

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.

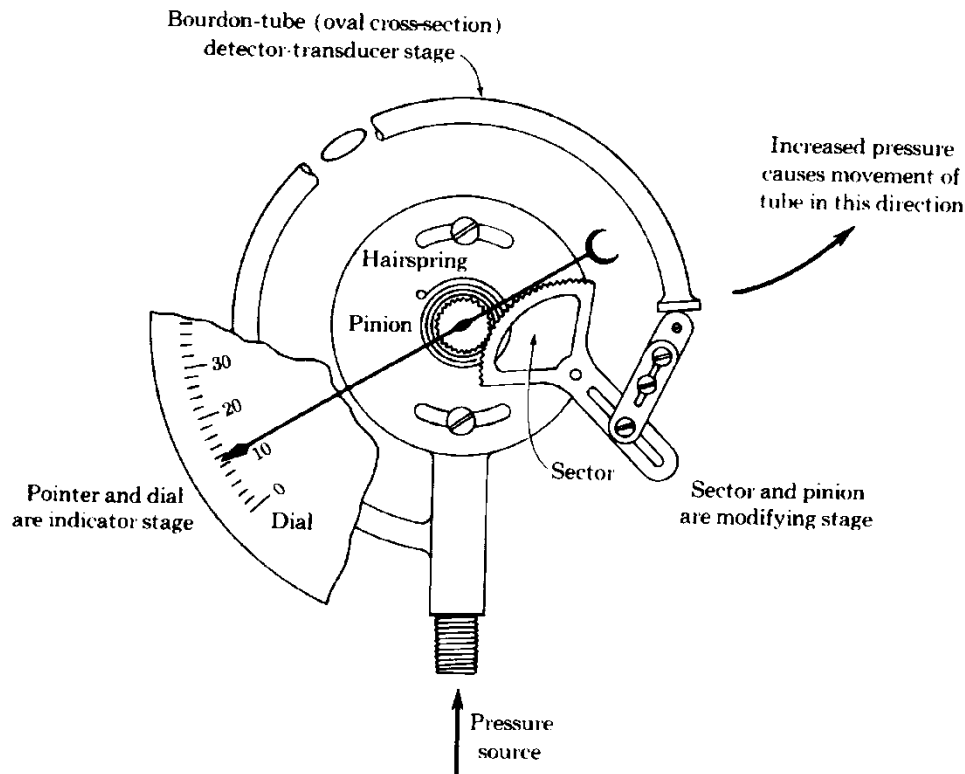


Fig. 1. Small displacement of tube is amplified at center of gear which visually displays the pressure.



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.

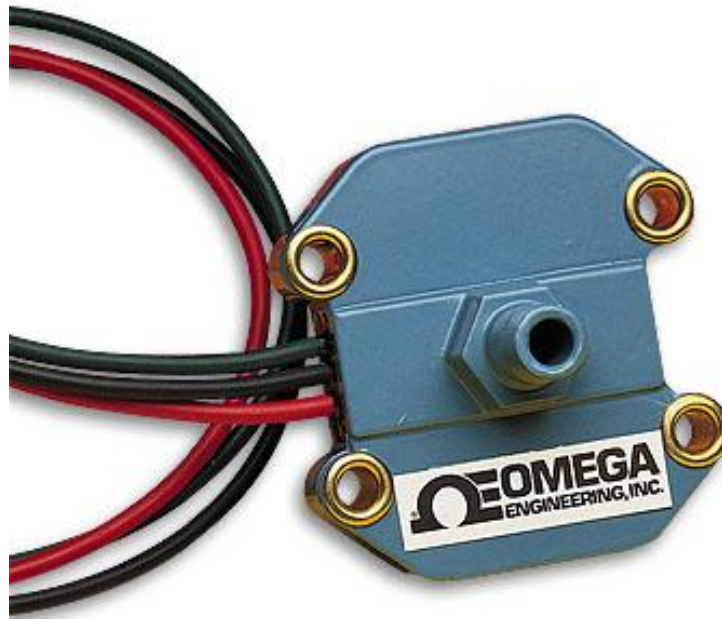


Fig. 2. PX242 Metal Case Transducer for Measuring Low Pressure and Vacuums



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: $\pm 1.5\%$ FS BFSL, $\pm 0.5\%$ FS for 60 to 100 psig

Hysteresis & Repeatability: $\pm 0.25\%$ 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

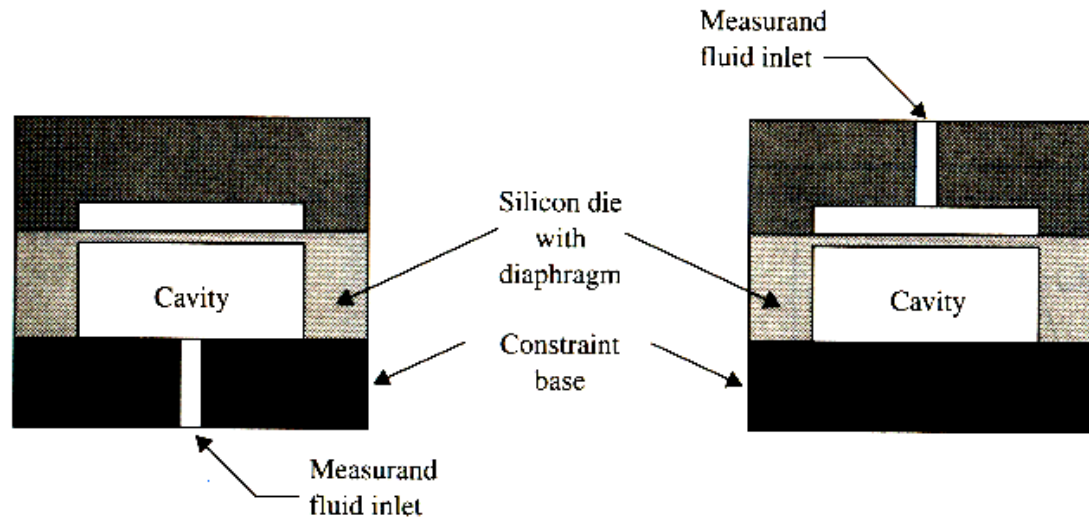
BFSL = Best fit straight line



Pressure transducer: Si (Silicon) diaphragm

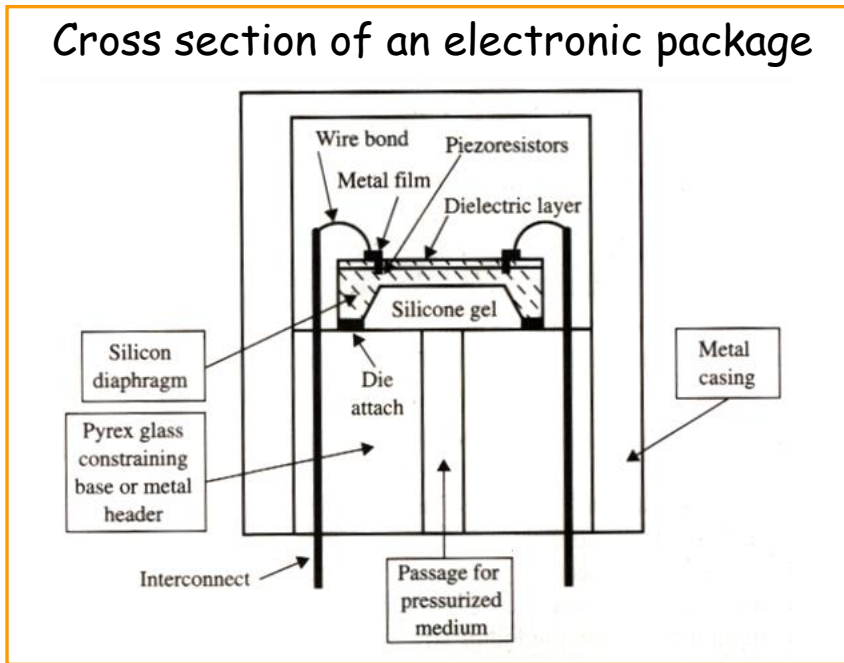
Back side pressurized

Front side pressurized



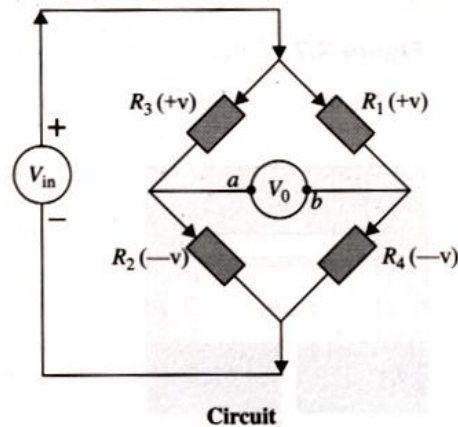
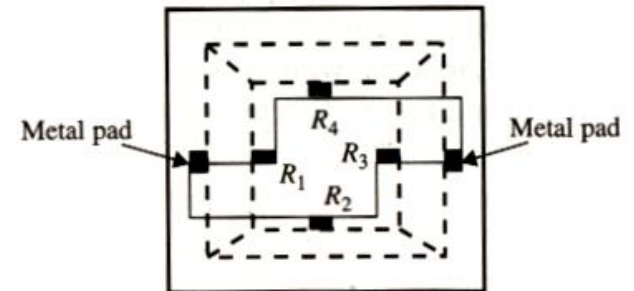
Pressure transducer: Silicon diaphragm. Resistive sensor

Cross section of an electronic package



Top view of silicon die

$R_1, R_2, R_3, R_4 =$ piezoresistors



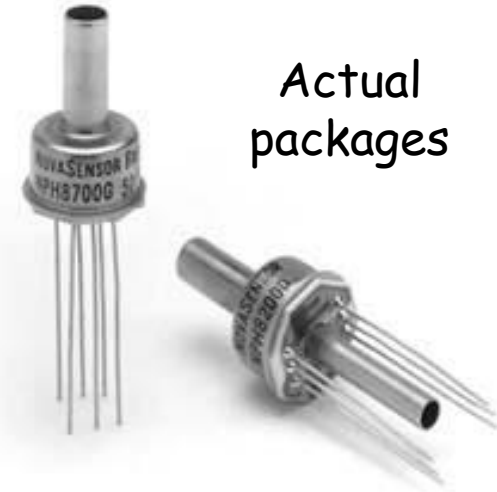
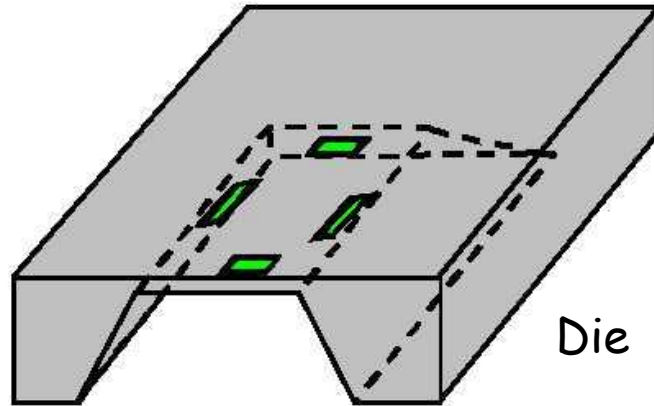
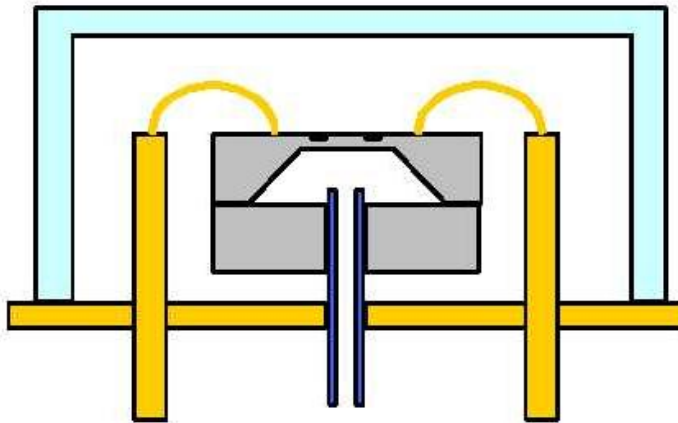
Wheatstone bridge:

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



Pressure transducer: Silicon diaphragm. Resistive sensor

Schematic



<http://www.novasensor.com>



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

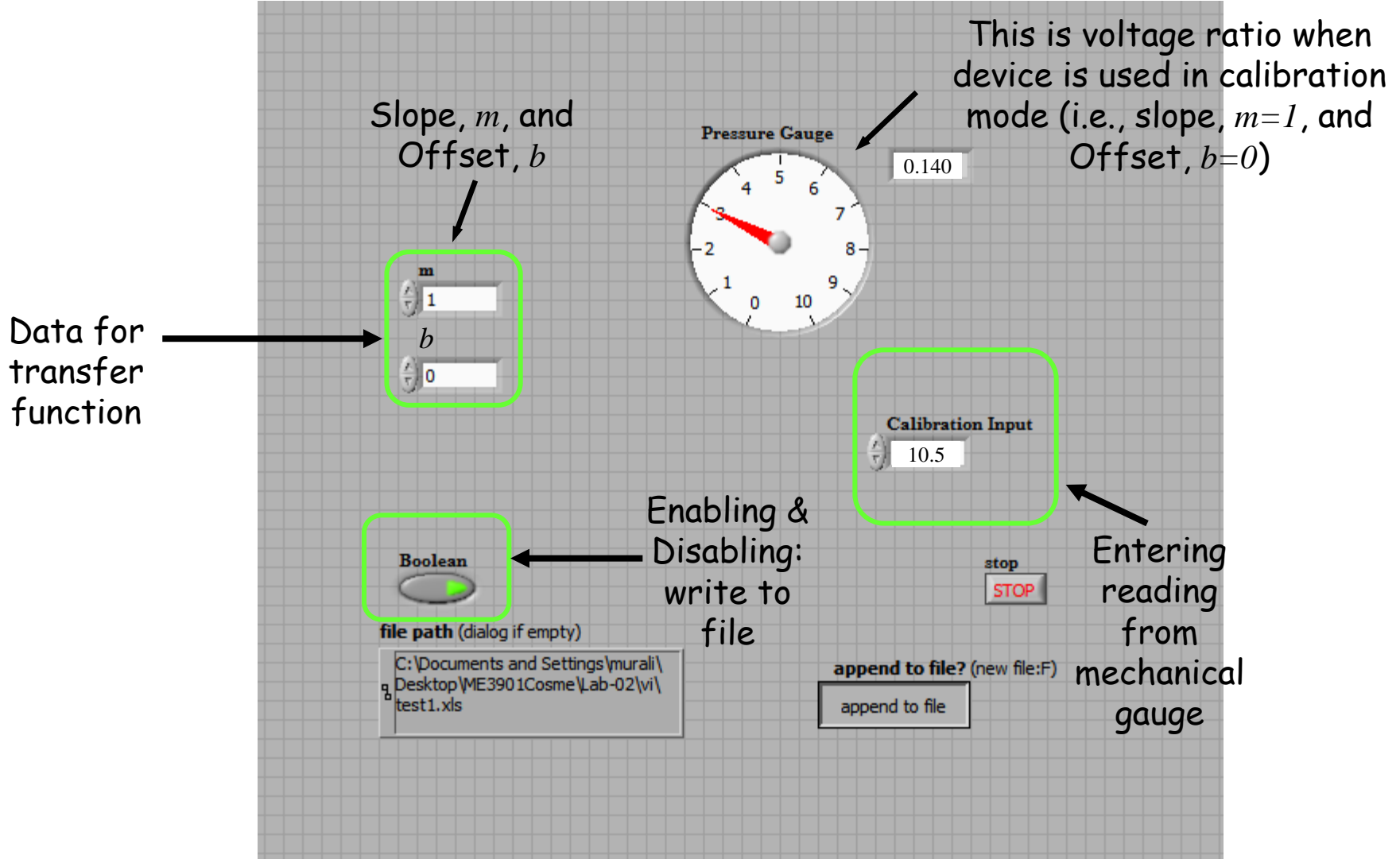
Take into account:

Linear regression to define “transfer function”

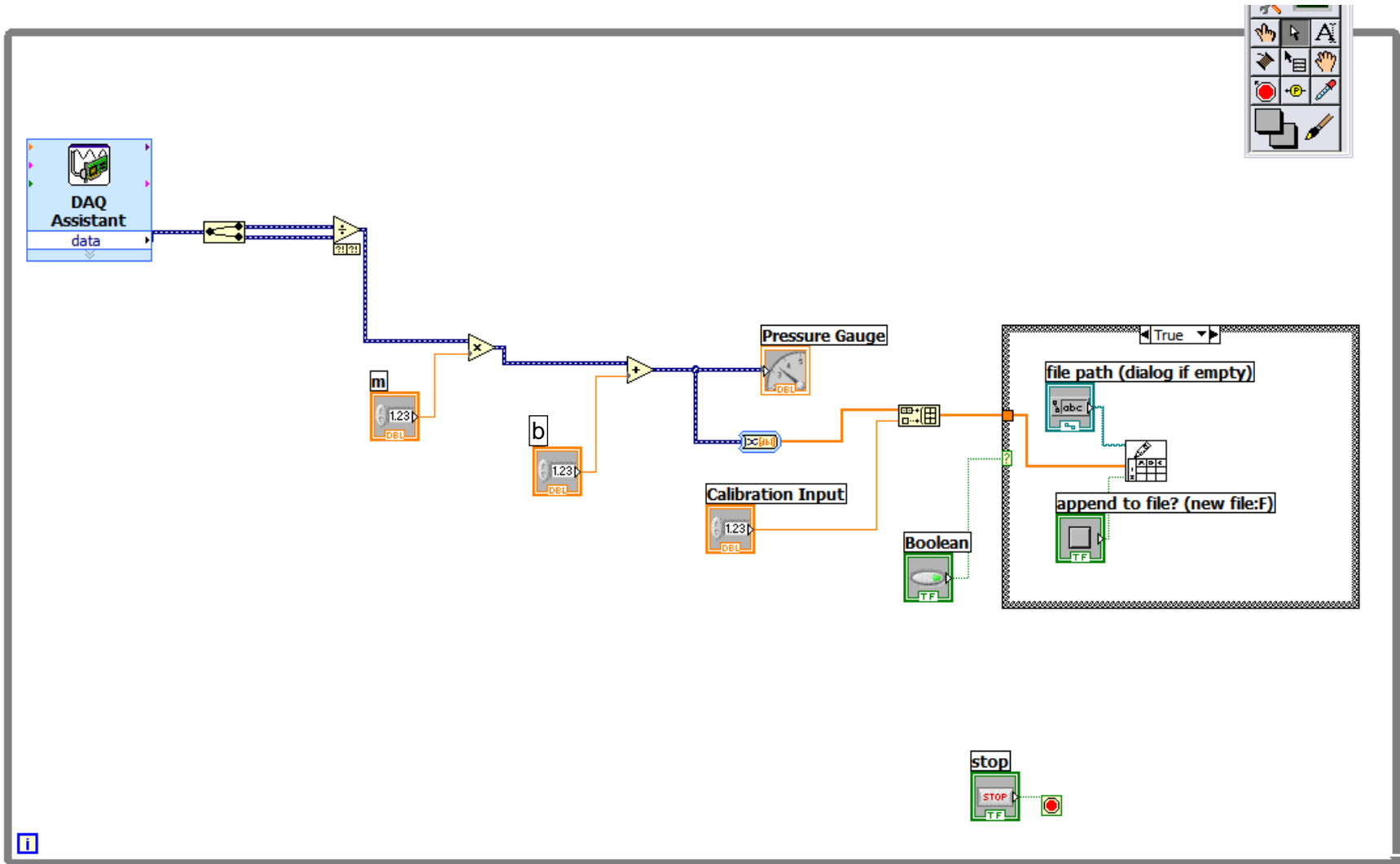
(i.e., Voltage \rightarrow Pressure function)



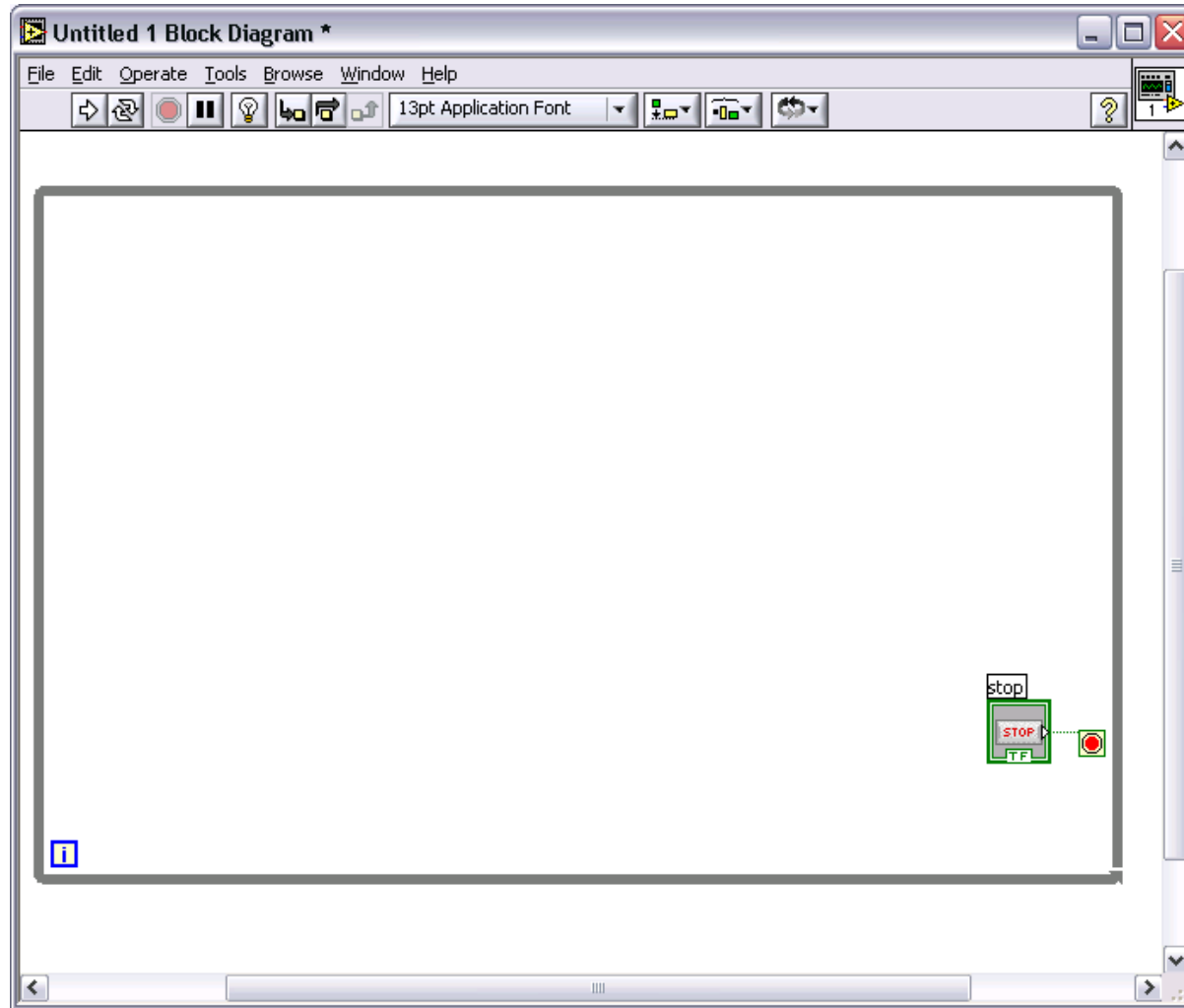
This is one possible VI to build



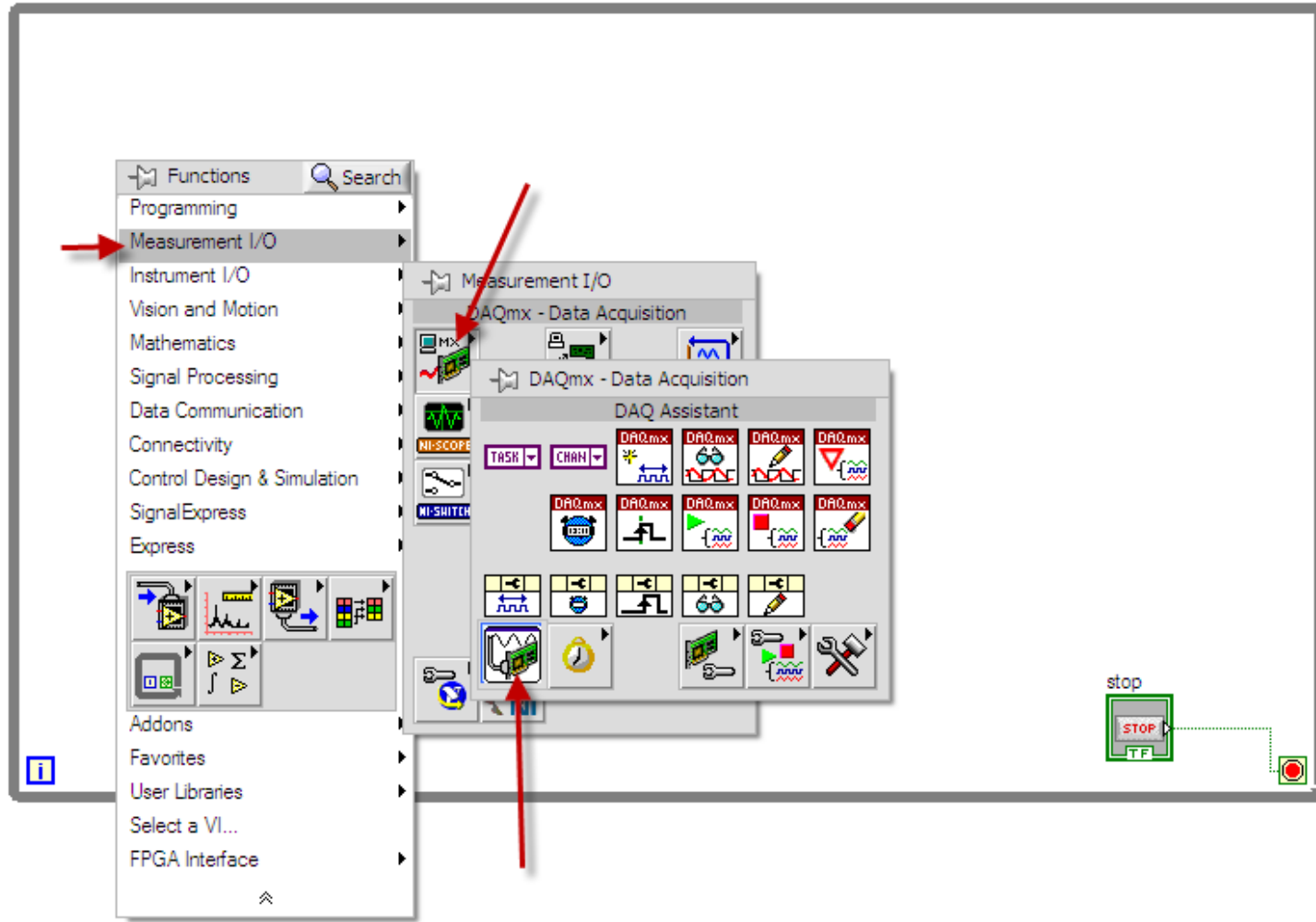
Block diagram of the VI



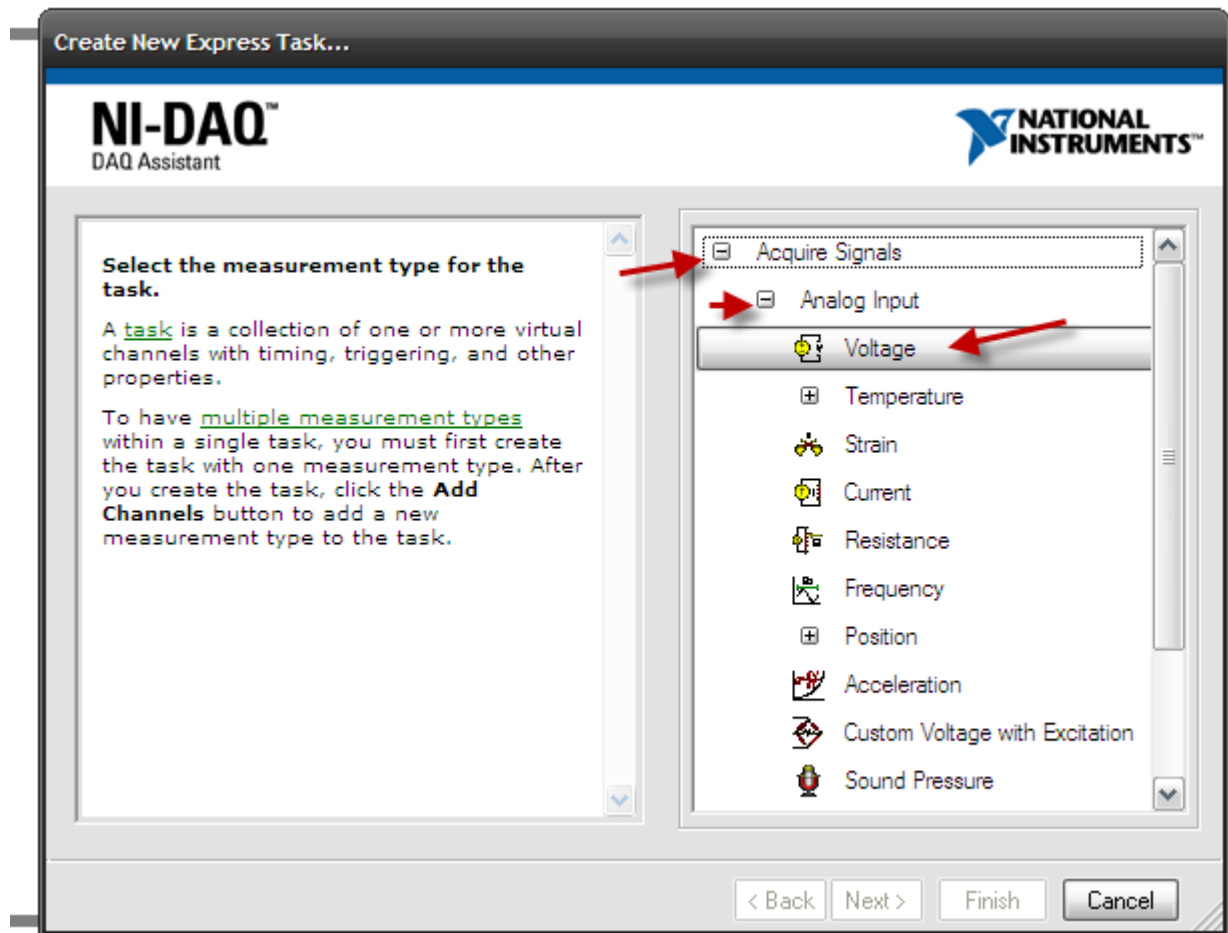
Create while loop and add a 'control' stop button



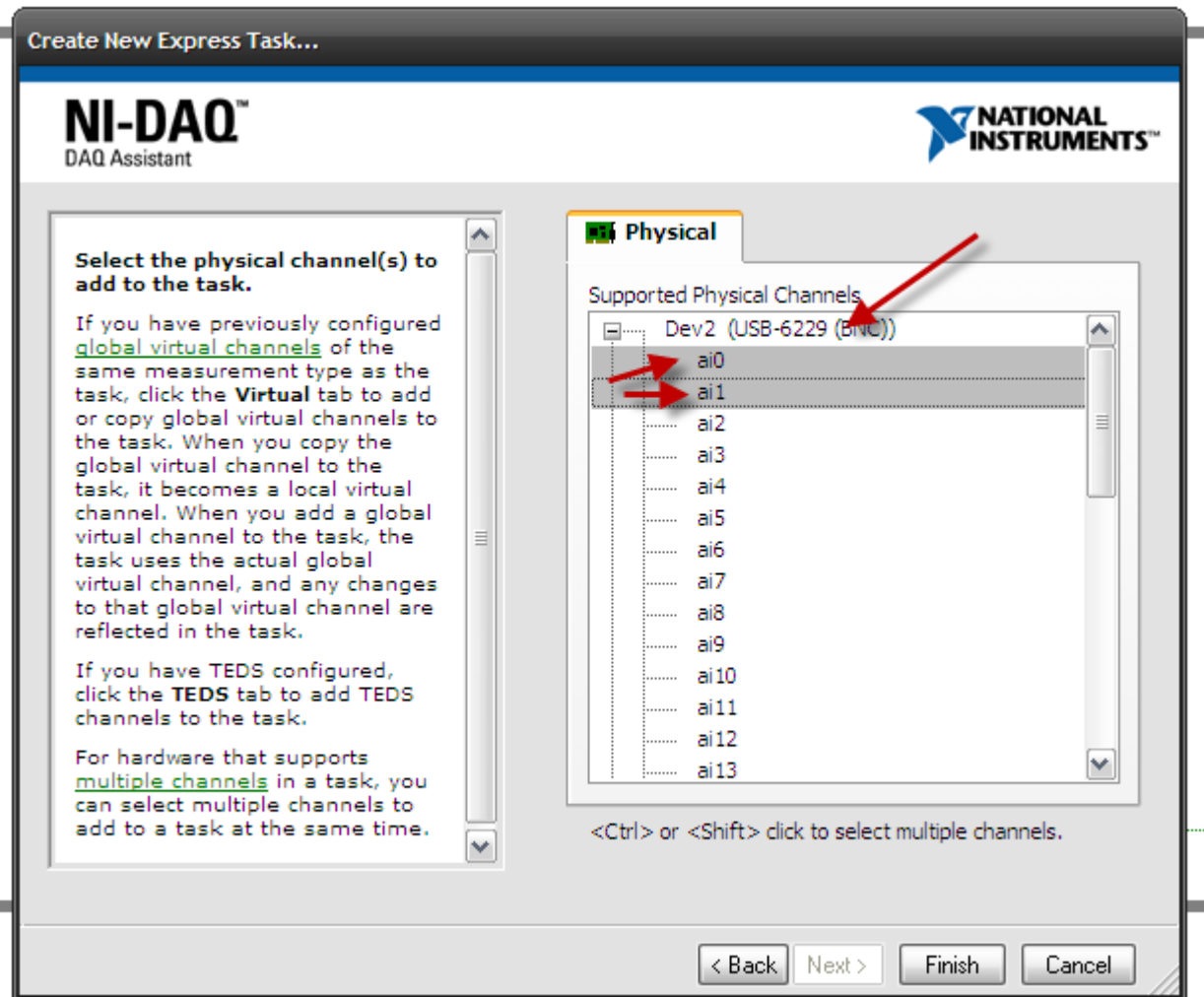
Configure 2 Input Channels using the DAQ Assistant



Configure 2 Input Channels using the DAQ Assistant



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

Configuration Triggering Advanced Timing

Channel Settings

+ X ↕ Details >> ↑

Voltage_0
Voltage_1

Click the Add Channels button (+) to add more channels to the task.

Voltage Input Setup

Settings Calibration

Signal Input Range

Max 10 Scaled Units Volts

Min -10

Terminal Configuration
Differential

Custom Scaling
<No Scale>

Timing Settings

Acquisition Mode Samples to Read Rate (Hz)

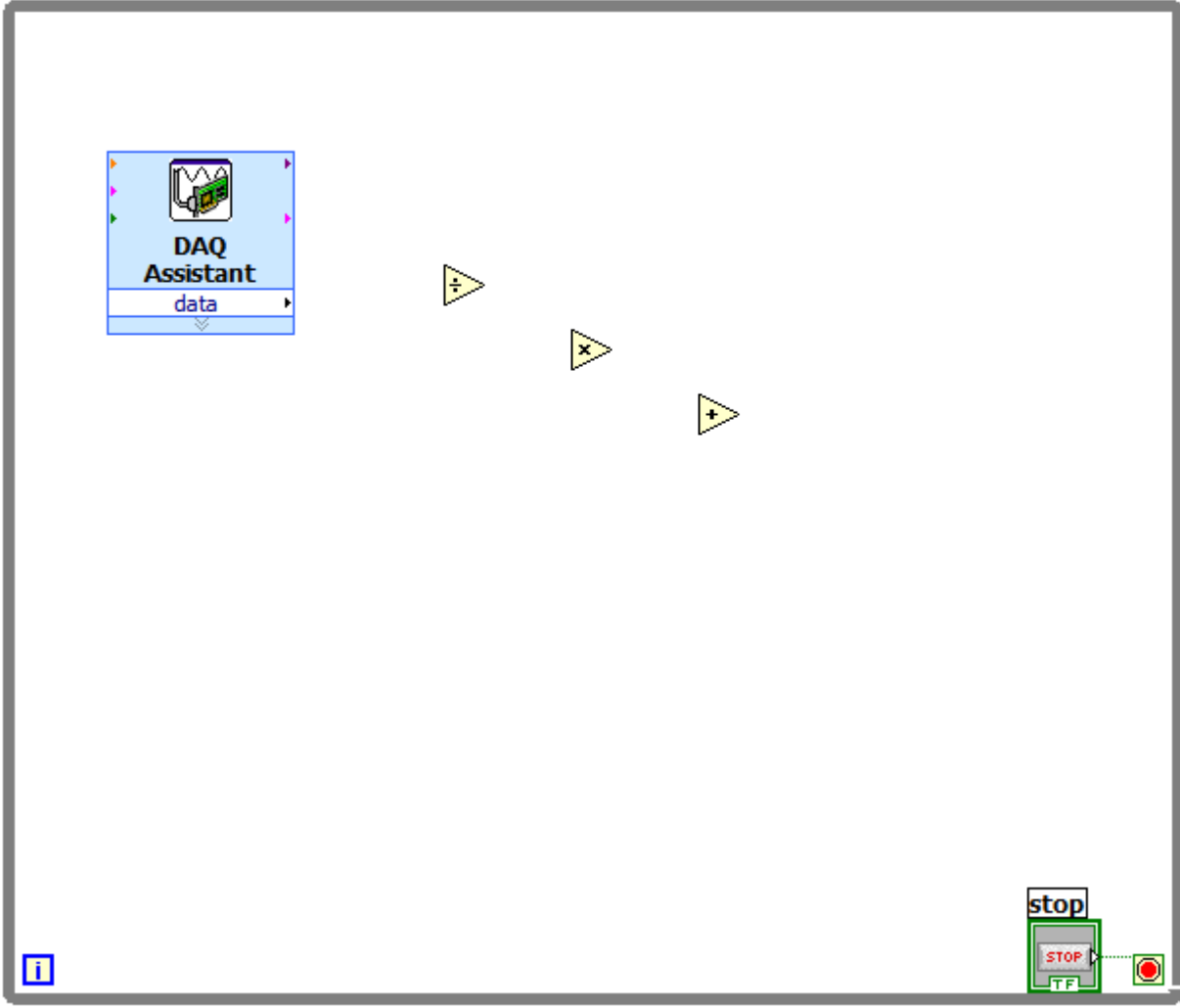
1 Sample (On Demand) 100 1k

Select a scale from the pull-down list or select **Create New** to create a new custom scale.

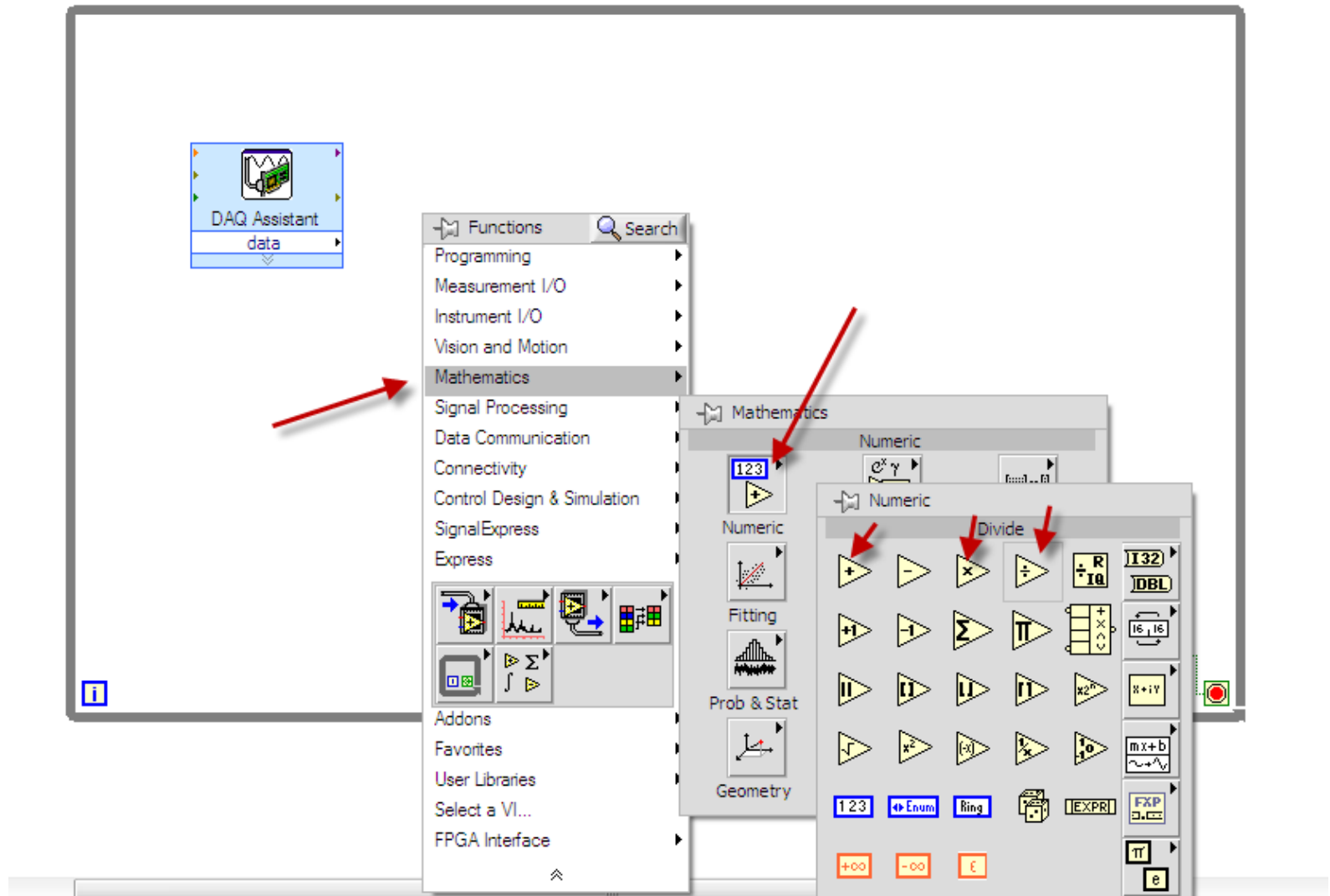
OK Cancel



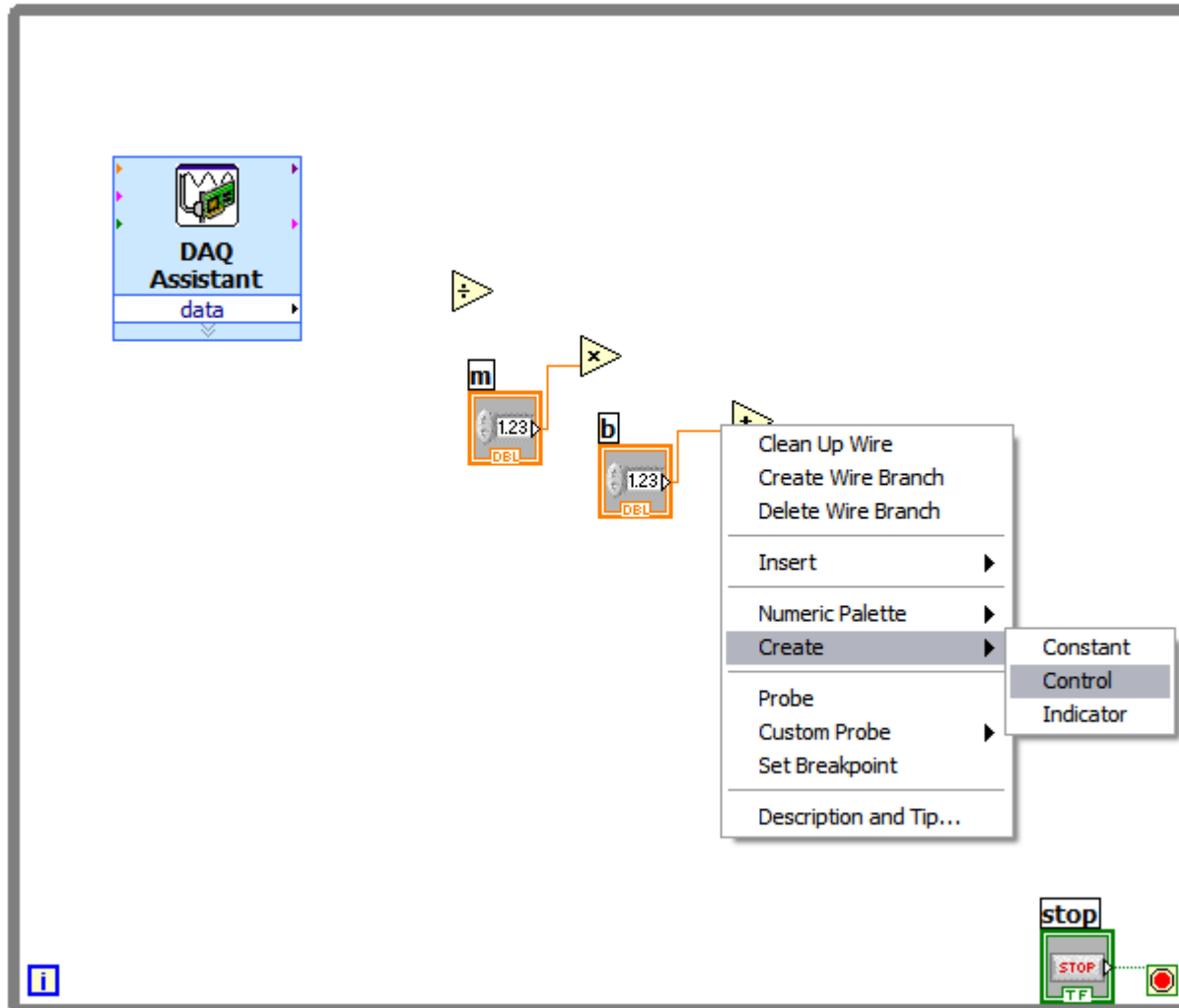
From the Math->Numeric icon menu get the following items:



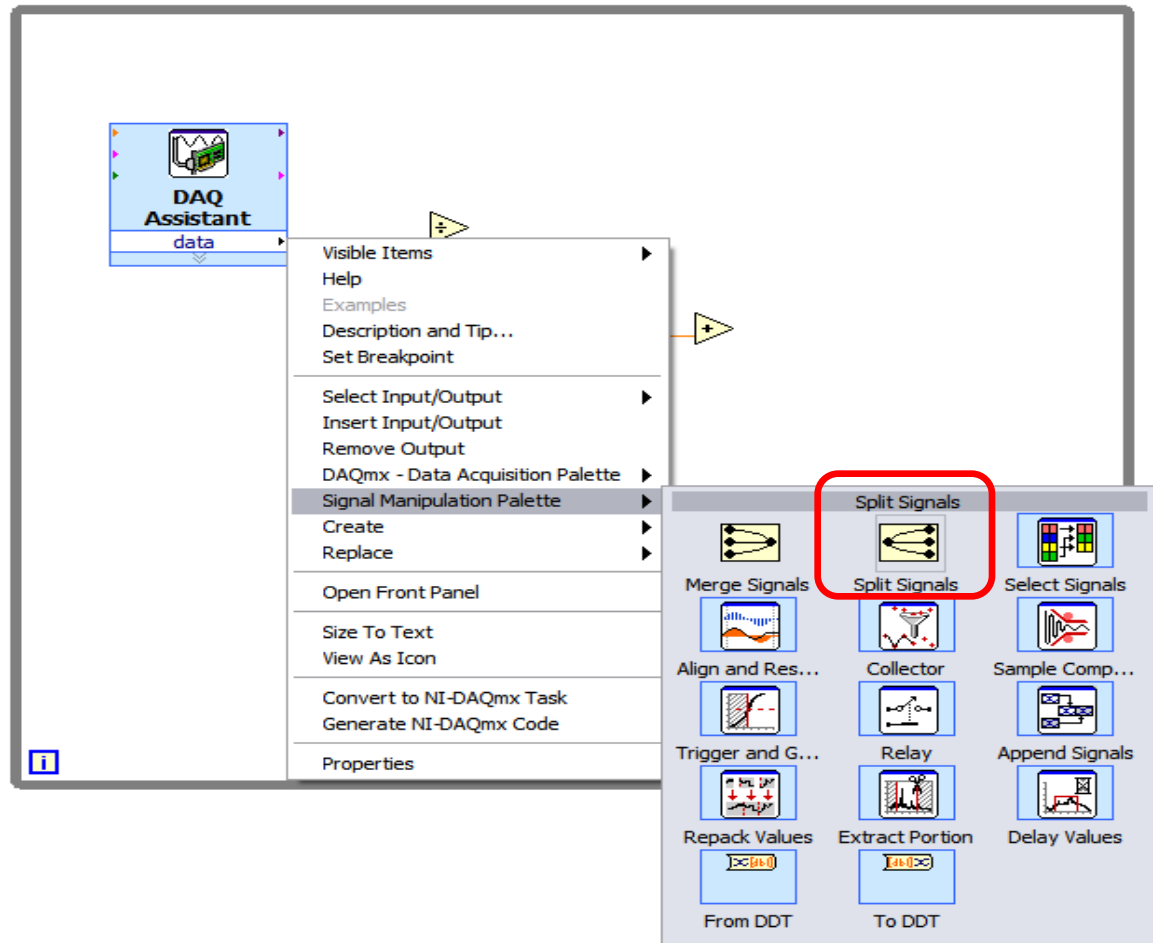
From the Math->Numeric icon menu get the following items:



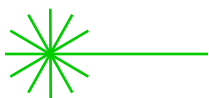
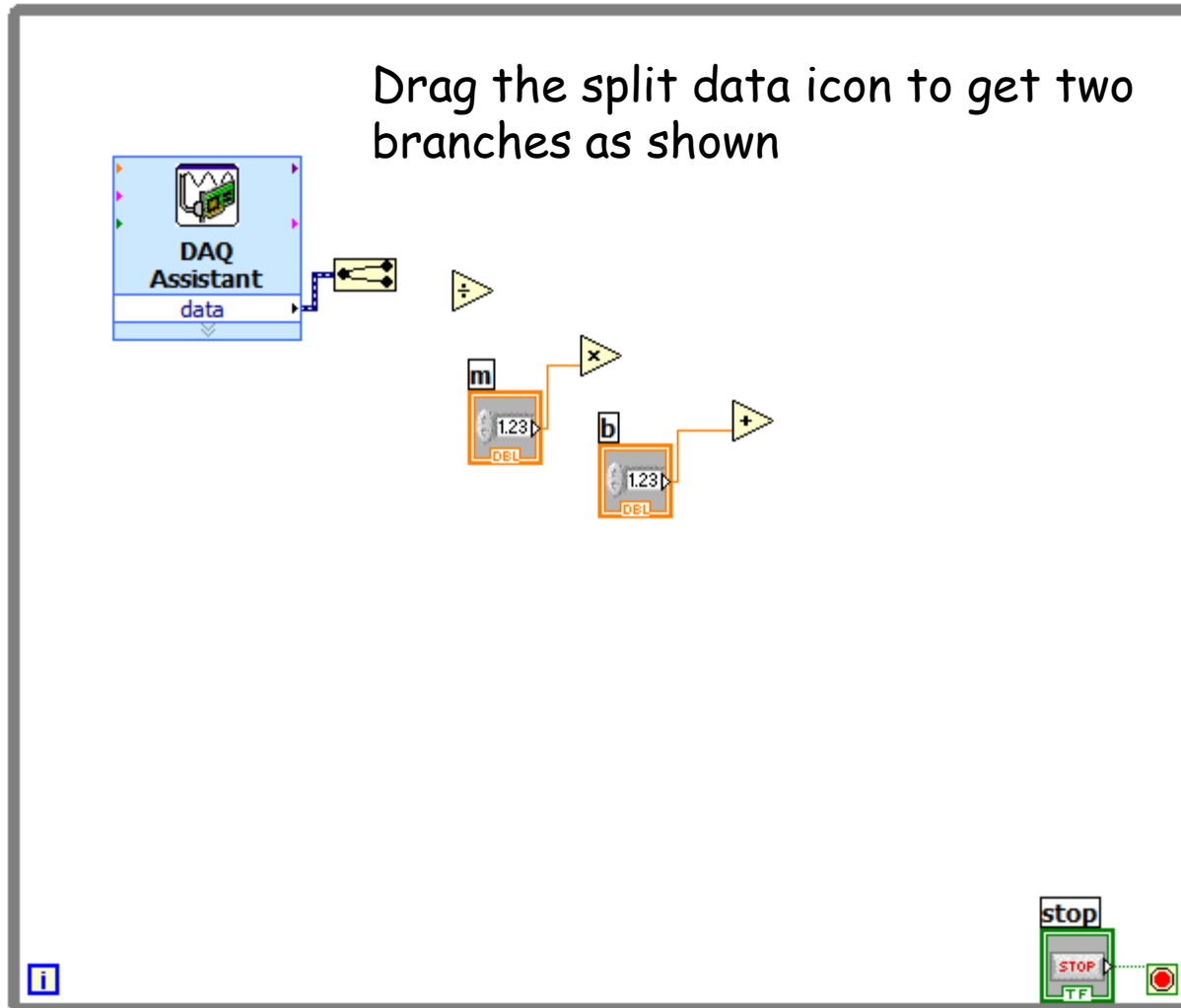
Add Controls for two of the numeric operators:



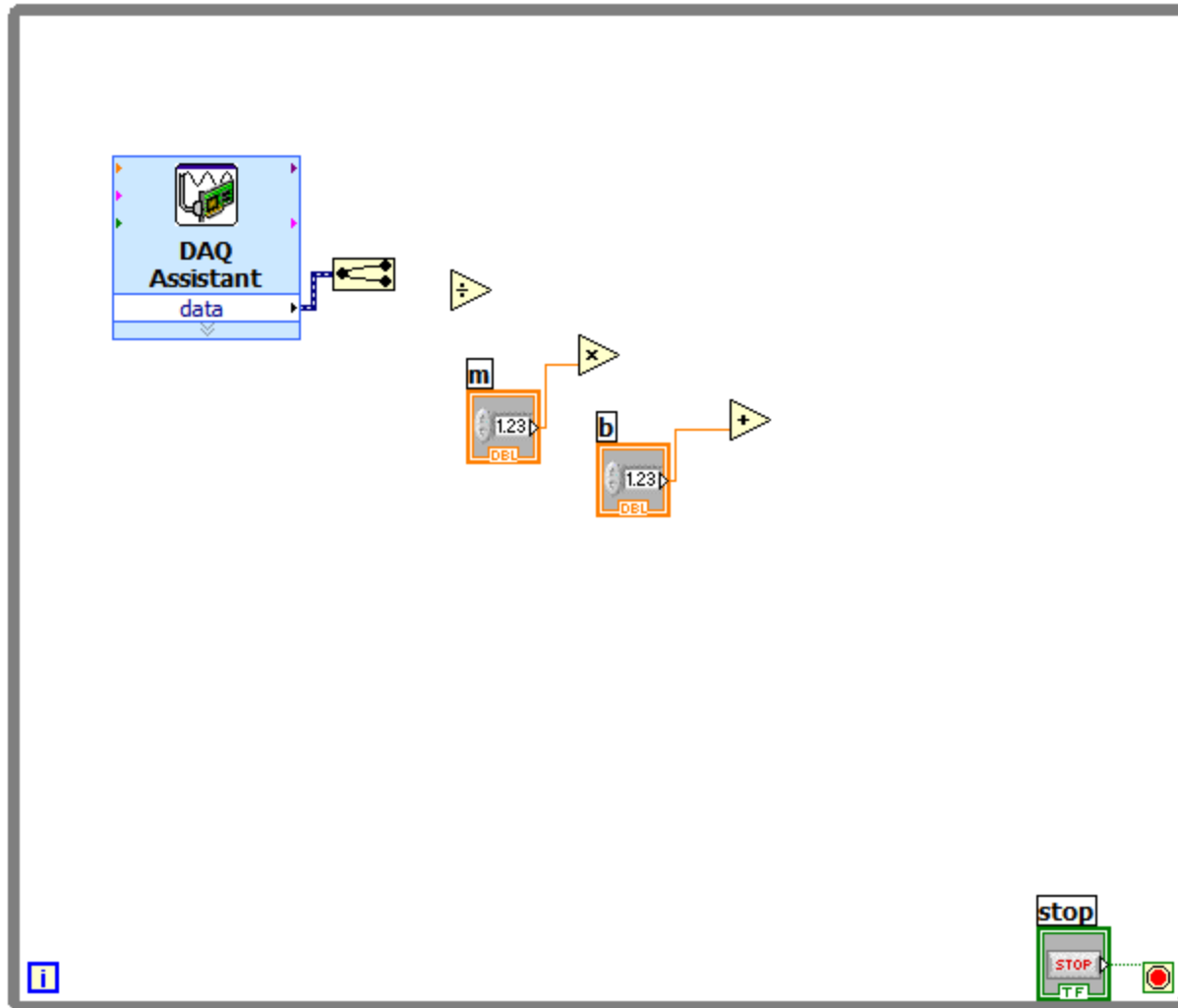
Need to split the data output into Pressure Transducer Output and Excitation Source



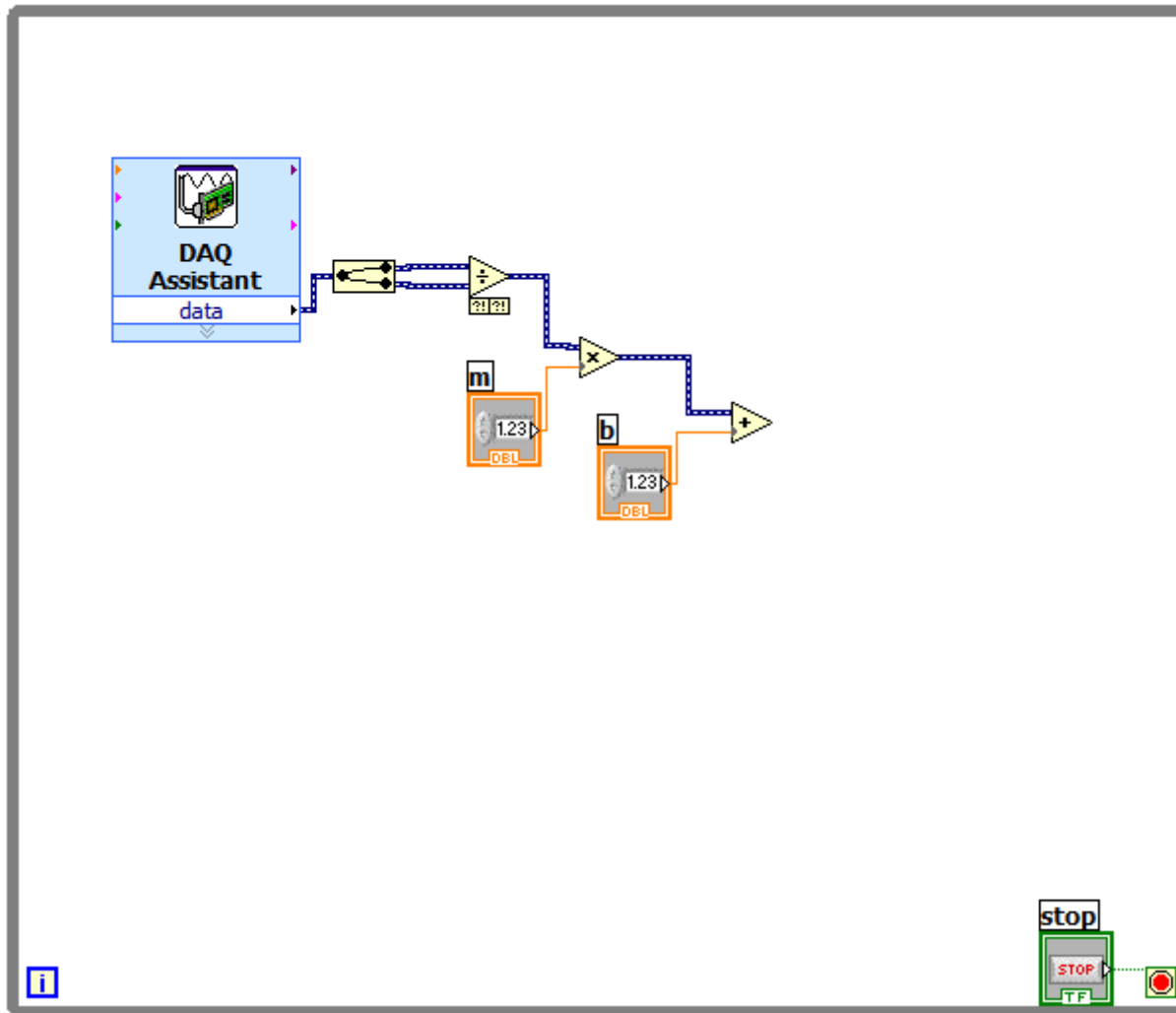
Split the data output into Pressure Transducer Output and Excitation Source



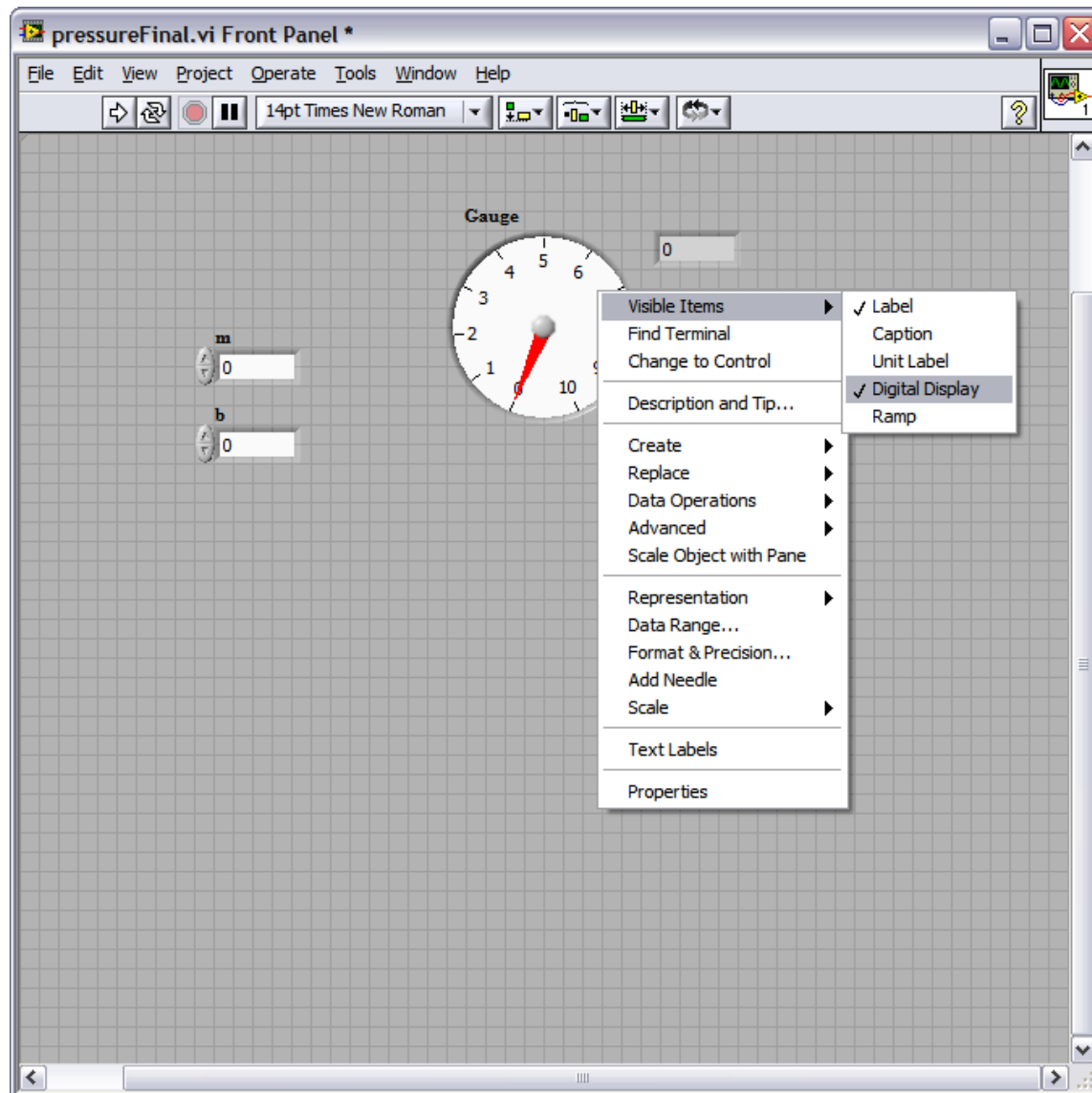
Make sure to divide the Pressure transducer Output by the Excitation Source



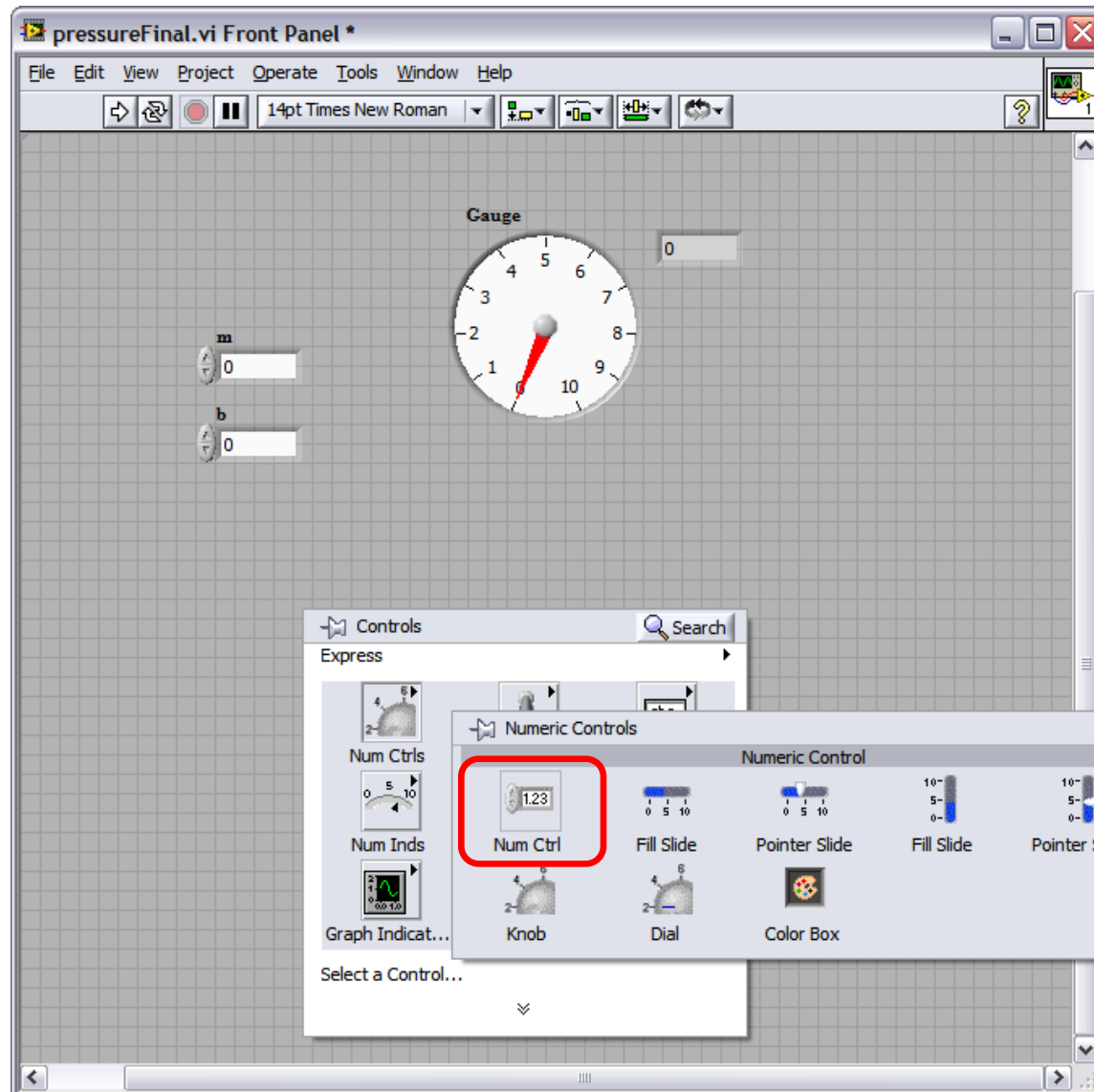
Wire them as follows



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



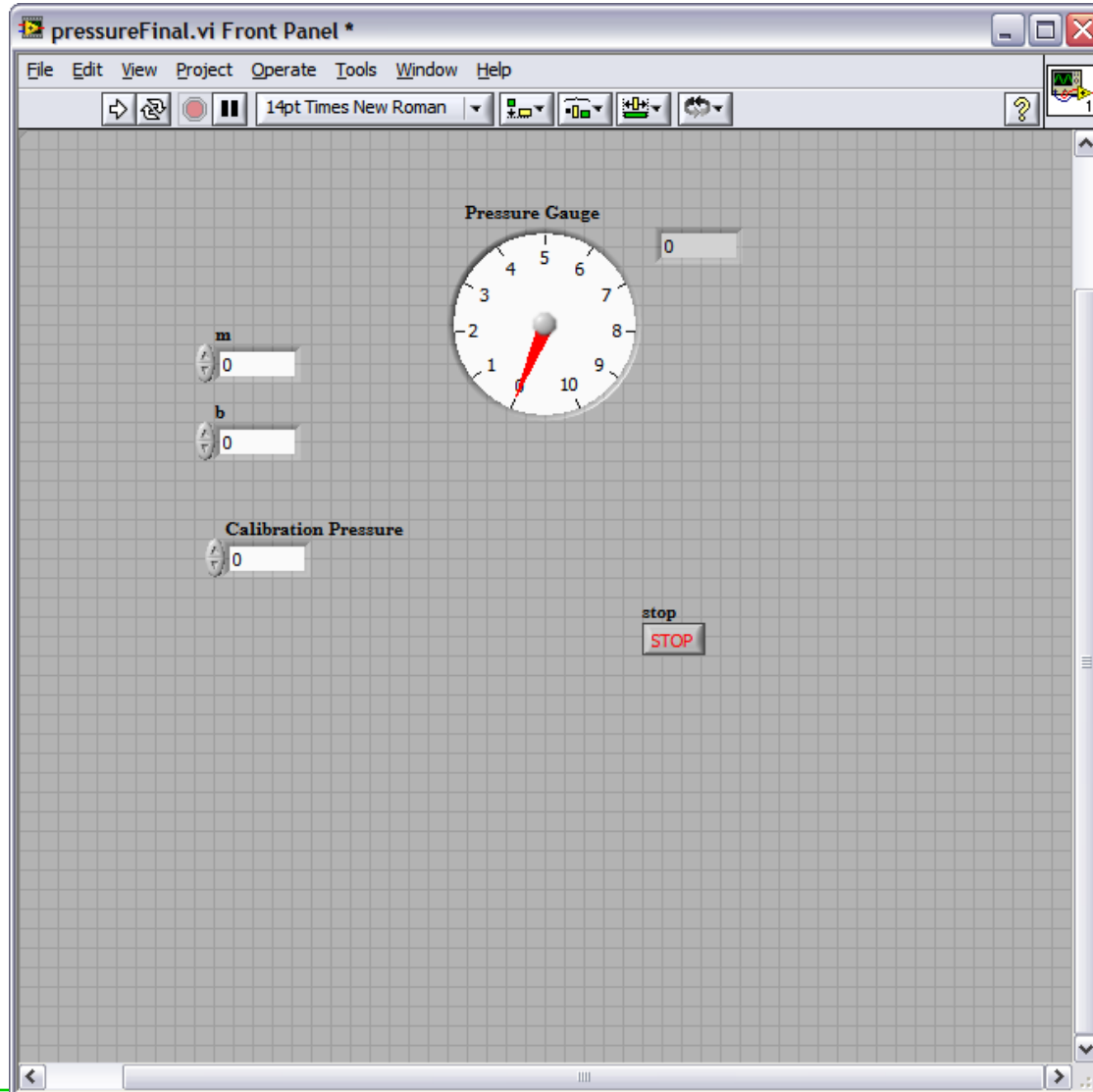
In the front panel add a Numerical Control Input



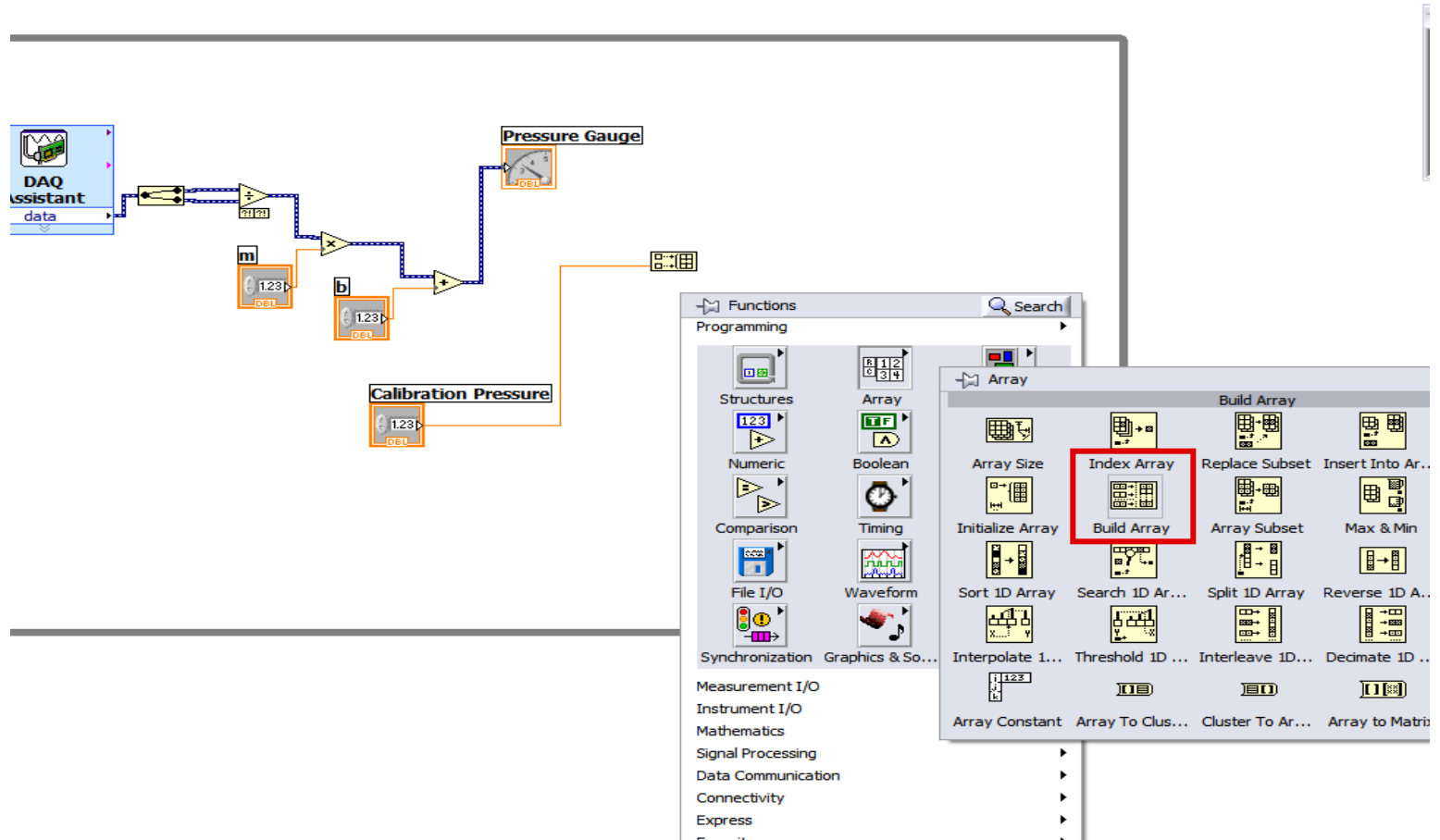
(For manual entering of gage reading)



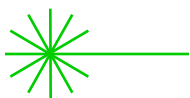
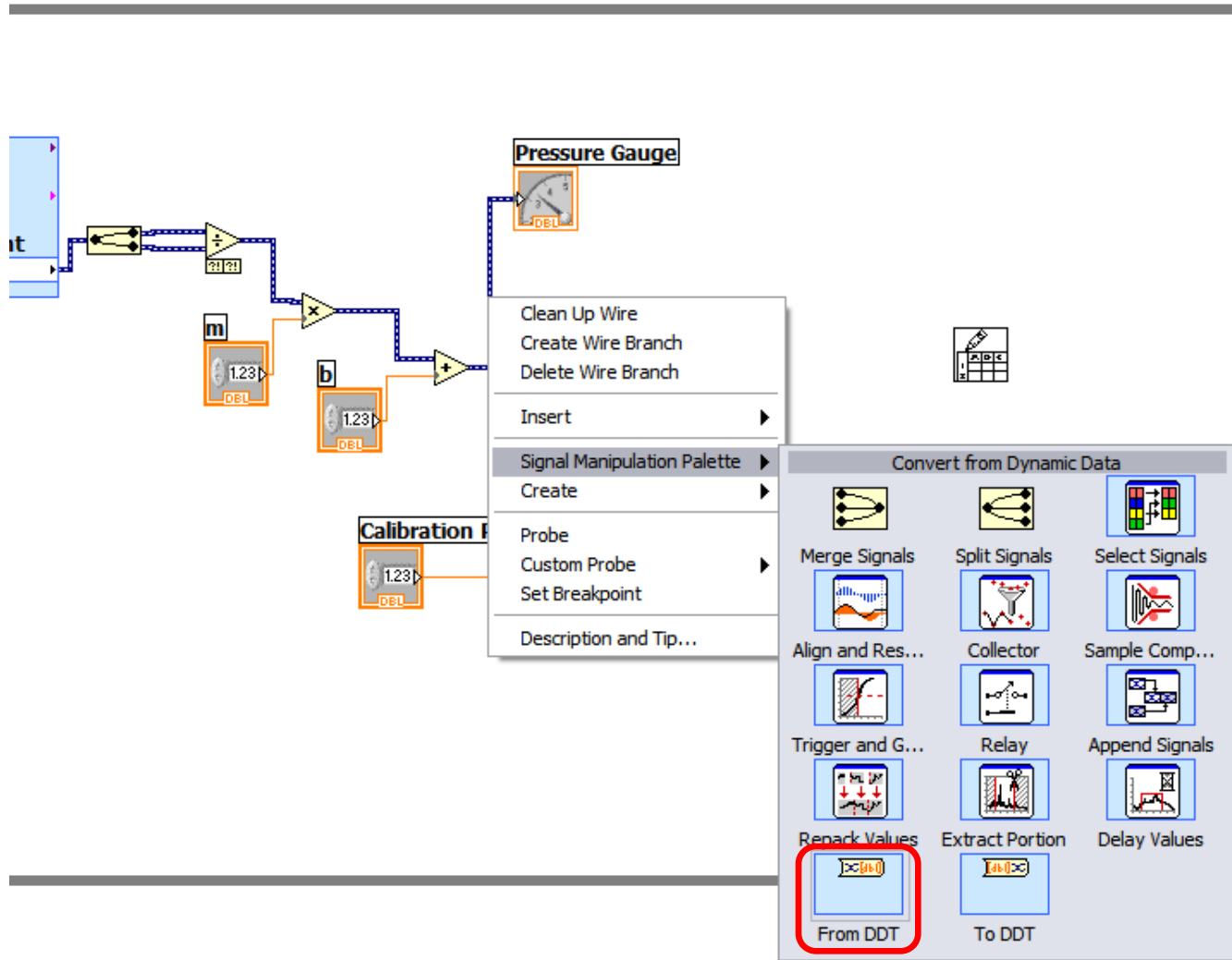
Front Panel now looks as follows



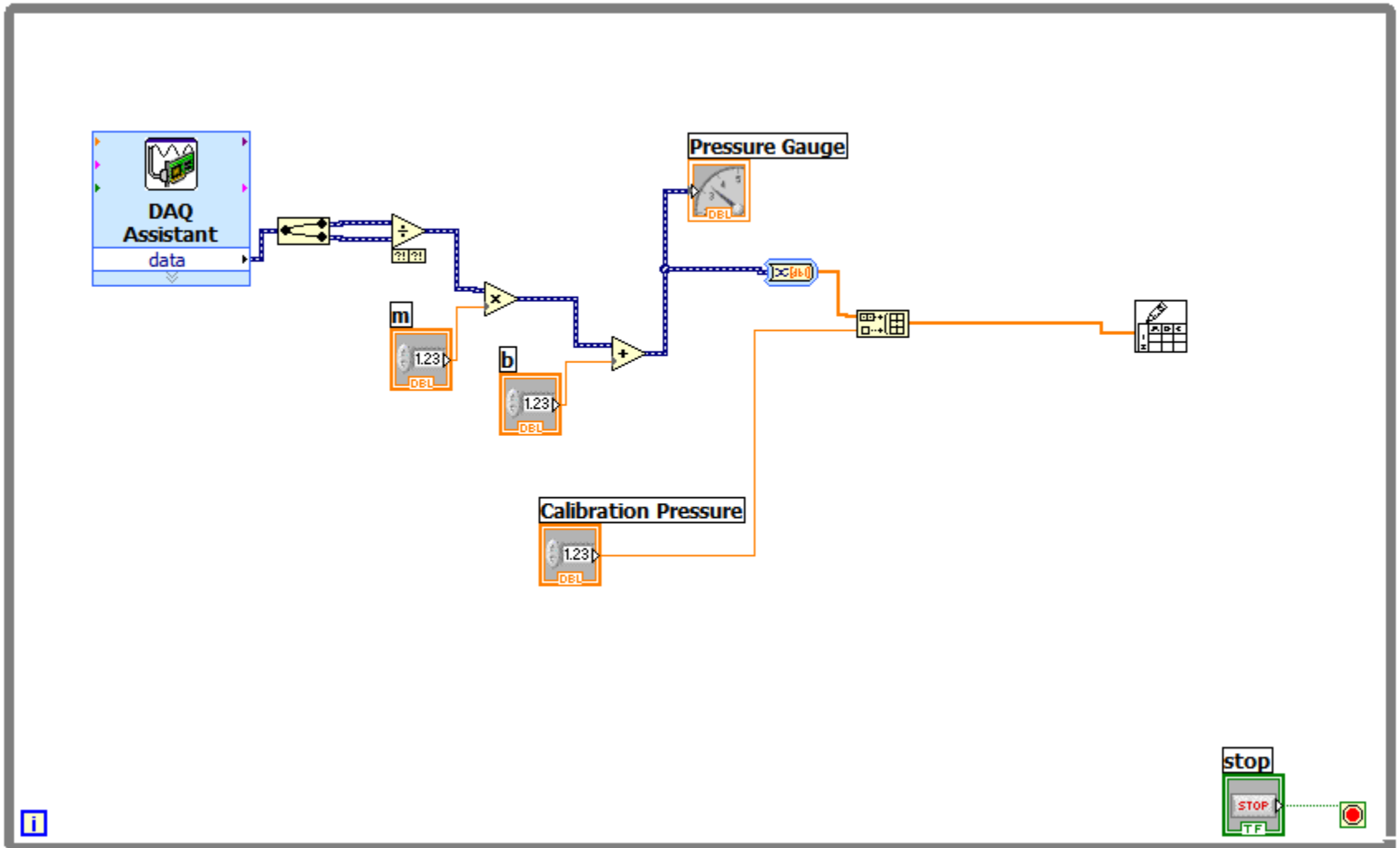
Wire the numeric control to a 'Build Array'
Pull down the array to increase the number of inputs to it
(we need two)



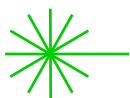
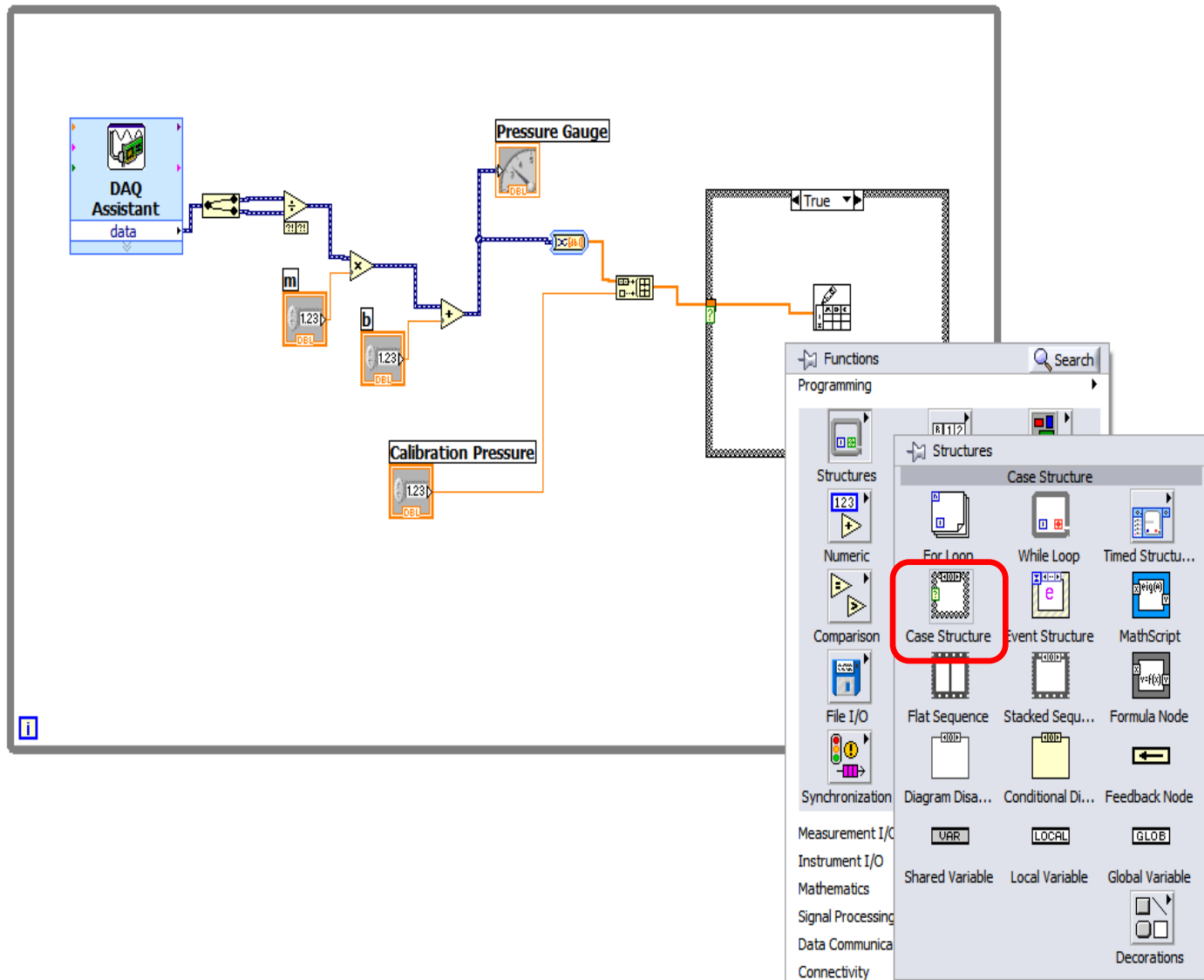
Complete the Wiring and add a convert from Dynamic Data with default options, as shown



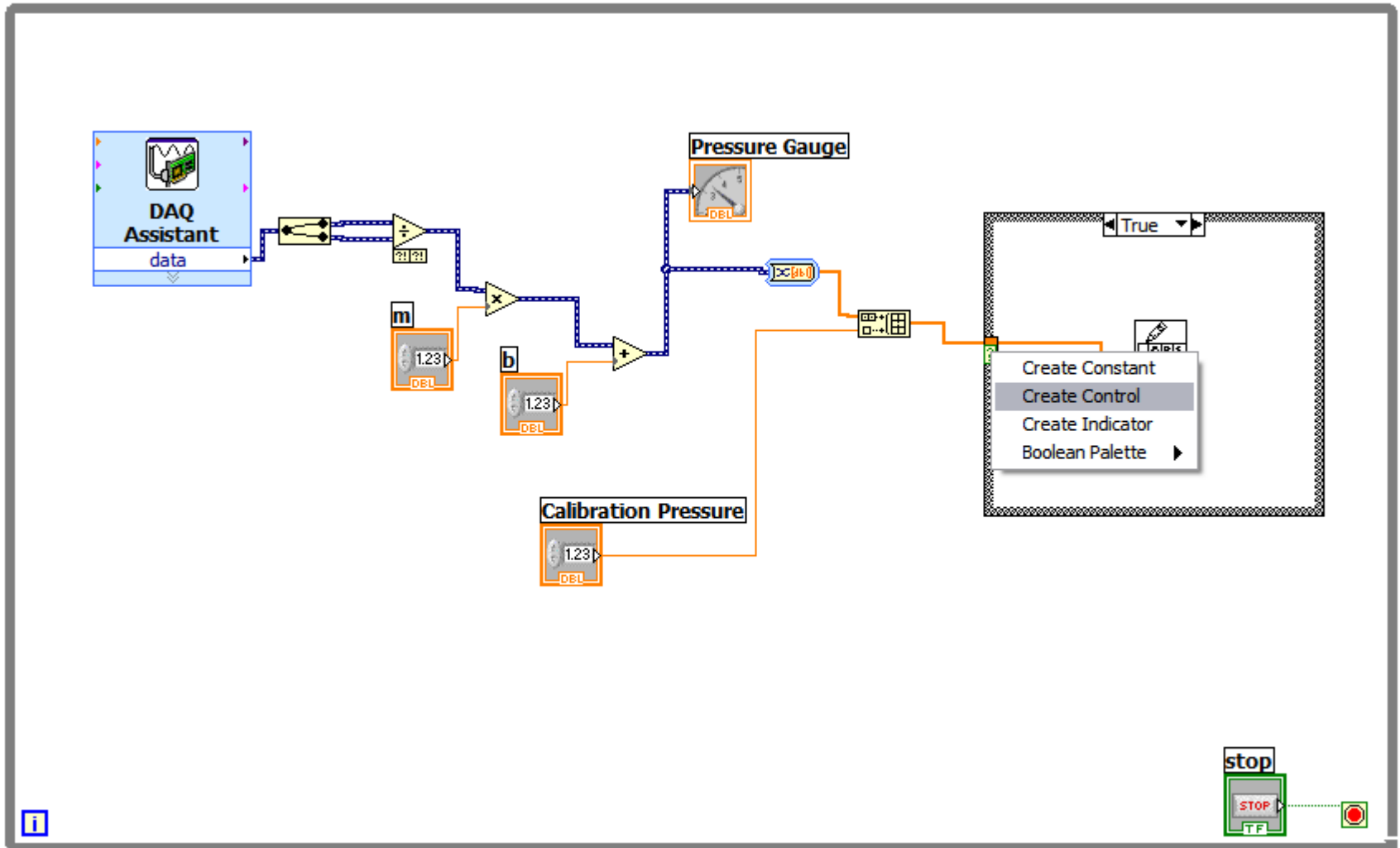
Now add a Write to text "*.xls" file as shown
(1D data port)



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'

The screenshot displays a LabVIEW block diagram with the following components:

- Pressure Gauge:** An indicator connected to a data source.
- Boolean:** A control with a 'TF' (True/False) label.
- file path (dialog if empty):** A control with a 'True' dropdown menu.
- append to file:** An indicator with a 'TF' label.

A context menu is open over the 'file path' control, with the following options:

- Visible Items
- Help
- Examples
- Description and Tip...
- Set Breakpoint
- File I/O Palette
- Create
- Replace
- Relink To SubVI
- SubVI Node Setup...
- Enable Database Access
- Call Setup...
- Find All Instances
- Open Front Panel
- Show VI Hierarchy
- View As Icon

The 'Create' option is selected, and a sub-menu is open showing the following options:

- Constant
- Control
- Indicator

The 'Context Help' window is open, showing the 'Write To Spreadsheet File.vi' help page. The help page includes the following text:

Write To Spreadsheet File.vi

format (%.3f)
file path (dialog if empty) new file path (Not A Pat
2D data
1D data
append to file? (new file:F)
transpose? (no:F)

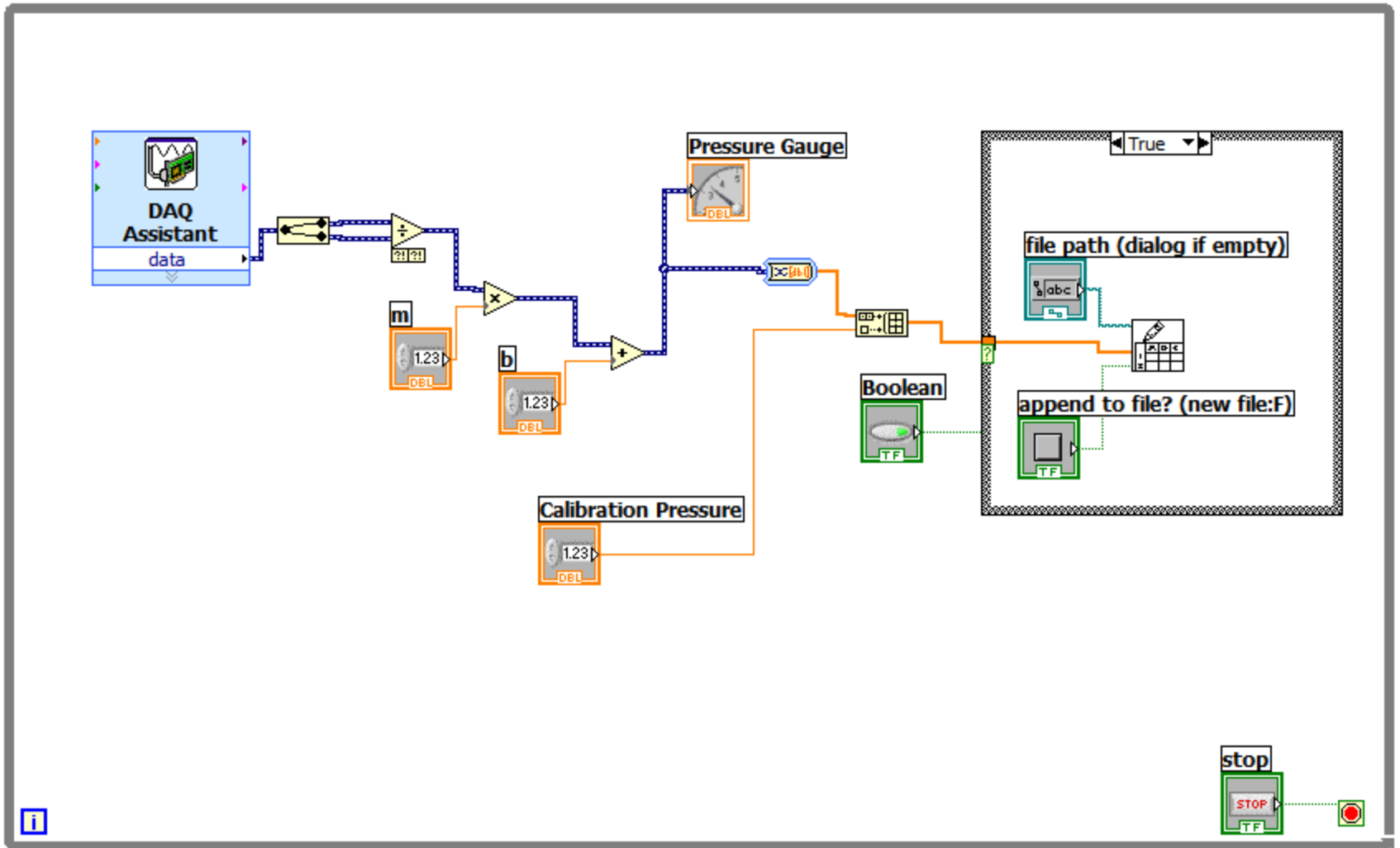
Converts a 2D or 1D array of single-precision numbers to a text string and writes the string to a new byte stream file or appends the string to an exist file.

[Detailed help](#)

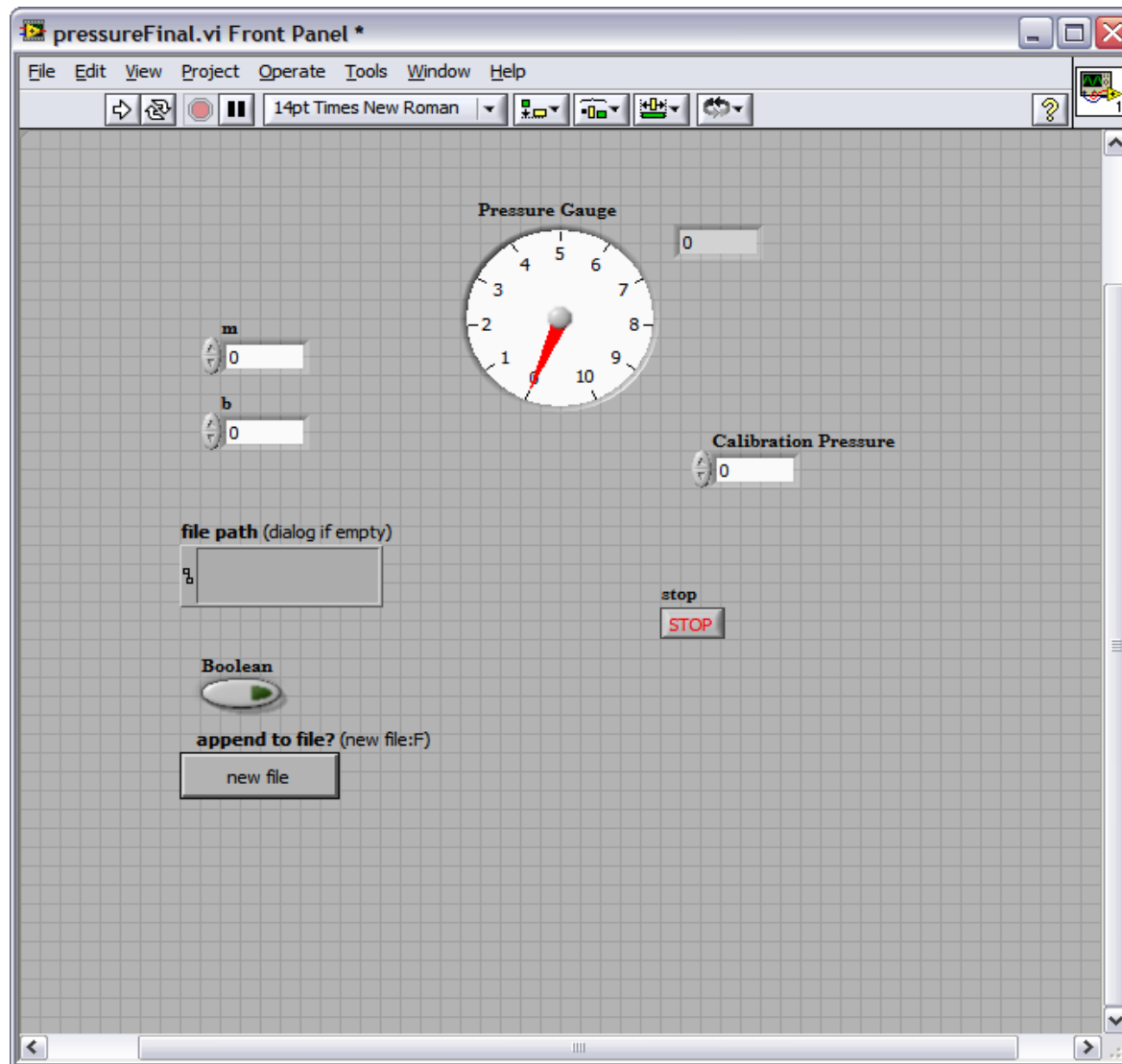
The 'Tools' palette is also visible, showing various tool icons.



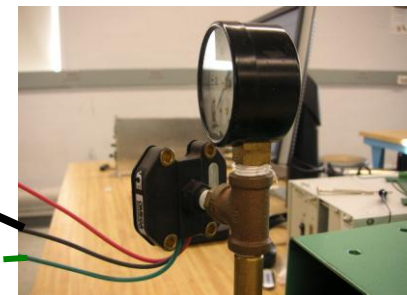
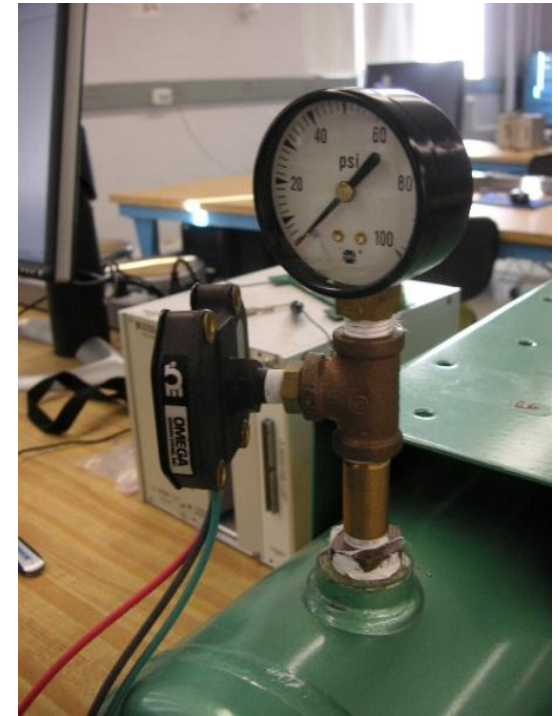
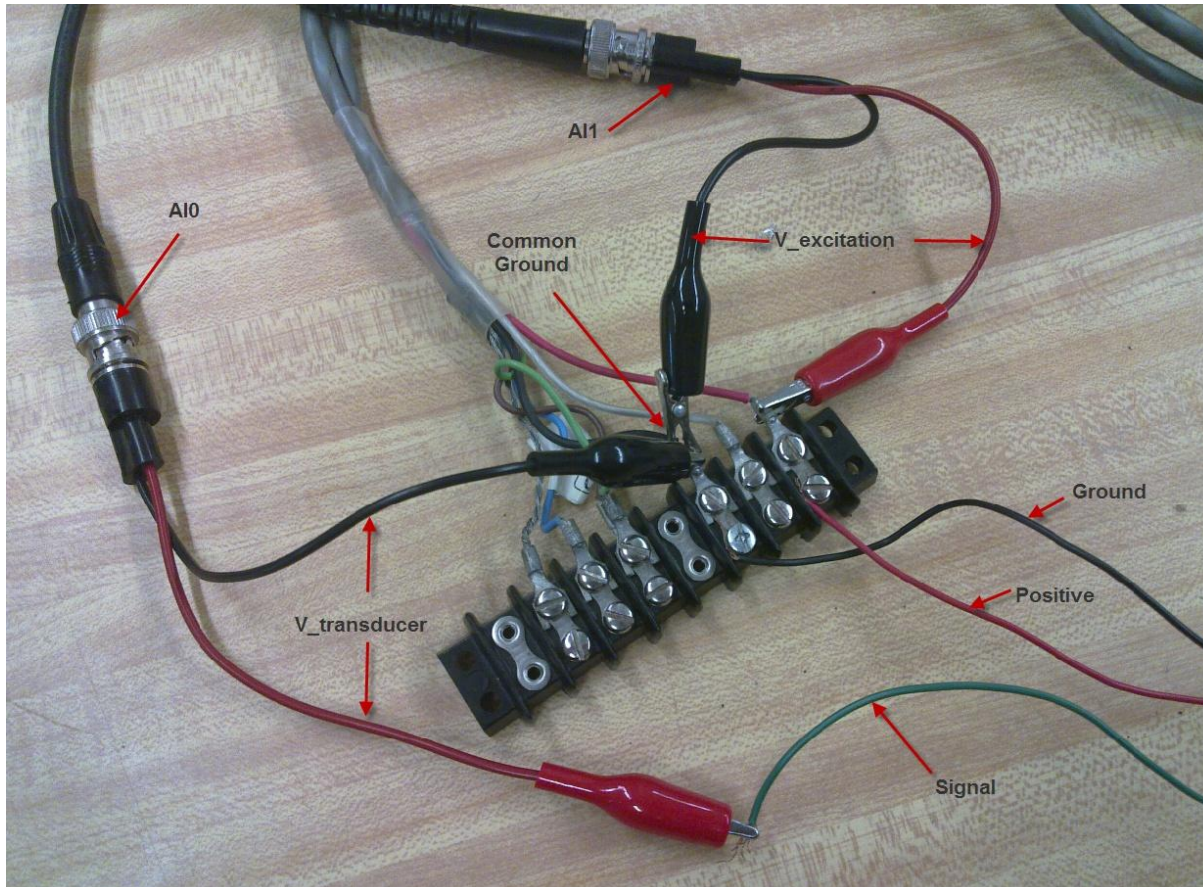
Completed Back Panel



Completed Front Panel



Channel configuration



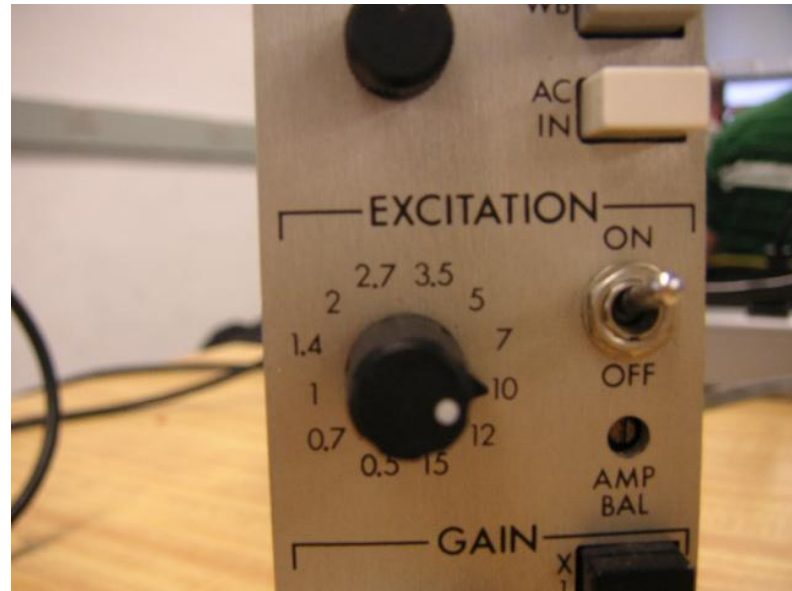
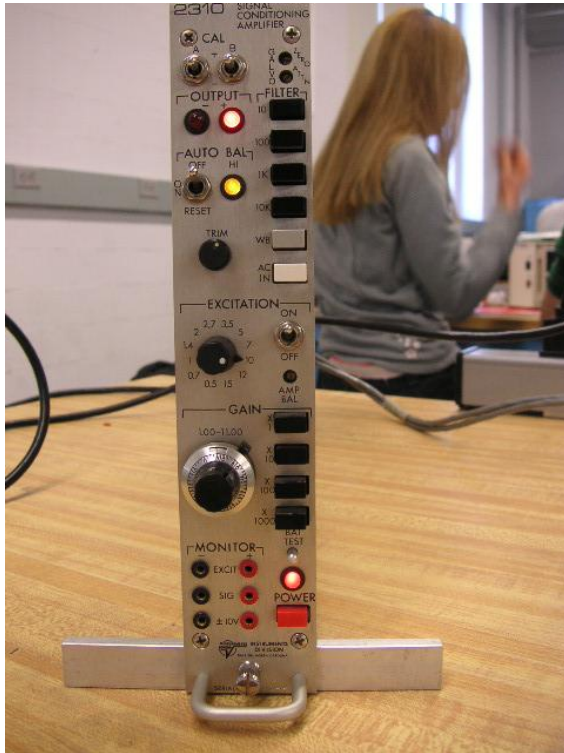
Red

Black

Green



Power supply



Test your VI and Hardware

