



Measuring a PRT or Thermistor without a Completion Resistor

GRANITE 6, CR6, CR1000X, CR300 Series

App Note Code: 2T-0

Table of contents

1. Introduction	1
2. Measuring a PRT or a thermistor using the CurrentSE() instruction	2
2.1 CR300 series	2
2.2 GRANITE 6, CR6 (serial number 8000 and higher), or CR1000X	4
3. Measuring an unknown resistor using the VoltDiff() instruction	6
4. Measurement example	8

1. Introduction

Platinum resistance thermometers (PRT) and thermistors (temperature sensors) typically require a completion resistor or terminal input resistor (TIM) to complete the measurement circuit. Newer Campbell Scientific data loggers have built-in high precision resistors for a variety of measurement purposes. With a simple understanding of Ohm's law, these resistors can be utilized to measure an unknown resistor using PRTs.

This application note discusses two methods of measuring a PRT or thermistor without an external completion resistor. The first method uses the `CurrentSE()` instruction to make a single-ended current measurement. The second method uses the `VoltDiff()` instruction to measure an unknown resistor. The `CurrentSE()` method requires only two analog terminals, while the `VoltDiff()` method requires four. However, the `VoltDiff()` method improves the accuracy of the measurement.

In many cases, the accuracy of the methods described in this application note are adequate. However, when high accuracy is required, using a TIM is recommended.

Table 1-1 (p. 1) shows data loggers with this capability.

Data logger	Terminals
CR300 series	SE1 and SE2, 100 Ω
CR1000X	RG1 and RG2, 101 Ω (91 Ω + 10 Ω) ¹
CR6, GRANITE 6 (serial number 8000+)	RG, 101 Ω (91 Ω + 10 Ω) ¹
¹ RG = resistive ground	

2. Measuring a PRT or a thermistor using the `CurrentSE()` instruction

The `CurrentSE()` instruction is used to make a single-ended current measurement using the **SE1** and **SE2** terminals on the CR300-series data loggers, or the resistive ground (**RG**) terminals on the GRANITE 6, CR1000X, and CR6 data loggers. Using `CurrentSE()` will also measure the value of a resistive sensor.

2.1 CR300 series

CR300-series terminals **SE1** and **SE2** have a built-in resistor of 100 Ω to read a 4-20 mA current sensor. The accuracy of the measured current is $\pm 0.14\%$ of the measurement from 0 to 40 $^{\circ}\text{C}$, or $\pm 0.26\%$ for the temperature range of -40 to 80 $^{\circ}\text{C}$. This method uses the value of the excited voltage. No additional analog channels are required.

NOTE:

Significant series-resistor errors may occur when 2-wire measurements are made with long cable lengths. In applications where high accuracy is critical, a TIM is recommended.

[CRBasic Example 1](#) (p. 4) uses the Omega 1000 Ω PRT to demonstrate the method.

[FIGURE 2-1](#) (p. 3) shows the wiring between the PRT/thermistor and the data logger.

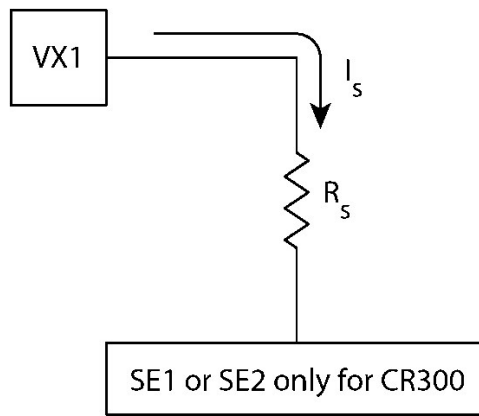


FIGURE 2-1. Wiring for PRT/thermistor measurement using the `CurrentSE()` instruction with the CR300

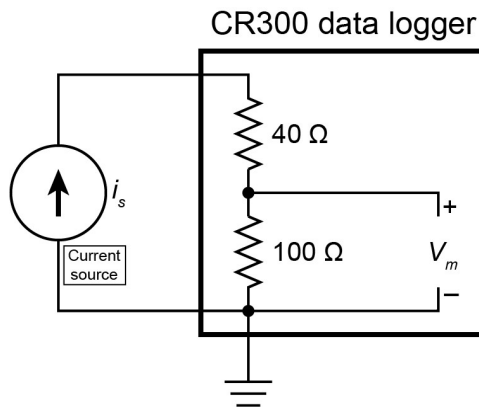


FIGURE 2-2. CR300-series internal resistance

The current in the circuit is given as I_s . This current is flowing through a total resistance of $140\ \Omega$ built into the data logger and the resistor R_s .

The resistance R_s can be determined using following equation:

$$R_s = \frac{V_{z1}}{I_s} - 140$$

CRBasic Example 1 (p. 4) demonstrates using the `CurrentSE()` instruction with a CR300-series data logger.

CRBasic Example 1: Measuring a PRT with the CR300-series data logger

```
'CR300 Series Datalogger
'Use CurrentSE() to measure an Omega 1000 Ω PRT

Public PTemp, Batt_volt, I_s, Rs, PRT_Temp

DataTable (PRTTemp,1,-1)
  DataInterval (0,15,Sec,10)
  Minimum (1,Batt_volt,FP2,False,False)
  Sample (1,PTemp,FP2)
  Sample (1,PRT_Temp,FP2)
EndTable

BeginProg
  Scan (1,Sec,0,0)
  PanelTemp (PTemp,60)
  Battery (Batt_volt)
  ExciteV (Vx1,250,0) 'Apply excitation
  CurrentSE (I_s,1,mv34,1,1,3000,60,1.0,0)
  ExciteV (Vx1,0,0) 'Turn off excitation
  Rs = (250/I_s - 140)
  PRTCalc (PRT_Temp,1,Rs/1000,1,1.0,0)
  CallTable PRTTemp
  NextScan
EndProg
```

2.2 GRANITE 6, CR6 (serial number 8000 and higher), or CR1000X

The GRANITE 6, CR6 (serial numbers 8000 and higher only), and CR1000X data loggers have a built-in resistance of 101 Ω which allows 4-20 mA sensors to be measured using an **RG** terminal. The measurement is made across a 10 Ω resistor with a 91 Ω resistor in series in the circuit. Any unknown resistor can be measured using an **RG** terminal.

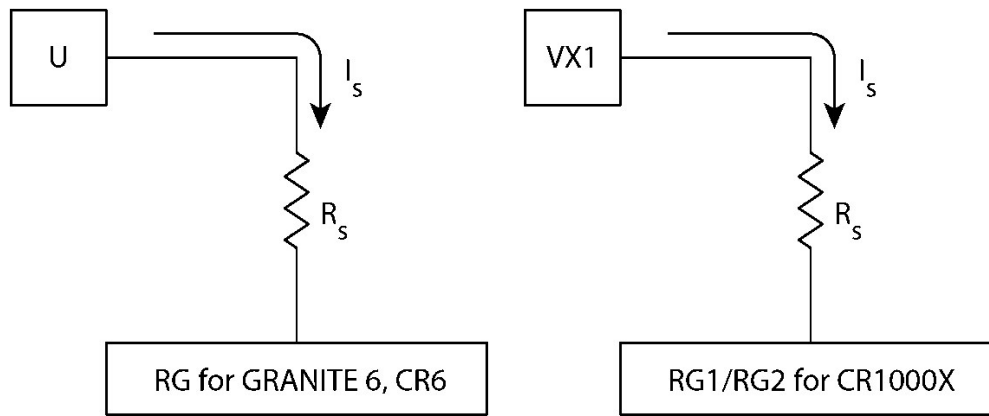


FIGURE 2-3. Wiring for PRT/thermistor measurement using [CurrentSE\(\)](#) instruction with the GRANITE 6, CR6, or CR1000X

Using [CurrentSE\(\)](#) will also measure the value of a resistive sensor. In the case of a PRT or thermistor, the temperature can be measured without the use of a TIM module or any other completion resistor. [FIGURE 2-4](#) (p. 5) shows the wiring for the GRANITE 6, CR6, and CR1000X. The [CurrentSE\(\)](#) instruction is used to measure the current I_s in the circuit.

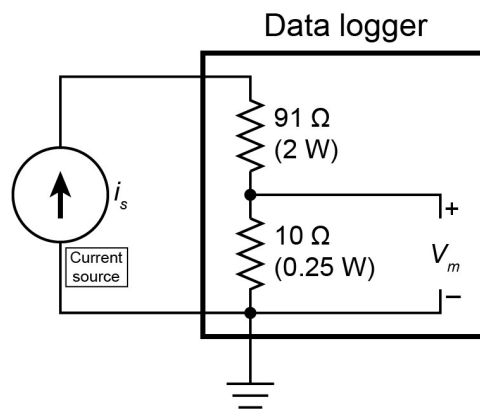


FIGURE 2-4. GRANITE 6, CR6, CR1000X internal resistance

The unknown sensor resistance can be calculated with this formula:

$$R_s = \frac{V_{x1}}{I_s} - 101$$

The accuracy of the current measurement is about 0.1%, and the accuracy on V_{x1} is 12-bit. Together these two values will determine the accuracy of the measurement.

[CRBasic Example 2](#) (p. 6) demonstrates measuring an Omega 1000 Ω PRT with the [CurrentSE\(\)](#) instruction.

CRBasic Example 2: Measuring a PRT with the GRANITE 6, CR6, and CR1000X data loggers

```
'GRANITE 6, CR6, and CR1000X data loggers
'Use CurrentSE() to measure an Omega 1000 Ω PRT

Public PTemp, Batt_volt, I_s, Rs, PRT_Temp

DataTable (PRTTemp,1,-1)
  DataInterval (0,15,Sec,10)
  Minimum (1,Batt_volt,FP2,False,False)
  Sample (1,PTemp,FP2)
  Sample (1,PRT_Temp,FP2)
EndTable

BeginProg
  Scan (1,Sec,0,0)
  PanelTemp (PTemp,60)
  Battery (Batt_volt)
  'Change Vx1 to U terminal when using the GRANITE 6/CR6.
  ExciteV (Vx1,250,0) 'Apply excitation
  'Change the RGChan parameter to RG when using the GRANITE 6/CR6.
  CurrentSE (I_s,1,mV200,RG1,1,3000,60,1.0,0)
  'Change Vx1 to U terminal when using the GRANITE 6/CR6.
  ExciteV (Vx1,0,0) 'Turn excitation off
  Rs = (250/I_s - 101)
  PRTCalc (PRT_Temp,1,Rs/1000,1,1.0,0)
  CallTable PRTTemp
NextScan
EndProg
```

3. Measuring an unknown resistor using the `Voltdiff()` instruction

NOTE:

This method is most relevant to the CR300-series and CR1000X data loggers. The GRANITE 6 and CR6 provide high accuracy 3-wire or 4-wire PRT measurements on native U terminals without a TIM. Refer to data logger specifications for details.

It is also possible to measure the voltage drop across R_s using the `Voltdiff()` instruction. This method requires an additional H and L terminal pair to measure the voltage drop across the sensor resistor. The wiring diagram is shown in [FIGURE 3-1](#) (p. 7).

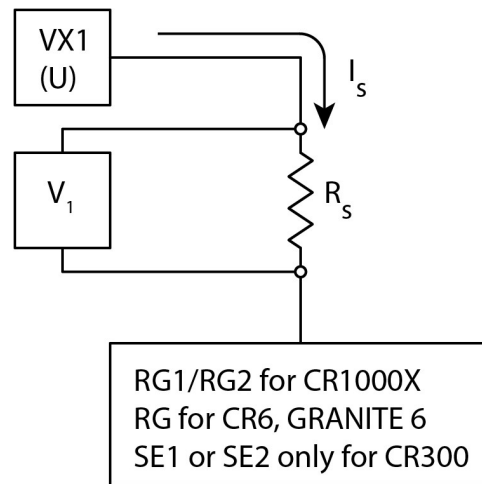


FIGURE 3-1. Wiring for PRT/thermistor measurements with extra volt diff measurement for high accuracy

The following equation can be used to determine the resistance R_s of the sensor.

$$R_s = \frac{V_1}{I_s}$$

Since V_1 is measured with 24-bit accuracy, this measurement results in better accuracy compared to the `CurrentSE()` method at the cost of one differential analog channel.

This example begins with the `CurrentSE()` instruction to determine the amperage value for I_s . It then uses the `Voltdiff()` instruction to measure the voltage value for V_1 . Those variables are then used to calculate the sensor resistance value of R_s .

CRBasic Example 3: Using VoltDiff() to measure V_1

```
'GRANITE 6, CR6, CR1000X, and CR300-series data loggers
'Use VoltDiff() to measure an Omega 1000  $\Omega$  PRT

Public PTemp, Batt_volt, I_s, Rs, PRT_Temp,V1

DataTable (PRTTemp,1,-1)
  DataInterval (0,15,Sec,10)
  Minimum (1,Batt_volt,FP2,False,False)
  Sample (1,PTemp,FP2)
  Sample (1,PRT_Temp,FP2)
EndTable

BeginProg
  Scan (1,Sec,0,0)
  PanelTemp (PTemp,60)
  Battery (Batt_volt)
  'Change excitation channel to U1 (or other U terminal) when using GRANITE 6/CR6.
  ExciteV (Vx1,2500,0,0) 'Apply excitation
  'Change RGChan parameter to RG for GRANITE 6/CR6, or to SE1 or SE2 for CR300.
  CurrentSE (I_s,1,mV200,RG1,1,3000,60,1.0,0)
  'Change differential channel to U3 (or other U terminal) for GRANITE 6/CR6.
  VoltDiff (V1,1,mV1000,2,True ,3000,60,1.0,0)
  'Change excitation channel to U1 (or other U terminal) when using GRANITE 6/CR6.
  ExciteV (Vx1,0,0,0) 'Turn off excitation
  Rs = (V1/I_s)
  PRTCalc (PRT_Temp,1,Rs/1000,1,1.0,0)
  CallTable PRTTemp
  NextScan
EndProg
```

4. Measurement example

FIGURE 4-1 (p. 9) shows a measurement from two Omega 1000 Ω PRTs using the **CurrentSE()** method. One sensor was dipped in a cold bath and the other in a hot bath, and then both were removed and left in the air near each other. This measurement was made on a CR310 using VX1 as excitation for both sensors.

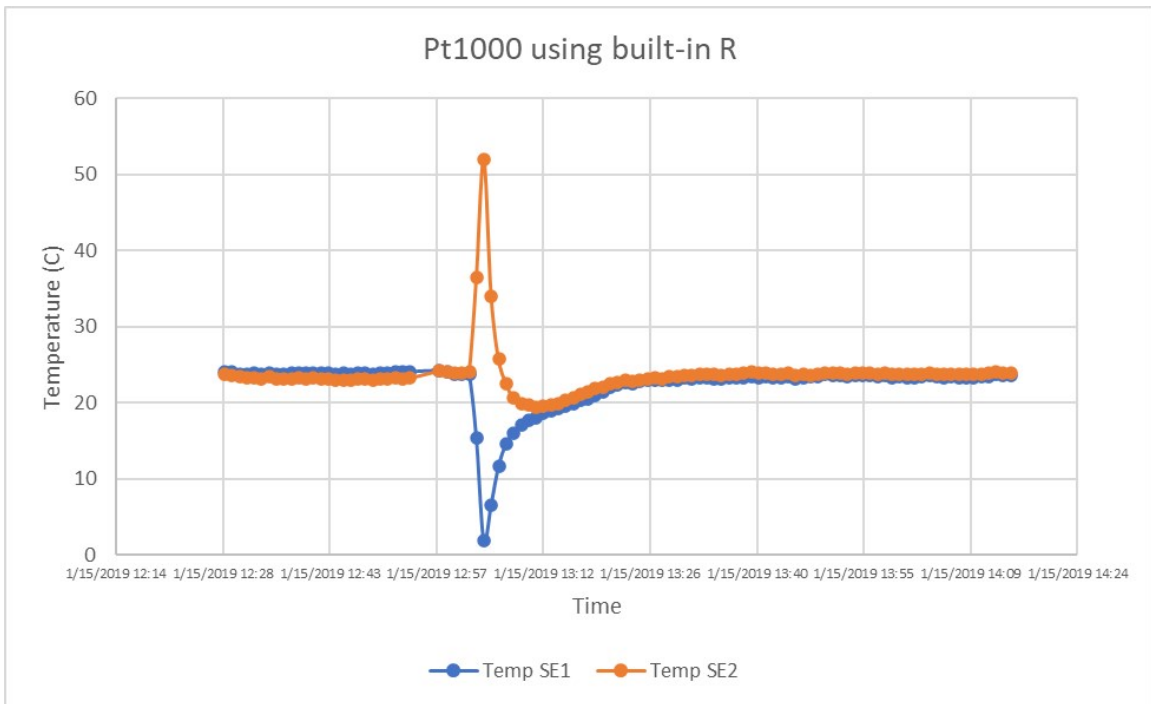


FIGURE 4-1. One minute average temperature measurement using CR310. Sensor on SE1 was dipped in cold water and sensor on SE2 was dipped in hot water for small period.



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