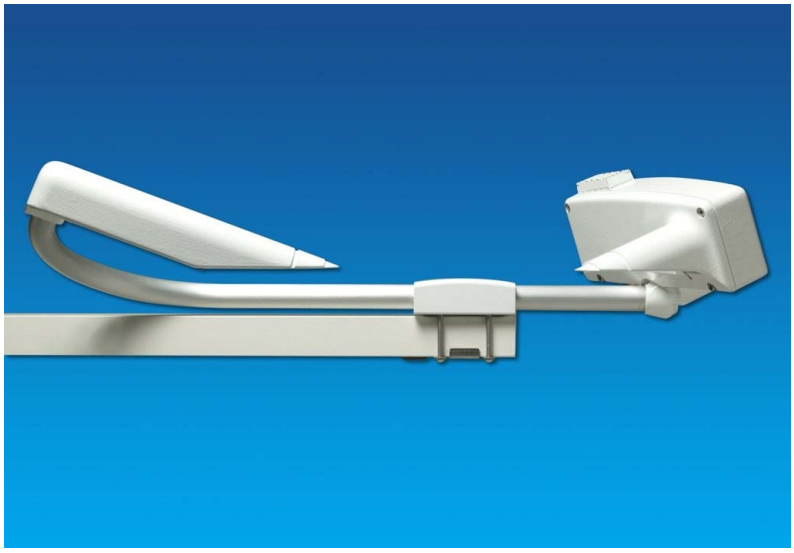
Visibility Sensor PWD10/20

USER'S GUIDE

M210541EN-B
March 2004



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CHAPTER 1

GENERAL INFORMATION

This chapter provides general notes for the product.

About This Manual

This manual provides information for installing, operating, and maintaining Vaisala Visibility Sensor 10/20.

Contents of This Manual

This manual consists of the following chapters:

- Chapter 1, General Information, provides general notes for the product.
- Chapter 2, Product Overview, describes Vaisala Visibility Sensor PWD10/20 features, advantages, and the product nomenclature.
- Chapter 3, Functional Description, describes the functionality of the product.
- Chapter 4, Installation, provides you with information that is intended to help you install this product.
- Chapter 5, Operation, contains information that is needed to operate this product.
- Chapter 6, Maintenance, provides information that is needed in basic maintenance of the product.
- Chapter 7, Troubleshooting, describes common problems, their probable causes and remedies, and contact information.
- Chapter 8, Technical Data, provides the technical data of the Product.

- Appendix A contains values for internal monitoring.
- Appendix B contains the jumper settings.
- INDEX is included at the end of the manual.

Version Information

Table 1 Manual Revisions

Manual Code	Description
M210541EN-B	This manual.

Related Manuals

Table 2 Related Manuals

Manual Code	Manual Name
M210542EN-B	Vaisala Present Weather Detector PWD12, User's Guide
M210543EN-C	Vaisala Present Weather Detector PWD22, User's Guide

Feedback

Vaisala Customer Documentation Team welcomes your comments and suggestions on the quality and usefulness of this publication. If you find errors or have other suggestions for improvement, please indicate the chapter, section, and page number. You can send comments to us by e-mail: manuals@vaisala.com

Safety

General Safety Considerations

Throughout the manual, important safety considerations are highlighted as follows:

WARNING	Warning alerts you to a serious hazard. If you do not read and follow instructions very carefully at this point, there is a risk of injury or even death.

CAUTION	Caution warns you of a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.

NOTE	Note highlights important information on using the product.

Product Related Safety Precautions

Vaisala Visibility Sensor PWD10/20 delivered to you has been tested for safety and approved as shipped from the factory. Note the following precautions:

WARNING	The chassis of the PWD10/20 must be connected to a good electrical earth.

WARNING	Do not operate the equipment in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

CAUTION	Do not modify or substitute parts in the instrument. Contact Vaisala or its authorized representative for repairs.

CAUTION	The component boards including CMOS microchips should be transported and stored in conductive packages. Although new CMOS devices are protected against overvoltage damages caused by static electric discharge of the operator, careful handling is recommended: the operator should be properly grounded. Unnecessary handling of component boards should be avoided.

RADIO FREQUENCY INTERFERENCE STATEMENT (USA)

The United States Federal Communications Commission (in 47 CFR 15.838) has specified that the following notice must be brought to the attention of users of this kind of a product in the USA:

Federal communications commission radio frequency interference statement

This equipment generates and uses radio frequency energy and if not installed and used properly, that is in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. The Present Weather Detector is designed to provide reasonable protection against such interference in an airport installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment causes interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna
- Relocate this device with respect to the receiver
- Move this device away from the receiver

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions.

ESD Protection

Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. Vaisala products are adequately protected against ESD for their intended use. However, it is possible to damage the product by delivering electrostatic discharges when touching, removing, or inserting any objects inside the equipment housing.

To make sure you are not delivering high static voltages yourself:

- Handle ESD sensitive components on a properly grounded and protected ESD workbench. When this is not possible, ground yourself to the equipment chassis before touching the boards. Ground yourself with a wrist strap and a resistive connection cord. When neither of the above is possible, touch a conductive part of the equipment chassis with your other hand before touching the boards.
- Always hold the boards by the edges and avoid touching the component contacts.

Trademarks

License Agreement

Warranty

For certain products Vaisala normally gives a limited one-year warranty. Please observe that any such warranty may not be valid in case of damage due to normal wear and tear, exceptional operating conditions, negligent handling or installation, or unauthorized modifications. Please see the applicable supply contract or Conditions of Sale for details of the warranty for each product.

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CHAPTER 2

PRODUCT OVERVIEW

This chapter describes Vaisala Visibility Sensor PWD10/20 features, advantages, and the product nomenclature.

Introduction to Vaisala Visibility Sensor PWD10/20

Vaisala Visibility Sensor PWD10/20 is an optical sensor that measures visibility (meteorological optical range, MOR). The sensor measures visibility using the principle of a forward scatter measurement.

Table 3 PWD Sensor Series Model and Performance Table

Model	Performance
Visibility Sensor PWD10	Visibility range 10 m ... 2000 m
Present Weather Detector PWD12	Visibility range 10 m ... 2000 m 4 different precipitation types
Visibility Sensor PWD20	Visibility range 10 m ... 20000 m
Present Weather Detector PWD22	Visibility range 10 m ... 20000 m 7 different precipitation types
Present Weather Detector PWD22M	For Vaisala TACMET stations

Hardware Structure

PWD10/20 is a self-contained instrument that can be fastened to the side of a mast and into a crossarm using the mounting clamps.

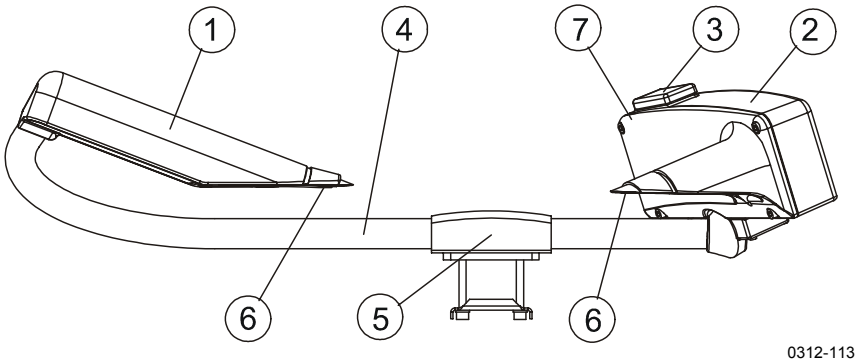

Figure 1 Visibility Sensor PWD10/20

The following numbers refer to Figure 1 above.

1 = Transmitter
2 = Controller/Receiver
3 = Blank plate
4 = Pt100 temperature sensor in the tube
5 = Mounting clamp
6 = Hood heaters (optional)
7 = Place for Vaisala Luminance Sensor PWL111 (optional)

Using PWD10/20

PWD10/20 is typically used as a component of a weather observing system.

The PWD10/20 output is either a digital serial interface or an analog current signal. The digital serial interface can be configured into two different operating modes: the sensor can be set to send a data message automatically at selected intervals, or PWD10/20 can be polled by the host computer. The same serial line is also used as an operator interface. The analog current signal can be used to report the prevailing visibility. Three relay controls can be used, driven by visibility limits.

The operator controls and checks the operation of PWD10/20 using a maintenance terminal. A set of built-in commands and test routines

are provided for configuring and monitoring the multiple functions of PWD10/20.

The standard data messages contain a status character for indicating faults detected by the internal diagnostics. If the error status is set, the operator can display a special status message, which contains the detailed results of the diagnostics and a written description of the fault. With this information the operator can take corrective action or give the maintenance personnel advice.

Product Nomenclature

Table 4 Vaisala Visibility Sensor PWD10/20 Nomenclature

Code	Common Name	Description
PWT11	Transmitter	LED Transmitter circuit board.
PWC10	Controller/Receiver	Controller and photo diode circuit board for PWD10.
PWC20	Controller/Receiver	Controller and photo diode circuit board for PWD20.

Table 5 Nomenclature for Options of the Vaisala Present Weather Detector PWD Family

Code	Common Name	Description
PWL111	Background Luminance Sensor	
PWH111	Hood Heater Foils	
PWA11	Calibration Set	Includes a pair of precalibrated scatterers, a piece of cloth for cleaning the lenses and tools.
16385ZZ	RS-232 (9-pin) maintenance cable	Connects to standard PC communication port.
APPKP60set -1/2 75set -1/2 100set -1/2	Attachment clamp	60 mm, 75 mm or 100 mm clamp according to the mast diameter

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CHAPTER 3

FUNCTIONAL DESCRIPTION

This chapter describes the functionality of the product.

Vaisala Visibility Sensor PWD10/20 is an optical sensor that measures visibility (meteorological optical range, MOR). The sensor measures visibility using the principle of a forward scatter measurement. Light scatters from particles whose diameter is in the order of magnitude of the wavelength of the light. The amount of scatter is proportional to the attenuation of the light beam.

Larger particles behave as reflectors and refractors and their effect on the MOR must be handled separately. Usually these particles are precipitation droplets. The optical arrangement of PWD10/20 is such that individual droplets can be detected from rapid signal changes.

Optical Measurements

Optical Arrangement

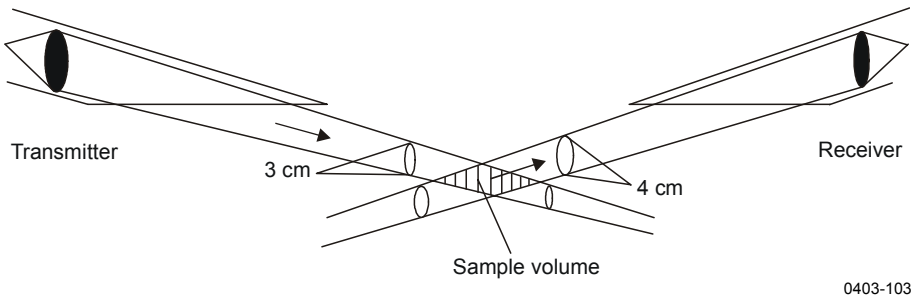

Figure 2 PWD10/20 Optical System

PWD10/20 measures light scattered at an angle of 45°. This angle produces a stable response in various types of natural fog. Precipitation droplets scatter light in a different manner as fog and their contribution to visibility must be analyzed separately. PWD10/20 can detect and measure precipitation droplets from the optical signal and use this information in processing the scatter measurement results.

PWD10/20 has a small sample volume of about 0.1 liters (see Figure 2 above). This allows for independent particles to be measured even at relatively heavy precipitation intensities. The signal levels from even the smallest precipitation droplets can also be detected.

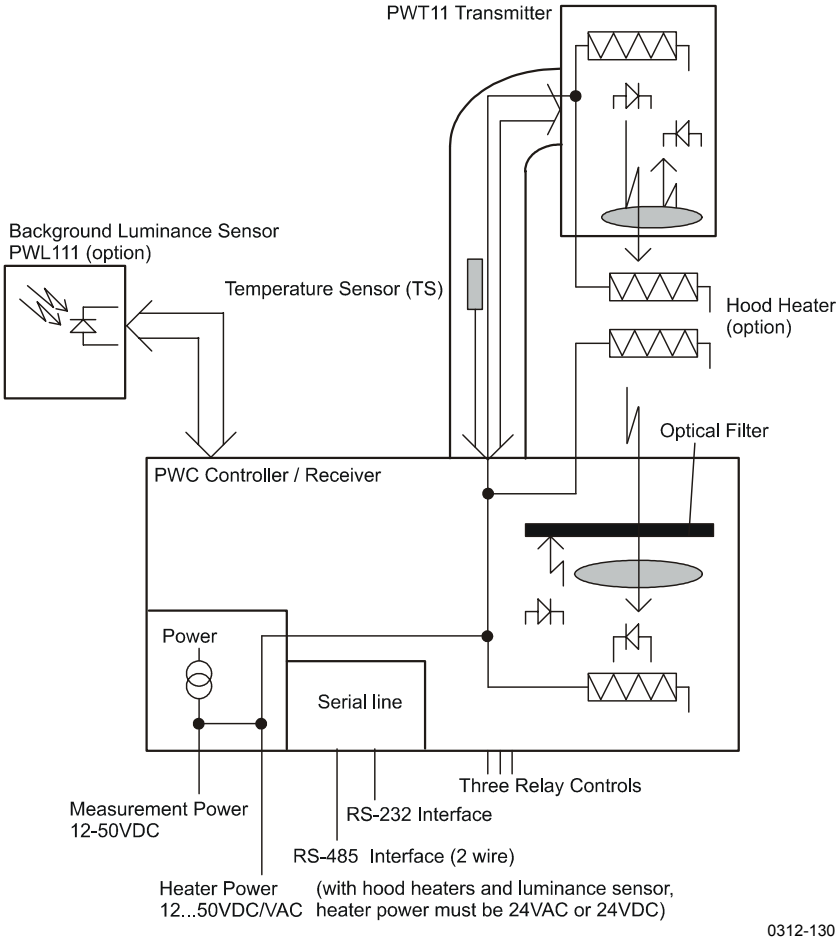

Figure 3 PWD10/20 Block Diagram

Vaisala Transmitter Unit PWT11

The transmitter unit consists of an infrared LED, control and triggering circuits, LED intensity monitor, and backscatter receiver.

The transmitter unit electronics pulses the IR-LED at a frequency of 2 kHz. A photodiode monitors the transmitted light intensity. The transmitter intensity level measurement is used to keep the intensity of the LED automatically at a preset value. The "LEDI" feedback voltage is monitored by the CPU to get information of the aging of the LED and possible defects.

The feedback loop compensates for temperature and aging effects of the light emitting diode. On the other hand, the active compensation slightly accelerates the LED aging. Thus, the initial LED current is set to a value, which ensures several years of operation without maintenance.

An extra photodiode measures the light scattered backwards from the lens, other objects, or contaminants. This signal is also monitored by the CPU.

Light Receiver

The Light Receiver consists of a PIN photodiode, preamplifier, voltage to frequency converter, backscatter measurement light source LED, and some control and timing electronics.

The receiving PIN photodiode senses the transmitted light pulses scattered from the aerosol particles. The signal voltage is filtered and detected by a phase sensitive lock-in amplifier synchronized with the transmitter.

An ambient light level as high as 30 kcd/m^2 does not influence the detection of the photo diode, neither does it saturate the preamplifier. The **AMBL** signal (proportional to the ambient light) is lead to the CPU for monitoring.

Background Luminance Sensor PWL111 (optional)

PWL111 is used for aeronautical visibility calculations, for example, to distinguish day and night conditions for a visibility calculation.

PWD10/20 measures the PWL111 signal every second. A new one-minute running average is calculated every 15 seconds.
The one-minute average is reported in the corresponding messages. The value range is 4 ... 20000 cd/m^2. The sensor heaters are controlled as the other PWD10/20 heaters.

BLSC Command

The background luminance sensor can be used in a continuous or day/night switch mode. When you give a positive BLSC value, the background luminance measurement mode will be continuous. When you give a zero value, the measurement turns into day/night switch mode.

When PWL111 is activated, its background luminance value is reported in message 7 and in the Status message.

Continuous Mode

The following command activates the sensor and gives the positive scaling factor for the luminance value. See the example below:

```
>BLSC 1.0
```

The response is the following:

```
BL SCALE 1.000
```

Background luminance is reported in a range of 4 ... 20000 cd/m^2 with the above settings.

Day/night Switch Mode

The following command activates the sensor in day/night switch mode, that is, the luminance value is either 0 or 1. Zero indicates night time and one indicates day time. See the example below:

```
>BLSC 0
```

Disabling PWL111

The negative scale directs PWD10/20 to skip the background luminance action. See the example below:

```
>BLSC -1
```

BCAL Command

PWD10/20 calculates the new BL scale if the current background luminance in cd/m^2 is known. The BL scale must be more than zero (>0). Also the BLSC sensor must be already activated by the BLSC command. When users type the following command, PWD10/20 calculates the BL scale.

```
>BLCAL 12300
```

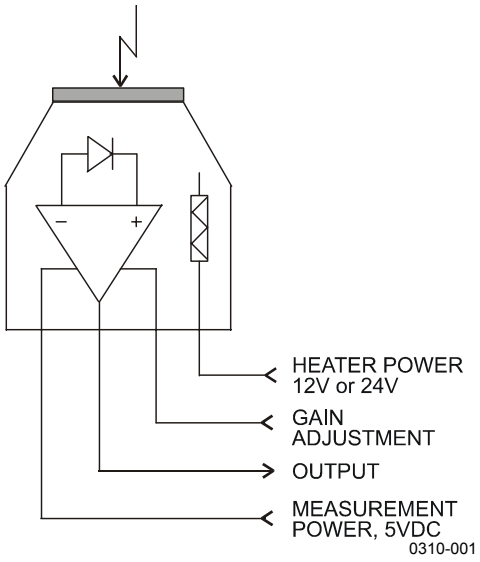

Figure 4 PWL111 Block Diagram

Temperature Sensor

The primary temperature sensor of PWD10/20 is a Pt100 thermistor attached to the crossarm. The temperature is measured once a minute using a high resolution A/D converter.

Algorithm Description

Visibility

Optical signal analysis calculates the difference of the measurement signal and offset averages for the visibility algorithm. The difference value (frequency) is given as a parameter to a calibrated transfer function. The transfer function converts frequency into visibility

(MOR). The transfer function has been defined with an accurate transmissometer (Vaisala MITRAS) as a reference.

The instantaneous (15 s) visibility values are averaged to get a 1-minute and 10-minute average output values. The averages are calculated from extinction coefficient values to better emulate human observations. The extinction coefficient (σ) is defined as follows:

σ (1/km) = 3000/MOR (m)

Internal Monitoring

Built-in Tests

Extensive, built-in tests are included in the PWD10/20 operation. Various voltages are measured and corresponding alarm and warning limits are checked. Optical contamination of both the transmitter and the receiver is continuously monitored by measuring the backscattered light. For this purpose an additional transmitting LED is installed in the receiver.

The software generates alarms, if visibility is less than a given limit. PWD10/20 generates warnings of suspected faulty hardware. If a fatal hardware failure is detected, visibility data is not generated; it is substituted with slashes (/////). A status message displays the cause of the error in status bits.

Built-in tests include a memory test, analog monitoring, and signal measurement monitoring. Results of the monitoring measurements are displayed in volts or hertz depending on their origin.

Program operation is monitored by the watchdog circuitry. If the circuit is not triggered in about two seconds, it will perform a hardware reset.

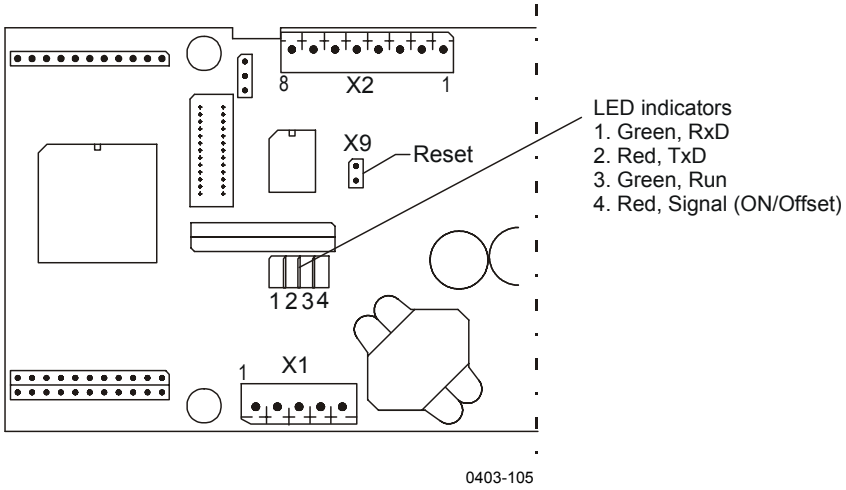

Figure 5 LED Indicators on the PWC10/20 Board

Normal operation is indicated by the Run LED blinking once every second. The Signal/Offset LED is on, when PWD10/20 measures the visibility signal.

The RxD and TxD LEDs are directly controlled by the serial line hardware indicating all action in the serial line.

Memory Tests

After resetting, PWD10/20 tests and clears its SRAM data memory. It indicates an error by the Signal/Offset LED blinking. After 50 blinks PWD10/20 tries to start the program anyway. Usually this causes a watchdog reset, if the SRAM is really faulty.

The data SRAM test is also done continuously in the background in normal operation. If a SRAM error is detected, the watchdog resets the system.

The checksum of the parameter memory (EEPROM) is calculated and checked for test. An error in the checksum may be fatal (visibility is indicated using /////). The cause is displayed in the status message.

The EEPROM checksum is calculated and checked during every update of saved parameters and after restart.

Signal Monitoring

PWD10/20 measures the optical signal, receiver backscatter, and offset as frequencies in about eight millisecond samples. Because the

measuring times are 10 s, 1 s, and 4 s correspondingly, they must have different numbers of samples in a batch. PWD10/20 checks that the frequencies are not zero and signal sample count is bigger than the offset sample count.

Errors in signal or offset are fatal, and data is set to /////.

Offset drift is monitored separately. The reference offset frequency is given in the configuration session. If the drift is more than 10 Hz, the software generates a warning.

The user can follow the progress of the measurement sequence as the Signal/Offset LED sequence of 10 seconds on, and 5 seconds off.

Hardware Monitoring

An eight-channel analog-to-digital converter is used to measure some signals and various voltages from the hardware. The **STA** command displays the internal monitoring values (For details, see section STA on page 64).

Monitoring Contamination

PWD10/20 monitors both transmitter and receiver contamination by measuring the backscattered signal. The **CLEAN** command is used to set the clean reference values of the backscatter signals. Deviation of the backscatter signal from the clean values is proportional to the contamination on the lenses

The alarm and warning limits are given in the configuration session. If the alarm limit is exceeded, data is set to ///// and an alarm is generated. The measured values are used only for warnings and alarms. No compensation for the visibility signal is calculated.

Transmitter backscatter is measured by an analog circuit using the transmitter LED as a light source. Its identifier is `TR. BACKSCATTER` in the status message. `TR. BACKSCATTER` is smaller for higher backscatter signals. Receiver backscatter is measured with the signal receiver using an additional, controlled LED as a transmitter. The result is in hertz. It is bigger, when more light is scattered back (REC. BACKSCATTER).

CHAPTER 4
INSTALLATION

This chapter provides you with information that is intended to help you install this product.

Selecting Location

Finding a suitable site for the Vaisala Visibility Sensor PWD10/20 is important for getting representative ambient measurements. The site should represent the general area of interest.

The main requirements for the location of PWD10/20 are as follows:

1. Locate PWD10/20 in such a way that the measurements will be representative of the surrounding weather conditions.
   - The ideal site for PWD10/20 has a minimum clearance of 100 m from all large buildings and other constructions that generate heat and obstruct precipitation droplets. Avoid the shade of trees because the trees may cause changes in the microclimate.
2. The site should be free of obstacles and reflective surfaces disturbing the optical measurement as well as obvious sources of contamination.
   - It is recommended that there are no obstacles in the line-of-sight of the transmitter and receiver units (see Figure 6 on page 28). If the transmitter beam is reflected from obstacles back to the receiver unit, then the sensor will indicate too low MOR values because the reflected signal cannot be distinguished from real scatter signal. Reflections can be detected by rotating the sensor crossarm. Any reflections will change depending on the crossarm orientation and the visibility reading will change accordingly.

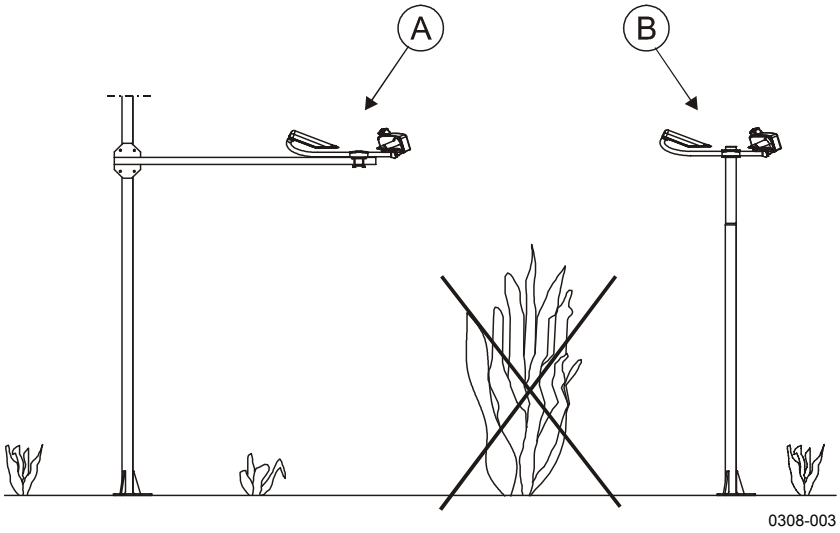

Figure 6 Recommended Location of PWD10/20. Alternative Ways to Mount the Sensor (A or B).

- The receiver and transmitter optics should not point towards powerful light sources. It is recommended that the receiver will point north in the northern hemisphere, and south in the southern hemisphere. The receiver circuit may become saturated in bright light, in which case the built-in diagnostics will indicate a warning. Bright daylight will also increase the noise level in the receiver.
- The transmitter and receiver should face away from any obvious source of contamination such as spray from passing vehicles. Dirty lenses will cause the sensor to report too high visibility values. Excessive contamination is automatically detected by the sensor.
- In the road environment the receiver should face away from passing vehicles. The preferred orientation is along the road. A receiver pointing towards driving direction of the closest lane.

3. Power supply and communication lines must be available.
   - When siting PWD10/20, consideration must be given to the available power supply and communication lines, as this influences the amount of work and accessories needed, and hence the actual cost of installation.

Although PWD10/20 is designed to withstand harsh weather conditions, there are locations where the environment places further demands for installation. For harsh wintry conditions, optional hood heaters are available to prevent ice and snow accumulation.

Grounding and Lightning Protection

Equipment Grounding

Equipment grounding protects the electrical modules of PWD10/20 among other things against lightning and prevents radio frequency interference. Equipment grounding for PWD10/20 is done via the weather station grounding cable.

The grounding principles are the following:

- Install the grounding rod as close to the pole mast as possible. That is, minimized the length of the grounding cable. The grounding cable can also be cast inside the concrete base.
- The length of the grounding rod depends on the local groundwater level. The lower end of the grounding rod should touch moist soil continuously.

The quality of the grounding can be checked with a georesistance meter. The resistance must be less than 10 Ω.

Internal Grounding of PWD10/20

The electronics enclosure of PWD10/20 is grounded using the power/data cable jacket. The other parts of the sensor are in galvanic contact with each other.

Grounding the Remote Units and the Communication Cable

It is also necessary to ground the remote units such as the PC data logger and display, and protect them against lightning.

WARNING	If the remote units are not properly grounded, a lightning strike through a communication wire can cause voltage surge dangerous to life at remote sites.

Installation Procedure

This section describes only one installation alternative, in other words, using a sensor support arm and Vaisala weather station as the host computer.

Unpacking Instructions

The contents of the delivery are specified in the packing list included with the delivery documents. The PWD10/20 equipment is usually delivered in one case.

NOTE	The case should be handled gently. Do not drop either end of the case more than five centimeters.

Unpacking Procedure

1. Read the packing list supplied within the delivery documents. Then compare the packing list against the purchase order to make sure that the shipment is complete.
2. Open the cover. In case of any discrepancies or damage, contact the supplier immediately.
3. Place the packing materials and cover back in the delivery case and store them for possible reshipment.

Storage

Store PWD10/20 in its package in dry conditions, not in the open air. The storage conditions are as follows:

- Temperature -40 °C to 70 °C
- Relative humidity up to 95 %

Mounting

When installing PWD10/20 with the sensor support arm, proceed as follows:

1. Install PWD10/20 to the support arm. See Figure 7 below.

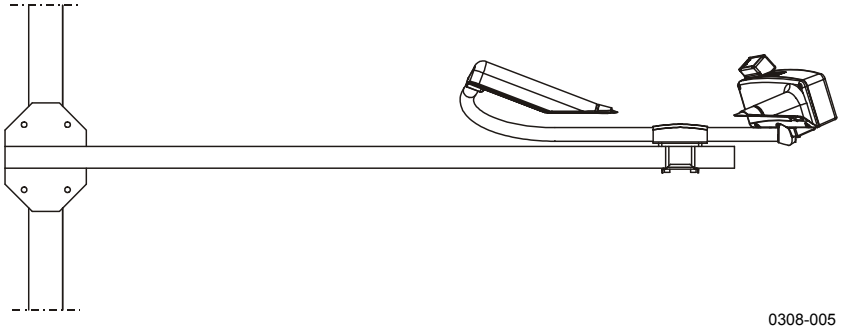

Figure 7 Installing PWD10/20 to the Support Arm

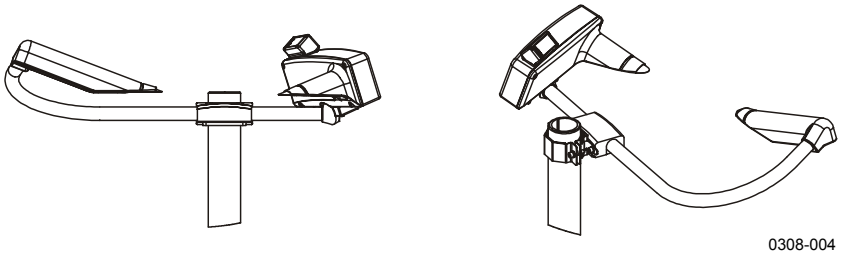

Figure 8 Installing the Subassembly to the Mast with the Vaisala Clamp Assembly

2. Or install the subassembly to the mast. See Figure 8 above.

Connections

Connecting Cables

The PWD10/20 enclosure is equipped with a connector for connecting signal and power cable. The connector enables easy installation and maintenance. The cable shield and connector is grounded to the PWD10/20 enclosure in order to keep EMI levels within the specifications.

1. Connect the PWD10/20 mast cable (power and signal cables) to a fixed connector underneath the PWD10/20 housing.

CAUTION	Tighten the connector properly. The cable connector must not swing in relation to the fixed connector.

2. Test if the connector swings. If it swings, the mating surface of the connector is not sealed and thus, it will leak. Also the connector terminals will be exposed to weather.

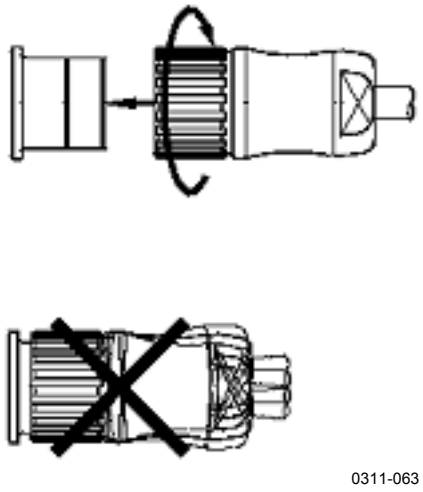

Figure 9 Testing the Connector

NOTE	The cable connector must be connected very tightly to the fixed connector on the PWD10/20 housing. No looseness is allowed.

3. Insulate the unused wires of the PWD10/20 mast cable from each other, for example, by connecting them to void screw terminals in the junction box.

Basic Wiring

The PWD10/20 cable has 16 connection wires.

Table 6 Receptable Connector Default Wiring

Signal Name	Connector in PWC10/20	Wire Color	
Sensor DC Power +	X1 - 4	RED	
Sensor DC Power GND	X1 - 5	BLK	
RS-485 B (-)	X1 - 2	WHT	
RS-485 A (+)	X1 - 3	BRN	
RS-232 Tx /PWD	X2 - 2	GRN	PC serial port connector D9 pin 2 or ROSA Service Connector pin 4
RS-232 Rx	X2 - 3	YEL	PC serial port connector D9 pin 3 or ROSA Service Connector pin 3
RS-232 GND	X2 - 1	GRY	PC serial port connector D9 pin 5 or ROSA Service Connector pin 5
Relay Control 1	X4 - 6	GRY/PNK	
Relay Control 2	X4 - 7	RED/BLU	
Relay Control 3/ Ext Vb	X4 - 5	VIO	Function of the pin is chosen by jumper X11.
Ext Vb	X3 - 9	PNK	Output voltage of the pin is +12VDC in reference to GND (X4-8 and X2-1)
Analog output	X3 - 12	BLU	Current range is chosen by jumper X13
Heating power+	X3 - 5	WHT/GRN	*All four heating power wires must be connected due to high current.*
Heating power+	X3 - 5	BRN/GRN	
Heating power-	X3 - 6	WHT/YEL	
Heating power-	X3 - 6	YEL/BRN	
Shield	Chassis	Shield	Connected to equipment grounding

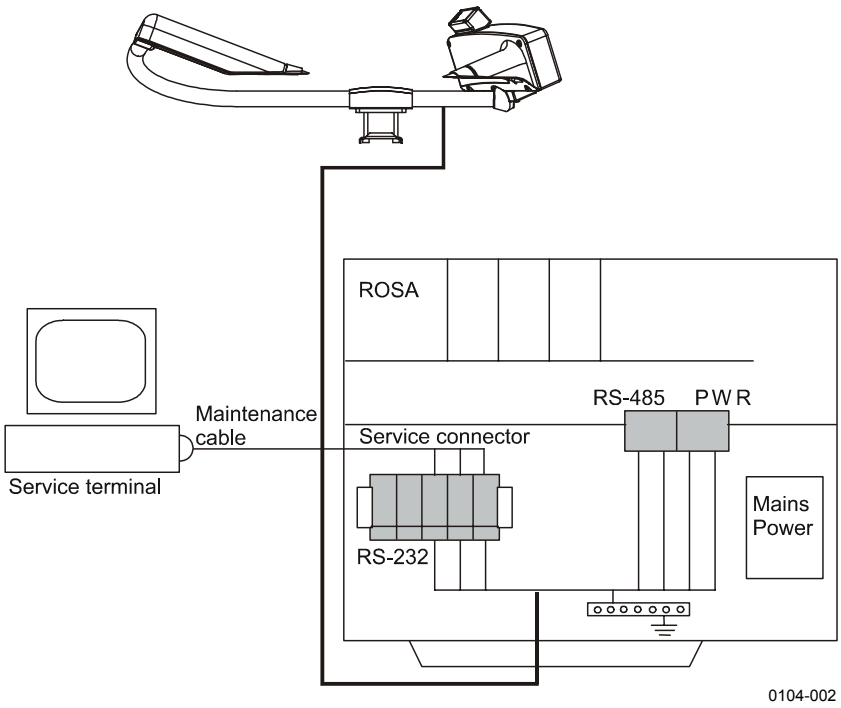

Figure 10 Cabling Principle

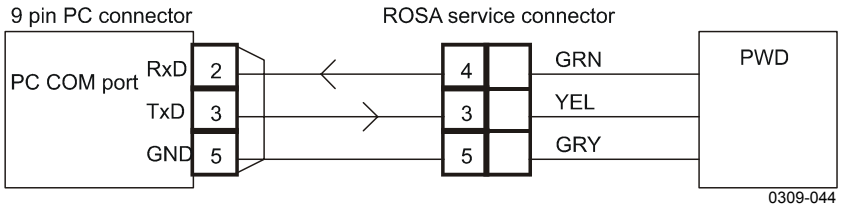

Figure 11 Maintenance Cable

Supplying Power to PWD10/20

Power supply can be connected separately for the measurement electronics and heating. This allows for the battery backup to be limited to the measurement power supply.

Measurement electronics require 12 VDC ... 50 VDC. All the heaters can take AC, DC, or rectified AC. Heater voltage dimensions are specified below.

Internal Heaters without PWL111(default)

Whenever separate heating power is not available, the measurement electronics supply of 12 VDC ... 50 VDC must be used to supply the internal heaters, too. When separate heater power is applied, it can be used to supply internal heaters.

Jumpers X5 and X8 on the PWC10/20 Controller/Receiver circuit board choose whether to use the separate supply for internal heaters or not. See Appendix B, PWC10/20 Connectors and Jumper Settings on page 93. As a default, electronics power supply is used for heating power.

Internal Heaters with PWL111 (optional)

The heaters for Background Luminance Sensor PWL111 (optional) are parallel to the PWD10/20 internal heaters (connector X18 on the PWC10/20 board). The PWL111 heaters can only be powered by 12 V or 24 V or something in-between. If PWD10/20 is equipped with PWL111 and measurement electronics, the DC supply must be used to power internal heaters also, and the DC voltage must not exceed 24 V. If the voltage is as low as 12 V, jumpers on PWL111 board must be set to 12 V to guarantee sufficient heating power.

When separate heater power is applied, it can be used to supply internal heaters, that is, including PWL111 heaters. In this case separate heater voltage must not exceed 28 V (24 V recommended).

Hood Heaters PWH111

A separate heating power of 24 V must be applied when using hood heaters . They use 30 W each, which is 60 W altogether. If PWL111 and PWD10/20 internal heaters are powered by this same supply, it is loaded by approximately 65 W.

Communication Options

PWD10/20 has one serial line with two interfaces. The two-wire RS-485 is intended to be the standard interface. The PWD10/20 software is designed to allow the RS-232 interface to be used as a service line, when the RS-485 interface is connected to the host computer.

Usually, PWD10/20 waits for input from both the RS-232 and RS-485 interfaces. Any character from the RS-232 interface disables the RS-485 communication for 10 seconds or until the line is closed by the operator.

Automatic messages are sent to both interfaces along with the messages polled from the RS-485 interface.

Serial Communication Settings

The default settings of the serial communications port are as follows:

- 9600 baud
- Even parity
- 7 data bits
- 1 stop bit

Serial Transmission RS-232

For the RS-232 communication connect the PWD10/20 signal wires to:

- YEL to PC 3/9: TxD RS-232
- GRN to PC 2/9: RxD RS-232
- GRY to PC 5/9: GND

Vaisala recommendation for the maximum length of the RS-232 cable is 50 m. Usually, the RS-232 connection can be used with distances up to 100 m without problems but that cannot be guaranteed.

Serial Multipoint Transmission RS-485

The RS-485 transmission standard allows several PWD10/20s to communicate (half duplex) with the host computer using a single twisted pair. For the RS-485 communication connect the PWD10/20 signal wires to:

- BRN RS-485 A (+)
- WHT RS-485 B (-)

NOTE In some RS232/RS-485 converters the markings may be mixed. If the connection does not work properly, switch the position of the wires.

NOTE	In PWD11 User's Guide the RS-485 markings were mixed. The markings are corrected in this manual. The actual wiring and wire colors are identical in PWD11 and PWD12.

Connection of the Maintenance Terminal

Any computer equipped with terminal emulation software or a VT 100 compatible terminal with RS-232 serial interface can be used as a Maintenance Terminal for PWD10/20.

Relay Controls

PWD10/20 has three open collector relay controls that are controlled by software using the alarms limits set in the **CONF** command.

The three relay control of PWD10/20 can all be driven by the visibility limits. The third relay control can also be driven by the hardware status.

- ALARM LIMIT 1
- ALARM LIMIT 2
- ALARM LIMIT 3

These are visibility alarm limits of the 10-minute average. Limit value 0 indicates that this limit is not used. The three visibility limits are independent of each other, which means that ALARM LIMIT 1 sets the limit for RELAY CONTROL 1 only. ALARM LIMIT 2 set the limit for RELAY CONTROL 2 only and so on. For example, RELAY CONTROL 1 is pulling whenever visibility is lower than ALARM LIMIT 1. See Table 7 and Table 8 on page 38.

- RELAY ON DELAY
- RELAY OFF DELAY

The visibility alarm conditions must last the corresponding time in minutes specified in *Relay on/off delay* parameter before the relay control changes. The default delays are five (5) minutes.

On the following page is table with a control logic example of relay controls 1 and 2 when the third relay control is driven by hardware status.

Table 7 Control Logic of Relay Controls 1 and 2

States of Relay 1 and 2	Corresponding Visibility Conditions
1 OFF 2 OFF	When visibility is higher than LIMIT 1 and LIMIT 2.
1 ON 2 OFF	When visibility is lower than LIMIT 1 but higher than LIMIT 2.
1 ON 2 ON	When visibility is lower than LIMIT 1 and LIMIT 2.

Below is a table of a control logic example of relay controls 1, 2, and 3 when all the relay control are driven by visibility limits.

Table 8 Control Logic of Relay Controls 1, 2, and 3

Relay States	Corresponding Visibility Conditions
1 OFF 2 OFF 3 OFF	When visibility is higher than all the limits.
1 ON 2 OFF 3 OFF	When visibility is lower than LIMIT 1 but higher than LIMIT 2 and LIMIT 3.
1 ON 2 ON 3 OFF	When visibility is lower than LIMIT 1 and LIMIT 2 but higher than LIMIT 3..
1 ON 2 ON 3 ON	When visibility is lower than all the limits.

When the third relay control output is set to be driven by the hardware status, it pulls whenever a hardware alarms is detected For details, see section System Configuration Commands on page 52.

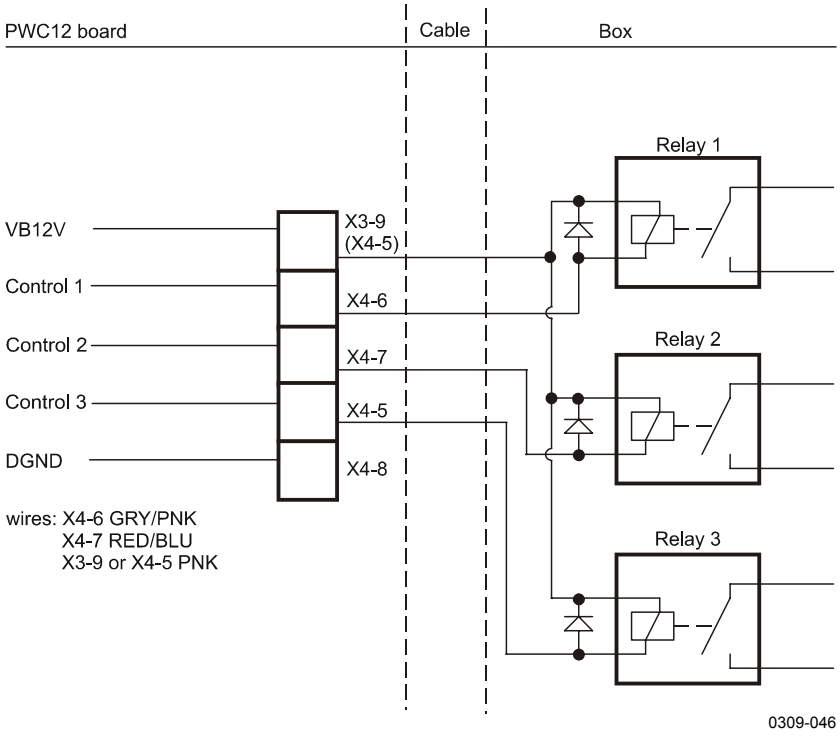

Figure 12 Relay Connection: PWD10/20 Supplies

Figure 12 on page 38 illustrates external relays connection when relay coils are powered by PWD10/20. Voltage pin VB 12 V and relay controls 1, 2, and 3 are wired by default.

NOTE	Do not load any of the relay control output pins by more than 35 mA or any Ext Vb voltage output pin by more than 200 mA.

If external relays require higher coil current, an external power supply must be used for one or two of them.

Relay control 3 can be changed to external voltage output of 12 V by jumper X11.

Figure 13 below illustrates external relays connecting when relay coils are powered by external voltage. In this case, one of the unused wires must be changed to ground pin (X4-8, see Appendix B, PWC10/20 Connectors and Jumper Settings on page 93). For example, if voltage pin X3-9 is not used, the pink wire may be changed to pin X4-8. The other end of the changed wire must be connected to the ground potential of the external relay power source.

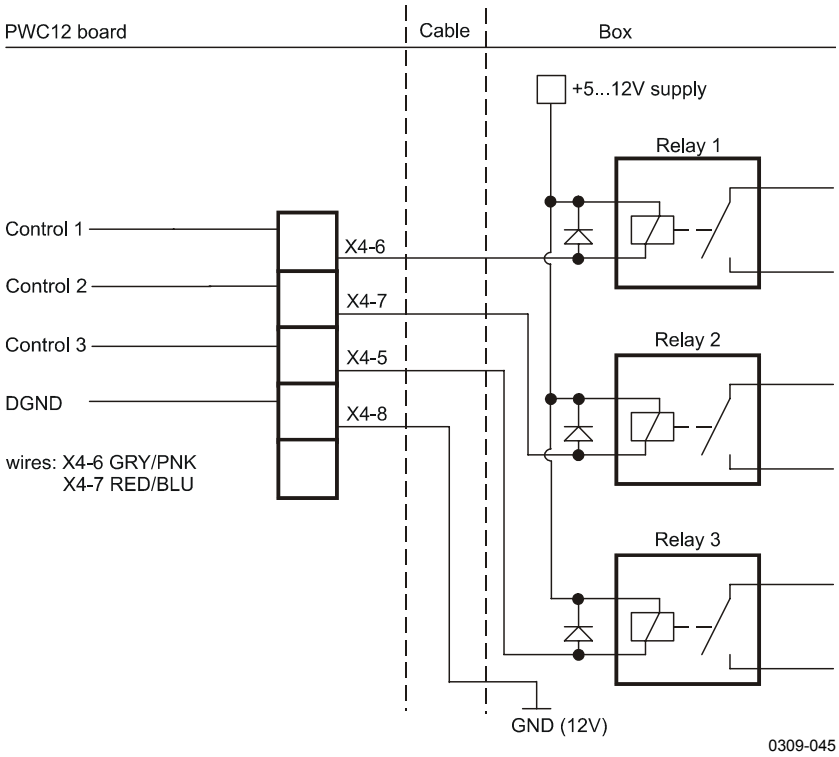

Figure 13 Relay Connection: External Relay Supply

RELAY Command

Set/display the relay control states.

When you type the following:

```
>RELAY
```

The result is the following:

```
RELAYS OFF OFF OFF
```

All relay controls can be set on by typing the following:

```
>RELAY ON
```

Relay control 1 can be set on until ESC is pressed. See the example below:

```
>RELAY 1 ON
```

Initial Settings

Vaisala Visibility Sensor PWD10/20 is typically interfaced to a host computer or a data logger in an automatic weather observing system. After the physical connection has been made, the details of the communication can be configured in the software. Suitable communication settings depend on the implementation of the whole system.

By default the sensor is on a polled mode, in other words, a data message is only sent when the host computer requests one with a special command. The sensor can also be used in an automatic message mode. The automatic message mode transmits a new ASCII data message through the serial line automatically. The interval and message type can be changed by the user (the **AMES** command). In addition, the baud rate of the serial line can be changed to another value, and the data frame can be selected between 7 data bits, even parity, one stop bit, and 8 data bits, no parity, one stop bit.

The default communication settings are described in Table 9 below.

Table 9 Default Communication Settings

Setting	Default
Baud rate	9600 bps (7E1)
Polled or automatic mode, message type	Polled mode
Sensor ID	No ID set

In multipoint communication, where several sensors share the same communication line, PWD10/20 should be used in the polled mode and individual sensors must have distinct identifiers.

The commands for changing the default settings are listed in Table 10 below. For details on the commands, refer to Chapter 5, Operation, on page 43.

Table 10 Commands for Changing Default Settings

Operation	Command
Baud rate selection	BAUD
Polled or automatic mode, message type setting	AMES
Sensor ID configuration	CONF

Verification

Before connecting PWD10/20 to a weather station or other host, a short startup procedure is recommended.

1. Connect a terminal via RS-232 serial line to the sensor.
2. Set the terminal baud rate to 9600 bps and the data frame to contain 7 data bits, 1 stop bit, even parity.
3. Switch the power supply on.
4. After startup, the PWD10/20 output is the following:

   ```
   VAISALA PWdxx V x.xx YYYY-MM-DD SN:XXXXXX
   ```

   (ID is also included, if configured, for example, in the following way:

   ```
   VAISALA PWDxx V x.xx YYYY-MM-DD SN:XXXXXX ID
   STRING: 1)
   ```

   If not, check the cabling and baud rate of the service terminal

(program). If wrong characters are shown, try other baud rates, such as, 300, 1200, 2400, and 4800.

5. Wait for 20 seconds and enter into the command mode with the **OPEN** command. Check with the **STA** command that no hardware errors or warnings are detected
6. Leave the command mode by typing **CLOSE** and check that the automatic message appears in the display, if it was not disabled.

Other commands are described in Chapter 5, Operation, on page 43.

CHAPTER 5

OPERATION

This chapter contains information that is needed to operate this product.

Getting Started

Vaisala Visibility Sensor PWD10/20 is a fully automatic instrument for continuous visibility measurement. Usually, PWD10/20 is either set to send a data message automatically or it is polled by a host computer. In addition, a set of user commands is provided for configuring and monitoring the system performance. These commands can be given in the command mode (see section Entering and Exiting the Command Mode on page 44).

Operating Instructions

User intervention is not required in the normal operation of PWD10/20. Operator commands are used only in the initial setup and during routine maintenance. Several commands are also available for troubleshooting.

When the sensor is installed, the user may need to change some of the default settings. Section Initial Settings on page 40 describes the initial setup in greater detail. The settings and corresponding commands are described in Table 11 below.

Table 11 Initial Settings and Corresponding Commands

Setting	Command
Baud rate	BAUD
Polled or automatic mode, message type	AMES
Sensor ID	CONF

The command for routine maintenance operations are described in Table 12 below.

Table 12 Commands for Routine Maintenance Operations

Operation	Commands
Sensor cleaning	CLEAN (optional)
Visibility calibration	ZERO, CHECK, CAL

The standard output messages contain a status character, which presents the results of the internal diagnostics to the host computer or the user. If the sensor indicates a warning or an alarm in a standard output message, the host computer or the user can obtain a detailed status report with a special **STA** command. The status report can also be polled (message 3) in place of the standard data message. Usually, the detailed status information is sufficient for locating the fault.

Entering and Exiting the Command Mode

Before any commands can be given to PWD10/20, the communication line in PWD10/20 has to be assigned to the operator. Otherwise, it is assigned to automatic messages or polled communication. The user assigns the command mode with the **OPEN** command.

OPEN

If no device identifier (ID) is defined, then type the following:

```
OPEN
```

If the ID is defined, for example, as A, type the following:

```
OPEN A
```

If the ID is defined but forgotten, type the following:

```
OPEN *
```

If there are two or more different sensors connected to the same RS-485 line, and if the sensors have the same ID, PWD10/20 can be opened by typing the following command:

```
OPEN PWD {id number}
```

PWD10/20 answers as follows:

```
LINE OPENED FOR OPERATOR COMMANDS
```

If no input is given within 60 seconds, PWD10/20 closes the line automatically.

CLOSE

The **CLOSE** command is used for releasing the line to automatic data messages or polling commands.

PWD10/20 answers as follows:

```
LINE CLOSED
```

Message Types

Message 0 is intended to be the standard weather message. The length of the **STA**tus Message 3 depends on the possible alarm and warning states.

PWD10/20 adds frame strings to the polled and automatic messages. The content of the frame strings is presented in the following:

$^{S}_{H}$PW id$^{S}_{X}$*message body*$^{E}_{X}{}^{C}_{R}{}^{L}_{F}$

Where

$^{S}_{H}$ = Start of heading (ASCII 1, non-printable character).
PW = PWD sensor identifier.
= Space character.
id = Unit identifier, 2 characters. If the ID is not defined, characters space and 1 are shown.
$^{S}_{X}$ = Start of text (ASCII 2, non-printable character).
message body
$^{E}_{X}$ = End of text (ASCII 3, non-printable character).
$^{C}_{R}{}^{L}_{F}$ = CR + LF (ASCII 13 + ASCII 10).

The contents of messages 0, 1, and 2 are illustrated in Figure 14 on page 46.

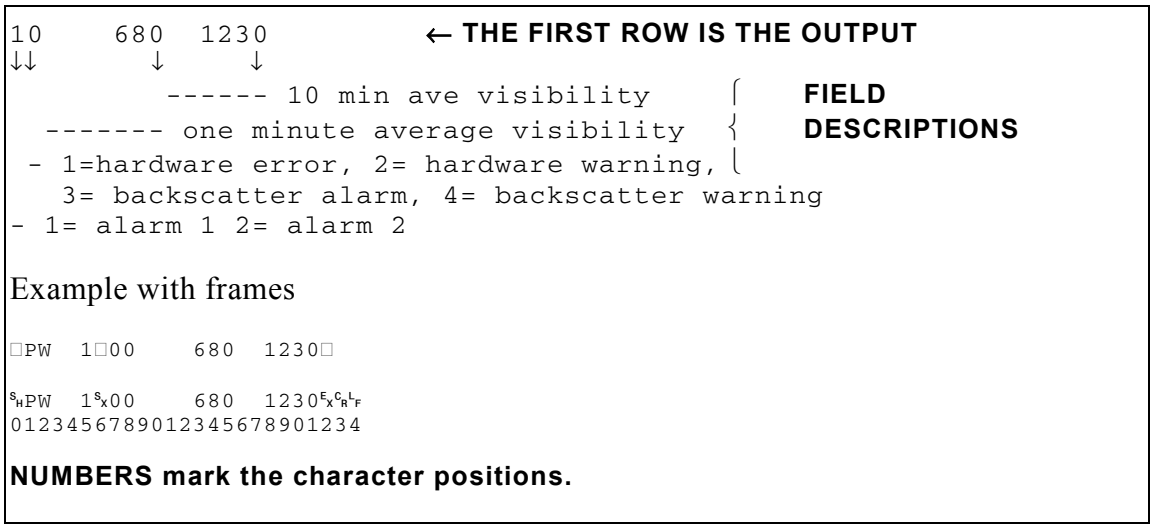

Figure 14 Illustration of Contents of Messages 0, 1, and 2

Message 0

Message 0 displays only the one-minute average visibility and ten-minute average visibility.

```
00    680  1230
         ------ 10 minute average visibility
  ------- one minute average visibility
 - 1=hardware error, 2= hardware warning,
   3= backscatter alarm, 4= backscatter warning
- 1= visibility alarm 1,  2= visibility alarm 2,
3=visibility alarm 3
```

The following is an example with frames:

```
□PW  1□00    680  1230□

SHPW  1SX00    680  1230EXCRLF
123456789012345678901234 5
```

Message 1

Message 1 displays the one-minute average visibility, instant precipitation type, and the one-minute average water intensity.

```
00   1839 61   0.3
            ------ water intensity 1min ave, mm/h
         --- instant precipitation type, 0 ... 99
  ------- visibility one minute average
 - 1=hardware error, 2= hardware warning,
   3= backscatter alarm, 4= backscatter warning
- 1= visibility alarm 1,  2= visibility alarm 2,
  3= visibility alarm 3
```

The following is an example with frames:

```
□PW  1□00   1839 61   0.3□

SHPW  1Sx00   1839 61   0.3EXCRLF
12345678901234567890123456789
```

Message 2

Message 2 is supported and it is the same as in PWD12 and PWD22 except that all the PW values are replaced by ////.

```
00 1839  1505  /// // // //  //////  //////  ////

        ------ visibility ten minute average, max 20000m
  ------ visibility one minute average, max 20000m
 - 1=hardware error, 2= hardware warning
   3= backscatter alarm, 4= backscatter warning
- 1= visibility alarm 1,  2= visibility alarm 2,
  3= visibility alarm 3
```

The following is an example with frames:

```
□PW  1□00  1839  1505  /// // // // ////// ////// ////□

SHPW  1Sx00  1839  1505 /// // // // ////// ////// ////EXCRLF
123456789012345678901234567890123456789012345678901234567890123456
```

Message 3

Message 3 is the same as the status message obtained by the **STA** command. See status message description in section STA on page 64.

Message 4

Message 4 is intended for replacing Fumosens E visibility sensors.

Messages 5 and 6

Messages 5 and 6 are for message emulation of MITRAS Transmissometer.

Message 7

Also message 7 is supported and it is the same as in PWD12 and PWD22 except that all the PW values are replaced by ////. METAR codes are not reported.

```
00  6839  7505  ///  // // //   //////  //////  ////  22.5 12345
                                                       -----
                                                        background
                                                        luminance,
                                                        cd/m²

       ------ visibility ten minute average, max 20000m
  ------ visibility one minute average, max 20000m
 - 1=hardware error, 2= hardware warning,
   3= backscatter alarm, 4= backscatter warning
- 1= visibility alarm 1,  2= visibility alarm 2,
  3= visibility alarm 3
```

The following is an example with frames:

```
□PW  1□00  6839  7505 ///  // // // ////// ////// //// 22.5 12345
//

□


ˢʜPW  1ˢˣ00  6839  7505 /// // // // ////// ////// ////  22.5 12345ᶜᴿᴸᶠ
//ᶜᴿᴸᶠ
ᶜᴿᴸᶠ
ᴱˣᶜᴿᴸᶠ
12345678901234567890123456789012345678901234567890123456789012345678901234567
```

Automatic Message Sending

In the automatic (**CLOSE**d) mode PWD10/20 sends the predefined message at selected intervals. Automatic message is selected with the **AMES** command.

AMES *Message_number Message_interval*

where

Message_number = Valid range 0 ... 7. Selects the corresponding message. Any negative message number is converted to 0. If only the message number is given, the previous message interval setting is used.

Message_interval = Given in multiples of 15 s (= measuring interval). Therefore, intervals 15, 30, 45... are valid. Other intervals are converted to multiples of 15 s. Maximum sending interval is 255 s (4 min 15 s).

See the example below:

```
AMES 0 60
```

Selects message number 0 to be sent once in a minute.

Messages can also be displayed in the command mode with the **MES** command, described in section MES on page 52.

Message Polling

In the polled (**CLOSE**d) mode, PWD10/20 sends a data message when the host computer transmits a polling command. The message polling mode is selected with the following command:

AMES *Message_number 0*

where

Message_number = Valid range 0 ... 7. Selects the corresponding message as the default polled message. Any negative message number is converted to 0.

Message_interval = Negative or zero interval is used to disable the automatic sending. This is used when messages are polled.

For example:

```
AMES 0 0
```

The above command selects message 0 for default answer for the polling and cancels the automatic sending.

The polling command format is the following:

$^{C}_{R}{}^{E}_{Q}$**PW** *id message_number* $^{C}_{R}$

where

$^{C}_{R}$	=	ASCII character 13 hex (Carriage Return)
$^{E}_{Q}$	=	ASCII character 05 hex (CTRL-E).
id	=	Selected in the configuration.
message number	=	This is optional.
$^{C}_{R}$	=	ASCII character 13 hex (Carriage Return)

When the PWD10/20 unit number one (ID=1) is polled for message number 3 (status), the command format is the following:

$^{C}_{R}{}^{E}_{Q}$**PW** *1 3* $^{C}_{R}$

This format can be used in all cases.

Use character 1 as the ID if the ID has not been set but a specific message type is polled. This is to enable the PWD10/20 software to distinguish the ID from the message number.

The $^{C}_{R}{}^{E}_{Q}$**PW**$^{C}_{R}$ command can be used, if only one PWD10/20 unit is on line (no ID is set) and the default message is wanted.

PWD10/20 does not echo the polling character string.

The answer message format is the following:

$^{S}_{H}$PW *id*$^{S}_{X}$*text*$^{E}_{X}{}^{C}_{R}{}^{L}_{F}$

The ID has a two-character field because it can be two characters long.

An example of the polled (and automatic) message 0 format is the following:

$^{S}_{H}$PW 1$^{S}_{X}$00 500 700$^{E}_{X}{}^{C}_{R}{}^{L}_{F}$

PWD10/20 waits about 100 ms before it transmits the polled message to give the host time to turn the RS-485 line into the receive mode.

NOTE For compatibility in the system level, PWD10/20 also accepts FD instead of PW in the polling commands because the data message formats and framing are the same as in the VAISALA FD12 and FD12P sensors. If PWD10/20 is polled by ^CR^EQ**FD** 1 2^C^R, the answer will start with ^S^H**FD** 1^S^X..

List of Commands

PWD10/20 Command Set

HELP

By typing **HELP**, the operator receives information about available commands.

Table 13 Command Set

Command	Description
OPEN	Assigns the line for operator commands.
CLOSE	Releases the line for automatic messages.
MES *Number*	Displays data message.
AMES *Number Interval*	Automatic message (with parameters *Number* and *Interval*).
STA	Displays status.
PAR	Parameter message.
HIST *Parameter*	For Vaisala systems use.
INTV *Time*	For Vaisala systems use.
TIME *hh:mm:ss*	Set/Display system time.
DATE *yyyy:mm:dd*	Set/Display system date.
CHEC	Displays calibrator test signal.
ZERO	Displays zero and noise test status.
CAL *Calibrator_frequency*	Calibration.
CONF *Password*	Updates configuration.
CLEAN	Sets clean references.
BAUD *Rate* C*ommn._type*	Baud rate setting (*Rate* 300, 1200, 2400, 4800, 9600) (*Communication type* E *(7E1)* or N *(8N1)*)
ACAL	Analog output calibration.
BLSC	Background luminance scale / enable.
RESET	Hardware reset by watchdog.

MES

After opening the line for operator commands (see section Entering and Exiting the Command Mode on page 44), a data message can be displayed using the **MES** command. Refer to section Message Types on page 45 for message type descriptions.

The command format is the following:

MES *Message_number*

The valid range is 0 ... 7.

For example, when choosing the data message number 0, type the following:

```
>MES 0
```

AMES

The **AMES** command defines the message, which PWD10/20 transmits as the automatic message or as the default polled message. Refer to section Automatic Message Sending on page 49.

System Configuration Commands

The following command can be used to display system parameters and to edit the current system configuration:

- **PAR**, Parameter message
- **CONF** *password*, Updates configuration
- **BAUD** *rate comm. type*, Sets baud rate and type (Rate 300, 1200, 2400, 4800, 9600), (*Communication type* E (7E1) or N (8N1)

PAR

The current system parameters can be displayed by using the **PAR** system parameters command.

The system output is the following:

```
SYSTEM PARAMETERS
VAISALA PWD20 v 1.00 2003-04-09 SN:X1234567 ID STRING:
AUTOMATIC MESSAGE 0 INTERVAL 0
BAUD RATE: 9600 N81
ALARM LIMIT 1 0
ALARM LIMIT 2 0
ALARM LIMIT 3 0
RELAY ON DELAY 10 OFF DELAY 11
OFFSET REF 152.38
CLEAN REFERENCES
TRANSMITTER 5.0 RECEIVER 1200
CONTAMINATION WARNING LIMITS
TRANSMITTER 0.5 RECEIVER 300
CONTAMINATION ALARM LIMITS
TRANSMITTER 3.0 RECEIVER 600
SIGN SIGNAL 1 1.000
DAC MODE: EXT1
MAX VIS 20000, 20.0 mA
MIN VIS 180, 4.5 mA
20 mA SCALE_1 184.6, SC_0 -2.8
1 mA SCALE_1 184.8, SC_0 -1.4
```

CONF

With the **CONF** command, PWD10/20 asks the system parameters one by one, showing the current value in most cases as the default. The old settings are not changed, if users simply press ENTER as the answer.

The **CONF** configuration command is used to set or update system parameters and adjust certain calibrations, reference values, and limits. Password protection can be used to limit the use of this command. New parameter values are saved in non-volatile memory (EEPROM)

System parameters saved in the EEPROM are:

- *Automatic message number*
- *Visibility alarm limits*
- *Offset reference*
- *Signal scale*

- *Password characters*
- *Unit id characters (2)*
- *References and limits for contamination monitoring*
- *Baud rate*
- *Serial number*
- *EEPROM checksum*
- *Relay control mode and Relay delays*
- *Analog output mode and range*
- *Hood heater usage*

To prevent unauthorized change of the system parameters, a four-character password can be set. If no password is set, the command continues as if it had the correct password.

When no password has been set, the command is the following:

CONF

When a password has been set in a previous session, the command format (max. four character string, printable characters) is the following:

CONF *password*

If the previous password is known, the password can be changed with the **CONF** *password* **N** command, where the N character stands for new.

After getting the correct password, the system asks for a new password. Press ENTER to remove the password. Otherwise, type a new password.

The system response to the **CONF** command is presented below:

```
CONF. PASSWORD (4 CHARS MAX)

UPDATE CONFIGURATION PARAMETERS
UNIT ID (2 CHAR)() 1
 UPDATED
SET REFERENCE PARAMETERS
OFFSET (  156.47) Y
 OFFSET REFERENCE UPDATED
 MODE UPDATED
ALARM LIMIT 1 (      0) 1500
 ALARM LIMIT 1 UPDATED
ALARM LIMIT 2 (      0) 1000
 ALARM LIMIT 2 UPDATED
ALARM LIMIT 3 (      0)  500
 ALARM LIMIT 3
RELAY CONTROL MODE
 0 = 3*VIS, 1 = 2*VIS & HW ( 0) 1
RELAY ON DELAY (   5)
RELAY OFF DELAY (   5)
TRANSMITTER CONTAMINATION LIMITS
WARNING LIMIT (  0.5)
ALARM LIMIT (  3.0)
RECEIVER CONTAMINATION LIMITS
WARNING LIMIT (    300)
ALARM LIMIT (    600)
ANALOG OUTPUT MODE
 0=LINEAR, 1=LN, 2=EXTI, 3=VG1, 4=VG2 ( 4)
ANALOG OUTPUT RANGE
 MAX VISIBILITY ( 2000)
   = mA ( 20.0)
 MIN VISIBILITY (   10)
   = mA (  4.0)
HOOD HEATERS USED 1=YES, 0=NO (    0)

END OF CONFIGURATION
```

The meaning of the questions asked by the system is described below. **Bold** text is used to indicate user actions. The old settings are not changed, if the user just presses ENTER as the answer.

First the system asks for a new password:

```
CONF. PASSWORD (4 CHARACTERS MAX)
```

This question is asked, when there is no valid password. If updating is requested by the *N* parameter and an empty line is given as an answer, the password is removed. Otherwise, the user gives a new password to the system.

The system asks the following:

```
UPDATE CONFIGURATION PARAMETERS
UNIT ID (2 CHAR) ( 1)
```

If the PWD10/20 unit is named by one or two character ID codes, the **OPEN** and polling commands use it as a parameter. The ID code is also included in the data message heading. ID 1 is used as a default in the message heading, if no other ID is given. The current ID can be removed by pressing the hyphen (-) as an answer to the question.

In the multidrop configuration, where several sensors are on the same communication line, the units are differentiated by the ID.

The next *CONF* parameters are hardware or system dependent. They can be changed from the factory set values for better performance or maintenance purposes. The example configuration session is explained in the following.

The currently measured **offset** value (not a parameter) is shown in the brackets.

```
OFFSET (  136.86) Y
OFFSET REFERENCE UPDATED
```

After receiving the Y answer, the system accepts the offset frequency to be the reference parameter for hardware monitoring. The parameter value is further compared with the current value to detect drift or other failure in the optical signal measurement electronics.

Visibility alarm limits are checked to ensure that Limit 1 is higher than Limit 2, and Limit 2 higher than Limit 3. Limit values are expressed in meters.

```
ALARM LIMIT 1 (   1000)
ALARM LIMIT 2 (    200) 300
ALARM LIMIT 2 UPDATED
ALARM LIMIT 3 (    100)
```

In the example above, alarm Limit 2 gets a new value 300 m. When the visibility now weakens below Limit 2, then the data message (0 ... 2) data status is set to 2. The visibility alarm is not shown in the **STA**tus message

The alarm limits are also used to control the two (pull down) alarm controls. Control 1 drives, when alarm 1 is on. Control 2 drives, when alarm 2 is on. Control 3 drives, when alarm 3 is on. The controls are

usually used to drive external relays. For details on relay logic description, see section Relay Controls on page 37.

Backscatter/contamination control is done by comparing the current values of backscatter signal with the reference values given with the **CLEAN** command. The limits given here are limits for the change in backscatter signals.

```
TRANSMITTER CONTAMINATION LIMITS
WARNING LIMIT ( 1.0) 1.5
WARNING LIMIT UPDATED
ALARM LIMIT (  5.0)
```

The transmitter values are in volts (V). The measurement range is 0 ... 13 V, where 0 V is a blocked lens. The limit value is given as a positive value although the signal becomes smaller when contamination increases. A contamination change of 5 V represents about a 10 % decrease in the transmitter's lens transmittance (and also a 10 % increase in visibility indication).

```
RECEIVER CONTAMINATION LIMITS
WARNING LIMIT (    200)
ALARM LIMIT (    500) 600
ALARM LIMIT UPDATED
```

The receiver values are expressed in hertz (Hz). The measurement range is 0 ... 10000 Hz, where 10000 Hz is a blocked lens. A contamination change of 500 Hz represents about a 10 % decrease in the receiver's lens transmittance.

```
ANALOG OUTPUT MODE
 0=LINEAR, 1=LN, 2=EXTI, 3=VGI, 4=VG2 ( 4)
ANALOG OUTPUT RANGE
 MAX VISIBILITY ( 2000)
  = mA ( 20.0)
 MIN VISIBILITY (   10)
  = mA (   4.0)
```

Hood Heaters

By default 0, no hood heaters are used. The hood heater option is factory installed and may be used or disabled in the **CONF** session. All the PWD10/20 heaters are switched on below 2 °C and off at 5 °C. When using hood heaters, a separate 24 V heating power must be supplied. Hood heating power is 30 W for each hood.

BAUD

The baud rate and communication type can be changed by the following operator command:

BAUD *value communication_type*

Baud rates *300, 1200, 2400, 4800, 9600*

Communication types E (7E1) and N (8N1)

The new value is saved in EEPROM and it is used also after reset or power up. The default baud rate set at the factory is 9600 bps (7E1). The communication type definition is optional. It does not change if the baud rate is changed.

The **BAUD** command displays the current baud rate and communication type.

```
BAUD RATE: 9600 E71
```

Analog Output

Analog output is wired in the default configuration.

The analog output connection is set at the factory as shown in Figure 15 on page 59. You will need to do the differential measurement connection at the user's end, which is also shown in Figure 15 on page 59.

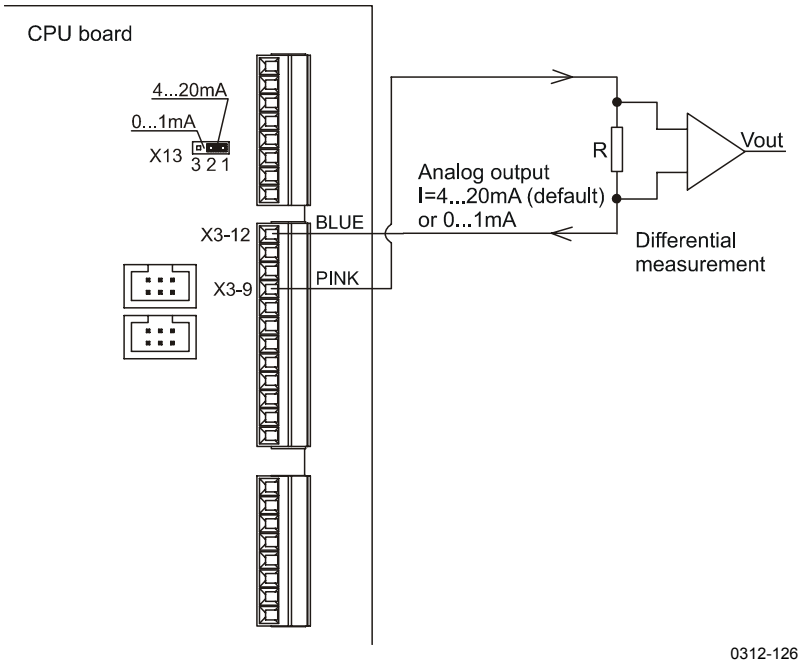

Figure 15 Analog Current Output Connection

If the PWD cable is so long that the 12 V power output is not adequate, the analog output connection will be done as shown in Figure 16 on page 60. When the external power output is used, one unused wire must be connected between connector X4-8 on the PWD CPU board and the ground of the data collector at the user's end. One of the following wires can be used for this if they are not in use anywhere else:

- VIO
- GRY/PNK
- RED/BLU
- PNK
- GRY

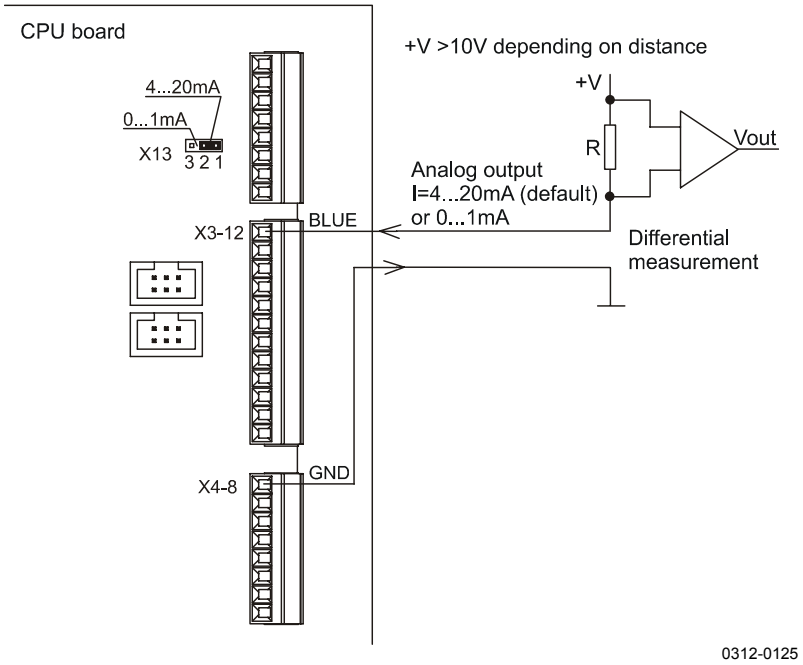

Figure 16 Analog Current Output Connection (External Current Source)

Analog Output Modes

The actual instant Visibility value used in the analog output calculation is first limited to the maximum range of the sensor. Thus, the maximum value of the analog output may be set higher whereas the actual output is limited by the sensor's range. The MIN VISIBILITY limits the low end.

If the abs (max current minus min current) is more than 1.0 (> 1.0), then the 0 ... 20 mA scales are used. This is a default configuration. Otherwise, the 0 ... 1 mA scales is jumper-selectable. For details, see Appendix B, PWC10/20 Connectors and Jumper Settings, on page 93.

Mode 0

Mode 0 indicates standard linear visibility to current mode. The maximum visibility must be higher than the minimum visibility as well as the corresponding currents.

Mode 1

Mode 1 is the logarithmic mode and it uses ln(visibility) values for the output. The calculation is the following:

$$I_{out} = I_{\min} + (I_{range} \cdot X_{coeff}),$$

where

I_{out} = Current that flows to analog out put current sink.
I_{min} = Specified lowest output current value (e.g. 4 mA).
I_{range} = Current range specified
(e.g. I_{range} = 20 mA - 4 mA =16 mA)

$$X_{coeff} = \frac{\ln(VIS_i) - \ln(VIS_{\min})}{\ln(VIS_{\max}) - \ln(VIS_{\min})} = \frac{\ln\left(\frac{VIS_i}{VIS_{\min}}\right)}{\ln\left(\frac{VIS_{\max}}{VIS_{\min}}\right)},$$

where

VIS_i = Initial visibility value in meters.
VIS_{min} = Lowest visibility value specified in configuration (e.g. 10 m or 100 m).
VIS_{max} = Corresponding maximum visibility value (e.g. 2000 m or 20000 m).

The corresponding DAC output LSB value is calculated from I_{out} by using *DAC scale* parameters.

Mode 2

Mode 2 is the extinction mode, which gives lower output for higher visibility. The maximum visibility must be higher than the minimum. The corresponding currents are automatically handled so that the lower current corresponds to the maximum visibility.

The calculation is the following:

$$I_{out} = I_{\max} - (I_{range} \cdot X_{coeff}),$$

where

I_{out} = Current that flows to analog output current sink.
I_{max} = Specified highest output current value (e.g. 20 mA).
I_{range} = Current range specified
(e.g. I_{range} = 20 mA - 4 mA =16 mA)

$$X_{coeff} = \frac{\ln(VIS_i) - \ln(VIS_{\min})}{\ln(VIS_{\max}) - \ln(VIS_{\min})} = \frac{\ln\left(\frac{VIS_i}{VIS_{\min}}\right)}{\ln\left(\frac{VIS_{\max}}{VIS_{\min}}\right)},$$

where

VIS_i = Initial visibility value in meters.
VIS_{min} = Lowest visibility value specified in configuration (e.g. 10 m or 100 m).
VIS_{max} = Corresponding maximum visibility value (e.g. 2000 m or 20000 m).

The corresponding DAC output LSB value is calculated from I_{out} by using *DAC scale* parameters.

Mode 3

Mode 3 is the Videograph mode that is non-linear. The visibility range from 100 m to 10000 m corresponds to the current range of 1 ... 0 mA.

Mode 4

Mode 4 is the Videograph mode that is non-linear. The visibility range from 180 m to 20000 m corresponds to the current range of 1 ... 0.1 mA.

Analog Output Calibration

The analog output is initially calibrated at the factory. The analog output has two ranges, 0 ... 1 mA and 0 ... 20 mA. The range is selected according to the jumper.

In the calibration command, the internal scaling factors for milliamperes to hardware control bits are calculated.

PWD10/20 set two-bit patterns to the DAC circuit and asks for the corresponding measured currents. If the higher current is less than 2 mA, PWD10/20 calculates the current range of 0 ... 1 mA. Otherwise, it calculates the current range of 0 ... 20 mA. The analog output calibration procedure is the following:

1. Connect a multimeter between the pink and the blue wires in PWD10/20.

2. Give the **ACAL** command to PWD10/20.
3. PWD10/20 sets two-bit values to the DAC hardware and asks for the corresponding currents. The currents can be measured with a standard (calibrated) multimeter.
4. PWD10/20 calculates the bits/current scales.

Following is an example of the calibration (current sink, 20 mA jumper):

Type the following command:

```
>ACAL
```

The output will be as follows:

```
MEASURED CURRENT (mA)
```

Then the user enter the value, for example, 21.69.

The output will be as follows:

```
MEASURED CURRENT (mA) 4.35
```

The output is the following:

```
DAC MODE: EXT1

MAX VIS 20000, 20 mA

MIN VIS 180, 4.5 mA

20mA SCALE_1 184.5, SC_0 -2.8

1mA SCALE_1 184.8, SC_0 -1.4
```

The parameters of the **ACAL** command in the current range of 0 ... 1 mA are the following:

DAC scale 1

DAC scale 0

The parameters of the **ACAL** command in the current range of 0 ... 20 mA are the following

DAC scale 21

DAC scale 20

Maintenance Commands

The maintenance commands are used in installation, maintenance, and troubleshooting. They are as follows:

- **STA**, Displays status
- **CAL** *Calibrator _frequency*, Calibration
- **CLEAN**, Sets clean references
- **ZERO**, Displays zero and noise test status
- **CHEC**, Displays calibrator test signal
- **TCAL**, Sets the TS temperature (ambient)
- **HEAT**, Pulls hood heater relays on

STA

The **STA** command (or **MES 3** command) displays the results from the built-in test system as a status message.

The system output is the following:

```
PWD STATUS
VAISALA PWD20 V 1.00 2003-12-15 SN:Y46101

SIGNAL      3.30 OFFSET    146.04 DRIFT     -0.08
REC. BACKSCATTER     2804  CHANGE      4
TR. BACKSCATTER      -2.3  CHANGE    0.0
LEDI    2.3  AMBL    -1.0
VBB    12.6  P12     11.4  M12     -11.3
TS     24.2  TB        28
BL       26
RELAYS  OFF OFF OFF

HOOD HEATERS OFF
HARDWARE :
 OK
```

The length of the message may vary depending on the options configured in PWD10/20 and whether there are warning messages. An asterisk (*) before a value indicates an exceeded limit.

If the Background Luminance Sensor PWL111 is not installed, line BL 26 is edited out. If the optional hood heaters are not installed, the line HOOD HEATERS OFF is edited out. For details on values of this message, see Appendix A, Values for Internal Monitoring, on page 89.

If warnings or errors are detected, one or many of the following texts will appear at the end of the message.

See Table 14 and Table 15 below.

Table 14 Hardware Error Texts

Error Text	Description
Backscatter High	Receiver or transmitter contamination signal has increased more than the ALARM limit given in the configuration allows.
Transmitter Error	LEDI signal is more than 7 V or less than -8 V.
±12 V Power Error	Receiver/transmitter power is less than 10 V or more than 14 V.
Offset Error	Offset frequency is <80 or over 170 (PWC10/20 hardware).
Signal Error	Signal frequency + offset frequency = 0, Signal frequency - offset frequency < -1
Receiver Error	Too low signal in receiver backscatter measurement.
Data RAM Error	Error in RAM read/write check.
EEPROM Error	EEPROM checksum error.
TS Sensor Error	Measurement is out of limits.
Luminance Sensor Error	PWL111 signal is out of limits.

Table 15 Warnings

Warning	Description
Backscatter Increased	Receiver or transmitter contamination signal has increased above the WARNING limit selected in the configuration.
Transmitter Intensity Low	LEDI signal less than -6 V.
Receiver Saturated	AMBL signal is less than -9 V.
Offset Drifted	Offset Drifted
Visibility Not Calibrated	Visibility calibration coefficient has not been changed from the default value (see section CAL below).

CAL

The **CAL** command is used to calibrate the visibility measurement. The calibration is done by using opaque glass plates with known scatter properties. The plates belong to the PWA11 calibrator kit.

Give the following command:

CAL *Calibrator_signal_value*

For example:

```
>CAL 485
```

The calibrator signal value is printed on the labels of the glass plates. Typically the signal is close to 500 Hz. PWD10/20 calculates a new scaling factor and stores it in the non-volatile memory (EEPROM).

NOTE	If the PWC10/20 board has been changed and the status message shows the VISIBILITY NOT CALIBRATED error, use **FCAL** instead of **CAL** to make a factory-like calibration.

CLEAN

The **CLEAN** command has no parameters and it is used to set the clean references for contamination control. This command is given during maintenance procedures after cleaning of the lenses or after replacement of the transmitter or receiver electronics.

Give the following command:

```
>CLEAN
```

The PWD10/20 output is the following:

```
CLEAN REFERENCES
TRANSMITTER 12.0
RECEIVER 1402

UPDATED
>
```

ZERO

The **ZERO** command has no parameters and it is used in calibrating visibility to display the zero signal status.

When the signal blocker of the PWA11 calibrator kit is installed to the lens hood of the receiver (box), the PWD10/20 software checks for the very low signal and low noise. If the signal or noise is out of the internal check limits, an error message is shown.

Give the following command:

```
>ZERO
```

The output is the following:

```
ZERO SIGNAL: OK

>
```

Or in the case of failure in the receiver (PWC10/20) on e of the following:

```
ZERO SIGNAL: FAIL
ZERO SIGNAL: NOISE HIGH
```

CHEC

The **CHEC** command has no parameters and it is used in calibrating visibility to display the one-minute average signal frequency in hertz (Hz).

The displaying is terminated by pressing ESC. If you press any other key, the displaying will only be paused. In the beginning, the four-location buffer, which is used to calculate the average, is filled with the first value.

When the calibrator is installed, the value displayed in the message should be the same as printed on the calibrator glass plate.

Give the following command:

```
>CHEC
```

The output is the following:

```
SCALED FREQUENCY AVE (1 MIN)
 499.9938
 499.9880
>
```

HEAT

This test command can be used to test the heater control relays and the heating elements and power.

The following is an example of the command:

```
HEAT ON
```

When you want to stop the heater test and quit the test mode, press ESC.

NOTE	Do not leave the heater testing on in warm conditions for long periods of time.

Other Commands

TIME

The **TIME** command is used for maintenance purposes. To display the current system time, type the following:

```
TIME
```

The following is an example of the system output:

```
10:11:12
```

To set the time, use the following command:

TIME *hh mm ss*

where

hh = hours
mm = minutes
ss = seconds

NOTE	The time and date has to be reset after a power break. There is no battery backup!

DATE

The **DATE** command is used to display the current date.

To set a new system date, type the following:

```
DATE yyyy mm dd
```

where

yyyy = year
mm = month

where

dd = day

RESET

The **RESET** command makes the hardware reset by the watchdog circuitry.

VER

The **VER** command shows the version of the software.

This page intentionally left blank.

CHAPTER 6

MAINTENANCE

This chapter provides information that is needed in basic maintenance of the product.

Periodic Maintenance

PWD10/20 has been calibrated at the factory. Thus, no initial calibration is required.

Periodic maintenance of PWD10/20 includes the following:

- Cleaning the transmitter and receiver lenses and hoods.
- Checking the visibility calibration and calibrating it, if necessary.

PWD10/20 is designed to operate continuously for several years without other maintenance than cleaning of the lenses.

Section Removing and Replacing on page 76 describes in detail how to remove and replace Transmitter PWT11 and Controller/Receiver PWC10/20 units. Removing the units comes into question, when there is reason to suspect that malfunction of PWD10/20 is caused by faults in these units.

Before any commands can be given to PWD10/20, the communication line has to be opened. Open the communication line by typing the following:

```
>OPEN
```

PWD10/20 answers as follows:

```
LINE OPENED FOR THE OPERATOR
```

The line can be released to automatic messages using the CLOSE command. For details, see Chapter 5, Operation on page 43.

Cleaning

It is very important to clean PWD10/20. No specific operations are necessary before cleaning the sensor, in other words, it is possible to use the service terminal while cleaning. Some erroneous data may, however, be generated. Problems from this can often be eliminated by restarting PWD10/20 after cleaning (by pressing power OFF/ON, for example).

Cleaning Lenses and Hoods

The lenses of the PWD10/20 transmitter and receiver units should be relatively clean to get reliable results as dirty lenses give better visibility values than the actual visibility is. Cleaning should be done every six months or more often depending on the conditions (for example, if there are roads nearby).

The cleaning need is indicated in the hardware alarm field of the data message (2nd character on the message). Refer to section Message Types on page 45.

Number 3 = backscatter warning indicates that the contamination level has increased and cleaning must be performed in the near future. The measurement values are still reliable and shown in the data message.

Number 4 = backscatter alarm indicates that the contamination level is too high and cleaning must be done at once. The measurement values are not shown in the data message.

The complete cleaning procedure is as follows:

1. Moisten a soft, lint-free cloth with isopropyl alcohol and wipe the lenses. Be careful not to scratch the lens surfaces. Lenses should dry indicating that the lens heating is functioning.
2. Check that the hoods and lenses are free of condensed water, or ice and snow deposits.
3. Wipe the dust from the inner and outer surfaces of the hoods.
4. After the optical surfaces are properly cleaned, give the **CLEAN** command.

NOTE	It is not necessary to give the **CLEAN** command after every cleaning. Alternatively choose the **STA** command and check that the Backscatter **CHANGE** value of both the receiver and the transmitter is close to zero (set to zero by the previous **CLEAN** command).

Calibration

PWD10/20 has been calibrated at the factory. Normally, PWD10/20 needs no recalibration as long as the circuit boards are not changed, or there is no call for warnings and alarms. The circuit boards need no hardware calibration.

A periodic check every year is recommended. The user checks the visibility calibration using the PWA11 calibration kit. If the check shows less than ±5 % change, recalibration is not recommended, because the change is within the repeatability of the calibration procedure.

If any mechanical damage changes or weakens the optical measurement path, that is, either the receiver or the transmitter, or the crossarm supporting them, PWD10/20 must be replaced. If the receiver unit (PWC10/20) or transmitter unit (PWT11) is replaced, both visibility and contamination measurements need recalibration.

Visibility Calibration

The calibration is checked and adjusted with the PWA11 calibration kit. The kit consists of a blocking plate and two opaque glass plates with known scatter properties. The **ZERO**, **CHEC**, and **CAL** commands are used in the procedure. The calibration procedure checks two points; zero scatter signal and a very high scatter signal. The zero signal is obtained using a blocking plate and the high signal using opaque glass plates.

When visibility measurement is calibrated, visibility should be more than 500 meters. Calibration is not recommended to be carried out in heavy rain or in bright sunshine. Bright sunlight on the calibrator plates will increase noise in the scatter measurement and make the **CHEC** command output less stable. However, light rain does not matter.

Calibration Check Procedure

Clean the lenses following the instructions in section Cleaning Lenses and Hoods on page 72 before the calibration check procedure. Also check the condition of the opaque glass plates and clean them if necessary.

1. For blocking the light path, place the blocking plate in the receiver hood and wait for 30 seconds.
2. Give the **ZERO** command. PWD10/20 should answer as follows:

   ```
   ZERO SIGNAL: OK>
   ```

3. Move the blocking plate.
4. Install the calibrator plates to the lens hoods. Refer to Figure 17 below.

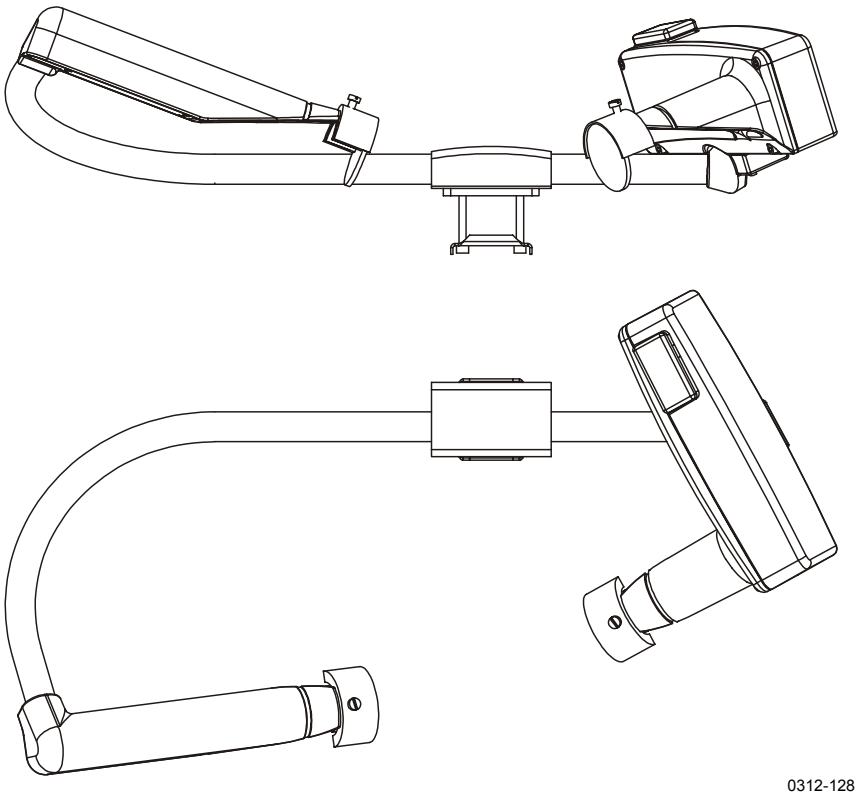

Figure 17 Assembling the Opaque Glass Plates

5. Fasten the opaque glass plates to the hoods. Pay attention to the signal value printed on the plates because it is needed during the following steps.

6. Move away from the optical path and wait for 30 seconds.
7. Give the **CHEC** command.
8. After one minute, read the displayed signal.
9. The signal value must be close to the one printed on the plates. If the difference is less than 5 %, calibration is correct. If not, continue with the calibration procedure.
10. Terminate the **CHEC** command by pressing the ESC key.

Calibration Procedure

If calibrating is needed according to the calibration check, follow the instructions below (see section Calibration Check Procedure on page 74).

1. Give the following command:

   CAL *calibrator signal value*

   For example: `CAL 485`

   The calibrator signal value is printed on the labels of the glass plates. Typically the signal is close to 500 Hz. PWD10/20 calculates a new scaling factor and stores it in the non-volatile memory (EEPROM).
2. Type **CHEC** to verify that the new scaling factor is in use. The displayed signal value should be equal to the calibrator signal value. If the difference between the new scaling factor and the factory calibrated one is more than 20 %, the **CAL** command will be ignored. Check PWD10/20 and the calibrator for hardware or mechanical errors.

   If the optical units PWC10/20 or PWT11 have been replaced, the new scaling factor might change more than 20 % from the original scaling factor, value and the **CAL** command is ignored. In this case use the **FCAL** command (factory calibration) instead of **CAL** during the calibration procedure.

Removing and Replacing

This section describes in detail how to remove and replace the optical units PWT11 Transmitter and PWC10/20 Controller/Receiver. Removing the units comes into question, when there is reason to suspect that malfunction of PWD10/20 is caused by faults in the optical units or the rain detector.

Removing and Replacing the Optical Units

CAUTION	Servicing the equipment must be performed by qualified personnel.

NOTE	After replacing the optical units you need factory calibration. (See section Calibration Procedure on page 75).

Removing Transmitter PWT11

To remove the transmitter, do the following:

NOTE	Use gloves suitable for handling optics.

1. Open the four countersunk screws to remove the transmitter cover and the gasket.
2. Disconnect the control cable connector (2).
3. Loosen the set screw (3) to release the transmitter module (5).
4. Pull the module out of the transmitter head by prying it from the back by a screwdriver.
5. Loosen the nylon screw (6) and slide the transmitter board (4) off the module (5).

See. Figure 18 on page 77.

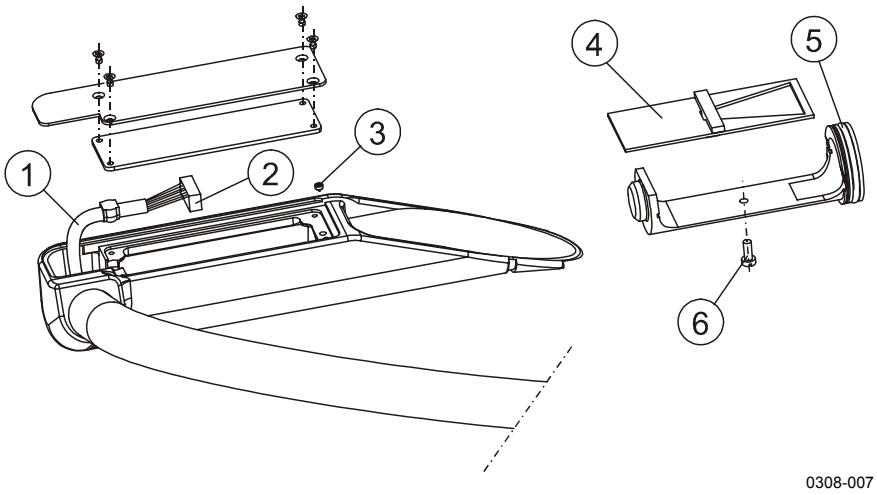

Figure 18 Removing PWT11

The following numbers refer to Figure 18 above.

1 = Signal and power cable
2 = Empty pin
3 = Stopper screw
4 = PWT11
5 = Module and O-ring
6 = Plastic screw

Assembling is done in reverse order. See the instructions below:

1. Slide the transmitter board (4) to the module (5) and tighten nylon screw (6).
2. Lightly grease the O-ring (5) surface on the optics module with silicon grease.
3. Press the optics assembly into the transmitter. Be careful not to touch the lens. Make sure that the module seats properly. If not, lead it to sink by pointed pliers.
4. Lock the module with a M4x4 set screw.
5. Connect the control cable (1) and make sure the cable gasket seats tight into its groove.
6. Check that all the optical surfaces, LED and lens, are clean.
7. Close the transmitter cover with the gasket by four counter sunk screws.

Removing PWC10/20

1. Open the four box screws in the corners of the controller box. See Figure 19 below.

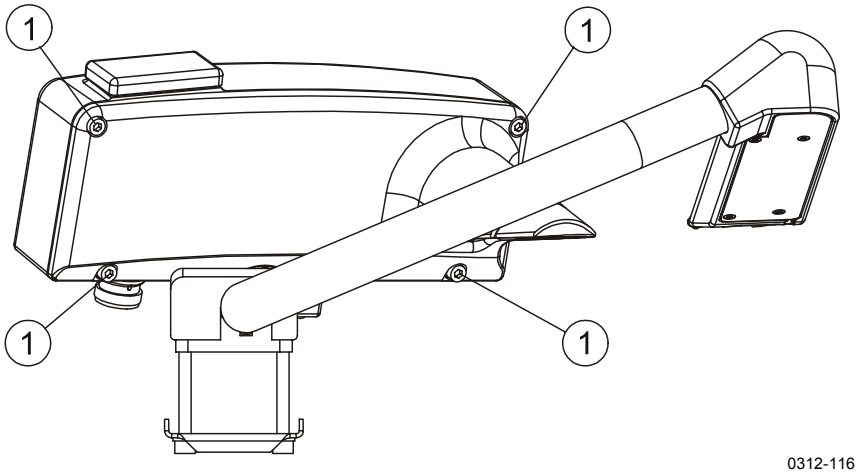

Figure 19 Opening Box Screws (1)

2. Remove the PWC10/20 board by opening the five screws to replace the board with a spare part. See Figure 20 on page 78.

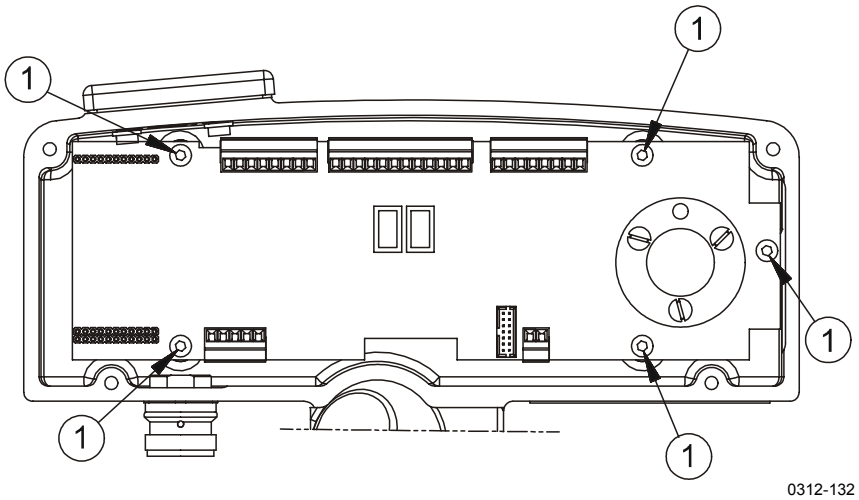

Figure 20 Removing the PWC10/20 Board

CHAPTER 7
TROUBLESHOOTING

This chapter describes common problems, their probable causes and remedies, and contact information.

Common Problems

CAUTION	Servicing the equipment must be performed by qualified personnel.

Message Indicating Warning or Alarm

1. Open the command mode and check the status information with the **STA** command (or poll Message 3 to get the same information).
   - See section STA on page 64 for descriptions of the status message errors and warnings.
   - Check the monitoring values against the internal monitoring limits. See Appendix A, Values for Internal Monitoring, on page 89
   - If the Backscatter increased warning is active (see section STA on page 64), clean the lenses and remove possible disturbances from the optical path.

Message Missing

1. Does your terminal have the right settings?
   - Change the baud rate, for example, to 9600 bps.
   - Check that you have 7 data bits, even parity, 1 stop bits.
2. First give the **OPEN** command (see section OPEN on page 44).
   - Then give other commands to see if PWD10/20 is already in the command mode.
3. Go to the site.
   - Take the maintenance PC (terminal), tools, and the calibrator set with you.
4. Is PWD10/20 powered?
   - Open the PWC10/20 electronics enclosure cover and see, if the Run and Signal/Offset LEDs are blinking.
5. If no LED is on:
   - Check the power supply voltage.
   - Check that all the connectors are properly inserted.
   - Check the power cable and connections.
6. If the Run LED is blinking (once per second for correct operation):
   - Connect a maintenance terminal to the RS port.
   - Check steps 1 and 2.
   - Try resetting by turning the power off/on. If the
7. Run LED is lit:
   - Try resetting as above.
   - If the state is continues, it is probably caused by either the program memory or CPU fault.

Message Exists but Visibility Value Does Not

1. PWD10/20 control electronics is probably working.
   - Check the status information with the **STA** command (see section STA on page 64). If there are any active alarms, the visibility value does not exist.
   - Check especially P12, M12, BACKSCATTER and LEDI. See section Values for Internal Monitoring on page 89.
2. Go to the PWD10/20 site.
   - Check the cable connectors.
   - Check the receiver and transmitter units. Follow the instructions in section Removing and Replacing on page 76 when removing the units.
   - Visually inspect the condition of the electronics.

Visibility Value is Continuously Too Good

This can be caused by several reasons. Most probably the light path from the transmitter to the receiver is disturbed.

1. The lenses may be excessively contaminated. A warning has been received.
   - Clean the lenses (see section Cleaning Lenses and Hoods on page 72).
2. One of the hoods has been filled with snow, leaves, or something similar. A warning is generated.
   - Clean the hoods (see section Cleaning Lenses and Hoods on page 72).
3. There is condensation on the lens surfaces. This is a sign of heating failure.
4. There is an electrical fault in the transmitter or receiver.
   - Check the status information with the **STA** command (see section STA on page 64).
   - Go to section Message Exists but Visibility Value Does Not on page 81.

Visibility Constantly Too Low

Usually there is something disturbing the sample volume.

1. Check the condition of the hoods. If the hoods are twisted, consult Vaisala.
2. Try to find a better direction for the receiver/transmitter optics. See section Selecting Location on page 27.
3. Electrical fault. See items in section Message Exists but Visibility Value Does Not on page 81.

PWD10/20 Electrical Troubleshooting

PWD10/20 is protected against reverse polarity connected to power feed wires. If the power feed is connected to other leads than those for power supply, damage may occur depending on feed voltage and current limiting features of the supply.

If there is no response from PWD10/20, do the following:

1. Check the connections. PWD10/20 diagnosis can be done through the RS-232 maintenance line.
2. Check the baud rates:
   - The factory default is 9600,7,E,1.
3. Open the cover of the receiver.
4. Connect the power and watch the internal LEDs.
   Initialization sequence (3 seconds):
   LED 4 RED lit (Signal lit / offset off)
   LED 3 YEL lit (RUN, 1 Hz)
   LED 2 RED off (Transmit Data)
   LED 1 YEL off (Receive Data)

Start sequence (1 second):
LED 4 RED lit (Signal lit / offset off)
LED 3 YEL off (RUN, 1 Hz)
LED 2 RED off (Transmit Data)
LED 1 YEL off (Receive Data)

Running sequence from start:
LED 4 RED lit 10s / off 5s, continuing sequence

LED 3 YEL flashing, 1 Hz
LED 2 RED short live when sending initialization string (Transmit Data)
LED 1 YEL off (Receive Data)

5. If the sequence is working and the transmit indicator gives response, check following:
   - Initialization string "VAISALA PWD Vn.nn 19yy-mm-dd SN:___ " should give some response to maintenance terminal, if the response is not understandable:
   - Check the communication set-up of terminal.
   - Try with other expected baud rates.
6. If the LEDs are not lit, check the internal connector connections of PWD10/20. The following measurement can be done:
   - Measure the input voltage:
     X1-5=power GND, X1-4=power +V
7. If the LEDs are lit but the sequence starts again and again, try the following:
   - Check the cable end for short-circuit with neighboring leads.
   - Try with a power with a higher current supply capability (the power supply may go to current limiting state for a short while).
   - Try with a higher supply voltage (max. 55 VDC.) This helps the starting current need.

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CHAPTER 8

TECHNICAL DATA

This chapter provides the technical data of the Product.

Specifications

Mechanical Specifications

Table 16 PWD10/20 Specifications

Property	Description / Value
Dimensions	199 mm (h) × 695 mm (w) × 404 mm (d)
Weight	3 kg
Mounting	To a metal rod or directly to the mast.
Material	Aluminum

1) Height × width × depth

Electrical Specifications

Table 17 PWD10/20 Electrical Specifications

Property	Description / Value
Maximum power consumption	3 W, 12-50 VDC Optional luminance sensor: 2 W, 24 V Optional hood heaters: 65 W, 24 V
Sensor electronics	Lock-in amplifier
	LED power stabilizer
	Contamination monitor
	Lens heater
	Temperature sensor
Outputs	Serial data line may be used either as RS-232 or RS-485 (2-wire) level signals
	Three relay controls (open collector)
	Analog output
	8-m power/data cable standard. The PWD10/20 end is equipped with connector.
Output data	Automatic or polled data messages
	Visibility and status data
	Automatic message type and interval is selectable at 15 s ... n x 15 s (n < 18) intervals.
Auxiliary data	Low visibility alarms in the data messages. Three adjustable alarm limits to set the three relay controls.
	Hardware status (fail/warning) in the data messages. Third relay output can also be driven by hardware status.

Optical Specifications

The operating principle of the device is to measure forward scatter at an angle of 45°.

Table 18 Optical Specifications of the Light Transmitter

Property	Description / Value
Light source	Near-infrared Light Emitting Diode
Peak wavelength	875 nm
Reference photodiode	For light source control
Backscatter photodiode	For contamination and blockage measurement
Eye safety	Eye safe in accordance with International Standard IEC/EN 60 825-1; edition 1.2

Table 19 Optical Specifications of the Light Receiver

Property	Description / Value
Detector	Photodiode
Optical filter/window	RG780 glass
Backscatter light source	Near-infrared LED for contamination and blockage measurement

Visibility Measurement Specifications

Table 20 Visibility Measurement Specifications

Property	Description / Value
Measurement range of MOR [1)]	10 ... 2000 m (PWD10) 10 ... 20000 m (PWD20)
Accuracy	+/-10%, range 10 ... 10000 m +/-15%, range 10km ... 20 km
Instrument consistency	+ 5%
Time constant	60 seconds
Update interval	15 seconds

1) Meteorological Optical Range

Environmental Specifications

Table 21 Environmental Specifications

Property	Description / Value
Operating temperature range	-40 ... +55 °C
Operating humidity range	Up to 100 % RH
Wind speed	Up to 60 m/s
Sun orientation	Sunlight into the light receiver must be avoided

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APPENDIX A
VALUES FOR INTERNAL MONITORING

The Typical values come from factory testing and are allowed to change within the given Min/Max limits. The Fault limits give hints for troubleshooting.

Table 22 Values from STA message for Internal Monitoring

Status Message	Typical	Min. / Max.	Fault	Description	Action
AMBL					
Ambient light	-0 V	-9 V / +3 V	> 3 V 'RECEIVER ERROR'	Preamplifier is not working.	Change PWC10/20.
			< -9 V 'RECEIVER SATURATED'	The sun is shining directly or from reflecting surface (snow etc.) to the receiver.	Check the orientation of PWD10/20.
OFFSET					
Measurement signal offset. The lowest frequency for measurement signal	140Hz... 150Hz	80 Hz / 170 Hz	< 80 Hz >170 Hz 'OFFSET ERROR'	Drifting may be caused by other disturbing optical sensors nearby or other interference problems.	1) Check other parts of STA message. 2) If offset does not remain stable, change the control unit PWC10/20.
REC. BACKSCATTER					
Measurement signal from the receiver contamination control circuit. 'CHANGE' value is the instant signal difference			Rec.backscatter change (Instant backscatter minus clean backscatter) > alarm limit 'BACKSCATTER HIGH'	Rising value can be caused by contamination of receiver optics, snow inside the receiver hood, spider net in front of the hood etc. Check the	Clean the outside of optical surfaces and remove possible disturbances from optical path.

Status Message	Typical	Min. / Max.	Fault	Description	Action
to clean value.				contamination limits also.	
			Rec.backscatter change (Instant backscatter minus clean backscatter) > warning limit 'BACKSCATTER INCREASED'		
			Instant backscatter < clean backscatter / 2 'BACKSCATTER HIGH'		1) Clean the outside of the optical surfaces and remove possible disturbances from the optical path. 2) Replace the clean contamination setting by giving the **CLEAN** command. 3) Change the PWC10/20 control unit.
TR. BACKSCATTER					
Control signal for the transmitter contamination. 'CHANGE' value is the instant signal difference to clean value.			<-15 V >14 V 'TRANSMITTER ERROR'	The decreasing value can be caused as above: (REC. BACKSCATTER)	
LEDI					
LED intensity. Actuating signal for the LED control (transmitter)		-8 V / +7 V	>+7 V <-8 V 'TRANSMITTER ERROR'	Changes in voltage can be caused by aging of the LED (voltage decreases).	Change the PWT11 transmitter unit.
			<-6 'TRANSMITTER INTENSITY LOW'	If the voltage is between -6 V... -7 V, the control loop is operating properly but the IR LED must be changed in the near future.	

Status Message	Typical	Min. / Max.	Fault	Description	Action
TS					
Temperature sensor. Ambient temperature	-40 °C... +50 °C	-75°C / +98°C	'TS SENSOR ERROR' (Measurement value under -75°C)	Sensor or cable short-circuits.	Check the temperature sensor cable on control unit. Resistance of Pt-100 should be 80Ω...130Ω.
			'TS SENSOR ERROR' (Measurement value over +98°C)	Sensor disconnected or bad connection.	Check X4 connection on control unit. Resistance of Pt-100 should be 80Ω...130Ω.
TB					
Temperature of the CPU board	Some degrees higher than ambient temp.		-	-	-
SIGNAL					
Frequency of the transmission signal between transducer and CPU (Hz), inversely proportional to visibility	0.00 Hz.... 10000.00 Hz		'SIGNAL ERROR' Signal frequency plus offset frequency = 0 or Signal frequency minus offset frequency < -1	Interference with other sensor of the same kind. Suddenly increased noise level. Failure in receiver circuitry.	Make sure that the device does not receive reflections or scattering from other sensors. Aim the receiver away from high intensity light sources. Change PWC10/20.
VBB					
Raw, unregulated voltage in the internal transformer output	12V... 13V	12 V / 15 V	<12 V >15 V	Switched-mode power supply is overloaded or working wrong. VBB measurement may also fail due to heavy electrostatic discharge to RAINCAP® plate.	1) Reset 2) Check connectors and cable 3) Change the control unit PWC10/20

Status Message	Typical	Min. / Max.	Fault	Description	Action
P12					
Positive voltages of the DC/DC converter for the transmitter and receiver	11.5 V	10 V / 14 V	>10.0 V <14.0 V '+-12 V POWER ERROR'	DC/DC converter is overloaded or working wrong. P12 measurement may also fail due to heavy electrostatic discharge to RAINCAP® plate.	1) Reset 2) Disconnect transmitter 3) Change the PWC10/20 control unit.
M12					
Negative voltages of the DC/DC converter for the transmitter and receiver	-11.5 V	-14 V / -10 V	>-14.0 V <-10.0 V '+-12 V POWER ERROR'	DC/DC converter is overloaded or working wrong. M12 measurement may also fail due to heavy electrostatic discharge to RAINCAP® plate.	1) Reset 2) Disconnect transmitter 3) Change the PWC10/20 control unit.
BL					
Background luminance	4...20000 cd/m²	4 cd/m² / 20000 cd/m²	'LUMINANCE SENSOR ERROR'	Cable disconnected or PWL111 short-circuits	Check connector X3 pins 1,2,3,4.
RELAYS					
States of the three external relays controls	ON / OFF		-	-	-
HOOD HEATERS					
Hood heater automatics is switched either on or off.	ON / OFF		-	If set to ON state, heater current starts flowing when ambient temperature goes below +2°C and stops when it raises over +5°C.	Heaters can be tested by the **HEAT ON** command. Warming of the heater foils should be felt by hand. If not check powering and cabling.

APPENDIX B

PWC10/20 CONNECTORS AND JUMPER SETTINGS

X1-1	Chassis (GND)
X1-2	RS-485 (B) (WHT)
X1-3	RS-485 (A) (BRN)
X1-4	DC power for measurement electronics (+, RED)
X1-5	DC power for measurement electronics (-, BLK)
X2-1	RS-232 (GND, GRY)
X2-2	RS-232 (TxD, GRN)
X2-3	RS-232 (RxD, YEL)
X2-4	Module 5
X2-5	Module 4
X2-6	Module 3
X2-7	Module 2
X2-8	Module 1
X3-1	Background Luminance Sensor PWL111 (Range, YEL)
X3-2	Background Luminance Sensor PWL111 (Level, GRN)
X3-3	Background Luminance Sensor PWL111 (+5 VA, RED)
X3-4	Background Luminance Sensor PWL111 (AGND, BLK)
X3-5	Separate heating power input for PWH111 hood heaters (+, BRN/GRN and WHT/GRN)
X3-6	Separate heating power input for PWH111 hood heaters (-, WHT/YEL and YEL/BRN)
X3-7	PWH111 hood heater foil (+)
X3-8	PWH111 hood heater foil (-)
X3-9	Ext Voltage +12 V (analog output current source (PNK)
X3-10	Ext (modem) control 1
X3-11	Ext (modem) control 2
X3-12	Analog output current sink (range is chosen by jumper X13), (BLU)
X4-1	Temperature sensor PT100 (+, BLU)
X4-2	Temperature sensor PT100 (+, YEL)
X4-3	Temperature sensor PT100 (-, RED)
X4-4	Temperature sensor PT100 (-, GRN)

X4-5	Ext relay control 3 (default) or Ext voltage +12 V (chosen by jumper X11), (VIO)
X4-6	Ext relay control 1 (GRY/PNK)
X4-7	Ext relay control 2 (RED/BLU)
X4-8	GND
X5 and X8	Jumpers between terminals 2 and 3 (default): Lens heaters are powered by DC voltage connected to X1-4 and X1-5. Jumpers between terminals 1 and 2: Lens heaters are powered by separate heater voltage (AC or DC) connected to X3-5 and X3-6.
X6	RAINCAP® connector No. 1. Connect single plate rain detector to this connector. The cable marked with a black stripe (forward tilted plate) is connected to X6 in double rain plate assemblies at PWD22.
X7	RAINCAP® connector No. 2 is used in PWD22 only (backward tilted plate).
X9	Reset
X10-1	+5 VA
X10-2	AUX: CPU ADC input (internally connected to X3-2)
X10-3	AGND
X11	The jumper between terminals 1 and 2 (default): output pin X4-5 acts as External relay control 3. The jumper between terminals 2 and 3: output pin X4-5 acts as external voltage output.
X12	FLASH programming connector.
X13	The jumper between terminals 1 and 2 (default): the analog current output range is 4 ... 20 mA (pins X3-9 and X3-12). The jumper between terminals 2 and 3: the analog current output range is 0 ... 1 mA (pins X3-9 and X3-12).
X14	Module connector.
X15	Module connector.
X16	Transmitter connector (pin 14 is not used).
X18-1	Background Luminance Sensor PWL111 heater (+, WHT)
X18-2	Background Luminance Sensor PWL111 heater (-, BLU)

See also Figure 21 on page 95.

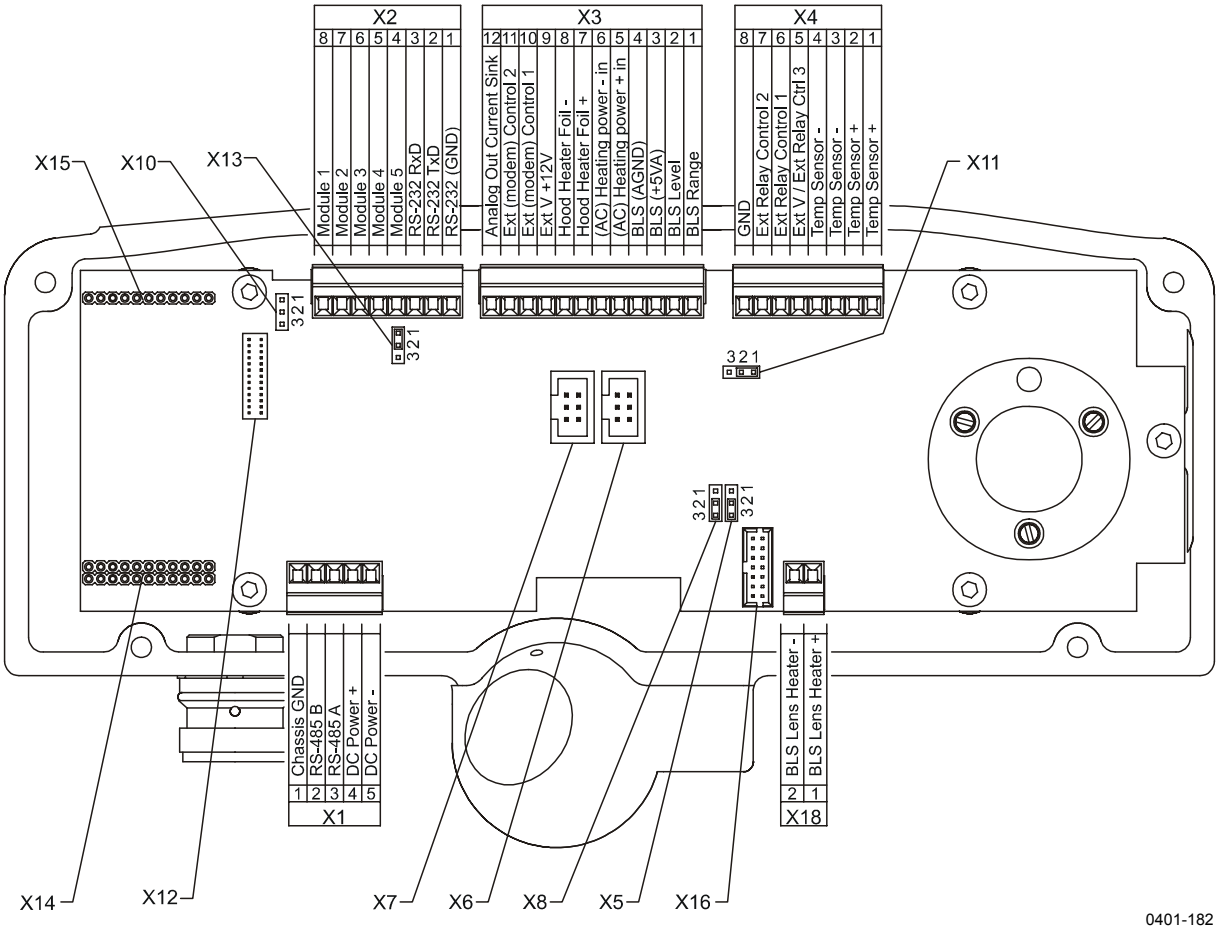

Figure 21 Location of Jumpers and Connectors on the PWC10/PWC20 Processor/Receiver Board

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