INSTRUCTION MANUAL

CS225 Temperature String

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Limited Warranty

"Products manufactured by CSI are warranted by CSI to be free from defects in materials and workmanship under normal use and service for twelve months from the date of shipment unless otherwise specified in the corresponding product manual. (Product manuals are available for review online at *www.campbellsci.com*.) Products not manufactured by CSI, but that are resold by CSI, are warranted only to the limits extended by the original manufacturer. Batteries, fine-wire thermocouples, desiccant, and other consumables have no warranty. CSI's obligation under this warranty is limited to repairing or replacing (at CSI's option) defective Products, which shall be the sole and exclusive remedy under this warranty. The Customer assumes all costs of removing, reinstalling, and shipping defective Products to CSI. CSI will return such Products by surface carrier prepaid within the continental United States of America. To all other locations, CSI will return such Products best way CIP (port of entry) per Incoterms ® 2010. This warranty shall not apply to any Products which have been subjected to modification, misuse, neglect, improper service, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied. The warranty for installation services performed by CSI such as programming to customer specifications, electrical connections to Products manufactured by CSI, and Product specific training, is part of CSI's product warranty. **CSI EXPRESSLY DISCLAIMS AND EXCLUDES ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE**. **CSI hereby disclaims, to the fullest extent allowed by applicable law, any and all warranties and conditions with respect to the Products, whether express, implied or statutory, other than those expressly provided herein.**"

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To obtain a Returned Materials Authorization (RMA), contact CAMPBELL SCIENTIFIC, INC., phone (435) 227-9000. After an application engineer determines the nature of the problem, an RMA number will be issued. Please write this number clearly on the outside of the shipping container. Campbell Scientific's shipping address is:

CAMPBELL SCIENTIFIC, INC.
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

For all returns, the customer must fill out a "Statement of Product Cleanliness and Decontamination" form and comply with the requirements specified in it. The form is available from our website at *www.campbellsci.com/repair*. A completed form must be either emailed to *repair@campbellsci.com* or faxed to (435) 227-9106. Campbell Scientific is unable to process any returns until we receive this form. If the form is not received within three days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. Campbell Scientific reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.

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 or by telephoning (435) 227-9000 (USA). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

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

Utility and Electrical

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

Elevated Work and Weather

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

Maintenance

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

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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CS225 Temperature String

1. Introduction

The CS225 Temperature String uses SDI-12 digital technology for simple integration and reliability. The CS225 consists of an arrangement of temperature sensors mounted in rugged steel reinforced cable. Temperature points are over molded to provide long-term connection in all mediums. Each CS225 is manufactured to the client's specific requirements and includes the SGB3 to provide electrical surge protection.

Before using the CS225, please study:

- Section 2, *Precautions* *(p. 1)*
- Section 7.1, *Wiring* *(p. 4)*

More details are available in the remaining sections.

2. Precautions

- READ AND UNDERSTAND the *Safety* section at the front of this manual.
- Although the CS225 is designed to be a rugged and reliable device for field use, care should be taken when handling or moving it to avoid damage.
- There are no user-serviceable parts and any attempt to disassemble the device will void the warranty.
- The CS225 ships with a SGB3 surge protector, a 2-ft cable, 2 pan Phillips screws and 2 grommets.

CAUTION Do not make tight bends near the temperature sensor(s). Doing so has the potential to damage the sensor assembly. The minimum bend radius at any sensor location is 15 cm (6 in). See image below.

3. Initial Inspection

- Upon receipt of the CS225, 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.

- 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 expected product and cable length are received.

- The CS225 ships with a SGB3 surge protector, a 2-ft cable, two pan Phillips screws, two grommets, and a *ResourceDVD*.

4. Overview

The CS225 Temperature String uses digital sensor technology allowing for a simple three-wire integration. The CS225 consists of an arrangement of over molded temperature points mounted in a rugged steel reinforced cable. Each CS225 is manufactured to the client's specific requirements.

The CS225 is suited to a wide variety of applications and environments that require temperature profiling. The completely sealed cable assembly permits the CS225 to be buried, submerged, or integrated directly into structures. Examples of applications include temperature profiling in boreholes, soils, water, and frost and permafrost monitoring.

The purpose of the SGB3 is to provide adequate surge protection for the CS225 Temperature String. The case of the SGB3 is suited for mounting to a back plate with 1 inch on center spacing.

5. Specifications

Features:

- Accurate and stable measurements
- Each sensor is individually addressed and referenced to its depth
- Lower power consumption
- Digital SDI-12 output
- Compatible with the following dataloggers: CR200(X) Series, CR800 Series, CR1000, CR3000, CR5000, CR510, CR10(X), CR23X, CR6

5.1 SGB3 3-Line Surge Protector

Operating Range:	–55 to 85 °C
Maximum Voltage:	±28 Vdc/20 Vac (L1, L2, L3 with respect to G terminals)
Maximum Current:	2 A per terminal, 4 A total (requires both ground terminals for return current)
Maximum Rated Surge:	1200 A (8/20 us)

5.2 CS225 Temperature String

Operating Range:	–55 to 85 °C
Accuracy	
Typical:	±0.2 °C over –40 to 85 °C
Worst Case:	±0.4 °C over –40 to 85 °C ±0.5 °C over –55 to –40 °C (includes lifetime drift of sensor)
Resolution:	0.0078 °C
Measurement Update Interval:	1 s (automatic), occurs in quiescent mode
Warm-up Time:	10 s
Maximum Sensors per String:	36 sensors
Maximum Pressure:	150 psi
Supply Voltage:	9 to 28 Vdc
Current Consumption	
Quiescent:	# sensors • 1.0 mA (max)
Active (during SDI-12communications):	20 mA + (# sensors • 1.0 mA)
Temperature Point Diameter:	2.22 cm (0.875 in)
Maximum Cable Length:	152 m (500 ft), individual CS225 and datalogger SDI-12 terminal maximum
Minimum Sensor Spacing:	15 cm (5.9 in)

NOTE The furthest temperature point from the datalogger (or the temperature point at the end of the string) is addressed starting at ‘1’. Each temperature point going up the string towards the datalogger changes by one address number/letter.

6. Installation

6.1 Siting

The CS225 is meant to be installed within the measurement medium. To make the most representative measurement, reliable contact needs to be made between the temperature string and medium. The temperature string should be representative of the intended application.

The CS225 consists of two distinct cables: the lead and the sensor array. The lead length is the length of cable between the datalogger and sensor array. The sensor array length is the length of cable that incorporates all temperature sensors in their specified configuration. The installation position of the string and its measurement points are referenced from the first sensor position at the end of the sensor array. This information needs to be addressed as part of the sensor configuration process.

6.2 Mounting

Orient and secure the CS225 in the measurement medium. Keep materials removed during installation and use that material as backfill.

If a burial depth is required for each temperature sensor, you need to know the length of the sensor array, the "measurement from end" metadata of each sensor in the array, and any offset used during installation of the string. You will also need to calculate the depth of each temperature sensor.

Orient the lead cable of the CS225 towards the datalogger to avoid loops or strain on the cable. Also use a suitable trench or conduit to protect the lead cable from damage.

Secure the SGB3 to an enclosure backplate using the supplied hardware.

7. Operation

When power is supplied to the CS225, the internal electronics continuously measure the temperature approximately once per second. The sensor output is a running average of 10 consecutive, 1 s readings. The accuracy specification is based on an average of 10 consecutive readings. After initial power up, a delay of 10 s is recommended to obtain the best accuracy.

Outputs of both lifetime and user resettable minimum and maximum temperatures are also available during powered operation from each temperature point in the CS225. The resettable minimum and maximum temperatures allow monitoring of specific seasons or measurement periods, without having to review the entire data set. The lifetime minimum and maximum temperatures are used for maintenance and warranty records.

7.1 Wiring

Connections for the SGB3 and CS225 to Campbell Scientific dataloggers are given in TABLES 7-1 and 7-2.

The SGB3 is required to protect against electrical surges (FIGURE 7-1). The SGB3 uses the cable to make final connections to the datalogger.

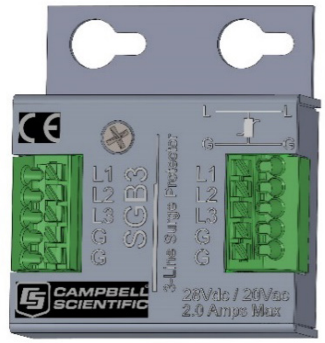

FIGURE 7-1. SGB3 3-Line Surge Protector

TABLE 7-1. CS225 Connection to SGB3

Color	Description	CS225
Red	Power	L1
Green	SDI-12 Signal	L2
	Not Used	L3
Black	Power Ground	G
Clear	Shield	G

TABLE 7-2. SGB3 Connection to Campbell Scientific Dataloggers

Color	SGB3 Description	CR200(X) CR800 CR1000 CR3000 CR5000	CR510 CR500 CR10(X)	CR23X
Red	L1	12V	12V	12V
Green	L2	Control Port[1]	Control Port	Control Port
Black	G	G	G	⏚
Clear	G	⏚	G	⏚

[1]Dedicated SDI-12 port of CR5000

To use more than one string per datalogger, you can either connect the different strings to different SDI-12 compatible ports on the datalogger or change the SDI-12 addresses of the strings and let them share the same connection. Using the SDI-12 addressing method minimizes the use of ports on the datalogger (see below for limits on the total cable length).

There are two ways to set the SDI-12 address of the CS225:

- By sending the required commands to the sensors via an SDI-12 recorder/datalogger that allows talk through to the sensor

- By loading a program into the datalogger that sends the required commands (see Section 7.3, *Changing the SDI-12 Address using LoggerNet and a Datalogger* *(p. 15)*)

7.1.1 Long Cables

As the measurement data is transferred between the temperature string and datalogger digitally, there are no offset errors incurred with increasing cable length as seen with analog sensors. However, with long enough cable lengths, digital communications will break down, resulting in either no response from the sensor or corrupted readings. The original SDI-12 standard specifies the maximum total cable length for the cable as being 61 m (200 ft), but we are able to exceed this limit by:

- Using low capacitance, low resistance, screened cable
- Ensuring that the power ground cable has low resistance and is connected to the same ground reference as the datalogger control ports

7.1.2 Power Conservation

The CS225 draws less than 1 mA of current per sensor between polling sessions from its 12 V supply. In many applications, this is minimal compared to overall system power use, so the sensor can be continually powered to avoid the warm-up period.

In very low power applications, you can switch the power on a minimum of 10 s (allowing for the warm-up period) before polling the CS225. This switching can be achieved in different ways depending on the type and model of the datalogger. If available, the switched 12 V output of the datalogger can be used.

7.2 Reading the CS225

When power is supplied to the CS225, the internal electronics continuously measure temperature at a rate of approximately once per second. Every output measurement (**aR0!** or **aM0!**) obtained from the sensor is a running average of 10 consecutive readings. For this purpose, after initial power up, a delay of 10 seconds is recommended to obtain the best accuracy.

As the sensor is obtaining a measurement every second, Campbell Scientific recommends using the continuous measurement command (**aR0!**) to obtain the temperature readings. Using the **aR0!** command reduces the time taken in comparison to the **aM0!** to obtain a reading via the SDI-12 protocol. The lifetime and user resettable minimum and maximum temperature values are single one-second readings. For more details, see TABLE 7-3.

The CS225 complies with a subset of the SDI-12 1.3 instruction set. Specifically, it supports these SDI-12 commands:

- **a!**, acknowledge active of individual sensor
- **aI!**, send identification
- **aR!** (**aR0!** to **aR7!**), continuous measurements of the sensor. The **R** command provides a faster means of obtaining the readings for

sensors that can provide continuous measurements. This instruction usually takes less than 300 ms to execute.

- **aM!**, initiate measurement (and the subsequent **aD0!** "get data" command which is automatically sent by the Campbell Scientific datalogger). This instruction usually takes about 700 ms to execute.

- **aAb!**, change address a to b

Where in all cases "a" is the address of the sensor and "!" is the command terminator. These two characters are normally sent implicitly by Campbell Scientific dataloggers.

The CS225 output is measured using a standard SDI-12 instruction to read the data from an SDI-12 sensor. For CRBasic dataloggers, the **SDI12Recorder()** instruction is used. If using the sensor with other SDI-12 recorders, please refer to your system's documentation.

NOTE In any configuration of CS225 that includes more than one sensor, the CS225 will not respond to the **?!** SDI-12 command as each individual sensor will respond at the same time thus disrupting all outputs. Use the **aI!** command in a trial and error fashion if you need to determine the individual addresses of temperature sensors.

TABLE 7-3. SDI-12 Commands for the CS225

SDI-12 Command	Variable Name	Description
aR0!	Temperature value	Temperature – floating point (°C)
aR1!	Serial number, location number, depth value (in cm)	Serial number, location number, depth value (in cm)
aR2!	Read user resettable min temperature	Min. temperature – floating point (°C)
aR3!	Read user resettable max temperature	Max. temperature – floating point (°C)
aR4!	Read lifetime min temperature	Min. temperature – floating point (°C)
aR5!	Read lifetime max temperature	Max. temperature – floating point (°C)
aR6!	Read and reset user resettable min temperature	Min. temperature – floating point (°C). This value constitutes the minimum of all 1-second measurements taken since the previous **aR6!** command.
aR7!	Read and reset user resettable max temperature	Max. temperature – floating point (°C). This value constitutes the maximum of all 1-second measurements taken since the previous **aR6!** command.
aV!	Verification command	S1 = BootRom Signature S2 = Firmware Signature

aAb!	Change Address command	Valid addresses in sequence are: 1–9 / A–Z / a–z (no address 0) Sending a broadcast message with the address change "{" can correct units that have conflicting addresses.
aI!	SDI-12 Identification command	X13CAMPBELLCS225 1.0 SN:XXXXX

7.2.1 SDI-12 Addressing

The CS225 comes pre-programed with addresses from the factory, but the user can also change it. This may be necessary if two CS225 strings need to be placed in the same SDI-12 channel to avoid duplicate addresses on the same SDI-12 channel.

The starting address will be 1 and this will coincide with the first temperature sensor, which is located at the end of the sensor array. It is recommended to start the readdressing process with the largest temperature sensor address to avoid duplicate addresses.

NOTE When readdressing temperature sensors, you must avoid giving multiple sensors the same address. If this does occur, you will no longer be able to communicate with these sensors. Use the **aA{!** command, where *a* is the affected address. This will reset the affected sensors to their factory configured address value.

TABLE 7-4. SDI-12 Addresses and Positions

Numeric Set	Uppercase Set	Lowercase Set
1 / 1	A / 10	a / 36
2 / 2	B / 11	b / 37
3 / 3	C / 12	c / 38
4 / 4	D / 13	d / 39
5 / 5	E / 14	e / 40
6 / 6	F / 15	f / 41
7 / 7	G / 16	g / 42
8 / 8	H / 17	h / 43
9 / 9	I / 18	i / 44
	J / 19	j / 45
	K / 20	k / 46
	L / 21	l / 47
	M / 22	m / 48
	N / 23	n / 49
	O / 24	o / 50
	P / 25	p / 51
	Q / 26	q / 52

	R / 27	r / 53
	S / 28	s / 54
	T / 29	t / 55
	U / 30	u / 56
	V / 31	v / 57
	W / 32	w / 58
	X / 33	x / 59
	Y / 34	y / 60
	Z / 35	z / 61
		{ – reset to factory address

7.2.2 Slow Sequence Program Instructions

Use of the slow sequence program instructions should be considered if the CS225 measurement will exceed the program scan interval of the additional instruments included in the station. For example, if a CS225 consists of 17 or more temperature sensors, the time required to poll all sensors and receive data back can be greater than 5 s based on the 300 ms execution time for the **aR0!** command. For more details on the use of the slow sequence program instructions, please reference the related *LoggerNet Help* or relevant datalogger manual.

7.2.2.1 CR1000 Program to Read 20 Temperature Sensors

In this example, a single CS225 is being polled on control port 1 of a CR1000 in a slow sequence. The CS225 includes 20 sensors with SDI-12 addresses 1 through 20. Each sensor is polled with the **aR0!** command every 60 s, and stored to a data table on the same interval. Other common station data is measured every 5 seconds and stored to daily and hourly data tables.

```
'CR1000 Series Datalogger
'The following Sample program reads a CS225 string that has 20 temperature Sensors

'Declare Public Variables

Public PTemp, batt_volt

'Enter the number of temperature sensors that are in the string (will need to be
'adjusted to fit specific applications)
Const  NumTempSensors=20

'Uses the control port C1 on the CR1000 (valid port options are 1,3,5,7)
Const  CS225_SDI12_Port=1

Public CS225Temp(NumTempSensors) As Float
Dim i As Long

'Define Data Tables
DataTable (Daily,1,-1)
  DataInterval (0,1440,Min,10)
  Minimum (1,batt_volt,FP2,0,False)
  Maximum (1,batt_volt,FP2,0,False)
  Average (1,batt_volt,FP2,0)
EndTable

DataTable (Hourly,1,-1)
  DataInterval (0,60,Min,10)
  Minimum (1,PTemp,FP2,0,False)
```

```
  Maximum (1,PTemp,FP2,0,False)
  Average (1,PTemp,FP2,0)
EndTable

DataTable (One_Minute,1,-1)
  DataInterval (0,60,Sec,10)
  Sample (NumTempSensors,CS225Temp(),IEEE4)
EndTable

'Define Subroutines

'******************************************************************************
'*  -------------------- ConvertNumToSDI12address() ---------------------  *
'*  Convert SDI-12 character address (0->9, A->Z, & a->z) to number value    *
'*  (0->61).                                                                   *
'******************************************************************************

Function ConvertNumToSDI12address(address As Long) As String * 1
  Select Case address
  Case 0 To 9  'ASCII Code 48->57 = 0->9
    Return(CHR(address + 48))
  Case 10 To 35  'ASCII Code 65->90 = A->Z = 10->35
    Return(CHR(address + 55))
  Case 36 To 61  'ASCII Code 97->122 = a->z = 36->61
    Return(CHR(address + 61))
  EndSelect
  Return("")
EndFunction  'ConvertNumToSDI12address()

'EndSub

'Main Program
BeginProg

  Scan (5,Sec,0,0)
    PanelTemp (PTemp,250)
    Battery (batt_volt)

    CallTable Daily
    CallTable Hourly

  NextScan

'Poll CS225 in Slow Sequence every minute
  SlowSequence
  Scan (60,Sec,3,0)

    'Read the current Temperature Value
    For i=1 To NumTempSensors
      SDI12Recorder (CS225Temp(i),CS225_SDI12_Port,ConvertNumToSDI12address(i),"R0!",1.0,0)
    Next

    CallTable One_Minute

  NextScan
EndProg
```

7.2.3 CS225 Metadata

Every temperature point in a string includes the following metadata, which can be retrieved using the **aR1!** SDI-12 command. The information can be used to identify details of the temperature string and its individual temperature points.

TABLE 7-5. Metadata

Name	Value Range	Description
Serial Number	0 to 65534	The serial number that is unique to each sensor unit
Location Number	1 to 225	Each temperature sensor within a string is assigned its own unique location number, which by default is in relation with the SDI-12 address (see TABLE 7-4)
Measurement from End Value	0 to 65535 cm	The value is in centimeters (cm). These are intended to reflect the distances of a sensor from the end of the sensor array. The bottom most temperature point would be designated as 0 cm. If the next temperature point below were 20 cm away, then its Measurement from end value would be 20 cm. Users may designate other starting values. These can be configured at the time of ordering.

7.2.3.1 CR1000 Program to Read the Metadata of 15 Sensors Daily

```
'CR1000 Series Datalogger
'The following Sample program reads a CS225 string that has 15 temperature Sensors

'Declare Public Variables
Public PTemp, batt_volt

'Enter the number of temperature sensors that are in the string (will need to be
'adjusted to fit specific applications)
Const  NumTempSensors=15
'Calculate the number of Meta Data points based on the number of sensors
Const  MetaData_pts=NumTempSensors*3
'Uses the control port C1 on the CR1000 (valid port options are 1,3,5,7)
Const  CS225_SDI12_Port=1

Public CS225Meta(NumTempSensors,3) As Float
Dim i As Long

'Define Data Tables
DataTable (MetaData,1,-1)
  DataInterval (0,1,Day,10)
  Sample (MetaData_pts,CS225Meta(),FP2)
EndTable

'Define Subroutines
'******************************************************************************
'*  --------------------- ConvertNumToSDI12address() ----------------------  *
'*  Convert SDI-12 character address (0->9, A->Z, & a->z) to number value    *
'*  (0->61).                                                                  *
'******************************************************************************

Function ConvertNumToSDI12address(address As Long) As String * 1
  Select Case address
  Case 0 To 9  'ASCII Code 48->57 = 0->9
    Return(CHR(address + 48))
  Case 10 To 35  'ASCII Code 65->90 = A->Z = 10->35
    Return(CHR(address + 55))
  Case 36 To 61  'ASCII Code 97->122 = a->z = 36->61
    Return(CHR(address + 61))
  EndSelect
```

```
  Return("")
EndFunction  'ConvertNumToSDI12address()
'EndSub

'Main Program
BeginProg
  Scan (60,Sec,0,0)
    PanelTemp (PTemp,250)
    Battery (batt_volt)

'Read the Meta Data from the sensor daily
    'Also read if a non-valid serial number is present (Startup values should be zero).
    'A valid serial number will be greater than 1
    If (CS225Meta(1,1) < 1) OR (IfTime (0,1440,Min)) Then
      For i=1 To NumTempSensors

SDI12Recorder(CS225Meta(i,1),CS225_SDI12_Port,ConvertNumToSDI12address(i),"R1!",1.0,
0)
      Next
    EndIf

    CallTable MetaData

  NextScan
EndProg
```

7.2.4 Example Programs

7.2.4.1 CR1000 Program for Measuring 15 Sensors Every 60 Seconds

In this example, a single CS225 is being measured on control port 1 of a CR1000. The CS225 includes 15 sensors with SDI-12 addresses 1 through 15. Each sensor is polled with the **aR0!** command every 60 s and stored to a data table on the same interval. Other common station data is measured every 60 s and stored to a daily data table.

```
'CR1000 Series Datalogger
'The following Sample program reads a CS225 string that has 15 temperature Sensors

'Declare Public Variables

Public PTemp, batt_volt

'Enter the number of temperature sensors that are in the string (will need to be
'adjusted to fit specific applications)
Const  NumTempSensors=15

'Uses the control port C1 on the CR1000 (valid port options are 1,3,5,7)
Const  CS225_SDI12_Port=1

Public CS225Temp(NumTempSensors) As Float
Dim i As Long

'Define Data Tables
DataTable (Daily,1,-1)
  DataInterval (0,1440,Min,10)
  Minimum (1,batt_volt,FP2,0,False)
  Maximum (1,batt_volt,FP2,0,False)
  Average (1,batt_volt,FP2,0)
  Minimum (1,PTemp,FP2,0,False)
  Maximum (1,PTemp,FP2,0,False)
  Average (1,PTemp,FP2,0)
EndTable

DataTable (TempSample,1,-1)
  DataInterval (0,60,Sec,10)
```

```
  Sample (NumTempSensors,CS225Temp(),IEEE4)
EndTable

'Define Subroutines

'*******************************************************************************
'*  --------------------- ConvertNumToSDI12address() ---------------------   *
'*  Convert SDI-12 character address (0->9, A->Z, & a->z) to number value    *
'*  (0->61).                                                                 *
'*******************************************************************************

Function ConvertNumToSDI12address(address As Long) As String * 1
  Select Case address
  Case 0 To 9  'ASCII Code 48->57 = 0->9
    Return(CHR(address + 48))
  Case 10 To 35  'ASCII Code 65->90 = A->Z = 10->35
    Return(CHR(address + 55))
  Case 36 To 61  'ASCII Code 97->122 = a->z = 36->61
    Return(CHR(address + 61))
  EndSelect
  Return("")
EndFunction  'ConvertNumToSDI12address()

'EndSub

'Main Program
BeginProg

  Scan (60,Sec,0,0)
    PanelTemp (PTemp,250)
    Battery (batt_volt)

  'Read the current Temperature Value
  For i=1 To NumTempSensors
    SDI12Recorder (CS225Temp(i),CS225_SDI12_Port,ConvertNumToSDI12address(i),"R0!",1.0,0)
  Next

CallTable Daily
CallTable TempSample

  NextScan
EndProg
```

7.2.4.2 CR1000 Program for Measuring 15 Sensors Every 5 Minutes

In this example a single CS225 is being measured on Control Port 1 of a CR1000. The CS225 includes 15 sensors with SDI-12 addresses 1 through 15. Each temperature sensor is polled both on power up and daily with the **aR1!** command to determine metadata, which is stored in a daily data table. The minimum and maximum temperature is each sensor is polled (**aR6!** and **aR7!**, respectively) every 5 minutes and stored to a data table on the same interval. Other common station data is measured every 60 seconds and stored to a separate daily data table.

```
'CR1000 Series Datalogger
'The following Sample program reads a CS225 string that has 15 temperature Sensors.
'Individual temperatures, user minimum & maximum are recorded every 5 minutes, and
'Meta Data is collected daily.

'Declare Public Variables
Public PTemp, batt_volt

'Enter the number of temperature sensors that are in the string (will need to be
'adjusted to fit specific application)
Const  NumTempSensors=15
```

```
'Calculate the number of Meta Data points based on the number of sensors
Const  MetaData_pts=NumTempSensors*3

'Uses the control port C1 on the CR1000 (valid port options are 1,3,5,7)
Const  CS225_SDI12_Port=1

Public CS225Temp(NumTempSensors) As Float
Public CS225TempUserMax(NumTempSensors) As Float
Public CS225TempUserMin(NumTempSensors) As Float
Public CS225Meta(NumTempSensors,3) As Float

Dim i As Long

'Define Data Tables
DataTable (Daily,1,-1)
  DataInterval (0,1,Day,10)
  Minimum (1,batt_volt,FP2,0,False)
  Maximum (1,batt_volt,FP2,0,False)
  Average (1,batt_volt,FP2,0)
  Minimum (1,PTemp,FP2,0,False)
  Maximum (1,PTemp,FP2,0,False)
  Average (1,PTemp,FP2,0)
EndTable

DataTable (MetaData,1,-1)
  DataInterval (0,1,Day,10)
  Sample (MetaData_pts,CS225Meta(),FP2)
EndTable

DataTable (TempSample,1,-1)
  DataInterval (0,5,Min,10)
  Sample (NumTempSensors,CS225TempUserMin(),IEEE4)
  Sample (NumTempSensors,CS225TempUserMax(),IEEE4)
EndTable

'Define Subroutines

'*****************************************************************************
'*  --------------------- ConvertNumToSDI12address() ----------------------  *
'*  Convert SDI-12 character address (0->9, A->Z, & a->z) to number value    *
'*  (0->61).                                                                 *
'*****************************************************************************

Function ConvertNumToSDI12address(address As Long) As String * 1
  Select Case address
  Case 0 To 9  'ASCII Code 48->57 = 0->9
    Return(CHR(address + 48))
  Case 10 To 35  'ASCII Code 65->90 = A->Z = 10->35
    Return(CHR(address + 55))
  Case 36 To 61  'ASCII Code 97->122 = a->z = 36->61
    Return(CHR(address + 61))
  EndSelect
  Return("")
EndFunction  'ConvertNumToSDI12address()
'EndSub

'Main Program
BeginProg

  Scan (60,Sec,0,0)
    PanelTemp (PTemp,250)
    Battery (batt_volt)

    'Read the Meta Data from the sensor daily
    'Also read if a non-valid serial number is present (Startup values should be zero).
    'A valid serial number will be greater than 1
    If (CS225Meta(1,1) < 1) OR (IfTime (0,1440,Min)) Then
      For i=1 To NumTempSensors
```

```
         SDI12Recorder(CS225Meta(i,1),CS225_SDI12_Port,ConvertNumToSDI12address(i),"R1!",1.0,0)
      Next
    EndIf

    'Read the current Temperature Min & Max Values Every 5 minutes and Reset the Value
    If TimeIntoInterval(0,5,Min) Then

    For i=1 To NumTempSensors

'To Read and Reset the User Min Values use SDI-12  R6! or M6! Command.  This command
'is preferred over the minimum instruction as it constitutes the minimum of all 1
'second measurements taken since the previous aR6! Command.
      SDI12Recorder (CS225TempUserMin(i),CS225_SDI12_Port,ConvertNumToSDI12address(i),"R6!",1.0,0)

      'To Read and Reset the User Max Values use SDI-12  R7! or M7! Command. This
      'command is preferred over the maximum instruction as it constitutes the
      'maximum of all 1 second measurements taken since the previous aR6! Command.
      SDI12Recorder (CS225TempUserMax(i),CS225_SDI12_Port,ConvertNumToSDI12address(i),"R7!",1.0,0)

    Next
  EndIf

  CallTable Daily
  CallTable MetaData
  CallTable TempSample

NextScan
EndProg
```

7.3 Changing the SDI-12 Address using *LoggerNet* and a Datalogger

It is possible to connect multiple CS225 or other SDI-12 sensors to a single datalogger control port. Each temperature sensor in the CS225 or output from an SDI-12 device must have a unique SDI-12 address (see TABLE 7-4, *SDI-12 Addresses and Positions* *(p. 8)*).

The factory-set SDI-12 addresses for the CS225 start at 1 and continue until the last temperature sensor. The CS225 SDI-12 address is changed in software by issuing the **aAb!** command to the CS225 over the SDI-12 interface, where *a* is the current address and *b* is the new address. The current addresses of the individual sensors can be found by issuing the **a!** command.

Campbell Scientific dataloggers (with the exception of the CR5000) support a method of directly interacting with SDI-12 sensors via a terminal emulator. This allows you to receive confirmation that the change of address has worked, using the **a!** command. This can be done using a computer running *LoggerNet* to issue and valid SDI-12 command through the datalogger to the CS225 as described in the following sections.

7.3.1 CR1000 and CR800 series Dataloggers

1. Connect the CS225 to the datalogger using Control Port C1 or C3, as described in Section 7.1, *Wiring* *(p. 4)*. Be sure the datalogger is not running a program that contains the **SDI12Recorder()** instruction on the port used.

2. Assume that the datalogger is configured to **Setup** and able to communicate via *LoggerNet*, navigate to the **Connect** screen. Select **Terminal Emulator** under the **Datalogger** menu. The **Terminal**

Emulator window will open. In the **Select Device** menu, located in the lower left-hand side of the window, select the station.

3. Click on the **Open Terminal** button.

4. Press the <enter> key until the datalogger responds with the CR800 prompt. Type *SDI12* and select the appropriate port.

5. If the CS225 temperature sensor addresses are unknown, then conduct a query for each sensor's current SDI-12 address with the **aI!** command. If no characters are typed within 12 seconds, then the mode is exited. Once a complete list of addresses is gathered, you will know what block of addresses are required to readdress the CS225. You will also be able to request the related metadata so that sensor locations are confirmed. Be sure to reference TABLE 7-4, *SDI-12 Addresses and Positions* *(p. 8)*, for a list of appropriate addresses.

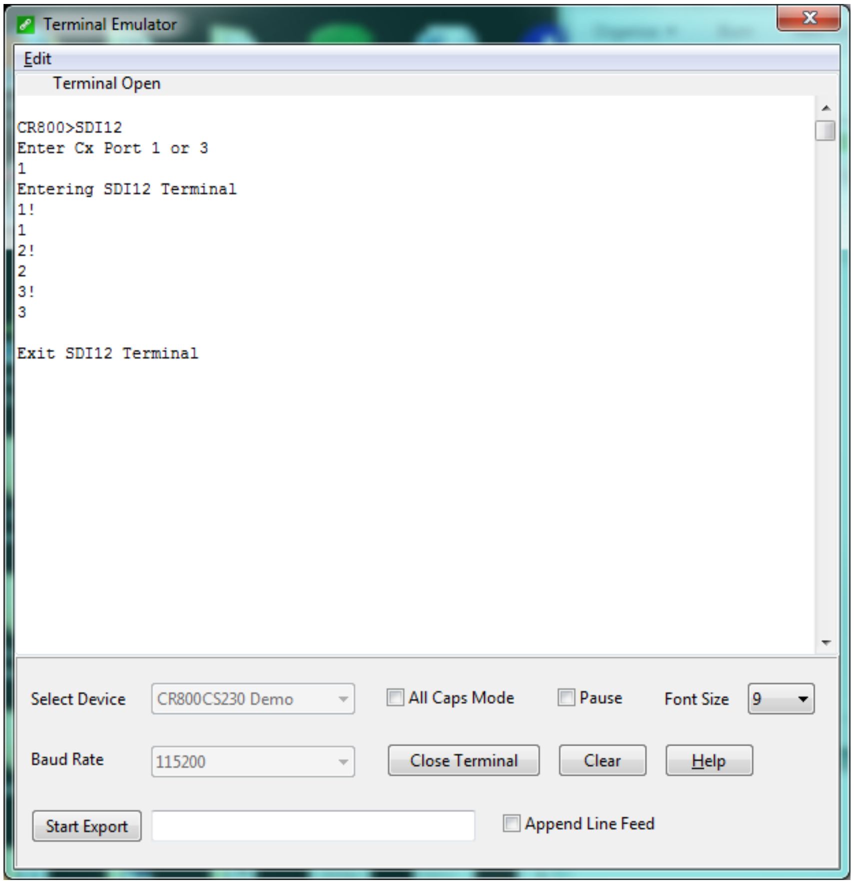

FIGURE 7-2. Screen capture of SDI-12 transparent mode on CRBasic CR800 datalogger using control port 1 and prompting for SDI-12 addresses

6. To change the SDI-12 address, press <enter>. At the "CR800>""CR1000>" prompt, enter the command **SDI-12** and press the <enter> key. Enter the appropriate control port, press the <enter> key and enter **aAb!**; where *a* is the current address from the above step and *b* is the

new address. The temperature sensor will change its address and the datalogger will respond with the new address and then exit SDI-12 transparent mode.

8. Maintenance and Calibration

The CS225 string requires no maintenance or calibration.

9. Troubleshooting

Symptom: –9999 or NAN for temperature

1. Verify the green wire is connected to the control port specified by the SDI-12 measurement instruction.

2. Verify the red power wire is connected to a 12 V terminal; check the voltage with a digital volt meter. If a switched 12 V terminal is used, temporarily disconnect the red wire to a 12 V terminal (non-switched) for test purposes.

Symptom: Sensor will not respond to command.

1. Expected address not used or has been changed.

   a. In this case, you may wish to confirm all addresses in use with the **aI!** command in a trial and error fashion. You will be able to determine the individual addresses of each temperature sensor.

2. Expected sensor address matches another sensor address already in use.

   a. When readdressing the temperature sensors, you must avoid giving multiple sensors the same address. If this occurs, you will no longer be able to communicate with these sensors. Use the **aA{!** command, where *a* is the affected address. This will reset the affected sensors to their factory configured address value.

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