Product Manual



253 and 257

Soil Matric Potential Sensors



Revision: 8/19

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- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
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- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

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

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253 and 257 Soil Matric Potential Sensors

1. Introduction

The 253 and 257 soil matric potential sensors are solid-state, electrical-resistance sensing devices with a granular matrix that estimate soil water potential between 0 and -2 bars (typically wetter or irrigated soils).

The 253 needs to be connected to an AM16/32-series multiplexer, and is intended for applications where a larger number of sensors will be monitored. The 257 connects directly to our data loggers.

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

2. Precautions

- READ AND UNDERSTAND the *Safety* section at the front of this manual.
- The black outer jacket of the cable is Santoprene® rubber. This jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.
- Avoid installing in depressions where water will puddle after a rain storm.
- Don't place the 253 or 257 in high spots or near changes in slope unless wanting to measure the variability created by such differences.
- When removing the sensor prior to harvest of annual crops, do so just after the last irrigation when the soil is moist.
- When removing a sensor, do not pull the sensor out by its wires.
- Careful removal prevents sensor and membrane damage.

3. Initial Inspection

- Upon receipt of a 253 or 257, inspect the packaging and contents for damage. File damage claims with the shipping company.
- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the correct product and cable length are received.

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 253 or 257 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 sections also describe programming with Short Cut.

NOTE Short Cut requires a soil temperature measurement before the 253 or 257 sensor is added. This is needed because there is a temperature correction factor in the equations that convert sensor resistance. In these Quickstart examples, a 107-L temperature probe is used to measure soil temperature.

4.1.1 257 Short Cut Programming

- 1. Open Short Cut and click Create New Program.
- 2. Double-click the data logger model.
- In the Available Sensors and Devices box, type 107. You can also locate the sensor in the Sensors > Temperature folder. Double-click 107 Temperature Probe. Use the default units of degree Celsius.

File Program Tools Help	Test			
Progress	Available Sensors and Devices		Selected Measurements A	vailable for Output
1. New/Open	107	X 🗹 Exact Match	Sensor	Measurement
2. Datalogger	CR1000X Series		 CR1000X Series 	
3. Sensors	✓ Image: Sensors		▲ Default	BattV
4. Output Setup	Iemperature 107 Temperature Prot)e	L	PTemp_C
5. Adv. Outputs				
6. Output Select		interpretation in the second secon	(Version: 1.1)	– 🗆 X
7. Finish		Properties Wiring		
Wiring Wiring Diagram Wiring Text		Te	emperature T107_C De	ig C ∨
	CR1000X Series		7 Temperature Probe ts for Temperature: Deg C, Deg F,	ĸ
L			ОК	Cancel Help

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

Properties Wiring		
	107	CR1000X Series
	Red	_1H
	Clear	_∔_ (Ground)
	Purple	_∔ (Ground)
	Black	VX1
	Click a CR1000X Series terminal name	to change a wire's location.
Ô	107 Temperature Probe Units for Temperature: Deg C, Deg I	F, K
	·	OK Cancel Help

 In the Available Sensors and Devices box, type 257. You can also locate the sensor in the Sensors > Meteorological > Soil Moisture folder. Double-click 257 Soil Moisture Sensor. Select the resistance units, soil water potential units, and soil reference temperature.

Drogross	Available Sensors and D	evices		Colocted Measurements Aug	able for Out		
1 New/Open	257	X	6 257 Soil M	oisture Sensor (Version: 2.2)	- 1	2	×
1. New/Open	CD1000V Carias		Properties	Wiring			
2. Datalogger	CRIDUUX Series						-
3. Sensors	v 📴 Soil			Resistance kohms	kilo	hms	
Output Setup	257 Soil Moist	ture Sensor		Soil Water Potential WP kPa	kD:		
5. Adv. Outputs							
6. Output Select			Soil R	eference Temperature (deg C) T107_C	\sim		
7. Finish							
Wiring							
Wiring Diagram							
Wiring Text							
				Model 257 (Watermark 200) Soil Mo	isture Sensor		-
				Units for Soil Water Potential: kPa,	Bars		
	CR1000X Series		\sim	Units for Resistance: kilonms			
	CRIDUON Selles			A soil temperature reference is requ	ired for this s	sensor.	
			- 🔊	Therefore, a soil temperature sense	r must be sel	ected	
		Model 257		sensor.	configuring	inis	
	📐 🔌	Units for Re	s				
	N N N N N N N N N N N N N N N N N N N			This sensor file provides a convenie	nt method fo	r (o o	

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

Properties Wiring		
:	257	CR1000X Series
	Red	1L
	White	_∔_ (Ground)
	Clear	_∔_ (Ground)
	Black	_vx2
(Click a CR1000X Series terminal name	to change a wire's location.
2	Model 257 (Watermark 200) Soil M Units for Soil Water Potential: kPa, Units for Resistance: kilohms	bisture Sensor A Bars
	A soil temperature reference is req temperature sensor must be select configuring this sensor.	uired for this sensor. Therefore, a soil ed and configured before selecting and
		OK Cancel Help

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

Short Cut (CR1000X Series) C	\Campbellsc\SCWin\untitled.scw -	×
<u>File Program Tools H</u> elp	Test	
Progress 1. New/Open 2. Datalogger	How often should the CR1000X Series measure its sensor(s)?	Ø
 Sensors Output Setup Adv. Outputs 	Data is processed by the datalogger and then stored in an output table. Two tables are defined by default; up to 10 tables can be added	0
6. Output Select 7. Finish	1 Hourly 2 Daily	
Wiring Wiring Diagram Wiring Text	Table Name Daily Delete Table Data Output Storage Interval Minutes Makes 17280 measurements per output interval based upon the chosen measurement interval of 5 Sconds. 1440 🕏	0
	Advanced Outputs (all tables) Advanced Outputs (all tables) Specify how often measurements are to be made and how often outputs are to be stored. Note that multiple output intervals can be specified, one for each output table. By default, an output table is set to send data to memory based on time. Select the Advanced Output option to send data to memory based on one or more of the following conditions: time, the state of a flag, or the value of a	v v up
	measurement.	~

8. Select the output options.

<u>File Program Tools H</u> elp	Test							
Progress	Selected Measurer for Output	nents Available		Selected M	easuremer	its for Outp	out	
2. Datalogger	Sensor	Measurement	Average	1 Hourly	2 Daily			
3. Sensors	CR1000X Series		ETo	Sensor	easuremer	Processing	utput Labe	Units
4. Output Setup	 Default 	BattV	Maximum	107	T107_C	Average	T107_C_A	Deg C
5. Adv. Outputs	L.	PTemp_C	Minimum	257	kohms	Sample	kohms	kilohms
6. Output Select	107	T107_C	Sample	257	WP_kPa	Sample	WP_kPa	kPa
7. Finish	4:257	KONMS	StdDev					
		WP_KPd	Total					
Wiring			WindVector					
Wiring Diagram			Windvector					
Wiring Text								
				Z Edit	Rem	ove		
				Z Luit	× Kem	000		
	Select which measurements to store in which tables and how each measurement should be processed. For each value to be stored in the table, choose a measurement from "Selected Measurement Svalable for Output." Next, select one of the processing functions, such as a function, such as the datalogger memory.							
				evious	Next	Finish		Help

- 9. Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.
- 10. If the sensor is connected to the data logger, check the output of the sensor in *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* to make sure it is making reasonable measurements.

4.1.2 253 Short Cut Programming

- 1. Follow steps 1 through 4 of Section 4.1.1, 257 Short Cut Programming (p. 2).
- 2. In the **Available Sensors and Devices** box, type AM16/32. You can also locate the multiplexer in the **Device** folder.

Progress	Available Sensors and Devices		Selected Measuremer	ts Available for Output
1. New/Open	Search	Exact Match	Sensor	Measurement
2. Datalogger	🗁 AM16/32	^	 CR1000X Series 	
3. Sensors	v 🦢 Sensors		 Default 	BattV
4 Output Setup	Generic Measurements			PTemp_C
E Adv. Outputs	Differential Voltage		107	T107_C
6. Output Select	SDI-12 Sensor		AM16/32 (not wire	d)
7. Finish Wiring Wiring Diagram Wiring Text	 Ceotechnical & Structura Strain, Foll Bonded Full Bridge Strain, J Full Bridge Strain, J Half Bridge Strain, J 	000 ohm 20 ohm 50 ohm 100 ohm with 4W 120 ohm with 4W 120 ohm with 4W 150 ohm with 4W 150 ohm with 4W	Z Edit Remo	ve
	AM16/ The A datalo throug	32, AM16/32A, and AM16, M16/32 Multiplexer increas gger. It sequentially multip h four common terminals.	/32B Multiplexers ses the number of sensors plexes 16 groups of four lin Alternately, a manual swit	that can be measured by a es (a total of 64 lines) ch setting allows it to

In the Available Sensors and Devices box, type 253. You can also locate the sensor in the Meteorological > Soil Moisture folder. Double click the 253 Soil Moisture Sensor. Select the number of sensors, resistance units, soil water potential units, and soil reference temperature.

Progress	Available Sensors and Dev	rices		Selected Measurement	s Available for Output
1. New/Open	253	X	Exact Match	Sensor	Measurement
2. Datalogger	🗁 AM16/32			 CR1000X Series 	
3. Sensors	v 🦢 Sensors		0.000.000.000	Contraction of the	
4. Output Setup	V G Soll	e Sensor	1 253 Soil Moistur	re Sensor (Version: 2.2)	- U ,
5. Adv. Outputs		e benbor	Properties W	iring	
6. Output Select			How mar	ny 253 sensors? (Max=32) 1	
7. Finish				Resistance kol	hms kilohms
Wiring				Soil Water Potential WF	P_kPa →
Wiring Diagram			Soil Refere	ence Temperature (deg C) T1	.07 C ~
Wiring Text					_
	CR1000X Series AM16/3	32	R	Model 253 (Watermark 200) Units for Soil Water Potentia Units for Resistance: kilohms The switch on the multiplexe the 2X32 mode.	Soil Moisture Sensor II: kPa, Bars a er wiring panel must be in
		AM16/32, Al The AM16/3 datalogger. through fou		A soil temperature reference Therefore, a soil temperatur and configured before select sensor.	e is required for this sensor. e sensor must be selected ting and configuring this

4. Click on the **Wiring** tab to see how the sensor is to be wired to the AM16/32B. Click **OK** after wiring the sensor.

🎯 253 Soil Moisture Senso	r (Version: 2.2)	- D X
Properties Wiring		
	253	AM16/32
	Black	_1H
	White	_1L
	Clear	_↓ or ⊥_ (Ground)
?	Model 253 (Watermark 200) Soil Mois Units for Soil Water Potential: kPa, B Units for Resistance: kilohms	ture Sensor , ars
2	The switch on the multiplexer wiring	panel must be in the 2X32 mode.
	A soil temperature reference is requir temperature sensor must be selected	red for this sensor. Therefore, a soil and configured before selecting and
		OK Cancel Help

5. In **Output Setup**, type a scan rate. When using a multiplexer, Campbell Scientific recommends a scan rate that is at least 30 s. Also type meaningful table names and the **Data Output Storage Interval**. Click **Next**.

Progress	
1 New/Onen	How often should the CR1000X Series measure its sensor(s)? 60 Seconds
2 Datalogger	
2. Sensors	
4 Output Setup	Data is processed by the datalogger and
F. Adv. Outputs	then stored in an output table. Two tables
6. Output Salast	be added.
7. Sinish	
7. Finish	1 Hourly 2 Daily
	Table Name
Wining Diseases	Hourly 😑 Delete Table
Wining Diagram	Data Output Storage Interval
ining fore	Makes 60 measurements per output interval based upon the chosen measurement interval of 60 Seconds. 60 Image: Minutes
	Copy to External Storage SC115 Flash Memory Drive Memory Card
	Advanced Outputs (all tables)
	Specify how often measurements are to be made and how often outputs are to be stored. Note that multiple output intervals can be specified, one for each output table. By default, an output table is set up to send data to memory based on time. Select the Advanced Output option to send data to memory based on one or more of the following conditions: time, the state of a flag, or the value of a measurement.

6. Select the output options.

s w/Open	for Output							
atalogger	Sensor	Measurement	Average	1 Hourly	2 Daily			
ansors	 CR1000X Series 		ETo	Sensor	easuremer	Processing	utput Labe	Units
itout Setun	 Default 	BattV	Maximum	107	T107 C	Average	T107 C A	Deg C
ty Outputs		PTemp_C	Minimum	253	kohms	Sample	kohms	kilohms
utput Select	- 107	T107_C	Comula	253	WP kPa	Sample	WP kPa	kPa
aich	 AM16/32 (2x3 		Sample	200		Compie		10.0
11511	▲ 253	kohms	StdDev					
	i	WP_kPa	Total					
Diaman			WindVector					
g Text								
				🖉 Edit	🗴 Rem	ove		
	Select	which measureme	nts to store in	which tables	and how ea	ach measur	ement shoul	d be
	proces	sed. For each valu	le to be stored	in the table	choose a n	neasuremen	t from "Sele	cted
	Measu	rements Available	for Output." N	ext, select o	ne of the pr	rocessing fu	for data to	ch as be store
	Averac	c, sumple, ecc. it	ore mar are or	reput tubics i	hase be see	up in oraci	ior data to	DC DCOIC
	Averaç the da	talogger memory.						

7. Click the **Wiring Diagram** on the left side panel to see how the AM16/32B is to be wired to the data logger.

Short Cut (CR1000X Series) (<u>File Program Tools Help</u>	C:\Campbellsci\SCWin\un			×
Progress	CR1000X Series	АМ16/32		
1. New/Open	CR1000X Series	Viring Diagram for untitled.scw (Wiring details can be found in the help file.)		
2. Datalogger				
3. Sensors	107 - T107_C	CR1000X Series		
4. Output Setup	_Red	1H		
5. Adv. Outputs	_Clear	= (Ground)		
6. Output Select	_Purple	(Ground)		
7. Finish	_Black	VX1		
	AM16/32 (2x32	mode) CR1000X Series		
Wiring	_COM ODD H	1L		
Wiring Disgram	_12V	12V		
winng biagram	_CLK	C1		
Wiring Text	_RES	C2		
	_G or GND	G		
	_COM ODD L	(Ground)		
	_COM Ground	(Ground)		
		1L		
		VX2		
	1	kilonm 0.1% Resistor Vexc		
	Print			
	As sensors are added to the Selected Sensors table, they are added automatically to this wining diagram. The wining diagram is a graphical depiction of the sensor leads and where each should be wired to the datalogger wining panel. The wining text provides a list of the datalogger channels and the sensor wires attached to each channel. If the datalogger program includes a multiplexer, there will be one wining diagram (or wining text) for the datalogger and one for the multiplexer. From the table at the sensor leads and the table attached to each channel. If the datalogger and one for the multiplexer. The table at table at the sensor wires attached to each channel. If the datalogger and one for the multiplexer. The sensor table at the sensor wires attached to each channel at the sensor wires attached to each channel. If the datalogger and the sensor wires attached to each channel. If the datalogger and the sensor wires attached to each channel. If the datalogger and the sensor wires attached to each channel. If the dataloger and the sensor wires attached to each channel. If the datalogger and the sensor wires attached to each channel. If the dataloger and the sensor wires attached to each channel. If the dataloger and the sensor wires attached to each channel. If the dataloger and the sensor wires attached to each channel. If the dataloger attached the sensor wires attached to each channel. If the dataloger attached to be sensor wires attached to each channel. If the dataloger attached to be sensor wires attached to be sensor wires attached to each channel. If the dataloger attached to be sensor wires attached to be sens			
			р	

- 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 *LoggerNet*, *PC400*, *RTDAQ*, or *PC200W* to make sure it is making reasonable measurements.

5. Overview

The 253 and 257 soil matric potential sensors provide a convenient method of estimating water potential of wetter soils in the range of 0 to -200 kPa. The 253 is the Watermark 200 Soil Matric Potential Block modified for use with Campbell Scientific multiplexers and the 257 is the Watermark 200 Soil Matric Potential Block modified for use with Campbell Scientific data loggers.

The –L option on the Model 257-L and 253-L indicates that the cable length is user specified. This manual refers to the sensors as the 257 and 253. The typical cable length for the 257 is 25 ft.

For 253 applications, most of the cable length used is between the data logger and the multiplexer, which reduces overall cable costs and allows each cable attached to the 253 to be shorter. The cable length of each 253 only needs to cover the distance from the multiplexer to the point of measurement. Typical cable length for the 253 is 25 to 50 ft.

The difference between the 253 and the 257 is that there is a capacitor circuit and completion resistor installed in the 257 cable (FIGURE 5-1) to allow for direct connection to a data logger, while the 253 does not have any added circuitry. For applications requiring many sensors on an analog multiplexer, the 253 is used and one or more completion resistors are connected to the data logger wiring panel. A capacitor circuit is not required for the 253 on a multiplexer because the electrical connection between the sensor and the data logger is interrupted when the multiplexer is deactivated. Any potential difference between the data logger earth ground and the electrodes in the sensor is thus eliminated.

The 253 and 257 consist of two concentric electrodes embedded in a reference granular matrix material. The granular matrix material is surrounded by a synthetic membrane for protection against deterioration. An internal gypsum tablet buffers against the salinity levels found in irrigated soils.

If cultivation practices allow, the sensor can be left in the soil all year, eliminating the need to remove the sensor during the winter months.



FIGURE 5-1. 257 Soil Matric Potential Sensor with capacitor circuit and completion resistor installed in cable. Model 253 is the same, except that it does not have completion circuitry in the cable.

6. Specifications

Features:

- Survives freeze-thaw cycles
- Rugged, long-lasting sensor
- Buffers salts in soil
- No maintenance required
- 257 contains blocking capacitors in its cable that minimizes galvanic degradation and measurement errors due to ground loops
- For the 253, the multiplexer connection prevents electrolysis from prematurely destroying the probe
- Compatible with Campbell Scientific CRBasic data loggers: CR6, CR800-series, CR1000X, CR1000, CR3000, and CR5000

Range:	0 to -200 kPa
Dimensions:	8.26 cm (3.25 in)
Diameter:	1.91 cm (0.75 in)
Weight:	363 g (0.8 lb)

7. Operation

If you are programming your data logger with *Short Cut*, skip Section 7.2, *Wiring (p. 11)*, and Section 7.3, *Programming (p. 14)*. *Short Cut* does this work for you. See Section 4, *QuickStart (p. 2)*, for a *Short Cut* tutorial.

7.1 Installation/Removal

NOTE

Placement of the sensor is important. To acquire representative measurements, avoid high spots, slope changes, or depressions where water puddles. Typically, the sensor should be located in the root system of the crop.

- 1. Soak sensors in water for one hour then allow them to dry, ideally for 1 to 2 days.
- 2. Repeat Step 1 twice if time permits.
- 3. Make the sensor access holes to the required depth. Often, a 22 mm (7/8 in) diameter rod can be used to make the hole. However, if the soil is very coarse or gravelly, an oversized hole (25 to 32 mm) may be required to prevent abrasion damage to the sensor membrane. The ideal method of making an oversized access hole is to have a stepped tool that makes an oversized hole for the upper portion and an exact size hole for the lower portion.
- 4. If the hole is oversized (25 to 32 mm), mix a slurry of soil and water to a creamy consistency and place it into the sensor access hole.

	5. Insert the sensors in the sensor access hole. A length of 1/2 inch class 315 PVC pipe fits snugly over the sensor collar and can be used to push in the sensor. The PVC can be left in place with the wires threaded through the pipe and the open end taped shut (duct tape is adequate). This practice also simplifies the removal of the sensors. When using PVC piping, solvent weld the PVC pipe to the sensor collar. Use PVC/ABS cement on the stainless steel sensors with the green top. Use clear PVC cement only on the PVC sensors with the gray top.		
	6. Force the soil or slurry to envelope the sensors. This will ensure uniform soil contact.		
NOTE	Snug fit in the soil is extremely important. Lack of a snug fit is the premier problem with sensor effectiveness.		
	 Carefully, back fill the hole, and tamp down to prevent air pockets which could allow water to channel down to the sensor. 		
	8. When removing sensors prior to harvest in annual crops, do so just after the last irrigation when the soil is moist.		
CAUTION	Do not pull the sensor out by the wires. Careful removal prevents sensor and membrane damage.		
	9. When sensors are removed for winter storage, clean, dry, and place them in a plastic bag.		

7.2 Wiring

7.2.1 257 Wiring

The 257 cable includes a capacitor circuit that stops galvanic action due to the differences in potential between the data logger earth ground and the electrodes in the block. This allows it to connect directly to a data logger (TABLE 7-1 and FIGURE 7-1).

TABLE 7-1. 257 Wiring				
Wire Color	Wire Function	Data Logger Connection Terminal		
Black	Voltage- excitation input	U configured for voltage excitation ¹ , EX, VX (voltage excitation)		
Red	Analog-voltage output	U configured for single-ended analog input ¹ , SE (single-ended, analog- voltage input)		
White	Negative signal	≟ (analog ground)		
Clear	Shield	≟ (analog ground)		
¹ U terminals are automatically configured by the measurement instruction.				





7.2.2 253 Wiring

The 253 typically connects to an AM16/32-series multiplexer (TABLE 7-2), but it also is compatible with the long retired AM32 and AM416 multiplexers.

TABLE 7-2. 257-to AM16/32-series Multiplexer Wiring					
Wire ColorWire FunctionMultiplexer Connectio					
White	Voltage-excitation input	Н			
Black	Analog-voltage output	L			
Clear	Shield	\forall or \neq (ground)			

The multiplexer connects to the data logger (refer to the multiplexer manual or *www.campbellsci.com/am16-32b-ordering* for information on the cables available for connecting the multiplexer to the data logger). A 1000 ohm resistor at the data logger wiring panel is used to complete the half bridge circuitry.

TABLE 7-3 and FIGURE 7-2 show the data logger-to-multiplexer connections for the 2 x 32 mode. TABLE B-2, *Wiring for 253 Example (B-2)*, shows wiring for the 4 x 16 mode.

TABLE 7-3. Data Logger to AM16/32-series MultiplexerWiring (2 x 32 Mode)				
Data Logger Connection Terminal	Multiplexer Connection Terminal			
12V	12V			
G	G			
C (control terminal)	RES			
C (control terminal)	CLK			
U configured for voltage excitation ¹ , EX , VX (voltage excitation)				
U configured for single-ended analog terminal ¹ , SE (single- ended, analog-voltage terminal)	COM ODD H			
\neq (analog ground)	COM ODD L			
= (analog ground)	$\overrightarrow{\text{COM}} \forall \text{ or } \neq (\text{ground})$			
¹ U terminals are automatically configured by the measurement instruction.				



FIGURE 7-2. 253 wiring example

7.3 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. 2). 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 CRBasic data loggers are in the following sections. Complete program examples for select CRBasic data loggers can be found in Appendix B, *Example Programs (p. B-1)*. Programming basics and programming examples for Edlog data loggers are provided at *www.campbellsci.com/old-manuals*.

7.3.1 BRHalf Instruction

CRBasic data loggers use the **BRHalf()** instruction with the *RevEx* argument set to *True* to excite and measure the 253 and 257. The result of the **BRHalf()** instruction is the ratio of the measured voltage divided by the excitation voltage. The result needs to be converted to resistance and then converted to soil water potential.

TABLE 7-4 shows the excitation and voltage ranges used with the CRBasic data loggers.

TABLE 7-4. Excitation and Voltage Ranges forCRBasic Data Loggers						
Data Logger	mV excitation	Full Scale Range				
CR800 Series	250	$\pm 250 \text{ mV}$				
CR6	200	$\pm 200 \text{ mV}$				
CR1000X	200	$\pm 200 \text{ mV}$				
CR1000	250	$\pm 250 \text{ mV}$				
CR3000	200	$\pm 200 \text{ mV}$				
CR5000	200	$\pm 200 \text{ mV}$				

7.3.2 Calculations

The CRBasic program should include the following to calculate resistance, adjust the resistance for soil temperature, and calculate soil water potential:

kohms=kohms/(1-kohms) kohms=(100+(1.8*T107_C+32)-69.8)/100*kohms If kohms<=1 Then WP_kPa=-(20*kohms-11) Else WP_kPa=-(-0.00279*kohms^3+0.19109*kohms^2+3.71485*kohms+6.73956) EndIf

where,

kohms = the variable storing the BRHalf() result

 $T107_C$ = the variable storing the temperature sensor measurement (degree Celsius)

WP kPa = water potential

7.3.2.1 Soil Water Matric Potential in Other Units

To report measurement results in other units, multiply the soil water potential by the appropriate conversion constant from TABLE 7-5.

TABLE 7-5. Conversion ofMatric Potential to Other Units				
Desired Unit Multiply Result By				
kPa	1.0			
MPa	0.001			
Bar	0.01			

7.4 Interpreting Results

As a general guide, 253 and 257 measurements indicate soil matric potential as follows:

0 to $-10 \text{ kPa} =$	Saturated soil
-10 to -20 kPa =	Soil is adequately wet (except coarse sands, which are beginning to lose water).
-20 to -60 kPa =	Usual range for irrigation (except heavy clay).
-60 to -100 kPa =	Usual range for irrigation for heavy clay soils.
100 to -200 kPa =	Soil is becoming dangerously dry for maximum production.

8. Troubleshooting

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All factory repairs and recalibrations require a returned material authorization (RMA) and completion of the "Declaration of Hazardous Material and Decontamination" form. Refer to the *Assistance* page at the beginning of this manual for more information.

To test the sensor, submerge it in water. Measurements should be from -3 to +3 kPa. Let the sensor dry for 30 to 48 hours. You should see the reading increase from 0 to 150+ kPa. If the reading does not increase to 150 kPA, replace the sensor. If the reading increases as expected, put the sensor back in the water. The reading should run right back down to zero in 1 to 2 minutes.

If the sensor passes these tests but it is still not functioning properly, consider the following:

- 1. Sensor may not have a snug fit in the soil. This usually happens when an oversized access hole has been used and the backfilling of the area around the sensor is not complete.
- 2. Sensor is not in an active portion of the root system, or the irrigation is not reaching the sensor area. This can happen if the sensor is sitting on top of a rock or below a hard pan which may impede water movement. Reinstalling the sensor usually solves this problem.
- 3. When the soil dries out to the point where you are seeing readings higher than 80 kPa, the contact between soil and sensor can be lost because the soil may start to shrink away from the sensor. An irrigation which only results in a partial rewetting of the soil will not fully rewet the sensor, which can result in continued high readings from the 257. Full rewetting of the soil and sensor usually restores soil to sensor contact. This is most often seen in the heavier soils and during peak crop water demand when irrigation may not be fully adequate. The plotting of readings on a chart is most useful in getting a good picture of this sort of behavior.

9. Reference

Thompson, S.J. and C.F. Armstrong, Calibration of the Watermark Model 200 Soil matric potential Sensor, Applied Engineering in Agriculture, Vol. 3, No. 2, pp. 186-189, 1987.

Parts of this manual were contributed by Irrometer Company, Inc., manufacturer of the Watermark 200.

Appendix A. Importing Short Cut Code Into CRBasic Editor

Short Cut creates a .DEF file that contains wiring information and a program file that can be imported into the *CRBasic Editor*. By default, these files reside in the C:\campbellsci\SCWin folder.

Import Short Cut program file and wiring information into CRBasic Editor:

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart (p. 2)*. After saving the *Short Cut* program, click the **Advanced** tab then the **CRBasic Editor** button. A program file with a generic name will open in CRBasic. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

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

- 2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder, and copy the wiring information, which is at the beginning of the .DEF file.
- 3. Go into the CRBasic program and paste the wiring information into it.
- 4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the *CRBasic* | *Features* video ▶.

Appendix B. Example Programs

CRBasic Example B-1 measures the resistance ($k\Omega$) of one 257 sensor with the data logger. A 107 temperature probe is measured first for temperature correction of the 257 reading. Voltage range codes for other CRBasic data loggers are shown in TABLE 7-4. Sensor wiring for this example is shown in TABLE B-1.

TABLE B-1. 107/257 Wiring for Example Program			
Sensor	Wire	Function	CR6
107	Black	Excitation	U1
	Red	Positive Signal	U2
	Purple	Negative Signal	Ŧ
	Clear	Shield	Ŧ
257	Black	Excitation	U4
	Red	Positive Signal	U3
	White	Negative Signal	Ŧ
	Clear	Shield	Ŧ

CRBasic Example B-1. CR6 Program Measuring a 107 and 257

```
'CR6 Series
'Declare Variables and Units
Public T107_C
Public kohms
Public WP_kPa
Units T107_C=Deg C
Units kohms=kilohms
Units WP_kPa=kPa
'Define Data Tables
DataTable(Table1,True,-1)
 DataInterval(0,60,Min,10)
  Average(1,T107_C,FP2,False)
  Sample(1,WP_kPa,FP2)
EndTable
'Main Program
BeginProg
  'Main Scan
  Scan(5,Sec,1,0)
    '107 Temperature Probe measurement 'T107_C'
    Therm107(T107_C,1,U2,U1,0,60,1,0)
    '257 Soil Moisture Sensor measurements 'kohms' and 'WP_kPa'
    BrHalf(kohms,1,mV200,U3,U4,1,200,True,0,15000,1,0)
    kohms=kohms/(1-kohms)
    kohms=(100+(1.8*T107_C+32)-69.8)/100*kohms
    If kohms<=1 Then</pre>
      WP_kPa=-(20*kohms-11)
```

Else

```
WP_kPa=-(-0.00279*kohms^3+0.19109*kohms^2+3.71485*kohms+6.73956)
EndIf
'Call Data Tables and Store Data
CallTable Table1
NextScan
EndProg
```

CRBasic Example B-2 measures five 107 temperature probes and five 253 sensors on an AM16/32-series multiplexer (4x16 mode) with the CR1000X data logger. In this example, a 107 temperature probe is buried at the same depth as a corresponding 253 sensor. Voltage range codes for other CRBasic data loggers are shown in TABLE 7-4. Sensor wiring is shown in TABLE B-2.

TABLE B-2. Wiring for 253 Example				
CR1000X	AM16/32B	Sensor	Wire	Function
12V	12V			
G	G			
C1	RES			
C2	CLK			
VX1	COM ODD H			
SE1 (1H)	COM ODD L			
Ground	COM GROUND			
SE2 (1L)	COM EVEN H			
Ground	COM EVEN L			
1000 ohm resistor from SE2 to VX2				
	1H	107	Black	Excitation
	1L		Red	Positive Signal
	Ť		Purple	Negative Signal
	Ŧ		Clear	Shield
	2Н	253	White	Positive Signal
	2L		Black	Negative Signal
	÷		Clear	Shield
	Continue wiring sensors to multiplexer with 107 probes attaching to odd numbered terminals and 253 sensors to even numbered terminals. AM16/32B in 4x16 mode.			

```
CRBasic Example B-2. CR1000X Program Measuring Five 107s and Five 253s
'CR1000X
Public T107_C(5), WP_kPa(5), k0hms(5)
Dim i
Units T107_C()=Deg C
Units kOhms()=kOhms
Units WP_kPa()=kPa
DataTable(Hourly,true,-1)
  DataInterval(0,60,Min,10)
  Average(5, T107_C, FP2, 0)
Sample(5, WP_kPa, FP2)
  Sample(5, kOhms, FP2)
EndTable
BeginProg
  Scan(60, Sec, 3, 0)
    PortSet(C1,1) 'Turn AM16/32 Multiplexer On
    Delay(0,150,mSec)
    i = 1
  SubScan (0,uSec,5)
      PulsePort(C2,10000)
      'Soil temperature measurement
      Therm107(T107_C(i),1,1,VX1,0,60,1,0)
       '253 Soil Moisture Sensor measurements
      BrHalf(k0hms(i),1,mV200,2,VX2,1,200,true,0,60,1,0)
      'Convert resistance ratios to kOhms
      kOhms(i) = kOhms(i)/(1-kOhms(i))
      kOhms(i)=(100+(1.8*T107_C(i)+32)-69.8)/100*kOhms(i)
      i = i+1
    NextSubScan
    PortSet(C1,0) 'Turn AM16/32 Multiplexer Off
    'Convert kOhms to water potential
    For i = 1 To 5
      If kOhms(i)<=1 Then</pre>
      WP_kPa(i)=-(20*k0hms(i)-11)
      Else
      WP_kPa(i)=-(-0.00279*kOhms(i)^3+0.19109*kOhms(i)^2+3.71485*kOhms(i)+6.73956)
      EndIf
    Next i
    CallTable Hourly 'Call Data Table and Store Data
  NextScan
EndProg
```



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