4WPB100, 4WPB1K
PRT Bridge Terminal Input Modules
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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 4WPB100 and 4WPB1K are used to provide completion resistors for 4 wire half bridge measurements of 100 Ω and 1 kΩ platinum resistance thermometer (PRT), respectively.

**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

Current limiting 10 kΩ resistor

- Tolerance @ 25 °C: ±5%
- Power rating: 0.25 W

Completion resistor

- Tolerance @ 25 °C: ±0.01%
- Maximum temperature coefficient: ±0.8 ppm/°C
- Power rating @ 70 °C: 0.25 W


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**FIGURE 2-1. Circuit schematic**
3. Wiring

When making 4-wire half bridge measurements, the 4WPB is connected to adjacent H and L terminals to perform a differential measurement. The sense wires from the PRT (indicated by dashed lines in FIGURE 3-1 on page 3) are connected to a second pair of H and L terminals to perform a differential measurement. The black excitation wire is connected to an excitation terminal. In the following example, the 4WPB is connected to the 1H and 1L terminals, and the PRT to the 2H and 2L terminals. The excitation wire is connected to the VX1 terminal.

![Diagram showing wiring setup](image)

**FIGURE 3-1. Wiring for example program**

The terminal spacing of the GRANITE 6 and GRANITE analog input module is different than other data loggers. The terminal input modules are still compatible, but the pins must be gently bent inward a small amount to allow the terminal input module to be mounted.

It is still possible to use terminal input modules in adjacent terminal blocks if the modules are staggered. This is done by gently bending one module forward and the next terminal backward enough to clear the first module. Continue to alternate the modules as needed.
Table 3-1: 4WPB100/4WPB1K connections to Campbell Scientific data loggers

<table>
<thead>
<tr>
<th>Function</th>
<th>Label/Wire</th>
<th>GRANITE analog input module</th>
<th>GRANITE 6, CR6</th>
<th>CR3000, CR1000X, CR800, CR850, CR1000</th>
<th>CR9000X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excitation</td>
<td>Black wire</td>
<td>X1</td>
<td>U5</td>
<td>VX1</td>
<td>Excitation 1</td>
</tr>
<tr>
<td>V1 high</td>
<td>H</td>
<td>1H</td>
<td>U1</td>
<td>1H</td>
<td>1H</td>
</tr>
<tr>
<td>V1 low</td>
<td>L</td>
<td>1L</td>
<td>U2</td>
<td>1L</td>
<td>1L</td>
</tr>
<tr>
<td>Ground</td>
<td>G</td>
<td>⊥</td>
<td>⊥</td>
<td>⊥</td>
<td>⊥</td>
</tr>
</tbody>
</table>

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.

\[
R_s/R_0 = R_s/R_0*100/R_0
\]

where R_0 is the sensor resistance at 0 °C

The following examples are for a 100 Ω PRT and 4WPB100. 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. 9). Using the 4WPB1K allows for a higher excitation voltage.
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.

<table>
<thead>
<tr>
<th>CRBasic Example 1: GRANITE 9/10 4-wire half bridge example</th>
</tr>
</thead>
<tbody>
<tr>
<td>'4-wire half bridge example</td>
</tr>
<tr>
<td>'GRANITE 9 and GRANITE 10 data loggers (with a VOLT 108)</td>
</tr>
<tr>
<td>'Declare Variables and Units</td>
</tr>
<tr>
<td>Public Temp_C_4wire</td>
</tr>
<tr>
<td>Public Rs_R0</td>
</tr>
<tr>
<td>'Define Data Tables</td>
</tr>
<tr>
<td>DataTable(Hourly,True,-1)</td>
</tr>
<tr>
<td>DataInterval(0,60,Min,10)</td>
</tr>
<tr>
<td>Average(1,Temp_C_4wire,IEEE4,False)</td>
</tr>
<tr>
<td>EndTable</td>
</tr>
<tr>
<td>'Main Program</td>
</tr>
<tr>
<td>BeginProg</td>
</tr>
<tr>
<td>'Configure the VOLT 108 Module and assign it CPI address 'CPI_BUSA+1'</td>
</tr>
<tr>
<td>CPIAddModule(VOLT108,&quot;&quot;,CPI_BUSA+1)</td>
</tr>
<tr>
<td>'Main Scan</td>
</tr>
<tr>
<td>Scan(5,Sec,1,0)</td>
</tr>
<tr>
<td>'Half Bridge, 4-wire measurements on the VOLT 108</td>
</tr>
<tr>
<td>CDM_BrHalf4W(VOLT108,CPI_BUSA+1,Rs_R0,1,mV1000,mV1000,1,1,1,400, _</td>
</tr>
<tr>
<td>True,True,500,60,1,0)</td>
</tr>
<tr>
<td>'PRT temperature calculation</td>
</tr>
<tr>
<td>PRTCALC(Temp_C_4wire,1,Rs_R0,0,1.0,0)</td>
</tr>
<tr>
<td>'Call Data Tables and Store Data</td>
</tr>
<tr>
<td>CallTable Hourly</td>
</tr>
<tr>
<td>NextScan</td>
</tr>
<tr>
<td>EndProg</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>CRBasic Example 2: GRANITE 6/CR6 4-wire half bridge example</th>
</tr>
</thead>
<tbody>
<tr>
<td>'GRANITE 6/CR6 data logger 4-wire half bridge</td>
</tr>
<tr>
<td>Public Rs_R0, Temp_C</td>
</tr>
<tr>
<td>DataTable (Hourly,True,-1)</td>
</tr>
<tr>
<td>DataInterval (0,60,Min,0)</td>
</tr>
<tr>
<td>Average (1,Temp_C,IEEE4,0)</td>
</tr>
<tr>
<td>EndTable</td>
</tr>
<tr>
<td>BeginProg</td>
</tr>
<tr>
<td>Scan (1,Sec,0,0)</td>
</tr>
<tr>
<td>BrHalf4W (Rs_R0,1,mV1000,mV1000,U1,U5,1,400,True,True,0,250,1.0,0)</td>
</tr>
<tr>
<td>PRTCalc (Temp_C,1,Rs_R0,0,1,0)</td>
</tr>
<tr>
<td>CallTable Hourly</td>
</tr>
<tr>
<td>NextScan</td>
</tr>
<tr>
<td>EndProg</td>
</tr>
</tbody>
</table>

4.3 CR1000X program example

<table>
<thead>
<tr>
<th>CRBasic Example 3: CR1000X 4-wire half bridge example</th>
</tr>
</thead>
<tbody>
<tr>
<td>'CR1000X-series data logger 4-wire half bridge</td>
</tr>
<tr>
<td>Public Rs_R0, Temp_C</td>
</tr>
<tr>
<td>DataTable (Hourly,True,-1)</td>
</tr>
<tr>
<td>DataInterval (0,60,Min,0)</td>
</tr>
<tr>
<td>Average (1,Temp_C,IEEE4,0)</td>
</tr>
<tr>
<td>EndTable</td>
</tr>
<tr>
<td>BeginProg</td>
</tr>
<tr>
<td>Scan (1,Sec,0,0)</td>
</tr>
<tr>
<td>BrHalf4W (Rs_R0,1,mV1000,mV1000,1,Vx1,1,400,True,True,0,250,1.0,0)</td>
</tr>
<tr>
<td>PRTCalc (Temp_C,1,Rs_R0,0,1,0)</td>
</tr>
<tr>
<td>CallTable Hourly</td>
</tr>
<tr>
<td>NextScan</td>
</tr>
<tr>
<td>EndProg</td>
</tr>
</tbody>
</table>
4.4 CR1000 program example

**CRBasic Example 4: CR1000 4-wire half bridge example**

'CR1000-series data logger 4-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)
    BrHalf4W(Rs_R0,1,mV250,mV250,1,Vx1,1,2500,True,True,0,250,1.0,0)
    PRTCalc (Temp_C,1,Rs_R0,0,1,0)
    CallTable Hourly
  NextScan
EndProg

4.5 CR9000X program example

**CRBasic Example 5: CR9000X 4-wire half bridge example**

'CR9000X data logger 4-wire half bridge

Public Rs_Ro, Temp_F

DataTable (Temp_F,1,-1)
  DataInterval (0,0,0,10)
  Sample (1,Temp_F,FP2)
EndTable

BeginProg
  Scan (1,mSec,0,0)
    BrHalf4W (Rs_Ro,1,mV1000,mV1000,4,1,5,7,1,400,True,True,30,40,1.0,0)
    PRTCalc (Temp_F,1,Rs_Ro,0,1.8,32)
    CallTable Temp_F
  NextScan
EndProg
5. PRT in 4-wire half bridge

A 4-wire half bridge is the best choice for accuracy where the platinum resistance thermometer (PRT) is separated from other bridge completion resistors by a wire length having more than a few thousandths of an Ohm resistance. Four wires to the sensor allows one set of wires to carry the excitation current with a separate set of sense wires allowing the voltage across the PRT to be measured without the effect of any voltage drop in the excitation wires. This arrangement cancels out both the effect of the wire length and differences in resistance of the excitation wires going out to and returning from the sensor.

FIGURE 2-1 (p. 2) shows the circuit used to measure the PRT. The 10 kΩ resistor allows the use of a high excitation voltage and low voltage ranges on the measurements. This insures noise in the excitation does not have an effect on signal noise, and that self heating of the PRT due to excitation is kept to a minimum. Because the fixed resistor (R_f) and the PRT (R_s) have approximately the same resistance, the differential measurement of the voltage drop across the PRT can be made on the same range as the differential measurement of the voltage drop across R_f.

The result of the four wire half bridge Instruction is:

\[ \frac{V_2}{V_1} \]

the voltage drop is equal to the current (I), times the resistance thus:

\[ \frac{V_2}{V_1} = \frac{I \cdot R_s}{I \cdot R_f} = \frac{R_s}{R_f} \]

The PRTCálc() 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_s/R_0 is used with the 4-wire half bridge instruction to obtain the desired intermediate, R_s/R_0 = (R_s/R_f x 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 data sheet for the sensor for the specific value.

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

\[ V_x = I_x (R_1 + R_{S\text{max}} + R_f) \]

Where:

- \( R_1 = 10 \text{ k}\Omega \), the current limiting resistor in the terminal input module
- \( R_{S\text{max}} \) = Maximum sensor resistance based on the maximum expected temperature to be measured
- \( R_f \) = PRT completion resistor value

Using the typical 0.35 mA maximum excitation current, the maximum excitation voltage for the sensor is:

For 4WPB100:

\[ V_x = 0.35 \text{ mA} \times (10,000 \Omega + 125 \Omega + 100 \Omega) = 3579 \text{ mV} \]

For 4WPB1K:

\[ V_x = 0.35 \text{ mA} \times (10,000 \Omega + 1250 \Omega + 1000 \Omega) = 4290 \text{ mV} \]

Small variations in sensor resistance do not cause significant differences in the calculated maximum excitation voltage. For example, changing the sensor resistance to 84 \( \Omega \) when used with the 4WPB100 reduces the maximum excitation from 3579 mV to 3564 mV.

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 4 wire half bridge is:

\[ \frac{V_2}{V_1} = \frac{I \cdot R_s}{I \cdot R_f} = \frac{R_s}{R_f} \]

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 4-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 reciprocal of this reading. For example, if the initial reading is 0.9890, the correct multiplier is: R_f/R_0 = 1/0.9890 = 1.0111.
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- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
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- 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.
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- 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.

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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