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USER GUIDE

CL31

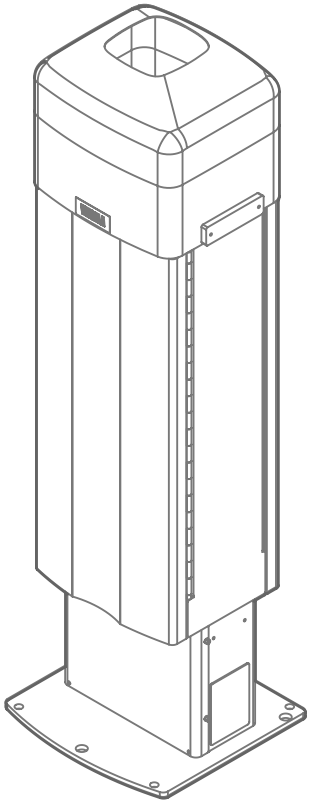
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M210482EN-L

User guide

Vaisala Ceilometer
CL31



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Table of contents

1. About this document 7
1.1 Version information 7
1.2 Related manuals 7
1.3 Documentation conventions 8
1.4 Trademarks 8

2. Product overview 9
2.1 Vaisala ceilometer 9
2.2 Product and part names 10
2.3 Safety 14
2.3.1 Laser safety 19
2.3.2 Grounding terms 21
2.3.3 Ceilometer ESD protection 21

3. Installation 22
3.1 Unpacking 22
3.2 Designing foundation 23
3.2.1 Creating new concrete foundation 25
3.2.2 Using existing concrete foundation 25
3.2.3 Grounding 25
3.3 Mounting ceilometer 26
3.4 Tilting ceilometer 28
3.5 Mounting bird deterrent 29
3.6 Assembling battery 33
3.7 External connectors 36
3.7.1 Connecting power supply 38
3.7.2 Data line connections 39
3.7.3 Maintenance terminal connection 41
3.8 Setting up LAN connection 42
3.9 Getting data from ceilometer 43
3.9.1 Entering real COM mode 43
3.9.2 Entering TCP client mode 45
3.9.3 Entering UDP mode 46

4. Operation 48
4.1 Serial lines - open and closed port 48
4.2 Operation modes 49
4.3 User commands 49
4.4 Switch settings 56
4.5 Opening maintenance terminal connection 57
4.6 Starting ceilometer 57
4.7 Data messages 59
4.7.1 Secondary message 59
4.7.2 CL31 data messages No. 1 and 2 60
4.7.3 CRC16 checksum 67
4.7.4 CL31 status message 67
4.7.5 CT12K messages 70
4.7.6 CT25K data messages 75
4.7.7 CT25KAM data messages 79
4.7.8 LD40 standard telegram 80
4.7.9 Manual message 85
4.8 Polling mode 85

4.9 Activating sky condition....87
4.9.1 Option code....87
4.9.2 Activation....87
4.10 Storing ceilometer....88

5. Maintenance....89
5.1 Periodic maintenance....89
5.2 Alarms and warnings....89
5.3 Cleaning window....90
5.3.1 Calibrating window contamination measurement....91
5.4 Checking door gasket....91
5.5 Checking battery....92
5.6 Cleaning and maintaining painted surfaces....92
5.6.1 Preparing for painting....92
5.6.2 Painting....93
5.6.3 Commonly used Vaisala colors....93

6. Service....94
6.1 Service overview....94
6.2 Replacing window....97
6.3 Replacing engine board and laser transmitter....99
6.3.1 Replacing both units....100
6.3.2 Replacing engine board....101
6.3.3 Replacing laser transmitter....103
6.4 Replacing receiver....105
6.5 Replacing battery....107
6.6 Replacing AC power unit....110
6.7 Replacing fuse....118
6.8 Replacing window blower....120
6.9 Replacing internal heater....121
6.10 Replacing laser monitor board....123
6.11 Replacing modem module....125

7. Troubleshooting....129
7.1 Troubleshooting overview....129
7.2 Accessing diagnostic information....129
7.3 Troubleshooting equipment....129
7.4 Troubleshooting ceilometer....130
7.5 Warning and alarm messages....133

8. Technical Data....138
8.1 CL31 specifications....138
8.2 DXL421 specifications....146

Appendix A: Factory settings of user-programmable parameters....148

Appendix B: Termhood....150

Appendix C: UL/CSA C22.2 regulatory caution and warning statements....152

Index....153

Warranty....157

Technical support....157

Recycling....157

List of figures

Figure 1 Vaisala Ceilometer CL31....10
Figure 2 Measurement unit main parts....13
Figure 3 CL31 measurement unit with LAN (Ethernet) interface option....14
Figure 4 Locations of warning, type, and certification labels....18
Figure 5 Location of CL31 laser aperture....20
Figure 6 CL31 foundation construction....24
Figure 7 Ceilometer CL31 bird deterrent....30
Figure 8 Assembling CL31 battery....34
Figure 9 External connectors (bottom view)....37
Figure 10 Data line RS-485 connection....40
Figure 11 Data line RS-232 connection....41
Figure 12 Open and closed port....49
Figure 13 Operation modes....49
Figure 14 CL31 maintenance parts....96
Figure 15 Laser transmitter CLT321....103
Figure 16 Receiver CLR321....106
Figure 17 AC power unit....111
Figure 18 Window blower CLB311-115 / CLB311-230....120
Figure 19 Internal heater CLH311-115 / CLH311-230....122
Figure 20 Laser monitor board CLM311....123
Figure 21 DXL421 leased line modem....126
Figure 22 DXL421 modem connections....127
Figure 23 DXL421 DIL switch....127
Figure 24 Type labels 115 V and 230 V CL31....142
Figure 25 Location of type labels....142
Figure 26 Termhood with adapter....150
Figure 27 Termhood slot for measurement unit handle....151

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List of tables

Table 1 Document versions (English)....7
Table 2 Related manuals....7
Table 3 CL31 main parts....10
Table 4 CL31 optional parts....11
Table 5 Grounding terms....21
Table 6 Default settings for data line RS-485 connection....40
Table 7 Default settings for data line RS-232 connection....41
Table 8 User level commands....50
Table 9 Advanced level commands....54
Table 10 Messages with 10 m resolution (standard mode)....60
Table 11 Messages with 5 m resolution (high resolution)....61
Table 12 Error group definition....81
Table 13 Error group 1 (byte 83)....82
Table 14 Error group 2 (byte 84)....82
Table 15 Error group 3 (byte 85)....82
Table 16 Error group 4 (byte 86)....83
Table 17 Error group 5 (byte 87)....83
Table 18 Error group 6 (byte 88)....83
Table 19 Error group 7 (byte 89)....83
Table 20 Command telegram description 'polling request'....86
Table 21 Spare parts....94
Table 22 Default settings for the DXL421 modem connection....128
Table 23 Ceilometer status, warnings....133
Table 24 Ceilometer status, alarms....135
Table 25 Ceilometer status, miscellaneous problems....136
Table 26 Mechanical specifications....138
Table 27 Measurement performance....138
Table 28 Operating environment....138
Table 29 Inputs and outputs....139
Table 30 Receiver specifications....140
Table 31 Transmitter specifications....140
Table 32 Optical system specifications....141
Table 33 Compliance....141
Table 34 External connector J1 - window blower specifications....143
Table 35 External connector J2 - power input specifications....143
Table 36 External connector J3 - data line specifications....144
Table 37 External connector J4 - maintenance line specifications....144
Table 38 NPort 5232-T serial device server specifications....145
Table 39 DXL421 operating environment....146
Table 40 DXL421 inputs....146
Table 41 DXL421 serial RS-232 interface....146
Table 42 DXL421 PSTN interface....146
Table 43 DXL421 mechanical specifications....147
Table 44 DXL421 compliance....147
Table 45 Factory defaults of user-programmable parameters....148

1. About this document

1.1 Version information

Table 1 Document versions (English)

Document code	Date	Description
M210482EN-L	June 2024	Updated safety and laser safety information. Added a figure showing the warning labels and type label and their locations. Added requirements for a disconnection device for the AC (mains) connection. Updated temperature specifications. Added a note about IP rating. Added instructions for replacing fuses. Updated cable requirements. Updated laser transmitter instructions. Added a note instructing to use a flat head screwdriver to open ceilometer door. Moved chapter Functional description to a new document *CL31 Technical Description (M212734EN)*. Updated battery information with new figures.
M210482EN-K	December 2020	Updated safety information.
M210482EN-J	October 2018	Added a note about fuse sizes.

1.2 Related manuals

Table 2 Related manuals

Document code	Name
M210310EN	Vaisala Termination Box TERMBOX-9000, 1200, 1212, 1222 User Guide
M212734EN	Vaisala Ceilometer CL31 Technical Description
M211185EN	Vaisala Boundary Layer View Software BL-View User Guide
M210717EN	*Vaisala Graphical User Interface for Ceilometers CL-View*

1.3 Documentation conventions



WARNING! Warning alerts you to a serious hazard. If you do not read and follow instructions 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.



Highlights important information on using the product.



Gives information for using the product more efficiently.



Lists tools needed to perform the task.



Indicates that you need to take some notes during the task.

1.4 Trademarks

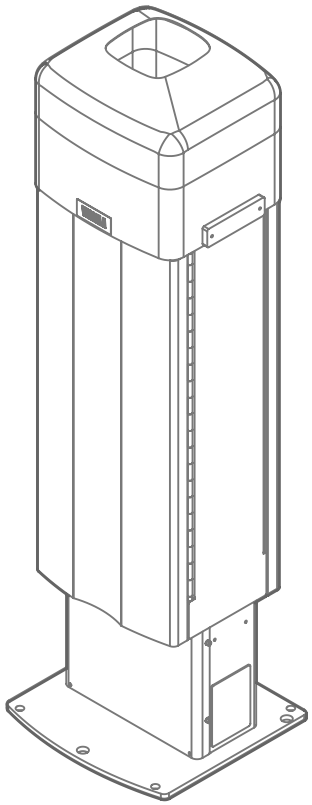
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2. Product overview

2.1 Vaisala ceilometer



Vaisala ceilometer measures cloud height and vertical visibility.

The ceilometer uses pulsed diode laser LIDAR technology (light detection and ranging, LIDAR), where short, powerful laser pulses are sent out in a vertical or near-vertical direction. The reflection of light, backscatter – caused by haze, fog, mist, virga, precipitation, and clouds – is measured as the laser pulses traverse the sky. The resulting backscatter profile, the signal strength versus the height, is stored and processed, and the cloud bases are detected. The time delay between the launch of the laser pulse and the detection of the backscatter signal indicates the cloud base height.

The ceilometer can detect 3 cloud layers simultaneously. If the cloud base is obscured due to precipitation or ground-based fog, the ceilometer reports vertical visibility. There is no need for adjustments in the field. The embedded software includes several service and maintenance functions and gives continuous status information from internal monitoring. The software is designed to give the full backscatter profile.

CL31 supports data messages used in CT12K, CT25K, CT25KAM, and LD40. Therefore it is easy to transfer from older ceilometer versions to CL31.

You can order the ceilometer with an optional air quality plug-and-play package. The package contains:

- 2 Ethernet cables
- Ethernet switch
- Ethernet switch AC (mains) power cables with plugs for the USA, the EU, and the UK
- Ceilometer AC (mains) power cables with plugs for the USA, the EU, and the UK
- Laptop with BL-View software installed

The LAN module rules out the radio kit and Humitter options.

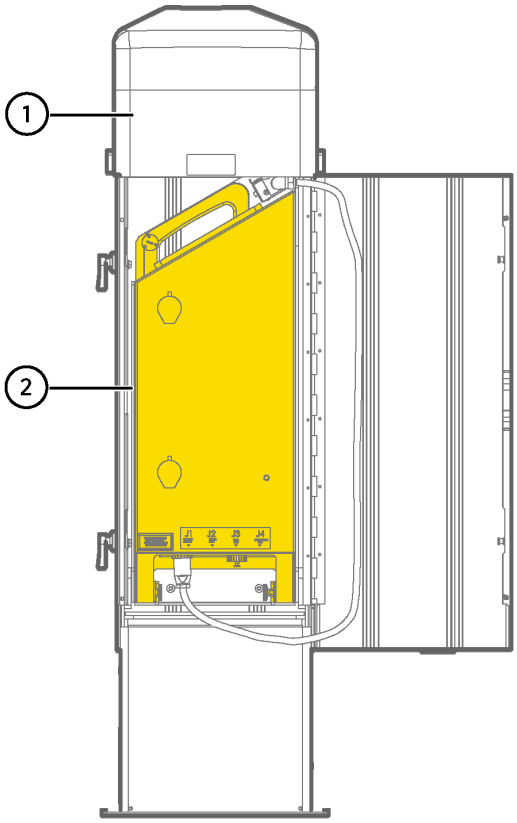


Figure 1 Vaisala Ceilometer CL31

1 Radiation shield
2 Measurement unit

2.2 Product and part names

Table 3 CL31 main parts

Item	Name
CLO321	Optics unit

Item	Name
CLW311	Window
CLT321	Transmitter
CLR321	Receiver
CLM311	Laser monitor board
CLE321	Engine board
CLP321	AC power unit
226116	Battery
CLH311-115	Internal heater (100–115 V AC)
CLH311-230	Internal heater (220–240 V AC)
CLB311-115	Window blower (100–115 V AC)
CLB311-230	Window blower (220–240 V AC)
CT3839	Power cable (230 V)
CT35324	Power cable (115 V)
CT3838	Data cable
226296	Coaxial cable

Table 4 CL31 optional parts

Item	Name	Description
CL31BIRDKIT	Bird deterrent	
DXL421	Modem module	
CLRADIOKIT	Radio modem installation kit	Excluding radio modem and antenna
TERMBOX-1200	Termination box, mains and signal	For extended surge and overvoltage protection
CLTERMBOX	Termination boxes for mains and signal	Without surge and overvoltage protection
QMZ101	Maintenance cable	
CLTERMHOOD	Optical termination hood	
CT35022	Shock absorber	For ship installations
CLHUMITTER	Internal humidity transmitter	
CL31USBCABLE	USB maintenance cable	
CLAQPACKAGE	Air quality plug-and-play package	Laptop, Ethernet switch, 2 Ethernet cables, Ethernet switch power source, 3 ceilometer AC (mains) power cables, BL-View software

The complete delivery also includes:

- Mating cables with connectors for power and communication
- Installation hardware
- User guide

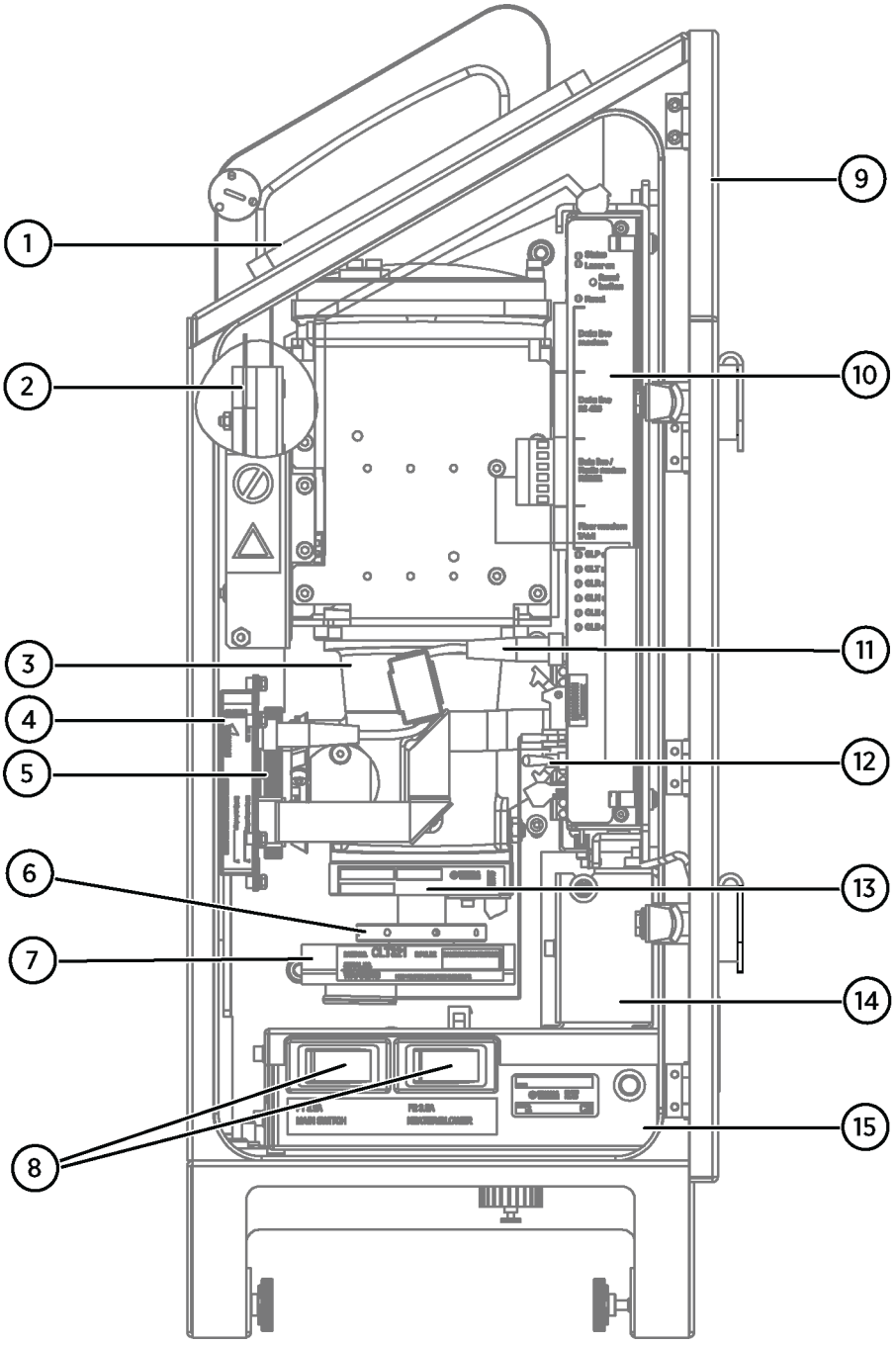


Figure 2 Measurement unit main parts

1 Window CLW311
2 Internal heater CLH311
3 Optics unit CLO321
4 Receiver CLR321
5 Receiver ring
6 Transmitter ring
7 Transmitter CLT321
8 Main circuit breakers, **F1** and **F2**
9 Measurement unit enclosure

10 Engine board CLE321
11 Coaxial cable 226296
12 Battery switch
13 Laser monitor board CLM311
14 Battery cage
15 AC power CLP321

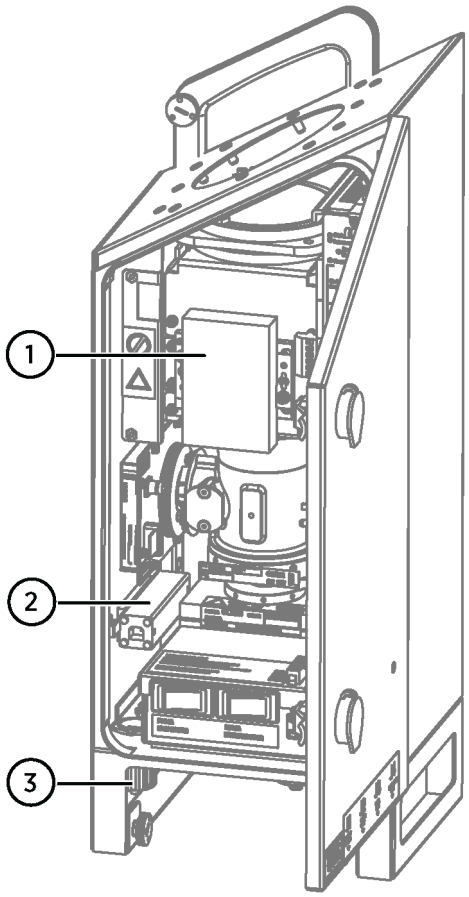


Figure 3 CL31 measurement unit with LAN (Ethernet) interface option

1 MOXA NPort 5232-T modem
2 Ethernet surge protector
3 RJ45 Connector

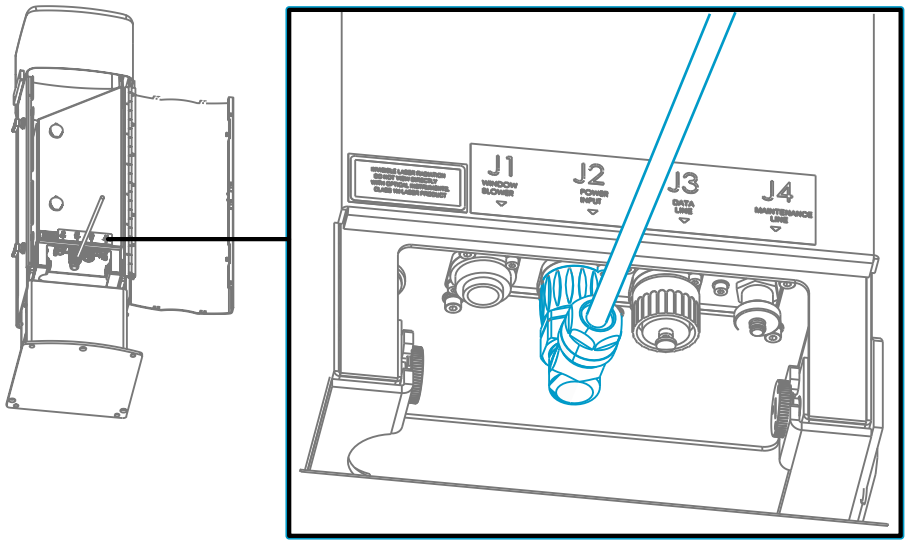
2.3 Safety

This product has been tested for safety. Note the following precautions:

WARNING! If you have Termbox, you need an external disconnection device (for example, a switch) for the AC (mains) power connection.

- The disconnection device must conform to local regulations.
- To prevent accidental switching on during installation and maintenance, the disconnection device must be visible from the enclosure, or lockable with a key.
- The installed enclosure must not block access to the disconnection device. The disconnection device must remain easy to operate.
- Mark the disconnection device as the disconnection device for the ceilometer.

WARNING! If you do not have Termbox, the power input connector is the disconnecting device. To disconnect the ceilometer from the electrical network without Termbox, disconnect the power cable from connector **J2**.



WARNING! Failure to comply with these precautions or with specific warnings elsewhere in these instructions violates safety standards of design, manufacture, and intended use of the product. Vaisala assumes no liability for the customer's failure to comply with these requirements.

WARNING! Do not substitute parts or modify the system, or install unsuitable parts in the system. Improper modification can damage the product or lead to malfunction.

WARNING! If the equipment is used in a manner not specified by Vaisala, the protection provided by the equipment may be impaired.

WARNING! Ground the product and verify outdoor installation grounding periodically. Failure to provide proper grounding can result in injury or death from electrical shock and can severely damage the equipment.

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WARNING! To minimize shock hazard, the chassis and cabinet must be connected to a safety ground. The ceilometer is equipped with a 3-conductor AC power connector. The power cable must be plugged into an approved, grounded three-contact electrical outlet or the ceilometer must be carefully grounded to a low-resistance safety ground.

WARNING! Do not operate in an explosive atmosphere, for example, when flammable gases or fumes are present. Operation of electrical equipment in such an environment constitutes a safety hazard.

WARNING! Do not perform installation or maintenance procedures when there is a risk of thunderstorm or lightning activity in the area.

WARNING! Do not service the system alone. Do not reach into parts and assemblies that are AC (mains) powered and live except in the presence of someone who can provide first aid.

WARNING! Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Vaisala office or authorized depot for service and repair to make sure that safety features are maintained.

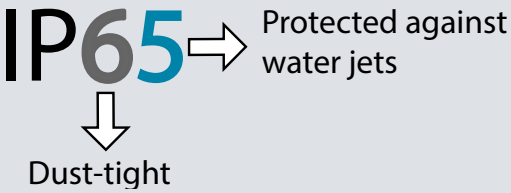
WARNING! Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

WARNING! High voltage is present when the laser transmitter CLT321 or receiver CLR321 covers are removed and they are connected to a powered unit. High voltage is present in the AC power unit CLP321, internal heater CLH311, engine board CLE321, and window blower CLB311 at the top of the radiation shield.

For laser transmitter specifications, see Table 31 (page 140).

CAUTION! Improper modification can damage the product or lead to malfunction. Any modification voids your warranty.

The ingress protection (IP) rating consists of 2 digits. The first digit indicates the protection against solids. The second digit indicates the protection against liquids.



The following warning is on the internal heater. The heater may be hot. Avoid touching it.



The following figure shows the locations of warning labels on the ceilometer.

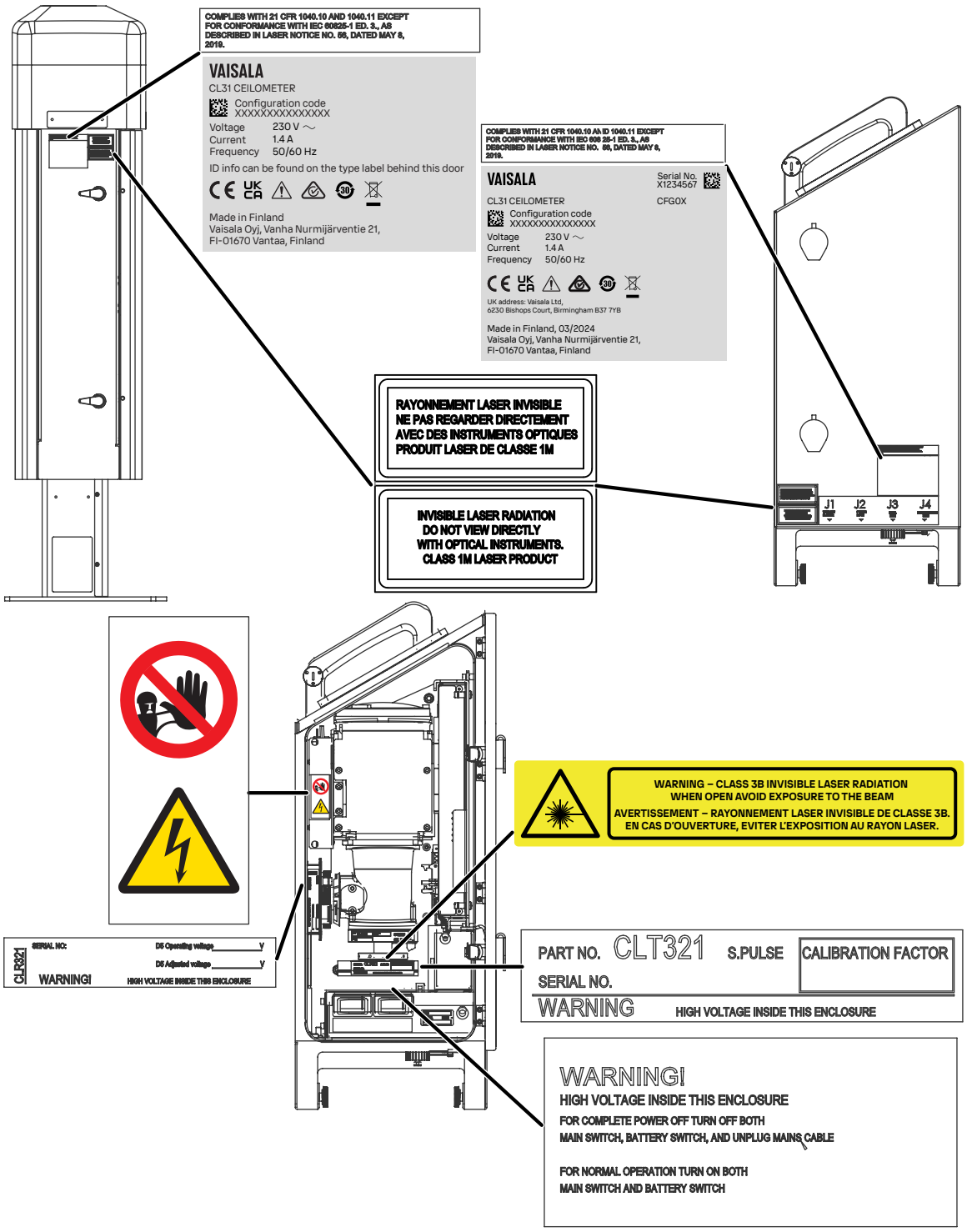


Figure 4 Locations of warning, type, and certification labels

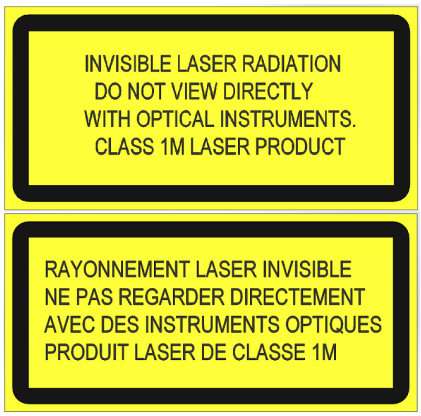
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2.3.1 Laser safety

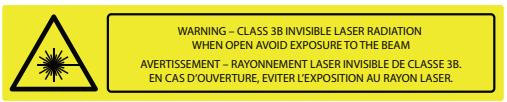
This Vaisala ceilometer is classified as a Class 1M laser device in accordance with International Standards IEC 60825-1:2014 and EN 60825-1:2014+A11:2021. It complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019. This means that when this ceilometer is installed in a field environment with instrument covers on and pointed vertically or near-vertically, it poses no established biological hazard to humans.

CAUTION! Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

The ceilometer has the following label on the measurement unit door and the radiation shield door:



The following warning is on the transmitter.



WARNING! This ceilometer must be operated in an area restricted from public access. It must be pointed vertically or near-vertically. Invisible laser radiation is emitted through the aperture on top of the ceilometer.

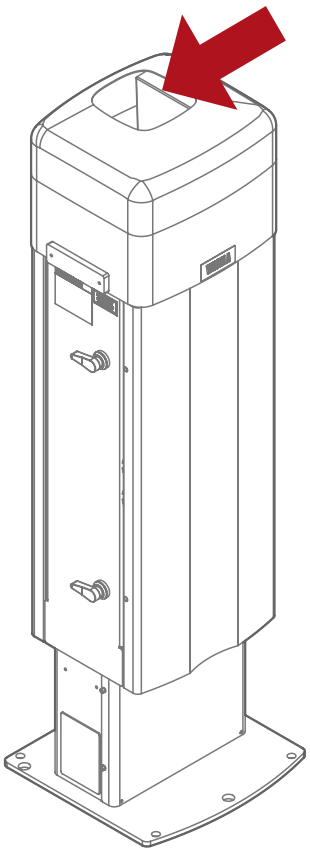


Figure 5 Location of CL31 laser aperture

Take the following precautions during service and maintenance:

WARNING! Do not look directly into the ceilometer transmitter or ceilometer optics with magnifying optics (such as glasses, binoculars, and telescopes). Do not direct the beam into an area where such instruments are used. Viewing the laser output may pose an eye hazard.

WARNING! Do not remove the ceilometer transmitter from its normal position without first switching off both the line and the battery power and detaching the transmitter ribbon cable from the ceilometer engine board.

WARNING! Only qualified maintenance personnel may perform maintenance procedures. Make sure unauthorized persons cannot access the work area during service operations.

2.3.2 Grounding terms

Table 5 Grounding terms

Term	Description
GND	Electronics common return, used only for signal and data circuits
SGND	Shield ground for signal cables shields
PE 	Protective earth, connects touchable metal structures to safe potential. Recognized by grounding symbol and green or yellow-green wire insulation.

2.3.3 Ceilometer ESD protection

The ESD handling instructions are for service persons who need to touch bare printed circuit boards and components inside the equipment.

2.3.3.1 ESD protection

Electrostatic discharge (ESD) can damage 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 in the equipment housing.

To avoid delivering high static voltages to the product:

- Handle ESD-sensitive components on a properly grounded and protected ESD workbench or by grounding yourself to the equipment chassis with a wrist strap and a resistive connection cord.
- If you are unable to take either precaution, touch a conductive part of the equipment chassis with your other hand before touching ESD-sensitive components.
- Hold component boards by the edges and avoid touching component contacts.

3. Installation

3.1 Unpacking

The ceilometer is shipped in a package that contains:

- Radiation shield
- Measurement unit inside the radiation shield
- Other equipment
- Accessories
- Documentation



CAUTION! When you open the package, place it on a flat surface with the indicated top side up. Open the container from the top side and carefully remove the ceilometer and other equipment.



CAUTION! Avoid touching the window or lens surfaces. Do not remove the protective sheet from the measurement unit window until the installation is ready.



CAUTION! Do not remove the integral protective caps from the unused external connectors (**J4** maintenance line).



Wear protective gloves and clothing against sharp edges.

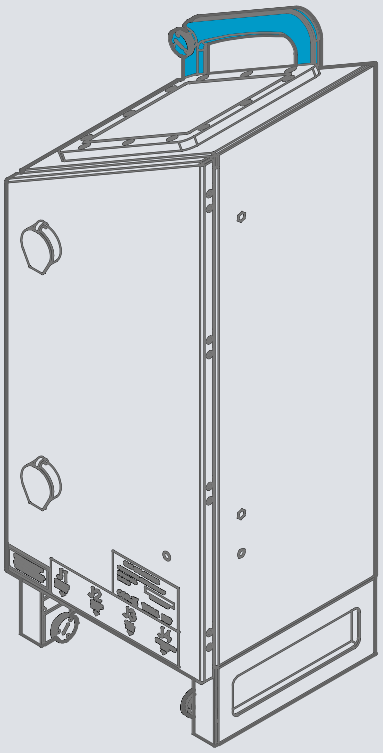


Store the original packaging for a possible later transportation need.



The unit is heavy. Vaisala recommends that unloading and unpacking is carried out by 2 people.

Use the measurement unit handle for lifting and carrying the measurement unit.



Use a flat head screwdriver to open the door.

3.2 Designing foundation

Place the ceilometer on a stable platform. Vaisala recommends installing the ceilometer so that the sensor points north, 3° off zenith. This minimizes solar background and helps avoiding specular reflection from ice clouds.

The standard foundation for the ground installation is a concrete foundation. For the recommended minimum dimensions, see the following figure. Mounting screws and bolts are included in the delivery.

If CL31 replaces another Vaisala ceilometer (CT25K, CT12K, LD40, LD25, or LD12), the existing foundation and foundation screws can be used.

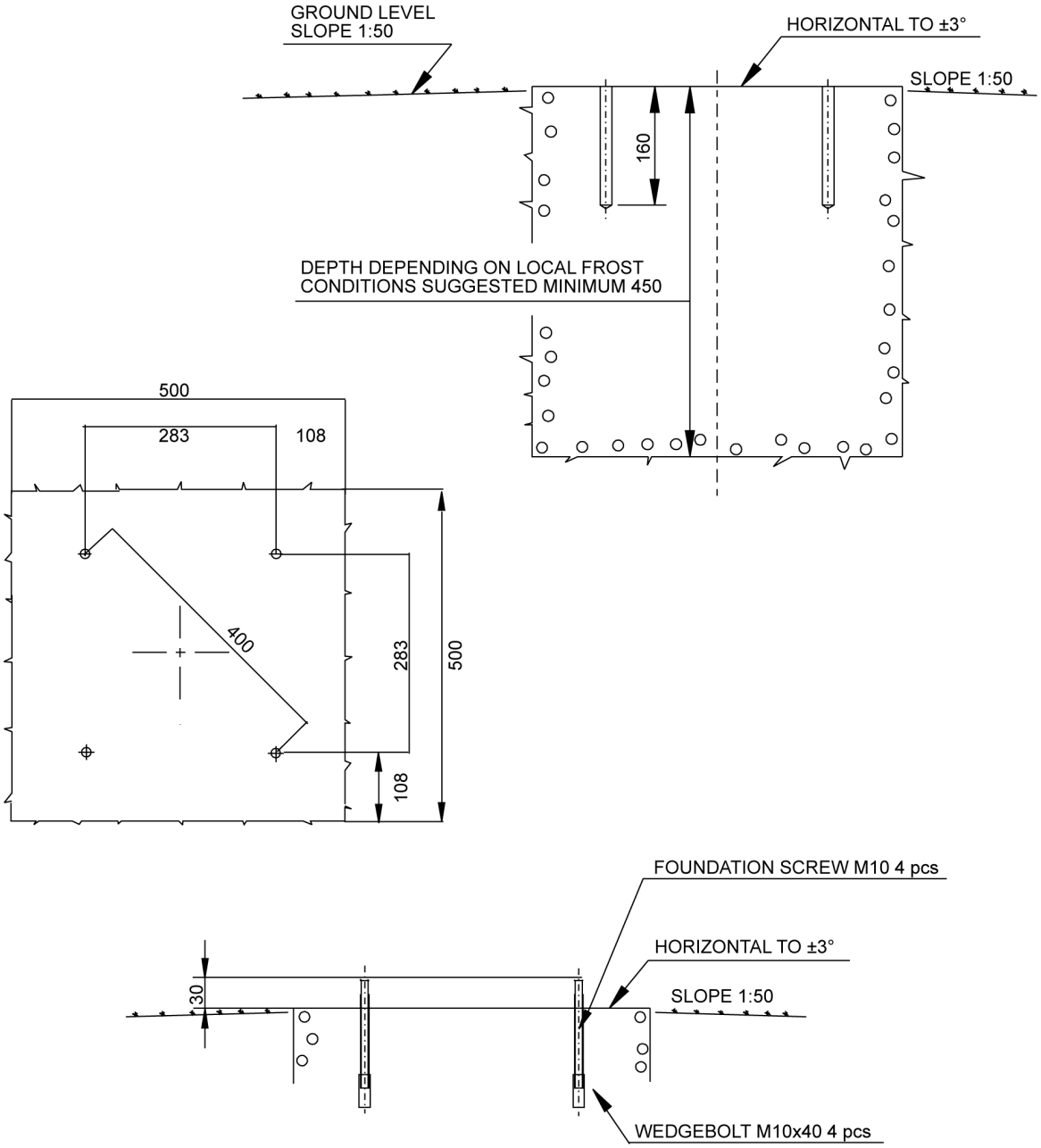


Figure 6 CL31 foundation construction

You can either use an existing concrete foundation or create a new one.

If you plan to use the tilt feature, consider this in the layout of the foundation screws and radiation shield placement.

3.2.1 Creating new concrete foundation

1. Fasten the M10×40 wedge bolts to the lower ends of the foundation screws (4 each).
2. Fix a drilling template to the upper ends of the foundation screws with nuts.
3. Place the template with the attached foundation screws into the hole so that approximately 30 mm (1.25 in) of the foundation screw threads stand above the surface.
4. Pour in the concrete and finish the foundation.

3.2.2 Using existing concrete foundation

1. Drill 4 holes with a diameter of 12 mm (0.5 in) and a depth of 165 mm (6.5 in) into the concrete. Note the cardinal points indicated in Creating new concrete foundation (page 25).
2. Fasten the M10×40 wedge bolts to the lower ends of the foundation screws (4 each).
3. Place the wedge bolt and foundation screw combinations into the holes, with the wedge bolts down, and hammer the protruding threads down.
4. Tighten the foundation screws a few turns to attach the wedge bolts to the hole walls.

3.2.3 Grounding

Proper grounding protects the system and users from transients caused by lightning and ensures operation of the electrical safety systems in fault conditions.

WARNING! The ceilometer is equipped with a separate grounding rail for external grounding at the bottom of the radiation shield. It must be connected to a low resistance ground.

WARNING! At the installation site, a connection to a low resistance ground is mandatory for adequate lightning and transient protection.

WARNING! To minimize shock hazard, the chassis and cabinet must be connected to a safety ground. The ceilometer is equipped with a 3-conductor AC power connector. The power cable must be plugged into an approved, grounded three-contact electrical outlet or the ceilometer must be carefully grounded to a low-resistance safety ground.

3.2.3.1 Grounding in marine applications

If the application requires a "floating" AC mains power without a safety ground connected to either line, such as in marine IT power grid, do the following:

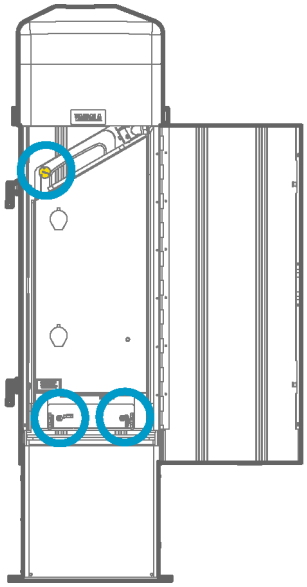
1. Use a 500 VA isolation transformer in the AC power input and bond the grounding rail at the bottom of the radiation shield ground to the installation platform (the metal hull/deck) and connect the grounding bolt at the bottom of the measurement unit to the grounding rail.
2. Connect the communication line to the data receiving system through a galvanic signal isolator or use fiber-optic communication.

3.3 Mounting ceilometer

The ceilometer is delivered with the measurement unit attached to the radiation shield.

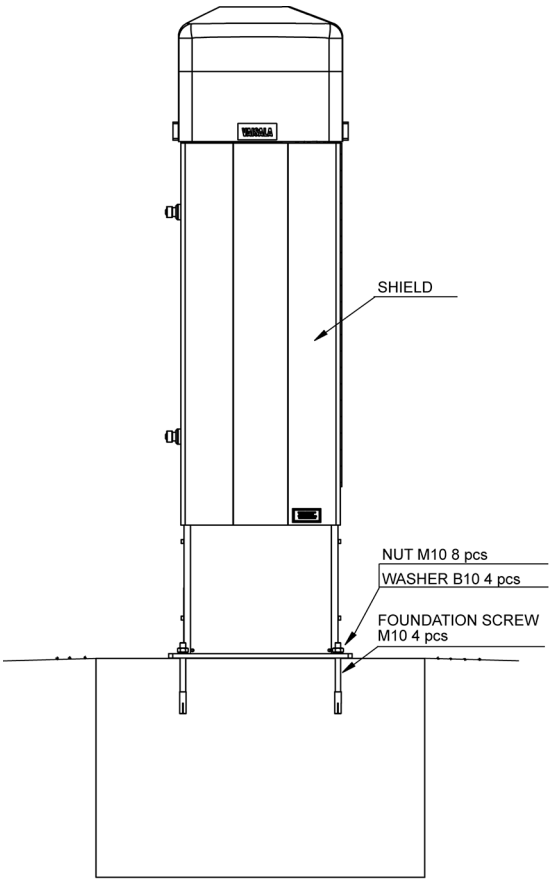
1. Remove the measurement unit from the radiation shield.

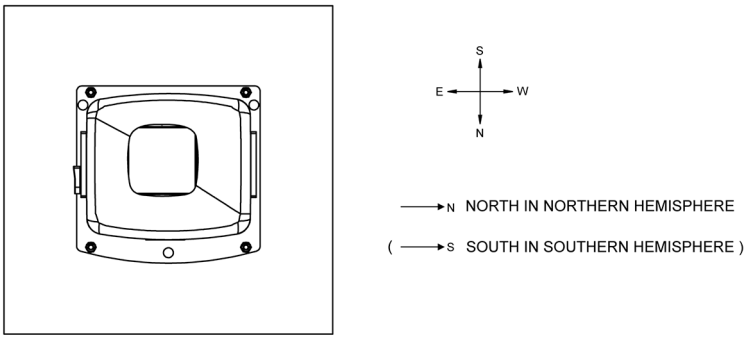
   Loosen the 3 attachment screws, disconnect the blower cable from connector **J1**, and pull out the unit.



A Attachment screws

2. Place the radiation shield on the foundation so that the door faces North in the Northern hemisphere and South in the Southern hemisphere.





3. Place the washers on the foundation screws and tighten the nuts.

For installing an optional bird deterrent, see Mounting bird deterrent (page 29) .

4. Place the measurement unit inside the radiation shield, tighten the 3 attachment screws and connect the blower cable to connector **J1**.

3.4 Tilting ceilometer

The ceilometer can operate in a tilted position. The built-in sensor detects the tilt angle, the deviation from the vertical. The tilt feature allows 3 tilt angles:

- Vertical
- 12 degrees with the measurement unit door upwards
- 12 degrees with the measurement unit door downwards

The tilt angle is used for an automatic correction of the detected cloud base height, enabling accurate measurements in a tilted position.

The tilt feature provides the following advantages:

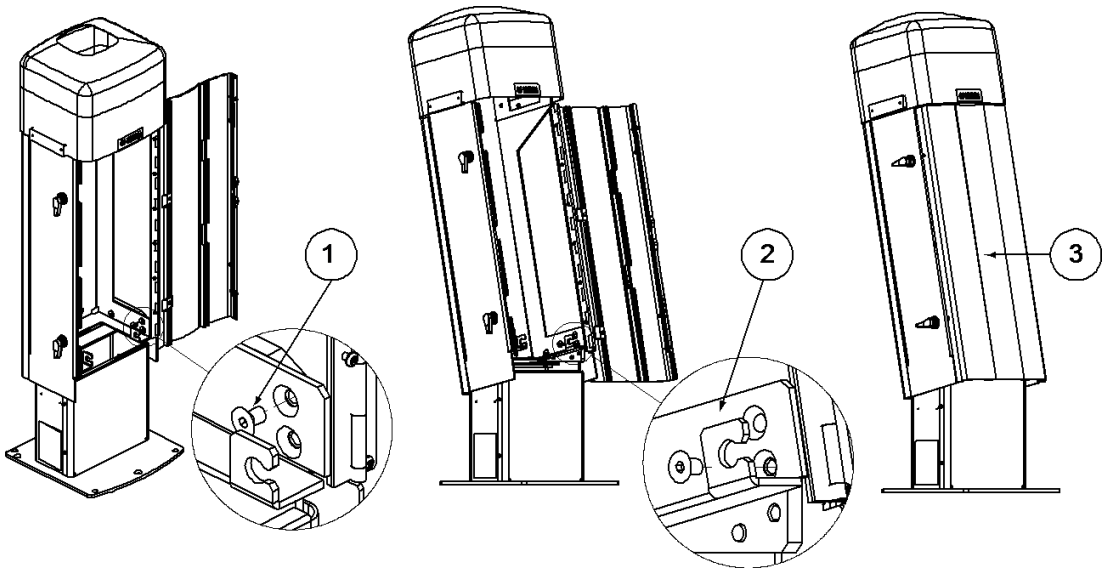
- Protection in heavy weather conditions: In heavy weather conditions, using a tilt angle of 12 degrees protects the measurement unit window from precipitation, thus enhancing performance.
- Precision in aircraft approach control: The beam can be pointed towards the approach direction of an aircraft. This is useful, for example, for helicopter approaches, and at sites where the ceilometer cannot be located exactly at the desired spot.



5-mm Allen key

1. Open the measurement unit door and switch off the power with all 3 switches (**F1**, **F2**, and battery).
2. Disconnect the cables from the measurement unit.

3. Remove the measurement enclosure as described in Mounting ceilometer (page 26).



1 Tilting screw
2 Frame
3 12 degree tilt

4. Loosen the tilting screws on both sides.
5. Tilt the ceilometer radiation shield 12 degrees with the measurement unit door facing up and lock it in place with the screws.

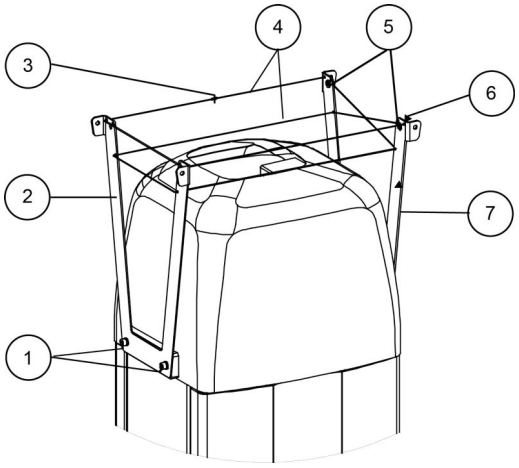
WARNING! When the unit is operating in a tilted position, make sure that it is not being viewed from the beam direction with magnifying optics.

To avoid direct sunlight, tilt the unit away from the sun. That is, tilt it North in the Northern hemisphere and South in the Southern hemisphere. Direct solar radiation exposure does not damage the unit but may cause alarms and temporarily invalidate the data.

The benefits of different tilting directions may be contradictory and cannot be realized simultaneously. You must decide the direction of the final installation.

3.5 Mounting bird deterrent

The optional bird deterrent prevents birds from landing on the ceilometer which could interfere with the measurements. The bird deterrent consists of 2 side plates, a piece of fluorocarbon line, and 2 optional perches.



1 Fixing screw M5xDIN912, spring washer B5 DIN127, flat washer A5,3 DIN125
2 Side plate
3 Blood knot, free place
4 Fluorocarbon line
5 Optional line holes
6 Line hole
7 Side plate

- 8 mm wrench
- 4 mm Allen key

1. Place the side plates on both sides of the ceilometer top cover and attach them with the washers and screws.

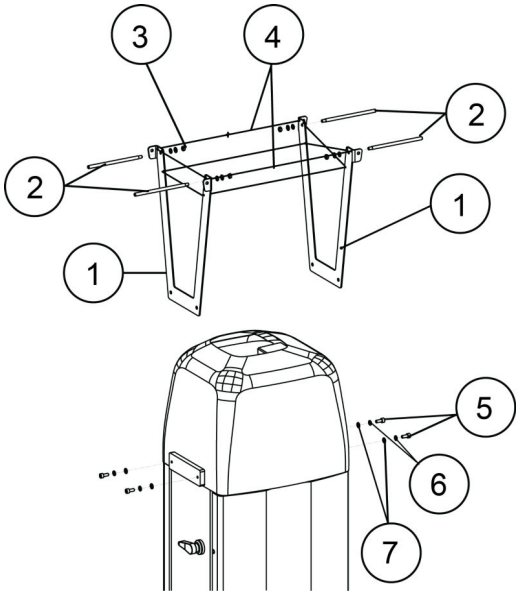


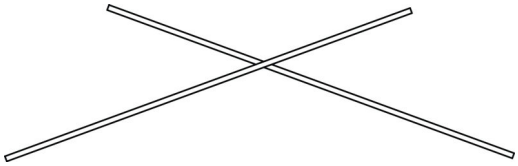
Figure 7 Ceilometer CL31 bird deterrent

1 Side plate
2 Optional perch
3 Nut M5 DIN934, spring washer B5 DIN127, flat washer A5, 3DIN125
4 Fluorocarbon line
5 Screw M5x12 DIN912
6 Spring washer B5 DIN127
7 Flat washer A5,3 DIN125

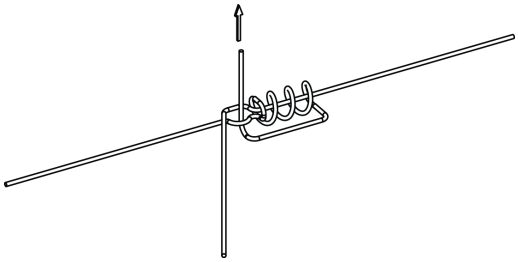
2. Slide a fluorocarbon line back and forth through the designated holes on the side plates, starting from the front of the ceilometer and continuing until the ends of the line meet on the back side of the ceilometer.
3. Adjust the line so that it is left slightly loose. Wrap both ends of the line around a screw, under the washer, and then tighten the screw.

4. Cut the remaining line ends short to avoid damage to the eyes when handling the ceilometer.

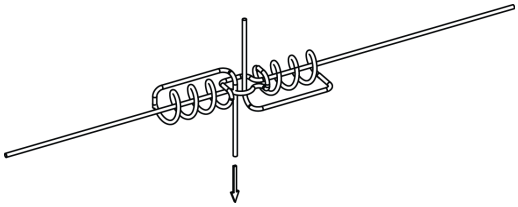
5. Tie the line ends together with a blood knot so that the line is left slightly loose.
   a. Cross both line ends.



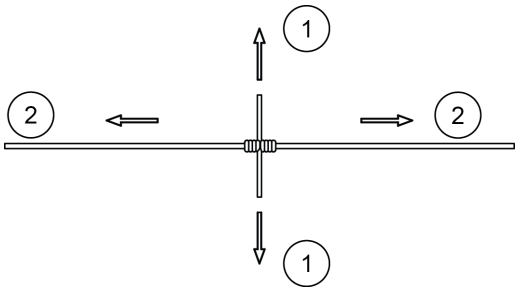
   b. Wind one wire end around the standing part of the other 3 times and pass the end on the other side.



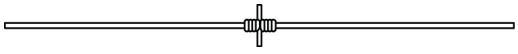
   c. Pinch the line and with the other hand wind the free end around the standing line in the opposite direction 3 times. Pass the end through the same loop but in the opposite direction.



   d. Hold in place the lines marked with (1) and pull those marked with (2), wet the knot and tighten.



   e. Trim tag ends.



6. Attach the optional bird perches to the side plates.

3.6 Assembling battery



WARNING! Do not replace the battery with a battery of an incorrect type. If you do, there is a risk of deflagration. Dispose of used batteries according to statutory regulations.



CAUTION! Make sure you do not short-circuit the battery.

The battery is delivered with the ceilometer, but it does not come attached to the measurement unit.



- Crosshead screwdriver
- 3-mm Allen key

1. Open the measurement unit door and loosen the 2 screws locking the lid of battery cage.

> Do not remove the screws entirely.

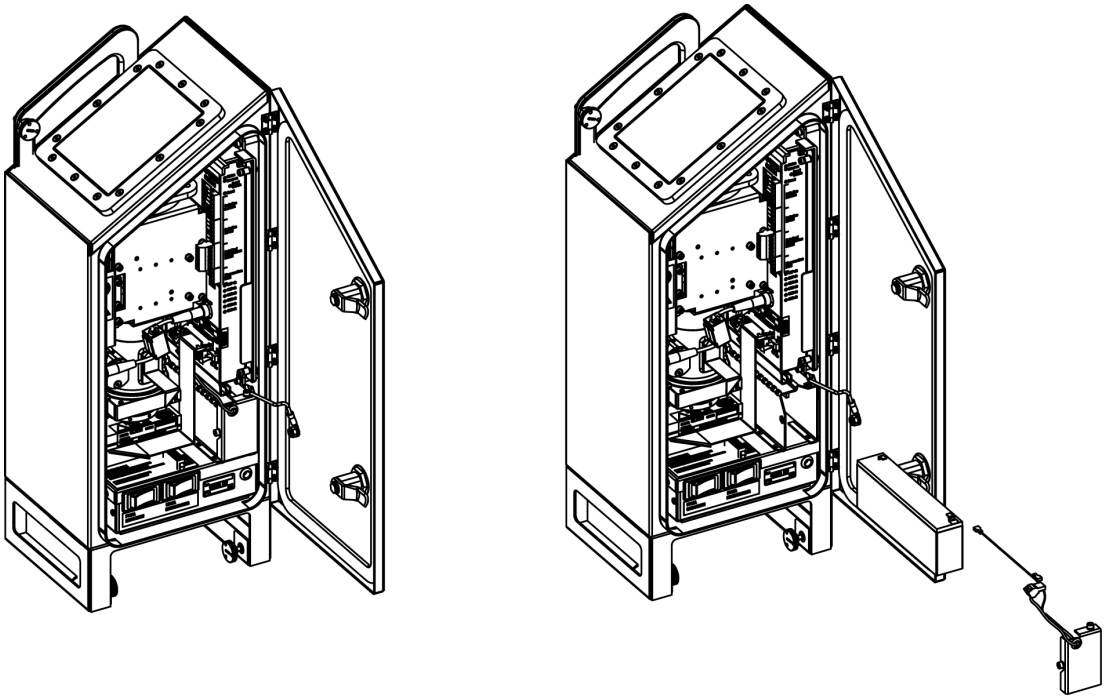
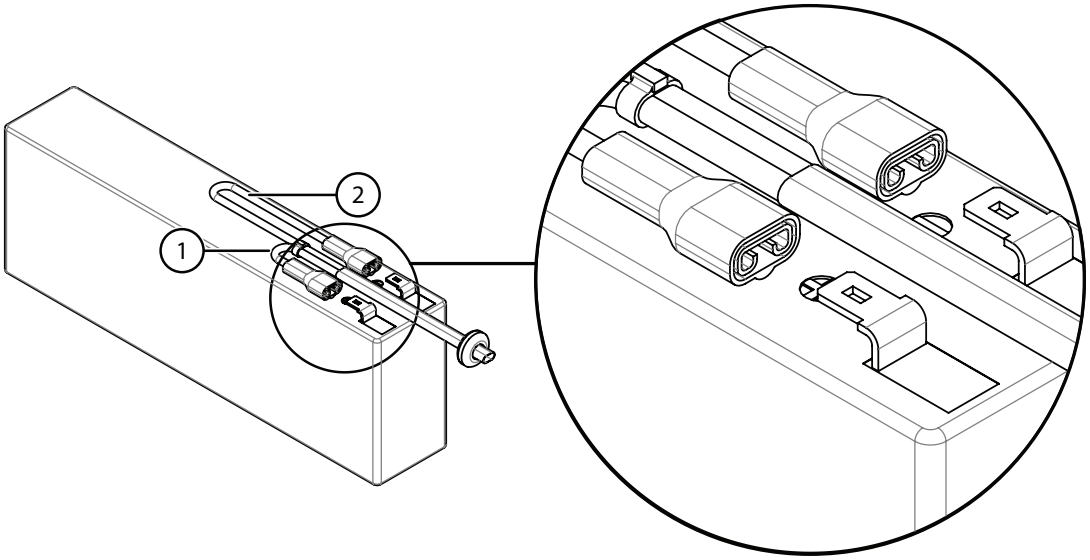


Figure 8 Assembling CL31 battery

2. Connect the battery cable to the new battery. Connect the red end to the positive (+) end terminal and the black end to the negative (-) end terminal.

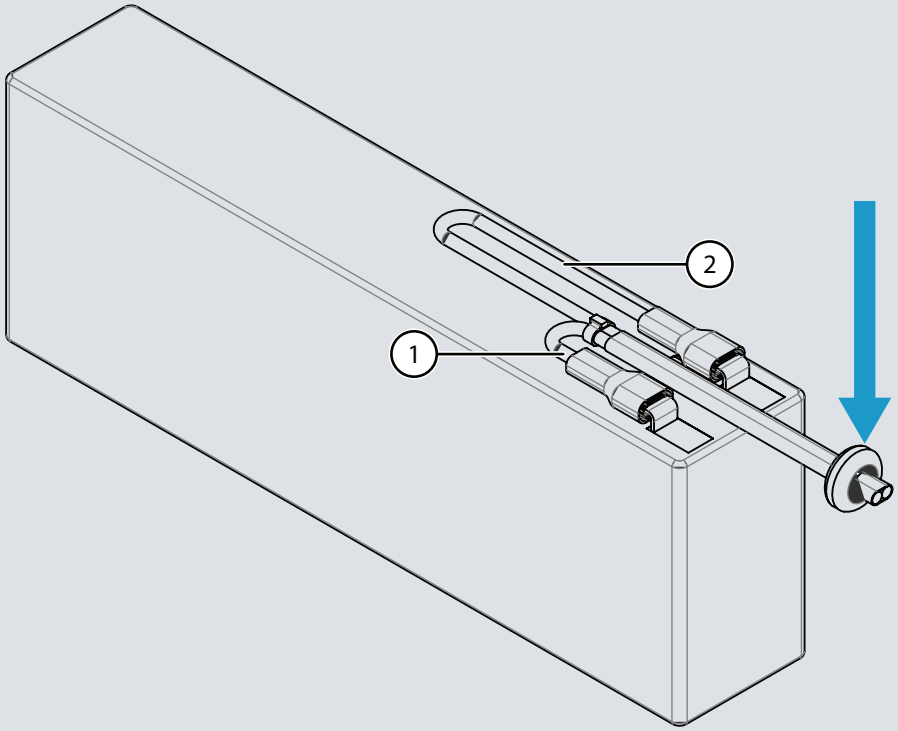
   Pay attention to the orientation of the wire connectors.



1 Red wire
2 Black wire

3. Open the battery cage lid and slide the battery into the battery cage.

Slide the grommet into the groove in the cover lid.



1 Red wire
2 Black wire

4. Close the battery cage lid and tighten the 2 screws to their places.
5. Make sure that the battery switch on the engine board is off.
6. Connect the battery cable to the engine board.

3.7 External connectors

All external connectors are located at the bottom of the measurement unit. The following figure shows the external connectors **J1**, **J2**, **J3**, and **J4**.

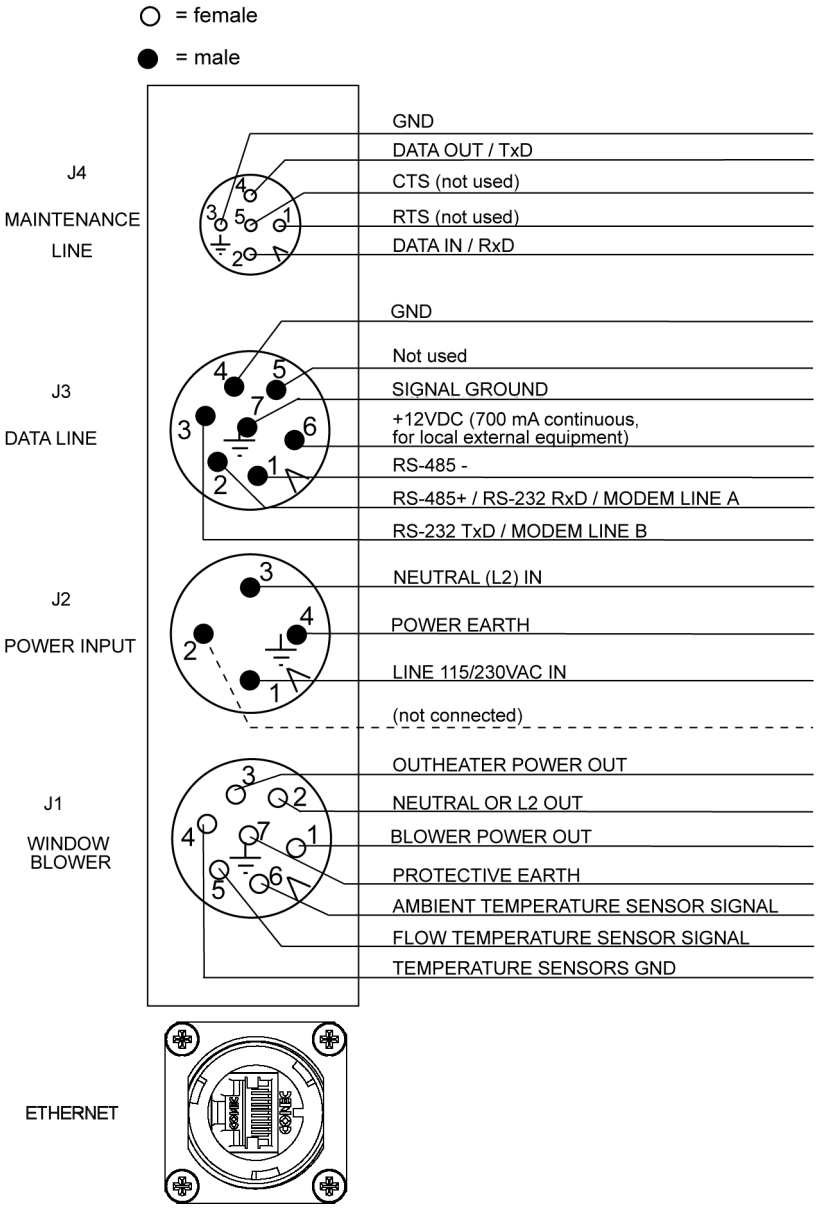


Figure 9 External connectors (bottom view)

You have the Ethernet connector only if you selected the LAN option when you placed the order.

Connector	Description
J1	The window blower mounted into the radiation shield is connected to **J1**.
J2	Line power is connected to **J2**. The power supply connector **J2** provides a standard protective ground for the instrument chassis.
J3	Remote communication is connected to **J3** in normal use.

Connector	Description
J4	A local maintenance terminal, such as a laptop, can be connected to **J4**. Use the provided protective cap for covering **J4** when it is not in use.

3.7.1 Connecting power supply

WARNING! Only licensed experts may install electrical components. They must adhere to local and state legislation and regulations.

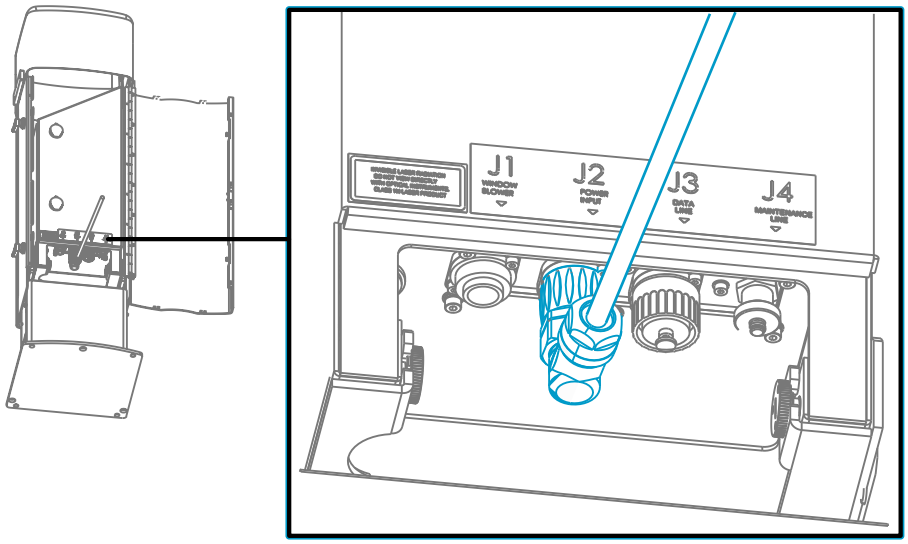
If you use the optional Termbox, make sure that the AC (mains) power cable material follows the UL/CSA C22.2 regulations. See UL/CSA C22.2 regulatory caution and warning statements (page 152).

WARNING! Use a copper (Cu) cable with a minimum cross-section of 3 x 1.5 mm^2 (15 AWG) that has the same operating temperature as the device.

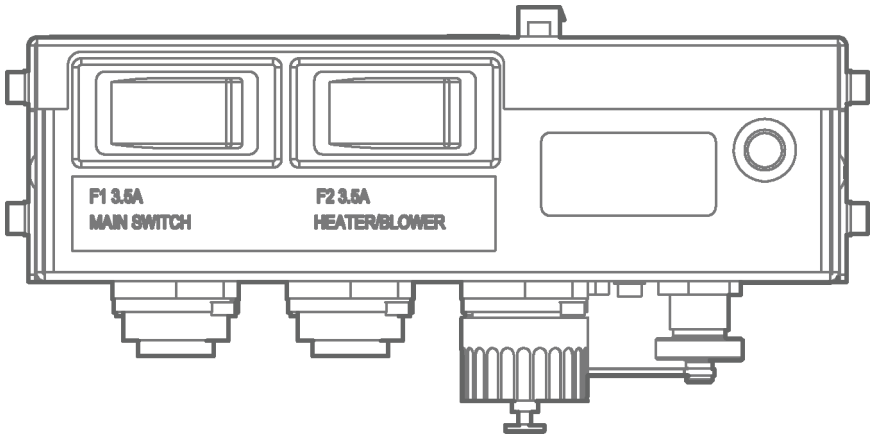
WARNING! The power supply must be protected with a fuse. The maximum sizes of the fuses protecting the power line:

- 10 A for 230 V power supply
- 15 A for 100 V / 115 V power supply

WARNING! If you do not have Termbox, the power input connector is the disconnecting device. To disconnect the ceilometer from the electrical network without Termbox, disconnect the power cable from connector **J2**.



1. Turn the **Main switch** and the **Heater/Blower** switches **OFF**.



2. Check the voltage of the power supply cable connector and plug in the AC (mains) power cable to connector **J2** at the bottom of the measurement unit.

J2 and **J3** include external mating connectors with a 2 m (7 ft) cable. You can remove the power plug from the **J2** cable when the unit is permanently installed at the site.

More information

‣ External connectors (page 36)

3.7.2 Data line connections

The ceilometer has the following data line options:

- RS-485 connection

- RS-232 connection
- LAN (Ethernet) connection (optional)

To change the connection type, see User commands (page 49).

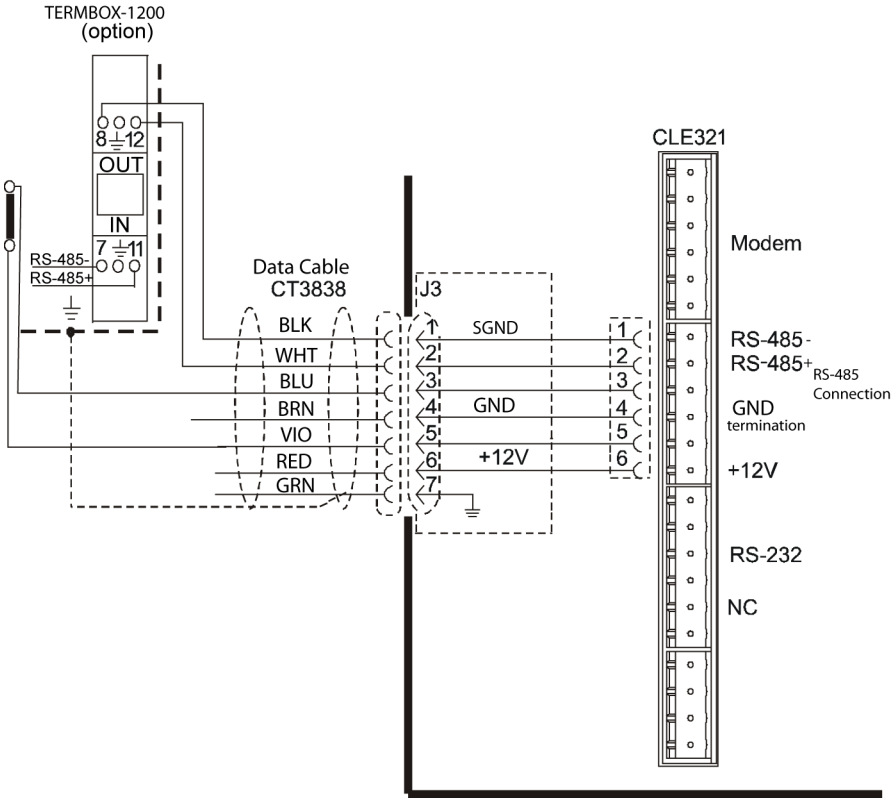


Figure 10 Data line RS-485 connection

The RS-485 connection is provided with a termination. If the ceilometer is connected to the end of a long line, consider connecting the 2 signals marked "termination" as shown in the previous figure. This can improve data transmission speed, quality, and reliability.

Table 6 Default settings for data line RS-485 connection

Setting	Value
Bit rate	19200
Data bits	8
Stop bits	1
Parity	None

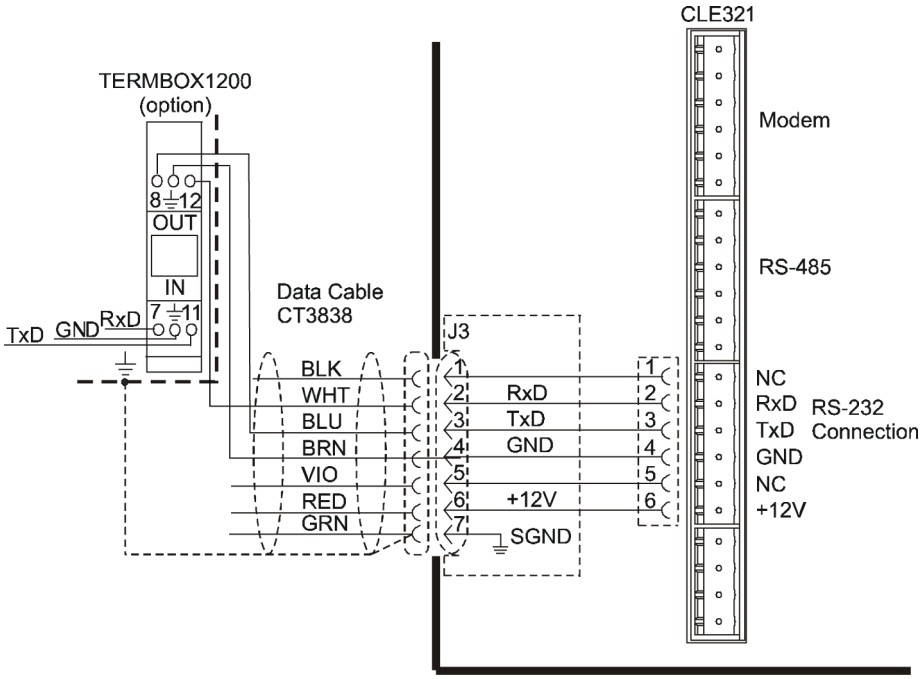


Figure 11 Data line RS-232 connection

Table 7 Default settings for data line RS-232 connection

Setting	Value
Bit rate	19200
Data bits	8
Stop bits	1
Parity	None
Handshake	None

3.7.3 Maintenance terminal connection

Use a flat head screwdriver to open the door.

You can use any terminal or laptop with a serial interface and a terminal emulation program for operating the ceilometer. The maintenance terminal connection is established with the QMZ101 maintenance cable, which connects the RS-232 port of the laptop to the maintenance port of the ceilometer.

3.7.3.1 Setting up maintenance terminal connection

1. Connect the RS cable to the ceilometer maintenance port (connector **J4**) and the terminal computer.
2. Configure the terminal:

Setting	Value
Bit rate	9600
Data bits	8
Stop bits	1
Parity	None
Handshake	None

3.7.3.2 Operating maintenance terminal connection

1. Turn on ceilometer power.
2. Open the maintenance line with the **open** command.

   The prompt `CEILO >` opens.

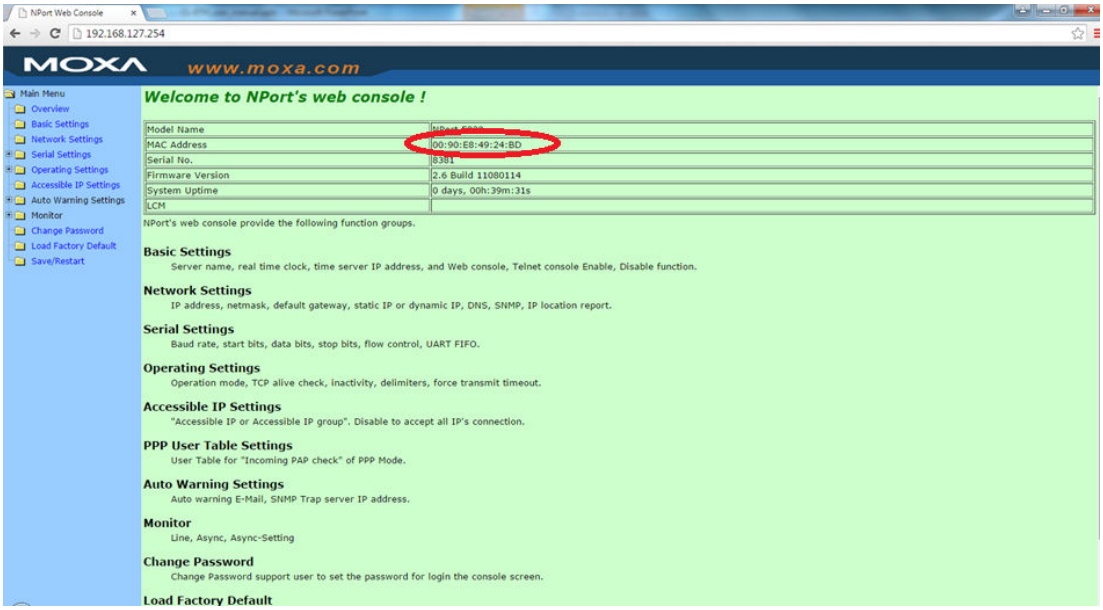
3.8 Setting up LAN connection

If you have the LAN output option or the air quality plug-and-play package, connect the laptop and the ceilometer to the Ethernet switch with Ethernet cables.

1. To open the LAN connection, connect the Ethernet cable to the laptop and to the ceilometer.

2. With the laptop Internet browser, go to *http://192.168.127.254/*.

   NPort Web console opens.



3. To change network settings, select **Network Settings**.

   If you use DHCP IP configuration, add the ceilometer MAC address to the allowed addresses on your DHCP server.

4. Select **Submit**.

More information

- External connectors (page 36)

3.9 Getting data from ceilometer

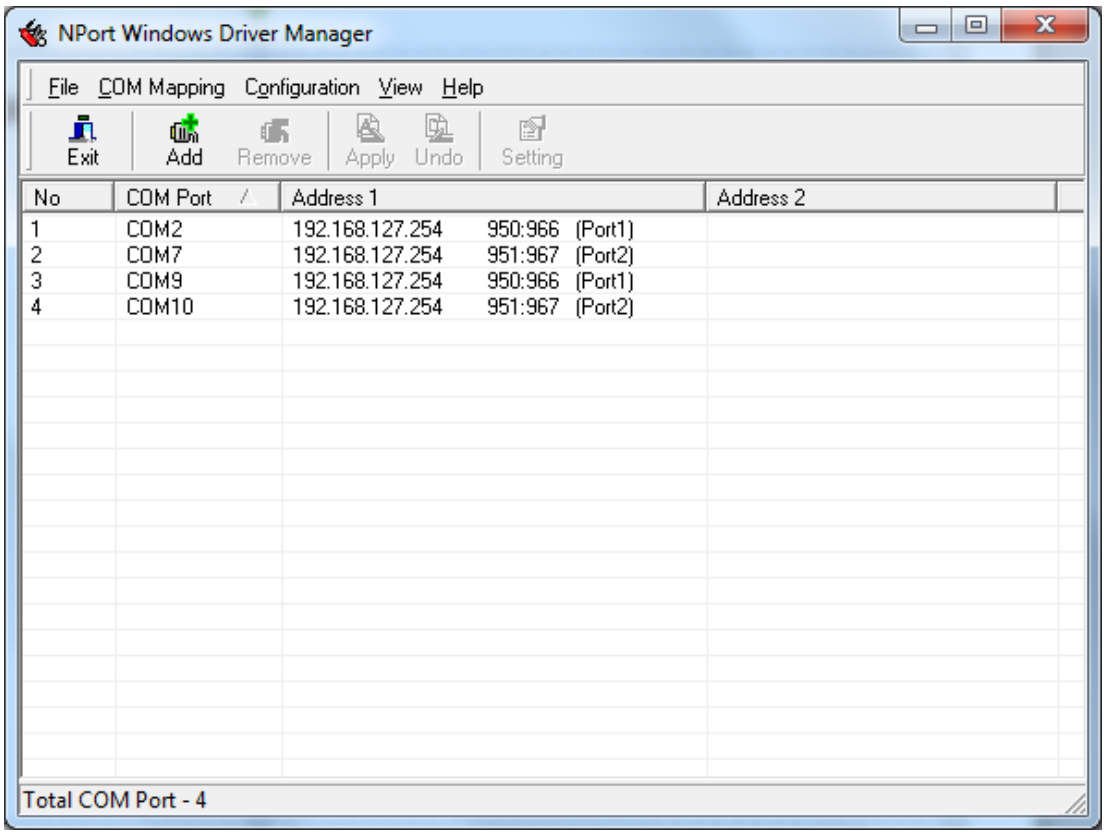
Ceilometer has the following modes for getting data from the ceilometer:

- Real COM mode
- TCP Client mode
- UDP mode

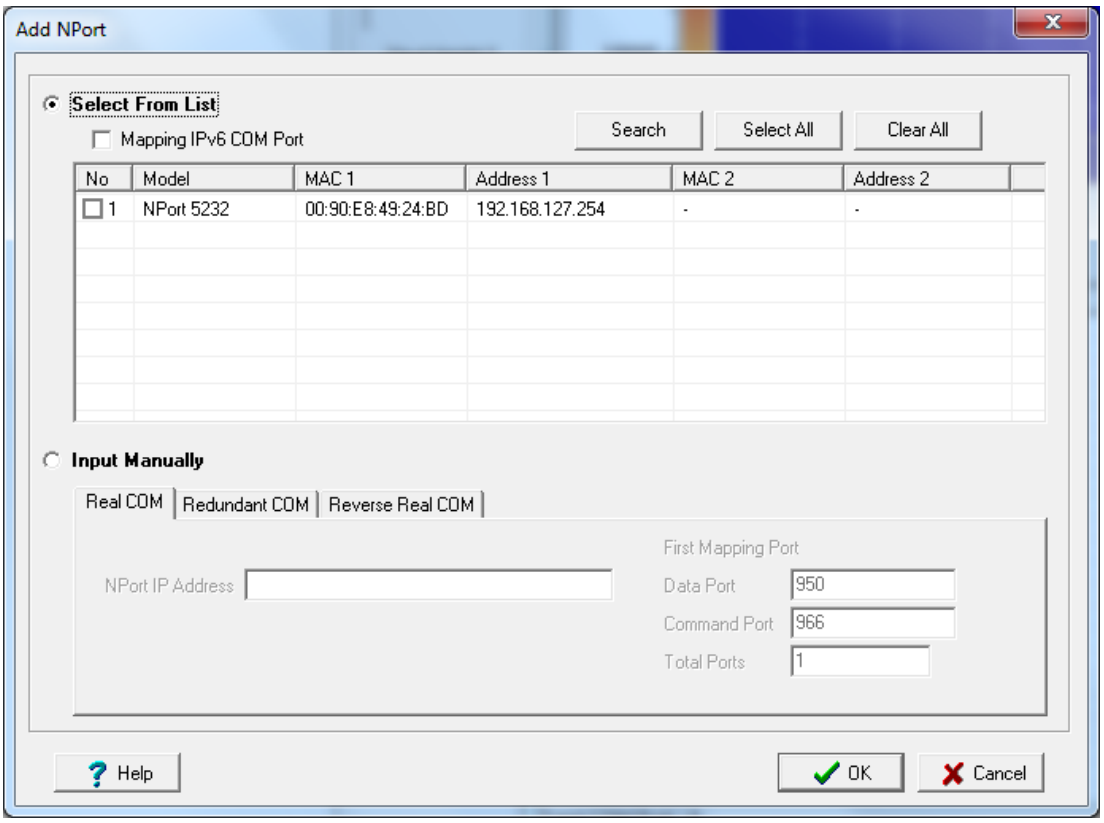
3.9.1 Entering real COM mode

1. Install and open NPort Windows Driver Manager:
   a. Download the NPort Windows Driver Manager file from
      http://www.moxa.com/support/download.aspx?d_id=1359
   b. Open the file and run installation.

2. Select **Add**.


NPort Windows Driver Manager
File COM Mapping Configuration View Help
Exit Add Remove Apply Undo Setting
No COM Port Address 1 Address 2
1 COM2 192.168.127.254 950:966 (Port1)
2 COM7 192.168.127.254 951:967 (Port2)
3 COM9 192.168.127.254 950:966 (Port1)
4 COM10 192.168.127.254 951:967 (Port2)
Total COM Port - 4

3. Select the correct NPort and **OK**.

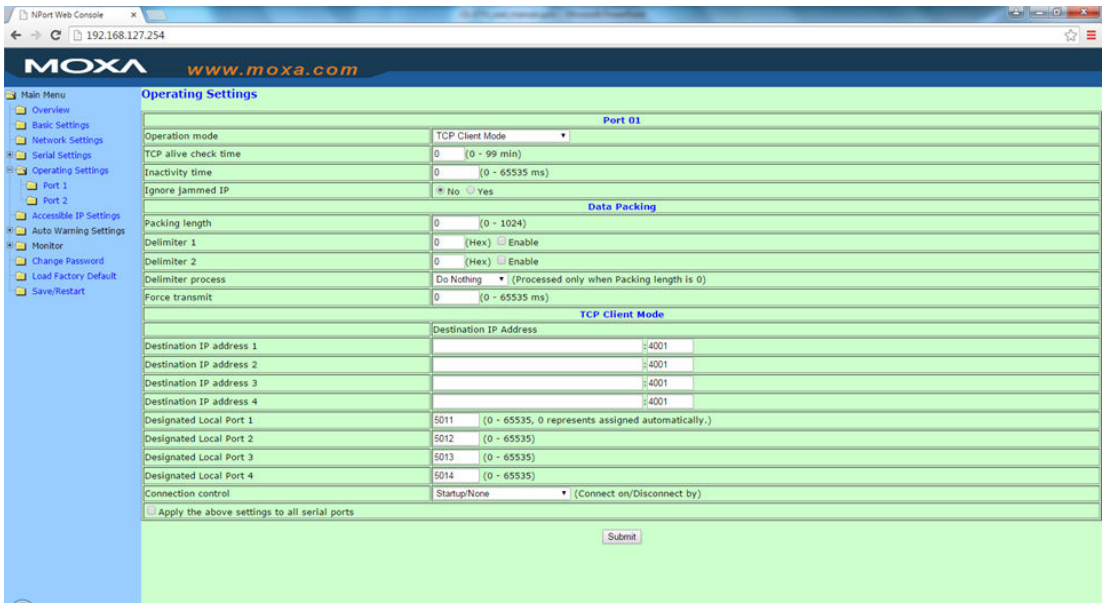


The created COM ports show in Windows Device Manager.

3.9.2 Entering TCP client mode

1. Select **Operating Settings**.
2. Select a port.

3. In **Operation Mode**, select **TCP Client Mode**.



4. In **Destination IP address 1**, type your destination address and port.

   You can add 4 destinations.

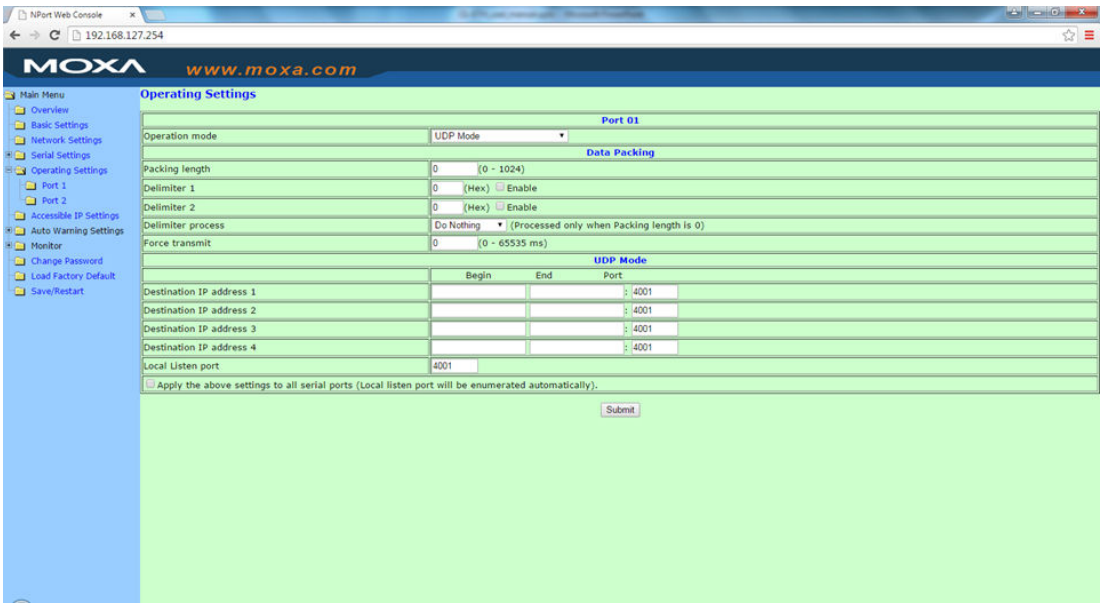
5. Select **Submit**.

3.9.3 Entering UDP mode

1. Select **Operating Settings**.
2. Select a port.

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3. In **Operation Mode**, select **UDP Mode**.



4. In **Destination IP address 1**, type your destination address and port.

   You can add 4 addresses.

5. Select **Submit**.

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4. Operation

4.1 Serial lines - open and closed port

The data line is used for measurement data communication and can be operated through a modem or a serial line (RS-232 or RS-485). It can also be used with a ceilometer maintenance terminal, PC, or other terminals. The maintenance line is for on-site maintenance access, and it is used only as an RS-232 serial line. It can be used with a ceilometer maintenance terminal, PC, or other terminal. Functionally the operation of the 2 lines is identical. The same commands, operations, and messages operate through both lines.

Ceilometer has the following line outputs:

- Data line (external connector **J3**)
- Maintenance line (external connector **J4**)

The factory default settings:

- 8 data bits
- No parity
- 1 stop bit and 9600 bps (for maintenance line)
- 19200 bps (for data line)

You can select the bit rate from the menu.

The lines use the 7-bit USASCII character format. Both the upper and lower case letters can be used.

The standard operation of the serial lines requires no handshake signals.

The communication port (the serial line), has the following internal states.

- CLOSED: This is the transmitting state of a measurement data message. Messages are transmitted as a response to a polling input string or automatically at predetermined intervals, depending on the settings (message transmission). User commands are not accepted, except for the **open** command, which turns the line into the OPEN state.
- OPEN: This is the user dialog state. The device responds to user commands and command input is echoed. A command prompt `CEILO >` indicates that the ceilometer is ready for command input from the user. Pressing **ENTER** executes the command, for example, **`OPEN 1 <enter>`**. No automatic transmission of the measurement data message is executed in the open state. The port reverts to the closed state with the **`close`** command. An automatic, 2-minute timeout after the last character input is applied. A 2 to 30-minute timeout may be set with the **`set port_timeout`** command. Command input echoing can be turned on or off by giving the command **`set echo on/off`**. When turned off, typed characters are not echoed, but the command responses are given normally. By default echoing is on.



Only one of the ports can be open for commands at a time. Only one of the ports transmits measurement messages at a time. Additionally, in the RS-485 mode, you must give the unit ID with the **open** command.

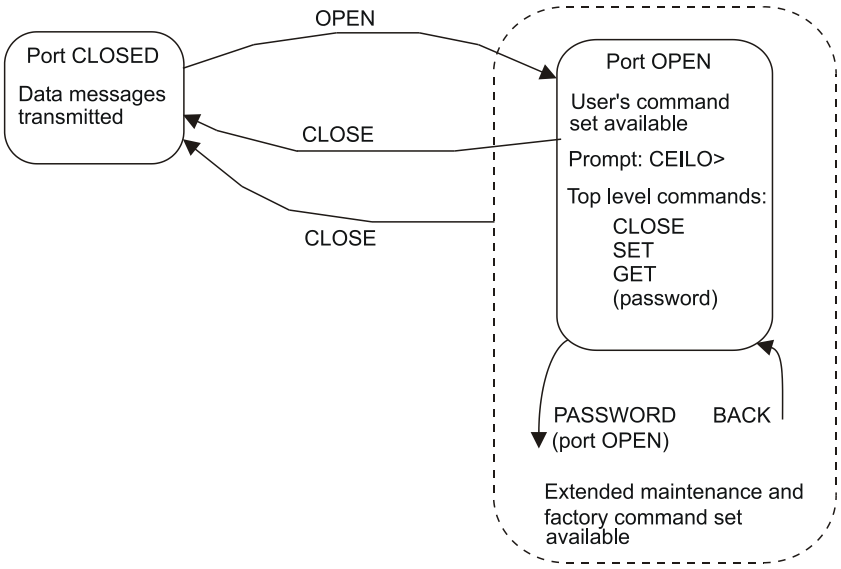


Figure 12 Open and closed port

4.2 Operation modes

There are 2 operation modes: normal and standby. The **`set oper_mode normal`** and **`set oper_mode standby`** commands are used to switch between the modes. In the normal mode, continuous measurement and message transmission occurs according to the chosen parameters. The standby mode, which involves turning off the wearing parts, can be used during periods when measurement is not needed.

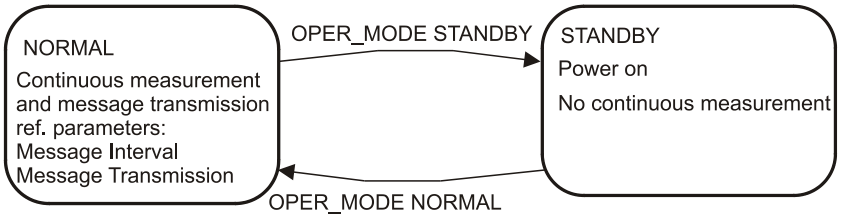


Figure 13 Operation modes

4.3 User commands

The following table describes the user commands. To access the user commands, open the line with the **open** command. You do not need a password.

The command line interpreter provides interactive support.

- At each menu level, pressing **ENTER** provides an output of the available menu.
- Inserting a letter and **ENTER** outputs all commands starting with that letter.
- Inserting 2 letters and **ENTER** outputs all commands that start with the 2 letters, and so on, until only the desired command is left.
- You can execute the commands by pressing **ENTER**.

In addition to the user menu and the user level command set, there is a second in-depth maintenance and service level menu and command set for more profound system changes and diagnostics.

Table 8 User level commands

Command	Description
close	Closes a user interface. Releases a port for message transmission.
get diag contamination	Prints diagnostic history of window contamination.
get diag angle	Prints diagnostic history of inclinometer angle.
get diag battery	Prints diagnostic history of internal battery voltage.
get diag int_temp	Prints diagnostic history of internal temperature.
get diag l_power	Prints diagnostic history of laser power.
get diag l_temp	Prints diagnostic history of laser temperature.
get failure history	Prints history of alarm and warning status.
get failure status	Shows active alarms and warnings.
get params data_acq	Prints data-acquisition related parameters.
get params factory	Prints factory calibration values.
get params message	Prints message related parameters.
get params port	Prints serial port and modem parameters.
get sensors	Prints data-acquisition values, tilt angles, and humidity, if available.
get temperatures	Displays temperatures.
get uptime	Displays uptime clock.
get voltages	Displays voltages.
name	Displays device type, name, and ID.
open	Opens a user interface.
reset	Resets the ceilometer using the watchdog reset.
set control blower on	Sets the window blower on.
set control blower off	Sets the window blower off.
set control blower manual	Sets manual control.
set control blower auto	Sets automatic control.
set control inheater on	Sets inheater on.
set control inheater off	Sets inheater off.
set control inheater manual	Sets manual control.
set control inheater auto	Sets automatic control.

Command	Description
set control outheater on	Sets outside heater on.
set control outheater off	Sets outside heater off.
set data_port baud 115.2 k	Data serial port speed
set data_port baud 57.6 k	Data serial port speed
set data_port baud 38.4 k	Data serial port speed
set data_port baud 19.2 k	Data serial port speed
set data_port baud 9600	Data serial port speed
set data_port baud 4800	Data serial port speed
set data_port baud 2400	Data serial port speed
set data_port baud 1200	Data serial port speed
set data_port baud 300	Data serial port speed
set data_port mode RS-232	Data serial port mode
set data_port mode RS-485	Data serial port mode
set data_port parity 7E1	Data serial port settings
set data_port parity 7O1	Data serial port settings
set data_port parity 7N2	Data serial port settings
set data_port parity 8N1	Data serial port settings
set defaults	Restores the following default settings: • Operation mode: **normal** • Measurement mode: **standard** • Data acquisition autoadjustments: **on** • Blower control: **auto** • Inheater control: **auto** • Diagnostics intervals: **2 min** • Power-save mode: **disabled** • Power-save sleep interval: **60 s** • Message angle correction: **on** • Message transmission: **periodic** • Message secondary transmission: **none** • Message transmission delay: **100 ms** • Message height-offset: **0** • Message interval: **2 s** • Message secondary interval: **2 s** • Manual message: **disabled** • Message port: **data** • Message profile scale: **1.0** • Message profile noise-h2: **off** • Message type: **msg2_base** • Message secondary type: **none** • Message units: **feet** • Message VV limit ceiling: **6562 ft (2000 m)** • Port timeout: 2 min • Unit ID: **0** • Echo: **on**

Command	Description
set diag interval angle	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval battery	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval contam	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval int_temp	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval l_power	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval l_temp	Sets diagnostic-data logging interval (min). 0 disables.
set diag clear	Clears all diagnostic-data history.
set echo on	Sets command input echoing on.
set echo off	Sets command input echoing off.
set failure history clear	Clears failure history.
set maint_port baud 115.2 k	Maintenance serial port speed.
set maint_port baud 57.6 k	Maintenance serial port speed
set maint_port baud 38.4 k	Maintenance serial port speed
set maint_port baud 19.2 k	Maintenance serial port speed
set maint_port baud 9600	Maintenance serial port speed
set maint_port baud 4800	Maintenance serial port speed
set maint_port baud 2400	Maintenance serial port speed
set maint_port baud 1200	Maintenance serial port speed
set maint_port baud 300	Maintenance serial port speed
set maint_port parity 7E1	Maintenance serial port settings
set maint_port parity 7O1	Maintenance serial port settings
set maint_port parity 7N2	Maintenance serial port settings
set maint_port parity 8N1	Maintenance serial port settings
set message transmission delay	Sets request-based delivery response delay (ms).
set message transmission request	Sets message request-based delivery.
set message interval [2 ... 120]	Sets message delivery interval in seconds.
set message port data	Delivers messages into data port.
set message port maintenance	Delivers messages into maintenance port.
set message secondary interval <interval>	Sets secondary message delivery interval in seconds.

Command	Description
set message secondary transmission none	Disables secondary message.
set message secondary transmission periodic	Sets periodic secondary message transmission.
set message secondary transmission request	Sets secondary message request-based delivery.
set message secondary type <message type>	Sets secondary message types, as in **set message type**.
set message type msg1_10x770	Sets Msg1 with 10x770 profile.
set message type msg1_20x385	Sets Msg1 with 20x385 sample profile with 385 samples and 20 m resolution.
set message type msg1_5x1500	Sets Msg1 with 5x1500 profile.
set message type msg1_5x770	Sets Msg1 with 5x770 profile.
set message type msg1_base	Sets Msg1 without a profile.
set message type msg2_10x770	Sets Msg2 with 10x770 profile.
set message type msg2_20x385	Sets Msg2 with 20x385 profile.
set message type msg2_ 5x1500	Sets Msg2 with 5x1500 profile.
set message type msg2_ 5x770	Sets Msg2 with 5x770 profile.
set message type msg2_base	Sets Msg2 without a profile.
set message type status	Sets status message.
set message type ld40_std_tg	Sets LD40 Standard Telegram.
set message type ct25k_msg1	Sets CT25K message 1.
set message type ct25k_msg6	Sets CT25K msg6 / CT25KAM msg60.
set message type ct25k_msg61	Sets CT25KAM msg61.
set message type ct12k_dmsg2	Set CT12K message no. 2.
set message type ct12k_dmsg3	Set CT12K message no. 3.
set modem v21 answer	Sets modem to answer with v21.
set modem v21 originate	Sets modem to call with v21.
set modem v22 answer	Sets modem to answer with v22
set modem v22 originate	Sets modem to call with v22.
set modem v22bis answer	Sets modem to answer with v22bis.
set modem v22bis originate	Sets modem to call with v22bis.
set modem off	Disables the communication module and uses serial line communication.
set name <string>	Sets the unit name.

Command	Description
set oper_mode standby	Sets standby mode. Profile sampling is inactive.
set oper_mode normal	Sets normal operation.
set port_timeout 0 ... 30	Sets the command line time-out to 0 ... 30 minutes. 0 disables.
set unit_id <character>	Sets the unit ID.
status	Prints the status message.
system	Lists system information: type, ID, SW version, HW modules, serial number.
version	Displays the SW version.



Use the advanced level commands only as described in this manual.

The advanced level commands are described in the following table. The password for this level is **advanced**.

Table 9 Advanced level commands

Command	Description
back	Go back one security level. Go back to the user level commands.
dump	Outputs all settings and diagnostics data. Includes the responses of the following commands: **system**, **status**, **get failure status**, **get failure history**, **get params factory**, **get params message**, **get params port**, **get params algorithm**, and **get failure diag**.
get failure diag	Shows failure diagnostics data.
get params algorithm	Prints cloud algorithm related parameters.
service replace_instr battery	Prints service instructions for replacing an internal battery.
service replace_instr cle_engine_board	Prints service instructions for replacing CLE321 engine board.
service replace_instr clp_ac_power	Prints service instructions for replacing CLP321 power unit.
service replace_instr clr_receiver	Prints service instructions for replacing CLR321 receiver.
service replace_instr clt_transmitter	Prints service instructions for replacing CLT321 transmitter.
service self_check	Runs the self-check.

Command	Description
service spare_part cle_engine mark	Marks CLE spare part status.
service spare_part cle_engine clear	Clears CLE spare part status.
service spare_part clt_transmitter mark	Marks CLT spare part status.
service spare_part clt_transmitter clear	Clears CLT spare part status.
service spare_part show_state	Shows spare part status of CLE and CLT.
service sw_update	Updates the software.
set data_acq autoadj on	Sets SW control of data acquisition parameters.
set data_acq autoadj off	Disables SW control of data acquisition parameters.
set data_acq meas_mode standard	Maximum range 7700 m, 10 m resolution, laser pulse rate 10 kHz.
set data_acq meas_mode high_res	Maximum range 7550 m, 5 m resolution, laser pulse rate 8 kHz.
set data_acq power_save disable	Disables power-save mode.
set data_acq power_save enable	Enables power-save mode.
set data_acq power_save interval 30 ... 30000	Power-save interval in seconds. Default is 60.
set data_acq receiver gain low	Sets receiver to low gain.
set data_acq receiver gain high	Sets receiver to high gain.
set data_acq transmit length_of_p short	Sets transmitter to short pulse.
set data_acq transmit length_of_p long	Sets transmitter to long pulse.
set data_acq transmit inlaser 0 ... 4095	Sets control value for laser pulse.
set factory calibr_outlaser	Starts automatic calibration of target outlaser.
set factory cross_talk	Calibrates factory cross talk.
set factory opt_sensit	Sets optics sensitivity.
set factory outlaser 0 .. 2500	Sets target outlaser.
set factory receiver_type clr311	Sets receiver type to CLR311.
set factory receiver_type clr321	Sets receiver type to CLR321.
set factory win_clean	Sets window clean status for window condition calibration.
set message angle_corr on	Heights in messages are corrected for the tilt angle.
set message angle_corr off	Heights in messages are not corrected for the tilt angle.

Command	Description
set message height_offset <value>	Sets height offset in current units. (Range is -304 ... 304 m or -1000 ... 1000 ft.) Positive values are added to and negative values are subtracted from the measured height.
set message manual_msg <string>	Sets a manual message. Empty string disables.
set message profile scale	Scaling factor for range gate data (%)
set message profile noise_h2 on	Normalizes range gate data, even noise.
set message profile noise_h2 off	Normalizes range gates data, if backscatter is contained.
set message units feet	Reported height unit is feet.
set message units meters	Reported height unit is meters.
set message vv_limit ceiling	Sets vertical visibility ceiling limit (meters/feet). No vertical visibility will be reported above this limit. (Default: 2000 m).
set option humitter on	Enables the humitter option.
set option humitter off	Disables the humitter option.
set option sky_cond off	Disables the sky condition option.
set option sky_cond on 0 .. 99999	Enables the sky condition option with an option code.

4.4 Switch settings

The switch settings for normal operation:

Switch	Setting
Main circuit breaker **F1**	ON
Heater/Blower circuit breaker **F2**	ON
Battery switch	ON

The data message and interface configuration and the configuration of measuring interval and transmission speed are standard factory settings. You can change them by giving commands from the terminal.

Optical adjustments have been made at the factory or depot. There is no need to readjust them in the field.



To switch the ceilometer fully off, turn off the battery switch and **J2**. Having the unit on with the battery supply drains the battery.

4.5 Opening maintenance terminal connection

1. Switch on ceilometer power.
2. Open the maintenance terminal connection with the **open** command.

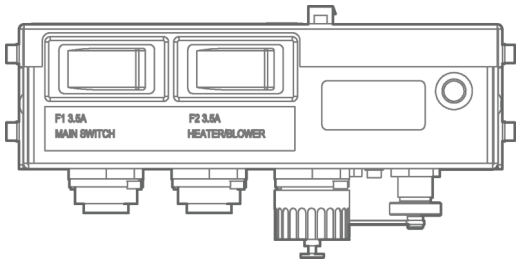
The `CEILO >` prompt opens.

4.6 Starting ceilometer

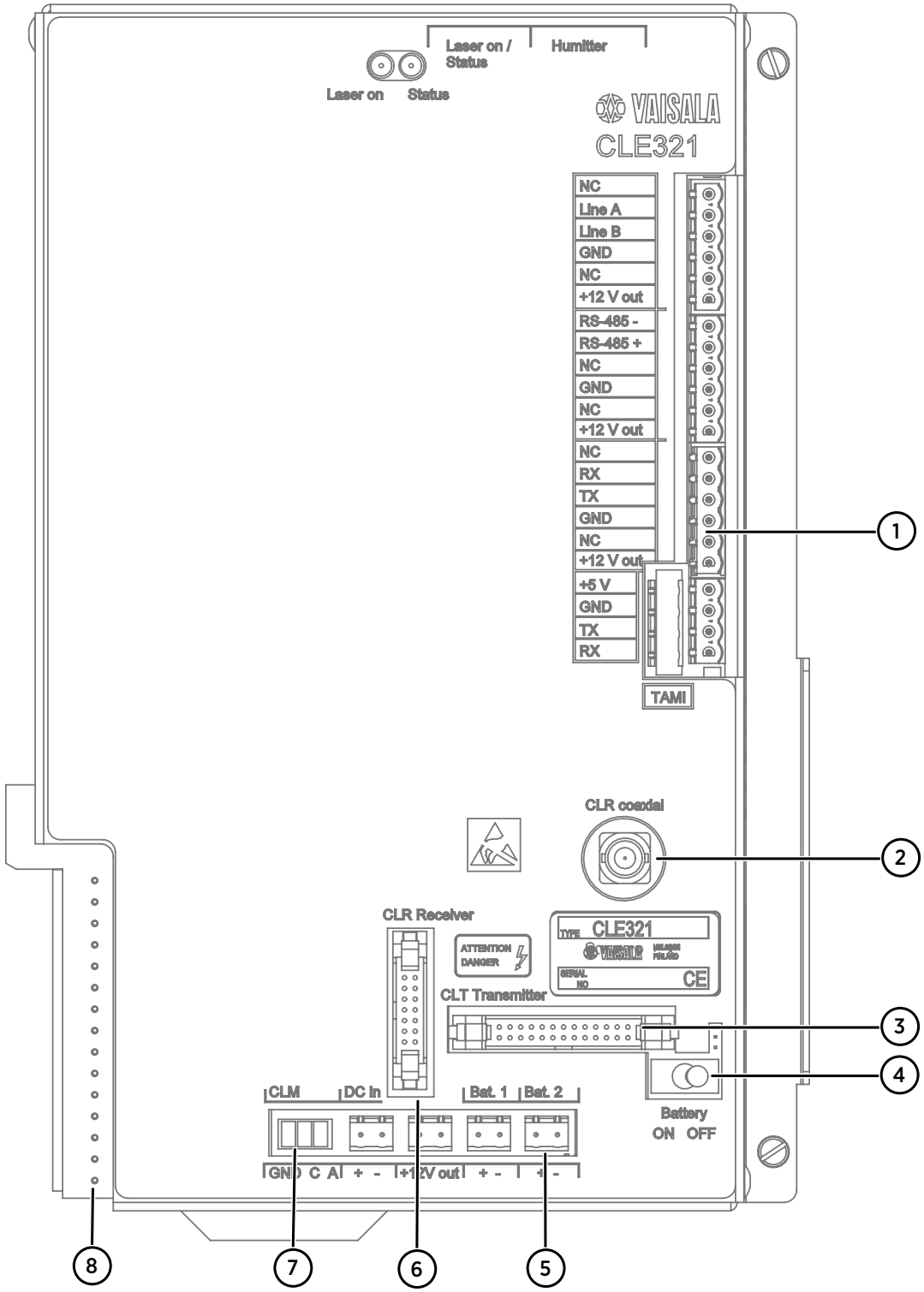
1. Open the unit door and make sure the internal connectors and subassemblies are intact.

> **WARNING!** Make sure that nobody is viewing the unit from the beam direction with magnifying optics.

2. Turn the **Main switch**, the **Heater/blower** switch, and the battery switch **ON**.



After initialization, the **Laser on** LED starts blinking at 2-second intervals. Also the 6 diagnostic LEDs light up.



1 Data line connection to AC power CLP321
2 Coaxial cable connection to receiver CLR321
3 Connection to transmitter CLT321
4 Battery switch
5 Connection to battery
6 Connection to receiver CLR321

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7 Connection to laser monitor board CLM311
8 Connection to AC power CLP321

More information

- Replacing laser transmitter (page 103)

4.7 Data messages

To ease the use of the ceilometer and to ease the transfer from older ceilometer versions to the new one, the ceilometer includes data messages used in CT12K, CT25K, CT25KAM, and LD40. The ceilometer provides the following data messages:

- CL31 data messages No. 1 and 2
- CL31 status message
- CT12K data messages No. 2 and No. 3
- CT25K data messages No. 1 and No. 6
- CT25KAM data messages No. 60 and No. 61
- LD40 standard telegram

Each port can be set to transmit a specified message automatically. Alternatively, the port can be set to transmit the set message only when polled by a predetermined polling string, or the polling string can contain the message identification.

The messages may provide a different resolution and require a different measurement mode. A change of a message always switches into the correct measurement mode automatically.

However, the status message and data messages No. 1 and 2 of subclass 5 (without profile data) may be used in both 10 m and 5 m resolutions. A selection of these messages always activates the 10 m resolution (standard mode). If needed, users can change into the 5 m resolution (high resolution) by typing the following advanced level command: **`set data_acq meas_mode high_res`**. The above messages work in 5 m resolution.



All characters are 7-bit USASCII.
In this document:

- [CRLF] = Carriage return + line feed (2 characters)
- [SH] = Start of header
- [SX] = Start of text
- [EX] = End of text
- [ET] = End of transmission

4.7.1 Secondary message

Two different messages can be separately output on the two ports. This is enabled by configuring a secondary message using the command **`set message secondary`**. The secondary message is always output to the other port, meaning that the port is not configured for the primary message. Note that if both messages contain a backscatter profile, the message intervals must not be set to values lower than 4 seconds.

4.7.2 CL31 data messages No. 1 and 2

Data message No. 1 contains cloud height/vertical visibility measurement and elementary status information that enables a host system or operator to see that no warnings or alarms are present. This message also includes a range and sensitivity normalized backscatter profile that is suitable, for example, for a graphical data presentation or research purposes. In addition to the content of data message No. 1, data message No. 2 also includes sky condition data.

The data resolution is 5 m/10 m/20 m (16 ft/33 ft/66 ft) in distance, and 20 bits (5 hex-ASCII characters) in signal magnitude.

An example of CL31 data message No. 1:

```
[SH]CLA10011[SX][CRLF]                                    1st line    12 char.
30 01230 12340 23450 FEDCBA987654[CRLF]                   2nd line    35 char.
00100 10 0770 098 +34 099 12 0621 L0112HN15 139[CRLF] 3rd line    49 char.
00000111112222233333 ... (5 x 770 bytes)[CRLF]            4th line    3852 char.
[EX]1a3f[ET][CRLF]                                        5th line    8 char.
                                                          Total       3956 char.
```

An example of CL31 data message No. 2:

```
[SH]CLA10021[SX][CRLF]                                    1st line    12 char.
30 01230 12340 23450 FEDCBA987654[CRLF]                   2nd line    35 char.
  3 055  5 170  0 ///  0 ///  0 ///[CRLF]                 3rd line    37 char.
00100 10 0770 098 +34 099 12 0621 L0112HN15 139[CRLF] 4th line    49 char.
00000111112222233333 ... (5 x 770 bytes)[CRLF]            5th line    3852 char.
[EX]1a3f[ET][CRLF]                                        6th line    8 char.
                                                          Total       3993 char.
```

For data lines with low bandwidth, there is also a base version of each message. In the base version of message No. 1, lines 3 and 4 are left out. In the base version of message No. 2, lines 4 and 5 are left out. In the following table, the data message types are summarized with the minimum bit rates and storage capacity.

The minimum reporting interval is 6 s.

The examples are divided into measurement resolutions of 10 m and 5 m. They have minimum reporting intervals of 2 s and 3 s, respectively.

Table 10 Messages with 10 m resolution (standard mode)

Message number and subclass	Message name	Length (bytes)	Min bps (2 s)	Data/ month (2 s)	Min bps (12 s)	Data/ month (12 s)
11	`msg1_10x770`	3956	28.8k	4890 MB	4800	815 MB
12	`msg1_20x385`	2031	14.4k	2510 MB	2400	418 MB

Message number and subclass	Message name	Length (bytes)	Min bps (2 s)	Data/ month (2 s)	Min bps (12 s)	Data/ month (12 s)
15	msg1_base	55	300	68 MB	300	11 MB
21	msg2_10x770	3993	28.8k	4940 MB	4800	423 MB
22	msg2_20x385	2068	14.4k	2560 MB	2400	425 MB
25	msg2_base	92	600	114 MB	300	19 MB

Table 11 Messages with 5 m resolution (high resolution)

Message number and subclass	Message name	Length (bytes)	Min bps (3 s)	Data/ Month (3 s)	Min bps (15 s)	Data/ Month (15 s)
13	msg1_5x1500	7606	28.8k	6267 MB	9600	1253 MB
14	msg1_5x770	3956	14.4k	3260 MB	4800	625 MB
15	msg1_base	55	300	45 MB	300	9 MB
23	msg2_5x1500	7643	28.8k	6230 MB	9600	1260 MB
24	msg2_5x770	3993	14.4k	3290 MB	4800	660 MB
25	msg2_base	92	600	76 MB	300	15 MB

The interpretation of the message lines is as follows:

1ST LINE

Example:

```
[SH]CLA10011[SX][CRLF]
```

[SH]	Start of heading
CL	Ceilometer identification string, always CL
A	Unit identification character 0 ... 9, A ... Z
100	Software level ID 100 ... 999
1	Message number 1 = message without sky condition data 2 = message with sky condition data

1	Character for subclasses of message 1 = 10 m x 770 samples, range 7700 m (**msg1_10x770**) 2 = 20 m x 385 samples, range 7700 m (**msg1_20x385**) 3 = 5 m x 1500 samples, range 7500 m (**msg1_5x1500**) 4 = 5 m x 770 samples, range 3850 m (**msg1_5x770**) 5 = without a backscatter profile
[SX]	Start of text
[CRLF]	Carriage return + line feed

2ND LINE

Example:

```
30 01230 12340 23450 FEDCBA987654[CRLF]
```

3	Detection status:	Detection status as follows:
	0	No significant backscatter
	1	One cloud base detected
	2	Two cloud bases detected
	3	Three cloud bases detected
	4	Full obscuration determined but no cloud base detected
	5	Some obscuration detected but determined to be transparent
	/	Raw data input to algorithm missing or suspect
0	Warning and alarm information:	Warning and alarm information as follows:
	0	Self-check OK
	W	At least one warning active, no alarms
	A	At least one alarm active
01230	Lowest cloud base height	If detection status is 1, 2, or 3
	Vertical Visibility as calculated	If detection status is 4
	/////	If detection status is 0 or 5
12340	Second lowest cloud base height	If detection status is 2 or 3
	Highest signal detected	If detection status is 4
	/////	If detection status is 0, 1, or 5

23450	Highest cloud base height	If detection status is 3
	/////	If detection status is 0, 1, 2, 4, 5

The message ends with FEDCBA987654.

It contains alarm (A), warning (W), and internal status (S) information. Each character is a hexadecimal representation of 4 our bits, that is, values between 0 and 9 are presented with numbers and values 10, 11, 12, 13, 14, and 15 are presented with letters A, B, C, D, E, and F, respectively. As each of the 12 characters represent the sum of four individual bits, the total number of bits is 48 (b00-b47), with the following breakdown and interpretation:

F:	b47	(8000 0000 0000)	Transmitter shut-off (A)
	b46	(4000 0000 0000)	Transmitter failure (A)
	b45	(2000 0000 0000)	Receiver failure (A)
	b44	(1000 0000 0000)	Voltage failure (A)
E:	b43	(0800 0000 0000)	(Spare) (A)
	b42	(0400 0000 0000)	Memory error (A)
	b41	(0200 0000 0000)	Light path obstruction (A)
	b40	(0100 0000 0000)	Receiver saturation (A)
D:	b39	(0080 0000 0000)	(spare) (A)
	b38	(0040 0000 0000)	(spare) (A)
	b37	(0020 0000 0000)	(spare) (A)
	b36	(0010 0000 0000)	(spare) (A)
C:	b35	(0008 0000 0000)	(spare) (A)
	b34	(0004 0000 0000)	(spare) (A)
	b33	(0002 0000 0000)	Coaxial cable failure (A)
	b32	(0001 0000 0000)	Ceilometer engine board failure (A)
B:	b31	(0000 8000 0000)	Window contamination (W)
	b30	(0000 4000 0000)	Battery voltage low (W)
	b29	(0000 2000 0000)	Transmitter expires (W)
	b28	(0000 1000 0000)	High humidity (W)
A:	b27	(0000 0800 0000)	(spare) (W)
	b26	(0000 0400 0000)	Blower failure (W)
	b25	(0000 0200 0000)	(spare) (W)
	b24	(0000 0100 0000)	Humidity sensor failure (W)

9:	b23	(0000 0080 0000)	Heater fault (W)
	b22	(0000 0040 0000)	High background radiance (W)
	b21	(0000 0020 0000)	Ceilometer engine board failure (W)
	b20	(0000 0010 0000)	Battery failure (W)
8:	b19	(0000 0008 0000)	Laser monitor failure (W)
	b18	(0000 0004 0000)	Receiver warning (W)
	b17	(0000 0002 0000)	Tilt angle > 45 degrees warning (W)
	b16	(0000 0001 0000)	(spare) (W)
7	b15	(0000 0000 8000)	Blower is on (S)
	b14	(0000 0000 4000)	Blower heater is on (S)
	b13	(0000 0000 2000)	Internal heater is on (S)
	b12	(0000 0000 1000)	Working from battery (S)
6	b11	(0000 0000 0800)	Standby mode is on (S)
	b10	(0000 0000 0400)	Self-test in progress (S)
	b09	(0000 0000 0200)	Manual data acquisition settings are effective (S)
	b08	(0000 0000 0100)	(spare) (S)
5	b07	(0000 0000 0080)	Units are meters if on, else feet (S)
	b06	(0000 0000 0040)	Manual blower control (S)
	b05	(0000 0000 0020)	Polling mode is on (S)
	b04	(0000 0000 0010)	(spare) (S)
4	b03	(0000 0000 0008)	(spare) (S)
	b02	(0000 0000 0004)	(spare) (S)
	b01	(0000 0000 0002)	(spare) (S)
	b00	(0000 0000 0001)	(spare) (S)

For example, if no clouds are detected, if the window is contaminated, the battery voltage is too low, the internal heater is on and units are meters, a warning is given, and the second line appears as follows:

```
0W  ///// ///// /////  0000C0002080
```

ADDITIONAL 3RD LINE IN MESSAGE NO. 2

Example:

```
3 055 5 170 0 /// 0 /// 0 ///[CRLF]
```

The line starts with 2 space characters.

3	Detection status:	
	0 ... 8	Cloud coverage of the first layer in octas
	9	Vertical visibility
	-1	Data missing, sky condition option not active or ceilometer in standby mode
	99	Not enough data (after start-up)
055	Height of the 1st cloud layer (550 m or 5500 ft depending on the units selection)	
5	Cloud amount of the 2nd layer in octas	
170	Height of the 2nd cloud layer (1700 m or 17000 ft depending on the selection)	
0	Cloud amount of the 3rd layer in octas	
///	Height of the 3rd cloud layer	
0	Cloud amount of the 4th layer in octas	
///	Height of the 4th cloud layer	
0	Cloud amount of the 5th layer in octas	
///	Height of the 5th cloud layer	

The reporting resolution is 10 m or 100 ft depending on the unit's selection. If the cloud amount is zero, the corresponding layer height is ///.

3RD LINE (4TH LINE IN MESSAGE NO. 2)

Example:

```
00100 10 0770 098 +34 099 12 621 L0016HN15 139[CRLF]
```

00100	Parameter SCALE, 100 (%) is normal (0 ... 99999 possible)
10	Backscatter profile resolution in meters
0770	Length of the profile in samples 385, 770, 1400, or 1500
098	Laser pulse energy, % of nominal factory setting (0 ... 999)
+34	Laser temperature in degrees Celsius (-50 ... +99)

`099`	Window transmission estimate % (0 ... 100)
`12`	Tilt angle, degrees from vertical (0 ... 90)
`0621`	Background light, millivolts at internal ADC input (0 ... 2500)
`L0016HN15`	Measurement parameters (pulse long/short, pulse qty 0116x1024, gain high/low, bandwidth narrow/wide, sampling 15/30 MHz) L = Long pulse 0116 = Pulse quantity H = High gain N = Narrow bandwidth 15 = 15 MHz sampling rate
`139`	Sum of detected and normalized backscatter, 0 ... 999. Multiplied by scaling factor times 10^4. At scaling factor 1.0 the sum range 0 ... 999 corresponds to integrated backscatter 0...0.0999 $srad^{-1}$

The next line is omitted if the message subclass is 5.

4TH LINE (5TH LINE IN MESSAGE NO. 2)

Example:

```
00000111112222233333........[CRLF](5 x 770 bytes)
```

The 2-way attenuated backscatter profile with sensitivity normalized units $(100000 \cdot srad \cdot km)^{-1}$ unless otherwise scaled with the **SCALE** parameter. Each sample is coded with a 20-bit HEX ASCII character set; msb nibble and bit first, 2's complement. The length of this line is equal to 5 times the length of the profile + 2. Note that the profile is not corrected with the tilt angle.

Using the **SCALE** parameter a total dynamic range of 29 bits can be achieved for this message.

The line ends with carriage return and line feed characters.

The next line is omitted if the message subclass is 5.

5TH LINE (6TH LINE IN MESSAGE NO. 2)

Example:

```
[EX]1a3f[ET][CRLF]
```

[EX]	End of text character
1a3f	Checksum, see CRC16 checksum (page 67) for calculation procedure.
[ET]	End of transmission character
[CRLF]	Carriage return + line feed

4.7.3 CRC16 checksum

The CRC16 checksum can be calculated using the following algorithm written in the C programming language:

```
/* 16-bit type. */
typedef unsigned short Word16;

/* Calculate CRC-16 value as used in CL31. */

Word16 crc16(const unsigned char *buf, int len)
{
       Word16 crc;
       Word16 xmask;
       int    i, j;

       crc = 0xffff;

       for (i = 0; i < len; ++i)
       {
            crc ^= buf[i] << 8;

            for (j = 0; j < 8; ++j)
            {
                 xmask = (crc & 0x8000) ? 0x1021 : 0;
                 crc <<= 1;
                 crc ^= xmask;
             }
        }

        return crc ^ 0xffff;
}
```

The calculation of the checksum starts after the start of heading character [SH] and ends after the end of text character [EX], that is, the first character included is C and the last one included is end of text.

4.7.4 CL31 status message

The status message displays the internal monitoring of the entire unit. It is mainly meant for testing and maintenance purposes. You can display the status message with the **`status`** command.

```
[SH]CL0100S0[SX][CRLF]
10 00850 ///// ///// 000000000080[CRLF]

Alarms↵
 Tmit Shutoff  OK    Transmitter   OK[CRLF]
 Receiver      OK    Voltages      OK[CRLF]
 Ext Memory    OK    Light Pth Obs OK[CRLF]
 Rec Saturat   OK    Coaxial Cable OK[CRLF]
 Engine        OK

Oper Mode:  normal   Autoadj:   on[CRLF]
Meas Mode:  standard Interval:  2.0 s[CRLF]
Power Save: disabled Sleep Int: 60 s[CRLF]

Transmitter         Receiver↵
 Pulse Len: long     Gain:      high[CRLF]
 Inlaser:   1745     Bandwidth: narrow[CRLF]
 Pulse Cnt: 16384    Smpl Rate: 15 MHz[CRLF]
 Pulse Frq: 10.0 kHz[CRLF]

Window Cnd: 100 %    Outlaser:  1064[CRLF]
Backg Rad:  2.4                 103 %[CRLF]

Tilt Angle: 0.4      Humidity: N/A[CRLF]

Temperatures[CRLF]
 Internal:  23.7     External:  8.7[CRLF]
 DC Power:  22.6     Inclinom:  28.9[CRLF]
 Laser:     25.6     Blower:    8.3[CRLF]

Internal heater: off (auto)
Blower:          on  (auto)
Blower heater:   on
Batt Use:        off

System Status:   OK[CRLF]
 Suspect Module: none[CRLF]
[EX][CRLF]
```

1ST LINE

The first line of the CL31 status message is structurally identical to the first line of the CL31 data message No. 1, except that the second to last character that identifies the message number, is always `S0[SX][CRLF]`.

2ND LINE

The second line of the CL31 status message is structurally identical to the second line of the CL31 data message No. 1.

LINES 4 ... 9

Lines 4 ... 9 display CL31 alarm status. If an alarm is present, CL31 invalidates the cloud data.

11TH LINE

Line 11 displays the operation mode and autoadjustment settings of CL31. In normal use, the operation mode must be set to `normal` and autoadjustment must be set to `on`.

12TH LINE

Line 12 displays the measurement mode and measurement interval settings of CL31. In normal use, the measurement mode must be set to `standard`. By default the measurement interval is 2.0 s.

13TH LINE

Line 13 displays the power-save mode status and sleep interval settings of CL31. In normal use, the power-save mode is `disabled`. If the power-save mode is on, the sleep interval indicates the interval when the CL31 does not measure.

LINES 15 ... 19

Lines 12 to 16 display the transmitter and receiver settings of the CL31.

`Transmitter`	`Pulse Len`	Pulse length, long in normal use (110 ns)
	`Inlaser`	Controls the peak laser power
	`Pulse Cnt`	Pulse count, the number of pulses during a single measurement cycle, 16384 by default
	`Pulse Frq`	Laser pulsing frequency (10.0 kHz)
`Receiver`	`Gain`	High by default, may be low in fog or heavy snow
	`Bandwidth`	Narrow by default
	`Smpl Rate`	Receiver signal sampling rate, defines the vertical resolution of the measurement. Default is 15 MHz which corresponds to a 10 m resolution.

21ST LINE

Line 21 displays the window contamination status and outlaser settings of CL31. The estimated transparency of 90 % to 100 % means that the window is clean. Vaisala recommends that you clean the window whenever there is a window contamination warning, that is, the transparency is estimated to be 70 % or lower.

Outlaser is the laser pulse energy measured with CLM311 laser monitor board. The value underneath the outlaser value (on line 17) refers to the percentage of the laser power relative to the factory setting. The embedded software maintains this value at 95 ... 105 %.

22ND LINE

Line 22 displays CL31 background radiance value. The background radiance varies according to the background illuminance condition and temperature.

24TH LINE

Line 24 displays the tilt angle in degrees from vertical. Humidity measurement is visible if the option is activated.

LINES 26 ... 29

Lines 26 to 29 display temperature values in Celsius degrees. These values are used for the automatic control of the internal heaters and the blower, and for status monitoring.

LINES 31 ... 34

Lines 31 and 34 display the status of the internal heater, the blower, the blower heater, and the battery.

36TH LINE

Line 36 displays a summary of the system status. It must be **OK**. Alternatively, it can display the texts **Warning** or **Alarm/Fail**, if there are warnings or alarms present.

37TH LINE

Line 37 displays the automatic diagnosis in case of a failure. The system suggests a module to be replaced. If there is a secondary option, it iswill be stated in parentheses.

38TH LINE

Example:

```
[EX][CRLF]
```

[EX]	End-of-text character
[CRLF]	Carriage return + line feed

4.7.5 CT12K messages

CL31 includes 2 ceilometer CT12K messages. These are digital message No. 2 and digital message No. 3.

4.7.5.1 CT12K digital message No. 2

This message contains detailed range gate data, and internal monitoring data for the most important variables.

Example:

```
[SH][CRLF]
10 04200 00150 ///// ///// 0000011010    [CRLF]
2 0 0.08 36 0 100 23.9 0.00 0 0           [CRLF]
0DD ..............................DD     [CRLF]
-1                                        [CRLF]
-2                                        [CRLF]
-3                                        [CRLF]
-4                                        [CRLF]
-5                                        [CRLF]
-6                                        [CRLF]
-7                                        [CRLF]
-8                                        [CRLF]
-9                                        [CRLF]
10                                        [CRLF]
11                                        [CRLF]
12DD..............................DD     [CRLF]
[EX][CRLF]
```

ON/OFF data is 1/0 accordingly. Other data is decimal or hexadecimal numbers. The total length of the message is 636 characters. The printout is 15 lines, the width is max 44 characters, of which 42 are visible.

Message interpretation:

1ST LINE

Example:

```
[SH][CRLF]
```

[SH]	Start of heading character
[CRLF]	Carriage return + line feed

2ND LINE

The first line of the message is status line 1. Status line 1 is identical in all CT12K messages.

Example:

```
NSB H1H1H1H1H1 T1T1T1T1T1 H2H2H2H2H2 T2T2T2T2T2 S1S2S3S4S5S6S7S8S9S10[CRLF]
```

Parameter	Value	Description
N	0	No significant backscatter (clear air)
	1	One layer detected
	2	Two layers detected
	3	Sky is fully obscured but no cloud base can be detected from echo signal received (for example, fog or precipitation)
	4	Sky is partially obscured and no cloud base is detected
S	0	No CL31 alarm is active
	1	Alarm is active
B		Space if S = 0
		'bel' character if S = 1. Because 'bel' is a nonprinting character, the alarming line appears one character shorter in a printout than normally.
N	0 / 4	H_1=H_2=T_1=T_2= /////
	1 / 2	$H_1H_1H_1H_1H_1$ = The lowest detected cloud height in 5 digits. Leading zeroes not suppressed.
		$T_1T_1T_1T_1T_1$ = Range of backscatter of first layer, ///// if not defined
	2	$H_2H_2H_2H_2H_2$ = Second cloud height, ///// if not defined
		$T_2T_2T_2T_2T_2$ = Range of backscatter of second layer, ///// if not defined
	3	$H_1H_1H_1H_1H_1$ = Calculated vertical visibility
		$T_1T_1T_1T_1T_1$ = Signal range, that is, height of highest detected backscatter
S_1		An alarm or a warning is active
S_2		Voltage alarm
S_3		Transmitter alarm or transmitter expires warning
S_4		Transmitter shutoff alarm (Laser temperature too high)
S_5		High radiance warning
S_6		Blower On
S_7		Heater On
S_8	0	Unit is feet
	1	Unit is meters
S_9	0	Always (data type in internal table. N/A)
S_{10}	0	Always (fast Heater Off is active. N/A)

3RD LINE

The second line of the message is status line 2.

Example:

```
G F N.NN SUM IIN LAS TLx OF.FS XX PP[CRLF]
```

Parameter	Value	Description
G	0	Low gain
	2	High gain
F	0	Always (laser pulse frequency. N/A)
N.NN		Background radiance/100. One digit, two decimals.
SUM		Sum of total backscattered power per unit solid angle, that is, range and instrument normalization applied. Three digits, no decimals. Leading zeroes replaced by space characters.
IIN	0	Always (algorithm related internal processing information. N/A) 3 digits
LASE		Measured laser power in percentages of current laser power of target laser power (LLAS). 3 digits.
TL.x		Internal variable indicating transmitter temperature. Two digits, one decimal; preceded by minus sign if negative. Degrees Celsius.
OF.FS	0.00	Always (Offset of zero signal. N/A) Two digits, two decimals.
XX	0	Always (Algorithm related internal processing information. N/A) Two digits.
PP	0	Always (A 2-digit number representing calculated extinction coefficient values. N/A)

LINES 4 … 16

Lines 3 to 15 are the data lines of the message.

Example:

```
HHD0D1D2D3..... D9[CRLF]
```

Parameter	Value / Description
HH	Height of the first value
D	Data values

The data is scaled to a hexadecimal number 0 … FE (decimal 0 … 254). Overflow is indicated by FF. A leading zero is replaced by a space character.

Data values are presented for each 50 ft range gate. The height of the first value in the line in thousands of feet. Two digits, a leading zero is replaced by a space. Twenty 50 ft values per line starting with 0 (ft), next line 1 000 (ft). 13 lines altogether. Last line (12 000 ft) has 10 values.

4.7.5.2 CT12K digital message No. 3

This message contains status line 1 identical to message No. 2) and one single range gate data line indicating the presence or absence of backscatter in each range gate.

Example:

```
[SH][CRLF]
10 04200 00150 ///// ///// 0000011010    [CRLF]
0001FFF80000000000007A000......000       [CRLF]
[EX][CRLF]
```

ON/OFF data is 1/0 accordingly. Other data is decimal or hexadecimal numbers. The total length of the message is 112 characters. The printout is 2 lines, the maximum width is 66 characters, of which 64 are visible. The time for message transmission at 300 baud is 3.73 s.

Message interpretation:

1ST LINE

```
[SH][CRLF]
```

Parameter	Value / Description
[SH]	Start of heading character
[CRLF]	Carriage return + line feed

2ND LINE

The first line of the message is status line 1. Status line 1 of digital message No. 3 is identical to that of message No. 2.

3RD LINE

The second line of the message is a backscatter data line.

Example:

```
D1D2D3D4.....................D64[CRLF]
```

Parameter	Value / Description
D	A single, ASCII coded hexadecimal character O ... F, where each bit of the 4-bit nibble of the hex character expressed in a binary form represents one range gate.
D_1	Represents the four lowest 15 m (approximately 50 ft) range gates, that is, 45 m (appr. 0 ft, 50 ft, l00 ft, 150 ft).
D_2	Represents the four next ones, that is, 60 m (appr. 200 ft,250 ft, 300 ft, 350 ft), etc.

0	Indicates no detectable backscatter in four adjacent range gates
F	Indicates backscatter in all four range gates
8	Indicates backscatter in the lowest range gate only
1	Indicates backscatter in the highest range gate only

All other characters indicate a gate-by-gate combination of backscatter according to the binary nibble, converted to hexadecimal.

4.7.6 CT25K data messages

The ceilometer includes 2 ceilometer CT25K data messages: data message No. 1 and data message No. 6.

4.7.6.1 CT25K data message No. 1

This message is intended for cloud height/vertical visibility measurement when no other measurement information is needed. The message includes the most elementary status information, which enables a host system or operator to see that no warnings or alarms are present.

Example:

```
[SH]CTA2010[SX][CRLF]                 1st line     11 char.
30 01230 12340 23450 FEDCBA98[CRLF]   2nd line     31 char.
[EX][CRLF]                            3rd line      3 char.
                                      ----------------------
                          total 44 characters
```

The transmission time and size is the following:

- 0.18 s at 2 400 bps (10-bit char.)
- 10.6 Kbytes/h, 253 Kbytes/d, 7.6 Mbytes/mo. at 4 msg./min., uncompressed.

Message interpretation:

1ST LINE

Example:

```
[SH]CTA2010[SX][CRLF]
```

[SH]	Start of heading character
CT	Ceilometer identification string; always CT
A	Unit number 0 ... 9, A ... Z
20	Software level id 00 ... 99
1	Message number; this message is always = 1
0	Spare character for future subclasses of message
[SX]	Start of text character

2ND LINE

Example:

```
30 01230 12340 23450 FEDCBA98[CRLF]
```

Second line of CT25K data message No. 1 is identical to that of CL31 data message No. 1, except for the status bit string, which is 4-byte hex coded.

The status bit string contains Alarm (A), Warning (W), and internal status information. Each character is a hexadecimal representation of four bits, that is, values between 0 and 9 are presented with respective numbers and values 10, 11, 12, 13, 14, and 15 are presented with letters A, B, C, D, E, and F respectively. As each character represents the sum of four individual bits, the total number of bits is 32 (b00-b31), with the following breakdown and interpretation:

The message ends with FEDCBA98.

It contains Alarm (A), Warning (W), and internal status information. Each character is a hexadecimal representation of four bits. Values between 0 and 9 are presented with respective numbers and values 10, 11, 12, 13, 14, and 15 are presented with letters A, B, C, D, E, and F respectively. As each character represents the sum of four individual bits, the total number of bits is 32 (b00-b31), with the following breakdown and interpretation:

F:	b31	(8000 0000)	Transmitter shut-off (Laser temperature high.) (A)
	b30	(4000 0000)	Transmitter failure (A)
	b29	(2000 0000)	Receiver or coaxial cable failure (A)
	b28	(1000 0000)	Engine, voltage or memory failure (A)

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E:	b27	(0800 0000)	(spare) (A)
	b26	(0400 0000)	(spare) (A)
	b25	(0200 0000)	(spare) (A)
	b24	(0100 0000)	(spare) (A)
D:	b23	(0080 0000)	Window contaminated (W)
	b22	(0040 0000)	Battery low (W)
	b21	(0020 0000)	Transmitter expire warning (W)
	b20	(0010 0000)	Heater or humidity sensor failure (W)
C:	b19	(0008 0000)	High radiance warning together with b02 (W)
	b18	(0004 0000)	Engine, receiver, or laser monitor failure warning (W)
	b17	(0002 0000)	Relative humidity is high > 85 % (option) (W)
	b16	(0001 0000)	Light path obstruction or receiver saturation (also receiver failure active, b29) (A)
B:	b15	(0000 8000)	Blower failure (W)
	b14	(0000 4000)	(spare) (W)
	b13	(0000 2000)	(spare) (W)
	b12	(0000 1000)	(spare) (W)
A:	b11	(0000 0800)	Blower is ON
	b10	(0000 0400)	Blower heater is ON
	b09	(0000 0200)	Internal heater is ON
	b08	(0000 0100)	Units are METERS if ON, else FEET
9:	b07	(0000 0080)	Polling mode is ON
	b06	(0000 0040)	Working from battery
	b05	(0000 0020)	Always 0 (single sequence mode is. N/A)
	b04	(0000 0010)	Always 0 (manual settings are effective. N/A)
8:	b03	(0000 0008)	Tilt angle is > 45 degrees (W)
	b02	(0000 0004)	High radiance warning together with b19. (W)
	b01	(0000 0002)	Manual blower control
	b00	(0000 0001)	(spare)

3RD LINE

```
[EX][CRLF]
```

[EX]	End of text

[CRLF]	Carriage return + line feed

4.7.6.2 CT25K data message No. 6

Message number 6 is similar to message number 1 but extended with a sky condition line.

Example:

```
[SH]CTA2060[SX][CRLF]                          1st line    11 char.
30 01230 12340 23450 FEDCBA98[CRLF]            2nd line    31 char.
  3 055 5 170 0 /// 0 ///[CRLF]                3rd line    30 char.
[EX][CRLF]                                     4th line     3 char.
                                              ----------------------
                            total 75 characters
```

The transmission time and size is the following:

- Total 75 characters
- 0.31 s at 2400 bps (10 bit char.)
- 18.0 Kbytes/h, 432 Kbytes/d, 12.7 Mbytes/mo. at 4 msg/min, uncompressed

Message interpretation:

LINES 1 and 2

Lines 1 and 2 are identical to that of Message No. 1.

LINE 3

Example:

```
3 055 5 170 0 /// 0 ///
```

Note that the string begins with 2 spaces.

3	The first number of line: detection status as follows:	
	`0 ... 8`	Cloud amount of the first layer in octas.
	`9`	Vertical visibility.
	`-1`	Data missing or the ceilometer is in standby mode.
	`99`	Not enough data (after start-up).
	`055`	The second number of line: Height of the 1st cloud layer (5500 ft or 550 m depending on feet or meter selection).
	`5`	The third number of line: Cloud amount of the 2nd layer in octas.
	`170`	The fourth number of line: Height of the 2nd cloud layer (17000 ft or 1700 m depending on feet or meter selection).
	`0`	The fifth number of line: Cloud amount of the 3rd layer in octas.
	`///`	The sixth number of line: Height of the 3rd cloud layer.
	`0`	The seventh number of line: Cloud amount of the 4th layer in octas.
	`///`	The eighth number of line: Height of the 4th cloud layer.

The reporting resolution is 100 ft or 10 m depending on feet or meter selection. If the cloud amount is zero, the corresponding layer height is ///.

4.7.7 CT25KAM data messages

The ceilometer includes 2 Ceilometer CT25KAM data messages. These are data message No. 60 and data message No. 61.

4.7.7.1 CT25KAM data message No. 60

CT25KAM message number 60 is identical to CT25K message number 6.

More information

- CT25K data message No. 6 (page 78)

4.7.7.2 CT25KAM data message No. 61

CT25KAM message number 61 is similar to CT25KAM message No. 60 (and CT25K message No. 6) but extended with a fifth layer in the sky condition line. An example:

```
[SH]CTA2061[SX][CRLF]                                  1st line   11 char.
30 01230 12340 23450 FEDCBA98[CRLF]                    2nd line   31 char.
  3 055  5 170  0 ///  0 ///  0 ///[CRLF]              3rd line   37 char.
[EX][CRLF]                                             4th line    3 char.
                                                     -------------------
                                                     total 82 characters
```

The transmission time and size is the following:

total 82 characters

⇒ 0.34 s at 2400 baud (10-bit char.)

⇒ 20.4 Kbytes/h, 490 Kbytes/d, 14.6 Mbytes/mo. at 4 msg/min, uncompressed

4.7.8 LD40 standard telegram

The ceilometer includes one Ceilometer LD40 data message. This is the standard telegram X1TA. This message is given in clear text and includes cloud heights and additional meteorological data, date, time, sensor address, and status information of the instrument.

An example of the X1TA telegram:

```
[SX]X1TA_8_015_00.00.00_00:00_00875_11150_NODET_0100_0325_NODT_11300_11600_
+025_ft_01_00000000_96 [CRLF][ET]
```

[SX]	Start of text character
X	Sensor type (X = LD40)
1	Sensor ID number (0 to 9..ABC..MN)
TA	Text telegram
8	Instrument type, always 8 = LD40
015	Telegram update time or message interval in seconds
00.00.00	Always (Date N/A)
00:00	Always (Time N/A)
00875	First cloud layer
11150	Second cloud layer
Second cloud layer NODET	Third cloud layer (in this case: not detected)
0100	Penetration depth of laser beam into second cloud layer
0325	Penetration depth of laser beam into second cloud layer
NODT	Penetration depth of laser beam into third cloud layer, not detected
11300	Vertical visibility
11600	Maximum range of detection
+025	Cloud height offset (in this case the ceilometer is situated 25 ft above the runway level)
ft	Dimensions of all values between byte 26 and byte 76 (ft or m_)
00	Always (precipitation index. N/A)
00000000	System status and messages

96	Checksum (this value is only an example; the correct value may be different from this one.)
[CRLF]	Carriage return + Line feed
[ET]	End of transmission character

The notation '_' stands for a space character.

4.7.8.1 Telegram structure remarks

- Spaces (20 hex) always appear with the following bytes: 5, 7, 11, 20, 26, 32, 38, 44, 49, 54, 59, 65, 71, 76, 79, 82, 91.
- The only other byte that may contain a <SPACE>, is byte 78, provided that the dimension is in meters.
- Numbers are always given with the leading zeros as in bytes 27 to 31 in the example.
- **NODET** (and **NODT**) indicates that the value in question has not been detected because, for example, there was only one cloud layer or no cloud layer at all.
- Like any measured value, **NODET** also contains information about the result of the measurement.
- **NODET** may appear instead of cloud layers, minimum vertical extensions of clouds, and vertical visibility.
- When bytes 83 to 90 signal a CL31 alarm, all cloud detection values within the telegram are replaced by minus signs (-, 2D Hex). For example: ----- is shown instead of bytes 27 to 31.
- All values given are height above the runway level. The ceilometer itself may be located above or below the runway level. Byte 72 must therefore contain a sign byte, either + or -.

4.7.8.2 Failure and warning messages

Bytes 83 to 89 of the LD40 standard telegram indicate warnings and errors. A 0 signifies that no error of that error group has happened.

An alarm causes data telegrams to contain invalid data. A warning status does not cause invalid data.

The following tables describe how the ceilometer is mapped to the LD40 error groups.

Table 12 Error group definition

Error group	Byte no.	Description
1	83	Engine board and voltages
2	84	Light path, receiver saturation and window condition
3	85	Receiver and coaxial cable
4	86	Transmitter
5	87	Memory failure and general warnings

Error group	Byte no.	Description
6	88	Temperature regulation
7	89	Always 0. Not used.

The following tables describe the single error codes in different error groups.

Table 13 Error group 1 (byte 83)

Error code	Description
0	Status OK
1	Engine or voltage failure (A)
2	Not used
3	Not used
4	Not used
5	Not used
6	Not used

Table 14 Error group 2 (byte 84)

Error code	Description
0	Status OK
1	• Light path obstruction (A) or • Window contamination warning (W)
2	Receiver saturation (A)

Table 15 Error group 3 (byte 85)

Error code	Description
0	Receiver OK
1	Not used
2	Not used
3	Not used
4	• Receiver failure (A) or • Coaxial cable failure (A) or • Receiver warning (W)
5	Not used
6	Not used

Table 16 Error group 4 (byte 86)

Error code	Description
0	Transmitter OK
1	Transmitter expires (laser power low) (W)
2	Transmitter failure
3	Not used
4	Not used
5	Not used
6	Transmitter shutoff (laser temperature too high) (A)

Table 17 Error group 5 (byte 87)

Error code	Description
0	Status OK
1	• Laser monitor failure (W) or • Blower failure (W) or • High radiation warning (W) or • Engine warning (W) or • Tilt angle warning (angle is > 45 degrees) (W) or • Internal battery voltage low (W) or • Internal battery failure (W) or • Humidity high (option) (W) or • Humidity sensor failure (option) (W)
2	Not used
3	Memory failure (A)
4	Not used

Table 18 Error group 6 (byte 88)

Error code	Description
0	Temperature regulation OK
1	Heater failure (W)

Table 19 Error group 7 (byte 89)

Error code	Description
0	Always 0 (data transmission. N/A)
1	Not used
2	Not used
3	Not used

Error code	Description
4	Not used
5	Not used
6	Not used
7	Not used
8	Not used

4.7.8.3 Calculating checksum

The checksum of a data or a command telegram is calculated by computing the sum of all signs (alphanumerical signs and control codes such as `STX`, `EOT` `CR`, `LF`, except the checksum bytes itself), building the two's complement and taking the lower byte of this result.

The higher half-byte and the lower half-byte converted to a visible ASCII character is the checksum.

An example with the **`polling`** command:

Telegram:

```
STX H0C!X1P----------83 EOT
```

1. Compute the sum:

   Sum = STX + 'H' + '0' + 'C' + !'' + 'X' + '1' + 'P'+ 10 x '-' + EOT
   Sum = 0x02 + 0x48 + 0x30 + 0x43 + 0x21 + 0x58+ 0x31 + 0x50 + 10 x 0x2D + 0x04
   Sum = 0x037D HEX = 893 DEZ

2. Build the complement:

   The complement is built by inverting the binary representation of the sum and adding 1:

   ```
   2Com = ¬ Sum + 1= ¬ 0x037D + 0x01 = 0x0C83 HEX = 3203 DEZ
   ```

3. Take the lower byte and build an ASCII-character:

   The lower byte of 2Com is 0x83 HEX, so the high byte of the checksum is 8 and the low byte is 3:
   Checksum = 83

4.7.9 Manual message

You can set the ceilometer to transmit user-defined cloud heights and status information. You can set a cloud message in the format of line 2 of any real cloud message (for example, Message No. 1 or CT25K data message). The message is a string and the maximum length is 33 characters. If the length is less than 33 characters, the remaining length is padded with spaces. (The CT25K messages use only 29 characters). The end of a string is determined by a new line and the leading spaces are omitted. This message is volatile. The manual message command is behind the password "advanced". Below is an example of a manual message:

```
CEILO >  advanced
Service password accepted.
CEILO >  set message manual_msg 30 00200 01000 05000
000000000000
OK
```

The **`get params message`** command displays the current manual message.

To return to the normal messages, type an empty string:

```
CEILO >   set message manual_msg
OK
```

The manual message is intended for testing purposes. After reset, the normal message takes effect.

4.8 Polling mode

You can set a port to transmit a message only when polled by a predetermined polling string. The polling string can contain the message identification.



Ceilometer CT12K messages cannot be polled.

The ceilometer unit can be assigned an identification of one-character digit or letter. The factory setting is 0.

To activate the polling mode, type:

```
CEILO > set message transmission request
```

To return to the autosend mode, type:

```
CEILO > set message transmission periodic
```

The polling string format:

```
<Enq> CLIdNo [CRLF]
```

Enq	Character ENQUIRE = ASCII 05H = control-E
CL	Fixed ceilometer identifier; CL for CL31 messages, CT for CT25K and CT25KAM messages.
Id	Identification character, 7-bit printable ASCII character.
No	Optional message identifier; 1 or 6 for CT messages and 1, 2 or S for CL messages. The CL identifier 1 returns the default option for data message No. 1. To return a particular subclass message, use one of the following identifiers: 11, 12, 13, 14, or 15. Data message No. 2 is requested similarly: 21, 22, 23, 24, or 25. . The identifier S returns the Status message.
[CRLF]	Carriage return + line feed

Examples of the polling command:

<Enq> CL112<Enter>	Message 1, subclass 2 from ceilometer No.1
<Enq> CT11<Enter>	CT25K message 1 from ceilometer No.1

If the id character in a polling string is replaced with a blank space, all ceilometers on the line will respond. Accordingly, if No is a blank space, the ceilometer sends the default message. In RS-485 mode id is always needed, the blank space is ignored.

LD40 message is polled by sending an LD40 command telegram.

Table 20 Command telegram description 'polling request'

Byte	Example	Description
0	<STX>	02 HEX (Start of text)
1	H	Command telegram header
2	0	Command telegram header
3	C	Command telegram header
4	!	Command telegram header
5	X	Instrument type --> Ceilometer

Byte	Example	Description
6	1	Sensor ID number (0 to 9..ABC..MIN). In this case --> 1
7-17	P----------	Command indicator --> P (polling), byte 8-17 not used and filled with '-'
18-19	83	Checksum (Hex-coded two's complement of the sum of bytes from 0 to 20, excluding bytes 18 and 19.
20	<EOT>	04 Hex (End of transmission)

4.9 Activating sky condition

4.9.1 Option code

The sky condition algorithm is included in software version 1.50, and later.

You can activate the sky condition algorithm by entering an option code to the ceilometer. The option code number is based on the ceilometer serial number. If you purchased the ceilometer with the sky condition activated, this has already been done at the factory. If you purchased the sky condition option, enter the following command to get the serial number:

```
CEILO >  system

Vaisala Ceilometer CL31

 Unit ID:    0
 Serial Nro: 421202
 SW Version: 1.500

 HW Options
  Modem:     N/A
  Humitter:  N/A
```



The ceilometer serial number is also in the label on the measurement unit door. Send it to Vaisala to get the option code. See Activation (page 87).

4.9.2 Activation

After you have received the option code, activate the sky condition algorithm as follows:

```
CEILO >  advanced
Service password accepted.

CEILO >  set option sky_cond on 63273
OK.
```

Select the sky condition message type (`msg2_base` or its subclass) to be reported:

```
CEILO >  set message type msg2_base
OK
CEILO>close
```

4.10 Storing ceilometer

Do not store the ceilometer in an unconditioned area.
If you store the ceilometer unpacked for a long time, store it in a conditioned area (temperature: −55 ... + 60 °C (−67 ... +140 °F), humidity below 95 %RH).

Save the container for future transport use. For transportation, the equipment must be placed and padded into the container in the same way as initially received.

5. Maintenance



CAUTION! Only qualified maintenance personnel may perform maintenance procedures.

5.1 Periodic maintenance

Periodic maintenance is normally limited to window cleaning. In addition, check warnings and alarms regularly with the maintenance terminal, another terminal, or PC with a serial connection. The only mechanically moving part, the window blower, is automatically checked once an hour. Malfunction is reported in the data and status messages.



WARNING! Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Vaisala office or authorized depot for service and repair to make sure that safety features are maintained.



WARNING! Verify outdoor installation grounding periodically to minimize shock hazard.



WARNING! Do not service the system alone. Do not reach into parts and assemblies that are AC (mains) powered and live except in the presence of someone who can provide first aid.

More information

- CL31 status message (page 67)

5.2 Alarms and warnings

Check the data message for alarms and warnings regularly. The second character in line 2 contains warning and alarm information indicating the present device status:

Character	Description
`0`	Self-check OK
`W`	At least one warning active, no alarms

Character	Description
A	At least one alarm active

If there is an active alarm or warning, more information is given at the end of the second line as a binary code indicating the cause. The status message gives detailed information about the failure.

More information

- Service overview (page 94)
- Warning and alarm messages (page 133)

5.3 Cleaning window



WARNING! Do not look directly into the ceilometer transmitter or ceilometer optics with magnifying optics (such as glasses, binoculars, and telescopes). Do not direct the beam into an area where such instruments are used. Viewing the laser output may pose an eye hazard.



WARNING! Only qualified maintenance personnel may perform maintenance procedures. Make sure unauthorized persons cannot access the work area during service operations.

Data messages include a warning when the window is contaminated. After the system has detected contamination, it starts the blower, which removes light contaminants and dries off raindrops.

If the blower cannot remove the contamination, the ceilometer issues the `Window Contaminated` warning indicating that you must clean the window manually.

1. Make sure that the enclosure is closed. Rinse the window with clean water to remove coarse grains.



CAUTION! Do not use pressure cleaners.

2. Clean the window with a soft, lint-free cloth moistened with a mild detergent.



CAUTION! Be careful not to scratch the window surface.

You can also check the operation of the window blower. The blower starts when you block the laser beam with the cleaning cloth for approximately 5 seconds. This verifies that the blower is functional. If there are no low clouds, precipitation, or fog present, the blower stops after the window is cleaned. In case of malfunction, you must replace the window blower.

5.3.1 Calibrating window contamination measurement

After 5 years of operation, calibrate the window contamination measurement.

If the ceilometer system starts issuing `Window Contamination` warnings frequently without a real reason, this may indicate that the window is worn out or the window contamination measurement has drifted. You can calibrate the window contamination measurement to ensure proper functioning.

1. Check the sky condition.

   In case of fog, smoke, precipitation, or otherwise unclear sky, use the termination hood (CLTERMHOOD) in calibration.
2. Make sure that the window is clean.
3. Open the command line and enter the Advanced level with the **`advanced`** command.
4. Type the **`set factory win_clean`** command.

   The calibration is carried out automatically.



If the window is visibly worn out, replace it.

5.4 Checking door gasket

The measurement unit door uses an electrically conductive gasket to suppress electromagnetic radiation.

1. When you open the door, check that the gasket and the opposite contact surfaces are clean.
2. If necessary, use a wet cloth for cleaning.

5.5 Checking battery

CAUTION! In freezing temperatures there is a danger of battery rupture if the battery is completely discharged. Do not store empty batteries in freezing temperatures. Replace the battery if signs of mechanical rupture are observed.

1. Check the battery condition annually.
2. If there are any signs of aging, such as a bulging battery case, white powder, or residue near the battery vent, leaking electrolyte, or corroded terminals, replace the battery.

   Lead acid batteries may age in 3 to 5 years and result in a rupture and loss of electrolyte.



When disposing of old batteries, follow local environmental regulations.

5.6 Cleaning and maintaining painted surfaces

Vaisala recommends that you wash all the painted surfaces at least once a year. Use only warm water or warm, mildly soapy water. Wipe with soft cloth or sponge and rinse with clean water.

CAUTION! Do not use solvents or abrasive sponges when cleaning painted surfaces.

5.6.1 Preparing for painting

1. Clean the surface and remove any loose coating with a scraper and a steel brush.
2. Use sandpaper on damaged areas and around the damaged area's edges.
3. Remove impurities, such as dirt and grease, with warm soapy water.

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4. Rinse with warm water.

   The surface must be completely dry before starting maintenance painting. Protect the surfaces that will not be painted with tape or paper.

> Make sure the air temperature, the paint, and the painted surface are at least +10 °C and the relative humidity below 80% during painting and drying. Do not paint in rain or in direct sunlight.

5.6.2 Painting

After preparing the surface, coat the surface as soon as possible. Follow your paint manufacturer's instructions carefully.

1. Use a primer, such as Teknos INERTA PRIMER 5 epoxy paint 60 ... 80 µm.
2. Paint the surface 2 to 3 times, so that the dry film layer thickness is 40 ... 60 µm. Use, for example, Teknos TEKNODUR 0190 polyurethane 40 µm, so that the total thickness is 100 ... 120 µm.

5.6.3 Commonly used Vaisala colors

- Solid White, Semi Gloss RAL 9003
- Shade Grey, Semi Gloss RAL 7035
- Construction Grey, Semi Gloss RAL 7024
- Signal Red, Semi Gloss RAL 3001

For more information on the paints, visit the paint manufacturer's website www.teknos.com.

> If you use other paints, make sure the paint is compatible with the polyester powder coating.

6. Service

CAUTION! Only qualified service personnel may perform service procedures.

CAUTION! Contact Vaisala or its authorized representative for repairs.

WARNING! Do not service the system alone. Do not reach into parts and assemblies that are AC (mains) powered and live except in the presence of someone who can provide first aid.

WARNING! Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Vaisala office or authorized depot for service and repair to make sure that safety features are maintained.

6.1 Service overview

Perform a general check annually.

Table 21 Spare parts

Spare part code	Common name
226116	Battery
CLB311-115SP	Window blower 115 V AC
CLB311-230SP	Window blower 230 V AC
CLE321SP	Engine board
CLH311-115SP	Internal heater 115 V AC
CLH311-230SP	Internal heater 230 V AC
CLHUMITTERSP	Humitter

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Spare part code	Common name
CLM311SP	Laser monitor board
CLP321SP	AC power
CLR321SP	Ceilometer receiver
CLT321SP	Ceilometer transmitter
CLTERMHOODSP	Optical termination hood
CLW311SP	Window assembly
CT35022SP	Shock absorber kit
CT35324SP	Power cable (115 V)
CT3838SP	Data cable
CT3839SP	Power cable (230 V)
DXL421SP-CL31	Modem module
226296SP	Coaxial cable
TERMBOX-1200SP	Termination box with overvoltage protection
CLTERMBOXSP	Termination box
QMZ101SP	Terminal cable for MAWS
CL31USBCABLESP	CL31 USB cable
CLRADIOKITSP	Radio modem kit
CL31BIRDKITSP	Bird deterrent
CL31TOPCOVERKIT	Top cover kit
220570	Surge protector
242701	Moxa device server

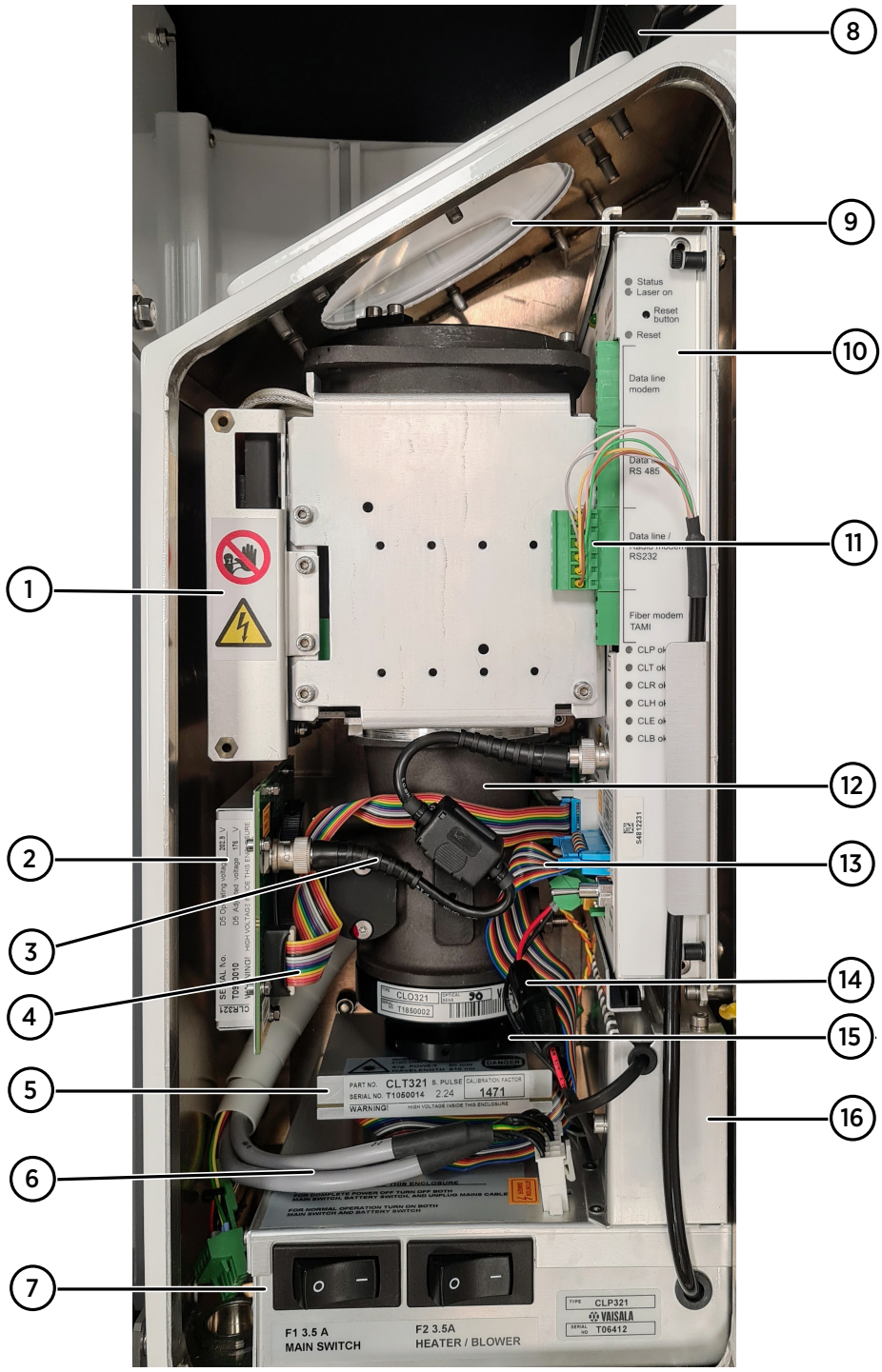


Figure 14 CL31 maintenance parts

1 Internal heater CLH311
2 Receiver CLR321
3 Coaxial cable 226296
4 Receiver ribbon cable
5 Transmitter CLT321
6 AC power cables

7 AC power CLP321
8 Window blower CLB311
9 Window CLW311
10 Engine board CLE321
11 Data line connector
12 Optics unit CLO321
13 Transmitter ribbon cable
14 Battery cable with glass fuse (F3 / 5.0 AT)
15 Laser monitor board CLM311
16 Battery

More information

- Replacing window (page 97)
- Replacing engine board (page 101)
- Replacing laser transmitter (page 103)
- Replacing receiver (page 105)
- Replacing battery (page 107)
- Replacing AC power unit (page 110)
- Replacing window blower (page 120)
- Replacing internal heater (page 121)
- Replacing laser monitor board (page 123)
- Replacing modem module (page 125)

6.2 Replacing window

Vaisala recommends that you replace the ceilometer window CLW311 indoors to prevent water and other contamination from getting into the measurement unit.

- 2.5-mm Allen key
- Screwdriver

1. Open the measurement unit door and switch the power off with all 3 switches (**F1**, **F2**, and battery).

WARNING! Before you continue, disconnect the power cable from the **J2** connector.

2. Close the door and remove the measurement unit.

   Loosen the 3 attachment screws, disconnect the blower cable from the **J1** connector and pull out the unit.

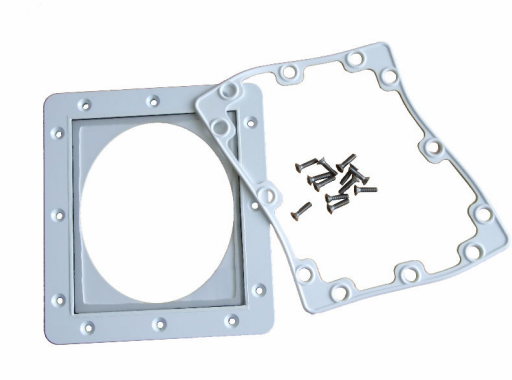
3. Loosen the 12 screws on the frame of the window and remove the window by lifting it out with the screws attached.

   Remove any pieces of the old gasket.

4. Use a solvent to clean the surface of the measurement unit before attaching the new window and make sure that the gasket on the window is undamaged and in place.

CAUTION! Avoid touching the new window with your bare hands as it may get scratched.

Avoid touching the clean window surface as it may get contaminated.



5. Place the window on the measurement unit and attach the 12 screws with your fingers to prevent the window from sliding off its place.

6. Tighten the screws in a crosswise order to allow the window gasket to tighten evenly.

   For example, tighten first the screw on top of the window frame, then the one on the bottom, then the one on the left, and the one on the right. Tighten the remaining 8 screws in a clockwise order so that you first tighten one screw and then the one opposite to this, then the one next to the first screw and so forth. Then retighten the first 4 screws.

Remember to use thread-locking compound on the window screws before final tightening.

7. After attaching the window, clean it properly.

8. Place the measurement unit inside the radiation shield, reconnect the blower cable to connector **J1**, and tighten the 3 attachment screws.
9. Connect the power cable to connector **J2**.
10. Switch the power on with all 3 switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs are lit.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

More information

- External connectors (page 36)
- Cleaning window (page 90)

6.3 Replacing engine board and laser transmitter



WARNING! Never replace both the engine board CLE321 and laser transmitter CLT321 at the same time. If you need to replace them both, see Replacing both units (page 100).



WARNING! Never replace an engine board or a transmitter from one ceilometer to another without consulting Vaisala.

The engine board and transmitter module are designed for plug-and-play replacements. To support plug-and-play replacement, they both contain all current system parameters in the internal memory.

Spare parts have an internal memory. By default, a new spare part component has the `spare_part mark` parameter on. For example, if you replace the engine board, the new engine board has the `spare_part mark` on. The ceilometer identifies that a new component is installed and fetches existing parameters from the transmitter board. No user settings are required. After installation, the `spare_part mark` is cleared from the engine board.

If you remove the engine board from one ceilometer and install it in another ceilometer without setting its `spare_part mark`, the replacing unit runs wrong parameters. This may severely affect ceilometer performance.
If you must change an engine board or a transmitter from one CL31 to another, change the `spare_part mark` setting:

```
service spare_part cle_engine mark
service spare_part clt_transmitter mark
```

After changing the setting, switch off CL31 and remove the module. The engine board is ready to be integrated into another CL31. The new parameters are applied automatically when the component is installed.

If you change both the engine board and the transmitter, the system returns to default settings.

More information

- Factory settings of user-programmable parameters (page 148)

6.3.1 Replacing both units

It is necessary to replace a unit if the unit has been generating warnings and alarms or when a malfunction has been detected.

Do not replace both the engine board and the laser transmitter at the same time. If you must replace both units, follow these instructions to avoid losing parameters.

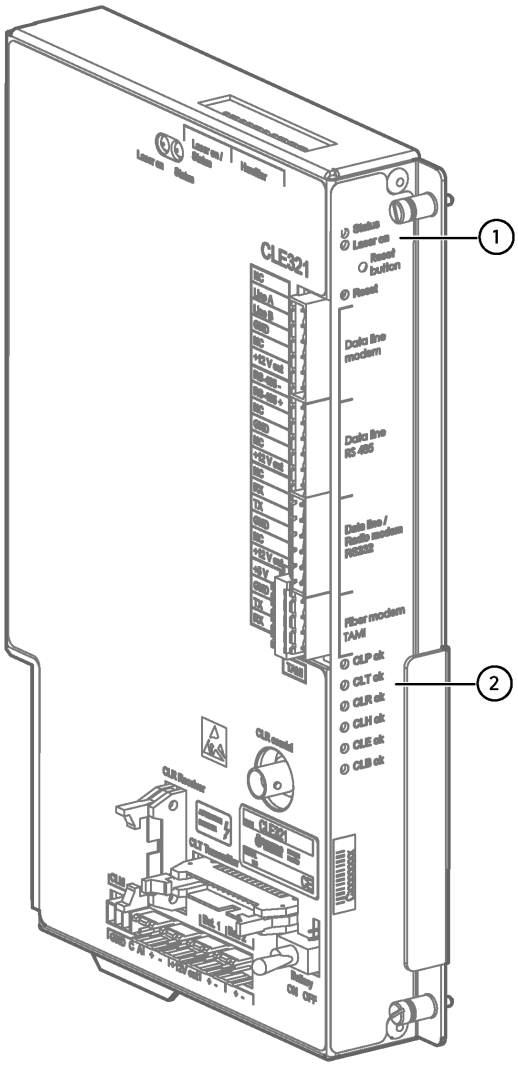
1. Perform either a or b.
   a. To replace the engine board first, perform Replacing engine board (page 101) and switch on the ceilometer and wait until the **Laser On** LED starts blinking at 2-second intervals.

      All parameters are restored and CLE321 spare bit is cleared. You can replace the laser transmitter.

   b. To replace the laser transmitter first, perform Replacing laser transmitter (page 103) and switch on the ceilometer and wait for at least 15 minutes.

      All parameters are restored and CLT321 spare bit is cleared. You can replace the engine board.

6.3.2 Replacing engine board



1 **Laser on** LED
2 Diagnostic LEDs

CAUTION! Only qualified service personnel may perform service procedures.

You must replace the ceilometer engine board CLE321 if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the CLE321 board has been detected.

If you must change both the laser transmitter and the engine board, see Replacing both units (page 100).

- Screwdriver

1. Open the measurement unit door and confirm that there is an active engine board CLE321 failure (**CLE ok** turns off).
2. Switch off power with all 3 switches (**F1**, **F2**, and battery)

WARNING! Before you continue, disconnect the power cable from the **J2** connector.

3. Detach the transmitter ribbon cable, the receiver ribbon cable, and the coaxial cable from the engine board CLE321.
4. Memorize the position of the data line connector in front of the CLE321 board and detach it.
5. Loosen the hand screws to release the CLE321 board from the frame.

   Gently pull the engine board CLE321 board halfway out of the measurement unit and detach the battery cable and the laser monitor board CLM311 cable. Then remove the entire CLE321 board.
6. Place the new CLE321 board onto the frame and reconnect the battery cable and the CLM311 cable .
7. Reattach the receiver ribbon cable, the transmitter ribbon cable, and the coaxial cable when the board is pushed halfway in.
8. Push the CLE321 board so that it connects to the back plane connector and tighten the hand screws to lock the board position.
9. Connect the data line connector to the same position as it was connected to on the previous board.
10. Connect the AC power cable to connector **J2**.
11. Switch on power with all 3 switches.

    Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs light up after the set-test.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

More information

- Replacing laser transmitter (page 103)
- Starting ceilometer (page 57)

6.3.3 Replacing laser transmitter

If you must change both the transmitter and the engine board, see Replacing both units (page 100).

The ceilometer transmitter CLT321 emits invisible laser radiation, which is harmful to the eye if viewed at a short distance. Never remove the ceilometer transmitter from its normal position without first switching off both the AC (mains) power and the battery power and detaching the transmitter ribbon cable from the ceilometer engine board.
When the transmitter is contained in the enclosure, the laser class is 1M, the transmitter is safe to the eye if magnifying instruments are not used.
When the transmitter is removed from the optics unit, the laser class is 3B, the laser is hazardous to the eye.

WARNING! Do not look at the transmitter module CLT321 of the ceilometer from the beam direction when the transmitter is powered.

- 2.5-mm Allen key

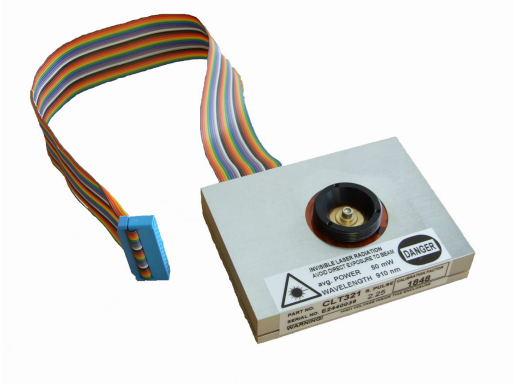


Figure 15 Laser transmitter CLT321

Replace the transmitter if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the transmitter has been detected.

If you must replace both the transmitter and the engine board, see Replacing both units (page 100).

1. Open the measurement unit door and confirm that there is an active transmitter failure. In case of a transmitter failure, the **CLT ok** LED turns off.

2. Switch off the power with all 3 switches (**F1**, **F2**, and battery). Disconnect the AC power cable from the **J2** connector and the data/DC cable from the **J1** connector.



WARNING! Before you continue, disconnect the power cable from the **J2** connector.

3. Detach the transmitter ribbon cable from ceilometer engine board CLE321.
4. Detach the battery cable.
5. To detach the transmitter, loosen the transmitter ring by turning it to the right.



If necessary, you can use a 2.5-mm Allen key as a lever.

   Remove the transmitter from the unit.
6. Place the new transmitter to its place and tighten the transmitter ring so that the labels of the transmitter face the measurement unit door.
7. Connect the transmitter ribbon cable to the CLE321 board.
8. Connect the power cable to connector **J2**.
9. Switch on the power with all 3 switches.

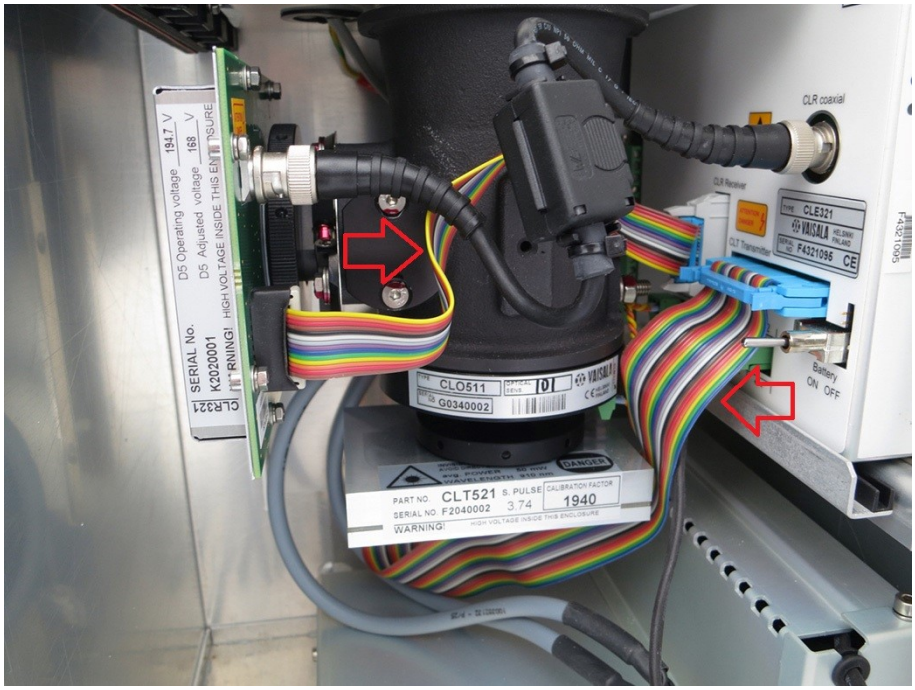
   Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs are lit.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.



If you must replace the engine board CLE321, wait for at least 15 minutes before proceeding.

To avoid interference, make sure that you keep the RX flat cable and the TX flat cable apart.



6.4 Replacing receiver

CAUTION! Only qualified service personnel may perform service procedures.

Replace the receiver if the ceilometer has been generating warnings and alarms, and you have detected a malfunction in the receiver operation.

- 2.5 mm Allen key

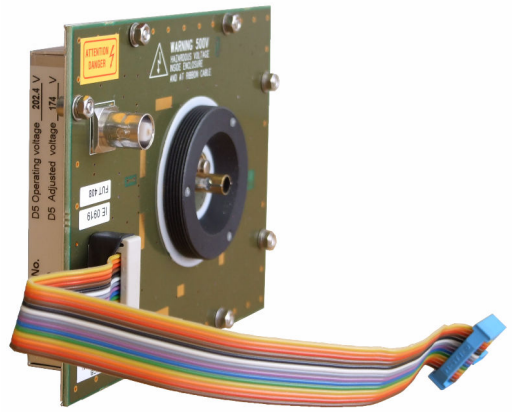


Figure 16 Receiver CLR321

1. Open the measurement unit door and confirm that there is an active receiver failure (the **CLR ok** LED turns off).
2. Switch off the power with all 3 switches (**F1**, **F2**, and battery).

> **WARNING!** Before you continue, disconnect the power cable from the **J2** connector.

3. Detach the coaxial cable from the receiver and the receiver ribbon cable from the ceilometer engine board CLE321.
4. To detach the receiver, loosen the receiver ring by turning it downwards and remove the receiver from the unit.

> You can use a 2.5 mm Allen key as a lever.

5. Place the new receiver to its place and tighten the receiver ring so that the labels of the receiver face the left wall of the enclosure.

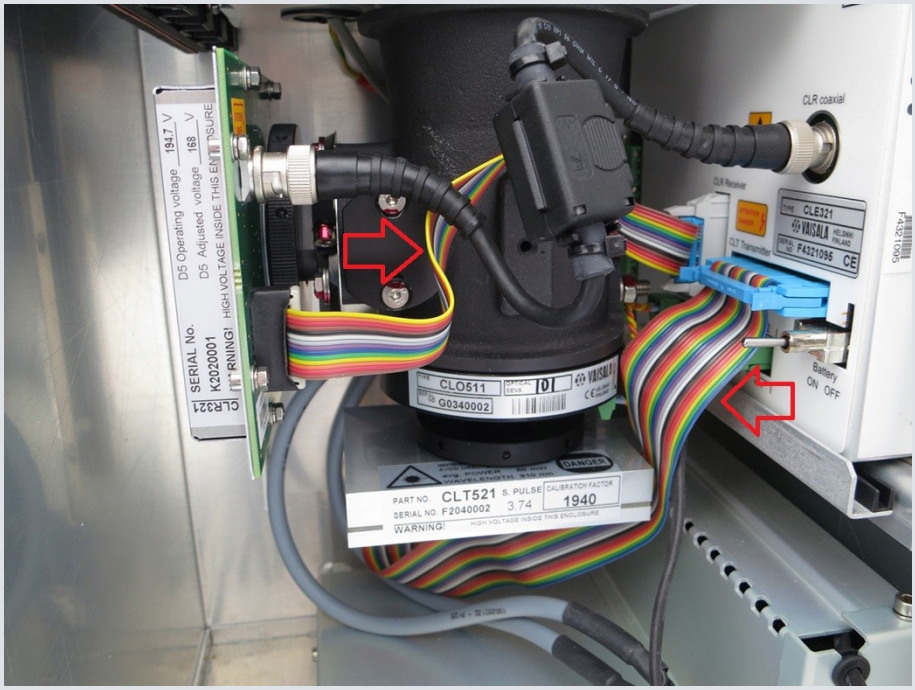
> **CAUTION!** When tightening the receiver, avoid applying force to the receiver enclosure. If the receiver starts rotating along when you tighten the ring, stop it from rotating by hand but do not apply force. If unnecessary force is used, the optical centering of the photo diode may be lost resulting in loss of cloud detection.

6. Connect the receiver ribbon cable to the CLE321 board and the coaxial cable to the receiver.
7. Connect the power cable to the connector **J2**.

8. Switch on the power with all 3 switches (**F1**, **F2**, and battery). Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs light up after the self-test.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

To avoid interference, make sure that you keep the RX flat cable and the TX flat cable apart.

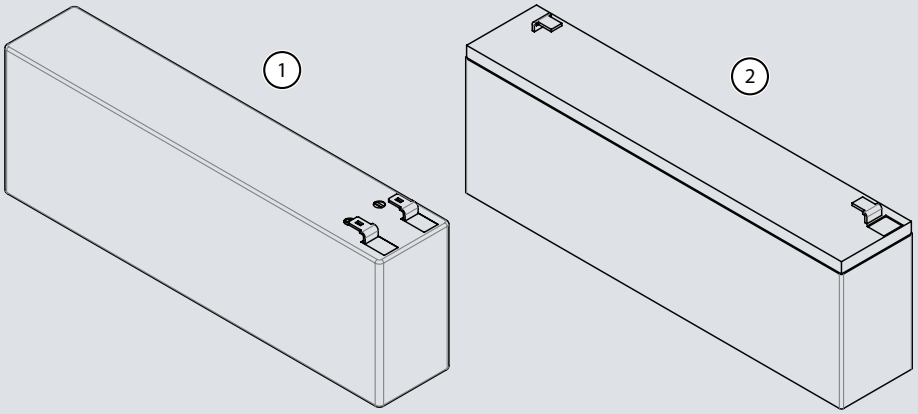


6.5 Replacing battery

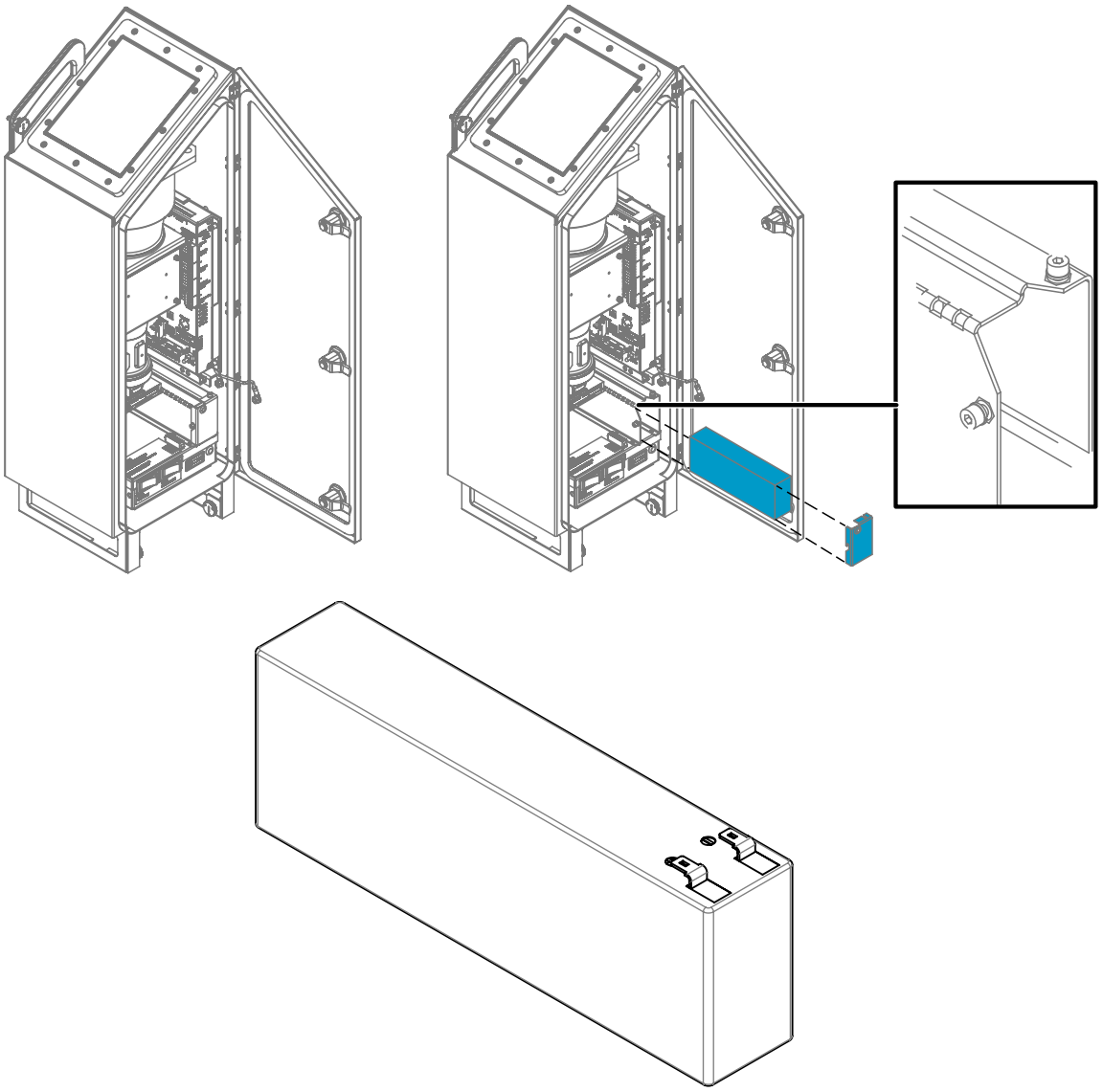
WARNING! Do not replace the battery with a battery of an incorrect type. If you do, there is a risk of deflagration. Dispose of used batteries according to statutory regulations.

CAUTION! Only qualified service personnel may perform service procedures.

Use a 12 V / 2.4 Ah valve-regulated-lead-acid battery with the maximum external dimensions of 178 mm x 34 mm x 64 mm.



1 Battery (available from June 2024)
2 Battery (available before June 2024)



You must replace the battery when it is damaged or you can no longer recharge it.

- 3-mm Allen key
- Crosshead screwdriver

The following instructions are applicable only to the 12 V / 2.4 Ah backup batteries supplied by Vaisala.

1. Open the measurement unit door and switch off the power with all 3 switches (**F1**, **F2**, and battery).

   WARNING! Before you continue, disconnect the power cable from the **J2** connector.

2. Disconnect the battery cable from the CLE321 board.
3. Remove the 2 screws locking the lid of the battery cage.

   One of the screws is located on top of the battery cage, the other is on the left side near the top of the cage.
4. Open the lid of the battery cage and slide out the battery and disconnect the battery cable.
5. Connect the battery cable to the new battery, connecting the red end to the positive (+) pin and the black end to the negative (-) pin.
6. Slide the new battery into the battery cage and close the lid and tighten the 2 screws back to their places.
7. Reconnect the battery cable to the CLE321 board.
8. Connect the power cable to the **J2** connector.
9. Switch on the power with all 3 switches.

   Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs light up after the self-test.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

Recycle the battery according to local rules and regulations.

6.6 Replacing AC power unit

WARNING! Do not replace the AC (mains) cable with an inadequately rated cable.

The figures in this procedure show CL31 but the instructions apply to both CL31 and CL51.

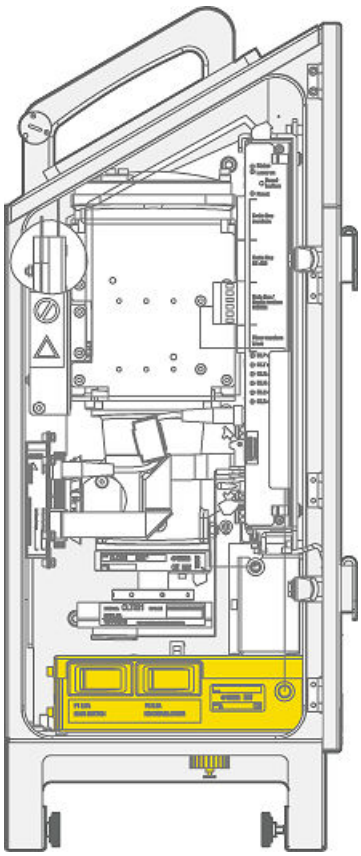


Figure 17 AC power unit

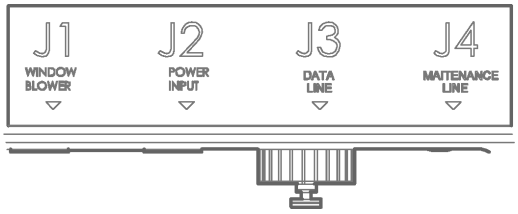
WARNING! High voltage is present in AC power unit CLP321, internal heater CLH311, ceilometer engine board CLE321, and window blower CLB311 at the top of the enclosure.

CAUTION! Only qualified service personnel may perform service procedures.

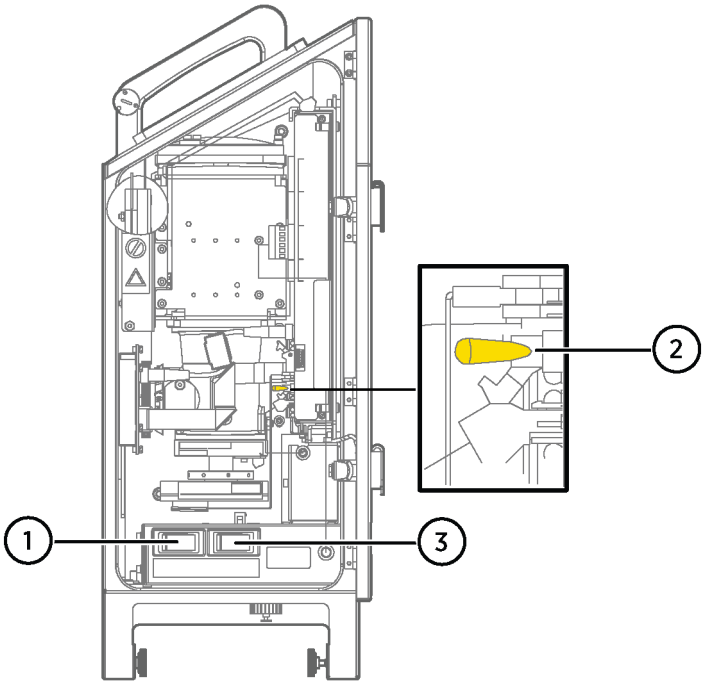
- 2-mm Allen key
- 2.5-mm Allen key
- 3-mm Allen key
- 3-mm flathead screwdriver

WARNING! Before you start, unplug the AC (mains) power cable from the external power source.

1. Open the ceilometer door.
2. Disconnect the cables from connectors **J1**, **J2**, **J3**, and **J4**.



3. Open the measurement unit door.
4. Switch off the power with all 3 switches (**F1**, **F2**, and battery).

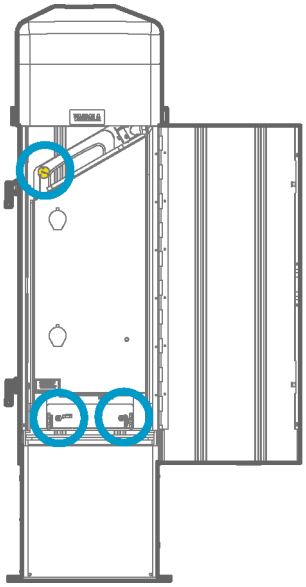


1 Power switch **F1**
2 Battery switch
3 Heater / blower switch **F2**

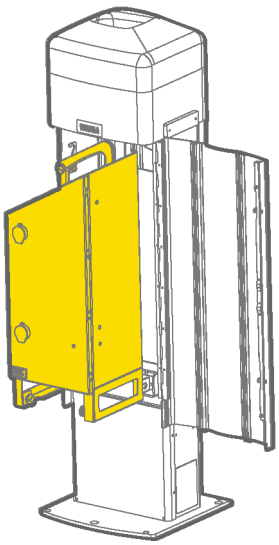
5. If you can replace the AC power indoors or in a service vehicle, remove the measurement unit from the ceilometer enclosure.

> You can try removing the AC power unit without removing the measurement unit from the enclosure, but the screws located on the bottom of the enclosure may be hard to reach.

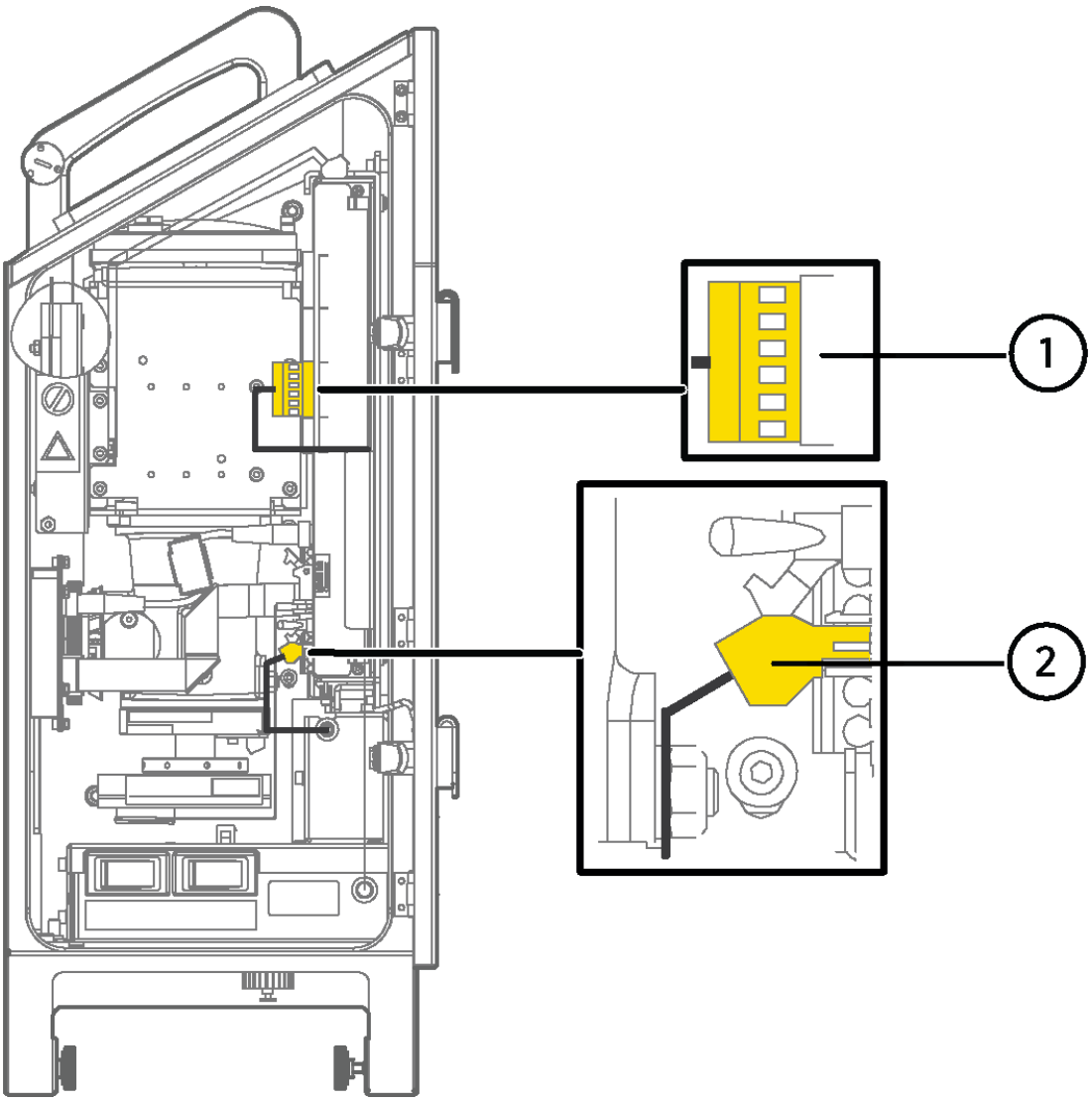
a. Open the 3 screws.



b. Pull out the measurement unit.



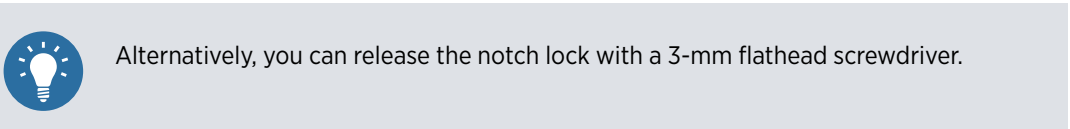
6. Disconnect the battery and data cables from the CLE321 board.



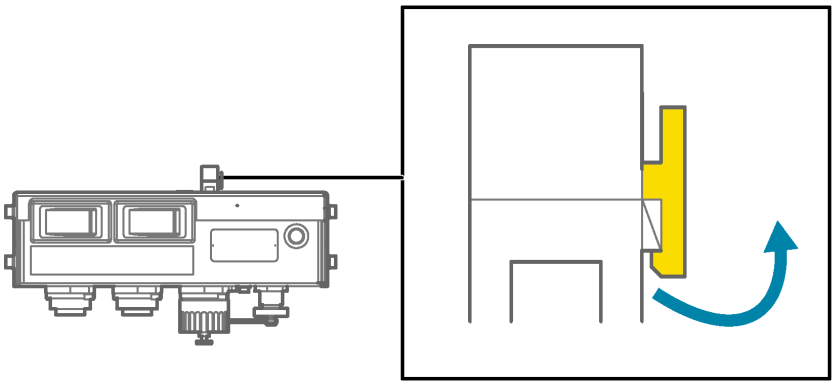
1 Data line connector
2 Battery cable

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7. Squeeze the notch lock with your fingers to release the connector and disconnect the cable from the CLP321 connector.

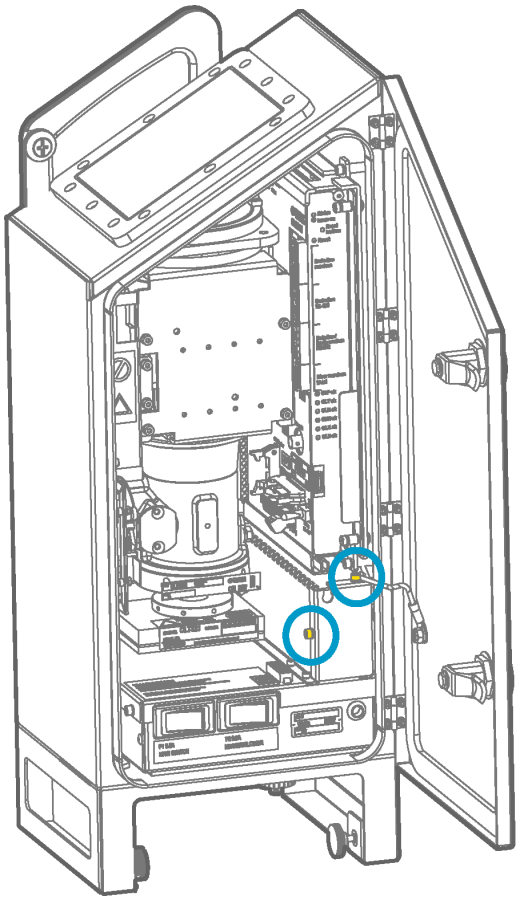


Alternatively, you can release the notch lock with a 3-mm flathead screwdriver.



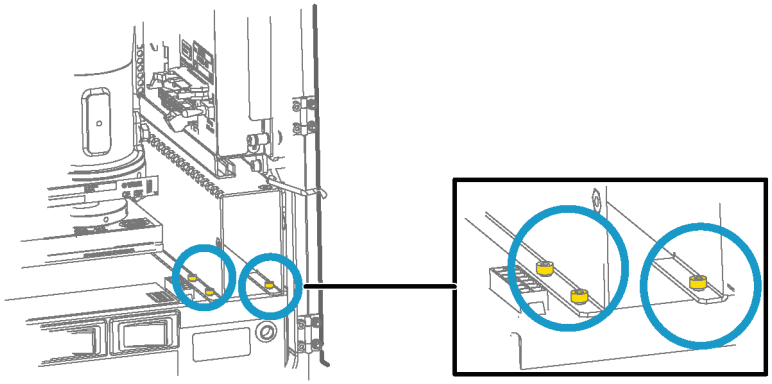
8. To remove the battery cage cover, open the 2 screws with a 3-mm Allen key.

   Press the Allen key firmly when you open the screw.

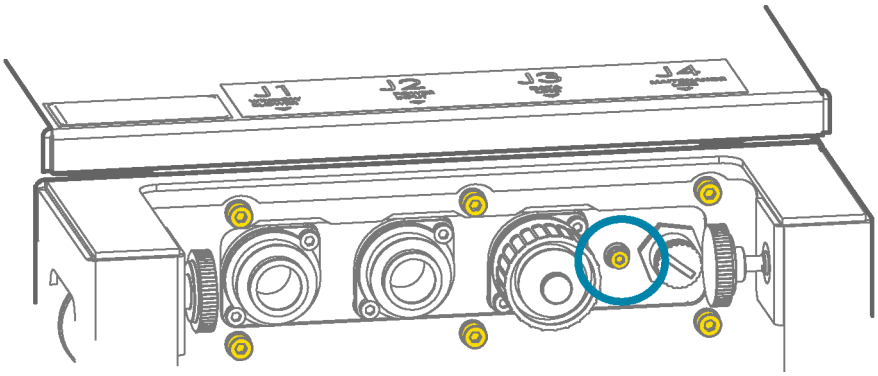


9. Remove the battery and the cable from the battery cage.
10. To remove the battery cage, open the 3 screws with a 2-mm Allen key.

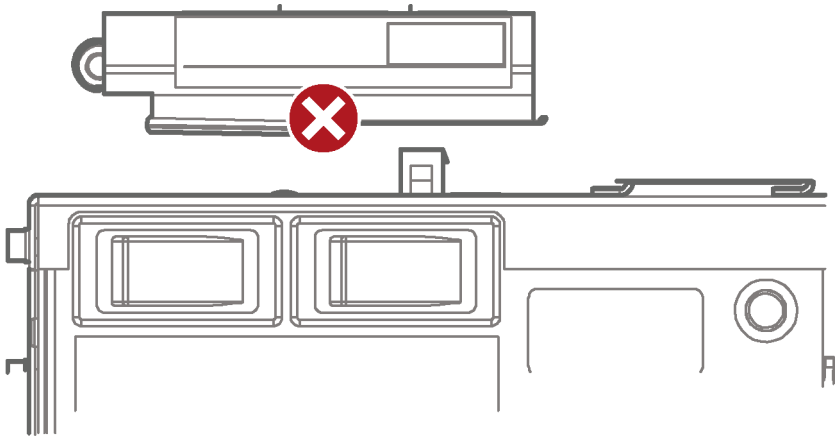
    One of the screws is located inside the battery cage, the other 2 are on the left side near the bottom of the cage.



11. If you removed the measurement unit from the enclosure, move the measurement unit in a horizontal position.
12. To remove the connector caps, open the screw between the data line connector and the maintenance line connector with a 2.5-mm Allen key. Removing them gives you more space to remove the AC power unit.



CAUTION! When lifting the AC power unit, be careful not to hit the transmitter above it. Hitting the transmitter may damage it or lead to incorrect measurements. If the transmitter is bent or twisted, the ceilometer may need a factory calibration.



13. Loosen the 6 CLP321 attachment screws with a 3-mm Allen key until you can carefully remove the AC power unit from the bottom of the measurement unit.

    Leave the screws and gasket in place to ease tightening. You do not need to remove them totally to remove the AC power unit.
14. To remove the connector caps from the new AC power unit, open the screw between the data line connector and the maintenance line connector.
15. Put the new AC power unit in place and perform the procedure in reverse order.
16. Put the connector caps back on and tighten the screw.

17. Tighten the 6 attachment screws on the bottom of the measurement unit. Hold the gasket to keep it in place.
18. Lift the measurement unit to a vertical position.
19. Put the battery cage back to its place and tighten the 3 screws with a 2-mm Allen key.
20. Insert and reconnect the battery and attach the battery cover with 2 screws with a 3-mm Allen key.
21. Connect the cable to the CLP321 connector.
22. Connect the battery and data cables to the CLE321 board.
23. Put the measurement unit back in the enclosure and attach the 3 screws.
24. Connect the blower cable to **J1**, power cable to connector **J2**, and data line cable to **J3**.
25. Switch on the power with all 3 switches (**F1**, **F2**, and battery).

    Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs light up after the self-test.

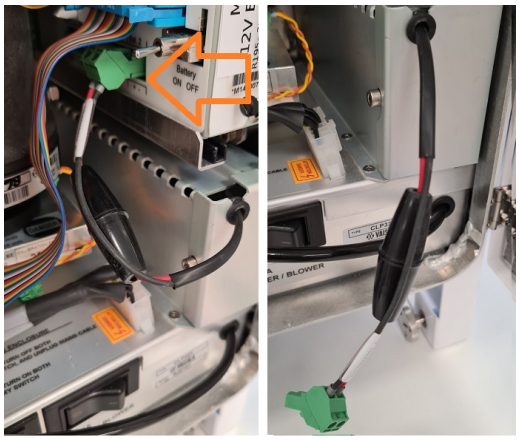
The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

6.7 Replacing fuse

1. Open the measurement unit door and switch off the power with all 3 switches (**F1**, **F2**, and battery).

   WARNING! Before you continue, disconnect the power cable from the **J2** connector.

2. Disconnect the battery cable shown in the following figure.

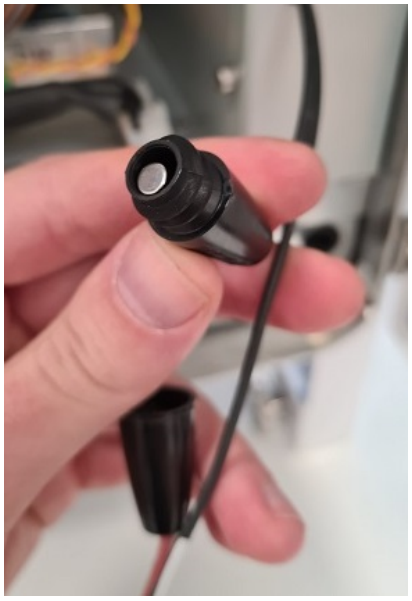


3. To open the fuse holder, rotate it by hand.



Make sure that the fuse does not fall when you open the fuse holder. The fuse is loose in the holder.

4. Remove the old fuse.
5. Place the new fuse in the fuse holder.



Make sure that the fuse does not fall when you open the fuse holder. The fuse is loose in the holder.

6. Close the fuse holder.
7. Connect the battery cable.
8. Connect the power cable to the **J2** connector and switch on power.

6.8 Replacing window blower

CAUTION! Only qualified service personnel may perform service procedures.

CAUTION! Make sure you do not to contaminate or scratch the window.

Replace the window blower if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the blower has been detected.



Figure 18 Window blower CLB311-115 / CLB311-230

- 5-mm Allen key

1. Open the measurement unit door and confirm that there is an active window blower failure. In case of a window blower failure, the **CLB ok** LED turns off.
2. Switch off the power with all 3 switches (**F1**, **F2**, and battery).

WARNING! Before you continue, disconnect the power cable from the **J2** connector.

3. As the blower is attached to the radiation shield, you first have to remove the measurement unit from the radiation shield to get to the blower. To remove the measurement unit, loosen the 3 attachment screws, disconnect the blower cable from connector **J1** and pull out the unit.
4. Use an Allen key to loosen the 2 screws on the side of the window blower, then pull out the blower.
5. Use the same Allen screws to attach the new window blower.
6. Reattach the measurement unit by placing it inside the radiation shield, reconnecting the blower cable to connector **J1**, and tightening the 3 attachment screws.
7. Connect the power cable to connector **J2**.
8. Switch on the power with all 3 switches. Wait for 5 minutes after the start-up until self-check is completed. Make sure that all 6 diagnostic LEDs are lit.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

6.9 Replacing internal heater

You must remove the optics unit before replacing CLH311.

CAUTION! Only qualified service personnel may perform service procedures.

Vaisala recommends replacing the internal heater CLH311 indoors.

- 3-mm Allen key
- Screwdriver

Replace the internal heater if the ceilometer unit generates warnings and alarms, and a malfunction with the operation of the heater has been detected.

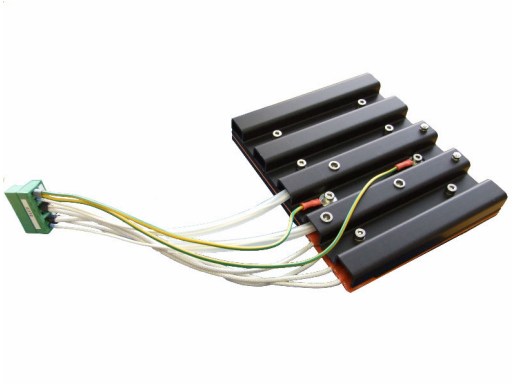


Figure 19 Internal heater CLH311-115 / CLH311-230

1. Open the measurement unit door and confirm that there is an active internal heater failure (the **CLH ok** LED is off).
2. Switch off the power with all 3 switches (**F1**, **F2**, and battery).

> **WARNING!** Before you continue, disconnect the power cable from the **J2** connector.

3. Close the enclosure door and remove the measurement unit. To do this, loosen the 3 attachment screws, disconnect the blower cable from connector **J1**, and pull out the unit.
4. Remove the metal plate protecting the heater by loosening its 2 screws.
5. Disconnect the battery, transmitter, receiver, and data cables from the CLE321 board.
6. To remove the optics unit, first remove the holder plate by loosening the 4 Allen screws on its front cover.
7. Detach the internal heater connector and holding the cable aside, carefully pull out the optics unit upper end first.

   Do not touch the lens of the optics unit.
8. Detach the CLM311 twisted pair cable from the CLE321 board.
9. To remove the internal heater, use an Allen key or a short screwdriver and loosen the 3 screws attaching the heater to the left wall of the measurement unit enclosure. Then slide out the internal heater.
10. Slide the new internal heater to its place and hold it there while tightening the 3 screws.
11. Attach the CLM311 twisted pair cable to the CLE321 board.
12. Slide the optics tube to its place with the bottom end first. Make sure no cables get stuck between the optics tube and other ceilometer components.
13. Snap the internal heater connector to its place.
14. Place all heater cables behind the holder and tighten the 4 holder screws.

15. Reconnect the battery, transmitter, receiver, and data cables to the CLE321 board.
16. Reattach the metal plate protecting the internal heater.
17. Insert the measurement unit inside the radiation shield, reconnect the blower cable to connector **J1**, and tighten the 3 attachment screws.
18. Connect the power cable to connector **J2**.
19. Switch on the power with all 3 switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs are lit.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

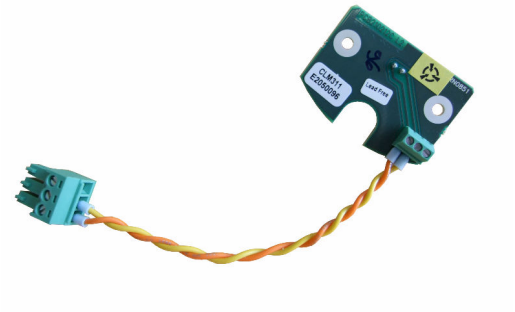
6.10 Replacing laser monitor board

The optics unit and transmitter module must be removed before replacing CLM311.

CAUTION! Only qualified service personnel may perform service procedures.

- 2.5 mm Allen key
- Calculator
- Computer
- Service cable

Figure 20 Laser monitor board CLM311



1. Open the measurement unit door and switch off the power with all three switches (**F1**, **F2**, and battery).

   WARNING! Before you continue, disconnect the power cable from the **J2** connector.

2. Disconnect the battery, transmitter, receiver, and data cables from the CLE321 board.

   For checking the maintenance parts locations, see Service overview (page 94)

3. To remove the optics unit, remove the holder plate by loosening the 4 Allen screws on its front cover.
4. Detach the internal heater connector and holding the cable aside, carefully pull out the optics unit upper end first.

   Do not touch the lens of the optics unit.

5. Detach the CLM311 twisted pair cable from the CLE321 board.
6. To detach the transmitter, loosen the transmitter ring by turning it to the right. If necessary, you can use the Allen key as a lever. Remove the transmitter from the Optics unit.
7. Detach the laser monitor board CLM311 by loosening the two screws. You can access the screws through the hole in the transmitter ring.
8. Write down the sensitivity value of the old defective board, for example, 102 %. If no value is written on the CLM311, use the standard value 100 %.
9. Write down the sensitivity value of the new CLM311 board, for example, 98 %. If there is no value on the CLM311, use the standard value 100 %.
10. Attach the new CLM311 board into the optics unit and tighten the 2 screws.
11. Place the transmitter to its place and tighten the transmitter ring so that the labels of the transmitter face the measurement unit door.
12. Attach the CLM311 twisted pair cable to the CLE321 board.
13. Slide the optics unit to its place with the bottom end first.

    Make sure that no cables get stuck between the optics tube and other ceilometer components.
14. Snap the internal heater connector to its place.

15. Place all heater cables behind the holder and tighten the 4 holder screws.
16. Reconnect the battery, transmitter, receiver, and data cables to the CLE321 board.
17. Connect the power cable to the connector **J2** and the maintenance terminal to CL31.
18. Switch on the power with all 3 switches.

    Wait until the **Laser on** LED starts blinking at 2-second intervals. Ensure that all 6 diagnostic LEDs are lit.
19. Open the command line with the **`open`** command.

    The password is **`advanced`**.
20. Type the **`get params factory`** command and write down the **Target Outlaser** value.
21. The new calibration value is calculated as follows:

    ```
    NEW OUTLASER = (OLD OUTLASER x NEW CLM311 SENSITIVITY VALUE) / (OLD CLM311
    SENSITIVITY VALUE)
    ```

    For example: 880 x 98 % / 102 % = 837 (rounded to the nearest integer value)
22. Type the following command:

    ```
    SET FACTORY OUTLASER <value>
    ```

    where **`<value>`** is the new, calculated target outlaser value.
23. Type the **`status`** command and check from the status message that the measured outlaser is close (±5 %) to the new outlaser value. Make sure that the system status is OK and there are no suspect units.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

6.11 Replacing modem module



CAUTION! Only qualified service personnel may perform service procedures.



Always replace the modem module indoors.

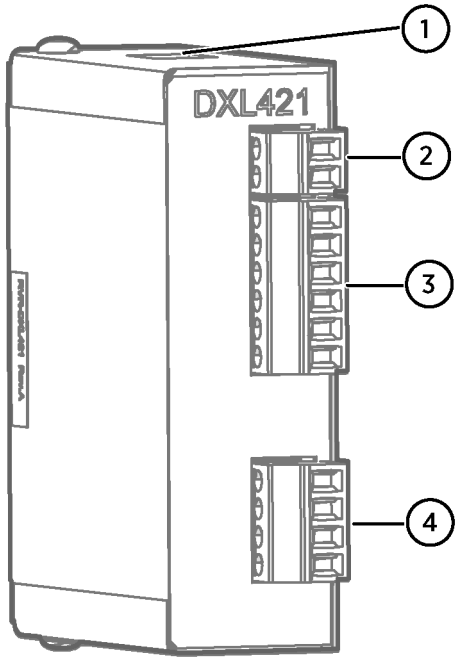


Figure 21 DXL421 leased line modem

1 DIL switch
2 Power input
3 RS-232 interface
4 Leased line interface

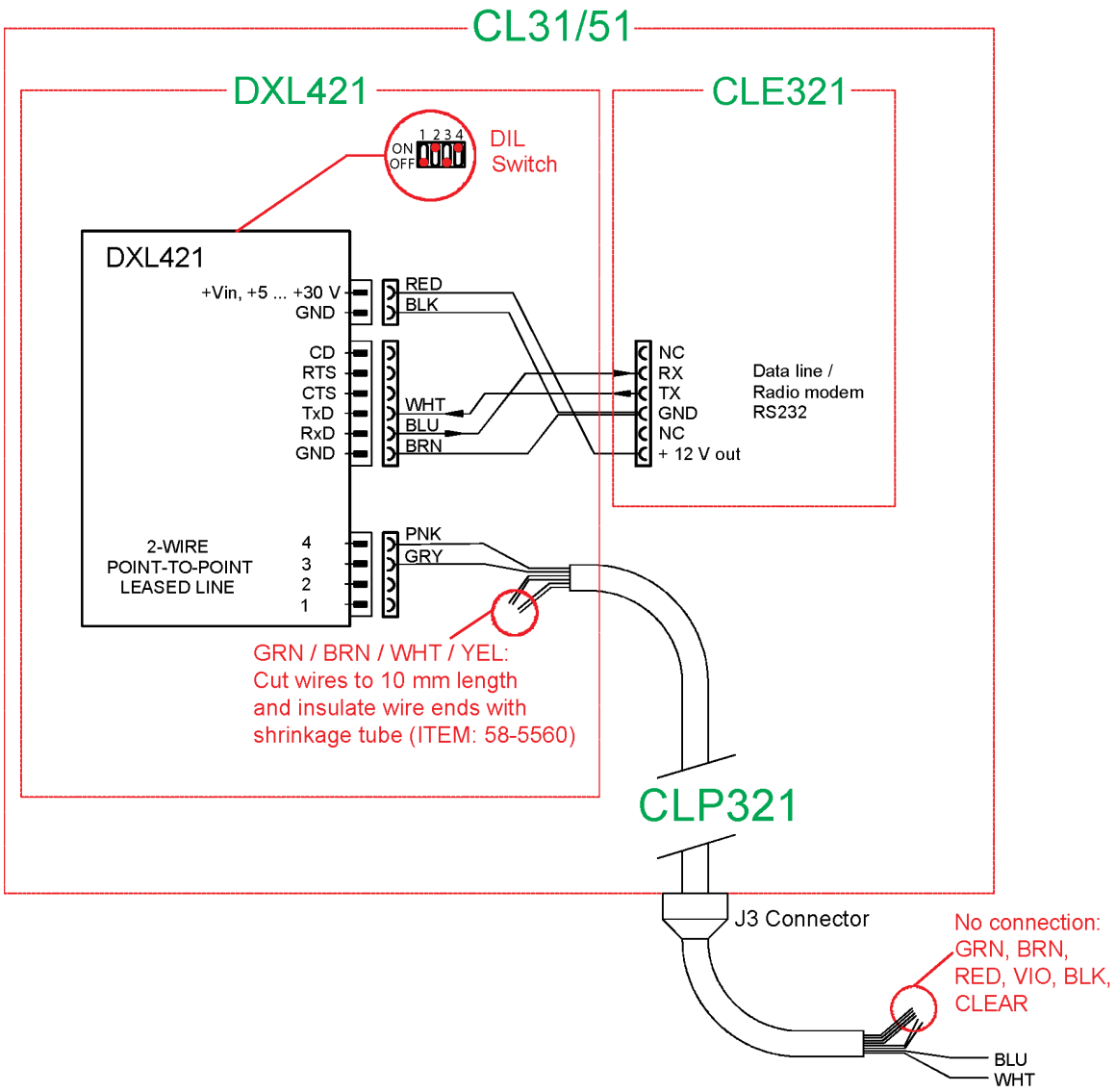


Figure 22 DXL421 modem connections

You can set the DXL421 operation mode by a DIL switch. The following figure shows the correct positions of the switches.

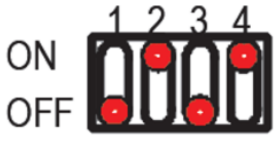


Figure 23 DXL421 DIL switch

Table 22 Default settings for the DXL421 modem connection

Bit rate	19200
Data bits	8
Stop bits	1
Parity	None
Handshake	None

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7. Troubleshooting

7.1 Troubleshooting overview

The goal of troubleshooting is to locate the cause for the potential problem. Failure situations are usually caused by dirt in optics or unclarity of the optical path. Also external conditions or the following replaceable subassemblies may be the source of problems:

- Ceilometer engine board CLE321
- Ceilometer transmitter CLT321
- Ceilometer receiver CLR321
- Coaxial cable 226296
- Laser monitor board CLM311
- AC power CLP321
- Blower CLB311-115/230
- Heater CLH311-115/230
- Battery

If damage is suspected in a subassembly or a board, replace it with a spare part and send the defective part to Vaisala for repair/replacement.

Replacements must only be performed by qualified maintenance personnel. As a principle, user repairs are restricted to the replacement of subassemblies.

7.2 Accessing diagnostic information

During normal operation, the ceilometer continuously monitors its internal status and regularly checks the blower and the heater. The ceilometer automatically analyzes the diagnostic test results and reports potential failures with every data message.

The ceilometer automatically identifies the potentially faulty subassemblies.

More information

- Warning and alarm messages (page 133)

7.3 Troubleshooting equipment

To establish a service connection to the ceilometer you must have a maintenance terminal which can be a laptop with an RS-232 interface or a PC with serial interface, maintenance cable QMZ101, and any terminal program. You can use the BL-View or CL-View software for this purpose. If you perform the operation check indoors, you must have an optical termination hood which absorbs the laser light that would otherwise reflect from the ceiling and possibly saturate the receiver.



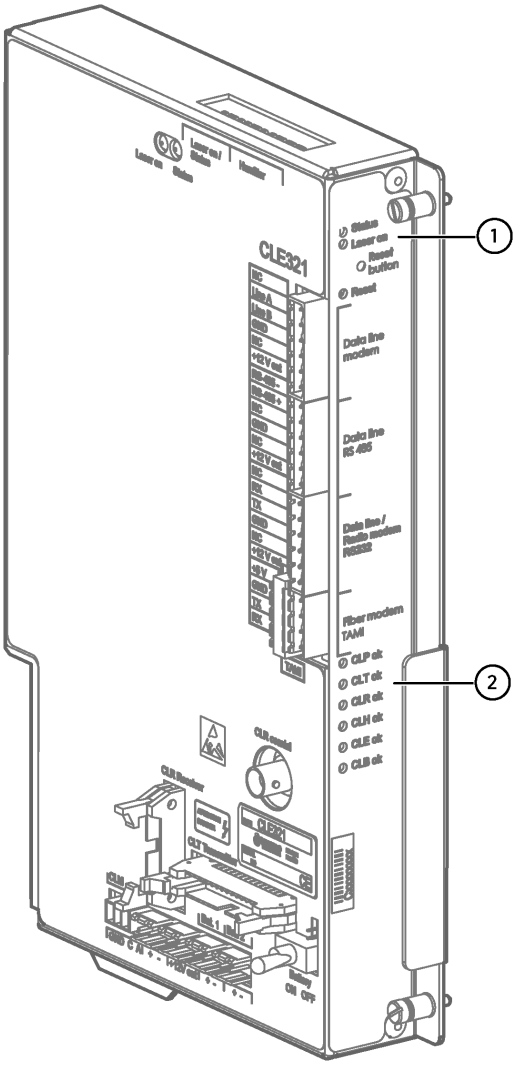
You can establish maintenance connection also through the data line if, for example, the ceilometer is out of use. This stops the data flow for as long as the command line is open.

7.4 Troubleshooting ceilometer

1. Clean the window carefully with a soft, lint-free cloth moistened with a mild detergent.

   Make sure you do not scratch the window surface.
2. If you are indoors, put the optical termination hood (CLTERMHOOD) on the ceilometer window. To the ceilometer this represents a clear, nighttime sky.
3. Connect the maintenance terminal to the maintenance port at the bottom of the ceilometer and turn on both the ceilometer and the maintenance terminal. .

4. Make sure that the ceilometer starts operating properly: the **Laser on** LED on the CLE321 board is blinking after initialization at 2 s intervals. If the key modules function properly, all 6 diagnostic LEDs light up.



1 **Laser on** LED
2 Diagnostic LEDs

During the first 5 minutes after startup an automatic blower check verifies that the blower heater functions properly. The result is available 5 minutes after starting the unit and it is indicated by the **CLB ok** LED. It is also displayed in the status message.

5. To get the failure status message, type **open** and press **ENTER** on the maintenance terminal (computer) keyboard.

   `CEILO` > prompt appears. Type **`get failure status`** and press **ENTER**.
   An example response:

```
Alarms
 Tmit Shutoff  OK    Transmitter  ALRM
 Receiver      OK    Voltages     OK
 Ext Memory    OK    Light Pth Obs OK
 Rec Saturat   OK    Coaxial Cable OK
 Engine        OK

Warnings
 Window Contam OK    Battery Low  OK
 Transm Expire OK    Humid High   OK
 Blower        OK    Humid Sensor OK
 Int Heater    OK    High Rad     OK
 Engine        OK    Battery      OK
 Laser Monitor OK    Receiver     OK
 Tilt Angle    OK

System Status:   FAIL
 Suspect Module: CLT
```

   The 2 last lines in the status message indicate if there are warnings or alarms present. The `Suspect module` line indicates the unit that is suspected to be faulty. In this example, it is transmitter CLT.

6. When the 5-minute blower check is over, check the result from the status message and place a piece of white paper on the ceilometer window. The blower starts within a minute. Remove the paper. The blower stops within 8 minutes.

7. Do one of the following:
   - If there are clouds, compare the ceilometer measurement with a qualified weather observer's height approximation.
   - If there are no clouds and the site is suitable, perform a hard target test: turn the measurement unit 90 degrees and aim it on a fixed target such as a wall or a forest front.
     The minimum distance to a hard target must be 300 meters (1 000 ft). The backscatter signal from a hard target is very strong compared to the signal from a cloud. The receiver may saturate if the distance is too short.



WARNING! When tilting the unit, make sure that nobody is watching the beam with binoculars or other magnifying optics.

Disable the automatic angle correction with the following commands:

```
CEILO > SET MESSAGE ANGLE_COR OFF
CEILO > CLOSE
```

Compare the distance reading of the ceilometer to a reference measurement.

More information

‣ Termhood (page 150)

7.5 Warning and alarm messages

Table 23 Ceilometer status, warnings

Status message	Reason	Instructions
`Battery failure`	Battery is dead.	Replace the battery. Make sure that the F3 fuse in the battery cable is intact.
`Battery voltage low`	The unit has been powered too long using the backup battery.	Connect the line voltage or replace the battery.
	Battery fails to recharge.	If the battery is old, replace it. If the battery is OK, check the operation of ceilometer engine board CLE321.

Status message	Reason	Instructions
`Blower failure`	Blower cable is not connected.	Check that the blower cable is connected.
	Window blower circuit breaker is not ON.	Check that the window blower circuit breaker is ON.
	Line voltage level is not correct.	Check that the line voltage is present and correct.
	Blower is stuck.	Check if visible obstacles disable blower operation.
	Blower is damaged.	Replace the blower.
	Blower is blowing, but only cool air. The blower heater is malfunctioning.	Replace the blower.
`Ceilometer engine board failure`	Non-critical fault in ceilometer engine board CLE321.	Replace ceilometer engine board CLE321.
`Heater fault`	Window blower circuit breaker is not ON.	Check that the window blower circuit breaker is ON.
	Line voltage level is not correct.	Check that the line voltage is present and correct.
	Heater is damaged.	Replace the heater.
`High background radiance`	Direct sunlight.	In case there are no alarms, the measurements are OK. If there is an alarm, the measurements are invalid.
`High humidity` (option)	Relative humidity > 85 %. Water has been condensed inside the ceilometer. Leakage in the enclosure or leakage in the door.	Take the ceilometer inside, open the maintenance door and let it dry in a warm air conditioned place. Condensed water on optical surface may disturb the measurement. There is a danger of short circuits.
`Humidity sensor failure` (option)	Humidity sensor is not connected.	Connect the humidity sensor or disable the option in the software.
	Humidity sensor is damaged.	Contact technical support and send the ceilometer to Service Center for the humidity sensor to be replaced.
`Laser monitoring failure`	Laser power monitor board CLM311 has failed.	Replace CLM311.
	Laser power measurement on ceilometer engine board CLE321 has failed.	Replace CLE321.
`Receiver warning`	A non-critical CLR321 receiver failure.	Replace CLR321.

Status message	Reason	Instructions
`Tilt angle > 45 degrees warning`	The unit is not correctly installed or the tilt angle is larger than 45°.	Check the installation. The height measurement accuracy is lost with tilt angles greater than 45°.
`Transmitter expires`	Laser diode is too old.	Replace transmitter. The measurement data is valid, but it is possible that some clouds are missed.
`Window contamination` (appears from time to time and lasts < 5 min)	Usually drizzle drops on the window.	The blower cleans the window. If clouds are detected, the height information is correct. If no clouds are detected, it is possible that high clouds are missed.
`Window contamination` (continuous)	For example, bird droppings, leaves, or dust have contaminated the window.	Clean the window.

Table 24 Ceilometer status, alarms

Status message	Reason	Instructions
`Ceilometer engine board failure`	Ceilometer engine board is damaged.	Replace ceilometer engine board CLE321.
`Coaxial cable failure`	Coaxial cable disconnected or broken.	Verify the connection or replace the coaxial cable.
`Light path obstruction`	Window is badly contaminated or severely scratched.	Clean the window or in case of damage, replace CLW311.
	Something blocks the laser beam.	Check the clarity of the optical path.
`Memory error`	A failure in the CLE321 memory.	Replace CLE321.
`Receiver failure`	Receiver CLR321 is damaged.	Replace CLR321.
	Loose cable connection.	Check that the cables from receiver CLR321 and ceilometer optics CLO321 are undamaged and correctly connected.
	Receiver test not operating.	Check that the optics unit CLO321 is not misplaced or damaged. If the unit is damaged or missing, contact Vaisala for repair and replacement, since the CLO321 unit is not field-replaceable.
`Receiver saturation`	Direct sunlight.	Wait for the sun to exit the field-of-view. The ceilometer returns to normal operation.
	Something is partially blocking the laser beam.	Check the clarity of the optical path.

Status message	Reason	Instructions
`Transmitter failure`	Laser is worn out or damaged.	Replace laser transmitter.
	Laser does not get electrical power.	Check from the status message that the line **Voltages** is marked **OK**.
`Transmitter shut-off` (Laser temperature > 85 °C)	Direct sunlight has heated the laser.	Wait for the sun to exit the field-of-view. The ceilometer returns to normal operation.
	Environment temperature is too high.	Check if there is a specific reason for the high temperature.
`Voltage failure`	Ceilometer engine board CLE321 is damaged.	Replace CLE321.

Table 25 Ceilometer status, miscellaneous problems

Problem	Reason	Instructions
The ceilometer does not start, no LEDs are lit	Power is not connected.	Check that both the main and the battery switches are in the ON position. Check the presence and correctness of the line voltage, and make sure that the battery is OK.
	Loose cable connection.	Check the cable connections.
Laser on LED is not blinking but the **Status** LED is lit.	Operation mode is standby.	Connect the maintenance terminal and check if the operation mode is normal.
	CLE321 is damaged.	Replace CLE321.
Data message is missing.	Dialogue is not operating.	Check the cable connections. Open the terminal.
	Wrong communication parameters.	Check the communication parameters (number of bits, parity, etc.).
	Wrong data port.	Open the terminal program and give **open** command and then **`get params message`** command. Check that the PORT is set to DATA.
	Operation mode is standby.	Open the terminal program and first give the **open** command and then the **status** command. Check that the OPERATION MODE is NORMAL.
Cloud detection is missing.	Equipment failure.	Open the terminal program and give **open** command and then **`get failure status`** command. Check the alarms and warnings. If there are no alarms or warnings in the data message, contact Vaisala.

Problem	Reason	Instructions
The capability to detect high clouds is reduced.	Low receiver gain (no fog or snow).	Check the automatic receiver gain setting in the status message. If it is low, check that the window is clean. Check that the optical path is clear. Visually check that the lens is clean.
	Extensive amount of dirt or water droplets on the window and a failure in the diagnostics.	Check the window clarity. Check the blower operation by giving the **`service self_check`** command and check that the blower works.

8. Technical Data

8.1 CL31 specifications

Table 26 Mechanical specifications

Property	Value
Tilt positions	Vertical or 12° tilted
Dimensions	
Measurement unit	620 × 235 × 200 mm (24.41 × 9.25 × 7.87 in)
Height with radiation shield	1190 mm (47 in)
Total	1190 × 335 × 324 mm (46.85 × 13.19 × 12.76 in)
Weight	
Measurement unit	12 kg (26.46 lb)
Radiation shield and blower	19 kg (41.89 lb)
Total	31 kg (68.34 lb)
Plywood transport container	
Container size	1400 × 490 × 450 mm (55.12 × 19.30 × 17.72 in)
Container weight	47 kg (103.62 lb)

Table 27 Measurement performance

Property	Value
Measurement range	0–7.6 km (0–25 000 ft)
Reporting resolution (units selectable)	With 5-m resolution: 5 m or 10 ft With 10-m resolution: 10 m or 30 ft
Reporting interval	Programmable 2–20 s, or polling
Measurement interval	2 s default
Distance measurement accuracy against a hard target	±5 m (16 ft)

Table 28 Operating environment

Property	Value
Operating environment	Outdoor use
Use in wet location	Yes
Operating temperature	−50 ... +60 °C (−58 ... +140 °F)

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Property	Value
Operating humidity	0–100 %RH
Wind tolerance	Up to 55 m/s (123 mph)
Vibration	Lloyds Register / IEC 60068-2-6 5–13.2 Hz, ±1.0 mm 13.2–100 Hz, ±0.79 g 9.1–150 Hz, ±0.5 g
Pollution degree for inside electronics	2
Maximum operating altitude	3000 m (approx. 9800 ft)
IP rating [1)]	IP65 (measurement unit) Dust-tight. Protected from water jets from any direction. IPX6 (with radiation shield) : Protected against strong jets of water.
UL 50E rating	Type 4: Dust-tight. Protected from hose-directed water.

1) The IP rating is valid only when the ceilometer is installed according to Vaisala instructions.

Table 29 Inputs and outputs

Property	Description/Value
Operating voltage	115/230 V AC 100–127 V AC, 207–253 V AC
Current consumption	
Current consumption (maximum)	2.7/1.4 A
Measurement unit	0.1/0.1 A
Internal heater	0.9/0.4 A
Window conditioner heater	1.5/0.8 A
Window blower	0.2/0.1 A
Frequency (min./max.)	50/60 Hz
Battery backup	12 V internal, VRLA (valve regulated lead acid), 2.4 Ah
Overvoltage protection	Low-pass filter, VDR
Overvoltage category	II
Interfaces	
Data	• RS-232 • RS-485, multidrop, 2-wire • DXL421 modem module • LAN (Ethernet) interface option
Maintenance	RS-232
Baud rate	

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Property	Description/Value
RS-232/RS--485	300–57 600 bps
Modem V.21, V.22	300–1200 bps

Table 30 Receiver specifications

Property	Value
Detector	Silicon avalanche photodiode (APD)
Surface diameter	0.5 mm (0.02 in)
Receiver bandwidth	3 MHz (–3 dB)
Interference filter	Center wavelength 915 nm typical
50 % pass band	36 nm
Transmissivity at 913 nm	80 % typical
Field-of-view divergence	±0.83 mrad

Table 31 Transmitter specifications

Property	Value
Laser source	Indium gallium arsenide (InGaAs) diode laser
Center wavelength	910 ±10 nm at 25 °C (77 °F)
Operating mode	Pulsed
Radiated pattern emitted from the protective housing (measurement unit window)	
Maximum average power through 7-mm aperture in the plane of the laser aperture	570 µW
Average pulse power	11 W
Peak power	18.5 W
Average power	16.0 mW
Beam divergence	±0.4 mrad × ±0.7 mrad
Pulse duration	110 ns
Repetition rate	10.0 kHz
Laser classification	Class 1M laser product, IEC 60825-1:2014 (Edition 3.0) and EN 60825-1:2014 + A11:2021
Incorporated laser source (CLT321 transmitter)	
Peak power	91 W
Maximum average power	82.5 mW
Typical beam divergence	±5 × 12.5 degrees FWHM
Pulse duration	110 ns

Property	Value
Repetition rate	10 kHz
Laser class according to IEC/EN 60825-1:2014	3B

Table 32 Optical system specifications

Property	Value
Optics system focal length	300 mm (11.81 in)
Effective lens diameter	96 mm (3.78 in)
Lens transmittance	96 % typical
Window transmittance	97 % typical, clean

Table 33 Compliance

Property	Value
EU directives and regulations	Low Voltage Directive (2014/35/EU) EMC Directive (2014/30/EU) RoHS Directive (2011/65/EU) as amended by 2015/863
EMC immunity	EN 61326-1:2013, Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements.
EMC emissions	EN 55032:2015 + A11:2020 EN 61000-3-2 EN 61000-3-3
Electrical safety	EN 61010-1:2010 + A1:2019
Environmental	EN IEC 63000:2018
Eye safety	EN 60825-1:2014+A11:2021 Complies with 21 CFR 1040.10 and 1040.11 except for the deviations pursuant to the *Laser Notice No. 56*, date May 8, 2019.
Compliance marks	CE, RCM, China RoHS, UKCA

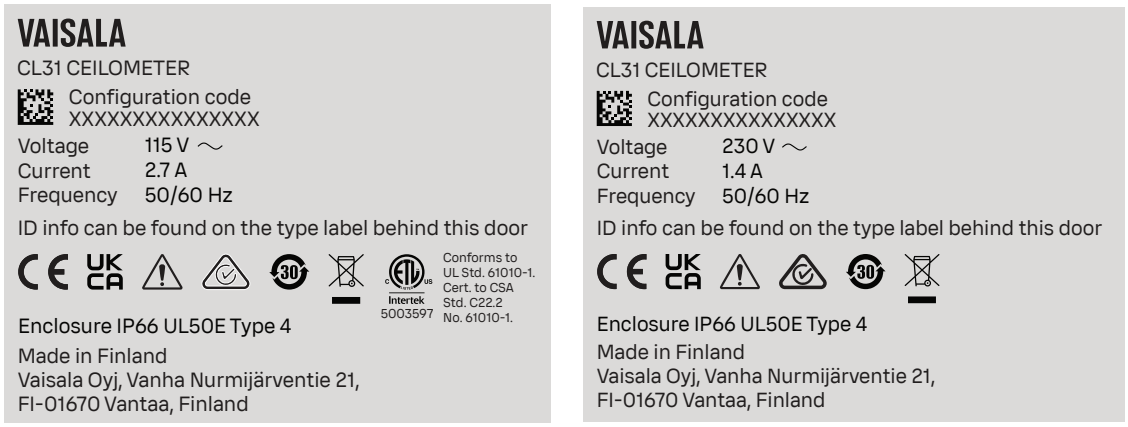


Figure 24 Type labels 115 V and 230 V CL31



Figure 25 Location of type labels

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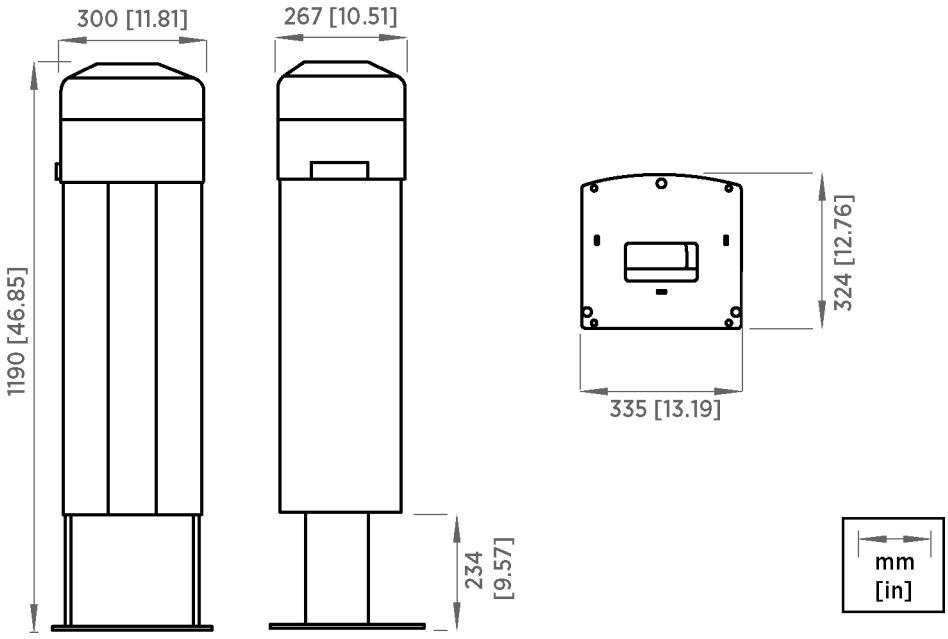


Table 34 External connector J1 - window blower specifications

Property	Value
Connector J1	Type Amphenol series 693, C016 30H006 110 10 (female)
Mating connector type	Type Amphenol series 693, C016 30H006 110 10 7-pin (male) elbow

Table 35 External connector J2 - power input specifications

Property	Value
Power connector J2	Type Amphenol series 693, C016 20C003 100 12 4-pin (male)
Mating connector type	Type Amphenol series 693, C016 20F003 100 10 (female) elbow
No-break power supply	12 V internal, VRLA (valve regulated lead acid), 2.4 Ah
Overvoltage protection	Low-pass filter, VDR

Output interface

The data port can operate according to the following serial line standards:

- RS-232
- RS-485, multidrop, 2-wire
- DXL421 modem module
- LAN (Ethernet) interface option

LAN is available as a data output option and with the air quality plug-and-play package.

Table 36 External connector J3 - data line specifications

Property	Value
Connector J3	Type Amphenol series 693, C016 30C006 100 12 7-pin (male)
Mating connector type	Type Amphenol series 693, C016 30F006 100 10 (female) elbow
Baud rate	19200 bps standard with RS-232 300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115 200 bps available 300 or 1200 bps available with modem DXL421
Maximum distance to operate	300 m (1000 ft) with RS-232 1.2 km (4000 ft) with RS-485, all at 2400 bps with typical communication cables 10 km (6.2 mi.) with modem
Standard character frame	1 start bit 8 data bits No parity 1 stop bit
Standard character code	USASCII
Pin connections	1 RS-485 -/RTS# (no SW support) 2 RS-485+/RS-232 RxD/Modem lead A 3 Modem lead B/RS-232 TxD 4 Ground 5 CTS# (no SW support) 6 +12 V DC (700 mA continuous, for local external equipment) 7 Signal ground
Overvoltage protection in each circuit	Primary: gas discharge tube Secondary: PCTs, thyristor overvoltage protector

Modem circuits are non-polar and symmetrical. All modem circuits are electrically floating to overvoltage protection rating (300 ... 500 V).

Table 37 External connector J4 - maintenance line specifications

Property	Value
Connector J4	Female 5-pin M12 connector (for example, Lumberg RKF 5 / 0.5 M)
Mating connector type	Male 5-pin M12 connector (for example, Lumberg RST 5-644)

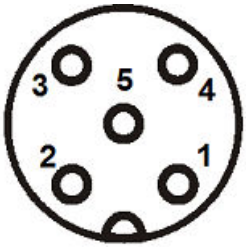
Property	Value
Baud rate	9600 default and standard 300, 2400, 4800, 9600, 19200, 38400, 57600, 115 200 bps available
Distance to operate	300 m (1000 ft) at 2400 baud with typical communication cables
Standard character frame	1 start bit 8 data bits No parity 1 stop bit
Standard character code	USASCII
Pin connections	 (RTS/CTS not used)
Overvoltage protection in each circuit	Primary: noble gas surge arrester Secondary: VDRs, transient Zener diodes or normal diodes

Table 38 NPort 5232-T serial device server specifications

Property	Value
Speed	10/100 Mbps, auto MDI/MDIX
Network protocols	ICMP, IPv4, TCP, UDP, DHCP, BOOTP, Telnet, DNS, SNMP V1, HTTP, SMTP, SNTP
Supply voltage	+12 to 48 V DC
Current consumption	280 mA at 12 V 150 mA at 24 V
Maximum operating altitude	2000 m (6560 ft)
Max. operation distance	100 m (328 ft)

8.2 DXL421 specifications

Table 39 DXL421 operating environment

Property	Description/Value
Operating temperature	−40 … +55 °C (−40 … +131 °F)
Storage temperature	−60 … +75 °C (−76 … +167 °F)
Operating humidity	0–100 %RH, non-condensing
IP rating	IP30: Protected against solid foreign objects of 2.5 mm Ø and greater.
UL 50E (NEMA) rating	Type 1: Protected against solid foreign objects of 50 mm Ø and greater.

Table 40 DXL421 inputs

Property	Description/Value
Supply voltage	+5 … +30 V DC
Power consumption	0.09 W
Fuse	0.5 A PTC
Transient protection	Yes, transil diode
Reverse connect protection	Yes
Connector	2-position screw terminal
Indicator	Green power LED

Table 41 DXL421 serial RS-232 interface

Property	Description/Value
Topology	EIA/TIA-232-F (RS-232C) interface
Serial port speed	300 … 57 600 bps
Connector	6-position screw terminal
Indicators	3 orange LEDs: **CD**, **TxD**, and **RxD**

Table 42 DXL421 PSTN interface

Property	Description/Value
Modem compatibility	• V.21 300/300 bps FSK • V.22 1200/1200 bps DPSK • V.23 1200/1200 bps FSK • 2-wire or 4-wire, point-to-point or multi-point
Transient protection	Yes, 350 V surge protector, PTC fuses, SIDACtor®

Property	Description/Value
Isolation	1500 V
Connector	4-position screw terminal

Table 43 DXL421 mechanical specifications

Property	Description/Value
Housing material	EN AW-1050A aluminum, gray anodized
Dimensions (H × W × L)	80 × 76 × 25 mm (3.15 × 2.99 × 0.98 in)
Weight	94 g (3.31 oz)

Table 44 DXL421 compliance

Property	Description/Value
Vibration (random)	IEC 60068-2-64 Fh, 10 … 500 Hz, up to 2.0 g
Free fall	IEC 60068-2-32 Ed, fall height 1000 mm (39 in)
Cold	IEC 60068-2-1, −40 °C (−40 °F) 16 hours
Dry heat	IEC 60068-2-2, +55 °C (+131 °F) 16 hours
Slow change of temperature, 1 °C/min	IEC 60068-2-14, −40 … +55 °C (−40 … +131 °F), 2 cycles
EMC immunity	EN 61326-1, industrial environment
EMC emissions	CISPR 22 / EN 55022, Class B
ESD	EN 61000-4-2, contact dis. 4 kV, air dis. 8 kV
RF field	EN 61000-4-3
Fast transient bursts (EFT)	EN 61000-4-4
Transient surges	EN 61000-4-5
Conducted RF	EN 61000-4-6

Appendix A. Factory settings of user-programmable parameters

The following table lists the factory defaults of user-programmable parameters. For information on commands to read or change parameters, see User commands (page 49).

Table 45 Factory defaults of user-programmable parameters

Parameter	Factory default
`Control blower`	Auto
`Control inheater`	Auto
`Data_acq power_save`	Disabled
`Data_port baud`	19200
`Data_port mode`	RS-232
`Data_port parity`	8N1
`Echo`	On
`Maint_port baud`	9600
`Maint_port parity`	8N1
`Message angle_corr`	On
`Message transmission`	Periodic
`Message secondary transmission`	None
`Message transmission delay`	100 ms
`Message height_offset`	0
`Message interval`	2 s
`Message secondary interval`	2 s
`Message port`	Data
`Message profile scale`	1.0
`Message profile noise h2`	Off
`Message type`	msg2_base
`Message secondary type`	None
`Message units`	Feet
`Message vv_limit ceiling`	2000 m (6562 ft)
`Oper_mode`	Normal

Parameter	Factory default
`Port_timeout`	2 min
`Unit_id`	0 (zero)

Appendix B. Termhood

You can use the optical termination hood (CLTERMHOOD) for calibration:

- Outdoors if the sky is unclear
- Indoors to represent a clear, nighttime sky

Outdoor use

If you use Termhood outdoors, place the termination hood adapter over the ceilometer and Termhood over the adapter. The adapter keeps the hood in place.

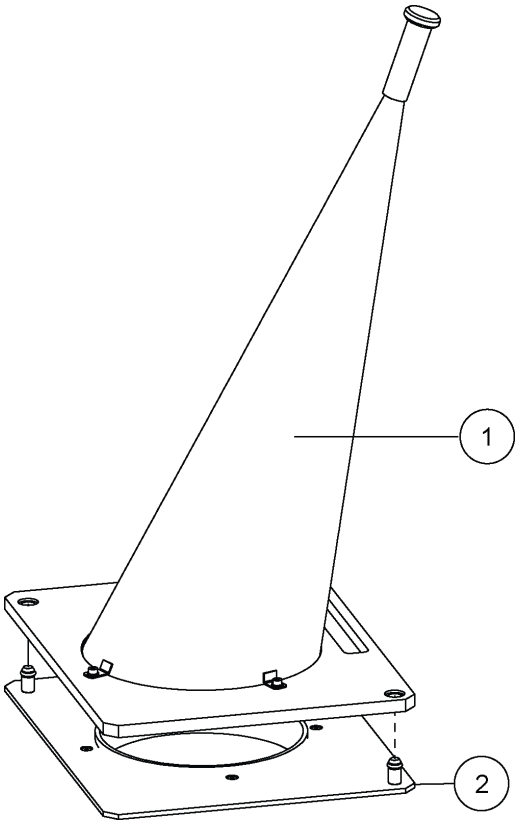


Figure 26 Termhood with adapter

1 Termhood
2 Termhood adapter

Indoor use

If you use Termhood indoors, place it on top of the ceilometer window so that the measurement unit handle goes in the slot to keep the hood in place.

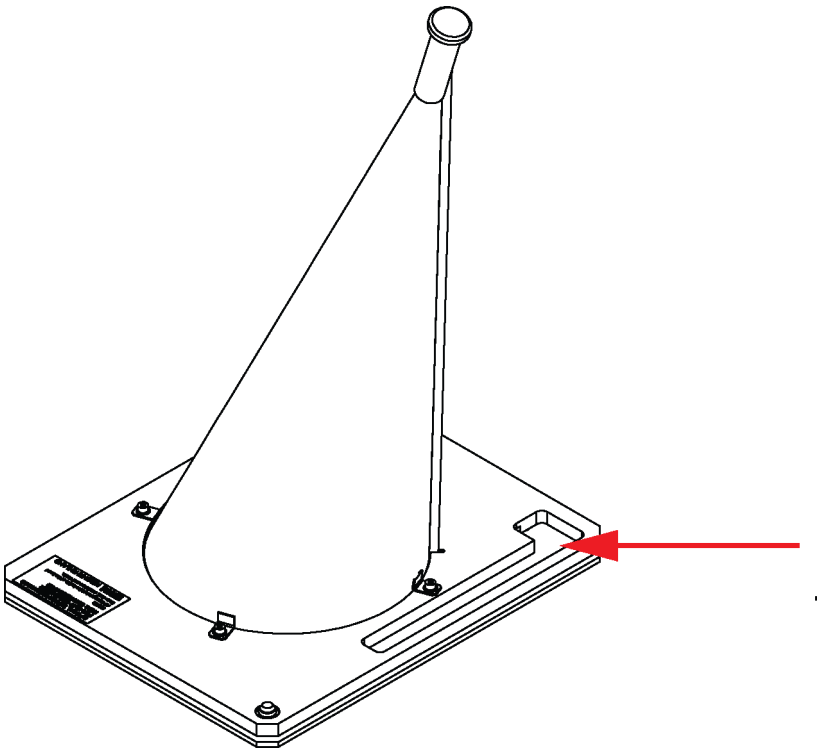


Figure 27 Termhood slot for measurement unit handle

More information

- Troubleshooting ceilometer (page 130)

Appendix C. UL/CSA C22.2 regulatory caution and warning statements

Note the following warning label on the product:

Notez l'étiquette d'avertissement suivante sur le produit:



WARNING! Use only copper cable for the AC (mains) connection. The cable must have the same operating temperature as the device.
AVERTISSEMENT ! Pour le raccordement au secteur, veuillez uniquement utiliser un câble en cuivre. Le câble doit avoir la même température de fonctionnement que l'appareil.

Index

A

accessing diagnostic information....129
AC power CLP321....110
activating sky condition....87
air quality plug-and-play package....9, 42
alarms....89, 133
assembling battery....33
automatic blower check....130

B

batteries....92
battery assembly....33
battery cable....118
battery replacement....107
bird deterrent....29
bird perch....29
BL-View software....129

C

calibrating window contamination....91
carrying measurement unit....22
ceilometer parts....10
changing parameter settings....148
checking battery....92
checking door gasket....91
checksum calculation....84
CL31 data messages No 1 and 2....60
CL31 status message....67
CL321 engine board....101
CLB311-115 / CLB311-230 window blower....120
cleaning the window....89, 90
CLH311 internal heater....121
closed port....48
cloud base....9
cloud layers....9
CLP321 AC power....110
CLR321 ceilometer receiver....105
CLT321 transmitter....103
CLTERMHOOD optical termination hood....130
CL-View software....129
CLW311 window....97
commands....49
communication port....48
concrete foundation....25
connecting
  data line....36
  Ethernet....36
  external cables....36
  maintenance line....36
  maintenance terminal....41
  power input....36
  power supply....38
  window blower....36
connector J4....42
connectors....36
contaminated window....90
CRC16 checksum....67
creating concrete foundation....25
CT12K digital message....70
CT12K digital message No 3....74
CT12K messages....70
CT25KAM data messages....79
CT25K data messages....75, 78

D

data line connections....36
  RS-232....39
  RS-485....39
data messages....59
diagnostic information....129
diagnostic LEDs....130
disconnecting device....14
door gasket....91
DXL421
  specifications....146
DXL421 modem module....125

E

earthing, *see* grounding
engine board replacement....101
entering real COM mode....43
entering TCP client mode....45
entering UDP mode....46
error groups....81
ESD protection....21
Ethernet connection....36
external connectors....36

F

F1 main switch....57
F2 heater/blower switch....57
factory setting....48
failure messages....81
floating installation....25
foundation....25
foundation dimensions....23

G

galvanic installation....25
getting data....43
GND....21
grounding....25
grounding bolt....25
grounding terms....21

I
installation....26
galvanic....25
marine applications....25
preparations....23
installing bird deterrent....29
internal heater CLH311....121

J
J1, J2, J3, J4, *see* external connectors

L
LAN....9, 42
laser monitor board....123
laser on LED....130
laser safety....19, 103
LD40 standard telegram....80
lifting handle....22
line outputs....48

M
main circuit breaker....57
maintenance....89
maintenance line connection....36
maintenance parts....94
maintenance port....41
maintenance terminal connection....42, 57
manual....7
manual message....85
marine applications....25
maritime installation....25
modem module DXL421....125
mounting
bird deterrent....29
ceilometer....26

N
NPort Windows Driver Manager....43

O
opening maintenance connection....57
open port....48
operating maintenance terminal connection....42
operation modes....49
optical termination hood....129, 150
option code....87

P
package....22
paint colors....93
painted surfaces....92
painting....93
painting preparations....92
parameters....148
parts....10
PE....21
periodic maintenance....89
polling mode....85
positioning the ceilometer....23
power input connection....36
power supply connection....38
preparing the foundation....23
product codes....10

Q
QMZ101 maintenance cable....41, 129

R
real COM mode....43
receiver CLR321....105
repairs....94
replacing
AC power....110
battery....107
engine board....100, 101
engine board CLE321....99
fuses....118
internal heater....121
laser monitor board....123
laser transmitter....99, 100, 103
modem module....125
receiver....105
subassemblies....129
window....97
window blower....120
RS-232 connection....39
RS-485 connection....39

S
safety....14, 19, 21
secondary message....59
serial lines....48
serial number....87
service....94
settings for normal operation....56
SGND....21
shipping container....22
sky condition....78
sky condition activation....87
sky condition algorithm....87
specifications....138
starting ceilometer....57
status messages....133
storage....88
switch settings....56

T
TCP client mode....43, 45

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telegram structure....81
Termhood....150
termination hood adapter....150
tilt....23
tilting the ceilometer....28
trademarks....8
transporting ceilometer....88
troubleshooting....129, 130

U

UDP mode....43, 46
unpacking....22
user commands....49
user-programmable parameters....148

W

warning messages....81
warnings....14, 89, 133
window blower....89, 90
window blower connection....36
window blower replacement....120
window contamination....90, 91
window replacement....97

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Warranty

For standard warranty terms and conditions, see vaisala.com/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.

Technical support



Contact Vaisala technical support at helpdesk@vaisala.com. Provide at least the following supporting information as applicable:

- Product name, model, and serial number
- Software/Firmware version
- Name and location of the installation site
- Name and contact information of a technical person who can provide further information on the problem

For more information, see vaisala.com/support.

Recycling



Recycle all applicable material according to local regulations.

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