

# Present Weather Detector PWD22

## *USER'S GUIDE*

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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 Present Weather Detector PWD22.

### 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, introduces Vaisala Present Weather Detector PWD22 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 includes Values for Internal Monitoring.
- Appendix B includes Jumper Settings.
- Appendix C includes NWS and WMO Code Tables.
- INDEX is located at the end of the manual.

## Version Information

**Table 1**      **Manual Revisions**

Manual Code	Description
M210543EN-A	This manual.

## Related Manuals

**Table 2**      **Related Manuals**

Manual Code	Manual Name
M210542EN-A	Vaisala Present Weather Detector PWD12, User's Guide
M210541EN-A	Vaisala Visibility Sensor PWD10/20, 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](mailto: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 Present Weather Detector PWD22 delivered to you has been tested for safety and approved as shipped from the factory. Note the following precautions:

**WARNING**

The chassis of the PWD22 must be connected to a good electrical earth.

**WARNING**

Do not touch the surface of the RAINCAP® Rain sensor plate. When you need to touch the sensors plate, for example during cleaning, touch first metallic part of PWD22 to discharge possible electrostatic load of your body. The measuring principle does not allow for proper ESD protection.

**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

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## License Agreement

All rights to any software are held by Vaisala or third parties. The customer is allowed to use the software only to the extent that is provided by the applicable supply contract or Software 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 introduces Vaisala Present Weather Detector PWD22 features, advantages, and the product nomenclature.

## Introduction to Vaisala Present Weather Detector PWD22

PWD22 is an intelligent, multi-variable sensor for automatic weather observing systems. The sensor combines the functions of a forward scatter visibility meter and a present weather sensor. PWD22 can measure the intensity and amount of both liquid and solid precipitation. As the detector is equipped with a background luminance sensor, it can also measure ambient light.

PWD22 suitable for automatic weather station applications especially for low-power requirement installations.

**Table 3 Model and Performance Table**

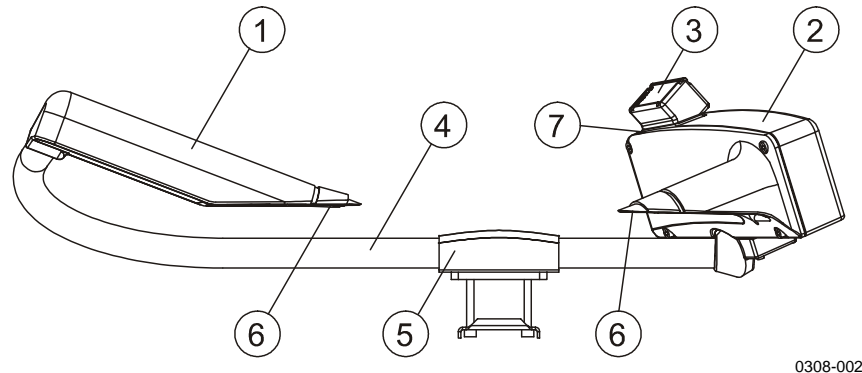
<b>Model</b>	<b>Performance</b>
Visibility Sensor PWD10	Visibility range 10 m ... 2000 m
Present Weather Detector PWD12	Visibility range 10 m ... 2000 m 4 different precipitation types
Visibility Sensor PWD20	Visibility range 10 m ... 20000 m
Present Weather Detector PWD22	Visibility range 10 m ... 20000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

The versatility of PWD22 is achieved with a unique operating principle. PWD22 measures an estimate of the precipitation water content with a capacitive device Vaisala RAINCAP<sup>®</sup> Rain Sensor and combines this information with optical scatter and temperature

measurements. These three independent measurements together provide sufficiently data for an accurate evaluation of prevailing visibility and weather type.

## Hardware Structure

PWD22 is a self-contained instrument that can be fastened to the side of the mast and into a crossarm using the mounting clamps.



**Figure 1 PWD22 Present Weather Detector**

The following numbers refer to Figure 1 above.

- 1 = Transmitter
- 2 = Controller/Receiver
- 3 = PWR211 Vaisala RAINCAP<sup>®</sup> Rain Sensor (PWR111 in PWD22M)
- 4 = Pt100 temperature sensor in the tube
- 5 = Mounting clamp
- 6 = Hood heaters (optional)
- 7 = Place for Vaisala Luminance Sensor PWL111 (optional)

## Sensing Element in PWD22

### PWT11 Transmitter

PWT11 Transmitter emits pulses of near infrared light. It is permanently tilted 20° downwards. The optical power is stabilized by a closed hardware loop. The unit also includes a receiver circuit for lens contamination monitoring.



## **PWC22 Controller/Receiver**

PWC22 Controller/Receiver measures the scattered part of the PWT11 light beam as the data signal. PWC22 contains an extra light transmitter for monitoring lens contamination. The receiver is tilted 20° downwards. Therefore, in addition to a small side angle, the receiver unit measures light scattered at an angle of 45°. PWD22 contains enhanced signal processing functions, which allows for a wider measurement range.

## **Vaisala RAINCAP® Rain Sensor**

The Vaisala RAINCAP® Rain Sensor Assembly produces a signal proportional to the amount of water on the RAINCAP® sensing element, which is the sensing part of RAINCAP®. This element consists of thin wires protected by an insulating glass coating. The presence of water changes the capacitance of the plate. The capacitance is measured by the integrated electronics. The integrated heating resistors keep the elements dry from condensation. RAINCAP® has an integrated temperature sensor for heating control. Vaisala Present Weather Detector PWD22 is equipped with a double-plate Vaisala RAINCAP® Rain Sensor Assembly, which has two tilted RAINCAP® elements. The tilted two-plate construction give better sensitivity for detecting light drizzle.

## **Temperature Sensor (TS)**

Temperature Sensor (TS) is a Pt100 thermistor that is used to measure the crossarm temperature. See Figure 1 on page 14.

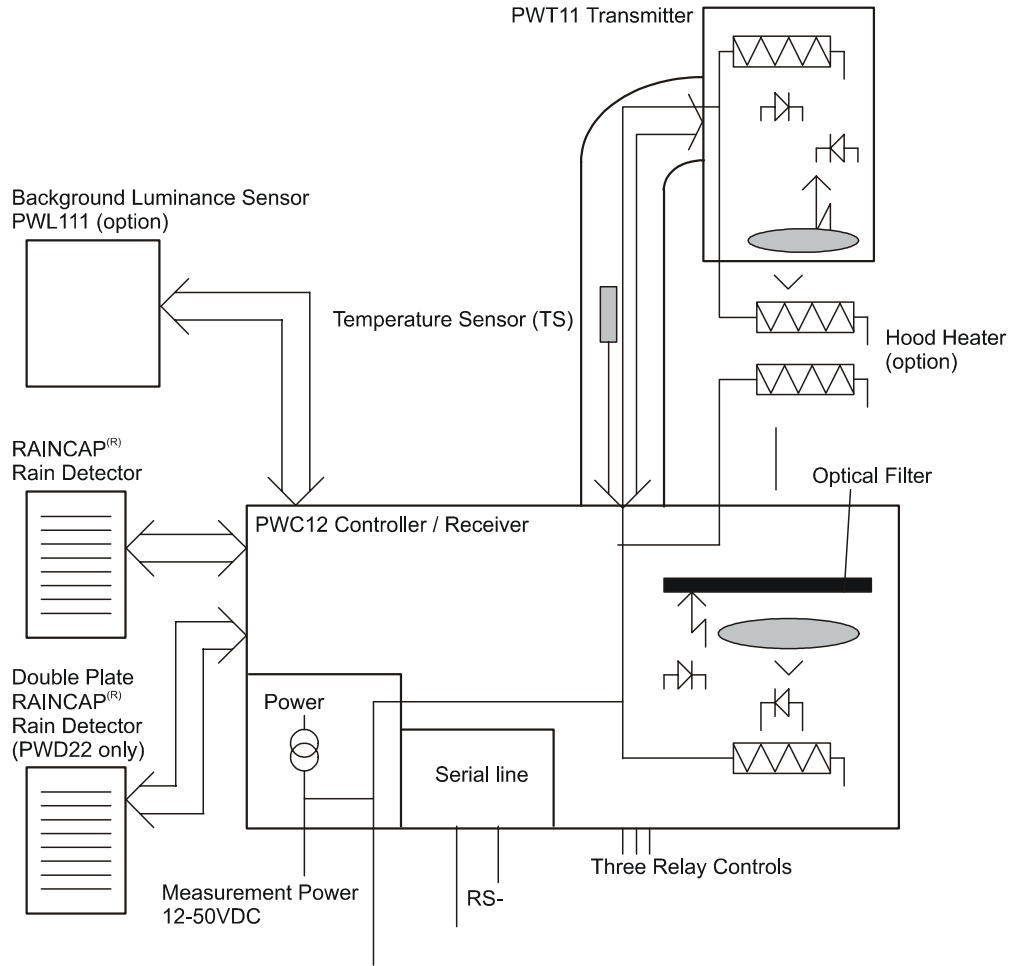
## **Power Supply**

The power supply can be connected separately for the measurement electronics and heating. Thus, the battery backup can be limited to the measurement power supply.

## **Operating Principle**

Vaisala Present Weather Detector PWD22 is a microprocessor controlled sensor that combines optical forward scatter measurement capacitive precipitation sensing, and temperature measurement. All

data processing is done by the embedded software. The main units are shown in Figure 2 below.



**F**  
**P**  
**m**  
**T**  
**a**  
**P**  
**T**  
**c**  
**P**  
**o**

®

The output of RAINCAP<sup>®</sup> is proportional to the water amount on the capacitive sensing surfaces while the optical intensity is proportional to the volume of the reflecting particles. The ratio of optical and capacitive intensities is used to determine the basic precipitation type.

The crossarm temperature (TS) is measured using the Pt100 temperature sensor. The temperature data together with the optical signal profile and the RAINCAP<sup>®</sup> surface sensor data are used to determine the actual weather code.

Several parameters are available for the operator for configuring and adjusting the PWD22 operation.

## Using PWD22

PWD22 is typically used as a component of a weather observing system.

The PWD22 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 PWD22 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 PWD22 using a maintenance terminal. A set of built-in commands and test routines are provided for configuring and monitoring the multiple functions of PWD22.

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 Present Weather Detector PWD22 Nomenclature**

<b>Code</b>	<b>Common Name</b>	<b>Description</b>
PWT11	Transmitter	LED Transmitter circuit board.
PWC22	Controller/Receiver	Controller and photo diode circuit board for PWD22.
PWR211	RAINCAP® Double-Plate Rain Sensor	A capacitive detector to sense water droplets and/or moisture. Two plate in a 90-degree angle towards each other.

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

<b>Code</b>	<b>Common Name</b>	<b>Description</b>
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.

## CHAPTER 3

# FUNCTIONAL DESCRIPTION

This chapter describes the functionality of the product.

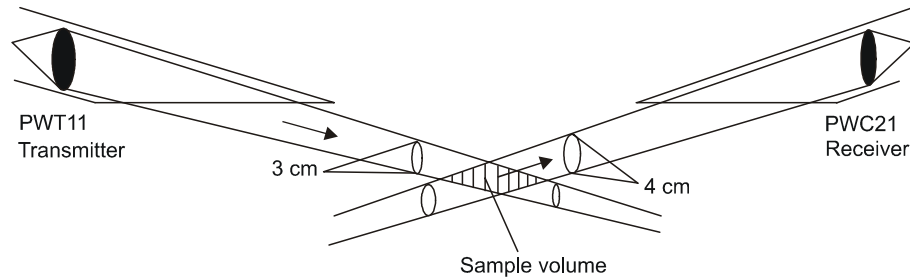
Vaisala Present Weather Detector PWD22 is an optical sensor that measures visibility (meteorological optical range, MOR), precipitation intensity, and precipitation type. The detector measures visibility using the principle of forward scatter measurement. Light scatters from particles whose diameter 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 PWD22 is such that individual droplets can be detected from rapid signal changes. The PWD22 software calculates the precipitation intensity by analyzing the amplitudes of these changes. This intensity estimate is proportional to the volume of the precipitation droplets.

The optical signal also contains some information about the precipitation type but not sufficiently for reliable identification. Additional information is needed, especially in conditions such as very light precipitation or windy weather. As the extra parameter, PWD22 measures an estimate of the water content of precipitation with Vaisala RAINCAP<sup>®</sup> Rain Sensor. In rain, the water equivalent and the volume are equal whereas in snow the optical volume estimate is about ten times larger. This difference of approximately one decade is used to distinguish between rain and snow.

# Optical Measurements

## Optical Arrangement



0104-026

**Figure 3 PWD22 Optical System**

PWD22 measures light scattered at an angle of  $45^\circ$ . 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. PWD22 can detect and measure precipitation droplets from the optical signal and use this information in processing the scatter measurement results.

PWD22 has a small sample volume of about 0.1 liters (see Figure 3 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.

## 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 PIN photodiode monitors the transmitted light intensity. The transmitter intensity level measurement is used to keep automatically the LED's intensity 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<sup>2</sup> 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.

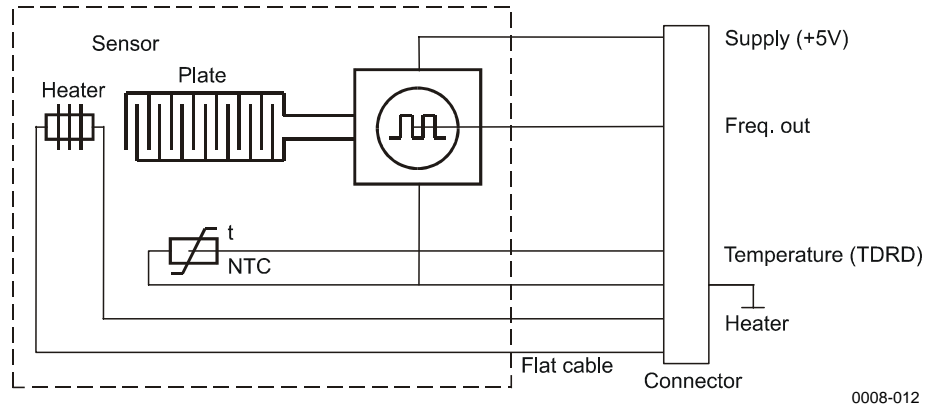
## Additional Measurements

PWD22 includes RAINCAP<sup>®</sup> for estimating the water content of precipitation, and the TS Temperature Sensor for measuring the sensor crossarm temperature (TS). Both additional sensors are measured and interfaced by the PWC22 board. The RAINCAP<sup>®</sup> temperature TDRD is measured for the RAINCAP<sup>®</sup> heating (drying) control, and the box (PWC22) temperature TB is measured for the box heating monitoring.

## Vaisala RAINCAP<sup>®</sup> Rain Sensor

The RAINCAP<sup>®</sup> signal is proportional to the water amount on the sensing surfaces. Water on RAINCAP<sup>®</sup> changes the capacitance of the sensor elements. The capacitance of the elements controls the output frequency of an oscillator. The maximum amplitude is normalized to 1.0 using the **DRY** and **WET** commands as a setup.

The frequency signal is measured once a second. The frequency is handled in the PWD22 internal units. The DRY value is about 800, which is also shown in the Status (STA) message.



**Figure 4 RAINCAP® Block Diagram**

The RAINCAP® sensing surface is heated by the heating element built into the surface. The heating power varies by software control.

PWD22 is equipped with a double-plate RAINCAP® to improve drizzle detection in certain conditions.

When the heating of the sensor elements is switched off, they become very sensitive to ambient moisture. If the relative humidity of the air is more than about 70 %, the surfaces produce a measurable signal even with no precipitation. In PWD22 this is used as an estimated humidity measurement. The estimated humidity is used to separate between dust and mist.

As PWD22 can detect the beginning of precipitation from the optical signal, RAINCAP® can be used as a cross-check for the detection of above zero temperatures. This eliminates false detection of rain caused by for example mosquitoes.

## Background Luminance Sensor PWL111 (optional)

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

The PWL111 signal is measured every second by PWD22. 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<sup>2</sup>. The sensor heaters are controlled as the other PWD22 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<sup>2</sup> 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

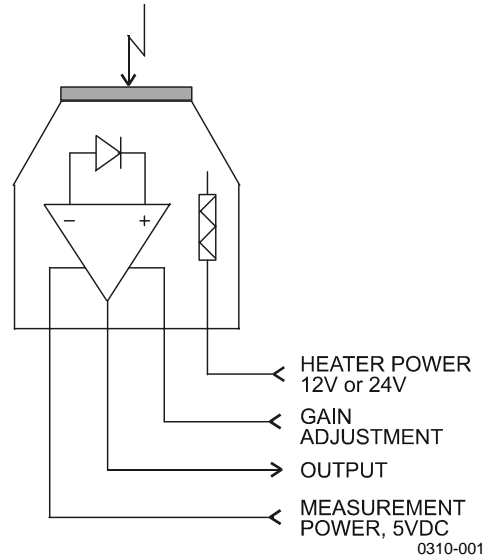
The negative scale directs PWD22 to skip the background luminance action. See the example below:

```
>BLSC -1
```

## BLCAL Command

PWD22 calculates the new BL scale if the current background luminance in cd/m<sup>2</sup> is known. The BL scale must be >0. Also the BLSC sensor must be already activated by the BLSC command. When you type the following command, PWD22 calculates the BL scale.

```
>BLCAL 12300
```



**Figure 5 PWL111 Block Diagram**

## Temperature Sensor

The primary temperature sensor of PWD22 is a Pt100 thermistor attached to the crossarm. The temperature is measured once a minute using a high resolution A/D converter.

The sensor crossarm temperature (TS) is used to select the default precipitation type. The sensor is not shielded from solar radiation, so it does not measure the exact air temperature. In rain, however, the radiation error is acceptable because of the shading of the clouds.

## RAINCAP<sup>®</sup> Signal Processing

The RAINCAP<sup>®</sup> output frequency is measured once a second by the CPU. The frequency drops when the sensing elements become wet (see Figure 6 on page 25).

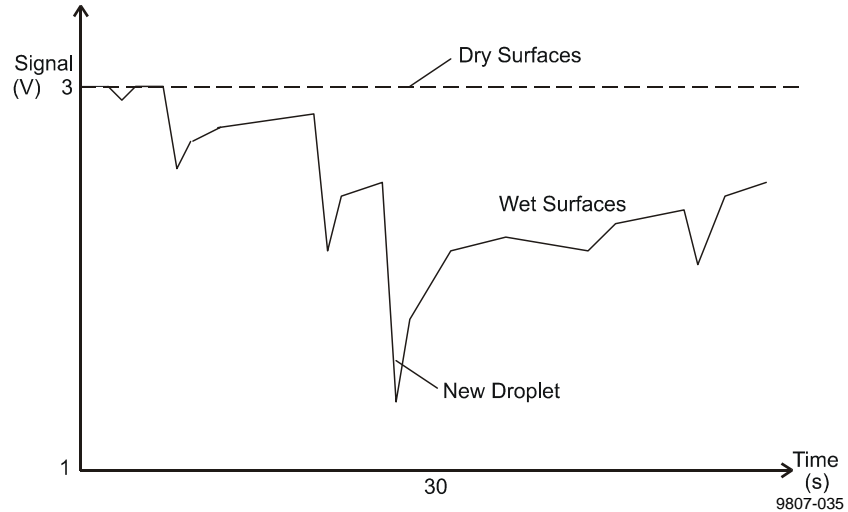


Figure 6 RAINCAP® Surface Signal (Heavy Rain Beginning)

## 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 emulate human observations better. The extinction coefficient ( $\sigma$ ) is defined as follows:

$$\sigma \text{ (1/km)} = 3000/\text{MOR (m)}$$

### Detecting Precipitation

Detecting the precipitation onset is based on measuring the signal peaks caused by precipitation droplets. The peak amplitudes that are detected during 10 minutes are summed. When the sum exceeds a threshold value, the sensor will indicate precipitation. The threshold

value is a *Precipitation limit* parameter, and it can be changed by the operator.

In addition to the optical detection, the RAINCAP<sup>®</sup> signal is used in lowest precipitation intensities. RAINCAP<sup>®</sup> is also used for some cross-checking of optical detection.

Precipitation cessation is detected when the summed optical signal amplitudes decrease below another, lower threshold value. The summing interval depends on the detected precipitation intensity. Typically, PWD22 will detect precipitation cessation within three minutes but in low intensity precipitation the detection time may reach 10 minutes.

## Precipitation Intensity

The light scattering from a precipitation particle is proportional to the volume of the particle. For rain this proportionality is quite stable because the droplets are all quite spherical. In solid precipitation the shape of particles varies but they are proportional to the average volume of the particles.

Optical precipitation intensity value is calculated from the signal change distribution data and then scaled by multiplying with Rain intensity scale, which is an adjustable parameter. The optical intensity value is proportional to the volume of the detected particles.

The RAINCAP<sup>®</sup> data is used to calculate another estimate of precipitation intensity. The intensity is scaled with the DRD scale parameter. For normal operation in liquid precipitation the scaled RAINCAP<sup>®</sup> intensity estimate should be higher than the optical intensity.

The water intensity value in the output messages is based on both the optical and capacitive measurements. In liquid precipitation the optical intensity is reported as such. When frozen precipitation is detected, PWD22 multiplies the optical intensity with a scaling factor to get an estimate of the water equivalent intensity. This scaling factor is calculated from the RAINCAP<sup>®</sup> and optical intensities. New intensity estimates are calculated every 15 seconds and averaged to get the 1-minute intensity value, which is shown in the output messages.

## Precipitation Accumulation

PWD22 calculates the accumulation of water (including the water content of snow) and snow. The water sum is automatically reset when it reaches 99.99 mm and the snow sum at 999 mm. There is also a command for forced resetting by the operator or the system host computer ( $E_C PW id C_R$ ).

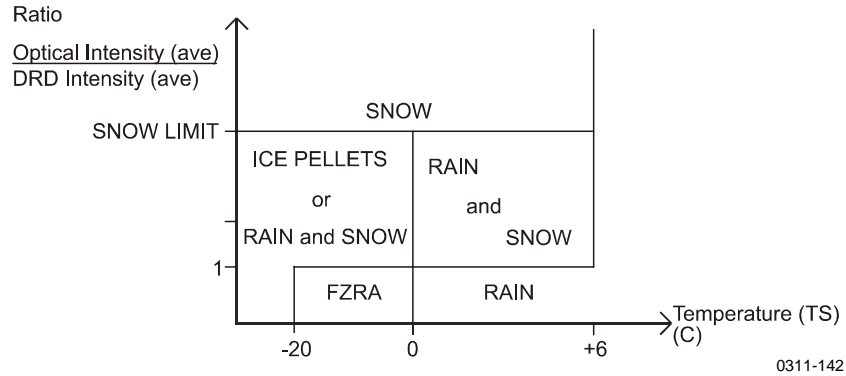
Two methods are used in calculating the water sum. In rain the optical intensity values are directly scaled to sum increments and added to the accumulated sum. In other types of precipitation an internal scaling factor is used to get the water increment. The scaling factor is calculated from optical and RAINCAP<sup>®</sup> intensities.

The snow sum is accumulated from the optical intensity when snow is detected. The snow sum is only a coarse estimate of the thickness of snow. In a shorter period the accumulated snow value is a reasonable measure of the new layer of snow above the previously fallen snow.

## Present Weather

### Precipitation Types

The ratio of the optical intensity and the RAINCAP<sup>®</sup> intensity estimates are the key factors used in defining the precipitation type (see section Precipitation Intensity on page 26). Some filtering is used in calculating the intensity ratio to get the parameter that is used in the type finding procedure. The *Weather delay* parameter is also used to eliminate unrealistic changes in the precipitation type. The sensor crossarm temperature TS is used in selecting the default precipitation type. The default precipitation type is rain when the temperature is above +6 °C. The default is snow when the temperature is below -0 °C and between -0 °C and +6 °C the default is unknown (P or 40).



**Figure 7 Principle for Determining Precipitation Type**

### Liquid Precipitation

In liquid precipitation the optical and the RAINCAP<sup>®</sup> intensities are near each other, or the RAINCAP<sup>®</sup> intensity is higher. Rain and drizzle are separated by the highest peak signal (largest droplet). If liquid precipitation is detected below 0 °C (TS), it is indicated as freezing rain or freezing drizzle (ZR, ZL)

#### **NOTE**

PWD22 freezing precipitation detection is based on the practical definition of "rain (or drizzle) freezing on surfaces", not on detecting supercooled water.

### Rain

If the maximum droplet size is bigger than the *Drizzle limit*, the precipitation type is rain. *Light rain limit* and *Heavy rain limit* are the (approx.) two-minute average intensity limits in mm/h, which are used to set the rain intensity type.

### Drizzle

Drizzle consists only of small droplets. The intensity ratio (optical/RAINCAP<sup>®</sup>) must be similar to that of rain.

#### **NOTE**

By definition, drizzle cannot be identified only by its size, but also by its origin (stratus cloud). PWD22 reports the instant weather code by the size information only. The 15-minute weather code in the PWD22 report is drizzle, when at least ten minutes of only drizzle precipitation has been observed. The one hour code is generated by the majority principle.

### Frozen Precipitation

Precipitation is frozen, if the optical-to-surface intensity ratio is high.

#### Snow

For snow, the intensity ratio (optical/RAINCAP<sup>®</sup>) must be larger than the *Snow limit* parameter and crossarm surface temperature (TS) less than 6 °C.

### Mixed Precipitation

PWD22 reports either rain and snow (WMO codes 67 and 68) or ice pellets (WMO codes 74, 75, and 76) when the intensity ratio is between 1 and *Snow limit*. The intensity is determined by estimating the water equivalent intensity and using the rain intensity limits.

#### Ice Pellets

Ice pellets is reported if the sensor crossarm temperature (TS) is below +3 °C and the maximum droplet size in internal units is less than 50.

#### Rain and Snow

Rain and snow is reported when TS is below +6 °C and the criteria for ice pellets are not met (see above).

### Precipitation Type Unknown

Precipitation type is unknown, when the default value is shown, when TS is between -0 °C and +6 °C, and before enough data is available for better analysis. The precipitation type is also unknown, when the intensity is very low and the intensity ratio is not reliable, or intensity ratio is otherwise not clear.

## Visibility Types

The weather type is determined from visibility, when precipitation is not detected. The visibility types for PWD22 are the following.

**Table 6 WMO SYNOP Code Limits**

Code	10-minute Visibility Average	Weather Condition
CLEAR (00)	Higher than or equal to 10 km.	No precipitation
MIST (10)	Higher than or equal to 1 km but below 10 km.	No precipitation. Reduction in visibility is caused by moisture in the air.
HAZE, SMOKE, DUST, or SAND (04)	Higher than or equal to 1 km but below 10 km.	No precipitation. Reduction in visibility is caused by dry particles in the air.
FOG (30)	Lower than 1 km.	No precipitation. Reduction in visibility is caused by moisture in the air.
HAZE, SMOKE, DUST, or SAND (05)	Lower than 1 km.	No precipitation. Reduction in visibility is caused by moisture in the air.

WMO has not clearly defined the upper visibility limit for mist reporting in SYNOP codes. PWD22 uses the 10000-meter upper limit as this is the widely used limit by the Meteorological offices.

### Fog Codes

The fog trend is calculated from the one-hour data. The average of the last 20 minutes and the first 20 minutes of the data is calculated. The change in these averages determines the trend.

Code 20 is reported, when fog has been reported during the preceding hour, but visibility is now better than 1 km and no fog patch detection is on.

Fog patches (code 31) are detected from rapid changes in visibility across the one-kilometer fog limit. If visibility of the one-minute average is more than twice or less than half of the two-minute average, then the internal patch indicator is set for about 30 minutes.



Thinner

Fog is reported to get thinner (32) if the last 20-minute average minus the first 20-minute average is more than zero ( $>0$ ), and the difference must be greater than 30 % of the first 20-minute average.

Stable

Fog has been stable (33) if the last 20-minute average minus the first 20-minute average is less than 20 % of the lower average visibility.

Thicker

Fog is reported to get thicker (34) if the last 20-minute average minus the first 20-minute average is less than zero ( $<0$ ) and the difference is more than 30 % of the new 20-minute average.

**Table 7 WMO METAR Code Limits**

Code	10-minute Visibility Average
None	Higher than 5 km.
MIST (BR)	Higher than or equal to 1 km but lower than or equal to 5 km.
FOG (FG)	Lower than 1 km.

## Weather Classes

The weather classes are continuous, and showers or intermittent.

The weather class is continuous if there are fewer than two clear (no precipitation) periods during the preceding hour.

The weather class is showers or intermittent if there are more than two clear periods during the preceding hour in precipitation.

However, if more than 30 minutes have elapsed from the last detected precipitation, the "PRECIPITATION DURING THE PRECEDING HOUR" code is used.

## Weather Code Selection

PWD22 presents the weather type using the World Meteorological Organization (WMO) code table 4680. Precipitation type is also reported using the United States National Weather Service (NWS) abbreviations. The complete list of WMO and NWS codes used in

PWD22 is presented in Appendix C, NWS and WMO Code Tables, on page 117. The weather type is selected every 15 seconds using the principles described earlier. Instant weather type will be selected from the 15-second types after *Weather delay* number of samples by weighted majority occurrences. Instant type is reported using both the NWS codes and the WMO codes.

For the 15-minute and 1-hour WMO weather codes, the latest 1-hour of instant precipitation types is stored in a buffer. The last 15-minute and 1-hour parts of this table are then analyzed. The number of each precipitation type in the buffer is counted.

The counts are stored in a table in a decreasing order (weighing) by the code value (in other words, the highest SYNOP code number first). This table is then analyzed from top down by adding the counts together until a minimum sum is obtained. The code number associated with the last added count is the 15-minute or 1-hour WMO code. The minimum sum is different for the 15-minute code and the 1-hour code.

## Applications

Obviously the (automatic) weather station that uses the PWD22 data can in many cases also use other weather parameters to select from the three PWD22 codes or even correct them. For example, humidity measurement can be used to select between smoke, fog, mist, and haze.

The 15-minute code might be a good selection for a general-purpose report.

## Internal Monitoring

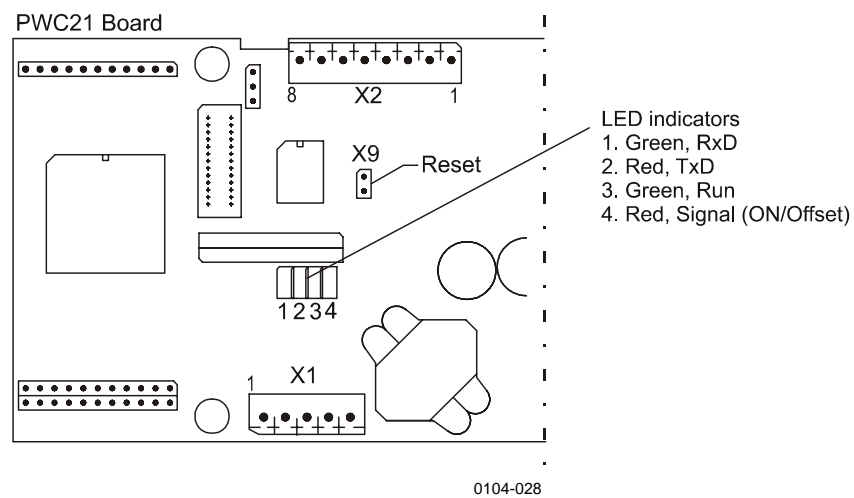
### Built-in Tests

Extensive, built-in tests are included in the PWD22 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. PWD22 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 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 8 LED Indicators on the PWC22 Board**

Normal operation is indicated by the Run LED blinking once every second. The Signal/Offset LED is on, when PWD22 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, PWD22 tests and clears its SRAM data memory. It indicates an error by the Signal/Offset LED blinking. After 50 blinks PWD22 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

PWD22 measures the optical signal, receiver backscatter, and offset as frequencies in about eight millisecond samples. As the measuring times are 10 s, 1 s, and 4 s correspondingly, they must have different numbers of samples in a batch. PWD22 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 Chapter 7, Troubleshooting, on page 99).

## Monitoring Contamination

PWD22 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).

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## CHAPTER 4

# INSTALLATION

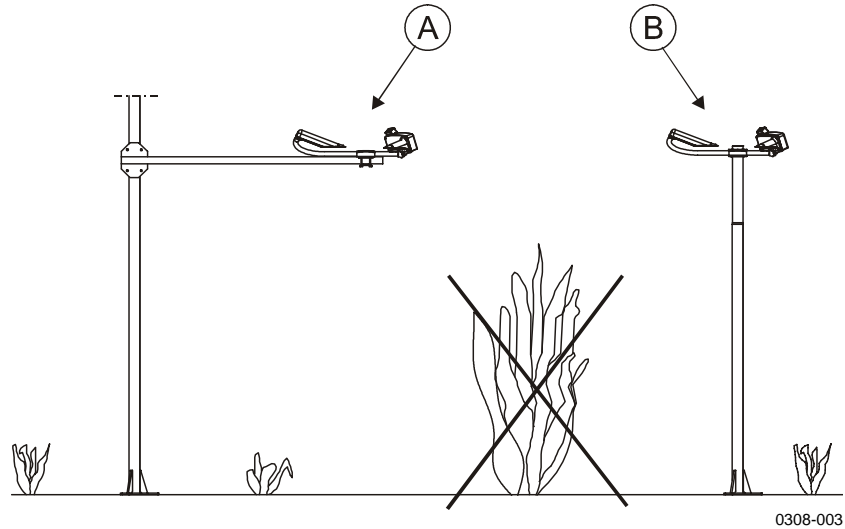
This chapter provides you with information that is intended to help you install this product.

## Selecting Location

Finding a suitable site for the Vaisala Present Weather Detector PWD22 is important for getting representative ambient measurements. The site should represent the general area of interest.

The main requirements for the location of PWD22 are as follows:

1. Locate PWD22 in such a way that the measurements will be representative of the surrounding weather conditions.
  - The ideal site for PWD22 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 9 on page 38). 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 9 Recommended Location of PWD22. 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. The possible reflections from the passing cars might generate false snow detections in the winter time.
3. Power supply and communication lines must be available.
- When siting PWD22, 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 PWD22 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 PWD22 among other things against lightning and prevent radio frequency interference. Equipment grounding for PWD22 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  $\Omega$ .

## Internal Grounding of PWD22

The electronics enclosure of PWD22 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**

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

## 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 PWD22 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.

**NOTE**

Do not touch or hit the Vaisala RAINCAP<sup>®</sup> Rain Sensor plate. It is fragile.

Do not bend the signal cable with less than 2 cm (1 inch) radius, and do not leave it unsupported to lean to the ground or table.

## Storage

Store PWD22 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 %

## Initial Settings

Vaisala Present Weather Detector PWD22 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 other 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 8 below.

**Table 8 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, PWD22 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 9 below. For details on the commands, refer to Chapter 5, Operation on page 55.

**Table 9 Commands for Changing Default Settings**

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

## Weather Parameters

PWD22 has also several changeable parameters, which control the operation of the present weather algorithm and precipitation measurement. The parameter values set at the factory have been tested and found appropriate. Thus, they usually do not need to be changed. There may, however, be conditions where other parameter values give better results.

The commands for displaying and changing the parameters are listed in Table 10 below.

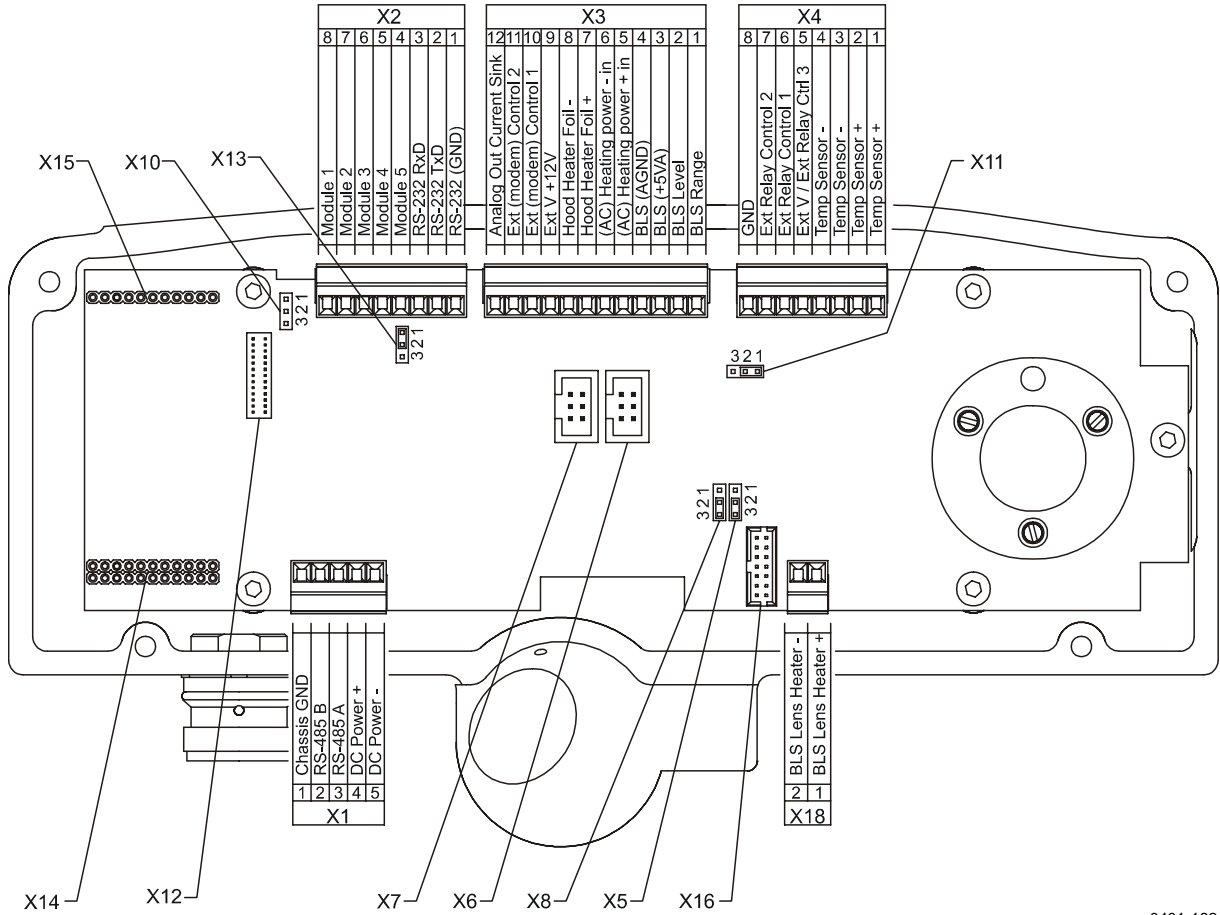
**Table 10**      **Commands for Displaying and Changing Parameters**

<b>Operation</b>	<b>Command</b>
Parameter listing	WPAR
Parameter setting	WSET

Local practice may require changes, especially in the precipitation intensity limits (moderate, heavy). See section WSET on page 68 for a description of the **WSET** command.

The precipitation intensity and amount measurement is not calibrated at the factory. Higher accuracy can be achieved by adjusting a scaling factor (RAIN INTENSITY SCALE) with the **WSET** command. The new scaling factor can be calculated by comparing PWD22 against a reference rain gauge. See section WSET on page 68 for a description of the **WSET** command, and for further instructions.

The low visibility alarm limits (3) are zero by default, in other words, no alarms will be generated or relays activated. The alarm limits can be set in the **CONF** command.



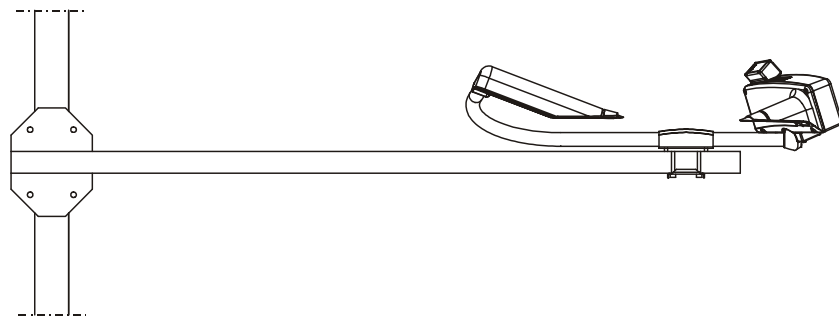
0401-182

**Figure 10** Location of Jumpers and Connectors on the PWC22 Processor/Receiver Board

## Mounting

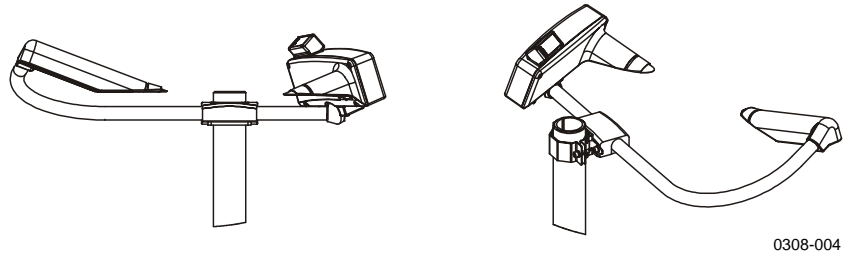
When installing PWD22 with the sensor support arm, proceed as follows:

1. Install PWD22 to the support arm. See Figure 11 below.



0308-005

**Figure 11** Installing PWD22 to the Support Arm



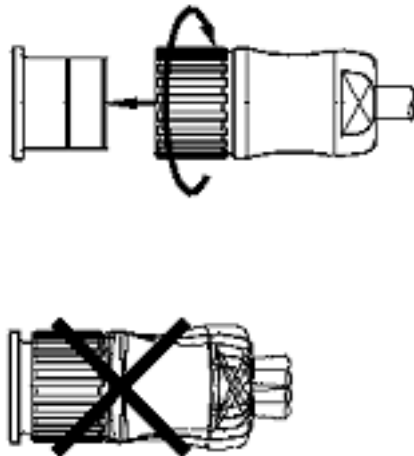
**Figure 12** Installing the Subassembly to the Mast with the Vaisala Clamp Assembly

2. Install the subassembly to the mast. See Figure 12 above.

**NOTE**

Do not damage the RAINCAP<sup>®</sup> plate.

3. Connect the PWD22 mast cable (power and signal cable) to a fixed connector underneath the PWD22 housing.
4. 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.



0311-063

**Figure 13** Testing the Connector

**CAUTION**

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

## Verification

Before connecting PWD22 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 PWD22 output is the following:

```
VAISALA PWD22 V x.xx YYYY-MM-DD SN:XXXXXX
```

(ID is also included, if configured, e.g., in the following way:

```
VAISALA PWD22 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 55.

## Connections

### Connecting Cables

The PWD22 enclosure is equipped with a connector for connecting signal and power cable. The connector enables easy installation and maintenance actions. The cable shield and connector is grounded to the PWD22 enclosure in order to keep EMI levels within the specifications

Insulate the unused wires of the PWD22 mast cable from each other, for example, by connecting them to void screw terminals in the junction box.

Connect the PWD22 mast cable (power and signal cable) to the fixed connector underneath the PWD22 housing.

**NOTE**

Tighten the connector properly to achieve proper sealing of the connector.

The cable connector must not swing at all in relation to the fixed connector. Test this by trying to swing the connector. If it swings, the mating surface of the connector is not sealed but it leaks and the connector terminals are exposed to weather.

**Basic Wiring**

The PWD22 cable has 16 connection wires.

**Table 11 Receptacle Connector Default Wiring**

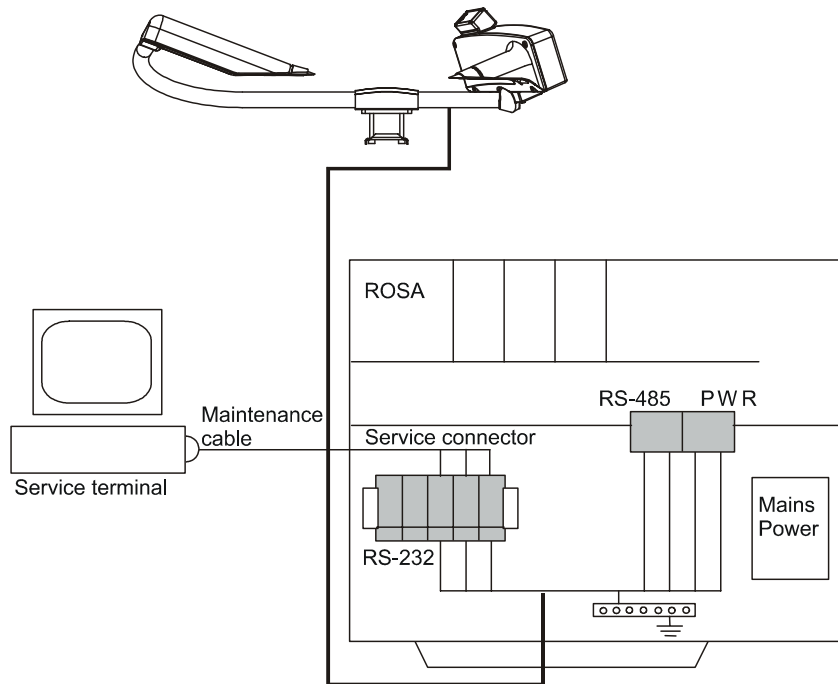
Signal Name	Connector in PWC	Wire Color	
Sensor DC Power +	X1 - 4	RED	
Sensor DC Power GND	X1 - 5	BLK	
RS-485 B ( - )	X1 - 2	WHT	
RS-485 A ( + )	X1 - 3	BRN	
RS-232 Tx /PWD	X2 - 2	GRN	PC serial port connector D9 pin 2 or ROSA Service Connector pin 4
RS-232 Rx	X2 - 3	YEL	PC serial port connector D9 pin 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



Signal Name	Connector in PWC	Wire Color	
			(X4-8 and X2-1)
Analog output	X3 - 12	BLU	Current range is chosen by jumper X13
Heating power+	X3 - 5	WHT/GRN	<i>All four heating power wires must be connected due to high current.</i>
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

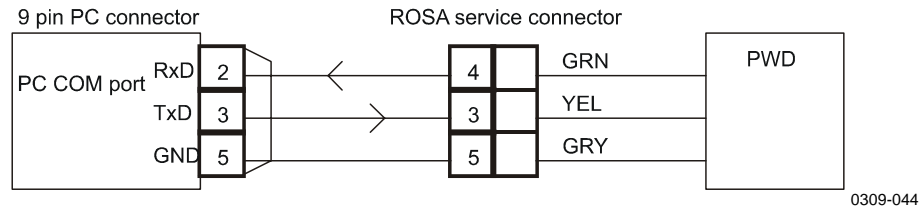
**Table 12 PT-100 Sensor Cable Wiring**

Signal Name	Connector - Pin Number	PT-100 Cable Wire Color	Notes
Sensor	X4-1	BLU	
Sensor	X4-2	YEL	
Sensor	X4-3	RED	
Sensor	X4-4	GRN	



0104-002

**Figure 14 Cabling Principle**



**Figure 15 Maintenance Cable**

## Supplying Power to PWD22

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.

Choosing whether to use or not separate supply for internal heaters, is done by jumpers X5 and X8 on PWC Controller/Receiver circuit board. See section Appendix B, PWC22 Connectors and Jumper Settings, on page 115. 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 PWD22 internal heaters (connector X18 on the PWC board). PWL111 heaters can only be powered by 12 V or 24 V or something in-between. If the DC supply is used to power internal heaters when PWD22 is equipped with PWL111, the DC voltage must not exceed 28 V (24 V recommended). If the DC voltage is as low as 12 V, the jumpers on the 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 PWD22 internal heaters are powered by this same supply, it is loaded by approximately 65 W.

## **Communication Options**

PWD22 has one serial line with two interfaces. The two-wire RS-485 is intended to be the standard interface. The PWD22 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, PWD22 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 PWD22 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 PWD22s to communicate (half duplex) with the host computer using a single twisted pair. For the RS-485 communication connect the PWD22 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.

## 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 PWD22.

## Relay Controls

PWD22 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 PWD22 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 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 13 and Table 14 on page 51.

- 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.

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

**Table 13 Control Logic of Relay Controls 1 and 2**

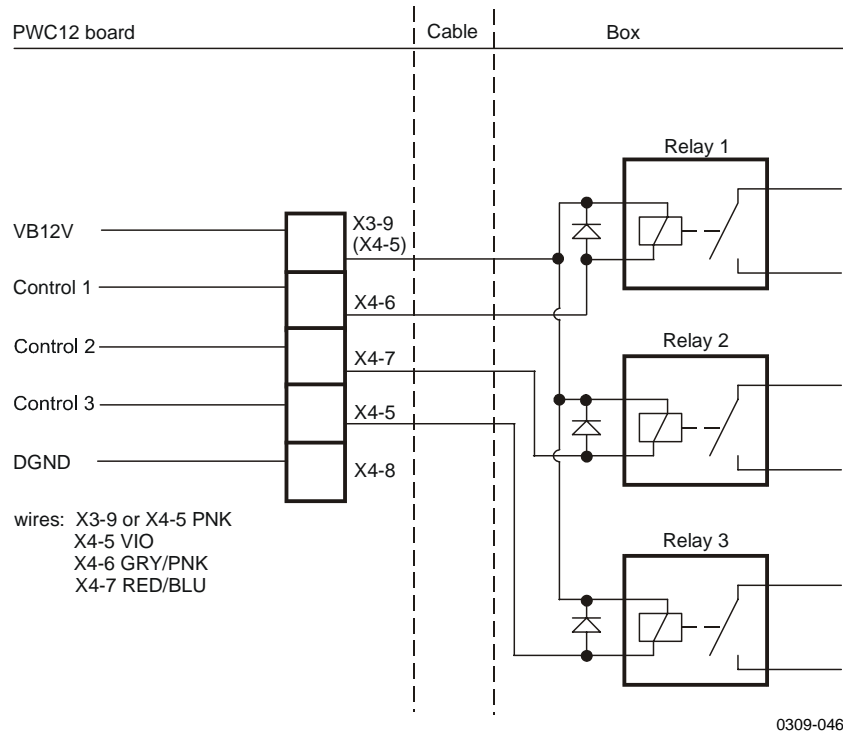
States of Relay 1 and 2	Corresponding Visibility Conditions
1 OFF 2 OFF	When visibility is higher than LIMIT 1 and LIMIT 2.
1 ON 2 OFF	When visibility is lower than LIMIT 1 but higher than LIMIT 2.
1 ON 2 ON	When visibility is lower than LIMIT 1 and LIMIT 2.

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

**Table 14 Control Logic of Relay Control 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 alarm is detected. For details, see section System Configuration Commands on page 70.



**Figure 16 Relay Connection: PWD22 Supplies**

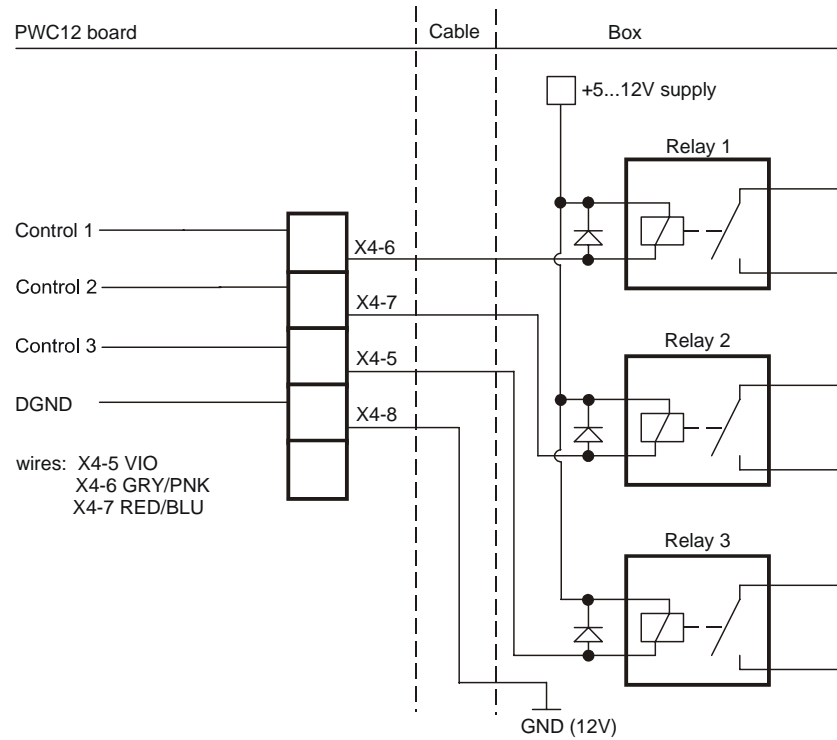
Figure 16 above illustrates external relays connection when relay coils are powered by PWD22. Voltage pin VB 12 V and relay controls 1, 2, and 3 are wired by default.

**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 17 on page 53 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). 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.



0309-045

**Figure 17 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
```

This page intentionally left blank.



## CHAPTER 5

# OPERATION

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

## Getting Started

Vaisala Present Weather Detector PWD22 is a fully automatic instrument for continuous weather measurement. Usually, PWD22 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 56).

PWD22 has four different standard message formats for data message output. It presents the weather type using the World Meteorological Organization (WMO) code table 4680 (WaWa, in other words, Present Weather reported from an automatic weather station). PWD22 report present weather also in WMO code table 4678 (METAR) format. In addition, the United States National Weather Service (NWS) abbreviations are available. The NWS list and WMO codes is presented in Appendix C, NWS and WMO Code Tables, on page 117.

## Operating Instructions

User intervention is not required in the normal operation of PWD22. 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 41 describes the initial setup in greater detail. The settings and corresponding commands are described in Table 15 below.

**Table 15 Initial Settings and Corresponding Commands**

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

The command for routine maintenance operations are described in Table 16 below.

**Table 16 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 PWD22, the communication line in PWD22 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 * or OPEN ^C (^C = Ctrl + C)
```

If there are two or more different sensors connected to the same RS-485 line, and if the sensors have the same ID, PWD22 can be opened by typing the following command:

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

PWD22 answers as follows:

```
LINE OPENED FOR OPERATOR COMMANDS
```

If no input is given within 60 seconds, PWD22 closes the line automatically.

## CLOSE

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

PWD22 answers as follows:

```
LINE CLOSED
```

## Message Types

Message 2 is intended to be the standard present weather message. The length of the **STAtus** Message 3 depends on the possible alarm and warning states.

PWD22 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 = Forward scatter sensor identifier.  
 = Space character.

where

- 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 18 below.

← THE FIRST ROW IS THE OUTPUT

```

10      680  1230
↓↓      ↓    ↓
----- 10 min ave visibility { FIELD
----- one minute average visibility { DESCRIPTIONS
- 1=hardware error, 2= hardware warning, \
  3= backscatter alarm, 4= backscatter warning
- 1= visibility alarm 1, 2= visibility alarm 2,
  3 = visibility alarm 3

Example with frames

PW 1 00      680  1230
 $s_{HPW}$  1 $s_x$ 00      680  1230 $E_x c_{R^L F}$ 
1234567890123456789012345

NUMBERS mark the character positions.

```

**Figure 18 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
1234567890123456789012345
```

The following is an example without frames:

```
00 680 1230
123456789012345
```

## 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
1234567890123456789012345678
```

The following is an example without frames:

```
00 1839 61 0.3
123456789012345678
```

## Message 2

Message 2 is intended to be the standard present weather message used in data loggers or display units and set as a default at the factory.

```
00 1839 1505 R- 61 61 61 0.33 12.16 0
                                     --- cumulative snow
                                     sum,0...999mm
----- cumulative water
                                     sum,0...99.99mm
----- water intensity 1 min
                                     ave,mm/h
                                     --- one hour present weather code,
                                     0...99
                                     --- 15 minute present weather code, 0...99
                                     --- instant present weather code, 0 ... 99
----- instant present weather, NWS codes
----- 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 C 61 61 61 0.33 12.16 0
sHPW 1sx00 1839 1505 C 61 61 61 0.33 12.16 0FxCRLF
12345678901234567890123456789012345678901234567890123456
```

The following is an example without frames:

```
00 1839 1505 C 61 61 61 0.33 12.16 0
1234567890123456789012345678901234567890123456
```

## Message 3

Message 3 is the same as the status message obtained by the **STA** command. See status message description in section Maintenance Commands on page 82.

## 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

Message 7 is meant for aviation specific purposes mainly. The message format is same as in FD12P message 7.

```

00 6839 7505 R 61 61 61 0.33 12.16 0 23.4 12345
-----
background
luminance,
cd/m²
----- Temp
----- cum. snow sum
----- cumulative water sum
----- prec. water intensity,mm/h
--- 1 hour pw code, 0... 99
--- 15 minute pw code, 0 ... 99
--- instant present weather code, 0 ... 99
---- instant present weather, NWS codes
----- 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

-RA , instant METAR weather codes
RERA , recent METAR weather (RE criteria used)

```

The following is an example with frames:

```

PW 1 00 6839 7505 R 61 61 61 0.33 12.16 0 23.4 12345
-RA
RERA

%PW 1%00 6839 7505 R 61 61 61 0.33 12.16 0 23.4 12345%F
-RA%F
RERA%F
%F
1234567890123456789012345678901234567890123456789012345678901234567

```

Message 7 consists of three lines. METAR present weather codes are output on the second and third lines. These lines are not of fixed length because METAR codes can be combined in many ways. The METAR codes may also be left out but the lines of the message are always terminated by a carriage return and line feed characters.

## Automatic Message Sending

In the automatic (**CLOSEd**) mode PWD22 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 ... 4 and 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 66 .

## Message Polling

In the polled (**CLOSEd**) mode, PWD22 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 ... 4 and 7. Selects the corresponding message as the default polled message. Any negative message number is converted to 0.



where

*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:

```
cRREQPW id message_numbercR
```

where

<sup>c<sub>R</sub></sup>	=	ASCII character 13 hex (Carriage Return)
<sup>E</sup> <sub>Q</sub>	=	ASCII character 05 hex (CTRL-E).
<i>id</i>	=	Selected in the configuration.
<i>message number</i>	=	This is optional.
<sup>c<sub>R</sub></sup>	=	ASCII character 13 hex (Carriage Return)

When the PWD22 unit number two (ID=1) is polled for message number 3 (status), the command format is the following:

```
cREQPW 1 3 cR
```

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 PWD22 software to distinguish the ID from the message number.

The <sup>c<sub>R</sub></sup><sup>E</sup><sub>Q</sub>PW<sup>c<sub>R</sub></sup> command can be used, if only one PWD22 unit is on the line (no ID is set) and the default message is wanted.

PWD22 does not echo the polling character string.

The answer message format is the following:

```
sHPW idstextEXcRLF
```

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:

```
sHPW 1sx00 500 700ExCRLF
```

PWD22 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, PWD22 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 PWD22 is polled by <sup>C</sup><sub>R</sub><sup>E</sup>FD 1 2<sup>C</sup><sub>R</sub>, the answer will start with <sup>s</sup><sub>H</sub>FD 1<sup>s</sup>x..

## Precipitation Sums

PWD22 has no internal clock for automatic resetting of the sum data at certain times. This can be done by the host with the following command:

```
ECPW id CCR
```

where

<sup>E</sup><sub>C</sub> = ESC (ASCII character 1B hex).  
<sup>C</sup><sub>R</sub> = Carriage Return (13 hex.)

PWD22 then responds to the accepted command with the ASCII character <sup>^</sup>k (06 hex).

The host computer can also maintain its own sum calculated from the continuous PWD22 data. This may be safer, if the PWD22 power breaks often and resets the sums before the scheduled time. The water sum is automatically reset, when it reaches 99.99 mm and the snow sum at 999 mm.

# List of Commands

## PWD22 Command Set

### HELP

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

**Table 17** Command Set

Command	Description
OPEN	Assigns the line for operator commands.
CLOSE	Releases the line for automatic messages.
MES <i>Number</i>	Displays data message.
AMES <i>Number Interval</i>	Automatic message (with parameters <i>Number</i> and <i>Interval</i> ).
CLRS	Clears precipitation sums.
STA	Displays status.
PAR	Parameter message.
HIST <i>Parameter</i>	For Vaisala systems use.
INTV <i>Time</i>	For Vaisala systems use.
TIME <i>hh:mm:ss</i>	Set/Display system time.
DATE <i>yyyy:mm:dd</i>	Set/Display system date.
WPAR	Weather parameter message.
CHEC	Displays calibrator test signal.
ZERO	Displays zero and noise test status.
CAL <i>Calibrator_frequency</i>	Calibration.
CONF <i>Password</i>	Updates configuration.
WSET	PRW reference values.
CLEAN	Sets clean references.
BAUD <i>Rate</i> <i>Commn._type</i>	Baud rate setting ( <i>Rate</i> 300, 1200, 2400, 4800, 9600) ( <i>Communication type</i> E (7E1) or N (8N1))
DRY ON	Sets RAINCAP <sup>®</sup> dry offset.
WET ON	Sets RAINCAP <sup>®</sup> wet scale.
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 56), a data message can be displayed using the **MES** command. Refer to section Message Types on page 57 for message type descriptions.

The command format is the following:

**MES** *Message\_number*

The valid range is 0 ... 4 and 7.

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

```
>MES 0
```

## AMES

The **AMES** command defines the message, which PWD22 transmits as the automatic message or as the default polled message.

The **AMES** command format is the following:

**AMES** *Message\_number Message\_interval*

where

*Message\_number* = The valid range is 0 ... 4 and 7. Selects the corresponding message. Any negative message number is converted to 0. Message number is also the default number for the **MES** command and polling. There are four messages, numbers from 0 to 3 available for different uses. For message type descriptions, refer to section Message Types on page 57.

where

*Message\_interval* = Given in multiples of 15 s (= measuring interval). Therefore, intervals 15, 30, 45... are valid. Other intervals are converted to integer multiples of 15 s. The maximum sending interval is 255 s (4 min. 15 s). Negative or zero interval ignores the automatic sending. This is used when messages are polled. For details, refer to section Automatic Message Sending on page 62.

For example, the following command selects message number 0 to be sent once in a minute:

```
AMES 0 60
```

The following command selects message number 0 and cancels the automatic sending:

```
AMES 0 0
```

The **AMES** command without parameters displays the current selection.

## Weather Related Commands

The following commands are used to display/set the weather analysis parameters and results.

- **WPAR**      Weather parameter message
- **WSET**      PRW reference values
- **CLRS**      Clear precipitation sums

## WPAR

The **WPAR** command displays the present weather analysis parameters.

### WEATHER PARAMETERS

PRECIPITATION LIMIT	40
WEATHER UPDATE DELAY	6
RAIN INTENSITY SCALE	1.00
HEAVY RAIN LIMIT	8.0
LIGHT RAIN LIMIT	2.0
SNOW LIMIT	5.0
HEAVY SNOW LIMIT	600
LIGHT SNOW LIMIT	1200
DRD SCALE	1.0
DRD DRY OFFSET	809.5
DRD WET SCALE	0.0017

## WSET

The **WSET** command is used to modify the present weather analysis parameters.

The **WSET** command asks for one parameter at a time, showing the parameter name and the current setting. The current value is accepted by pressing ENTER. A new value can be given by typing the value before pressing ENTER.

The output is as follows:

```
SET PRESENT WEATHER PARAMETERS
PRECIPITATION LIMIT ( 40)
WEATHER UPDATE DELAY ( 6)
RAIN INTENSITY SCALE ( 1.00)
HEAVY RAIN LIMIT ( 8)
LIGHT RAIN LIMIT ( 2)
SNOW LIMIT ( 5.0)
HEAVY SNOW LIMIT ( 600)
LIGHT SNOW LIMIT ( 1200)
DRD SCALE ( 1.0)
```

where

Precipitation limit	=	The threshold of accumulated particle magnitudes (in PWD22 internal units) to report the precipitation state 'on'. A typical parameter value is 20 to 60 (max. 255). A smaller value is more sensitive operation and faster response at the beginning of an event. and it is also more sensitive to false rain and snow reports.
Weather update delay	=	A time as multiple of 15 seconds, during which the instant precipitation type is not changed. The intensity may change faster.
Rain intensity scale	=	It is multiplied by the measured raw intensity gives the reported precipitation intensity (optical). The rain amount is scaled with the same coefficient because the amount is a direct integral of 15-second intensities. A typical value for the <i>Rain intensity scale</i> is 1.0. Since the optimal value depends on the optical, optoelectronic, and electronic parameters in a very complex way, no applicable factory calibration method has been developed yet.
Heavy rain limit	=	The minimum rain intensity (mm/h), when the intensity is reported as heavy.
Light rain limit	=	The maximum rain intensity (mm/h), when the intensity is reported as light. If rain intensity is between the above heavy and light limits, it is reported as moderate.
Snow limit	=	The minimum ratio of optical precipitation intensity to surface sensor (RAINCAP®) precipitation intensity, when precipitation is snow.  A typical value for <i>Snow limit</i> is 5. Smaller value directs PWD22 to report more wet precipitation as snow.
Heavy snow limit	=	The maximum visibility (m) of two-minute average in heavy snow.
Light snow limit	=	The minimum visibility (m) of two-minute average in light snow. If snow is detected and the two-minute average visibility is between the above heavy and light limits, snow intensity is reported as moderate.
DRD scale	=	The scaling factor for the calculated intensity of the RAINCAP® surface sensor. A typical value for this parameter is 1.0.

The precipitation measurement can be calibrated by comparing the PWD22 rain amount to measurements made with a suitable reference rain gauge.

This comparison should be made after a few rain events with 5 mm or more of total accumulated rain. A new scaling factor can be calculated using the following formula:

$$\text{NEWSCALE} = \text{OLDSCALE} * (\text{REF\_AMOUNT} / \text{PWD\_AMOUNT})$$

where

OLDSCALE = The old value of rain intensity scale.  
REF\_AMOUNT = The amount measured with the reference rain gauge.  
PWD\_AMOUNT = The corresponding amount measured by PWD22.

## CLRS

The **CLRS** command resets (to 0.00) the precipitation cumulative sums.

This can be done by the host with the following command:

$\text{E}_c \text{PW } id \text{ C}_R$

where

$\text{E}_c$  = ESC (ASCII character 1B hex).  
 $\text{<A}_k$  = ASCII character (06 hex).  
 $\text{C}_R$  = ASCII character (13 hex.)

## 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 PWD22 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, PWD22 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(UPDATED)
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 PWD22 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 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 **STAtus** 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 50.

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 ... 10 000 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.

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

```
ANALOG OUTPUT MODE
Default 0, linear visibility to current mode.
```

```
ANALOG VISIBILITY MAX
Default 2000m.
```

```
MAX VISIBILITY CURRENT
Default 20 mA.
```

```
ANALOG VISIBILITY MIN
Default 10m.
```

```
MIN VISIBILITY CURRENT
Default 4 mA.
```

## 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 PWD22 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.

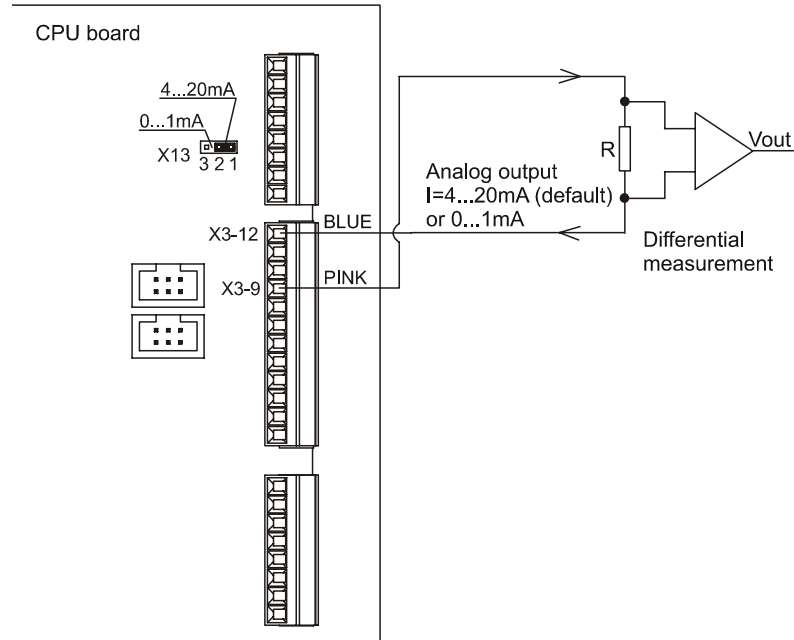
The **BAUD** command displays the current baud rate and communication type.

```
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 19 on page 77. You will need to do the differential measurement connection at the user's end, which is also shown in Figure 19 on page 77.

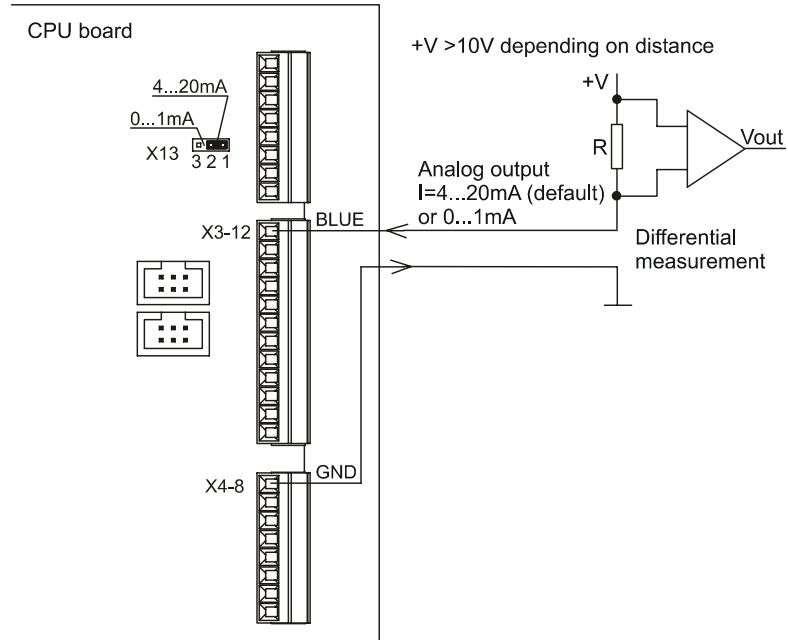


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**Figure 19 Analog Current Output Connection**

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 20 on page 78. 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



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**Figure 20 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  $\text{abs}(\text{max current} - \text{min current})$  is more than ( $>$ ) 1.5, then the current range of 0 ... 20 mA will be used. This is a default configuration. Otherwise, the current range of 0 ... 1 mA must be jumper X13. For details, see section Jumper Settings and Connectors on page 52.

### Mode 0

Mode 0 indicates standard linear visibility to the 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  $\ln(\text{visibility})$  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 output current sink.
- $I_{min}$  = Specified lowest output current value (e.g. 4 mA).
- $I_{range}$  = Current range specified  
(e.g.  $I_{range} = 20 \text{ mA} - 4 \text{ mA} = 16 \text{ mA}$ )

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

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).

where

$I_{\text{range}}$  = Current range specified  
(e.g.  $I_{\text{range}} = 20 \text{ mA} - 4 \text{ mA} = 16 \text{ mA}$ )

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

where

$VIS_i$  = Initial visibility value in meters.

$VIS_{\text{min}}$  = Lowest visibility value specified in configuration  
(e.g. 10 m or 100 m).

$VIS_{\text{max}}$  = Corresponding maximum visibility value (e.g. 2000 m or 20000 m).

The corresponding DAC output LSB value is calculated from  $I_{\text{out}}$  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.

PWD22 set two-bit patterns to the DAC circuit and asks for the corresponding measured currents. If the higher current is less than

2 mA, PWD22 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 PWD22.
2. Give the **ACAL** command to PWD22.
3. PWD22 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. PWD22 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
- **DRY ON**, Sets RAINCAP<sup>®</sup> dry offset
- **WET ON**, Sets RAINCAP<sup>®</sup> wet scale
- **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 PWD22 V 1.00 2003-12-15 SN:Y46101

SIGNAL      3.43 OFFSET    146.11 DRIFT      0.00
REC. BACKSCATTER    2802 CHANGE      2
TR. BACKSCATTER    -2.3 CHANGE      0.0
LEDI      2.3 AMBL     -1.0
VBB      12.6 P12      11.4 M12      -11.3
TS       24.6 TB        29
TDRD      24    25 DRD      858 854 DRY      857.5
BL        26
RELAYS  OFF OFF OFF

HOOD HEATERS OFF
HARDWARE :
OK
```

The length of the message may vary depending on the options configured in PWD22 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 BL680 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 111.

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

See Table 18 and Table 19 below.

**Table 18 Hardware Error Texts**

<b>Error Text</b>	<b>Description</b>
Backscatter High	Receiver or transmitter contamination signal has increased more than the ALARM limit given in the configuration allows.
Transmitter Error	LED1 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 (PWC22 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.
DRD Error	RAINCAP <sup>®</sup> signal is close to zero.
Luminance Sensor Error	PWL111 signal is out of limits.

**Table 19 Warnings**

<b>Warning</b>	<b>Description</b>
Backscatter Increased	Receiver or transmitter contamination signal has increased above the WARNING limit selected in the configuration.
Transmitter Intensity Low	LED1 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.

The command is the following:

**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. PWD22 calculates a new scaling factor and stores it in the non-volatile memory (EEPROM).

### NOTE

If the PWC22 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 PWD22 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 PWD22 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 (PWC22) one 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
>
```

## DRY ON and WET

The **DRY ON** and **WET** commands are used to check and adjust the operation of the Vaisala RAINCAP® Rain Sensor measurement.

### DRY ON

The **DRY ON** command is used to set the reference level of the dry signal for the RAINCAP® signal normalization calculation. When giving the **DRY ON** command, the sensor surface must be dry and also the weather conditions must be dry.

The output is the following:

```
DRD DRY OFFSET 715.6
```

The **DRY OFFSET** value must be between 700 and 900, when the RAINCAP® hardware operates normally. The **DRY** command without a parameter just shows this parameter.

### WET

The **WET** command without a parameter shows the scaling factor that normalizes the RAINCAP® signal change from the dry state to the wet state to be 1.00. A typical value is close to 0.0015.

```
DRD WET SCALE 0.00169
```

The **WET ON** command is used to set the parameter. The RAINCAP® measuring surfaces must be coated with a wet cloth or immersed in water for at least 30 seconds, when the **WET ON** command is given. Make sure the wet cloth touches only the RAINCAP® sensor.

The wet scale normalizes the measured signal range (DRY - WET) to 1.00.



## 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  
dd  = day
```

## **RESET**

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

## **VER**

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

## CHAPTER 6

# MAINTENANCE

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

## Periodic Maintenance

PWD22 has been calibrated at the factory. Thus, no initial calibration is required.

Periodic maintenance of PWD22 includes the following:

- Cleaning the transmitter and receiver lenses and hoods.
- Cleaning the RAINCAP<sup>®</sup> Rain Detector.
- Checking the visibility calibration and calibrating it, if necessary.

PWD22 is designed to operate continuously for several years without other maintenance than cleaning of the lenses and the RAINCAP<sup>®</sup> sensing surface.

PWD22 is designed to operate continuously for several years without other maintenance than cleaning of the lenses.

Section Removing and Replacing on page 90 describes in detail how to remove and replace Transmitter PWT11 and Controller/Receiver PWC22 units. Removing the units comes into question, when there is reason to suspect that malfunction of PWD22 is caused by faults in these units.

Before any commands can be given to PWD22, the communication line has to be opened.

Open the communication line by typing the following:

```
OPEN
```

PWD22 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 55.

## Cleaning

It is very important to clean PWD22. 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 PWD22 after cleaning (by pressing power OFF/ON, for example).

### Cleaning Lenses and Hoods

The lenses of the PWD22 transmitter and receiver units should be relatively clean to get reliable results as dirty lenses give too good visibility values. Cleaning should be done every six months or more often depending on the conditions (for example, if there are roads nearby).

Use the **STA** command for monitoring the system performance.

Usually a data message announces, if there are some warnings. Cleaning should be done after the warning the following warning:

```
BACKSCATTER INCREASED.
```

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).

## Cleaning RAINCAP®

Vaisala RAINCAP® Rain Sensor should be cleaned every six months or more often depending on the conditions.

**NOTE**

The measuring principle does not allow for proper ESD protection of the RAINCAP® electronics, so you must follow the following instructions:

- Ground your hand first by touching grounded metallic parts of the installation to remove excessive static charges from your body.
- Clean the RAINCAP® rain detector carefully with a soft, lint-free cloth moistened with mild detergent. Be careful not to scratch the surface.
- Check that the detector is free of ice and snow deposits.

## Calibration

PWD22 has been calibrated at the factory. Normally, PWD22 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 6 months is recommended. The user checks the visibility calibration using the PWA11 calibration kit. If the check shows less than  $\pm 5\%$  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, PWD22 must be replaced. If the receiver

unit (PWC22) or transmitter unit (PWT11) is replaced, both visibility and contamination measurements need recalibration.

In addition, the Temperature Sensor value should be compared with air temperature. In daytime TS is higher than the air temperature, in sunshine, for example, more than five degrees (Celsius) higher.

## Visibility Calibration

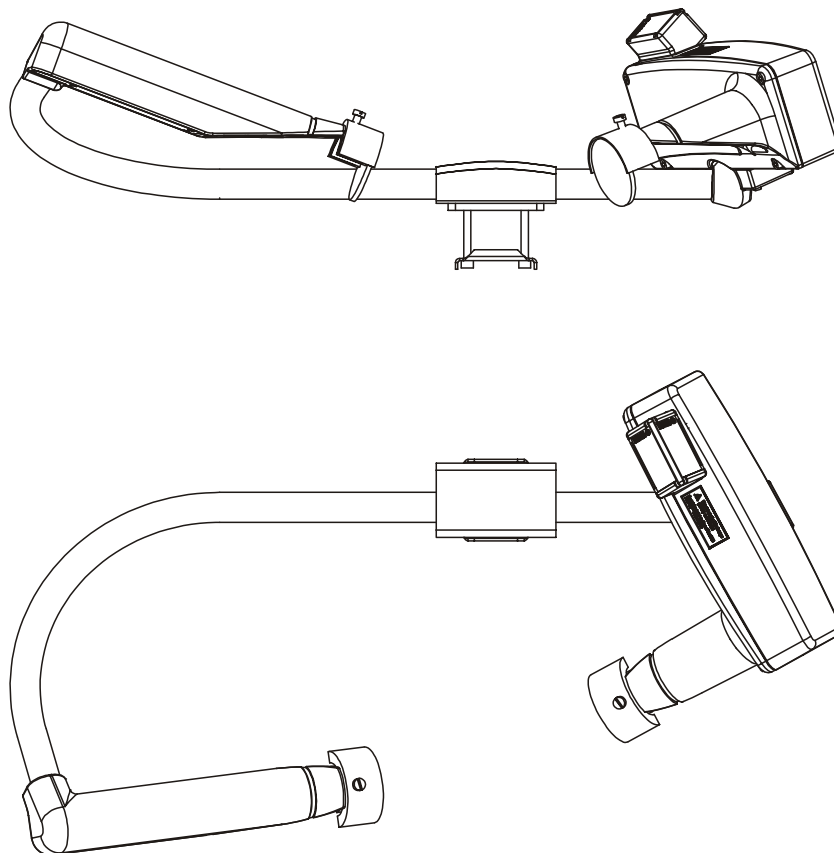
The calibration is checked and adjusted with the PWA11 calibration kit. The kit consists of a blocking plate and two opaque glass plates with known scatter properties. The **ZERO**, **CHEC**, and **CAL** commands are used in the procedure. The calibration procedure checks two points; zero scatter signal 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 better 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 90 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. PWD22 should answer as follows:  
  
ZERO SIGNAL: OK>
3. Move the blocking plate.
4. Install the calibrator plates to the lens hoods. Refer to Figure 21 on page 93.



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**Figure 21** 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 92).

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. PWD22 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 PWD22 and the calibrator for hardware or mechanical errors. Also consult Vaisala

If the optical units PWC22 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 PWC22 Controller/Receiver. Removing the units comes into question, when there is reason to suspect that malfunction of PWD22 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 93).



## Removing PWT11

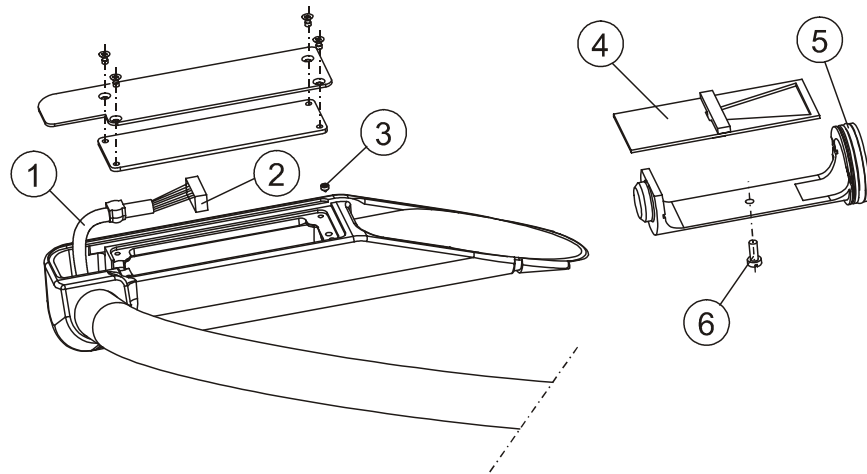
To remove the transmitter, do the following:

**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 22 below.



0308-007

**Figure 22** Removing PWT11

The following numbers refer to Figure 22 above.

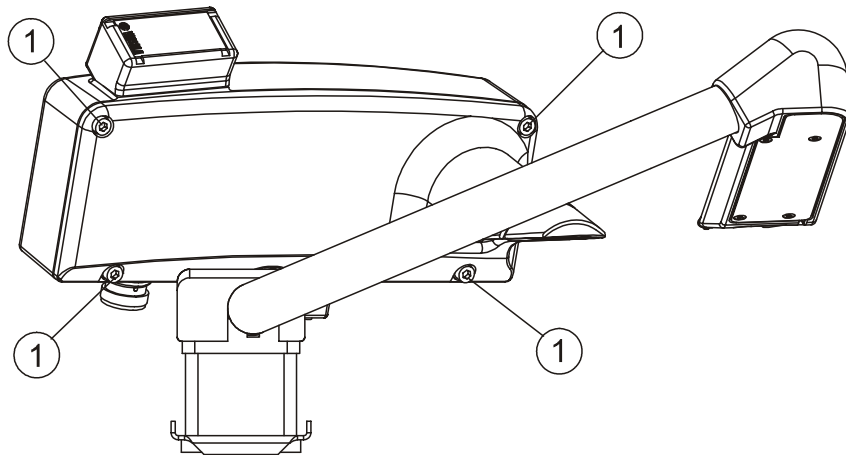
- 1 = Signal and power cable
- 2 = Empty pin
- 3 = Set screw
- 4 = PWT11
- 5 = O-ring and module
- 6 = Plastic screw

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

1. Slide the transmitter board (4) to the module (5) and tighten the 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 the sink by pointed pliers.
4. Lock the module with a M4x4 set screw.
5. Connect 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 PWC22

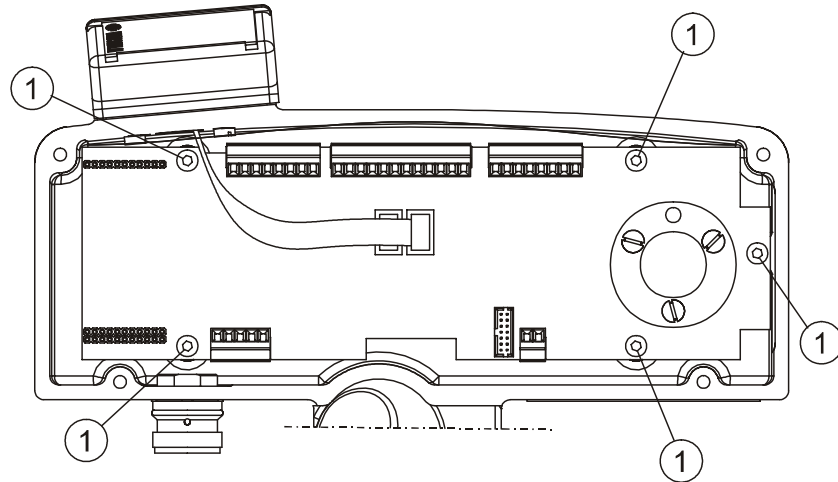
1. Open the four box screws in the corners of the controller box. See Figure 23 below.



0308-008

**Figure 23** Opening Box Screws (1)

2. Remove the PWC22 board by opening the five screws to replace the board with a spare part. See Figure 24 on page 97.

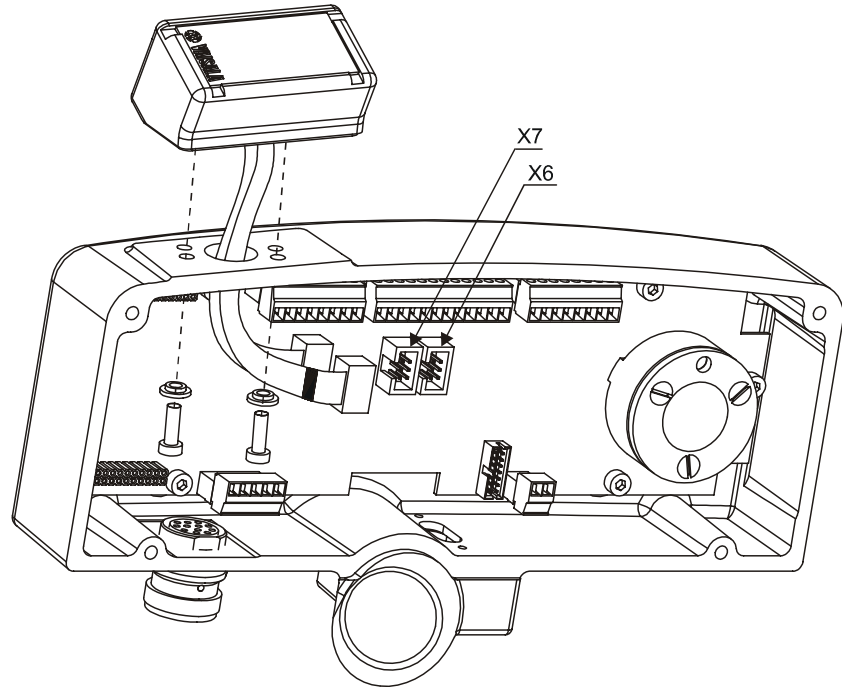


0308-009

**Figure 24** Removing the PWC22 Board

### Replacing RAINCAP®

1. Open the control box (see section Removing PWC22 on page 96).
2. Unplug the rain sensor cables (X6 and X7).
3. Remove the two screws below RAINCAP®.
4. Remove RAINCAP® by pulling it out of the control box.
5. Reassemble in the reverse order. Note that the flat cable marked with a stripe is connected to X6.
6. Calibrate the new RAINCAP® by giving the **WET ON** and **DRY ON** commands as described in section DRY ON and WET on page 86.



0312-112

**Figure 25** Removing the Rain Sensor

## 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 82 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 111.
  - If the Backscatter increased warning is active (see section STA on page 82), 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 56).
  - Then give other commands to see if PWD22 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 PWD22 powered?
  - Open the PWC22 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. PWD22 control electronics is probably working.
  - Check the status information with the **STA** command (see section STA on page 82). If there are any active alarms, the visibility value does not exist.
  - Check especially P12, M12, BACKSCATTER and LEDI. See section PWD22 Electrical Troubleshooting on page 103 for internal monitoring values of the limits.
2. Go to the PWD22 site.
  - Check the cable connectors.
  - Check the receiver and transmitter units. Follow the instructions in section Removing and Replacing on page 94 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 90).
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 90).
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 82).
  - Go to section Message Exists but Visibility Value Does Not on page 101.

## 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 37.
3. Electrical fault. See items in section Message Exists but Visibility Value Does Not on page 101.

## PWD22 Reports Precipitation When There Is None

In temperatures under 0 °C, only the optical measurement is used in detecting precipitation. In temperatures above 0 °C, the RAINCAP® detection is used in cross-checking the optical detection, and false detection can only be caused by problems in both measurements.

1. Check that there are no flashing lights close to PWD22. Flashing lights may cause PWD22 to detect peaks in the optical signal.
2. Check that there are no foreign objects in the sample volume. Tree branches or other moving objects may cause sudden changes in the scatter signal.
3. Check that receiver is not facing cars passing by. If the sun beams are reflected from the passing cars towards the receiver, this could cause false precipitation reports especially in the winter. These short sun beam reflections can cause short spikes to the PWD22 optical signal and they are interpreted as light snow. This might even happen if there are sharp changes of the lighting condition of the ground where the receiver is looking at. If the area where the receiver is looking at is bright and shiny and passing cars cause shadows to that area, it might be possible that it will cause similar short spikes to the receiver signal.
4. If the false detection has occurred in temperatures above 0 °C, RAINCAP® does not function correctly. The RAINCAP® sensing surfaces should be thoroughly cleaned.



## PWD22 Reports Frozen Precipitation during Rain

The ratio of optical intensity measurement to the RAINCAP<sup>®</sup> measurement is too high.

1. Check the optical calibration and RAINCAP<sup>®</sup> operation.
2. If everything else seems to be functioning correctly, change the parameter settings.
  - If possible, check the accumulated water sum against a reference rain gauge. This will indicate how close the Rain intensity scale is to the optimal value. Decrease the scaling factor if the PWD22 rain amount is too high.
  - Otherwise, increase RAINCAP<sup>®</sup> scale (the **WSET** command).

## PWD22 Electrical Troubleshooting

PWD22 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 PWD22, do the following:

1. Check the connections. PWD22 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 PWD22 Vn.nn yyyy-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 PWD22. 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. Unused wires of the PWD22 mast cable must be insulated from each other, for example, by connecting them to void screw terminals in the junction box.
  - 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.

## Technical Support

For technical questions, contact the Vaisala technical support:

E-mail [helpdesk@vaisala.com](mailto:helpdesk@vaisala.com)

Phone (int.) +358 9 8949 2789

Fax +358 9 8949 2790

## Return Instructions

If the product needs repair, please follow the instructions below to speed up the process and avoid extra costs.

1. Read the warranty information.
2. Write a Problem Report with the name and contact information of a technically competent person who can provide further information on the problem.
3. On the Problem Report, please explain:
  - What failed (what worked / did not work)?
  - Where did it fail (location and environment)?
  - When did it fail (date, immediately / after a while / periodically / randomly)?
  - How many failed (only one defect / other same or similar defects / several failures in one unit)?
  - What was connected to the product and to which connectors?
  - Input power source type, voltage and list of other items (lighting, heaters, motors etc.) that were connected to the same power output.
  - What was done when the failure was noticed?
4. Include a detailed return address with your preferred shipping method on the Problem Report.
5. Pack the faulty product using an ESD protection bag of good quality with proper cushioning material in a strong box of adequate size. Please include the Problem Report in the same box.
6. Send the box to:  
Vaisala Oyj  
Contact person / Division  
Vanha Nurmijärventie 21  
FIN-01670 Vantaa  
Finland

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## CHAPTER 8

# TECHNICAL DATA

This chapter provides the technical data of the Product.

## Specifications

### Mechanical Specifications

**Table 20 PWD22 Specifications**

<b>Property</b>	<b>Description / Value</b>
Dimensions	220 mm (h) × 720 mm (w) × 320 mm (d)
Weight	3 kg
Mounting	To a metal rod or directly to the mast.
Material	Aluminum

1) Height × width × depth

## Electrical Specifications

**Table 21 PWD22 Electrical Specifications**

Property	Description / Value
Maximum power consumption	6 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.
Outputs	Temperature sensor.
	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 PWD22 end is equipped with connector.
Output data	Automatic or polled data messages.
	Visibility, present weather, precipitation, 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 22 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 23 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 24 Visibility Measurement Specifications**

Property	Description / Value
Measurement range of MOR <sup>1)</sup>	10 ... 20000 m
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

## Weather Sensing Specifications

**Table 25 Weather Sensing Specifications**

Property	Description / Value
Precipitation detection sensitivity	0.05 mm/h or less, within 10 minutes
Weather type identification	7 different types of precipitation (rain, freezing rain, drizzle, freezing drizzle, mixed rain/snow, snow, ice pellets) Precipitation (unknown type) Fog (mist), haze (smoke, sand) or clear
Weather type reporting	WMO code table 4680 Code letters for precipitation, NWS (National Weather Service, USA)
Precipitation intensity measurement	Range 0.00 ... 999 mm/h

## Environmental Specifications

**Table 26**      **Environmental Specifications**

<b>Property</b>	<b>Description / Value</b>
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



## 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 27 Values from STA message for Internal Monitoring**

Status Message	Typical	Min. / Max.	Fault	Description	Action
<b>AMBL</b>					
Ambient light	-0 V	-9 V / +3 V	> 3 V 'RECEIVER ERROR'	Preamplifier is not working.	Change PWC22.
			< -9 V 'RECEIVER SATURATED'	The sun is shining directly or from reflecting surface (snow etc.) to the receiver.	Check the orientation of PWD22.
<b>OFFSET</b>					
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 PWC22.
<b>REC. BACKSCATTER</b>					
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 <b>CLEAN</b> command. 3) Change the PWC22 control unit.
<b>TR. BACKSCATTER</b>					
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)	
<b>LEDI</b>					
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 PWC22 control 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
<b>TS</b>					
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.
<b>TB</b>					
Temperature of the CPU board	Some degrees higher than ambient temp.		-	-	-
<b>SIGNAL</b>					
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 PWC22.
<b>VBB</b>					
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 PWC22

Status Message	Typical	Min. / Max.	Fault	Description	Action
<b>P12</b>					
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 PWC22 control unit.
<b>M12</b>					
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 PWC22 control unit.
<b>DRD</b>					
Instant value of RAINCAP® Rain Sensor	64...900Hz	64 / DRY	< 64 Hz 'DRD ERROR'	Cable disconnected or rain detector RAINCAP® short-circuits	1) Check connector X7 and X6 on the PWC22 control unit. 2) Change the RAINCAP® Rain Sensor.
<b>BL</b>					
Background luminance	4...20000 cd/m <sup>2</sup>	4 cd/m <sup>2</sup> / 20000 cd/m <sup>2</sup>	'LUMINANCE SENSOR ERROR'	Cable disconnected or PWL111 short-circuits	Check connector X3 pins 1,2,3,4.
<b>RELAYS</b>					
States of the three external relays controls	ON / OFF		-	-	-
<b>HOOD HEATERS</b>					
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 <b>HEAT ON</b> command. Warming of the heater foils should be felt by hand. If not check powering and cabling.

## APPENDIX B

**PWC22 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 <sup>®</sup> 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 <sup>®</sup> 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 10 on page 43.

## APPENDIX C

# NWS AND WMO CODE TABLES

**Table 28 Internal Weather Types and Supported NWS Codes**

<b>Internal Weather Types</b>	<b>NWS Codes</b>
NO PRECIPITATION	C
PRECIPITATION	P
DRIZZLE	L
RAIN	R
SNOW	S
SLEET	IP
FREEZING DRIZZLE	ZL
FREEZING RAIN	ZR

NWS codes are used with intensity indicator '+' (plus) for heavy intensity, '-' (minus) for light, and none (space) for moderate. For example, 'R+' means heavy rain.

**Table 29 WMO SYNOP Codes (Table 4680, W<sub>a</sub>W<sub>a</sub>) Used by PWD22**

<b>SYNOP Codes</b>	<b>Weather Types</b>
00	Clear
04	Haze or smoke, or dust in suspension in the air, visibility equal to, or greater than, 1 km
05	Haze or smoke, or dust in suspension in the air, visibility less than 1 km
10	Mist
Code figures 20 to 25 are used, if precipitation or fog was observed during the preceding hour but not at the time of observation	
20	Fog
21	PRECIPITATION
22	Drizzle (not freezing) or snow grains
23	Rain (not freezing)
24	Snow
25	Freezing rain or freezing drizzle
The following code figures are used if precipitation or fog is observed at the time of observation	
30	FOG
31	Fog or ice fog, in patches
32	Fog or ice fog, has become thinner during the past hour
33	Fog or ice fog, no appreciable change during the past hour
34	Fog or ice fog, has begun or become thicker during the past hour
40	PRECIPITATION
41	Precipitation, slight or moderate
42	Precipitation, heavy
50	DRIZZLE
51	Drizzle, not freezing, slight
52	Drizzle, not freezing, moderate
53	Drizzle, not freezing, heavy
54	Drizzle, freezing, slight
55	Drizzle, freezing, moderate
56	Drizzle, freezing, heavy
60	RAIN
61	Rain, light
62	Rain, moderate
63	Rain, heavy
64	Rain, freezing, light
65	Rain, freezing, moderate
66	Rain, freezing, heavy
67	Rain (or drizzle) and snow, light
68	Rain (or drizzle) and snow, moderate or heavy
70	SNOW
71	Snow, light
72	Snow, moderate
73	Snow, heavy
74	Ice pellets, light
75	Ice pellets, moderate
76	Ice pellets, heavy
80	SHOWERS OR INTERMITTENT PRECIPITATION



SYNOP Codes	Weather Types
81	Rain showers, light
82	Rain showers, moderate
83	Rain showers, heavy
84	Rain showers, violent ( >32 mm/h )
85	Snow showers, light
86	Snow showers, moderate
87	Snow showers, heavy

**Table 30 WMO METAR Codes (Table 4678) Used by PWD22**

Qualifier		Weather Phenomena					
INTENSITY 1	DESCRIPTOR 2		PRECIPITATION 3		OBSCURATION 4		OTHER 5
- Light	BC	Patches	DZ	Drizzle	BR	Mist	
Moderate (No qualifier)	SH	Shower(s)	RA	Rain	FG	Fog	
+ Heavy	FZ	Freezing	SN	Snow	DU	Widespread dust	
			PL	Ice pellets	HZ	Haze	

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