# CS140

## Background Luminance Sensor

RELIABLE SINCE 1974 MONITORING

CAMPBELL SCIENTIFIC®

# *Guarantee*

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

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

- Batteries

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

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

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

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

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

# *About this manual*

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

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

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

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

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

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

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

## Recycling information

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

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

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

**CAMPBELL SCIENTIFIC**
WHEN MEASUREMENTS MATTER

# *Safety*

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

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

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

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

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

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

# Table of contents

# 1. General information

## 1.1 General safety

This manual provides important safety considerations for the installation, operation and maintenance of the CS140. These safety considerations are classified into three levels:

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

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

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

## 1.2 Sensor unit safety

The CS140 sensor has been checked for safety before leaving the factory and contains no internally replaceable or modifiable parts.

> **WARNING:**
> Do not modify the CS140 unit. Such modifications will damage of the unit.

## 1.3 Recommended tools

The following tools are recommended for installation:

- 10 mm open spanner/wrench (for grounding boss, must be open)
- 13 mm spanner/wrench

# 2. Product overview
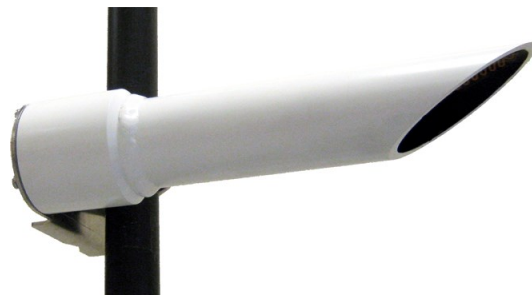


*Figure 2-1. CS140 Background Luminance sensor*

The CS140 Background Luminance Sensor provides the luminance data required to assess the visibility range for lights such as runway lights or warning lights. It accurately measures background luminance over a wide range from 0 cd/m$^2$, to a maximum of 45,000 cd/m$^2$. The CS140 uses a photodiode with a spectral response close to the CIE human eye model and removes any unwanted wavelengths via an inbuilt band-pass filter.

The CS140 features a fixed 6° field of view as specified by the FAA. For easy installation, the CS140 is mounted horizontally with the required 6° inclination built into the design. (Other angles are possible via the sensors mounting bracket.)

A heated hood will prevent ice and snow from building up, dew heaters will prevent condensation on the glass window, and a dirty window detection system measures window contamination.

The sensor is undamaged when pointed directly at the sun, allowing complete flexibility in orientation. In addition, the sensor has a rugged IP66 rated environmental enclosure that protects it from the harshest conditions and will measure the atmosphere with high stability and repeatability.

# 3. Specifications

# 3.1 Optical specifications

Accuracy:      $\pm 0.2$ cd/m$^2$ < 2 cd/m$^2$, $\pm 10\%$ > 2 cd/m$^2$

Field of view:      6°

Spectral response:      CIE 1931

Measurement range:      0 to 45,000 cd/m$^2$

Resolution:      0.1 cd/m$^2$

# 3.2 Electrical specifications

| | Minimum value | Nominal value | Maximum value |
|---|---|---|---|
| **Main power supply for DSP and dew heater** | | | |
| Power supply, DC only | 9 V | 12 V | 30 V |
| Current consumption, sampling continuously (at 12 V) | 5 mA | 7 mA | 9 mA |
| Current consumption, sampling continuously with dew heater active (at 12 V) | 90 mA | 95 mA | 100 mA |
| **Hood heater power supply** | | | |
| Hood heater voltage (AC or DC) | – | 24 V | 30 V |
| Hood heater power (at 24 V AC or DC) | – | 48 W | 55 W |

# 3.3 Communications specifications

Supported serial setting:      8 bits, no parity, 1 stop bit (default)

Supported data rates:      1200 baud      38400 baud (default)

     2400 baud      57600 baud

     9600 baud      115200 baud

     19200 baud

Supported standards:      RS-232 (full duplex, no hardware handshaking)

     RS-485 half duplex

Signal voltage levels:

| | Minimum value | Nominal value | Maximum value |
|---|---|---|---|
| RS-232 communications | | | |
| RS-232 input threshold low | 0.8 V | 1.5 V | – |
| RS-232 input threshold high | – | 2.0 V | 2.4 V |
| RS-232 input absolute maximum | –15 V | – | +15 V |
| RS-232 input resistance | 12 KΩ | – | – |
| RS-232 output voltage low | – | – | 0.4 V |
| RS-232 output voltage high (into 3 KΩ) | 4.4 V | – | – |
| RS-485 communications | | | |
| RS-485 input threshold voltage | –0.2 V | – | +0.2 V |
| RS-485 output (unloaded) | – | – | 5V |
| RS-485 output (load 50 Ω) | 2 V | – | – |
| Maximum voltage at any terminal | –7 V | – | +7 V |

# 3.4 Environmental specifications

Temperature ranges

| | |
|---|---|
| Operating: | –25 to +60 °C |
| Extended operating: | –40 to +70 °C (only guaranteed if sensor has been tested and verified by Campbell Scientific to operate over this range) |
| Storage: | –40 to +85 °C |

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 |
| Ingress protection: | IP66 |

# 3.5 Mechanical specifications
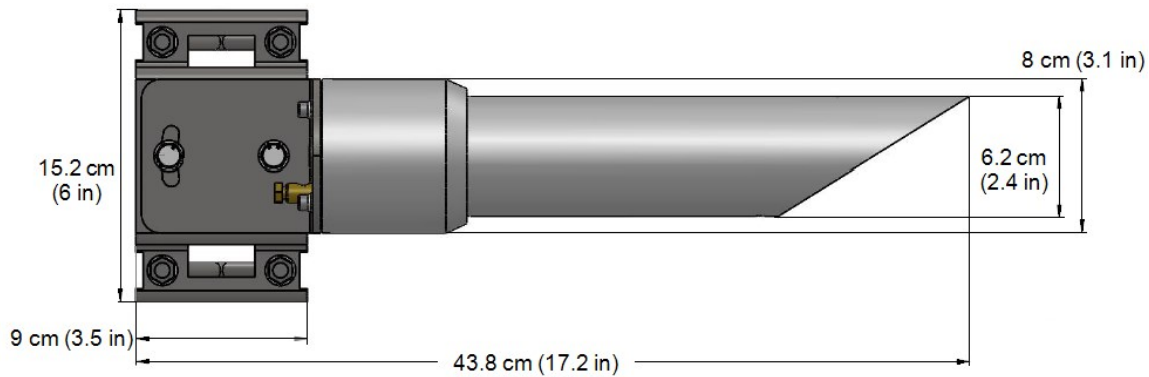


*Figure 3-1. CS140 dimensions*

| | |
|---|---|
| Weight: | 2.4 kg (5.3 lb) |
| Shipping weight: | 3.5 kg (7.7 lb) |

# 3.6 Calibrator specifications

| | |
|---|---|
| Temperature range: | 0 to 40 °C |
| Calibration value: | 4,500 cd/m$^2$ |
| Accuracy: | ±6% |
| Ingress protection: | IP52 |
| Communication: | RS-232, 38400 baud (connecting the calibrator to the CS140 forces communications to RS-232, 38400 baud, and the sensor ID to 0.) |
| Dimensions (excluding cables): | 7.2 cm (2.8 in) long, 4.6 cm (1.8 in) diameter |
| Weight: | 300 g (10.5 oz) |

# 4. Installation

## 4.1 Location and orientation

The CS140 is designed for harsh weather conditions and sunlight shining directly into the CS140 does not damage it. However there are a few considerations to take into account if accurate and representative data from a site are to be obtained.

The CS140 should be placed away from contamination sources. More frequent maintenance is required when the instrument is placed in areas where contamination is unavoidable or where measurements may be safety related.

Point the CS140 towards the desired luminance sources. Ensure that only the light sources in which you are interested are within the sensor field of view. The centre of the field of view is 6° above horizontal. The mounting bracket can adjust by ±12° if the mast is not vertical or if it is necessary to elevate the field of view at an angle other than 6°.

## 4.2 Grounding

The CS140 must be properly grounded with a ground wire that has a minimum cross sectional area of 6 mm$^2$ and maximum length of 5 m from the brass grounding lug at the rear of the unit to an adequate grounding point. The pole and foundations of a pole-mounted installation will also provide some basic lightning protection and protection against radio frequency interference when correctly grounded.

# 4.3 Mounting

A pole mounting kit is supplied with the CS140. This kit includes a mounting plate, two V-bolts and suitable bolts for clamping the pole between the plate and brackets.

To mount the CS140 onto a pole:

1.  The mounting plate is supplied ready fixed to the CS140. Line up the plate to the pole and insert the brackets and bolts from the other side of the pole to fit into the matching holes of the plate as in the following figure.
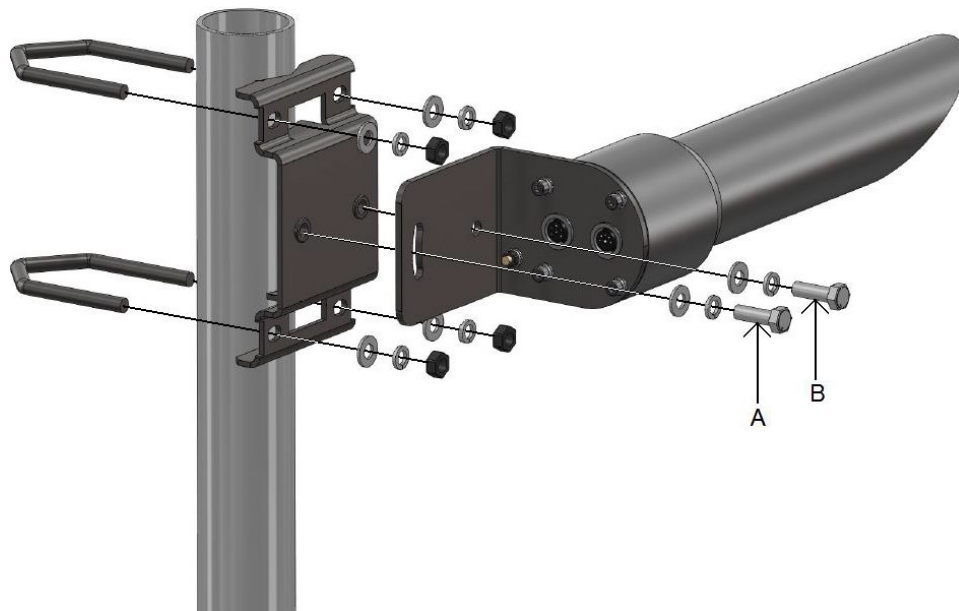


*Figure 4-1. CS140 mounted on pole*

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

The machine screws A and B in Figure 4-1 (p. 7) are used to level the CS140. Screw A is used to lock the CS140 at the right elevation with screw B acting as a pivot. Usually, this will be with the hood horizontal which gives a field of view elevated by 6°.

> **CAUTION:**
> Do not overtighten the nuts because this may distort or damage the brackets, and cause the nuts to seize up. Only tighten the nuts enough to hold the CS140 firmly in place.

> **CAUTION:**
> Do not reposition once nuts are tightened. Forcing the sensor to a different position after tightening the nuts can damage the sensor or bracket.

# 4.4 Connectors

The CS140 has two connectors. One connector supports communications and supplies power to the sensor. The other connector provides power to the hood heater.
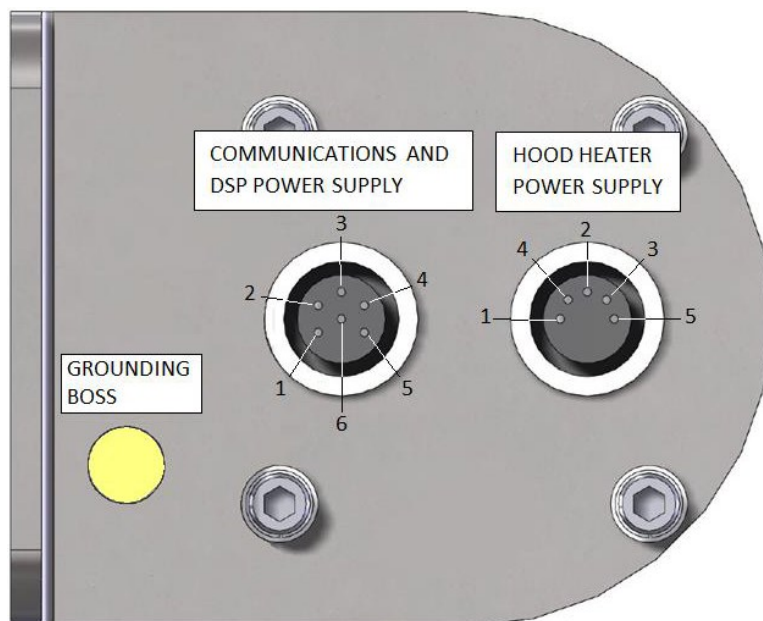


*Figure 4-2. Connector layout*

(p. 8) shows the pin-outs of the sockets viewed from outside. Colours shown are the colours of the cores in the supplied cables.
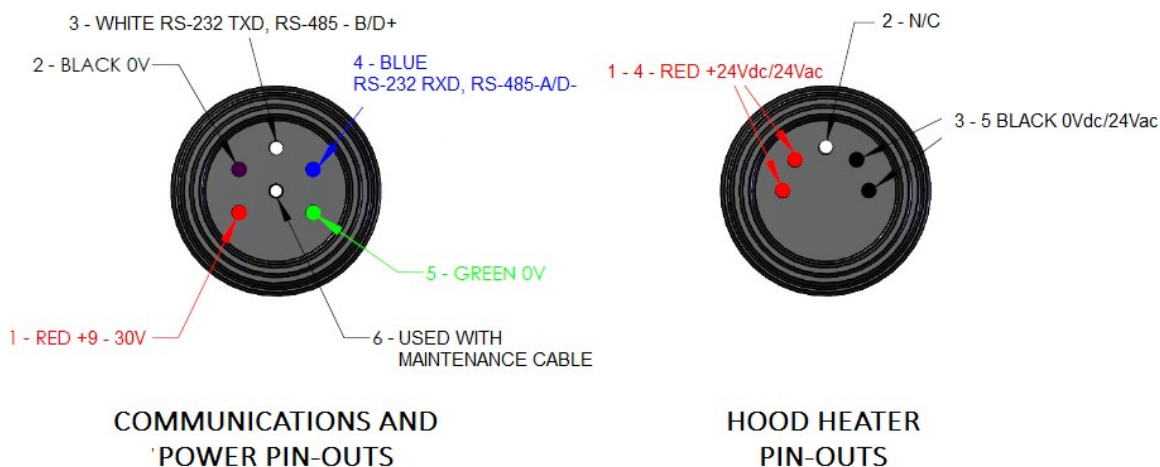


*Figure 4-3. Connector pin-outs*

# 4.5 Wiring using supplied Campbell Scientific cables

Two 5 m cables are shipped with the CS140. One cable supports communications and supplies power to the sensor. The other cable provides power to the hood heater.

> **CAUTION:**
> Incorrectly wiring the communications/power cable to the CS140 can irrevocably damage the unit.

At one end, the communications cable terminates with a 9-pin D-connector (DB9). The D-connector can be connected directly to a computer or data logger such as the Campbell Scientific CR1000X using a suitable interconnecting cable such as the SC110. If another type of connection is required, the D-connector can be easily removed.

> **NOTE:**
> The maximum recommended cable length is 10 m. Use a twisted pair cable if the RS-485 cable needs to be longer than 10 m. Please contact Campbell Scientific if you need a longer cable.

**COMMUNICATIONS AND POWER CONNECTOR**
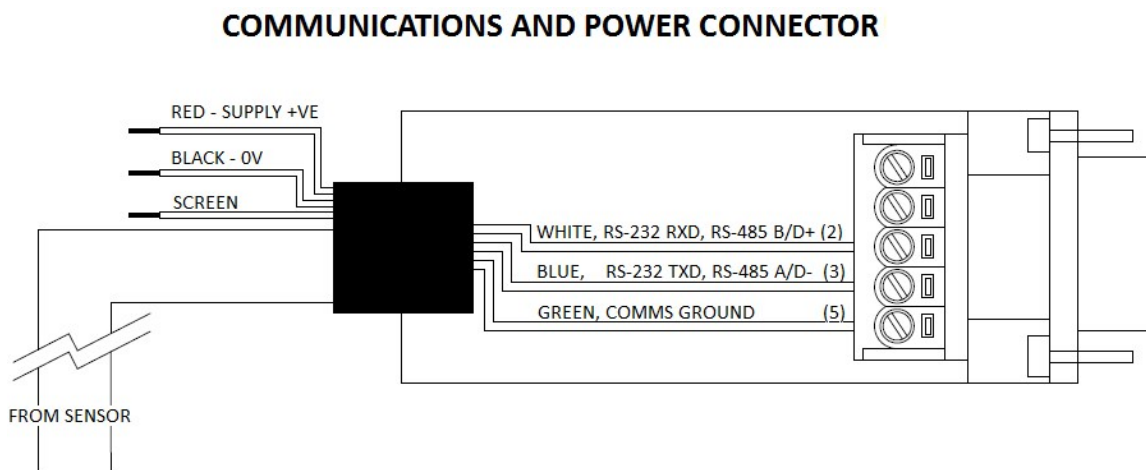


*Figure 4-4. Cable connections*

# 4.6 Maintenance cable

Campbell Scientific offers a maintenance cable that will force communications to RS-232, 38400 baud, and sensor id to 0. The cable connectors allow it to be put in between the CS140 and the existing connection and a 5 m flying lead with a 9-way D connector for RS-232 communication.

The sensor will continue to draw power from the existing source. When installed, the existing communication path is disconnected and communication using the flying lead is forced to RS-232, 38400 baud with a sensor ID of 0. When the maintenance cable is removed and replaced with the cable previously used the baud rate and ID will return to those previously set.
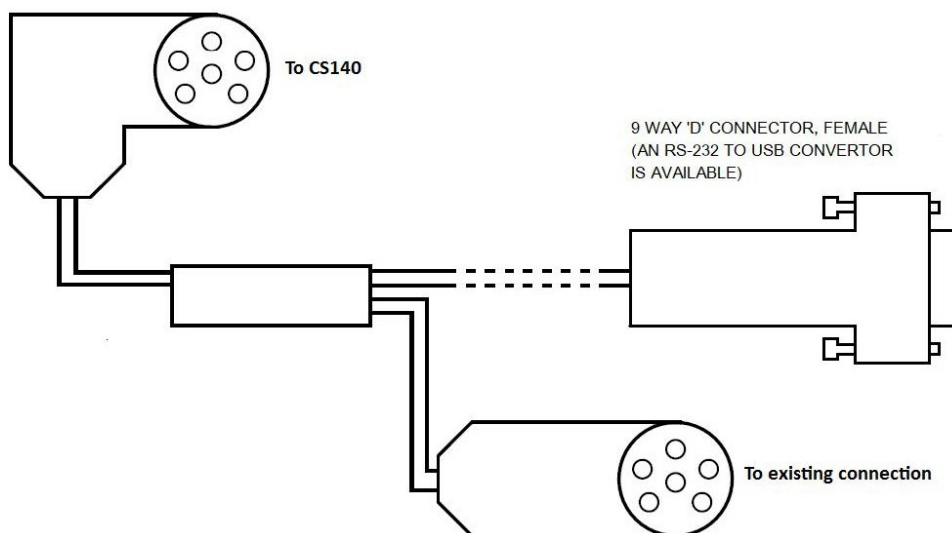


*Figure 4-5. Maintenance cable*

# 4.7 Storage information

The CS140 should be stored between –40 to 85 °C in a dry place. The optics should be protected from possible accidental damage.

# 5. Message structure

| Table 5-1: Basic format | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| STX | Message ID | Sensor ID | System Status | Luminance | Units | Checksum (CCITT) | ETX | Carriage return | Line feed |
| 0x02 | 0 | 0 | 3 | 35833.7 | 1 | 4E7C | 0x03 | 0x0D | 0x0A |

Example basic format output:

```
0 0 3 35833.7 1 4E7C
```

## Table 5-2: Partial Format

| STX | Message ID | Sensor ID | System Status | Message Interval | Luminance | Units | User alarms | Checksum (CCITT) | ETX | Carriage return | Line feed |
|-----|-----------|-----------|---------------|------------------|-----------|-------|-------------|------------------|-----|-----------------|-----------|
| 0x02 | 1 | | 3 | 10 | 15732.2 | 1 | 0 0 0 0 | 1ED9 | 0x03 | 0x0D | 0x0A |

Example partial format output:

```
1 0 3 10 15732.0 1 0 0 0 0 1ED9
```

## Table 5-3: Full Format

| STX | Message ID | Sensor ID | System Status | Message Interval | Luminance | Units | Average duration | User alarms | System alarms | Checksum (CCITT) | ETX | Carriage return | Line feed |
|-----|-----------|-----------|---------------|------------------|-----------|-------|------------------|-------------|---------------|------------------|-----|-----------------|-----------|
| 0x02 | 2 | 0 | 3 | 10 | 15292.4 | 1 | 1 | 0 0 0 0 | 1 0 3 0 0 0 0 0 0 | F8DA | 0x03 | 0x0D | 0x0A |

Example full format output:

```
2 0 3 10 15292.4 1 1 0 0 0 0 1 0 3 0 0 0 0 0 0 F8DA
```

## Table 5-4: Message ID break down

| ID | Definition |
|----|------------|
| 0 | Basic format. Contains only luminance and system information |
| 1 | Partial format. Contains user alarm outputs |
| 2 | Full format. Contains all system alarms codes |

## Table 5-5: Sensor ID break down

| ID | Definition |
|----|------------|
| 0 to 9 | Unit number defined by the user to aid identification of data. Default is 0. Useful for RS-485 networks. Operates as an address in RS-485 mode. |

## Table 5-6: System status break down[1,2]

| Status level | Definition |
|--------------|------------|
| 0 | Basic format. Contains only luminance and system information |
| 1 | Partial format. Contains user alarm outputs |
| 2 | Full format. Contains all system alarms codes |
| [1]System status break down reflects the highest level of severity of any active alarm. | |
| [2]Refer to the individual alarms (below) for details of the response times of the alarms. | |

**Table 5-7: Message interval**

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

**Table 5-8: Luminance break down**

| Luminance | Definition |
|---|---|
| 1 to 50000 | Current luminance being detected by the sensor. The maximum luminance level reported by the sensor can be defined by the user via the menu system. |

**Table 5-9: Visibility units break down**

| Option | Definition |
|---|---|
| 1 | cd/m$^2$ |
| 2 | fL |

**Table 5-10: Averaging duration break down**

| Duration | Definition |
|---|---|
| 1 | One minute average |
| 10 | Ten minute average |

**Table 5-11: User and system alarms break down**

| Alarm | Range | System status | Definition |
|---|---|---|---|
| User Alarm | 0 or 1 | 1 | 0 = User alarm not active<br>1 = User alarm active |
| Spare | – | – | Reserved for future use |
| Spare | – | – | Reserved for future use |
| Spare | – | – | Reserved for future use |
| Window contaminated[1] | 0 to 3 | 0<br>1<br>3 | 0 = OK. The reported attenuation is below 10%.<br>1 or 2 = Reported dirt level is over 10%<br>3 = High level of returned dirty signal. This could be either a blocked sensor or a broken dirty window system. |

| Table 5-11: User and system alarms break down | | | |
|---|---|---|---|
| **Alarm** | **Range** | **System status** | **Definition** |
| Photo diode temperature | 0 to 3 | 0<br>1<br>1<br>3 | 0 = Temperature is within operating conditions.<br><br>1 = Too low. Less than –40 °C.<br><br>2 = Too high. Over 70 °C.<br><br>3 = Sensor fault (No sensor detected or below -49°C) |
| Hood temperature | 0 to 3 | 0<br>1<br>1<br>2 | 0 = Temperature is within operating conditions.<br><br>1 = Too low. Less than –40 °C.<br><br>2 = Too high. Over 70 °C.<br><br>3 = Sensor fault (No sensor detected or below -49°C) |
| Detector DC saturation level[2] | 0 or 1 | 0<br>2 | The amount of background light as seen by the detector hood.<br><br>  0 = Within limits<br><br>  1 = Saturated. The CS140 is experiencing direct light levels that are saturating the photo diode |
| Signature error | 0 or 1 | 3 | 0 = Signature of entire flash was checked and matches the stored version<br><br>1 = Signature does not match previous readings |
| Flash write error | 0 or 1 | 3 | 0 = No errors<br><br>1 = One or more errors reading user variables from flash occurred |

| Table 5-11: User and system alarms break down | | | |
|---|---|---|---|
| Alarm | Range | System status | Definition |
| Internal voltages | 0 or 1 | 3 | 0 = No errors<br>1 = One or more errors reading user variables from flash occurred |
| Spare | – | – | Reserved for future use |

[1]With OS version 9 or newer, this alarm flag will not increase in level until the dirt detector has been above the "dirt" threshold continuously for 15 minutes or more. This prevents transient setting of the flag caused by reflections, insects, or dust.

[2] With OS version 9 or newer, this alarm flag will not change to level 1 unless the sensor has been continuously saturated for 60 minutes or more. This is to avoid false alarms if the sun shines directly into the sensor.

# 6. Interface methods

## 6.1 Command line menu

The CS140 can be setup and controlled in one of two ways. The first method is by using the command line interface where discrete commands are sent without response from the sensor. This method is preferred for setting up a CS140 that is connected to a data logger. The data logger can send configuration setting commands to the CS140 removing the need for a computer to set up the unit.

The second method is by using the simple menu interface built into the CS140 using RS-232 or RS-485 communications and a terminal emulator program. This menu system gives access to the more common settings.

# 6.2 Configuring computer

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

The following settings should then be used by default:

Bits per second: 38400

Data bits: 8

Parity: none

Stop bits: 1 Flow control: none

> **NOTE:**
> After adjusting the baud rate of the unit, use the terminal emulator to adjust the bits per second value in the port settings. The CS140 can not communicate with the computer if the unit and port setting baud rates differ.

The CS140should now be ready to accept commands.

# 6.3 Variable definitions

The command line interface can access all the following user configurable variables:

| Table 6-1: Command line variable definitions | | | | |
|---|---|---|---|---|
| ID | Name | Range | Description | Default |
| 1 | Sensor ID | 0 to 9 | Separate ID used as an identifier for a particular CS140 on a network. | 0 |
| 2 | Serial port protocol | 0 or 1 | Selects the physical serial interface: <br> 0 = RS-232 mode <br> 1 = RS-485 mode | 2 |

| ID | Name | Range | Description | Default |
|----|------|-------|-------------|---------|
| | | | **Table 6-1: Command line variable definitions** | |
| 3 | Serial baud rate | 0 to 6 | Baud rate for the main RS-232/RS-485 interface:<br><br>0 = 115200 bps<br>1 = 57600 bps<br><br>2 = 38400 bps<br><br>3 = 19200 bps<br><br>4 = 9600 bps<br><br>5 = 2400 bps<br><br>6 = 1200 bps | 2 |
| 4 | Serial number (read only) | 0 to 32000 | Internal serial number | – |
| 5 | Luminance units | 0 or 1 | Units for the CS140 luminance value:<br><br>0 = Candela per metres square (cd/m$^2$)<br>1 = Foot lamberts (fL) | 0 |
| 6 | Message interval | 1 to 3600 | Interval, in seconds, between outputs in continuous mode. This value has no effect if the polled mode selected for the **Measurement mode** (see the following row). | 60 |
| 7 | Measurement mode | 0 or 1 | Selects polled or continuous modes. In continuous mode, the sensor outputs a string in the format as set by **Message Format** at regular intervals as defined by **Continuous Interval**.<br><br>0 = Continuous mode<br><br>1 = Polled mode | 0 |

| ID | Name | Range | Description | Default |
|----|------|-------|-------------|---------|
| | **Table 6-1: Command line variable definitions** | | | |
| 8 | Message Format | 0 to 2 | Level of detail outputted by polled or continuous modes:<br><br>0 = Basic<br><br>1 = Partial<br><br>2 = Full | 2 |
| 9 | Sample timing | 1 to 60 | Not currently implemented | 1 |
| 10 | Averaging period | 1 or 10 | The period of time that the luminance value should be averaged over. | 1 |
| 11 | Dew heater override | 0 or 1 | 0 = Allow the CS140 to automatically control the dew heater<br><br>1 = Turn the dew heater off | 0 |
| 12 | Hood heater override[1] | 0 or 1 | 0 = Allow the CS140 to automatically control the hood heater<br><br>1 = Turn the hood heater off | 0 |
| 13 | Dirty window compensation | 0 or 1 | 0 = No compensation applied<br><br>1 = Compensation for dirt on window applied. The CS140 will compensate for up to 10% signal loss due to dirt on the window. | 0 |
| 14 | Use CRC | 0 or 1 | 0 = Disable command line CRC checking[2]<br><br>1 = Enable command line CRC checking.<br><br>**NOTE:**<br>This does not affect communications using *Device Configuration* utility or terminal emulator. | 0 |

| Table 6-1: Command line variable definitions | | | | |
|---|---|---|---|---|
| ID | Name | Range | Description | Default |
| 15 | Power Supply Unit (PSU) voltage level shutdown | 9 to 30 | PSU input voltage level below which the CS140 will enter low power mode. This helps protect the batteries.<br><br>**NOTE:**<br>The CS140 shuts itself down via hardware at about 8 VDC. | 9 |
| 16 | Enable alarm | 0 or 1 | 0 = Alarm off<br>1 = Alarm on | 0 |
| 17 | Alarm high/low | 0 or 1 | 0 = Alarm triggered by a luminance higher than the alarm level<br>1 = Alarm triggered by a luminance lower than the alarm level | 0 |
| 18 | Alarm level | 0 to 45000 | Luminance level, in cd/m$^2$, that triggers the alarm. | 10000 |

[1] Hood heater override needs to be set to **1** (off) when the hood heater has no power connected. 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 CS140 being configured incorrectly by accident.

# 6.4 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 CS140. 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 CS140 can be configured to expect any commands sent to it to include a valid checksum. For simple commands such as **GET** and **POLL**, fixed value checksums can be used. For more complex **SET** commands the checksum needs to be calculated. The use of the checksum is disabled by default. Campbell Scientific recommends enabling the checksum functionality, especially when long cable runs are used, or in electronically noisy environments. Example C code of the CCITT CRC (p. 34) provides example code for programmers implementing their own code. For

Campbell Scientific data logger users, downloadable example programs are available at www.campbellsci.eu/downloads/cs140-program-examples ⬈

## 6.4.1 SET command

The **SET** command is used to configure the CS140 using the command line. The **SET** command is a single space delimited string that can be sent from any data logger or computer equipped with an RS-232 or RS-485 port. The **SET** command accesses identical settings within the CS140. This command is used to change the default power up state of the sensor. The `Set` command is echoed back.

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

```
SET: 0:0 0 2 0 0 10 1 2 1 1 0 0 0 1 9.5 0 0 10000 :E52F:
0 0 2 1000 0 10 1 2 1 1 0 0 0 1 9.5 0 0 10000 0146
```

Table 6-2: SET transmitted/echoed data

| Example | Description |
|---|---|
| 0x02[1] | STX |
| : | Delimiting character |
| SET | Set command |
| : | Delimiting character |
| 0 | Address based on sensor ID |
| : | Delimiting character |
| 0 | Sensor ID |
| 2 | Serial port protocol |
| 0 | Serial baud rate |
| 1000 | Sensor serial number (only in echoed reply) |
| 0 | Luminance units |
| 10 | Continuous mode output interval |
| 1 | Polling or continuous modes |
| 2 | Message format (basic/partial/full) |
| 1 | Averaging period |
| 1 | Sample timing |
| 0 | Dew heater override |

| Table 6-2: SET transmitted/echoed data | |
|---|---|
| Example | Description |
| 0 | Hood heater override |
| 0 | Dirty window compensation |
| 1 | CRC checking on received commands |
| 9.5 | Sensor power down voltage |
| 0 | Enable alarm |
| 0 | Alarm high/low |
| 10000 | Alarm level |
| : | Delimiting character |
| 0146 | Checksum (use the valid CCITT checksum) |
| : | Delimiting character |
| 0x03[1] | ETX |
| 0x0D[1] | Carriage return |
| [1]These values are shown in hexadecimal format not ASCII. | |

## 6.4.2 SETNC command

The format of the **SETNC** command is the same as the **SET** command except it starts with **SETNC**. The only functional difference is that the **SETNC** command does not commit the values set into flash memory. This means that the next time the CS140 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.

## 6.4.3 GET command

The **GET** command retrieves settings data from the CS140, including message format data and user alarm settings amongst others. This command does not retrieve visibility or environmental information from the CS140. To retrieve visibility data refer to the **POLL** command.

### Table 6-3: GET command transmitted data

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

Example of a **GET** request:

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

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

```
GET : 0 : 0 : 2C67 :
0 0 2 1000 0 60 0 2 1 1 0 0 0 1 7.0 0 0 10000 626C
```

### Table 6-4: GET command returned data

| Example | Description |
|---|---|
| 0x02[1] | STX |
| 0 | Sensor ID |
| 0 | Serial port protocol |
| 2 | Serial baud rate |
| 1000 | Sensor serial number (read only) |
| 0 | Luminance units |
| 60 | Continuous mode output interval |

| | |
|---|---|
| **Table 6-4: GET command returned data** | |
| Example | Description |
| 0 | Polling or continuous modes |
| 2 | Message format (Basic/Partial/Full) |
| 1 | Averaging period |
| 1 | Sample timing |
| 0 | Dew heater override |
| 0 | Hood heater override |
| 0 | Dirty window compensation |
| 1 | CRC checking on received commands |
| 7.0 | Sensor power down voltage |
| 0 | Enable alarm |
| 0 | Alarm high/low |
| 10000 | Alarm level |
| : | Delimiting character |
| 626C | Checksum |
| : | Delimiting character |
| 0x04[1] | EOX |
| 0x0D[1] | Carriage return |
| 0x0A | Line feed |
| [1] These values are shown in hexadecimal format not ASCII. | |

## 6.4.4 Poll command

The **POLL** command requests the current visibility and/or alarm conditions from the CS140. The output format of this command depends on how the CS140 is configured using the **SET** command or the menu interfaces.

Example of a **POLL** request with returned message:

```
POLL : 0 : 0 : 3 A3B:
2 0 0 60 22.9 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5EC7
```

| Table 6-5: POLL transmitted data | |
| --- | --- |
| Example | Description |
| 0x02[1] | STX |
| POLL | POLL command |
| : | Delimiting character |
| 0 | Address based on sensor ID |
| : | Delimiting character |
| 0 | Reserved for future use; zero default |
| : | Delimiting character |
| 3A3B | Checksum |
| : | Delimiting character |
| 0x03[1] | ETX |
| 0x0D[1] | Carriage return |
| [1] These values are shown in hexadecimal format not ASCII. | |

# 6.5 Menu system

When connected to the CS140, the user can enter the menu system by typing **open id** in their terminal program then pressing the return key on their keyboard. The ID corresponds to the sensor ID number. The sensor ID number can be in the range of 0 to 9. The factory default is 0.

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

The following text will now be displayed:

```
WELCOME TO THE CAMPBELL SCIENTIFIC LTD CS140 SETUP MENU
  ID 0
  S/N 1009
  (1) Message output menu
  (2) User alarm menu
  (3) Communications setup
  (4) System information
  (5) System configuration
  (6) Calibration

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

The displayed options are accessed 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.

Type **1** to open the message menu containing settings relating to the CS140 outputs.

Menu 1: Message output:

```
CS140 MENU 1
  ID 0
  S/N 1009
  (1) Toggle message format: FULL
  (2) Toggle units: cd/m2

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

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

For example typing **2** will toggle the units through the options $cd/m^2$ and fL and typing **4** will allow the message interval to be entered.

Option (2) allows the user alarms to be set, again by toggling through options or changing values. It also allows the measurement range to be set. Upper and lower limits can be set individually or the CS140 can be set to report between FAA limits (6.85-41115.0 $cd/m^2$, 2 to 12000 fL) or UK CAA limits (5-35000.0 $cd/m^2$).

Menu 2: User alarm:

```
CS140 ALARM AND LIMIT 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 cd/m2

  (4) Set upper output limit: 45000 cd/m2

  (5) Set lower output limit: 5 cd/m2

  (6) Set to FAA limits
  (7) Set to CAA limits

  (9) Refresh
  (0) Return to main menu

  ->
```

Option (3) gives the communications menu. This is used to set baud rates and the mode of operation (RS-232/RS-485).

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

Menu 3: Communications:

```
CS140 COMMUNICATIONS MENU 3
  ID 0
  S/N 1009
  (1) Set sensor ID
  (2) Set RS232/RS485 baud rate: 38400
  (3) Toggle RS232/RS485 modes: RS232

  (9) Refresh
  (0) Return to main menu

  ->
```

Option (4) gives the systems information menu containing useful information such as temperature and system alarms.

Menu 4: Information:

```
CS140 INFORMATION MENU 4
  ID 0
  S/N 1009
  OS version: 7644-07
                                           Alarm      Value
  - One Minute Luminance value:            -          3100.0
  - Overall system status:                 0          No faults
  - Detector dirty window alarm:           0          0%
  - Sensor internal temperature:           0          28.0
  - Hood heater temperature:               0          22.7
  - CS140 Rig Constant:                    -          100
  - CS140 Reference Value:                 -          100.00
  - Calibration value Fac offset:          -          -33.00
  - Calibration value Fac scale:           -          30.00
  - User Reference Value, cd/m²:           -          4500.00
  - User calibration value offset:         -          19.66
  - User calibration value scale:          -          332.4
  - Signature fault:                       0          -
  - Flash write errors:                    0          0
  - Flash read errors:                     0          0
  - Supply voltage:                        <9.0V      11.5V
  - Aux supply voltages:                   +5V=5.0    +3V=3.0


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


    ->
```

If the dirty window alarm is set, clean the sensor as described in Cleaning (p. 33). If there is a flash error or signature error, contact Campbell Scientific.

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

Menu option (5) allows configuration of heaters, window compensation, CRC Checking and the power down voltage.

```
CS140 CONFIGURATION MENU 5
  ID 0
  S/N 1009
  (1) Toggle dew heater override: AUTOMATIC
  (2) Toggle hood heater override: AUTOMATIC
  (3) Toggle dirty window compensation: NO COMPENSATION
  (4) Toggle command line CRC Checking: DO NOT CHECK
  (5) Sensor power down voltage: 9.0V

  (9) Refresh
  (0) Return to main menu

  ->
```

Menu option (6) allows calibration of the CS140 using an optional calibration device. It also allows the user to reset the CS140 to factory default values.

```
CS140 CONFIGURATION MENU 6
  ID 0
  S/N 1009
  (1) Perform a user calibration
  (2) Reset the user calibration to factory values

  (9) Refresh
  (0) Return to main menu

  ->
```

To perform a calibration choose option (1); see Calibration (p. 27). Once a calibration is finished changes are immediate, but factory calibrations can be restored if needed using option (2) in the calibration menu.

# 7. Calibration

The CS140 can be checked and adjusted using the optional calibration device. The calibration must be run using the onboard menu system. If you have Campbell Scientific **Device Configuration** utility program, a terminal emulation screen is provided in the CS140 screens to let you access this function.

To perform the calibration, you will need the calibrator device and a computer with a compatible USB port. The calibrator device is sealed to IP52 and will generate a test light level of 4,500 cd/m$^2$ accurate to ±6% over a temperature range of 0 to 40°C.

Campbell Scientific recommends cleaning the window before calibrating the CS140. The system is self-regulating. However, the CS140 should be calibrated at least every two years. The

calibration is performed from menu item 6 on the main terminal screen. Once you have selected menu item 6 you will be presented with the following screen.

```
CS140 CONFIGURATION MENU 6
  ID 0
  S/N 1009
  (1) Perform a user calibration
  (2) Reset the user calibration to factory values

  (9) Refresh
  (0) Return to main menu


  ->
```

Select option 1 to start the calibration. At this point the calibration device and cable should be installed as shown in the following figures. Connecting the calibrator switches the CS140 to communication at 38400 baud with a sensor ID of 0. This will happen whatever the previous setting or whether the CS140 was set to RS-232 or RS-485.
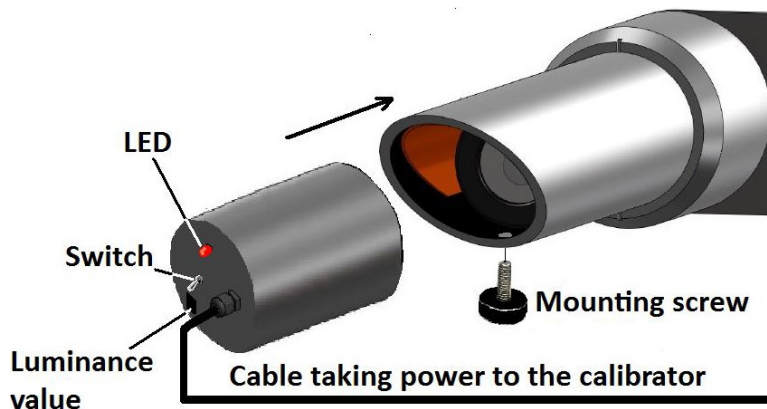


*Figure 7-1. Calibrator device*
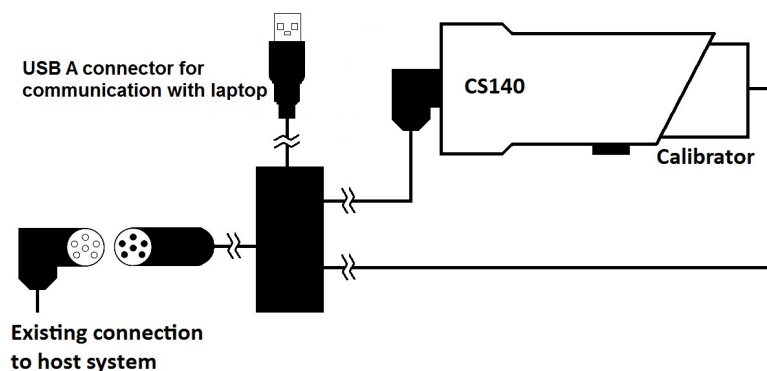


*Figure 7-2. Calibrator device connections*

The CS140 menu structure will still be available while the calibrator is connected. You will then be asked to confirm that you would like to perform a calibration.

Once you have typed yes, 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. After starting the tests, you will be asked for the calibrator device luminance value with a confirmation at each step giving you the chance to correct typing mistakes. The luminance value will be 4500.0 for the calibrator device.

> **NOTE:**
> When asked for confirmation, you do not need to press return after you type y.

```
Input the CS140CAL luminance value (cd/m2) -> 4500.0

Is 4500.0 correct? (Y/N)?
Y

Place the CS140CAL into the hood.

Ensure the CS140CAL is turned off, then press any key.

H

Starting dark level calibration.............

Dark level test complete.
```

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. The CS140 will then ask you to turn on the calibrator device.

```
Turn the CS140CAL on.

Press any key once this is done.
```

Once confirmed the light level calibration will begin.

```
Starting light level calibration. (This will take 5-6
minutes)...................................
Saving user calibration settings.

Calibration is now complete. You may remove the
CS140CAL at any time.

CS140CAL Val:4500.0 Offset:20.33 Scale:332.0

Press any key to exit.
```

Once the light level calibration 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.

# 8. OS update

Operating system updates for the sensor are performed using Campbell Scientific *Device Configuration Utility* software. This is available as a free download from the Campbell Scientific website. Please refer to the help built into the *Device Configuration Utility* for full instructions on how to update the CS140.

> **NOTE:**
> To use the *Device Configuration Utility* to carry out an OS change requires RS-232 communication. However, if a sensor is set to communicate by RS-485, it is not necessary to change this in the sensor.
>
> Connect a computer with the *Device Configuration Utility* running to the sensor with RS- 232 communications. Run the *Device Configuration Utility* to the stage shown in Figure 8-1 (p. 31). Then turn on the sensors power supply. The update will then take place through RS-232. The sensor will however remain in RS-485 mode afterwards.

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

File   Language   Backup   Options   Help   New Version ★

3. Click Send OS

Device Type

CS140   Send OS

**CS140 OS Download Instructions**

Using this panel, you can download a new operating system into the CS140. As the CS140 will need to be power cycled during programming, data output will be momentarily interrupted.

1. Connect the CS140 to an RS-232 serial port on your computer using either a CS140 to RS232 service cable (which can be purchased from Campbell Scientific) or a cable wired as shown in the following table:

| CS140 Communications and power connector | | RS232 Signal | 9 Pin Connector | 25 Pin Connector |
|---|---|---|---|---|
| CS140 Connector  Pin 1 | | +12-24V | | |
| CS140 Connector  Pin 2 | | 0V | | |
| CS140 Connector  Pin 3   TXD | | TX | 2 | 3 |
| CS140 Connector  Pin 4   RXD | | RX | 3 | 2 |
| CS140 Connector  Pin 5   0V | | 0V | 5 | 7 |

2. Remove the communications and power cable (refer to the manual for further connector information) from the CS140 and replace with your CS140 to RS232 cable.
3. Ensure that the correct serial port is selected in the panel on the left.
4. Disconnect power from the CS140.
5. Click on the Start button below.
6. From the pop up dialogue box that appears, find and select the new CS140 OS that you wish to send to the sensor then click OK.

7. Restore power to the CS140.
8. The operating system will now be sent to the CS140. You should allow this to run to completion, cancelling the operation can leave the CS140 without a valid operating system. If power was accidentally removed and the OS didn't load, then start this procedure again from step 1 to restore a valid copy of the OS. Programming the CS140 will take in the region of two minutes to complete.
9. Once the code has been sent the new OS will start executing immediately.
10. You may now remove power from the CS140 if desired.

1. Select sensor

**Connection Type**

Direct    IP

Communication Port  ⓘ
COM1  ▼

2. Select communication settings and connect to sensor

Baud Rate  ⓘ
38400  ▼

Connect

Start    Print Instructions

*Figure 8-1. CS140 **Device Configuration Utility** OS download instructions*

*Figure 8-2. **Device Configuration Utility** screen when OS update is complete*

# 9. Maintenance

## 9.1 General

The CS140 is a robust weather resistant instrument and there is no need for routine maintenance other than cleaning. The instrument performance is monitored and any potential problems are covered by error messages. Other maintenance is carried out by return to Campbell Scientific.

# 9.2 Cleaning

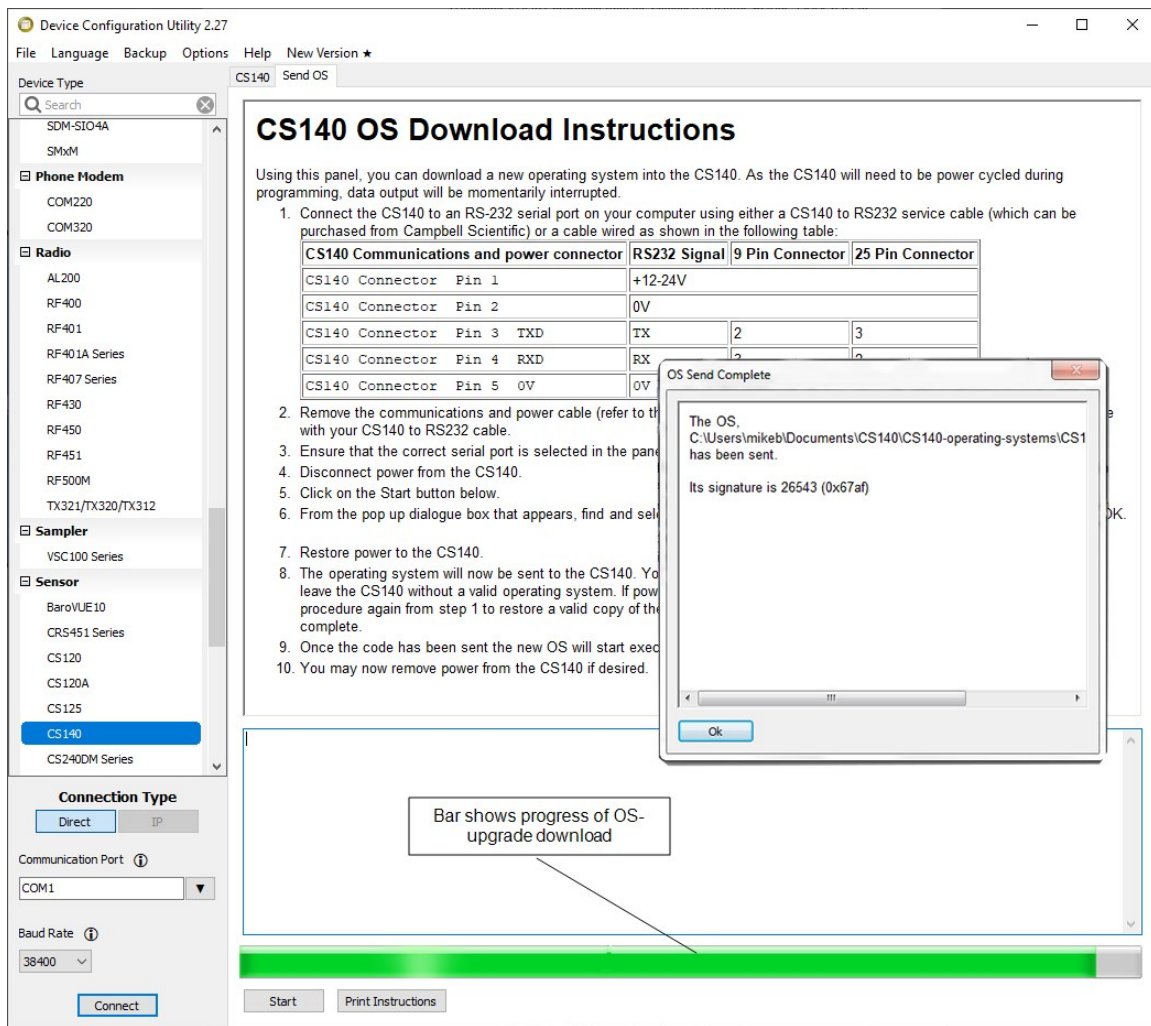The CS140 window will require cleaning from time to time. The frequency of required cleaning depends on the exposure of the instrument to contaminants such as salt and dust. This will vary depending on the site location. The CS140 is capable of self-diagnosing a dirty window and will indicate in its output when the window is contaminated.

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

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

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

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

# Appendix A. Example C code of the CCITT CRC

The following code is provided as an example for programmers implementing their own code to communicate with the sensor. Users using Campbell data loggers can use the checksum command in *CRBasic Editor* to generate a CCITT checksum. Refer to the downloadable example programs available at www.campbellsci.eu/downloads/cs140-program-examples ↗

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

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

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

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