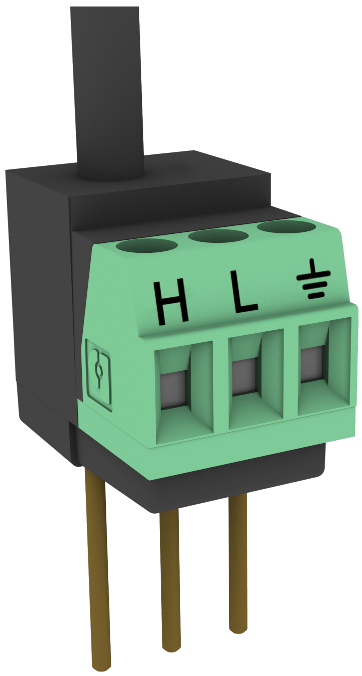
Product Manual

Measurement & Control Peripheral

3WHB10K

3-Wire Half Bridge Terminal Input Module



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1. Function

A terminal input module (TIM) connects directly to a data logger or GRANITE analog input module. It provides completion resistors for resistive bridge measurements, voltage dividers, and precision current shunts. The 3WHB10k is used in 3-wire half bridge measurements and includes a 10 kΩ completion resistor.

> **NOTE:**
> The GRANITE 6 and CR6 include the fixed resistor and current excitation required to complete the half-bridge circuit without a terminal input module. However, the GRANITE 6 and CR6 are still compatible with a terminal input module and may be used with one, should the application require it.

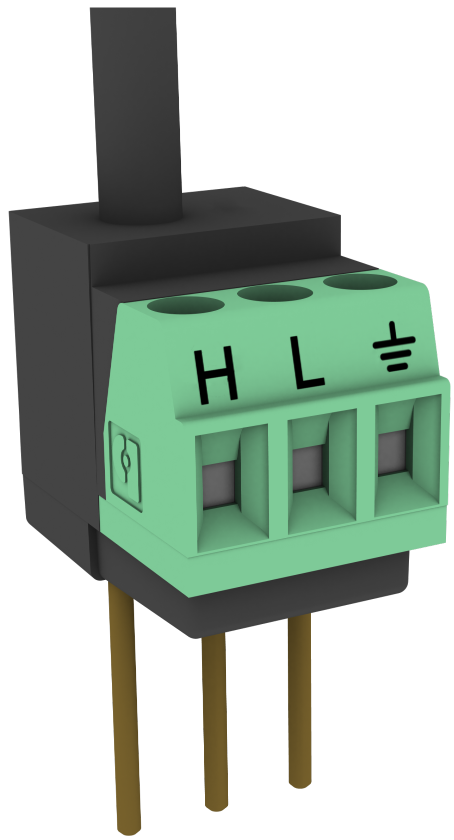

Figure 1-1. Terminal input module

2. Specifications

10 kΩ completion resistor	
Tolerance @ 25 °C:	±0.01%
Maximum temperature coefficient	±0.8 ppm/°C
Power rating @ 70 °C:	0.25 W
Compliance:	View compliance documents at: www.campbellsci.com/3whb10k

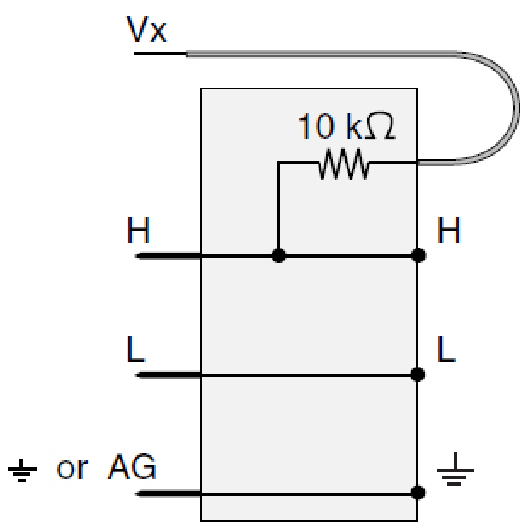

Figure 2-1. Schematic

3. Wiring

The terminal input module is connected to adjacent **H** and **L** terminals. When making 3-wire half bridge measurements, the 3WHB10K performs two single-ended measurements. The sense wires from the platinum resistance thermometer (PRT) attach to the 3WHB10K. The black excitation wire is connected to an excitation terminal. In the following example, the 3WHB10K is connected to the **1H** and **1L** terminals, using them for two single-ended measurements. The excitation wire is connected to excitation terminal **VX1** (Figure 3-1 [p. 3]).

Often, sensors only have two wires. Use the 3WHB10K as a fixed, known resistor to measure them. Wire a jumper between the **H** and **L** terminals on the 3WHB10K to allow the sensor to receive excitation voltage. Without the jumper, the sensor will not function. See Figure 3-1 (p. 3).

When using a 2-wire sensor with the 3WHB10K, use the `BrHalf()` (or `CDM_BrHalf()`) instruction in place of the `BrHalf3W()` (or `CDM_BrHalf3W()`) instruction. The parameters of the `BrHalf3W()` and `BrHalf()` instructions are identical; so, only the instruction name needs to be changed in the Programming examples (p. 4) example programs.

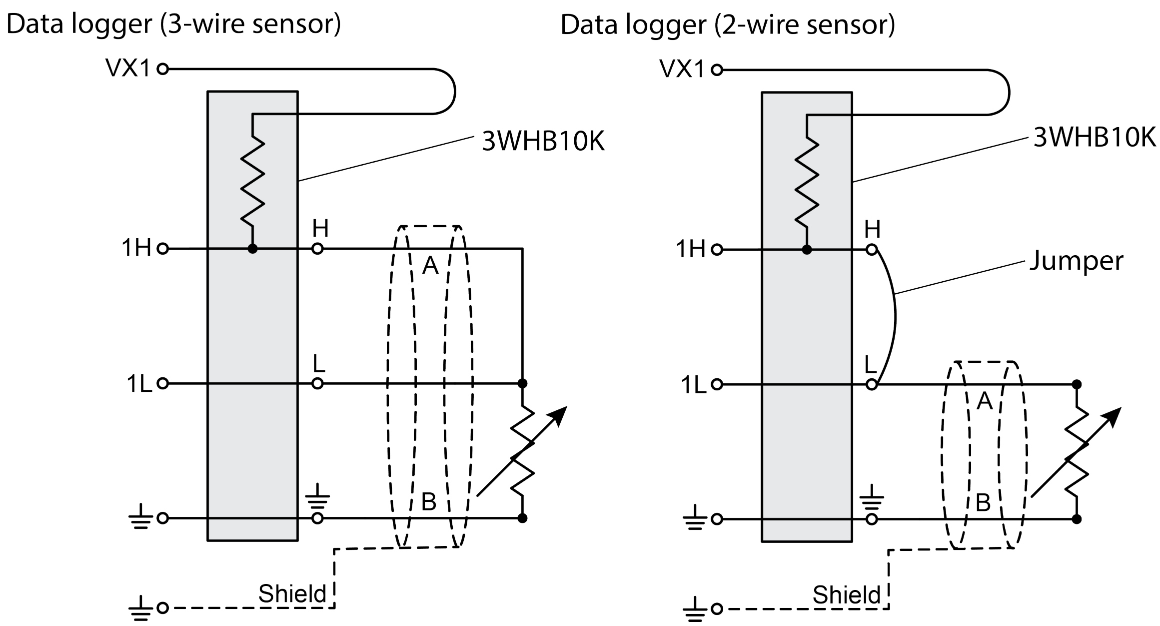

Figure 3-1. 3-wire half bridge used to measure PRT

Table 3-1: 3WHB10K connections to Campbell Scientific data loggers					
Function	Label/Wire	GRANITE analog input module	GRANITE 6, CR6	CR3000, CR1000X, CR800, CR850, CR1000	CR9000X
Excitation	Black wire	X1	U5	VX1	Excitation 1
V1 high reference	H	1H	U1	1H	1H
V1 low sense	L	1L	U2	1L	1L
Ground	G	⏚	⏚	⏚	⏚

[1] The GRANITE 9 and GRANITE 10 do not directly make analog measurements. Instead, they use analog input modules such as the VOLT 108 or VOLT 116. When making a half-bridge measurement, the terminal input module is connected to the analog input module, which is then connected to the GRANITE 9 or GRANITE 10.

4. Programming examples

The following examples show the two instructions necessary to 1) make the measurement and 2) calculate the temperature. The result of the half bridge measurement as shown is R_s/R_0, the input required for the PRT algorithm to calculate temperature.

If using a calibrated sensor, the exact measurement of R_0 will be known. Use this value to increase the accuracy of the `PRTCalc()` instruction by inserting the following equation between the `BrHalf4W()` and `PRTCalc()` instructions in the example programs.

Rs_R0 = Rs_R0*100/R0

where R0 is the sensor resistance at 0 °C

The following examples are based on a maximum sensor resistance of 100 Ω at 0 °C. The excitation voltages used were chosen with the assumption that the temperature would not exceed 50 °C. Calculation of optimum excitation voltage is discussed in Excitation voltage (p. 8).

4.1 GRANITE 9/10 program example

The GRANITE 9 and GRANITE 10 require the use of an analog input module, such as the VOLT 108, when making a half-bridge measurement.

CRBasic Example 1: GRANITE 9/10 3-wire half bridge example

```
'3-wire half bridge example
'GRANITE 9 and GRANITE 10 data loggers (with a VOLT 108)

'Declare Variables and Units
Public Temp_C_3wire
Public Rs_R0

'Define Data Tables
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,10)
  Average(1,Temp_C_3wire,IEEE4,False)
EndTable

'Main Program
BeginProg
  'Configure the VOLT 108 Module and assign it CPI address 'CPI_BUSA+1'
  CPIAddModule(VOLT108,10," ",CPI_BUSA+1)
  'Main Scan
  Scan(5,Sec,1,0)
    'Half Bridge, 3-wire measurements on the VOLT 108
    CDM_BrHalf3W(VOLT108,CPI_BUSA+1,Rs_R0,1,mV1000,1,1,1,3200,True,500,60,1,0)
    'PRT temperature calculation
    PRTCalc (Temp_C_3wire,1,Rs_R0,0,1.0,0)
    'Call Data Tables and Store Data
    CallTable Hourly
  NextScan
EndProg
```

4.2 GRANITE 6/CR6 program example

The GRANITE 6 and CR6 include the fixed resistor and current excitation required to complete the half-bridge circuit without a terminal input module. However, the GRANITE 6 and CR6 are still compatible with a terminal input module and may be used with one, should the application require it.

CRBasic Example 2: GRANITE 6/CR6 3-wire half bridge example

```
'GRANITE 6/CR6 data logger 3-wire half bridge using a terminal input module

Public Rs_R0, Temp_C

DataTable (Hourly,True,-1)
  DataInterval (0,60,Min,0)
  Average (1,Temp_C,IEEE4,0)
EndTable

BeginProg
  Scan (1,Sec,0,0)
    BrHalf3W (Rs_R0,1,mV1000,U1,U4,1,2500,True ,0,250,100,0)
    PRTCalc (Temp_C,1,Rs_R0,0,1,0)
    CallTable Hourly
  NextScan
EndProg
```

4.3 CR1000X program example

CRBasic Example 3: CR1000X 3-wire half bridge example

```
'CR1000X-series data logger 3-wire half bridge

Public Rs_R0, Temp_C

DataTable (Hourly,True,-1)
  DataInterval (0,60,Min,0)
  Average (1,Temp_C,IEEE4,0)
EndTable

BeginProg
  Scan (1,Sec,0,0)
    BrHalf3W (Rs_R0,1,mV1000,1,Vx1,1,3200,True ,0,250,100,0)
    PRTCalc (Temp_C,1,Rs_R0,0,1,0)
    CallTable Hourly
  NextScan
EndProg
```

4.4 CR1000 program example

CRBasic Example 4: CR1000 3-wire half bridge example

```
'CR1000-series data logger 3-wire half bridge

Public Rs_R0, Temp_C

DataTable (Hourly,True,-1)
  DataInterval (0,60,Min,0)
  Average (1,Temp_C,IEEE4,0)
EndTable

BeginProg
  Scan (1,Sec,0,0)
    BrHalf3W (Rs_R0,1,mV2500,1,Vx1,1,2500,True,0,250,100,0)
    PRTCalc (Temp_C,1,Rs_R0,0,1,0)
    CallTable Hourly
  NextScan
EndProg
```

4.5 CR9000X program example

CRBasic Example 5: CR9000X 3-wire half bridge example

```
'CR9000X data logger 3-wire half bridge

Public Rs_Ro, Temp_F

DataTable (Temp_F,1,-1)
  DataInterval (0,60,Min,0)
  Sample (1,Temp_F,FP2)
EndTable

BeginProg
  Scan (1,mSec,0,0)
    BrHalf3W (RS_Ro,1,mV1000,5,1,6,1,1,3200,True,30,40,100,0)
    PRTCalc (Temp_F,1,Rs_Ro,0,1.8,32)
    CallTable Temp_F
  NextScan
EndProg
```

5. 100 Ohm PRT in 3-wire half bridge

The advantages of the 3-wire half bridge over other measurements that correct for wire resistance such as a 4-wire half bridge, are that it only requires 3 wires going to the sensor and takes 2 single-ended terminals, whereas the 4-wire half bridge requires 4 wires and 2 differential channels.

The result of the 3-wire half bridge instruction is equivalent to the ratio of the PRT resistance, R_s to the resistance of the 10 k fixed resistor, R_f.

$$\frac{R_s}{R_f}$$

The `PRTCalc()` instruction computes the temperature (°C) for a DIN 43760 standard PRT from the ratio of the PRT resistance at the temperature being measured (R_s) to its resistance at 0 °C (R_0). Thus, a multiplier of R_f/R_0 is used with the 3-wire half bridge instruction to obtain the desired intermediate, $R_s/R_0 = (R_s/R_f \times R_f/R_0)$. If R_f and R_0 are equal, the multiplier is 1.

The fixed resistor must be thermally stable. The 0.8 ppm/°C temperature coefficient would result in a maximum error of 0.035 °C at 125 °C. This measurement is ratiometric (R_s/R_f) and does not rely on the absolute values of either R_s or R_f.

The properties of the 10 kΩ resistor do not affect the result. The purpose of this resistor in the circuit is to limit current.

5.1 Excitation voltage

When determining the excitation voltage, it is important to consider the maximum excitation current the sensor can experience without self-heating. This is typically less than 0.35 mA. Refer to the manufacturer's sensor data sheet for the specific value.

Once the maximum excitation current is known, the excitation voltage is then calculated.

$$V_x = I_x (R_f + R_{Smax})$$

Where:

R_f = PRT completion resistor value

R_{Smax} = Maximum sensor resistance based on the maximum expected temperature to be measured

Using the typical 0.35 mA maximum excitation current, the maximum excitation voltage for the sensor when R_{Smax} is 100 Ω is:

$$V_x = 0.35 \text{ mA } (10 \text{ k}\Omega + 100\ \Omega) = 3.54 \text{ V}$$

When R_{Smax} is 1.25 kΩ, this changes to:

$$V_x = 0.35 \text{ mA } (10 \text{ k}\Omega + 1.25 \text{ k}\Omega) = 3.94 \text{ V}$$

5.2 Calibrating a PRT

The greatest source of error in a PRT is likely to be that the resistance at 0 °C deviates from the nominal value. Calibrating the PRT in an ice bath can correct this offset and any offset in the fixed resistor in the terminal input module.

The result of the 3-wire half bridge is:

$$\frac{V_2}{V_1} = \frac{I \bullet R_s}{I \bullet R_f} = \frac{R_s}{R_f}$$

With the PRT at 0 °C, R_s=R_0. Thus, the above result becomes R_0/R_f, the reciprocal of the multiplier required to calculate temperature, R_f/R_0. By making a measurement with the PRT in an ice bath, errors in both R_s and R_0 can be accounted for.

To perform the calibration, connect the PRT to the data logger and program the data logger to measure the PRT with the 3-wire half bridge as shown in the example section (multiplier = 1). Place the PRT in an ice bath (@ 0 °C; R_s=R_0). Read the result of the bridge measurement. The reading is R_s/R_f, which is equal to R_0/R_f since R_s=R_0. The correct value of the multiplier, R_f/R_0, is the multiplier used divided by this reading. For example, if, with a 100 Ω PRT, the initial reading is 0.9890, the correct multiplier is: R_f/R_0 = 100/0.9890 = 101.11.

5.3 Compensation for wire resistance

The 3-wire half bridge compensates for wire resistance by assuming that the resistance of wire A is the same as the resistance of wire B (Figure 3-1 [p. 3]). The maximum difference expected in wire resistance is 2%, but is more likely to be on the order of 1%. The resistance of R_s calculated with `BrHalf3W()`, is actually R_s plus the difference in resistance of wires A and B.

For example, assume that a 100 Ω PRT is separated from the data logger by 500 feet of 22 AWG wires. The average resistance of 22 AWG wire is 16.5 Ω per 1000 feet, which would give each 500-foot wire a nominal resistance of 8.3 Ω. Two percent of 8.3 Ω is 0.17 Ω. Assuming that the greater resistance is in wire B, the resistance measured for the PRT (R_0 = 100 Ω) in the ice bath would be

100.17 Ω, and the resistance at 40 °C would be 115.71. The measured ratio R_s/R_0 is 1.1551; the actual ratio is 115.54/100 = 1.1554. The temperature computed by `PRTCalc()` from the measured ratio would be about 0.1 °C lower than the actual temperature of the PRT. This source of error does not exist in a 4-wire half bridge where a differential measurement is used to directly measure the voltage across the PRT.

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- Use only manufacturer recommended parts, materials, and tools.

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- 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.

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.

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.

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