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3-Wire Strain Gage in Full Bridge Configuration

Sensor Application Note #11

Overview

This Sensor Application Note provides additional information to connect and configure a Wheatstone Bridge measurement, with a single active arm using a 120ohm strain gage, with excitation lead compensation. Three completion resistors are required for each channel, a matched pair and a precision resistor to match the sensor resistance, or a bridge completion module, such as the Micro-Measurements MR1-350-127. Preferably the completion resistors should be installed at the gage location, alternately they may be installed in the multiplexer.

Strain gage measurements using bonded resistance strain gages are prone to error from a variety of sources often encountered in field environments. This Sensor Application Note is not intended to address these issues. Please review the following Tech Notes available from Micro-Measurements for more information on these potential sources of error:

- **TN-501 – Noise Control in Strain Gage Measurements**
- **TN-504 – Temperature Induced Strain Variation**
- **TN-507 – Errors due to Wheatstone Bridge Non-linearity**
- **TN-509 – Errors due to Transverse Sensitivity**
- **TN-502 – Errors due to Gage Self Heating**
- **TN-514 – Shunt Calibration of Strain Gage Instrumentation**

This Sensor Application Note will assume a 120ohm strain gage element however, with an appropriate matching bridge resistor, any available gage resistance may be used, in fact higher resistance gages such as 350ohm are preferable due to reduced lead-loss and temperature effects. Note: The support in MultiLogger for these sensor types was added beginning with version 2.1.6, contact your software vendor or Canary Systems to obtain software updates.

Wiring

Connection to the multiplexers is shown in the following table (see figure following for resistor wiring schematic). Refer to the wiring diagram supplied with the instrument to match the lead descriptions to wire colors or other designations.

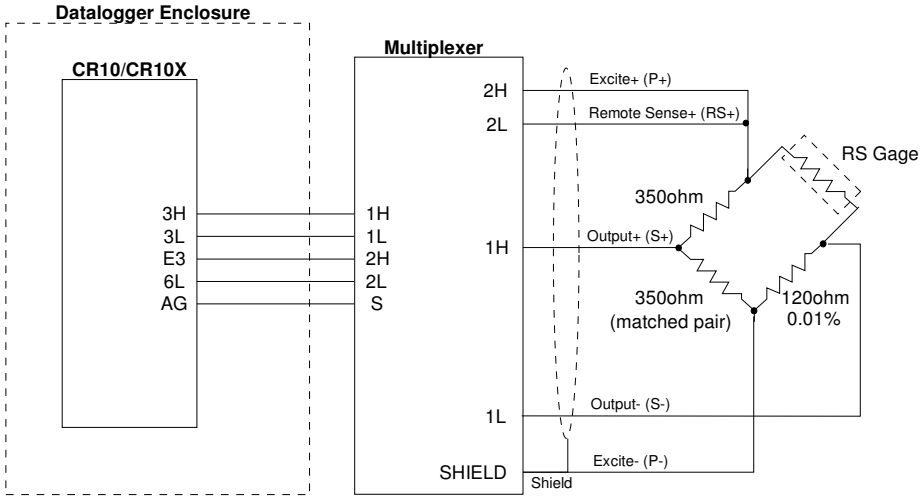
Description	Non-MultiSensor Mux	MultiSensor Mux
Bridge Output S+	1H	1H
Bridge Output S-	1L	1L
Excitation P+	2H	2H
Remote Sense RS+	2L	2L
Excitation P- Instrument Shield	S	S

Channel Configuration

Type	Make	Model	Instruction File	Description	Output Units
ResistanceSG	Generic	3Wire_FullB1	3wire_fullb1.ins	3-Wire Full Bridge narrow range	±15000 digits
		3Wire_FullB2	3wire_fullb2.ins	3-Wire Full Bridge wide range	±50000 digits

For the Upper Channel configuration use **RSG Remote Sense**, this will read the remote sense and output a correction factor, expressed as a multiplier, to be applied to the bridge output data.

Non-MultiSensor Multiplexer Wiring



Contact Canary Systems to obtain the required precision resistors. It is essential to use high accuracy low-temperature coefficient fixed resistors.

Data Reduction

The output equation for the Wheatstone bridge with a single active gage in uniaxial tension or compression (without correction for output nonlinearity) is as follows;

$$\frac{E_o}{E} = \frac{F\varepsilon \times 10^{-3}}{4}$$

where;
E_o is the output voltage (S+, S-) of the bridge in mV.
E is the input voltage (P+, P-) to the bridge in V.
F is the gage factor.
ε is the strain in microinches/inch ($\mu\varepsilon$).

This formula rearranges as follows;

$$\varepsilon = \frac{\frac{E_o}{E} \times 4000}{F}$$

The **3Wire_FullBn** Gage Type output, commonly referred to as “digits”;

$$\frac{E_o}{E} \times 4000$$

To convert the output to strain, divide by the gage factor or multiply (as can be entered into the Channel Configuration) by the inverse of the gage factor.

The magnitude of the initial readings and sign indicate the degree and direction of "unbalance" in the circuit. Usually, the non-linearity (or error) due to this "unbalance" is small and can be ignored. However, this error is a function of the magnitude of the "unbalance" and the strain being measured so for large strains (>10,000 $\mu\varepsilon$) may need to be considered. For additional information on this issue and other data reduction considerations see Micro-Measurements Tech Note TN-507. Increasing readings for this configuration indicate increasing compressive strains while decreasing readings indicate increasing tensile strains. Pay strict attention to the sign when reducing data.

Gage Type Instruction File (narrow range)

```
;Read Bridge output
P6    Full Bridge ;
1:[1                    ]      Reps  ;
2:[2                    ]      Range (7.5 mV Slow Range)     ;
3:[3                    ]      DIFF Channel      ;
4:[3                    ]      Ex Chan (Excite all reps w/Exchan 3)      ;
5:[2000                 ]      mV Excitation     ;
6:[ReadingLoc           ]      Loc   ;
7:[4000                 ]      Mult  ;
8:[0                    ]      Offset      ;
```

Upper Channel Instruction File

```
;Read Remote sense - Output correction factor
P4    Excite-Delay (SE) ;
1:[1                    ]      Reps  ;
2:[5                    ]      New Range (2500 mV Slow Range)      ;
3:[12                   ]      SE Channel  ;
4:[3                    ]      Ex Chan (Excite all reps w/Exchan 1)      ;
5:[10                   ]      Delay (units 0.01 sec)  ;
6:[2000                 ]      mV Excitation     ;
7:[ReadingLoc           ]      Loc   ;
8:[1                    ]      Mult  ;
9:[0                    ]      Offset      ;

;Divide output into Vex
P37   Z=X*F ;
1:[ReadingLoc           ]      X Loc ;
2:[.0005                ]      F     ;
3:[ReadingLoc           ]      Z Loc ;

;Invert for correction factor
P42   Z=1/X ;
1:[ReadingLoc           ]      X Loc ;
2:[ReadingLoc           ]      Z Loc ;
```