CS120
Visibility
Sensor

User Guide

Issued: 15.1.13

CSL 880

Guarantee

This equipment is guaranteed against defects in materials and workmanship. This guarantee applies for twelve months from date of delivery. We will repair or replace products which prove to be defective during the guarantee period provided they are returned to us prepaid. The guarantee will not apply to:

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

- Batteries

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

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

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

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

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

PLEASE READ FIRST

About this manual

Some useful conversion factors:

Area:	1 in^2 (square inch) = 645 mm^2	**Mass:**	1 oz. (ounce) = 28.35 g
			1 lb (pound weight) = 0.454 kg
Length:	1 in. (inch) = 25.4 mm		
	1 ft (foot) = 304.8 mm	**Pressure:**	1 psi (lb/in^2) = 68.95 mb
	1 yard = 0.914 m		
	1 mile = 1.609 km	**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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CS120 Visibility Sensor

1. Introduction

The CS120 is an infrared forward scatter visibility sensor for automatic weather stations including road, marine and airport based stations. The CS120 uses the well established forward scatter system for visibility measurement, utilising a 42º scatter angle. The CS120 uses high speed sampling to reduce missed events such as rain and hail and improves response to other suddenly changing conditions.

1.1 Version Information

Manual Version	Revisions
1.0	None
2.0	Updated for O/S Version 4
3.0	Updated for O/S Version 5
4.0	Updated for O/S Version 6

1.2 General Safety

This manual provides important safety considerations for the installation, operation and maintenance of the CS120. These safety considerations are classified into three levels:

WARNING

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

CAUTION

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

NOTE

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

1.3 Sensor Unit Safety

The CS120 sensor has been checked for safety before leaving the factory and contains no internally replaceable or modifiable parts.

WARNING

Do not modify the CS120 unit. Such modifications will lead to damage of the unit and could expose users to dangerous light levels and voltages.

WARNING

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.

CAUTION

Ensure that the correct voltage supply is provided to the sensor.

2. Technical specification

	Minimum Value	Nominal Value	Maximum Value
Visibility characteristics			
Reported Visibility (metric)	12 metres	-	32,000 metres
Reported Visibility (imperial)	39 feet	-	104,985 feet
Visibility accuracy up to 10,000m	-	+/-10%	**-**
Visibility accuracy up to 20,000m	-	+/-20%	**-**
Optical characteristics			
LED centre wavelength	-	850nm	**-**
LED spectral bandwidth	-	+/-35nm	**-**
Pulse characteristics			
Light pulse rate	-	1KHz	**-**

3. Electrical specification

	Minimum Value	Nominal Value	Maximum Value
Main power supply for DSP and dew heaters			
Power supply, +12V connection (DC only)	7V	12V	30V
Current consumption sampling continuously with dew heaters active (at 12V DC)	-	180mA	228mA
Current consumption sampling continuously with dew heaters disabled (at 12V DC)	-	100mA	150mA
Current consumption without any sampling occurring and dew heaters disabled (at 12V DC)	-	8mA	12mA
Active power consumption with dew heaters and RS232 communications interface active[5] (at 12V DC)	-	184mA	232mA
Hood heater power supply			
Hood heater voltage (AC or DC)	-	24V[1]	30V[1]
Hood heater wattage (at 24V AC or DC)[6]	-	60W[2]	-
RS232 Communications			
RS232 input threshold Low	0.8V	1.5V	-
RS232 input threshold High	-	2.0V	2.4V
RS232 input absolute maximum	-15V	-	+15V
RS232 input resistance	12KΩ	-	-
RS232 output voltage low	-	-	0.4V

RS232 output voltage high (into 3KΩ)	4.4V	-	-
RS485 Communications			
RS485 input threshold voltage	-0.2V	-	+0.2V
RS485 output (Unloaded)	-	-	5V
RS485 output (Load 50Ω)	2V	-	-
Maximum voltage at any terminal[4]	-7V	-	+7V
User alarm outputs			
User output high level (at 85ºC)	3.8V	-	-
User output high level (at 25ºC)	4.13V	-	-
User output low (All temperatures)	0.25V	-	0.55V
User output current	-	-	32mA

(1) It is recommended that the hood heaters are run at 24V AC/DC. It's 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.

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

(3) The ground of the CS120 and the earth of any RS485 equipment cannot be further apart than this voltage. A 100Ω resistor can be used to connect the CS120 RS485 earth to other equipment. This will reduce any parasitic currents and bring the two earths closer together if a direct connection cannot be made.

(4) The RS232 communications interface will automatically turn itself off when not transmitting.

(5) If hood heaters are not being used ensure `Hood heater override' (details in Section 13) is set to off.

4. Supported data rates for RS232 and RS485

Serial setting   8N1

Supported data rates

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

Supported formats

- RS232 (Full duplex only), default
- RS485 (Half duplex)
- 8 bit data bytes
- 1 stop bit
- Parity checking is not supported as most communication protocols used by the CS120 have built in checksums as well as checks that communications have been understood

5. Environmental specifications

	Minimum Value	Nominal Value	Maximum Value
Sensor temperature ranges			
Operating temperature	-25	-	+60
Extended operating temperature	-40	-	+70[1]
Storage temperature	-40	-	+85
Sensor humidity ranges			
Operating humidity range	0%	-	100%
Sensor heater thresholds			
Dew heater Turn On	-	<35°C	-
Dew heater Turn Off	-	>40°C	-
Hood heater Turn On	-	<5°C	-
Hood heater Turn Off	-	>15°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. Physical specification

Main body including base mount

Height: 447 mm

Width: 640 mm

Depth: 245 mm

Sensor weight: 3 Kg

Sensor mounting: mounts on vertical pole 32-52.5 mm diameter

Shipping weight: 6 Kg (including packing box)

7. Installation procedure

The CS120 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.

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

The CS120 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).

Avoid locations where the transmitter is pointing at a light scattering or reflecting surface. If possible the receiver should point north in the northern hemisphere and south in the southern hemisphere.

To give non-microclimatic measurements the CS120 should be sited away from possible physical obstructions that could affect the fall of precipitation. The CS120 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 CS120 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 CS120 should be located outside this zone of influence in order to obtain representative values for the region.
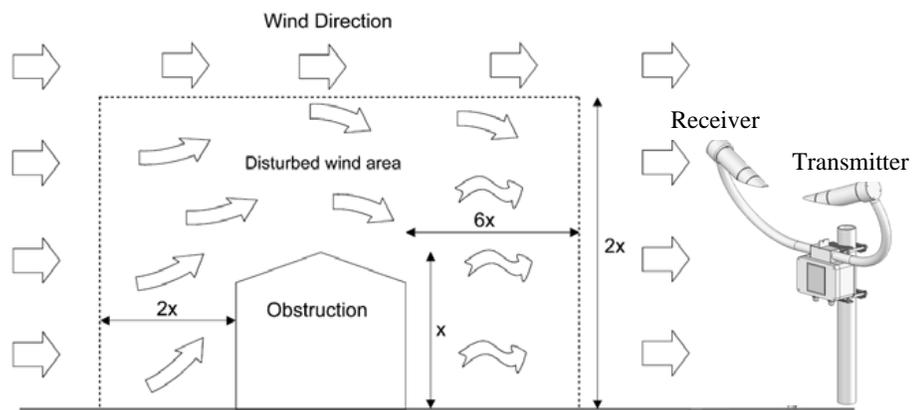
In order to reduce the service frequency with the unit, the CS120 should be placed away from sources of contamination, in the case of roadside monitoring; larger mounting poles can be used. More regular maintenance will be required when the instrument is placed in areas where contamination is unavoidable 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.

NOTE	If operating a CS120 indoors it is likely that there will be sources of light and/or reflections that will create false readings and erratic results.

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

7.1 Equipment grounding
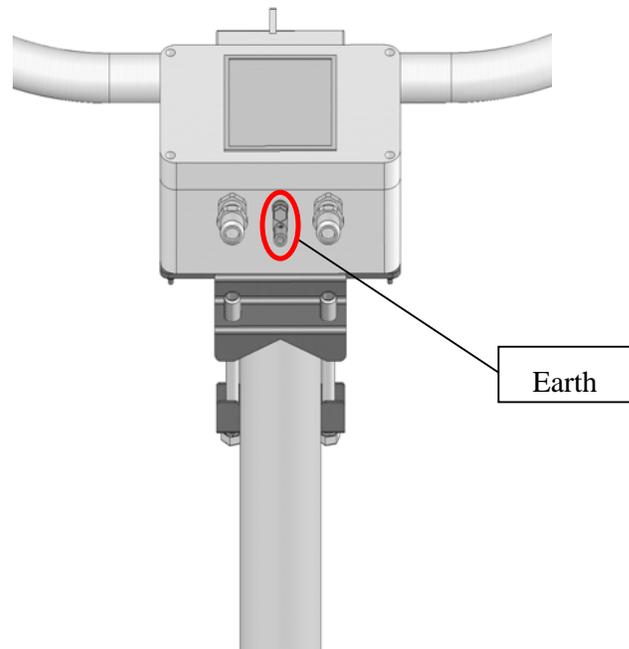
The CS120 must be properly grounded by taking a ground wire with a minimum cross sectional area of 6 mm^2 and maximum length of 5 m from the brass grounding lug in the lower face of the electronics enclosure to an adequate grounding point. The pole and foundations of a pole mounted installation will provide some basic lightning protection and protection against radio frequency interference and should also be correctly grounded.

7.2 Mounting the CS120

A pole mounting kit is supplied with the CS120. This kit includes a DSP plate, two brackets and suitable bolts for clamping the pole between the DSP plate and brackets. To mount the CS120 onto a pole:

1. Check the pole diameter and select the correct bolts. If the pole is between 32 mm OD and 46.5 mm OD use the M8 x 75 mm bolts. If the pole is between 46.5 mm OD and 52.5 mm OD use the M8 x 90 mm bolts.

2. Slide the bolts into the brackets with the V cut out as shown in Figure 3-10.

3. The DSP plate is supplied ready fixed to the CS120 on the DSP enclosure. Offer up the DSP plate to the pole and present the brackets and bolts from the other side of the pole to fit into the matching holes of the DSP plate.

4. Clamp the pole between the DSP plate and brackets by tightening using the nuts provided.

5. 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.

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 CS120 firmly in place.

Where the CS120 is to be mounted onto another type of mast, please refer to the manual for that mast for mounting details.

CAUTION

Ensure that the CS120 is mounted according to figure below. Do not reposition, once fixings are tightened, by forcing the arms of the unit as this can damage the unit.

Slots are provided to allow band clamps to be used with larger diameter masts.
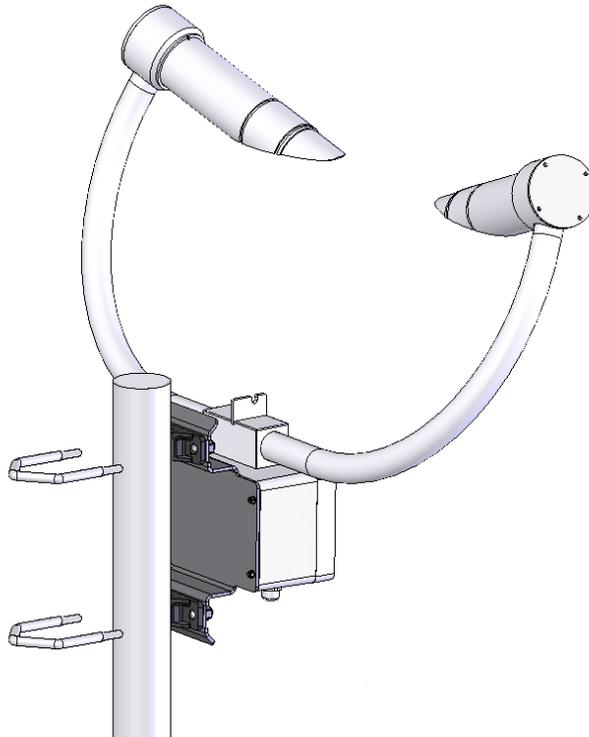
7.3 Optional Campbell Scientific Mount

A Campbell Scientific `optical sensor mount', part number 009354, 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', 7th Edition, Section 9.3.4.
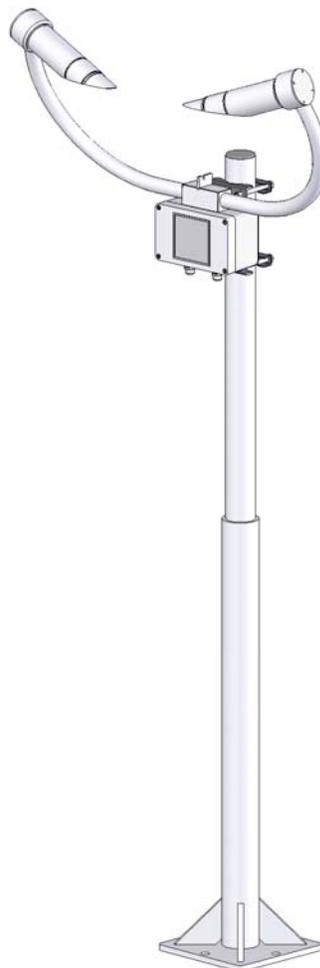
If one is to be used, follow the installation instructions below.

The mount should be installed 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 following the drawing below to a depth of 77 mm.
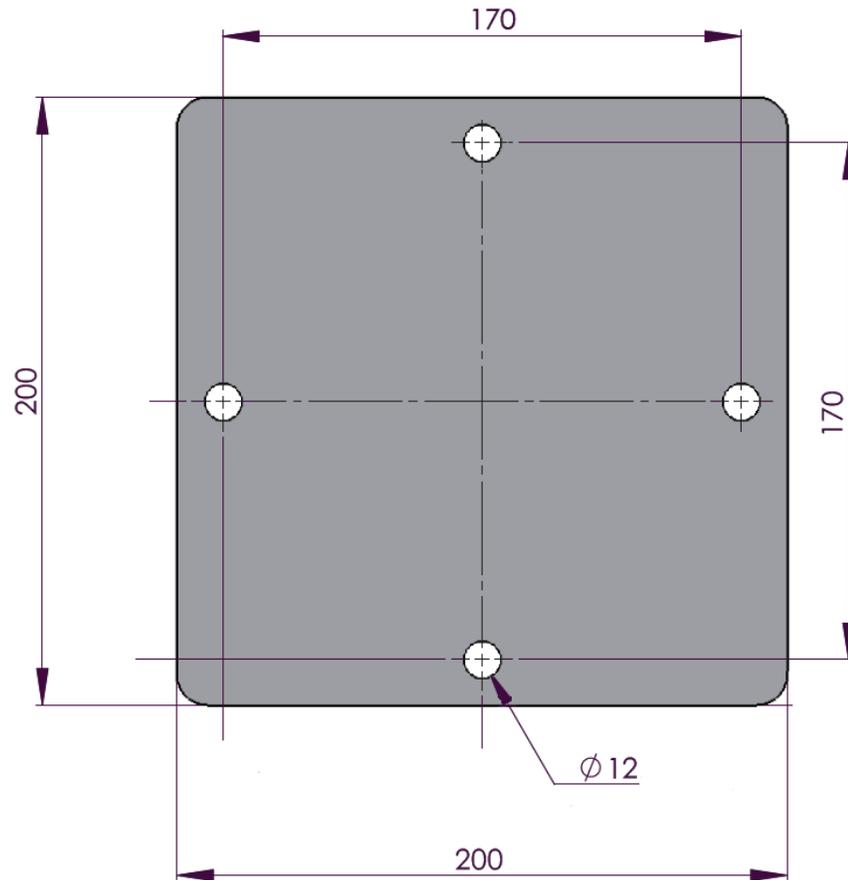
Clean the holes of all debris.

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. CS120 internal connectors' description

The CS120 has two standard IP66 rated glands for connecting to external equipment. The first gland is by default used by the power/communications line. This comprises of the +12V/24V for the main electronics, and the serial communications wires. The CS120 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 10 m cable.

WARNING	**If the power cable is incorrectly wired to the CS120 then irrevocable damage can be done to the unit.**

CAUTION	10 m is the longest length of the cable type supplied recommended. In particular, additional RS485 communication should be twisted pair. Please contact Campbell Scientific if you wish to use a longer length of cable.
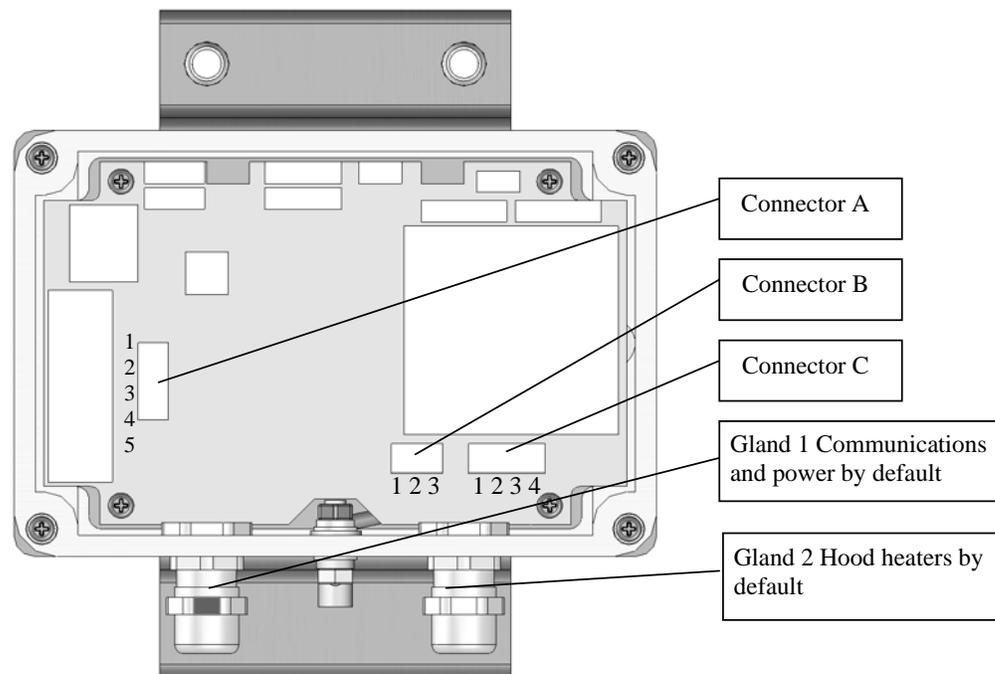
A configuration cable, part number 010817, is available from Campbell Scientific that plugs directly into connector B, in place of the normal connector and cable. The configuration cable is fitted with a 9-way D connector for use with a PC serial port or USB to serial adaptor.

Connector A		
Five way connector		
Pin number	**Description**	**Notes**
Pin 1	+12V	Main electronics 12V supply input (also supports 24V DC)
Pin 2	0V	Auxiliary Electronics 0V. Common with the main electronics 0V.
Pin 3	Hood low	Hood heater –V input, this input is totally separate to the main electronics 0V within the sensor so can be connected to a separate power supply. However, this pin should not be more than 5V different from the main electronics 0V.
Pin 4	0V	Auxiliary Electronics 0V. Common with the main electronics 0V.
Pin 5	Hood high	Hood heater +V input (Normally 24V)

Connector B		
Three way connector		
Pin number	**Description**	**Notes**
Pin 1	0V	0V connection for serial communications. This connection is common with the main electronics 0V (Connector A, pin 2).
Pin 2	Receive	RS232 receive line. Also, acts as the Y transmit line in RS485 half duplex mode and the A receive line
Pin 3	Transmit	RS232 transmit line. Also, acts as the Z transmit line in RS485 half duplex mode and the B receive line

Connector C – USER ALARMS		
Four way connector		
Pin number	**Description**	**Notes**
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

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 CS120 recommended wiring using Campbell Scientific cables
(this cable is supplied already connected as standard)

The CS120 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 Scienific CR1000 using a suitable interconnecting cable such as the SC110. If another type of connection is required then the D-connector should be removed.
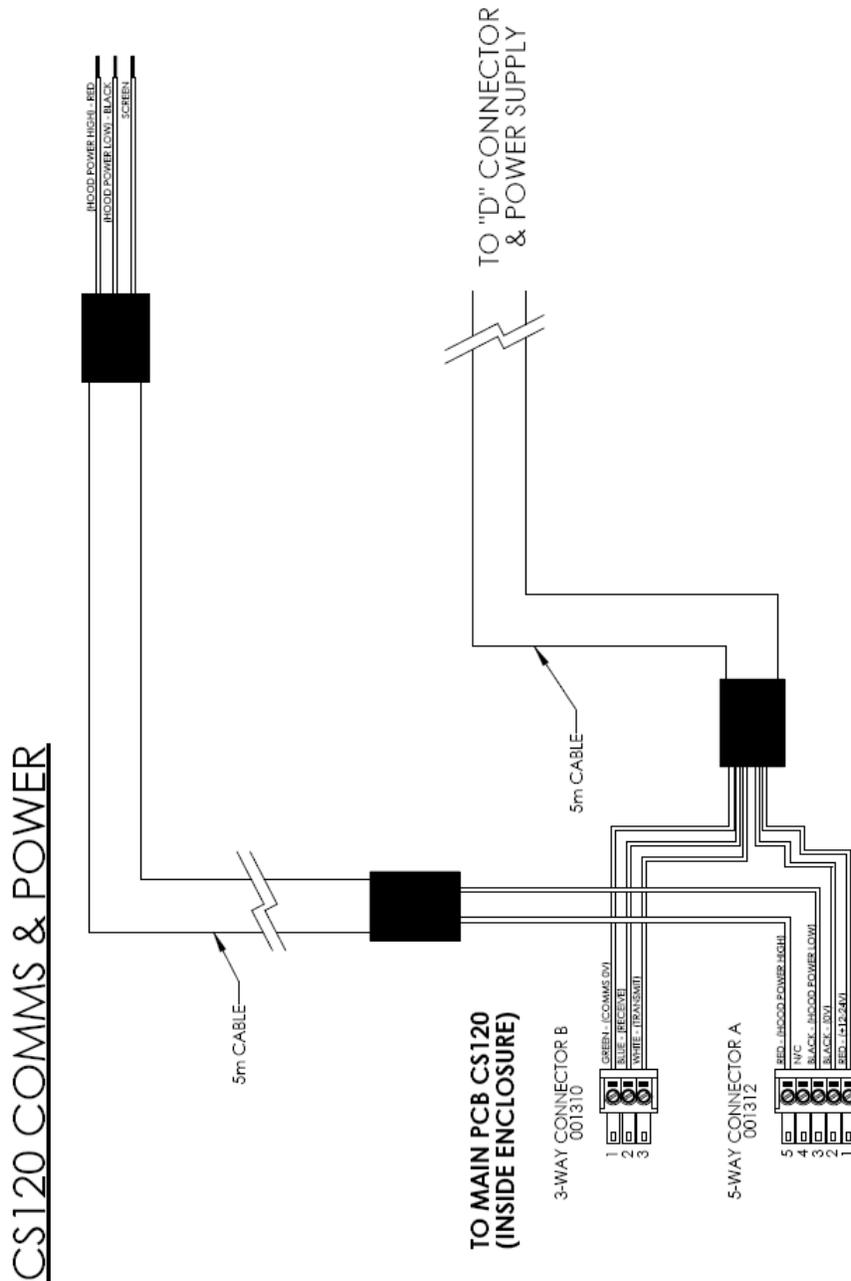
CS120 COMMS & POWER CABLE CONNECTOR

WHITE RXD/RS485-B (2)

BLUE TXD/RS485-A (3)

GREEN GND (5)

SCREEN

(+V SUPPLY) - RED

(0V) - BLACK

5m CABLE

FROM CS120
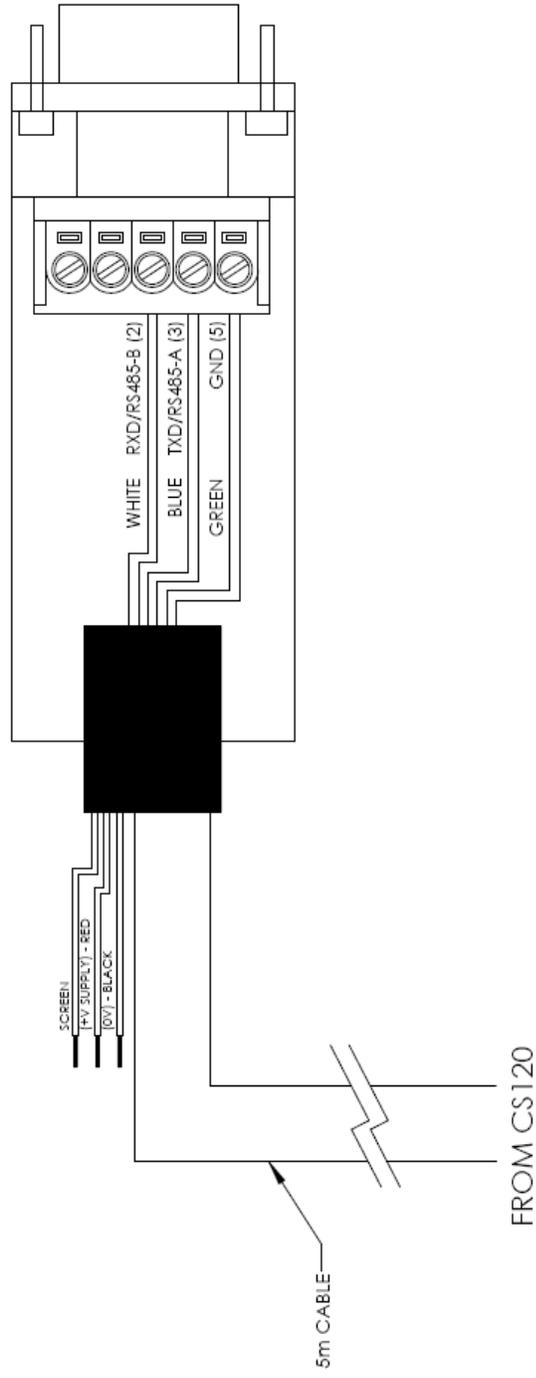
CS120 CONFIGURATION CABLE
PART NUMBER 010817

9WAY "D" CONNECTOR

3m CABLE

3-WAY CONNECTOR B
001310
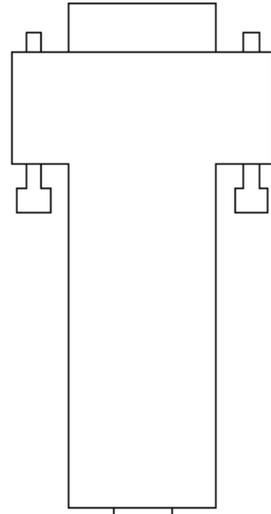
A RS232 TO USB CONVERTER IS
AVAILABLE PART NUMBER 010777

CONNECTOR B	COLOUR	9WAY
TX-3	WHITE	2
RX-2	GREEN	3
0V-1	BLACK	5
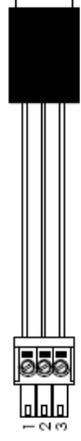
9. Functions of the internal switches

The CS120 is equipped with four switches located within the main enclosure. These switches perform certain functions at power up, their functions are detailed below.

IMPORTANT   The switches are only read during the power up sequence of the CS120. This means that if the switches are pressed whilst the CS120 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.

Switch 4
Switch 3
Switch 2
Switch 1
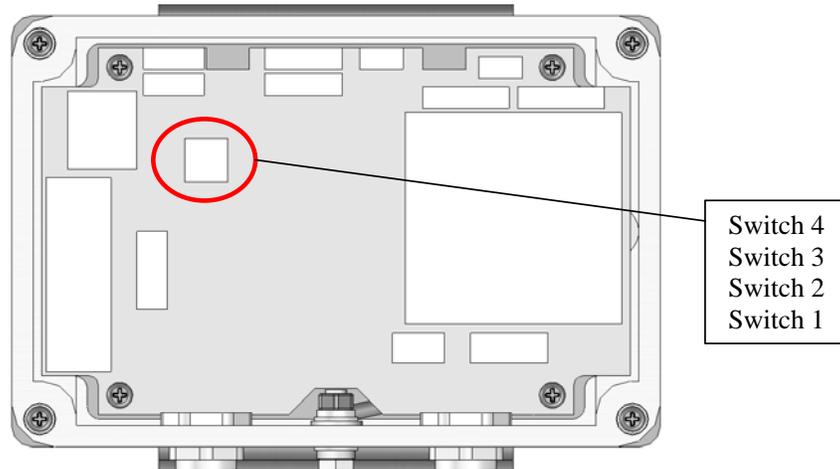
Internal switch functions	
Switch number	**Function**
4	*Reserved for future use*
3	When switched to the ON position this switch temporarily sets the CS120 communications port to a default RS232 communication state (38400 bps). This is useful during field tests or maintenance when the CS120 has been remotely configured for RS485 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 CS120 is power cycled the CS120 will return to its previous communications settings.
2	*Reserved for future use, set to OFF.*
1	When switched to the ON position this switch will reset the CS120 to its factory default values. This reset will affect all communication setting and will replace the user calibration settings with the factory defaults. This will take immediate effect upon power up.

10. Message Formats: A breakdown of the different default outputs of the CS120 – Basic/Partial/Full

The CS120 has three different standard message formats available to the user. These three outputs are named Basic, Partial and Full. All three standard outputs 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 Full Format message is the default message.

NOTE	STX and ETX are hexadecimal command characters.

NOTE	Refer to Appendix B for the checksum algorithm.

Basic format

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

Partial format

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

Full format

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

Message ID break down	
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

Sensor ID break down	
ID	Definition
0-9	Unit number defined by the user to aid identification of data. Zero by default. Useful for RS485 networks. Operates as an address in RS485 mode

System status break down[1]	
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.

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

Visibility distance break down	
ID	Definition
0-32,000 metres	Current visibility distance being detected by the sensor

Visibility units break down	
ID	Definition
M	Metres
F	Feet

Averaging duration break down	
ID	Definition
1	One minute average
10	Ten minute average

In accordance with WMO requirements the CS120 produces 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		
Alarm	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

System alarms break down			
Alarm	Range	Severity [2]	Definition
Emitter failure	0-2[1]	3	The emitter hoods main LED output power level. 0 = Everything is within normal parameters 1 = Light output level too low 2 = Light output level too high
Emitter lens dirty	0-3	1	0 = OK. The reported attenuation is below 10%. 1 = Reported window signal value is too low (Possible sensor fault) 2 = Slight dirt build up (10% signal attenuation or higher) 3 = High level of dirt build up (The hood could be blocked)
Emitter temperature	0-3	1 or 2	0 = Temperature is within operating conditions 1 = Too low. Less than -40°C. 2 = Too high. Over 80°C. 3 = Sensor fault (No sensor detected or below -54°C) (Severity 2)
Detector lens dirty	0-3	1	0 = OK. The reported attenuation is below 10%. 1 = Reported window signal value is too low (Possible sensor fault) 2 = Slight dirt build up (10% signal attenuation or higher) 3 = High level of dirt build up (The hood could be blocked)
Detector temperature	0-3	1 or 2	0 = Temperature is within operating conditions. 1 = Too low. Less than -40°C. 2 = Too high. Over 80°C. 3 = Sensor fault (No sensor detected or below -54°C) (Severity 2)
Detector DC saturation level	0-1	1	The amount of background light as seen by the detector hood. 0 = Within limits 1 = Saturated. The CS120 no longer has enough head room to perform visibility readings in most circumstances.
Hood temperature	0-3	1 or 2	0 = Temperature is within operating conditions. 1 = Too low. Less than -40°C. 2 = Too high. Over 80°C. 3 = Sensor fault (No sensor detected or below -56°C) (Severity 2)
Signature error	0-1	3	0 = Signature of entire flash was checked and matches the stored version 1 = Signature does not match previous readings
Flash read error	0-1	3	0 = No errors 1 = One or more errors reading user variables from flash occurred
Flash write error	0-1	3	0 = No errors 1 = One or more errors writing user variables to flash occurred

[1]The emitter power level reporting too high will cause the CS120 to shutdown and go into low power mode.

[2]The severity of the alarm. The higher the number the more serious the error is considered to be.

10.1 Example CS120 message outputs

Example outputs from the CS120.

Basic output

```
0 1 0 12345 M XXXX
```

Partial output

```
1 1 0 60 12345 M 0 0 XXXX
```

Full output

```
2 1 0 60 12345 M 1 0 0 0 0 0 0 0 0 0 0 0 0 XXXX
```

11. Interface methods – Device Configuration Utility/Command line/Menu

The CS120 can be setup and controlled in one of three ways.

The first method is by using Campbell Scientifics 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 CS120 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 CS120 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 CS120 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 CS120 if it was connected to a logger for instance. The configuration setting commands can be sent via a logger to the CS120 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 CS120 communicating via RS232 or RS485, using a terminal emulator program. This menu system gives access to the more common settings.

All three of these methods use the CS120s serial port A to communicate with the sensor. Configuration cable part number 010817, described in section 8.1 can be used.

11.1 Configuring a PC for talking to the CS120

Described below is 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 CS120 should now be ready to accept commands.

It is possible to set the CS120 into the default communication state via one of the internal switches on the CS120 main board. See section 9.

12. Definition of the variables that can be set by the user on the CS120

Both DevConfig and the command line interface can access all the user configurable variables within the CS120. The acceptable range and the identification number for these variables are listed below along with a short description.

ID	Name	Range	Description	Factory default
1	Sensor ID	0-9	Separate ID used as an extra identifier for a particular CS120 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 *less than* 'User alarm 1 Distance' 1=Check if distance is *greater than* 'User alarm 1 Distance'	0
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

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6	User Alarm 2 Active	0-1	0=Check if distance is *less than* 'User alarm 2 Distance' 1=Check if distance is *greater than* 'User alarm 2 Distance'	0
7	User alarm 2 Distance	0-60000	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 RS232/RS485 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	0-32000	Internal serial number for the CS120. (*Read only)*	-
10	Visibility Unit	M or F	Unit the visibility value will be presented as. M = Metres F = feet	M
11	Message Interval	1-3600	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	0-2	Level of detail outputted by polled or continuous modes 0 = Basic 1 = Partial 2 = Full	2
14	Serial port protocol	0-1	Selects the physical serial interface 0 = RS232 mode 1 = RS485 mode	0
15	Averaging period	1 or 10	The period of time that the visibility value should be averaged over. Either one minute or ten.	1
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. 1 = Sample every second 10 = Sample one second in every ten 60 = Sample one second in every sixty	1
17	Dew heater override	0-1	0=Allow the CS120 to automatically control the dew heaters 1=Turn the dew heaters off	0
18	Hood heater override[1]	0-1	0=Allow the CS120 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 CS120 will compensate for up to 10% signal loss due to dirt per lens.	0

20	Use CRC	0-1	0 = Disable command line CRC checking[2] 1 = Enable command line CRC checking Note: this does not affect communications via DevConfig or terminal emulator.	0
21	Sensor power down voltage[3]	7-30	PSU Input voltage level below which the CS120 will enter low power mode. This is usually used to protect batteries.	7.0

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

(2) If disabled the sensor does not check the validity of received data against the checksum sent. It is, however, recommended that checksum checking is enabled to remove any chance of the CS120 being configured incorrectly by accident.

(3) Only available if the sensor is running firmware version 4 or later and only functional for sensors with serial number greater than E1029.

13. 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 CS120. 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 CS120 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 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.

13.1 The SET command

The set command is used to configure the CS120 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 an RS232 or RS485 port. The SET command and the 'Device Configuration Utility' software access identical settings within the CS120, 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[1]	STX ^B[2]
:	Delimiting character
SET	SET
:	Delimiting character
0	Address based on Sensor ID
:	Delimiting character
	Sensor 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
	Sensor serial number (read only)
	Visibility Units
	Message interval
	Polling Or Continuous modes
	Message Format (Basic/Partial/Full)
	RS232 or RS485 serial communications enabled
	Averaging Period
	Sample timing
	Dew heater override
	Hood heater override
	Dirty window compensation
	CRC checking on received commands
	Sensor power down voltage
:	Delimiting character
XXXX	Checksum (use the valid CCITT checksum)
:	Delimiting character
0x03[1]	ETX ^C[2]
0x0D[1]	Carriage return

(1) These values are shown in hexadecimal format not ASCII.
(2) As entered on a keypad.

13.1.1 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 :68A3:•
```

13.2 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 CS120 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.

13.2.1 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 :D82D:•
```

13.3 The GET Command

The GET command retrieves settings data from the CS120, including message format data and user alarm settings amongst others. This command does not retrieve visibility or environmental information from the CS120. To retrieve visibility data refer to the POLL command.

The GET request

GET transmitted data	
Example	**Description**
0x02[1]	STX (^B)[2]
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[1]	ETX (^C)[2]
0x0D[1]	Carriage return

(1)   These values are shown in hexadecimal format not ASCII.
(2)   As entered on a keypad

Example of a GET request

```
GET:0:0:XXXX:
```

Example data returned by the GET command – See Section 12 for more information on values returned by the `GET' command

GET returned data	
Example	**Description**
0x02[1]	STX
	Sensor 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
	Sensor serial number (read only)
	Visibility Units
	Message interval
	Polling Or Continuous modes
	Message Format (Basic/Partial/Full)
	RS232 or RS485 serial communications enabled
	Averaging Period
	Sample timing
	Dew heater override
	Hood heater override
	Dirty window compensation
	CRC checking on received commands
	Sensor power down voltage 7.0
:	Delimiting character
XXXX	Checksum
:	Delimiting character
0x04[(1)]	EOT
0x0D[(1)]	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 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 (=38400Bd)

Serial number = 1009

Visibility Units = M

Continuous mode output interval = 30 seconds

Polling mode = 0 (continuous mode)

Message format = 2 (full message)

RS232 or RS485 serial communications = 1 (RS485)

Averaging period = 1 minute

Sample timing = 1 sample per second

Dew heater override = 0 (CS120 will automatically control the dew heaters)

Hood heater override = 0 (CS120 will automatically control the hood heaters)

Dirty window compensation = 0 (dirty window compensation off)

CRC checking on received commands = 1 (CRC checking enabled)

Sensor power down voltage = 11.5V

Checksum = D4FD

13.4 The POLL command – Polling the CS120

The POLL command requests the current visibility and/or alarm conditions from the CS120. The output format of this command depends on how the CS120 is configured using the SET command or the menu interfaces.

The POLL request

POLL transmitted data	
Example	**Description**
0x02[1]	STX, ^B[2]
POLL	POLL
:	Delimiting character
0	Address based on Sensor ID
:	Delimiting character
0	Reserved for future use, zero default
:	Delimiting character
XXXX	Checksum[3]
:	Delimiting character
0x03[1]	ETX, ^C[2]
0x0D[1]	Carriage return

(1)   These values are shown in hexadecimal format not ASCII.
(2)   As entered on a keypad.
(3)   Not case sensitive.

Example of a POLL request

```
POLL:0:0:XXXX:
```

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

14. Entering the CS120 menu system

The user can enter the menu system by typing 'open 0' into their terminal program then pressing the return key on their keyboard. The '0' in 'open 0' corresponds to the sensor ID number. The Sensor ID number can be in the range of 0 to 9. When first purchased or when the sensor is reset to factory defaults the sensor ID will be set to 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:

```
WELCOME TO THE CAMPBELL SCIENTIFIC LTD CS120 SETUP
MENU
 ID 0
 S/N 9999
 (1) Message output menu
 (2) User alarm menu
 (3) Calibrate CS120
 (4) System information
 (5) Communications setup

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


  ->
```

Menu 1: The message output menu

```
CS120 MESSAGE - MENU 1
 ID 0
 S/N 1002
 (1) Toggle message format:FULL
 (2) Toggle units:METRES
 (3) Toggle polled or continuous mode:CONTINUOUS
 (4) Set continuous mode message-interval:60 second(s)
 (5) Toggle output averaging period: 1 minute(s)
 (6) Sampling interval:1 second(s)


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

The message menu contains settings relating to the CS120s default visibility outputs such as modes of operation and output formats.

Menu 1: The message output menu. Sub menu 1: Continuous mode operation (Option 4)

```
CS120 MESSAGE - SUB 1
 Set the continuous mode message-interval in seconds (i.e. 120=2 minutes).
 Current value 60.  Range 1-3600.
 Or, type 0 to exit without changes.
```

Menu 1: The message output menu. Sub menu 2: Sample timing (Option 6)

```
CS120 MESSAGE - SUB 2
 Set sample timing for this sensor in seconds.
Current value 1.  (Valid range is 1-60)
 Or, type '0' to return without changes.


 ->
```

Menu 2: The user alarm menu

```
CS120 ALARM - MENU 2
 ID 0
 S/N 9999
 (1) Toggle user alarm one: DISABLED
 (2) Toggle alarm one threshold: LESS THAN
 (3) Set new user alarm one activation point: 10000 m
 (4) Toggle user alarm two: DISABLED
 (5) Toggle alarm two threshold: LESS THAN
 (6) Set new user alarm two activation point: 10000 m

 (9) Refresh
 (0) Return to main menu

  ->
```

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

```
 CS120 ALARM - SUB MENU 2
  Select new alarm trigger level between 10 and 60000
 inclusive.
  Current value 10000.
  Or, type '0' to return without changes.


  ->
```

Menu 3: The calibration menu

```
CS120 CALIBRATION - MENU 3
 ID 0
 S/N 9999
 (1) Perform calibration
 (2) Restore the factory calibration

 (9) Refresh
 (0) Return to main menu

 ->
```

Consult the 'calibration' section of this manual for information on how to calibrate the CS120 visibility sensor.

NOTE   Once a calibration is finished changes are immediate, but factory calibrations can be restored if needed from here.

Menu 4: The system information menu

```
CS120 INFORMATION - MENU 4
 ID 0
 S/N 1030
 OS version: CS120v5
                              Alarm   Value
 - Last visibility reading:     -     999999M
 - Overall system status:       0     No faults
 - Emitter dirty window alarm:  0     0%
 - Emitter internal temperature: 0    28.4
 - Detector dirty window alarm: 0     0%
 - Detector internal temperature: 0   26.7
 - Detector DC light saturation: 0     -
 - Hood heater temperature:     0     25.7
 - CS120 Calibrator Serial No:  -     1000
 - CS120 Calibrator Constant:   -     30.5
 - Calibration value Fac offset: -    -0.128
 - Calibration value Fac scale: -     0.02866
 - Calibration value Cal offset: -    -0.128
 - Calibration value Cal scale: -     0.02866
 - Signature fault:             0      -
 - Flash write errors:          0     0
 - Flash read errors:           0     0
 - Supply voltage:            <9.0V   12.5V


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

The systems information menu contains useful information such as temperature and system alarms.

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 only available if the sensor is running firmware version 4 or later and only functional for sensors with serial number greater than E1029.

Menu 5: The communication menu

```
CS120 COMMUNICATIONS - MENU 5
ID 0
S/N 9999
(1) Set sensor ID
(2) Set RS232/RS485 baud rate:38400
(3) Toggle RS232/RS485 modes:RS232

(9) Refresh
(0) Return to main menu

 ->
```

The communications menu is used to set baud rates and the mode of operation (RS232/RS485).

NOTE	No change will take effect until you `exit and save'.

Menu 5: The communication menu. Sub menu 1: Sensor ID (Option 1)

```
CS120 COMMUNICATIONS - SUB 1
Set the new ID the sensor is to use - Range: 0-9.
Current value 0.
Or, type anything except 0-9 to exit without changes.

->
```

Menu 5: The communication menu. Sub menu 2: Serial data rate selection (Option 2)

```
CS120 COMMUNICATIONS - SUB 2
 Set the new serial baud rate.
 Changes will take effect when 'Exit and Save' is
 selected.
 Current baud rate is 38400bps.
 Use the numbers 0-6 to set the baud rate.
   0 - 115200
   1 - 57600
   2 - 38400
   3 - 19200
   4 - 9600
   5 - 2400
   6 - 1200
Or, type any other number to exit.

  ->
```

Menu 9 and 0: Exiting the menu system

```
CAMPBELL SCIENTIFIC LTD CS120 menu exited.
```

15. Calibrating the CS120

The CS120 can be checked and adjusted using the optional CS120 calibrator part number 010816. 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 CS120 screens to let you access this function. To perform the calibration you will need a CS120 calibrator disk and a computer with a standard serial port compatible with the CS120. If your CS120 is not currently configured for RS232 communications you can set the internal switch, switch three, to temporarily set the sensor to RS232 mode 38400bps. If the sensor is already set in RS232 mode it should not be necessary to change any internal switches. (See Section 10 for more information on the CS120 internal switches.)

The test should ideally be performed in the following conditions:

- Ambient temperature should be 20ºC +/-10ºC

- The local visibility should be approximately 10,000 metres or higher.

The system is self-regulating. However, it is recommended that the CS120 is calibrated 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.

```
CS120 CALIBRATION - MENU 3
 ID 0
 S/N 9999
 (1) Perform calibration
 (2) Restore the 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?
```

Once you have started the tests you will be asked for the CS120 calibrator serial number and coefficient with a confirmation at each step giving you the chance to correct typing mistakes.

NOTE

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

```
Starting calibration.
Input the CS120 calibrator serial number ->12345
Is 12345 correct? (Y/N)?
Input the CS120 calibrator constant ->10000
Is 10000 correct? (Y/N)?


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


CS120 calibrator serial number and coefficients will be within this area.
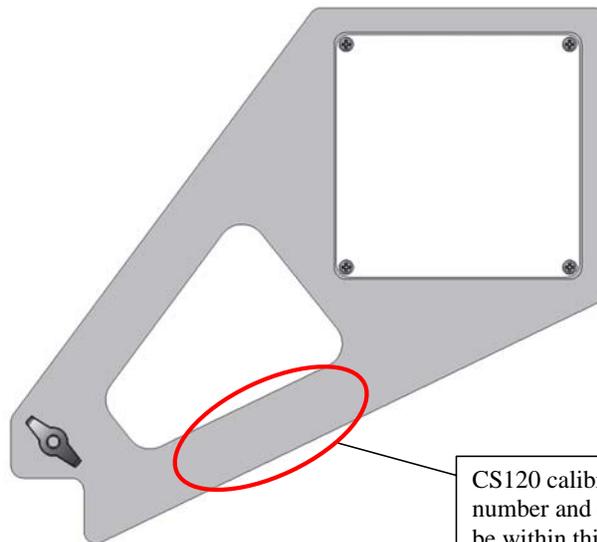
When you have entered the calibrator information the sensor will wait for you to place the foam bungs into the sensor hoods. The bungs are designed to block all light from the outside reaching inside the head. Place one bung into each hood. If either of the bungs are damaged or appear to have any gaps around the edge please contact Campbell Scientific.
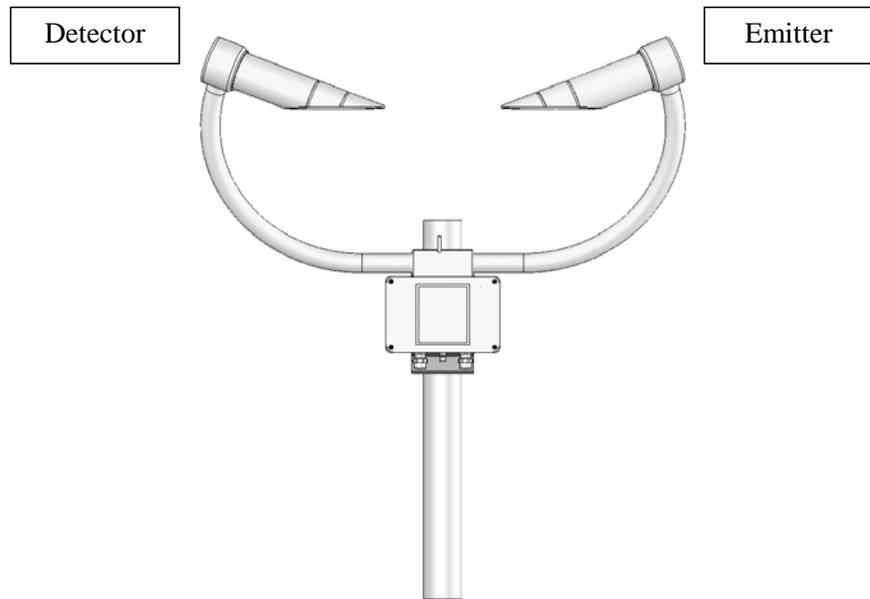
```
   Starting dark level calibration.
   This test will take approximately two minutes
```

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 CS120 calibrator into the sampling
   volume.
   Press any key once this is done.
```

Remove the bungs once the sensor instructs you to. Place the CS120 calibrator into the volume by fastening it to the central mounting point.

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.

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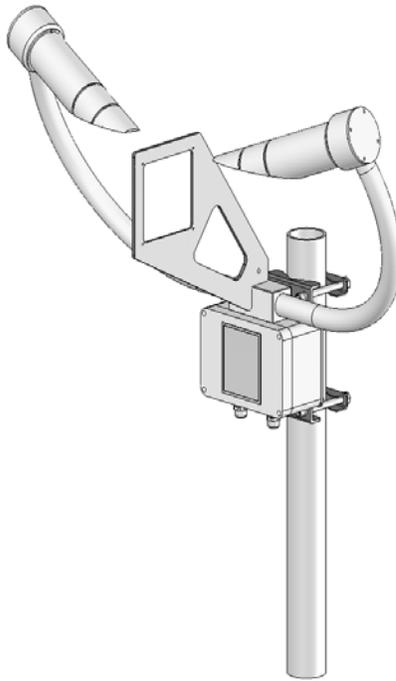
```
  Calibration is now complete.
  Saving user settings
  Press any key to exit.
```

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.

16. Performing a firmware update

Firmware updates for the CS120 visibility sensor are performed using Campbell Scientifics Device Configuration Utility (DevConfig) software. Please refer to the help built into the DevConfig software for full instructions on how to update the CS120 firmware.

17. Cleaning

The CS120 visibility sensor is a robust instrument that will provide years of uninterrupted weather monitoring. Calibration of the instrument is carried out at the factory and can be redone easily on site with the optional CS120 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 CS120 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 CS120 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 will attempt to make a correction for contamination although the accuracy of that correction depends on the `type of dirt'.

In any case 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 as they can emulate precipitation. Cleaning the 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.

18. Lubricating the enclosure screws

The CS120 enclosure screws should be lubricated with a suitable anti-seize grease (often copper loaded) 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.

19. 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 infrared 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 infrared 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.

Appendix A. CS120 block diagram

Power level + Driver circuitry

850nm Emitter

Amplifier and filter

Emitter power feedback

Dirty window detector

Hood temperature

Photo-detector

Transimpedance amplifier

Amplifier and filter

Dirty window detector

Second stage amplifiers and filters

14-bit Analogue to digital converter

MCU (Micro controller unit)

Hood heater drive

Low noise PSU

Two 5V user alarm outputs

RS232 or RS485 serial communications

24V AC/DC

12V DC

Appendix B. Example C code of the CCITT CRC

The code below is provided as an example for programmers implementing their own code to communicate with the sensor. Users using Campbell loggers can use the Checksum command in CRBasic to generate a CCITT checksum. Command: Checksum/ChkSumString,1,0).

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

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

```
//-------------------------------------------------------------------------
// Creates a CCITT CRC16 checksum seeded with 0x0000 (XModem style) using a
//  fast non table based algorithm.
// Pass in the data to convert into a CRC in the form of a NULL terminated
//  character array (a string).
// Returns the CRC in the form of an unsigned 16 bit integer value
// Note: This algorithm has only been tested on a native 16-bit processor with
//       a hardware barrel shifter
//       All integers are 16-bits long
//-------------------------------------------------------------------------
unsigned int CRC_CCITT(char LineOfData[]){

        unsigned int crc; // returned CRC value
        unsigned int i;   // counter

        crc = 0x0000;

        // create a check sum for the incoming data
        for(i=0;i < strlen(LineOfData); i++){
        unsigned crc_new = (unsigned char)(crc >> 8) | (crc << 8);
          crc_new ^= LineOfData[i];
          crc_new ^= (unsigned char)(crc_new & 0xff) >> 4;
          crc_new ^= crc_new << 12;
          crc_new ^= (crc_new & 0xff) << 5;
          crc = crc_new;
        }

        return(crc);
}
```

Appendix C. Example CRBasic programs

C.1 CRBasic read program

```
'CR1000
'Demonstration program to read data from a CS120 set to continuous output
'With the full message being transmitted
'Note: the sensor should be preconfigured, it is not setup by this program

'Declare Variables
Public Visibility

'These variables could be defined as DIM in a final program
Public InString As String * 60    'Incoming string
Public SerialIndest(20) As String, NBytesReturned
Public ChecksumOK As Boolean


'Define the aliases for the full message
Alias SerialIndest(1)=Message_ID '0..2
Alias SerialIndest(2)=Sensor_ID '0..9
Alias SerialIndest(3)=System_status '0..3
Alias SerialIndest(4)=Interval_time '1..3600
Alias SerialIndest(5)=Visibilitystr '0..32000 metres
Alias SerialIndest(6)= VisibilityUnits 'M or F for Metres or Feet
Alias SerialIndest(7)=Averaging_duration '1 or 10 minutes
Alias SerialIndest(8)=User_alarm_1 '0..1 - Visibility compared to Threshold One
Alias SerialIndest(9)=User_alarm_2 '0..1 - Visibility compared to Threshold Two
Alias SerialIndest(10)=Emitter_failure '0..2 - Emitter Failure
Alias SerialIndest(11)=Emitter_lens_dirty '0..3 - Emitter Lens Dirty
Alias SerialIndest(12)=Emitter_temp_error '0..3 - Emitter Temperature
Alias SerialIndest(13)=Detector_lens_dirty '0..3 - Detector Lens Dirty
Alias SerialIndest(14)=Detector_temp_error '0..3 - Detector Temperature
Alias SerialIndest(15)=Detector_saturated '0..1 - Detector DC Saturation Level
Alias SerialIndest(16)=Hood_temp_error  '0..3 - Hood Temperature
Alias SerialIndest(17)=Signature_error '0..1 - Signature Error
Alias SerialIndest(18)=Flash_read_error '0..1 - Flash Read Error
Alias SerialIndest(19)=Flash_write_error  '0..1 - Flash Write Error
Alias SerialIndest(20) = checksumrx 'CCITT Checksum

'Define the serial port to which the CS120 is connected - ammend as needed
Const CS120_Comport = COM2

'Main Program
BeginProg
  'Open the logger serial port to which the CS120 is connected
  SerialOpen (CS120_Comport,38400,3,0,1000)

  'Scan at 10 sec - the sensor must be set to output quicker than the scan rate,
  'e.g. 5 sec in this case to guarantee some data is available
  Scan(10,Sec,1,0)
    'Read the newest data in the buffer, return NaN if there is no data OR
    'the last parameter can be set to 00 if you are calling this instruction faster
    'than the sensor outputs and you are happy to see the last data received
    SerialInRecord(CS120_Comport,InString,02,0,03,NBytesReturned,01)
```

```
Split out the data into strings
    SplitStr (SerialIndest(),InString," ",20,5)
   'Check the received checksum is valid
    ChecksumOK = ( HexToDec(checksumrx) = CheckSum(InString,1,InStr
(1,InString,checksumrx,2)-2))
     'Check if the checksum does not match set the vis to NaN.
  'Copy the string into a float so can be manipulated and stored efficiently
    'Do likewise for other variables if used
    'In critical applications the visibility can be set to NaN if the system status
    'is degraded or a critical error flag is set.
    If ChecksumOK Then Visibility = Visibilitystr Else Visibility =NaN
    'Call data storage commands here
  NextScan
EndProg
```

C.2 CRBasic POLL program

```
'CR1000
'Demonstration program to read data from a CS120 set to polled mode
'with the full message being transmitted.
'Note: the sensor should be preconfigured, it is not setup by this program

'Declare Variables
Public Visibility

'These variables could be defined as DIM in a final program
Public InString As String * 60   'Incoming string
Public SerialIndest(20) As String, NBytesReturned
Public ChecksumOK As Boolean


'Define the aliases for the full message
Alias SerialIndest(1)=Message_ID '0..2
Alias SerialIndest(2)=Sensor_ID '0..9
Alias SerialIndest(3)=System_status '0..3
Alias SerialIndest(4)=Interval_time '1..3600
Alias SerialIndest(5)=Visibilitystr '0..32000 metres
Alias SerialIndest(6)= VisibilityUnits 'M or F for Metres or Feet
Alias SerialIndest(7)=Averaging_duration '1 or 10 minutes
Alias SerialIndest(8)=User_alarm_1 '0..1 - Visibility compared to Threshold One
Alias SerialIndest(9)=User_alarm_2 '0..1 - Visibility compared to Threshold Two
Alias SerialIndest(10)=Emitter_failure '0..2 - Emitter Failure
Alias SerialIndest(11)=Emitter_lens_dirty '0..3 - Emitter Lens Dirty
Alias SerialIndest(12)=Emitter_temp_error '0..3 - Emitter Temperature
Alias SerialIndest(13)=Detector_lens_dirty '0..3 - Detector Lens Dirty
Alias SerialIndest(14)=Detector_temp_error '0..3 - Detector Temperature
Alias SerialIndest(15)=Detector_saturated '0..1 - Detector DC Saturation Level
Alias SerialIndest(16)=Hood_temp_error  '0..3 - Hood Temperature
Alias SerialIndest(17)=Signature_error '0..1 - Signature Error
Alias SerialIndest(18)=Flash_read_error '0..1 - Flash Read Error
Alias SerialIndest(19)=Flash_write_error  '0..1 - Flash Write Error
Alias SerialIndest(20) = checksumrx 'CCITT Checksum

'Define the serial port to which the CS120 is connected - ammend as needed
Const CS120_Comport = COM1

'Preload the poll command for a sensor for address 0, in this example
'If the sensor has a different address uncomment the relevant line
Const CS120_Poll = CHR(2)&"POLL:0:0:3A3B:"&CHR(3)&CHR(13) 'address 0
'Const CS120_Poll = CHR(2)&"POLL:1:0:0D0B:"&CHR(3)&CHR(13) 'address 1
'Const CS120_Poll = CHR(2)&"POLL:2:0:545B:"&CHR(3)&CHR(13) 'address 2
'Const CS120_Poll = CHR(2)&"POLL:3:0:636B:"&CHR(3)&CHR(13) 'address 3
```

```
'Const CS120_Poll = CHR(2)&"POLL:4:0:E6FB:"&CHR(3)&CHR(13) 'address 4
'Const CS120_Poll = CHR(2)&"POLL:5:0:D1CB:"&CHR(3)&CHR(13) 'address 5
'Const CS120_Poll = CHR(2)&"POLL:6:0:889B:"&CHR(3)&CHR(13) 'address 6
'Const CS120_Poll = CHR(2)&"POLL:7:0:BFAB:"&CHR(3)&CHR(13) 'address 7
'Const CS120_Poll = CHR(2)&"POLL:8:0:939A:"&CHR(3)&CHR(13) 'address 8
'Const CS120_Poll = CHR(2)&"POLL:9:0:A4AA:"&CHR(3)&CHR(13) 'address 9


'Main Program
BeginProg
  'Open the logger serial port to which the CS120 is connected
  SerialOpen (CS120_Comport,38400,3,0,1000)

  'Scan at 10 sec, in this case
  Scan(10,Sec,1,0)
    'Send the poll command, delay then read data out of the buffer
    'Note the type of delay used in combination with these specific serial
    'instructions allows this to work in pipeline and sequentialmode programs
    SerialOutBlock(CS120_Comport,CS120_Poll,17)
    Delay(2,100,msec) 'Wait 100 ms for sensor to respond
    SerialInRecord(CS120_Comport,InString,02,0,03,NBytesReturned,01)
    'Split out the data into strings
    SplitStr (SerialIndest(),InString," ",20,5)
   'Check the received checksum is valid
    ChecksumOK = ( HexToDec(checksumrx) = CheckSum(InString,1,InStr
(1,InString,checksumrx,2)-2))
    'Check if the checksum does not match set the vis to NaN.
    'Copy the string into a float so can be manipulated and stored efficiently
    'Do likewise for other variables if used
    'In critical applications the visibility can be set to NaN if the system status
    'is degraded or a critical error flag is set.
    If ChecksumOK Then Visibility = Visibilitystr Else Visibility =NaN
    'Call data storage commands here
  NextScan
EndProg
```

C.3 Example CRBasic SET program

```
'-------------------------------------------------------------------------------
' CS120 Visibility
'
' Program to test the SET command part of the command line interface on the CS120
' Do not run this script for extended periods of time (days!) as it writes
' to flash over and over and will eventually wear the flash out
' Logger:CR1000
'-------------------------------------------------------------------------------

Public InString As String * 200
Public TempString As String *100

' Variables for the SET command subroutine
Dim CS120CArray(21) As String * 6 ' CS120 Command Array

'--------------------------------------------------------
' This function creates a SET command string for the
' CS120 visibility sensor.  Including all delimiting
' characters and checksums
' then returns the string in "CS120CommandString"
' Array variable order is as follows:
' 1. Sensor ID
' 2. User Alarm 1 Set
' 3. User Alarm 1 Active
' 4. User Alarm 1 Distance
' 5. User Alarm 2
' 6. User Alarm 2 Active
' 7. User Alarm 2 Distance
' 8. Serial BaudRate
' 9. Serial number (Read only so not used)
' 10. Visibility Units
' 11. Continuous mode output interval
' 12. Polling Or Continuous modes
' 13. Message Format (Basic/Partial/Full)
' 14. RS232 or RS485 serial communications enabled
' 15. Averaging Period
' 16. Sample timing
' 17. Dew heater override
' 18. Hood Heater override
' 19. Dirty window compensation
' 20. Use CRC checking
' 21. PSU input voltage shutdown level
Function CS120_SETCommand As String *100
  Dim TempStringFunc As String * 100
  Dim CS120CommandString As String * 100
  Dim i As Long
  Dim CheckVal As Long

  ' Create a string containing the values going out to the CS120
  TempStringFunc = "SET:0:"
  For i = 1 To 21
    TempStringFunc = TempStringFunc + CS120CArray(i) + " "
  Next
  ' Create a check sum of the values going out
```

```
  CheckVal = CheckSum (TempStringFunc,1,0)    ' Use the CCITT CRC16 checksum
  ' Create final string going out to CS120 including start characters and end
characters
  CS120CommandString = CHR(2) + TempStringFunc + ":" + FormatLong (CheckVal,"%04X") +
":" + CHR(3) + CHR(13) + CHR(10)
  'CS120CommandString = CHR(2) + TempStringFunc + CHR(3) + CHR(13) + CHR(10) ' Use
this line if no checksum is desired
  Return(CS120CommandString)
EndFunction
'------------------------------------------------------

'Main Program
BeginProg

  ' open port to the visibility sensor using Com1
  SerialOpen (Com1,38400,3,0,10000)

  ' Note: Change the following array variable to suit your own application
  ' load example/dummy values into the array
  CS120CArray(1) = 0        ' Set ID to 0
  CS120CArray(2) = 1        ' Enable alarm 1
  CS120CArray(3) = 1        ' Set alarm 1 to if greater than
  CS120CArray(4) = 1000     ' Set alarm 1 trigger distance to 1000
  CS120CArray(5) = 1        ' Enable alarm 2
  CS120CArray(6) = 0        ' Set alarm 2 to if less than
  CS120CArray(7) = 15000    ' Set alarm 2 trigger distance to 15000
  CS120CArray(8) = 2        ' Set serial baud rate to 38400bps
  CS120CArray(9) = 0        ' Read only so dummy value added here, but not needed
  CS120CArray(10) = "M"     ' Set unit type to metres (use upper case)
  CS120CArray(11) = 60      ' Set output period to 60 seconds
  CS120CArray(12) = 1       ' Polling mode
  CS120CArray(13) = 2       ' Set FULL output message format
  CS120CArray(14) = 0       ' Set RS232 serial mode
  CS120CArray(15) = 1       ' Set averaging over one minute
  CS120CArray(16) = 1       ' Set sample timing to one second
  CS120CArray(17) = 0       ' Set dew heaters to automatic
  CS120CArray(18) = 0       ' Set hood heaters to automatic
  CS120CArray(19) = 0       ' Don't use dirty window compensation
  CS120CArray(20) = 1       ' Use CRC checking on incoming command line data
  CS120CArray(21) = 7.0     ' Set Low voltage battery shutdown to a very low value so
it doesn't trigger

  ' Send information once every 10 seconds
  Scan (10,Sec,0,0)

  TempString = CS120_SETCommand()      ' Create the outgoing string
  SerialOut (Com1,TempString,"",0,100) ' Send SET command to the CS120

  Delay (1,1,Sec)

  SerialIn (InString,Com1,100,0,1000)  ' Grab retuned data from the CS120
                                       ' Returned data is identical to the
                                       ' data a GET command would return

  NextScan
EndProg
```

C.4 Example CRBasic SETNC Command

```
'-------------------------------------------------------------------------------
' CS120 Visibility
'
' Program to test the SETNC command part of the command line interface on the CS120
' This command does not commit the settings to flash so settings will be lost if
' the sensor is power cycled
' This example uses a CS215 temperature and humidity probe to determine dew point.
' The CS120s hood heaters are then turned on only when needed, this is to save
power.
' Logger:CR1000
'-------------------------------------------------------------------------------


'Declare Public Variables
Public InStringSETNC As String * 200
Public InStringGET As String * 200
Public TRHData(2)
Public OutString As String * 40, CheckVal

Dim CS120CArray(21) As String * 6 ' CS120 Command Array
Dim TempDewPoint
Dim StatusDewHeater
Dim TempString As String * 100

Alias TRHData(1)=AirTC
Alias TRHData(2)=RH


'-------------------------------------------------------
' This function creates a SETNC command string for the
' CS120 visibility sensor.  Including all delimiting
' characters and checksums then returns the string
' in "CS120CommandString"
' Array variable order is as follows:
' 1. Sensor ID
' 2. User Alarm 1 Set
' 3. User Alarm 1 Active
' 4. User Alarm 1 Distance
' 5. User Alarm 2
' 6. User Alarm 2 Active
' 7. User Alarm 2 Distance
' 8. Serial BaudRate
' 9. Serial number (Read only so not used)
' 10. Visibility Units
' 11. Continuous mode output interval
' 12. Polling Or Continuous modes
' 13. Message Format (Basic/Partial/Full)
' 14. RS232 or RS485 serial communications enabled
' 15. Averaging Period
' 16. Sample timing
' 17. Dew heater override
' 18. Hood Heater override
' 19. Dirty window compensation
' 20. Use CRC checking
' 21. PSU input voltage shutdown level
Function CS120_SETNCCommand As String *100
  Dim TempStringFunc As String * 100
```

```
        Dim CS120CommandString As String * 100
        Dim i As Long
    Dim CheckVal As Long

    ' Create a string containing the values going out to the CS120
    TempStringFunc = "SETNC:0:"
    For i = 1 To 21
      TempStringFunc = TempStringFunc + CS120CArray(i) + " "
    Next
    ' Create a check sum of the values going out
    CheckVal = CheckSum (TempStringFunc,1,0)   ' Use the CCITT CRC16 checksum
    ' Create final string going out to CS120 including start characters and end
  characters
    CS120CommandString = CHR(2) + TempStringFunc + ":" + FormatLong (CheckVal,"%04X") +
  ":" + CHR(3) + CHR(13) + CHR(10)

  'CS120CommandString = CHR(2) + TempStringFunc + CHR(3) + CHR(13) + CHR(10) ' Use this
  line if no checksum is desired
    Return(CS120CommandString)
  EndFunction
  '----------------------------------------------------


  'Main Program
  BeginProg

    ' Open port to the visibility sensor using Com1
    SerialOpen (Com1,115200,3,0,10000)

    ' Note: Change the following array variable to suit your own application
    ' load example/dummy values into the array
    ' Loading the array is not strictly necessary, but is done as a fail safe in
    ' case the GET command does not return data
    CS120CArray(1) = 0        ' Set ID to 0
    CS120CArray(2) = 0        ' Disable alarm 1
    CS120CArray(3) = 1        ' Set alarm 1 to if greater than
    CS120CArray(4) = 10000    ' Set alarm 1 trigger distance to 10000
    CS120CArray(5) = 0        ' Disable alarm 2
    CS120CArray(6) = 0        ' Set alarm 2 to if less than
    CS120CArray(7) = 10000    ' Set alarm 2 trigger distance to 10000
    CS120CArray(8) = 0        ' Set serial baud rate to 115200bps
    CS120CArray(9) = 0        ' Read only so dummy value added here, but not needed
    CS120CArray(10) = "M"     ' Set unit type to metres (use upper case)
    CS120CArray(11) = 60      ' Set output period to 60 seconds
  CS120CArray(12) = 1       ' Polling mode
  CS120CArray(13) = 2       ' Set FULL output message format
  CS120CArray(14) = 0       ' Set RS232 serial mode
  CS120CArray(15) = 1       ' Set averaging over one minute
  CS120CArray(16) = 1       ' Set sample timing to one second
  CS120CArray(17) = 0       ' Set dew heaters to automatic
  CS120CArray(18) = 0       ' Set hood heaters to automatic
  CS120CArray(19) = 0       ' Don't use dirty window compensation
  CS120CArray(20) = 1       ' Use CRC checking on incoming command line data
  CS120CArray(21) = 7.0     ' Set Low voltage battery shutdown to a very low value so it
doesn't trigger

StatusDewHeater=False

  Scan (10,Sec,0,0)
```

```
    'CS215 Temperature & Relative Humidity Sensor measurements AirTC and RH
    SDI12Recorder(TRHData(),5,"0","M!",1,0)

    'Calculate DewPoint
    DewPoint(TempDewPoint,AirTC,RH)

    ' Gather the current settings from the CS120
    SerialFlush (Com1)
    TempString = "GET:0:0"
    CheckVal = CheckSum (TempString,1,0)  ' Use the CCITT CRC16 checksum
    OutString = CHR(2) + TempString + ":" + FormatLong (CheckVal,"%04X") + ":" +
CHR(3) + CHR(13) + CHR(10)
    SerialOut (Com1,OutString,"",0,100)   ' Send GET command to the CS120
    Delay (1,1,Sec)
    SerialIn (InStringGET,Com1,100,0,200) ' Save the data returned from the GET
command
    If Len(InStringGET) > 1 Then          ' Check data was returned
      SplitStr (CS120CArray(1),InStringGET, " ",21,5)  ' Strip the settings from the
returned data string
      CS120CArray(1) = Right (CS120CArray(1),1)' Trim the SOT from the first data
point
    EndIf

    'Enable Dew Heaters if AirTC < DewPoint
    If AirTC <= TempDewPoint  AND StatusDewHeater=False Then
      CS120CArray(17)=0
      SerialFlush (Com1)
      TempString = CS120_SETNCCommand()
      SerialOut (Com1,TempString,"",0,100)
      Delay (1,1,Sec)
      SerialIn (InStringSETNC,Com1,100,0,1000)
      StatusDewHeater=True
    EndIf

    'Disable Dew Heaters if AirTC > DewPoint+3
    If AirTC > TempDewPoint+3 AND StatusDewHeater=True Then
      CS120CArray(17)=1
      SerialFlush (Com1)
      TempString = CS120_SETNCCommand()
      SerialOut (Com1,TempString,"",0,100)
      Delay (1,1,Sec)
      SerialIn (InStringSETNC,Com1,100,0,1000)

StatusDewHeater=False
    EndIf

    NextScan
  EndProg
```

C.5 Example CRBasic GET program

```
'-----------------------------------------------------------------------------
' CS120 Visibility
'
' Program to test the GET command part of the command line interface on the CS120
' Connecting to serial port one on a CR1000 logger
' Logger:CR1000
'
' Example outputs including checksums (varies with sensor ID)
'  GET:0:0:2C67:
'  GET:1:0:1B57:
'  GET:2:0:4207:
'  GET:3:0:7537:
'  GET:4:0:F0A7:
'  GET:5:0:C797:
'  GET:6:0:9EC7:
'  GET:7:0:A9F7:
'  GET:8:0:85C6:
'  GET:9:0:B2F6:
'-----------------------------------------------------------------------------
Public OutString As String * 40  ' Outgoing string
Dim CheckVal As Long             ' Checksum value
Public InString As String * 200  ' Incomming string
Dim TempString As String * 16

'Main Program
BeginProg

    SerialOpen (Com1,38400,3,0,10000) ' open port to the visibility sensor

    ' Send a request for information once every 10 seconds
    Scan (10,Sec,0,0)

    ' Create the basic GET string for the CS120
    TempString = "GET:0:0"
    CheckVal = CheckSum (TempString,1,0)  ' Use the CCITT CRC16 checksum
    OutString = CHR(2) + TempString + ":" + FormatLong (CheckVal,"%04X") + ":" + CHR(3)
+ CHR(13) + CHR(10)


    SerialOut (Com1,OutString,"",0,100)  ' Send GET command to the CS120

    Delay (1,1,Sec)

    SerialIn (InString,Com1,100,0,200)  ' Save the data returned from the GET command

    NextScan
EndProg
```

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