PRODUCT MANUAL

Sensor

CS120A and CS125

Visibility and Present Weather Sensors

RELIABLE MONITORING SINCE 1974

Campbell SCIENTIFIC®

Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific

- Batteries

- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

About this manual

Some useful conversion factors:

Area: 1 in^2 (square inch) = 645 mm^2

Length: 1 in. (inch) = 25.4 mm
1 ft (foot) = 304.8 mm
1 yard = 0.914 m
1 mile = 1.609 km

Mass: 1 oz. (ounce) = 28.35 g
1 lb (pound weight) = 0.454 kg

Pressure: 1 psi (lb/in^2) = 68.95 mb

Volume: 1 UK pint = 568.3 ml
1 UK gallon = 4.546 litres
1 US gallon = 3.785 litres

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

CAMPBELL® SCIENTIFIC
WHEN MEASUREMENTS MATTER

Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC**. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.eu or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical
- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather
- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance
- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

Table of contents

1. General information

1.1 General safety

This manual provides important safety considerations for the installation, operation and maintenance of the CS120A/CS125. These safety considerations are classified into three levels:

> **WARNING:**
> Warnings alert the installer or user to serious hazards. Ignoring these warnings could result in injury or death and/or irrevocable damage to the sensor unit.

> **CAUTION:**
> Cautions warn of potential hazards. Ignoring these cautions could result in the sensor being damaged and data being lost.

> **NOTE:**
> Notes highlight useful information in the installation, use and maintenance of this product. These should be followed carefully in order to gain the maximum benefit from the use of this product.

1.2 Sensor unit safety

The sensor has been checked for safety before leaving the factory and contains no internally replaceable or modifiable parts.

> **WARNING:**
> Do not modify the sensor because it can damage the unit and expose users to dangerous light levels and voltages.

> **WARNING:**
> Do not attempt to repair the sensor unit without consulting Campbell Scientific.

> **CAUTION:**
> Ensure the correct voltage supply is provided to the sensor.

1.3 Recommended tools

The following installation tools are recommended:

- 10 mm open spanner/wrench (for grounding boss, must be open ended)
- 13 mm spanner/wrench
- 19 mm open spanner/wrench (for cable glands, must be open ended)
- 2 mm flat screwdriver
- Number 2 cross-head screwdriver

2. Introduction

The CS120A and CS125 are visibility sensors with the same visibility measurement specifications. The difference between the two sensors is the CS125 additionally detects and reports present weather in the form of SYNOP, METAR, or NWS codes. A CS120A can be upgraded to a CS125 (contact Campbell Scientific for more details).

The sensors are infrared forward scatter visibility and present weather sensors for automatic weather stations in road, marine, and airport applications. They both use the forward-scatter system for visibility measurement, with a 42 º scatter angle. The CS125 uses high-speed sampling to reduce missed events and to improve response to other suddenly changing conditions.

The CS125 includes a temperature sensor mounted in the crossarm as part of the process for identifying precipitation.

When an optional HygroVUE5 or HygroVUE10 temperature and relative humidity (T/RH) sensor is connected, the CS125 can distinguish wet and dry obscuration, such as mist and haze, and more precisely discriminate between liquid and frozen precipitation. Dew heaters are provided to keep the sensor optics clear of condensation, and more powerful hood heaters to prevent the build up of snow or ice.

The CS120A and CS125 are certified for aviation use by the German Meteorological Service, Deutscher Wetterdienst (DWD).

3. QuickStart

3.1 Default settings

The default settings for the CS120A are 38400 baud, 8 bits, no parity, 1 stop bit, sensor ID 0, and returning message type 2 (full, visibility only). The CS125 has the same default communications settings, but the default returning message is type 5 (full SYNOP present weather) and uses 1-minute intervals (see Messages [p. 32]).

3.2 Short Cut

The CS120A/CS125 can be programmed using Short Cut if the sensor is set to the default settings. The CS125 can also use Short Cut to output full visibility only messages if the returning message format is set to type 2.

A video that describes data logger programming using *Short Cut* is available at: www.campbellsci.eu/videos/cr1000x-data logger-getting-started-program-part-3. ▶ *Short Cut* is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. *Short Cut* is available as a download on www.campbellsci.eu. ⬈ It is also included in installations of *LoggerNet*, *RTDAQ*, and *PC400*.

The following procedure shows using Short Cut to program the CS125.

1. Open *Short Cut* and click **Create New Program**.
2. Double-click the data logger model.

3. In the **Available Sensors and Devices** box, type CS125 or find the sensor in the **Sensors** > **Meteorological** > **Present Weather** folder, and double-click **CS125 Present Weather & Visibility Sensor**.**Visibility** units default to **metres**, which can be changed by clicking the **Visibility** box and selecting another option. By default, the sensor sends messages automatically (no polling required). To poll the sensor every minute, or poll the sensor every scan, click the **Poll sensor** box and select another option.
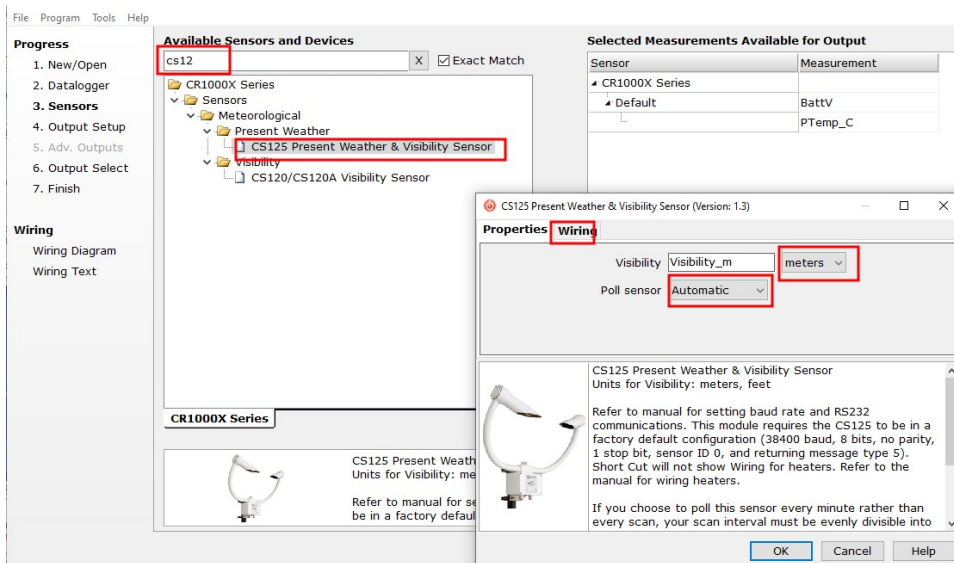
4. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.
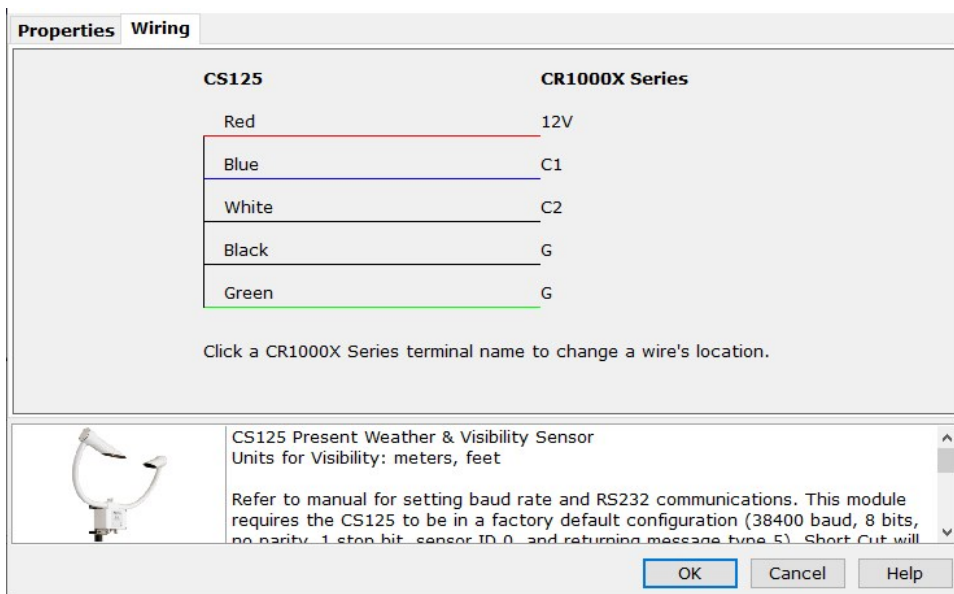
> **NOTE:**
> The heaters wiring is not shown. Refer to Connectors (p. 22) for information on wiring the heaters.

5. Repeat steps three and four for other sensors you want to connect. Click **Next**.

6. In **Output Setup**, type the scan rate, a **Table Name**, and **Data Output Storage Interval**. Click **Next**.

> **NOTE:**
> If this sensor is polled every minute, the scan interval must be evenly divisible into a minute (for example, 2, 5, 10, 15 secs) and must be less than one minute. If polled every scan, the sensor will take a couple of seconds (at least) to respond and shouldn't be polled quicker than every 30 seconds. If the sensor is set up to automatically send a message, select Automatic (no polling required).
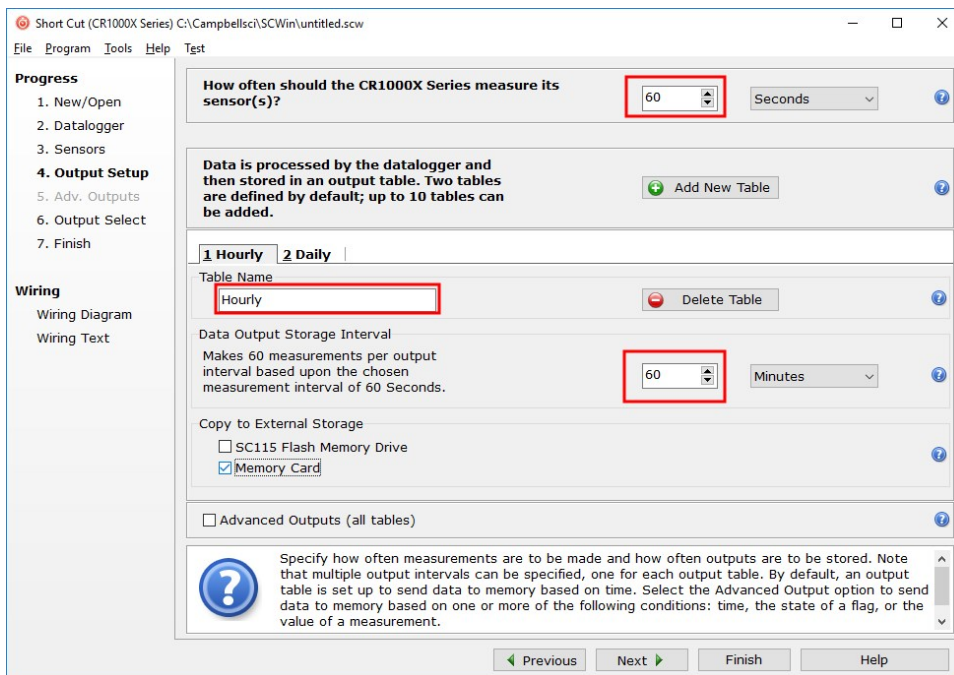
7. Select the output options. The variables for the output options are shown in Short Cut variables (p. 6).
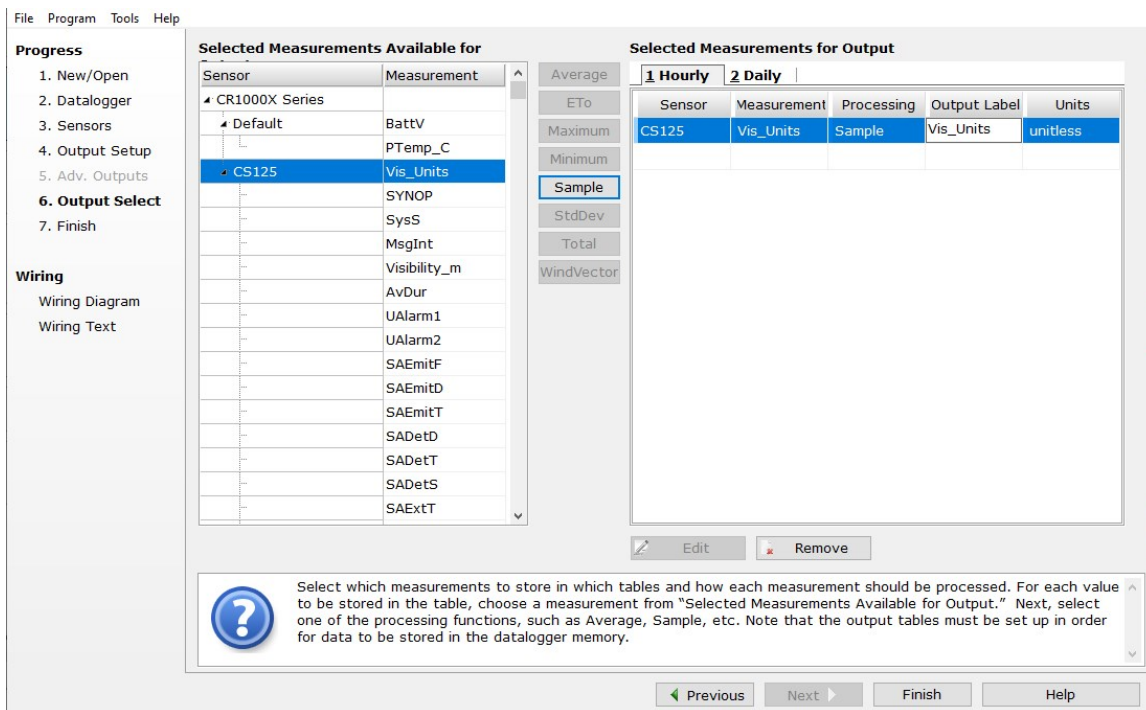
8. If the sensor is connected to the data logger, check the output of the sensor in the data display in **LoggerNet**, **RTDAQ**, or **PC400** to make sure it is making reasonable measurements.

9. Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.

3.3 Short Cut variables

Table 3-1: Description of Short Cut variables		
SCWin Variable	**Field description**	**Purpose**
SysS	System status	Status/Diagnostic
MsgInt	Message interval (seconds)	Setup Info
Visibility_m	Visibility distance	Data
Vis_Units	Visibility units	Setup Info
AvDur	Averaging duration	Setup Info
UAlarm1	User alarm 1	Status/Diagnostic

Table 3-1: Description of Short Cut variables		
SCWin Variable	Field description	Purpose
UAlarm2	User alarm 2	Status/Diagnostic
SAEmitF	Emitter fail (see	Status/Diagnostic
SAEmitD	Emitter dirty[1]	Status/Diagnostic
SAEmitT	Emitter temperature[1]	Status/Diagnostic
SADetD	Detector dirty[1]	Status/Diagnostic
SADetT	Detector temperature[1]	Status/Diagnostic
SADetS	Detector saturation[1]	Status/Diagnostic
SAHoodT	Hood temperature[1]	Status/Diagnostic
SAExT	External temperature[1]	Status/Diagnostic
SASigE	Signature error[1]	Status/Diagnostic
SAFlasR	Flash read error[1]	Status/Diagnostic
SAFlasW	Flash write error[1]	Status/Diagnostic
SAPlimE[2]	Particle limit error[1]	Status/Diagnostic
PartCount[2]	Particle count	Data
Intensity[2]	Intensity (mm/hr)	Data
SYNOP[2]	SYNOP code[3]	Data
Temp[2]	Temperature (°C)	Data
RH[2]	Relative humidity (%)	Data
[1] Refer to System alarms for more information. [2]Variable only for the CS125 present weather sensor. [3]Refer to Present weather codes produced by the CS125 for more information.		

4. Overview
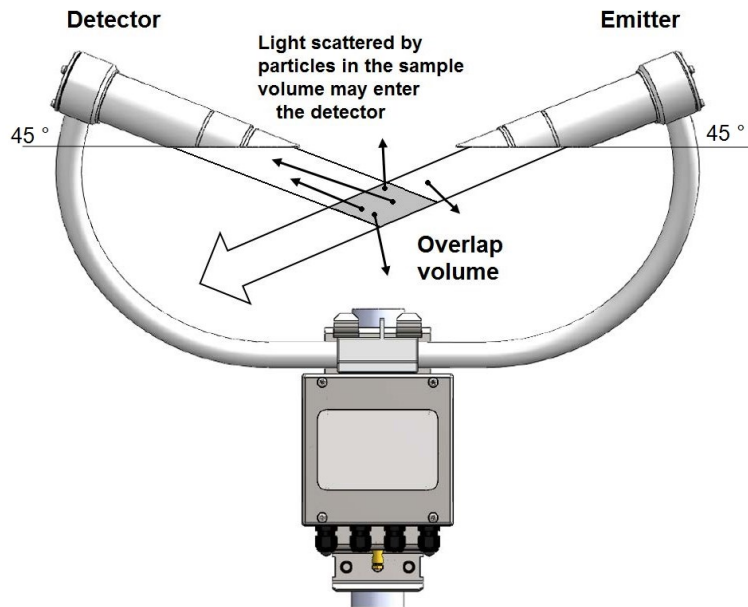
*Figure 4-1. Particles in the sample volume scatter
light in all directions, including into the detector*

The CS120A/CS125 comprise an emitter and detector aligned as in Figure 4-1 (p. 8). The emitter produces a beam of near infrared light pulsed at 1 kHz. A detector has a field of view that overlaps the beam. Light scattered by a particle (for example, a fog droplet or particle of precipitation) from the overlap or sample volume towards the detector is detected by a photodiode and recorded as a signal. The size of the signal is proportional to the extinction of the emitted beam caused by scattering. The scattering signal averaged over 1-second is used to calculate an extinction coefficient or EXCO, assuming the relationship between forward scatter and EXCO is linear. Sixty 1-second averages are then themselves averaged to give a 1-minute average EXCO. This is then converted to a value of meteorological optical range (MOR) using Koschmieder law:

MOR = 3/EXCO, where MOR is in km and EXCO in units of km^{-1}.

The CS125 calibration for visibility was derived by comparison with other high-grade, forward-scatter sensors and has been verified in a study by trained meteorological observers. This is called MOR calibration in this manual.

An alternative calibration, known as TMOR, is also available. This was derived by following the ICAO procedure of calibrating the sensor against a transmissometer. An empirical equation to convert from MOR to TMOR was developed. This non-linear equation results in significantly higher visibility readings at lower visibilities below 5000 m. Comparison of alternate visibility calibrations (p. 84) provides calibration details and graphs comparing the two calibration options.

The TMOR calibration should be used for aviation applications since the values resulting from this calibration are considered more representative of visibility during plane landings and viewing landing lights. Use of the TMOR calibration is obligatory for use of this sensor on German airfields.

The CS125 can switch between outputting data using the MOR or TMOR calibration with a configuration switch (see Internal switches [p. 29]). Sensors made from early December 2020 leave the factory with this switch set to **ON** to make the sensor output values according to the TMOR calibration.

The CS125 is capable of identifying weather type in addition to measuring visibility. Weather type is identified through analysis of the amplitude and width of spikes in the APD signal, which corresponds to the particles of precipitation traversing the sample volume. The width of the spikes, which reflects the time taken for the particles to descend through the sample volume, serves as a proportional indicator of their fall speed. (see Figure 4-2 [p. 9]).
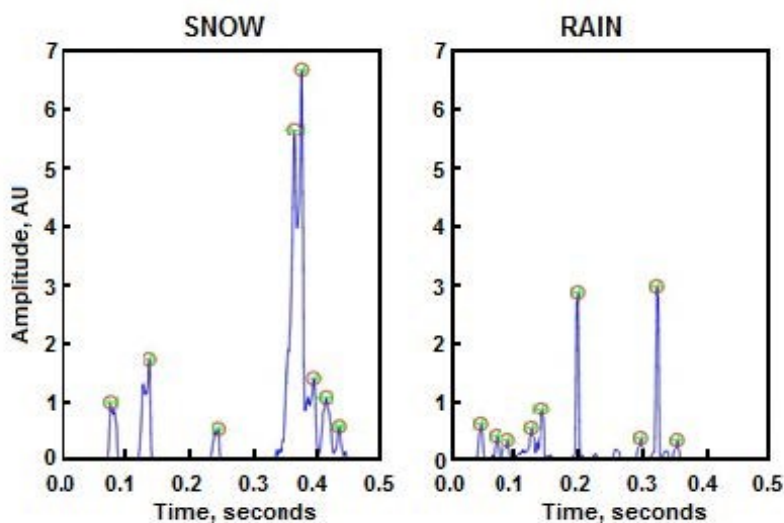
Figure 4-2. Signals from large, slow-falling snowflakes and smaller, faster, raindrops

The CS125 has a temperature sensor. Three parameters (fall speed, size, and temperature) are used to identify the particle type. If an additional external temperature and relative humidity

probe is connected, then a wet-bulb temperature can be calculated. This provides additional information to more accurately distinguish between liquid and frozen particles, especially when the temperature in near 0 °C. Figure 4-3 (p. 10) shows how these temperatures are used to define possible precipitation types around 0 °C.

Figure 4-3. Possible precipitation types based on wet-bulb, and dry-bulb temperatures

The processing algorithm then works with several maps, such as Figure 4-4 (p. 10), to identify each particle.
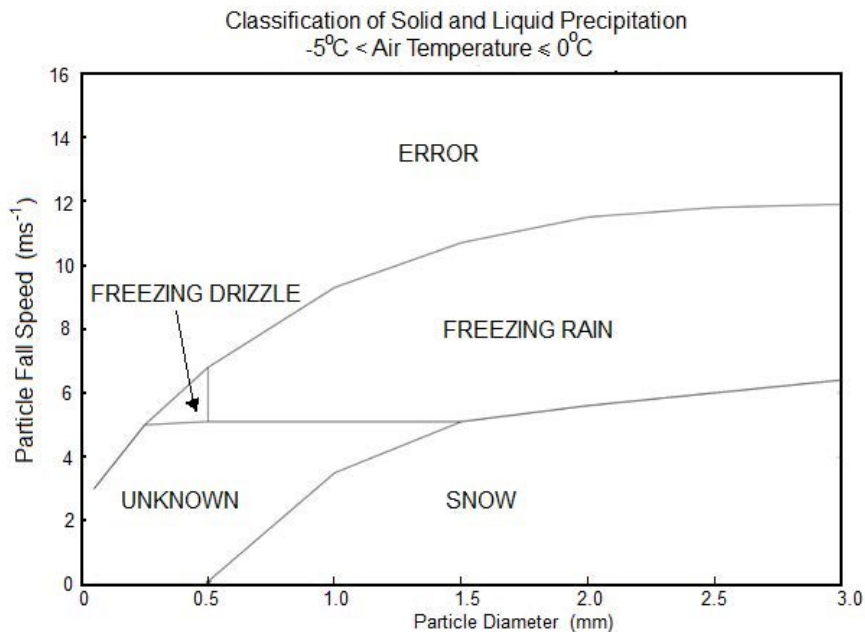
Figure 4-4. A typical size/speed map used by the CS125 present weather algorithm

5. Specifications
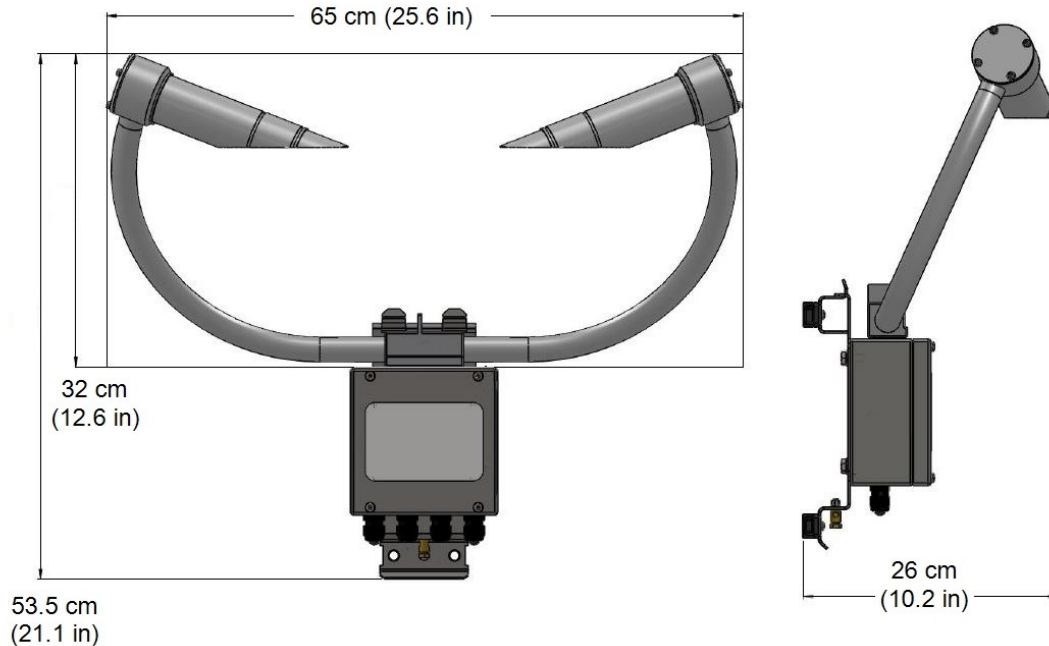
Figure 5-1. Dimensions

Sensor weight:	3 kg (6.6 lb)
Shipping weight:	6 kg (13.2 lb) including packing box
Sensor mounting:	Bracket mounts on a vertical pole 32 to 52.5 mm diameter. The mounting bracket has cut-outs for band clamps masts with larger diameters.

5.1 Optical specifications

LED centre wavelength:	850 nm
LED spectral bandwidth:	±35 nm
Light pulse rate:	1 kHz

5.2 Environmental specifications

Sensor heater thresholds

Dew heater turn on:	<35 °C
Dew heater turn off:	>40 °C
Hood heater turn on:	<15 °C
Hood heater turn off:	>25 °C

Operating humidity range: 0 to 100%

Temperature range

Operating:	–25 to +60 °C
Extended operating:	–40 to +70 °C
Storage:	–40 to +85 °C

> **NOTE:**
> Extended temperature ranges are only guaranteed if the sensor has been tested by Campbell Scientific and verified within this temperature range. Some degradation of absolute accuracy can be expected at the extremes of the extended ranges.

5.3 Measurement specifications

Visibility

Maximum reported visibility:	75 km (46.6 m)
Minimum reported visibility:	5 m (16.4 ft)
Accuracy calibration:	±2% against factory calibration disk
Accuracy:	±8% at < 600 m (< 1968.5 ft)
	±10% at < 10,000 m (< 32,808.4 ft)
	±15% at < 15,000 m (< 49,212.6 ft)
	±20% at < 75,000 m (< 246,063 ft)

Precipitation and water equivalent (CS125 only)

Reported accumulation range:	0 to 999.9 mm (0 to 39.4 in)
Accumulation accuracy:	±15% (against factory calibration standards in the laboratory, for liquid precipitation)
Accumulation resolution:	0.1 mm
Reported intensity range:	0 to 999.9 mm/hr (0 to 39.4 in/hr); maximum intensity reported depends on mixture of

5.4 Electrical specifications

Electronics supply voltage: 7 to 30 VDC, 12 VDC nominal

> **CAUTION:**
> If a HygroVUE 5 or HygrVUE 10 probe is used with the CS125, the supply voltage must not exceed 28 VDC.

Hood heater supply

Supply voltage (DC or AC):	24 V nominal, 30 V maximum
Power:	2 x 30 W (total of 60 W)

Dew heater power: 2 x 0.6 W (total of 1.2 W)

Current drain at 12 VDC

Continuous sampling with dew heaters ON and RS-232 communications active:	200 to 248 mA
Continuous sampling with dew heaters disabled:	110 to 151 mA
No sampling with dew heaters disabled:	21 to 30 mA

User alarm outputs

High level:	3.8 V (85 °C), 4.13 V (25 °C)
Low level:	0.25 to 0.55 V
Accumulation resolution:	0.1 mm
Current:	32 mA

> **NOTE:**
> 1. If the hood heaters are not being used, ensure that the hood heater override is set to off.
>
> 2. Campbell Scientific recommends that the hood heaters are powered with 24 VAC/DC. While the heaters may run at voltages below 24 V, they will generate proportionally less heat reducing their ability to prevent ice build-up.

5.5 Communication specifications

> **NOTE:**
> The RS-232 communications interface will automatically turn itself off when not transmitting.

Supported formats:	RS-232 full duplex only (default)
	RS-485 half duplex
	Choice of 8 bit, no parity or 7 bit, even parity
	1 stop bit
	Parity checking is not supported as most communication protocols used by the CS120A/CS125 have built in checksums as well as checks that communications have been understood.
Serial setting:	8N1
Supported data rates:	1200 bps, 2400 bps, 9600 bps, 19200 bps, 38400 bps (default), 57600 bps, 115200 bps
Serial setting:	8N1

RS-232 communications

RS-232 input threshold, low:	0.8 V (minimum), 1.5 V (nominal)
RS-232 input threshold, high:	2.0 V (nominal), 2.4 V (maximum)
RS-232 input absolute maximum:	±15 V
RS-232 input resistance:	12 kohm
RS-232 output voltage:	0.4 to 4.4 V

RS-485 communications

RS-485 input threshold voltage:	±0.2 V
RS-485 output (unloaded):	5 V
RS-485 output (load 5 ohm):	2 V
Maximum voltage at any terminal:	±7 V; the sensor ground and any RS-485 equipment ground cannot be further apart than this voltage. The sensor ground (pin 1) on connector B can be connected to the ground of the host equipment to reduce parasitic currents.

6. Installation

6.1 Location and orientation

The sensor measures environmental variables and is designed to be located in harsh weather conditions. However, a few considerations should be taken into account if accurate and representative data from a site is to be obtained.

> **NOTE:**
> The descriptions in this section are not exhaustive. Refer to meteorological publications for further information on locating weather instruments.

The sensor should be sited in a position representative of local weather conditions and not of a specific microclimate, unless the analysis of microclimate weather is being sought.

The sensor has good resistance to background light, but Campbell Scientific recommends avoiding locations where the transmitter points at a light scattering or reflecting surface. Ideally, the receiver should point north in the northern hemisphere or south in the southern hemisphere but this is not critical; the higher priority is making sure the receiver avoids pointing towards possible sources of reflected light in its field of view, such as nearby sensors or enclosures mounted below it on a mast. Where those objects cannot be moved, pointing the sensor away from north/south is acceptable. Failure to do this can result in a DC light saturation error when there is bright sunlight.

Figure 6-1. Top view of sensor oriented for the northern hemisphere

To give non-microclimatic measurements, the sensor should be sited away from possible physical obstructions that could affect the fall of precipitation. The sensor should also be positioned away from sources of heat, electrical interference, and in such a position as to not have direct light on the sensor lenses. Whenever possible, the sensor should be located away from windbreaks.

Several zones have been identified upwind and downwind of a windbreak in which the airflow is unrepresentative of the general speed and direction. Eddies are generated in the lee of the windbreak, and air is displaced upwind of it. The height and depth of these affected zones varies with the height and to some extent the density of the obstacle.

Generally, a structure disturbs the airflow in an upwind direction for a distance of about twice the height of the structure, and in a downwind direction for a distance of about six times the height. The airflow is also affected to a vertical distance of about twice the height of the structure. Ideally, therefore, the sensor should be located outside this zone of influence in order to obtain representative values for the region.
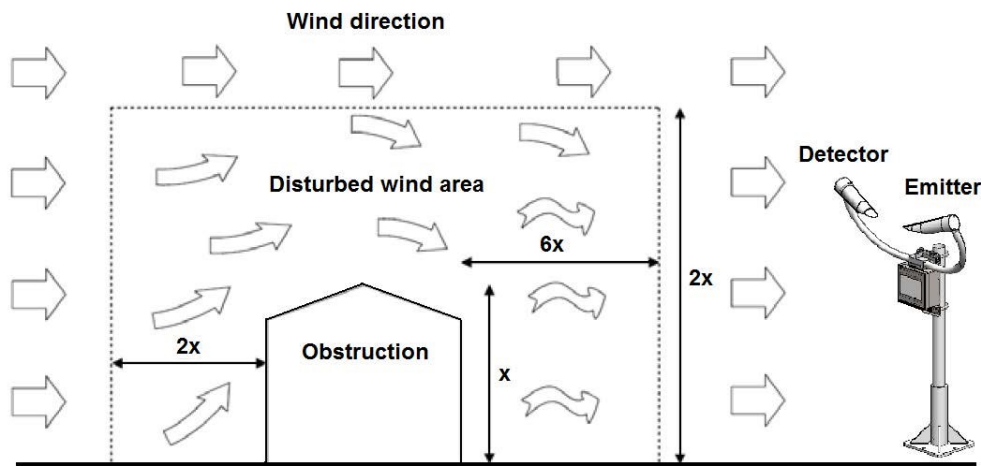
Figure 6-2. Airflow

To reduce the frequency of service requirements, place the sensor away from contamination sources; for roadside monitoring, larger mounting poles can be used. More frequent maintenance will be required when the instrument is in areas where contamination is unavoidable or where measurements may be safety critical.

The WMO recommends a sample volume height of 1.5 m; however, for applications such as aviation or road visibility other heights may be appropriate.

> **NOTE:**
> If operating indoors, sources of light and/or reflections will likely create false readings and erratic results.

> **NOTE:**
> Remember, while performing simple checks, blocking a lens or the sample volume will simulate an increase in visibility, not a decrease.

6.2 Equipment grounding

The sensor must be properly grounded. It is sufficient to ground the mounting bracket if the sensor is connected to a grounded metal mast and is in electrical contact with it. Otherwise, the mounting bracket should be earthed with the supplied ground lug (see Figure 6-3 [p. 18]).

A ground wire with a minimum cross section of 6 mm^2 and maximum length of 5 m should be used. The pole and foundations of a pole-mounted installation will provide some basic lightning protection and against radio frequency interference when correctly grounded.
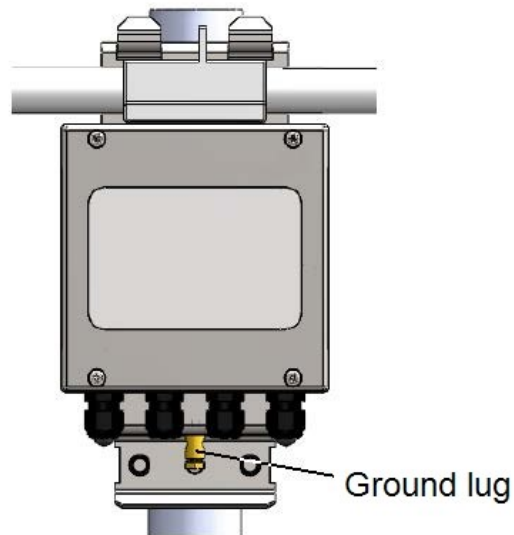
Figure 6-3. Ground lug

6.3 Mounting

A quick release pole mounting kit is supplied with the sensor.

If a power supply enclosure has been supplied with the sensor, it can be mounted on the pole, near its base with the brackets supplied with the enclosure. Alternatively, the power supply can be mounted elsewhere, such as on a wall at some distance from the sensor. The power supply enclosure should be mounted away from the sensor head to avoid wind-flow disturbance or rain drops bouncing back up into the sensor sensing volume.

> **CAUTION:**
> Avoid overtightening the nuts on the bolts, as overtightening may distort and/or damage the brackets or DSP plate, and/or the nuts may seize up. Only tighten the nuts to a degree necessary to hold the sensor firmly in place.

If mounting the sensor onto another type of mast, refer to the manual for mounting details.

> **CAUTION:**
> Ensure that the sensor is mounted correctly (see Figure 6-4 [p. 19]). Once the nuts and bolts of the mounting plate are tightened, do not reposition the sensor by forcing the arms of the unit, as this can cause damage.

> **CAUTION:**
> Do not remove the mounting plate as this will compromise resistance to water ingress.
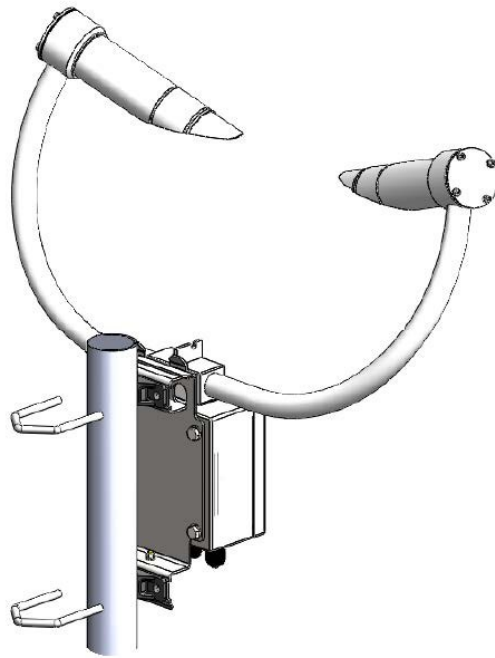
Figure 6-4. Pole mount

To mount the sensor to a flat surface, remove the plastic formers from the mounting brackets and use the holes as shown in Flat surface mount (p. 20).

> **NOTE:**
> If mounting to a flat surface, ensure airflow through the sample volume is not obstructed.
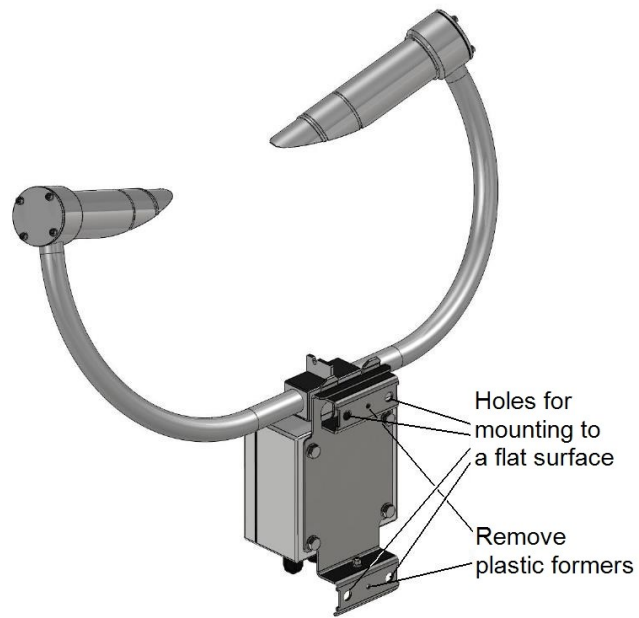
Figure 6-5. Flat surface mount

Slots are provided to allow band clamps to be used with larger diameter masts (see Figure 6-6 [p. 20]).
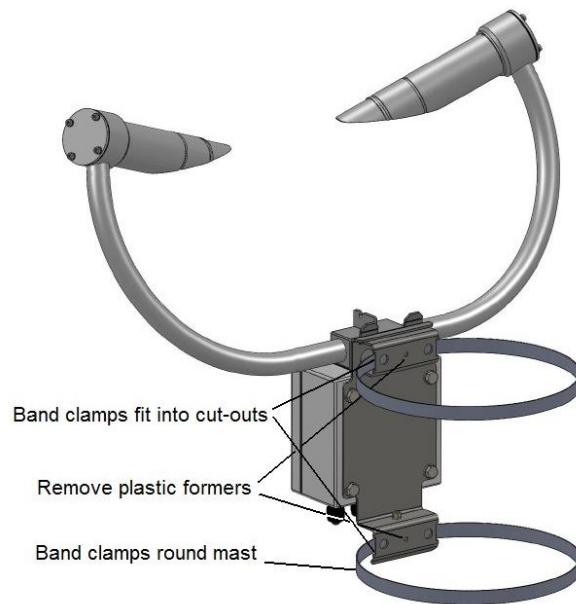
Figure 6-6. Use of band clamps

6.4 Optical sensor mount

The optical sensor mount places the sample volume at about 1.5 m, which complies with the WMO *'Guide to Meteorological Instruments and Methods of Observation'*, 7th Edition, Section 9.3.4.
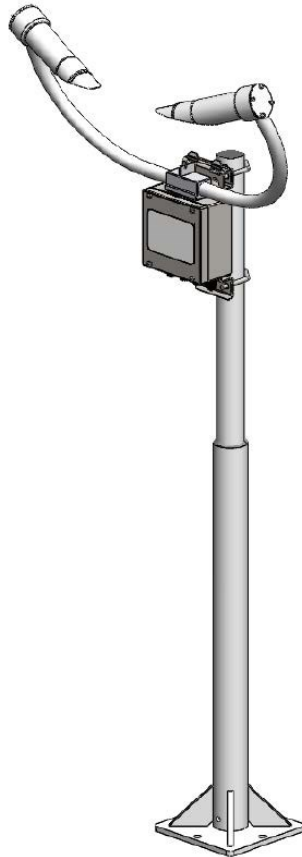
Figure 6-7. Optical sensor mount

The following are the installation instructions for the optical sensor mount:

1. Install the mount on a concrete foundation with at least a 600 mm length, 600 mm width, and 600 mm depth. Ensure the ground consistency is not too loose and will be able to support the mount and concrete foundation.

2. Drill four 12 mm diameter holes to a depth of 77 mm at the locations indicated in Figure 6-8 (p. 22). The mount base can be used as a template.
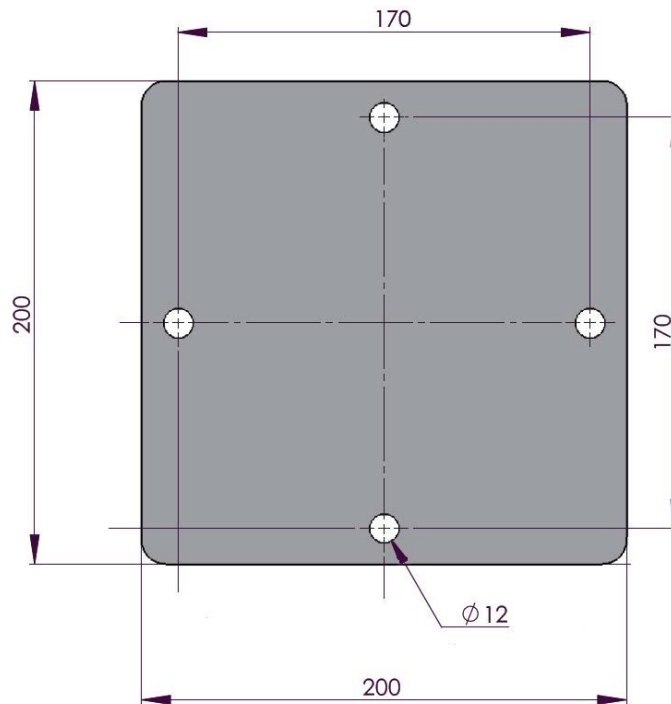
Figure 6-8. Mounting footprint (in mm)

3. Place washers and nuts on the ends of the wedge anchors supplied (to protect the threads during installation).

4. Hammer the wedge anchors into the holes until the start of the threads are below the surface.

5. Tighten the nuts until about 25 mm of thread protrudes above the surface.

6. Remove the washers and nuts from the protruding length screw and lower the mount into place.

7. Secure the mount with the washers and nuts.

> **NOTE:**
> If the surface is not level and flat, washers may be added under the base of one or more of the foundation screws.

6.5 Connectors

The sensor has four standard IP66 rated glands. By default, the first gland is used by the power/communications line, which comprises the 7 to 30 V for the main electronics and the serial

communications wires. The sensor is supplied with a 5 m cable already connected to the first gland.

The second gland is used for the 24 V feeds for the hood heaters and is fitted with a 5 m cable.

Glands 3 and 4 are spare. Optional user alarms usually use gland 3, and the optional HygroVUE 5 or HygroVUE 10 probe (CS125 only) usually uses gland 4.

To run cables through the cable glands, follow these guidelines. If a torque wrench is available, use a torque of 2.5 Nm to run cables through the cable glands. Otherwise, finger-tighten as tight as possible, then add a further ¾ turn with a 19 mm wrench/spanner.

> **CAUTION:**
> Do not overtighten.

The glands are suitable for cables between 5 and 9 mm diameter.

> **CAUTION:**
> If the power cable is incorrectly wired to the sensor then damage can be done to the unit.

> **CAUTION:**
> The longest recommended length for the supplied sensor cable is 10 m. Use a twisted-pair cable if the RS-485 cable needs to be longer than 10 m. Contact Campbell Scientific, if needing a cable longer 10 m is needed.
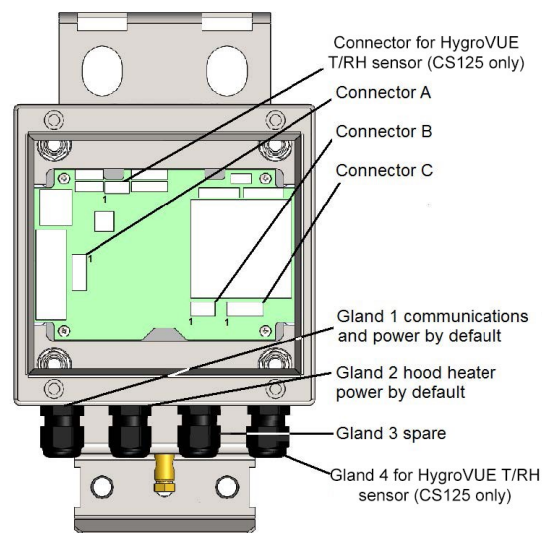
Figure 6-9. Connections

Table 6-1: Connector A – 5-pin connector		
Pin number	Function	Description
1	+ve supply	Main electronics +ve supply input.
2	0 V	Auxiliary electronics 0 V; this connection is common with the main electronics 0 V.
3	Hood low	For the hood heater power supply; if the hood heater supply is DC, it should be the negative connection and if AC, it should be the neutral or ground connection if there is one.
4	0 V	Auxiliary electronics 0 V; this connection is common with the main electronics 0 V.
5	Hood high	For the hood heater power supply; if the hood heater supply is DC, it should be the positive connection.

CAUTION:

To avoid damage to noise filters on the hood heater inputs if the heater voltage is DC, the **–ve** connection should be made to pin 3 and the **+ve** to pin 5. If the heater voltage is AC with a ground or neutral wire then this should be connected to pin 3. Pin 3 should not be more than 5 V from the main electronics 0 V.

Table 6-2: Connector B – 3-pin connector		
Pin number	Function	Description
1	0 V	0 V connection for serial communications; this connection is common with the main electronics 0 V (connector A, pin 2).
2	Receive	RS-232 receive line, RXD, B/D+ for RS-485 half duplex
3	Transmit	RS-232 transmit line, TXD, A/D– for RS-485 half duplex

CAUTION:

A 120 ohm termination resistor may be required to reduce signal distortion when using RS-485 for cable runs over about 500 m and baud rates above 38400. Connect the resistor between pins 2 and 3.

Table 6-3: Connector C – 4-pin connector		
Pin number	Function	Description
1	0 V	0 V connection for user alarms; this connection is common with the main electronics 0 V (connector A, pin 2).
2	User 2	Output for user alarm 2.
3	0 V	0 V connection for user alarms; this connection is common with the main electronics 0 V (connector A, pin 2).
4	User 1	Output for user alarm 1.

Table 6-4: Connector for HygroVUE 5 and HygroVUE 10 T/RH probe (CS125 only)	
Pin number	Function
1	+12 V
2	SDI-12 input
3	0 V

NOTE:
To use these connections, either use the cable gland taking the hood heater power or, if the hood heater is also required, use different cables to those supplied. Contact Campbell Scientific for choice cable choice assistance.

6.6 Wiring using Campbell Scientific cables

The sensor is provided pre-wired with a default 5 m power and communications cable which is terminated at one end with a 9 pin D-connector (DB9). The D-connector can be connected directly to a computer or to a data logger, such as the CR1000X, using a suitable interconnecting cable such as the SC110. If another type of connection is required then the D-connector should be removed.

COMMUNICATIONS AND POWER CONNECTIONS

RED - HOOD POWER HIGH
BLACK - HOOD POWER LOW
SCREEN

5m CABLE

CONNECTOR A

5		RED - HOOD POWER HIGH
4		N/C
3		BLACK - HOOD POWER LOW
2		BLACK - 0V
1		RED - + 7 - 30VDC

MAIN PCB INSIDE ENCLOSURE

5m CABLE

CONNECTOR B

1		GREEN - COMMS 0V
2		BLUE - RECEIVE
3		WHITE - TRANSMIT

TO 'D' CONNECTOR AND POWER SUPPLY
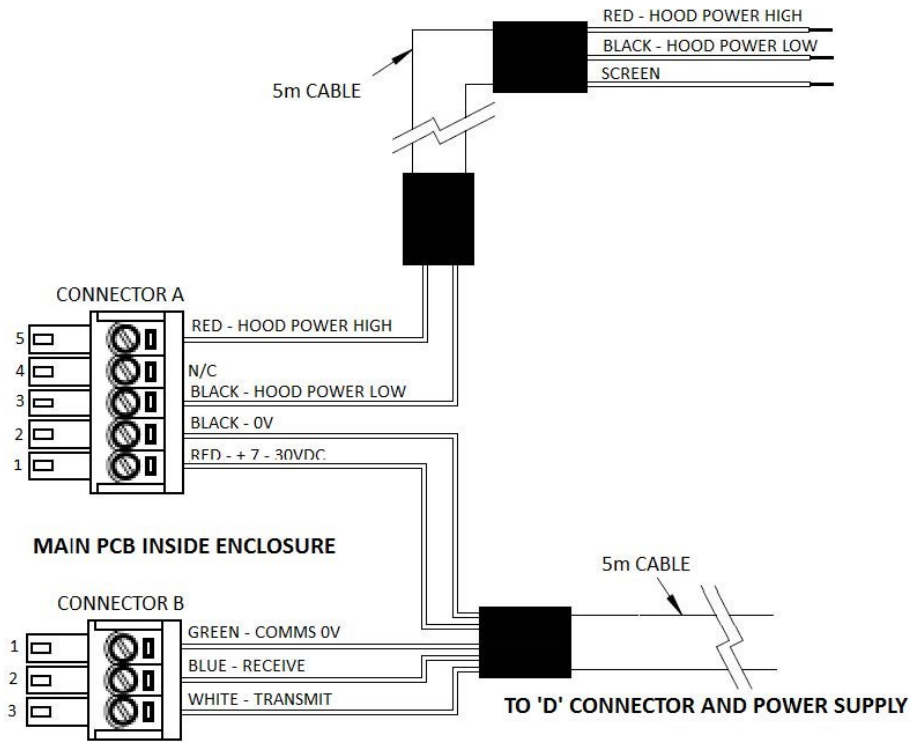
Figure 6-10. Communications and power cable diagram

COMMUNICATIONS AND POWER CONNECTOR

RED - SUPPLY +VE
BLACK - 0V
SCREEN

WHITE, RS-232 RXD, RS-485 B/D+ (2)
BLUE, RS-232 TXD, RS-485 A/D- (3)
GREEN, COMMS GROUND (5)

FROM SENSOR
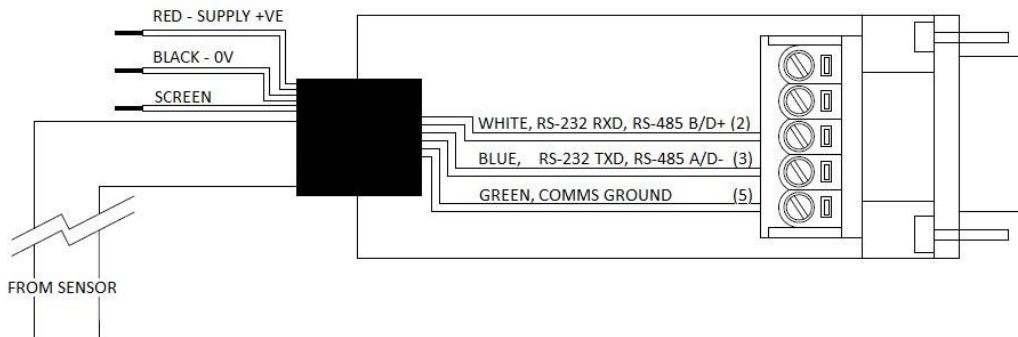
Figure 6-11. Communications and power connector

Campbell Scientific offers two types of configuration cable that plug directly into connector B in instead of the normal connector and cable. One cable provides an RS-232 or RS-485 output according to the CS120A/CS125 configuration (Figure 6-12 [p. 27]) and one has a USB output (Figure 6-13 [p. 27]).
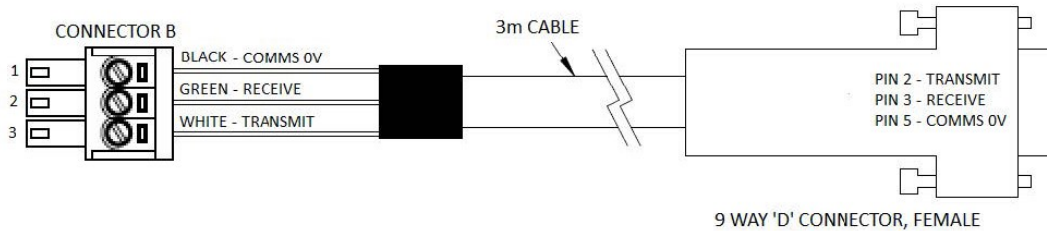
Figure 6-12. RS-232/RS-485 configuration cable
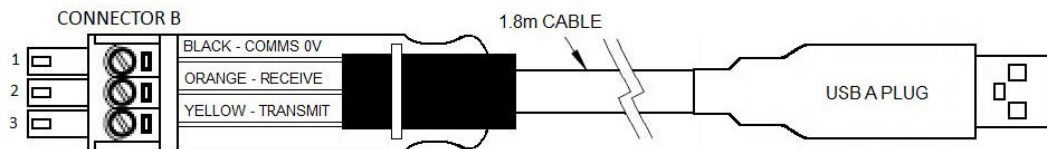
Figure 6-13. USB configuration cable

6.7 HygroVUE 5 or HygroVUE 10 T/RH sensor installation (CS125 only)

The CS125 has a temperature sensor mounted in the crossarm that is used in determining precipitation type.

A HygroVUE 5 or HygroVUE 10 T/RH sensor can be connected to a CS125 to allow the CS125 to better identify different precipitation types, for example, distinguish between mist and haze. The T/RH sensor improves the precipitation identification at temperatures near freezing and its use is highly recommended in regions where temperatures close to 0 °C are common. The T/RH sensor also allows relative humidity information to be included in data messages.

> **NOTE:**
> The retired CS215 T/RH sensor can also be connected to the CS125. Refer to an older manual at www.campbellsci.com/old-manuals for information on connecting the CS215 to the CS125.

If a HygroVUE 5 or HygroVUE 10 is connected to the CS125, the temperature used for assessment of precipitation type and included in data messages will come from the HygroVUE 5 or HygroVUE 10 instead of the temperature sensor mounted in the crossarm.

The connections for the HygroVUE 5 or HygroVUE 10 are shown in and . The T/RH sensor must be housed in a radiation shield, typically the RAD06 6-plate shield for the HygroVUE 5 or the RAD10E 10-plate shield for the HygroVUE 10.

WMO – No. 8, 2.1.4.1 recommends temperature measurement at a height of between 1.2 and 2.0 m above ground.

Table 6-5: HygroVUE 5 and HygroVUE 10 wiring		
Wire colour	Function	Pin number
Brown	+12 V	1
White	SDI-12 input	2
Black	Power ground	3
Clear	Shield	3

Connections for temperature and RH sensor
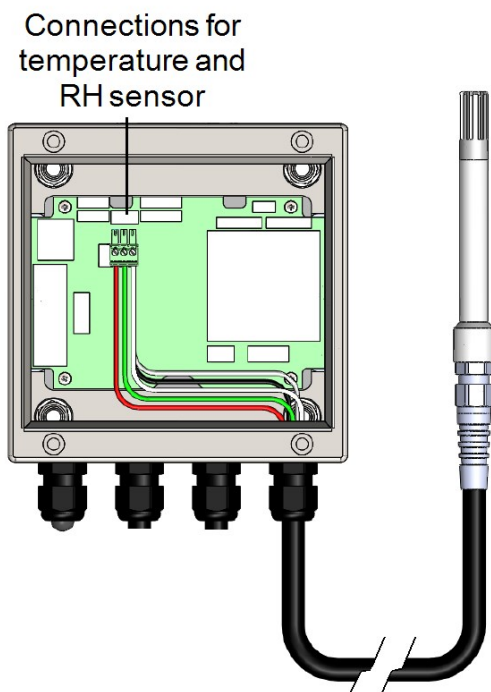
Figure 6-14. Connection for optional HygroVUE 5 and HygroVUE10 T/RH sensors

6.8 Internal switches

The sensor is equipped with four switches located within the main enclosure. These switches perform certain functions when the sensor is turned on; their functions are detailed in Figure 10-1.

> **NOTE:**
> The switches are only read during the sequence to turn on the sensor. This means that if the switches are pressed while the sensor is running nothing will happen. The sensor will need to be power cycled, leaving the sensor off for at least 10 seconds with the sensor off for any of their functions to be performed.
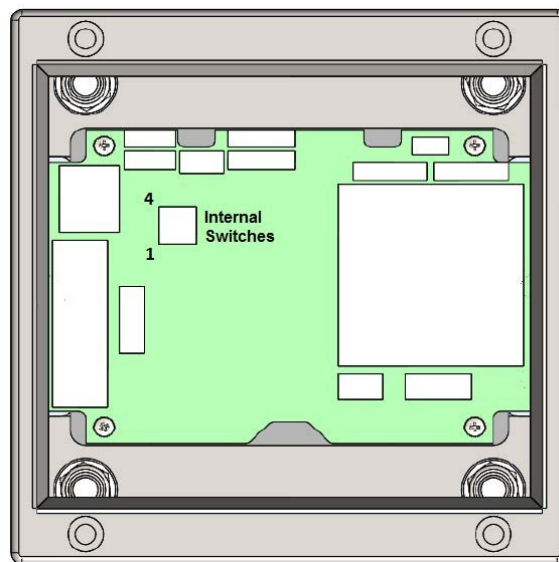
Figure 6-15. Internal switches

Table 6-6: Internal switch functions	
Switch number	Function
4	When **ON**, the sensor uses TMOR calibration; when OFF, it uses MOR calibration. Refer to Overview (p. 8) for a description of these two calibration options.
3	When **ON** position and sensor is power cycled, this switch temporarily sets the sensor communications port to a default RS-232 communications, state at 38400 bps. This is useful during field tests or maintenance when the sensor has been remotely configured for RS-485 mode or a baud rate the computer does not support. This change is temporary and will not be stored to flash. However, if the menu system is accessed and a **Save and exit** command is performed, the new data rate setting will be committed to flash. Once the switch **OFF** and the sensor is power cycled, the sensor will return to its previous communications settings.
2	*Reserved for future use, set to* **OFF**.
1	When **ON**, this switch will reset the sensor to its factory default values affecting all communication settings. This will take immediate effect when the sensor is turned on. NOTE: To use this, the power supply must be stable. Do not leave this switch permanently **ON**.

NOTE:
If the lid is removed, do not to overtighten the screws when it is replaced. A small gap should remain between the lid and box.

6.9 Programming

Short Cut is the best source for up-to-date programming code for Campbell Scientific data loggers. If your data acquisition requirements are simple, you can probably create and maintain a data logger program exclusively with *Short Cut*. If your data acquisition needs are more complex, the files that *Short Cut* creates are a great source for programming code to start a new program or add to an existing custom program.

> NOTE:
> *Short Cut* cannot edit programs after they are imported and edited in CRBasic Editor.

A *Short Cut* tutorial is available in Short Cut (p. 3). If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in Importing Short Cut code into CRBasic Editor (p. 75). Programming basics for *CRBasic* data loggers are provided in the following section.

6.9.1 CRBasic programming

CRBasic programs can be used to read continuous data and polled data using the SET command (p. 52), SETNC command (p. 53), MSGGET command (p. 57), POLL command (p. 1)and GET command (p. 55). The program can power the CS125 hood heaters according to the dew point. A HygroVUE Air Temperature and Relative Humidity Sensor is required to provide the measurements used in the dew point calculation (refer to the HygroVue manual for information about programming the HygroVue sensor and calculating dew point).

Table 6-7 (p. 31) shows the CRBasic instructions often used in programs for the CS120A/CS125 sensor. For more information, refer to the example programs available at www.campbellsci.eu/downloads/cs125-example-programs ⬀ or www.campbellsci.eu/downloads/cs120a-example-programs. ⬀

Table 6-7: CRBasic instructions and function	
Instruction	Function
`SerialOpen()`	Opens the serial port in which the CS120A/CS125 is connected.
`SerialInRecord()`	Read in and parse a string/record from the CS120A/CS125.
`SerialOut()`	Sends **SET** or **SETNC** commands.
`SerialIn()`	Saves the data returned from the **GET** command.
`SplitStr()`	Separate the data into strings.
`CheckSum()`	Calculates the expected checksum.

7. Operations

7.1 Messages

The CS125 has 13 output message formats available. The CS120A Visibility Sensor can only output messages 0 to 2 and a limited custom message. The message format is selected from the **Message – Sub 3** menu. Refer to Menu system (p. 60) on how to set the message output format.

```
CS125 MESSAGE - SUB 3
Set the message output format.Current format is: FULL SYNOP
 - Basic = 0
 - Partial = 1
 - Full = 2
 - Basic SYNOP = 3
 - Partial SYNOP = 4
 - Full SYNOP = 5
 - Basic METAR = 6
 - Partial METAR = 7
 - Full METAR = 8
 - Generic Basic SYNOP = 9
 - Generic Partial SYNOP = 10
 - Generic Full SYNOP = 11
 - Custom output = 12
 - Vaisala FD12 = 13

 ->
```

The message fields are space delimited with a unique start and end character allowing easy storage into any data logger. The messages have the following format, where the specific fields

output depend on the message format chosen. Examples of the different message types are provided in the following sections.

Table 7-1: Message output structure									
STX	Message ID	Sensor ID	System Status	Fields		Checksum (CCITT)	ETX	Carriage return	Line feed
0x02				Fields displayed depends on the output option chosen (see the following sections)		XXXX	0x03	0x0D	0x0A

> **NOTE:**
> STX and ETX are hexadecimal command characters.

> **NOTE:**
> Refer to Example C code to calculate a CCITT CRC (p. 79) for checksum algorithm.

Details about the fields for the standard Campbell Scientific message outputs are provided in Table 7-20 (p. 42). Vaisala FD12 (p. 41) for information about output Option 13.

7.1.1 Visibility messages with examples

The following are examples of visibility only messages. The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. Refer to Table 7-20 (p. 42) for details about the fields.

Example basic format output (visibility units = M):

```
0 0 0 19837 M FC92
```

Table 7-2: Example basic format with field descriptions									
STX	Message ID	Sensor ID	System Status	Visibility distance	Units	Checksum (CCITT)	ETX	Carriage return	Line feed
0x02	0	0	0	19837	M	FC92	0x03	0x0D	0x0A

Example partial format output (message interval = 12 s; visibility units = M):

```
1 0 0 12 20405 M 0 0 EF07
```

Table 7-3: Example partial format with field descriptions

STX	Message ID	Sensor ID	System Status	Message Interval	Visibility distance	Units	User alarms	Checksum (CCITT)	ETX	Carriage return	Line feed
0x02	1	0	0	12	20405	M	0 0	EF07	0x03	0x0D	0x0A

Example full format output (message interval = 12 s; visibility units = M):

```
2 0 0 12 21793 M 1 0 0 0 0 0 0 0 0 0 0 0 0 0 CB0F
```

Table 7-4: Example full format with field descriptions

STX	Message ID	Sensor ID	System Status	Message Interval	Visibility distance	Units	Average duration	User alarm	System alarms	Checksum (CCITT)	ETX	Carriage return	Line feed
0x02	2	0	0	12	21793	M	1	0 0	0 0 0 0 0 0 0 0 0 0	CB0F	0x03	0x0D	0x0A

7.1.2 SYNOP code messages with examples

Format options 3 through 5 are similar to options 1 through 3, except they include a SYNOP code (see Table D-1 [p. 80]). **Partial SYNOP** (option 4) and **Full SYNOP** (option 5) also include present weather fields. The following are examples of the format outputs. Refer to Table 7-20 (p. 42) for details about the fields.

Example basic SYNOP format output (visibility units = M):

```
3 0 0 20428 M 0 20B8
```

Table 7-5: Example basic SYNOP fields[1]

Message ID	Sensor ID	System Status	Visibility distance	Units	SYNOP code	Checksum (CCITT)
3	0	0	20428	M	0	20B8
[1]The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. These values are not shown in this table.						

Example partial SYNOP format output (message interval = 12 s; visibility units = M):

```
4 0 0 12 21157 M 0 0 0 0.00 0 24.1 –99 5A55
```

Table 7-6: Example partial SYNOP field[1]

Message ID	Sensor ID	System Status	Message Interval	Visibility distance	Units	User alarm	Particle count	Intensity	SYNOP code	Temp.	RH	Checksum (CCITT)
4	0	0	12	21157	M	0 0	0	0.00	0	24.1	−99[2]	CB0F

[1] The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. These values are not shown in this table.

[2] The –99 value is reported when a HygroVUE temperature and relative humidity sensor is not connected to the CS125.

Example full format output (message interval = 12 s; visibility units = M):

```
5 0 0 12 20880 M 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.00 0 24.1 –99 CAFA
```

Table 7-7: Example full SYNOP fields[1]

Mess. ID	Sensor ID	System Status	Message Interval	Visibility distance	Units	Average duration	User alarm	System alarm[2]	Particle count	Intensity	SYNOP code	Temp.	RH	Checksum (CCITT)
5	0	0	12	20880	M	1	0 0	000000000 0000	0	0.00	0	24.1	−99[3]	CAFA

[1] The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. These values are not shown in this table.

[2] See System alarms (p. 44) for details.

[3] The –99 value is reported when a HygroVUE temperature and relative humidity sensor is not connected to the CS125.

7.1.3 METAR code messages with examples

Format options 6 through 8 are similar to options 3 through 5, except they include a METAR code (see Present weather codes produced by the CS125 [p. 80]). The following are examples of the format outputs. Refer to Table 7-20 (p. 42) for details about the fields.

Example basic METAR format output (visibility units = metres, no significant weather [NWS]):

```
6 0 0 20573 M 0 NSW 291A
```

Table 7-8: Example basic METAR fields[1]

Message ID	Sensor ID	System Status	Visibility distance	Units	SYNOP code	METAR code	Checksum (CCITT)
6	0	0	20573	M	0	NSW	291A

[1] The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. These values are not shown in this table.

Example partial METAR format output (60 s interval, visibility units =metres, NWS):

```
7 0 0 12 20673 M 0 0 0 0.00 0 NSW 24.2 -99 BD78
```

Table 7-9: Example partial METAR fields[1]

Message ID	Sensor ID	System Status	Message Interval	Visibility distance	Units	User alarm	Particle count	Intensity	SYNOP code	METAR code	Temp.	RH	Checksum (CCITT)
7	0	0	12	20673	M	0 0	0	0.00	0	NSW	24.2	-99[2]	BD78

[1] The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. These values are not shown in this table.

[2]The –99 value is reported when a HygroVUE temperature and relative humidity sensor is not connected to the CS125.

Example full METAR format output (60 s interval, visibility units =metres, 1-minute average, heavy rain):

```
8 9 0 60 6682 M 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 54 4.5 63 +RA 20.2 91 40A2
```

Table 7-10: Example full METAR fields[1]

Mess. ID	Sensor ID	System Status	Message Interval	Visibility distance	Units	Avg. dur.	User alarm	System alarm[2]	Particle count	Intensity	SYNOP code	METAR code	Temp.	RH	Checksum (CCITT)
8	9	0	60	6682	M	1	0 0	0 0 0 0 0 0 0 0 0 0 0 0 0	54	4.5	63	+RA	20.2	91	40A2

[1] The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. These values are not shown in this table.

[2]See System alarms (p. 44) for details.

7.1.4 Generic SYNOP code messages with examples

Format options 9 through 11 are similar to options 6 through 8, except they include a generic SYNOP code (see Present weather codes produced by the CS125 [p. 80]). The following are examples of the format outputs. Refer toTable 7-20 (p. 42) for details about the fields.

Example basic generic SYNOP format output (visibility units = metres, no significant weather [NWS]):

```
9 0 0 20481 M 0 0 NSW 73DF
```

Table 7-11: Example basic generic SYNOP fields[1]

Message ID	Sensor ID	System Status	Visibility distance	Units	Generic SYNOP code	SYNOP code	METAR code	Checksum (CCITT)
9	0	0	20481	M	0	0	NSW	73DF

[1]The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. These values are not shown in this table.

Example partial generic SYNOP format output (12 s interval, visibility units =metres, NWS):

```
10 0 0 12 20909 M 0 0 0 0.00 0 0 NSW 24.2 –99 AB02
```

Table 7-12: Example partial generic SYNOP fields[1]

Message ID	Sensor ID	System Status	Message Interval	Visibility distance	Units	User alarm	Particle count	Intensity	Generic SYNOP code	SYNOP code	METAR code	Temp.	RH	Checksum (CCITT)
10	0	0	12	20909	M	0 0	0	0.00	0	0	NSW	24.2	–99[2]	BD78

[1] The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. These values are not shown in this table.

[2]The –99 value is reported when a HygroVUE temperature and relative humidity sensor is not connected to the CS125.

Example full generic SYNOP format output (12 s interval, visibility units =metres, 1-minute average, NWS):

```
11 0 0 12 21342 M 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.00 0 0 NSW 24.3 –99 9AD6
```

Table 7-13: Example full generic SYNOP fields[1]

Mess. ID	Sensor ID	Sys. Sta.	Mess. Int.	Vis. dist.	Units	Avg. dur.	User alarm	System alarm[2]	Particle count	Intensity	Generic SYNOP code	SYNOP code	METAR code	Temp.	RH	Checksum (CCITT)
11	0	0	12	21342	M	1	0 0	000000 0000000 0	0.00	0	0	0	NSW	24.4	–99[3]	9AD6

[1] The messages start with STX (a hexadecimal command character), and end with ETX (a hexadecimal command character), carriage return, and a line feed. These values are not shown in this table.

[2]See System alarms (p. 44) for details.

[3]The –99 value is reported when a HygroVUE temperature and relative humidity sensor is not connected to the CS125.

7.1.5 Custom messages

The custom message format allows the CS120A/CS125 message to be modified to meet specific requirements. The custom message contains a fixed basic set of variables and up to 16 additional fields.

The custom message output is only available on OS7 and higher.

The custom message output format is option 12 from the **MESSAGE- SUB 3** menu.

```
CS125 MESSAGE - SUB 3
Set the message output format.Current format is: FULL SYNOP
 - Basic = 0
 - Partial = 1
 - Full = 2
 - Basic SYNOP = 3
 - Partial SYNOP = 4
 - Full SYNOP = 5
 - Basic METAR = 6
 - Partial METAR = 7
 - Full METAR = 8
 - Generic Basic SYNOP = 9
 - Generic Partial SYNOP = 10
 - Generic Full SYNOP = 11
 - Custom output = 12
 - Vaisala FD12 = 13


 ->
```

The following is the custom message format:

Table 7-14: Custom format descriptions									
STX	Message ID	Unit ID	System Status	Message interval	Visibility distance	Visibility unit	Up to 16 custom fields	Checksum (CCITT)	EOT
0x02	12							XXXX	0x04

Custom messages are configured either using data logger commands (MSGSET command [p. 54] and MSGSET command [p. 54]) or using the user menu system. The following is the procedure for configuring the custom message by using the user menu:

1. Enter the sensor menu system (see Menu system (p. 60)).

2. Go to the **MESSAGE - MENU 1** and select option 7 to the accesses **MESSAGE SUB 4** menu.

```
WELCOME TO THE CAMPBELL SCIENTIFIC LTD CS125 SETUP MENU
  ID 0
  S/N 1009
  (1) Message output menu
  (2) User alarm menu
  (3) Communications setup
  (4) System information
  (5) System configuration
  (6) Calibration

  (9) Exit and save
  (0) Exit and don't save
```

3. Type the number corresponding to the desired message field then press Enter.

```
CS125 MESSAGE - SUB 4
  Configure the message output format:
    1 - Averaging duration = 0
    2 - User alarms = 0
    3 - System alarms = 0
    4 - Dirty windows values = 0
    5 - Sensor serial number = 0
    6 - Particle count = 0
    7 - Intensity = 0
    8 - Accumulation = 0
    9 - Generic SYNOP = 0
    10 - SYNOP code = 0
    11 - METAR code = 0
    12 - NWS code = 0
    13 - Temperature (Degrees C) = 0
    14 - Humidity (%) = 0
    15 - 10 minute ave. vis. = 0
    16 - Special 1 = 0
    17 - One second vis = 0
    18 - Past SYNOP = 0
    19 - EXCO = 0
  Or, choose 0 to exit when done.

    ->0
```

4. Repeat for each message field.

5. Type 0 when all fields have been selected.

6. Type 9 and press enter to **Exit and save**.

Example

The following example selects options 1, 3, 4, 10, 15 and 17 to include averaging duration, system alarms, dirty windows values, SYNOP code, 10 minute average visibility, and 1 sec visibility in the custom message.

The following is the example output:

```
12 0 0 10 92 M 1 000000000000 2 0 30 92 135 88EF
```

Table 7-15: Custom format descriptions

STX	Message ID	Unit ID	System Status	Message interval	Visibility distance	Visibility unit	Up to 16 custom fields	Checksum (CCITT)	EOT	Carriage return	Line feed
0x02	12	0	0	10	92	M	1 000000000000 2 0 30 92 135	88EF	0x04	0x0D	0x0A

The custom fields are:

1 = 1 minute averaging duration

000000000000 = system alarms not set

2 = 2% contamination for emitter reading

0 = 0% contamination for detector reading

30 = SYNOP code

92 = 92 m , 10-minute-average visibility

135 = 135 m, 1-second visibility

Table 7-16: Custom output values

Field	Description	Number of values output
1	Averaging duration	1
2	User alarms	2
3	System alarms	12
4	Dirty windows values, as percentages, emitter followed by detector	2
5	Sensor serial number	1
6	Particle count[1], particles in the previous minute	1
7	Intensity[1], mm/hr	1
8	Accumulation [1,2]	1
9	Generic SYNOP code[1]	1
10	SYNOP code[1]	1
11	METAR code[1]	1
12	NWS code[1]	1

Table 7-16: Custom output values		
Field	Description	Number of values output
13	Temperature (°C)[1]	1
14	Humidity (%) [1,3]	1
15	Visibility averaged over the last 10 minutes	1
16	Special 1 (reserved)	1
17	One second visibility[4]	1
18	Past SYNOP	1
19	EXCO	1

[1] These options are only available with a CS125.

[2] This increments to 999.99 mm before resetting to zero. It may be reset to zero at any time with the ACCRES command.

[3] Only outputs a valid value when a HygroVUE temperature and humidity probe is connected.

[4] The 1 second visibility output is provided for special applications and research purposes only. This output will have increased noise levels especially at high visibilities.

7.1.6 Vaisala FD12

Example Vaisala FD12 emulation format output:

```
FD 0 00 10558 10484 /// // /////
```

Table 7-17: Example Vaisala FD12 message 2 emulation with field descriptions												
SOH	FS11 sensor ID	Unit identifiers	STX	Data status and hardware status	MOR 1 minute	MOR 10 minute	Reserved	Reserved	Reserved	EOT	Carriage return	Line feed
0x01	FD	0	0X02	00	10558	10484	///	//	/////	0X03	0x0D	0x0A

Example Vaisala FD12 emulation format output with an alarm flagged (see :

```
FD 0 02 9563 9549 /// // /////
```

Table 7-18: Example Vaisala FD12 message 2 emulation with field descriptions and alarm flag												
SOH	FS11 sensor ID	Unit identifiers	STX	Data status and hardware status	MOR 1 minute	MOR 10 minute	Reserved	Reserved	Reserved	EOT	Carriage return	Line feed
0x01	FD	0	0X02	02	9563	9549	///	//	/////	0X03	0x0D	0x0A

Table 7-19: Alarm emulation from CS125 to Vaisala FD12	
CS125 status level	Vaisala FD12 emulated alarm level
0	0
1	2
2	2
3	1

7.1.7 Field descriptions for output messages

Table 7-20: Campbell Scientific output message field descriptions		
Field	Range	Description
Message ID	0 to 13	0. Basic format; only visibility distance and system information. 1. Partial format adds user alarms to option 0 2. Full format adds user alarms and system alarms to option 0 3. Basic SYNOP format; adds SYNOP code to option 0[1]. 4. Partial SYNOP format; adds SYNOP code and present weather values to option 1[1]. 5. Full SYNOP format; adds SYNOP code and present weather values to option 2[1] 6. Basic METAR format; adds METAR code to option 3[1]. 7. Partial METAR format; adds METAR code to option 4[1]. 8. Full METAR format; adds METAR code to option 5[1]. 9. Generic basic SYNOP format; adds generic SYNOP code to option 6[1]. 10. Generic partial SYNOP format; adds generic SYNOP code to option 7[1]. 11. Generic full SYNOP format; adds generic SYNOP code to option 8[1]. 12. Custom messages (p. 38). 13. Vaisala FD12 (p. 41) .
Sensor ID	0 to 9	Unit number defined by the user to identify data; default is 0. Useful for RS-485 networks. Operates as an address in RS-485 mode.

Table 7-20: Campbell Scientific output message field descriptions		
Field	**Range**	**Description**
System status	0 to 3	0. No fault 1. Possible degraded performance 2. Degraded performance 3. Maintenance required
Message interval	0 to 36000	The amount of time, in seconds, between outputs in continuous mode.
Visibility distance	0 to 75000 m	Current visibility distance being detected by the sensor.
Visibility units	M or F	M. metres F. feet
Averaging duration[2]	1 or 10	1. One-minute average 10. Ten-minute average
User alarms	0 or 1	The sensor outputs two user alarm values (one for each user alarm). 0. User alarm not active 1. User alarm active
System alarms (p. 1)	Format option 2 outputs 10 error code values. The other full format options output 12 error code values	
Particle count[1]	0 to 7200; or –99	Number of particles per minute; –99 indicates a sensor error or that the sensor has been powered less than one minute.
Intensity[1]	0 to 999.99 mm/hr; or –99	One precision value of the last minutes rainfall intensity (mm/hr); –99 indicates a sensor error or that the sensor has been powered less than one minute.
Generic SYNOP code[1]	See Table D-1 (p. 80)	Simplified, generic present weather codes, which may be required for some data collection systems.
SYNOP code[1]	See Table D-1 (p. 80)	
METAR code	See Table D-2 (p. 83)	
Temperature[1]	–40.0 to +80.0 °	External temperature in degrees Celsius

Table 7-20: Campbell Scientific output message field descriptions		
Field	Range	Description
Relative humidity[1]	0 or 100%; or –99	Only outputs a valid external relative humidity (%RH) value if a HygroVUE temperature and relative humidity sensor is connected to the CS125. The sensor will output –99 if a HygroVUE is not connected. The sensor will also output –99 is there is a fault
Checksum	Refer to Example C code to calculate a CCITT CRC (p. 79) for the checksum algorithm.	

[1]Only available for the CS125 present weather sensor.

[2]In accordance with WMO requirements, the sensor produces visibility measurement, that are either one-minute or ten-minute rolling averages that are updated at the chosen output interval or when the sensor is polled. Those averages are not direct averages of MOR measurements but are averages of the extinction coefficient and that average is then used to calculate the MOR for that period. As the relationship between the extinction coefficient and MOR is not linear, it is possible to see quite rapid changes in MOR that might not be expected if the result was a rolling average of MOR. Take this into consideration, especially when testing the sensor with artificial obscurants or using the calibration disk.

7.1.8 System alarms

Full format options report system error alarms (Table 7-21 [p. 45]). Most errors are checked every 10 seconds, then the message output is updated. The following errors are checked at a different rate:

- Signature error—checked and reset at power up.

- Flash read and write errors—checked when flash memory is updated (for example, when changes are made through the memory structure). These errors are also reset on power up.

- Particle limit—checked every minute and reset when read.

Table 7-21: System alarms and descriptions		
Alarm	Range	Description
Emitter failure (emitter hoods main LED output power level)	0 to 2	0. Everything is within normal parameters 1. Light output level too low 2. Light output level too high
Emitter lens dirty[1]	0 to 3	0. OK; the reported attenuation is below 10% 1. Reported window signal value out of range (>30%); possible sensor fault or blocked hood 2. Slight dirt build up (10% signal attenuation or higher) 3. High level of dirt build up (>20%)
Emitter temperature	0 to 3	0. Temperature within operating conditions 1. Too low, less than −40 °C 2. Too high, over 80 °C 3. No sensor detected or below −54 °C
Detector lens dirty[1]	0 to 3	0. OK; the reported attenuation is below 10% 1. Reported window signal value out of range (>30%); possible sensor fault or blocked hood 2. Slight dirt build up (10% signal attenuation or higher) 3. High level of dirt build up (>20%)
Detector temperature	0 to 3	0. Temperature within operating conditions 1. Too low, less than −40 °C 2. Too high, over 80 °C 3. No sensor detected or below −54 °C
Detector DC saturation level (amount of background light seen by the detector hood) [1]	0 or 1	0. Within limits 1. Saturated; the sensor may not be able to perform visibility readings in some circumstances, possibly due to high level of reflections into the detector.
Hood temperature	0 to 3	0. Temperature within operating conditions 1. Too low, less than −40 °C 2. Too high, over 80 °C 3. No sensor detected or below −54 °C

Table 7-21: System alarms and descriptions		
Alarm	Range	Description
External temperature[2]	0 to 3	0. Temperature within operating conditions 1. Too low, less than –40 °C 2. Too high, over 80 °C 3. No sensor detected or below –54 °C
Signature error	0 to 4	0. No fault 1. OS signature error at power up 2. User memory signature did not match when last reading 3. User memory fault at power up; secondary copy was reinstated to correct error. 4. User memory fault at power up; no secondary copy was found to reinstate. Factory defaults have been reinstated. System will need re-calibrating.
Flash read error	0 or 1	0. No errors 1. One or more errors reading user variables from flash occurred
Flash write error	0 or 1	0. No errors 1. One or more errors writing user variables to flash occurred
Particle limit[2]	0 or 1	0. No errors 1. More particles detected than can be processed
[1]With operating system 14 onwards, to avoid short term appearance of alarms caused by transient events, such as insects or raindrops on the lens, the condition that triggers an increase in alarm level must persist for 15 minutes before the alarm is set.		
[2]CS125 only. Error code is only reported in format options 5, 8, 11, and 12.		

7.2 Interface methods

The sensor can be set up and controlled in one of three ways. The first method is by using Campbell Scientific *Device Configuration Utility* software, which is available as a download on www.campbellsci.eu. It is included in installations of *LoggerNet*, *RTDAQ*, and **PC400**. This software allows an easy menu driven interface for configuring the sensor on any Microsoft™ based personal computer. All settings can be accessed using this program.

The program includes online help instructions that describe its general use with the sensor and also how to load an operating system. The **Device Configuration Utility** can also be used as a terminal emulator to use the builtin menu system of the sensor and to access its calibration menu. The second method is by using the command line interface where discrete commands are sent without response from the sensor. This would be the preferred method of setting up a sensor if it was connected to a logger for instance. The configuration setting commands can be sent via a logger to the sensor removing the need for a local computer to set up the unit.

The third method is by using the simple menu interface built into the sensor communicating via RS-232 or RS-485, using a terminal emulator program. This menu system gives access to the more common settings.

All three of these methods use the sensor serial connector B to communicate with the sensor. This can be via the normal communications cable or a configuration cable as described in .

7.3 Configuring computer

This section describes setting up communications using a terminal emulator program. The terminal emulators built into many Campbell Scientific software products such as **LoggerNet** can also be used.

The following settings should then be used by default:

Bits per second: 38400

Data bits: 8

Parity: none

Stop bits: 1 Flow control: none

> **NOTE:**
> After adjusting the baud rate of the unit, use the terminal emulator to adjust the bits per second value in the port settings. The CS120A/CS125 can not communicate with the computer if the unit and port setting baud rates differ.

The CS120A/CS125 should now be ready to accept commands.

The CS120A/CS125 can be set to the default communication state using an internal switch on the sensor main board (see).

7.4 Variable definitions

Both the *Device Configuration Utility* and the command line interface can access all the user configurable variables within the sensor. The following lists the acceptable range and the identification number for these variables along with a short description.

Table 7-22: User definable settings and descriptions				
ID	**Name**	**Range**	**Description**	**Factory default**
1	Sensor ID	0 to 9	Separate ID used as an extra identifier for a particular sensor on a network.	0
2	User alarm 1 enabled	0 or 1	User alarm 1 activation state 0. Alarm 1 disabled 1. Alarm 1 enabled	0
3	User alarm 1 active	0 or 1	0. Check if distance is less than user alarm 1 distance (see next row) 1. Check if distance is greater than user alarm 1 distance (see next row)	0
4	User alarm 1 distance	0 to 60000	Distance value that alarm 1 will trigger against (see previous row). The units of this value is set the visibility unit variable.	10000
5	User alarm 2 enabled	0 or 1	User alarm 2 activation state 0. Alarm 1 disabled 1. Alarm 1 enabled	0
6	User alarm 2 active	0 or 1	0. Check if distance is less than user alarm 2 distance 1. Check if distance is greater than user alarm 2 distance	0
7	User alarm 2 distance	0 to 60000	Distance value that alarm 2 will trigger against. The units of this value is set the visibility unit variable	10000

ID	Name	Range	Description	Factory default
			Table 7-22: User definable settings and descriptions	
8	Baud rate	0 to 6	Baud rate for the main RS-232/RS-485 interface 0. 115200 bps 1. 57600 bps 2. 38400 bps 3. 19200 bps 4. 9600 bps 5. 2400 bps 6. 1200 bps	2
9	Serial number		Internal serial number for the sensor (read only)	
10	Visibility unit	M or F	Unit the visibility value will be presented as: M. metres F. feet	M
11	Message interval	1 to 36000	Interval, in seconds, between outputs in continuous mode (see next row). This value has no effect if polled mode has been selected as the measurement mode.	
12	Measurement mode	0 or 1	Selects polled or continuous modes. In continuous mode the sensor outputs a string in the format as set by the message format at regular intervals as defined by the message interval (see previous row). 0. Continuous mode 1. Polled mode	0

Table 7-22: User definable settings and descriptions				
ID	Name	Range	Description	Factory default

13	Message format	0 to 12	Output message:
			
			  0, 1, or 2. Basic, partial, or full visibility messages
			  3, 4, or 5. Basic, partial, or full SYNOP messages
			  6, 7, or 8. Basic, partial, or full METAR messages
			  9, 10, or 11. Generic basic, partial or full SYNOP messages
			  12. Custom message
				5

14	Serial port protocol	0 or 1	Selects the physical serial interface: 0. RS-232 mode 1. RS-485 mode	0
15	Averaging period	1 or 10	The time period (in minutes) that the visibility measurement is averaged over.	1
16	Sample timing	0 to 60	Defines the interval (in seconds) between sampling the volume. Typically ,this value should be 1, except when low power demands are needed. The 1 s sample timing is required for the present weather measurement.	1
17	Dew heater override	0 or 1	0. Allows automatic control the dew heaters 1. Turns the dew heaters off	0
18	Hood heater override[1]	0 or 1	0. Allows automatic control the hood heaters 1. Turns the hood heaters off	0
19	Dirty window compensation	0 or 1	0. No compensation applied 1. Applies compensation for dirt on lenses. Up to 10% signal loss due to dirt per lens. will be compensated	0

ID	Name	Range	Description	Factory default
20	Use CRC-16	0 or 1	0. Disable command line CRC-16 checking[2] 1. Enable command line CRC-16 checking. This does not affect communications using the *Device Configuration Utility* or terminal emulator.	0
21	Sensor power down voltage	7 to 30	PSU input voltage level below which the sensor will enter low power mode. This protects the batteries.	7.0
22	Relative humidity threshold[3]	1 to 99	Threshold at which the sensor will define obscuration as liquid or dry if a HygroVUE sensor is attached.	80%
23	Data format[4]	0 or 1	0. 8 bit, no parity 1. 7 bit, even parity	0

[1]Hood heater override needs to be set to '1' (off) when either no hood heaters are installed or the hood heaters have no power connected to them. This will save power as the relay is not enabled at low temperatures in this mode.

[2]If disabled the sensor does not check the validity of received data against the checksum sent. It is, however, recommended that checksum checking is enabled to remove any chance of the sensor being configured incorrectly by accident.

[3]CS125 only.

[4] The data format variable was added to OS 16. CS120A/CS125 with an operating system that preceded OS16 uses only the 0 bit, no partity data format.

7.5 Command line mode

The command line interface includes three major commands. These are **GET**, **SET** and **POLL**. The **GET** command is used to request all current user settable values from the CS120A/CS125. The **SET** commands sets user settable values, and the **POLL** command is used to request the current visibility and/or alarm conditions from the sensor.

The CS120A/CS125 can be configured to expect any commands sent to it to include a valid checksum. For simple commands such as **GET** and **POLL**, fixed value checksums can be used. For more complex **SET** commands, the checksum needs to be calculated. The use of the checksum is disabled by default. Campbell Scientific recommends enabling the checksum functionality, especially when long cable runs are used, or in electronically noisy environments. Example C

code to calculate a CCITT CRC (p. 79) provides example code for programmers implementing their own code. For Campbell Scientific data logger users, downloadable example programs are available at www.campbellsci.eu/downloads/cs125-example-programs ⬈ or www.campbellsci.eu/downloads/cs120a-example-programs ⬈

7.5.1 SET command

The **SET** command is used to configure the CS120A/CS125 using the command line. The **SET** command is a single space delimited string that can be sent from any data logger or computer equipped with an RS-232 or RS-485 port. The **SET** command accesses identical settings within the CS120A/CS125 and *Device Configuration Utility*. This command is used to change the default power up state of the sensor. The `Set` command is echoed back.

Example of a **SET** command:

```
SET:0:0 1 1 1000 1 0 15000 2 0 M 60 1 2 0 1 1 0 0 0 1 7 70 0 :8AB9:
```

Table 7-23: SET transmitted

Example	Description
0x02[1]	STX^ B[2]
SET	Set command
:	Delimiting character
0	Current sensor ID
:	Delimiting character
0	Sensor ID (may be a new ID)
1	User alarm 1 set (1=set)
1	User alarm 1 active (1=active)
1000	User alarm 1 distance
1	User alarm 2 set (1=set)
0	User alarm 2 active (0=not active)
15000	User alarm 2 distance
2	Serial baud rate (2 = 38400 bps)
0	Sensor serial number (read only)
M	Visibility units (M=metres)

Table 7-23: SET transmitted	
Example	Description
60	Continuous mode output interval (60 s)
1	Polling or continuous modes (1 =polling mode)
2	Message format, Basic/Partial/Full (2 = Full)
0	RS-232 or RS-485 serial communications enabled (0 = RS-232)
1	Averaging period (1 minute)
1	Sample timing (1 sample per second)
0	Dew heater override (0 =sensor automatically controls the dew heaters)
0	Hood heater override (0 =sensor automatically controls the hood heaters)
0	Dirty window compensation (0 = dirty window compensation turned off
1	CRC checking on received commands (1= CRC-16 checking enabled)
7	Sensor power down voltage
70	Relative humidity threshold[3]
0	Data format and parity (0=8 bit, no parity)
:	Delimiting character
8AB9	Checksum (use the valid CCITT checksum)
:	Delimiting character
0x03[1]	ETX ^ C[2]
0x0D[1]	Carriage return
0x0A	Line feed
[1]These values are shown in hexadecimal format not ASCII.	
[2]As entered on a keypad	
[3]CS125 only.	

7.5.2 SETNC command

The format of the **SETNC** command is the same as the **SET** command except it starts with **SETNC**. The only functional difference is that the **SETNC** command does not commit the values set into flash memory. This means that the next time the CS120A/CS125 is power cycled, it will

revert back to its previous settings. This command should be used when a setting in the sensor is changed regularly, such as heater functions, because this command avoids the risk of wearing out the flash storage memory.

> **NOTE:**
> This includes communication data rates as well.

Example SETNC command:

```
SETNC:0:0 1 1 1000 1 0 15000 2 0 M 60 1 2 0 1 1 0 0 0 1 7 80:68A3:
```

7.5.3 MSGSET command

The user customizable message format can be configured using the **MSGSET** command. When a valid **MSGSET** command is issued, the sensor sends a **MSGGET** response.

Example of a **MESGSET** command and the echoed reply:

```
MSGSET:0:121C:9794:
121C 7067
```

Table 7-24: MSGSET command transmitted data descriptions

Example	Descriptions
0x01(Hex)	SOH
:	Delimiting character
MSGSET	MSG SET
:	Delimiting character
0	Sensor ID
:	Delimiting character
121C	HEX value is the sum of all the required fields (see Table 7-25 [p. 55]).
:	Delimiting character
9794	Checksum
:	Delimiting character
0x04(Hex)	EOT

Table 7-25: Description of custom message bits	
Bit	Description
8000	*Reserved*
4000	*Reserved*
2000	Humidity (%)[1,2]
1000	Temperature (° C)[1]
0800	NWS code[1]
0400	METAR code[1]
0200	SYNOP code[1]
0100	Generic SYNOP[1]
0080	Accumulation[1]
0040	Intensity[1]
0020	Particle count[1]
0010	Sensor serial number
0008	Dirty windows values
0004	System alarms
0002	User alarms
0001	Averaging duration
[1]Only available if using a CS125.	
[2]Only available if a HygroVUE sensor is connected.	

The hex value is the hexadecimal sum of the hex values of the chosen fields. The **MSGSET** example use a **MSGSET**

message to set a CS125 to output temperature, SYNOP code, sensor serial number, dirty windows values and system alarms. The calculated HEX value is 121C.

7.5.4 GET command

The **GET** command retrieves settings data from the CS120A/CS125, including message format data and user alarm settings amongst others. This command does not retrieve visibility or environmental information from the CS120A/CS125. To retrieve visibility data refer to the **POLL** command.

Example of a **GET** request:

```
GET : 0 : 0 : 2C67 :
```

Table 7-26: GET command transmitted data	
Example	Description
0x02[1]	STX
GET	GET command
:	Delimiting character
0	Address based on sensor ID
:	Delimiting character
0	Reserved for future use; zero default
:	Delimiting character
2C67	Checksum
:	Delimiting character
0x03[1]	ETX
0x0D[1]	Carriage return
[1] These values are shown in hexadecimal format not ASCII.	

Example data returned by the **GET** command:

```
GET : 0 : 0 : 2C67 :
0 1 1 1000 1 0 15000 2 32000 M 60 1 2 0 1 1 0 0 0 1 7.0 80 0 CC8D
```

Table 7-27: GET command returned data	
Example	Description
0x02[1]	STX
0	Sensor ID
1	User alarm 1 set (1 = set)
1	User alarm 1 active (1 = active)
1000	User alarm 1 distance
1	User alarm 2 set (1 = set)
0	User alarm 2 active (0 = not active)

Table 7-27: GET command returned data	
Example	Description
15000	User alarm 2 distance
2	Serial baud rate (2 = 38400 bps)
32000	Sensor serial number (read only)
M	Visibility units (M = metres)
60	Continuous mode output interval (60 s)
1	Polling or continuous modes (1 =polling mode)
2	Message format, Basic/Partial/Full (2 = Full)
0	RS-232 or RS-485 serial communications enabled (0 = RS-232)
1	Averaging period (1 minute)
1	Sample timing (1 sample per second)
0	Dew heater override (0 =sensor automatically controls the dew heaters)
0	Hood heater override (0 =sensor automatically controls the hood heaters)
0	Dirty window compensation (0 = dirty window compensation turned off)
1	CRC checking on received commands (1= CRC-16 checking enabled)
7.0	Sensor power down voltage
80	Relative humidity threshold (only for CS125 with a HydroVUE sensor attached)
0	Data format and parity (0=8 bit, no parity)
CC8D	Checksum
0x04[1]	EOX
0x0D[1]	Carriage return
0x0A	Line feed
[1] These values are shown in hexadecimal format not ASCII.	

7.5.5 MSGGET command

The Message Get (**MSGGET**) command retrieves the current settings of the custom message from the sensor.

Example of a **MESGGET**command and the echoed reply:

```
MSGGET:0:0:C6ED:
161C 7067
```

Table 7-28: MSGGET command transmitted data descriptions

Example	Descriptions
0x01[(Hex)]	SOH
:	Delimiting character
MSGGET	MSG GET
:	Delimiting character
0	Address based on sensor ID
:	Delimiting character
0	Payload
:	Delimiting character
C6ED	Checksum
:	Delimiting character
0x04[(Hex)]	EOT

7.5.6 Poll command

The **POLL** command requests the current visibility and/or alarm conditions from the CS120A/CS125. The output format of this command depends on how the CS120A/CS125 is configured using the **SET** command or the menu interfaces.

Example of a **POLL** request:

```
POLL : 0 : 0 : 3 A3B:
```

Table 7-29: POLL transmitted data

Example	Description
0x02[1]	STX ^B[2]
POLL	POLL command
:	Delimiting character
0	Address based on sensor ID
:	Delimiting character

Table 7-29: POLL transmitted data	
Example	Description
0	Reserved for future use; zero default
:	Delimiting character
3A3B	Checksum[2]
:	Delimiting character
0x03[1]	ETX ^C[2]
0x0D[1]	Carriage return
0x0A	Line feed
[1] These values are shown in hexadecimal format not ASCII.	
[2] As entered on a keypad.	
[3]Not case sensitive.	

If the setting to check the checksum on received commands is enabled the checksum varies with the Sensor ID value. The following table gives the POLL command for different sensor IDs with the correct checksum.

Table 7-30: POLL commands for different sensor IDs	
ID	POLL command with checksum
0	POLL:0:0:3A3B:
1	POLL:1:0:0D0B:
2	POLL:2:0:545B:
3	POLL:3:0:636B:
4	POLL:4:0:E6FB:
5	POLL:5:0:D1CB:
6	POLL:6:0:889B:
7	POLL:7:0:BFAB:
8	POLL:8:0:939A:
9	POLL:9:0:A4AA:

7.5.7 ACCRES command

If accumulation is included in a custom message, the **ACCRES** command resets the accumulation to zero.

Example of a **ACCRES** command and the echoed reply:

ACCRES:2:0:3A68:

Table 7-31: ACCRES command transmitted data

Example	Description
0x02[1]	STX^ B[2]
ACCRES	**ACCRES** command
:	Delimiting character
2	Address based on sensor ID
:	Delimiting character
0	Reserved for future use, zero default
:	Delimiting character
3A68	Checksum
:	Delimiting character
0x03[1]	ETX ^ C[2]
0x0D[1]	Carriage return
0x0A	Line feed

[1]These values are shown in hexadecimal format not ASCII.

[2]As entered on a keypad

> **NOTE:**
> If the setting to check the checksum on received commands is enabled, the checksum will vary with the Sensor ID value.

7.6 Menu system

When connected to the CS120A/CS125, the user can enter the menu system by typing **open id** in their terminal program then pressing the return key on their keyboard. The ID corresponds to the

sensor ID number. The sensor ID number can be in the range of 0 to 9. The factory default is 0.

> **NOTE:**
> The **open 0** command is not normally echoed. The terminal menu only gives access to more common settings.

The following text will now be displayed:

```
WELCOME TO THE CAMPBELL SCIENTIFIC LTD CS125 SETUP MENU
  ID 0
  S/N 1009
  (1) Message output menu
  (2) User alarm menu
  (3) Communications setup
  (4) System information
  (5) System configuration
  (6) Calibration

  (9) Exit and save
  (0) Exit and don't save
```

The displayed options are accessed by typing the corresponding number then pressing Enter. No changes will take effect until you **Exit and Save**. The exception to this is the calibration menu, but you will be informed before any changes are made.

Type **1** to open the message menu containing settings relating to the CS120A/CS125 outputs.

Menu 1: Message output:

```
CS125 MENU 1
  ID 0
  S/N 1009
  (1) Toggle message format: FULL
  (2) Toggle units: cd/m2

  (3) Toggle polled or continuous mode:CONTINUOUS
  (4) Set continuous mode output interval: 6 second(s)
  (5) Toggle output averaging period: 1 minute(s)
  (6) Sampling interval: 1 second(s)

  (9) Refresh
  (0) Return to main menu
```

While in **Message – menu 1**, type 1 to set the message format. When the following options appear, type the appropriate number to set the required message format. The messages are described in more detail in Messages (p. 32).

> **NOTE:**
> The CS120A Visibility Sensor can only output messages 0 to 2 and a limited custom message.

```
CS125 MESSAGE - SUB 3
Set the message output format.Current format is: FULL SYNOP
  - Basic = 0
  - Partial = 1
  - Full = 2
  - Basic SYNOP = 3
  - Partial SYNOP = 4
  - Full SYNOP = 5
  - Basic METAR = 6
  - Partial METAR = 7
  - Full METAR = 8
  - Generic Basic SYNOP = 9
  - Generic Partial SYNOP = 10
  - Generic Full SYNOP = 11
  - Custom output = 12
  - Vaisala FD12 = 13

  ->
```

While in **Message - sub 3**, typing **2** will toggle the units through the options (metres and feet) and typing **4** will allow the message interval to be entered.

In **Setup**, typing 2 allows the user alarms to be set, again by toggling through options or changing values.

Menu 2: User alarm:

```
CS125 ALARM MENU 2
  ID 0
  S/N 1009
  (1) Toggle user alarm one: DISABLED
  (2) Toggle alarm one threshold: LESS THAN
  (3) Set new user alarm one activation point: 10000 m
  (4) Toggle user alarm two: DISABLED
  (5) Toggle alarm two threshold: LESS THAN
  (6)Set new user alarm two activation point: 10000 m

  (9) Refresh
  (0) Return to main menu

  ->
```

Menu 3: Calibration

```
CS125 CALIBRATION MENU 3
  ID 0
  S/N 1003
  (1) Perform calibration
  (2) Restore the factory calibration
  (3) Perform dirty windows zero offset calibration
  (4) Restore dirty windows factory calibration

  (9) Refresh
  (0) Return to main menu


  ->
```

Refer to Visibility calibration (p. 66)) for information on how to calibrate the sensor.

While in **Setup**, typing 4 opens the systems information menu containing useful information such as temperature and system alarms.

Calibration value factory offset and **Calibration value factor scale** are the factory calibration coefficients from the last factory calibration. **Calibration value cal offset** and **Calibration value cal scale** are the calibration coefficients from the latest calibration.

Menu 4: Information

```
CS120A/CS125 INFORMATION MENU 4
  ID 0
  S/N E1007
  OS version:007646v14

                                   Alarm     Value
  - Last visibility reading:         –        14899m
  - Overall system status:           0        No faults
  - Emitter dirty window alarm:      0        0%
  - Emitter internal temperature:    0        27.6
  - Detector dirty window alarm:     0        0%
  - Detector internal temperature:   0        25.1
  - Detector DC light saturation:    0        –
  - Hood heater temperature:         0        20.3
  - CS125 Calibrator Serial No:      –        2000
  - CS125 Calibrator EXCO:           –        23.7
  - Calibration value factory offset: –       0.031
  - Calibration value factory scale: –        0.02493
  - Calibration value cal. offset:   –        0.031
  - Calibration value cal scale:     –        0.02493
  - Signature fault:                 0        –
```

```
 - Flash write errors:                       0         0
 - Flash read errors:                        0         0
 - Supply voltage:                           <7.0V     12.4V
 - Aux supply voltages:                       +5V=5.0  -5V=-5.1 +6V=5.9
 - External temperature:                      0         22.2
 - Present weather mode enabled
 - TMOR mode disabled

 (8) Get debug
 (9) Refresh
 (0) Return to main menu

   ->
```

If the dirty window alarm is set, clean the sensor as described in Cleaning (p. 73). If there is a flash error or signature error, contact Campbell Scientific.

The aux supply voltages are internal 5 volt and 3 volt supplies. They should be between 4.5 and 5.5 and 2.7 and 3.3 volts respectively.

MENU 5 is the communications menu. This is used to set baud rates and the mode of operation (RS-232/RS-485).

> **NOTE:**
> No change will take effect until you **Exit and Save**.

Menu 5: Communications:

```
CS125 COMMUNICATIONS MENU 5
  ID 0
  S/N 1009
  (1) Set sensor ID
  (2) Set RS232/RS485 baud rate: 38400
  (3) Toggle RS232/RS485 modes: RS232

  (9) Refresh
  (0) Return to main menu

  ->
```

Menu 6 Configuration

```
CS125 CONFIGURATION - MENU 6
ID 0
S/N E1007
(1) Dew heater:                   AUTOMATIC
(2) Hood heater:                  AUTOMATIC
(3) Dirty window compensation:    COMPENSATED
(4) Command line CRC Checking:    DO NOT CHECK
(5) Sensor power down voltage:    7.0V
(6) RH threshold:                 80%
```

```
(7) Toggle patchy fog:             ON
(8) Toggle status LED:             AUTOMATIC
(10) Set hood heater ON above:     15
(11) Set hood heater OFF below:    25


(9) Refresh
(0) Return to main menu


->
```

Configuration - menu 6 sets dew and hood heaters to automatic or off, dirty window compensation and CRC-16 checking. In addition, it allows the **Sensor power down voltage** to be set. If set, this will put the sensor into a low power state (which will not make measurements) before the battery voltage has fallen low enough to damage a back-up battery.

The RH threshold for a CS125 can also be set from **Configuration**. This applies if a HygroVUE sensor is attached and defines the level of RH below which obscuration is deemed to be dry (for example, haze, SYNOP 04, or 05, METAR HZ) rather than wet (for example, mist, SYNOP 10, METAR BR or fog, SYNOP 30, or METAR FG).

The default for patchy fog is ON, which include BCFG in the message outputs. If patchy fog is toggled to OFF, the message output will not include BCFG. Sometimes it is preferable to not output BCFG for some aviation systems.

Menu 8 is reserved for future use.

Typing 10 or 11 in **Configuration** allows the user to manually set the temperatures at that the hood heaters turn on and off. These values are not normally changed, as they are set to reduce the chances of icing in bad weather conditions and dew formation on the lenses.

In **Setup**, type 9 or 0 to exit from the menu system.

> CAUTION:
> Typing 0 will lose all changes made including communications settings.

7.7 Calibration

7.7.1 Visibility calibration

The sensor can be checked and adjusted using the optional sensor high grade calibration kit. The calibration must be run using the menu system. Campbell Scientific *Device Configuration Utility* program includes a terminal emulation screen that allows access to the onboard menu. The calibration procedure requires a sensor calibrator disk and a computer with a standard serial port compatible with the sensor. If your sensor is not configured for RS-232 communications, switch internal switch 3 to ON, which sets the sensor communications port to RS-232 with a 38400 bps baud rate (see Internal switches [p. 29]). If the sensor is already set to the RS-232 mode, the internal switch does not need to be changed.

> **NOTE:**
> Ideally perform the test in the following conditions:
>
> - Ambient temperature: 0 to 50 °C
>
> - Local visibility: approximately 10,000 m or higher.
>
> - The system is self-regulating. However, it is recommended that the sensor is calibrated at least every two years.

1. Clean lenses using pure alcohol or diluted detergent and a lint free cotton cloth. Refer to the Cleaning (p. 73) for more information. A simple visual check may be enough to confirm the lenses are clean.

2. Connect computer with *Device Configuration Utility* software to the RS-232 or Micro USB port on the data logger. Select the **Terminal** tab. Press Enter twice for the prompt (for example, **CR1000x>**). Type P and press Enter. Type the CS120A/CS125 serial port and press Enter.

3. Type **open 0** and press Enter to access the CS120A/CS125 **Setup Menu**.

4. Type 3 and press enter for the **Calibration Menu**.

```
CS125 CALIBRATION MENU 3
  ID 0
  S/N 1003
  (1) Perform calibration
  (2) Restore the factory calibration
  (3) Perform dirty windows zero offset calibration
  (4) Restore dirty windows factory calibration

  (9) Refresh
  (0) Return to main menu

  ->
```

5. Select option 1 to start the calibration process. When prompted, type Y to perform a calibration. Please note, after typing Y, the calibration process can not be exited until the test is complete. However, power cycling the unit at this point will have no adverse effect on the sensor.

```
Do you want to perform a calibration Y/N?
```

> **NOTE:**
> A confirmation is included at each calibration step to correct typing mistakes. Pressing Enter is not required after typing **y**.

6. When prompted, type the sensor calibrator serial number and extinction coefficient (EXCO) with a confirmation at each step.

> **NOTE:**
> Do not type the E at the beginning of the calibration disk serial number.

```
Do you want to perform a calibration (Y/N)? Y
Starting calibration.
Input the calibration disk serial number ->2000
Is 2000 correct? (Y/N)? Y
Input the calibration disk EXCO ->23.7
Is 23.7 correct? (Y/N)? Y

Place one calibration bung into each hood, then
press any key.
```

7. Place the foam bungs into the sensor hoods (see Figure 7-1 [p. 68]). The bungs are designed to block all light from the outside reaching inside the head. Place one bung into each hood. If either of the bungs are damaged or appear to have any gaps around the edge, contact Campbell Scientific (see Assistance for more information).

Figure 7-1. Calibration disk

```
Starting dark level calibration.
This test will take approximately two minutes.
```

This part of the test will take approximately two minutes. Every ten seconds a dot should appear indicating that the test is progressing as normal.

```
Dark level test complete. Please remove the bungs.
Now place the sensor calibrator into the sampling volume.
Press any key once this is done.
```

8. When instructed, remove the bungs.

9. Place the sensor calibrator into the volume by fastening it to the central mounting point (see Figure 7-2 [p. 69]).

> **NOTE:**
> At this stage it is advisable to perform a simple visual check of the cleanliness of the calibration plate. If contaminated clean it on both sides. Refer to the Cleaning section of the CS120A-CS125 Product Manual for more information.
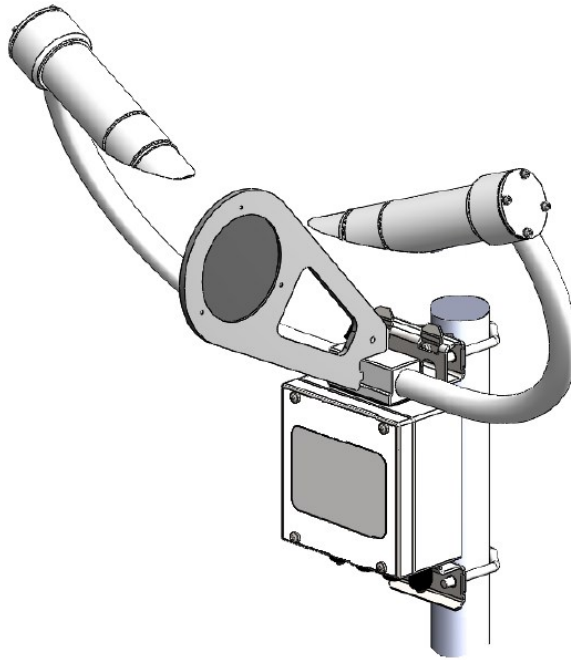
Figure 7-2. Mounting calibration disk

```
Starting light level calibration.
This test will take approximately two minutes.
```

This part of the test will take approximately two minutes. Every ten seconds a dot should appear indicating that the test is progressing as normal.

```
Calibration is now complete.
Saving user settings.
Press any key to exit.
```

Once the second stage of the test has been completed the new calibration constants will be saved automatically. All calibration constants including both the user and the factory setting can be viewed from menu item 4 from the main menu once the test is completed.

10. Type 0 and press Enter to return to the **Main Menu**.

11. Type 90 and press Enter to save settings and exit the **Main Menu**.

12. Press Esc four times to exit the **Terminal mode**.

13. Disconnect *Device Configuration Utility* from the data logger.

7.7.2 Dirty window zero calibration

Typing 3 in **Calibration - menu 3** allows the user to reset the zero contamination level for dirty windowsdetection. Typing 4 allows a return to the factory value if something goes wrong with the calibration process.

The dirty window zero calibration should be done every two years to correct for any slight drift in the dirty window detection or changes caused by scratches or degradation of the lenses some of which may not be visible to the naked eye.

To carry out the dirty window zero offset calibration make sure the windows are clean (see Cleaning [p. 73]). Temperature should ideally be in the range 15 to 30 °C and the sensor should be turned on for over 5 minutes. Before starting this process, make sure the lenses are dry and that neither the calibration bungs nor calibration disk are in place.

```
CS125 CALIBRATION MENU 3
  ID 0
  S/N 1003
  (1) Perform calibration
  (2) Restore the factory calibration
  (3) Perform dirty windows zero offset calibration
  (4) Restore dirty windows factory calibration

  (9) Refresh
  (0) Return to main menu

  ->
```

Typing 3 returns text similar to the following:

```
Current values EO=3200 DO=4649 DD=995
Cal DW offset? Y/N?
```

Type Y and the sensor will indicate to wait while the sensor is calibrating. When the calibration is done, the sensor will report numbers that are internal measurements used by the factory in case of a fault.

```
Calibrating dirty window system...Please wait

EO=3230 ES=371 DO=2251 DS=234 DD=1140
Press any key to exit (Not return)
```

Press any key and the dirty window zero offset calibration is complete. To verify calibration, return to the information screen and check the two dirty window alarm values; these values should be away from 0%.

7.7.3 Internal temperature check (CS125 only)

The CS125 has an internal temperature sensor in one of the crossarms. This is used as part of the present weather identification if a HygroVUE temperature and RH sensor is not connected. This does not need recalibration, but can be checked if a suitable nearby reference temperature measurement is available. The CS125 external temperature given in some standard messages (see Messages [p. 32]) or in the system information menu (see Menu system [p. 60]) should be within about 3 °C of the reference. Ideally, compare the temperatures in cloudy and windy conditions when the air temperature is as close to 0 °C as possible.

8.1 Operating system (OS) update

Operating system (OS) updates for the sensor are performed using Campbell Scientific **Device Configuration Utility** software. This is available as a free download from the Campbell Scientific website. Please refer to the help built into the **Device Configuration Utility** for full instructions on how to update the CS120A/CS125.

> NOTE:
> To use the **Device Configuration Utility** to carry out an OS change requires RS-232 communication. However, if a sensor is set to communicate by RS-485, it is not necessary to change this in the sensor. If a sensor is set to communicate by RS-485 it can be temporarily set to RS-232 with switch 3 (see Internal switches [p. 29]).

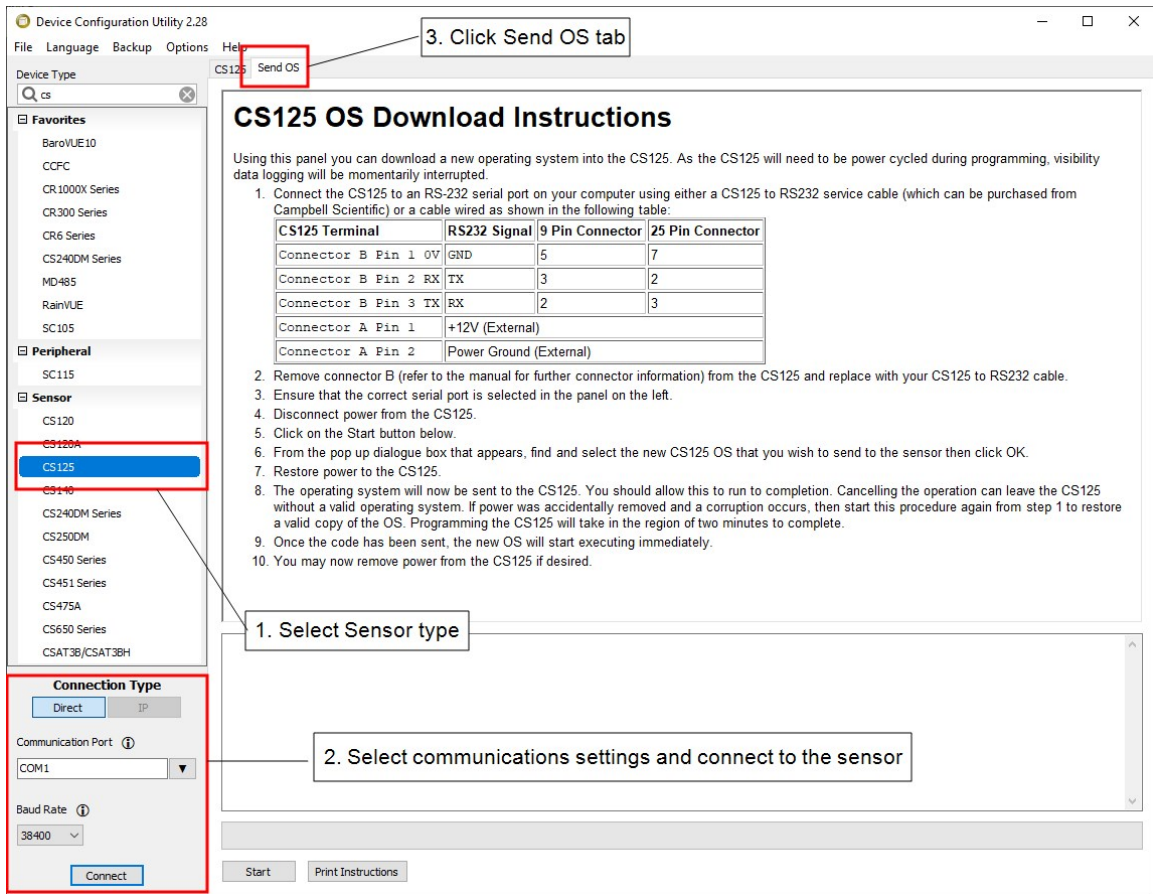The following figures show the instructions for downloading an OS using the **Device Configuration Utility**.

Figure 8-1. CS120A/CS125 **Device Configuration Utility** *OS download instructions*
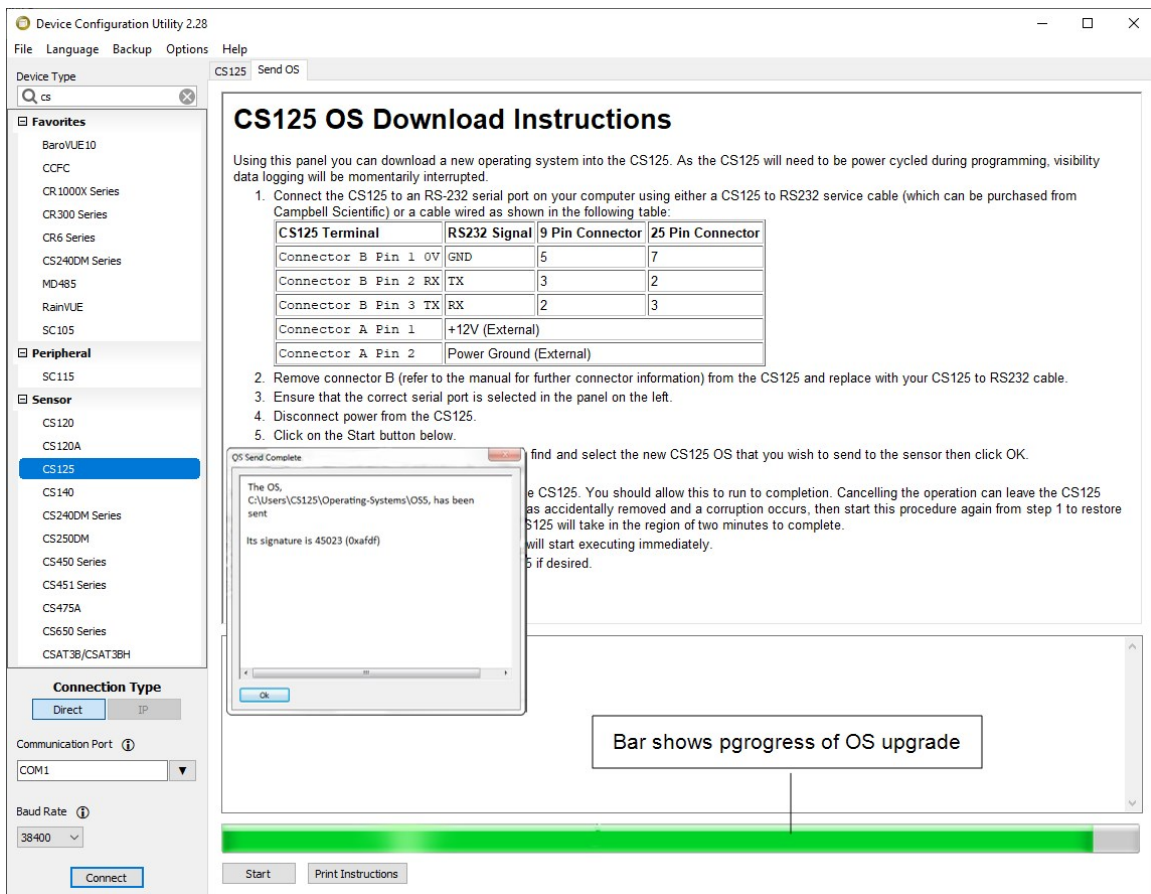
*Figure 8-2. **Device Configuration Utility** screen when OS update is complete*

9. Maintenance

9.1 Cleaning

The CS120A/CS125 window will require cleaning from time to time. The frequency of required cleaning depends on the exposure of the instrument to contaminants such as salt and dust. This will vary depending on the site location. The CS120A/CS125 is capable of self-diagnosing a dirty window and will indicate in its output when the window is contaminated.

> **NOTE:**
> A lower level of contamination than is detected by the dirty window alarms, can affect the visibility measurements. The sensor can be configured to correct for low-level contamination

> although the correction accuracy depends on the type of dirt.

Campbell Scientific suggests cleaning at six-month intervals for locations not prone to contaminants and monthly intervals for those prone to contamination (coastal, roadside or airport use). In some cases, more frequent cleaning may be required where there are high levels of contaminants and high dependency on the instrument output.

> **CAUTION:**
> If the window requires cleaning, it is very important that only a proper lens cloth or lens tissue is used. The use of inappropriate materials to clean the window can permanently damage or reduce the effectiveness of the window leading to errors in measurement of precipitation and visibility.

Use an air duster to blow any loose dust and dirt from the window as a first step. Using a lint-free lens cloth or lens tissue impregnated with a small amount of isopropyl alcohol solvent, clean the surface by dragging the cloth across it being careful not to apply excessive pressure.

> **CAUTION:**
> Excessive pressure may lead to some types of contaminant scratching the window surface. Over time such scratches can lead to reduced sensitivity.

Spiders webs and certain seeds may get lodged in the optical path, leading to low readings and false precipitation reports. Cleaning the visibility contamination with a duster will return the sensor to normal operation. If spiders are a persistent problem, carefully applying insecticide can deter them. Avoid getting insecticide on the windows.

9.2 Lubricating enclosure screws

The sensor enclosure screws should be lubricated with a suitable anti-seize grease to protect the threads from corrosion. This should be reapplied when resealing the enclosure at regular intervals, normally after replacing the desiccant. This is of particular importance if using the sensor in corrosive or salt laden atmospheres.

Appendix A. Importing *Short Cut* code into *CRBasic Editor*

Short Cut creates a .DEF file that contains wiring information and a program file that can be imported into *CRBasic Editor*. By default, these files reside in the C:\campbellsci\SCWin folder.

Import *Short Cut* program file and wiring information into *CRBasic Editor*:

1. Create the *Short Cut* program, then save it. Click the **Advanced** tab then the **CRBasic Editor** button. Your program file will open in CRBasic with a generic name. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

   > **NOTE:**
   > Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the program.

2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder. Copy the wiring information found at the beginning of the .DEF file.

3. Go into the CRBasic program and paste the wiring information at the beginning of the program.

4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the CRBasic | Features video ▶.

Appendix A. Hail monitoring (CS125 only)

The CS125 can specifically report hail in its output messages by connecting to it a WXT531 hail sensor via the internal SDI-12 port, which is otherwise used for connecting the CS215 T/RH sensor to the CS125. The connections are shown in .
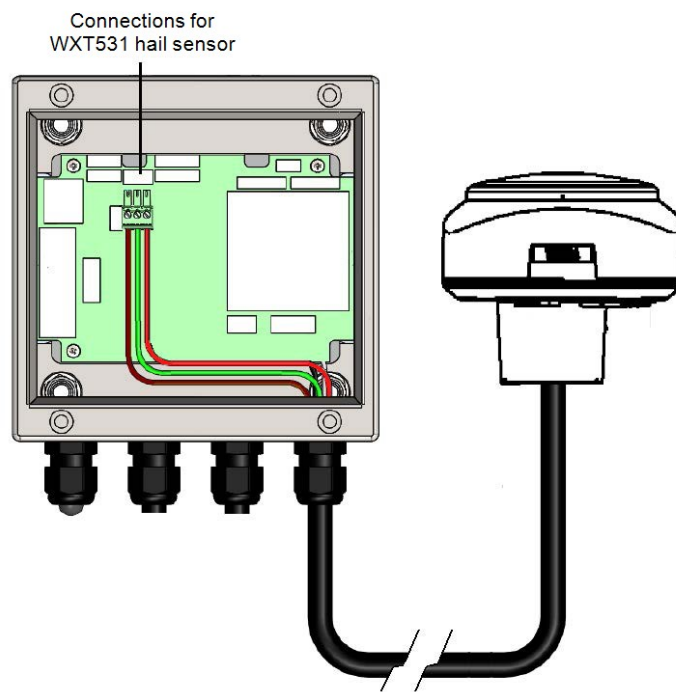
Figure A-1. Electrical connections between the WXT531 (shown) or WXT535 Hail Sensor and host CS125.

When connected to a WXT531, the CS125 reads the number of hail particles that are detected every minute. To ensure that hail is attributed accurately, the CS125 only reports hail, sensed by the WXT531 if, during the same period, the CS125 has detected one or more particle passing through its sensing volume. In this case, it will change the WMO code to the hail code.

Use the WXT535 hail sensor if monitoring hail, RH, and temperature. This combined sensor connects to the CS125 in the same manner as the WXT531, but can monitor all three measurements simultaneously.

Both WXT sensors can be mounted on the same mast as the CS125, but care should be taken to ensure that it is placed to avoid the sampling zone for the CS125.

Operation of the CS125 with either the WXT531, or WXT535, requires the CS125 to be installed with operating system 11 (OS11) or later. Free OS upgrades for CS125 sensors are available from Campbell Scientific.

See also Wiring using Campbell Scientific cables (p. 25) and HygroVUE 5 or HygroVUE 10 T/RH sensor installation (CS125 only) (p. 27).

Appendix B. Block-diagram
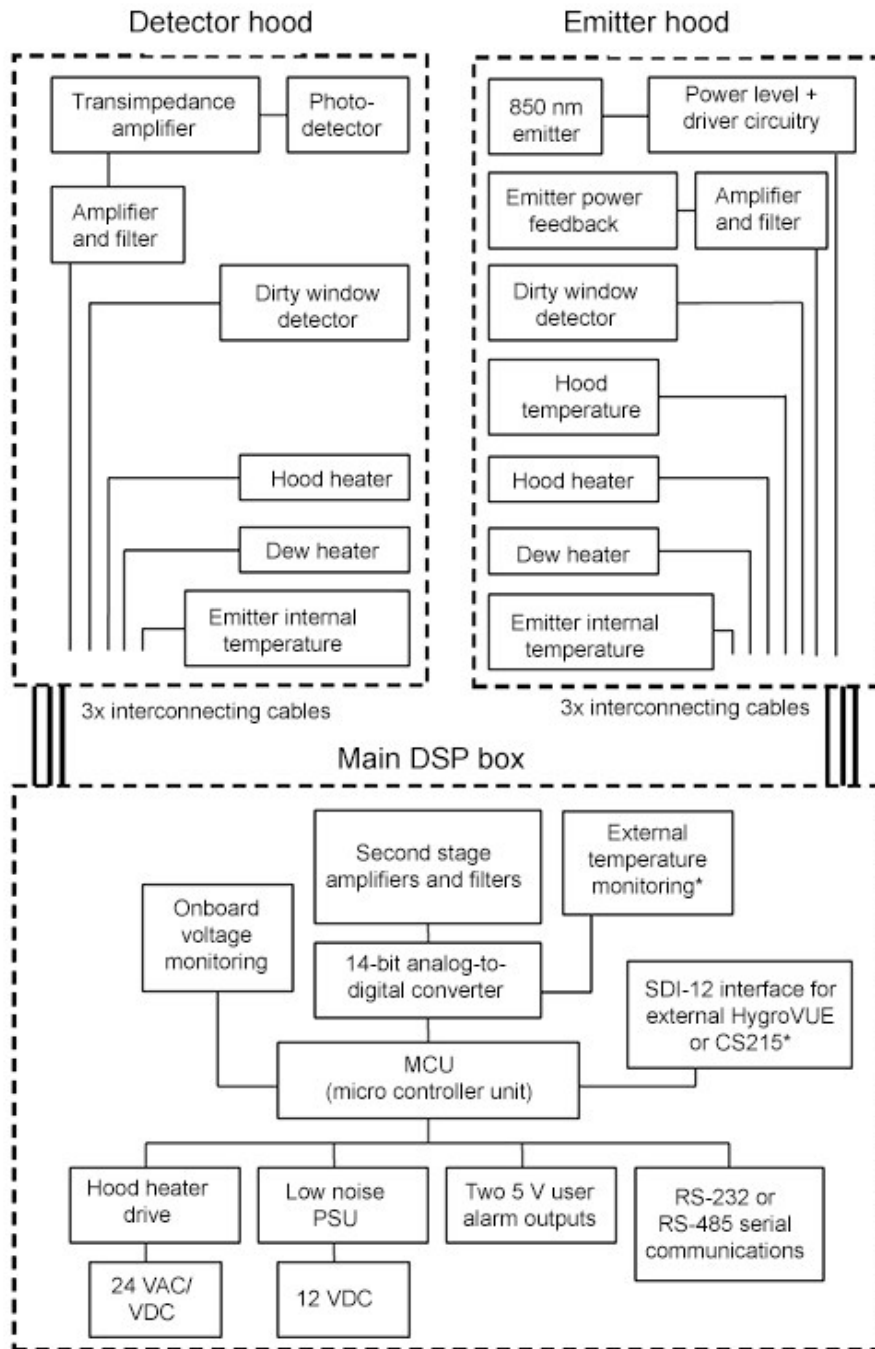
Appendix C. Example C code to calculate a CCITT CRC

The following code is provided as an example for programmers implementing their own code to communicate with the sensor. Campbell Scientific data logger users can use the checksum command in *CRBasic Editor* to generate a CCITT checksum. Refer to the downloadable example programs available at www.campbellsci.eu/downloads/cs125-example-programs ⬏ or www.campbellsci.eu/downloads/cs120a-example-programs. ⬏

The checksum includes all characters after the **STX** and before the space preceding the checksum.

The **SET** and **SETNC** commands also exclude the two delimiting **:** characters, one on each side of the checksum itself.

```
//---------------------------------------------------------- ------------
// Creates a CCITT CRC16 checksum seeded with 0x0000 (XModem style) using a
// fast non table based algorithm.
// Pass in the data to convert into a CRC in the form of a NULL terminated
// character array (a string).
// Returns the CRC in the form of an unsigned 16 bit integer value
// Note: This algorithm has only been tested on a native 16-bit processor with
// a hardware barrel shifter // All integers are 16-bits long
//---------------------------------------------------------- ------------
unsigned int CRC_CCITT(char LineOfData[])
{
unsigned int crc;
// returned CRC value unsigned int i;
// counter crc = 0x0000;
// create a check sum for the incoming data for(i=0;i < strlen(LineOfData); i++)
{
unsigned crc_new = (unsigned char)(crc >> 8) | (crc << 8);
crc_new ^= LineOfData[i];
crc_new ^= (unsigned char)(crc_new & 0xff) >> 4;
crc_new ^= crc_new << 12;
crc_new ^= (crc_new & 0xff) << 5; crc = crc_new;
}
return(crc);
}
```

Appendix D. Present weather codes produced by the CS125

Table D-1 (p. 80) provides the 56 SYNOP and generic SYNOP codes that can be output by the sensor. Table D-2 (p. 83) provides METAR codes from WMO table 4678. Table D-3 (p. 83) provides the NWS codes that may be produced by the CS120A/CS125 in a custom message:

Table D-1: SYNOP and generic SYNOP code definitions	
Weather type	4680 code
No significant weather observed	0
Haze or smoke, or dust in suspension in the air, visibility ≥ 1 km[1]	4
Haze or smoke, or dust in suspension in the air, visibility < 1 km[1]	5
Mist	10
Fog (in the preceding hour)	20
Precipitation (in the preceding hour)	21
Drizzle (not freezing) or snow grains (in the preceding hour)	22
Rain (not freezing), (in the preceding hour)	23
Snow (in the preceding hour)	24
Freezing rain or freezing drizzle (in the preceding hour)	25
FOG	30
Fog or ice fog in patches	31
Fog or ice fog in patches, has become thinner during the past hour	32
Fog or ice fog in patches, no appreciable change during the past hour	33
Fog or ice fog in patches has begun or become thicker during the past hour	34
Fog depositing rime	35
PRECIPITATION	40
Precipitation, slight or moderate	41

Table D-1: SYNOP and generic SYNOP code definitions	
Weather type	4680 code
Precipitation, heavy	42
Solid precipitation, slight or moderate[2]	43
Freezing precipitation, slight or moderate[2]	44
Freezing precipitation, heavy[2]	45
DRIZZLE[2]	50
Drizzle, not freezing, slight	51
Drizzle, not freezing, moderate	52
Drizzle, not freezing, heavy	53
Drizzle, freezing, slight	54
Drizzle, freezing, moderate	55
Drizzle, freezing, heavy	56
Drizzle and rain, slight	57
Drizzle and rain, moderate or heavy	58
RAIN[2]	60
Rain, slight	61
Rain, moderate	62
Rain, heavy	63
Rain, freezing, slight	64
Rain, freezing, moderate	65
Rain, freezing, heavy	66
Rain (or drizzle) and snow, slight	67
Rain (or drizzle) and snow, moderate or heavy	68
SNOW[2]	70
Snow, slight (snow includes graupel)	71
Snow, moderate (snow includes graupel)	72
Snow, heavy (snow includes graupel)	73
Ice pellets, slight	74

Table D-1: SYNOP and generic SYNOP code definitions	
Weather type	4680 code
Ice pellets, moderate	75
Ice pellets, heavy	76
Snow grains	77
SHOWER(S) OR INTERMITTENT PRECIPITATION	80
Rain shower(s) or intermittent rain, slight	81
Rain shower(s) or intermittent rain, moderate	82
Rain shower(s) or intermittent rain, heavy	83
Rain shower(s) or intermittent rain, violent	84
Snow shower(s) or intermittent snow, slight	85
Snow shower(s) or intermittent snow, moderate	86
Snow shower(s) or intermittent snow, heavy	87
Hail	89
[1]Only reported if a HygroVUE sensor is connected to provide relative humidity; otherwise, it will default to mist (10) or fog (20, 30, 31, 32, 33, 34 or 35). [2]Only reported in the generic SYNOP messages.	

Table D-2: METAR code definitions[1]	
Weather type	**METAR code**
Unidentified precipitation	UP
Haze[2]	HZ
Mist[3]	BR
Fog[3]	FG
Drizzle[3, 4]	DZ
Rain[3, 4]	RA
Snow grains	SG
Snow[4]	SN
PL[4]	Ice pellets
Hail[5]	SMGR
No significant weather	NSW

[1] Combinations of the codes can be reported. (for example, RASN for rain and snow).

[2] HZ is only be reported if a HygroVUE sensor is connected to the CS125 to provide relative humidity information.

[3] FZ (freezing) may be added as a descriptor in front of BR, FG, DZ, and RA (for example, FZBR for freezing mist).

[4] Intensity qualifiers (– for light and + for heavy) may be added in front of DZ, RA, SN, and PL (for example –RA for light rain or+SN for heavy snow).

[5] SMGR is only reported if an optional hail sensor is connected. Contact Campbell Scientific for details.

Table D-3: NWS code definitions	
Weather type	**NWS code[1]**
Drizzle[2]	L
Rain[2]	R
Snow	S
Snow grains	SG

[1] Intensity qualifiers (– for light and + for heavy) may be added after the NWS code (for example –R for light rain or+S for heavy snow).

[3] FZ (freezing) may be added as a descriptor in front of L and R(for example, FZL for freezing drizzle).

Appendix E. Comparison of alternate visibility calibrations

E.1 Introduction

The original standard calibration of the sensor was derived from comparison with several other forward-scatter sensors and later verified by trained meteorological observers. The calibration assumes a linear relationship between the forward-scatter signal and extinction coefficient. This calibration is referred to as the MOR calibration. It is used as the base calibration of the sensor.

A secondary calibration was derived by comparison of the MOR output against measurements made with short pathlength transmissometers, following the procedures laid down by the ICAO. The process involved collecting data from two CS125 sensors running alongside two calibrated transmissometers, at the test site of a National Meteorological Service. An empirical, non-linear calibration was fitted to data collected on that site. This was later verified by a third party at another site run by a different National Meteorological Service (see following section).

Over the entire range of the sensor the relationship between the two calibrations is broadly linear (see Figure D-1). The relationship is formed by two intersecting linear functions with a steeper slope at low visibility. The resultant TMOR calibration gives much higher visibility readings at visibilities lower than 2000 metres, which is a key measurement range for aviation.

The first three graphs show the relationship of the whole sensor range (Figure E-1 [p. 85]), over 0 to 2000 metres (Figure E-2 [p. 85]) and the ratio of the two outputs (Figure E-3 [p. 86]).
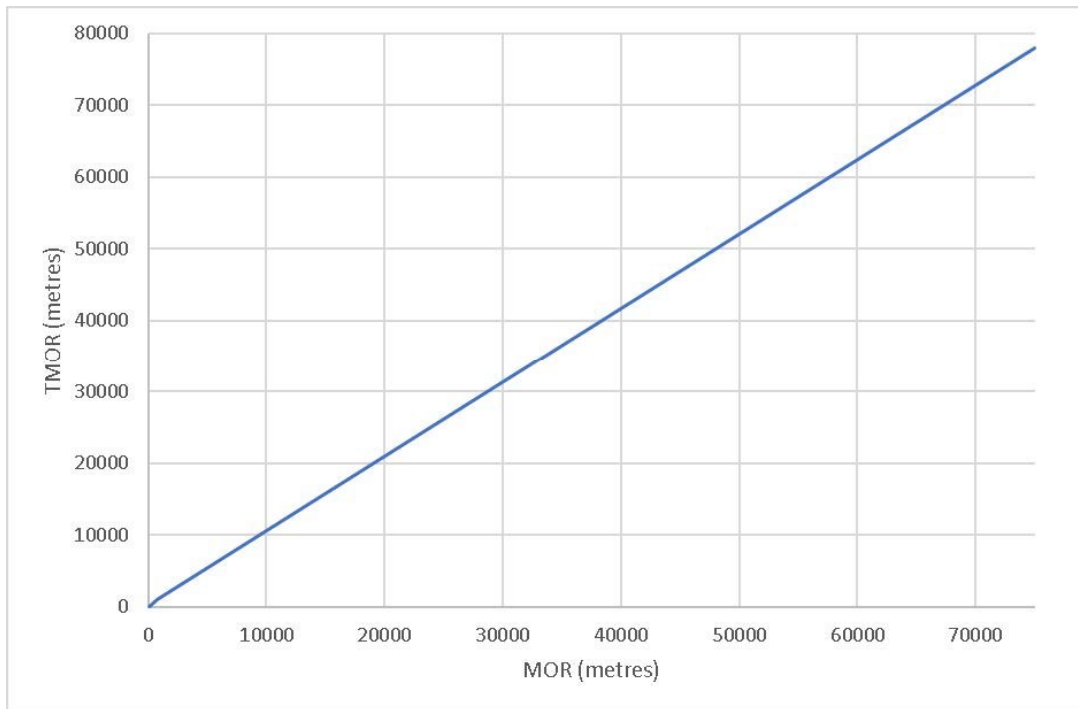
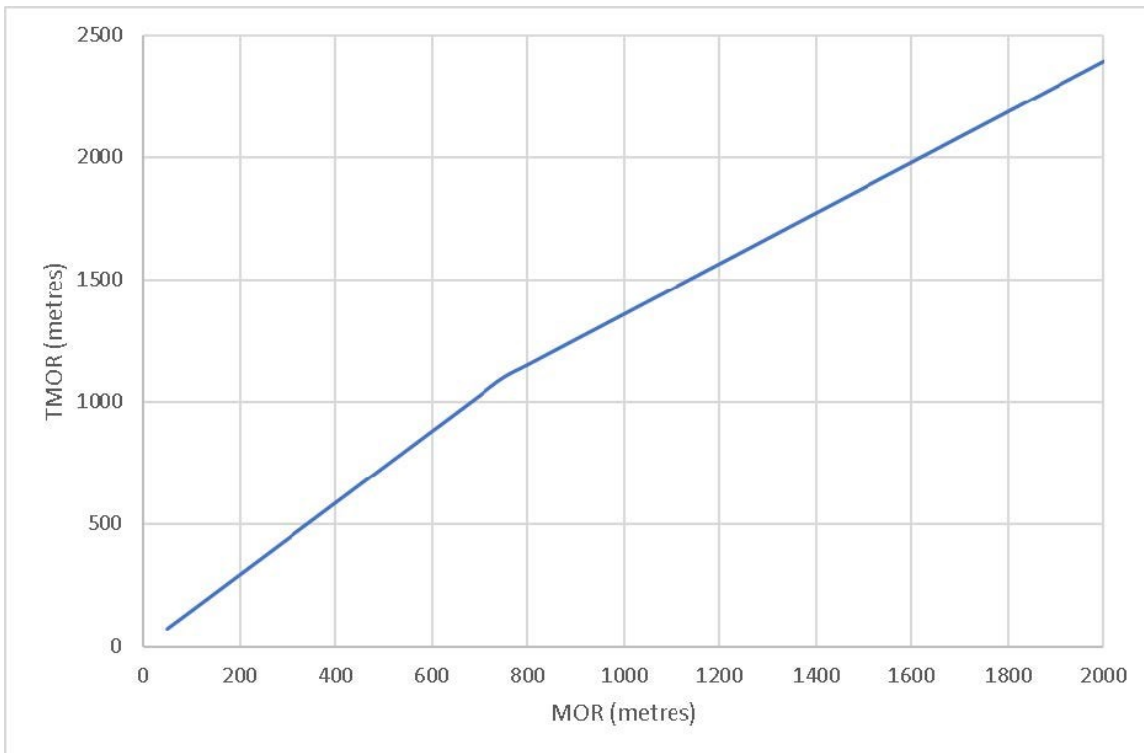*Figure E-1. TMOR plotted against MOR over the full 0 to 75 km range.*

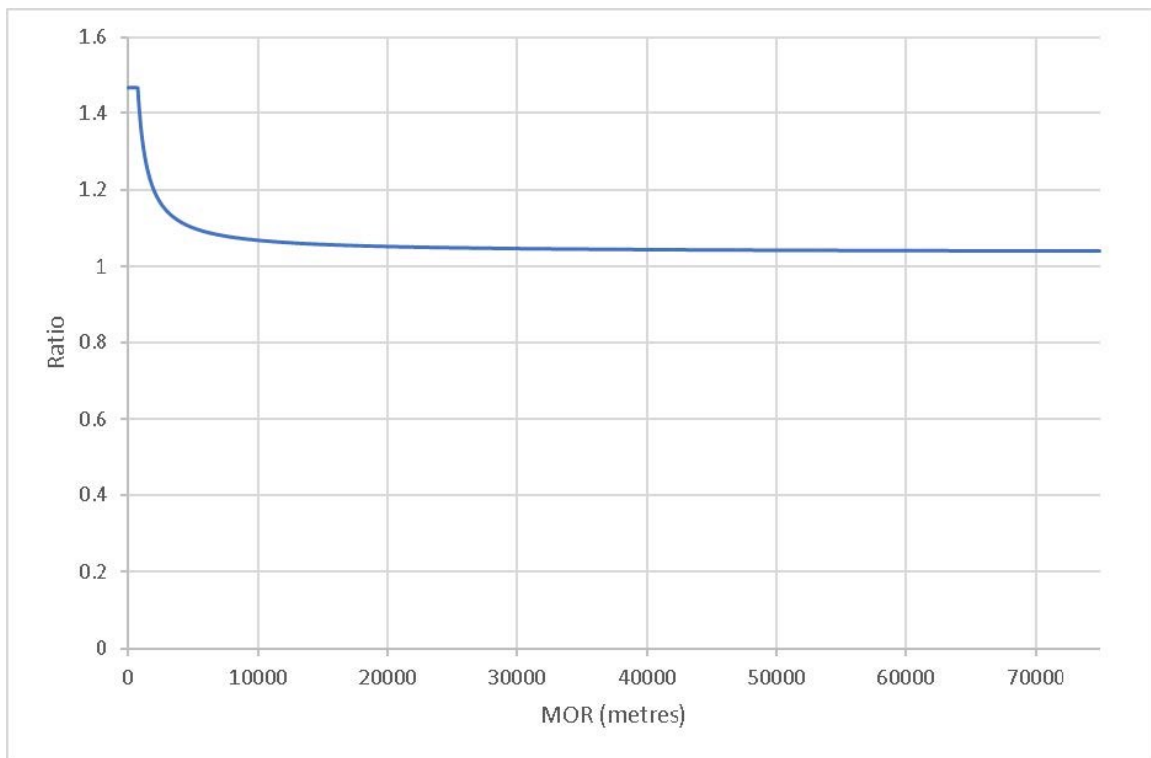*Figure E-2. TMOR plotted against MOR over the 0 to 2000 m range.*

Figure E-3. Ratio of TMOR to MOR over the full 0 to 75 km range.

E.2 Validation of the TMOR calibration

The fitted TMOR function was used to validate the suitability of the sensor for aviation use by following the process of comparison defined in the ICAO Manual of Runway Visual Range Observing and Reporting Practices (Doc 9328, AN/908). This procedure defines the selection and processing of the data from a sensor under test and the method of comparison with a calibrated transmissometer. This involves presenting the data as a form of box plot and checking the data does not fall outside certain accuracy limits. An example plot of one sensor under test is shown in .
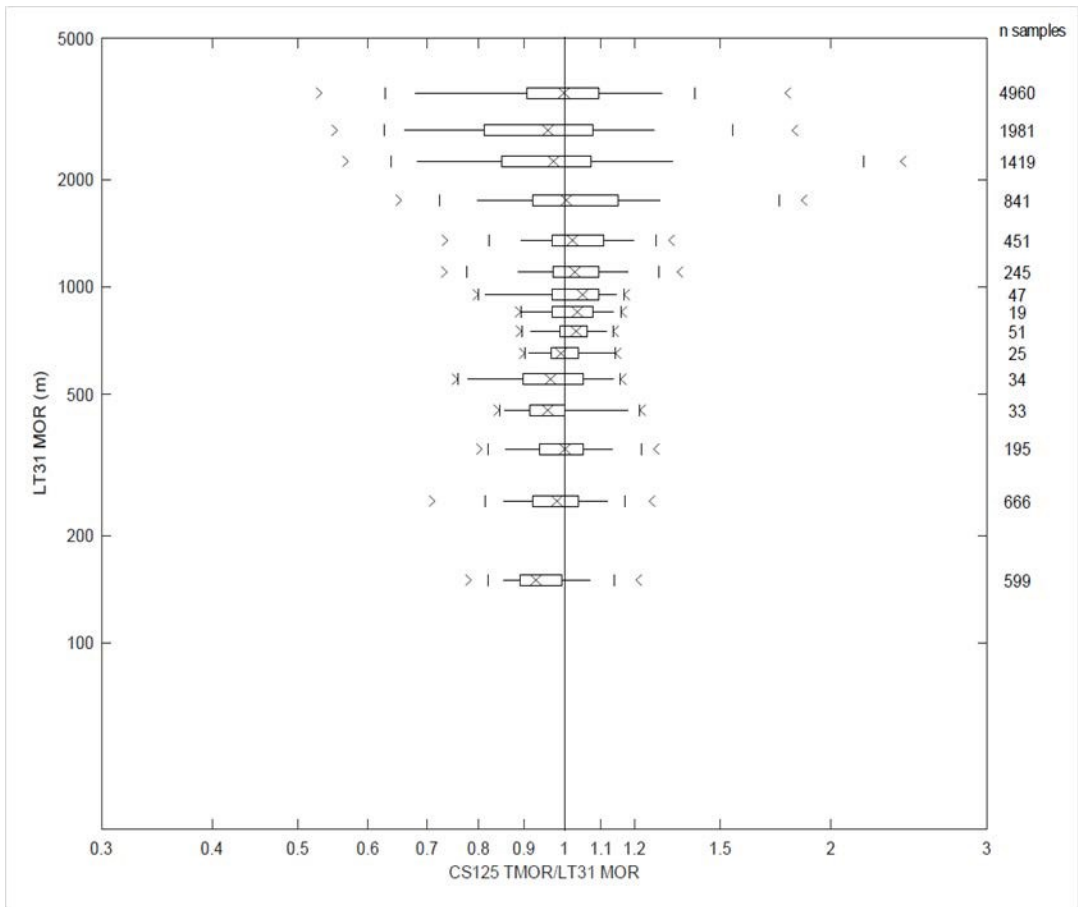
Figure E-4. Performance of the CS125 TMOR calibration compared to a test transmissometer

Campbell Scientific

WHEN MEASUREMENTS MATTER

Global Sales & Support Network

A worldwide network to help meet your needs

Campbell Scientific Regional Offices

Australia

Location:	Garbutt, QLD Australia
Phone:	61.7.4401.7700
Email:	info@campbellsci.com.au
Website:	www.campbellsci.com.au

Brazil

Location:	São Paulo, SP Brazil
Phone:	11.3732.3399
Email:	vendas@campbellsci.com.br
Website:	www.campbellsci.com.br

Canada

Location:	Edmonton, AB Canada
Phone:	780.454.2505
Email:	dataloggers@campbellsci.ca
Website:	www.campbellsci.ca

China

Location:	Beijing, P. R. China
Phone:	86.10.6561.0080
Email:	info@campbellsci.com.cn
Website:	www.campbellsci.com.cn

Costa Rica

Location:	San Pedro, Costa Rica
Phone:	506.2280.1564
Email:	info@campbellsci.cc
Website:	www.campbellsci.cc

France

Location:	Montrouge, France
Phone:	0033.0.1.56.45.15.20
Email:	info@campbellsci.fr
Website:	www.campbellsci.fr

Germany

Location:	Bremen, Germany
Phone:	49.0.421.460974.0
Email:	info@campbellsci.de
Website:	www.campbellsci.de

India

Location:	New Delhi, DL India
Phone:	91.11.46500481.482
Email:	info@campbellsci.in
Website:	www.campbellsci.in

South Africa

Location:	Stellenbosch, South Africa
Phone:	27.21.8809960
Email:	sales@campbellsci.co.za
Website:	www.campbellsci.co.za

Spain

Location:	Barcelona, Spain
Phone:	34.93.2323938
Email:	info@campbellsci.es
Website:	www.campbellsci.es

Thailand

Location:	Bangkok, Thailand
Phone:	66.2.719.3399
Email:	info@campbellsci.asia
Website:	www.campbellsci.asia

UK

Location:	Shepshed, Loughborough, UK
Phone:	44.0.1509.601141
Email:	sales@campbellsci.co.uk
Website:	www.campbellsci.co.uk

USA

Location:	Logan, UT USA
Phone:	435.227.9120
Email:	info@campbellsci.com
Website:	www.campbellsci.com