3WHB10K 3-Wire Half Bridge Terminal Input Module

User Manual

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3WHB10K 3-Wire Half Bridge Terminal Input Module

1. Function

Terminal input modules connect directly to the datalogger's input terminals to provide completion resistors for resistive bridge measurements, voltage dividers, and precision current shunts.

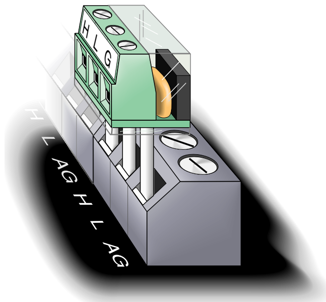

Figure 1-1. Terminal Input Module

2. Specifications

10 kOhm Completion Resistor

Tolerance @ 25°C	±0.01%
Temperature coefficient	
0°-60°C	±4 ppm/°C
-55°-125°C	±8 ppm/°C
Power rating @ 70°C	0.25 W

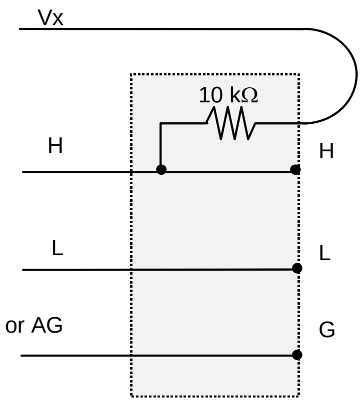

Figure 2-1. Schematic

3. Wiring

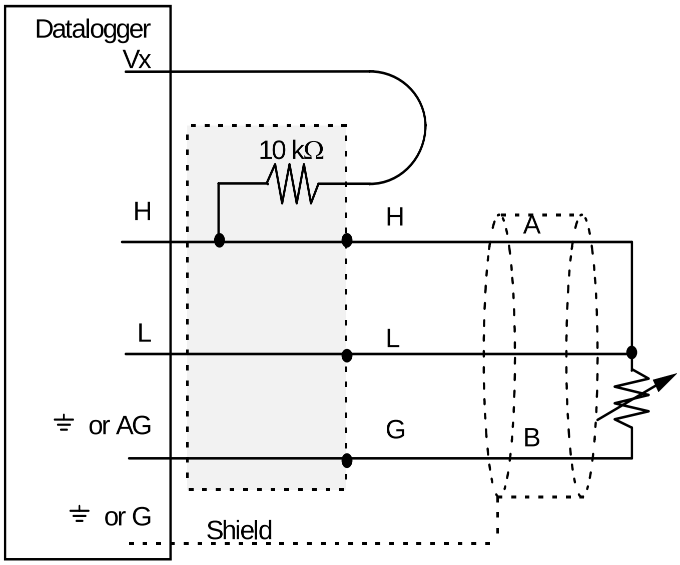

Figure 3-1. 3-Wire Half Bridge Used to Measure PRT

Table 3-1. 3WHB10K Connections to Campbell Scientific Dataloggers

Function	Label/Lead	CR10X, CR510	CR23X, CR1000, CR800, CR850, CR3000	21X, CR7, CR9000X
Excitation	Black Wire	E1	EX1	Excitation 1
V1 Reference	H	SE1	SE1	1H
V2 Sense	L	SE2	SE2	1L
Ground	G	AG	⏚	⏚

4. Programming Examples

The following examples simply show the two instructions necessary to 1) make the measurement and 2) calculate the temperature. The result of the 3-wire half bridge measurement as shown is R_s/R_o, the input required for the PRT algorithm to calculate temperature.

All the examples are for a 100 Ohm PRT in the 3WHB10K. The excitation voltages used were chosen with the assumption that the temperature would not exceed 50°C. Table 4-1 lists excitation voltage as a function of maximum temperature and the input voltage ranges used with the different dataloggers. Calculation of optimum excitation voltage is discussed in Section 5.1.

The multiplier shown is for a 100 Ohm PRT. The multiplier for a 1000 Ohm PRT is 10.

Table 4-1. Excitation Voltage for 100 Ohm PRT in 3WHB10K Based on Maximum Temperature and Input Voltage Range

Max. Temp °C	PRT Resistance Ohms	Excitation Voltage, mV ±25 mV Input Range, CR10(X), CR800, CR850, CR1000,	Excitation Voltage, mV ±50 mV Range, 21X, CR7, CR3000, CR9000X
50	119.4	2119	4237
100	138.5	1830	3660
150	157.31	1614	3228
200	175.84	1447	2893
250	194.07	1313	2626
300	212.02	1204	2408
350	229.67	1113	2227
400	247.04	1037	2074
450	264.11	971	1943
500	280.9	915	1830
550	297.39	866	1731
600	313.59	822	1644
650	329.51	784	1567
700	345.13	749	1499
750	360.47	718	1437
800	375.51	691	1381
850	390.26	666	1331

4.1 CR9000X

```
'CR9000X Datalogger
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)
      BrHalf3W (Rs_Ro,1,V50,5,1,6,1,1,4200,True,30,40,100,0)
      PRT (Temp_F,1,Rs_Ro,1.8,32)
      CallTable Temp_F
NextScan
EndProg
```

4.2 CR1000

```
'CR1000 Series Datalogger

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,mV25,1,Vx1,1,2100,True ,0,250,100,0)
            PRT (Temp_C,1,Rs_R0,1.0,0)
            CallTable Hourly
      NextScan
EndProg
```

4.3 CR10(X)

```
1:  3W Half Bridge (P7)
   1:    1              Reps
   2:    23             ± 25 mV 60 Hz Rejection Range
   3:    1              SE Channel
   4:    1              Excite all reps w/Exchan 1
   5:    2100           mV Excitation
   6:    1              Loc [ Rs_R0     ]
   7:    100            Mult
   8:    0              Offset

2:  Temperature RTD (P16)
   1:    1              Reps
   2:    1              R/RO Loc [ Rs_R0     ]
   3:    2              Loc [ Temp_C    ]
   4:    1.0            Mult
   5:    0.0            Offset
```

4.4 21X

```
1:  3W Half Bridge (P7)
   1:    1              Reps
   2:    3              ± 50 mV Slow Range
   3:    1              SE Channel
   4:    1              Excite all reps w/Exchan 1
   5:    4200           mV Excitation
   6:    1              Loc [ Rs_R0     ]
   7:    100            Mult
   8:    0              Offset

2:  Temperature RTD (P16)
   1:    1              Reps
   2:    1              R/RO Loc [ Rs_R0     ]
   3:    2              Loc [ Temp_C    ]
   4:    1.0            Mult
   5:    0              Offset
```

4.5 CR7

1: 3-Wire Half Bridge (P7)		
1:	1	Reps
2:	4	± 50 mV Slow Range
3:	1	In Card
4:	1	SE Channel
5:	1	Ex Card
6:	1	Ex Channel
7:	1	Meas/Ex
8:	4200	mV Excitation
9:	1	Loc [Rs_R0]
10:	100	Mult
11:	0	Offset
2: Temperature RTD (P16)		
1:	1	Reps
2:	1	R/RO Loc [Rs_R0]
3:	2	Loc [Temp_C]
4:	1	Mult
5:	0	Offset

5. 100 Ohm PRT in 3-Wire Half Bridge

The advantages of the 3-wire half bridge over other measurements that correct for lead wire resistance such as a 4-wire half bridge, are that it only requires 3 lead wires going to the sensor and takes 2 single-ended input channels, 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 RTD Instruction (16) 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 x R_f/R_o). When R_f = 10,000 and R_0 = 100, the multiplier is 100; when R_0 is 1000 the multiplier is 10.

The fixed resistor must be thermally stable. Over the -55° to 85°C extended temperature range for the datalogger, the ±4 ppm/°C temperature coefficient would result in a maximum error of ±0.04°C at 60°C. The ±8 ppm/°C temperature coefficient would result in a maximum error of ±0.13°C at -55°C.

5.1 Excitation Voltage

The best resolution is obtained when the excitation voltage is large enough to cause the signal voltage to fill the measurement voltage range. The voltage drop across the PRT is equal to the current, I, multiplied by the resistance of the PRT, R_s, and is greatest when R_s is greatest. For example, if it is desired to measure a temperature in the range of -10 to 40°C, the maximum voltage drop will be at 40°C when R_s = 115.54 Ohms. To find the maximum excitation voltage that can be used when the measurement range is ±25 mV, we assume V2 equal to 25 mV and use Ohm's Law to solve for the resulting current, I.

$$I = 25 \text{ mV}/R_s = 25 \text{ mV}/115.54 \text{ Ohms}$$

$$= 0.216 \text{ mA}$$

V_x is equal to I multiplied by the total resistance:

$$V_x = I(R_s+R_f) = 2.18 \text{ V}$$

If the actual resistances were the nominal values, the 25 mV range would not be exceeded with V_x = 2.18 V. To allow for the tolerances in the actual resistances and to leave a little room for higher temperatures, set V_x equal to 2.1 volts.

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.

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 datalogger and program the datalogger to measure the PRT with the 3-wire half bridge as shown in the example section. For a 100 Ohm PRT use a multiplier of 100; for a 1000 Ohm PRT use a multiplier of 10. 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 Ohm 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 lead wire resistance by assuming that the resistance of wire A is the same as the resistance of wire B (Figure 3-1). 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 Instruction 7, is actually R_s plus the difference in resistance of wires A and B.

For example, assume that a 100 Ohm PRT is separated from the datalogger by 500 feet of 22 awg wires. The average resistance of 22 AWG wire is 16.5 Ohms per 1000 feet, which would give each 500 foot lead wire a nominal resistance of 8.3 Ohms. Two percent of 8.3 Ohms is 0.17 Ohms. Assuming that the greater resistance is in wire B, the resistance measured for the PRT (R_0 = 100 Ohms) in the ice bath would be 100.17 Ohms, 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 Instruction 16 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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