PRODUCT MANUAL

Sensor

CS140

Background Luminance Sensor

RELIABLE
MONITORING
— SINCE —
1974

CS
Campbell
SCIENTIFIC®

Please read first

About this manual

Please note that this manual was produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this. 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 from Campbell Scientific it will be suitable for use in your country*.

Reference to some radio transmitters, digital cell phones and aerials (antennas) 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.

Recycling information for countries subject to WEEE regulations 2012/19/EU

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, per The Waste Electrical and Electronic Equipment (WEEE) Regulations 2012/19/EU. Campbell Scientific 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 support, please contact Campbell Scientific, or your local agent.

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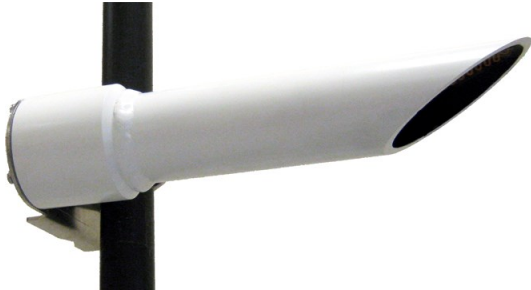
1. Introduction

Figure 1-1. CS140 Background Luminance sensor

The CS140 Background Luminance Sensor provides the luminance data required to assess the visibility range for lights, such as runway or warning lights. It accurately measures background luminance over a wide range from 0 cd/m^2 with 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 with a built-in 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 using the mounting bracket.)

A heated hood will prevent ice and snow build up, dew heaters will prevent condensation on the glass window, and a dirty window detection system will measure 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 allows the sensor to measure the atmosphere with high stability and repeatability.

2. Precautionary statements

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.

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.

3. Specifications

3.1 Optical specifications

Accuracy:	±0.2 cd/m^2 < 2 cd/m^2; ±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
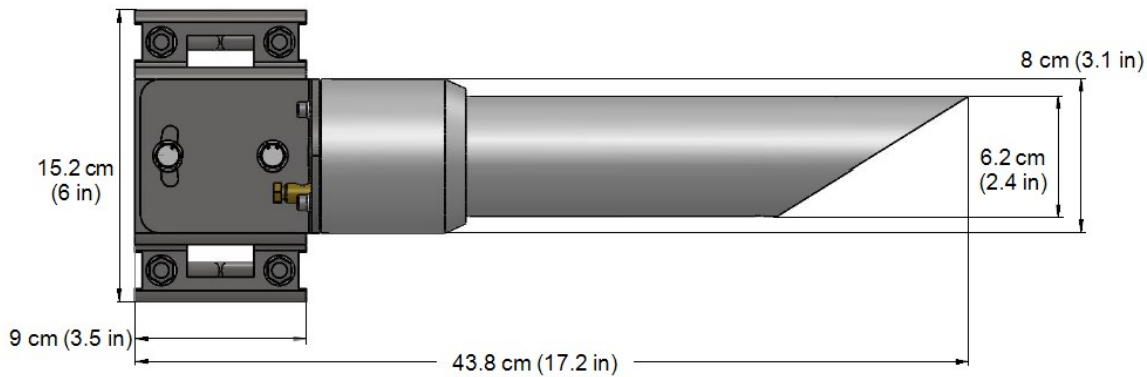
Figure 3-1. CS140 dimensions

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, with a 38400 baud rate, and a sensor ID of 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 Recommended tools

The following tools are recommended for installation:

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

4.2 Location and orientation

The CS140 is designed for harsh weather conditions. Additionally, sunlight shining directly into the CS140 does not damage it. However, there are a few considerations to take into account if accurate data from a site is 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 only the light sources you are measuring are within the sensor field of view. The center of the field of view is 6° above horizontal. The mounting bracket can adjust by ±12° if the mast is not vertical or if the field of view is at an angle other than 6°.

4.3 Grounding

The CS140 must be properly grounded with a ground wire that has a minimum cross sectional area of 6 mm^2. The ground wire must have a 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 andradio frequency interference protection when correctly grounded.

4.4 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 as shown in the following figure.
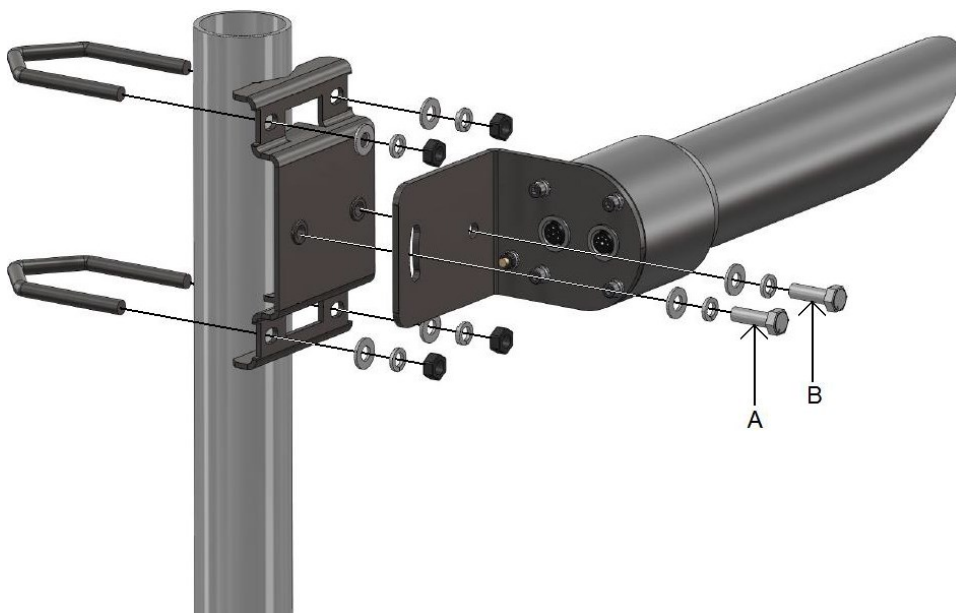
Figure 4-1. CS140 mounted on pole

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

The machine screws A and B in Figure 4-1 (p. 7) are used to level the CS140. Screw A locks 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 overtightening 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.

4.5 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.
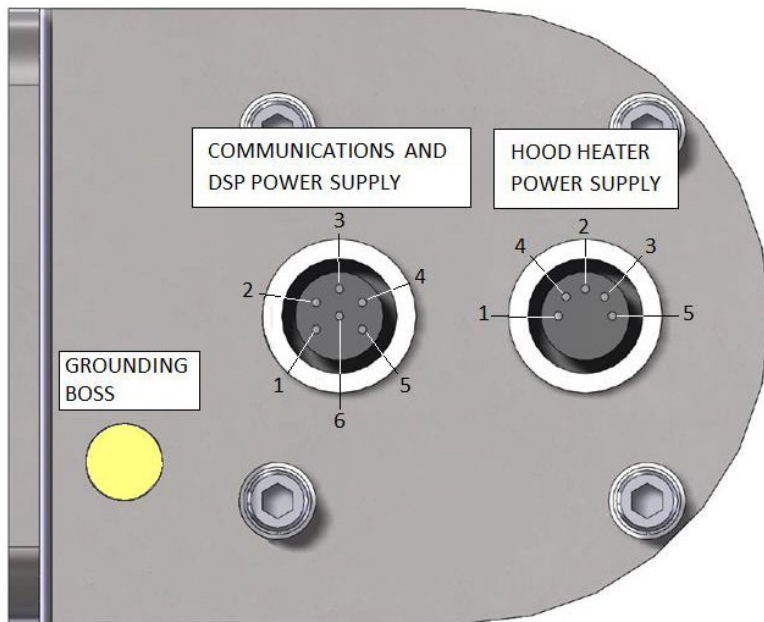
Figure 4-2. Connector layout

shows the pin-outs of the sockets viewed from outside. Colors shown are the colors of the cores in the supplied cables.
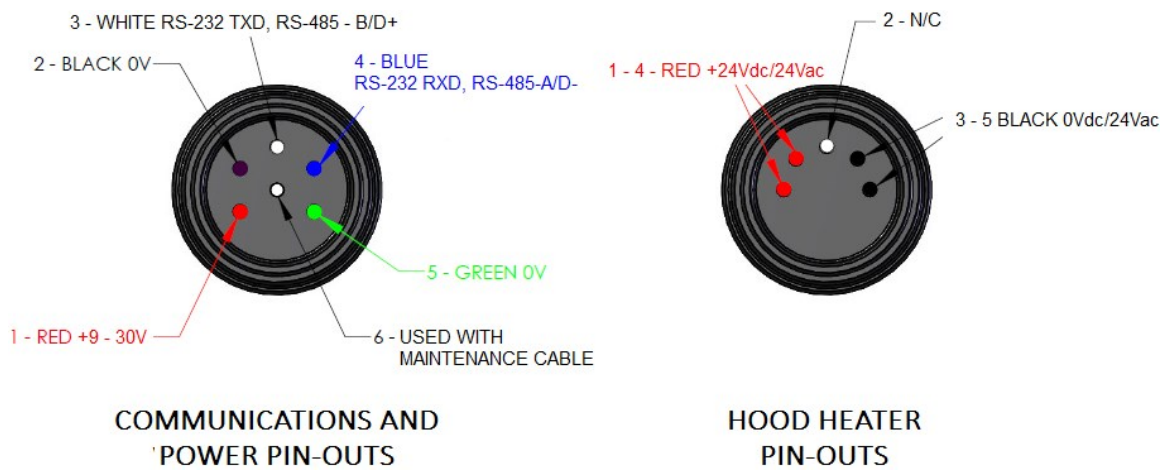
Figure 4-3. Connector pin-outs

4.6 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
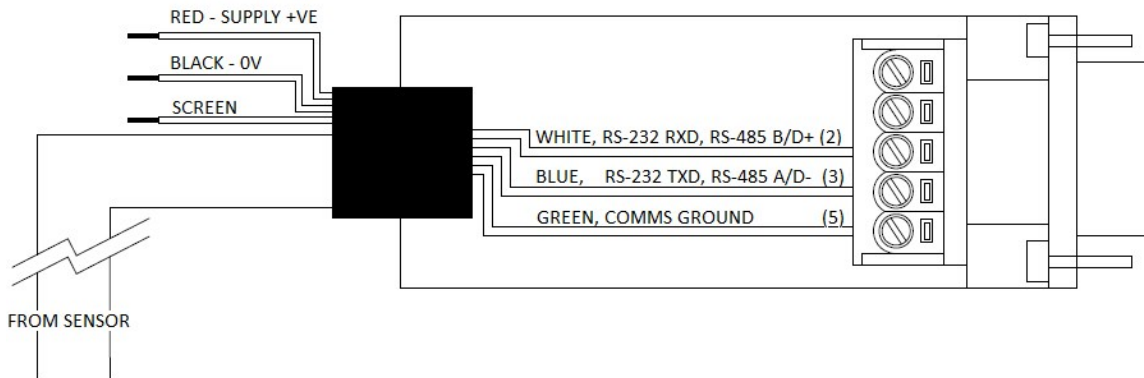
Figure 4-4. Cable connections

4.7 Maintenance cable

Campbell Scientific offers a maintenance cable that will force communications to RS-232, with a 38400 baud rate, and a sensor ID of 0. The maintenance cable is used between the CS140 and the existing connection. It provides a 5 m (16.4 ft) flying lead with a nine-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 and a sensor ID of 0. When the configuration cable is replaced with the previously used cable, the baud rate and ID will return to those previously set.

CS140 MAINTENANCE CABLE

To CS140

9 WAY 'D' CONNECTOR, FEMALE
(AN RS-232 TO USB CONVERTOR
IS AVAILABLE)

To existing connection
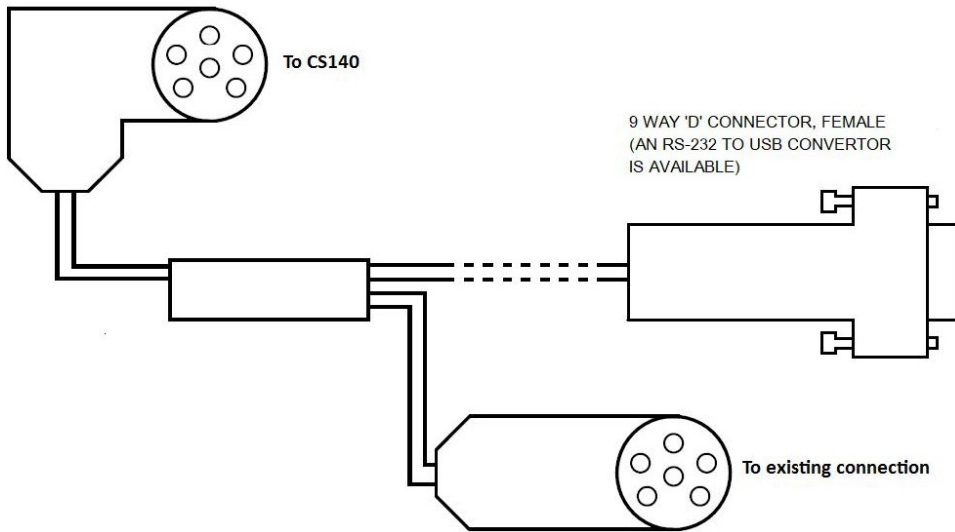
Figure 4-5. Maintenance cable

4.8 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 0 0 3 0 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 0 0 3 0 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. 1 = User alarm active.
Spare	0	–	Reserved for future use.
Spare	0	–	Reserved for future use.
Spare	0	–	Reserved for future use.

Table 5-11: User and system alarms break down			
Alarm	Range	System status	Definition
Window contaminated[1]	0 to 3	0 1 3	0 = OK. The reported attenuation is below 10%. 1 or 2 = Reported dirt level is over 10%. 3 = High level of returned dirty signal. This could be either a blocked sensor or a broken dirty window system.
Photo diode temperature	0 to 3	0 1 1 3	0 = Temperature is within operating conditions. 1 = Too low. Less than –40 °C. 2 = Too high. Over 70 °C. 3 = Sensor fault (No sensor detected or below –49°C).
Hood temperature	0 to 3	0 1 1 2	0 = Temperature is within operating conditions. 1 = Too low. Less than –40 °C. 2 = Too high. Over 70 °C. 3 = Sensor fault (No sensor detected or below -49°C)
Detector DC saturation level[2]	0 or 1	0 2	The amount of background light as seen by the detector hood. 0 = Within limits. 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. 1 = Signature does not match previous readings.

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

[1] 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] alarm flag will not change to level 1 unless the sensor has been continuously saturated for 60 minutes or more. This prevents 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 two ways.

1. 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.

2. 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 CS140 should 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: 0 = RS-232 mode 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: 0 = 115200 bps 1 = 57600 bps 2 = 38400 bps 3 = 19200 bps 4 = 9600 bps 5 = 2400 bps 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: 0 = Candela per meters squared (cd/m^2) 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 is 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**. 0 = Continuous mode 1 = Polled mode	0

Table 6-1: Command line variable definitions				
ID	Name	Range	Description	Default
8	Message Format	0 to 2	Level of detail outputted by polled or continuous modes: 0 = Basic 1 = Partial 2 = Full	2
9	Sample timing	1 to 60	Not currently implemented.	1
10	Averaging period	1 or 10	The period of time the luminance value should be averaged over.	1
11	Dew heater override	0 or 1	0 = Allows the CS140 to automatically control the dew heater. 1 = Turns the dew heater off.	0
12	Hood heater override[1]	0 or 1	0 = Allows the CS140 to automatically control the hood heater. 1 = Turns the hood heater off.	0
13	Dirty window compensation	0 or 1	0 = No compensation applied. 1 = Compensation for dirt on window applied. The CS140will compensate for up to 10% signal loss due to dirt on the window.	0
14	Use CRC	0 or 1	0 = Disables command line CRC checking[2]. 1 = Enables command line CRC checking. NOTE: 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. **NOTE:** The CS140 shuts itself down via hardware at about 8 VDC.	9
16	Enable alarm	0 or 1	0 = Alarm off 1 = Alarm on	0
17	Alarm high/low	0 or 1	0 = Alarm triggered by a luminance higher than the alarm level. 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 includes three major commands: **GET**, **SET**, and **POLL**.

1. **GET** is used to request all current user settable values from the CS140.

2. **SET** specifies user settable values.

3. **POLL** requests 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 of calculating a CCITT CRC using C program language (p. 35) provides example code for

programmers implementing their own code. For Campbell Scientific data logger users, downloadable example programs are available at

www.campbellsci.com/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

Table 6-2: SET transmitted/echoed data	
Example	Description
1	Sample timing
0	Dew heater override
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 the **SETNC** command does not commit the values set into flash memory. This means 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, such as heater functions, because this command avoids the risk filling 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. This command does not retrieve visibility or environmental information from the CS140. To retrieve visibility data, refer to the **POLL** command.

Example of a **GET** request:

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

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 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

Table 6-4: GET command returned data	
Example	Description
2	Serial baud rate
1000	Sensor serial number (read only)
0	Luminance units
60	Continuous mode output interval
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 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 by typing the corresponding number then pressing Enter. No changes will take effect until you **Exit and Save**. The exception to this is the calibration menu, but you will be informed before any changes are made.

Type **1** to open the message menu containing settings relating to the 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
```

While in **Message – menu 1**, type 1 to set the message format. When the following options appear, type the appropriate number to set the required message format. The messages are described in more detail in Message structure (p. 11).

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

In **Setup**, typing 2 allows the user alarms to be set, 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


  ->
```

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

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

Menu 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

  ->
```

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. 34). If there is a flash error or signature error, contact Campbell Scientific.

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

Menu 5: Configuration

```
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

  ->
```

CALIBRATION - menu 6

```
CS140 CALIBRATION 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 chose option (1); see Calibration (p. 28). 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 CALIBRATION 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 no matter the previous setting or whether the CS140 was set to RS-232 or RS-485.
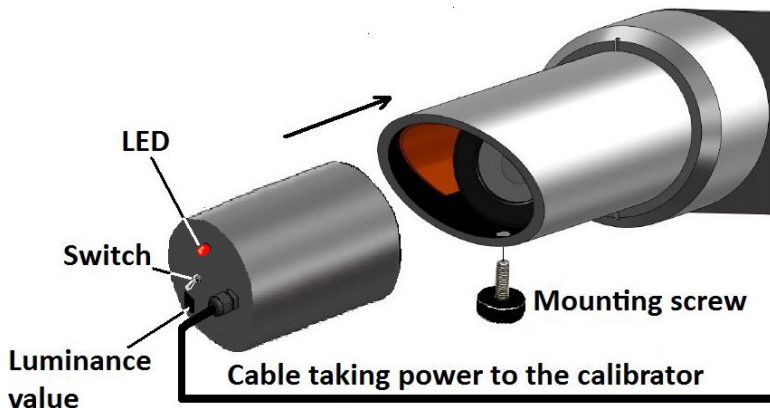

Figure 7-1. Calibrator device

USB A connector for
communication with laptop

CS140
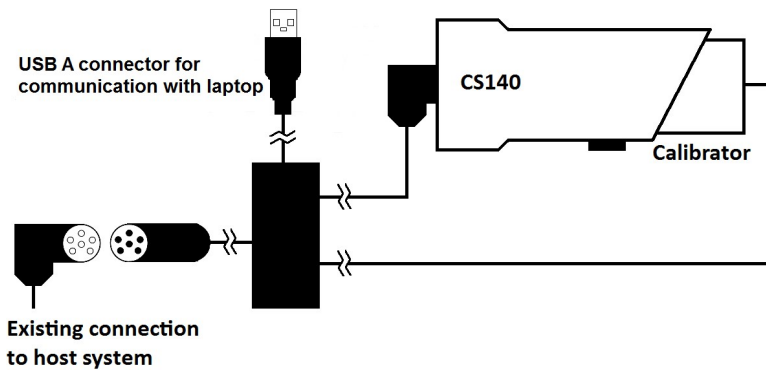
Calibrator

Existing connection
to host system

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 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. Operating system (OS) update

Operating system (OS) updates for the sensor are performed using Campbell Scientific *Device Configuration Utility* software. This is available as a free download from the Campbell Scientific website. Please refer to the help in 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 running the *Device Configuration Utility* to the sensor with RS- 232 communications. Run the *Device Configuration Utility* to the stage shown in Figure 8-1 (p. 32). Then turn on the sensors power supply. The update will then take place through RS-232. The sensor, however will remain in RS-485 mode afterwards.

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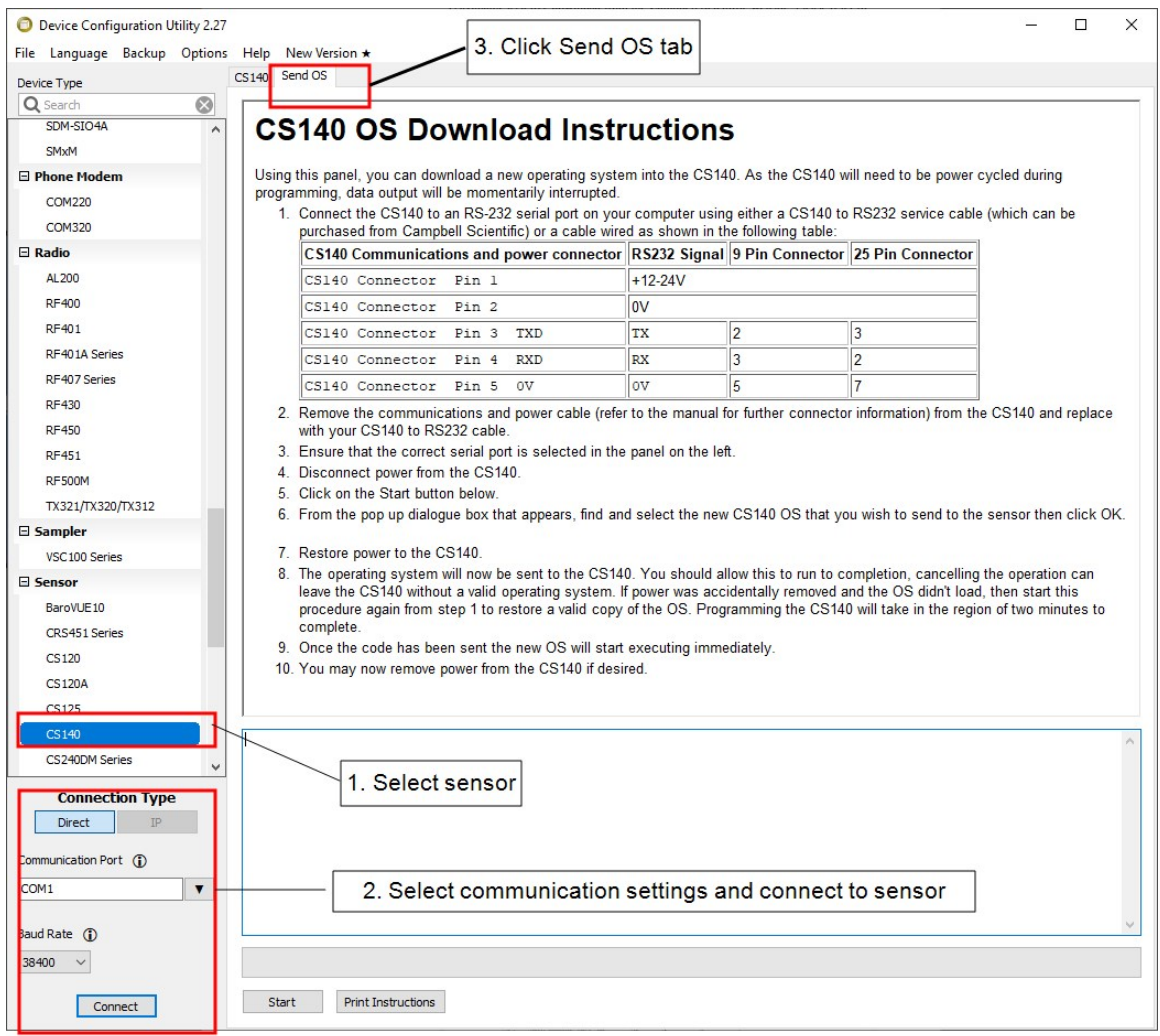
3. Click Send OS tab

Device Configuration Utility 2.27

File   Language   Backup   Options   Help   New Version ★

CS140   Send OS

Device Type

Search

SDM-SIO4A
SMxM

⊟ **Phone Modem**
   COM220
   COM320

⊟ **Radio**
   AL200
   RF400
   RF401
   RF401A Series
   RF407 Series
   RF430
   RF450
   RF451
   RF500M
   TX321/TX320/TX312

⊟ **Sampler**
   VSC100 Series

⊟ **Sensor**
   BaroVUE10
   CRS451 Series
   CS120
   CS120A
   CS125
   CS140
   CS240DM Series

Connection Type
   Direct   IP

Communication Port ⓘ
   COM1 ▼

Baud Rate ⓘ
   38400 ▼

   Connect

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

2. Select communication settings and connect to sensor

   Start   Print Instructions

*Figure 8-1. CS140 **Device Configuration Utility** OS download instructions*
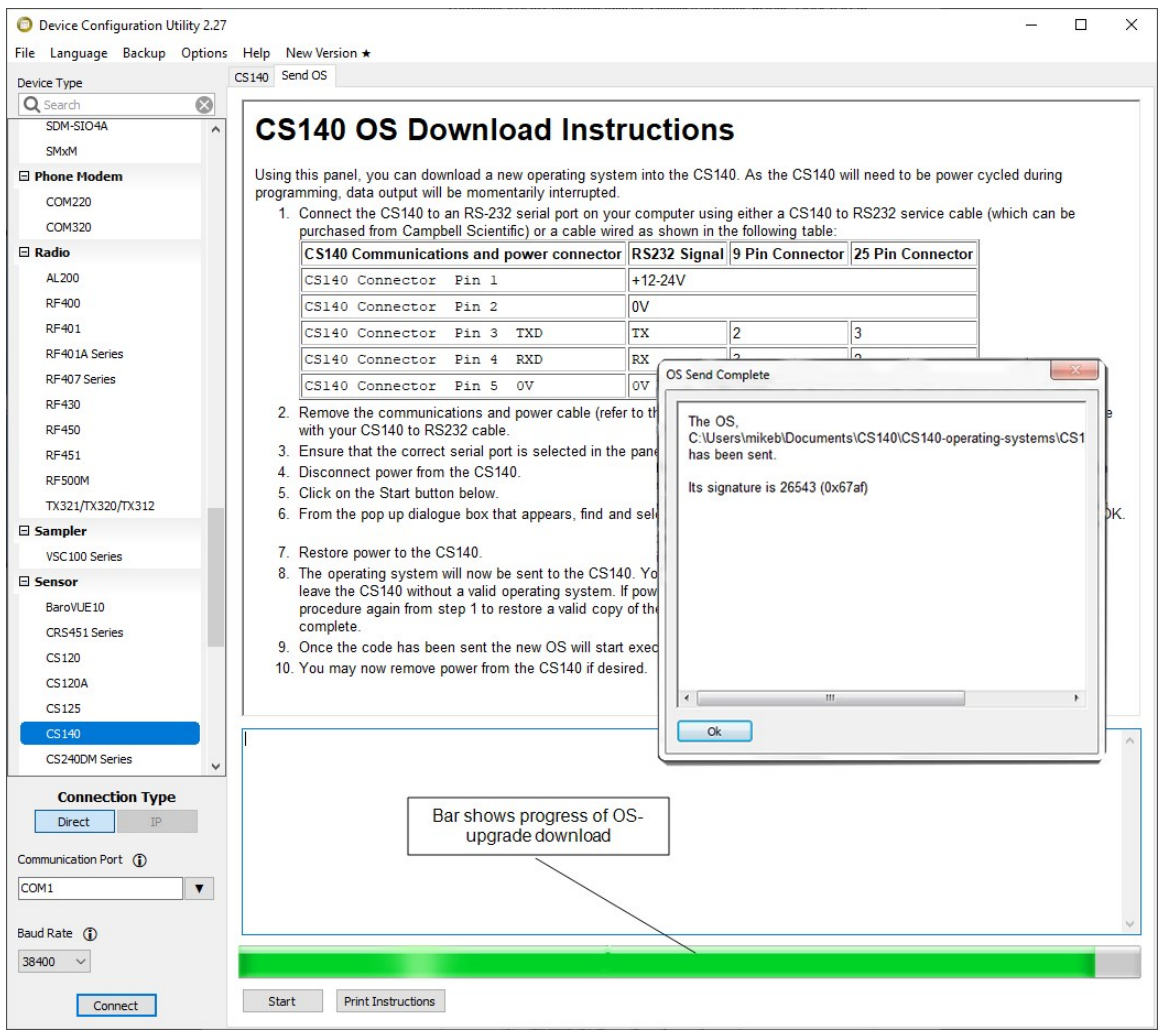
*Figure 8-2. **Device Configuration Utility** screen when OS update is complete*

9. Maintenance

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 sending the sensor to Campbell Scientific.

9.1 Cleaning

The CS140 window will require cleaning from time to time. The frequency of required cleaning depends on 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 only a proper lens cloth or lens tissue is used. The use of inappropriate materials to clean the window can permanently damage or reduce the effectiveness of the window, leading to errors in measurement of precipitation and visibility.

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

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

Appendix A. Example of calculating a CCITT CRC using C program language

The following code is provided as an example for programmers implementing their own code to communicate with the sensor. Campbell Scientific data logger users can use the checksum command in *CRBasic Editor* to generate a CCITT checksum. Refer to the downloadable example programs available at www.campbellsci.com/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);
}
```

Limited warranty

Covered equipment is warranted/guaranteed against defects in materials and workmanship under normal use and service for the period listed on your sales invoice or the product order information web page. The covered period begins on the date of shipment unless otherwise specified. For a repair to be covered under warranty, the following criteria must be met:

1. There must be a defect in materials or workmanship that affects form, fit, or function of the device.

2. The defect cannot be the result of misuse.

3. The defect must have occurred within a specified period of time; and

4. The determination must be made by a qualified technician at a Campbell Scientific Service Center/ repair facility.

The following is not covered:

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

2. Batteries; and

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

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact ⬀ to determine which Campbell Scientific office serves your country. For directions on how to return equipment, see Assistance.

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In the event of any conflict or inconsistency between the provisions of this Warranty and the provisions of Campbell Scientific's Terms, the provisions of Campbell Scientific's Terms shall prevail. Furthermore, Campbell Scientific's Terms are hereby incorporated by reference into this Warranty. To view Terms and conditions that apply to Campbell Scientific, Logan, UT, USA, see Terms and Conditions ⬀. To view terms and conditions that apply to Campbell Scientific offices outside of the United States, contact the regional office that serves your country.

Assistance

Products may not be returned without prior authorization. Please inform us before returning equipment and obtain a **return material authorization (RMA) number** whether the repair is under warranty/guarantee or not. See Limited warranty for information on covered equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact ↗ to determine which Campbell Scientific office serves your country.

When returning equipment, a RMA number must be clearly marked on the outside of the package. Please state the faults as clearly as possible. 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, when equipment is returned to Campbell Scientific, Logan, UT, USA, it is mandatory that a "Declaration of Hazardous Material and Decontamination" form be received before the return can be processed. If the form is not received within 5 working days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. For details on decontamination standards specific to your country, please reach out to your regional Campbell Scientific office.

> **NOTE:**
> All goods that cross trade boundaries may be subject to some form of fee (customs clearance, duties or import tax). Also, some regional offices require a purchase order upfront if a product is out of the warranty period. Please contact your regional Campbell Scientific office for details.

Safety

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

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

General

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, 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, 6 meters (20 feet), or the distance required by applicable law, whichever is greater, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

Elevated Work and Weather

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

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.

- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

Use and disposal of batteries
- Where batteries need to be transported to the installation site, ensure they are packed to prevent the battery terminals shorting which could cause a fire or explosion. Especially in the case of lithium batteries, ensure they are packed and transported in a way that complies with local shipping regulations and the safety requirements of the carriers involved.
- When installing the batteries follow the installation instructions very carefully. This is to avoid risk of damage to the equipment caused by installing the wrong type of battery or reverse connections.
- When disposing of used batteries, it is still important to avoid the risk of shorting. Do not dispose of the batteries in a fire as there is risk of explosion and leakage of harmful chemicals into the environment. Batteries should be disposed of at registered recycling facilities.

Avoiding unnecessary exposure to radio transmitter radiation
- Where the equipment includes a radio transmitter, precautions should be taken to avoid unnecessary exposure to radiation from the antenna. The degree of caution required varies with the power of the transmitter, but as a rule it is best to avoid getting closer to the antenna than 20 cm (8 inches) when the antenna is active. In particular keep your head away from the antenna. For higher power radios (in excess of 1 W ERP) turn the radio off when servicing the system, unless the antenna is installed away from the station, e.g. it is mounted above the system on an arm or pole.

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

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

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