WORCESTER POLYTECHNIC INSTITUTE

MECHANICAL ENGINEERING DEPARTMENT

Engineering Experimentation
ME-3901, D'2012

Laboratory #2

20 and 22 March 2012

General information

Office hours

Instructors: **Cosme Furlong**

Office: HL-151

Everyday:

9:00 to 9:50 am

Christopher Scarpino

Office: HL-153

During laboratory sessions

Teaching Assistants: **During laboratory sessions**

General information

Please refer to handout:

"Laboratory 2: Pressure Transducer Calibration"

Objectives

The objectives of this laboratory are:

- Calibrate a pressure transducer;
- Perform linear regression of data (least squares fitting);
- Verify appropriate manufacturer's specifications

Background

A pressure gage, such as that shown in Fig. 1, requires the operator to take manual readings.

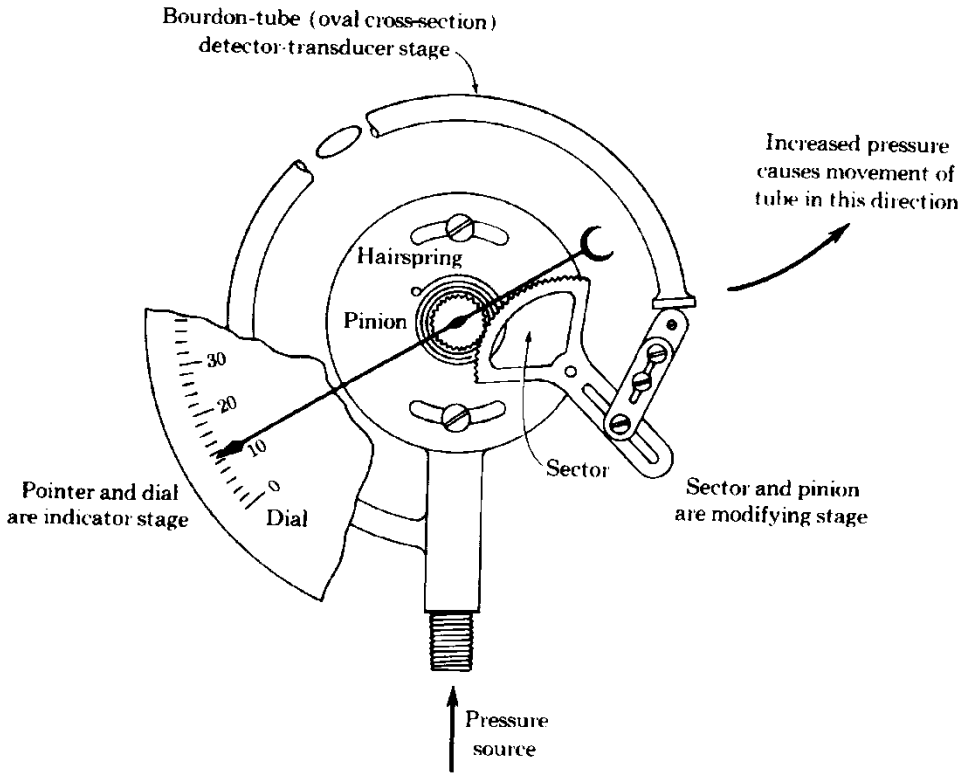


Fig. 1. Small displacement of tube is amplified at center of gear which visually displays the pressure.

Background

A pressure transducer produces an electrical output that can be recorded continuously with an automated data acquisition system. In this experiment a pressure transducer will be calibrated and the results will be compared to the specifications shown in Fig. 2.

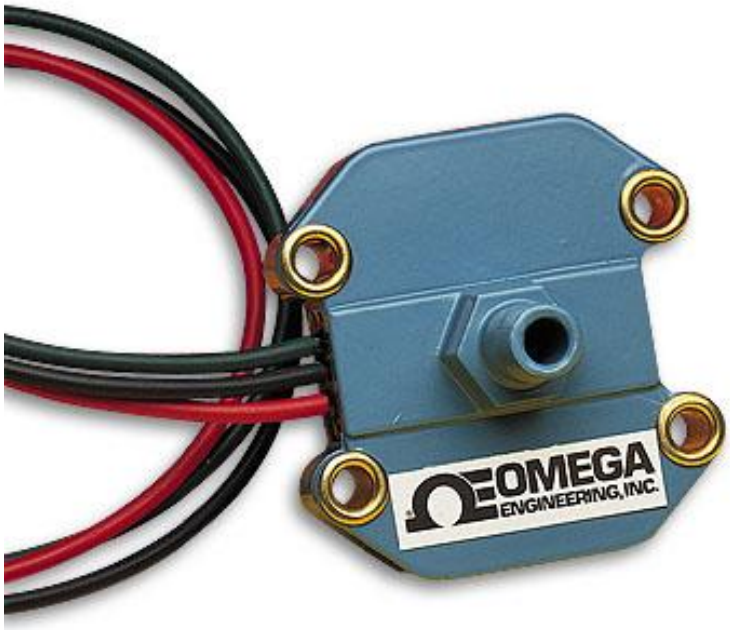


Fig. 2. PX242 Metal Case Transducer for Measuring Low Pressure and Vacuums

Background: specifications

PX242-100G5V

- **Silicon Diaphragm**
- **Buna-N Seals**
- **8.0 Vdc Excitation**
- **12 Inch Lead Wires**
- **-40 to +85°C**
- **1 to 6 Vdc Output**
- **Temperature Compensated**
- **Rugged Low Profile Easy-to-Mount**

SPECIFICATIONS

Excitation: 8 Vdc regulated (16 V max.)
Output: 1 to 6 Vdc into 800 Ω min
Linearity: ±1.5% FS BFSL, ±0.5% FS for 60 to 100 psig
Hysteresis & Repeatability: ±0.25% FS
Zero Balance: 1.0 Vdc ±0.05, PX243 3.5 Vdc ±0.05
Compensated Temperature Range: 0 to 145°F (-18 to 63°C)
Operable Overpressure: 2 x FS
Response Time: 1 ms
Gage Type: Solid State Piezo-Resistive
Body Material: Die-Cast Aluminum
Pressure Port: 1/8 -27 NPT male

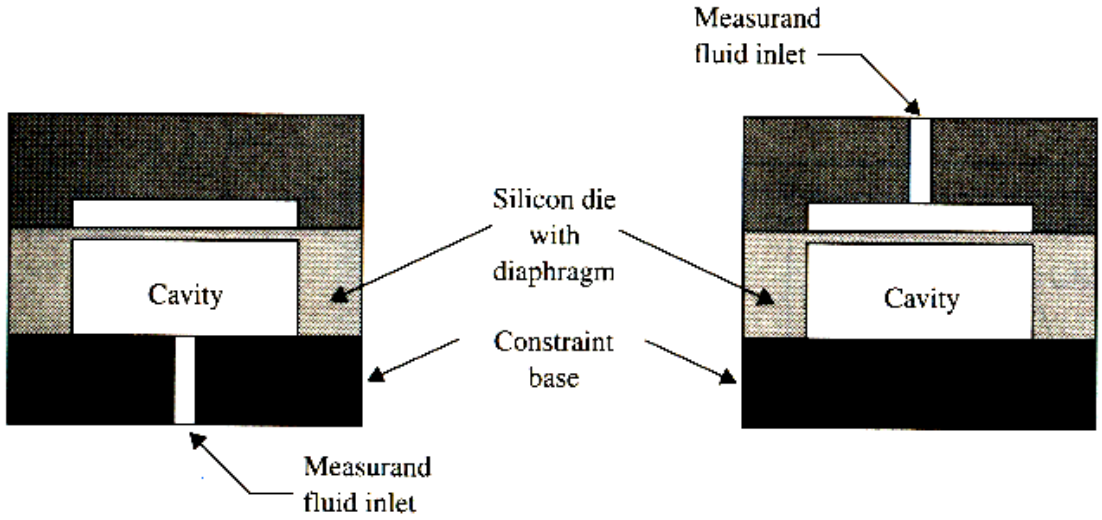
Notes:

FS = Full scale
BFSL = Best fit straight line

Pressure transducer: Si (Silicon) diaphragm

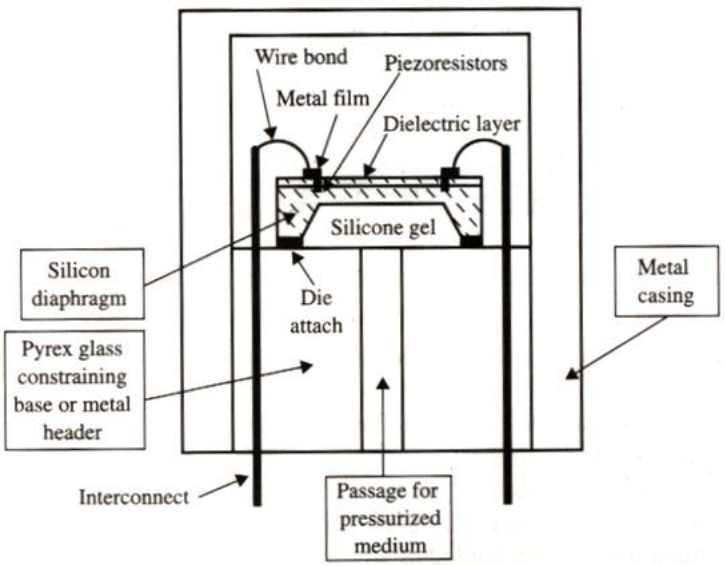
Back side pressurized

Front side pressurized

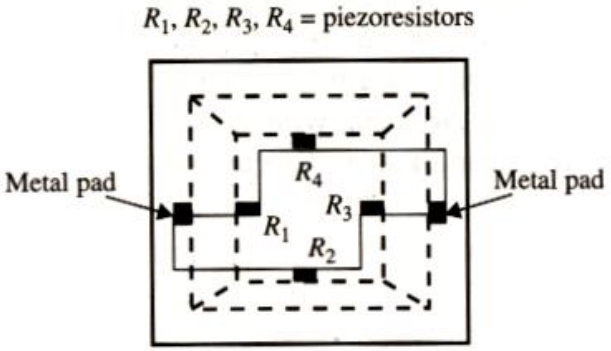


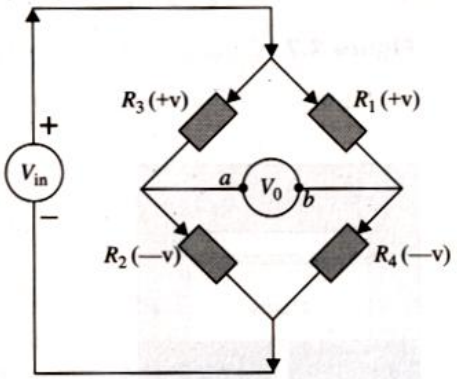
Pressure transducer: Silicon diaphragm. Resistive sensor

Cross section of an electronic package



Top view of silicon die





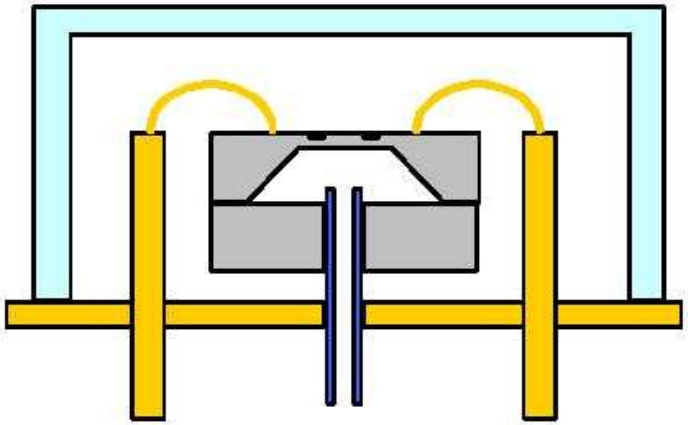
Circuit

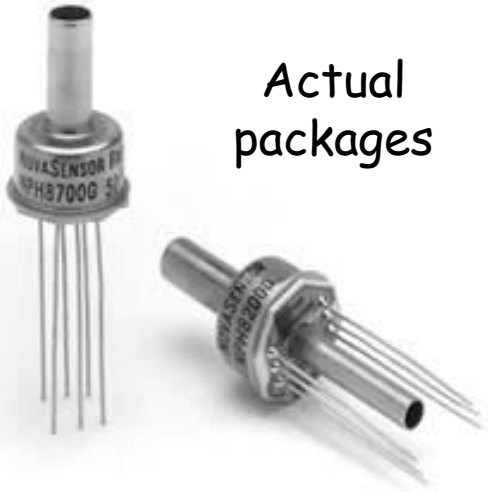
Wheatstone bridge:

$$V_o = V_{in}\left(\frac{R_1}{R_1+R_4} - \frac{R_2}{R_2+R_3}\right)$$

Pressure transducer: Silicon diaphragm. Resistive sensor

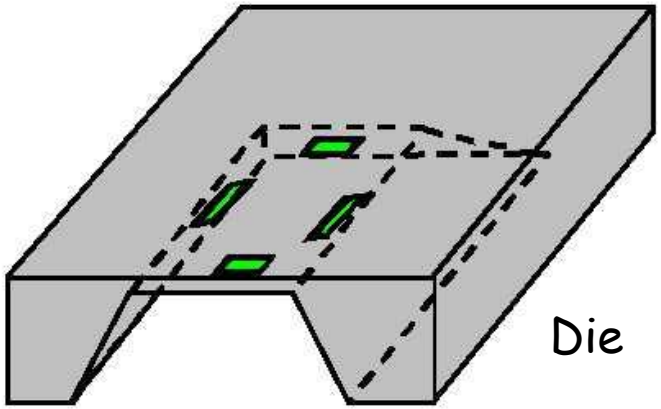
Schematic





Actual packages

http://www.novasensor.com



Die

Background: specifications

- The transducer requires a regulated excitation voltage between 8 and 16Volts
- With 8Volts excitation the nominal output is 1 V at zero pressure and 6 V at a full-scale pressure of 100 psig
- Therefore, the nominal voltage change is 5.00 V (6-1) for a pressure change of 100 psig (100-0)
- This gives a V/EU (Volts/Engineering Unit) of 50 mV/psi combined with an offset at zero *psi*
- If the excitation voltage is doubled to 16 V, the output voltage is also doubled to give a V/EU value of 100 mV/psi
- You will calibrate the pressure transducer using a mechanical gage as the reference

Background: specifications

Note 1:

For our experiment, a regulated excitation voltage selectable between 10, 12 and 15 volts will be provided by a strain gage amplifier

Voltages less than 8 volts are outside the specified limits for the transducer and should not be used

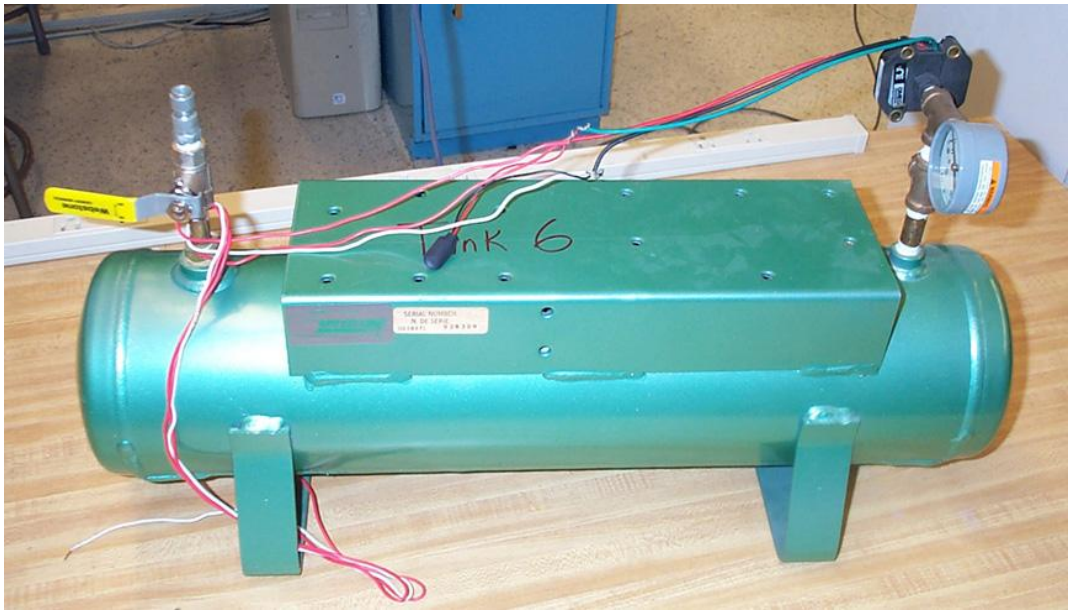
Background: specifications

Note 2:

- We will assume that the mechanical pressure gage is calibrated and reads exactly
- You should be able to read the pressure to within ± 1.0 psi (that is, ± 0.5 of one small division)
- When you record your measurements write down the appropriate number of digits
- For example, 24 is not the same as 24.0. In the first instance you are implying that it is ± 0.5 psi while in the second you are implying ± 0.05 psi.
- A note should indicate the all readings are within a specific resolution
- In a certified calibration lab we would use a much more accurate and precise calibration standard such as a dead-weight tester or a pressure transducer with an accuracy of at least four times that of the transducer we are trying to calibrate

Equipment

A compressed-air tank, of about 3 gallons volume. Note the pressure gage and pressure transducer on the tank, as well as the air hose connection and valve. Make sure all connections are secure before beginning the lab. Make sure all lab partners are wearing safety glasses!



Equipment

Enlarged view of pressure gage and pressure transducer with its 3 wires (red, black, and blue)

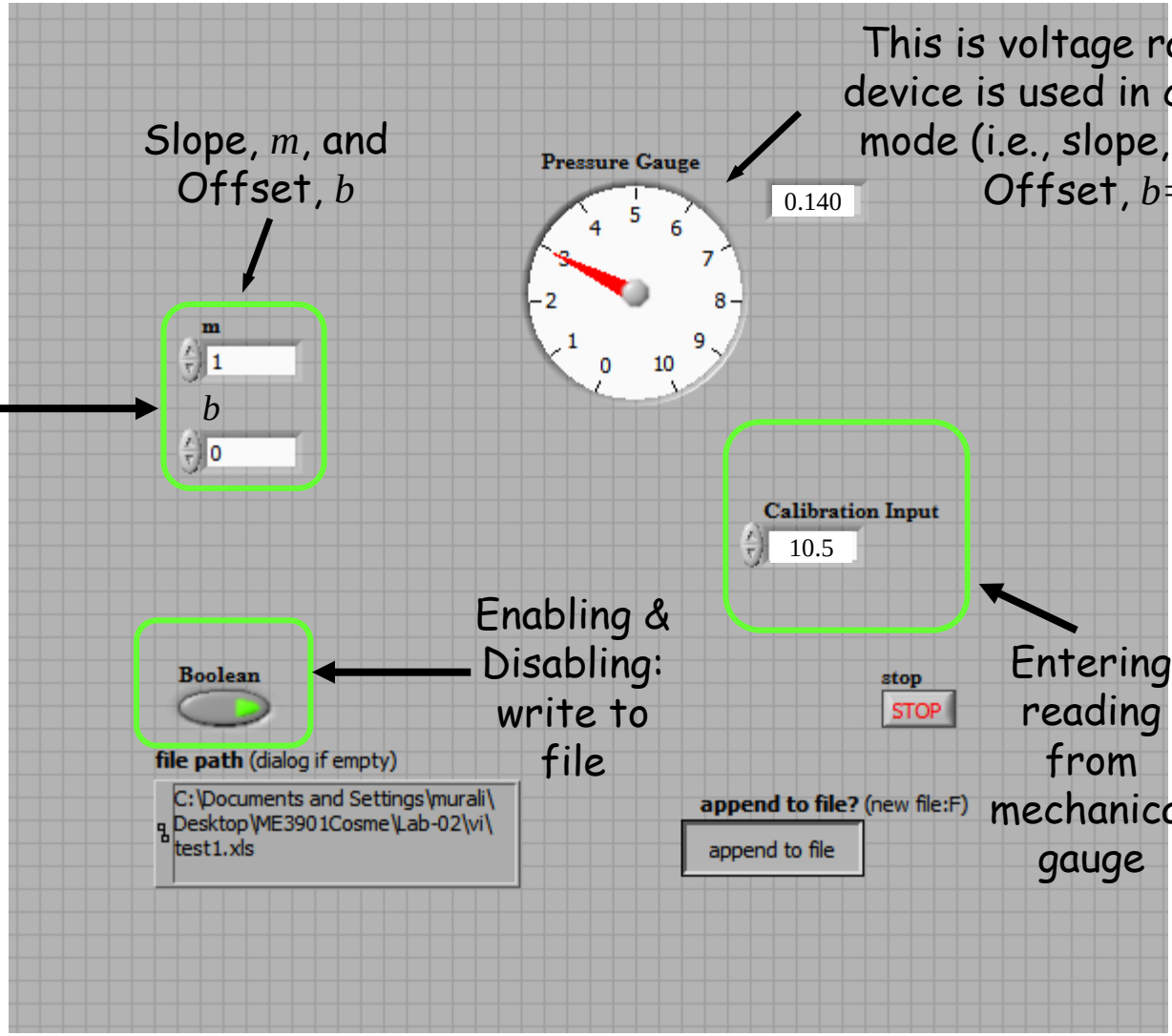
Build VI for calibration

Take into account:

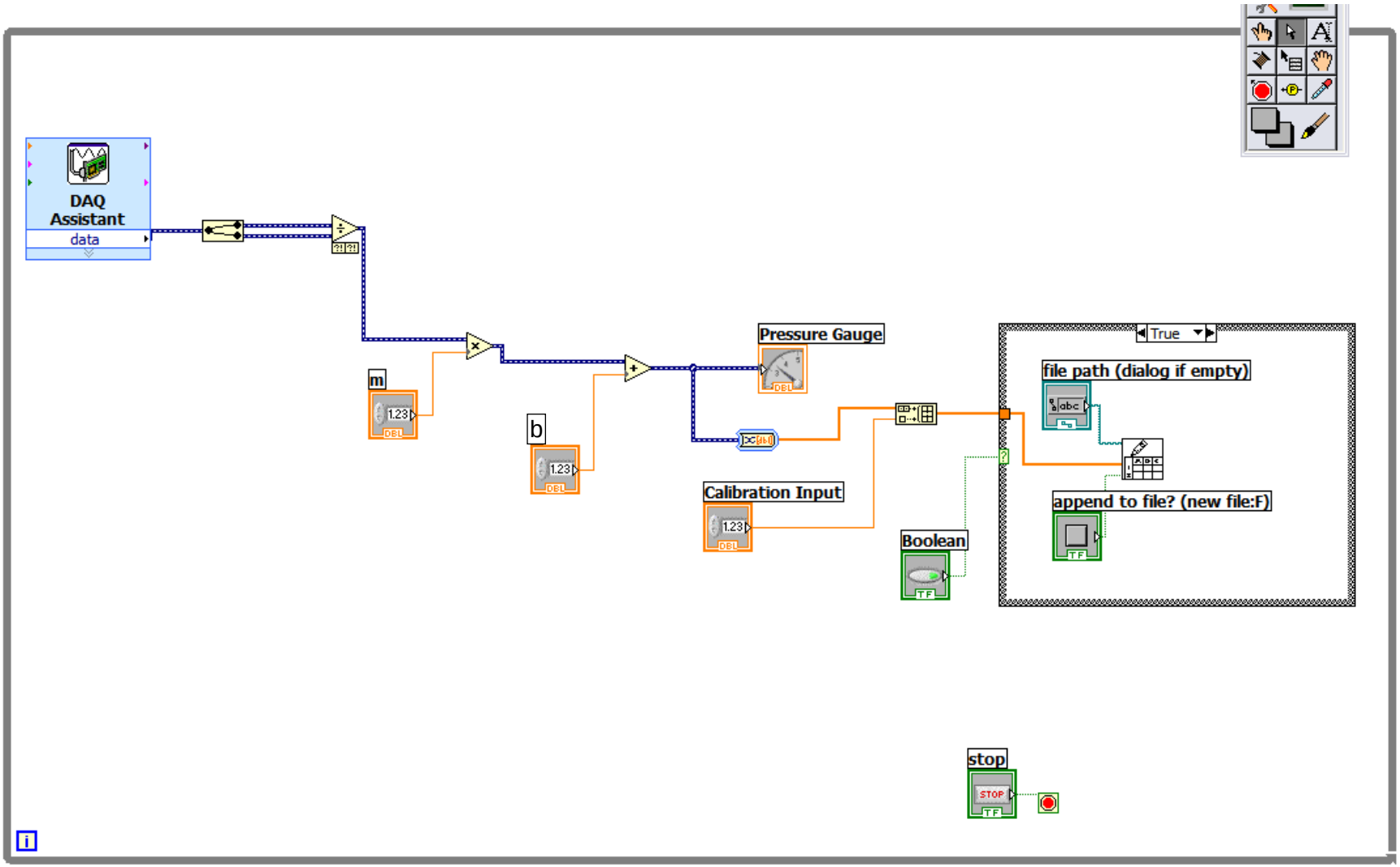
Linear regression to define "transfer function"

(i.e., Voltage → Pressure function)

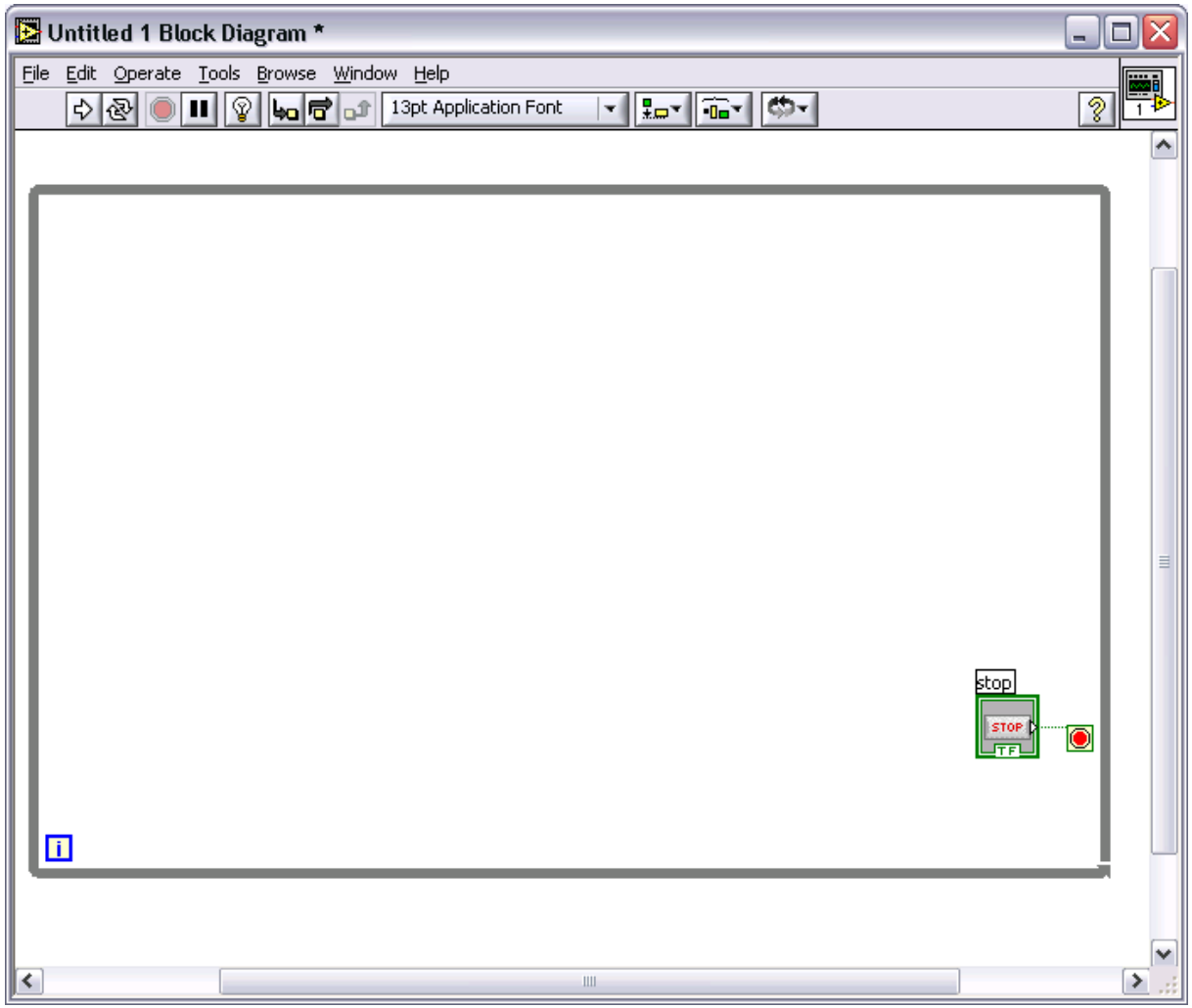
This is one possible VI to build



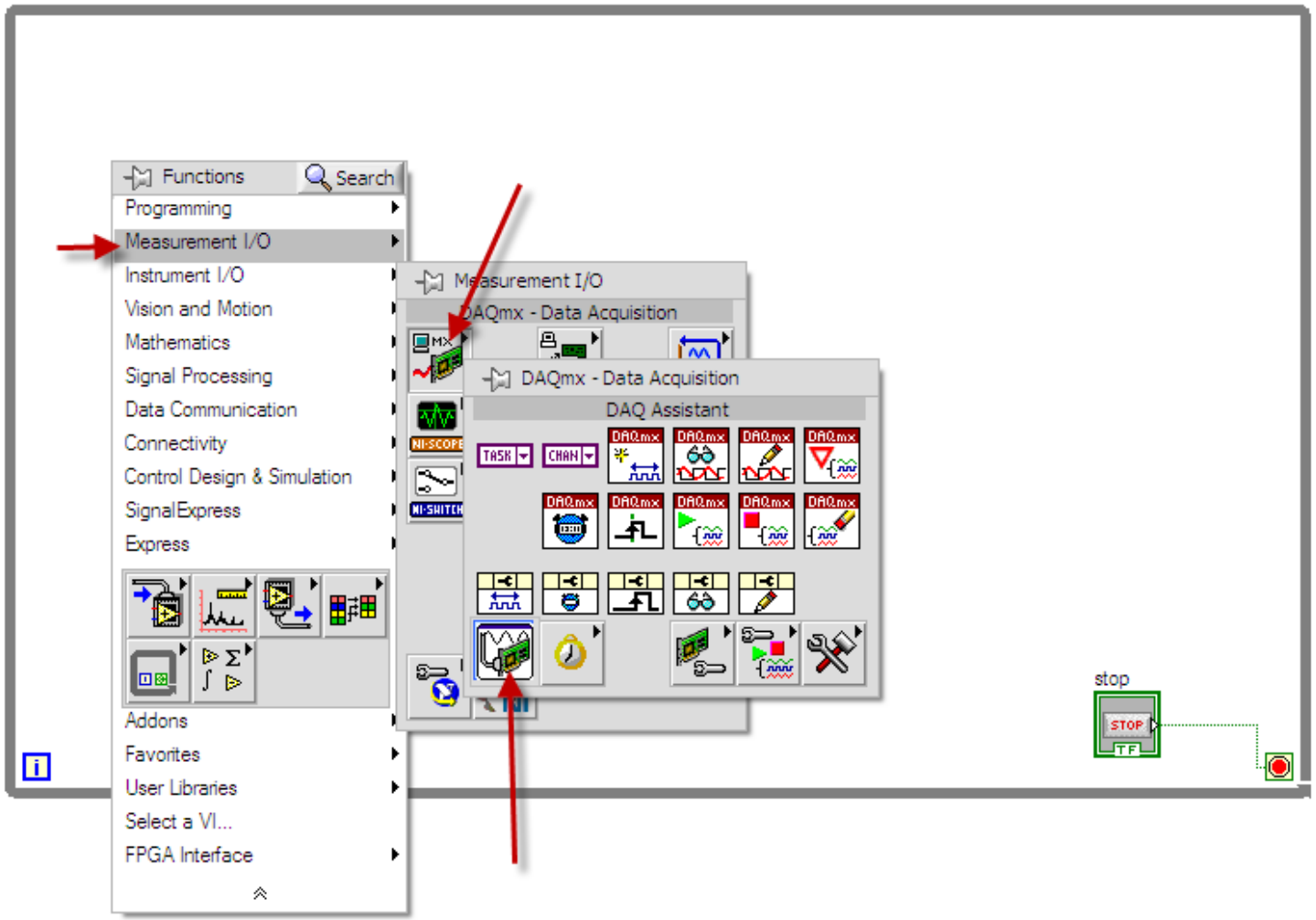
Block diagram of the VI



Create while loop and add a 'control' stop button



Configure 2 Input Channels using the DAQ Assistant



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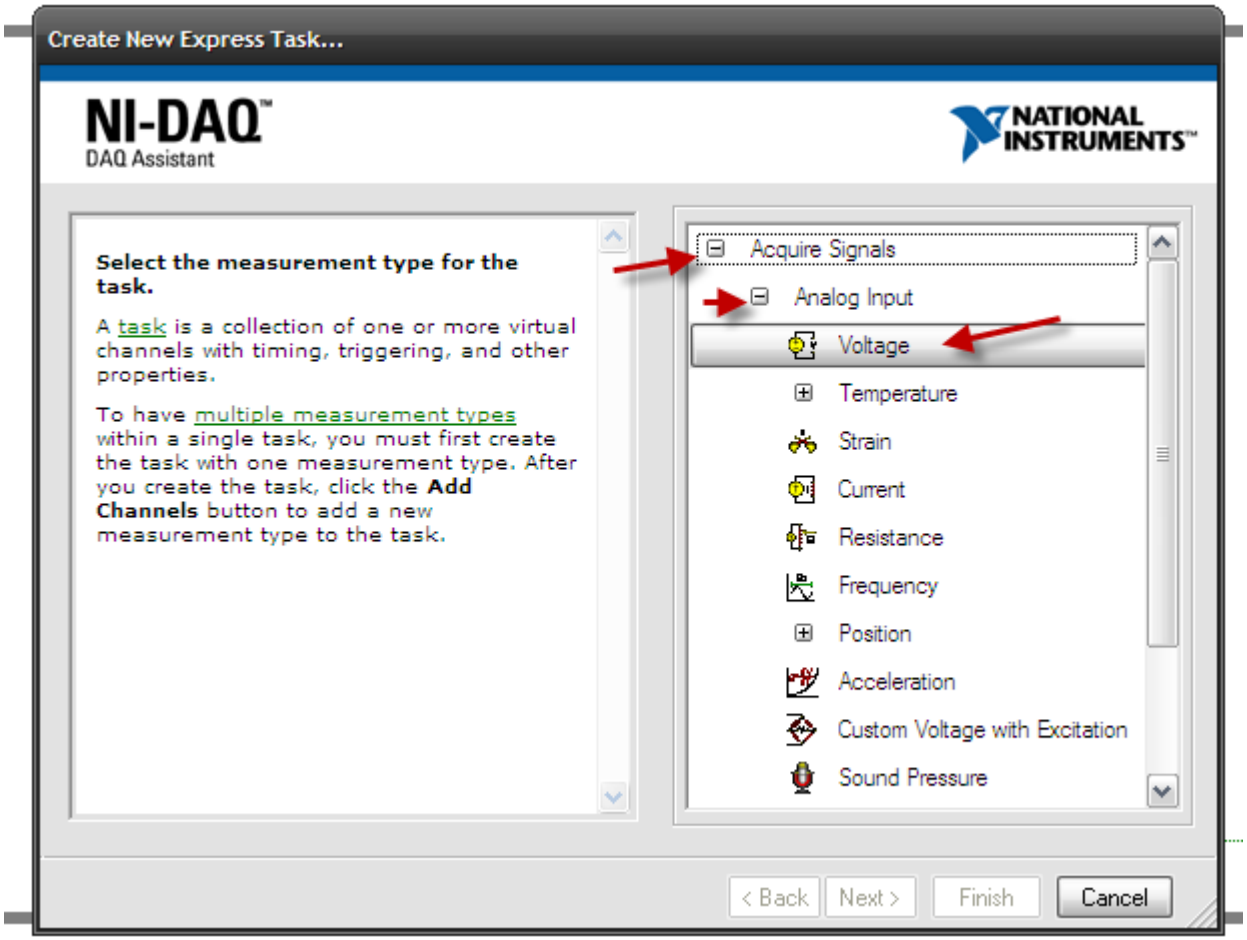
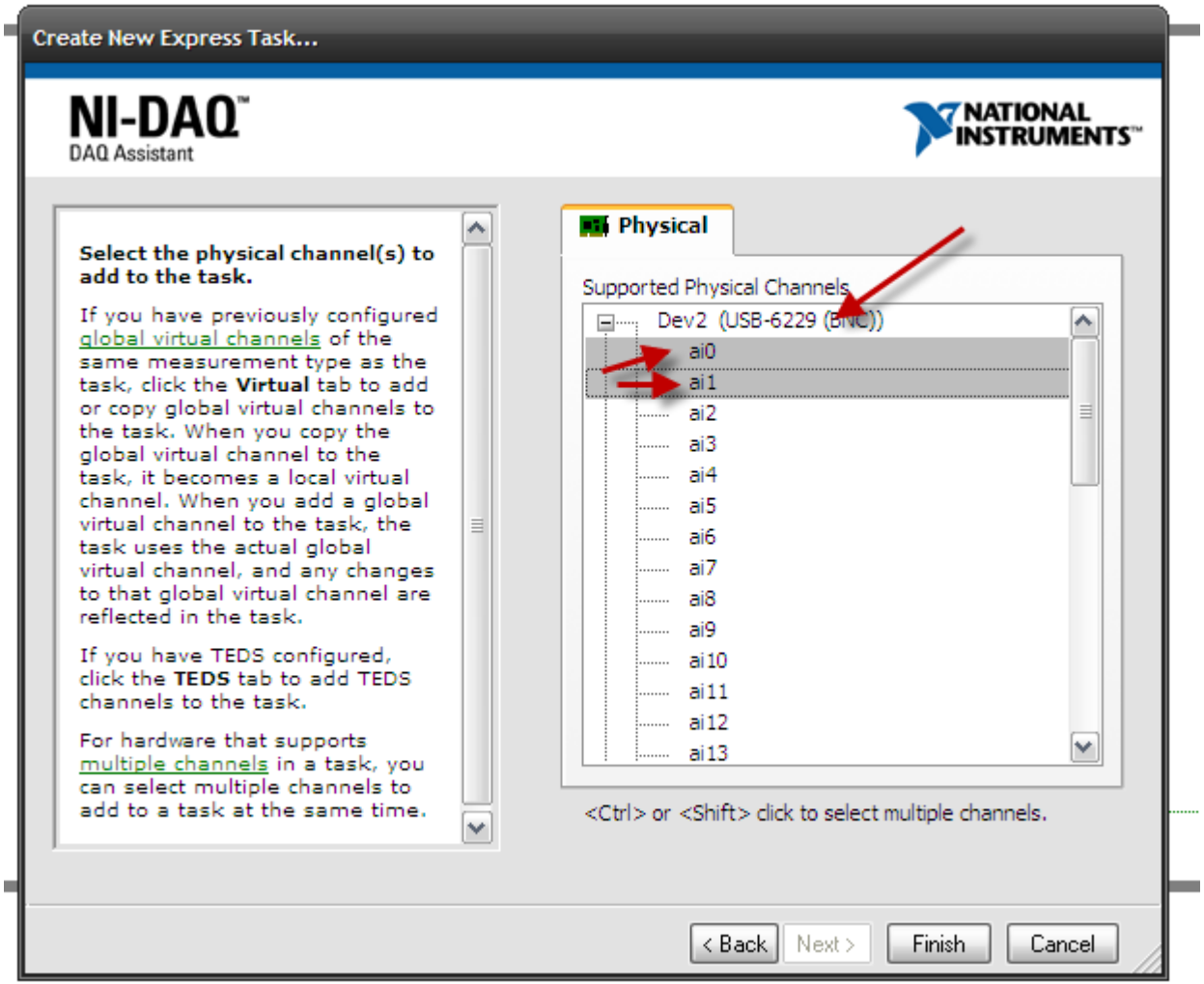
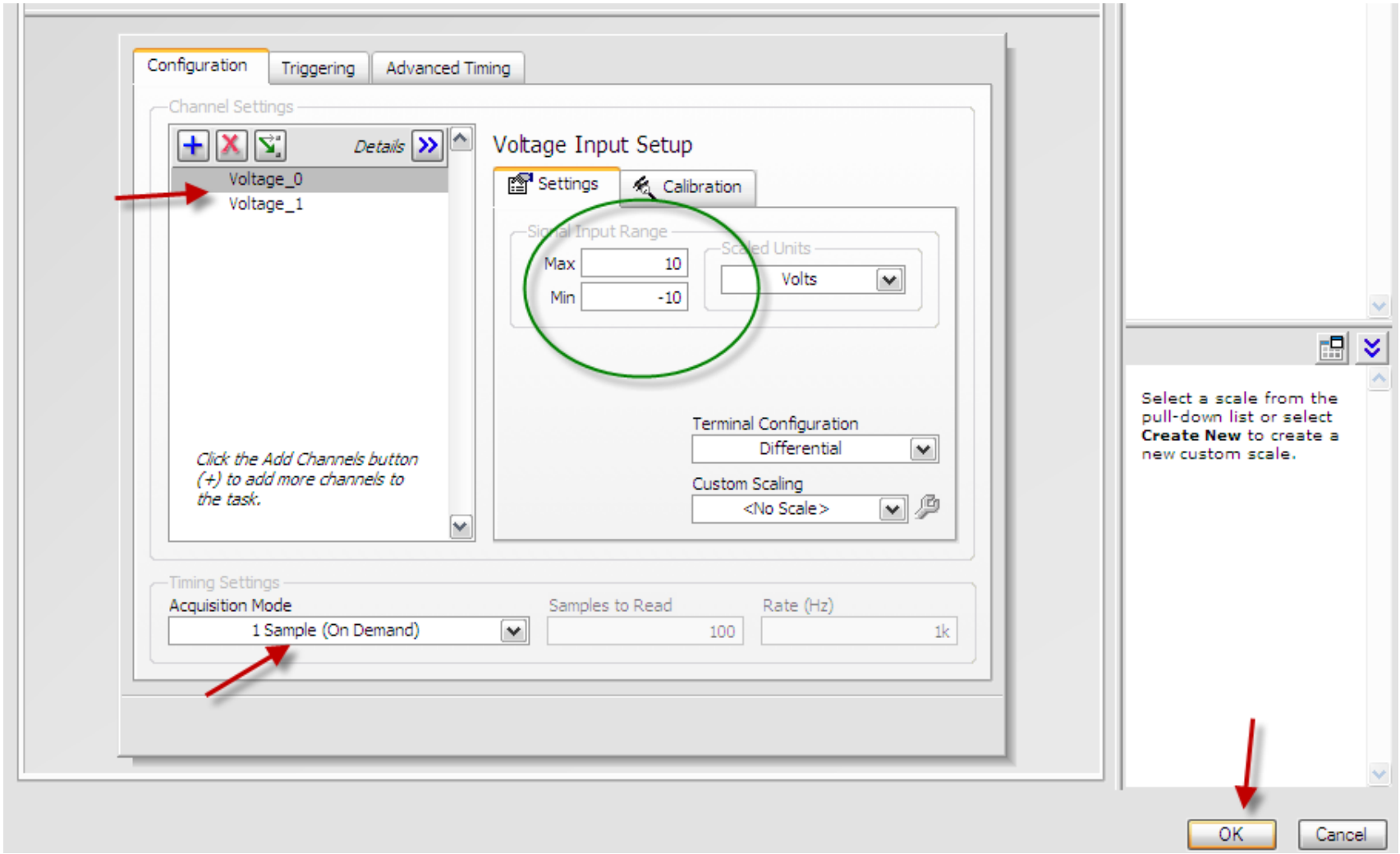


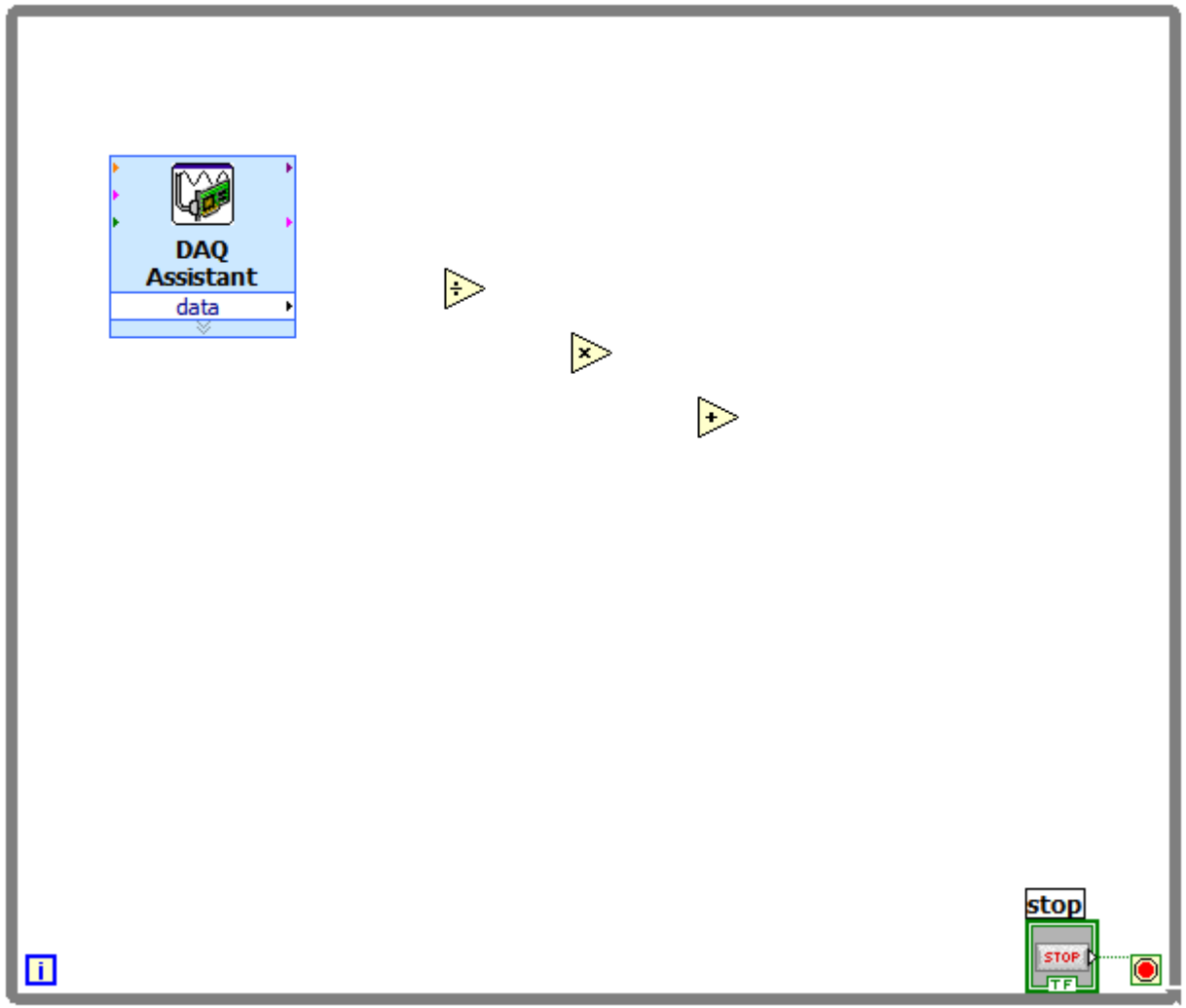
Configure 2 Input Channels using the DAQ Assistant:
one for the *Source* voltage and another for the *Pressure Gage Excitation Voltage* – *Hold CTRL to select both channels*



Set Range 10 to -10 V and other parameters as shown



From the Math->Numeric icon menu get the following items:



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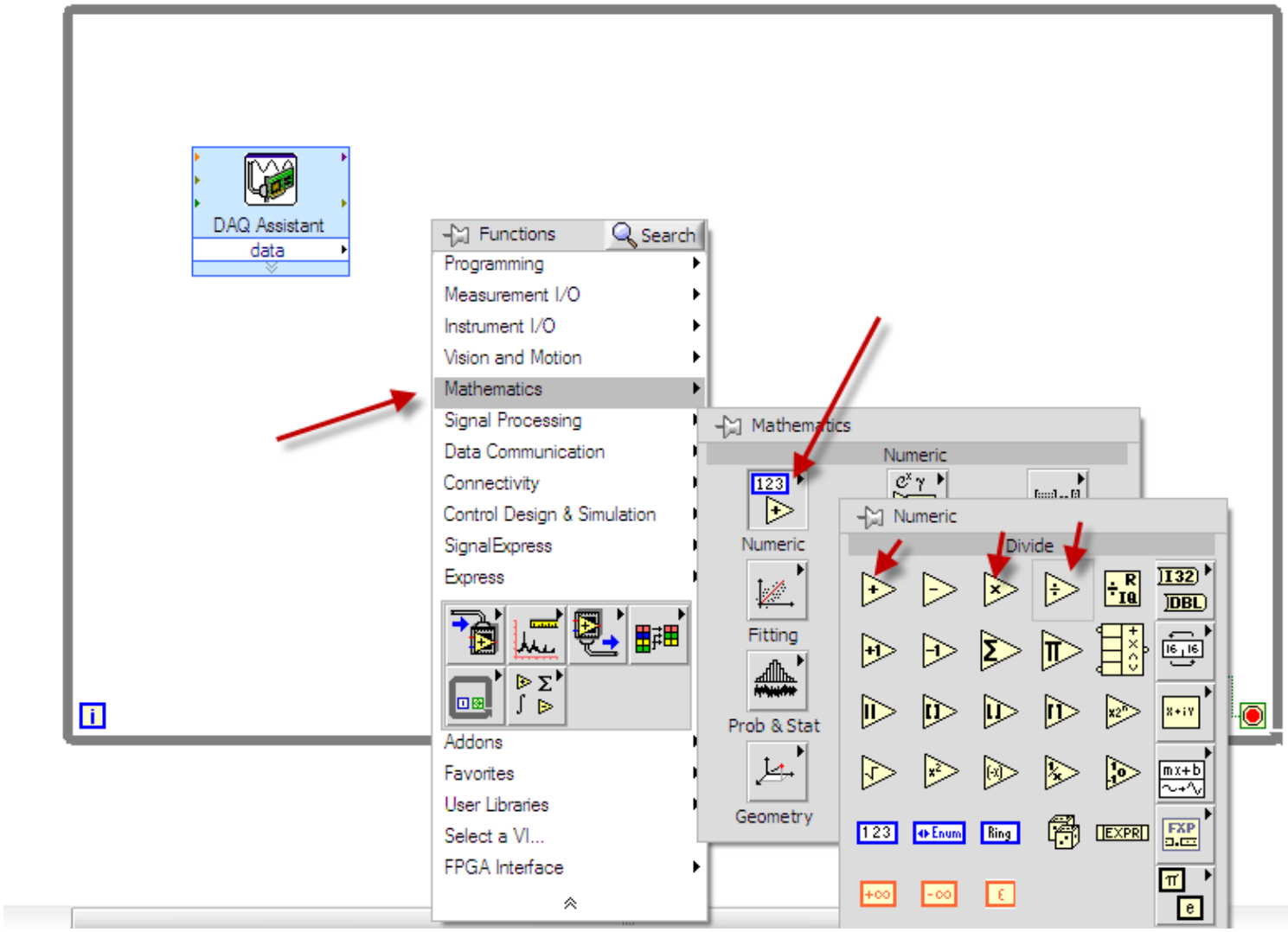
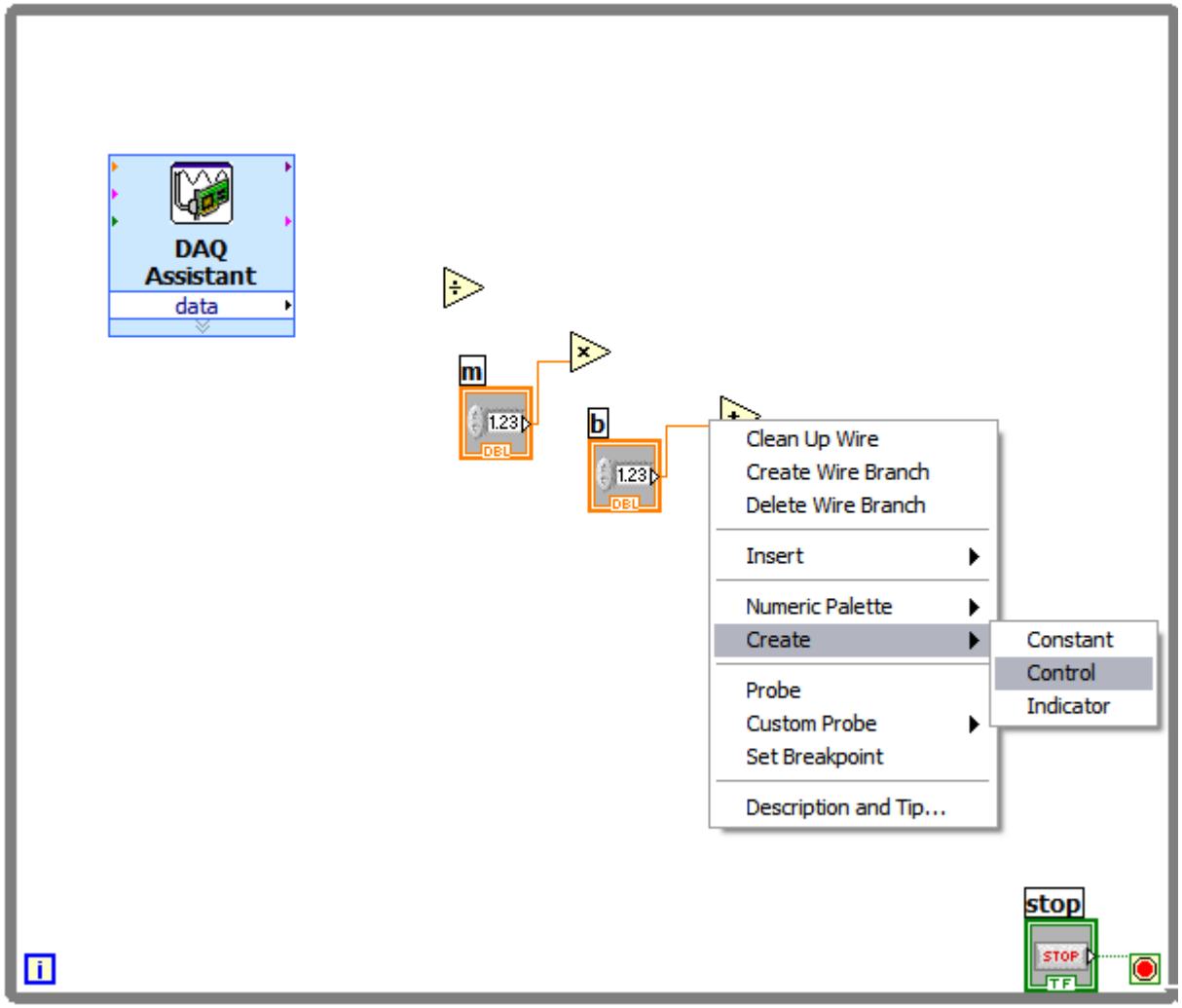
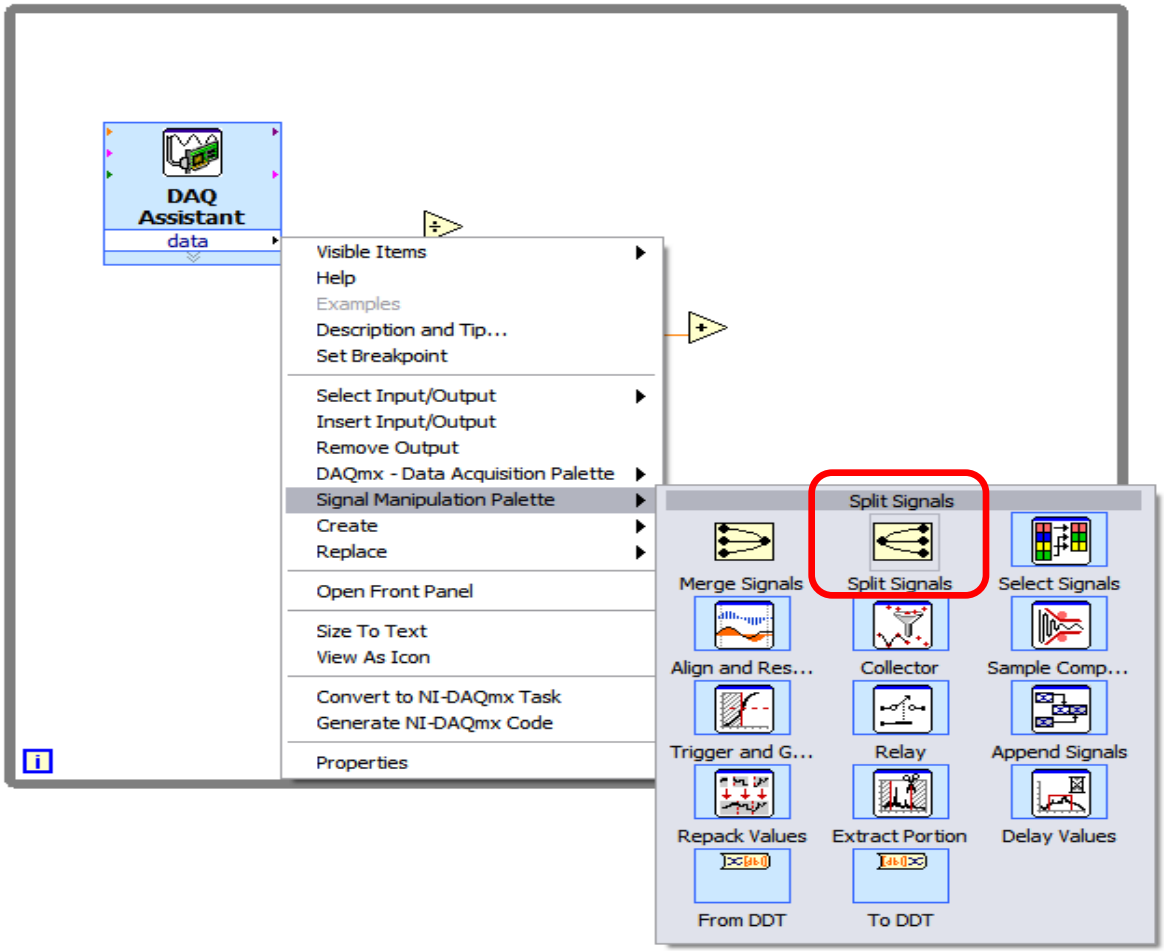


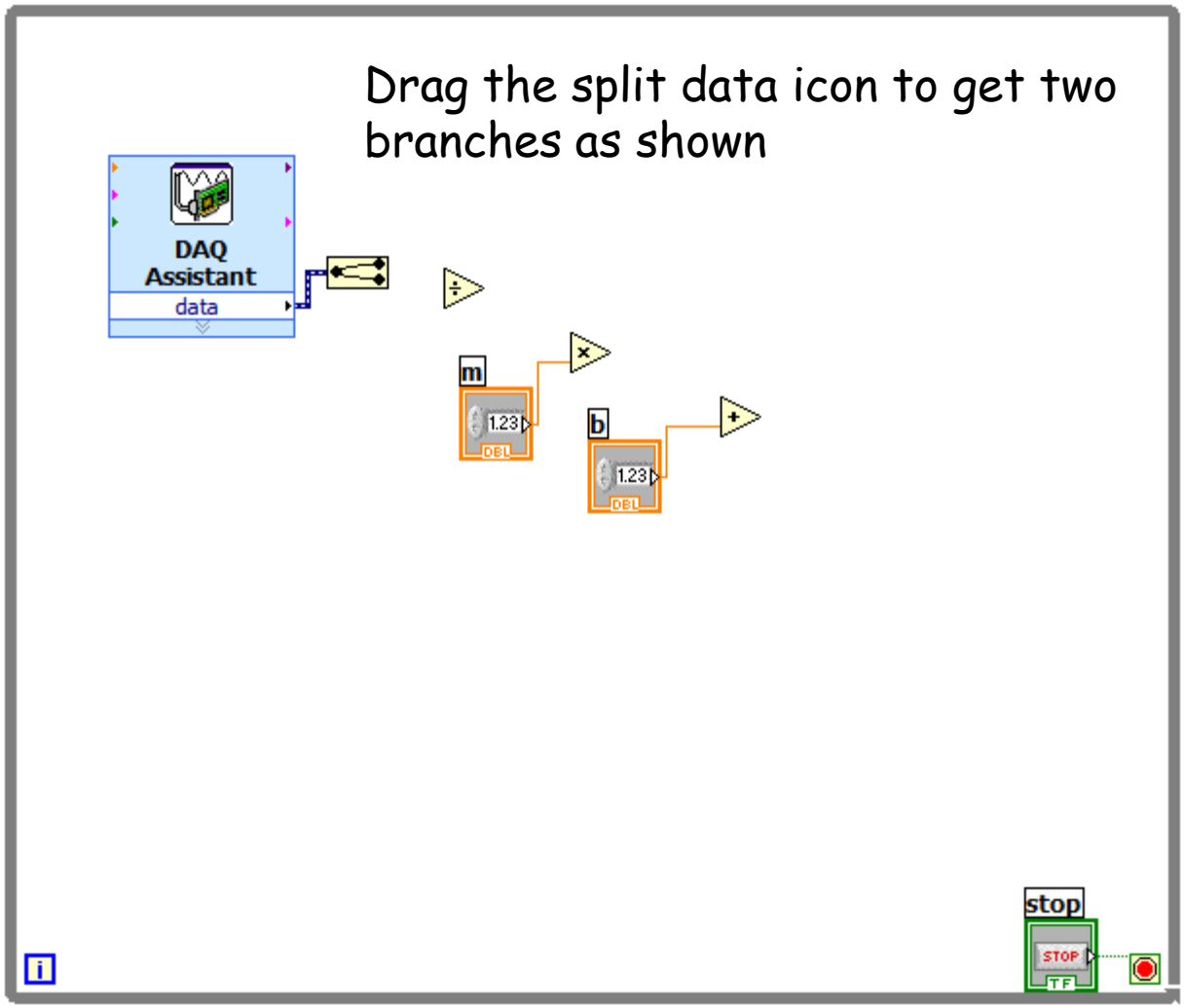
Add Controls for two of the numeric operators:



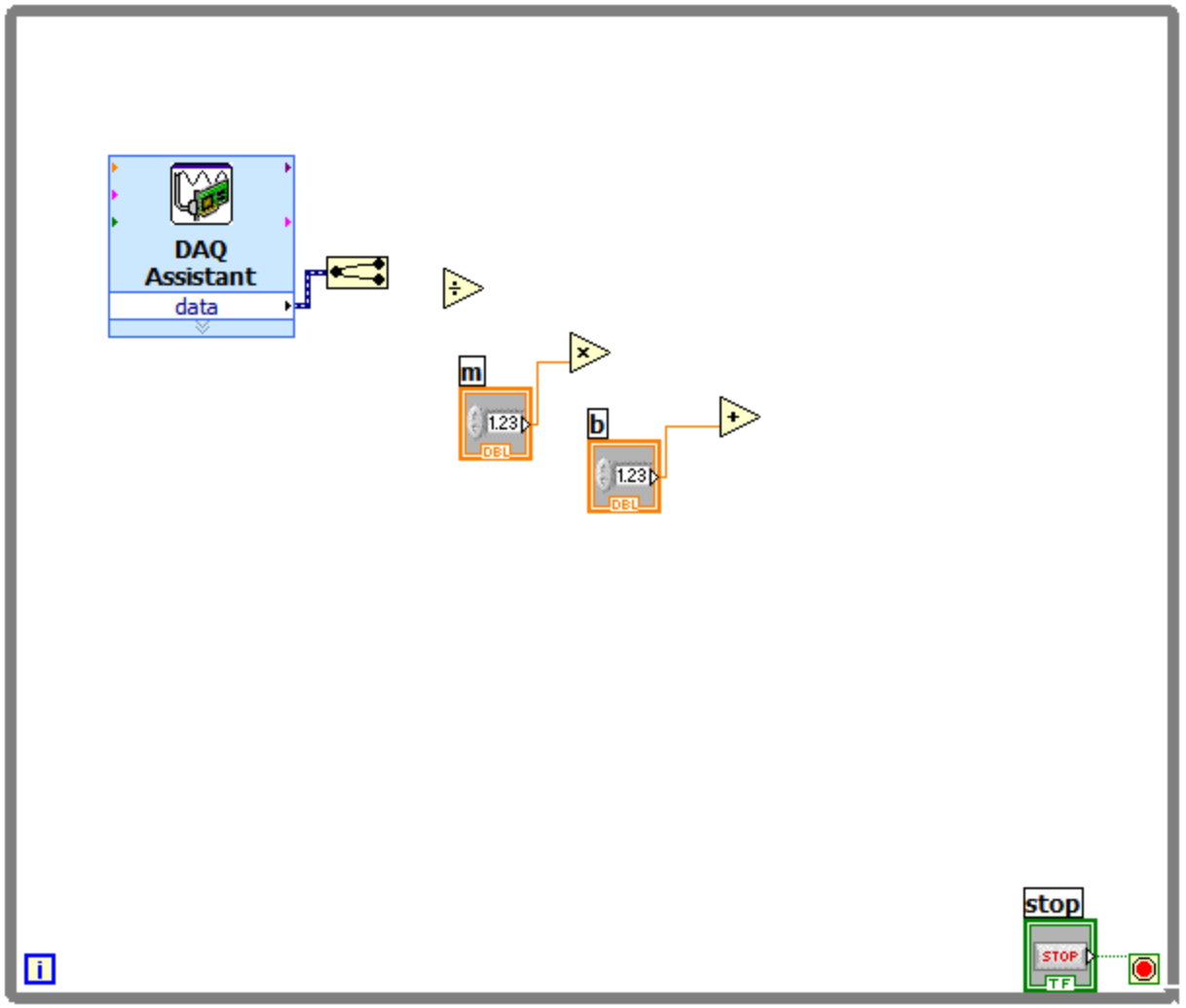
Need to split the data output into Pressure Transducer Output and Excitation Source



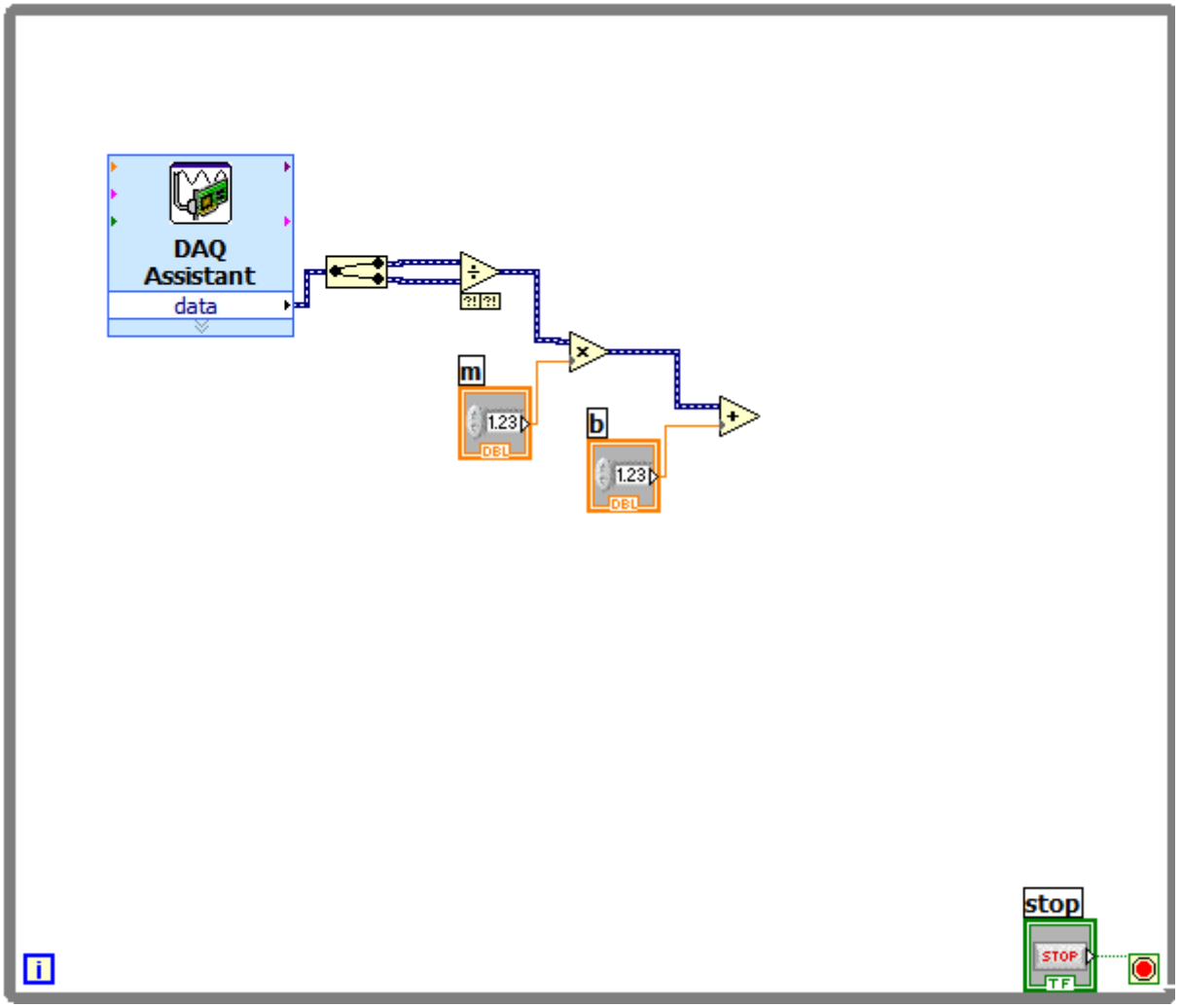
Split the data output into Pressure Transducer Output and Excitation Source



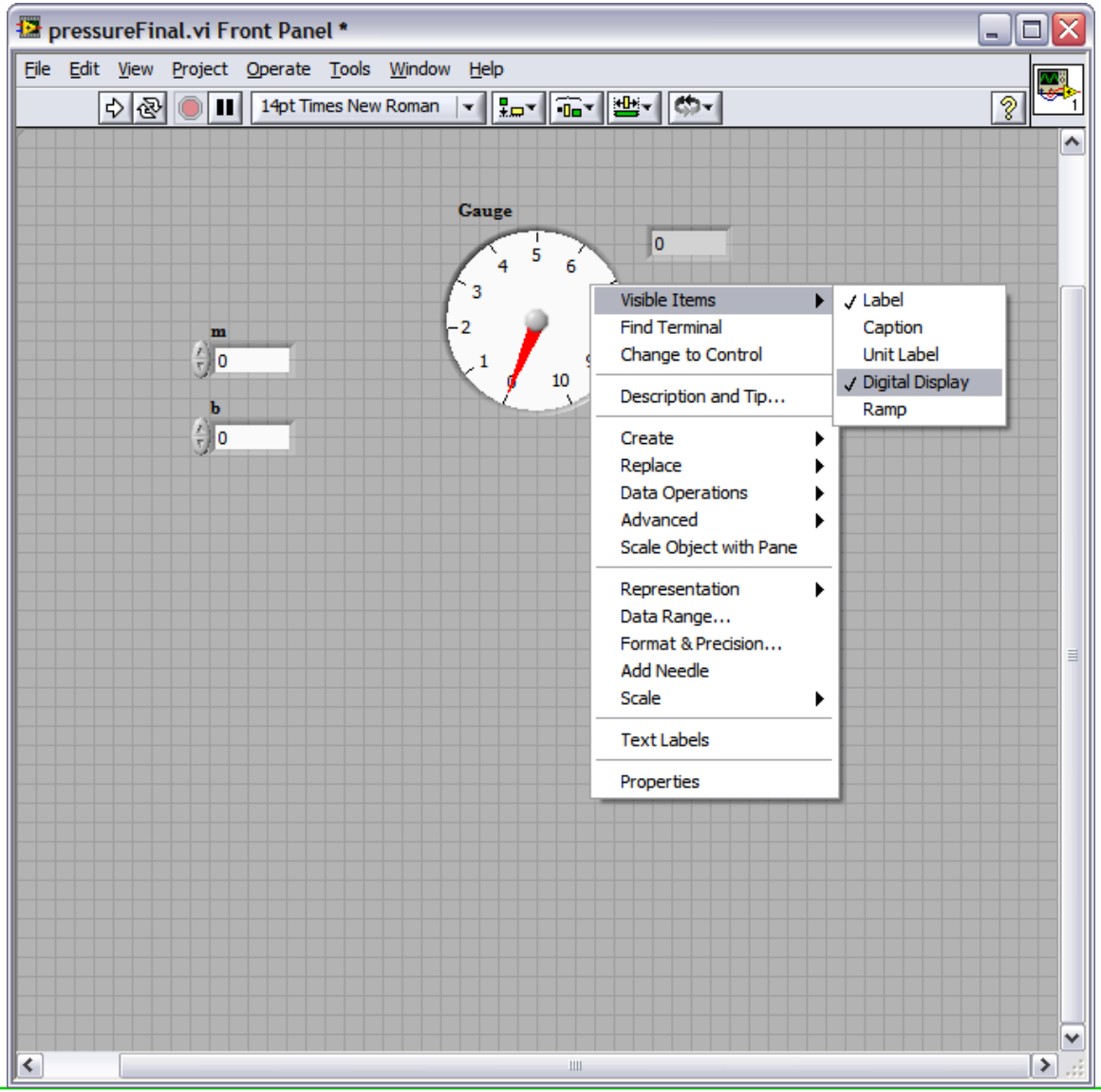
Make sure to *divide the Pressure transducer Output by the Excitation Source*



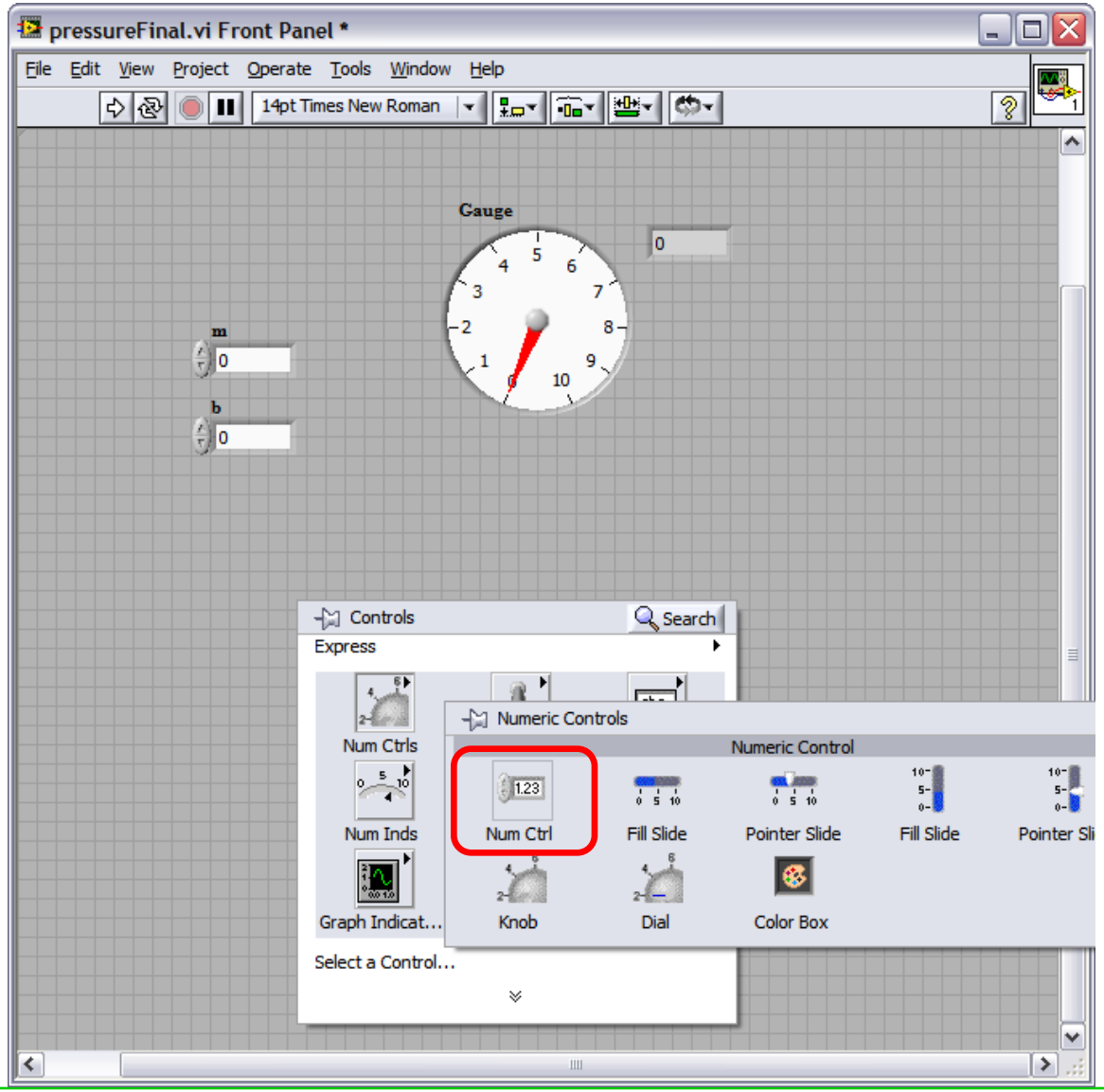
Wire them as follows



In the front panel add a Gage and 'enable' digital display

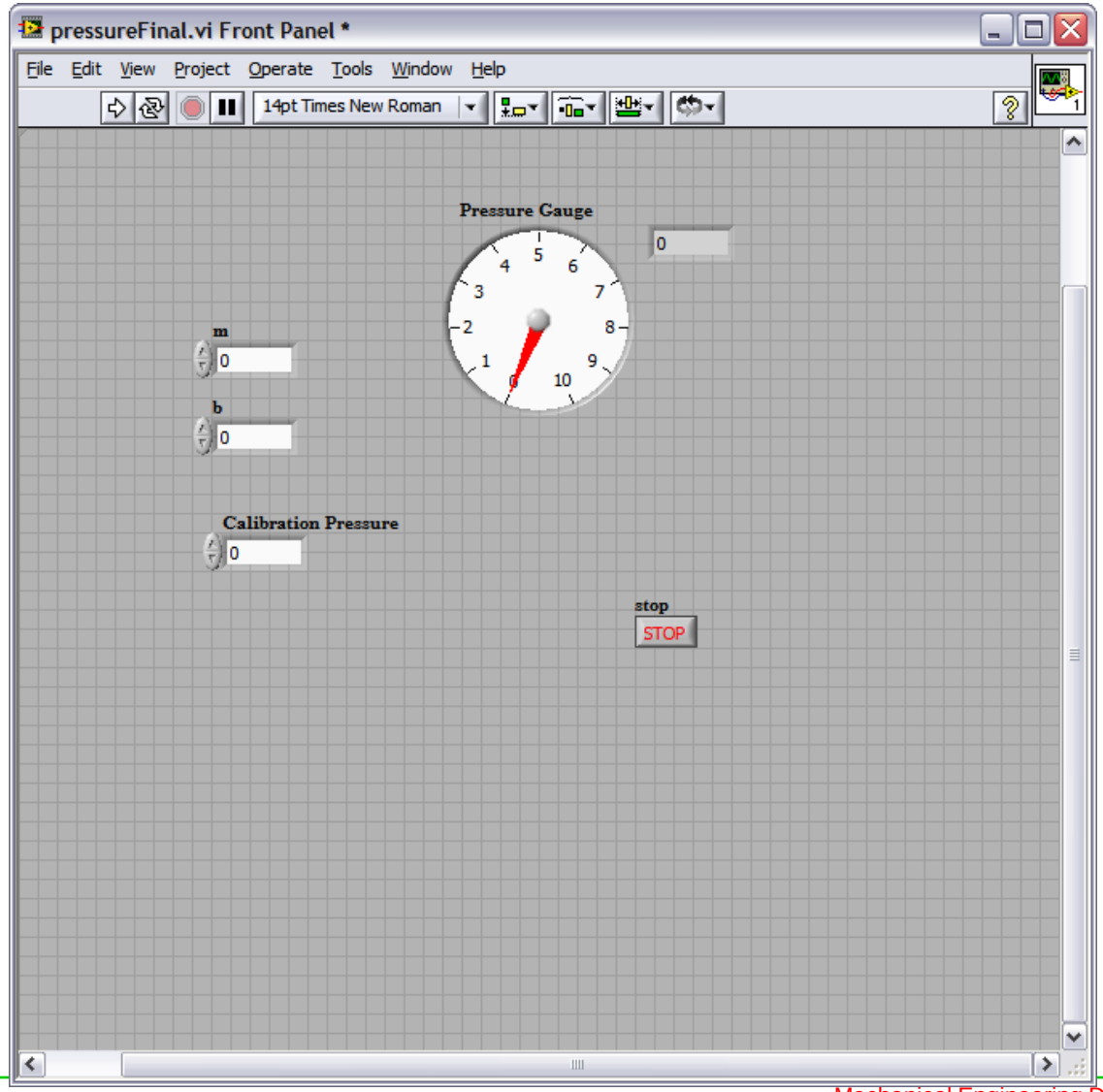


In the front panel add a Numerical Control Input

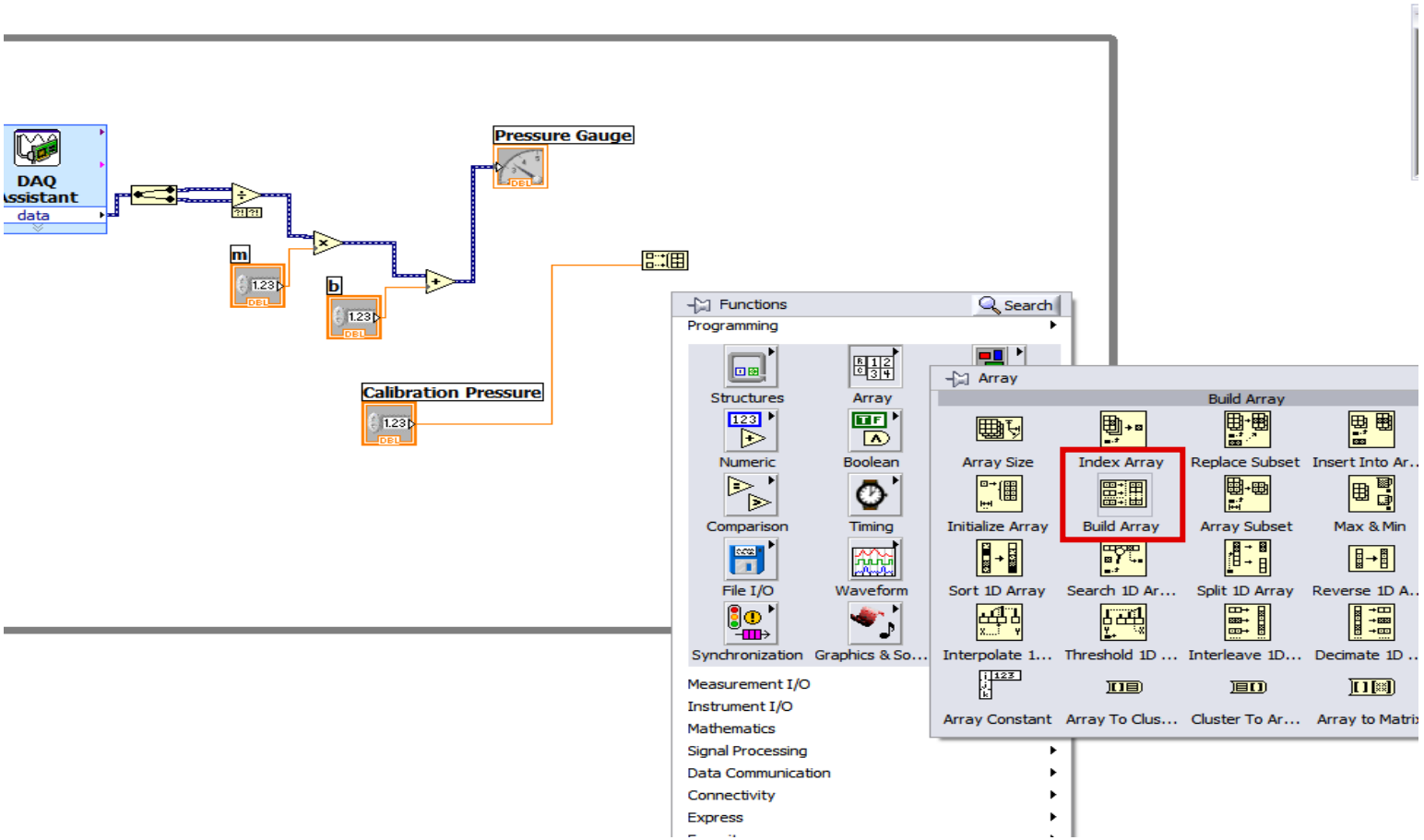


(For manual entering of gage reading)

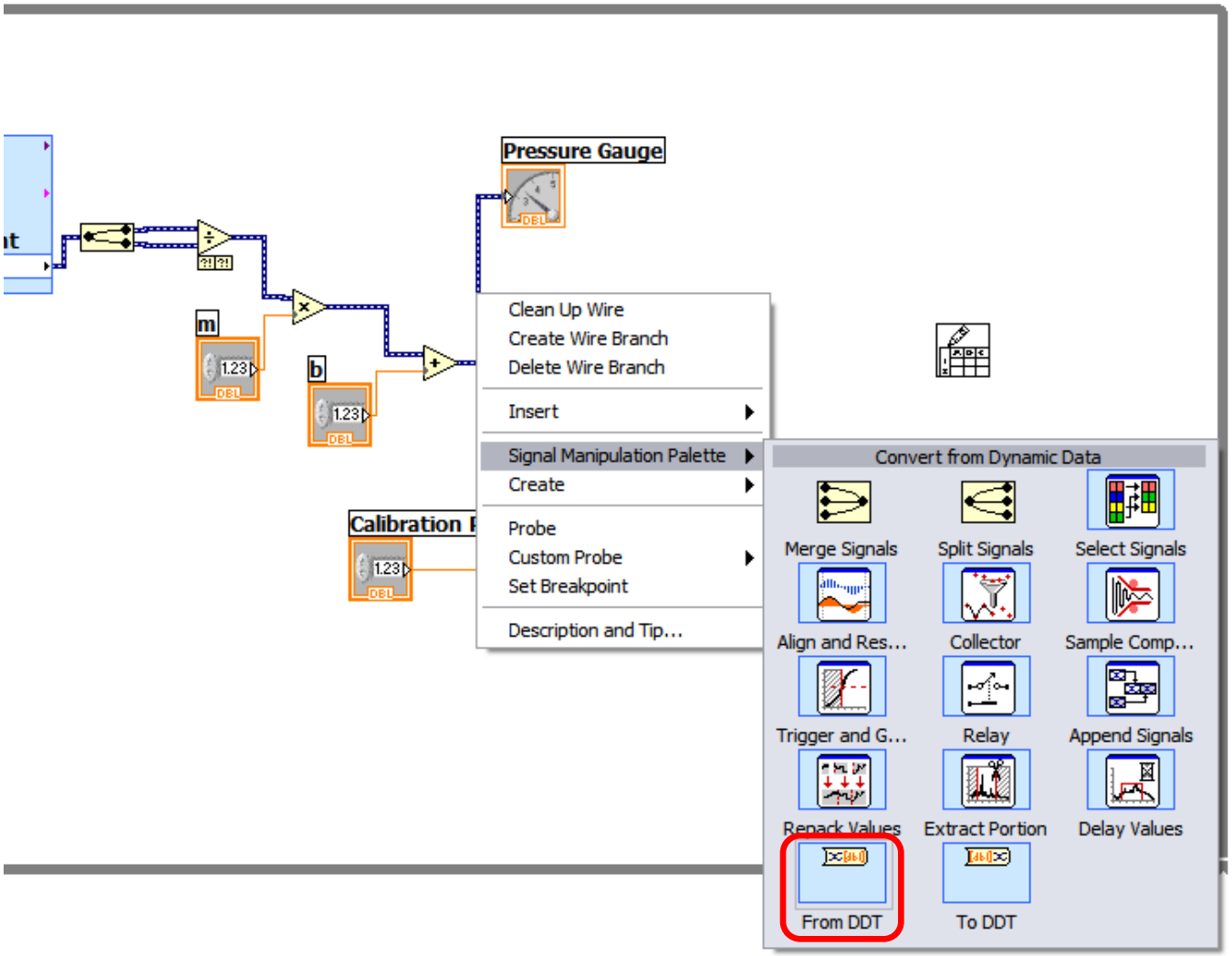
Front Panel now looks as follows



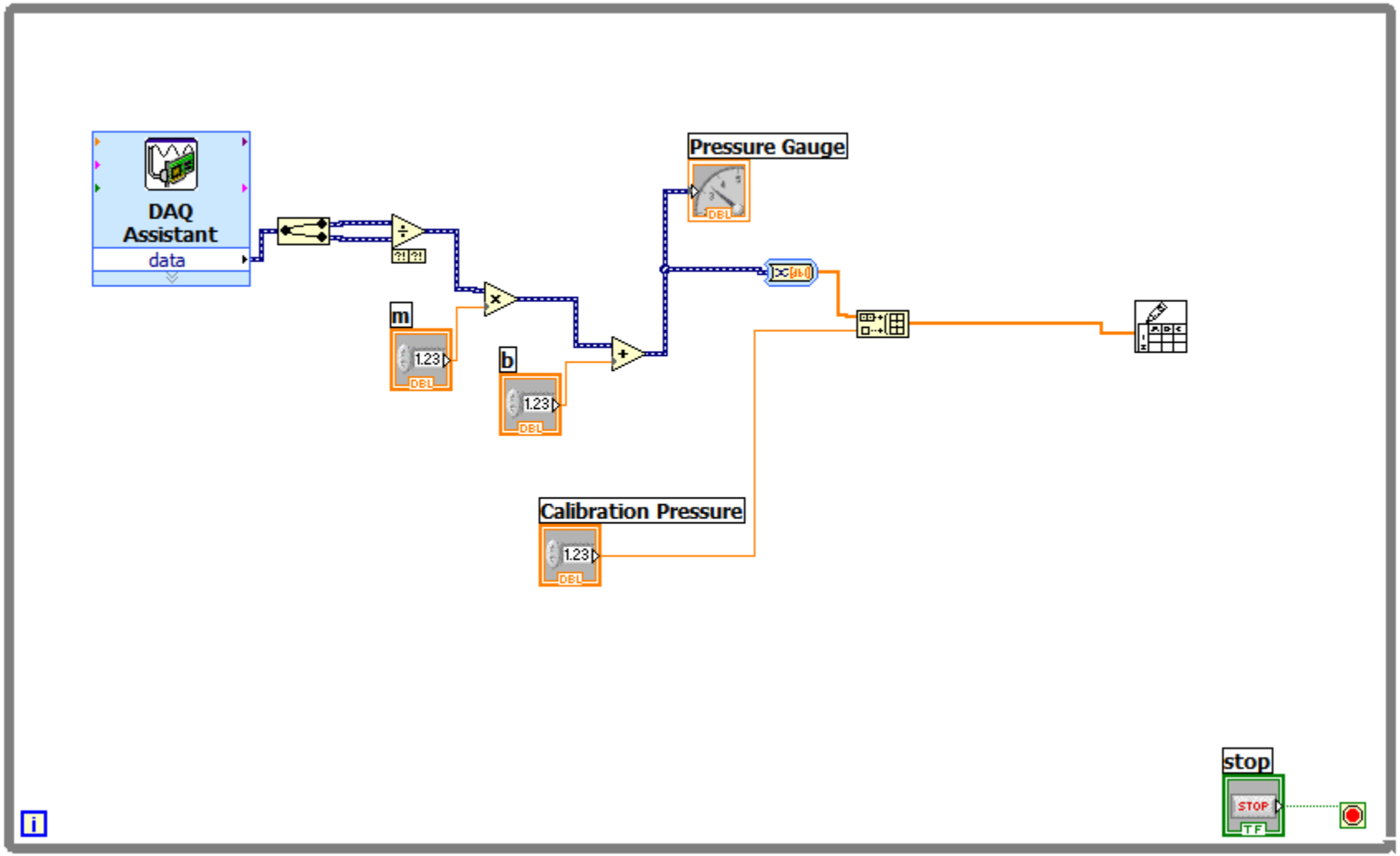
Wire the numeric control to a 'Build Array'
Pull down the array to increase the number of inputs to it
(we need two)



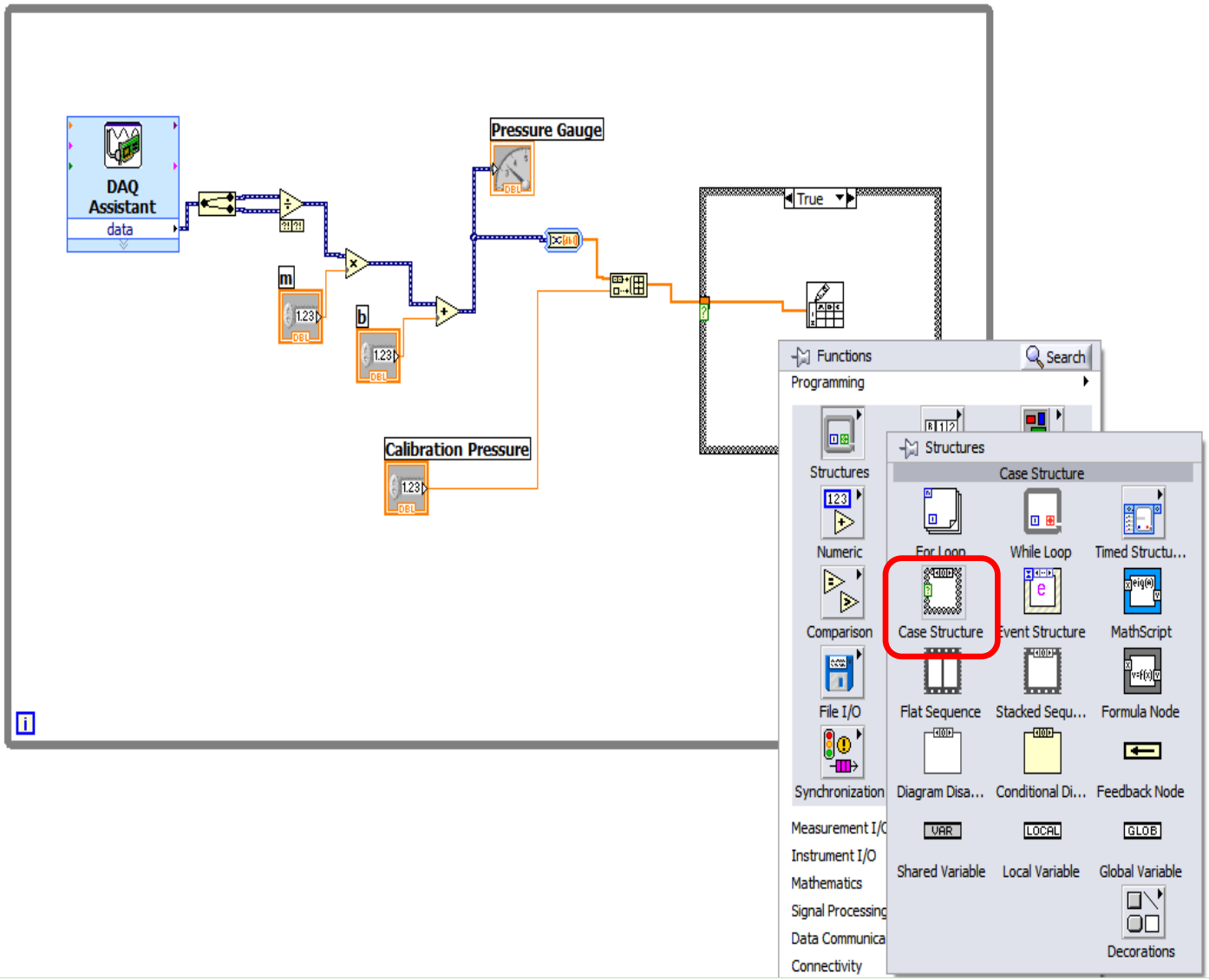
Complete the Wiring and add a convert from Dynamic Data with default options, as shown



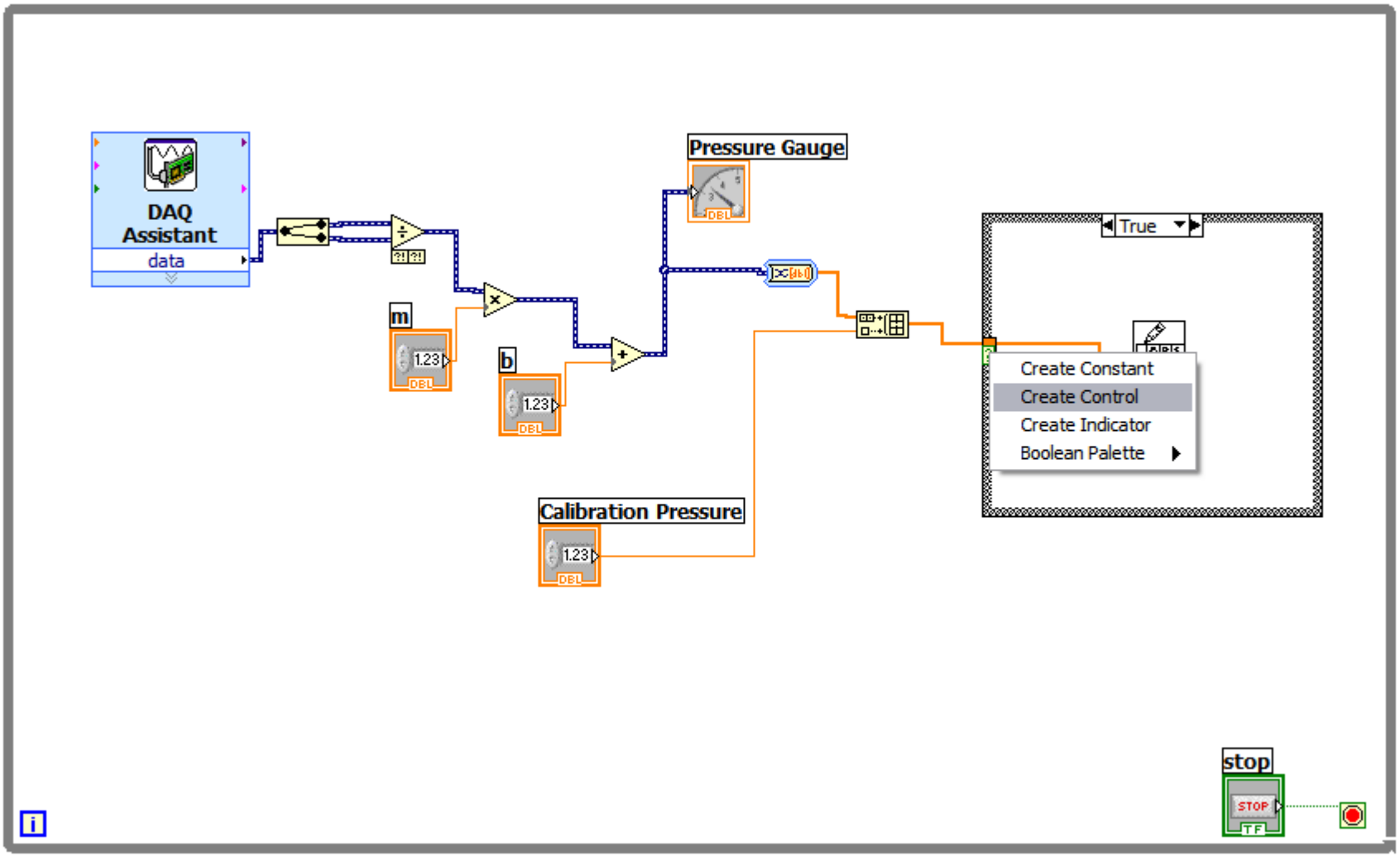
Now add a Write to text "*.xls" file as shown (1D data port)



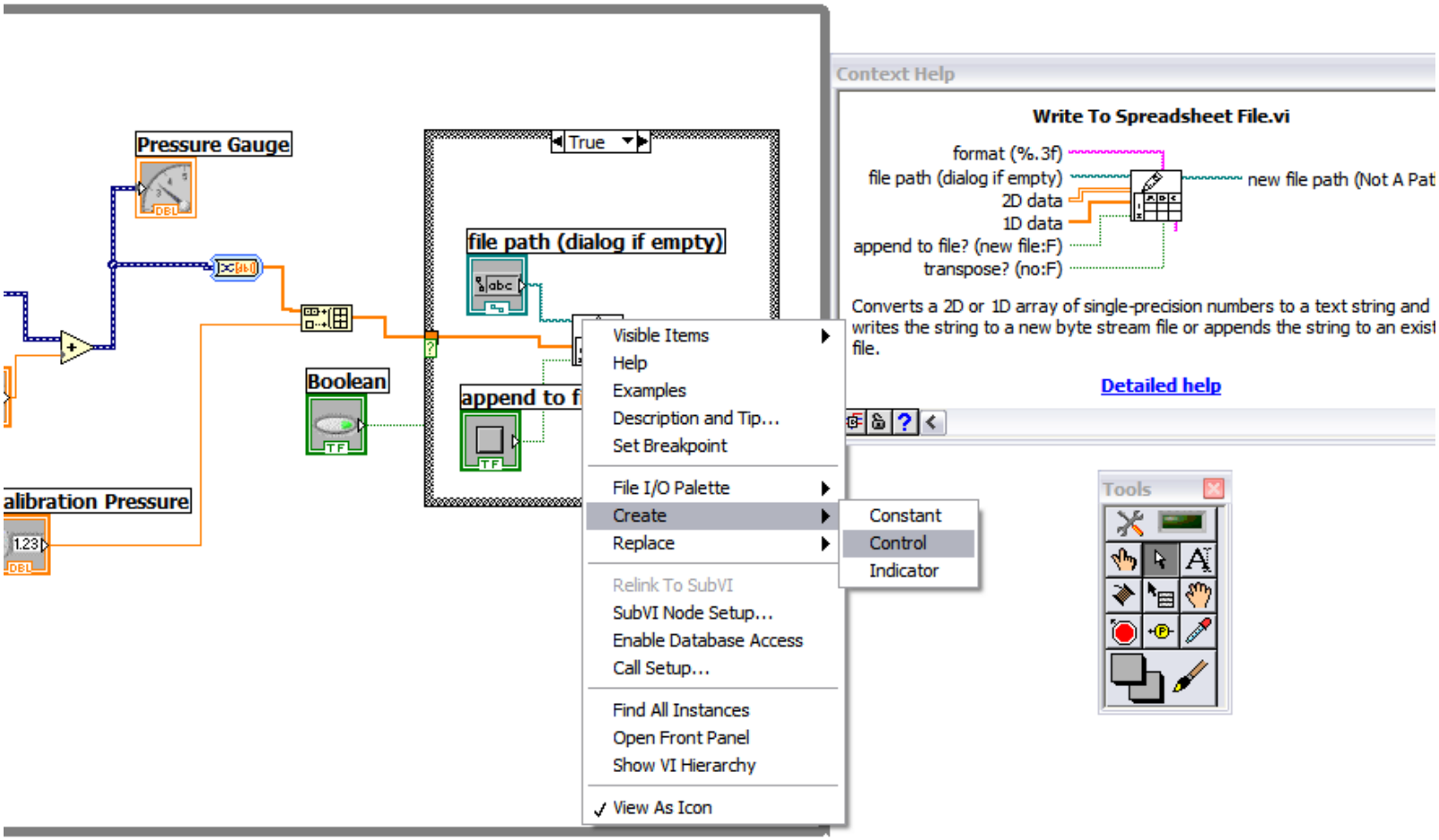
Now add a 'Write if True' case Structure



Create a Control to the internal True case Structure

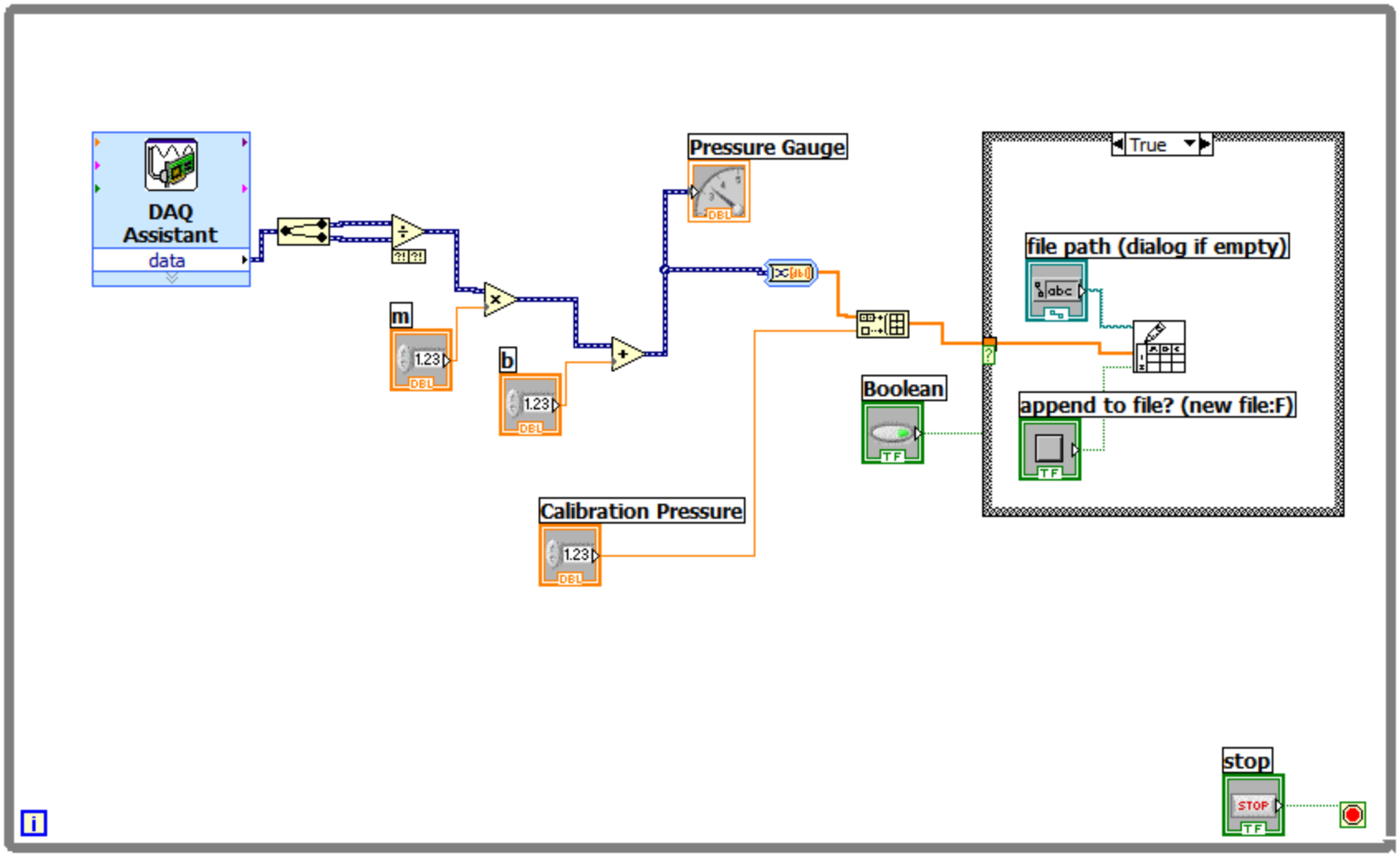


Create Control for 'file path' and 'append to file'

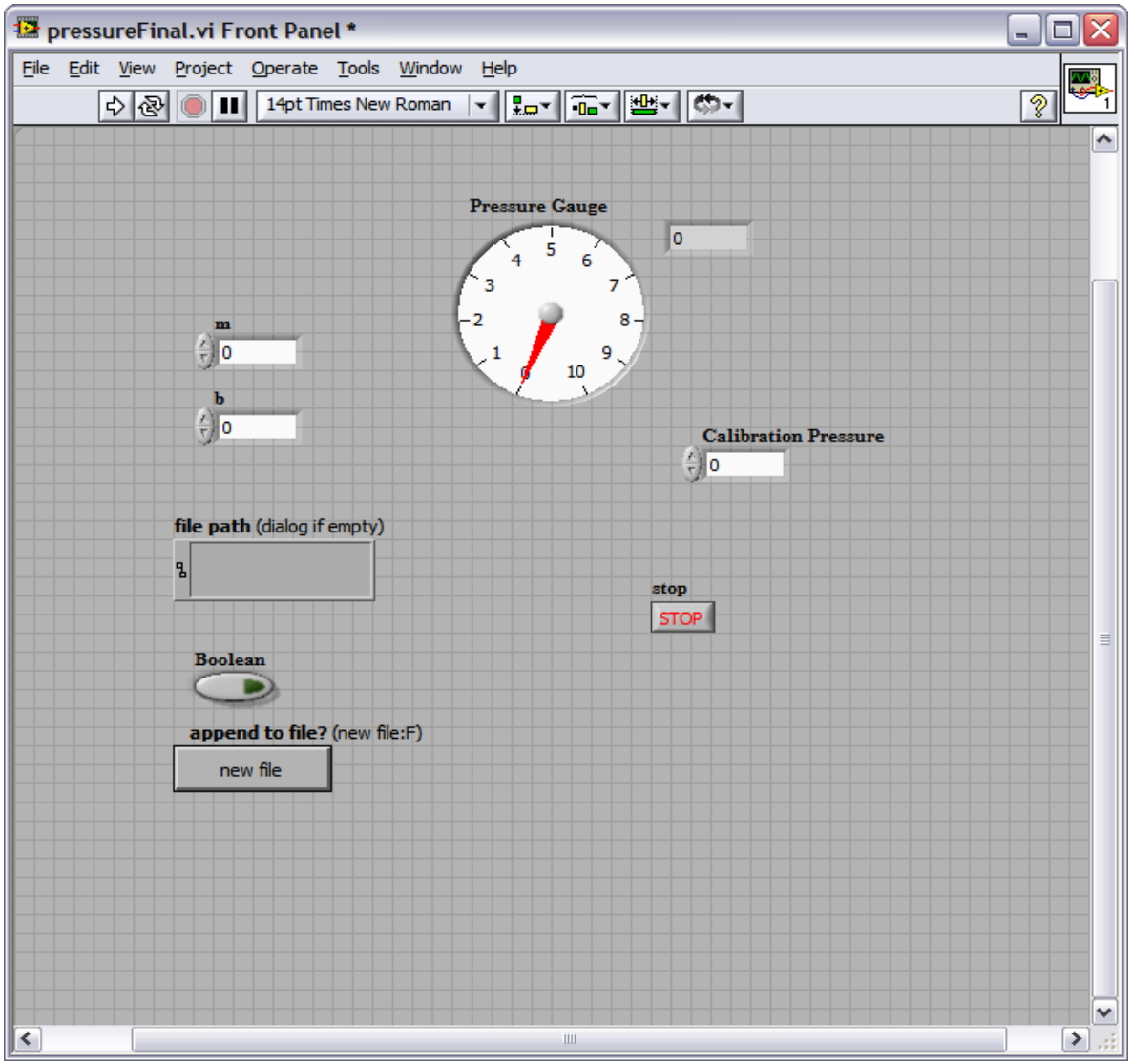


WPI

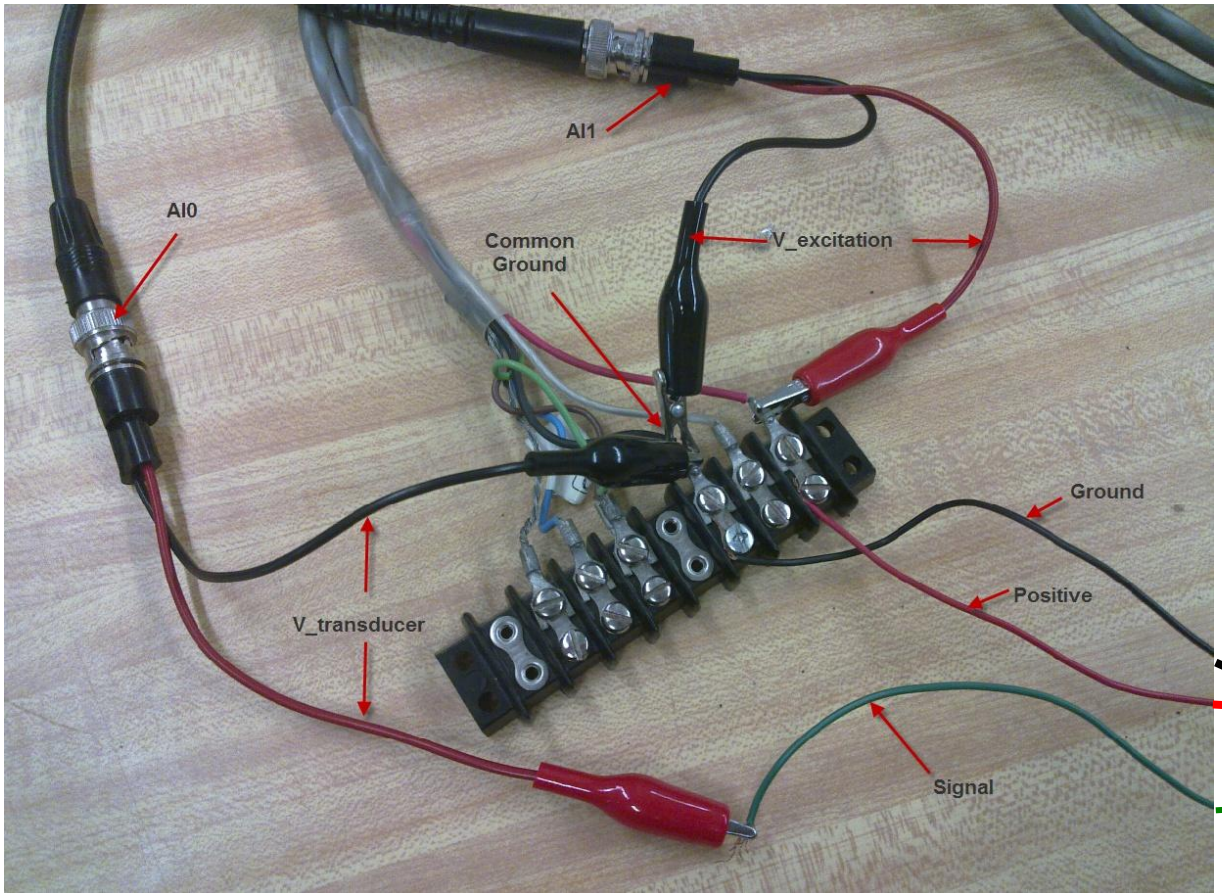
Completed Back Panel

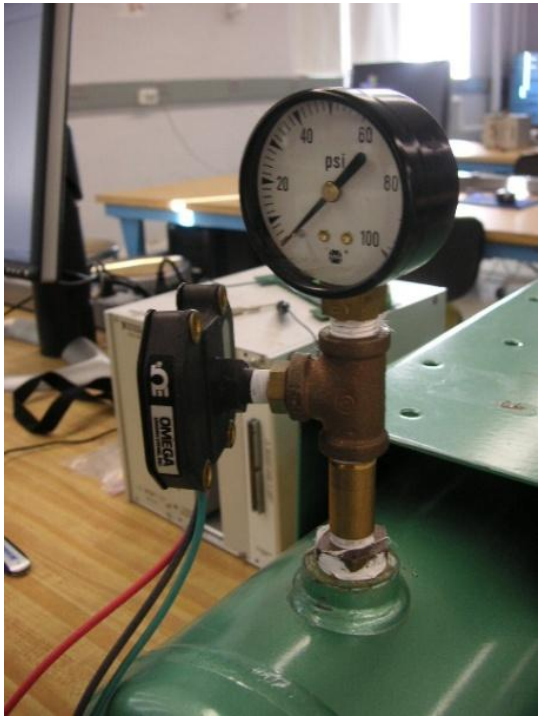


Completed Front Panel



Channel configuration

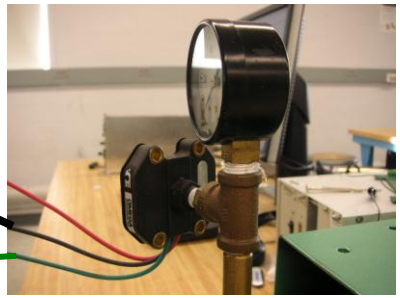




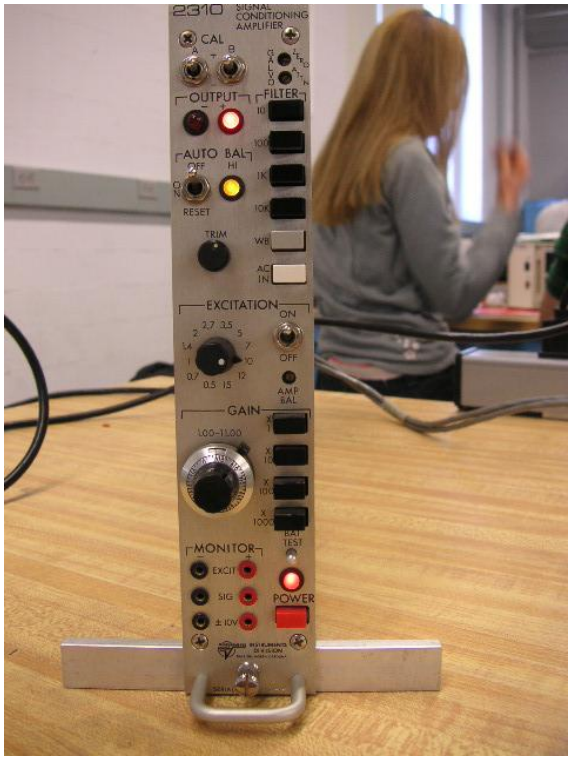
Red

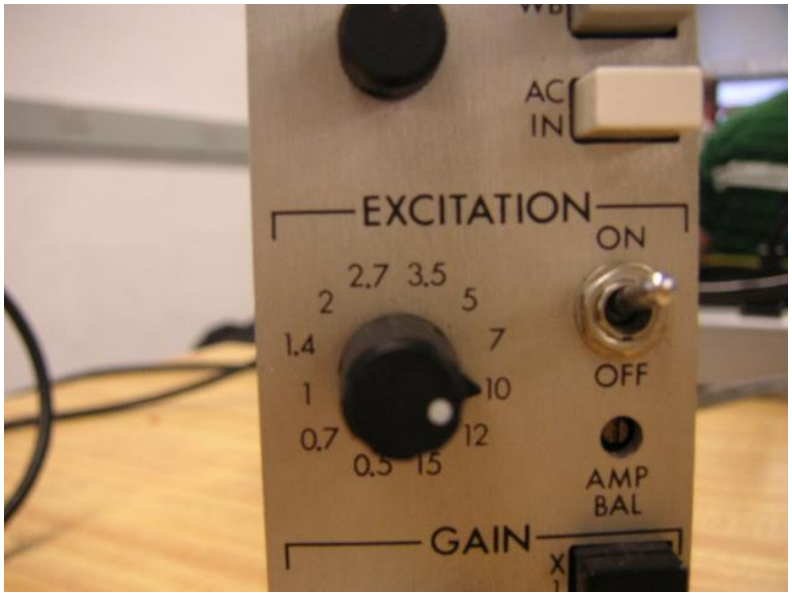
Black

Green



Power supply





Test your VI and Hardware