Model 8200

Ceilometer

PRODUCT MANUAL

8200/Rev A

A.0 Disclaimer / Standard Warranty

CE certification

The equipment listed as CE certified means that the product complies with the essential requirements concerning safety and hygiene. The European directives that have been taken into consideration in the design are available on written request to ADB SAFEGATE.

ETL certification

The equipment listed as ETL certified means that the product complies with the essential requirements concerning safety and C22.2 No.180:13 (R2018) regulations. The CSA directives that have been taken into consideration in the design are available on written request to ADB SAFEGATE.

All Products Guarantee

ADB SAFEGATE will correct by repair or replacement per the applicable guarantee below, at its option, equipment or parts which fail because of mechanical, electrical or physical defects, provided that the goods have been properly handled and stored prior to installation, properly installed and properly operated after installation, and provided further that Buyer gives ADB SAFEGATE written notice of such defects after delivery of the goods to Buyer. Refer to the Safety section for more information on Material Handling Precautions and Storage precautions that must be followed.

ADB SAFEGATE reserves the right to examine goods upon which a claim is made. Said goods must be presented in the same condition as when the defect therein was discovered. ADB SAFEGATE furthers reserves the right to require the return of such goods to establish any claim.

ADB SAFEGATE's obligation under this guarantee is limited to making repair or replacement within a reasonable time after receipt of such written notice and does not include any other costs such as the cost of removal of defective part, installation of repaired product, labor or consequential damages of any kind, the exclusive remedy being to require such new parts to be furnished.

ADB SAFEGATE's liability under no circumstances will exceed the contract price of goods claimed to be defective. Any returns under this guarantee are to be on a transportation charges prepaid basis. For products not manufactured by, but sold by ADB SAFEGATE, warranty is limited to that extended by the original manufacturer. This is ADB SAFEGATE's sole guarantee and warranty with respect to the goods; there are no express warranties or warranties of fitness for any particular purpose or any implied warranties of fitness for any particular purpose or any implied warranties other than those made expressly herein. All such warranties being expressly disclaimed.

Standard Products Guarantee

Products manufactured by ADB SAFEGATE are guaranteed against mechanical, electrical, and physical defects (excluding lamps) which may occur during proper and normal use for a period of two years from the date of ex-works delivery, and are guaranteed to be merchantable and fit for the ordinary purposes for which such products are made.

NOTE

See your applicable sales agreement for a complete warranty description.

Replaced or repaired equipment under warranty falls into the warranty of the original delivery. No new warranty period is started for these replaced or repaired products.

FAA Certified products manufactured by ADB SAFEGATE

ADB SAFEGATE L858 Airfield Guidance Signs are warranted against mechanical and physical defects in design or manufacture for a period of 2 years from date of installation, per FAA AC 150/5345-44 (applicable edition).

ADB SAFEGATE LED products (with the exception of obstruction lighting) are warranted against electrical defects in design or manufacture of the LED or LED specific circuitry for a period of 4 years from date of installation, per FAA EB67 (applicable edition). These FAA certified constant current (series) powered LED products must be installed, interfaced and powered with and through products certified under the FAA Airfield Lighting Equipment Program (ALECP) to be included in this 4 (four) year warranty. This includes, but is not limited to, interface with products such as Base Cans, Isolation Transformers, Connectors, Wiring, and Constant Current Regulators.

Contents

Revision History

Revision	Date	Summary of Changes
A	2024 Dec 15	Initial release in new format

1. General Information

This manual provides all the information needed to enable the end user to install, maintain and troubleshoot the Model 8200 Ceilometer.

1.1 Precautions

The Model 8200 Ceilometer uses an infrared laser classified as Class I according to FDA regulation CFR Title 21, Section 1040.10. This standard is system-specific, meaning that it is possible to reconfigure the system into a dangerous mode. To ensure continued eye safety over the life of the product,

1. Never use external condensing optics devices, such as binoculars, lenses, etc., to investigate the aperture. Also avoid reflections from mirrors with condensing properties, i.e., mirrors with concave curvatures. The Ceilometer is safe only as long as the beam remains unmodified from its output form.
2. Never make modifications or adjustments to the Optical Module.

1.2 Feedback

ADB Safegate welcomes your suggestions and comments on how we may improve our documentation further. If you have a contribution or correction you would like to make, please contact us at: info@adbsafegate.com

1.3 General Safety

Within this manual there are specific pieces of information highlighted in the following ways and with these respective purposes:

NOTE

Lists important information in this section, important related information from other sections of the manual or advice on best practice in the usage of the instrument or its accessories.

CAUTION

This highlighted information cautions the reader of a potential hazard. Failure to read, understand and employ information contained in this instruction could result in the damage of the instrument or the loss of data.

WARNING

Non-compliance with the precaution described in these specific warning messages violates the manufacturers approved method of use of the instrument. ADB Safegate assumes no liability for the user's failure to comply with these specific warning messages.

1.4 Device-Related Safety Precautions

The Model 8200 Ceilometer was designed to comply with regulatory safety requirements. The following precautions relating to the safe operation of the device must be followed at all times when transporting, installing, using, maintaining or troubleshooting the device.

CAUTION

Do not modify the device without specific instruction from the manufacturer. Non-approved modifications can result in sensor malfunction, product damage or increased safety risk to personnel.

WARNING

Ensure that the device is well grounded prior to initial operation and prior to each requirement for touching the device.

WARNING

Operation of electrical devices in areas where flammable gases, fumes or explosive atmospheres poses a safety hazard. As the Model 8200 Ceilometer is an electrical device it should not be operated in such an area.

WARNING

Do not attempt service of the internal parts of the device unless there are suitably trained personnel on hand to render first aid should it be required.

WARNING

All power cables to the sensor should be removed and the residual power allowed to dissipate for a period of not less than 5 minutes prior to internal maintenance of the device.

WARNING

The device should not be maintained by personnel other than suitably qualified and trained maintenance personnel.

1.5 Laser Safety

The Model 8200 Ceilometer is certified as a Class 1M laser device in accordance with European standard IEC-60825-1.

This means that an 8200 Ceilometer installed in a field environment with instrument covers on and pointed vertically or near-vertically poses no established biological hazard to humans.

Under IEC-60825-1 no label needs to be fitted to the instrument,but the Laser Class must be included in product documentation. The instrument is intended for operation in an area restricted from public access and pointed up vertically or near-vertically. The following precautions are to be noted and followed during service and maintenance of the instrument.

WARNING

This device emits laser radiation in the event of malfunction there may be a laser hazard. Laser safety best practice should be observed in the event of a malfunction.

WARNING

Never look directly into the Transmitter with magnifying optics (glasses, binoculars, telescopes, etc.).

WARNING

When operating, avoid looking at the ceilometer from the beam direction. Make sure that it is not being viewed from the beam direction with magnifying optics.

WARNING

The device should not be maintained by personnel other than suitably qualified and trained maintenance personnel. Untrained personnel should not be present in the work area when maintaining the device.

1.6 Safety Grounding

The sensor AC power cable has three wires.

WARNING

The power cable must be installed with a safety ground connection.

1.7 Surge Protection

The device is manufactured with built in surge protection for AC and Communications Lines. The sensor is equipped with a three-conductor AC power connector. The power cable must be installed with a ground connection.

CAUTION

For the surge protection feature of the device to work effectively the sensor must be grounded to a low-impedance ground.

1.8 Electrical Shock Hazard

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components while AC power is connected.

High voltage will be accessible when the covers of the transmitter, receiver and power are removed, and the ceilometer is connected to AC power.

WARNING

High voltages are present within the device when it is energized. Areas of caution relating to high voltages are clearly marked with warning stickers.

1.9 Electrostatic Discharge Precautions

Circuitry inside the Model 8200 Ceilometer is susceptible to damage from ESD.

CAUTION

When handling electronic components ensure that an ESD protected workbench or ESD strap are used to ensure protection of the equipment.

1.10 Tilt Function

Where possible, tilt the instrument away from the equator. By tilting 12 degrees, the user can prevent any direct solar irradiance at all latitudes greater than 11 degrees either side of the equator. With no tilt solar irradiance will occur at latitudes between 11 and 23 degrees.

1.11 Recycling

The Model 8200 Ceilometer has been designed to be highly recyclable.

NOTE

Recycling of electronic devices should be in conformance with your organizations e-waste policy and also in conformance with the applicable laws in your state, territory or country.

CAUTION

The optionally supplied backup batteries contain toxic
substances. Dispose of batteries in accordance with your local regulations.

2. Product Description

The 8200 Ceilometer emits pulsed laser radiation, and detects radiation as reflected by particles and atmospheric aerosol for the purposes of measuring and reporting the attributes of the detected subject matter. The technology is most commonly referred to as LIDAR (Light Detection And Ranging). Whereas RADAR uses the reflection of radio waves LIDAR uses light to sense remote objects. The time the pulse of light takes to reach and be reflected by the distant object gives us a calculation of the distance to the target.

The 8200 is capable of detecting up to 4 layers of cloud simultaneously and report back the data through 22 standard message types. In the event that there is localized fog surrounding the sensor, the 8200 will report Vertical Visibility. The device is fully calibrated and configured at the factory and for all use other than research should require no further field calibration or adjustment.

The device's firmware provides a comprehensive collection of commands for the operation and maintenance of the device. Test equipment is built into the device (BITE) to allow for diagnostics either in the field, workshop or remotely. The device monitors the status of all key components and reports their status through various message types.

Two models are available.

Model	Description
8200-120	120 V AC
8200-240	240 V AC

Table 1. Model 8200 Ceilometer Options

The following replacement parts are available.

Part Number	Description
M403607-00	120 VAC Blower Assembly
M403607-01	240 VAC Blower Assembly
M438169-00	24 V DC Power Supply
M438171-00	Backup Battery
M442117-00	7.5 A 32 VDC Mini Blade Fuse
M460188-00	AC Power Line Surge Suppressor

2.1 Theory Of Operation

The Model 8200 Ceilometer is a lightweight compact instrument designed for fixed and tactical installations where accurate and reliable cloud height information is required.

2.2 Lidar Principle

The measurement is based on the LIDAR principle. This is based on the measurement of the time needed for a short pulse of light to traverse the atmosphere from the ceilometer transmitter to a backscattering cloud base and back to the ceilometer receiver.

2.3 Determination Of Range

With the speed of light being $c = 2.99 \times 10^8$ m/s (= 186,000 miles per second), a reflection from 25000 ft will be seen by the receiver 50.9 µs after the emission of the pulse.

The time delay (t) and backscattering height (h) is $h = ct/2$ where c is the speed of light.

2.4 Scattering Effects

A short pulse from an infrared laser is transmitted. The pulse energy is limited to ensure eye safety. As the pulse travels through the atmosphere, its intensity is reduced by scattering and absorption. Because the particles, molecules and aerosol are distributed through the atmosphere, only a very small amount is backscattered for each range increment, and that backscattered energy is in turn attenuated by the atmosphere. The signal detected by the ceilometer is a continuous profile indicative of the progressive loss of energy of the original pulse and the distributed backscatter from the atmosphere. This signal contains information about the concentration of the atmospheric constituents and the distances from the ceilometer.

2.5 Lidar Equation

The LIDAR equation expresses the power received at the ceilometer lens as a function of the instrument constant, distance, atmospheric scattering and attenuation, and backscatter coefficient.

The round-trip time of flight (t) between the transmission of an outgoing laser pulse and the arrival at the receiver of the pulse reflected by the target are used to calculate the target range (R, in meters) based on the speed of light in vacuum (c) and the average group refractive index of the optical path between the LIDAR system and the target (n):

$$R = \left(\frac{c}{2n}\right)t$$

Each of the factors in the LIDAR Equation is explained below.

2.5.1 Atmospheric Backscatter

The atmospheric backscatter has 3 components:

- Molecular Backscatter — This includes molecules and vapor.
- Particulates— Solid particles, dust, smoke, fume or particulates suspended in the air.
- Aerosol — This is falling or suspended water droplets, as found in cloud, fog, mist and rain

The ceilometer is optimized to detect aerosol backscatter, and can detect hard targets, cloud, or fog.

2.5.2 Distance Effect

The intensity of power received at the ceilometer is inversely proportional to the square of the distance of the backscattering particle from the sensor.

2.5.3 Atmospheric Extinction

Constituents of the atmosphere cause a reduction of the outgoing beam and a reduction of the amount of backscattered light returning to the instrument. In a turbid atmosphere the ability to detect cloud is reduced by the effects of extinction, which both reduce the laser energy hitting the cloud base and reduce the energy returning to the sensor.

This is termed atmospheric extinction, and comprises 3 terms:

- Aerosol Scattering Coefficient — This represents the effect of water droplets which reduce the amount of backscattered light returning to the instrument and is the dominant effect which the ceilometer looks for when determining Vertical Visibility.
- Molecular Scattering Coefficient — This is very low and is ignored for the purposes cloud detection, however, longer integration times can be used to detect scattering in the near field for boundary layer studies.
- Absorption Coefficient — This is generally very low except when there is smoke or dust in the atmosphere and is ignored for the purposes of the operation of the ceilometer.

2.5.4 Instrument Constant

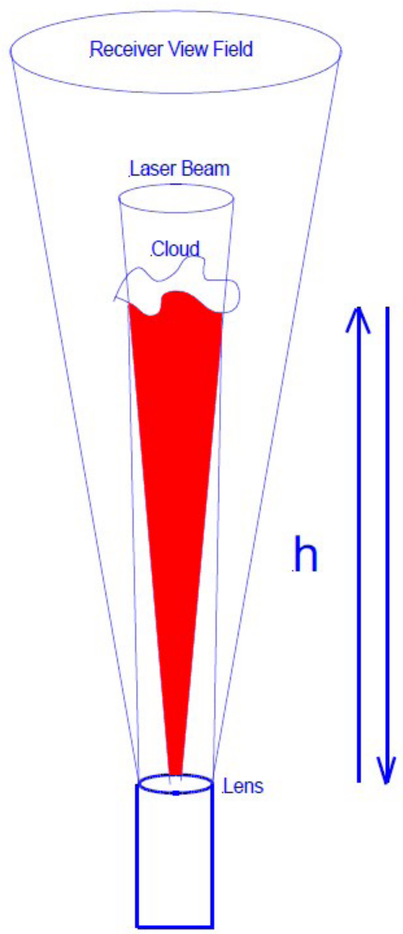
This constant takes account of the laser pulse power, the beam divergence, the telescope lens effective area, the sensor and signal processing characteristics and the multiplying factor to convert the voltage measured into power.

2.5.5 Overlap Function

A coaxial LIDAR has an overlap function that has been accurately determined and incorporated into the algorithms of the measurement process. Unlike bi-axial instruments, which have separate lenses for transmit and receive and thus have a low-level blind spot or dead band before the onset of any overlap, the 8200 overlap function allows the instrument to measure aerosol backscatter without any significant dead band. The overlap function acts to enhance performance of the 8200 by reducing the near-field dynamic range and enabling the range of the instrument to be increased.

The receiver field of view is shown as a cone expanding upward from the receiver aperture, and the transmitter beam is shown as an expanding cone diverging from the transmitter aperture. The altitude for complete crossover is the minimum altitude where the transmitter cone is completely within the receiver field-of-view. Below this minimum altitude, the laser pulse is in the overlap or crossover region and not all of the pulse energy is contained within the receiver field of view.

The behavior in this region can be described by an overlap function f(r) that describes an altitude-dependent energy loss. The overlap function for the 8200 is shown in the following graph. Complete overlap occurs at an altitude of 630 ft.



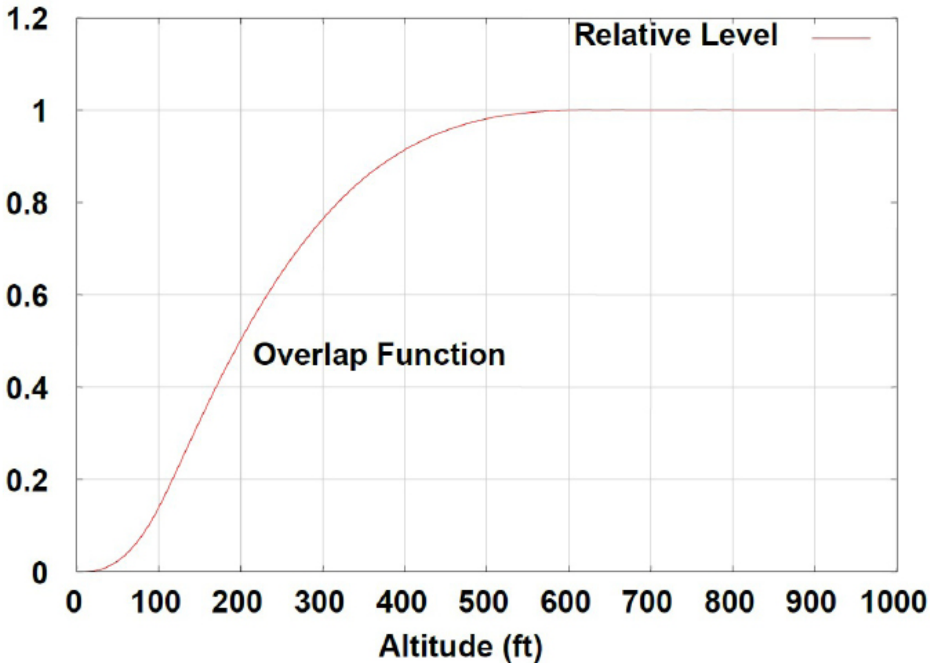


Table of Overlap Function vs Distance

Alt(ft)	FOVLP	Alt(ft)	FOVLP
10	0.000253	200	0.525
20	0.001869	220	0.5646
30	0.005829	240	0.6217
40	0.01284	260	0.6740
50	0.0234	280	0.7214
60	0.0379	300	0.7642
70	0.0565	320	0.8025
80	0.0795	340	0.8366
90	0.1069	360	0.8665
100	0.1390	380	0.8920
110	0.1748	400	0.9142
120	0.2124	440	0.9492
130	0.2507	480	0.9728
140	0.2890	520	0.9881
150	0.3269	560	0.9963
160	0.3641	600	0.9999
170	0.4000	640	1.0
180	0.4354	680	1.0

Figure 1. 8200 Overlap Function

2.6 Measuring The Backscatter Of Each Laser Pulse

The backscattered power is concentrated on a photo sensor and converted to a voltage by the amplifier. This signal is filtered and digitized by a very fast analog-to-digital converter. The 8200 uses an oversampled rate of around 50 mega samples per second so that samples are representative of the backscatter at distances exactly 10 ft apart. A total of 2700 samples is collected over a period of about 54 µs, giving a full range of just over 8200 m.

2.6.1 Noise Reduction Algorithm

Traditional LIDAR was not eye safe. In fact, aircraft exclusion zones were set up around LIDAR sites to prevent the very high-power lasers from causing eye damage to pilots and passengers flying overhead.

With high-energy pulses, the return signal is easy to resolve, and traditional LIDAR can probe deep into the atmosphere with a small number of shots. In the case of eye safe ceilometers, the laser pulse energy is so low [less than 2 µJ] and the noise of the ambient light exceeds the backscattered signal in the far field. To overcome this, a large number of laser pulses is accumulated in "range bins" or a backscatter array in memory. The desired signal is unipolar and increases with the number of pulses, whereas the noise, which is bipolar and Gaussian in its characteristic averages out. The presence of noise actually enables the instrument to measure signals below the resolution of the converter. In this way signals can be measured over a range of at least 4 orders of magnitude.

The degree of averaging for white noise is proportional to the square root of the number of samples; thus, the resulting signal-to-noise ratio improvement extends the range of measurement while the instrument remains eye safe.

2.6.2 Backscatter Profiles

The backscatter signal array stored after noise reduction is further processed by range correction. In this process the signal is scaled by the instrument constant to read attenuated backscatter power, then range corrected by multiplying by a function combining the inverse square of distance and the overlap function.

2.7 Cloud Detection

It is not necessary to solve the LIDAR equation to detect clouds. Digital signal processing techniques are used to examine the backscatter profile for slope and level changes and comparisons are made with thresholds determined by testing and by DSP analysis of the signal itself.

2.8 Range Limits

The limit to the range of the ceilometer at any time is determined by the signal to noise ratio of the ceilometer signal processing system, the height and optical density of the clouds and the fixed limit of pulse energy output by the ceilometer. For example, in the case of thick low stratocumulus, which extinguishes the laser pulse, no cloud will be detectable above it. Or at the other extreme, a thin cloud at the end of the range will not be detectable, because of the low level of returned energy relative to the noise.

2.9 Solution Of The Lidar Equation — Vertical Visibility

The LIDAR equation can be solved using a number of assumptions, which are generally reasonable. In this event, the solution yields the attenuation of the atmosphere, and this is used to estimate the vertical visibility when clouds are not detected.

The LIDAR ratio is the ratio of backscatter to extinction coefficient. The solution or inversion of the LIDAR equation assuming a starting point and assumption of a constant LIDAR ratio enables the ceilometer to have the auxiliary function of estimation of the vertical visibility when cloud base cannot be detected. The assumption is that the extinction-to-backscattering ratio for aerosols remains constant with range. It essentially states that the size distribution and composition of the aerosol scatterers are not changing with range from the ground, and that variations in backscattering from aerosols are due to changes in their number density. This is so generally true that the results based on this assumption usually agree with human observers estimates.

The 8200 uses the Fernald algorithm to determine the vertical visibility based on the Bouguer Lambert Law relating visibility to extinction coefficient and contrast ratio. The Fernald algorithm does not need to evaluate an integral as such to invert the LIDAR equation; rather, the retrieval at each successive point uses the data from the previous point and the attenuation correction over the intervening interval.

2.10 Lidar Calibration

Whilst calibration of a ceilometer is not necessary to detect cloud, the calibration is necessary to generate calibrated backscatter profile data.

The calibration constant of the 8200 has been measured using the inherent characteristics of stratocumulus cloud, which universally displays a LIDAR ratio in the range 18-19.6 sr. using a method developed by O'Connor Illingworth and Hogan

The path integrated backscatter is equal to the reciprocal of twice the effective LIDAR ratio in a stratocumulus cloud that totally attenuates the LIDAR signal. In stratocumulus the LIDAR ratio is constant and equal to 18 sr. Multiple scattering does have a slight effect on the accuracy of the calibration and is taken into account. Care has been taken to ensure that rain and drizzle were not present, and the clouds used had sufficient optical depth to extinguish the beam.

2.11 Planetary Boundary Layer (PBL)

This is the layer immediately above the ground in which energy exchange between the earth's surface and the atmosphere takes place. The height of the PBL is important to air quality, atmospheric chemistry and spread of atmospheric pollutants. There are a number of ways commonly used to define the boundary layer extent, including the height of the inversion, the height at which air stops rising, heat flow boundary etc. Although the PBL is often determined using sondes, these methods can be ambiguous. Typical levels are in the range 500 –1500 meters.

LIDAR can be used to detect the PBL but must be sensitive enough to detect molecular and particulate scattering which is much lower than the aerosol scattering used to detect clouds.

In the absence of cloud, the 8200 can detect the height of the boundary layer if the number of samples is increased to enhance the signal to noise. If the atmosphere is very clean the discrimination becomes more difficult. As the PBL grows in height, it becomes increasingly difficult to detect the boundary. Where cloud is mixed in the boundary layer, more complex analysis is needed to eliminate the cloud readings and individual profiles cannot be used.

The 8200 outputs a number of backscatter profile formats to facilitate users' further analysis of backscatter profiles to determine PBL

2.11.1 Rain

Rain is detected as a strong scattering signal from the cloud base to the ground. When water droplets appear on the window they are detected by the ceilometer and are discounted from the device's calculations.

2.11.2 Fog

Because fog is essentially a cloud at ground level that completely envelops the device no cloud base can be detected. Fog is detected as a strong scattering signal from the cloud base to the ground, which is also strongly extinguished and often prevents detection of cloud above the fog layer. In the conditions where the device is surrounded by fog to the extent where the signal is completely extinguished by the fog vertical visibility is reported.

2.11.3 Cloud

The 8200 detects a range of cloud types within its detection range. Referring to the image below, a number of cloud types can be seen. High clouds generally are composed of ice, and present special difficulties, because they occur at the limits of the range and the backscattered power is low. Low and middle clouds will easily be detected, unless they are optically thin.

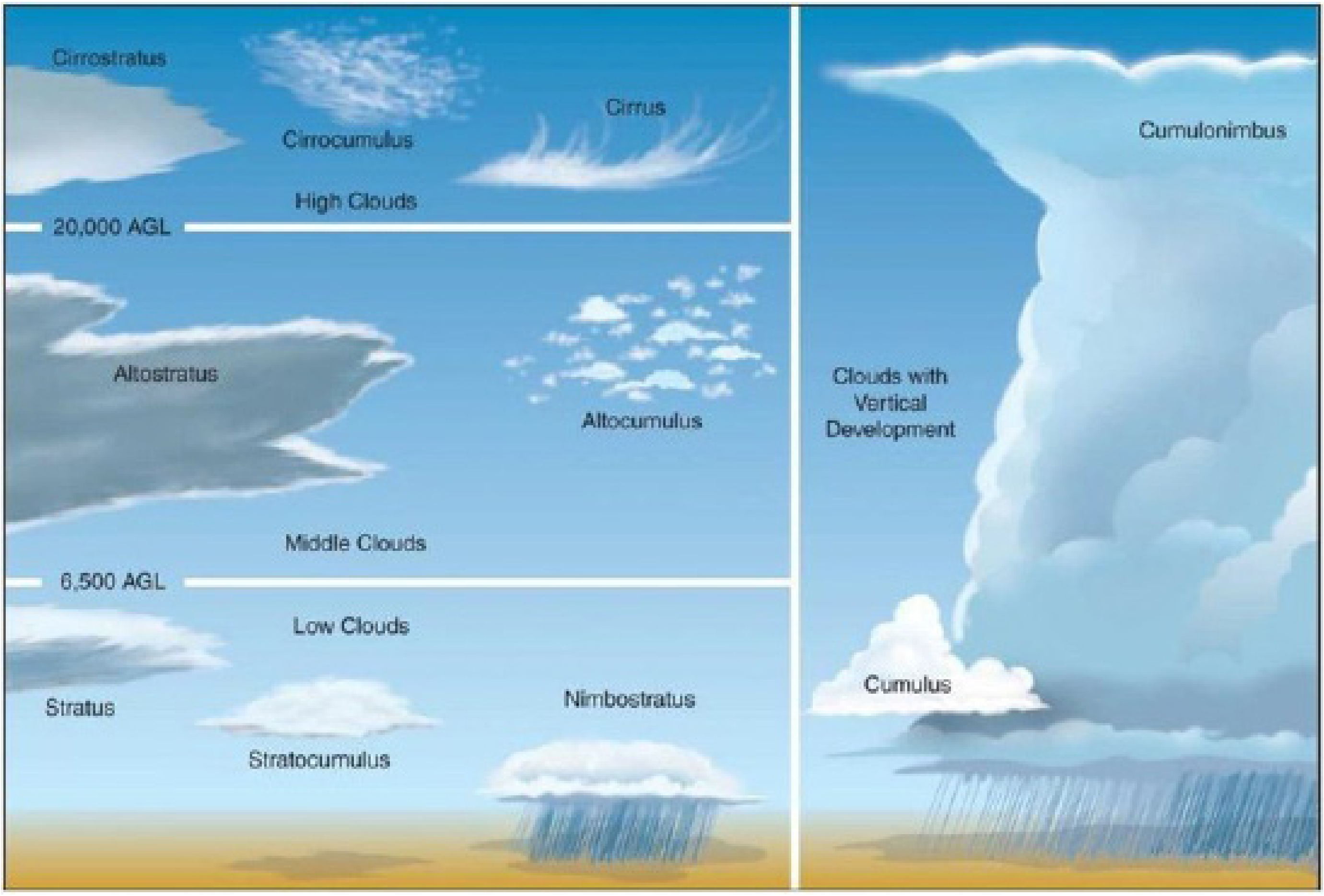


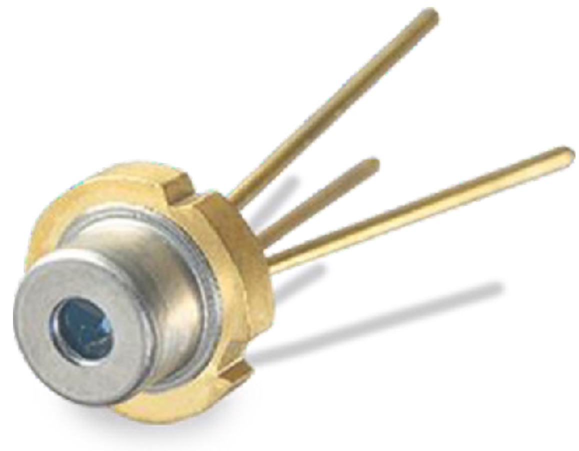
Figure 2. Cloud Types

2.11.4 Haze

The backscatter within the planetary boundary layer is very high as a result of haze in some countries and climates. When these conditions are severe, the laser beam is attenuated, and the maximum detection height is limited.

3. Technical Description

3.1 Laser Diode



A 100 ns pulse of infrared radiation is emitted at 905 nm by an indium gallium arsenide (InGaAs) laser diode. The laser diode current is controlled by the microprocessor by adjustment of the laser firing circuit high voltage supply via a digital to analogue converter.

To maintain the wavelength close to 905 nm, the laser diode is held in a temperature stabilizing mounting block. The laser beam has inherent elliptical shape, which is adjusted optically so the beam profile has a circular cross section.

The emitted beam is confined to the center 50 mm of the ceilometer lens with a small right-angle mirror in the optical path and kept at a level to comply with Class 1m under ISO 60825-1.

The laser firing circuit fires the laser at 10 kHz, which complies with laser safety requirements.

The laser beam diverges naturally as it travels over distance — the beam is only 50 mm in diameter at the window of the ceilometer, is over 2 m in diameter 1000 m away, and os16 m in diameter at a distance of 8 km.

3.2 Pulse Receiver

The backscattered, attenuated signal naturally reduces according to the inverse square law. In order to measure the small signal at the extent of the instrument's range, a very sensitive silicon avalanche photodiode [APD] optimized for the 900 nm band is used. The sensor is biased with a high voltage of several hundred volts DC. The adjustment of the high voltage supply is done under processor control via a digital to analog converter. The APD bias voltage is a function of the desired gain and the APD operating temperature.

The sensor is limited to a narrow waveband surrounding the center wavelength of 905 nm with an interference filter and both the filter and the laser diode are held in a temperature stabilized mounting block.

The sensor preamp is a very high frequency trans-impedance amplifier, with built in low pass filter. The filter frequency is chosen carefully to ensure the best signal to noise capability of the system.

3.3 Main Lens And Window

A key element in the design is the large plano-convex lens used in the ceilometer. This 150 mm lens provides enhanced ability to collect the weak returned and spread laser pulse reflections from high cloud. The lens is anti-reflection coated to reduce backscatter. Shown below, the 8200 lens mounting plate, which is located under the window. The four gold-colored devices are the lens/window heaters. The heat from these is distributed between the lens mounting plate and the window by convection.

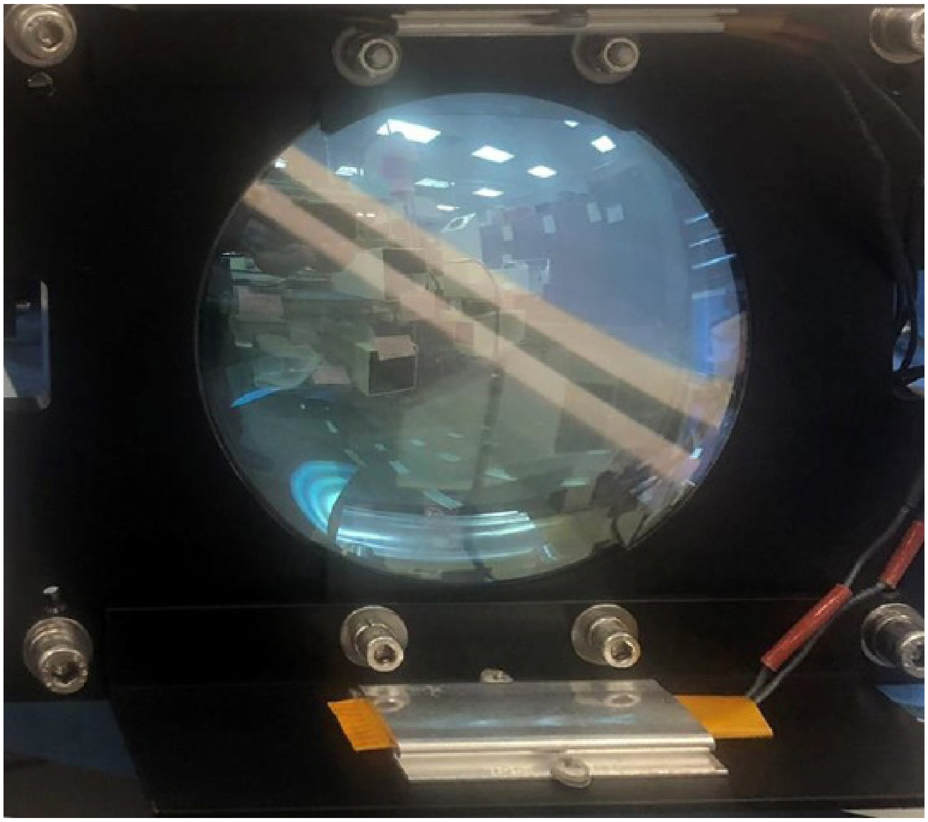


Figure 3. Ceilometer Lens

The 8200 enclosure window is treated with special coatings to assist with the reduction of light interference in bandwidths outside the specific operational bandwidth of the sensor.

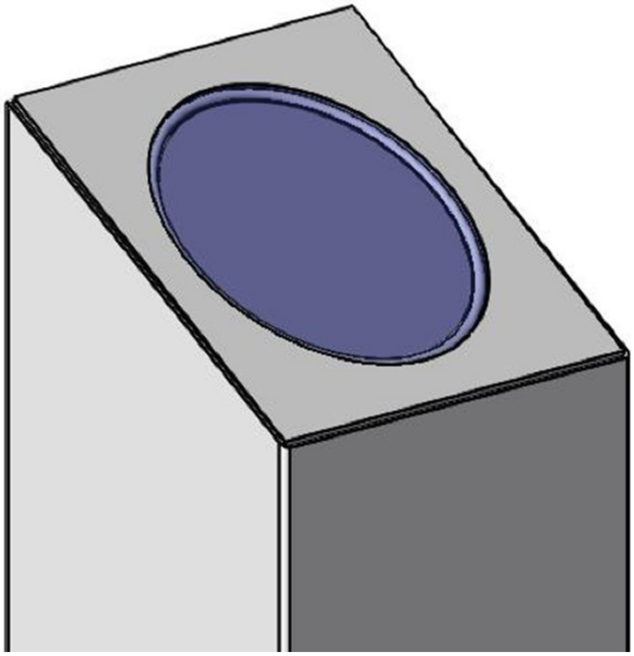


Figure 4. Ceilometer Window Coating

The window slopes to allow water droplets to run off. While it is raining, the presence of rain or snow cannot be eliminated completely from the ceilometer readings, however the window heaters will dry the remaining droplets once the rain stops.

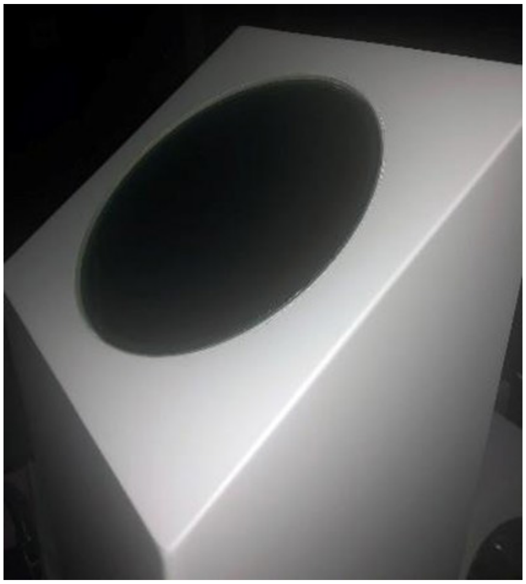


Figure 5. Ceilometer Window Slope

The window also serves as a solar radiation cover to mitigate warming up the enclosure by solar radiation.

If the window is contaminated by dust or bird droppings, the ceilometer reports the window contamination, and it will need to be cleaned. The cleaning interval varies, but the window should be checked and cleaned as needed at least monthly.

3.4 (APD) Avalanche Photodiode Card

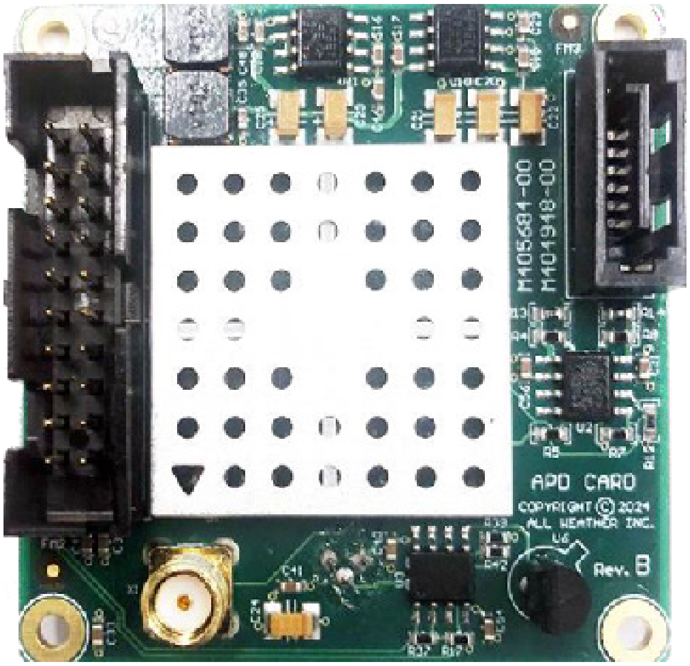


Figure 6. APD Board

The APD module comprises a circuit card, with high voltage smoothing components, processor controlled transimpedance amplifier, and ambient light compensation circuitry. The APD gain can be controlled by changing the APD high voltage, also under processor control. The board also contains the APD temperature sensor and the ambient temperature sensors.

3.4.1 APD Operating Point Control

The APD is subject to the external effects of environmental temperature, its own heat dissipation resulting from its bias voltage, and photocurrent and sky radiation within its spectral band.
The ceilometer controller manages the operating point of the APD by adjusting the bias voltage with any change in APD temperature, to maintain a constant gain and reduces the bias voltage in the event of high radiance impinging on the APD. If the APD amplifier becomes saturated, the APD bias voltage is reduced and is allowed to increase up to its set-point over a period of 5 minutes, the time it takes the sun to transit over the ceilometer. The ceilometer is essentially disabled during this time.

3.4.1.1 Amplifier Gain Setting

There are 2 amplifier gain settings: 100 and 10. When the detected backscatter increases under such conditions as low cloud or fog, the ceilometer controller backs the gain down to the low gain setting.

3.4.1.2 Channel Bandwidth

The bandwidth of the amplifier chain is DC to 5 MHz. The response down to DC allows detection of low levels of uniformly distributed aerosol and atmospheric particulates which have very low frequency components. Response down to DC is required for Planetary Boundary layer applications.

3.4.1.3 Baseline Adjustment

The baseline adjustment operates in both the analog circuitry and in the digital signal processing sections of the ceilometer and allows the ceilometer to work at night and under bright daytime conditions, when the radiant flux DC component is at a maximum.

3.5 Main Controller Board

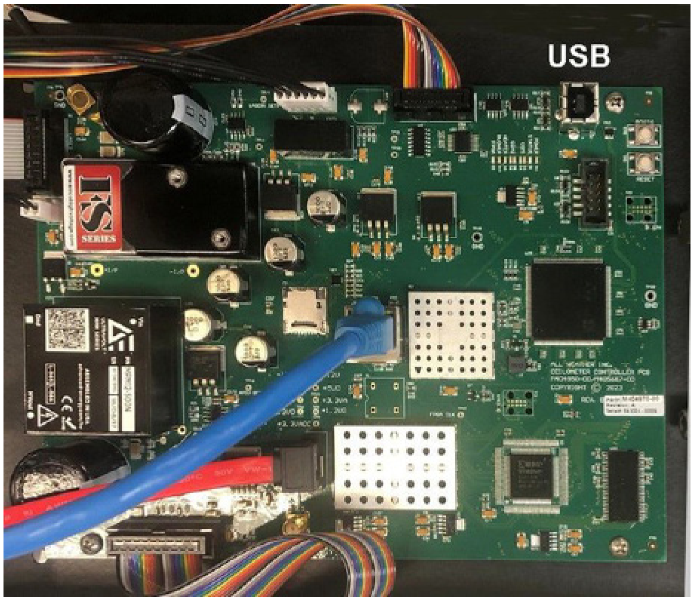


Figure 7. Main Controller Board

After the APD sensor preamp, the signal path includes a differential amplifier that enables the optimization of the signal path to ensure the analog to digital converter operates in the optimum range. The ceilometer uses a very fast analog to digital converter with 16-bit resolution, running at 50 megasamples per second, giving an inherent resolution of 10 ft.

The output of the analog to digital converter, together with the over-range bit enables the system to determine and set the signal path gain automatically. Each scan lasts approx. 51 µs and the 2700 samples in each scan are processed using a dedicated FPGA-based processing engine. The FPGA has a 36-bit resolution and uses digital signal processing techniques to improve the ceilometer resolution.

The powerful 32-bit 480 MHz ARM microprocessor transfers the samples from the FPGA into a backscatter array at the conclusion of each measurement sequence.

The FPGA and microprocessor have separate firmware modules and run simultaneously.

At the end of the measurement sequence, the contents of the backscatter array are normalized, and the using advanced signal processing algorithms perform the cloud-base detection using a combination of tests to detect multiple cloud bases and sky condition.

3.6 Laser Module

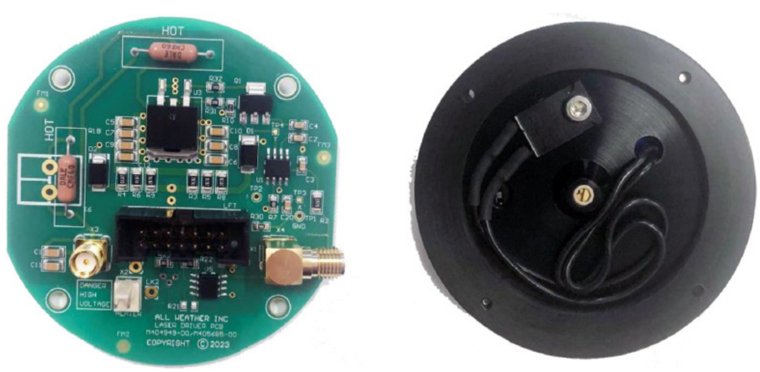


Figure 8. Laser Module

The Laser module comprises a circuit card with a high-current pulse driving circuit, FET switches with low-RDS on, and a laser diode heat sink temperature monitoring circuit. The laser diode heat sink is fitted inside the annular ring with laser diode temperature control elements.

3.7 Ceilometer Power Supply

Figure 9. 24 VDC Power Supply

The AC/DC power supply module is a switched mode power supply that converts 85–264 VAC or DC to 12 VDC to power the circuit cards inside the unit.

This switched mode supply is certified CE compliant for EMC and has been tested for CE compliance in the ceilometer.

3.8 Power Supply Board

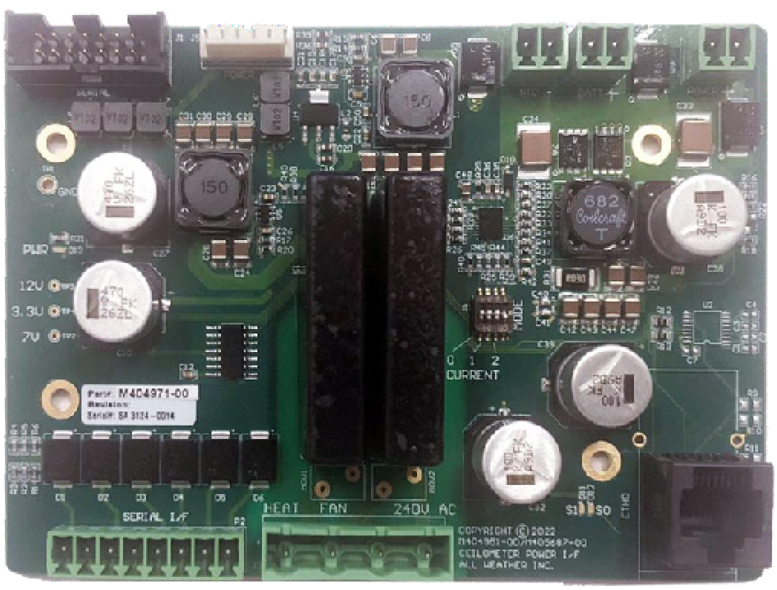


Figure 9. 24 VDC Power Supply

The Power Supply Board provides power to the Main Controller Board, and has these connections:

- Backup Battery (with battery fuse)
- 12 VDC Power Supply
- Blower and Heater Power
- Serial Data, with options for RS-232 and RS-422, depending on which pins are used

3.9 Features

3.9.1 Environmental Performance

The Model 8200 Ceilometer performs in all environmental conditions from desert to the wet equatorial tropics. The heated windows and the double skinned design with internal heating and cooling maintain the internal systems at a stable temperature and eliminate internal condensation under all conditions.

The internal optical components are protected from direct solar radiation by an optical solar radiation filter. All electrical connections to the unit are surge protected.

A sloping enclosure with a solar radiation window fitted with a heater minimize dust and debris buildup (including condensation and ice), and the slope maximizes the cleansing effect of rainfall.

3.9.2 Built In Test

A built-in test system indicates failures in the event of a malfunction. A key feature for field maintenance is the small number of modules.

3.9.2.1 Startup BIT

On restart the full startup BIT is sent out at on the Maintenance Port this includes basic checks like memory test, FPGA test, all voltages, temperatures and key settings

3.9.2.2 Operational BIT

The 8200 monitors the laser and APD function by monitoring the scattered laser emissions to verify both laser and APD.

A range of other readings is taken, and alarms or shutdown action is taken by the microprocessor according to the programmed settings.

Depending on the message type, status is reported in operational messages or can be accessed using the GET STATUS command.

3.10 Solar Effects

Optical elements are protected by the solar optical filtering window and internal baffling — 99% of the solar radiation hitting the window is reflected from the window and does not enter the sensor.

Sunlight has a high level of 905 nm radiation within its spectrum. This is noisy and swamps the return signal, so the DC current level of the APD is monitored continuously and the bias on the APD is automatically reduced whenever the sun appears in the instrument field of view; this prevents excessive heat dissipation and damage to the APD. Cloud height reporting is suspended during the transit of the sun and the instrument restarts when the sun is out of the receiver field of view.

The signal to the ceilometer control board is AC coupled so the DC level does not affect operation.

3.11 Sky Condition Algorithm

3.11.1 General Description

The Sky Condition Algorithm is based on the U.S. National Weather Service algorithm for their automated surface observing system (ASOS) units and guidelines published by the World Meteorological Organization.

This algorithm is mature and proven in the U.S. and other countries. The U.S. uses a 12 second averaging of cloud base returns.

A study by the Hughes STX Corp. found that this algorithm agreed with the human observer 78% of the time when ceilings were under 5,000 ft. With fog, the comparability was 84%, with rain it was 69%, and when snowing 74%. During rain, the algorithm reported more changes than the human observer.

However, at the transition between scattered and broken cloud coverage, 4 oktas, humans often report too much cloud coverage. This is attributed to the "packing effect," a condition where an observer does not see the openings in the cloud decks near the horizon because of the viewing angle. Pilots tend to overestimate the coverage even more than ground observers because of visual compression.

The 8200 algorithm is not biased by the "packing effect" because it measures only the sky conditions passing over the sensor. ASOS does not view the sky at an angle. Thus, human observers and pilots may feel that ASOS does not report enough cloud coverage, but this is subjective.

Model 8200 Ceilometer

The sky condition algorithm processes cloud height measurements provided by a single vertically pointing ceilometer. The sensor readings are processed into cloud height and mount estimates for a maximum of four cloud layers. The cloud layer data are then used to compute total cloud amount. The data gathered from the most recent one-third of the sampling period are double-weighted in calculating the cloud cover. This technique allows for a more rapid detection of changing cloud cover conditions.

Ceiling and sky condition are determined from sensor outputs every 30 seconds and are integrated over a 30-minute sample period. A weighting scheme is employed for data collected during the last 10 minutes of the 30-minute sample period to make the algorithm more responsive to rapid changes in ceiling/sky conditions.

Each minute calculates the ratio of total number of weighted valid reports and the maximum weighted reports for the most recent 30 minutes. If the ratio is less than 0.80 indicate ceiling/sky condition as missing,

3.11.2 Sky Condition Algorithm Operation

The sky condition algorithm processes cloud height measurements provided by a single vertically pointing ceilometer. The sensor readings are processed into cloud height and amount estimates for a maximum of three cloud layers. The cloud layer data are then used to compute total cloud amount. The data gathered from the most recent one-third of the sampling period are double-weighted in calculating the cloud cover. This technique allows for a more rapid detection of changing cloud cover conditions.

The algorithm also tests for obscuration. Since the ceilometer cannot directly sense the presence of obscuration, they must be inferred by analyzing the average visibility.

3.11.3 Definitions

3.11.4 Sky Condition

For the purposes of automation, sky condition is determined from such variables as cloud element height, amount, and presence of obscuring phenomena. These data are processed through algorithms and reported as cloud layer height and amount and presence of obscuring phenomena.

3.11.5 Cloud Height

The height of the base of a cloud or cloud layer above the surface of the earth.

3.11.6 Ceiling

The height above the earth's surface of the lowest layer of clouds or obscuring phenomena aloft or the vertical visibility in a surface-based layer of obscuring phenomena that is not classified as a partial obscuration, that together with all lower clouds or obscuring phenomena covers more than half the sky as detected from the point of observation.

3.11.7 Layer

An array of clouds or obscuring phenomena aloft whose bases are at approximately the same level.

Multiple Layers More than one layer.

Sky Cover

The amount of clouds and/or other obscuring phenomena that are detectable from the point of observation.

Layer Amount

The amount of sky cover at a given level.

3.11.8 Sky Condition Algorithm Detail Description

The sky condition algorithm used by the 8200 is similar to those used for ASOS and WMO sky condition reports. Ultimately, the sky condition algorithm used in an AWOS Central Data Processor determines the sky condition reported by the AWOS.

3.11.9 Ceiling and Sky Conditions

Ceiling and sky condition are determined from sensor outputs at least every 30 seconds and are integrated over a 30-minute sample period. A weighting scheme is employed for data collected during the last 10 minutes of the 30-minute sample period to make the algorithm more responsive to rapid changes in ceiling/sky conditions. Heights are reported in hundreds of feet. (e.g., 30 represents a height of 3 000 feet). Obtain cloud height data as follows:

- At least once every 30 seconds, sample the cloud height sensor and store the lowest cloud height and penetration depth or vertical visibility (VV) detected (i.e., a hit) or negative response (i.e., no hit). For reports of vertical visibility, the height parameter will be taken as a valid report of cloud base.
- At least once each 30 seconds, round the sampled height to the nearest 100 ft, (i.e., 100, 200, 300 ,... 12,400, 12,500 ft). Midpoint values shall be rounded down, except that hits at 50 ft or less shall be rounded up to 100 ft. Assign hits to 100-ft height bins, (i.e., 100, 200 ,...etc.). Reports during the most recent 10-minute period shall be counted as two reports. Reports during the preceding 20-minute period shall be counted once.

3.11.10 Calculate Weighted Valid Reports and Maximum Weighted Reports

Each minute calculate the total number of weighted valid reports and the maximum weighted reports for the most recent 30 minutes.

The weighted valid reports are computed using those sensor reports when hits were detected as well as those when no hits were detected. Exclude reports with a sensor error/fault from the total weighted valid reports. The total number of weighted valid reports is found by adding the following:

1. Two times the number of valid sensor reports received during the past 10 minutes.
2. The number of valid sensor reports in the 20-minute period preceding (a).

The maximum weighted reports are the maximum number of reports possible, including reports where there is a sensor error or fault, from the cloud height sensor for the preceding 30-minute period with reports for the most recent 10-minute period counted twice.

3.11.11 Calculate Ratio

Each minute calculate the ratio

$$r = \frac{\text{weighted valid reports}}{\text{Maximum Weighted Reports}}$$

- If the ratio r is less than 0.80, indicate ceiling/sky condition as missing, (i.e., CLD: /////). No further processing shall proceed.
- If the ratio r is equal to or greater than 0.80, proceed to the next stage (cloud clustering process).

3.11.12 Cloud Layer Clustering Process

Each minute, cluster the bins established during the 30-minute sampling period using the following criteria:

1. Determine the number of bins (Section 0). If there are 5 or less bins, proceed to the cloud combination process (Section 3.11.13) otherwise continue.
2. The bins shall be ordered from the lowest to the highest height.
3. Calculate the least square distance between all adjacent bins using:

   $$D = \frac{\{N(J) \times N(K) \times [H(J) \times N(K)]\}^2}{[N(K) + N(J)]^{0.5}}$$

   where:

   D = least square distance

   H = bin height

   N = number of hits in that bin

   (J) = bin for the higher height

   (K) = bin for the lower height
4. Combine the two adjacent bins having the smallest least square distance. If more than one pair of bins has the same least square distance, combine the pair with the lowest height.

5. Combine the bins using the formulas below:

   Height:

   $$H(L) = \frac{\{N(J) \times H(KJ) + [H(K) \times H(K)]\}}{[N(J) + N(K)]}$$

   Number of hits:

   $N(L) = N(J) + N(K)$

   where H(L) is the height of the combined bin and N(L) is the number of hits for the combined bin. The height H(L) shall be rounded to the nearest one foot.

6. The H(L) and N(L) bin shall replace the H(J), H(K), N(J) and N(K) bins. If there are more than 5 bins (or clusters), return to Step 2. Otherwise, continue to the next step (combining clusters).

3.11.13 Cloud Layer Combination Process

Each minute, after clustering of bins has been completed, determine whether the clusters can be combined using the following criteria:

1. Order the clusters from lowest to highest height, H(L).
2. Compute the height difference of all adjacent clusters.
3. If the lower height of any adjacent pair is equal to or less than 1 000 ft, and the difference between heights is 300 ft or less, go to Step 8. If the difference is greater than 300 ft, continue to the next pair.
4. If the lower height of any adjacent pair is greater than 1 000 ft but less than or equal to 3 000 ft, and the difference between height is 400 ft or less, go to Step 8). If the difference is greater than 400 ft, continue to the next pair.
5. If the lower height of any adjacent pair is greater than 3 000 ft but less than or equal to 5 000 ft, and the difference between heights is 500 ft or less, go to Step 8. If the difference is greater than 500 ft, continue to next pair.
6. If the lower height of any adjacent pair is greater than 5 000 ft but less than or equal to 8 000 ft, and the difference between heights is 800 ft or less, go to Step 8. If the difference is greater than 800 ft continue to the next pair.
7. If the lower height of any adjacent pair is greater than 8 000 ft, and the difference between heights is 1,600 ft or less, go to Step 8. If the difference is greater than 1,600 ft, continue to the next pair. When all cluster pairs have been tested go to (j).
8. Combine the clusters using the equations in Section 3.11.12, Step 5.
9. When two clusters are combined the new cluster height shall be rounded to the nearest one foot as specified in Section 3.11.12, Step 5. The new cluster shall replace the two that were combined, the clusters reordered and the process of combining continued (i.e., return to Step 1). All adjacent pairs shall continue to be examined until no further combining is possible.
10. At the end of this combining process, all cluster heights shall be rounded down as specified below. Cluster heights shall now be referred to as HC.
    a. Heights surface to 10 000 ft: In steps of 100 ft starting with 100 ft (i.e., 100, 200,.. ..10 000, etc.)
    b. Heights above 10 000 ft: In steps of 500 ft (i.e., 10000, 10500, 11000, 11500, 12000, etc.) For example, a cloud base height of 10,700 ft will be reported as 10500 ft.

3.11.14 Cloud Amount Algorithm

1. Obtain the total number of weighted valid reports from Section 3.11.10.
2. Calculate the cluster factors (RC) using the following formula for each cluster, starting with the lowest cluster at height HC.
3. If RC of each cluster is less than 0.06 or there are no clusters (i.e., no hits), and the visibility (VA) rounded to the nearest reportable value is:
   a. Less than or equal to 1000 m: Indicate sky obscured (i.e., CLD:SKY MAY BE OBSC).
   b. Greater than 1000 m: Indicate no cloud below design range of sensor (i.e., CLD:CLR BLW 125).
4. If RC of any cluster at height HC is equal to or greater than 0.06, discard the clusters with RC less than 0.06 and continue to process the remaining clusters.
5. Using the remaining clusters, calculate the cloud cover factor RL for each layer from the following formula, and starting with the lowest layer.

   RC = No valid weighted cluster hits/weighted valid reports

   where:

   N = Layer number starting with the lowest layer,

   Weighted cluster hits = Number of weighted hits in the cluster at height HCN,

   Weighted valid reports = Number of possible hits calculated per Section 3.11.10.

   For example, if a lower cluster at height HC1 has 25 weighted hits and the next cluster at HC2 has 13 weighted hits, RL for HC2 would be computed using 38 for the number of weighted hits in that layer.
6. If the current RL is equal to or greater than 0.45 but less than 0.50, and the associated RL height is within (less than or equal to) 200 ft of the computed height of any broken layer for the previous minute, before any height adjustment per paragraph 3.7(g) was made, add 0.05 to the current RL.

   That is, if

   RL(t1) > 0.50 && 0.45 < RL(t2) < 0.50 && |HC(t2)-HC(t1)| < 200 ft

   then

   RL(t2) = RL(t2) + 0.05.

   where

   RL(t1), HC(t1) are the cloud cover factor and cluster height for any given minute,

   RL(t2) and HC(t2) are cloud cover factor and cluster height for the minute which immediately follows.

   (Example: Assume the cloud report for any particular minute is BKN030 and that in the following minute the cloud layer has RL = 0.45 and HC=028. Because the new HC is within 200 ft of HC for the previous minute then add 0.05 to RL.)
7. Each minute, using the current RL value, (as modified by Step 6) cloud layers shall be reported as follows:
   a. If the RL is equal to or greater than 0.06 but less than 0.50, the layer shall be reported as scattered (e.g., CLD:SCT030).
   b. If RL is greater than or equal to 0.50 but less than or equal to 0.87, the layer shall be reported as broken (e.g., CLD:BKN050).
   c. If RL is greater than 0.87, the layer shall be reported as overcast (e.g.,CLD:OVC050).

3.11.15 Reporting Cloud Layers and Their Priority

1. If RL for all layers is less than 0.06, report no clouds below the upper design range of the sensor (i.e., CLD:CLR BLW 125).
2. Obscured ceiling/sky conditions are reported as specified in paragraph 3.6(c).
3. Up to three layers can be reported; however, if there is more than one overcast layer, the lowest is reported and the other(s) shall be disregarded.

$$RL = \frac{\text{Weighted Cluster Hits}}{\text{weighted valid reports}}$$

4. Layers shall be reported from the lowest to the highest using the height HC assigned to each layer as specified in paragraph 3.5(j).
5. If there are more than three layers, only three layers shall be reported using the priority below:
    1. The lowest scattered layer.
    2. The lowest broken layer.
    3. The lowest overcast layer.
    4. The second lowest scattered layer.
    5. The second lowest broken layer.
    6. The highest broken layer.
    7. The highest scattered layer.
6. The following examples illustrate the reporting of multiple cloud layers following the clustering and combination process.
    a. SCT010 SCT030 BKN050 BKN080 OVC100 will be reported as CLD:SCT010 BKN050 OVC100.
    b. SCT010 SCT030 BKN050 BKN080 will be reported as CLD:SCT010 SCT030 BKN050
    c. SCT010 SCT050 SCT080 OVC100 will be reported as CLD:SCT010 SCT050 OVC100.
7. Starting with the lowest layer the reported layer height shall be adjusted as follows:
    a. If for any reportable layer the calculated height, HC, is equal to or greater than 700 feet, but equal to or less than 10 000 feet and is within (less than or equal to) 100 feet of a layer height reported for the previous minute, use the height HR reported for the previous minute.

    That is, if

        700 < HC(t2) < 10 000 && [HC(t2)-HR(t1)| < 100

    then HR(t2) = HR(t1)

    where

        t1 is the previous minute

        t2 is the current minute

        HC is the calculated height

        HR is the reported height

    b. If for any reportable layer the calculated height, HC, is greater than 10 000 ft and is within (equal to or less than) 500 ft of a layer height reported for the previous minute, use the height HR reported for the previous minute.

    That is, if

        HC(t2) > 10 000 && [HC(t2)-HR(t1)] <500 then HR(t2) = HR(t1) ,

    c. The sky condition designation (i.e., scattered, broken or overcast) shall not change as a result of these procedures.

3.11.16 Other Requirements

Set a measurement cycle of 30 seconds or less because the algorithm is called every 30 seconds.

4. Installation

This chapter describes the steps when installing the Model 8200 Ceilometer.

The Ceilometer is mounted on two base feet that are bolted to a foundation or a pole base, with external data and power connections made via a conduit embedded in the center concrete base.

See the example installation shown below in Figure 11. This shows a standalone installation on a concrete base. The 8200 may also be installed at the side of an H frame with other sensors mounted on the H frame.

Figure 11. 8200 Installation on Concrete Base

CAUTION

The 8200 Ceilometer must have clear line of sight upwards.

4.1 Unloading And Unpacking

The 8200 Ceilometer is shipped in two double-wall cardboard boxes with high-density foam protection. One contains the measurement unit, the other contains the blower assembly.

NOTE

If possible, store the original packaging to allow the safe future shipment or storage of the device.

When opening the box, place it on a clear level surface with the side indicated as “top” facing upwards.

WARNING

The side of the boxes should not be penetrated with tools.

WARNING

Materials handling equipment should be used by properly trained personnel.

WARNING

Do not drop either box. Exercise caution when removing the device from packaging.

CAUTION

Avoid touching the window at the top of the measurement unit.

NOTE

Retain all protective covers, foam inserts, protective caps, covers and place holders for future use.

NOTE

If obvious mishandling has occurred then immediately contact ADB Safegate

4.1.1 Cardboard Packaging

There are two packages.

Measurement Unit	**Blower**
	
Measurement Unit	Blower Assembly

Contents Box 1 of 2

8200 unit and tilt feet components

Contents Box 2 of 2

Heater/Blower

Enclosure

Cables

Printed User's Manual

Test Certificate and other Documentation

4.2 Concrete Base Preparation

Prior to beginning the installation, the sensor and site should be selected. This is usually at the center field site or at the middle marker.

These parts are needed to install the 8200 Ceilometer on the concrete base.

1. Mounting feet (included) or mounting pole and ground rod.
2. Foundation Hardware: 5/8"-11 × 8" foundation bolts, washers, nuts and foundation bolt template.

NOTE

The foundation bolts should be installed using the foundation bolt template as part of the site preparation activities.

4.3 Foundation Design [Site Dependent]

The foundation design needs to be done based on the site soil conditions. This determines the volume of concrete required. A soil report might be required according to the local regulations and building codes and practices.

The drawings below show the bolt pattern that must be adhered to strictly and suggested concrete base size for most soil conditions.

Note: Ensure that a sufficient length [75 mm minimum] of the foundation bolts is exposed.

NOTE

The 8200 uses the same foundation specification and bolt hole pattern as the LD40, LD25, LD12, CT12K, CT25K or CL-31 ceilometers. The existing foundation and foundation bolts may be used when replacing any of these ceilometers with the 8200.

4.3.1 Foundation Plan View

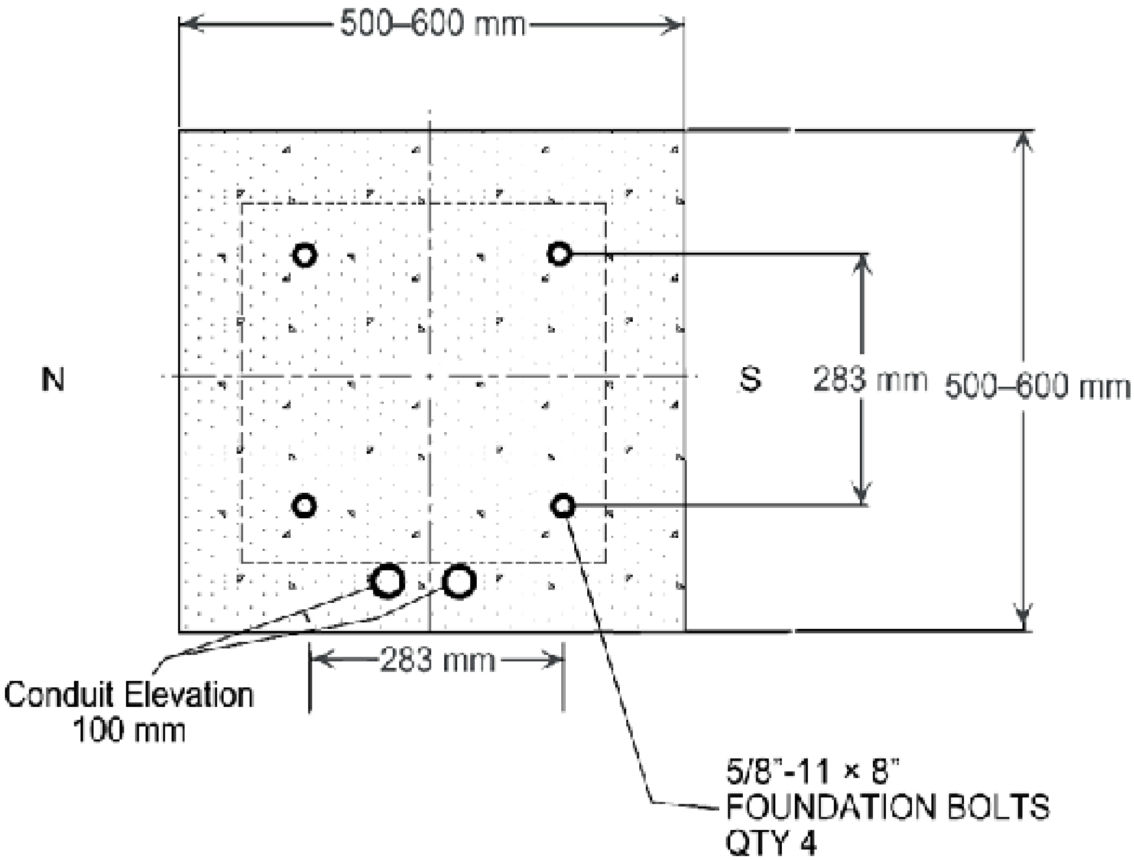


Figure 12. **Foundation Plan View**

NOTE

The foundation should be aligned to ±15 within degrees of the North/South axis.

4.3.2 Foundation Base Elevation View

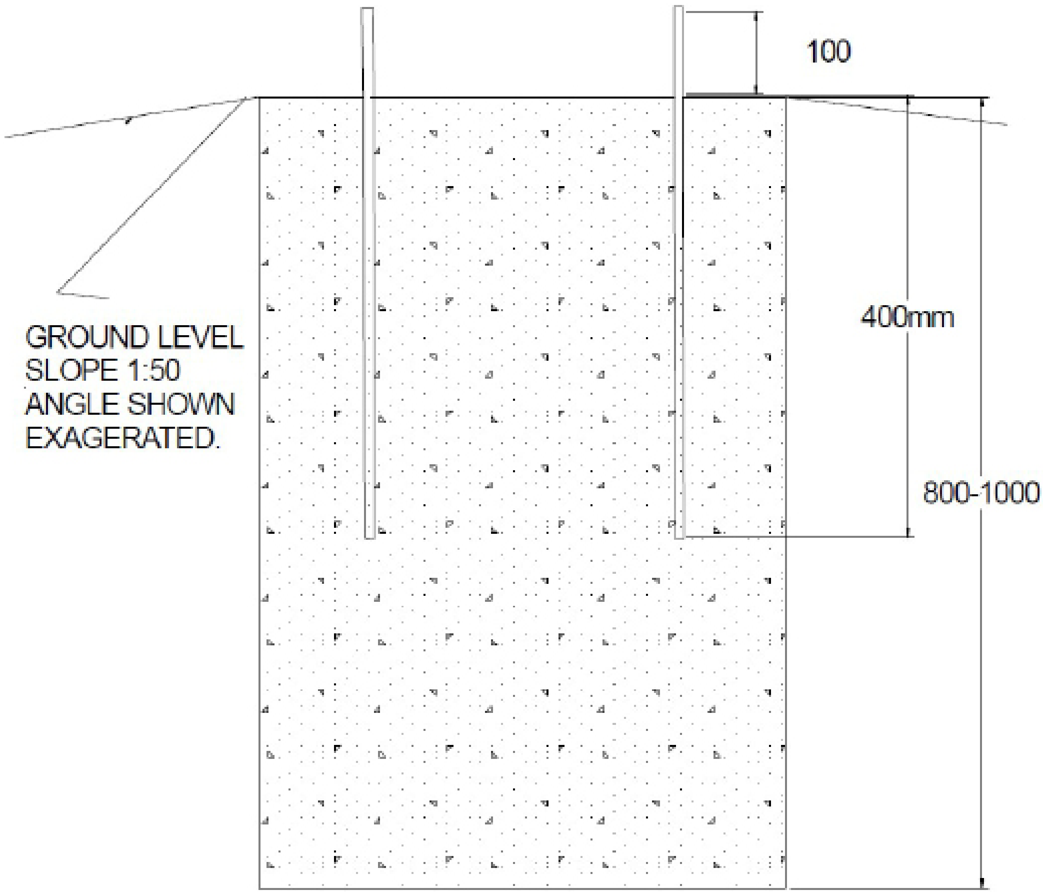


Figure 13. Foundation Elevation View (conduit not shown)

Two conduits should be provided — one for AC power and one for data.

4.4 Suggested Mechanical Installation

4.4.1 Foundation Hole and Formwork

Install a concrete mounting base following applicable electrical and building codes. cables or draw wire, and ground rod as follows. Dig the foundation hole, then cut and fit the form according to the foundation design.

Figure 14. Foundation Hole with Form

Prepare a plywood foundation bolt template according to the foundation bolt pattern shown in Figure 12. The template dimensions should be the same as the pad to facilitate centering the foundation bolts. Once the concrete has been poured, place the template with the four 5/8"-11 × 8" foundation bolts in the concrete before it sets and use a level to work the foundation bolt template so that it is level. The finished concrete level should be above the natural ground level according to site policy. This is typically 100 mm (4").

Ensure a sufficient length of foundation bolt is exposed (minimum 75 mm). Nuts and washers may be used to facilitate this.

Figure 15. Foundation Bolts in Template Plate

4.4.2 Clean Up

Remove the foundation bolt template once the concrete has set. Replace the nuts on the foundation bolts.

4.5 Mounting The Sensor

1. Remove the 8200 and its accessory parts from its box.
2. There are two sets of foot components that need to be assembled, a rotating part (M106043-00) and a fixed part. Assemble each of the two foot components as shown in Figure 16.

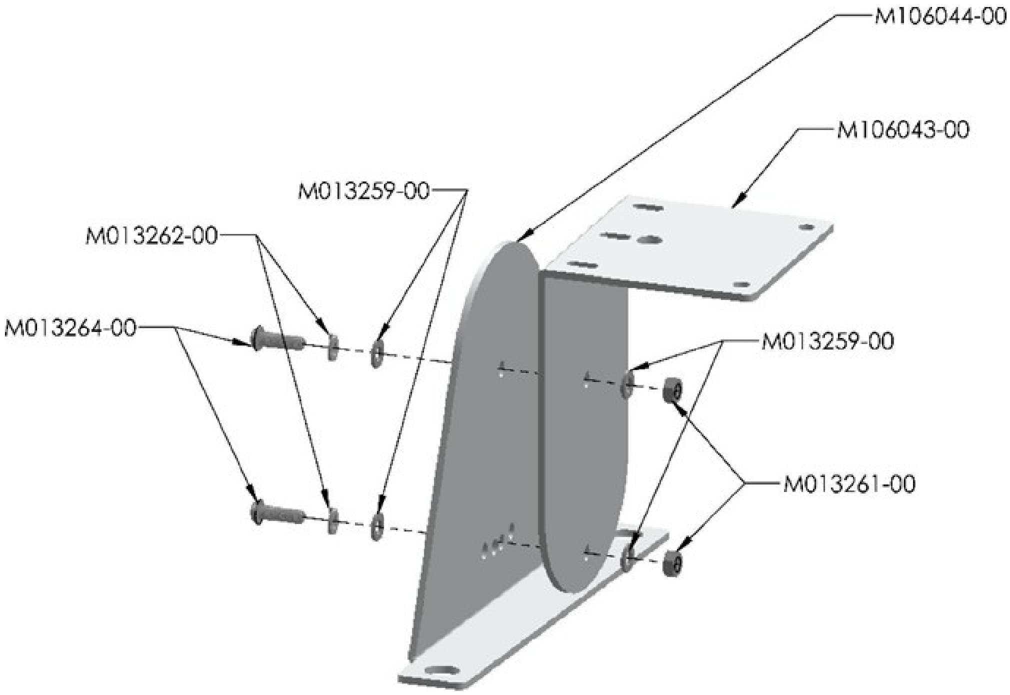


Figure 16. Assemble Rotating and Fixed Foot Components

3. Secure the feet using the M8 screws and washers provided to the base of the 8200 as shown in Figure 17. Do not tighten the screws completely.

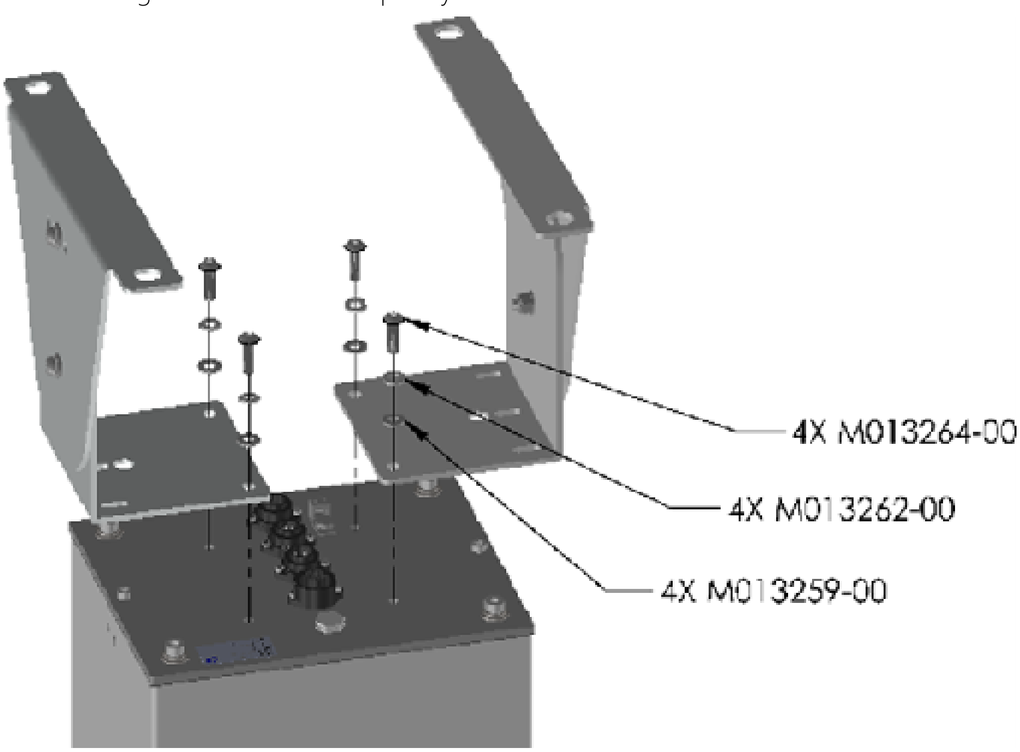


Figure 17. Secure Feet with M8 Screws and Washers

4. Screw the four M10 nuts that were used to place the foundation bolt template onto the foundation bolts leaving at least 25 mm (1") of thread. Level the nuts and fit washers. See Figure 18.
5. Mount the sensor on the bolts and then fit washers, spring washers and nuts. Tighten the four M8 screws (Figure 17) holding the feet to the 8200 body.

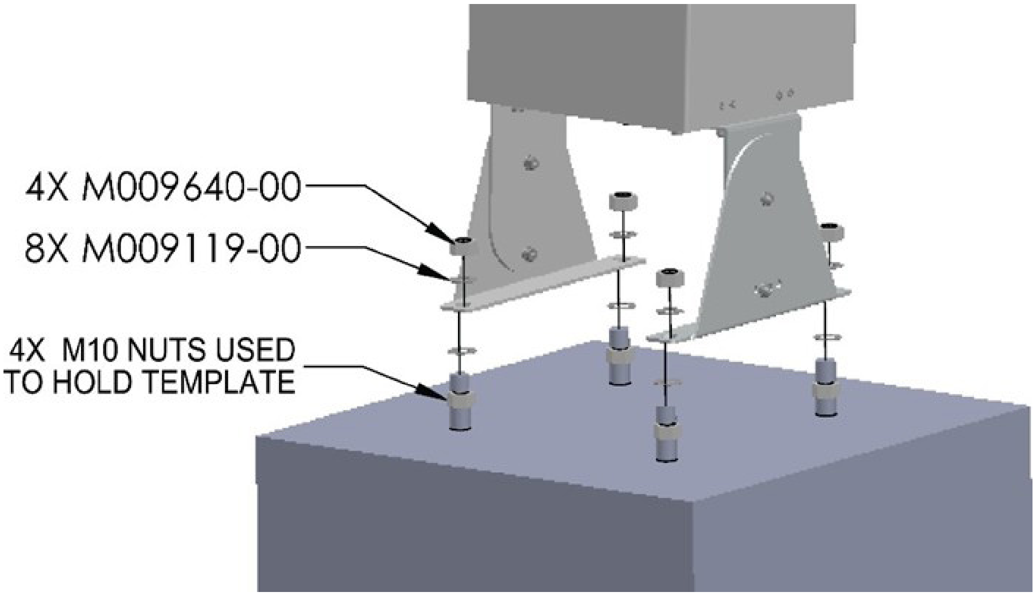
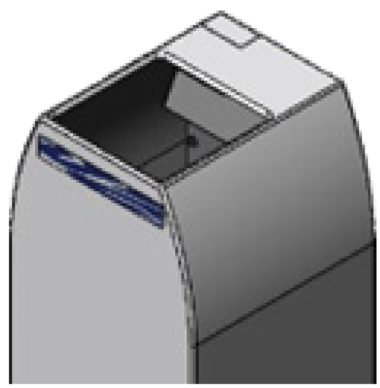


Figure 18. Mount 8200 Feet on Foundation Bolts

6. Level the 8200 and plumb the sensor by adjusting the lower nuts.
7. Finally tighten the top nuts
8. Place the enclosure containing the blower over the 8200 as shown in Figure 19.

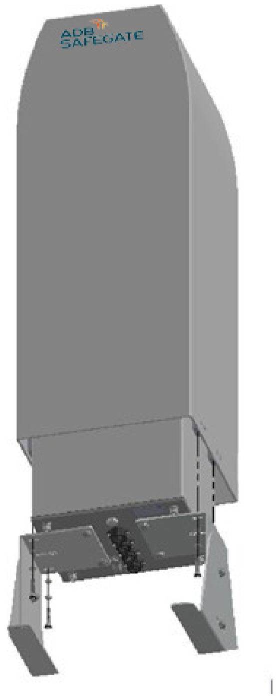


The blower is under the top part of the enclosure without the window. Place this part of the enclosure over the top of the 8200 inclined top.

Route the blower power cable so it is between the feet holding the 8200 to the foundation bolts.

Figure 19. Place Enclosure with Blower Over 8200

9. Secure the enclosure to the tilt feet using the four sets of M6 screws, washers, and lock washers as shown in Figure 20. Chapter 6 describes setting the tilt, which is useful in equatorial regions to minimize sunlight entering directly into the ceilometer.



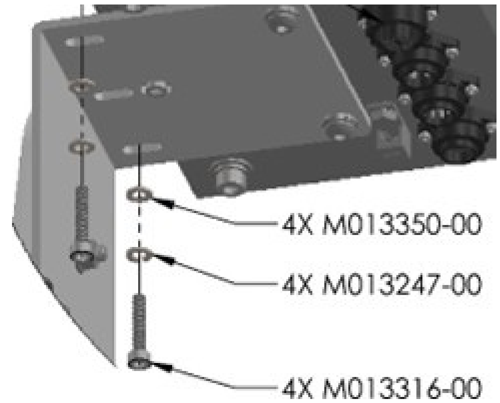


Figure 20. Secure Enclosure to Tilt Feet

4.6 Electrical Connections

Power and data connections are made using the connectors on the bottom plate of the 8220 between the tilt feet (Figure 21).

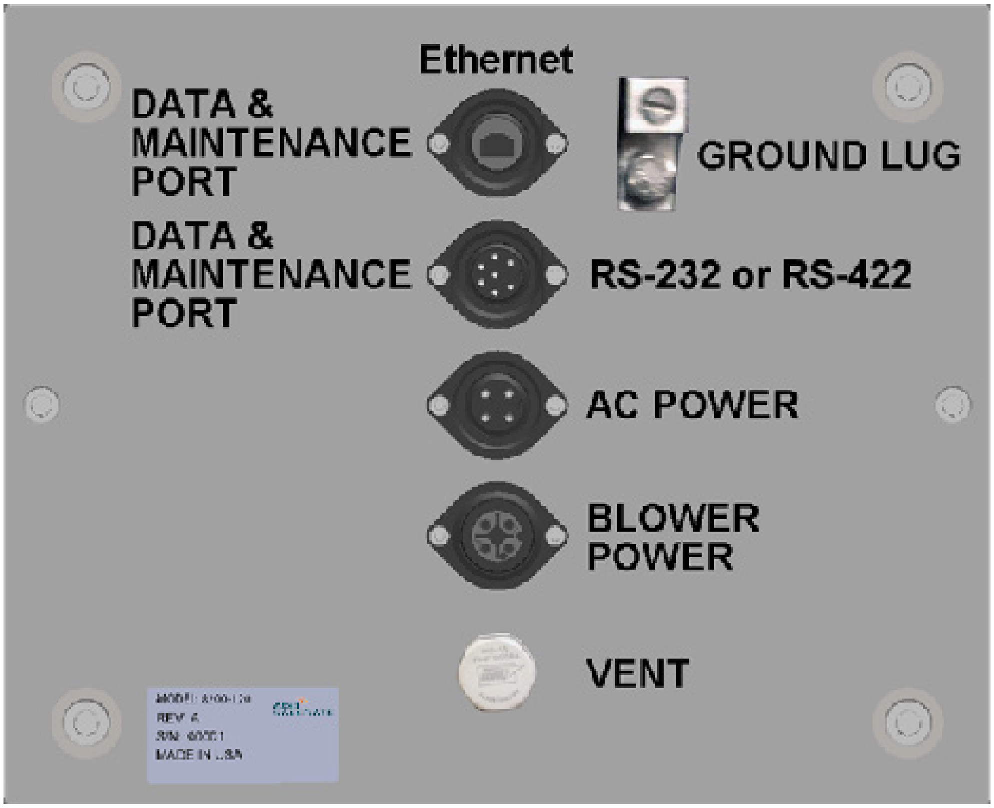


Figure 21. Power and Data Connections

4.6.1 Grounding

Equipment grounding protects the electronics of the 8200 against lightning and prevents radio frequency interference.

The 8200 is be grounded using a 2 AWG ground wire connected to the ground lug on the bottom plate, The other end of the 2 AWG ground wire is connected to a ground rod driven into the ground.

Install the ground rod near the 8200 pad location. The lower end of the ground rod should reach moist soil for a high-integrity ground.

CAUTION

The power supply ground is connected to the chassis ground inside the ceilometer.

The signal ground is connected to the chassis ground at a single point inside the ceilometer.

CAUTION

During power supply transients and lightning activity, significant transient current may flow through ground loops, so power supply ground should be grounded at the sensor and the external signal wiring should be kept as short as possible or an isolated interface device must be used.

4.6.2 Power Connections

1. Connect AC power to the AC power connector shown in Figure 21.
2. Connect the blower power connector to the blower power connector shown in Figure 21. Do not swap the blowers supplied with different 8200 models since the blowers are intended to be used with the AC voltage specified for each 8200 model.

CAUTION

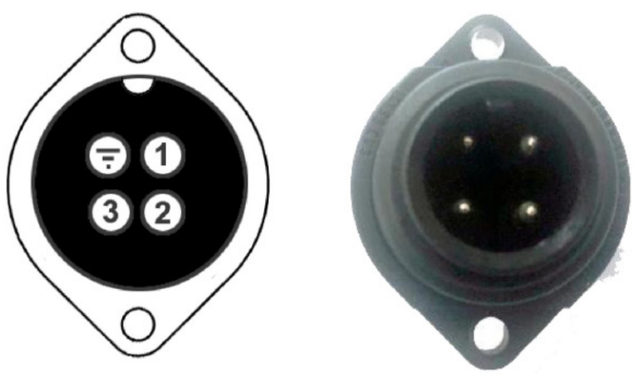
While all the 8200 models will operate on power supplies of 120 or 240 VAC, the blower is specific to the voltage specified for the 8200 model.

DANGER

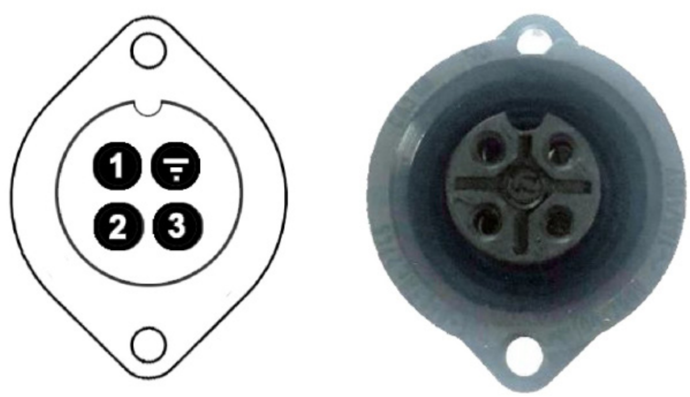
Do not fit an M403607-00 (120 VAC) blower assembly to a Model 8200- 240 ceilometer.

4.6.2.1 Power Connector Pinouts

AC Power



Blower Power



Power Function	Pin
L	1
N	2
Electrical Ground	4

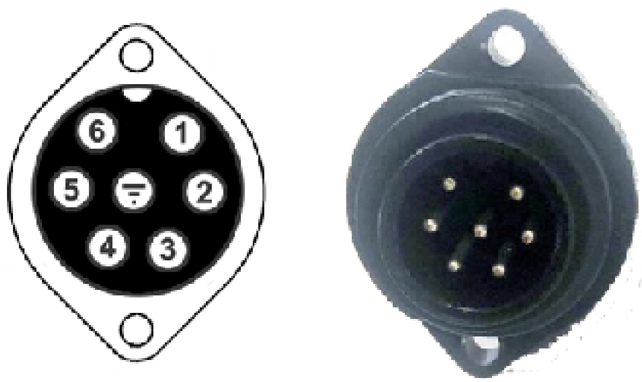
Power Function	Pin
L	1
N	2
Electrical Ground	4

4.6.3 Serial, USB, and Ethernet Ports

4.6.3.1 Serial

The 8200 ceilometers are shipped with a default RS-232 data port, which may be changed to RS-422 (full duplex RS-485). The data cable also brings out an extension of the connection to the minus terminal of the battery is disconnected while the signal cable is removed. This prevents the battery from becoming discharged prior to the ceilometer installation

Connector Pinout



RS-232 (default)	Pin	RS-422 (optional)
Rx	1	Tx–
SGND	2	Tx+
Tx	3	Rx–
	4	Rx+
BATT–	5	BATT–
BATT RTN	8	BATT RTN

Internal RS-232 and RS-422 Connections

Connector P2 on the M404971-00 Power Supply Board, the serial interface, can be wired for RS-232 (default) or RS-422 by relocating the wires connected to P2.

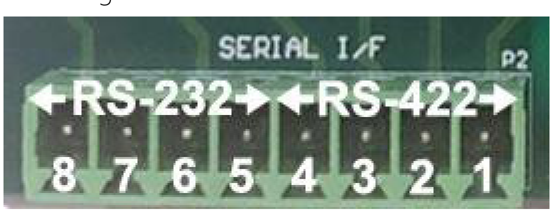


Figure 22. **P2 Serial Interface on Power Controller Board**

RS-232 (default)		Pin	RS-422 (optional)		Pin
Rx	GRN	8	Tx–	GRN	4
SGND	BRN	7	Tx+	BRN	3
Tx	ORG	6	Rx–	ORG	2
	YEL	5	Rx+	YEL	1

Type the following command to indicating the final serial protocol before making any changes.

SET PORT 2 RS422 or SET PORT 2 RS232

WARNING

Disconnect the AC power cable from the sensor prior to swapping these wires, and allow any residual power to dissipate for a period of not less than 5 minutes.

CAUTION

Do not loosen the corner M8 screws securing the base plate to the 8200. These are integral to its structure and alignment; the 8200 may be damaged if these are loosened or removed. The M8 screws are marked below in red circles.

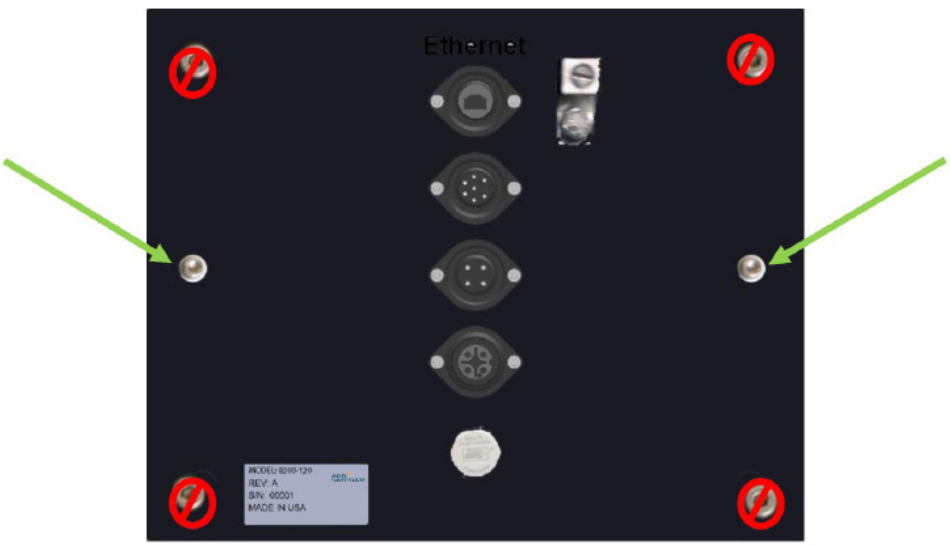


Figure 23. Loosen Screws Holding Enclosure Cover

1. Disconnect power and allow power to dissipate for a minimum of 5 minutes.
2. Remove the enclosure from the tilt feet.
3. Loosen the M6 screws (green arrows).
4. Lift the enclosure to expose the Power Supply Board in the lower compartment.
5. Swap the wire connectors between pins 1–4 and pins 5–8 according to the desired serial protocol .
6. Reconnect power.
7. Replace the aluminum cover and the enclosure.
8. Reconnect AC power.
9. Verify that the output from the serial port is using the desired serial protocol.

4.6.3.2 USB Port

The USB port is inside the 8200 unit on the Main Controller Board (Figure 7). The enclosure cover has to be removed to access the USB port.

4.6.3.3 Ethernet

The Ethernet port is also available for data and maintenance. In order to use the Ethernet port, it must be enabled first by setting an IP address using the following commands.

SET IP ADDR

SEP IP NETMASK

SET IP GW ADDR

These are the typical network settings/

SET IP ADDR 192.168.5.6

SEP IP NETMASK 255.255.255.0

SET IP GW ADDR 192.168.5.1

The Ethernet port is capped when not in use. Remove this cap to allow a computer to be connected using a CAT 5/6 cable, and then replace the cap when done. If the Ethernet port is to be used permanently in a network setup, connect a waterproof CAT5/6 cable and route the cable through the cable gland zip-tied to the cap, then attach the cable gland to the Ethernet port instead of the cap.

CAUTION

The cap should be fitted at all times whenever the Ethernet connection is not being used.

4.6.3.4 Battery Fuse

The data cable that connects to the serial port has a wire extension between pins 5 and 8 of the data connector. A fuse holder holds a replaceable fuse that is in line between the battery return (battery – terminal on the M404971-00 Power Supply Board) and the battery – post. The fuse can then be replaced as needed without having to remove the enclosure.

4.7 DCP Connections

"Figure 24" shows the serial RS-232 data cable connections from the 8200 ceilometer to the Model 1192 Data Collection Platform.

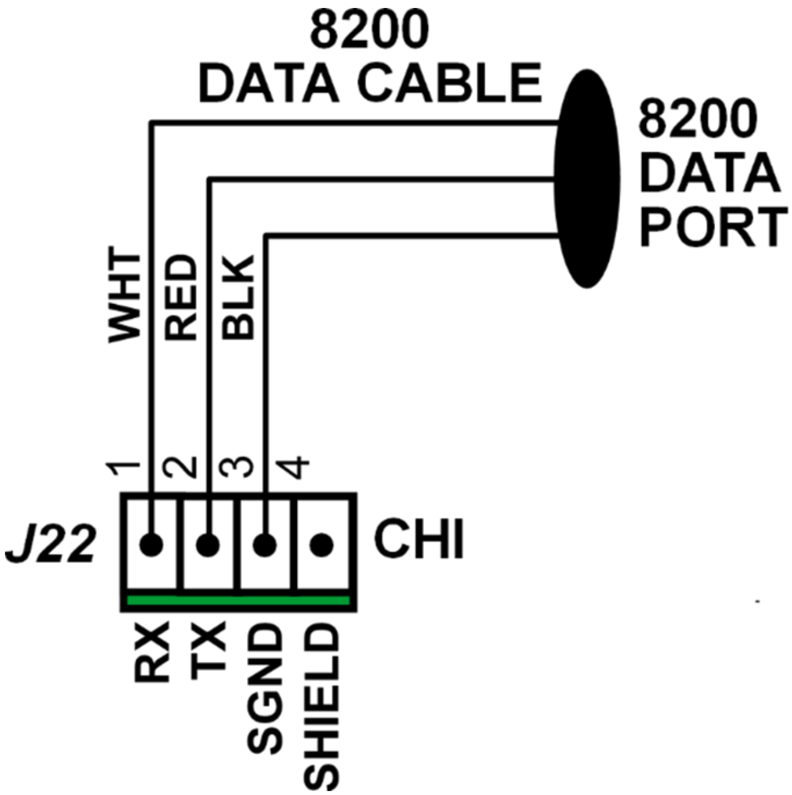


Figure 24. 8200 Ceilometer to 1192 DCP Connections

5. Orientation

The window should be arranged so that window side of the enclosure faces away from the sun or equator per the following diagram.

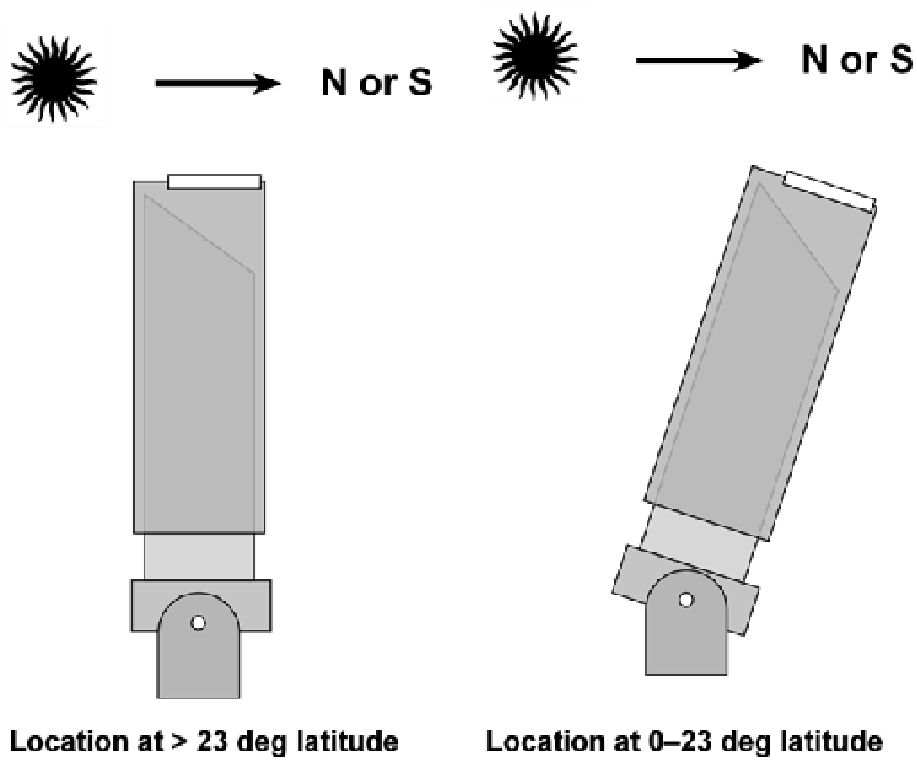


Figure 25. Orient 8200 to Avoid Sunlight

CAUTION

Improperly orientation may affect the instrument performance and also the long-term reliability.

---

6. Tilt Angle and Function

The 8200 can be tilted up to ±12°. This is useful for minimizing the effect of direct sunlight near the equator, allowing for better performance in harsh weather conditions or for allowing for cloud detection further into the approach paths of airports where the most suitable installation location is not possible.

Where possible, the 8200 should be tilted away from the sun. By tilting 12 degrees, the user can prevent any direct solar irradiance at all latitudes greater than 11 degrees either side of the equator. With no tilt solar irradiance will occur at latitudes between 11 and 23 degrees. The line of the tilt angle must be North South.

It is important that the ceilometer be mounted close to vertical. If the installation inclines without software compensation there will be a slight measuring deviation, which is negligible under 5° (+0.4%), but will be approximately 2% at 10° inclination.

6.1 Setting The Physical Tilt Of The Device

The legs of the device have three lower holes that allow the selection of -12 / 0 / +12 degrees of inclination. The holes can be seen in Figure 26.

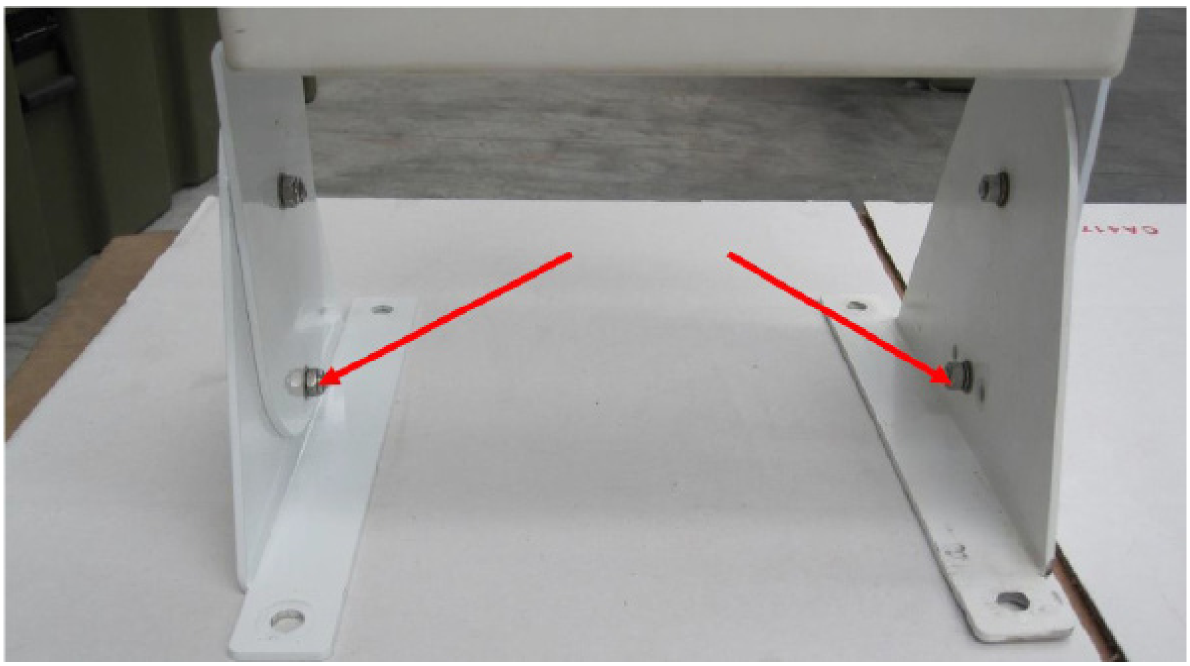


Figure 26. Selection Holes for Tilt Options

WARNING

When angling / tilting the device ensure that the 8200 cannot fall over. When both lower bolts are removed, the 8200 is free to move forward and backward. Either conduct this activity with another qualified person or rest the device against a suitable support such as an "A-frame" ladder.

6.2 Starting Up The 8200

Prior to powering up the 8200, ensure that the AC circuit breaker to the 8200 is switched off. Connect the power and communications cables. Switch the AC circuit breaker on.

6.2.1 Connecting to the Device

COM 1 (Data) – 9,600 bps 8-N-1 (8 data bits, No parity, 1 Stop bit).

Ethernet port (Maintenance) DHCP by default.

Once connected, the baud rate and other communications settings can be changed.

Both use the 7-bit USASCII character format. The input is case sensitive (Upper Case is used).

NOTE

Instructions on opening a session to communicate with the device can be found in the section "Commands and Messages" of this manual.

7. Data Messages

The 8200 has the ability to send 22 standard types of messages to enable the 8200 to be used as a replacement for obsolete ceilometers without having to change the software in the receiving system.

7.1 Setting Message Type

To select a message type, use the command:

SET MESSAGE TYPE x where x= 0,1,2,3,.........20

The default **M 0** means no message is sent.

NOTE

Setting the message type to "0" will result in no message coming out the specified port. The maintenance port is set to message type "0" by default to allow uninterrupted maintenance of the device via serial console. If the device has been set to output a message out either the data or maintenance ports (this can be switched off using this command.

7.1.1 Standard Output Message Types

The output messages listed below are all 100% fully compatible with their respective manufacturer's specifications for these data messages. Either the documented specification within this document or alternatively the respective OEM supplier's documentation can be used for integration into existing or new systems.

Message	Model	OEM Message	Sub-Class	Status
1	CBME-40 / 80	2	1	Standard
2	CBME-40 / 80	2	2	Standard
3	CBME-40 / 80	3	-	Standard
4	CL31	1	5	Standard
5	CL31	1	1	Standard
6	CL31	1	2	Standard
7	CL31	1	3	Standard
8	CL31	1	4	Standard
9	CL31	2	5	Standard
10	CL31	2	1	Standard
11	CL31	2	2	Standard
12	CL31	2	3	Standard
13	CL31	2	4	Standard
14	CT12K	2	-	Standard
15	CT12K	3	-	Standard
16	CT25K	1	-	Standard
17	CT25K	2	-	Standard
18	CT25KAM	60	-	Standard

Message	Model	OEM Message	Sub-Class	Status
19	CT25K	7	-	Standard
20	CT25KAM	61	-	Standard
21	MTECH BSP	1	-	Standard
22	8339	Native	-	Standard

7.2 Setting Message Interval

SET MESSAGE INTERVAL x

where x=2,3,4,... 600 seconds

NOTE

Do not change the default setting of 25 seconds when using the 8200 with the Model 1192 Data Collection Platform or the F1 STA AWOS.

7.3 Setting Data Acquisition Interval And Message Interval

The Data Acquisition Interval must be set to be equal to or less than the Message Interval. The Number of Samples in 1000 seconds should be set to be less than the Data Acquisition Interval.

CAUTION

The device cannot by definition have a Data Acquisition Interval ;pnger than the Message Interval. Incorrect values will not be saved into memory and the previous value will continue to be used.

To set these values enter the advanced level using the command AL <

The following sequence sets the Message interval, Data acquisition Interval and Number of samples and saves it to flash memory.

OPEN <

AL <

SET DATA_ACQ INTERVAL 15 <

SET SAMPLES 10000 <

SET MESSAGE INTERVAL 15 <

SAVE <

CLOSE <

NOTE

See Section 8.2.1.2 for further information on entering Advanced Level.

7.4 Abbreviations

In the following definitions the following expressions represent the characters listed:

<SOH> = ASCII 02 HEX

<ETX> = ASCII 03 HEX

<EOT> = ASCII 4 HEX

<LF> = ASCII 0A HEX

<CR> = ASCII 0D HEX

<BEL> = ASCII 7 HEX

NOTE

In some older generation message formats, most notably the CT12K messages and their derivatives, the penetration depth is coded into the data message. The penetration depth may under some circumstances be the cloud thickness, however, in many instances nimbus, stratus, cumulus and cumulonimbus clouds will completely extinguish the laser pulse. This means that the cloud thickness may be much greater than the indicated penetration depth.

7.5 Message Type 0 — No Message

This message enables the user to prevent output of any message from the port.

NOTE

Setting the message type to “0” will result in no message coming out the specified port. The maintenance port is set to message type “0” by default to allow uninterrupted maintenance of the device via serial console. If the device has been set to output a message out either the data or maintenance ports (COM1 & COM2) this can be switched off using this command.

7.6 Message Type 1 — CBME40/80 Message 2 Type 1

This format is a fully compatible emulation of the Eliasson CBME Message 2 format. This message includes status, cloud bases, penetration depths in the first line and Sky Condition estimation in the second row expressed in Oktas.

The maximum reading is 26650 ft [8200 m].

7.6.1 Definition of Message

<STX><CR><LF> DATA BLOCK1<CR><LF>DATA BLOCK2 <CR><LF><ETX>><LRC>

<STX><CR><LF> SIGNAL PROFILE BLOCK<ETX><LRC>

7.6.2 Definition of Data

7.6.2.1 First Row: Data Descriptors

IIIII<sp>SSSS<sp>HHHHH$_1$<sp>TTTTT$_1$<sp>HHHHH$_2$<sp>TTTTT$_2$ <sp>
HHHHH$_3$<sp>TTTTT$_3$ <sp>VVVVV<sp>RRRRR<sp>

Datablock 1 Key:

Field	Field Description
IIIII	IDENTITY : 8200
SSSS	Status word.
HHHHHx	Height of base in ft or Meters or ///// if no detection
TTTTTx	Penetration depth in ft or Meters or ///// if no detection
VVVVV	Vertical Visibility or / / / / /
RRRRR	Measuring range ; Normally 7500 [m] or 25000 [ft]

7.6.2.2 Second Row: Layer Descriptors

OOO$_1$:LLLLLl$_1$<sp> OOO$_2$:LLLLLl$_2$<sp> OOO$_3$:LLLLLl$_3$<sp> OOO$_1$:LLLLLl$_4$<sp>TTT$_C$
Datablock 2 Key

Field	Field Description
OOO$_X$	Cloud amount in OKTAS/8 for layer x=1,2,3,4 or if missing /// EG 1/8
LLLLL$_X$	Height of layer x=1,2,3,4
TTT$_C$	Total amount of cloud in Oktas, that is OOO$_1$+ OOO$_2$+ OOO$_3$+ OOO$_4$, LIMIT 8

7.6.2.3 Third Row : Signal Profile Block

<sp>DDD<sp>DDD<sp>DDD<sp>20 ENTRIES PER LINE <CR><LF>

Resolution of data in profile block.

[Meters only irrespective of selected unit for the data message]

Row	Resolution	Range
1-8	10m	10-1600 m
9-18	30m	1610-7600 m

7.6.3 Example Message

CHS1 0000 01070 00180 ///// ///// ///// ///// 07500
1/8: 00140 8/8: 00690 0/8: ///// 0/8: ///// 0/8: ///// 8/8
^
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
T

7.6.4 Definition of Status Bits SSSS

The status field is a 4-byte hexadecimal code the rightmost bit is D0 and the left most bit is D15

Bit	Description
D0	Low Laser Power
D1	Laser current fault
D2	Laser temperature fault
D3	Abnormal operating temperature
D4	Faulty reference Voltage
D5	Abnormal supply Voltage
D6	Faulty Laser HV
D7	Faulty APD voltage
D8	Fault on BITE
D9	Not Used
D10	Memory Checksum
D11	Not Used
D12	Not Used
D13	Not Used
D14	Error Indicator
D15	Not Used

7.7 Message Type 2 — CBME40/80 Message 2 Type 2

This format is a fully compatible emulation of the Eliasson CBME Message 2 format. This message includes status, cloud bases, penetration depths in the first line and Sky Condition estimation in the second row expressed in WMO306 acronyms.

The maximum reading is 26650 ft [8200 m]

7.7.1 Definition of Message

<STX><CR><LF> DATA BLOCK1<CR><LF>DATA BLOCK2 <CR><LF><ETX>><LRC>
<STX><CR><LF> SIGNAL PROFILE BLOCK<ETX><LRC>

7.7.2 Definition of Data

7.7.2.1 First Row: Data Descriptors

IIIII<sp>SSSS<sp>$HHHHH_1$<sp>$TTTTT_1$<sp>$HHHHH_2$<sp>$TTTTT_2$ <sp>
$HHHHH_3$<sp>$TTTTT_3$ <sp>VVVVV<sp>RRRRR<sp>
Datablock 1 Key:

Field	Field Description
IIIII	IDENTITY : 8200
SSSS	Status word.
HHHHHx	Height of base in ft or Meters or ///// if no detection
TTTTTx	Penetration depth in ft or Meters or ///// if no detection
VVVVV	Vertical Visibility or / / / / /
RRRRR	Measuring range ; Normally 7500 [m] or 25000 [ft]

7.7.2.2 Second Row: Layer Descriptors

OOO_1 :$LLLLLl_1$<sp> OOO2 :$LLLLLl_2$<sp> OOO_3 :$LLLLLl_3$<sp> OOO_1 :$LLLLLl_4$<sp>TTT_C
Datablock 2 Key:

Field	Field Description
OOO_X	Cloud amount in OKTAS/8 for layer x=1,2,3,4 or if missing /// EG 1/8
$LLLLL_X$	Height of layer x=1,2,3,4
TTT_C	Total amount of cloud in Oktas, that is OOO_1+ OOO_2+ OOO_3+ OOO_4, LIMIT 8

7.7.2.3 Third Row: Signal Profile Block

<sp>DDD<sp>DDD<sp>DDD<sp>20 ENTRIES PER LINE <CR><LF>

Resolution of data in profile block.

[Meters only irrespective of selected unit for the data message]

Row	Resolution	Range
1-8	10m	10-1600 m
9-18	30m	1610-7600 m

7.7.3 Sample Message

```
CHS1 0000 01070 00180 ///// ///// ///// ///// 07500
FEW: 00140 OVC: 00690 CLR: ///// CLR: ///// CLR: ///// OVC
^
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 020 030 020 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
000 000 020 030 020 035 020 030 020 035 000 000 020 030 020 035 020 030 020 035
T
```

7.7.4 Definition of Status Bits SSSS

The status field is a 4-byte hexadecimal code the rightmost bit is D0 and the left most bit is D15.

Bit	Description
D0	Low Laser Power
D1	Laser current fault
D2	Laser temperature fault
D3	Abnormal operating temperature
D4	Faulty reference Voltage
D5	Abnormal supply Voltage
D6	Faulty Laser HV
D7	Faulty APD voltage
D8	Fault on BITE
D9	Not Used
D10	Memory Checksum
D11	Not Used
D12	Not Used
D13	Not Used
D14	Error Indicator
D15	Not Used

7.8 Message Type 3 — CBME40/80 Message 3

The standard data output format is a fully compatible emulation of the industry standard CT12K and Eliasson CBME Message 3 format. This message includes status, cloud bases, penetration depths in the first line and Sky Condition estimation in the second row with cloud cover encoded as oktas.
The maximum reading is 26650 ft [8200 m]
<SOH><CR><LF> DATA <ETX><CR><LF>
where
<SOH> = ASCII 02 HEX <ETX> = ASCII 03 HEX <CR> = ASCII 0D HEX <LF> = ASCII 0A HEX

7.8.1 Definition of Data

7.8.1.1 First Row: Data Descriptors

This message is exactly 40 characters incl. <CR><LF>]
N S B<sp>H1H1H1H1H1<sp>T1T1T1T1T1<sp>H2H2H2H2H2<sp>T2T2T2T2T2
<sp>S1S2S3S4S5S6S7S8S9S10<CR><LF>

7.8.1.2 Data Key

N= Backscatter Analysis Codes

N	Condition Detected
0	Clear Sky
1	One cloud base detected
2	Two cloud bases detected
3	No cloud base can be detected from echo signal received (vertical visibility)
4	Sky is partly obscured, and no cloud or vertical visibility detected

S = BITE

S	Condition Detected
0	No alarm status bits S1....S4 (normal status)
1	At least one alarm status bit S1....S4 is on

B = BITE ALERT

B	Condition Detected
20H	No alarm status bits S1....S4 (normal status)
07H	The Bel character if S=1

Data Fields, Case N=0 or N=4

Field	Data Field
H1H1H1H1H1	/////
T1T1T1T1T1	/////
H2H2H2H2H2	/////
T2T2T2T2T2	/////

Data Fields, Case N=1

Field	Data Field
H1H1H1H1H1	The lowest detected cloud height in 5 digits
T1T1T1T1T1	Penetration depth of first cloud base, Leading zeroes are not suppressed, / / / / / if not defined

Data Fields, Case N=2

Field	Data Field
H1H1H1H1H1	The lowest detected cloud height in 5 digits
T1T1T1T1T1	Penetration depth of first cloud base, Leading zeroes are not suppressed, / / / / / if not defined
H2H2H2H2H2	The second detected cloud height in 5 digits
T2T2T2T2T2	Penetration depth of second cloud base, Leading zeroes are not suppressed, / / / / / if not defined

Data Fields, Case N=3

Field	Data Field
H1H1H1H1H1	Vertical Visibility
T1T1T1T1T1	Limit of detected backscatter

S1 to S8 = Status Codes

Field	Condition Detected
S1	1=Hardware alarm
S2	1= Supply voltage alarm
S3	1= Laser power low
S4	1= Temperature alarm
S5	1= Solar Detected
S6	1= Blower ON
S7	1= Heater ON
S8	Units 0=ft, 1 = meters
S9	Reserved
S10	Reserved

7.8.1.3 Second Row: Layer Descriptors

<sp>OKTAS1<sp>CH1<sp> OKTAS 2<sp>CH2<sp> OKTAS 3<sp>CH3<sp>OKTAS 4 <sp>CH4<CR><LF>

Field	Description
OKTASn	Oktas of cloud cover estimated for Layer 1[0-8] or vertical visibility [layer 1 only] 100s of feet or 10s of meters
CHTn	Height of cloud Layer N 100s of feet or 10s of meters

OKTAS1= -1 if less than "30 minutes" (parameter) of data available.

OO1 = Layer 1 amount (0....8) or 9 if vertical visibility reported

-1 if less than "30 minutes" (parameter) of data available.

7.8.2 Sample Message

Where no cloud or vertical visibility detected, unit is feet cloud amount is 1 okta at 1000ft.

00 ///// ///// ///// ///// 0000000100
1 100 0 0 0 0 0 0

7.9 Message Type 4–13 — CL31 Message Emulation

This message group is a fully compatible emulation of the industry[-standard CL31 messages. 4–8 are Message Type 1 without the sky condition line and 9–13 are Message Type 2 with the sky condition line.

These messages include status and cloud bases containing the sky condition. The maximum reading is 25000 ft.

The CL31 message set includes subclasses for defining one of a range of different backscatter profile types.

The subclasses are Message Subclass 1, 2, 3, 4, 5:

1. 7700 m divided into 770 samples of 10 m
2. 7700 m divided into 385 samples of 20 m
3. 7500 m divided into 1500 samples of 5 m
4. 3850 m divided into 770 samples of 5 m
5. No profile

Each one of the valid combinations of Message numbers and subclasses is encoded as a unique message number as per the table below.

8200 Message No.	Emulated Message	OEM Message	Sub-Class Type	Profile Specification
4	CL31	1	5	None
5	CL31	1	1	770 samples of 10 m
6	CL31	1	2	385 samples of 20 m
7	CL31	1	3	1500 samples of 5 m
8	CL31	1	4	770 samples of 5 m
9	CL31	2	5	None
10	CL31	2	1	770 samples of 10 m
11	CL31	2	2	385 samples of 20 m
12	CL31	2	3	1500 samples of 5 m
13	CL31	2	4	770 samples of 5 m

7.9.1 Definition of Data

7.9.1.1 First Row of Data

[exactly 12 characters including <CR><LF>]

<SOH>CLA20015<STX><CR><LF>

Character	Explanation
<SOH>	ASCII start of heading Character
CL	Ceilometers' identification string; always CL
A	ID
200	Software ID
1	Message Number 1, or 2
1	Message Subclass 1, 2, 3,4, 5: 1. 7700 m divided into 770 samples of 10 m 2. 7700 m divided into 385 samples of 20 m 3. 7500 m divided into 1500 samples of 5 m 4. 3850 m divided into 770 samples of 5 m 5. No profile
<STX>	ASCII Start of Text Character
<CR><LF>	ASCII Carriage return and Line Feed

7.9.1.2 Second Row of Data

cloud base Heights and Status

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.9.2 Data Key:

N= Backscatter Analysis Codes

N	Condition Detected
0	Clear Sky
1	1 cloud base detected
2	2 cloud bases detected
3	3 cloud bases detected
4	No cloud base can be detected from echo signal received
5	Sky is partly obscured, and no cloud or vertical visibility detected
/	Raw data error

S = BITE

S	Condition Detected
0	No alarm status bits S1....S4 (normal status)
W	At least one warning is on
A	At least one alarm is on

Data Fields, Case N=0 or N=/

Field	Data Field
H1H1H1H1H1	/////
H2H2H2H2H2	/////
H3H3H3H3H3	/////

Data Fields, Case N=1 [if N=4, 00123 is the vertical visibility]

Field	Data Field
H1H1H1H1H1	00123
H2H2H2H2H2	/////
H3H3H3H3H3	/////

Data Fields, Case N=2

Field	Data Field
H1H1H1H1H1	00123
H2H2H2H2H2	01234
H3H3H3H3H3	/////

Data Fields, Case N=3

Field	Data Field
H1H1H1H1H1	00123
H2H2H2H2H2	01234
H3H3H3H3H3	12345

Data Fields, Case N=5

Field	Data Field
H1H1H1H1H1	/////
H2H2H2H2H2	/////
H3H3H3H3H3	/////

7.9.2.1 Sky Condition Data Line

Included in Message Type 2 as Row 3

[exactly 37 characters incl <CR><LF>]

<sp><sp>OKTAS$_1$<sp>CH$_1$<sp> OKTAS $_2$<sp>CH$_2$<sp> OKTAS $_3$<sp>CH$_3$<sp> OKTAS $_4$ <sp>CH$_4$ <sp>OKTAS $_5$ <sp>CH$_5$<CR><LF>

Field	Description
OKTASn	Oktas of cloud cover estimated for Layer 1 [0-8] or vertical visibility [layer 1 only] 100s of feet or 10s of meters
CHTn	Height of cloud Layer N 100s of feet or 10s of meters

OKTAS1= -1 if less than "30 minutes" (parameter) of data available

OO1 = Layer 1 amount (0....8) or 9 if vertical visibility reported

-1 if less than "30 minutes" (parameter) of data available

7.9.2.2 Status Information Row

Example:

00100 10 0770 098 +34 099 12 0621 L0112HN15 139.↲

where

00100 = Parameter SCALE, 100 (%) is normal (0 ... 99999 possible)

10 = Backscatter profile resolution in m. (05, 10, or 20 possible)

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 degrees C (-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)

L0112HN15 = Measurement parameters (pulse Long/Short, pulse qty

0112x1024, gain High/Low, bandwidth Narrow/Wide, sampling 15/30 MHz)

139 = SUM of detected and normalized backscatter, 0....999. Multiplied by scaling factor times 104. At scaling factor 100 the SUM range 0....999 corresponds to integrated backscatter 0 ... 0.srad-1.

NOTE

This line is omitted if the message subclass is 5.

The bit fields encode as hexadecimal numbers encoding up to 48 status bits in 3 groups:

Alarm: these are the bits in the first 4 characters fedc :

Warning: these are the bits in the third and 4th characters, ba98

Status: these are the bits in the 5th and 6th characters, 7654

If there are active Alarm or Warning codes, the Status Byte in the second row indicates that fact.

7.9.2.3 Status Codes

Code	Bit Number	Weight	Description
F	47	8	Alarm Laser Turned Off
F	46	4	Alarm: Laser Fail
F	45	2	Alarm: Receiver Fail
F	44	1	Alarm: Voltage Fail
E	43	8	Alarm: Alignment Fail
E	42	4	Alarm: Memory Error
E	41	2	Alarm: Obstruction
E	40	1	Alarm: Receiver Saturation
D	39	8	Spare
D	38	4	Spare
D	37	2	Spare
D	36	1	Spare
C	35	8	Spare
C	34	4	Spare
C	33	2	Alarm: Coaxial cable failure
C	32	1	Alarm: Ceilometer engine board failure
B	31	8	Warning: Window contamination
B	30	4	Warning: Battery voltage low
B	29	2	Warning: Transmitter expires
B	28	1	Warning: High humidity
A	27	8	Warning: Spare
A	26	4	Warning: Blower failure
A	25	2	Warning: Spare
A	24	1	Warning: Humidity sensor failure
9	23	8	Warning: Heater fault
9	22	4	Warning: High background radiance
9	21	2	Warning: Ceilometer engine board failure
9	20	1	Warning: Battery failure
8	19	8	Warning: Laser monitor failure
8	18	4	Warning: Receiver warning
8	17	2	Warning: Tilt angle > 45 degrees warning

Code	Bit Number	Weight	Description
8	16	1	Warning: Spare
7	15	8	Status: Blower is on
7	14	4	Status: Blower heater is on
7	13	2	Status: Internal heater is on
7	12	1	Status: Working from battery
6	11	8	Status: Standby mode is on
6	10	4	Status: Self-test in progress
6	9	2	Status: Manual data acquisition settings are effective
6	8	1	Status: Spare
5	7	8	Status: Units are meters if on, else feet
5	6	4	Status: Manual blower control
5	5	2	Status: Polling mode is on
5	4	1	Status: Spare
4	3	8	Status: Spare
4	2	4	Status: Spare
4	1	2	Status: Spare
4	0	1	Status: Spare

7.9.2.4 Last Row of Data

[exactly 8 characters incl <CR><LF>]

Character	Explanation
<ETX>	ASCII End of Text Character
ABCD	CRC Checksum from the character after the <SOH> to the <ETX>
<EOT>	ASCII Start of Text Character
<CR><LF>	ASCII Carriage return and Line Feed

7.9.2.5 CRC Checksum

The CRC checksum is included in the message the C source to generate the code is as follows: This code a can be used to verify the integrity of the message.

```
INT16U crc16( char *buf, int len)

{
INT16U crc, 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 =crc << 1;
                        crc = crc^xmask;
                        }
                }
        return(crc ^ 0xffff);
}
```

The calculation of the checksum starts after the Start-of-Heading character and ends after the End-of-Text character. The first character included is C and the last one included is End-of-Text.

7.10 Message Type 4 — CL-31 Message 1, Sub-Class Type 5

The Message Type 4 output is a fully compatible emulation of the industry standard CL31 Message Type 1 format. This message includes status, and 3 cloud bases and a line containing the sky condition. The maximum reading is 25000 ft.

7.10.1 Definition of Data

7.10.1.1 First Row of Data

[exactly 12 characters including <CR><LF>]

<SOH>CLA20015<STX><CR><LF>

7.10.1.2 Second Row of Data

Cloud base Heights and Status

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.10.1.3 Third Row of Data

[exactly 8 characters incl <CR><LF>]

7.10.2 Sample Message

<ETX>1a3f<EOT><CR><LF>

7.11 Message Type 5 — CL-31 Message 1 Profile Sub-Type 1

This message implements the previously described CL-31 message type 1 with a backscatter profile generated with a different height increment.

7.11.1 Definition of Data

7.11.1.1 First Row of Data

[exactly 12 characters including <CR><LF>]

<SOH>CLA20011<STX><CR><LF>

7.11.1.2 Second Row: Data & Status Line

[exactly 35 characters incl <CR><LF>]
N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.11.1.3 Third Row: Additional Status Line

Example:

00100 10 0770 098 +34 099 12 621 L0112HN15 139↵

7.11.1.4 Fourth Row: Profile Line

This is output in a contiguous block of 5 hexadecimal digit data without separators.

Resolution (m)	Number of Points	Height Increment	Total Length (bytes)	Range (m)
10	770	10	3956	7700

7.11.1.5 Fifth Row

Example:

<ETX>1a3f<EOT><CR><LF>

7.11.2 Sample Message

CLA10011☺↵	1st line 12 char.
30 01230 12340 23450 FEDCBA987654↵	2nd line 35 char.
00100 10 0770 098 +34 099 12 0621 L0112HN15 139↵	3rd line 49 char.
00000111112222233333 … (5 x 770 bytes)↵	4th line 3852 char.
1a3f♦↵	5th line 8 char.

Total 3956 char.

7.12 Message Type 6 — CL-31 Message 1 Type 2

This message implements the previously described CL-31 Message Type 1 with a backscatter profile generated with a different height increment.

7.12.1 Definition of Data

7.12.1.1 First Row of Data

[exactly 12 characters including <CR><LF>]

<SOH>CLA20012<STX><CR><LF>

7.12.1.2 Second Row of Data & Status Line

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.12.1.3 Third Row: Additional Status Line

Example:

00100 10 0770 098 +34 099 12 621 L0112HN15 139↵

7.12.1.4 Fourth Row: Profile Line

This is output in a contiguous block of 5 hexadecimal digit data without separators.

Resolution (m)	Number of Points	Height Increment	Total Length (bytes)	Range (m)
10	385	20	2031	7700

7.12.1.5 Fifth Row

Example:

<ETX>1a3f<EOT><CR><LF>

7.13 Message Type 7 — CL-31 Message 1 Type 3

This message implements the previously described CL-31 Message Type 1 with a backscatter profile generated with a different height increment.

7.13.1 Definition of Data

7.13.1.1 First Row

[exactly 12 characters including <CR><LF>]

<SOH>CLA20013<STX><CR><LF>

7.13.1.2 Second Line: Data & Status Line

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.13.1.3 Third Row: Additional Status Line

Example:

00100 10 0770 098 +34 099 12 621 L0112HN15 139↵

7.13.1.4 Fourth Row: Profile Line

This is output in a contiguous block of 5 hexadecimal digit data without separators.

Resolution (m)	Number of Points	Height Increment	Total Length (bytes)	Range (m)
5	1500	10	7606	7500

7.13.1.5 Fifth Row

Example:

<ETX>1a3f<EOT><CR><LF>

7.14 Message Type 8 — CL-31 Message 1 Type 4

This message implements the previously described CL-31 Message Type 1 with a backscatter profile generated with a different height increment.

7.14.1 Definition of Data

7.14.1.1 First Row

[exactly 12 characters including <CR><LF>]

<SOH>CLA20014<STX><CR><LF>

7.14.1.2 Second Line: Data & Status Line

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.14.1.3 Third Row: Additional Status Line

Example:

00100 10 0770 098 +34 099 12 621 L0112HN15 139↵

7.14.1.4 Fourth Row: Profile Line

This is output in a contiguous block of 5 hexadecimal digit data without separators.

Resolution (m)	Number of Points	Height Increment	Total Length (bytes)	Range (m)
5	770	5	3956	7700

7.14.1.5 Fifth Line

Example:

<ETX>1a3f<EOT><CR><LF>

where

<ETX> = End-of-Text character

1a3f = Checksum, see below for calculation procedure

<EOT> = End-of-Transmission character

<CR><LF> = Carriage Return + Line Feed

7.15 Message Type 9 — CL-31 Message 2 Type 5

This message implements the CL-31 message type 2 with status, 3 cloud bases, and an additional line containing the sky condition.

The maximum reading is 25000 ft

7.15.1 Definition of Data

7.15.1.1 First Row of Data

[exactly 12 characters incl <CR><LF>]

<SOH>CLA20025<STX><CR><LF>

7.15.1.2 Second Row of Data

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.15.1.3 Third Row of Data

[exactly 37 characters incl <CR><LF>]

<sp><sp>OKTAS$_1$<sp>CH$_1$<sp> OKTAS $_2$<sp>CH$_2$<sp> OKTAS $_3$<sp>CH$_3$<sp> OKTAS $_4$ <sp>CH$_4$ OKTAS $_5$ <sp>CH$_5$<CR><LF>

7.15.1.4 Fourth Row of Data

[exactly 8 characters incl <CR><LF>]

Example:

<ETX>1a3f<EOT><CR><LF>

7.16 Message Type 10 — CL-31 Message 2 Type 1

This message implements the CL-31 message type 2 with status, 3 cloud bases, and an additional line containing the sky condition with a backscatter profile generated with a different height increment.
The maximum reading is 25000 ft

7.16.1 Definition of Data

7.16.1.1 First Row of Data

[exactly 12 characters incl <CR><LF>]

<SOH>CLA20021<STX><CR><LF>

7.16.1.2 Second Row of Data

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.16.1.3 Third Row: Additional Status Line

Example:

00100 10 0770 098 +34 099 12 621 L0112HN15 139↵

7.16.1.4 Fourth Row: Layer Data

[exactly 37 characters incl <CR><LF>]

<sp><sp>OKTAS$_1$<sp>CH$_1$<sp> OKTAS $_2$<sp>CH$_2$<sp> OKTAS $_3$<sp>CH$_3$<sp> OKTAS $_4$ <sp>CH$_4$ OKTAS $_5$ <sp>CH$_5$<CR><LF>

7.16.1.5 Fifth Row: Profile

This is output in a contiguous block of 5 hexadecimal digit data without separators.

Resolution (m)	Number of Points	Height Increment	Total Length (bytes)	Range (m)
10	770	10	3993	7700

7.16.1.6 Sixth Row of Data

[exactly 8 characters incl <CR><LF>]

Example:

<ETX>1a3f<EOT><CR><LF>

7.17 Message Type 11 — CL-31 Message 2 Type 2

This message implements the CL-31 Message Type 2 with status, 3 cloud bases, and an additional line containing the Sky Condition with a backscatter profile generated with a different height increment.

The maximum reading is 25000 ft.

7.17.1 Definition of Data

7.17.1.1 First Row of Data

[exactly 12 characters incl <CR><LF>]

<SOH>CLA20022<STX><CR><LF>

7.17.1.2 Second Row of Data

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.17.1.3 Third Row: Additional Status Line

Example:

00100 10 0770 098 +34 099 12 621 L0112HN15 139↲

7.17.1.4 Fourth Row: Layer Data

[exactly 37 characters incl <CR><LF>]

<sp><sp>OKTAS$_1$<sp>CH$_1$<sp> OKTAS $_2$<sp>CH$_2$<sp> OKTAS $_3$<sp>CH$_3$<sp> OKTAS $_4$ <sp>CH$_4$ OKTAS$_5$ <sp>CH$_5$<CR><LF>

7.17.1.5 Fifth Row: Profile

This is output in a contiguous block of 5 hexadecimal digit data without separators.

Resolution (m)	Number of Points	Height Increment	Total Length (bytes)	Range (m)
10	385	20	2068	7700

7.17.1.6 Sixth Row of Data

[exactly 8 characters incl <CR><LF>]

Example:

<ETX>1a3f<EOT><CR><LF>

7.18 Message Type 12 — CL-31 Message 2 Type 3

This message implements the CL-31 Message Type 2 with status, 3 cloud bases, and an additional line containing the Sky Condition with a backscatter profile generated with a different height increment.

The maximum reading is 25000 ft.

7.18.1 Definition of Data

7.18.1.1 First Row of Data

[exactly 12 characters incl <CR><LF>]

<SOH>CLA20023<STX><CR><LF>

7.18.1.2 Second Row of Data

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.18.1.3 Third Row: Additional Status Line

Example:

00100 10 0770 098 +34 099 12 621 L0112HN15 139↵

7.18.1.4 Fourth Row: Layer Data

[exactly 37 characters incl <CR><LF>]

<sp><sp>OKTAS$_1$<sp>CH$_1$<sp> OKTAS $_2$<sp>CH$_2$<sp> OKTAS $_3$<sp>CH$_3$<sp> OKTAS $_4$ <sp>CH$_4$ OKTAS $_5$ <sp>CH$_5$<CR><LF>

7.18.1.5 Fifth Row: Profile

This is output in a contiguous block of 5 hexadecimal digit data without separators.

Resolution (m)	Number of Points	Height Increment	Total Length (bytes)	Range (m)
5	1500	10	7643	7500

7.18.1.6 Sixth Row of Data

[exactly 8 characters incl <CR><LF>]

Example:

<ETX>1a3f<EOT><CR><LF>

7.19 Message Type 13 — CL-31 Message 2 Type 4

This message implements the CL-31 Message Type 2 with status, 3 cloud bases, and an additional line containing the Sky Condition with a backscatter profile generated with a different height increment.

The maximum reading is 25000 ft.

7.19.1 Definition of Data

7.19.1.1 First Row of Data

[exactly 12 characters incl <CR><LF>]

<SOH>CLA20024<STX><CR><LF>

7.19.1.2 2nd row of data

[exactly 35 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3 <sp>fedcba987654<CR><LF>

7.19.1.3 Third Row: Additional Status Line

Example:

00100 10 0770 098 +34 099 12 621 L0112HN15 139↵

7.19.1.4 Fourth Row: Layer Data

[exactly 37 characters incl <CR><LF>]

<sp><sp>OKTAS$_1$<sp>CH$_1$<sp> OKTAS $_2$<sp>CH$_2$<sp> OKTAS $_3$<sp>CH$_3$<sp> OKTAS $_4$ <sp>CH$_4$ OKTAS $_5$ <sp>CH$_5$<CR><LF>

7.19.1.5 Fifth Row: Profile

This is output in a contiguous block of 5 hexadecimal digit data without separators.

Resolution (m)	Number of Points	Height Increment	Total Length (bytes)	Range (m)
5	770	5	3993	7700

7.19.1.6 Sixth Row of Data

[exactly 8 characters incl <CR><LF>]

Example:

<ETX>1a3f<EOT><CR><LF>

7.20 Message Type 14 — CT12k Message 2

Message Type 14 output is a fully compatible emulation of the industry standard CT12K Message Type 2 format. This message includes status, cloud bases, penetration depths in the first line status information and backscatter data.

The maximum reading is 12500 ft.

<SOH><CR><LF> DATA <ETX><CR><LF>

7.20.1 Definition of Data

7.20.1.1 First Row of Data

[exactly 40 characters incl <CR><LF>]

N S B<sp>H1H1H1H1H1<sp>T1T1T1T1T1<sp>H2H2H2H2H2<sp>T2T2T2T2T2

<sp>S1S2S3S4S5S6S7S8S9S10<CR><LF>

The total length of the message is 636 characters. The message has 15 lines,

Typical data message:

```
10 04200 00150 ///// ///// 0000011010 □
2 0 0.08 36 0 100 23.9 0.00 0 0 □
0DD..............................DD □
-1 □
-2 □
-3 □
-4 □
-5 □
-6 (data values;) □
-7 □
-8 □
-9 □
10 □
11 □
12DD..............................DD □
```

Message Interpretation

N= Backscatter Analysis Codes

N	Condition Detected
0	Clear Sky
1	One cloud base detected
2	Two cloud bases detected
3	No cloud base can be detected from signal received (vertical visibility)
4	Sky is partly obscured, and no cloud or vertical visibility detected

S = BITE

S	Condition Detected
0	No alarm status bits S1....S4 (normal status)
1	At least one alarm status bit S1....S4 is on

B = BITE ALERT

S	Condition Detected
20H	No alarm status bits S1....S4 (normal status)
07H	The Bel character if S=1

Data Fields, Case N=0 or N=4

Field	Data Field
H1H1H1H1H1	/////
T1T1T1T1T1	/////
H2H2H2H2H2	/////
T2T2T2T2T2	/////

Data Fields, Case N=1

Field	Data Field
H1H1H1H1H1	The lowest detected cloud height in 5 digits
T1T1T1T1T1	Penetration depth of first cloud base, Leading zeroes are not suppressed, / / / / / if not defined

Data Fields, Case N=2

Field	Data Field
H1H1H1H1H1	The lowest detected cloud height in 5 digits
T1T1T1T1T1	Penetration depth of first cloud base, Leading zeroes are not suppressed, / / / / / if not defined
H2H2H2H2H2	The second detected cloud height in 5 digits
T2T2T2T2T2	Penetration depth of second cloud base, Leading zeroes are not suppressed, / / / / / if not defined

Data Fields, Case N=3

Field	Data Field
H1H1H1H1H1	Vertical Visibility
T1T1T1T1T1	Limit of detected backscatter

S1 to S8 = Status Codes

Field	Data Field
S1	1=Hardware alarm
S2	1= Supply voltage alarm
S3	1= Laser power low
S4	1= Temperature alarm
S5	1= Solar Detected
S6	1= Blower ON
S7	1= Heater ON
S8	Units 0 = ft, 1 = m
S9	0
S10	0

7.20.1.2 Second Line of Data

The second line of the message is status line 2.

Example:

G F N.NN SUM IIN LAS TLx OF.FS XX PP

where:

Field	Condition Detected
G	0
F	0
N.NN	Background radiance/100. One digit, two decimals.
SUM	Sum of total backscattered power per unit solid angle i.e. range and instrument normalization applied. Three digits, no decimals. Leading zeroes replaced by space characters.
IIN	0
LAS	Measured laser power in % of current laser power of target laser power (LLAS). 3 digits.
TLx	Laser transmitter temperature. Two digits, one decimal; preceded by minus sign if negative. Degrees c.
OF.FS	0.00
XX	00
PP	00

7.20.1.3 Lines 4... 16

These are the backscatter profile

Example:

HHD0D1D2D3....... D9

where:

HH = Height of the first value

D = Data values

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

The data values are for 50 ft range bins.

The height of the first value in the line is in thousands of feet. There are 2 digits, and leading zeroes are replaced by a space.

There are 20 data values per line starting with 0 (ft), next line 1000 (ft).

There are 13 lines in total. Last line (12000 ft) has 10 values and reads up to 12500 ft only.

The Backscatter data are encoded using the following formula:

DD = 50 X ln(RAWDATA-MINV)+1

The backscatter data can be decoded using the following formula.

RAWDATA = EXP(dd/50)-1+MINV

7.21 Message Type 15 — CT12k Message 3

Message Type 14 output is a fully compatible emulation of the industry standard CT12K Message Type 2 format. This message includes status, cloud bases, penetration depths in the first line status information and backscatter data.

The maximum reading is 12500 ft.

<SOH><CR><LF> DATA <ETX><CR><LF>

7.21.1 Definition of Data

7.21.1.1 First Row of Data

[exactly 40 characters incl <CR><LF>]

N S B<sp>H1H1H1H1H1<sp>T1T1T1T1T1<sp>H2H2H2H2H2<sp>T2T2T2T2T2

<sp>S1S2S3S4S5S6S7S8S9S10<CR><LF>

7.21.1.2 Backscatter Data Line

D D D D D.................................D <cr> <lf>

Dn when=1 to 64 is a single ASCII coded hexadecimal character 0–F where each bit of th4 bit nibble of the hex character expressed in binary form represents one range gate.

With EMOD on range gate bit is 1 if ceilometer determined exco at that range gate exceeds a value corresponding to 10 km... The first 3 range gates have higher thresholds.

D1 represents the 4 lowest range gates 0,50,100,150;

D2 represents 200,250,300,350

0 represents no detectable backscatter in 4 adjacent range gates.

F represents backscatter in all adjacent gates

8 represents backscatter in the lowest gate only

1 represents backscatter in the highest range gate only.

7.21.2 Message Example

10 04200 00150 ///// ///// 0000011010<cr> <lf>

001FFF80000000000007A000... 000<cr> <lf>

<Etx><cr> <lf>

7.22 Message Type 16 — CT25k Message 1

This output format is similar to the industry standard CT25K Message Type 1 format. This message includes status and 3 cloud bases in the second line.

The maximum reading is 25000 ft.

Refer to the CT25K handbook for details of the status codes.

Message Format

<SOH><CR><LF> DATA <ETX><CR><LF>

7.22.1 Definition of Data

7.22.1.1 First Row: Data Descriptors

CTA2010<STX> 10 characters [not including the SOH]

Character	Explanation
CT	Ceilometers' identification string; always CT
A	ID
20	Software ID
1	Message Number is 1
0	
<STX>	Start of text

7.22.1.2 Second Row: Data Descriptors

[exactly 31 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3

<sp>S1S2S3S4S5S6S7S8S9S10<CR><LF>

Data Key:

N= Backscatter Analysis Codes

N	Condition Detected
0	Clear Sky
1	1 cloud base detected
2	2 cloud bases detected
3	3 cloud bases detected
4	No cloud base can be detected from echo signal received
5	Sky is partly obscured, and no cloud or vertical visibility detected
/	Raw data error

S = BITE

S	Condition Detected
0	No alarm status bits S1....S4 (normal status)
W	At least one warning is on
A	At least one alarm is on

Data Fields, Case N=0 or N=/

Field	Data Field
H1H1H1H1H1	/////
H2H2H2H2H2	/////
H3H3H3H3H3	/////

Data Fields, Case N=1 [if N=4, 00123 is the vertical visibility]

Field	Data Field
H1H1H1H1H1	00123
H2H2H2H2H2	/////
H3H3H3H3H3	/////

Data Fields, Case N=2

Field	Data Field
H1H1H1H1H1	00123
H2H2H2H2H2	01234
H3H3H3H3H3	/////

Data Fields, Case N=3

Field	Data Field
H1H1H1H1H1	00123
H2H2H2H2H2	01234
H3H3H3H3H3	12345

Data Fields, Case N=5

Field	Data Field
H1H1H1H1H1	/////
H2H2H2H2H2	/////
H3H3H3H3H3	/////

7.22.1.3 Last Line

<ETX><CR><LF>

7.23 Message Type 17 — CT25k Message 2

This message includes status, 3 cloud bases in the second line, and a signal profile.
The maximum reading is 25000 ft.

<SOH>DATA <ETX><CR><LF>

7.23.1 Definition of Data

7.23.1.1 First Row: Data Descriptors

CTA2020<STX> 10 characters [not including the SOH]

Character	Explanation
CT	Ceilometers' identification string; always CT
A	ID, A,B,....Z
20	Software ID
2	Message Number is 2
0	
<STX>	Start of text

7.23.1.2 Second Row: Data Descriptors

[exactly 31 characters incl <CR><LF>]

N S<sp>H1H1H1H1H1<sp> H2H2H2H2H2<sp>H3H3H3H3H3

<sp>S1S2S3S4S5S6S7S8S9S10<CR><LF>

Data Key:

N= Backscatter Analysis Codes

N	Condition Detected
0	Clear Sky
1	1 cloud base detected
2	2 cloud bases detected
3	3 cloud bases detected
4	No cloud base can be detected from echo signal received
5	Sky is partly obscured, and no cloud or vertical visibility detected
/	Raw data error

S = BITE

S	Condition Detected
0	No alarm status bits S1....S4 (normal status)
W	At least one warning is on
A	At least one alarm is on

Data Fields, Case N=0 or N=/

Field	Data Field
H1H1H1H1H1	/////
H2H2H2H2H2	/////
H3H3H3H3H3	/////

Data Fields, Case N=1 [if N=4, 00123 is the vertical visibility]

Field	Data Field
H1H1H1H1H1	00123
H2H2H2H2H2	/////
H3H3H3H3H3	/////

Data Fields, Case N=2

Field	Data Field
H1H1H1H1H1	00123
H2H2H2H2H2	01234
H3H3H3H3H3	/////

Data Fields, Case N=3

Field	Data Field
H1H1H1H1H1	00123
H2H2H2H2H2	01234
H3H3H3H3H3	12345

Data Fields, Case N=5

Field	Data Field
H1H1H1H1H1	/////
H2H2H2H2H2	/////
H3H3H3H3H3	/////

7.23.1.3 Third Row: Additional Status Line

[exactly 44 characters incl <CR><LF>]

Example:

200 N 53 +34 204 146 +2 621 LF7HN1 139

Out-of-Range is indicated by slashes (/////).

Contents:

200	Parameter Scale, 100 (%) is normal (0…999 possible)
N	measurement mode; N = Normal, (C = Close range, not available in CT25K)
53	laser pulse energy, % of nominal factory setting (0…999)
+34	laser temperature degrees C (-50…+99)
204	receiver sensitivity, % of nominal factory setting (0…999)
146	window contamination, millivolts at internal ADC input (0…2500)
+2	tilt angle, degrees from vertical (-15…+90)
621	background light, millivolts at internal ADC input (0…2500)
LF7HN1	measurement parameters (pulse Long/Short, freq F (const.), pulse qty
47+1	gain High/Low, bandwidth Narrow/Wide, sampling 10/20 MHz)
139	SUM of detected and normalized backscatter, 0. 999. Multiplied by scaling factor times 104. At scaling factor 100 the SUM range 0. 999 corresponds to integrated backscatter 0…0.0999 srad-1

7.23 1.4 Row 4–19

Backscatter profile, sensitivity and range normalized, at 100 ft = 30 m resolution, normally scaled to units of (10000·srad·km)-1.

Example of line 8:

064FDFDFDFDFDFCFCFCFCFCFCFCFCFBFBFBFBFBFBFBFAFBFAFBFBFAFAFBFAF9F AF9¿

where:

064 is start distance (height) of line backscatter data items; decimal, unit is 100 ft.

FDFC, FBFA, … are 16 four-character data items per line, at 100 ft = 30 m = 200 ns resolution; 16-bit HEX-ASCII; msb nibble and bit first. 2's complement.

Data is range and sensitivity normalized backscatter, units (10000·srad·km)-1 unless otherwise scaled by parameter SCALE.

CTA2023

30 01230 12340 23450 FEDCBA98

100 N 53 +34 204 146 +2 621 LF7HN1 139

00047F2000000000000000000000000000000000000050D010000000000000000

01600FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFEFEFEFEFEFEFEFEFEFEFEFEFDFDFDFDFDFD

03200FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFEFEFEFEFEFEFEFEFEFEFEFEFDFDFDFDFDFD

048FDFDFDFDFDFCFCFCFCFCFCFCFCFBFBFBFBFBFBFBFAFBFAFBFBFAFAFBFAF9FAF9

064FDFDFDFDFDFCFCFCFCFCFCFCFCFBFBFBFBFBFBFBFAFBFAFBFBFAFAFBFAF9FAF9

080F9FAF9F9F9F9F9F9F9F8F7F8F7F9F8F7F7F8F6F7F7F7F6F6F7F6F7F6F6F6F6F6

096F9FAF9F9F9F9F9F9F9F8F7F8F7F9F8F7F7F8F6F7F7F7F6F6F7F6F7F6F6F6F6F6

112F5F5F5F6F5F2F4F5F6F5F5F4F4F4F4F3F4F3F4F5F3F5F4F4F2F3F3F3F3F4F4F3

128F5F5F5F6F5F2F4F5F6F5F5F4F4F4F4F3F4F3F4F5F3F5F4F4F2F3F3F3F3F4F4F3

144F2F2EFF1F4F1F2F2F1F3F2F2EFF1EFF0F0EFF1EFF0F1EFF0F0F2F0EFF0EFEFF0

160F2F2EFF1F4F1F2F2F1F3F2F2EFF1EFF0F0EFF1EFF0F1EFF0F0F2F0EFF0EFEFF0

176EEF1EFEDEFEEEFEEEEF0EDF0F2EFEDEFEFEFF0EFECECECEEEAF0EDEDECEAEAEA

192EEF1EFEDEFEEEFEEEEF0EDF0F2EFEDEFEFEFF0EFECECECEEEAF0EDEDECEAEAEA

208EEF1EFEDEFEEEFEEEEF0EDF0F2EFEDEFEFEFF0EFECECECEEEAF0EDEDECEAEAEA

224F0ECEFEDF0ECEBEEEDEEE9EAEFF0EEECEAEDECEBEAEEE7EDEAEAEAEBECEAEAEA

240F0ECEFEDF0ECEBEEEDEEE9EAEFF0EEECEAEDECEBEAEEE7ED0000000000000000

7.23.1.5 Last Line

<ETX><CR><LF>

7.24 Message Type 18 — CT25kam Message 60

This is the same as Message Type 16 which is an emulation of CT25K Message Type 1.

7.25 Message Type 19 — CT25k Message 7

This is the same as Message Type 17 with an additional line including the Sky Condition.

7.25.1 Layer Descriptors

<sp>OKTAS$_1$<sp>CH$_1$<sp> OKTAS $_2$<sp>CH$_2$<sp> OKTAS $_3$<sp>CH$_3$<sp> OKTAS $_4$ <sp>CH$_4$<CR><LF>

Field	Data Field
OKTASn	Oktas of cloud cover estimated for Layer 1 [0-8] or vertical visibility [layer 1 only] 100s of feet or 10s of meters
CHTn	Height of cloud Layer N 100s of feet or 10s of meters

OKTAS1= -1 if less than "30 minutes" (parameter) of data available

OO1 = Layer 1 amount (0....8) or 9 if vertical visibility reported

-1 if less than "30 minutes"(parameter) of data available

7.26 Message Type 20 — CT25kam Message 6

This is the same as Message Type 16, which is an emulation of CT25K Message Type 1 except that an extra Sky Condition data field is added to the message.

The third line is 37 characters long and is defined as follows:

<sp><sp>OKTAS$_1$<sp>CH$_1$<sp> OKTAS$_2$<sp>CH$_2$<sp> OKTAS$_3$<sp>CH$_3$<sp> OKTAS$_4$
<sp>CH$_4$ <sp>OKTAS$_4$ <sp>CH$_4$ <CR><LF>

7.27 Message Type 21 —Raw Backscatter Profile

This message is the raw backscatter profile message.

The data line starts with the # character.

2700 5-byte hexadecimal characters follow.

This message is issued from COM2 for test and calibration purposes.

7.28 Message Type 22—8339 Format

The 8339 Native Data format is output from the Ceilometer in a data string consisting of eight fields.

Output Data String
TR1 AAAAAA HHHHH TTTT HHHHH TTTT HHHHH TTTT HHHHH TTTT VVVV RRRRR

Character Sequence	Meaning
TR1	TR1 is an identifier that enables the system to be put onto a universal bus. It communicates the data source (8339 Ceilometer) to the data receiver
AAAAAA	Status message (see Troubleshooting for a definition of the status message)
HHHHH	Cloud height in feet
TTTT	Penetration depth in feet
VVVV	Vertical visibility
RRRRR	Range setting in feet

Table 2. 8339 Native Data Output Data Format

7.28.1 8339 Sky Condition Format

The 8339 Sky Condition Format provides real-time reports of cloud bases and depths as well as the Sky Condition based on the NWS ASOS Sky Condition algorithm.

The Sky Condition algorithm uses a weighted average of 30-second cloud hit reports over a 10- minute period to determine the cloud cover. The output of the Sky Condition algorithm produces results such as "OVC020 BKN230" representing an Overcast layer at 2,000 feet and a Broken layer at 23,000 feet. Notice that the height is reported in hundreds of feet. Layers are always reported in ascending order and may contain up to four distinct layers. The Sky Condition output field from the Ceilometer is acceptable for METAR reporting based on the ICAO Annex 3 requirements.

Model 8200 Ceilometer

The possible Sky Condition outputs are listed in Table 3.

Parameter	Definition
MM	Not enough data exists to produce an output. 30 minutes of valid reports are required to produce a Sky Condition output.
CLR	Less than 6% coverage of any layer.
FEW	More than 6% coverage and less than 25% for the specified layer.
SCT	More than 25% coverage and less than 50% for the specified layer.
BKN	More than 50% coverage and less than 87.5% for the specified layer.
OVC	More than 87.5% coverage.

Table 3. Sky Condition Output Values

A data package is available every 30-seconds. The required settings for communicating with the Ceilometer are the same ones shown in Error! Reference source not found. for the 8339 Native D ata format.

7.28.1.1 Data Format

The 8339 Sky Condition Format is output from the Ceilometer in a data string consisting of seven fields.

Output Data String	
TR1 AAAAAA HHHHH TTTT HHHHH TTTT HHHHH TTTT HHHHH TTTT VVVV RRRRR ,SKYCOND	
Character Sequence	**Meaning**
TR1	TR1 is an identifier that enables the system to be put onto a universal bus. It communicates the data source (8339 Ceilometer) to the data receiver
AAAAAA	Status message (see Troubleshooting for a definition of the status message)
HHHHH	Cloud height in feet
TTTT	Penetration depth in feet
VVVV	Vertical visibility
RRRRR	Range setting in feet
SKCOND	The Sky Condition string utilizing the condition codes as described above. Heights are reported in 100's of feet. For example, "SCT003 BKN022" indicates that there is a scattered layer at 300 feet and a broken layer at 2,200 feet. The Sky Condition string is terminated with a comma ','.

Table 4. 8339 Sky Condition Output Data Format

7.29 Status Indicators

A comprehensive superset of status indicators is used in the 8200. When the various messages are generated, a subset or logical combination of this set is used in the message status report sections of the data messages.

Due to slight differences in the hardware, not all these status variables are in active use for all message types. For instance, there is no Tilt sensor in the 8200 as the tilt compensation setting is input manually, so the status of this is reported as OK in the relevant CL31 and CT25K reports.

Table 5 explains the Status Indicators and the reporting in the various message types. For details of the way status is encoded in each message type, refer to the section on message formats.

Indicator	CL-31	CT25K	CT12K	CBME40/80	8339
Laser Over Temperature shutoff	■	■	■	■	■
Laser failure	■	■			■
APD Board failure	■	■			
Voltage failure	■	■			
Alignment failure	■				
Memory Test Fail	■	■			
Light path obstruction	■	■			
Receiver saturation	■	■			
Ceilometer Control Board failure	■	■			■
Window contamination	■	■			
Battery voltage low	■	■			
High Temperature	■	■	■	■	
Humidity Sensor failure	■	■			
High background radiance	■	■	■	■	
Battery failure	■	■			
Laser monitor failure	■	■			
Receiver warning	■	■			■
Blower is on	■	■	■	■	
Blower heater is on	■	■			■
Internal heater is on	■	■	■	■	
Working from battery	■	■			
Standby mode is on	■	■			
Self-test in progress	■	■			
Data acquisition effective	■	■			
Units in meters	■	■	■	■	
Manual blower control	■	■			

Indicator	CL-31	CT25K	CT12K	CBME40/80	8339
Polling mode is on	■	■		■	
Automatic Gain Control failure					■
Blower Heater fault					■
Configuration failure					■
Laser Temperature low					■
Supply Voltage					■
Window Dirty					■

Table 5. 8200 Status Indicators for Various Message Types

8. Commands

The ceilometer has three ports, one serial, one TCP/IP, and one USB. All data and maintenance functions of the 8200 can be accessed from any of these ports.

- The serial port is on the bottom 8200 base plate (Figure 21).
- The TCP/IP port is on the bottom 8200 base plate (Figure 21).
- The USB port is inside the 8200 unit on the Main Controller Board (Figure 7).

By default, the serial port is set up for RS-232 (9600 8N1) and is used with the M493173-00 data cable supplied with the ceilometer.

Use a terminal such as PuTTY to connect to one of these ports. Some clients cannot be used on one or more ports.

Once connection is established, data should be seen coming from the 8200 unless the unit is in standby mode or is being polled. Under this condition, the PORT is considered “CLOSED” for commands. In this state commands are not echoed and there is no message diagnostic response.

By default, the serial port is set up for RS-232 (9600 8N1)(bootloader uses 115200 bps during startup) and is used with the M493173-00 data cable supplied with the ceilometer.

8.1 Connection Setup

Disconnect AC power to the 8200 while connecting/disconnecting cables or opening the enclosure.

8.1.1 Serial I/F Port

Regardless of whether RS-232 or RS-422 is used, the base plate serial port can most easily be accessed at the Data Collection Platform side by disconnecting the data cable from the DCP Serial Interface Board and connecting the wires to a serial adapter connected to the laptop. Most likely a serial to USB adapter will be used since laptops do not have older style COM ports.

8.1.2 TCP/IP

The TCP/IP port on the base plate may be used as long as TCP/IP has been enabled (SectionError! Reference source not found.). Similarly, the TCP/IP port on the DCP may be u sed instead.

8.1.3 USB Port

Access the USB port by removing the enclosure cover (Figure 19 and Figure 23); do not adjust or loosen the four screws at the corner holding the frame together.

8.1.4 Using the Terminal Emulator

8.1.4.1 Serial or USB Port

1. Connect one of the computer's USB ports to the USB port inside the 8200 or to the data cable via a serial to USB adapter.
2. Identify the COM port related to the USB cable connection on the computer. To identify the COM port related to a USB cable in a computer running Windows, open the Device Manager located in the Control Panel. Go to the Ports (COM & LPT) area and expand the tree. Unplug the USB cable, wait for 30 seconds or so, and then plug the USB cable back in. A communications port will appear in the device manager when the USB cable is connected. This is the communications port directly related to the USB cable.
3. Open a terminal emulation utility such as TeraTerm and select the serial COM port related to the USB cable.
4. Set up the terminal emulation utility serial port as follows.

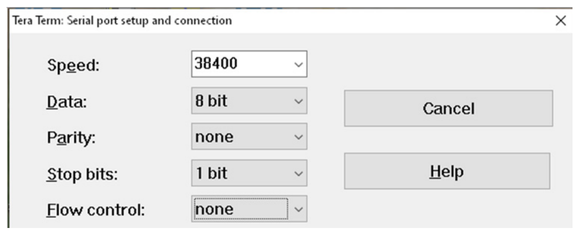
Baud Rate: 9600 (115200 to load firmware)

Data Bits: 8

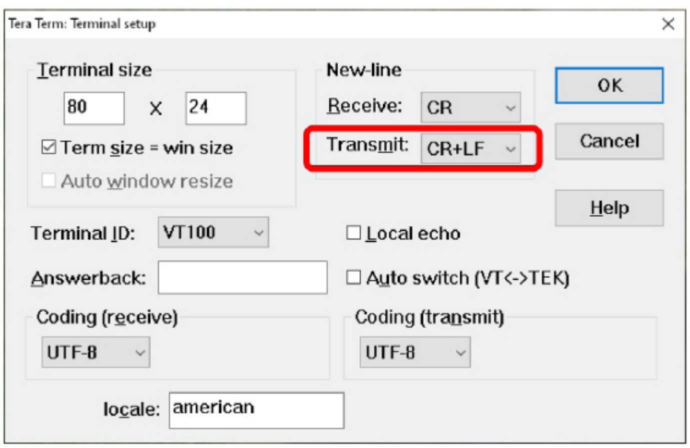
Parity: None

Stop Bits: 1

Flow Control: None



5. Click OK.
6. Set Transmit in the Terminal Setup to CR+LF. Leave Local echo unchecked.



A communication session with the 8200 has now been established.

8.1.4.2 TCP/IP

1. Connect a laptop to the RJ45 jack at the 8200 base plate or inside the DCP using a standard CAT5/6 cable. (Administrator access is required to perform the steps in this procedure.)
2. Navigate to the Control Panel > Network and Sharing Center and then click on Change Adapter settings.
3. Right-click on the network adapter connected to the DCP and click Properties.
4. Select Internet Protocol Version 4 (TCP/IPv4) and click Properties.
5. Enter the information shown here.

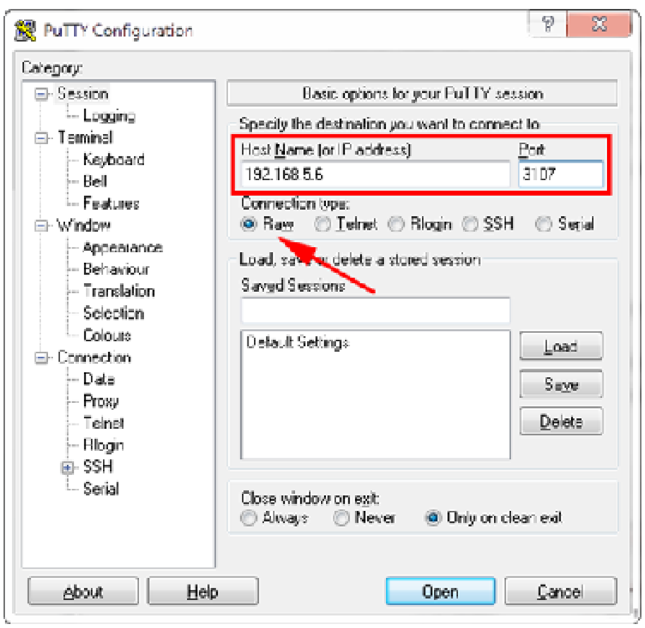
    IP Address: 192.168.5.6

    Subnet mask: 255.255.255.0

    Default gateway: 192.168.5.1

    DNS information can be left blank.

    Click OK.
6. Click Close.
7. Open a terminal emulation utility such as PuTTy on the test computer.
8. Enter 192.168.5.6 for the host name and 3107 (via 1192 DCP) or 2101 (connected directly to the 8200) for the port. Select the Raw connection type.

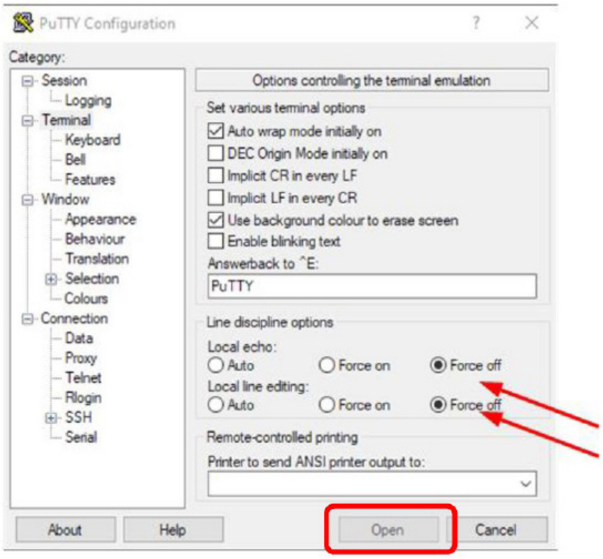


The screenshots were obtained using Putty v 0.71 on a Windows 10 computer. Other terminal emulation utilities and operating systems may be used. Please contact ADB Safegate Customer Service for additional assistance if needed.

NOTE

TCP/IP connection via the 1192 DCP is really a serial connection with extra steps.

9. Click on Terminal in the list on the left and set Local echo to Force off and Local line editing to Force off.



10. Click Open. The window for the terminal emulation program will enter.

A communication session with the 8200 has now been established.

8.2 Opening The Port

8.2.1 Modes of Operation

The device has two modes of operation, "User Mode" and "Advanced Level." User mode enables all settings relating to the everyday operation of the device to be changed. Everyday tasks such as setting message type, communications settings, identification variables, etc. can be achieved at this level. In Advanced Level settings that can alter the performance characteristics of the devices are allowed.

8.2.1.1 Opening User Mode

To OPEN the 8200 into "user" mode for commands, enter the command:

OPEN [Enter]

The 8200 responds with the following prompt:

CEILO >

The port will remain open for a period of 120 seconds and close if no user input is received. The 8200 then returns to the state it was in prior to being opened, as modified by the commands issued during the session.

When commands are entered the 8200 will respond with the following prompt if the command is unrecognized.

CEILO ?

NOTE

User Mode is for every day, non-performance related settings of the device.

8.2.1.2 Timeout

The open mode timeout can be specified or checked. Once the timeout is over, the ceilometer will exit the command mode and resume normal operation. Any user activity during the timeout resets the timer..

CEILO > SET TIMEOUT xx

Set the open mode timeout to be between 30 and 600 seconds.

Example:

CEILO > SET TIMEOUT 100

Open mode timeout set to 100 seconds.

The timeout set can be checked using GET **TIMEOUT** at the **CEILO>** prompt.

CEILO > GET TIMEOUT
CEILO > Open mode timeout is 100 seconds

8.2.1.3 Opening Advanced Level

OPEN [Enter]

AL [Enter]

The 8200 responds with the following prompt:

CEILO ADVANCED >

When commands are entered in ADVANCED LEVEL the 8200 will respond with the following if the command is unrecognized:

CEILO ADVANCED ?

To exit the ADVANCED LEVEL key in

BACK [Enter]

or

CLOSE [Enter]

If either the **CLOSE** or **BACK** command is issued, the 8200 will exit ADVANCED LEVEL.

- **CLOSE** exits the advanced mode and user mode.
- **BACK** exits the advanced mode and goes back to user mode.
- **SAVE** exits the advanced mode and user mode, and saves data to NV memory. Generally, commands are in the form of a direct verb, such as **OPEN**, or as a **GET xxxx**

command with parameter to query a ceilometer status value or a Ceilometer operational setting.

In order to change a Ceilometer operational setting, the commands generally use the form **SET XXX** where **XXX** is the operational setting.

CAUTION

The changing of settings in Advanced Level may result in a degradation of the factory certified performance of the device. Changes to these settings should only be undertaken by either LIDAR experts, suitably factory trained personnel or under the guidance of the manufacturer.

NOTE

It is recommended that the user of the device record the original values for any setting they wish to modify so that it may be reverted should the desired outcome not be achieved.

8.3 Factory Settings

Factory settings are stored in the program firmware and can only be set in the factory.

SET FACTORY [Enter]

Sets all of the values to a default value.

GET PARAMS [Enter]
A message similar to that shown in Section 8.3.1 is displayed.

SAVE

When the USER enters OPEN or ADVANCED level and changes any one of the parameters settings, this change will not be SAVED in the non-volatile memory unless the user issues the command SAVE to exit without saving.

CLOSE

The **CLOSE** command causes an exit from the command mode, without SAVING parameters in flash memory.

RESET

This causes a restart.

8.3.1 Factory Parameter Set (Example)

NOTE

The prompts have been removed from the following output for clarity.

IDENTIFICATION UNIT ID=	F
SERIAL NUMBER=	1241
SOFTWARE ID=	44
Height=	0
SYSTEM	
APD Voltage=	220
Laser Amps=	28
Laser Temp Setpoint	20
Outlaser =	90
APD Tempco =	2000
Tilt =	0
Auto Heater =	0
Auto Blower =	0
Operating Mode =	N
SKY CONDITION AND VERTICAL VIS	
Sky Condition Enabled=	0
Maximum Layers=	3
VV Enabled=	0
VVMax =	1000
CLOUD DETECTION	
SLOPE THRESHOLD=	10.0000
PEAK RATIO LOW ALTITUDE=	8.0000
PEAK RATIO HIGH ALTITUDE=	4.0000
PEAK RATIO THRESHOLD ALTITUDE=	5000.0000
MAXIMUM CLOUD THICKNESS=	500.0000
PEAK POWER THRESHOLD=	1000.0000

SCANNING

Number of Shots=	16000
Offset Counts=	137
Scan Interval=	30

SIGNAL PROCESSING

Scale Factor=	10000
Sliding Window Average=	5
Sliding Window type=	S
Invert Scan=	1

REPORTING

Poll String=	VOID
Message Type=	1
Message Interval=	30
Profile Type=	1
Message Port=	1

9. Command Listing

The following commands are accepted by the Model 8200 Ceilometer when in the Closed Mode. Since the commands are parsed, anything can be appended to a valid command and the command will still work.

Section 8.1.4 describes how to set up a terminal emulator to send these commands and view the responses.

Command	Function
OPEN	Opens the connected port for Get and Set and other commands.
RESET	Reboots the device.
GET POLLSTRING	The Poll string is defined sequence which requests the currently selected data message.

The following commands can be used to exit the Open Mode

Command	Function
CLOSE	This closes the commands session, WITHOUT storing any changes in non-volatile memory and the ceilometer resumes in the modified operational mode, but after the next restart the changes will be lost.
RESET YES or RESET	Reboots the device.

The following commands gain access to ADVANCED level or allow exit from ADVANCED level.

Command	Function
CLOSE	This closes the commands session WITHOUT storing any changes in non-volatile memory, and the ceilometer resumes in the modified operational mode, but after the next restart the changes will be lost.
RESET YES or RESET	Reboots the device.
AL	Changes to ADVANCED command level
BACK	Reverts to Normal command mode

When the port is in the OPEN state, the HELP command may be useful.

Command	Function
HELP	Prints the Help Menu

9.1.1 Operational Control

Command	Function
RESET	Reboots the device.
RESET YES	Reboots the device.

9.1.2 Identity

Command	Function
SET UNIT_ID	The ID can be set to a single character in the range A-Z or 0-9
GET UNIT_ID	This prints the current value of the parameter in the ACTIVE parameter set to the terminal.
GET VERSION	This prints the Version of the software to the terminal.
HELP	This prints a summary of all commands to the terminal

9.1.3 Operating Mode

Command	Function
SET OPER_MODE STANDBY	Sets the operating mode to Standby. No messages are sent, and no data are processed, but the laser is operating normally.
SET OPER_MODE CONTINUOUS	This is an "autosend" mode. Messages are sent periodically without polls.
GET OPER_MODE	Returns the operating mode of the Ceilometer as one of the following: AUTOSEND, POLLING, STANDBY.

9.1.4 Message Control

Command	Function
SET POLLSTRING ABCDEFG	ABCDEFG" is set by the SET POLLSTRING command.
SET MESSAGE MODE AUTOSEND	Sets the mode to CONTINUOUS
SET MESSAGE MODE POLLING	Sets the mode to POLLING
GET MESSAGE MODE	Returns the operating mode of the Ceilometer as one of the following: AUTOSEND, POLLING, STANDBY.
SET MESSAGE TYPE	Sets the message type.
GET MESSAGE TYPE	This sends the current value of the parameter in the ACTIVE parameter set to the terminal.
SET MESSAGE MODE NORMAL	Same as SET MESSAGE MODE AUTOSEND.
SET MESSAGE MODE STANDBY	Same as SET OPER_MODE STANDBY.
SET MESSAGE ANGLE_COR ON	If set to ON [12 degrees,] a correction factor 0.0978 is automatically applied to readings prior to reporting.
SET MESSAGE UNITS FEET	The heights reported will be in feet.
SET MESSAGE UNITS METRES	The heights reported will be in meters.
SET MESSAGE UNITS METERS	The heights reported will be in meters.
GET MESSAGE UNITS	This sends the current value of the parameter in the ACTIVE parameter UNITS to the terminal.
SET MESSAGE HGTH_OFFSET	Sets a value between -1000 and +1000 ft offset applied to reported heights.
SET MESSAGE INTERVAL	Specifies message interval (in seconds) when in autosend mode.
GET MESSAGE INTERVAL	This sends the current value of the parameter in the ACTIVE parameter MESSAGE INTERVAL to the terminal.

9.1.5 Message Type

Chapter 7 provides complete details on the message types/

Command	Function
SET MESSAGE TYPE 0	No message output on port.
SET MESSAGE TYPE 1	CBME-40 / 80 - 2 - 1
SET MESSAGE TYPE 2	CBME-40 / 80 - 2 - 2
SET MESSAGE TYPE 3	CBME-40 / 80 - 3
SET MESSAGE TYPE 4	CL31 - 1 - 5
SET MESSAGE TYPE 5	CL31 - 1 - 1
SET MESSAGE TYPE 6	CL31 - 1 - 2
SET MESSAGE TYPE 7	CL31 - 1 - 3
SET MESSAGE TYPE 8	CL31 - 1 - 4
SET MESSAGE TYPE 9	CL31 - 2 - 5
SET MESSAGE TYPE 10	CL31 - 2 - 1
SET MESSAGE TYPE 11	CL31 - 2 - 2
SET MESSAGE TYPE 12	CL31 - 2 - 3
SET MESSAGE TYPE 13	CL31 - 2 - 4
SET MESSAGE TYPE 14	CT12K - 2
SET MESSAGE TYPE 15	CT12K - 3
SET MESSAGE TYPE 16	CT25K - 1
SET MESSAGE TYPE 17	CT25K - 2
SET MESSAGE TYPE 18	CT25KAM - 60
SET MESSAGE TYPE 19	CT25K - 7
SET MESSAGE TYPE 20	CT25KAM - 61
SET MESSAGE TYPE 21	MTECH BSP - 1
SET MESSAGE TYPE 22	8339 Native

9.1.6 Blower/Heater Control Commands

Command	Function
GET BLOWER	Gets the Blower Control Setting
SET HEATER AUTO	Sets the INTERNAL HEATER to MANUAL control and enables the function of the commands SET INHEATER ON and SET INHEATER OFF
SET HEATER MANUAL	Sets the INTERNAL HEATER to AUTO control. In this mode the ceilometer maintains the minimum internal temperature to a defined set-point (25°C default, can be modified with SET HEATER TEMP)
SET BLOWER AUTO	Same as SET CONTROL BLOWER AUTO
SET BLOWER MANUAL	SET CONTROL BLOWER MANUAL
SET BLOWER ON	Turns on the BLOWER power supply
SET BLOWER OFF	Turns off the BLOWER power supply
SET HEATER ON	Turns on the Internal Heating element
SET HEATER OFF	Turns off the Internal Heating element
GET HEATER	Gets the heater Control Setting
GET HEATER TEMP	Gets the heater Temperature
SET HEATER TEMP	Sets the heater Temperature
SET BLOWER ALTITUDE	Set altitude in feet for precipitation determination
SET BLOWER LEVEL	Set integrated backscatter level for precipitation determination
SET BLOWER ON TIME	Set minimum blower on time in automatic mode

9.1.7 Option Control

Command	Function
GET OPTIONS	This sends the current value of the OPTIONS parameters in the ACTIVE to the terminal.
SET OPTION SKY_COND ON	Enables the Sky Condition Estimation. This feature is on by Default.

NOTE

Both Sky Condition and Vertical Visibility calculations are included with the standard device. Both are also "ON" or enabled by default with the device as delivered from the factory.

9.1.8 Status

Command	Function
GET STATUS	This sends the current STATUS values to the terminal.
GET VALUE TEMPERATURE	This sends the current temperature STATUS values to the terminal.
GET VALUE VOLTAGE	This sends the current power supply voltage STATUS values to the terminal.

9.1.9 Advanced Level

Command	Function
GET PARAMS	Displays the current parameter set. Immediately after start-up this is the same as the non-volatile set.
SET FACTORY	Resets the configuration to the FACTORY set.
SET SAMPLES	Sets the number of samples accumulated in a measurement cycle
GET SAMPLES	Returns the number of samples accumulated in a measurement cycle
SET BITE OFF	Turns on the BITE test.
SET SLOPE THD	Cloud detect Parameter refer to Factory
SET PRTLA	Cloud detect Parameter refer to Factory
SET PRTHA	Cloud detect Parameter refer to Factory
SET PRTA	Cloud detect Parameter refer to Factory
SET MCT	Cloud detect Parameter refer to Factory
SET TOFFSET	Sets the offset counts between the laser firing pulse and the start of the recording. This is factory set to a value close to 45
GET TOFFSET	Gets the offset counts between the laser firing pulse and the start of the recording.
SET BSPTYPE	Sets the type of profile output in Message type 2
GET BSPTYPE	Gets the type of profile output in Message type 2
SET FACTORY INLASER	Sets the LASER Power according to the value marked on the laser module
GET A2D	Shows all values measured by the analog to digital converter
SET SAW	Sets the sliding Window Averaging in the FPGA to 1 [off] 3,5,7, etc. 5 is standard
BACK	Reverts to Normal command mode

9.1.10 Message Setting Commands

Command	Function
SET MESSAGE ANGLE_COR OFF	If set to 0 degrees, a correction factor of 1.0 is applied to readings prior to reporting. the default is OFF.
SET MESSAGE MODE AUTOSEND	This is the default state. A data message is output on the current data port every DATA MESSAGE INTERVAL.
SET MESSAGE MODE POLLING	This command sets up a poll string which will be recognized by the 8200. The current data message will be sent after a poll. Poll responses may take up to 15 seconds depending on the measurement cycle.

9.1.11 Communications Parameter Commands

Command	Function
SET PORT 1 BAUD 1200	1200 8 1 N
SET PORT 1 BAUD 2400	2400 8 1 N
SET PORT 1 BAUD 4800	4800 8 1 N
SET PORT 1 BAUD 9600 (default)	9600 8 1 N
SET PORT 1 BAUD 19200	19200 8 1 N
SET PORT 1 BAUD 38400	38400 8 1 N
SET PORT 1 BAUD 115200	115200 8 1 N
Command	**Function**
SET PORT 2 BAUD 1200*	1200 8 1 N
SET PORT 2 BAUD 2400*	2400 8 1 N
SET PORT 2 BAUD 4800*	4800 8 1 N
SET PORT 2 BAUD 9600*	9600 8 1 N
SET PORT 2 BAUD 19200*	19200 8 1 N
SET PORT 2 BAUD 38400*	38400 8 1 N
SET PORT 2 BAUD 115200* (default)	115200 8 1 N

*Baud rate changes require a reset (Section 9.1.1)

10. Maintenance

10.1 Window Cleaning

10.1.1 When

NOTE

Different sites have different cleaning frequency requirements.

If the window is dusty, fouled by bird excrement, or blocked by insect activity a degraded mode of operation may result and ultimately a persistent low cloud reading will occur.

At different locations there are different sources of window contamination. For example:

1. Salt in coastal locations.
2. If birds roost on the Ceilometer there may be guano. Fit a bird spike kit.
3. In desert environments dust and sand may accumulate on the window
4. Dust may accrete on the window when wet after rain

NOTE

Regular inspection may be needed in dusty environments.

10.1.2 How

WARNING

When a Bird Spike kit is fitted, the cover is a physical hazard when handling. Exercise extreme care.

WARNING

The window has an antireflection coating on it. It is important not to scratch it. In particular chemical residues such as guano must be softened and removed as soon as possible to prevent chemical attack.

The lens and window should always be clean of any dirt or particles during operation. The lens is inside the window and should not have any condensate or dust on it.

Cleaning Procedure

1. Take the cleaning kit to site inspections, ensure water bottle is full
2. Flush the window with clean water to remove coarse grains using spray bottle in kit.
3. Allow time to ensure any hardened material e.g., bird excrement has softened.
4. Clean the window with a soft, lint-free cloth moistened with a mild detergent

NOTE

Be careful not to scratch the window surface.

10.2 Pre-Maintenance Safety

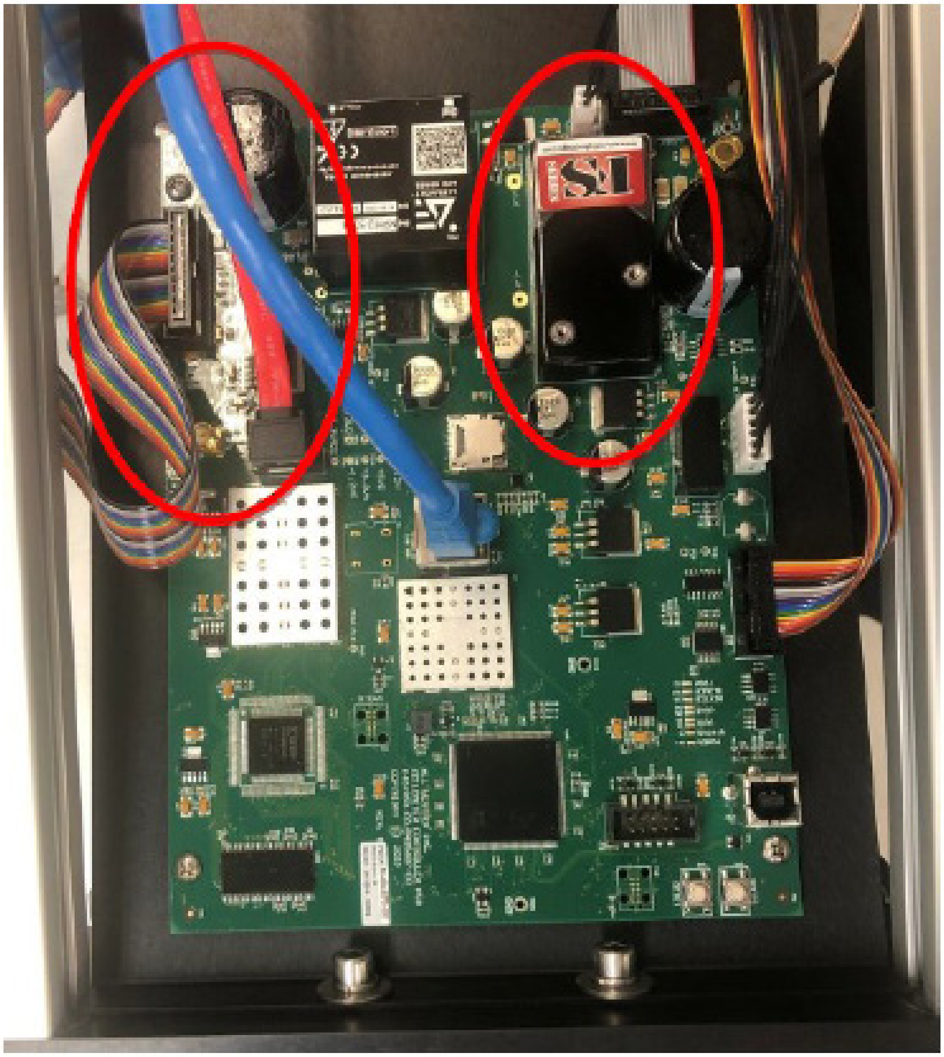
Ensure that all appropriate safety equipment is available when performing any work on the device.

Do not touch capacitors and power unless residual power has been allowed to dissipate. Lethal voltages are present protected within the enclosure during normal operation of this equipment. This device also emits laser radiation.

The 8200 is certified as a Class 1M laser device in accordance with European standard IEC- 60825-1. This means that an 8200 Ceilometer installed in a field environment with instrument covers on and pointed vertically or near-vertically poses no established biological hazard to humans. Under IEC-60825-1 no label needs to be fitted to the instrument, but the Laser Class must be included in product documentation. The instrument is intended for operation in an area restricted from public access and pointed up vertically or near-vertically. The following precautions are to be noted and followed during service and maintenance of the instrument:

- Never look directly at the laser transmitter through the lens with magnifying optics (glasses, binoculars, telescopes, etc.).
- When operating, avoid looking at the ceilometer from the beam direction. Make sure that it is not being viewed from the beam direction with magnifying optics. Only trained personnel should perform maintenance functions.
- The 8200 is equipped with a three-conductor AC power connector. The power cable must be installed with the AC ground connection.

Avoid the high-voltage areas while AC power is connected.



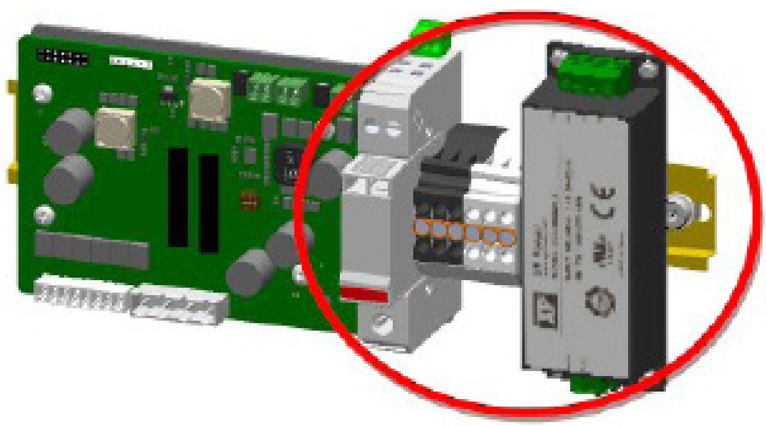


Figure 27. **Power Supply High Voltage Areas at 8200 Top and Base Sections**

WARNING

The power cable to the sensor should be removed and the residual power allowed to dissipate for a period of not less than 5 minutes prior to internal maintenance of the device. Areas circled in red above indicate areas where lethal voltages exist prior to the device being der- energized and dissipated.

---

1. No baffle covers need to be removed to change laser or APD modules, all baffle covers that can be removed to permit access to Class 3b laser exposure are marked accordingly.
2. Use appropriate laser safety goggles when exposed to intra-beam viewing (Class 3b laser radiation). Intra-beam viewing is not normally possible with typical use. There are labels in place to forewarn of this danger when the area is exposed.
3. The equipment operates as standard from a 120/240 VAC power source and the lower compartment contains 120/240 VAC circuits. There are warning labels in these high- voltage areas.
4. To the certification of all staff should be ascertained to ensure minimum levels of competency.
5. Check test equipment regularly to ensure correct operation.

10.3 Periodic Maintenance Procedures

Section 8.1.4 describes how to set up a terminal emulator to send these commands and view the responses.

10.3.1 Check Data Messages for Alarms

Most message types have fields for alarm reporting. The software used for the recording of data should also record alarms and alert the user.

10.3.2 Support Personnel Investigation of Alarms

When an alarm is detected the technical support personnel should check the alarm type and investigate the possible causes with reference to this handbook troubleshooting section

10.3.3 Some Alarms are Normal

At certain times of the year in equatorial regions, the radiance is too high during solar impingement. Under these circumstances, the alarm will come on every day at about the same time. This is an example of an alarm which is normal.

10.3.4 Blower Operation Testing

Some data messages include a warning if the window is dirty.

After the system has detected the contamination, it starts the blower, which removes contamination caused by precipitation, etc.

Section 8.1.4 describes how to set up a terminal emulator to send these commands and view the responses.

The Blower can be checked with a laptop connected. Give these commands.

SET CONTROL BLOWER ON

SET CONTROL BLOWER OFF

In case of malfunction, replace the blower.

In addition, the blower can be checked holding a small cover in front of the unit. This should trigger the blower to come on in AUTO mode.

Refer to the Chapter 9 for details on the commands.

10.3.5 Window Heating and Condensation

A combination of tight seal, heating, and a ventilation port should eliminate the situation of moisture condensing on the optics. If, condensate does appear on the inside of the window, check the heaters, seals, enclosure integrity and the vent.

10.3.6 Visual Battery Check

The 8200 should be stored with the battery disconnected. The battery voltage can be monitored periodically using the **STATUS** command.

The battery is a sealed lead acid type. It is in the lower compartment in case of outgassing. The battery should be inspected every year for leakage, bulging, etc.

The power supply needs to be checked and the voltage reduced to 13.65 V if greater than that value.

NOTE

Recycling of electronic devices should be in conformance with your organizations e-waste policy and in conformance with the applicable laws in your sate, territory, or country.

CAUTION

The backup battery contains toxic substances. Dispose of batteries in accordance with your local regulations.

Battery does not charge.

- Check and replace the fuse in the data cable, if needed.
- Check and replace the Power Controller Board, if needed.
- Check and replace the battery (Section 11.2.7).

10.3.7 Check Vent

The vent is located on the base of the unit. It is a waterproof membrane to equalize the water vapor pressure inside and outside the unit. This prevents cyclic thermal water pumping into the enclosure. The vent eliminates the need for desiccant packs.

NOTE

Desiccant packs do not need to be used.

The vent should be checked for build-up of mud or dust and cleaned or replaced if required.

Figure 28. Vent at Bottom of Enclosure

NOTE

The vent is expected to last for the life of the sensor unless subjected to unusual force, mechanical action, or solvents. Under normal use the vent should not need servicing.

10.3.8 Storage

It is recommended that the 8200 remain stored in the original packaging.

The unit should be labelled and with paper over the window to prevent dust accumulation.

NOTE

If possible, store the original packaging to allow the safe future shipment or storage of the device.

10.3.9 Calibration

There are several types of calibration of a ceilometer:

- Range Accuracy
- Instrument Constant
- Cloud Detection Sensitivity
- Vertical Visibility

The following sections detail methods for completing setup of calibration, and sensitivity adjustment.

10.3.9.1 Calibration Procedure — Range Accuracy

Item	Description
Task Description	Verify accuracy of range finding capability
Purpose of Task	Verify crystal accuracy and ceilometer engine function
Tools Required	None
Time to complete	10 minutes [not including set up on calibration range]

WARNING

Ensure the unit is well supported on a stable base.

This is an evaluation of the accuracy of measurement of range of a hard target,

First locate a target such as a wall 30 –150 m (100–500 ft) away.

Measure the distance to this target by EDM, measuring tape or other independent means.

Aim the ceilometer at the target, monitor the reading from the message or on the Model 1192 DCP.

Turn Vertical Visibility off (Section 10.3.9.3) when evaluating against a near hard target.

The measurement should agree to the nearest 10 ft. A correct reading verifies the functioning of the ranging function in the 8200.

CAUTION

Only perform this calibration when using the ceilometer for research purposes.

Item	Description
Task Description	Calibrate the instrument constant
Purpose of Task	Use ceilometer for research purposes
Tools Required	None
Time to complete	60 minutes [not including set up and waiting for suitable cloud]

WARNING

Ensure the unit is well supported on a stable base.

As supplied the ceilometer is not precisely calibrated in terms of the LIDAR constant, since this is not necessary for correct operation and cloud detection. However, it is quite simple to determine the LIDAR constant for each instrument,

This is only necessary when the user wishes to use the ceilometer for research purposes. The method is described in the paper:

A Technique for Autocalibration of Cloud LIDAR, Ewan J. O'Connor, Anthony J. Illingworth, and Robin J. Hogan

It is shown that the LIDAR extinction-to-backscatter ratio derived from integrated backscatter for stratocumulus is, in the absence of drizzle, constrained to a theoretical value of 18.8 ± 0.8 sr at a wavelength of 905 nm. The LIDAR can be calibrated by scaling the backscatter signal so that the observed LIDAR ratio matches the theoretical value when suitable conditions of stratocumulus are available. Multiple scattering introduces an uncertainty of about 10% into the calibration

The integrated backscatter is equal to the reciprocal of twice the LIDAR ratio of 18.8 Accordingly, the calibration technique is to scale the received backscatter signal until the integrated backscatter reads 0.026595, provided the signal is extinguished in the cloud.

The method is simple:

1. Wait for prevalent thick stratocumulus cloud
2. Select message type 108, which gives a value for integrated backscatter every measurement cycle.
3. Ensure there is no precipitation or virga from the cloud by viewing the backscatter profile.
4. Note the normal value of the setting SCALE using the command GET SCALE.
5. Find the SCALE value using the SET SCALE command at which the integrated backscatter reads 0.026595. This can be done by trial and error or by calculating the ratio from the measured results.

CAUTION

Be sure to return the value of SCALE to standard if measurement of cloud base height is required, since the cloud detection algorithms are based on that setting.

CAUTION

Instrument constant is not required for cloud detection. Use factory settings

10.3.9.3 Calibration Procedure: Cloud Detection Sensitivity Setting

Item	Description
Task Description	Cloud Detection Sensitivity Setting
Purpose of Task	Eliminate false detections
Tools Required	None
Time to complete	60 minutes [not including set up and waiting for suitable cloud]

WARNING

Ensure the unit is well supported on a stable base.

Ceilometers are expected to operate out of the box in the Arctic, on the Indian subcontinent, near the equator, or in temperate latitudes.

The condition of the atmosphere varies very dramatically and generally in temperate latitudes, with low industrial pollution, the atmosphere is very clean, whereas there is considerable haze in tropical latitudes, and in places like India or Shenyang in China the presence of fumes and haze from photochemical smog makes the atmosphere highly turbid.

When there is significant haze, smoke or fume present, both the atmospheric 2-way transmission of the atmosphere are reduced, and the scattering of the solar flux at the wavelength 910 nm means that the signal to noise ratio of the ceilometer is reduced, compared with a clean atmosphere. The high level of noise effects the cloud detection algorithms.

MAIN LIMIT SETTING

To compensate for that there is a setting within the ceilometer that can desensitize it, by increasing its signal to noise ratio threshold. The table of typical SNR factors to be used under different atmospheric conditions is shown below.

Atmosphere Category	SNR Factor
Clean	70
Moderate scattering	75
Tropical Atmosphere e.g., coastal tropics	80–85
Smoke under boundary layer (e.g., Delhi)	85–100

The procedure for connection to the ceilometer serial port for maintenance is in the Handbook. When connected follow this procedure.

Section 8.1.4 describes how to set up a terminal emulator to send these commands and view the responses.

OPEN<-

AL<-

GP<-

Note the current setting of the SNR THRESHOLD e.g., 70.

Add 3 to 5 to the number e.g., 70 +5 =75.

|Then enter:

SET SNR FACTOR 75<-

RESPONSE : SNR LIMIT SET TO 75

SAVE<-

The setting should be changed until the ceilometer will not detect a cloud base when one does not exist.

At a certain level of turbidity, the ceilometer will just report vertical visibility all the time, because of high levels of scattering and dispersion in the boundary layer. This prevents effective use of ceilometers in highly polluted atmospheres.

LOWER LIMIT SETTING

At the low end of the range there is an effect due to the crosstalk between the laser pulse and the high-level scattered pulse inside the ceilometer itself. Although there is very effective optical baffling and a sophisticated mathematical method is used to eliminate the effects of the crosstalk pulse, it cannot be removed entirely.

Therefore, a lower limit is set on the SNR Factor which can be adjusted to eliminate any false detections at around 100 ft. Because of the differences in optical components inside the Ceilometer and different amounts of scattering back from the window, this may need to be adjusted.

The Lower Limit is adjusted using the following procedure:

OPEN<-

AL<-

GP<-

Note the current setting of the SNR THRESHOLD e.g., 2.

Add 2 to the number e.g., 2+2 =4.

Then enter:

SET SNR MINIMUM 4<-

RESPONSE : SNR MINIMUM SET TO 75

SAVE<-

The setting should be changed until the ceilometer will not detect a cloud base when one does not exist at the low end of the range.

CAUTION

Ensure the window has been cleaned before doing the lower limit setting.

10.3.9.4 Calibration Procedure: Vertical Visibility

Item	Description
Task Description	Set Vertical Visibility Limits and Threshold
Purpose of Task	Adjust Sensitivity for various atmospheres
Tools Required	None
Time to complete	60 minutes a suitable fog is required to make a setting.

WARNING

Ensure the unit is well supported on a stable base.

The 8200 uses the Fernald algorithm to determine the vertical visibility based on the Bouguer Lambert Law relating visibility to extinction coefficient and contrast ratio. The Fernald algorithm does not need to evaluate an integral as such to invert the LIDAR equation; rather, the retrieval at each successive point uses the data from the previous point and the attenuation correction over the intervening interval.

There are a number of commands. that control the Vertical Visibility Operation. Section 8.1.4 describes how to set up a terminal emulator to send these commands and view the responses.

Use **SAVE** to commit the setting to Flash Memory.

Command	Description
SET OPTION VERT_VIS ON	If set to ON, the VV is evaluated and reported if no cloud base is detected.
SET OPTION VERT_VIS OFF	If set to OFF, the VV is not evaluated or reported.
SET VLIM	Sets the limit above which vertical visibility is not reported. This is also the initial estimate for the vertical visibility algorithm.
SET VV THRESHOLD	Sets the value in range 100-3000 at which the integrated exco limit represents a vertical visibility result.

Then the ceilometer is into a direction with no visible hard target and the reading from the message is monitored using a terminal.

The measurement should agree with the visibility estimate. A correct reading verifies the functioning of the vertical visibility function in the Ceilometer.

10.4 Firmware Update

The firmware can be updated using a laptop via the serial port or Ethernet.

Section 8.1.4 describes how to set up a terminal emulator to send these commands and view the responses.

On startup, the bootloader starts printing to all available ports. The first message is always:

ADB Safegate BOOTLOADER

followed by:

Looking for firmware image...

Finally, the bootloader start printing:

Waiting...

at 1 second intervals.

If no data are received at any port during the 15 second timeout, the bootloader will print:

Starting boot process...

and transfer control to the main application.

If a character is received on a port,

1. This port becomes the only active port, and data from any other port are ignored. Output messages are still sent to all ports.
2. The character is stored in SDRAM, and the bootloader switches to a firmware upload mode.

Open a terminal emulator as described in Section 8.1.4 and select the firmware update to send. If you are using a serial port, initiate the send during the 15 second timeout described below in Section 10.4.1.1 If it takes more than 15 seconds to initiate the file transfer, the application will be running, and the update will be stored in SDRAM; Section 10.4.1.2.

NOTE

Upload happens over a serial port at 115200 bps during the boot, but only at 9600 bps when the application is running.

10.4.1.1 Primary Firmware Upload Mode

In the firmware upload mode, incoming data are stored progressively in SDRAM. Every second, the bootloader outputs the amount of data received so far. Regular checks are performed to make sure the accumulated image is not obviously invalid. If any problems are detected in the accumulated image, the bootloader will print an error message and boot the existing firmware.

ADB Safegate BOOTLOADER

Looking for firmware image...

Waiting...

Waiting...

Waiting...

Waiting...

Waiting...

Waiting...

Waiting...

Received 11 bytes...

Firmware can't be right...

Booting existing firmware...

Starting boot process...

Booting 8200 firmware version 1.0.0

If the upload is successful, a full integrity check of the image is done. This involves extracting the data embedded in the image (name, version number), verifying the length and a CRC checksum. If the image passes, the bootloader erases the Flash and programs the new image.

ADB Safegate BOOTLOADER

Looking for firmware image... Waiting...

Waiting... Waiting...

Received 26 bytes...

Received 105001 bytes...

Received 208301 bytes...

Received 314601 bytes...

Received 422401 bytes...

Received 526901 bytes...

Received 635901 bytes...

Received 742001 bytes...

Received 845301 bytes...

Received 952226 bytes...

Received 1055901 bytes...

Received 1162601 bytes...

Received 1269326 bytes...

Received 1374251 bytes...

Received 1479901 bytes...

Received 1577210 bytes... No data received...

Looking for firmware image... Found firmware image, analyzing...

Model: 8200

Version: 1.0

CRC OK

Received valid firmware image...

Erasing Flash...

Flashing firmware image...

Verifying firmware image...

Firmware image flashed OK...

Starting boot process...

Booting 8200 firmware version 1.0.0

Control is then transferred to the main application.

10.4.1.2 Alternate Firmware Upload

In some circumstances it may not be possible to upload the firmware during the boot. For example, if TCP/IP is the only communication interface used, and establishing connectivity on startup takes longer than the bootloader timeout, then the main application will be running.

The alternative is to use the main application to receive a firmware image and store it in the SDRAM. The bootloader will detect this image on the next reboot, flash it, and start the updated application.

To switch to image upload mode, send the following command over any communication port.

FIRMWARE<CR>

Then, the upload process works just like it would during the boot time. The difference is that the 8200 resumes normal operation when the image has been received and stored in SDRAM. To the reboot so that flashing happens, use the following command.

RESET<CR>

After the restart, the bootloader takes control and checks whether a valid firmware image is found in SDRAM:

ADB Safegate BOOTLOADER

Looking for firmware image...

Found firmware image, analyzing...

Model: 8200

Version: 1.0 CRC OK

Found a valid firmware image in SDRAM Erasing Flash...

Flashing firmware image...

Verifying firmware image...

Firmware image flashed OK...

Starting boot process...

Booting 8200 firmware version 1.0.0

11. Troubleshooting Guide

This chapter describes the best practice when troubleshooting issues with the 8200 Ceilometer.

11.1 Troubleshooting Procedure

The goal of the troubleshooting procedure is to find the root cause of issues relating to the operation of the ceilometer. By systematically checking elements of the device's operation, we can quickly identify which hardware component or firmware setting is causing the issue. Failure situations are usually caused by dirty optics or dirt in the optical path. The 8200 status message includes information on suspect modules in its output.

The following is the list of replaceable sub-assemblies that may be a cause of hardware issues:

Part Number	Description
M404971-00	Ceilometer Power Controller Card
M438169-00	Ceilometer Power Supply
M403607-00 (120 VAC) M403607-01 (240 VAC)	Enclosure with Blower Assembly for Frost/Snow/Dust Conditions
M442117-00	Backup Battery

If damage is discovered or suspected on a sub-assembly then please remove and replace the suspect component and return to ADB Safegate for testing or replacement.

In each case the procedure to change the LRU is described in the Maintenance Manual.

CAUTION

Replacement of LRU components should only be undertaken by suitably qualified maintenance staff. Field maintenance should be limited to only the replacement of LRU components. Please refer to the Maintenance Manual for information on the removal and replacement of LRU components.

What follows is a series of test procedures designed to systematically determine the cause of the fault and describe a remedy for correcting the fault.

11.1.1 Test 1 — Basic Operation Test

1. Obtain a copy of the test sheet and record of the user setting changes for the ceilometer under test.
2. Power up the unit.
3. Connect to the data port as described in the Commands section.
4. Start a terminal session with comms settings 9600 8N1.
5. Use a terminal emulator such as HyperTerminal or TeraTerm.
6. If the main card processor is operating the preset message will be output at the preset message interval.

For example:

CTA2070

50 ///// ///// ///// 00000200

100 N 101 +19 90 200 +6 21 LF7HN1 27

00000030004000300030003000200030003000300010001000100000000000000000016000000

0000000000000000000000FFFF000100000002000000001FFFFFFFE0000032FFFC0000FFFE0

0000001FFFF000000010000FFFE000000020000000000000000040480000FFFE00030007FFFE

0000FFFEFFFE000100050011FFFF000000000000FFFE0640001FFFEFFFF00000000000200

**00000100000000FFFF00010003FFFEFFFE000008000010000FFFF0002FFFEFFFEFFFEFFF D0
00000020001FFFEFFFD0000000000001096000200030000000000000000010000FFFF000000
000000FFFC0000FFFFFFFEFFFF1120000000000000001FFFCFFFF00000002FFFE00000000 FFFFFFFF00010000FFFE12800
000000000000000010000FFFFFFFF00000000FFFE000000 000003000000011440002000100000FFFFFFFFFFFEFFFEFFFF
FFFF00000000FFFE0001FFFF FFFF0000160FFFE0000FFFE0015004300B200B300E300540022000C0030FFFF0000000000
01176FFFF000000000001FFFC0000000000000000000001FFFF0000000100000001FFFD19200**

0000000000FFFE000000000000100010001000000000001FFFFFFFFFFFFFFFE2080000FFFE

0000FFFE00000001FFFF00000002000000000000010000FFFFFFFF000122400000000FFFE000

000020001FFFEFFFFFFFEFFFF00000000000100010001000 1240FFFE0000FFFE0000FFFFF FFD0000000400000001FF
FF0000000000000000000001 028 5 135 0 /// 0 ///

If there is no message output, key in the following command.

OPEN<return>

If working, the 8200 will return with the prompt:

CEILO>

Key in

AL<return>

If working, the 8200 will return with the prompt

CEILO ADVANCED>

FAILURE

If the 8200 does not respond to the commands, it must be exchanged for a working unit and taken to an electronics lab. The Main Circuit card or power supply need to be checked

11.1.2 Test 2 — Interpret Status Data

Key in the command

OPEN<return>

GET STATUS<return>

The ceilometer should return the STATUS message.

The user should compare each value item with test sheet and record of the user setting changes to ensure all settings are correct and equivalent to last known good configuration.

At the end of the status message the suspect module, if any, is identified. Note that you should review the STATUS values carefully with respect to the suspect module.

```
GET STATUS

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


Operating Mode
Oper Mode:        Normal      Autoadj:          ON
Meas Mode:        Standard    Interval:         131 s
Power Save:       Disabled    Sleep Int:        Disabled s

Transmitter                    Receiver
Pulse Len:        100 ns      Gain:              Low
Inlaser:          100         Bandwidth:        5.0
Pulse Cnt:        131000      Smpl Rate:        49MHz
Pulse Frq:        10000 Hz
Window Cnd:       100 %       Outlaser:         100
Backg Rad:        2000

Temperatures
Internal:         5269174     External:         -30278094000
DC Power:         11.79       Inclinom:         N/A
Laser:            -113051     Blower:           -30278094000
Heater:           ON          Outheater:        ON
Blower:           ON          Batt use:         OK

System Status:     OK
Suspect Module:    N/A
```

If all the above settings are correct, enter the command:

GET VALUE VOLTAGE<return>

The voltages should read correctly.

- Supply voltage 12 ± 0.75 V
- APD voltage is set individually to match the APD label
- 7 V supply should be 7 ± 0.75 V

```
GET VALUE VOLTAGE:

CEILO > Supply Voltage=11.79
CEILO > APD Voltage=236.76
> 7 VDC Supply Voltage=6.44
```

Then enter the command

GET VALUE TEMPERATURE<return>

The laser, ambient and APD temperatures should read correctly.

- Laser temperature is set individually, 50°C ± 5°C
- APD and AIR temperatures are not controlled

```
GET VALUE TEMPERATURE:

CEILO > APD Temperature=32.30
CEILO > AIR Temperature=33.98
CEILO > Laser Temperature=49.99
```

Also check the message status bits which will indicate and localize problems.

FAILURE

If STATUS values are suspect this will indicate which if any of the modules may be defective.

11.1.3 Test 3 — Check Range Finding with Hard Target

Identify a hard target at least 4 x 4 m, 200 – 600 ft away from the 8200, with an uninterrupted line of sight between them.

Measure the distance to the hard target. Tip the ceilometer on its side and point towards the hard target. Line it up carefully ensuring the beam does not go over the top of the target.

Enter the command sequence:

OPEN<return>

If working, the ceilometer will return with the prompt:

CEILO>

When using the ADB Safegate DCP, type in

SMT 22<return>

This sets the message type to an 8339 message.

This sets the message type to the ADB Safegate default message.

Type in

CLOSE<return>

The 8200 should now read the distance to the hard target ±10 ft, as a vertical visibility.

FAILURE

If the 8200 does not report a cloud base or vertical visibility reading, then either the APD, Main Board or Laser is suspect.

11.1.4 Test 4 — Checking Laser Output

Ensure that the 8200 Laser Voltage is correct.

Use the command

OPEN<return>

GET VALUE VOLTAGE<return>

The APD voltage is set individually to match the APD label.

Place a piece of cardboard 2–3 m away from the 8200 when it is on its side on a bench.

Connect a PC WEB camera to a PC USB port and point it at the location on the paper where the beam is supposed to hit.

Check that the beam appears and cycles on and off as per the settings for Message Report rate and Number of samples set.

Check that the beam appears to be approx. 50–60 mm in diameter.

FAILURE

If no laser beam is visible, then change out the Laser Module LRU and retest.

11.1.5 Test 5 — Checking APD Input

Use the commands

OPEN<return>

GET VOLTAGE VALUE<return>

Ensure the high voltage is being generated by the system. The APD voltage is set individually to match the APD label.

Check visually that there are no high-radiance sources at 905 nm impinging on the unit. Type in

SET MESSAGE TYPE 111<return>

to obtain the height of the T0 pulse the integrated backscatter. Make a note of the normal message type using the command

GET MESSAGE TYPE<return>

The message type just entered will be returned.

FAILURE

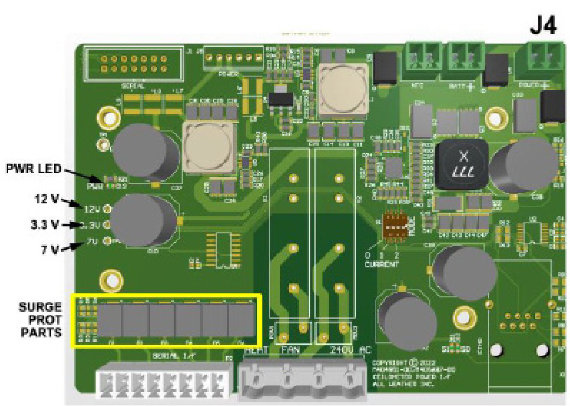
If the T_0 pulse is less than 15000, then either the laser power is low, or the APD is not receiving in band signals or the APD is defective.

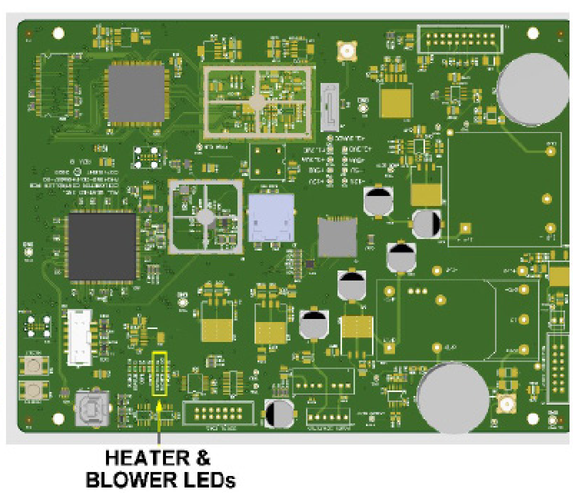
11.1.6 Test 6 — Basic Hardware Checks

M404971-00 Power Controller Board

Check:

- 24 V present at J4, but power LED (D13) is off, or 12 V, 7 V or 3.3 V are off by more than 10%
- Visible damage to surge protection components
- Fan LED on the Controller Board is on, but no power to the fan connector
- Heater LED on the controller board on, but no power to the heater connector





Power Controller Board **Controller Board**

Replace the M404971-00 Power Controller Board if these issues occur (Section 11.2.4).

Power Supply

If AC voltage is present but the power supply output voltage is not 24 ±1 V, replace the power supply (Section 11.2.5).

Surge Suppressor

Check the window near the top left of the surge suppressor. If it is red, replace the surge suppressor (Section 11.2.6).

11.2 LRU Replacement Procedures

These procedures describe the methods required to replace Line Replaceable Units (LRUs). It includes the description of the removal or adjustment of components of the device which are obstructions to the maintenance activity.

The following are reference part numbers for the LRUs and standard built-in elements that are involved in the maintenance of the 8200.

Part Number	Description
M404971-00	Ceilometer Power Controller Card
M438169-00	Ceilometer Power Supply
M403607-00 (120 VAC) M403607-01 (240 VAC)	Enclosure with Blower Assembly for Frost/Snow/Dust Conditions
M442117-00	Backup Battery
M460188-00	Power Line Surge Suppressor

11.2.1 8200 Enclosure Removal and Replacement

Item	Description
Task Description	Removal of the enclosure to access the 8200 blower and other internal components
Purpose of Task	Gain access to cover, to access the internal compartment
Tools Required	M6 hex wrench
Time to complete	1 minute

WARNING

- Ensure the unit is well supported on a stable base.
- DO NOT remove the 4 M8 screws in the corners of the 8200 base plate.

Reverse Procedure	Replacement is the reverse of this procedure; ensure mating surfaces are clean of water and dirt.

1. Turn the breaker off that supplies AC power to the 8200.
2. Disconnect the AC power connector.
3. Disconnect the Blower unit connector.
4. Disconnect the signal cable.
5. Remove the blower assembly if the 8200 is already assembled completely by removing the two MX hex head screws securing it to the 8200 ceilometer assembly. Set the screws aside to reuse them.
6. Locate the cap-screws that hold the 8200 enclosure in place. Remove these two M6 socket headed screws
7. Lift the enclosure off vertically, ensuring clearance from the internal frame to avoid scratching the ceilometer optics.
8. Place the 8200 enclosure in a safe location in a stable position, taking care not to damage the surface.
9. Keep the screws in the base plate to avoid loss.
10. This completes this procedure.

11.2.2 8200 Tilt Feet Removal and Replacement

Item	Description
Task Description	Removal of the Tilt Feet.
Purpose of Task	Enable alignment or deeper levels of maintenance, prepare for shipping.
Tools Required	M6 hex wrench
Time to Complete	2 minutes

WARNING

- Ensure the unit is well supported on a stable base.
- DO NOT remove the 4 M8 screws in the corners of the 8200 base plate.
- Ensure the AC power is off.

Reverse Procedure	Replacement is the reverse of this procedure; ensure mating surfaces are clean of water and dirt.

1. Turn the breaker off that supplies AC power to the 8200.
2. Disconnect the AC power connector.
3. Disconnect the Blower power connector.
4. Disconnnect the data cable.
5. Locate the four screws that secure the 8200 to the tilt feet.
6. Remove these four screws.
7. Lift the 8200 off vertically by grasping the base of the unit with your hands.
8. Place the 8200 in a safe location in a stable position, taking care not to damage the solar radiation shield.
9. Place the four screws in the 8200 to avoid loss.
10. This completes this procedure.
11. Turn on the breaker that supplies AC power to the 8200.

11.2.3 8200 Removal and Replacement

Item	Description
Task Description	Removal of 8200 in the field
Purpose of Task	Enable alignment or deeper levels of maintenance, prepare for shipping. Exchange 8200 units.
Tools Required	M6c hex wrench
Time to complete	2 minutes

WARNING

- The tilt base is bolted to the foundation directly or via frangible bolts.
- DO NOT remove the 4 M8 screws in the corners of the 8200 base plate.
- Ensure the AC power is off

Removal Phase

1. Turn the breaker off that supplies AC power to the 8200.
2. Disconnect the AC power connector.
3. Disconnect the Blower power connector.
4. Disconnect the data cable.
5. Remove the four screws that hold the 8200 to the tilt feet.
6. Lift the 8200 vertically by grasping the base of the unit with your hands.
7. Place the 8200 in a safe location in a stable position, taking care not to damage the solar radiation shield.
8. Note the Serial Number of the 8200 that was removed.
9. Set the four screws aside to avoid loss.
10. Remove the blower assembly if only the 8200 assembly inside the blower shroud is being replaced by removing the two M6 hex head screws securing it to the 8200 ceilometer assembly. Set the screws aside to reuse them.
11. This completes this procedure.

Replacement Phase

1. The Serial Number of the replacement 8200 is different from the Serial Number of the 8200 that has been removed if the 8200 units are being exchanged.
2. If the blower assembly from the removed 8200 assembly was removed for use with the replacement, replace the blower shroud by securing the two M6 hex head screws to the replacement 8200 ceilometer assembly.
3. Locate the four screws that will hold the 8200 in place on the tilt feet.
4. Place the 8200 on the tilt feet.
5. Replace the four screws in the 8200 and tighten them hand tight.
6. Reconnect the data cable.
7. Reconnect the Blower power connector.
8. Resconnect the AC power connector.
9. Turn on the breaker that supplies AC power to the 8200.

11.2.4 M404971-00 Power Controller Board Removal and Replacement

This Power Controller Board houses the solid-state relays that control internal heating and the blower.

Item	Description
Task Description	Remove and replace power supply card
Purpose of Task	Change out defective unit
Tools Required	3 mm Flat screwdriver
Time to complete	5 minutes

WARNING

Ensure the data connector is replaced in the correct position.

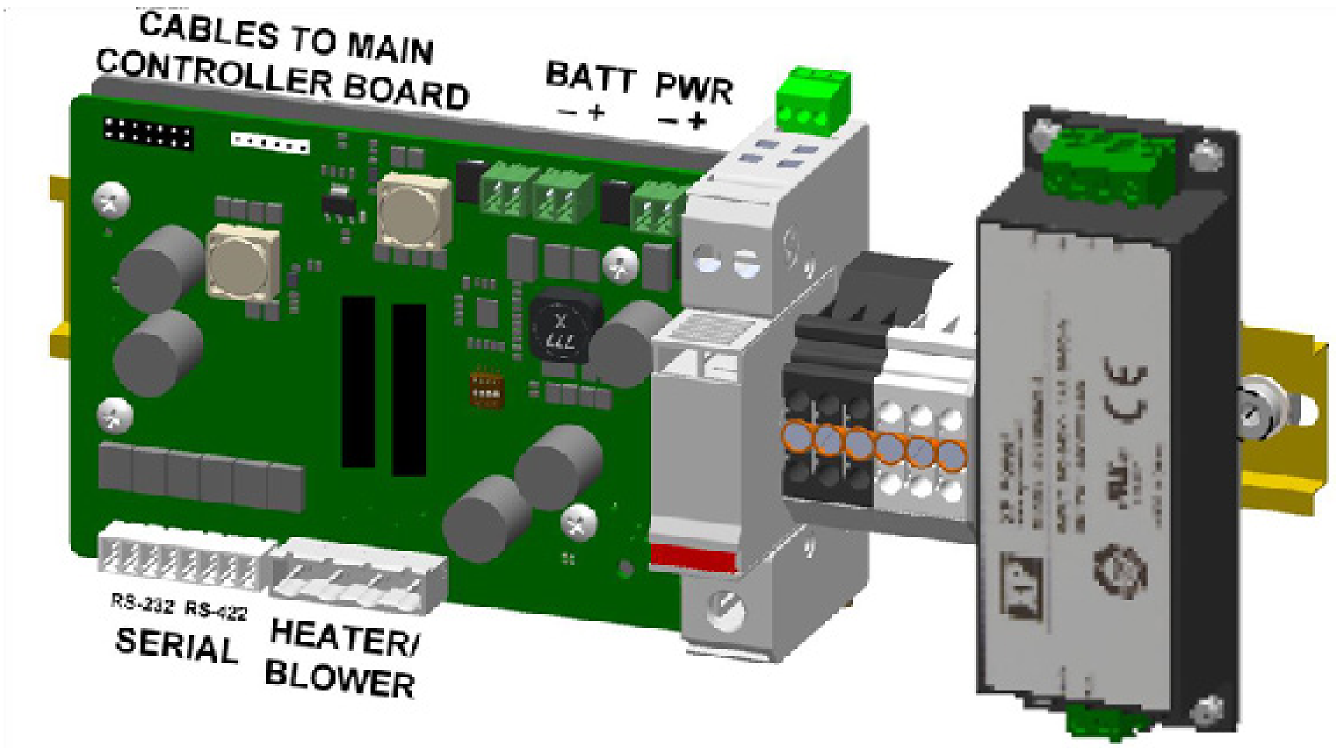


Figure 29. M404971-00 Power Controller Card Connections

WARNING

This card has AC power connected to it. Exercise due care when working on this part of the unit.

WARNING

The power cable to the sensor should be removed and the residual power allowed to dissipate for a period of not less than 5 minutes prior to internal maintenance of the device.

Model 8200 Ceilometer

1. Turn the breaker off that supplies AC power to the 8200 and disconnect the AC power cable.
2. Remove the blower shroud and the enclosure (Section 11.2.1).
3. Remove the cables shown in Figure 29.
4. Remove the board from the DIN rail, using the screw driver to lever out the latch, or sliding the module off the rail.
5. The installation procedure is the reverse of the above.

11.2.5 M438169-00 Power Supply Removal and Replacement

Item	Description
Task Description	Replace AC power supply
Purpose of Task	Remove defective unit
Tools Required	3 mm Flat screw driver
Time to complete	2 minutes

WARNING

The power cable to the sensor should be removed and the residual power allowed to dissipate for a period of not less than 5 minutes prior to internal maintenance of the device.

1. Turn the breaker off that supplies AC power to the 8200.
2. Disconnect the AC power connector. Allow power to dissipate as explained in the Warning above.
3. Disconnect the blower power connector.
4. Disconnect the data cable.
5. Remove the blower shroud and the enclosure (Section 11.2.1).
6. Use the screwdriver open the latch at the base to release the module from the DIN rail.
7. Remove the power supply from the DIN rail.
8. Remove the wires from the terminal block connectors.
9. Connect the new power supply module using the wired in terminal block connectors.
10. Install the new module on the DIN rail.
11. Secure the module to the DIN rail.
12. Replace the enclosure and the blower shroud.
13. Reconnect the data cable.
14. Reconnect the blower power connector.
15. Reconnect the AC power connector.
16. Turn on the breaker that supplies AC power to the 8200.

11.2.6 8200 Surge Protection Failure

The signal line surge suppressor is mounted on the DIN rail with the power supply and the M404971-00 Power Controller Board (Figure 29).

Item	Description
Task Description	A surge can cause failure of the transzorbs on the power controller card
Purpose of Task	Remove defective unit
Tools Required	3 mm Flat screw driver
Time to complete	30 minutes

WARNING

Ensure AC power is disconnected before starting work on this unit.

Ensure the ground connection is reconnected to this unit or it will not function correctly.

The residual power allowed to dissipate for a period of not less than 5 minutes prior to internal maintenance of the device.

1. Turn the breaker off that supplies AC power to the 8200.
2. Disconnect the AC power connector. Allow power to dissipate as explained in the Warning above.
3. Disconnect the blower power connector.
4. Disconnect the data cable.
5. Disconnect the power wires from the surge protector.
6. Disconnect the ground wire going to the ground bar.
7. Remove the surge suppressor from the DIN rail.
8. Install the replacement surge suppressor on the DIN rail.
9. Connect the power wires to the surge protector.

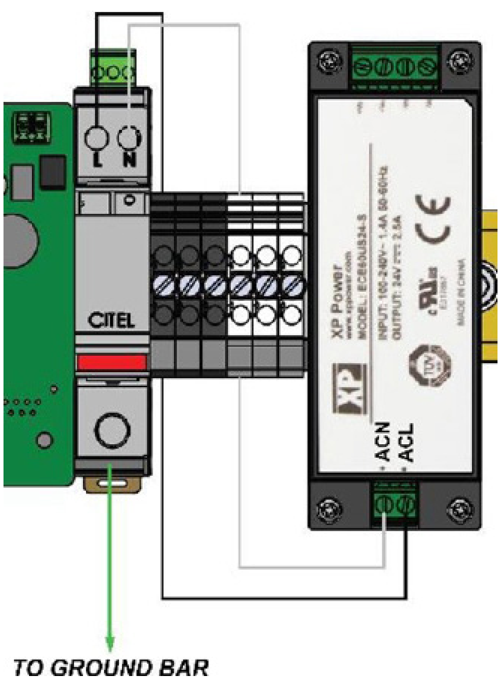


Figure 30. Power Surge Suppressor Connections

10. Connect the ground wire going to the ground bar.
11. Reconnect the data cable.
12. Reconnect the blower power connector.
13. Reconnect the AC power connector.
14. Turn on the breaker that supplies AC power to the 8200.

11.2.7 Backup Battery

The backup battery is strapped to a DIN rail opposite the Power Supply Board (Figure 29). Turn the AC power breaker on.

Item	Description
Task Description	Replace backup battery
Time to complete	10 minutes

WARNING

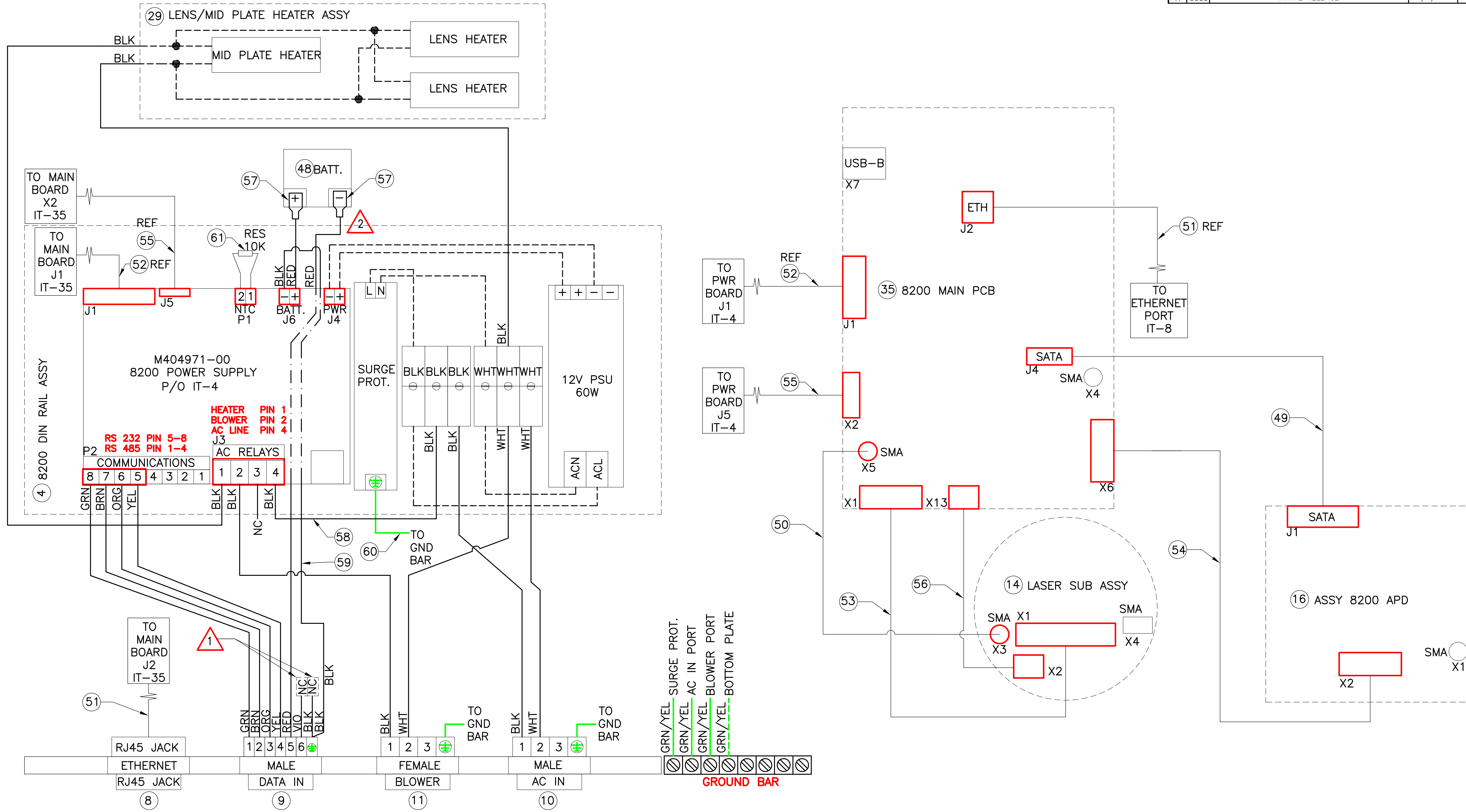
Ensure AC power is disconnected before starting work on this unit.

1. Turn the breaker off that supplies AC power to the 8200.
2. Disconnect the battery from the Power Supply Board.
3. Undo the cinch straps holding the battery to the DIN rail, and remove the battery.
4. Position the replacement battery and use the cinch straps to strap it to the DIN rail.
5. Connect the battery to the Power Supply Board, observe the polarity as marked on the Power Supply Board and in Figure 29.
6. Turn on the breaker that supplies AC power to the 8200.

12. Wiring Diagram

REV	ECO	REVISIONS DESCRIPTION	DATE	APPROVED
A	5853	INITIAL RELEASE	10/7/2024	K.YOUNG

DWG NO M403603-00-019



NOTES: UNLESS OTHERWISE SPECIFIED:

1. TRIM RED AND VIO NTC WIRES; APPLY SHRINK TUBE TO WIRE ENDS.
2. LABEL RED WIRES AT BATTERY AS «BATT +» AND «BATT –».

APPEND THE FOLLOWING DOCUMENTS WHEN CHANGING THIS DOCUMENT:

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES
.XX=±.010 ANGLES ±1/2°
.XXX=±.005 CONCENTRICITY: .003 TIR
DO NOT SCALE DRAWING

MATL: SEE BILL OF MATERIALS

FINISH: AS ISSUED

TREATMENT: NONE

APPROVALS	DATE
DRAWN BY: K. YOUNG	6/10/2024
REVISED BY: T. IWANOWSKI	10/7/2024
CHECKED BY: T. IWANOWSKI	10/7/2024
DESIGN ENGINEER: K. YOUNG	6/10/2024
PROJECT MANAGER: AARON HUSTEAD	6/10/2024

TITLE: WIRING DIAGRAM, ASSY SINGLE LENS CEIL 8200

allweatherinc

SIZE: D DWG NO. M403603-00-019

SCALE: NONE RELEASE DATE: 6/10/2024 SHEET: 1 OF 1

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