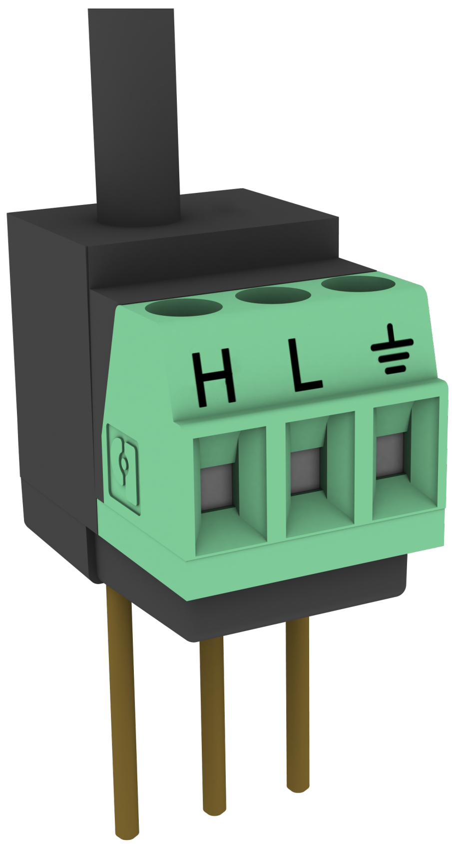
Product Manual

Measurement & Control Peripheral

4WPB100, 4WPB500, 4WPB1K

PRT Bridge Terminal Input Modules



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Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

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- Batteries
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About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area:	1 in^2 (square inch) = 645 mm^2	**Mass:**	1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Length:	1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km	**Pressure:**	1 psi (lb/in^2) = 68.95 mb
		Volume:	1 UK pint = 568.3 ml 1 UK gallon = 4.546 litres 1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

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Safety

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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, or 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.

Table of contents

1. Function

A terminal input module (TIM) connects directly to a data logger or GRANITE analogue input module. It provides completion resistors for resistive bridge measurements, voltage dividers, and precision current shunts. The 4WPB100, 4WPB500, and 4WPB1K are used to provide completion resistors for 4-wire half-bridge measurements of 100 Ω, 500 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.

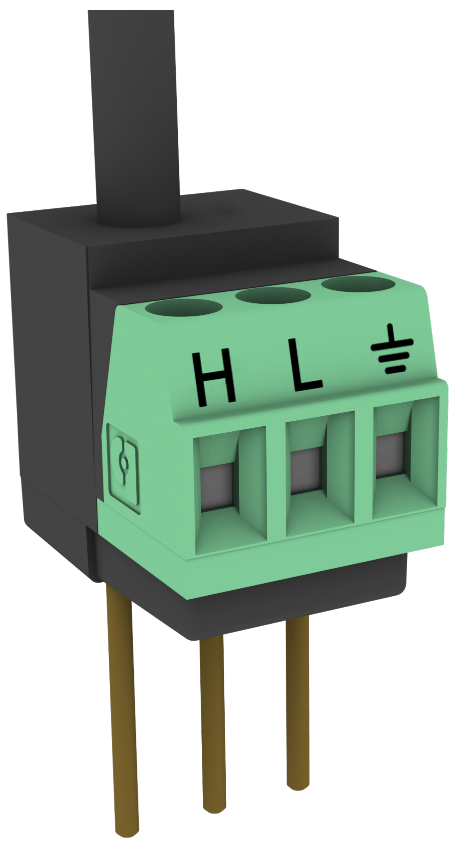

Figure 1-1. Terminal input module

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
Compliance:	View compliance documents at: www.campbellsci.eu/4wpb100 www.campbellsci.eu/4wpb500 www.campbellsci.eu/4wpb1k

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 (p. 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.

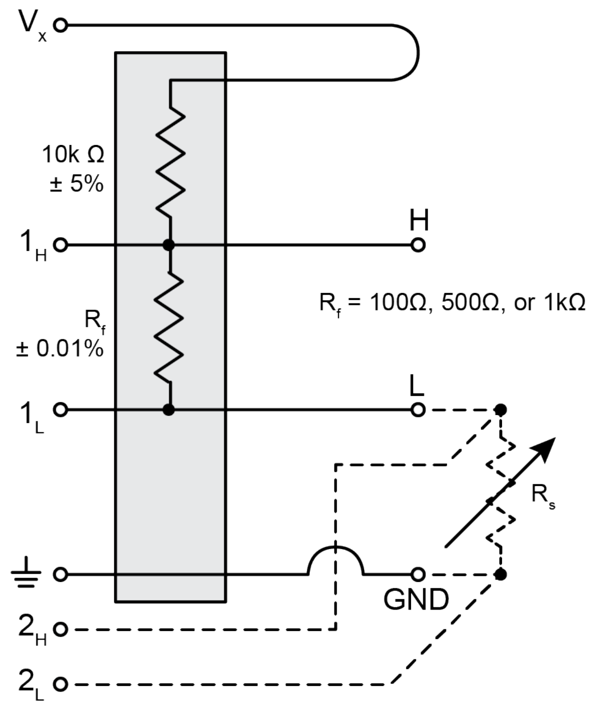

Figure 3-1. Wiring for example program

Table 3-1: 4WPB100/4WPB500/4WPB1K connections to Campbell Scientific data loggers

Function	Label/Wire	GRANITE analogue input module	GRANITE 6, CR6	CR3000, CR1000X, CR800, CR850, CR1000	CR9000X
Excitation	Black wire	X1	U5	VX1	Excitation 1
V1 high	H	1H	U1	1H	1H
V1 low	L	1L	U2	1L	1L
Ground	G	⏚	⏚	⏚	⏚

[1] The GRANITE 9 and GRANITE 10 do not directly make analogue measurements. Instead, they use analogue input modules such as the VOLT 108 or VOLT 116. When making a half-bridge measurement, the terminal input module is connected to the analogue 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 examples are for a 100 Ω PRT and 4WPB1K. 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.

When using the 4WPB100, the excitation voltage parameter in the `BrHalf4W()` instruction on data loggers with a 4000 mV maximum excitation voltage must be set to a lower value. As shown in Excitation voltage (p. 9), the maximum excitation voltage when using the 4WPB100 is 3579 mV for sensors with a 0.35 mA maximum excitation current. The excitation voltage parameter must be set below this threshold.

4.1 GRANITE 9/10 program example

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

CRBasic Example 1: GRANITE 9/10 4-wire half-bridge example

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

'Declare Variables and Units
Public Temp_C_4wire
Public Rs_R0

'Define Data Tables
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,10)
  Average(1,Temp_C_4wire,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, 4-wire measurements on the VOLT 108
    CDM_BrHalf4W(VOLT108,CPI_BUSA+1,Rs_R0,1,mV1000,mV1000,1,1,1,4000, _
    True,True,500,60,1,0)
    'PRT temperature calculation
    PRTCalc (Temp_C_4wire,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 4-wire half-bridge example

```
'GRANITE 6/CR6 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,mV1000,mV1000,U1,U5,1,2500,True ,True ,0,250,1.0,0)
    PRTCalc (Temp_C,1,Rs_R0,0,1,0)
    CallTable Hourly
  NextScan
EndProg
```

4.3 CR1000X program example

CRBasic Example 3: CR1000X 4-wire half-bridge example

```
'CR1000X-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,mV1000,mV1000,1,Vx1,1,4000,True ,True ,0,250,1.0,0)
    PRTCalc (Temp_C,1,Rs_R0,0,1,0)
    CallTable Hourly
  NextScan
EndProg
```

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,mV1000,4,1,5,7,1,4000,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 3-1 (p. 3) 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 ensures 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:

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

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 4-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.

$$V_x = I_x (R_1 + R_{Smax} + R_f)$$

Where:

R_1 = 10 kΩ, the current limiting resistor in the terminal input module

R_{Smax} = 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:

4WPB100

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

4WPB500

$$V_x = 0.35\ \text{mA}\ (10{,}000\ \Omega + 1250\ \Omega + 500\ \Omega) = 4113\ \text{mV}$$

4WPB1K

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

Small variations in sensor resistance do not cause significant differences in the calculated maximum excitation voltage. For example, changing the sensor resistance to 84 Ω 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:

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

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 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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