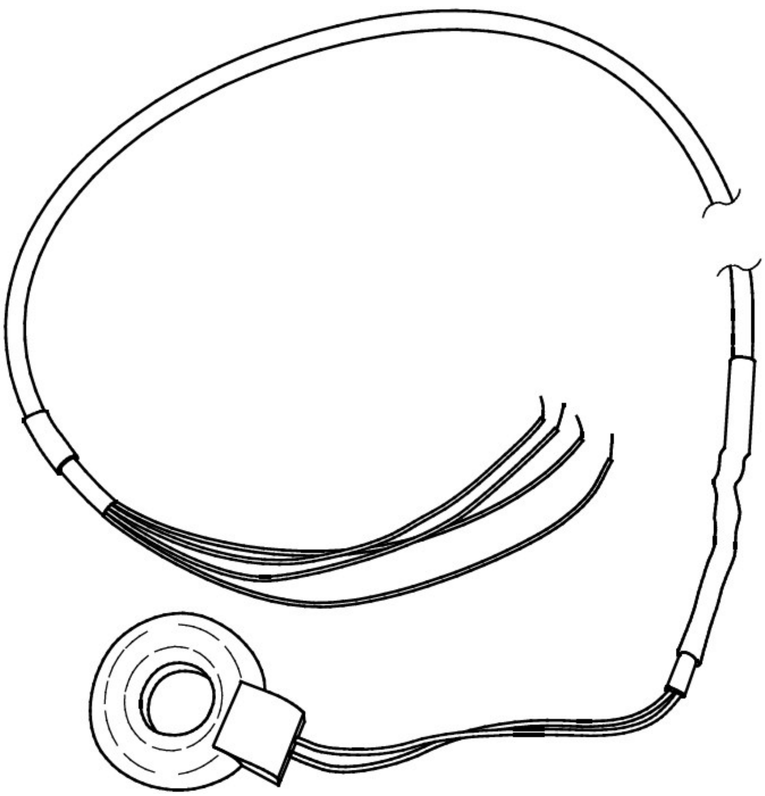
PRODUCT MANUAL

Sensor

CS11

Current Transformer



Revision: 04/2025

RELIABLE MONITORING SINCE 1974

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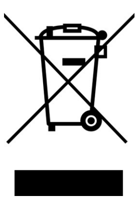
About this manual

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.

Table of Contents

PDF viewers: These page numbers refer to the printed version of this document. Use the PDF reader bookmarks tab for links to specific sections.

Appendices

Figures

Tables

CRBasic Examples

CS11 Current Transformer

1. Introduction

The CS11 detects and measures the current along an AC wire using the magnetic field that is generated by that current. The sensor outputs a millivolt signal allowing it to be directly connected to our data loggers. The CS11 is recommended for measurements that do not require high accuracy, such as motor or generator load condition monitoring, efficiency studies, intermittent fault detection, and rough submetering.

NOTE This manual provides information only for CRBasic data loggers. For retired Edlog data logger support, see an older manual at *www.campbellsci.com/old-manuals*.

2. Precautions

- READ AND UNDERSTAND the *Safety* section at the back of this manual.
- Care should be taken when opening the shipping package to not damage or cut the CS11 cable jacket. If damage to the cable is suspected, consult with a Campbell Scientific support and implementation engineer.
- Working with live electrical equipment is dangerous! The user is responsible for ensuring all wiring conforms to local safety regulations and that the enclosure is labeled accordingly.

3. Initial Inspection

Upon receipt of the CS11, inspect the packaging and contents for damage. File any damage claims with the shipping company. Immediately check package contents against the shipping documentation. Contact Campbell Scientific about any discrepancies.

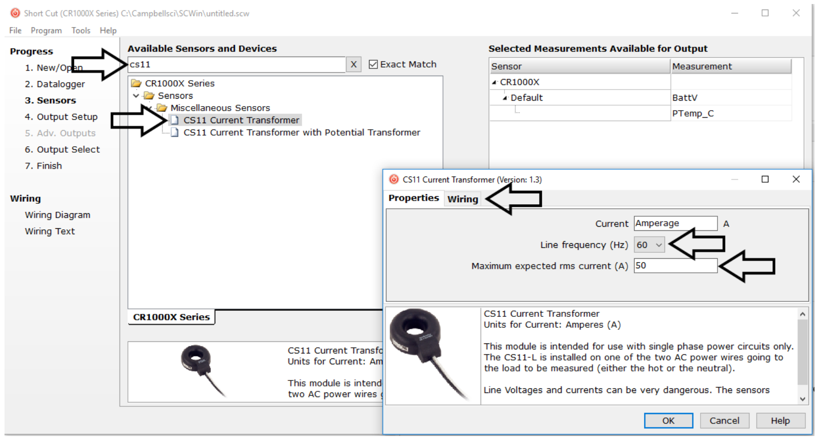
4. QuickStart

A video that describes data logger programming using Short Cut is available at: *www.campbellsci.com/videos/cr1000x-datalogger-getting-started-program-part-3*. *Short Cut* is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. *Short Cut* is available as a download on *www.campbellsci.com*. It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

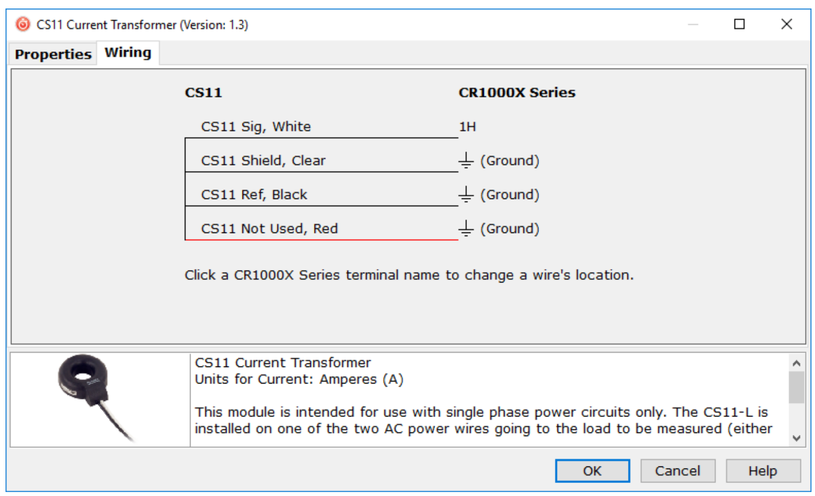
The following procedure also shows using *Short Cut* to program the sensor.

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

3. In the **Available Sensors and Devices** box, type CS11 or locate the sensor in the select **Sensors | Miscellaneous Sensors** folder. Double-click **CS11 Current Transformer**. The default line frequency is 60 Hz. This can be changed by clicking the **Line frequency (Hz)** box and selecting 50 Hz. Type the **Maximum expected rms current (A)**.

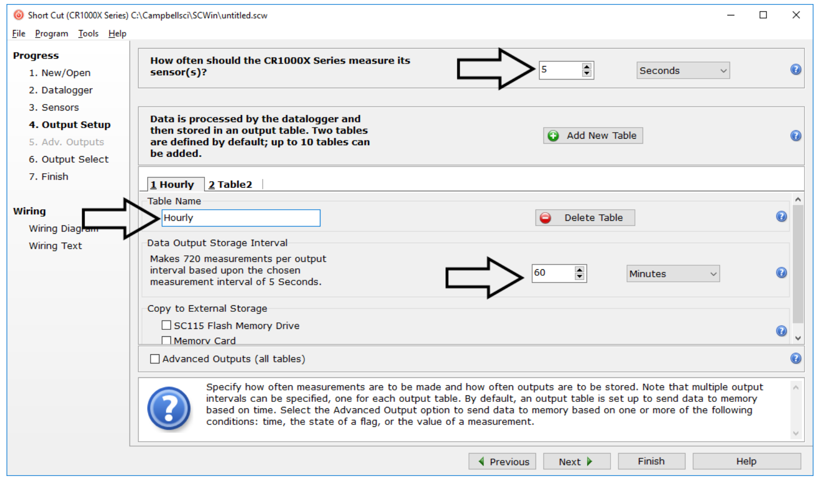


4. Click the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.

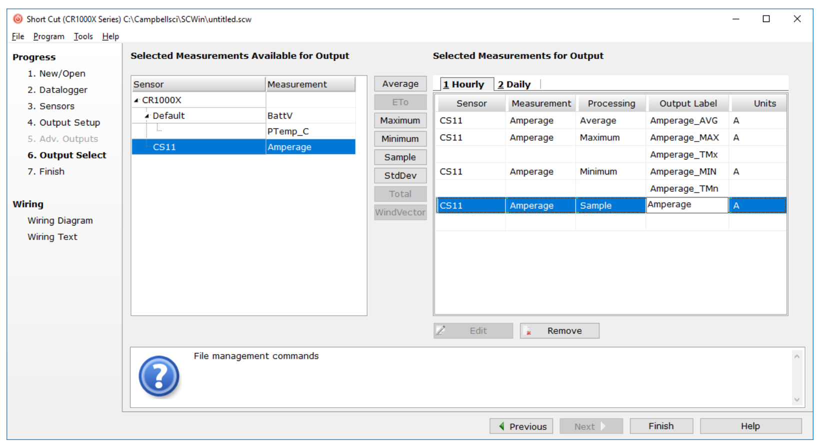


5. Repeat steps three and four for other sensors.

6. In **Output Setup**, type the scan rate, meaningful table names, and **Data Output Storage Interval**.



7. Select the output options.



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

9. If the sensor is connected to the data logger, check the output of the sensor in data display in *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* to make sure it is making reasonable measurements.

5. Overview

The CS11 (FIGURE 5-1) uses CR Magnetic's CR8459 Current Transformer to detect the current along an AC wire using the magnetic field that is generated by that current. The CS11 is external to the AC-wire jacket and has no direct electrical connection to the system.

FIGURE 5-1. Top (right) and bottom views of the CS11 Current Transformer

The CS11 was designed to be compatible with most of the data loggers.

6. Specifications

Features:

- Ideal applications include motor or generator load conditions, efficiency studies, intermittent fault detection, and rough submetering
- Sensor is external to the wire jacket and has no direct electrical connection to the system
- Compatible with Campbell Scientific CRBasic data loggers: CR200(X) series, CR300 series, CR6 series, CR800 series, CR1000, CR1000X series, and CR3000

Measurement Ranges:	0.2 to 200 A
Frequency:	50 and 60 Hz
Insulation Resistance:	100 MΩ @ 500 Vdc
High Potential:	2000 V
Rated Current:	200 A
Storage Temperature:	–25 to 70 °C
Operating Temperature:	–25 to 55 °C
Case Material:	Polypropylene Resin
Construction:	Epoxy Encapsulated

Accuracy with 10 Ω Burden Max. (resistive):	Typically ±1% of actual value with provided multiplier
Dimensions	
Outer Diameter:	4.8 cm (1.89 in)
Inner Diameter:	1.9 cm (0.75 in)
Height:	1.7 cm (0.67 in)
Multiplier:	i^{Mult} = 200 A/1000mV = 0.2

7. Installation

If you are programming your data logger with *Short Cut*, skip Section 7.1, *Data Logger Connections* *(p. 5)*, and Section 7.2, *Programming* *(p. 6)*. *Short Cut* does this work for you. See Section 4, *QuickStart* *(p. 1)*, for a *Short Cut* tutorial.

Place one AC wire through the hole of the CS11 (see FIGURE 7-1). The sensor may be placed on either the hot or neutral AC wire.

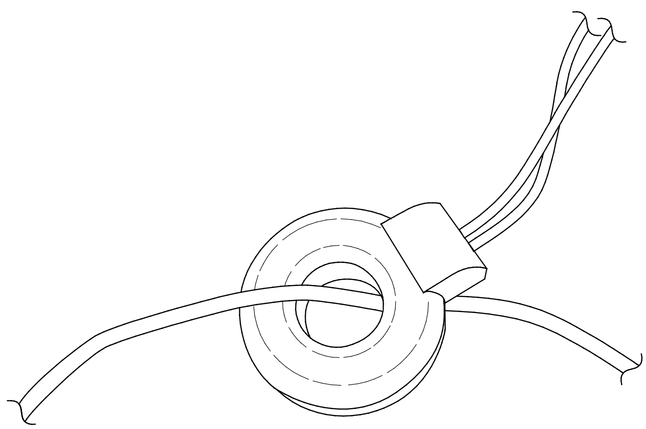


FIGURE 7-1. AC load wire installed in CS11

Multiple AC-wire passes are possible and described in Appendix C.5, *Multiple Passes Through the Sensor* *(p. C-5)*.

7.1 Data Logger Connections

FIGURE 7-2 provides the schematic of the CS11.

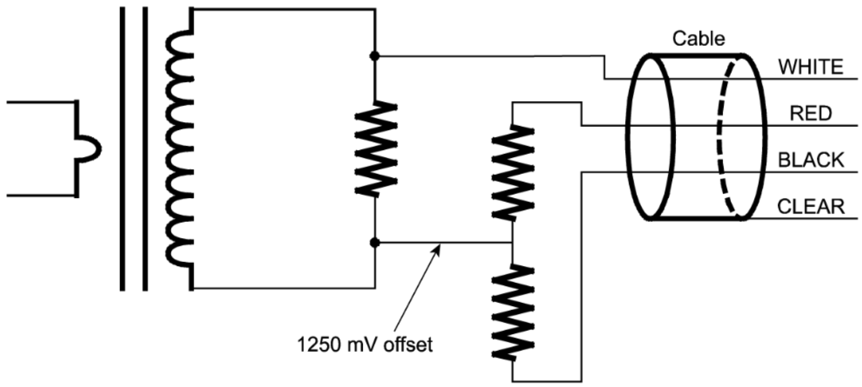


FIGURE 7-2. CS11 schematic

TABLE 7-1 provides CS11 connections to the data logger. When using the **ACPower()** CRBasic instruction, another sensor, a potential transformer, is required in addition to the CS11 sensor to obtain all of these measurements and values. If the potential transformer is used, its signal wire needs to be connected to a data logger single-ended terminal and its reference wire needs to be connected a data logger signal ground terminal. Refer to Section 7.2.1, *ACPower() Instruction* *(p. 7)*, for more information.

TABLE 7-1. CS11 Wire Color, Function, and Data Logger Connection

CS11 Wire Color	Function	CR300-Series or CR200(X)-Series Connection Terminals	All Other Data Logger Connection Terminals
White	Signal	**SE** (single-ended, analog input)	**U** configured for single-ended analog input[1], **SE** (single-ended, analog input)
Black	Signal Reference	⏚ (signal ground)	⏚ (signal ground)
Red	Voltage Excitation or Ground	**VX** or **EX**	⏚ (signal ground)
Clear	Shield	⏚ (signal ground)	⏚ (signal ground)

[1] **U** terminals are automatically configured by the measurement instruction.

7.2 Programming

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

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

A *Short Cut* tutorial is available in Section 4, *QuickStart* *(p. 1)*. If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in Appendix A, *Importing Short Cut Code Into CRBasic Editor* *(p. A-1)*. Programming basics for most CRBasic data loggers are provided in the following sections. Complete program examples for select CRBasic data loggers can be found in Appendix B, *Example Programs* *(p. B-1)*.

To monitor the amperage of an alternating current circuit, the program must take many samples from the CS11 sensor to capture the waveform over a specified time, and then calculate the average energy under the curve. There are many methods to do this, depending on the data logger, the untapped programming capacity, and other factors. Typically the **ACPower()** or **VoltSE()** CRBasic instructions are used.

7.2.1 ACPower() Instruction

Most CRBasic data loggers can use the **ACPower()** instruction to measure the CS11. This instruction is not available for the CR300-series or CR200(X)-series data loggers.

The **ACPower()** instruction measures the voltage, frequency and amperage of an AC load, then calculates the phase angle, harmonic distortion of both the voltage and the current, as well as the real power of the load. To obtain all of these measurements and values, a potential transformer is required in addition to the CS11 sensor. The data logger measures the current of the CS11 and measures voltage signal and frequency of the potential transformer.

If a potential transformer is not used, the **ACPower()** instruction will provide amperage, but the other values returned will show up as NAN (not a number) or another inaccurate value.

Syntax

```
ACPower ( DestAC, ConfigAC, LineFrq, ChanV, VMult, MaxVrms, ChanI,
IMult, MaxIrms, RepsI )
```

The ***DestAC*** parameter is variable array with a length of 7. Use option 1 for the ***ConfigAC***. ***LineFrq*** is typically 50 or 60 Hz. ***ChanV*** is the single-ended terminal in which the potential transformer is connected. The ***VMult*** parameter is the potential transformer multiplier represented as input volts per output mV. A typical value is 115 V/333 mV (or 0.345345). The ***MaxVrms*** parameter is the expected maximum rms (root mean square) voltage to measure. The data logger uses ***VMult*** and ***MaxVrms*** to calculate which input range to use for the voltage measurement. ***ChanI*** is the single-ended terminal in which the potential transformer is connected. The calculation for the ***IMult*** parameter is in Section 7.3, *Multiplier* *(p. 10)*. Refer to TABLE 7-2 for the ***MaxIrms***. The data logger uses ***IMult*** and ***MaxIrms*** to calculate which input range to use for the current measurement.

7.2.2 Millivolt Burst Measurements

Refer to Section 7.2.1, *ACPower() Instruction (p. 7)*, if using a potential transformer. Refer to Section 7.2.3, *CR300 Series (p. 9)*, or Section 7.2.4, *CR200X Series (p. 9)*, if using these data loggers.

For most CRBasic data loggers, amperage can be monitored by making millivolt burst measurements then calculating rms. The millivolt burst measurements are made by using the **VoltSE()** instruction with multiple reps on the same channel (negative value for terminal number). The **StdDevSpa()** instruction calculates rms. Section 7.3, *Multiplier (p. 10)*, provides information about calculating the multiplier that is applied to the rms value. TABLE 7-2 shows the maximum amperage for each data logger, depending on the range code in the **VoltSE()** instruction.

NOTE Program must be run in the pipeline mode on CRBasic data loggers.

When using these instructions, it is important to measure complete cycles. If 100 measurements are taken during a 0.1 second time period, the result will be five complete cycles for a 50 Hz waveform or six complete cycles for a 60 Hz waveform.

CAUTION Do not average the waveform reading in the data table nor use the 60 Hz or 50 Hz noise rejection in the **VoltSE()** instructions in the program. Doing so would result in an incorrect zero amperage reading.

TABLE 7-2. Measurement Range, Maximum Amperage, and Amperage Resolution (one pass only)

VoltSE Voltage Range (mV)	Maximum Amps (MaxIrms)	Amperage Resolution
2.5	0.5	0.000133
5	1	0.000067
7.5	1.5	0.000400
10	2	0.000133
15	3	0.000200
20	4	0.000134
25	5	0.001334
50	10	0.000666
200	40	0.002660
250	50	0.013340
500	100	0.006660
1000	200	0.013320

TABLE 7-2. Measurement Range, Maximum Amperage, and Amperage Resolution (one pass only)

VoltSE Voltage Range (mV)	Maximum Amps (MaxIrms)	Amperage Resolution
2500	200[1]	0.133400
5000	200	0.066600

7.2.3 CR300 Series

CR300-series data loggers can measure the CS11 with either the **VoltSe()** or **VoltDiff()** instruction in the CRBasic program. **VoltDiff()** is the preferred method due to increased noise rejection and better accuracy for low-level signals. **VoltSe()** should only be used when there are not enough differential measurement terminals available. When **VoltSe()** is used, the CRBasic program uses the **ExciteV()** instruction to create a positive reference output that the CR300-series data loggers can measure.

See the example programs in Appendix B, *Example Programs* ***(B-1)***.

CAUTION Do not average the waveform reading in the data table nor use the 60 Hz or 50 Hz noise rejection in the measurement instructions in the program. Doing so would result in an incorrect zero amperage reading.

7.2.4 CR200X Series

The CR200X-series data logger program uses an **ExciteV()** instruction to create a positive reference output that the CR200X-series can measure.

The recommended programming method for CR200X-series data loggers (where the scan interval is limited to once per second) is to place the **VoltSE()** instruction within a loop. A 25-sample loop produces almost two cycles of a 60 Hz waveform, and a 30-sample loop produces almost two cycles of a 50 Hz waveform (FIGURE 7-3). The average energy under the curve is calculated using the **RMSSpa()** instruction. Section 7.3, *Multiplier* ***(p. 10)***, provides information about calculating the multiplier that is applied to the rms value.

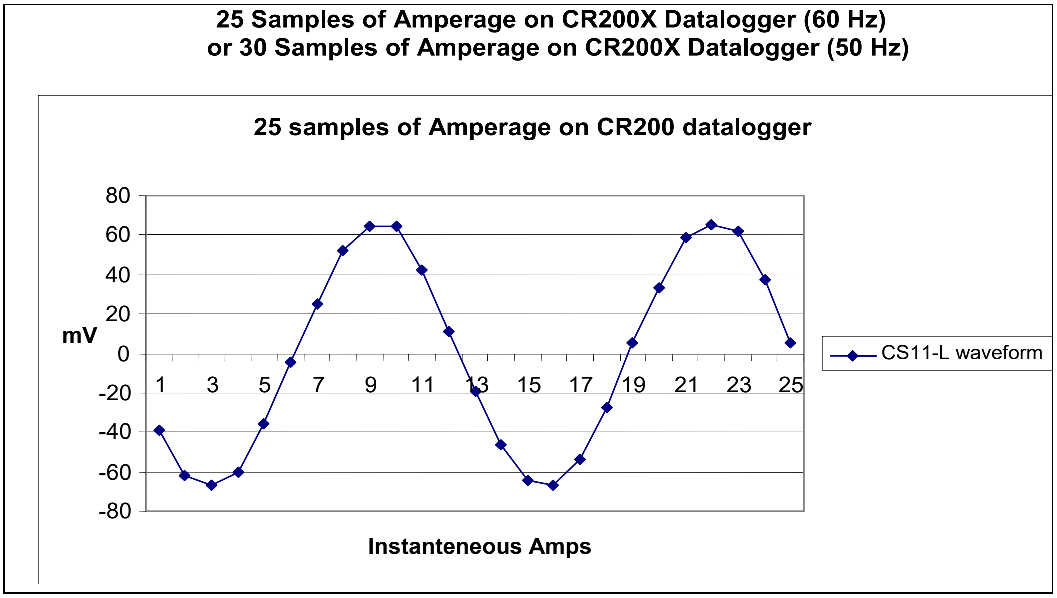


FIGURE 7-3. Graph of a CS11 waveform

7.3 Multiplier

Use Equation 1 to calculate the multiplier that is applied to the RMS value.

$$m = C \bullet n_2/n_1 \bullet (1/R) \bullet (1\ \text{V}/1000\ \text{mV}) \qquad \text{Equation 1}$$

Where, C = a correction constant

If a correction constant of 1 is assumed, then the equation can be solved from the above information.

$$m = 1 \bullet 2000/1 \bullet (1/10) \bullet (1/1000) = 0.2 \text{ multiplier}$$

Appendix A. Importing Short Cut Code Into CRBasic Editor

This tutorial shows:

- Importing a *Short Cut* program into a program editor for additional refinement

- Importing a wiring diagram from *Short Cut* into the comments of a custom program

Short Cut creates files, which can be imported into *CRBasic Editor*. Assuming defaults were used when *Short Cut* was installed, these files reside in the C:\campbellsci\SCWin folder:

- .DEF (wiring and memory usage information)
- .CR2 (CR200(X)-series data logger code)
- .CR300 (CR300-series data logger code)
- .CR6 (CR6-series data logger code)
- .CR8 (CR800-series data logger code)
- .CR1 (CR1000 data logger code)
- .CR1X (CR1000X-series data logger code)
- .CR3 (CR3000 data logger code)
- .CR5 (CR5000 data logger code)

Import *Short Cut* code and wiring diagram into *CRBasic Editor*:

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart* *(p. 1)*. Finish the program. On the **Advanced** tab, click the **CRBasic Editor** button. The program opens in CRBasic with the name **noname.CR_**. Provide a name and save the program.

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

2. The program can now be edited, saved, and sent to the data logger.

3. Import wiring information to the program by opening the associated .DEF file. By default, it is saved in the c:\campbellsci\SCWin folder. Copy and paste the section beginning with heading "–Wiring for CRXXX–" into the CRBasic program, usually at the head of the file. After pasting, edit the information such that an apostrophe (**'**) begins each line. This character instructs the data logger compiler to ignore the line when compiling. You can highlight several lines of CRBasic code then right-click and select **Comment Block**. (This feature is demonstrated at about 5:10 in the *CRBasic | Features* video.)

Appendix B. Example Programs

B.1 ACPower() Example

This program uses a potential transformer and the **ACPower()** instruction. Although this is a CR1000X program, other data loggers are programmed similarly. TABLE B-1 provides wiring for the program.

TABLE B-1. Wiring for ACPower Example

CS11 Wire Color	Function	CR1000X
	Potential Transformer Signal	**SE1**
	Potential Transformer Reference	⏚ (signal ground)
White	CS11 Signal	**SE2**
Black	CS11 Signal Reference	⏚ (signal ground)
Red	CS11 Ground	⏚ (signal ground)
Clear	CS11 Shield	⏚ (signal ground)

CRBasic Example B-1. CR1000X Program Using ACPower Instruction

```
'CR1000X Series Data Logger
'CS11_with_ACPower_Instruction.CR1

PipeLineMode  'must be pipeline mode
Public Batt_volt
Public Array1(7)
Alias Array1(1) = Real_Power
Alias Array1(2) = Frequency
Alias Array1(3) = Voltage
Alias Array1(4) = Amperage
Alias Array1(5) = Phase_Angle
Alias Array1(6) = V_Harm_Ratio
Alias Array1(7) = I_Harm_Ratio

PreserveVariables  'to store values between power cycles

DataTable (AmpTable,True,-1)
  DataInterval (0,1,Min,10)
    Totalize (1,Real_Power,IEEE4,False)
    Average (1,Frequency,FP2,False)
    Average (1,Voltage,FP2,False)
    Average (1,Amperage,FP2,False)
    Maximum (1,Phase_Angle,FP2,False,False)
    Maximum (1,V_Harm_Ratio,FP2,False,False)
    Maximum (1,I_Harm_Ratio,FP2,False,False)
EndTable

BeginProg
  Scan (500,mSec,0,0)
    Battery (Batt_volt)
    '0.2 multiplier for the CS11 (200Amps/1000mV=0.2)
    ACPower (Array1(),1,60,1,0.345345,120,2,.2,200,1)
    CallTable (AmpTable)
  NextScan
EndProg
```

B.2 Millivolt Burst Measurement and Multiplexer Sample Program

This program uses the CR1000X and an AM16/32-series multiplexer to read 32 CS11 Current Transformers. Although this program is for the CR1000X, other data loggers are programmed similarly. TABLE B-2 provides wiring for the program.

TABLE B-2. Wiring for Multiplexer Example

CR1000X	AM16/32B (2x32 mode)	CS11
12V	12V	
G	G	
C4	RES	
C5	CLK	
⏚ (signal ground)	COM ODD H	
SE2	COM ODD L	
⏚	COM ▽	
	High Channels 1H – 24H	White
	Low Channels 1L – 24L	Black
	▽	Red, Clear

CRBasic Example B-2. CR1000X Program Reading 32 CS11 Current Transformers

```
'CR1000X program to measure rms current
PipeLineMode                'must be pipeline mode
Const num_samples = 100     '6 waveforms for 60 Hz, 5 waveforms for 50 Hz
Const   NumSensors=32       'Number of Sensors on the Mux   MUX in 2X32 Mode *****
                            'Sensor wired to Low on each of the 32 channels.
                            'Odd Low on Mux wired to SE2 on data logger
Public Amps(NumSensors)     'the line current
Public i, Batt_Volt
Public Amp_mult
Dim i_sig (num_samples)     'to hold the burst measurements, each 100 samples long
PreserveVariables           'to store values between power cycles

DataTable (AmpTable,True,-1)
  DataInterval (0,1,Min,10)
  Maximum (NumSensors,Amps,IEEE4,False,False)
  Average (NumSensors,Amps,FP2,False)
EndTable

BeginProg
  Amp_mult = 0.2     '0.2 multiplier for the CS11
  Scan (10,Sec,0,0)
    Battery (Batt_volt)
    'Turn AM16/32 Multiplexer On
    PortSet(C4,1)
    i=0
    SubScan(0,uSec,NumSensors)
      'Switch to next AM16/32 Multiplexer Channel
      PulsePort(C5,10000)
      i=i+1
      VoltSe (i_sig (1), num_samples,mV5000,-2, True, 1000, 0, 1.0, 0)
```

```
      StdDevSpa (Amps(i), num_samples, i_sig (1))
      Amps(i) = Amps(i) * Amp_mult  'put in amps
      If Amps(i) <= 0.15 Then Amps(i) = 0
    NextSubScan
    'Turn AM16/32 Multiplexer Off
    PortSet(C4,0)
    CallTable (AmpTable)
  NextScan
EndProg
```

B.3 CR300 Series VoltDiff() Example

The following is a CR300 series **VoltDiff()** example program for measuring the CS11. TABLE B-3 provides wiring for the program.

TABLE B-3. Wiring for CR300 Series Program

CS11 Wire Color	Function	CR300 Series
White	Signal	**SE1** (Diff H)
Black	Signal Reference	**SE2** (Diff L)
Red	Not used	⏚ (signal ground)
Clear	Shield	⏚ (signal ground)

CRBasic Example B-3. CR300 Series VoltDiff() Program for Measuring the CS11

```
'Program name: ACAmpsCR350.CRB
'Measuring CS10-L, CS15-L, and CS11-L sensors
'Wiring:
'  Red (if present) and Clear to signal ground. NOTE: VoltDiff does not require
'  the Red wire to excitation.
'  White & Black to Diff H & L
'When using the 4000 fN1, the integration time is 0.5 ms
'200 measurements @ 0.5ms = 100 ms (6 complete waveforms of 60 Hz or 5 of 50Hz
'power)
Const NumSamples=(200) '200 measurements, do not change!
Const Amp_Multi=0.2    'for the CS10, CS11, and CS15, do not change multiplier.
Public Amps
Dim DiffVolt(NumSamples)

DataTable (Amps_AC,True,-1 )
  DataInterval (0,5,Sec,10)
  Average (1,Amps,FP2,False)
  Maximum (1,Amps,FP2,False,False)
EndTable

BeginProg
  Scan(1,Sec,1,0)
    'Start of Measure AC Amperage.    NOTE: CR350, only on DiffChan 1 or 2.
    'CR310 can use DiffChan 1, 2, or 3.
    VoltDiff (DiffVolt(),NumSamples,mV2500,-1,False,0,4000,1.0,0)
    'Do not change the fN1 = 4000 or the NumSamples
    RMSSpa (Amps,NumSamples,DiffVolt())
    Amps *= Amp_Multi
    If Amps < 0.2 Then Amps = 0.0
    'end of Measure AC Amperage
    CallTable Amps_AC
  NextScan
EndProg
```

B.4 CR300 Series VoltSE() Example

The following is a CR300 series **VoltSE()** example program for measuring the CS11. TABLE B-4 provides wiring for the program.

TABLE B-4. Wiring for CR300 Series Program

CS11 Wire Color	Function	CR300 Series
White	Signal	**SE1** (Diff H)
Black	Signal Reference	⏚ (signal ground)
Red (2500 mV)	Voltage Excitation	**Vx1**
Clear (drain)	Shield	⏚ (signal ground)

CRBasic Example B-4. CR300 Series VoltSE() Program for Measuring the CS11

```
'Program name:  AmpsVoltSE_CS11
'Measuring amperage sensors
'CS15, CS11 amperage sensor
' Wiring:
'           SE1: White wire CS11-L
'  Signal Ground: Black wire CS11-L
'           Vx1: Red (2500 mV)
'  Signal Ground: Clear (drain)
'
Const NumSamples=(200) '200 measurements @ 0.5ms = 100 ms (6 complete waveforms of
                       '60 Hz or 5 of 50Hz power)
Const Amp_Multi = 0.2
Public  AmpAC

Dim  SEVolts(NumSamples) 'Units  SEVolts()= mV
Dim  Amps_Offset

DataTable (FiveSecAmps,True,-1 )
  DataInterval (0,5,Sec,10)
  Average (1,AmpAC,FP2,False)
EndTable

Sub FindOffset 'No load reading (what is the reading of the sensor with no amps
               'going though?)
  ExciteV (Vx1,2500,0)
  VoltSe(SEVolts(),NumSamples,mV2500,-1,False,500,4000,1,Amps_Offset)
  RMSSpa (AmpAC,NumSamples,SEVolts())
  Amps_Offset = -AmpAC
EndSub

BeginProg
  'With no load connected, or with the sensor connected to the data logger before
  'being installed on a wire leading to the load, measure the sensor's natural
  'offset on this data logger.
  Call FindOffset

  Scan(1,Sec,1,0)
    'Use ExciteV with VoltSE only (applicable to CS15-L or CS11-L sensors) to
    'shift the voltage into the positive range of the CR300 or CR350. Maximum
    'current range: 200 amps.
    ExciteV (Vx1,2500,0)
    VoltSe(SEVolts(),NumSamples,mV2500,-1,False,500,4000,1,Amps_Offset)
    RMSSpa (AmpAC,NumSamples,SEVolts())
    AmpAC = AmpAC * Amp_Multi
```

```
    If AmpAC < 0.2 Then AmpAC = 0.0
    CallTable FiveSecAmps
  NextScan
EndProg
```

B.5 CR200(X)-Series Example

The following is a CR200(X)-series program for measuring the CS11. TABLE B-5 provides wiring for the program.

TABLE B-5. Wiring for CR200(X)-Series Program

CS11 Wire Color	Function	CR300
White	Signal	**SE1**
Black	Signal Reference	⏚ (signal ground)
Red	Voltage Excitation	**Vx1**
Clear	Shield	⏚ (signal ground)

CRBasic Example B-5. CR200(X) Program to Measure the CS11

```
'CR200 Series Data Logger
'Program name: CS11Manual60Hz.cr2

Const Samples = 25   '25 samples for 2 waves of 60 Hz
'Const Samples = 30  '30 samples for 2 waves of 50 Hz
Public Crnt_A
Public mV(Samples)
Dim Counter

DataTable (Amp,1,-1)
  DataInterval (0,1,min)
  Average (1,Crnt_A,False)
  Maximum (1,Crnt_A,False,0)
EndTable

BeginProg
    Scan (1,Sec)
    ExciteV (Ex1,mV2500)
    For Counter = 1 To Samples
      VoltSe (mV(Counter),1,1,1.0,-1250)
    Next
    ExciteV (Ex1,mV0)
    RMSSpa (Crnt_A,(Samples-0),mV(1))
    Crnt_A=Crnt_A*0.2      'Multiplier for sensor
    If Crnt_A<0.15 Then    'Eliminate noise below 0.15 amps.
      Crnt_A = 0
    EndIf
    CallTable Amp
  NextScan
EndProg
```

Appendix C. Theory of Operation

C.1 Typical Electrical Circuit

An example of a typical electrical circuit is a generator that provides energy in the form of a 60 Hz sine wave. The energy is carried from the point of generation to the point of consumption via two wires. The generator creates an electrical load that lights up the light bulb (see FIGURE C-1).

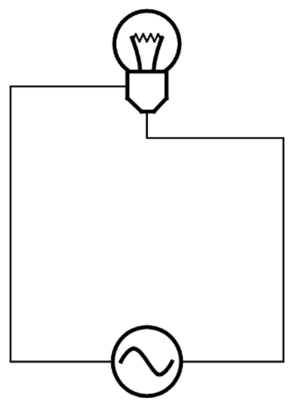


FIGURE C-1. Generator schematic

To determine the consumption (amps) of the load, a way is needed to measure what is passing through the wires.

A sensor is added to the circuit to measure the amperage going through the circuit (see FIGURE C-2 through FIGURE C-4). This sensor is called a CT or Current Transformer. The CS11 is a current transformer.

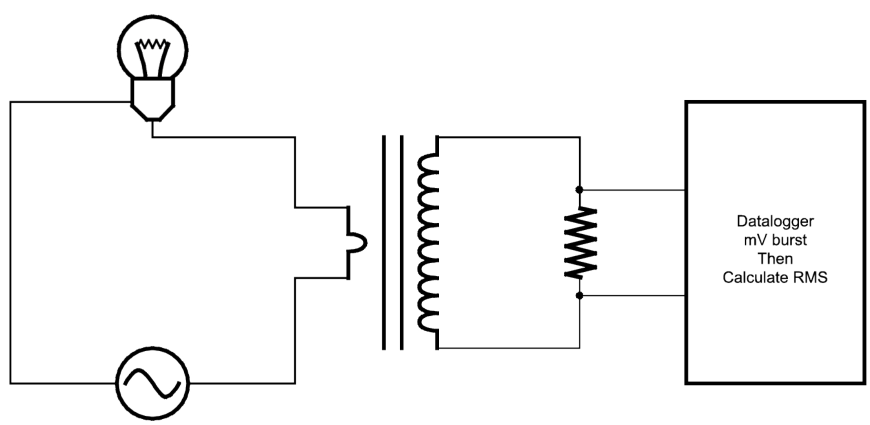


FIGURE C-2. Schematic of generator with current transformer

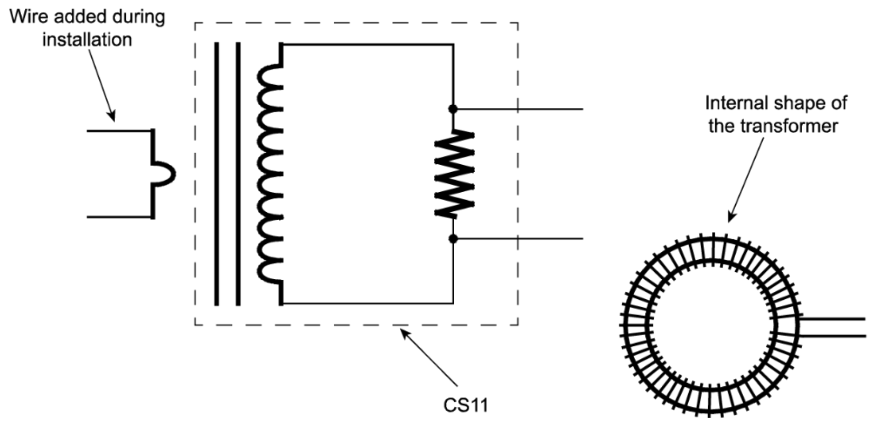


FIGURE C-3. Schematic of current transformer with the AC wire

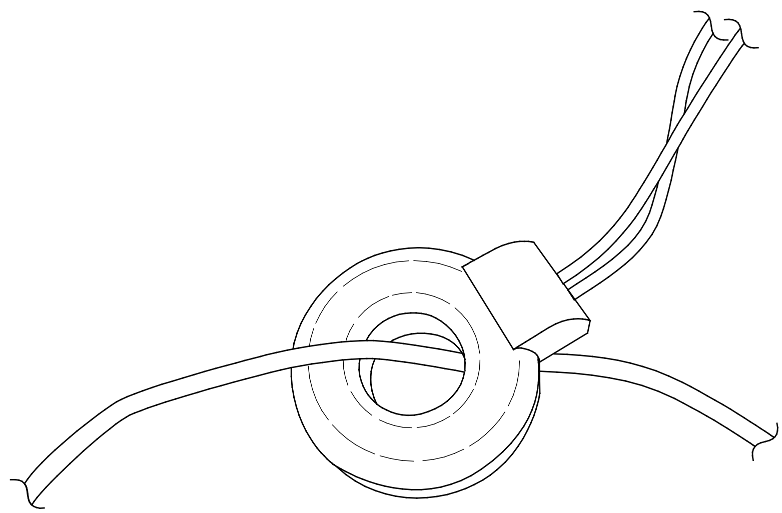


FIGURE C-4. CS11 with the AC wire

C.2 Current Transformer Description

A current transformer is a special kind of transformer that transfers energy from one side to another through magnetic fluxes (see FIGURE C-5).

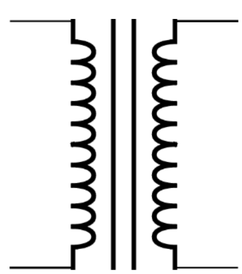


FIGURE C-5. Magnetic flux schematic

The formula for a transformer is as follows (Equation A):

$$i_1 \bullet n_1 = i_2 \bullet n_2 \qquad \text{Equation A}$$

Where i = amps and n = number of turns or windings

And where n_1 is the primary winding and n_2 is the secondary

With the current transformer, the primary coils or windings are minimized to avoid removing power out of the circuit, but still have a signal large enough to measure (see FIGURE C-6).

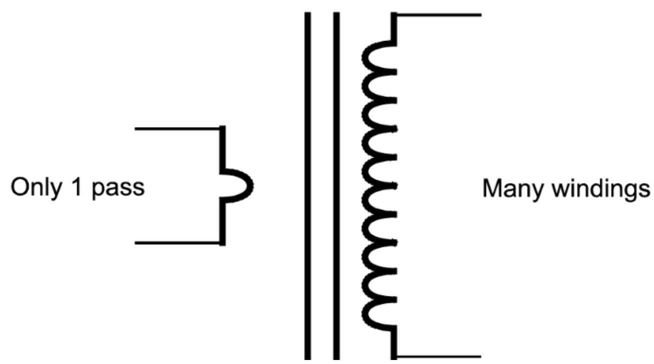


FIGURE C-6. Windings schematic

A small amount of current is transferred to the secondary coil.

Find the current induced on the secondary windings by solving for i_2:

$$i_2 = i_1 \bullet n_1/n_2 \qquad \text{Equation B}$$

For example: The CS11 current transducer has an n_2 value of 2000 windings. If 20 amps pass through the primary winding, the following amperage is produced on the secondary winding:

$$i_2 = 20 \bullet (1/2000) = 0.01 \text{ amp on secondary winding}$$

C.3 Converting a Milliamp Signal to a Millivolt Signal

After the current is transformed from one level to another level, the amperage signal must be converted to a voltage signal so that the data logger can measure it.

Use Ohm's Law (Equation C) to convert amperage to voltage:

$$E = I \bullet R \quad (E = \text{Volts}, I = \text{Amps}, R = \text{Ohms}) \qquad \text{Equation C}$$

For example: Using the previous example:

$$E = 0.01 \text{ amps} \bullet R$$

The CS11 contains a 10-ohm burden (shunt) resistor (R=10 ohm). Therefore, E is:

E = 0.01 amps • 10 ohms = 0.1 volts (or 100 mV)

From these calculations, it can be determined if a better resolution on the measurement is needed. The Range Code can be lowered to 250 mV for some data loggers.

C.4 Using a CR300-Series or CR200(X)-Series Data Logger

The CS11 consists of a CR Magnetic's CR8459 Current Transducer with a 10-ohm burden resistor incorporated into its cable. The resistor allows most of our data loggers to measure it.

The voltage range of the CR300-series and CR200X-series data loggers require a voltage excitation to shift the measurement range (see FIGURE C-7 and FIGURE C-8).

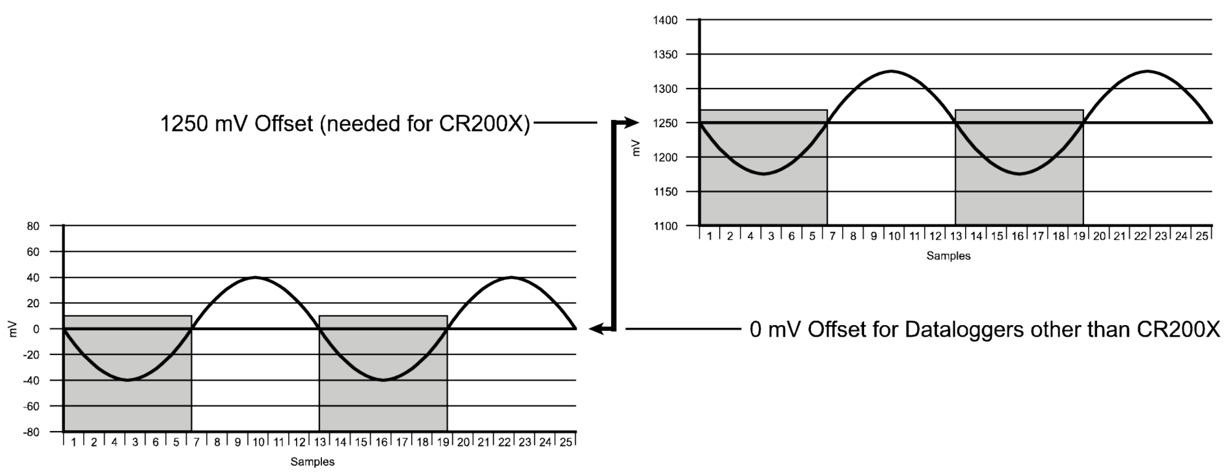


FIGURE C-7. Adding 1250 mV creates positive output

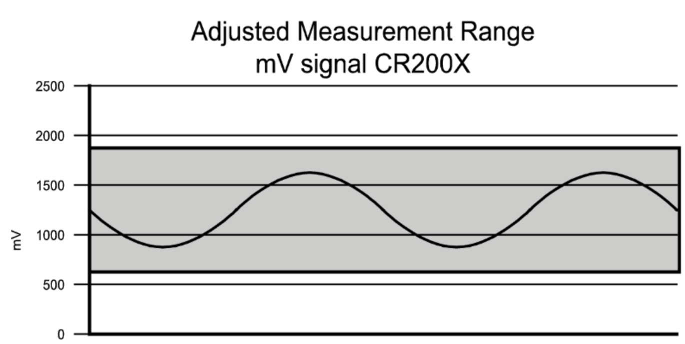


FIGURE C-8. CS11 measurement range

C.5 Multiple AC-Wire Passes Through the CS11

You can pass the AC wire multiple times through the CS11 to amplify the amperage signal of the AC wire (FIGURE C-9). However, the data logger program needs a different multiplier and the **VoltSE()** instruction needs a different measurement range (TABLE C-1).

TABLE C-1. Passes, Multiplier, and Voltage Range

Passes	Multiplier	VoltSE Voltage Range
2	0.1	x2
4	0.05	x4
5	0.04	x5
8	0.025	x8
10	0.02	x10
20	0.01	x20

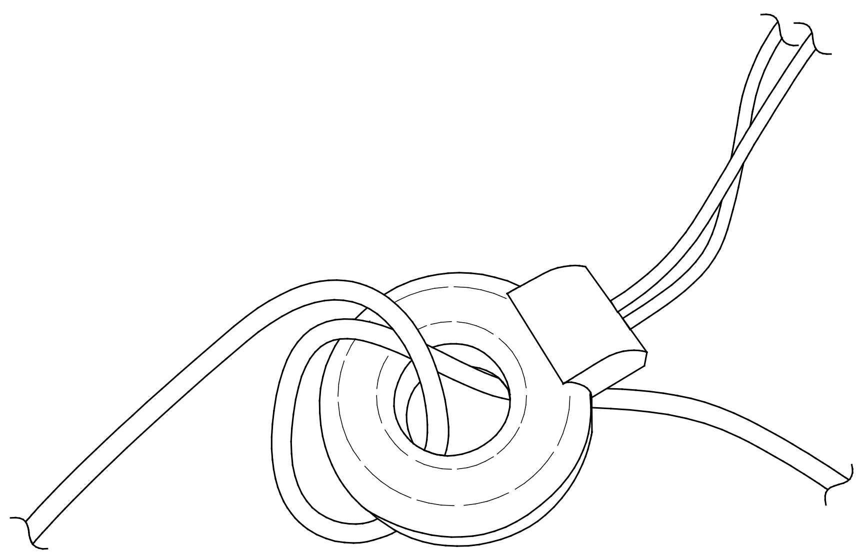


FIGURE C-9. CS11 with the AC wire making two passes through the CS11

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.

Other manufacturer's products, that are resold by Campbell Scientific, are warranted only to the limits extended by the original manufacturer.

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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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