

# CS120A and CS125

Visibility and Present  
Weather Sensors



# About this manual

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## Some useful conversion factors:

**Area:** 1 in<sup>2</sup> (square inch) = 645 mm<sup>2</sup>

**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<sup>2</sup>) = 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.



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# CS120A and CS125 Visibility and Present Weather Sensors

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## 1. Introduction

The CS120A is a visibility sensor. The CS125 additionally detects and reports present weather in the form of SYNOP, METAR or NWS codes. The CS125 has the same specification for visibility measurement as the CS120A. It is possible to upgrade a CS120A to a CS125, please contact Campbell Scientific for more details.

The sensors are infra-red forward scatter visibility and present weather sensors for automatic weather stations including road, marine and airport based stations. They both use the well-established forward scatter system for visibility measurement, utilising a 42° scatter angle. The CS125 uses high speed sampling to reduce missed events and improves response to other suddenly changing conditions.

The CS125 has a temperature sensor mounted in the cross arm used as part of the process for identifying precipitation.

When an optional CS215 or HygroVUE temperature and RH sensor is connected, the CS125 can distinguish wet and dry obscuration (for example mist and haze) and make more precise discrimination 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.

This sensor is certified for Aviation use by the German Meteorological Service, Deutscher Wetterdienst (DWD) (see Section 1.3 regarding the settings).



## 1.1 General Safety

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

<b>WARNING</b>	<b>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.</b>
<b>CAUTION</b>	Cautions warn of potential hazards. Ignoring these cautions could result in the sensor being damaged and data being lost.
<b>NOTE</b>	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.

<b>WARNING</b>	<b>Do not modify the sensor unit. Such modifications will lead to damage of the unit and could expose users to dangerous light levels and voltages.</b>
<b>WARNING</b>	<b>In unusual failure modes and environmental conditions the sensor hood could become hot. In normal operation they will be at ambient temperature or slightly above.</b>
<b>CAUTION</b>	Ensure that the correct voltage supply is provided to the sensor.

### 1.3 Principle of operation

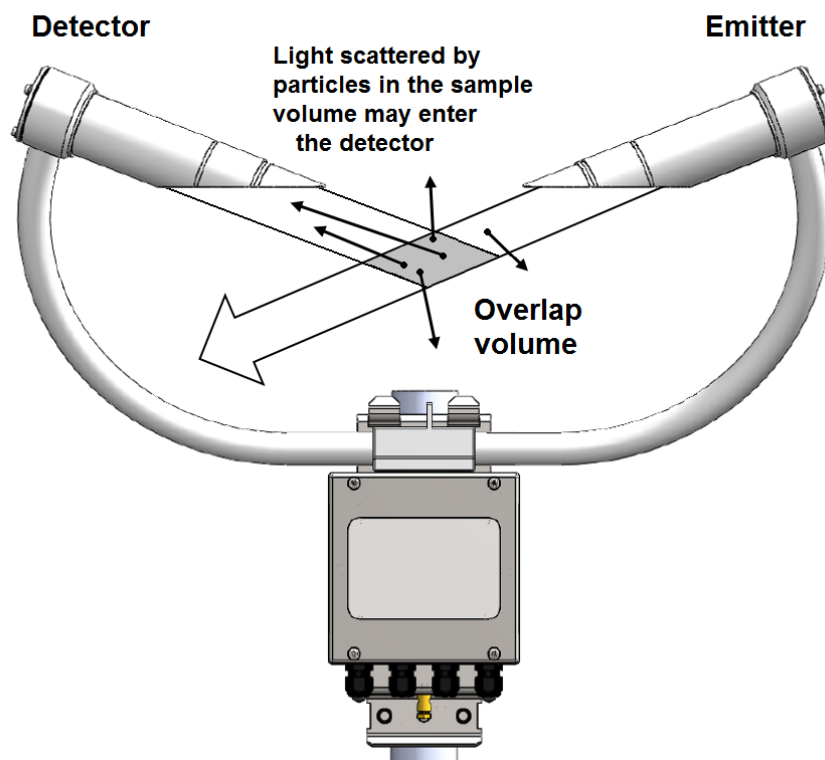


Figure 1-1. Particles in the sample volume scatter light in all directions, including into the detector

The CS120A and CS125 comprise an emitter and detector aligned as in [Figure 1-1](#). The emitter produces a beam of near infra-red light pulsed at 1 kHz. A detector has a field of view which overlaps the beam and is inclined at 42 degrees to it. 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 therefore proportional to the extinction of the emitted beam caused by scattering. The scattering signal averaged over one second is used to calculate an extinction coefficient or EXCO assuming the relationship between forward scatter and EXCO is linear. Sixty one second averages are then themselves averaged to give a one minute average EXCO. This is then converted to a value of Meteorological Optical Range (MOR) using Koschmieder's law:

$$\text{MOR} = 3/\text{EXCO} \quad \text{where MOR is in km and EXCO in units of km}^{-1}.$$

The CS125 calibration for visibility was derived by comparison with other high grade, forward scatter sensors and has also been verified in a study by trained meteorological observers. This is called the 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 metres. Further details of the calibration and graphs comparing the two calibration options are given in Appendix D.

The TMOR calibration should be used for aviation applications as it is considered to give more representative visibility values for a plane landing and viewing landing lights. Use of the TMOR calibration is obligatory for use of this sensor on German airfields.

The CS125 can be switched between outputting data using the original MOR or the alternative TMOR calibration by using a configuration switch (See Section 10). 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. It does this by analysing the amplitude and width of spikes in the APD signal corresponding to particles of precipitation passing through the sample volume. The amplitude of the signal is a guide to the size of the particle and the width, because it represents the time taken for the particle to fall through the sample volume, is proportional to the fall speed, see [Figure 1-2](#).

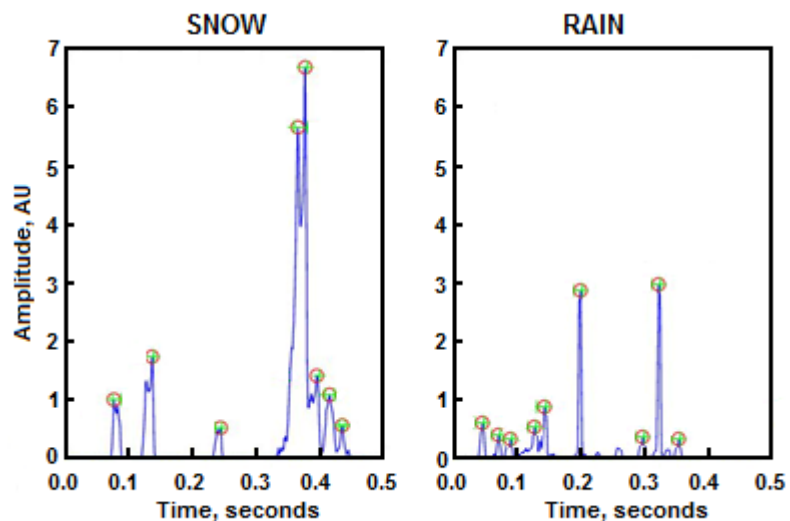


Figure 1-2. Signals from large, slow falling snowflakes and smaller, faster, raindrops

The CS125 also has a temperature sensor. These three parameters, fall speed, size and temperature are used to identify the type of particle. If an additional external temperature and relative humidity probe is connected then a wet-bulb temperature can be calculated. This provides useful additional information identifying particles more accurately especially, between liquid and frozen around 0°C.

[Figure 1-3](#) shows how these temperatures are used to define possible precipitation types around 0°C.

<b>Wet bulb temperature</b>		SNOW ICE PELLETS SNOW GRAINS	FREEZING DRIZZLE FREEZING RAIN SNOW	DRIZZLE RAIN SNOW	DRIZZLE RAIN
<b>Dry bulb temperature if wet bulb temperature is unavailable</b>	SNOW ICE PELLETS SNOW GRAINS	FREEZING DRIZZLE FREEZING RAIN SNOW		DRIZZLE RAIN SNOW	DRIZZLE RAIN
	-5.0	-2.2	0.0	+2.0	+4.0
	Temperature °C				

Figure 1-3. Defining possible precipitation types based on wet bulb and dry bulb temperatures

The processing algorithm then works with several 'maps' such as [Figure 1-4](#) to identify each particle.

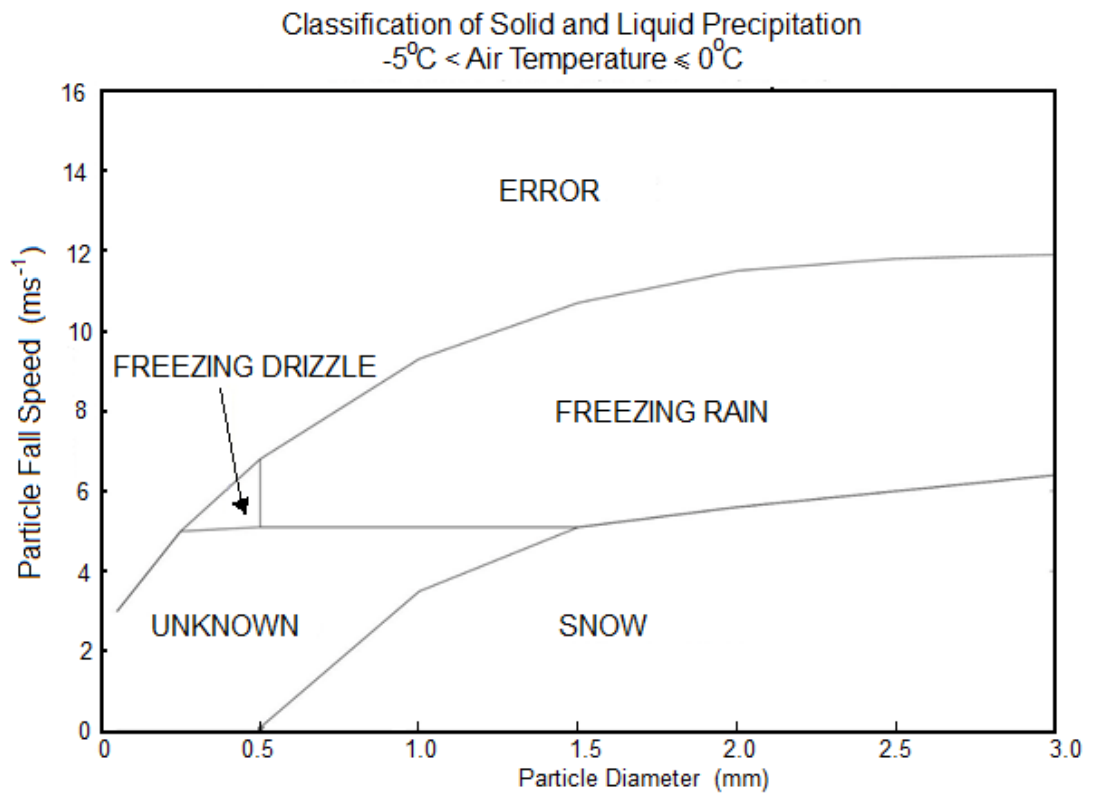


Figure 1-4. A typical size/speed map used by the CS125 present weather algorithm

## 1.4 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

## 1.5 Quickstart

The sensor is shipped set to the following default communication RS-232, 8N1, 38400 baud, a sensor ID = 0 and set to transmit default messages, full format, visibility only for the CS120A, SYNOP present weather full format for the CS125, at 1 minute intervals (see [Section 11](#)).

To start using the CS120A or CS125, first connect a DC supply matching the specification in [Section 3.1](#) to the red and black wires on the ‘D-connector’ (see [Figure 8-3](#)) and connect to a PC communications port with a terminal emulator set to RS-232, 38400 baud, 8N1. After a couple of minutes, data messages will be received. Typing ‘open 0’ will access the menu structure, see [Section 15](#).

## 2. Measurement specification

	Minimum Value	Nominal Value	Maximum Value
<b>Visibility characteristics</b>			
Reported visibility (metric)	5 metres	-	75,000 metres
Reported visibility (imperial)	16 feet	-	46 miles
Visibility accuracy calibration against factory calibration disk**	-	+/- 2%	-
Visibility accuracy up to 600 m	-	+/-8%	-
Visibility accuracy up to 10,000 m	-	+/-10%	-
Visibility accuracy up to 15,000 m	-	+/-15%	-
Visibility accuracy above 15,000 m	-	+/-20%	-
<b>Precipitation characteristics, water equivalent (CS125 only)</b>			
Reported accumulation range	0 – 999.9 mm		
Accumulation accuracy	+/-15%		
Accumulation resolution	0.1 mm		
Reported intensity range (up to *)	0 - 999.99 mm/hr		
Intensity accuracy**	+/-15%		
Intensity resolution	0.01 mm/hr		

\*The maximum intensity reported is dependent on the mixture of precipitation falling.

\*\*Please refer to Section 1.3 regarding the calibration options for the sensor.

## 3. Technical specification

### 3.1 Electrical specification

	Minimum Value	Nominal Value	Maximum Value
<b>Main power supply for DSP and dew heaters</b>			
Power supply, (DC only)	7V	12V	30V <sup>(1)</sup>
Current consumption sampling continuously with dew heaters ON and RS-232 communications active <sup>(2, 3)</sup> (at 12V DC)	-	200 mA	248 mA
Current consumption sampling continuously with dew heaters disabled (at 12V DC)	-	110 mA	151 mA
Current consumption without any sampling occurring and dew heaters disabled (at 12V DC)	-	21 mA	30 mA
<b>Hood heater power supply</b>			
Hood heater voltage (AC or DC)	-	24V <sup>(3)</sup>	30V <sup>(4)</sup>
Hood heater wattage (at 24V AC or DC)	-	60W <sup>(5)</sup>	-
<b>User alarm outputs</b>			
User output high level (at 85°C)	3.8V	-	-
User output high level (at 25°C )	4.13V	-	-
User output low (All temperatures)	0.25V	-	0.55V
User output current	-	-	32 mA

(1) If a CS215 or HygroVUE probe is being used with a CS125 the supply voltage should not exceed 28V.

(2) The RS-232 communications interface will automatically turn itself off when not transmitting.

(3) If hood heaters are not being used ensure 'Hood heater override' (details in [Section 13](#)) is set to off.

(4) It is recommended that the hood heaters are run at 24V AC/DC. It is possible to run the heaters at any voltage below 24V but the heaters will generate proportionally less heat reducing their ability to prevent ice build-up.

(5) Each hood takes 30W, 60W is the total for both hoods on the sensor together.

#### CAUTION

If a CS215 or HygroVUE probe is being used the supply voltage should not exceed 28V.

### 3.2 Optical specification

	Minimum Value	Nominal Value	Maximum Value
<b>Optical characteristics</b>			
LED centre wavelength	-	850 nm	
LED spectral bandwidth	-	+/-35 nm	
<b>Pulse characteristics</b>			

Light pulse rate	-	1KHz	
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## 4. Communications specification

### 4.1 Communications electrical specifications

	Minimum Value	Nominal Value	Maximum Value
<b>RS-232 Communications<sup>(1)</sup></b>			
RS-232 input threshold Low	0.8V	1.5V	-
RS-232 input threshold High	-	2.0V	2.4V
RS-232 input absolute maximum	-15V	-	+15V
RS-232 input resistance	12K $\Omega$	-	-
RS-232 output voltage low	-	-	0.4V
RS-232 output voltage high (into 3K $\Omega$ )	4.4V	-	-
<b>RS-485 Communications</b>			
RS-485 input threshold voltage	-0.2V	-	+0.2V
RS-485 output (Unloaded)	-	-	5V
RS-485 output (Load 50 $\Omega$ )	2V	-	-
Maximum voltage at any terminal <sup>(2)</sup>	-7V	-	+7V

- (1) The RS-232 communications interface will automatically turn itself off when not transmitting.
- (2) The ground of the sensor and the ground of any RS-485 equipment cannot be further apart than this voltage. The sensor ground (pin 1) on connector B, see page 18, can be connected to the ground of the host equipment. This will reduce any parasitic currents.

### 4.2 Supported data rates and formats

Serial setting 8N1

#### Supported data rates

- 1200 bps
- 2400 bps
- 9600 bps
- 19200 bps
- 38400 bps - default
- 57600 bps
- 115200 bps

#### Supported formats

- RS-232 (Full duplex only), default
- RS-485 (Half duplex)
- 8 bit data bytes
- 1 stop bit
- Parity checking is not supported as most communication protocols used by the CS125 have built in checksums as well as checks that communications have been understood.

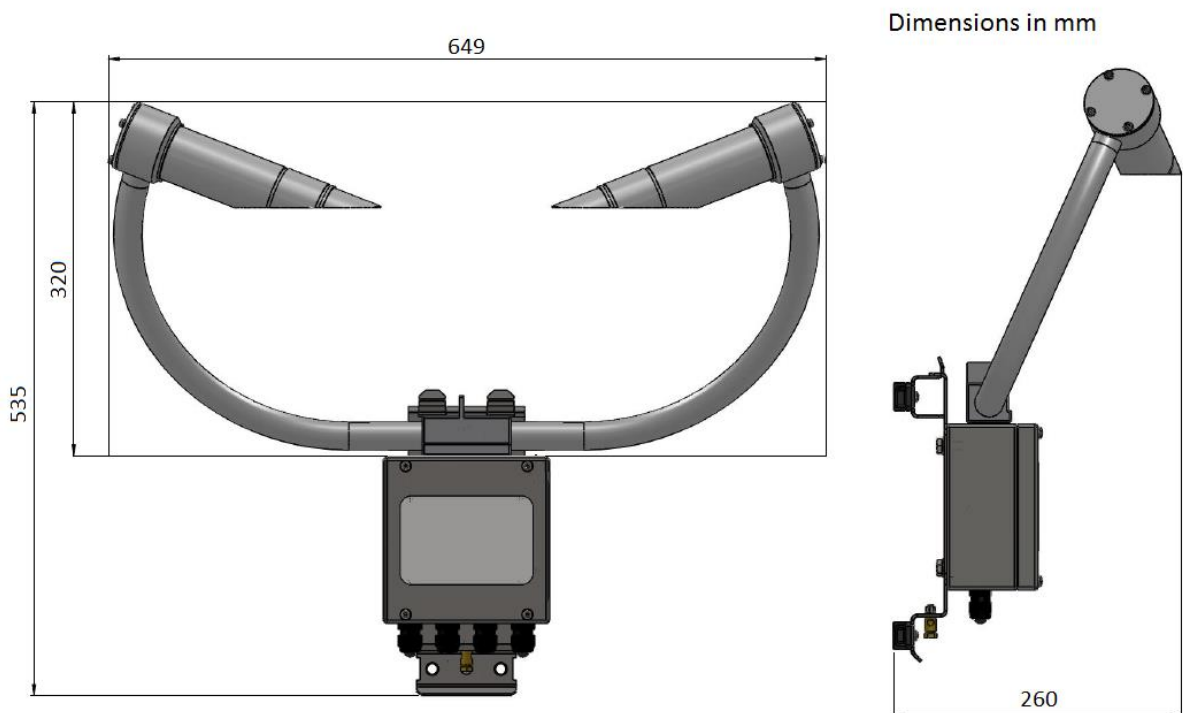
## 5. Environmental specifications

	Minimum Value	Nominal Value	Maximum Value
<b>Sensor temperature ranges</b>			
Operating temperature	-25°C	-	+60°C
Extended operating temperature	-40°C	-	+70°C <sup>(1)</sup>
Storage temperature	-40°C	-	+85°C
<b>Sensor humidity ranges</b>			
Operating humidity range	0%	-	100%
<b>Sensor heater thresholds</b>			
Dew heater Turn On	-	<35°C	-
Dew heater Turn Off	-	>40°C	-
Hood heater Turn On	-	<15°C	-
Hood heater Turn Off	-	>25°C	-

- (1) 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.

## 6. Mechanical specifications

### 6.1 Dimensions



## 6.2 Weights

Sensor weight: 3 Kg  
Shipping weight: 6 Kg (including packing box)

## 6.3 Mounting

Sensor mounting: Bracket mounts on a vertical pole 32-52.5 mm diameter. The mounting bracket has cut-outs for band clamps for larger diameter masts.

# 7. Installation procedure

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

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### NOTE

The descriptions in this section are not exhaustive. Please refer to meteorological publications for further information on locating weather instruments

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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 it is a good idea to avoid locations where the transmitter is pointing 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. This is because it is more important to make sure the receiver is not pointing towards any possible sources or reflected light in its field of view, for instance 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 the sensor reporting a DC light saturation error when there is bright sunlight.

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.

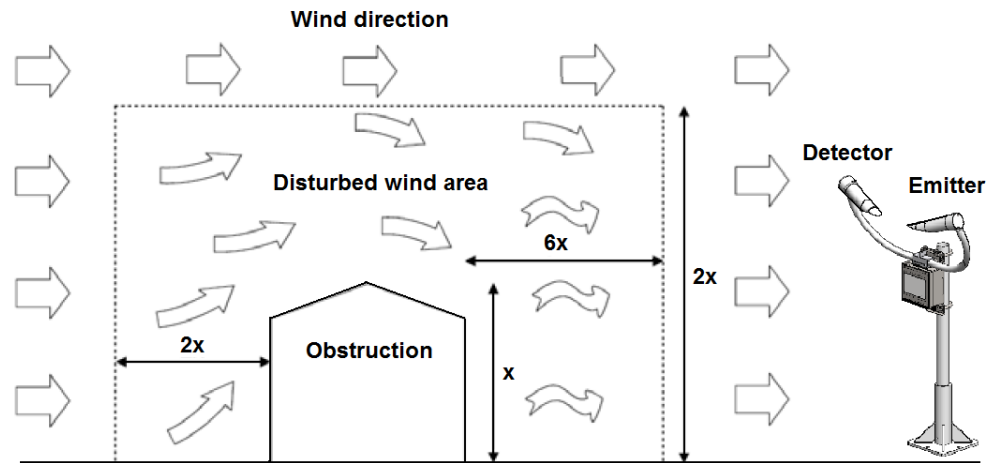


Figure 7-1. Airflow

In order to reduce the service frequency with the unit, the sensor should be placed away from sources of contamination, in the case of roadside monitoring; larger mounting poles can be used. More regular maintenance will be required when the instrument is placed in areas where contamination is unavoidable or where measurements may be safety critical.

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

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**NOTE** If operating a sensor indoors it is likely that there will be sources of light and/or reflections that will create false readings and erratic results.

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**NOTE** If carrying out simple checks, blocking a lens or the sample volume will simulate an INCREASE in visibility not a decrease.

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## 7.1 Equipment grounding

The sensor must be properly grounded. It is sufficient to ground the mounting bracket and if the sensor is connected to a grounded metal mast, and in electrical contact with it, then this will be sufficient. Otherwise, the mounting bracket should be earthed and a grounding boss is supplied to allow this.

A ground wire with a minimum cross section of 6 mm<sup>2</sup> 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 protection against radio frequency interference and should also be correctly grounded.



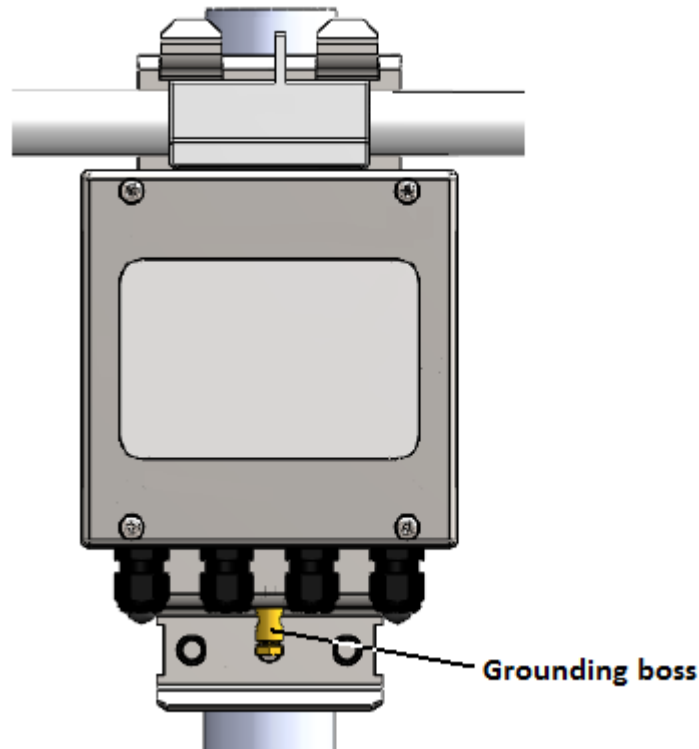


Figure 7-2. Grounding boss

## 7.2 Mounting the sensor

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 using the brackets supplied with the enclosure. Alternatively the power supply can be mounted elsewhere, e.g. 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's sensing volume.

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### CAUTION

Take care not to overtighten the nuts on the bolts, as it may be possible to distort and/or damage the brackets or DSP plate by doing so, and/or the nuts may seize up. Only tighten the nuts to a degree necessary to hold the sensor firmly in place.

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Where the sensor is to be mounted onto another type of mast, please refer to the manual for that mast for mounting details.

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### CAUTION

Ensure that the sensor is mounted according to the following figure. Do not reposition, once fixings are tightened, by forcing the arms of the unit as this can cause damage.

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**CAUTION**

Do not remove the mounting plate as this will compromise resistance to water ingress.

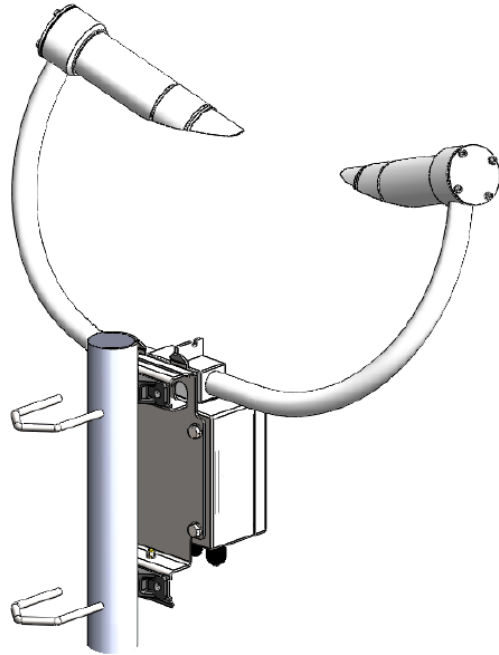


Figure 7-3. Mounting arrangement

If you need to mount the sensor to a flat surface, remove the plastic formers from the mounting brackets and use the holes as shown in [Figure 7-4](#).

**NOTE**

If mounting to a flat surface ensure that there is no obstruction to airflow through the sample volume.

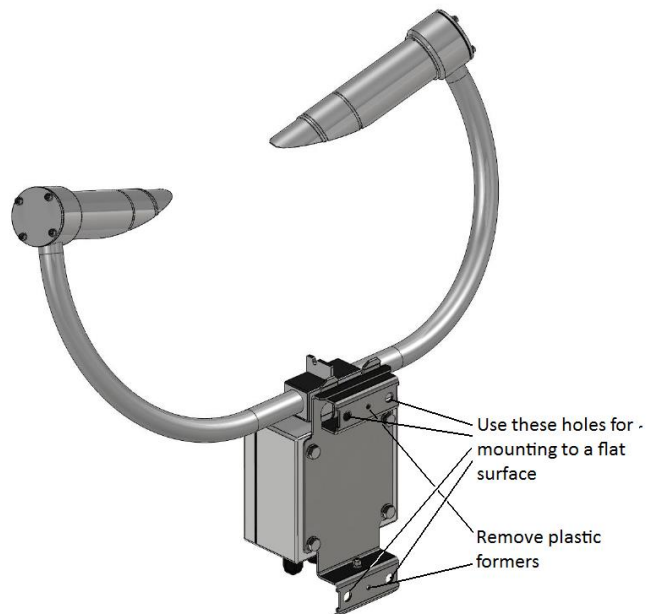
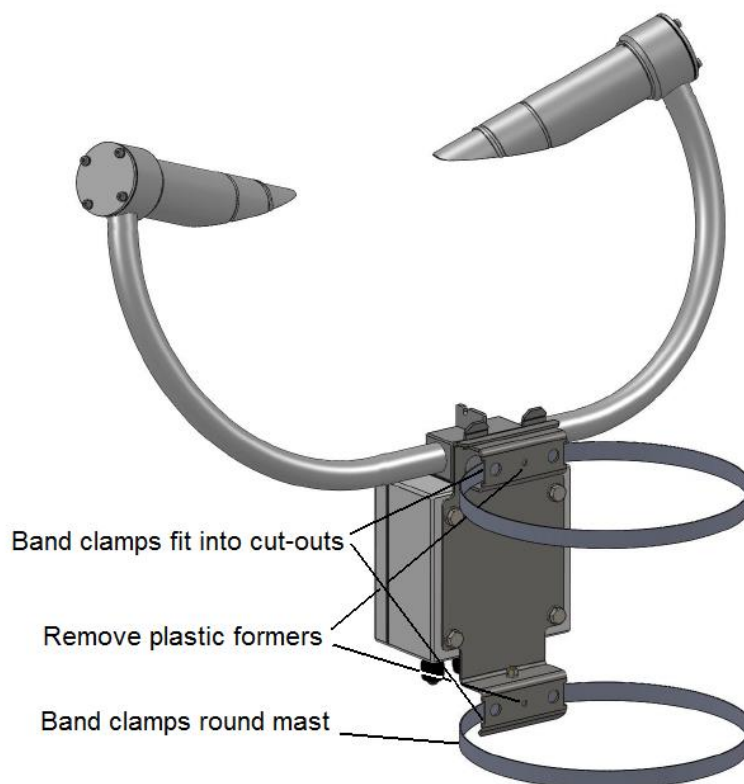


Figure 7-4. Mounting to a flat surface

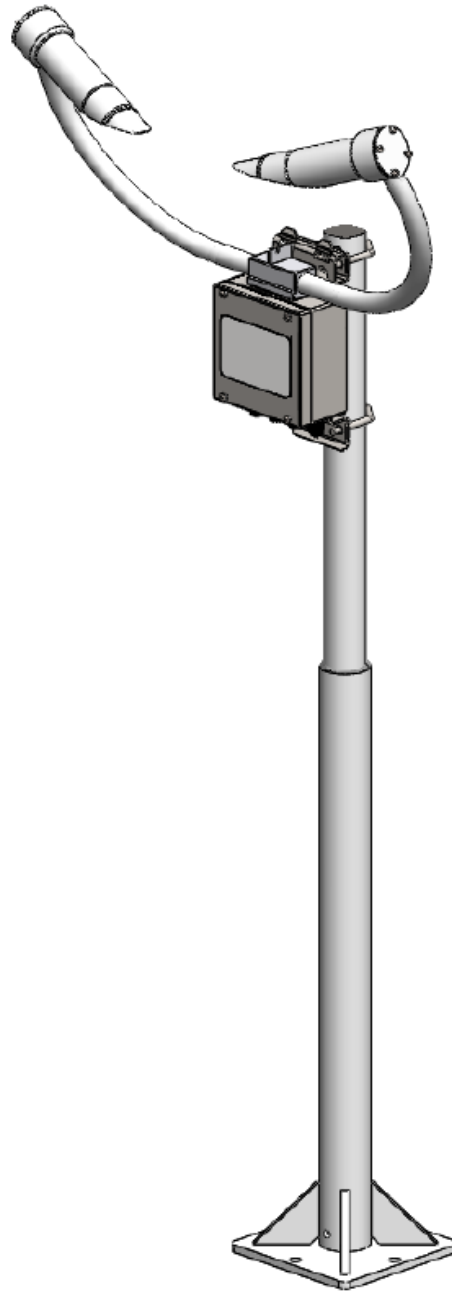
Slots are provided to allow band clamps to be used with larger diameter masts, see [Figure 7-5](#).



*Figure 7-5. Use of band clamps*

### **7.3 Optional Campbell Scientific Mount**

A Campbell Scientific ‘optical sensor mount’ is available. This will put the sample volume at about 1.5 m in compliance with the WMO ‘Guide to Meteorological Instruments and Methods of Observation’, 7<sup>th</sup> Edition, Section 9.3.4.



*Figure 7-6. Optical sensor mast*

If one is to be used, use the following installation instructions.

Install the mount on a concrete foundation. If one does not already exist then a concrete foundation should be constructed at least 600 mm square and 600 mm deep. Ensure the ground consistency is not too loose and will be able to support the mount and concrete foundation.

Drill four 12 mm diameter holes using the mount base as a template or using the following in Figure 7-7 to a depth of 77 mm.

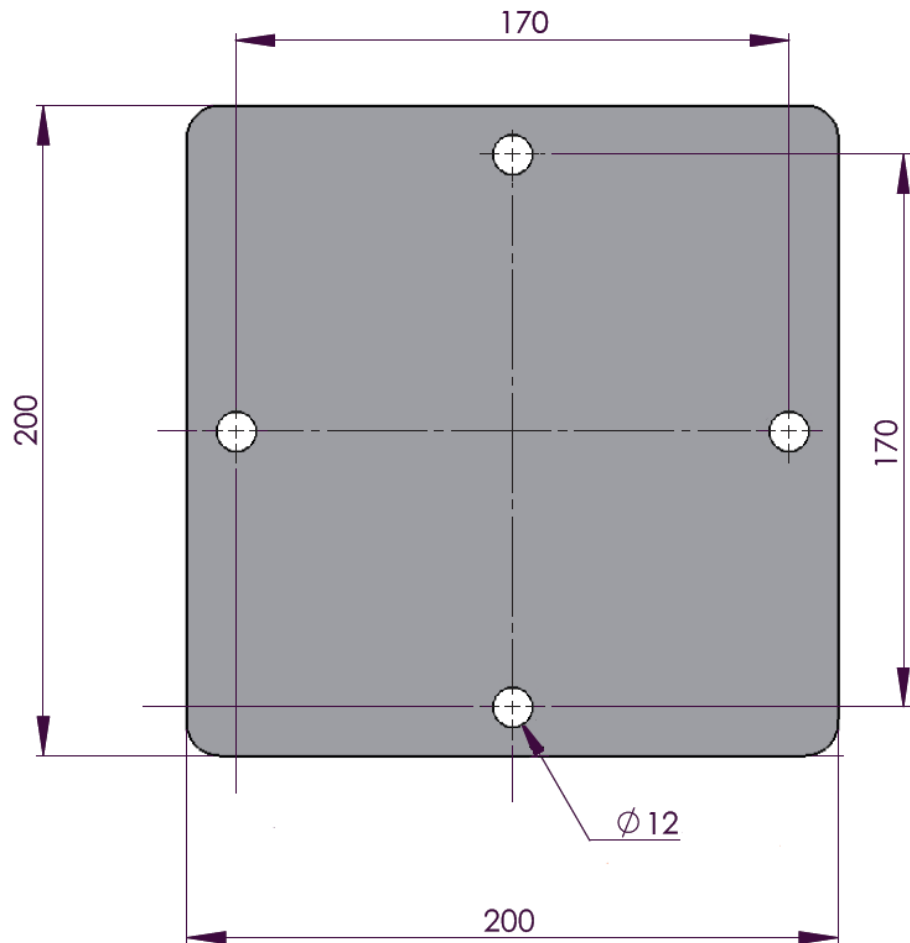


Figure 7-7. Mounting footprint

Clean the holes of all debris.

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

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

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

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

Finally secure the mount with the washers and nuts.

If the surface is not level and flat it may be necessary to add washers under the base on one or more of the foundation screws.

## 8. Sensor internal connectors' description

The sensor has four standard IP66 rated glands. The first gland is by default used by the power/communications line. This comprises the 7-30 V for the main electronics, and the serial communications wires. The sensor is supplied with 5 m cable already connected.

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

Glands 3 and 4 are spare. If user alarms are connected they usually use gland 3 and if a CS215 or HygroVUE probe is fitted this usually uses gland 4.

If you need to run cables through the cable glands follow these guidelines. If a torque wrench is available use a torque of 2.5 Nm (do not over tighten).

Otherwise tighten with fingers as tight as possible and then add a further ¼ turn with a 19 mm spanner (do not over tighten).

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** 10 m is the longest length of the cable type supplied recommended. In particular, additional RS-485 communication should be twisted pair. Please contact Campbell Scientific if you wish to use a longer length of cable.

---

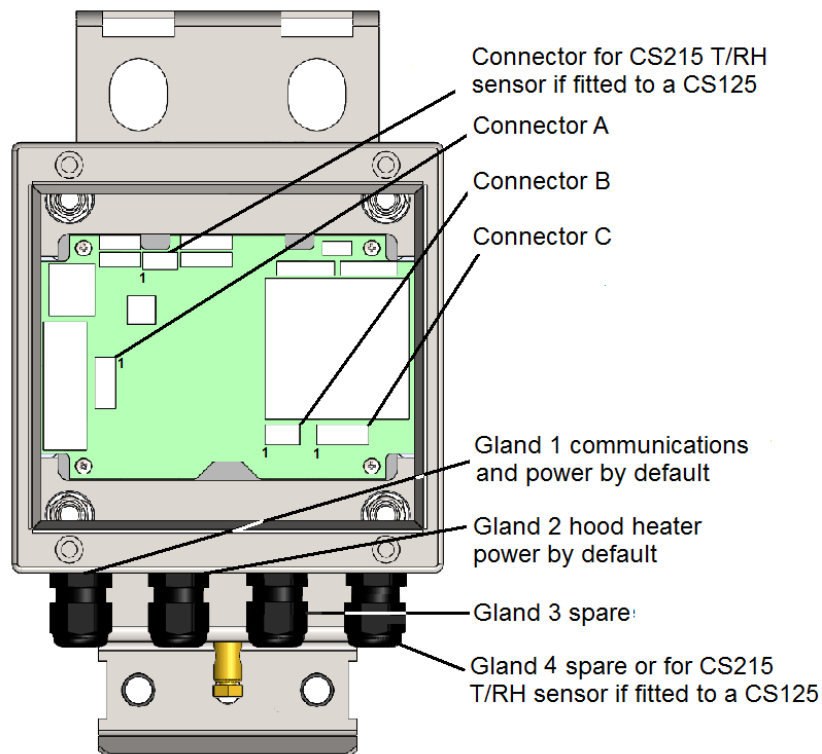


Figure 8-1. Connections

<b>Connector A - Five way connector</b>		
<b>Pin number</b>	<b>Description</b>	<b>Notes</b>
Pin 1	+ve supply	Main electronics +ve supply input
Pin 2	0V	Auxiliary Electronics 0V. Common with the main electronics 0V.
Pin 3	Hood low	This is for the hood heater power supply. If the hood heater supply is DC it should be the negative connection and if it is AC it should be the 'neutral' or 'ground' connection if there is one.
Pin 4	0V	Auxiliary Electronics 0V. Common with the main electronics 0V.
Pin 5	Hood high	This is 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 volts from the main electronics 0V.

<b>Connector B - Three way connector</b>		
<b>Pin number</b>	<b>Description</b>	<b>Notes</b>
Pin 1	0V	0V connection for serial communications. This connection is common with the main electronics 0V (Connector A, pin 2).
Pin 2	Receive	RS-232 receive line, RXD, B/D+ for RS-485 half duplex
Pin 3	Transmit	RS-232 transmit line, TXD, A/D- for RS-485 half duplex

It may be necessary to use a 120 ohm termination resistor to reduce signal distortion when using RS-485 for cable runs over about 500 m and baud rates above 38400. It should be connected between pins 2 and 3.

<b>Connector C - Four way connector</b>		
<b>Pin number</b>	<b>Description</b>	<b>Notes</b>
Pin 1	0V	0V connection for user alarms. This connection is common with the main electronics 0V (Connector A, Pin 2).
Pin 2	User 2	Output for user alarm 2
Pin 3	0V	0V connection for user alarms. This connection is common with the main electronics 0V (Connector A, Pin 2).
Pin 4	User 1	Output for user alarm 1

<b>CS125 only</b>	
<b>Pin number</b>	<b>Description</b>
Pin 1	+12V
Pin 2	SDI-12
Pin 3	0V

**NOTE**

To use these connections it is necessary to either use the cable gland taking the hood heater power or, if the hood heater is also required, to use different cables to those supplied. Please contact Campbell Scientific if you need any advice on choice of cable.

## 8.1 Sensor recommended wiring using Campbell Scientific cables (this cable is supplied already connected as standard)

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 PC or to a datalogger such as the Campbell Scientific CR1000 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

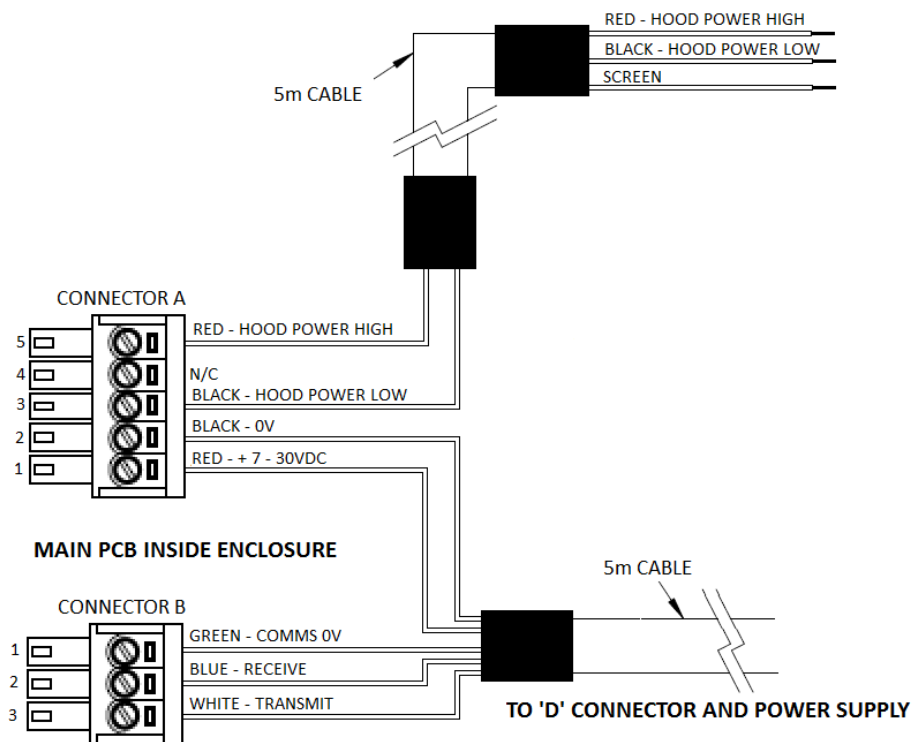


Figure 8-2. Communications and power connections



**COMMUNICATIONS AND POWER CONNECTOR**

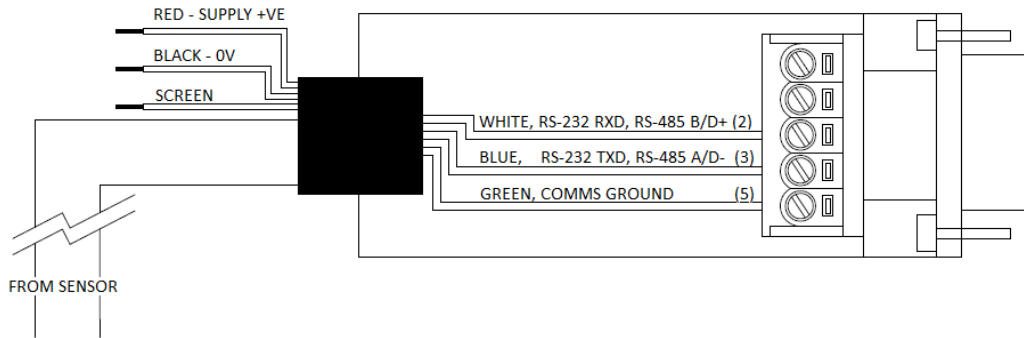


Figure 8-3. Communications and power connector

Two types of configuration cable are available from Campbell Scientific that plug directly into connector B in place of the normal connector and cable. One has a RS-232 or RS-485 output according to how the CS120A/CS125 is configured (Figure 8-4) and one has a USB output (Figure 8-5).

**NOTE**

If the lid is removed, take care not to overtighten the fixing screws. A small gap should remain between the lid and box.

**CONFIGURATION CABLE  
PART NUMBER 010817**

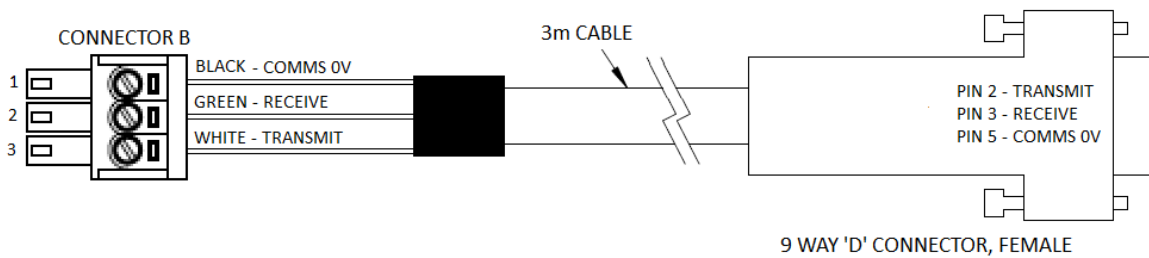


Figure 8-4. Configuration cable

**USB CONFIGURATION CABLE  
PART NUMBER 009063**

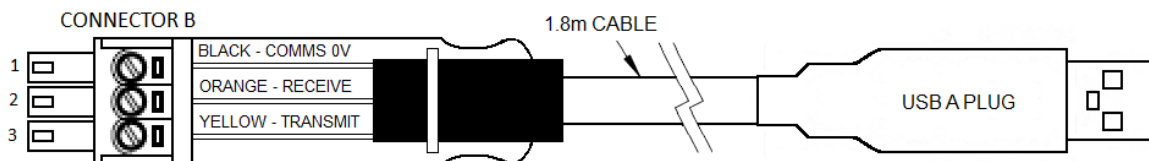


Figure 8-5. USB configuration cable

## 9. HygroVUE 5, HygroVUE 10 or CS215 T/RH Sensor (CS125 only)

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

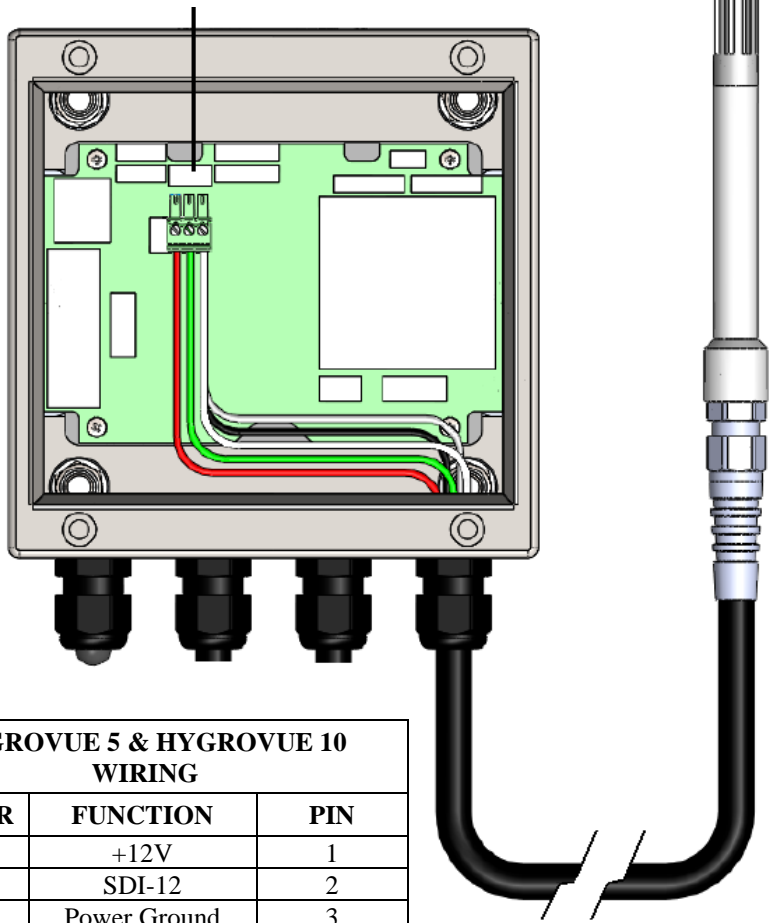
A HygroVUE 5, HygroVUE 10 or CS215 temperature and RH sensor can be connected to a CS125. This is recommended as it will improve the performance of the CS125 in identifying precipitation and allows it to, for example, distinguish between mist and haze. Precipitation identification at temperatures close to freezing will be much improved by a CS215 and its use is highly recommended in regions where temperatures close to 0°C are common if information on precipitation type is important. It also allows RH information to be included in data messages.

If a HygroVUE 5, HygroVUE 10 or CS215 is connected then the temperature used for assessment of precipitation type and included in data messages will come from the HygroVUE 5, HygroVUE 10 or CS215 instead of the temperature sensor mounted in the cross arm.

The connections for the HygroVUE 5, HygroVUE 10 or CS215 are shown in Figure 9-1. The HygroVUE 5 can be mounted in the Rad 6, the HygroVUE 10 in the Rad 10E, or CS215 itself can be mounted in a Met20 screen on the same mast as the CS125. The screen can be mounted on the top section of an OSM1 optical mast below a CS125.

WMO – No. 8, 2.1.4.1 recommends temperature measurement at a height of between 1.2 and 2.0 m above ground. The screen should be below the height of the CS125 electronics box.

**Connections for temperature and RH sensor**



<b>HYGROVUE 5 &amp; HYGROVUE 10 WIRING</b>		
<b>COLOUR</b>	<b>FUNCTION</b>	<b>PIN</b>
Brown	+12V	1
White	SDI-12	2
Black	Power Ground	3
Clear	Shield	3

<b>CS215 WIRING</b>		
<b>COLOUR</b>	<b>FUNCTION</b>	<b>PIN</b>
Red	+12V	1
Green	SDI-12	2
Black	Power Ground	3
Clear	Shield	3
White	Power Ground	3 or NC

Figure 9-1. Connection for the optional HygroVUE 5, HygroVUE 10 and CS215 T/RH sensors

## 10. Functions of the internal switches

The sensor is equipped with four switches located within the main enclosure. These switches perform certain functions at power up, their functions are detailed in Figure 10-1.

### IMPORTANT

The switches are only read during the power up sequence of the sensor. This means that if the switches are pressed whilst the sensor is running nothing will happen, the sensor will need to be power cycled leaving at least 10 seconds with the sensor off for any of their functions to be performed.

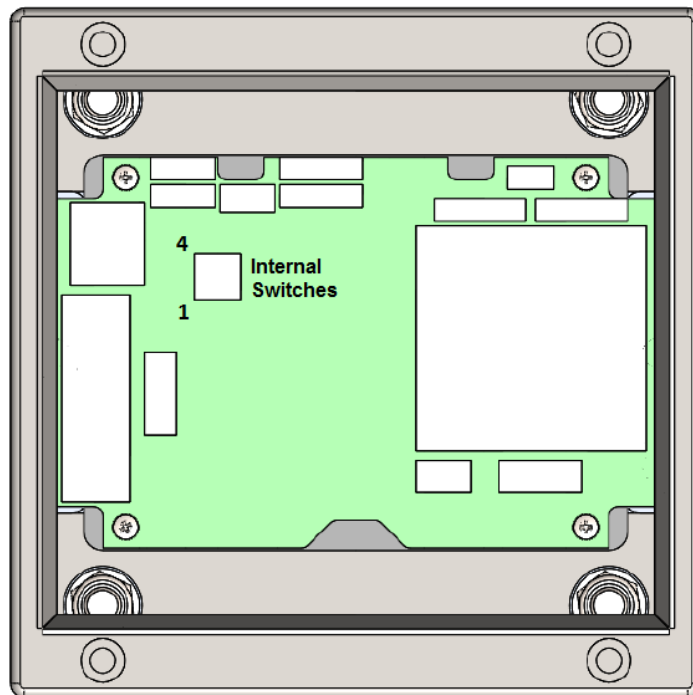


Figure 10-1. Internal switches

<b>Switch number</b>	<b>Function</b>
4	When switched ON the sensor uses the TMOR calibration and OFF it uses the MOR calibration. Please refer to Section 1.3 for a description of these two calibration options.
3	When switched to the ON position and the sensor is power cycled this switch temporarily sets the sensor communications port to a default RS-232 communication state at 38400 baud. This is useful during field tests or maintenance when the sensor has been remotely configured for RS-485 mode or a baud rate your PC 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 these new data rate settings will be committed to flash.  Once this switch is returned to its OFF position and the sensor is power cycled the sensor will return to its previous communications settings.
2	<i>Reserved for future use, set to OFF.</i>
1	When switched to the ON position this switch will reset the sensor to its factory default values. This reset will affect all communication settings. This will take immediate effect upon power up.  NOTE: To use this the power supply must be stable. Do not leave this switch set permanently.

---

**NOTE** If the lid is removed take care not to overtighten the screws when it is replaced. A small gap should remain between the lid and box.

---

## 11. Message Formats: A breakdown of the different default outputs of the sensor – Basic/Partial/Full

The sensor has twelve different message formats available to the user. All parameters are space delimited with a unique start and end character allowing easy storage into any logger (see [Section 15](#) on how to set default outputs). The SYNOP Full Format message is the default message for the CS125 and the Full Format Visibility only message is the default for the CS120A. These can be selected 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
->
    
```

---

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

---



---

**NOTE** Refer to Appendix B for the checksum algorithm.

---

## 11.1 Visibility only messages

### Basic Format, Visibility Only

STX	Message ID	Sensor ID	System status	Visibility distance	Visibility units	Checksum (CCITT)	ETX	Carriage return	Line feed
0x02	0				M or F	XXXX	0x03	0x0D	0x0A

0 0 0 19837 M FC92 (Example message, visibility units = metres)

---

**NOTE** In the following example messages the shown message intervals are 12 seconds and visibility units are in metres unless otherwise indicated.

---

### Partial Format, Visibility Only

STX	Message ID	Sensor ID	System status	Message interval	Visibility distance	Visibility units	User alarms	Checksum (CCITT)	ETX	Carriage return	Line feed
0x02	1					M or F	0 0	XXXX	0x03	0x0D	0x0A

1 0 0 12 20405 M 0 0 EF07 (Example message)

Full Format, Visibility Only (Default message for CS120A)

STX	Message ID	Sensor ID	System status	Message interval	Visibility distance	Visibility units	Averaging duration	User alarms	System alarms 10 characters	Checksum (CCITT)	ETX	Carriage return	Line feed
0x02	2					M or F		00	00000...	XXXX	0x03	0x0D	0x0A

2 0 0 12 68218 F 1 0 0 0 0 0 0 0 0 0 0 0 0 0 D378 (Example with Visibility Units = Feet)

2 0 0 12 21793 M 1 0 0 0 0 0 0 0 0 0 0 0 0 0 CB0F (Example with Visibility Units = Metres)

### 11.2 Messages with SYNOP Present Weather Codes (CS125 only)

SYNOP Present Weather Basic Format

STX	Message ID	Sensor ID	System status	Visibility distance	Visibility units	SYNOP Code	Checksum (CCITT)	ETX	Carriage return	Line feed
0x02	3				M or F	0-99	XXXX	0x03	0x0D	0x0A

3 0 0 20428 M 0 20B8 (Example message)

SYNOP Present Weather Partial Format

STX	Message ID	Sensor ID	System status	Message interval	Visibility distance	Visibility units	User alarms	Particle count (minute)	Intensity (mm/h)	SYNOP Code	Temperature (deg C)	Relative humidity*	Checksum (CCITT)	ETX	Carriage return	Line feed
0x02	4					M or F	00			0-99			XXXX	0x03	0x0D	0x0A

4 0 0 12 21157 M 0 0 0 0.00 0 24.1 -99 5A55 (Example message)







Generic SYNOP Present Weather Partial format

0x02	STX
10	Message ID
	Sensor ID
	System status
	Message interval
	Visibility distance
M or F	Visibility units
00	User alarms
	Particle count (minute)
	Intensity (mm/h)
	Generic SYNOP code
	SYNOP code
	METAR code
	Temperature (deg C)
	Relative humidity (%)
XXXX	Checksum(CCITT)
0x03	ETX
0x0D	Carriage Return
0x0A	Line feed

10 0 0 12 20909 M 0 0 0 0.00 0 0 NSW 24.2 -99 AB02 (Example message)

Generic SYNOP Present Weather Full format

0x02	STX
11	Message ID
	Sensor ID
	System status
	Message interval
	Visibility distance
M or F	Visibility units
	Averaging duration
00	User alarms
00000...	System alarms
	Particle count (minute)
	Intensity (mm/h)
	Generic SYNOP code
	SYNOP code
	METAR code
	Temperature (deg C)
	Relative humidity (%)
XXXX	Checksum(CCITT)
0x03	ETX
0x0D	Carriage Return
0x0A	Line feed

11 0 0 12 21342 M 1 0 NSW 24.3 -99 9AD6 (Example message)

**Table 11-1. Summary of message IDs and descriptions**

<b>Message ID break down</b>	
ID	Definition
0	Basic format. Contains only distance and system information
1	Partial format. Contains user alarm outputs
2	Full format. Contains all system alarms codes
3*	Basic SYNOP present weather format
4*	Partial SYNOP present weather format
5*	Full SYNOP present weather format
6*	Basic METAR present weather format
7*	Partial METAR present weather format
8*	Full METAR present weather format
9*	Generic Basic SYNOP present weather format
10*	Generic Partial SYNOP present weather format
11*	Generic Full SYNOP present weather format
12	Custom output

\*CS125 only

<b>Sensor ID break down</b>	
ID	Definition
0-9	Unit number defined by the user to aid identification of data. Zero by default. Useful for RS-485 networks. Operates as an address in RS-485 mode

<b>System status break down<sup>(1)</sup></b>	
Status level	Definition
0	No fault
1	Possible degraded performance
2	Degraded performance
3	Maintenance required

(1) System status break down reflects the highest level of severity of any active alarm.

<b>Message interval</b>	
Time	Definition
1-3600	The amount of time, in seconds, between outputs in continuous mode

<b>Visibility distance break down</b>	
ID	Definition
0-75,000 metres	Current visibility distance being detected by the sensor

<b>Visibility units break down</b>	
ID	Definition
M	Metres
F	Feet

<b>Averaging duration break down (see note)</b>	
ID	Definition
1	One minute average
10	Ten minute average

**NOTE**

In accordance with WMO requirements the sensor produces visibility measurement that are either one 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 extinction coefficient and that average is then used to calculate the MOR for that period. As the relationship between 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. Please consider this, especially when testing the sensor with artificial obscurants or using the calibration disc.

User alarms		
ID	Range	Definition
1	0-1	Visibility either less or greater than a user specified threshold
2	0-1	Visibility either less or greater than a user specified threshold

**Table 11-2. Summary of system alarms and descriptions**

System alarms break down			
Alarm	Range	Severity	Definition
Emitter failure (emitter hoods main LED output power level)	0-2	0	0 = Everything is within normal parameters
		3	1 = Light output level too low
		3	2 = Light output level too high
Emitter lens dirty <sup>(1)</sup>	0-3	0	0 = OK. The reported attenuation is below 10%
		3	1 = Reported window signal value is out of range (>30%) Possible sensor fault or hood could be blocked
		1	2 = Slight dirt build up (10% signal attenuation or higher)
		2	3 = High level of dirt build up (>20%)
Emitter temperature	0-3	0	0 = Temperature is within operating conditions
		1	1 = Too low. Less than -40°C
		1	2 = Too high. Over 80°C
		3	3 = No sensor detected or below -54°C
Detector lens dirty <sup>(1)</sup>	0-3	0	0 = OK. The reported attenuation is below 10%
		3	1 = Reported window signal value is out of range (>30%) Possible sensor fault or hood could be blocked
		1	2 = Slight dirt build up (10% signal attenuation or higher)
		2	3 = High level of dirt build up (>20%)
Detector temperature	0-3	0	0 = Temperature is within operating conditions
		1	1 = Too low. Less than -40°C
		1	2 = Too high. Over 80°C
		2	3 = No sensor detected or below -54°C
Detector DC saturation level (amount of background light seen by the detector hood) <sup>(1)</sup>	0-1	0	0 = Within limits
		2	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.

<b>System alarms break down</b>			
Alarm	Range	Severity	Definition
Hood temperature	0-3	0	0 = Temperature is within operating conditions
		1	1 = Too low. Less than -40°C
		1	2 = Too high. Over 80°C
		2	3 = No sensor detected or below -56°C
External temperature (CS125 only)	0-3	0	0 = Temperature is within operating conditions
		1	1 = Too low. Less than -40°C
		1	2 = Too high. Over 80°C
		2	3 = No sensor detected or below -54°C
Signature error	0-4	0	0 = No fault
		3	1 = OS signature error at power up
		2	2 = User memory signature did not match when last read
		2	3 = User memory fault at power up. Secondary copy was reinstated to correct error.
		3	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	0-1	0	0 = No errors
		3	1 = One or more errors reading user variables from flash occurred
Flash write error	0-1	0	0 = No errors
		3	1 = One or more errors writing user variables to flash occurred
Particle limit (CS125 only)	0-1	0	0 = No errors
		1	1 = More particles detected than can be processed

<sup>(1)</sup>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 which triggers an increase in alarm level must persist for 15 minutes before the alarm is set.

Errors are checked every 10 seconds and the next message output is updated with the following exceptions:

Signature error is checked and reset at power up.

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

Particle limit is checked every minute and reset when read.

<b>Particle count*</b>	
Range	Definition
0-7200	Value represented by an integer number of the current number of particle per minute. (-99 indicates either an error or that the sensor has been powered less than one minute)

<b>Intensity value*</b>	
Range	Definition
0 - 999.99	Value represented by a single precision value of the last minutes rainfall intensity in mm/hr (-99 indicates either an error or that the sensor has been powered up less than one minute)

<b>SYNOP code*</b>	
Range	Definition
See Appendix C	SYNOP weather code for the last minute as defined by the WMO code table 4680. (-1 indicates either an error or that the sensor has been powered up less than one minute)

<b>Generic SYNOP code*</b>	
Range	Definition
See Appendix C	SYNOP weather code for the last three minutes as defined by the WMO code table 4680 simplified to give generic codes. (-1 indicates either an error or that the sensor has been powered up for less than one minute)

<b>METAR code*</b>	
Range	Definition
See Appendix C	METAR weather code for the last minute as defined by the WMO code table 4678.

<b>External temperature*</b>	
Range	Definition
-40.0 - +80.0°C	External temperature in degrees Celsius

<b>Relative humidity*</b>	
Range	Definition
0 - 100	External relative humidity in %RH (-99 indicates either a fault or no CS215 or HygroVUE T/RH sensor is connected)

\*CS125 only, see Appendix C.

## 11.5 Example sensor message outputs

### Full format, visibility only (CS120A default)

2 0 0 10 9622 M 1 0 0 0 0 0 0 0 0 0 0 0 0 0 46AA

### SYNOP present weather full format (CS125 default)

5 0 0 10 112 M 1 0 0 0 0 0 0 0 0 0 0 0 0 0 6 0.14 52 24.0 -99 9190

### METAR present weather full format

8 9 0 60 6682 M 1 0 0 0 0 0 0 0 0 0 0 0 0 0 54 4.5 63 +RA 20.2 91 ABCD

Where:

- 9 is the sensor id
- 60 is the message interval (60 seconds)
- 6682 is the visibility in metres
- M is the visibility units (metres)
- 54 is particle count
- 4.5 is intensity (4.5 mm/hr)
- 63 is the SYNOP code (heavy rain)
- +RA is the METAR code (heavy rain)
- 20.2 is the temperature (20.2 deg. C)
- 91 is the RH (91%)
- ABCD is the checksum

## 11.6 Custom message format

Once a custom message has been formatted it can be output by selecting 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
->
    
```

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

---

**NOTE** The custom message output is only available on OS7 and above.

---

The custom message is as follows:

**Custom format**

STX	Message ID	Unit ID	System status	Message interval	Visibility distance	Visibility units	Up to 16 custom fields	Checksum	EOT
0x02	12					M or F	X X X ...	XXXX	0x04

There are two ways to configure the custom message. The first is through the user menu system. The second is through the use of logger commands. These logger commands are MSGSET and MSGGET.

To configure the message using the user menu you will need to enter the sensor menu system, see the following and [Section 15](#). Entering the sensor menu system.

Return to the message menu 1 and select option 7. You will now be presented with the list of options shown below:

**Menu 1: The message output menu**

```

CS125 MESSAGE - MENU 1
ID 0
S/N E1007
(1) Set message format: FULL METAR
(2) Toggle units: METRES
(3) Toggle polled or continuous mode: CONTINUOUS
(4) Set continuous mode message-interval: 1 second(s)
(5) Toggle output averaging period: 1 minute(s)
(6) Sampling interval: 1 second(s)
(7) Configure custom message format

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

This will take you to message sub 4 so that the parameters required can be selected from the available options to configure the message output format;

```

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
    
```

Enter the number of a custom message field you wish to use and type return. The screen will update with a 1 next to the chosen field. Repeat for each field you want then exit the menu. The changes take effect after selecting “Exit and Save” from the main menu.

**Example**

In the following example selecting options 1, 3, 4, 10, 15 and 17 puts averaging duration, system alarms, dirty windows values, SYNOP code, 10 minute average visibility, and 1 sec visibility into the custom message.

This would give the following output:

```

12 0 0 1 0 92 M1 000000000000 2 0 3 0 92 135 88EF
    
```

Above the custom fields are “1 000000000000 2 0 30 92 135”. The averaging duration is 1 minute, no system alarms are set, the emitter is reading 2% contamination, the detector is reading 0% contamination, the SYNOP code is 30, the 10 minute average visibility is 92 m and the 1 sec reading is 135 m.



The following describes the number of values output.

List of 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 <sup>(1)</sup> , particles in the previous minute	1
7	Intensity <sup>(1)</sup> , mm/hr	1
8	Accumulation <sup>(1),(2)</sup>	1
9	Generic SYNOP <sup>(1)</sup>	1
10	SYNOP code <sup>(1)</sup>	1
11	METAR code <sup>(1)</sup>	1
12	NWS code <sup>(1)</sup>	1
13	Temperature (degrees C) <sup>(1)</sup>	1
14	Humidity (%) <sup>(1),(3)</sup>	1
15	Visibility averaged over the last 10 minutes	1
16	Special 1 (reserved)	1
17	One second visibility <sup>(4)</sup>	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 CS215/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.

## 12. Interface methods – Device Configuration Utility/Command line/Menu

The sensor can be set up and controlled in one of three ways.

The first method is by using Campbell Scientific’s Device Configuration Utility Software (DevConfig) which is included with each delivery on the manuals/resource disk. 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 Configurator can also be used as a terminal emulator to use the built-in 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 PC 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's serial connector B to communicate with the sensor. This can be via the normal communications cable or a configuration cable as described in [Section 8.1](#).

## 12.1 Configuring a PC for talking to the sensor

The following describes the procedure for setting up communications using a terminal emulator program. The terminal emulators built into many Campbell Scientific software products 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

Ensure that if the baud rate of the unit has been adjusted and then the corresponding bits per second value is entered in the port settings of the terminal emulator. The sensor should now be ready to accept commands.

It is possible to set the sensor into the default communication state via one of the internal switches on the sensor main board. See [Section 9](#).

## 13. Definition of the variables that can be set by the user on the sensor

Both DevConfig 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.

<b>ID</b>	<b>Name</b>	<b>Range</b>	<b>Description</b>	<b>Factory default</b>
1	Sensor ID	0-9	Separate ID used as an extra identifier for a particular sensor on a network.	0
2	User Alarm 1 Enabled	0-1	User alarm one activation state 0 = Alarm one disabled 1 = Alarm one enabled	0
3	User Alarm 1 Active	0-1	0 = Check if distance is <i>less than</i> 'User alarm 1 Distance' 1 = Check if distance is <i>greater than</i> 'User alarm 1 Distance'	0

<b>Table 13-1. User definable settings and descriptions</b>				
<b>ID</b>	<b>Name</b>	<b>Range</b>	<b>Description</b>	<b>Factory default</b>
4	User Alarm 1 Distance	0-60000	Distance value that alarm one will trigger against. This value will correspond to metres or feet depending upon which is selected in 'Visibility Unit'	10000
5	User Alarm 2 Enabled	0-1	User alarm two activation state 0 = Alarm two disabled 1 = Alarm two enabled	0
6	User Alarm 2 Active	0-1	0 = Check if distance is <i>less than</i> 'User alarm 2 Distance' 1 = Check if distance is <i>greater than</i> 'User alarm 2 Distance'	0
7	User Alarm 2 Distance	0-60000	Distance value that alarm one will trigger against. This value will correspond to metres or feet depending upon which is selected in 'Visibility Unit'	10000
8	Baud rate	0-6	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. ( <i>Read only</i> )	-
10	Visibility Unit	M or F	Unit the visibility value will be presented as M = metres F = feet	M
11	Message Interval	1-3600	Interval in seconds between outputs in continuous mode. This value has no effect if polled mode has been selected in 'Measurement mode'	60
12	Measurement mode	0-1	Selects polled or continuous modes. In continuous mode the sensor will output a string in the format as set by 'Message Format' at regular intervals as defined by 'Continuous Interval'. 0 = Continuous mode 1 = Polled mode	0
13	Message Format	0-12	Output message 0, 1 and 2 = Basic, partial or full visibility messages 3, 4 and 5 = Basic, partial or full SYNOP messages 6, 7 and 8 = Basic, partial or full METAR messages 9, 10 and 11 = Generic basic, partial or full SYNOP messages 12 = Custom message	5
14	Serial port protocol	0-1	Selects the physical serial interface 0 = RS-232 mode 1 = RS-485 mode	0
15	Averaging period	1 or 10	The period of time that the visibility measurement is averaged over. Either one minute or ten.	1

ID	Name	Range	Description	Factory default
16	Sample timing	1-60	Used to define the time interval between sampling the volume. It is recommended that this value is left at one except when very low power demands are needed. Note that 1s sample timing is needed for present weather measurement. For example: 1 = Sample every second 2 = Sample one second in every two 3 = Sample one second in every three etc.	1
17	Dew heater override	0-1	0 = Allow the sensor to automatically control the dew heaters 1 = Turn the dew heaters off	0
18	Hood heater override <sup>(1)</sup>	0-1	0 = Allow the sensor to automatically control the hood heaters 1 = Turn the hood heaters off	0
19	Dirty window compensation	0-1	0 = No compensation applied 1 = Compensation for dirt on lenses applied. The sensor will compensate for up to 10% signal loss due to dirt per lens.	0
20	Use CRC-16	0-1	0 = Disable command line CRC-16 checking <sup>(2)</sup> 1 = Enable command line CRC-16 checking Note: this does not affect communications via DevConfig or terminal emulator.	0
21	Sensor power down voltage	7-30	PSU Input voltage level below which the sensor will enter low power mode. This is usually used to protect batteries.	7.0
22	Relative humidity <sup>(3)</sup> threshold	1-99	Threshold at which the sensor will define obscuration as liquid or dry if a CS215 is fitted.	80%

(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.

## 14. Command line mode

The command line interface is broken down into three major commands. These are GET, SET and POLL. The GET command is used to request all current user settable values from the sensor. 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 sensor can be configured to expect any commands sent to it to include a valid checksum. For simple commands, e.g. GET and POLL, fixed value checksums can be used (see the downloadable example programs at:

[www.campbellsci.com/downloads/cs125-example-programs](http://www.campbellsci.com/downloads/cs125-example-programs) or [www.campbellsci.com/downloads/cs120a-example-programs](http://www.campbellsci.com/downloads/cs120a-example-programs) ).

For more complex SET commands the checksum needs to be calculated (see Appendix B). The use of the checksum is disabled by default. It is recommended that the checksum functionality is enabled where possible, especially when long cable runs are used, or in electronically noisy environments.

## 14.1 The SET Command

The set command is used to configure the sensor via the command line. The SET command is a single space delimited string that can be sent from any data logger or PC equipped with serial communications. The SET command and the ‘Device Configuration Utility’ software access identical settings within the sensor, please refer to the ‘Device Configuration Utility’ section of this document for a more detailed breakdown of the setting available here. This command is used to change the default power up state of the sensor. See [Section 14.2](#) if a setting is going to be changed on a regular basis e.g. heater controls.

See [Section 12](#) for more information on the values used by the ‘SET’ command.

SET transmitted data	
Example	Description
0x02 <sup>(1)</sup>	STX ^ B <sup>(2)</sup>
SET	SET
:	Delimiting character
	Current Sensor ID
:	Delimiting character
	Sensor ID (may be a new ID)
	User Alarm 1 Set
	User Alarm 1 Active
	User Alarm 1 Distance
	User Alarm 2 Set
	User Alarm 2 Active
	User Alarm 2 Distance
	Serial Baud Rate
	<i>Sensor serial number (read only)</i>
	Visibility Units
	Message interval
	Polling or Continuous modes
	Message Format
	RS-232 or RS-485 serial communications enabled
	Averaging Period
	Sample timing
	Dew heater override
	Hood heater override
	Dirty window compensation
	CRC-16 checking on received commands
	Sensor power down voltage
	Relative humidity threshold <sup>(3)</sup>
:	Delimiting character
XXXX	Checksum (use the valid CRC-16 checksum)
:	Delimiting character
0x03 <sup>(1)</sup>	ETX ^ C <sup>(2)</sup>
0x0D <sup>(1)</sup>	Carriage return
0x0A	Line feed

(1) These values are shown in hexadecimal format not ASCII.

(2) As entered on a keypad.

(3) CS125 only.

### 14.1.1 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 80 :68A3:
```

## 14.2 The SETNC Command

The format of the SETNC command is nearly exactly the same as the SET command. 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 sensor 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, e.g. heater functions, as this command avoids the risk of wearing out the flash storage memory.

---

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

---

### 14.2.1 Example of a 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 :XXXX:
```

## 14.3 The MSGSET Command

The user customisable message format can be configured using the MSGSET command.

When a valid MSGSET command is issued a MSGGET response comes back from the sensor.

Example	Bit	Description
0x01 <sup>(Hex)</sup>	-	SOH
:	-	Delimiting character
MSGSET	-	MSG SET
:	-	Delimiting character
0	-	Sensor ID
:	-	Delimiting character
The following represent 16 bits of a hex value		
	16	<i>Reserved</i>
	15	<i>Reserved</i>
	14	Humidity (%) <sup>(1)(2)</sup>
	13	Temperature (Degrees C) <sup>(1)</sup>
	12	NWS code <sup>(1)</sup>
	11	METAR code <sup>(1)</sup>
	10	SYNOP code <sup>(1)</sup>
	9	Generic SYNOP <sup>(1)</sup>
	8	Accumulation <sup>(1)</sup>
	7	Intensity <sup>(1)</sup>
	6	Particle count <sup>(1)</sup>
	5	Sensor serial number
	4	Dirty windows values
	3	System alarms
	2	User alarms
	1	Averaging duration
:		Delimiting character
XXXX		Checksum
:		Delimiting character
0x04 <sup>(Hex)</sup>		EOT

These selections output more than one variable

- (1) These options will only be available if you're using a CS125
- (2) Only outputs a valid final message value when a CS215 temperature and humidity probe is connected

Description of the custom message bits	
Bit	Description
8000	<i>Reserved</i>
4000	<i>Reserved</i>
2000	Humidity (%)
1000	Temperature (Degrees C)
0800	NWS code
0400	METAR code
0200	SYNOP code
0100	Generic SYNOP
0080	Accumulation
0040	Intensity
0020	Particle count
0010	Sensor serial number
0008	Dirty windows values
0004	System alarms
0002	User alarms
0001	Averaging duration

The HEX value is the sum of all the required fields.

The following example shows the calculation of the HEX value to use a MSGSET message to set a CS125 to output temperature, SYNOP code, sensor serial number, dirty windows values and system alarms.

Description of the custom message bits	
Bit	Description
8000	<i>Reserved</i>
4000	<i>Reserved</i>
2000	Humidity (%)
<b>1000</b>	<b>Temperature (Degrees C)</b>
0800	NWS code <sup>(3)</sup>
0400	METAR code
<b>0200</b>	<b>SYNOP code <sup>(3)</sup></b>
0100	Generic SYNOP <sup>(3)</sup>
0080	Accumulation <sup>(3)</sup>
0040	Intensity <sup>(3)</sup>
0020	Particle count <sup>(3)</sup>
<b>0010</b>	<b>Sensor serial number</b>
<b>0008</b>	<b>Dirty windows values</b>
<b>0004</b>	<b>System alarms</b>

0002	User alarms
0001	Averaging duration
<b>121C</b>	<b>Sum for MSGSET message</b>

The hex value is the hexadecimal sum of the hex values of the chosen fields (in bold text).

The message sent is:

MSGSET:0:161C:9794:
---------------------

The response is:

161C 7067
-----------

In this case “7067” is the checksum

## 14.4 The GET Command

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

### The GET command

GET command transmitted data	
Example	Description
0x02 <sup>(1)</sup>	STX ^ B <sup>(2)</sup>
GET	GET
:	Delimiting character
0	Address based on Sensor ID
:	Delimiting character
0	Reserved for future use, zero default
:	Delimiting character
XXXX	Checksum
:	Delimiting character
0x03 <sup>(1)</sup>	ETX ^ C <sup>(2)</sup>
0x0D <sup>(1)</sup>	Carriage return
0x0A	Line feed

(1) These values are shown in hexadecimal format not ASCII.

(2) As entered on a keypad

### Example of a GET command

GET : 0 : 0 : XXXX :
----------------------



**Data returned by the GET command**

GET returned data	
Example	Description
0x02 <sup>(1)</sup>	STX
	Sensor ID
	User Alarm 1 Set
	User Alarm 1 Active (0 = less than)
	User Alarm 1 Distance
	User Alarm 2 Set
	User Alarm 2 Active
	User Alarm 2 Distance
	Serial Baud Rate
	<i>Sensor serial number (read only)</i>
	Visibility Units
	Message interval
	Polling or Continuous modes
	Message Format
	RS-232 or RS-485 serial communications enabled
	Averaging Period
	Sample timing
	Dew heater override
	Hood heater override
	Dirty window compensation
	CRC-16 checking on received commands
	Sensor power down voltage
	Relative humidity threshold
XXXX	Checksum
0x04 <sup>(1)</sup>	EOT
0x0D <sup>(1)</sup>	Carriage return
0x0A	Line feed

(1) These values are shown in hexadecimal format not ASCII.

**Example of a GET returned data**

0 0 0 10000 0 0 10000 2 1009 M 30 0 2 1 1 1 0 0 0 1 11.5 80 D4FD
--

Explanation:

Sensor ID = 0

User Alarm 1 not set

User Alarm 1 not active

User Alarm 1 distance = 10000 metres

User Alarm 2 not set

User Alarm 2 not active

User Alarm 2 distance = 10000 metres

Serial baud rate 2 (= 38400 Bd)

Serial number = 1009

Visibility Units = M

Continuous mode output interval = 30 seconds  
 Polling mode = 0 (continuous mode)  
 Message format = 2 (full message)  
 RS-232 or RS-485 serial communications = 1 (RS-485)  
 Averaging period = 1 minute  
 Sample timing = 1 sample per second  
 Dew heater override = 0 (sensor will automatically control the dew heaters)  
 Hood heater override = 0 (sensor will automatically control the hood heaters)  
 Dirty window compensation = 0 (dirty window compensation off)  
 CRC-16 checking on received commands = 1 (CRC-16 checking enabled)  
 Sensor power down voltage = 11.5V  
 Relative humidity threshold 80 (CS125 only)  
 Checksum = D4FD

## 14.5 The MSGGET Command

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

MSGGET command transmitted data	
Example	Description
0x01 <sup>(Hex)</sup>	SOH
:	Delimiting character
MSGGET	MSG GET
:	Delimiting character
0	Address based on Sensor ID
:	Delimiting character
0	Payload
:	Delimiting character
XXXX	Checksum
:	Delimiting character
0x04 <sup>(Hex)</sup>	EOT

Example of the MSGGET command as sent to the sensor

The message sent is:

MSGGET:0:0:C6ED:

The response is:

161C 7067

## 14.6 The POLL command – Polling the sensor

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

### The POLL command

POLL command transmitted data	
Example	Description
0x02 <sup>(1)</sup>	STX, ^B <sup>(2)</sup>
POLL	POLL
:	Delimiting character
0	Address based on Sensor ID
:	Delimiting character
0	Reserved for future use, zero default
:	Delimiting character
XXXX	Checksum <sup>(3)</sup>
:	Delimiting character
0x03 <sup>(1)</sup>	ETX, ^C <sup>(2)</sup>
0x0D <sup>(1)</sup>	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.

### NOTE

The maximum response time to a poll command is 100 ms.

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 ID's with the correct checksum.

### 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:

## 14.7 The ACCRES command – Resetting the accumulation value

If accumulation is included in a custom message the ACCRES command resets the accumulation to zero. See [Section 11.6](#).

### The ACCRES command

ACCRES command transmitted data	
Example	Description
0x02 <sup>(1)</sup>	STX, ^B <sup>(2)</sup>
ACCRES	ACCRES
:	Delimiting character
0	Address based on Sensor ID
:	Delimiting character
0	Reserved for future use, zero default
:	Delimiting character
XXXX	Checksum <sup>(3)</sup>
:	Delimiting character
0x03 <sup>(1)</sup>	ETX, ^C <sup>(2)</sup>
0x0D <sup>(1)</sup>	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.

### Example of an ACCRES command

```
ACCRES : 2 : 0 : 3A68 :
```

If the setting to check the checksum on received commands is enabled the checksum varies with the Sensor ID value.

## 15. Entering the sensor menu system

The user can enter the menu system by typing 'open *id*' into 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 should now be displayed:

**The setup menu**

```
WELCOME TO THE CAMPBELL SCIENTIFIC LTD CS125 SETUP
MENU
ID 0
S/N 2003
(1) Message output menu
(2) User alarm menu
(3) Calibrate sensor
(4) System information
(5) Communications setup
(6) System configuration

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

The displayed options are accessed simply by typing the corresponding number then pressing return. 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.

Typing '1' opens the message menu containing settings relating to the sensor's outputs.

**Menu 1: The message output menu**

```
CS125 MESSAGE - MENU 1
ID 0
S/N E1007
(1) Set message format: FULL METAR
(2) Toggle units: METRES
(3) Toggle polled or continuous mode: CONTINUOUS
(4) Set continuous mode message-interval: 1 second(s)
(5) Toggle output averaging period: 1 minute(s)
(6) Sampling interval: 1 second(s)
(7) Configure custom message format

(9) Refresh
(0) Return to main menu

->0
```

While in the message output menu, typing '1' allows the message format to be set ([Section 11.6](#)). The following lists options. Type the appropriate number to set the required message format. The messages are described in more detail in [Section 11](#).

Note that the CS120A Visibility Sensor can only output messages 0-2 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
->

```

While in the message output menu, typing '2' will toggle the units through the options 'METRES' and 'FEET' or by typing '4' it will allow the message interval to be entered.

In setup menu, typing '2' allows the User Alarms to be set, again by toggling through options or changing values.

### **Menu 2: The user alarm menu. Sub menu 2: Alarm two activation level (Option 6)**

Option (3) is the calibration menu

```

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

->

```

Typing '3' while in the setup menu opens the calibration menu.

**Menu 3: 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

->
```

Consult the 'calibration' section ([Section 16](#)) of this manual for information on how to calibrate the sensor.

---

**NOTE**

Once a calibration is finished changes are immediate, but factory calibrations can be restored if needed using Option '(2)' in the calibration menu. The disk constants however remain as the last disk used.

---

Typing '4' while in the setup menu option opens the systems information menu containing useful information such as temperature and system alarms.

The parameters 'calibration value factory offset' and 'calibration value factors scale' are the factory calibration coefficients from the last factory calibration. The parameters 'calibration value cal offset' and 'calibration value cal scale' are the calibration coefficients from the latest calibration.

**Menu 4: The system information menu**

```

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

->0

```

If either of the dirty window alarms are set it is recommended you follow the cleaning section of this manual ([Section 18](#)).

If there is a flash error or signature error it is recommended that you contact Campbell Scientific.

The sensor power down voltage shown before the supply voltage is not available for CS120A sensors with serial numbers less than E1030.



### Menu 5: The communication menu

```

CS125 COMMUNICATIONS - MENU 5
ID 0
S/N 1009
(1) Set sensor ID
(2) Set RS-232/RS-485 baud rate: 38400
(3) Toggle RS-232/RS-485 modes: RS-232

(9) Refresh
(0) Return to main menu

->
    
```

The communications menu 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 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

->
    
```

This menu 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 this menu. This applies if a CS215 sensor is attached and defines the level of RH below which obscuration is deemed to be dry (that is haze, SYNOP 04 or 05, METAR HZ) rather than wet (mist, SYNOP 10, METAR BR or fog, SYNOP 30 etc. METAR FG).

The default for Patchy Fog is ON in which case the message outputs will include BCFG. If patchy fog is toggled to OFF the message output will not include BCFG. It can be better sometimes to not output BCFG with some aviation systems.

Option (8) is reserved for future use.

Option (10) and (11) allows the user to manually set the temperatures at which 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.

Menu 9 and 0: Exiting the menu system

Options '9' and '0' exit from the menu system. Note that typing '0' will lose all changes made including communications settings.

```
CAMPBELL SCIENTIFIC LTD sensor menu exited.
```

## 16. Calibrating the sensor

### 16.1 Visibility calibration

The sensor can be checked and adjusted using the optional sensor high grade calibration kit. The calibration must be run using the onboard menu system. If you have Campbell Scientific's Device Configuration program a terminal emulation screen is provided in the sensor screens to let you access this function. To perform the calibration you will need a sensor calibrator disk and a computer with a standard serial port compatible with the sensor. If your sensor is not currently configured for RS-232 communications you can set the internal switch, switch three, to temporarily set the sensor to RS-232 mode 38400 bps. If the sensor is already set in RS-232 mode it should not be necessary to change any internal switches. (See [Section 10](#) for more information on the sensor internal switches.)

The test should ideally be performed in the following conditions:

- Ambient temperature should be between 0°C and 50°C
- The local visibility should be approximately 10,000 metres or higher.

The system is self-regulating. However, it is recommended that the sensor is calibrated at least every two years.

The calibration is performed from menu item 3 on the main terminal screen. Please refer to the menu section ([Section 13](#)) of this manual for further information on how to access this menu.

Once you have selected menu item 3 you should be presented with the following screen.

```
CS125 CALIBRATION - MENU 3
ID 0
S/N 1006
(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
```

Select option 1 to start the calibration. You will then be asked to confirm that you would like to perform a calibration. Please note, once you have entered yes at this point you will not be able to exit 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**

---

At this stage it is advisable to clean the lenses. Refer to [Section 18](#) 'Cleaning' for more information. A simple visual check may be enough to confirm the lenses are clean.

---

Once you have started the tests you will be asked for the sensor calibrator serial number and extinction coefficient (EXCO) with a confirmation at each step giving you the chance to correct typing mistakes.

You should not enter the "E" at the start of the calibration disk serial number.

**NOTE**

---

When asked for confirmation you do not need to press return after you type 'y'.

---

```
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.
```

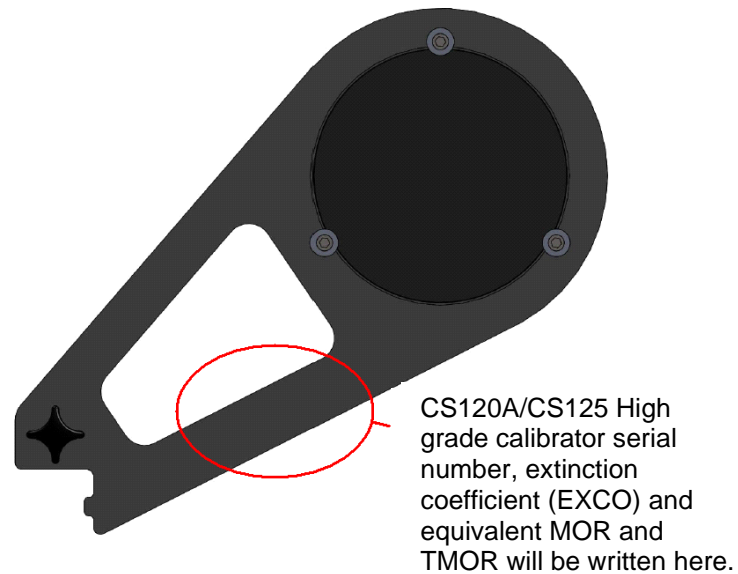


Figure 16-1. Calibration disk

When you have entered the calibrator information the sensor will wait for you to place the foam bungs into the sensor hoods. 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 please contact Campbell Scientific.

```
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.
```

Remove the bungs once the sensor instructs you to. Place the sensor calibrator into the volume by fastening it to the central mounting point.

---

**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 [Section 18](#), Cleaning.

---

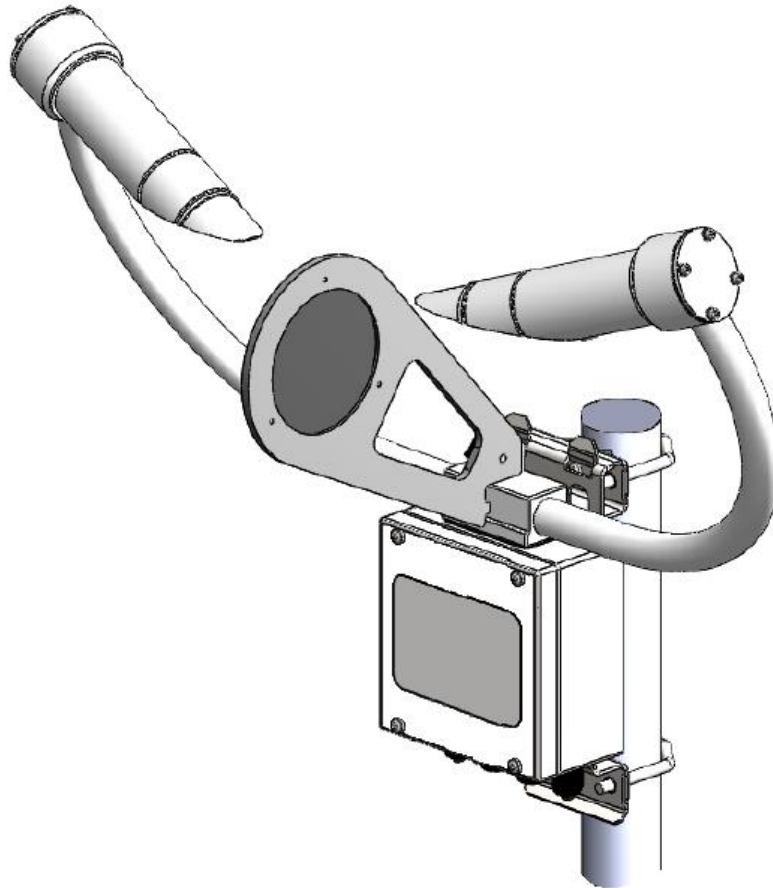


Figure 16-2. Mounting calibration disk

```
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. It is generally good practice to check the process has worked by observing the measured visibility values output by the sensor with the calibration disk still in place. The sensor should output a visibility reading in its messages or in the information screen which is close to the value printed on the disc. On disks made from late 2020 on two values are printed on the disk arm, a value of MOR and a value of TMOR. Use the value that matches the setup of your sensor (the MOR/TMOR mode is set by switch 4).

## 16.2 Dirty window zero calibration

Option 3 in the calibration menu allows the user to reset the zero contamination level for dirty windows detection (option 4 allows a return to the factory value if something goes wrong with the calibration process.)

This should be carried out 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 very clean (see Section 18). Temperature should ideally be in the range 15-30°C and the sensor should have been powered up for over 5 minutes. Before starting this process make sure the lenses are dry and that neither the calibration bungs or calibration disk are in place.

```
CS125 CALIBRATION - MENU 3
ID 0
S/N 1006
(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?
```

Then type 'Y'. The sensor responds in a similar way to the following:

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

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

The numbers reported are internal measurements reported for reporting to the factory in case of a fault. Press any key and the dirty window zero offset calibration is complete. As a final check of a successful calibration return to the information screen and check the two dirty window alarm values which should not report close to 0%.

## 16.3 Internal temperature check (CS125 only)

The CS125 has an internal temperature sensor in one of the cross arms. This is used as part of the present weather identification if a CS215 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 [Section 11](#)) or in the system information menu (see [Section 15](#)) should be within about 3°C of the reference. The comparison should ideally be made in cloudy and windy conditions and as near to 0°C as possible.

## 17. Performing an operating system update

Operating system updates for the present weather sensor are performed using Campbell Scientific’s Device Configuration Utility (DevConfig) software. Please refer to the help built into the DevConfig software for full instructions on how to update the sensor operating system. The following figures show the procedure using DevConfig.

**NOTE** To use DevConfig to carry out an OS change requires RS-232 communication. If a sensor is set to communicate by RS-485 it can be temporarily set to RS-232 with switch 3 (see [Section 10](#)).

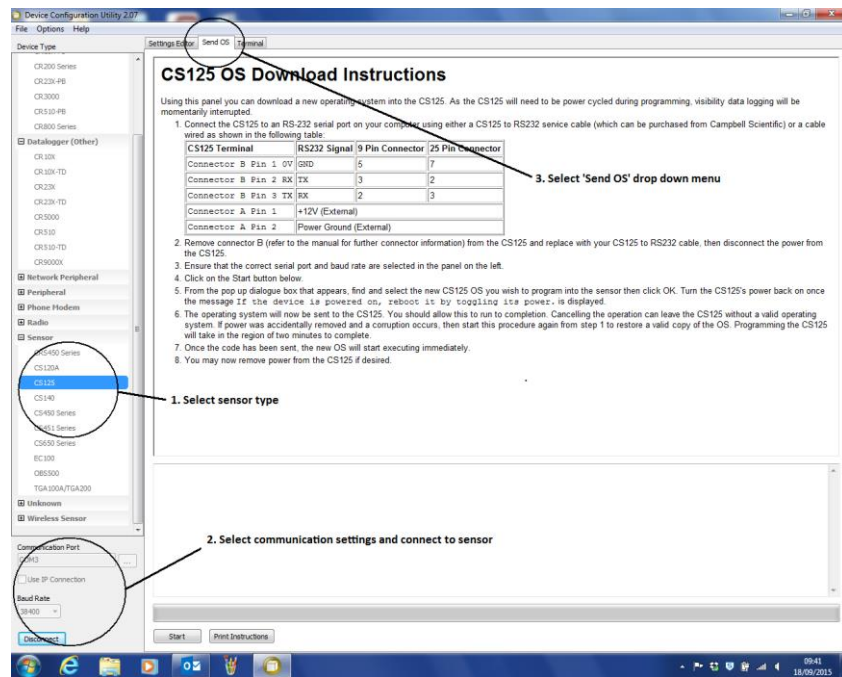


Figure 17-1. Sensor DevConfig download instructions

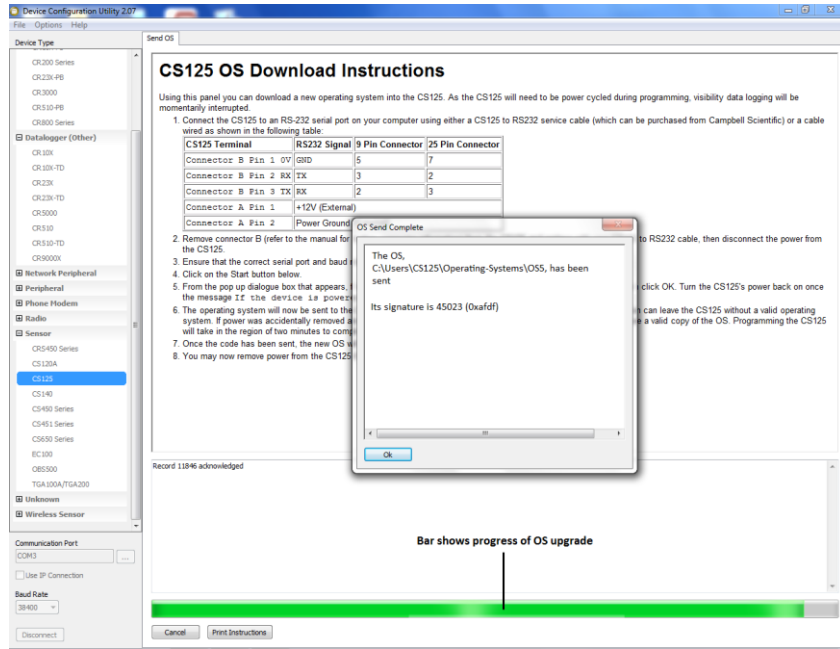


Figure 17-2. Sensor DevConfig screen when OS update is complete



## 18. Cleaning

The sensor is a robust instrument that will provide years of uninterrupted weather monitoring. Calibration is carried out at the factory and can be redone easily on site with the optional sensor calibrator or carried out by Campbell Scientific if required. Only general cleaning of the lenses is required to keep the sensor working efficiently.

Cleaning of the sensor will be required from time to time to ensure that the lenses are free from contaminants. The frequency of required cleaning depends on the exposure of the instrument to such contaminants. This will vary depending on the site location. The sensor is capable of self diagnosing dirty lenses and will indicate in its output when the lenses are contaminated to such a degree that its visibility measurements may be affected.

---

**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 attempt to make a correction for contamination although the accuracy of that correction depends on the ‘type of dirt’.

---

We suggest 6 monthly intervals for locations not prone to contaminants and monthly intervals for those prone to contamination (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 lenses require cleaning, it is very important that only a proper lens cloth or lens tissue be used. The use of inappropriate materials to clean the lenses can permanently damage or reduce the effectiveness of the lenses leading to errors in measurement of precipitation and visibility.

---

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

Excessive pressure may lead to some types of contaminant scratching the lens surface. Over time such scratches can lead to reduced sensor accuracy.

---

**NOTE**

Spiders webs and certain ‘fluffy’ seeds which get lodged in the optical path can lead to the sensor permanently giving low readings and can lead to false reports of precipitation. Cleaning the visibility contamination away with a duster will return the sensor to normal operation.

If spiders are a persistent problem, using some carefully applied insecticide can deter them.

---

## 19. Lubricating the 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.

## 20. Desiccant

Two bags of desiccant are supplied. One is inside the enclosure, the other is separate and sealed in a plastic bag. Desiccant use depends on your application but for use in typical temperature conditions one bag is sufficient for a twelve month period. The desiccant should be placed inside the enclosure taking care that it is not trapped between the lid and the enclosure when the lid is replaced.

The second bag of desiccant should be kept in the plastic shipping bag as a replacement for when the initial bag needs to be dried out. The bags can be rotated in this way many times. Desiccant bags can be dried out by the following method:

1. Arrange the bags on a wire tray in a single layer to allow for adequate air flow around the bags during the drying process. The oven's inside temperature should be room or ambient temperature (25°C - 30°C). A convection, circulating, forced air type oven is recommended for this regeneration process. Seal failures may occur if any other type of heating unit or appliance is used.
2. When placed in a forced air, circulating air, or convection oven, allow a minimum of 4 to 5 cm of air space between the top of the bags and the next metal tray above the bags. If placed in a radiating exposed infra-red element type oven, shield the bags from direct exposure to the heating element, giving the closest bags a minimum of 40 cm clearance from the heat shield. Excessive surface film temperature due to infra-red radiation will cause the Tyvek material to melt and/or the seals to fail. Seal failure may also occur if the temperature is allowed to increase rapidly. This is due to the fact that the water vapour is not given sufficient time to diffuse through the Tyvek material, thus creating internal pressure within the bag, resulting in a seal rupture. Temperature should not increase faster than 0.1°C to 0.3°C per minute.
3. Set the temperature of the oven to 118°C, and allow the bags of desiccant to reach equilibrium temperature.

---

**CAUTION**

Tyvek has a melting temperature of 121°C - 127°C.

---

(NON MIL-D-3464E activation or reactivation of both silica gel and Bentonite clay can be achieved at temperatures of 104°C).

4. Desiccant bags should be allowed to remain in the oven at the assigned temperature for 24 hours. At the end of this period, the bags should be immediately removed and placed in a desiccators jar or dry (0% relative humidity) air tight container for cooling. If this procedure is not followed precisely, any water vapour driven off during reactivation may be re-adsorbed during cooling and/or handling.

5. After the bags of desiccant have been allowed to cool in an airtight desiccator, they may be removed and placed in either an appropriate type polyliner tightly sealed to prevent moisture adsorption, or a container that prevents moisture from coming into contact with the regenerated desiccant. Some care should be taken when re-activating desiccant bags. If heated in an oven which is too hot, the bags may burst. If in any doubt, we recommend purchasing new desiccant packs instead of oven drying. Failure to use or exchange the desiccant may lead to condensation inside the enclosure. Not only will this lead to corrupted data but, in the long term, can also cause corrosion which is expensive to repair.

# ***Addendum - 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 A1 overleaf.

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.

If it is required that the CS125 monitor hail, RH and Temperature, the alternative WXT535 hail sensor should be used. This is a combined sensor that connects to the CS125 in the same manner as the WXT531.

Either WXT sensor 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.

## **Note on connecting a hail sensor to a CS125**

### **Summary**

This describes the wiring and mechanical arrangement in connecting a WXT531, or WXT535, hail sensor to a CS125.

This is applicable to CS125 sensors running OS11 or above.

### **Wiring**

The hail sensor connects to the SDI-12 port inside the CS125 otherwise used for a T/RH sensor as shown in Figure A1. It draws power over this connection in addition to communicating to the CS125.

See also Sections 8 and 9 of this instruction manual.

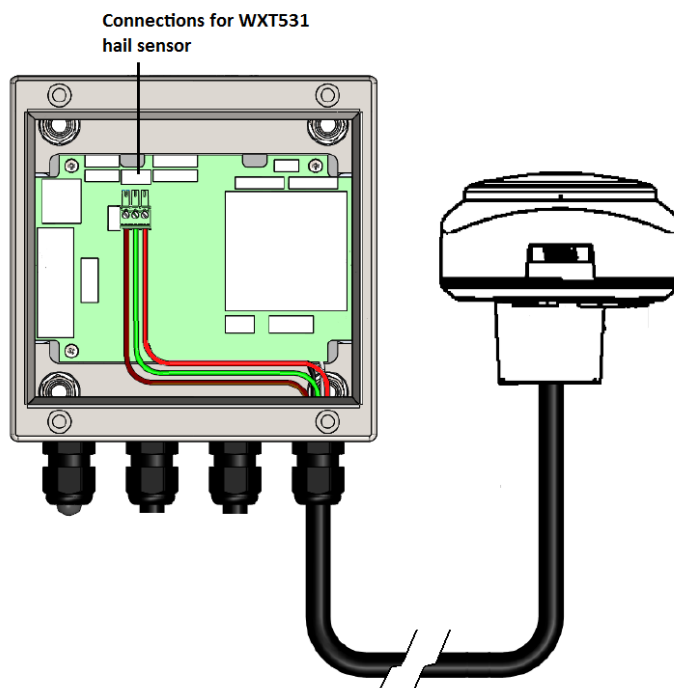
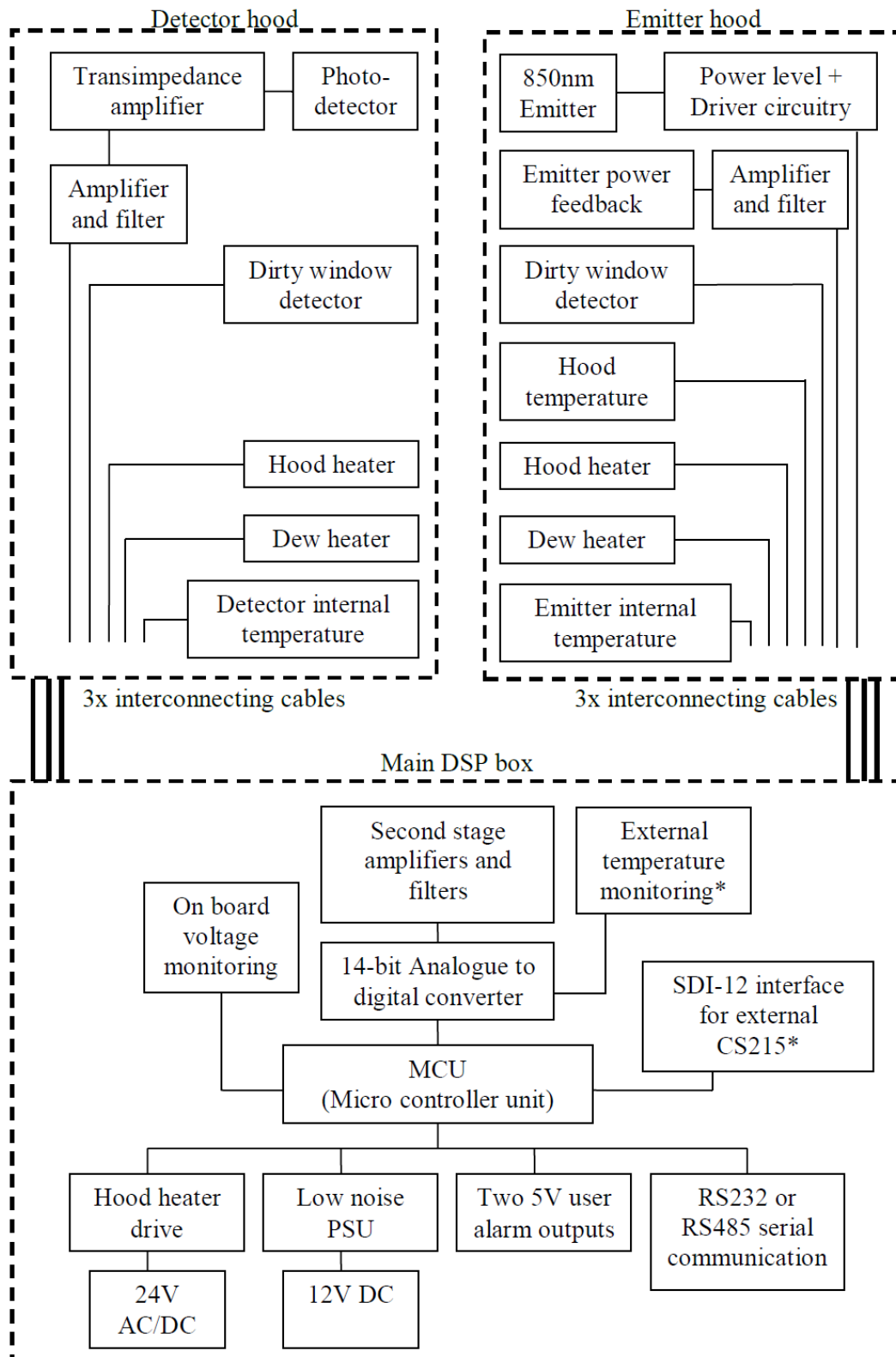


Figure A1. Electrical connections between the WXT531 (shown) or WXT535 Hail Sensor and host CS125

# Appendix A. CS120A/CS125 block diagram

Block diagram



\*CS125 only

## Appendix B. Example C code of the CRC-16 checksum

---

This appendix is an example for programmers implementing their own code to communicate with the sensor. The Checksum command in CRBasic can generate a CRC-16 checksum. Command: Checksum/ChkSumString,1,0).

The checksum includes all characters excluding the SOT, EOT and the checksum itself.

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

```
//-----  
// Creates a CCITT CRC-16 checksum seeded with 0x0000 (XModem style) using a  
// fast non table based algorithm.  
// Pass in the data to convert into a CRC-16 in the form of a NULL terminated  
// character array (a string).  
// Returns the CRC-16 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-16_CCITT(char LineOfData[]){  
  
    unsigned int crc; // returned CRC-16 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 C. Present Weather Codes

## C1. SYNOP Codes produced by the CS125

56 codes are available.

Weather Type	4680 Code
No significant weather observed	0
Haze or smoke, or dust in suspension in the air, visibility $\geq 1$ km*	4
Haze or smoke, or dust in suspension in the air, visibility $< 1$ km*	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, has become thinner during the past hour	32
Fog or ice fog, no appreciable change during the past hour	33
Fog or ice fog has begun or become thicker during the past hour	34
Fog depositing rime	35
PRECIPITATION	40
Precipitation, slight or moderate	41
Precipitation, heavy	42
Solid precipitation, slight or moderate**	45
Freezing precipitation, slight or moderate**	47
Freezing precipitation, heavy**	48
DRIZZLE**	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**	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**	70
Snow, slight (snow includes graupel)	71
Snow, moderate (snow includes graupel)	72
Snow, heavy (snow includes graupel)	73
Ice pellets, slight	74
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

\*Only reported if a CS215 is connected to provide relative humidity, otherwise they will default to mist (10) or fog (20, 30, 31, 32, 33, 34 or 35).

\*\*Only reported in the generic SYNOP messages.

## C2. METAR Codes produced by the CS125

The following METAR codes from WMO table 4678 can be output by the sensor.

UP	Unidentified precipitation
HZ	Haze
BR	Mist
FG	Fog
DZ	Drizzle
RA	Rain
SG	Snow grains
SN	Snow
PL	Ice pellets
SMGR	Hail*

### Notes:

HZ will only be reported if a CS215 is connected to allow relative humidity information to be available.

FZ (freezing) may be added as a descriptor in front of BR, FG, DZ and RA

Intensity qualifiers, '-' for light, '+' for heavy, may be added in front of DZ, RA, SN, and PL

Combinations, for example RASN for rain and snow can be reported.

\*Only reported if an optional hail sensor is connected. Contact Campbell Scientific for details.

## C3. NWS Codes produced by the CS125

NWS codes produced by the CS125 available in a custom message

Weather type	NWS code
Drizzle	L
Rain	R
Snow	S
Snow grains	SG

Z (freezing) may be added as a descriptor in front of L and R

Intensity qualifiers, '-' for light, '+' for heavy, may be added after the NWS code.

# Appendix D. A comparison of the two alternate visibility calibrations

---

## D.1. Introduction

The original and standard calibration of the sensor was derived by 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. We have named this calibration 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 Section D.2).

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 below show the relationship of the whole sensor range (Figure D-1), over 0-2000 metres (Figure D-2) and the ratio of the two outputs (Figure D-3).

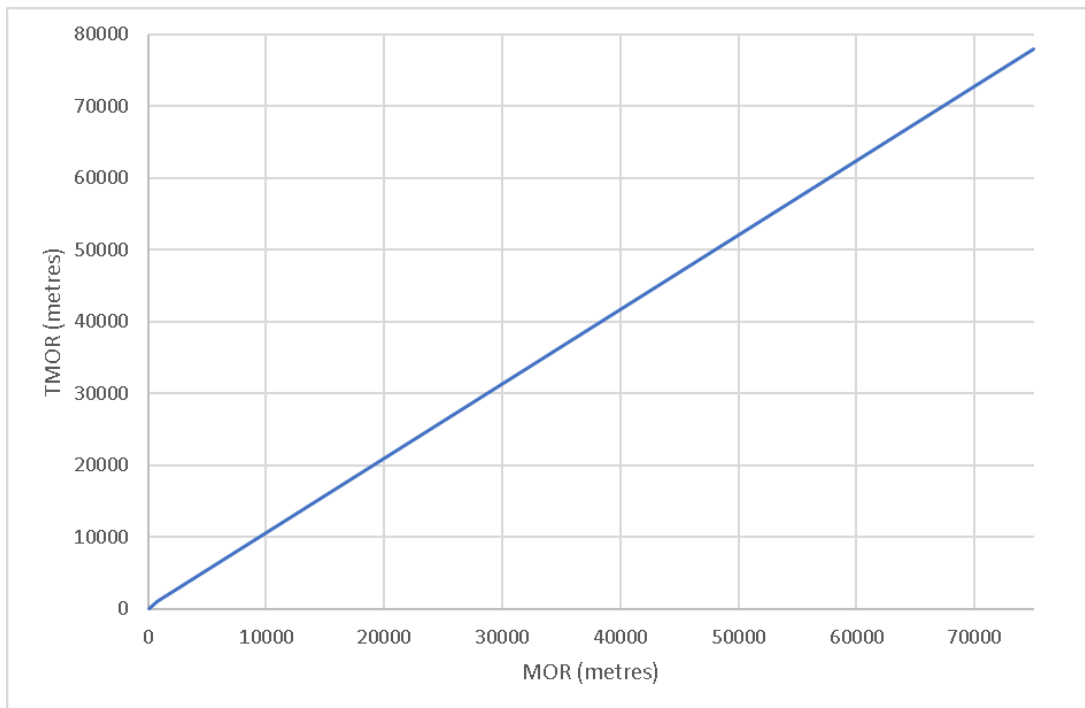


Figure D-1. TMOR plotted against MOR over the full 0-75 km range.

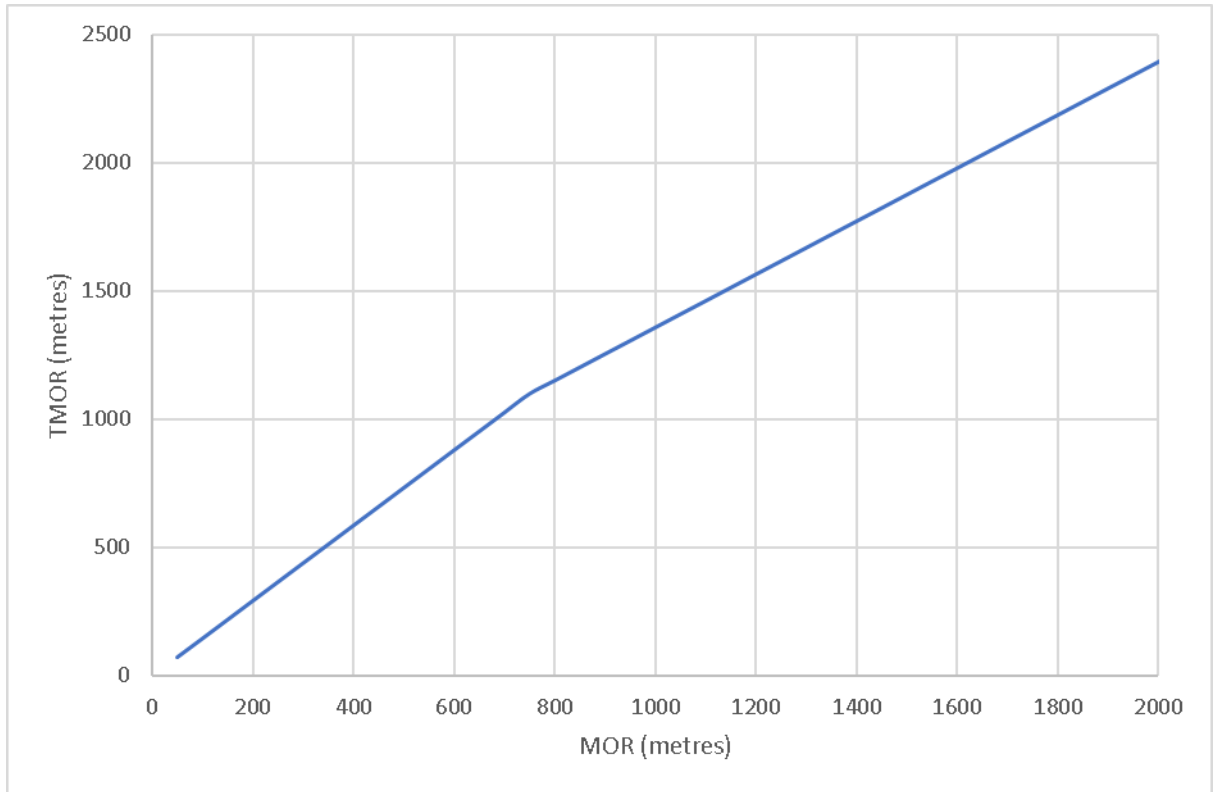


Figure D-2. TMOR plotted against MOR over the 0-2000 m range.

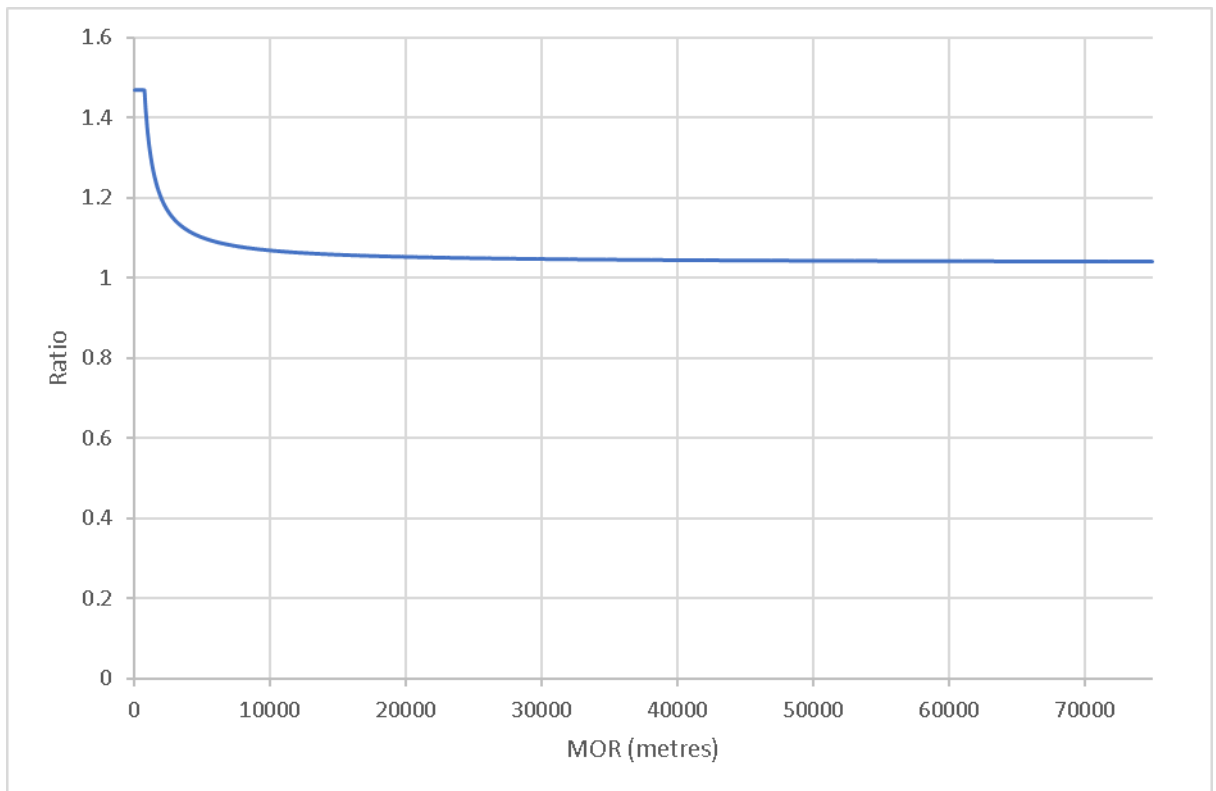


Figure D-3 The ratio of TMOR to MOR over the full 0-75 km range.

## D.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 below (Figure D-4).

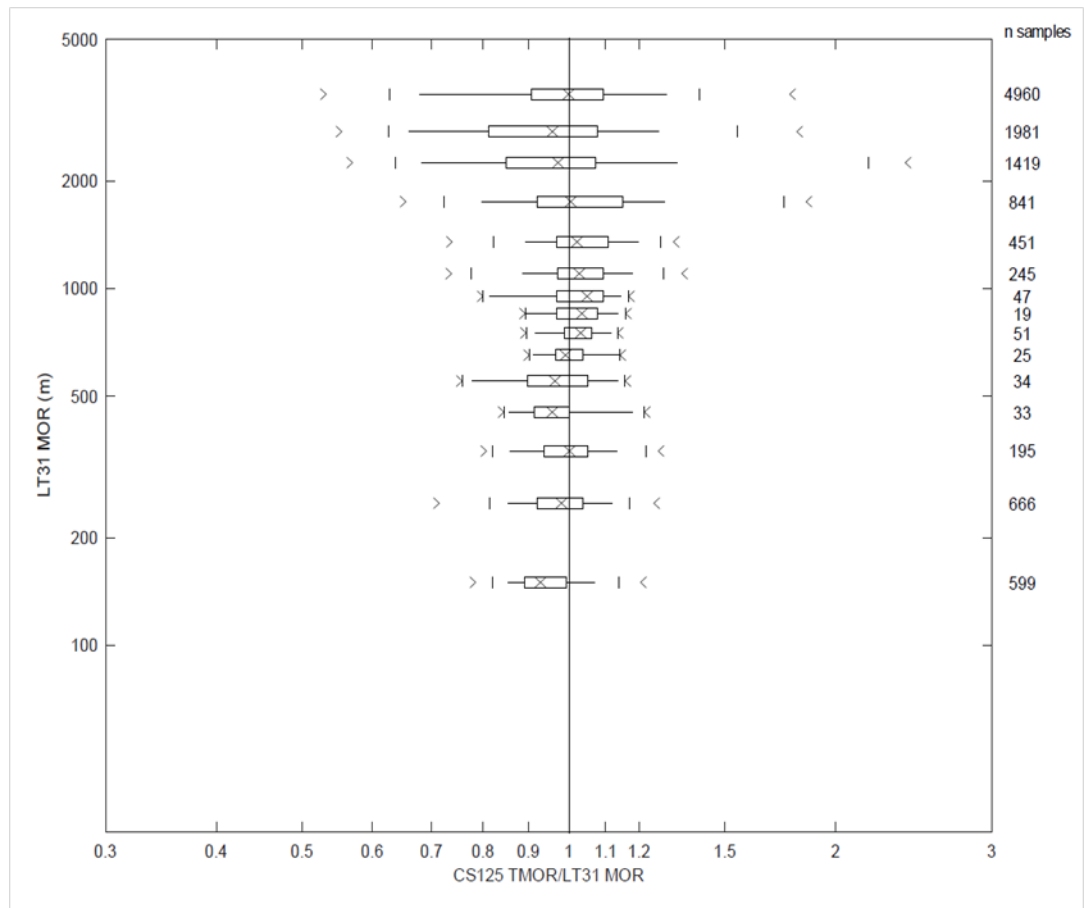


Figure D-4. A typical box plot showing the performance of the CS125 TMOR calibration in comparison to a test transmissometer.

# ***Limited warranty***

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Products manufactured by Campbell Scientific are warranted by Campbell Scientific to be free from defects in materials and workmanship under normal use and service for twelve months from the date of shipment unless otherwise specified on the corresponding product webpage. See Product Details on the Ordering Information pages at [www.campbellsci.com](http://www.campbellsci.com). Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

Refer to [www.campbellsci.com/terms#warranty](http://www.campbellsci.com/terms#warranty) for more information.

**CAMPBELL SCIENTIFIC EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Campbell Scientific hereby disclaims, to the fullest extent allowed by applicable law, any and all warranties and conditions with respect to the Products, whether express, implied or statutory, other than those expressly provided herein.**

# Assistance

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Products may not be returned without prior authorization.

Products shipped to Campbell Scientific require a Returned Materials Authorization (RMA) or Repair Reference number and must be clean and uncontaminated by harmful substances, such as hazardous materials, chemicals, insects, and pests. Please complete the required forms prior to shipping equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page for the Global Sales and Support Network or visit [www.campbellsci.com/contact](http://www.campbellsci.com/contact) to determine which Campbell Scientific office serves your country.

To obtain a Returned Materials Authorization or Repair Reference number, contact your CAMPBELL SCIENTIFIC regional office. Please write the issued number clearly on the outside of the shipping container and ship as directed.

For all returns, the customer must provide a “Statement of Product Cleanliness and Decontamination” or “Declaration of Hazardous Material and Decontamination” form and comply with the requirements specified in it. The form is available from your CAMPBELL SCIENTIFIC regional office. Campbell Scientific is unable to process any returns until we receive this statement. If the statement is not received within three days of product receipt or is incomplete, the product will be returned to the customer at the customer’s expense. Campbell Scientific reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.

# 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.com](http://www.campbellsci.com). 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

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations.
- 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, 6 meters (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.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

## 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.

## Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.
- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

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.



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