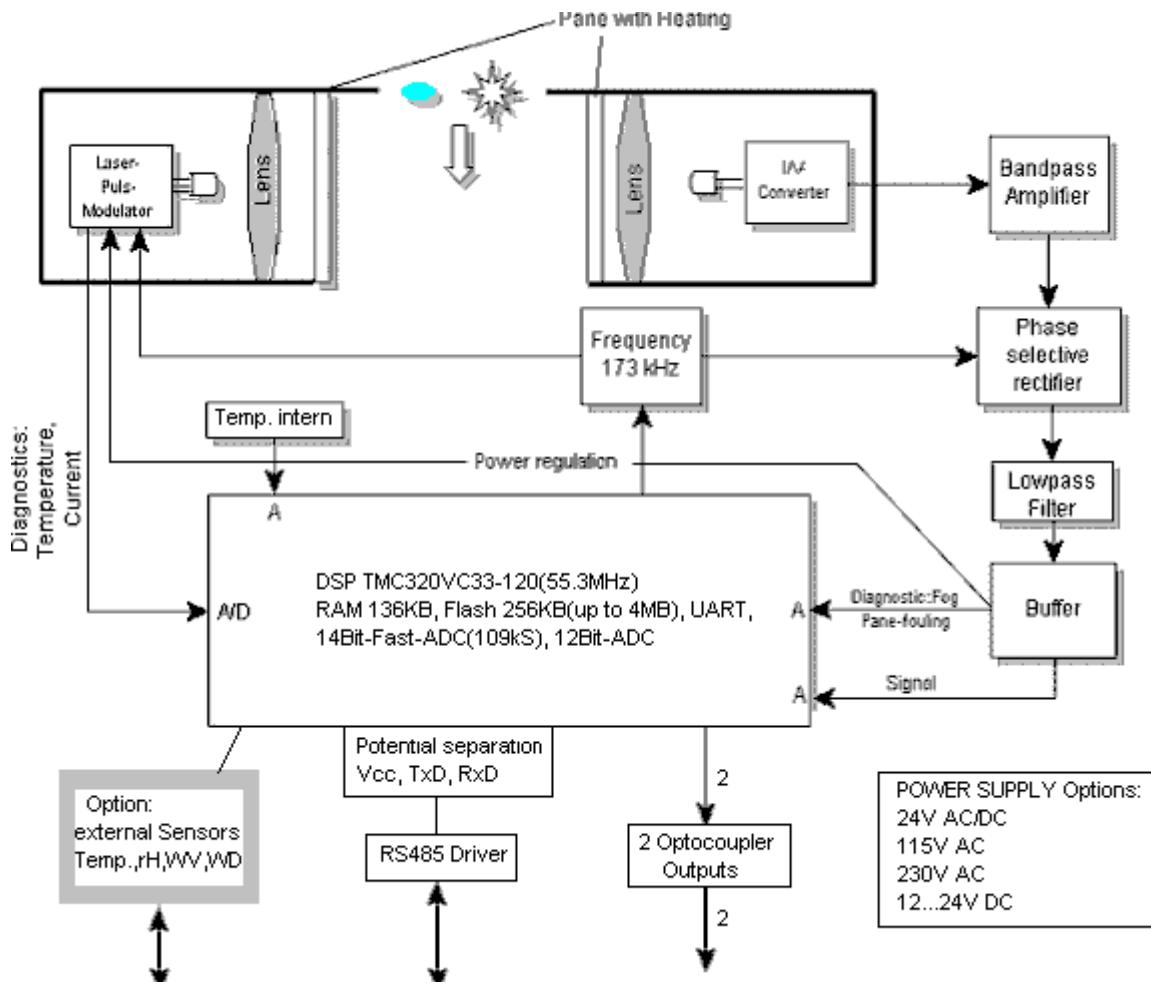


Figure 2: Schematic Block Diagram

In explanation of the construction, and the basic function the block diagram (fig. 2) shows schematically the most important functional connections

4 Construction of the Measuring Instrument

The Laser Precipitation Monitor consists of the following: a varnished aluminium housing, protection IP 65, a laser head (anodised aluminium), fixed at the housing cover, a receiver head (anodised aluminium) fastened by means of carrier arms (see also fig. 3+4)

In the aluminium housing there is the electronics with all necessary interfaces. Furthermore, the electronics is equipped with light diodes (LED's), which facilitate an easy and efficient check resp. diagnosis of the sensor even without serial data connection (fig.5). In the chapter "Maintenance" you will find a functional description of the LED's.

The replaceable laser head consists of a laser driver circuit board (incl. laser diode), a rectangular window for the beam forming, a lens as well as of a heated glass pane. The electrical connection to the electronics is carried out by means of a 10-pole ribbon flat cable leading to the "Connector Laser Driver".

The receiver head consists of a receiving circuit board with photo diode and electronics, a lens and a heated glass pane. The electrical connection is done by a 6-pole ribbon flat cable leading to the "Connector Receiver".



Attention: Do not look into the invisible laser beam! In case the laser caution labels on the housing are not legible any more the sensor must not be operated!
Even with a longer exposure time the intensity of the invisible laser beam is considered as safe for the human eye (without using optical instruments). A skin-contact with the invisible radiation is, in general, harmless.

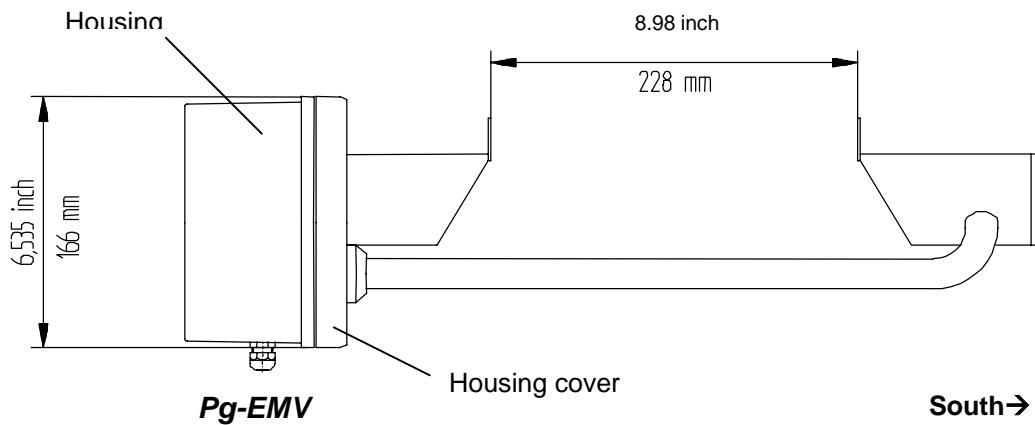


Figure 3: Side view

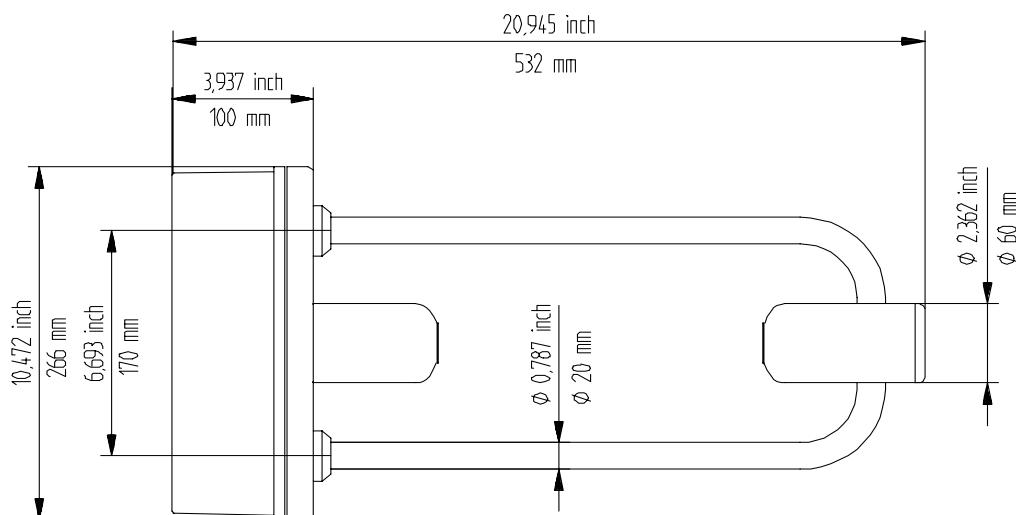


Figure 4: Top view

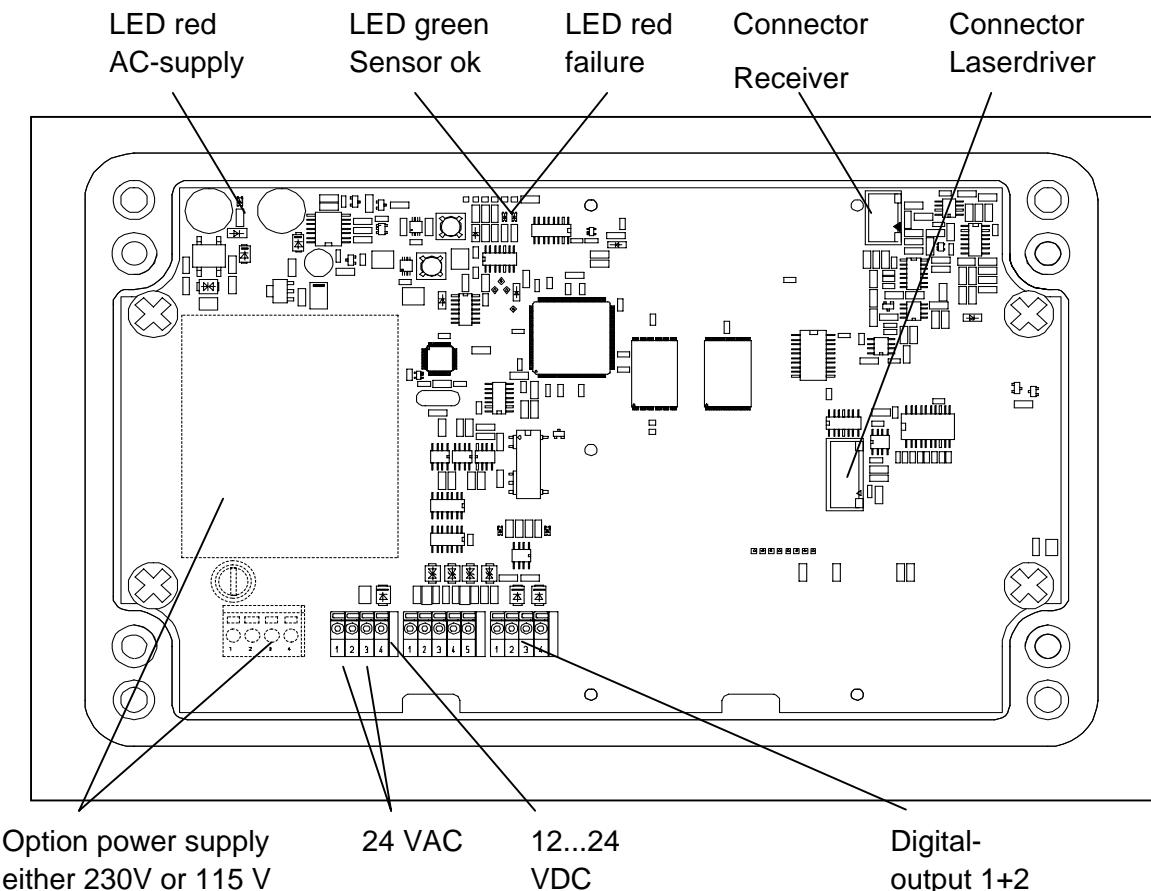


Figure 5: View of the electronics

5 Installation



Attention: *The instrument must be mounted and wired only by a qualified expert, who knows and observes the generalities of technics, and applicable regulations and norms.*

5.1 Suggestions for Mounting Place

Please note the following when selecting the location:

The sub-surface under the Laser Precipitation Monitor shall not consist of dark stone, asphalt or the like, as otherwise, in case of strong sunshine radiation, the ascending air will form so-called streaks. As sub-surface we recommend a lawn.

Depending on the wind speed and wind direction the precipitation particles are swirled by the Laser Precipitation Monitor so that the fall speed is changed. This might cause a deterioration of the sensor quality. Therefore, you should avoid an installation in the open country (particularly mountain tops) or directly in the lee of an obstacle. Well-suited are locations with wind breaks (e.g. hedges).

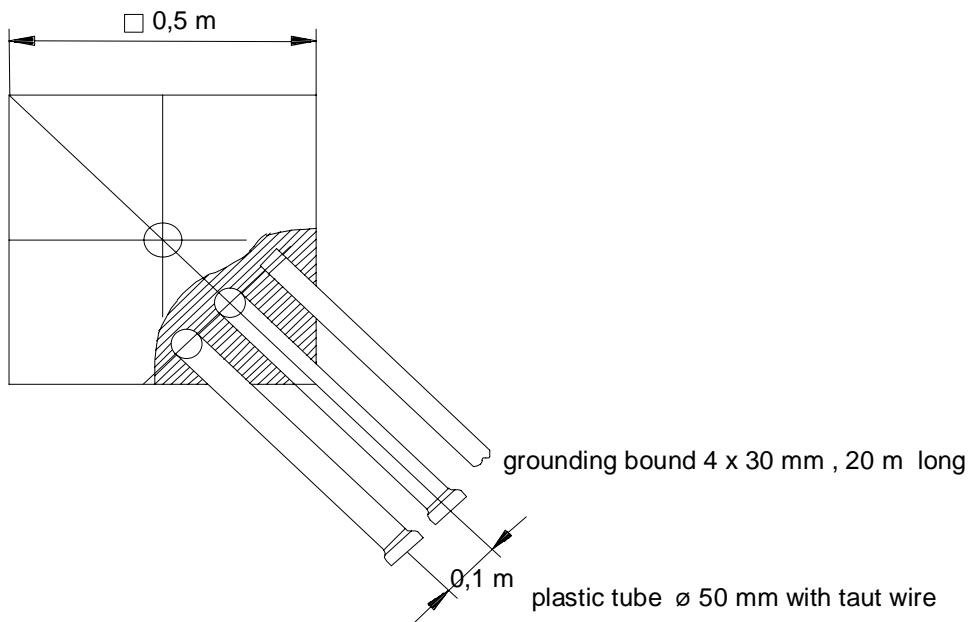
According to the WMO-directive for precipitation measuring instruments the distance between the installed sensors and the next obstacle should be at least four times the height of this obstacle. If this is not practicable, at least keep an azimuth angle of < 45° with regard to the surrounding plants, buildings etc. Logically consistent would be also to mount the sensor on a mast top.

We recommend to operate the Laser Precipitation Monitor in an enclosed area, so that nobody gets hurt by the laser radiation, or to install it at a height where no-one can be harmed.

It is not advisable to install the Laser Precipitation Monitor directly on a street, because it is, for example, possible that water particles, whirled up by the vehicles, might lead to erroneous measurements. In this case, we recommend to install the instrument with a respective distance.

5.2 Mast

The delivered mast holder of the Laser Precipitation Monitor is designed for a mast diameter of 48... 102 mm (1.9... 4 inch). The mast should be electro-conductive, and be connected to the ground potential (foundation/grounding bound). Otherwise, the sensor is to be connected to the ground potential by means of a cable (>6mm²). Due to its sensitivity the sensor is sensitive for vibrations. Therefore, the mast diameter should be preferably large, and the mast should be fixed on a concrete foundation by means of firmly welded-on struts (fig.6). From a mast height of approx. 2 m up the mast should be additionally fixed by three stay-wires.



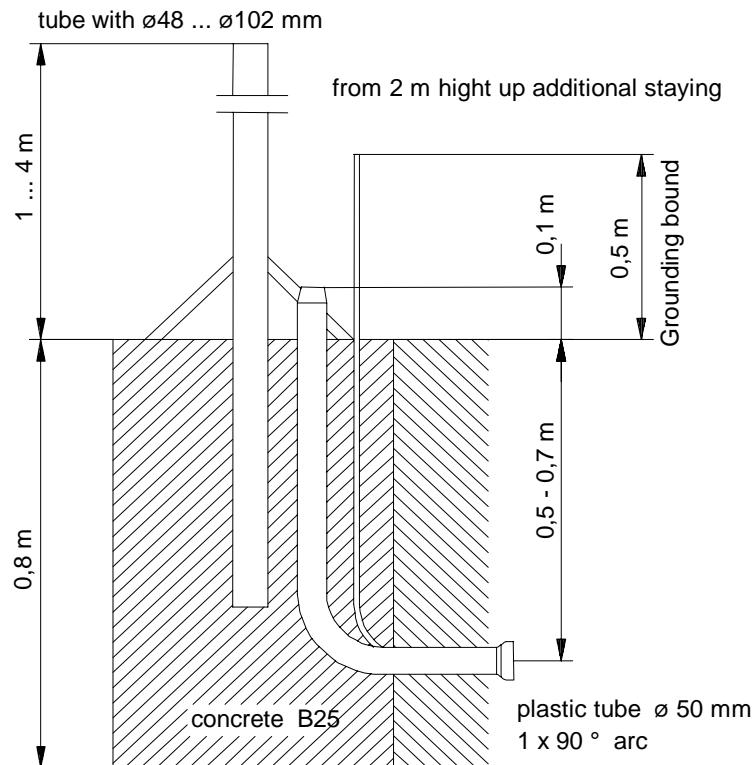


Figure 6: Example for an appropriate mast foundation (Connect grounding bound to the mast)

5.3 Installation of Sensor



Attention : Do not look into the invisible laser beam!
In case the laser caution labels on the housing are not legible any more the sensor must not be operated!
Even with a longer exposure time the intensity of the invisible laser beam is considered as safe for the human eye (without using optical instruments).
A skin-contact with the invisible radiation is, in general, harmless.

Tools:

- Allen wrench (Inbus) SW4
- Combination wrench or ring spanner wrench SW10
- Combination wrench SW16 und SW20
- Tools to work in cables (for example: skinning tool, gripper for cable end sleeve)
- Screw driver for slotted screws, blade width 2 and 6 mm
- Tools for the shortening of straps

5.3.1 Mounting Angle

First, the mounting angle (with or without housing) should be fastened at the mast. Because of the shading effect of the mast the angle is to be mounted at the highest possible place. Align the angle to the south ($\pm 10^\circ$, Northern hemisphere), and fasten it at the top of the mast. It is advisable to have a second person holding the Laser Precipitation Monitor during the mounting. In case no second person is available, it is also possible to separate the mounting angle from the Laser Precipitation Monitor (2 nuts M6 below, 2 screws above [accessible after removing the housing cover]). In case an electro-conductive mast is used, the straps should be fastened directly, i.e. without insulator. If the mast is not electro-conductive, a potential equalisation should be established between ambiance and sensor

1. Cut 2 pieces of the necessary length off the strap (1 meter) acc. to the table below.
2. Insert the strap into the housing from the screw head side, and bend a projection of 20 mm over the ridge. (Fig.7).
3. Put the free end of the prepared clamp around the mast and the mounting angle, and screw it on. (Fig.8)
4. 2 Straps are provided for each mounting angle.

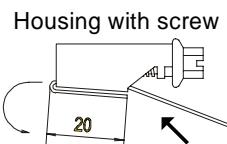


Figure 7: Strap housing

Mast Ø	Mast Ø	Length strap
48 mm	1.9 inch	250 mm (10 inch)
60 mm	2.4 inch	310 mm (12.2 inch)
80 mm	3.2 inch	370 mm (14.6 inch)
90 mm	3.5 inch	400 mm (15.8 inch)
102 mm	4 inch	440 mm (17.3 inch)

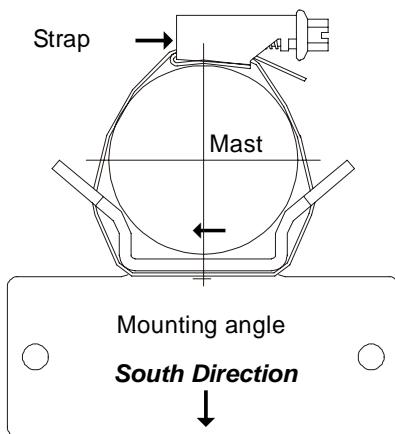


Figure 8: Strap, Mast, Mounting angle

5.3.2 Mounting of the Housing Cover

Remove, first, the 4 screws in the edges. Afterwards, turn down the cover carefully.

When the housing is open, please take care that no humidity (precipitation) can lay down on the electronics.

5.3.3 Electrical Installation



ATTENTION: *Do not look into the invisible laser beam!*
In case the laser caution labels on the housing are not legible any more the sensor must not be operated!

After the housing cover (chap. 5.3.2) has been opened, electrical connection can be carried out.

In order to carry out an EMC-compatible installation the cable screen/shielding (except the supply cable, which, in general, is not shielded) is to be connected to the contact spring of the screwed cable gland (fig. 9). You will find the wiring plan in chapter 7.

1. With the Standard Contacting (see fig. 9-1)

- Strip back the outer sheath and screen (shielding)
- Make a round cut in the outer sheath approx. 15 mm along but do not remove the sheath
- Guide the cable through the cable gland
- Pull off the outer sheath
- Pull back the cable until the connection is made between the cable screen and contact spring
- Turn shut... and it is ready for use!

2. With thin Wires without an Inner Sheath (see fig. 9-2)

- Strip back the outer sheath
- Pull back the screen braid approx. 15-20mm over the outer sheath
- Insert the cables into the cable gland until the contact is made between the cable screen and contact spring
- Turn shutand it is ready for use!

3. When Routing the Cable Screen to another Connection (see fig. 9-3)

- Expose the screen braid approx. 10 mm
- Guide the cable through the cable gland until the connection is made between the cable screen and contact spring
- Turn shut...and it is ready for use!

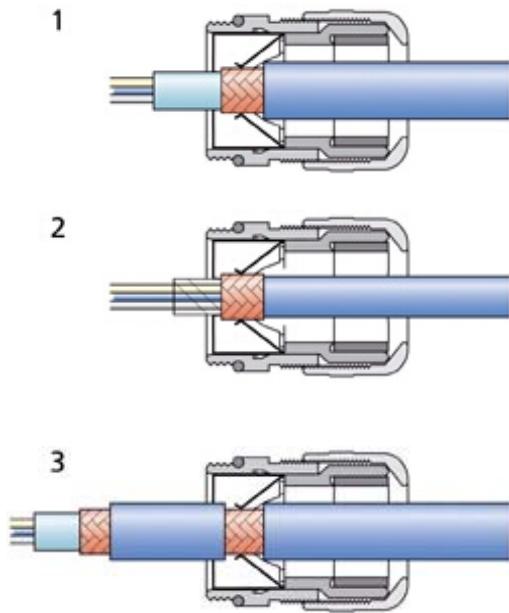


Figure 9: Screen cable connection to the cable gland

The cables are guided through the respective cable gland to the sensor connecting terminals (fig. 5), see also wiring plan (chap. 9). They are connected by means of the respective tension clamp technique. For the orange-coloured power connection (remark: optionally either 115V or 230V) put a commercially available screw-driver with a blade width of up to 2mm resp. 0,1 inch into the upper rectangular opening. Insert the respective cable into the lower round opening. After the screw driver has been removed the cable is fixed by spring tension.

With the green- and orange-coloured connecting terminals please press down the orange-coloured lever by means of a screw-driver (cable 0,1-1,5 mm² resp. 26-16 AWG).

After having been guided through the cable gland into the cover, the supply cable is to be shielded against EMC-disturbances by means of the available grey ferrite tube. For this, after connection of the cables, the ferrite tube is to be fastened directly at the cover panel by means of the binder (see fig. 10).

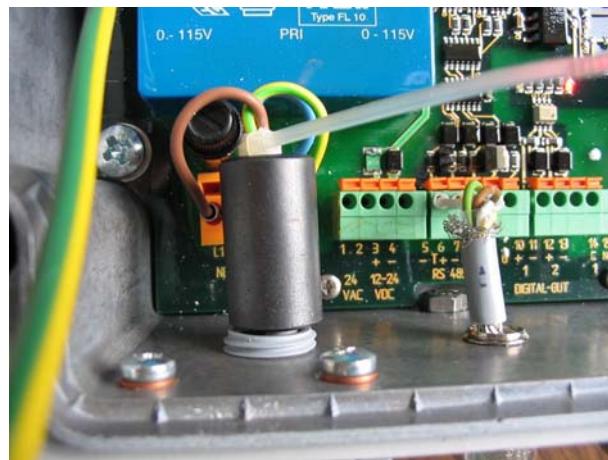


Figure 10: Connection of current supply (here 115 or 230VAC) with ferrite tube and binder

After all connections have been established the supply can be switched on. With an operating AC-supply (24 VAC or optionally 115VAC, 230 VAC as well as with optional 12...24DC supply (5.4110.XX.3XX) the red AC-power-LED (top left corner of PCB) must shine continuously . The green sensor-ok-LED flashes with 5hz when the signal processor operates properly (after approx. 5 seconds). In case the LED's show a different behaviour please refer to chapter 6 how to delimit the possible error .

NOTE: All supply voltages must be potential-free (exception 115VAC and 230VAC). For example, with the 24VAC-supply there must be used a separate winding of the transformer only for this sensor. In addition, we recommend to provide for a separator in the installation (for example switch or fuse), and to mark this.

When the instrument operates properly the cover should be fastened (see the following chapter), and the instrument should possibly be configured by means of a commercially available terminal program (chap. 4)

5.3.4 Closing the Instrument Cover

Lift up the housing cover carefully, and take care that no cable is jammed between cover and housing. Moreover, the gasket must fit in the groove provided for. When screwing down please take care that, for proper tightness reason, the screws are screwed down strongly and crosswise (torsional moment of at least 2,0Nm).

5.3.5 Opto-Coupler output

In fig 11 you see 2 ways of connecting external instruments ("pull-up"-circuit to clamp 10/11 (output 1) and "pull-down" circuit to clamp 12/13 (output 2)). The load resistance R should preferably be low (for example $V_{cc}=5V$, $R = 5V/1mA = 5 k\Omega$). The connecting cables should be shielded, and the receiving input should be equipped with respective EMC-filters (not showed in fig11).

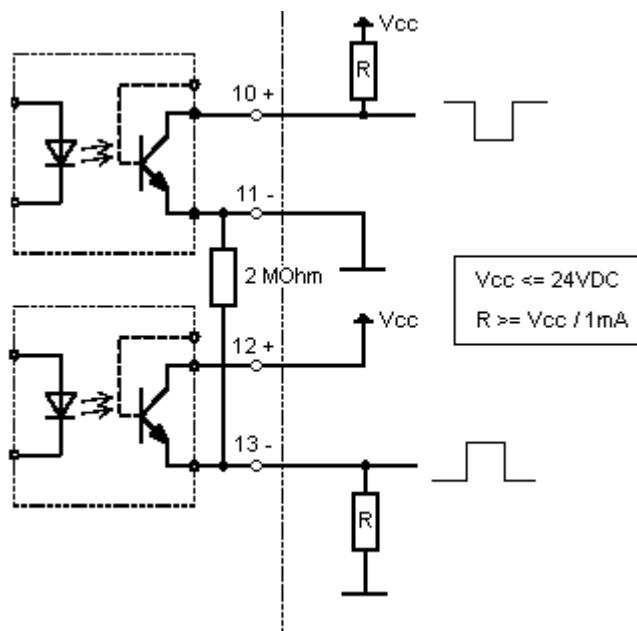


Figure 11: Examples for the connection to the opto-couplers

6 Maintenance



ATTENTION: Do not look into the invisible laser beam!

6.1 Cleaning

Approximately every 3 months the glass panes of the sensor should preventively be cleaned. Depending on the location this period might be different. Please use a commercially available cloth which is used, for example, for cleaning spectacles. If the Laser Precipitation Monitor outputs the error message "panes soiled", and the error remains still after cleaning the instrument has to be sent-in to the manufacturer for inspection.

Insect nests, spider webs, pollen flight sediments or the like shall be removed regularly. Depending on the environment and season the periods for control might be different.

6.2 Calibration

A calibration is necessary with the replacement of certain components. It is carried out in the factory.

6.3 Checking the sensor

The simulation of precipitation can be generated as follows:

Move an object (or a finger) at least 15 times per minute as quick as possible through the invisible laser beam between the sensor heads. Then, with the next minute-change, the sensor outputs the precipitation type "unknown precipitation" as well as a respective precipitation quantity. This simulation can be started five minutes after the instrument has been switched on.

6.3.1 Checking the LED's

In case no terminal program with pc is available the checking of the Laser Precipitation Monitor is limited to the control of the following LEDs. You will see them after removing the cover:

- AC-POWER (red, on the left above) must shine when AC supply is switched on.
- SENSOR-OK (green, middle above) flashes with 5Hz if DSP operates properly
- FAILURE (red, middle above) flashes with 5Hz if an error has been detected



**ATTENTION: Never look into the sensors while the instrument is in operation.
Risk of injury by the invisible laser beams.**

In case the AC-POWER LED does not shine the supply should be checked. The models „115VAC“ and „230VAC“ of the Laser Precipitation Monitor have a safety fuse situated directly above the orange connecting terminal „L1“ (left, below). All models have an electronic fuse for the AC-supply. In case this fuse has triggered off the external AC-supply must be switched off for approx. 30 seconds so that the fuse can cool down.

If the FAILURE LED shines you should control the glass panes, and possibly clean them. After the supply has been switched on the FAILURE LED lights up for 5 seconds.

6.3.2 Checking by means of a terminal programm

First, the Laser Precipitation Monitor must be connected to the respective COM interface of the used pc by means of an interface converter (RS485/RS232).

Start a terminal program, and configure the interface according to the sensor interface (baud rate, parity, etc.). Now the Laser Precipitation Monitor is ready for request. See also section 5. The factory setting of the serial interface: 9600 Bd, 8, N, 1

Check the control voltage (4010 ± 5) through the diagnostic command („00dd“). In case the value is outside the value range, and cleaning the glass panes shows no effect the Laser Precipitation Monitor is to be sent-in for inspection. Moreover, the internal temperature (max. $\pm 4^\circ$ difference compared with the ambient temperature) as well as the laser driver temperature (approx. 10° higher than the internal temperature) can be checked.

- Switch-on the telegram „Particle Event“ („00tm00003“). Drop a preferably spherical object with a diameter of <7mm through the measuring area.

Example 1: with 4 mm steel ball (dropped from the middle of the laser head screen):

Reply from the sensor:

9476;588;497800898;4.04;00.90;3.71;00.89;+19

Diameter: 4.04 mm

Speed: 0.9 m/s

Example 2: with finger through the measuring area:

Reply from the sensor:

16370;2158;499106556;7.71;00.39;6.19;00.34;+19

Re-activate the starting conditions after test end, for example, the data format set before.

7 Serial communication

An RS485 interface is available at the Laser Precipitation Monitor for the serial communication. At the moment, it is to be operated in duplex-mode only, and with different baud rates.

The communication can be carried out, for example, by means of a standard terminal program and a pc. With a Windows-based operating system delivery , for example, contains Hyper Terminal. If necessary, it must be installed later.

The receiver lines in the sensor are terminated with a resistance of 560Ω when a so-called Jumper is directly above the contacts “R-“ and “R+“ on the 2-pole connecting-pin-line.; see wiring diagram.

7.1 General telegram format

A fixed telegram format is used for the serial communication:

- Data request:

„00bb<CR>“ <CR> means Carriage Return (enter key)

- Change of parameters
„00bbpppp<CR>“ <CR> means Carriage Return (enter key)

The single letters have the following meaning:

- bb: two-digit command code
 pppp: A new parameter is set by entering a 5-digit value. The parameter is right-aligned, and must be completed with zeros from the left.

Example for a Change of Parameters:

The baud rate is to be set to 4 (corresponds to 4800 baud 8, N, 1). The respective command is:

„00BR00004<CR>“

Example data request:

The set record for the baud rate is returned with the command

„00BR<CR>“

Reply:

„!00BR00004“

The reply from the sensor is marked by an exclamation mark at the beginning of the return.

7.2 List of Commands

<id>: always „00“

command ?

<id>? Help

description: Output list of commands

example reply:

BR: Set/Get baud rate (5: 9600Bd 8N1)

RS: Reset Sensor (1: Reset)

SV: Get Software Version

TM: Set/Get Telegram (3:Particle Event 4:SYNOP,METAR,Disdrometer
5: SYNOP,METAR,Disdrometer,aux. Measuring
Channel)

ZH: Set Hour (0..23)

ZM: Set Minute (0..59)

ZS: Set Second (0..59)

ZT: Get Sensor Time

DD: Get Diagnostic Data

DX: Get Self Diagnostic

AV: Set/Get Amount Adjustment (50...150%)

RA: Reset Amount (1: Reset)

PT: Get Time Duration Amount

D1/D2: Set/Get Digital Output 1/2

DA: Auxiliary Measuring Channel (Option)

Range of Value: -

Initial value: -

Command BR

<id>BR<para5>

description:

Setting the baud rate.

The communication can be carried out with different baud rates. The setting range is from 1200baud to 115.2Kbaud. The following baud rates are defined for BR:

Parameter description:

2:	1200 baud	8,N,1
3:	2400 baud	8,N,1
4:	4800 baud	8,N,1
5:	9600 baud	8,N,1 *
6:	19200 baud	8,N,1
7:	38400 baud	8,N,1
8:	57600 baud	8,N,1
9:	115200 baud	8,N,1
10:	1200 baud	7,E,1
11:	2400 baud	7,E,1
12:	4800 baud	7,E,1
13:	9600 baud	7,E,1
14:	19200 baud	7,E,1
15:	38400 baud	7,E,1
16:	57600 baud	7,E,1
17:	115200 baud	7,E,1

Table 2: List of baud rates with telegram BR

* Setting by the factory

Value range: 2..17
Initial value: 00005

Command RS

00RS00001 Reset of the sensor.
Description: Re-start of the sensor.
Value range: 1
Initial value: 0

Command SV

00SV Request of the software version.
Description: Output of the software version (example reply: „!00SV00104“ -> V1.04)
Value range: -
Initial value: -

Command TM

00TM<para5> Telegram selection measuring data
Description: Setting the telegram,, telegram 3, 4,5, **6 and 7** see chapter 7.3.
Value range: Telegram 1 and 2 are for internal test purpose.
Initial value: 0...**7**
4 (5.4110.00.XXX) resp. 5 (5.4110.10.XXX)

Command ZH

00ZH<para5> Setting the sensor clock (hour)
Description: Setting the hour. The sensor time can be requested by the command „ZT“.
Value range: 0...23
Initial value: 0

Command ZM

00ZM<para5> Setting the sensor clock (minute)
Beschreibung: Setting the minute. The sensor time can be requested by the command „ZT“
Value range: 0...59
Initial value: 0

Command ZS

00ZS<para5> Setting the sensor clock (second)
Description: Setting the second. The sensor time can be requested by the command „ZT“
Value range: 0...59
Initial value: 0

Command ZT

00ZT Request of sensor clock
Description: Output of the sensor time (example: “14:20:19” or “2:1:0”) Remark: no fixed number of signs
Value range: --
Initial value: --

Command AZ

00AZ Alignment of sensor clock
Description: Correction of clock accuracy. For standard requirements (accuracy approx. 10-20 minutes/year) no correction is necessary. In case of higher requirements the accuracy can be increased by this command.
As the clock accuracy depends on aging and temperature we recommend a correction after one year of operation.
Resolution of correction: 1 millisecond/minute = 1,44 seconds/day
Parameter > 100 are negative
Example: AT00105 -> -5ms/min (-7.2s/day) correction of clock
Value range: 0...123
Initial value: 105

Command DA

00DA

Description:

Output of the optional measuring channels (5.4110.10.XXX)

Temperature/humidity: 30s-mean value (measurement every second)

Wind speed: 1s-mean value

Wind direction: instantaneous value (measurement every second)

column	description
1-5	Temperature [°C]
7-11	Relative air humidity [%r.h.]
13-16	Wind speed [m/s]
18-20	Wind direction [°]

If no sensor is available, or in case of exceeding of the measuring range interrogation marks are output.

Example reply:

„-01.6;040.3;02.6;090“

(-1.6°C temperature; 40.3% relative humidity,
2.6m/s wind speed, 90° wind direction)

Value range:

-

Initial value:

-

Command DD

00DD

Description:

Request of the diagnostic data

Column	Description
1-3	interior temperature [°C]
5-6	Temperature of laser driver 0-80°C
8-11	Mean value laser current [1/100 mA]
13-16	Control voltage [mV] reference value: 4010±5
18-21	Optical control output [mV]/ control variable (2300 ... 6500)

Example reply:

„+20;30;1690;4010;2580“

(+20°C interior temperature; 30°C temperature of the laser driver;
16.9 mA laser current; 4010mV actual control voltage,
2580mV optical control output)

Value range:

-

Initial value:

-

Command DX

00DX

Description:

Requesting source of error resp. condition of the lasers.

When an error has been detected the reason can be requested by means of this command.

„1“: error

„0“: no error

No.	Description
1	1: laser on 0: laser off
2	1: static signal outside the permissible range
3	1: laser temperature (analogue) too high
4	1: laser temperature (digital) too high
5	1: laser current (analogue) too high
6	1: laser current (digital) too high
7	Not used at the moment

Example reply in case of no error :

„1;0;0;0;0;0;0“ (laser on, no error detected)

Value range:

-

Initial value:

-

Command AV

00AV<para5>

Description:

Value range:

Adjusting measurement of quantity resp. intensity

Correcting precipitation quantity and intensity. Scaling in %.

80 ... 120

Initial value:

100

Command RA

00RA00001

Description:

Value range:

Reset of precipitation quantity and duration of quantity measurement.

By this command the precipitation quantity, output in the telegram, is set to 0

1

-

Command PT

00PT

Description:

Output of duration of quantity measurement.

The duration of the quantity measurement is output in the format „H:M“ (H=hour, M=minute, max. 9999 hours). The duration is set to 0 by the command „RA“.

Remark: no fixed number of signs

Value range:

-

Initial value:

-

Command AT

00AT	Alignment of the interior temperature
Description:	The interior temperature is necessary for the determination of the precipitation type. With an outside temperature range from -4 to 10 °C the interior temperature should deviate by max. ± 2 °C (without solar radiation). With solar radiation the difference can be up to 6 ± 2 °C. Please note: The alignment time with great temperature changes is (due to the compact housing) approx. 20 minutes.
	Parameter > 100 are negative.
	Example: AT00103 -> -3° temperature correction
Value range:	0...112
Initial value:	set in the factory

Command D1

00D1<para5>	Setting the function of the digital output 1 (opto-coupler)
Description:	

Parameter	Description	Inactive (open)	Active (closed)	Frequency [Hz]
0	Always inactive	always	=====	=====
1	Sensor error active	No sensor error	Sensor error	=====
2	Sensor error inactive	Sensor error	No sensor error	=====
3	Sensor In operation	=====	=====	50
4	Sensor in operation + error	=====	=====	No error: 50 Sensor error: 1
5	Sensor in operation + precipitation+ error	=====	=====	No error: 50 precipitation: 10 Sensor error: 1
6	Sensor in operation + liquid precipitation + solid precipitation. + error	=====	=====	No error: 50 liquid precipitat.: 25 solid precip.: 10 sensor error: 1
7	precipitation active	No precipitation	precipitation	=====
8	precipitation inactive	precipitation	no precipitation	=====
9	liquid precipitation active	No liquid precipitation	liquid precipitation	=====
10	Liquid precipitation inactive	liquid precipitation	No liquid precipitation	=====
11	Solid precipitation active	No solid precipitation	Solid precipitation	=====
12	Solid precipitation inactive	Solid precipitation	No solid precipitation	=====
13	Precipitation quantity 0.1mm	=====	=====	10 (1impulse: 0.1mm)
14	Precipitation	=====	=====	50 (1impulse:

	quantity 0.01mm			0.01mm)
15	Precipitation quantity 0.005 mm			50 (1impulse: 0.005mm)
16	Always active		always	
17	Precipitation type SYNOP(Tab.4680 s.a. following chapter) Frequency output			See the following table

Value range: 0...16
 Initial value: 1

Table Parameters 17 (command D1 and D2):

	Frequency [Hz]	SYNOP (Tab.4680)	Description
0	1	-1	Sensor error
1	5	0	No precipitation
2	10	51	Light drizzle
3	20	52,53	Moderate/heavy drizzle
4	25	41,42	Unknown precipitation
5	33,33	57,61	Light drizzle with rain, Light rain
6	41,66	58,62,63	Moderate/heavy drizzle with rain, moderate/heavy rain
7	50	67	Light rain and/or drizzle with snow
8	62,5	68	Moderate/heavy rain and/or drizzle with snow
9	83,33	77	Snow grains
10	100	71	Light snow fall
11	125	72,73	Moderate/heavy snow fall
12	166,67	87,88	Soft hail/ ice grains
13	250	89	hail

Remark: Frequency output changes every minute

Command D2

00D2<para5> Setting the function of the digital output 2 (opto-coupler).
 Description: see command „D1“
 Value range: 0...16
 Initial value: 5

7.3 Data Telegrams

Telegram: Synop, Metar, Disdrometer („00tm00004“)

This telegram is transmitted every minute by the instrument (without request of receiver).

List separator: ; (Semicolon)

Decimal separator: . (Point)

End of telegram: CRLF (carriage return + line feed)

Fixed length and leading zeros.

Interrogation mark is output in case no data are available.

Example:

```
$PWSThies1;000000;51;-DZ ;000.008;51;-DZ  
;000.008;0022.48;08:22;+07;14;1522;4010;2580;0025;00000.000;0000;00000.000;0000;00000.000  
;0000;00000.000;0001;00000.007;0000;00000.000;0000;00000.000;0000;00000.000;0000;00000.0  
00;0000;00000.000;0000;00000.000;0000;00000.000;0003;00000.622;0021;00000.761;000;000;00  
0;001;000;000;001;000;001;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
003;002;001;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
004;001;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;001;001;  
001;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;001;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;  
000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;000;
```

Telegram: Synop, Metar, Disdrometer , optional measuring channel („00tm00005“)

In addition to the output given above (with „00tm00004“) the optional measuring channels are output at the end (see also command “DA”)

Number	Column	Description
1	1-10	„\$PWSThies1“ Sensor name / Start of telegram
2	12-17	„000000“ Serial number
3	19-20	SYNOP Tab.4680 (mean value of 3...5 minutes)
4	22-26	METAR Tab.4678 (mean value of 3...5 minutes)
5	28-34	Intensity [mm/h] (mean value of 5 minutes)
6	36-37	SYNOP Tab.4680 1-minute-value
7	39-43	METAR Tab.4678 1-minute-value
8	45-51	Intensity [mm/h] 1-minute-value
9	53-59	Precipitation amount [mm]
10	61-65	Time of the instrument
11	67-69	Internal temperature [°C]
12	71-72	Temperature of laser driver 0-80°C
13	74-77	Mean value laser current [1/100 mA]
14	79-82	Control voltage [mV] reference value: 4010±5
15	84-87	Optical control output [mV]
16	89-92	Number of all measured particles
17	94-102	„00000.000“ (internal data)
18	104-107	Number of particles < minimal speed (0.15m/s)
19	109-117	„00000.000“ (internal data)
20	119-122	Number of particles > maximal speed (20m/s)
21	124-132	„00000.000“ (internal data)
22	134-137	Number of particles < minimal diameter (0.15mm)
23	139-147	„00000.000“ (internal data)
24	149-152	Number of particles no hydrometeor
25	154-162	„00000.000“ (internal data)
26	164-167	Number of particles with unknown classification
27	169-177	Total volume (gross) of this class
28	179-182	Number of particles hail-class
29	184-192	Total volume (gross) of this class
30	194-197	Number of particles solid-precipitation-class
31	199-207	Total volume (gross) of this class
32	209-212	Number of particles great-pellet-class
33	214-222	Total volume (gross) of this class
34	224-227	Number of particles small-pellet-class

35	229-237	Total volume (gross) of this class
36	239-242	Number of particles snowgrain-class
37	244-252	Total volume (gross) of this class
38	254-257	Number of particles rain-class
39	259-267	Total volume (gross) of this class
40	269-272	Number of particles small-rain-class
41	274-282	Total volume (gross) of this class
42	284-287	Number of particles drizzle-class
43	289-297	Total volume (gross) of this class
44	299-301	From here (294) to the end(1892): precipitation spectrum (distrometer data) Number of particles 0.125mm< diameter <0.25mm and speed <0.2m/s
...	303-	Remaining 399 classes (first all speeds, then the next diameter class , see table “distrometer class binning” below)
...	...	
443	-1897	
444	1898-1899	End of telegram CRLF

Additionally with “00TM00005”

444	1899-1903	Temperature [°C]
445	1905-1909	Relative Air humidity [%r.h.]
446	1911-1914	Wind speed [m/s]
447	1916-1918	Wind direction [°]
448	1919-1920	End of Telegram CRLF

Particle diameter class		
Class	Diameter [mm]	Class width [mm]
1	=> 0.125	0.125
2	=> 0.250	0.125
3	=> 0.375	0.125
4	=> 0.500	0.250
5	=> 0.750	0.250
6	=> 1.000	0.250
7	=> 1.250	0.250
8	=> 1.500	0.250
9	=> 1.750	0.250
10	=> 2.000	0.500
11	=> 2.500	0.500
12	=> 3.000	0.500
13	=> 3.500	0.500
14	=> 4.000	0.500
15	=> 4.500	0.500
16	=> 5.000	0.500
17	=> 5.500	0.500
18	=> 6.000	0.500
19	=> 6.500	0.500
20	=> 7.000	∞

Particle speed class		
Class	Speed [m/s]	Class width [m/s]
1	=> 0.000	0.200
2	=> 0.200	0.200
3	=> 0.400	0.200
4	=> 0.600	0.200
5	=> 0.800	0.200
6	=> 1.000	0.400
7	=> 1.400	0.400
8	=> 1.800	0.400
9	=> 2.200	0.400
10	=> 2.600	0.400
11	=> 3.000	0.400
12	=> 3.400	0.800
13	=> 4.200	0.800
14	=> 5.000	0.800
15	=> 5.800	0.800
16	=> 6.600	0.800
17	=> 7.400	0.800
18	=> 8.200	0.800
19	=> 9.000	1.000
20	=> 10.000	10.000

Table: Disdrometer class binning

Type of Precipitation	Internal	NWS Code	SYNOP ww Tab.4677	METAR/SPECI w'w' Tab.4678	SYNOP wawa Tab.4680
Sensor error	0			?????	-1
No precipitation	1	C	00	NP	00
Precipitation (not identified)	2	P-,P,P+		-UP,UP,+UP	41,41,42

Drizzel (also freezing)	3	L-,L,L+	51,53,55	-DZ,DZ,+DZ	51,52,53
Freezing drizzle (see drizzle)	3	[ZL] L-,L,L+	[56,57,57] 51,53,55	[FZDZ] -DZ,DZ,+DZ	[54,55,56] 51,52,53
Drizzle with rain (also freezing)	4	RL- ,RL,RL+	58,59,59	- RADZ,RADZ,+RA DZ	57,58,58
Rain (also freezing)	5	R-,R,R+	61,63,65	-RA,RA,+RA	61,62,63
Freezing rain (see rain)	5	[ZR] R-,R,R+	[66,67,67] 61,63,65	[FZRA] -RA,RA,+RA	[64,65,66] 61,62,63
Rain and/or drizzle with snow	6	RLS-,RLS, RLS+	68,69,69	- RASN,RASN,+RA SN	67,68,68
Snow	7	S-,S,S+	71,73,75	-SN,SN,+SN	71,72,73
Ice pellets (see soft hail)	9	[IP] SP	[79] 87,88,88	[PE/PL] GS	[74,75,76] 87,88,88
Snow grains (also ice prisms)	8	SG	77	-SG,SG,+SG	77
Ice crystals /-needles (see snow grains)	8	[IC] SG	[76] 77	[IC] SG	[78] 77
Soft hail (also ice pellets)	9	SP	87,88,88	-GS,GS,+GS	87,88,88
Hail	10	A	89,90,90	GR	89

[...]not identifiable / code in brackets will be not transmitted.

SYNOP intensities [mm/h]	light	moderate	heavy
Drizzle	<=0,2		>0,5
Rain, snow, precipitation sleet, drizzle with rain	<=0,5		>4,0
Ice pellets/soft hail	<=0,4	>0,4	—————

NWS/METAR/SPECI intensities [mm/h] [(inch/h)]	light	moderate	heavy
drizzle	<=0,25 (<=0,01)		>0,5 (>0,02)
Rain, precipitation, drizzle with rain, sleet	<=2,5 (<=0,1)		>7,6 (>0,3)
Snow ,soft hail, snow grains Ice pellets	<=1,25 (<= 0,05)		>2,5 (>0,1)

Telegramm: Synop, Metar („00tm00006“)

This telegram is transmitted every minute by the instrument (without request of receiver).

List separator: ; (Semicolon)

Decimal separator: . (Point)

End of telegram: CRLF (carriage return + line feed)

Fixed length and leading zeros.

Interrogation mark is output in case no data are available.

Example:

```
$PWSThies1;000000;51;-DZ ;000.008;51;-DZ  
;000.008;0022.48;08:22;+07;14;1522;4010;2580;0025
```

Telegramm: Synop, Metar, optional Measuring Channels („00tm00007“)

In addition to the output given above (with „00tm00006“) the optional measuring channels are output at the end (see also command “DA”)

Example:

```
$PWSThies1;000000;51;-DZ ;000.008;51;-DZ  
;000.008;0022.48;08:22;+07;14;1522;4010;2580;0025;  
-00.8;?????;00.0;???
```

No.	Column	Description
1	1-10	„\$PWSThies1“ sensor name / telegram start
2	12-17	„000000“ serial number
3	19-20	SYNOP Tab.4680 (mean value of 3..5 minutes)
4	22-26	METAR Tab.4678 (mean value of 3..5 minutes)
5	28-34	Intensity [mm/h] (mean value of 5 minutes)
6	36-37	SYNOP Tab.4680 1-min. value
7	39-43	METAR Tab.4678 1- min. value
8	45-51	Intensity [mm/h] 1- min. value
9	53-59	Precipitation sum [mm]
10	61-65	Time of instrument
11	67-69	Internal temperature [°C]
12	71-72	Temperature of the laser driver 0-80°C
13	74-77	Mean value of the laser current [1/100 mA]
14	79-82	Control voltage [mV] reference value: 4010±5
15	84-87	Control output [mV]
16	89-92	Number of all measured particles
17	93-94	Telegram end CRLF (not with „00TM00007“)

Additionally with „00TM00007“:

17	94-98	Temperature [°C]
18	100-104	Relative humidity[%r.F.]
19	106-109	Wind speed [m/s]
20	111-113	Wind direction[°]
21	114-115	Telegram-end CRLF

Telegram: Particle-Event („00tm00003”)

The instrument transmits (without request of the receiver) this telegram with every event (particle falling through the measuring area).

List separator: ; (Semicolon)

Decimal separator: . (Point)

End of telegram: CRLF (Carriage return + Line Feed)

No.	Description
1	Maximal value of A/D-converter [0...16,383]
2	Duration of event [10µs]
3	Time stamp (0...4,294,967,295) [ms]
4	Diameter sphere [mm]
5	Speed sphere [m/s]
6	Diameter “Hamburger”(rain) [mm]
7	Speed “Hamburger” (rain) [m/s]
8	Internal Temperature [°C]

Example: 14764;8728;493413279;7.01;00.09;5.75;00.08;+19

Diameter sphere: 7.01 mm

Speed sphere: 00.09 m/s

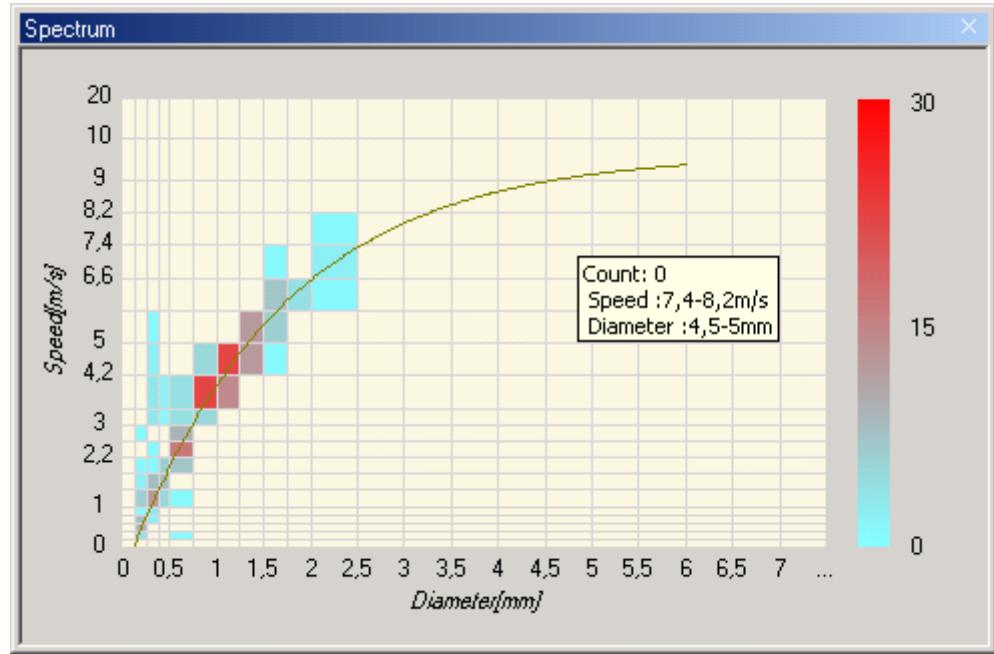


Figure 12: Rain

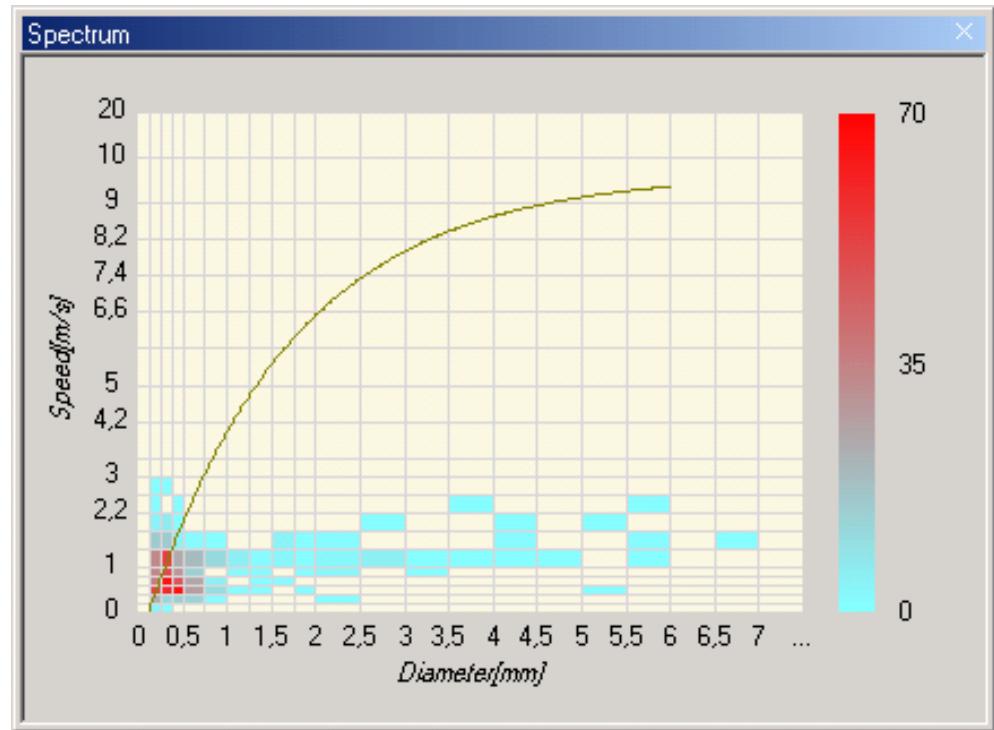


Figure 13: Snow (dry)

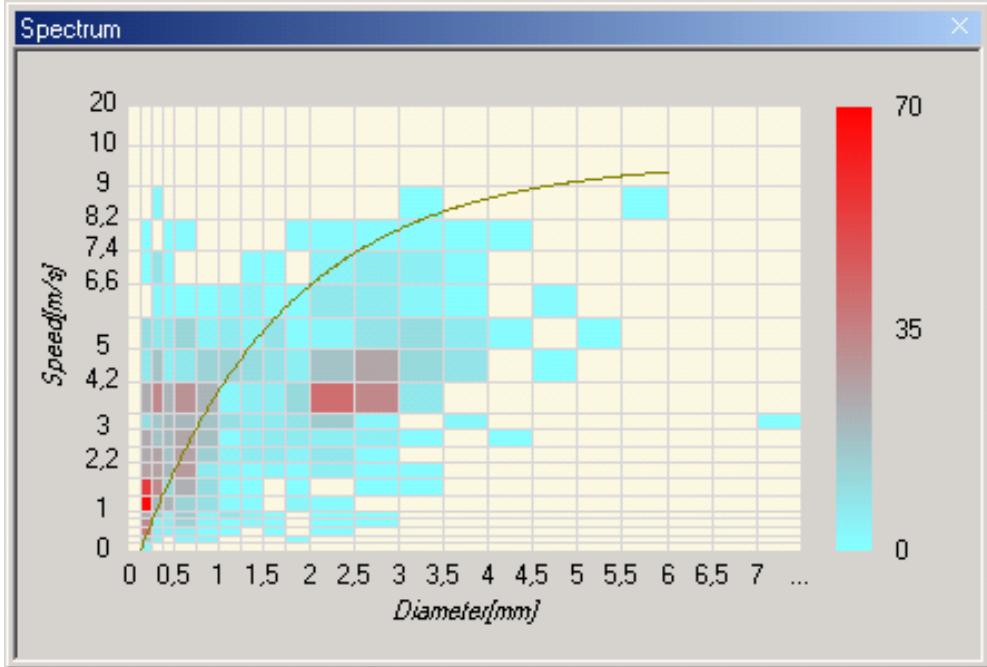


Figure 14: Soft Hail (and Rain)

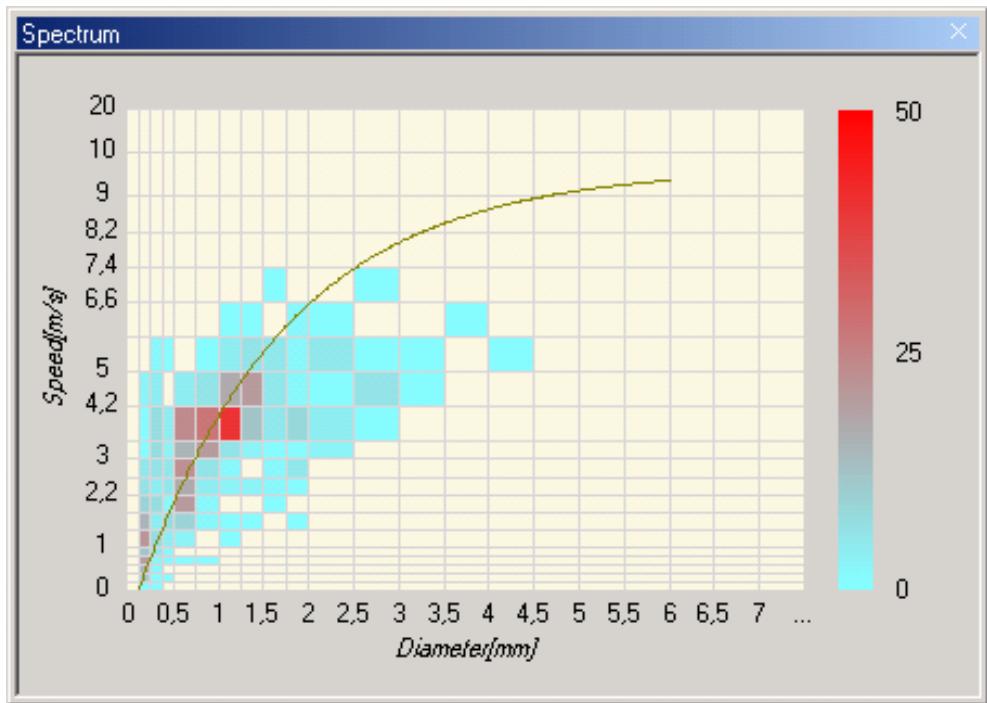


Figure 15: Sleet

The figures 12 to 15 show some typical distributions (telegram „Synop Metar Distrometer“). Screen copies are from the optionally available Windows-Software „LNM View“ (9.1700.99.000).

8 Technical Data

General:	
Ambient conditions	-40... +70 °C, 0... 100% r.h.
Maximum altitude	<1500m N.N. (for greater heights please refer to the manufacturer)
Dimensions	0,27 x 0,17 x 0,54 m 10.63 x 6.7 x 21.3 inch (w/o mast holder)
Weight	4,8 kg (w/o options)
Housing electronics	Aluminium die-casting, varnished
Housing sensors	Aluminium (anodised)
Protection	IP65
Maintenance	Automatic soil-recognition for cleaning the optics
EMC	
Immunity	EN61326 in conjunction with EN61000-4-3 20V/m EN61000-4-4 level 4 (power line ±4kV, signal line ±2kV) EN61000-4-5 level 4 (power line ±2kV _{symmetric} ±4kV _{asymmetric} , signal line ±2kV _{symmetric})
Radiation	EN61326 class B
Mounting	Mast mounting (Ø 48... 102mm, 1.9... 4 inch) Stainless steel
Current supply:	
Buffer input (not for 5.4110XX.300)	
Supply voltage DC (only electronics)	12 ... 24 V DC ±10%
Current consumption DC input (only electronics)	< 150mA (12V DC) < 75mA (24V DC)
Remark: supply must be potential-free	
5.4110.XX.000: Supply voltage AC (heating + electronics) Supply voltage DC (heating + electronics) Current consumption 24VAC/DC-input Remark: supply must be potential-free	24V AC ±15% 22...30V DC < 750mA
5.4110.XX.100: Supply voltage AC (heating + electronic) Maximum current consumption	115VAC +10% -25% <15W

5.4110.XX.200:	
Supply voltage AC (heating + electronic)	230VAC +10% -25%
Maximum current consumption	<15W
5.4110.XX.300:	
Supply voltage DC (heating + electronic)	12 ... 24 V DC ±10%
Maximum current consumption 12V..24VDC	<550mA(12VDC) <500mA(24VDC)
Remark: supply must be potential-free	
Heating:	
Glass pane heating	2.5W each (with temperature regulation)
Optional: heating for extreme conditions	t.b.d.
Sensors:	
Laser diode	785nm, max. 0,5mW optical power
Laser class	Laser class 1M (EN 60825-1:1994 A2: 2001)
Modulation frequency	172.8 KHz
Photo diode	with day light filter (< 700nm)
Measuring area	45,6cm ² (288 x 20 mm) 7.067inch ² (8.98 x 0.787 inch)
Electronics for evaluation:	
Digital signal processor	TMC320VC33 (55.3 MHz)
RAM-memory	136KB
Flash-memory	256KB (to be uploaded via serial interface)
14Bit-A/D-converter	scanning 109 KHz (for optical measuring signal)
12Bit-A/D-converter	For self diagnosis and optional measuring input
Data output:	
RS485	1200...115200 Bd Potential isolation up to 1KV Full-duplex
Digital output	2 Opto coupler (max. 24VDC, max. 1mA) Potential isolation up to 1KV Function selectable

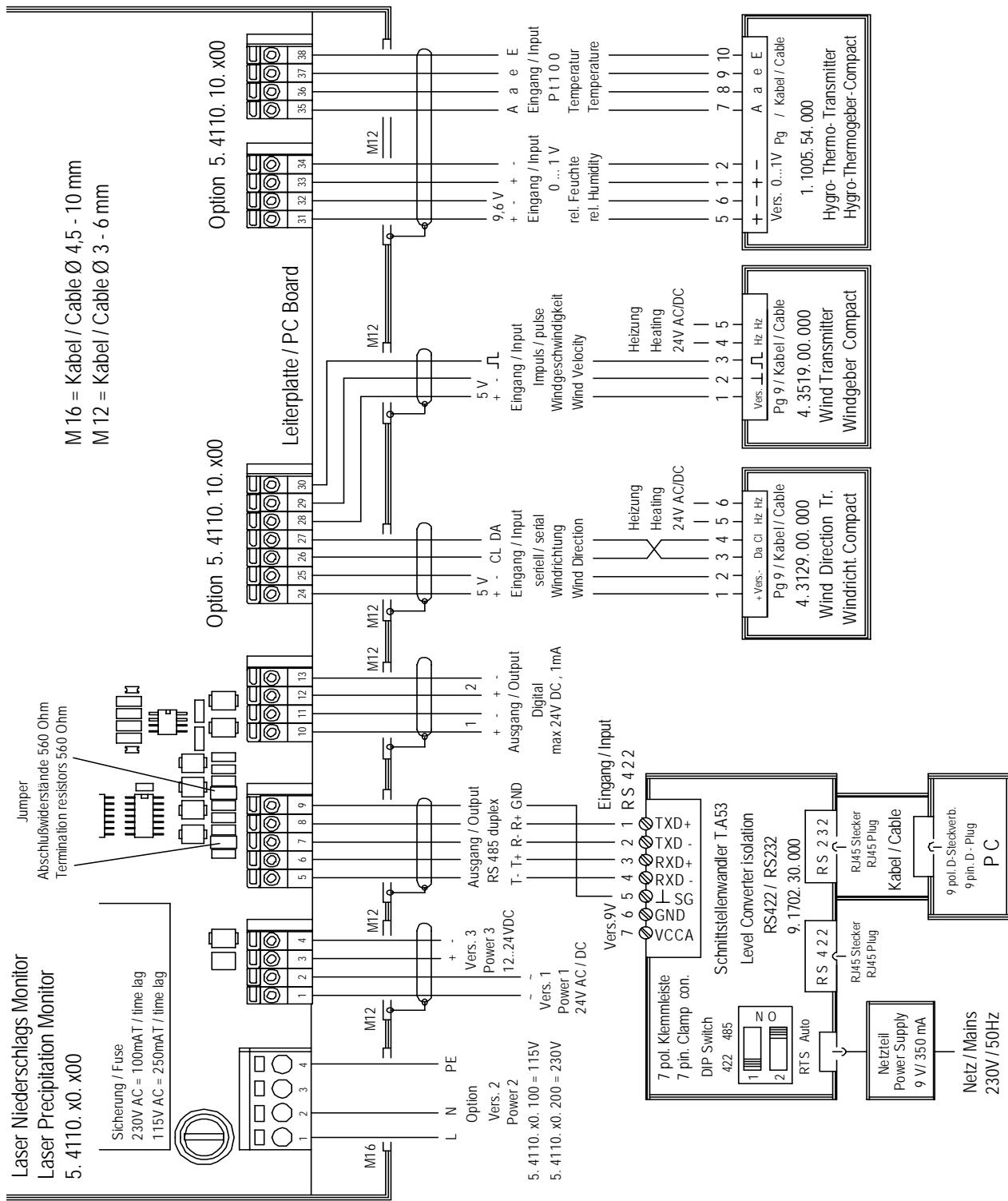
Precipitation:	
Particle size	0,16 ... >8 mm Ø
Particle speed	0,2 ... 20 m/s
Identification of precipitation types: -drizzle(DZ), freezing drizzle (FZDZ) -rain(RA), freezing rain (FZRA) -hail(GR) -snow (SN) -snow grains (SG), ice needles(IC) -soft hail(GS), ice grains(PL)	Hit rate (compared with synoptic observation), wind speed < 3m/s) >97% (Intensity > 0.01 mm/h) >99% (>= 2 particles/min, no solid precipitation) >95% (>= 2 particles/min) >99% (no mixed precipitation) >60 % t.b.d.
Output Precipitation Type	SYNOP (Tab.4680), METAR (Tab.4678)
Error intensity-/quantity measurement (rain equivalent) compared with reference sensor (wind speed< 3m/s)	≤15% (rain, 0,5... 20mm/h) ≤30% (snow)
Minimum Intensity (depending on precipitation type)	<0,005 mm/h (drizzle)
Maximum Intensity	>250 mm/h
Optional Measuring Inputs: 5.4110.1X.XXX	
Temperature (Pt100)	Meas. range: -40... 70°C Accuracy: ±0.1°C (measuring input)
Rel. humidity(0-1V)	Meas. range: 0 ... 100 % r. h. Accuracy: ±0.1% (meas. range)
Wind Speed (Thies Compact)	Meas. range: 0 ... 60 m/s Accuracy: ±0.1m/s (measuring input)
Wind direction (Thies Compact)	Meas. range: 0 ... 360°
Optional Visualization-Software (9.1700.99.000)	For Windows operating systems (Win98(SE), WinMe, Win2000, XP)

Alteration of technical data reserved

9 Wiring Diagram



ATTENTION: Do not look into the invisible laser beam!



Article-No.	Supply-Connection	Voltage
5.4110.X0.000	1+3	24 VAC/DC + 12-24 VDC (buffering electronics)(both potential-free)
5.4110.X0.100	2+3	115 VAC + 12-24 VDC (buffering electronics, potential-free) do not use supply connection 1
5.4110.X0.200	2+3	230 VAC + 12-24 VDC (buffering electronics, potential-free) do not use supply connection 1
5.4110.X0.300	3	12-24 VDC (potential-free)

Remark: Run supply voltages in the cover through the ferrite tubes available!

10 Accessories (Optional)

Instrument Support For the vibration-reduced operation of the LPM at 2 m height on an available concrete foundation, provided by the customer.	4.3187.60.000	Tube length: 2 m Tube diameter: 60 mm Weight: 30 Kg Material: Steel, hot-dip galvanized
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PC – Program LPM View The program LPM serves for the display of data, which are induced by the LPM. The program can file the data sent by the LPM as well as represent them in graphic form.	9.1700.99.000	System requirements The program is made for Microsoft Windows® 98 / XP / 2000 / NT. Minimum PC requirement PC: 800MHz, 64 MBRAM Graphic resolution: 800*600 Graphic colours: 16Bit TrueColor
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The following measuring value transmitters are suited for the Laser Precipitation Monitor with „optional measuring channels“:

Hygro Thermo Transmitter	1.1005.54.000	Meas. range: 0 ... 100% Rel. F. - 30 ...+70°C
Weather and Thermal Radiation Shield	1.1025.55.xxx	
Wind Transmitter	4.3519.00.000	Meas. range: 0,5 ... 50 m/s
Wind Direction Transmitter	4.3129.00.000	Meas. range: 0 ... 360 °

Other accessories such as cables, power supply units, masts as well as additional mast- or system-constructions on request.

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