Experiment BI-7: Build Your Own Force Transducer

Equipment Required

PC or Mac Computer

IX-TA data acquisition unit and power supply

USB cable

A-BYFT-Kit: Make your force transducer kit

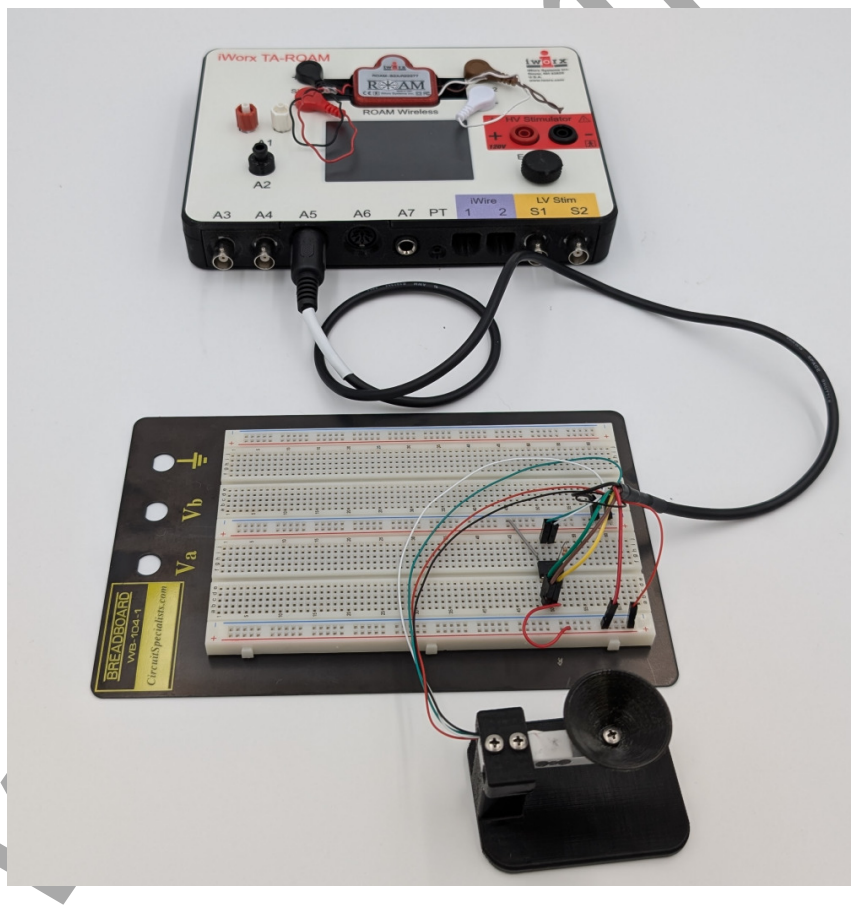
C-DIN-BB: Din to Breadboard cable

A-BREADBOARD: Breadboard.

Instrumentation Amplifier such as AD-620, LT1167, INA118 etc... from the A-BREADBOARD kit

Breadboard Setup

1. Insert the DIN8 connector of the C-DIN-BB cable into the A5 port of the TA.
2. Connect the other end of the C-DIN-BB cable to the breadboard.



For the various experiments, build the circuit on the breadboard, such that

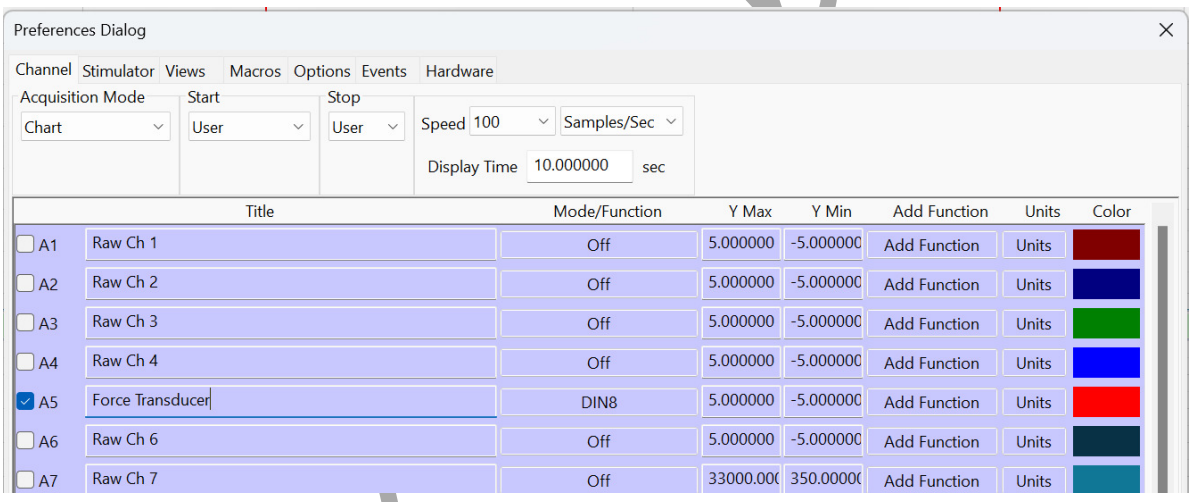
- Use the C-DIN-BB (+5V and -5V) cable to provide power to the circuit.
- Use the C-DIN-BB (+ input) to send the signal to the TA
- Connect the C-DIN-BB (- input) to ground.

Setting up LabScribe

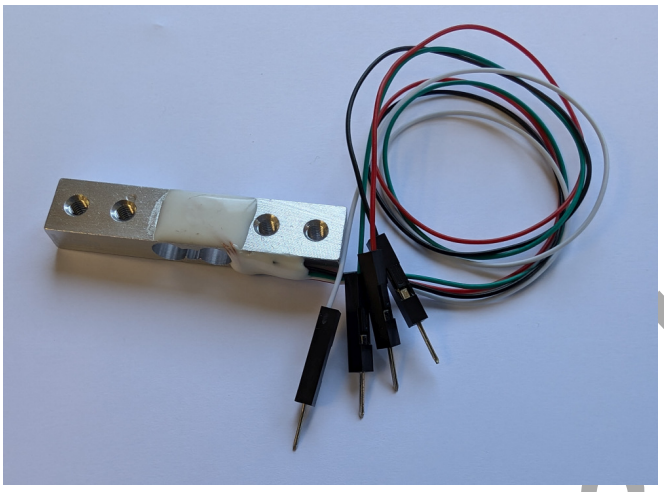
The provided BuildYourOwnTransducer LabScribe setting file has been preset with the following settings. The instructions here are for your information and to help you modify other iWorx lab experiments to add the option for additional signal conditioning.

Open the Preferences dialog, by choosing Edit→Preferences (LabScribe → Preferences on a Mac) from the Main Menu.

- ***Channels Tab***.
  - Enable the Channels to be recorded and Label them. These channels will be used:
    - A5 (Force Transducer): This is the output of the Filter



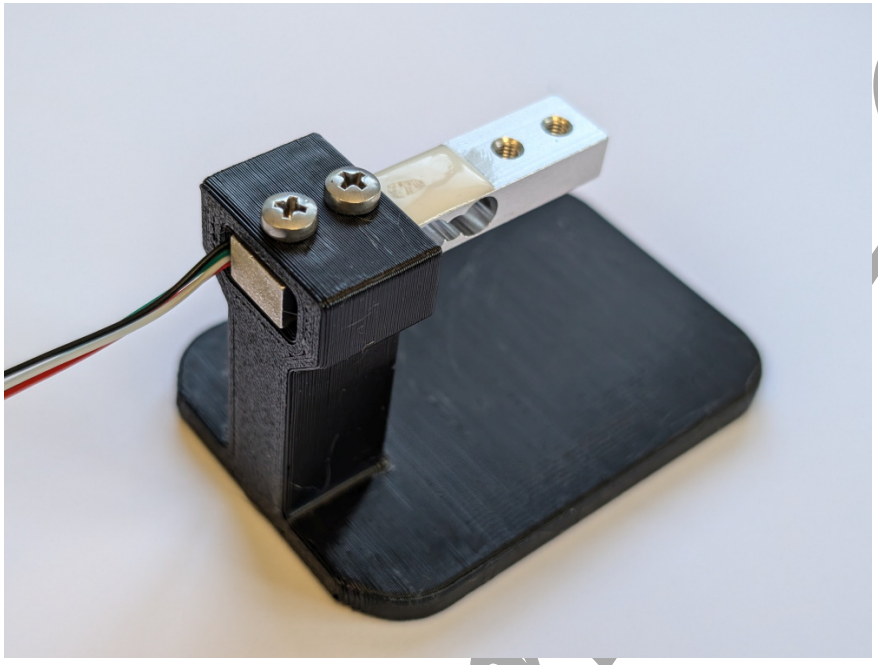
Strain Guage Specs



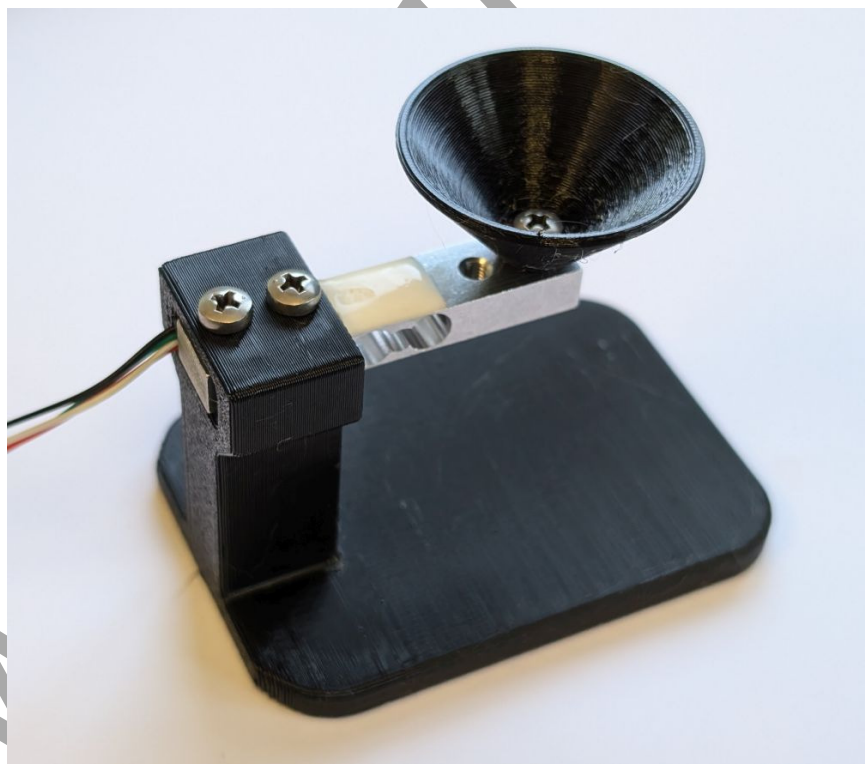
Capacity	300g
Comprehensive Error	0.05 % F.S
Output sensitivity	0.7±0.15mV/V
Non-linearity	0.05 (%F.S.)
Repeatability	0.05 (%F.S.)
Hysteresis	0.05 (%F.S.)
Creep	0.1 [(3 min)%F.S.]
Zero Output	± 0.1 m V/V
Temp. Effect on Zero	0.2(%F.S/10℃)
Temp. Effect on Span	0.05(%F.S 10℃)
Input Resistance	1000 ± 10 Ω
Output Resistance	1050 ± 100 Ω
Insulation Resistance	≥ 2000 MΩ
Excitation Voltage	3~10Vdc
Operating Temperature range	-10~+40℃
Four corner error	± 0.1% F.S
Safe overload	120% F.S
Ultimate Overload	150% F.S
Cable length	Φ0.6 x 110 mm
Wiring	Excitation +: Red, Excitation-: Black Signal+: Green, Signal- : White

Setting up the Strain Guage

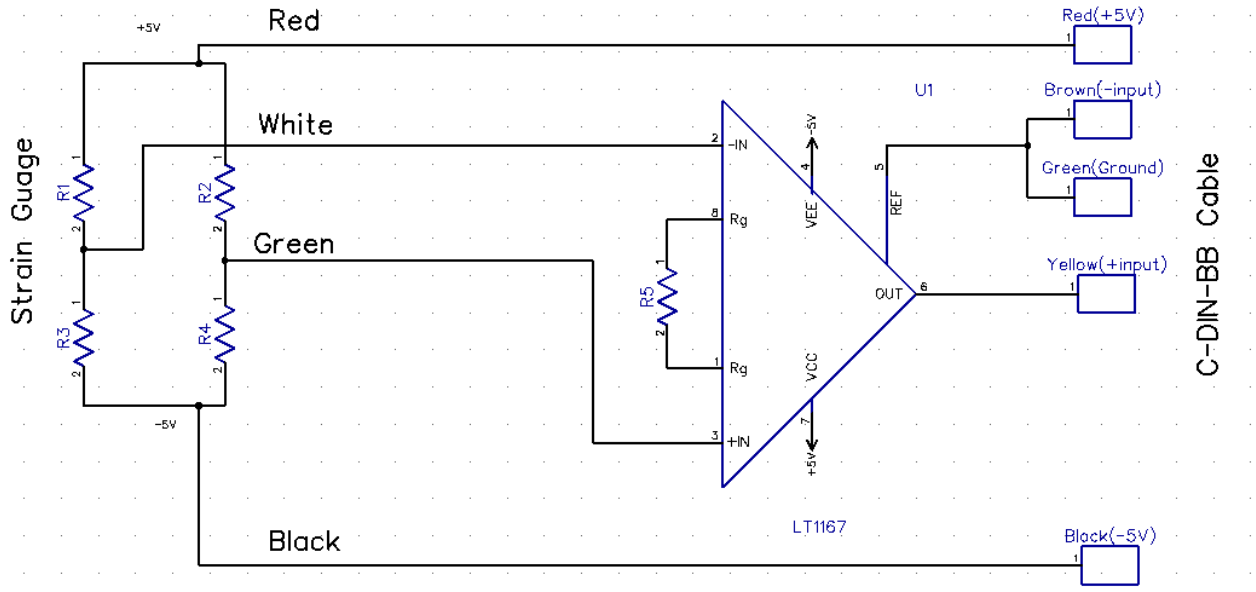
Slide the wires of the strain guage through the hole in the A-MYFT. Attach the strain gauge transducer to the stand using the 2 (M3 screws).



Attach the basket to the strain gauge transducer using a M3 screw.



Wire the breadboard according to the following circuit



R1, R2, R3, R4 are inside the strain gauge, The value of R1, R2, R3, R4 will change depending on the force or strain on the force transducer. We will be measuring this using the instrumentation amplifier such as LT1167 or AD620.

Calculating the required gain

R5 sets the gain of the amplifier. The output of the strain gauge is 0.7±0.15mV/V . We are applying +/- 5V (or 10V) of excitation voltage. For our application the output of the strain gauge will be

7 +/ 1.5mV. AD 620 and other instrumentation amplifiers have a head room of about 1.5 to 2V. So for a +/- 5V power supply the output can only go between +/- 3V. So we could have a maximum gain of 3000/7 = 428. The TA is a very high resolution recorder, with a resolution of less than 1mV, so we do not need to maximize the gain.

If we apply a gain of x100 we will get 700 mV of output for a force of 300g. That corresponds to about 2.33 mV per gram.

If we apply a gain of x200 we will get 1400 mV of output for a force of 300g. That corresponds to about 4.67 mV per gram.

The gain equation for the instrumentation amplifier is $$G = \frac{49.4k\Omega}{R_G} + 1$$

$$R_G = \frac{49.4k\Omega}{G-1}$$

In the A-BYFT-Kit, a 240 ohm resistors is provided:

The 240 ohm resistor at R5, will give a gain of 207, corresponding to an output range of 1.45V, and 4.83mV per gram.

The value of the resistor does not have to be exact, you can choose a resistor that is different calculate the gain from the above equation..

Experiment BI-7: Build Your Own Force Transducer

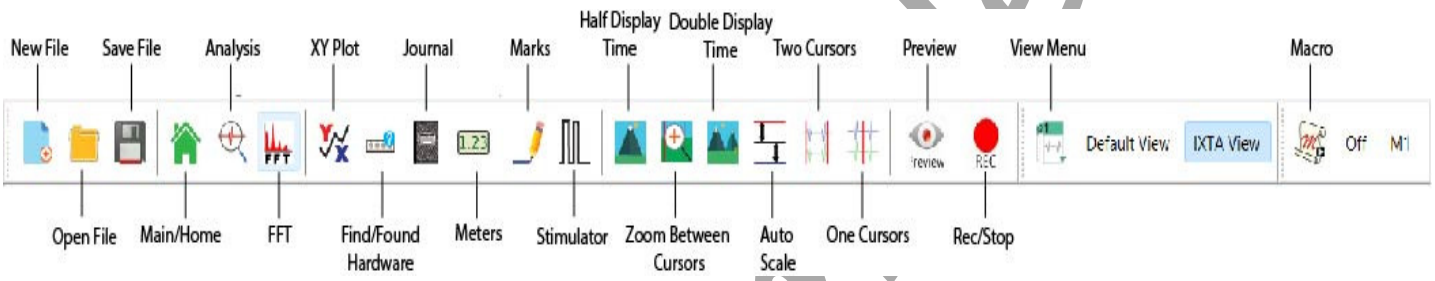
Exercise 1: Calibrating to Grams & Noise Measurement

Procedure

We need a known weight for calibrating the force transducer to grams. If you do not have a weight set, you can use coins to calibrate. US coins have the following weights:

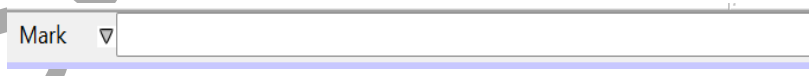
pennies (2.5g), nickels (5g), dimes (2.268g), quarters (5.67g)

1. We want to zero the force transducer with the weight of the basket. Remove all weights from the basket.
2. Click on the Record button. The signal should begin scrolling across the screen.



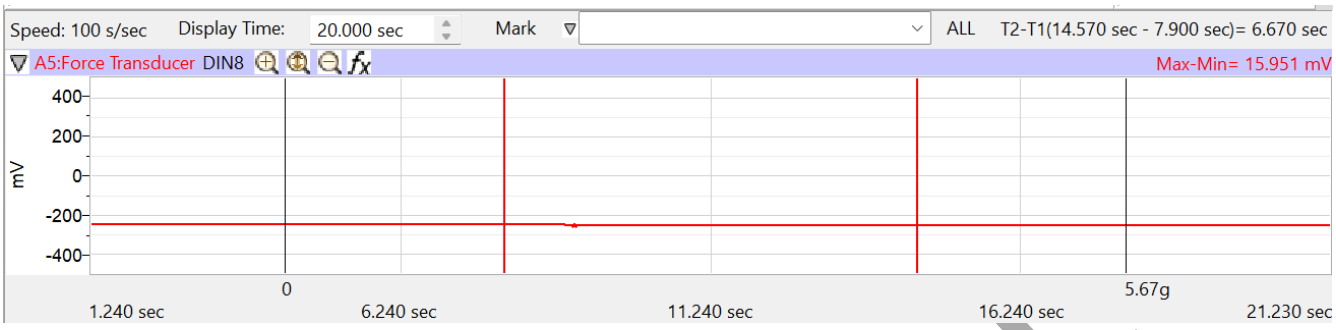
Note: *If there is no communication between the iWorx unit and computer, an error window will appear in the center of the Main window. Make sure the iWorx unit is turned on and connected to the USB port of the computer. Click OK and select the Find Hardware function on the LabScribe toolbar.*

3. Type the text "0" in the mark text box and click enter. This will mark the record with the text "0"

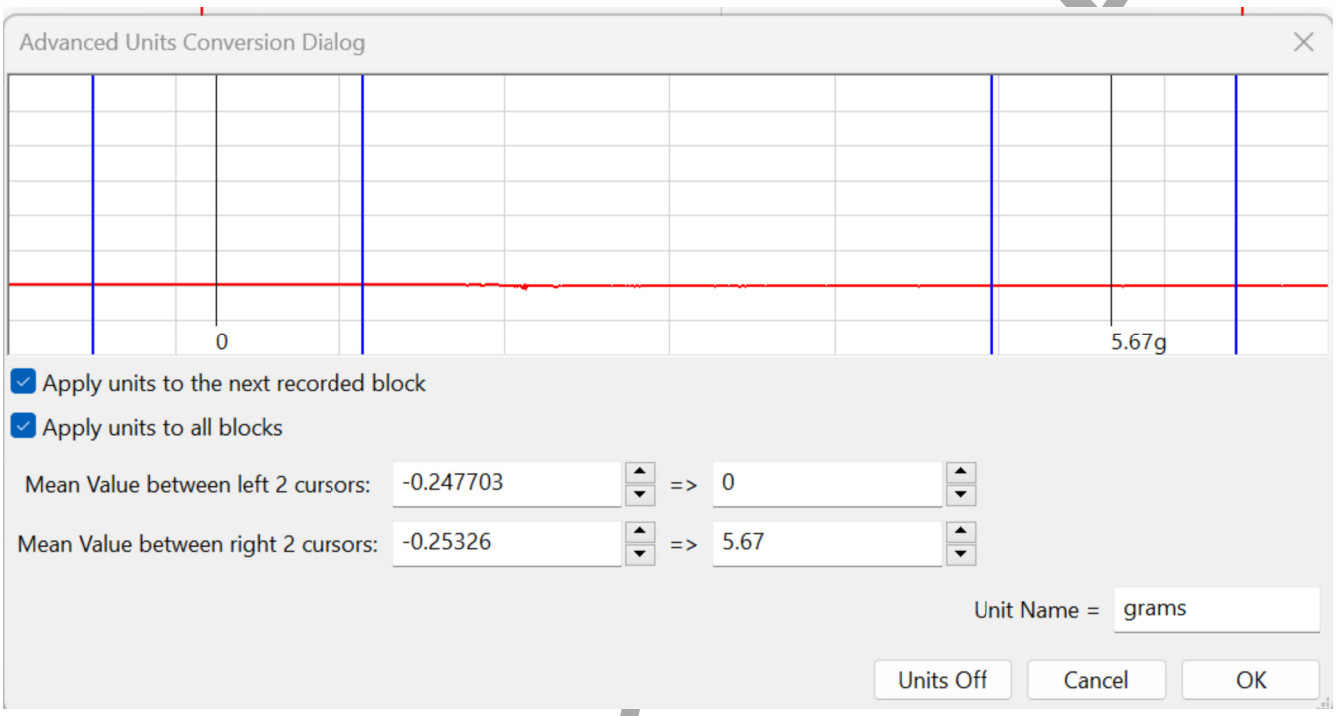


4. Record for about 5-10 seconds.
5. Place the coin in the basket and mark the recording with the weight of the coin. If you are using a quarter, enter "5.67g"
6. Record for a few more seconds.
7. Click Stop to halt the recording and click File → Save As to save your data file.

Calibrating to grams:



Right click on the channel and choose Units→ Advanced…



Place the first 2 cursors around the "0" mark and the last 2 cursors around the mark with the weight (5.67g in this case).

We want the mean value between the left cursors to be 0, and the mean value between the right cursors to be 5.67 as shown in the image above.

Change the unit name to "grams".

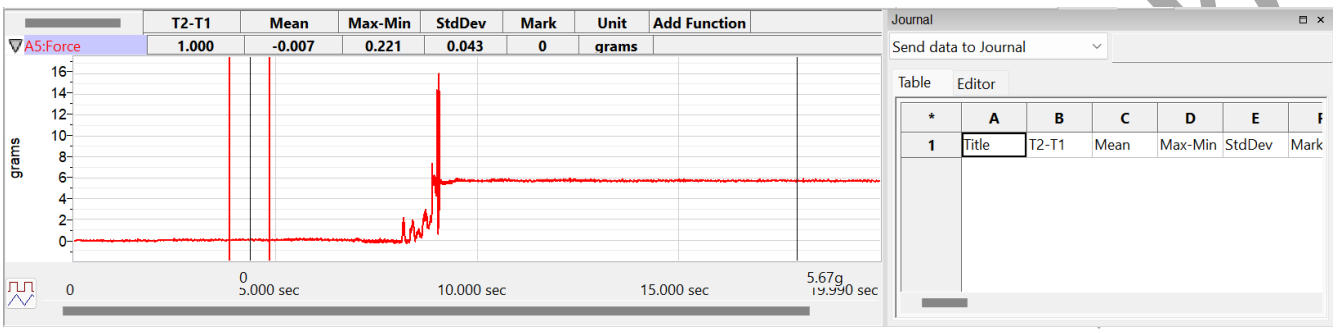
Click OK.

The channel is now calibrated in grams. Click on the "Autoscale All" to autoscale the channel.

Measuring the noise:

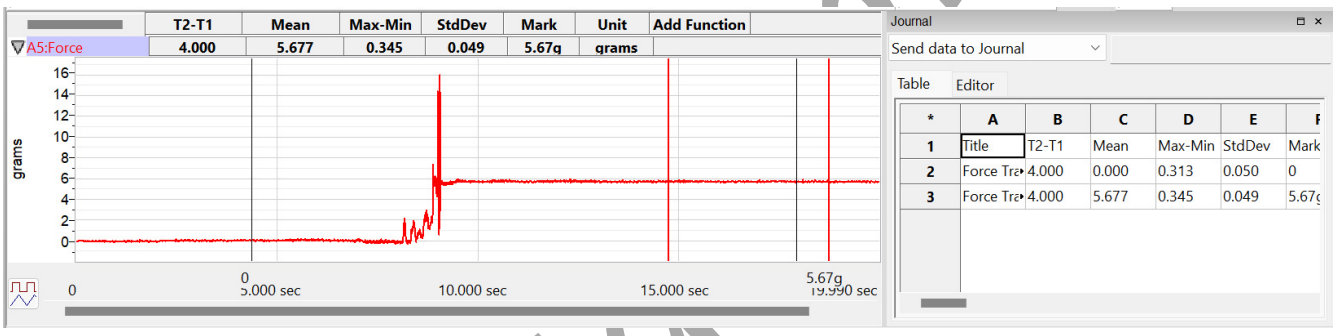
Click on the Analysis icon on the toolbar to switch to the Analysis window.

Click on the Journal icon to show the journal.



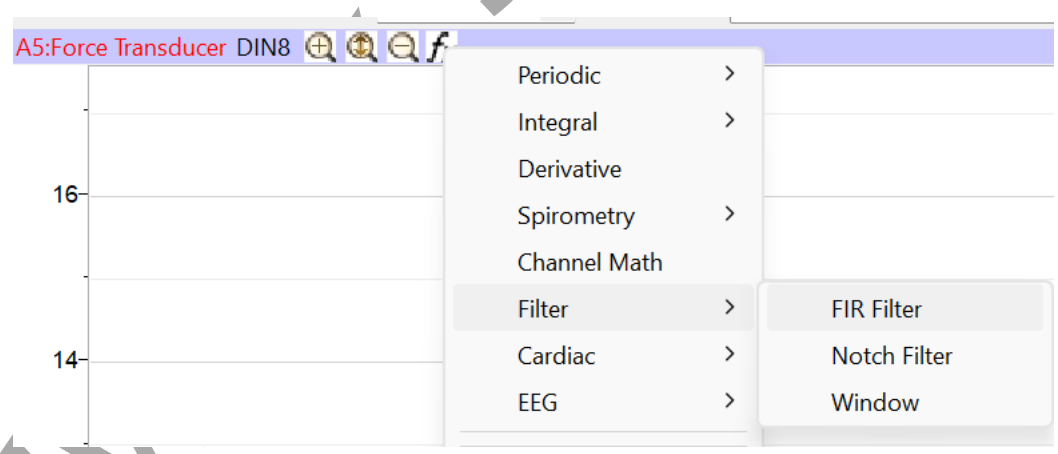
Place the 2 cursors, around the "0" mark. The Max-Min and Std-dev are measures of noise. Right click on the channel and choose "Add Ch. Data to Journal"

Move the cursors to around the weight mark (5.67g) and add that data to the Journal as well.



Exercise 2: Filtering the data to reduce noise.

Click on the f_x button on the Force transducer channel, and choose the Filter → FIR Filter function.



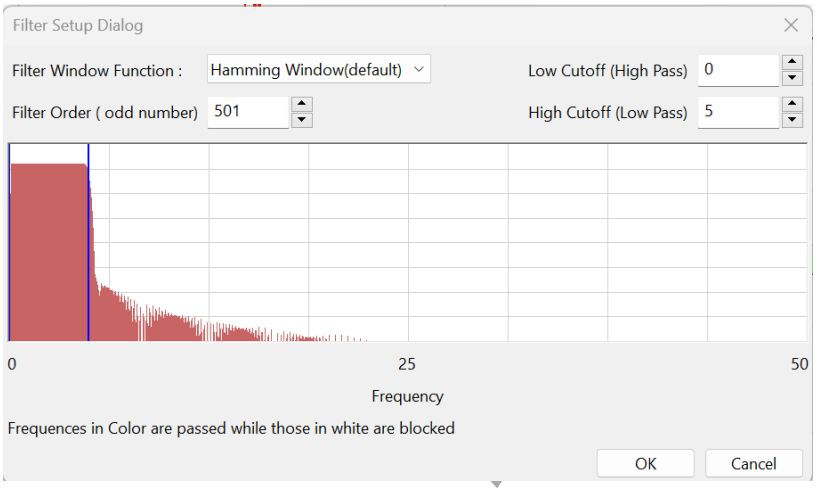
We want to low pass filter the data to reduce the noise.

Set the Low Cutoff (High Pass) to 0 (Hz)

Set the High Cutoff (Low Pass) to 5 (Hz)

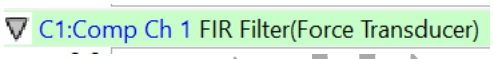
Set the Filter Order to 501.

Click OK.

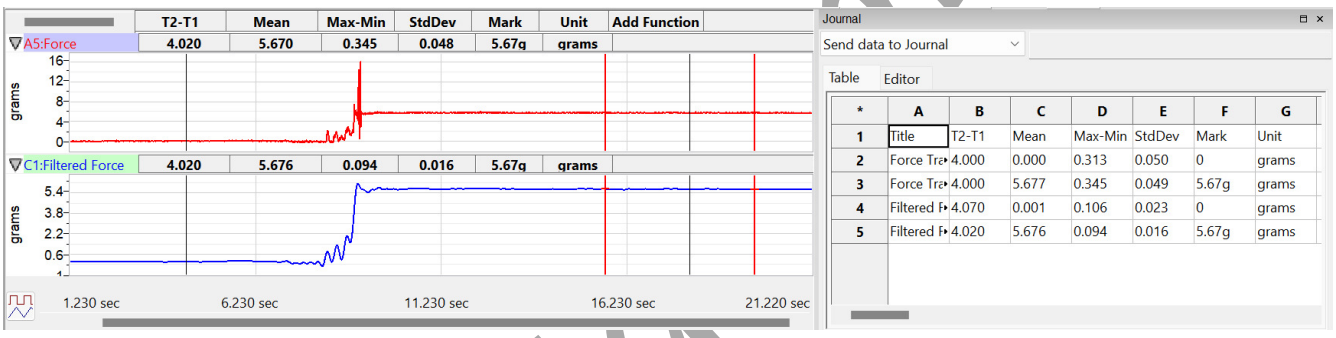


A new filtered channel has been created.

Click on the "Comp Ch1" on the Channel bar and change the channel title to "Filtered Force".

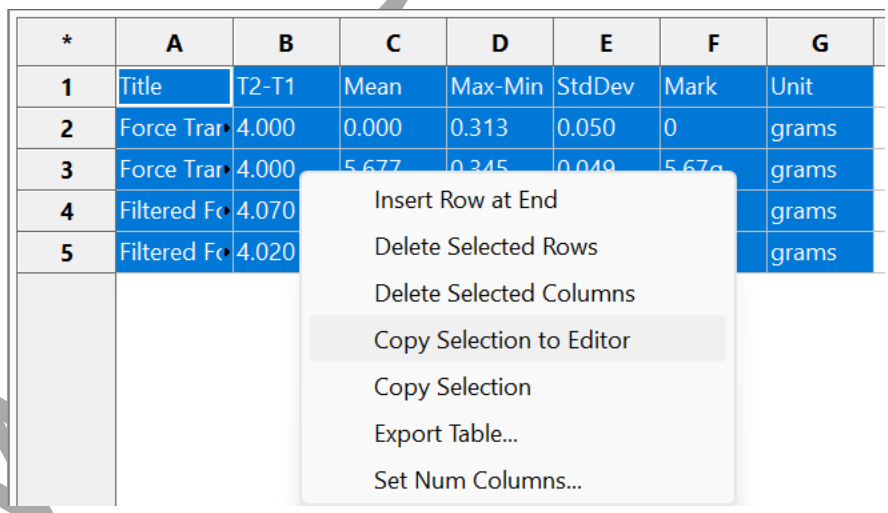


Switch to the Analysis window and repeat the noise measurements from Exercise 1 on the Filtered Force channel. The Max-Min and the Std-Dev values of the filtered channel should be less than the unfiltered channel.

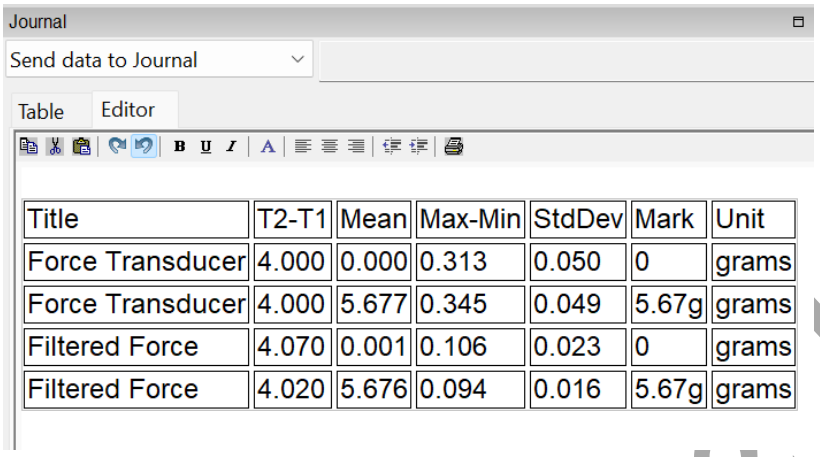


Select the value in the journal and right click in the journal.

Choose "Copy Selection to Editor"



The table will be copied to the Editor of the journal. You can use the editor to write your lab report or make notes.



Title	T2-T1	Mean	Max-Min	StdDev	Mark	Unit
Force Transducer	4.000	0.000	0.313	0.050	0	grams
Force Transducer	4.000	5.677	0.345	0.049	5.67g	grams
Filtered Force	4.070	0.001	0.106	0.023	0	grams
Filtered Force	4.020	5.676	0.094	0.016	5.67g	grams

Exercise 2: Linearity

Procedure

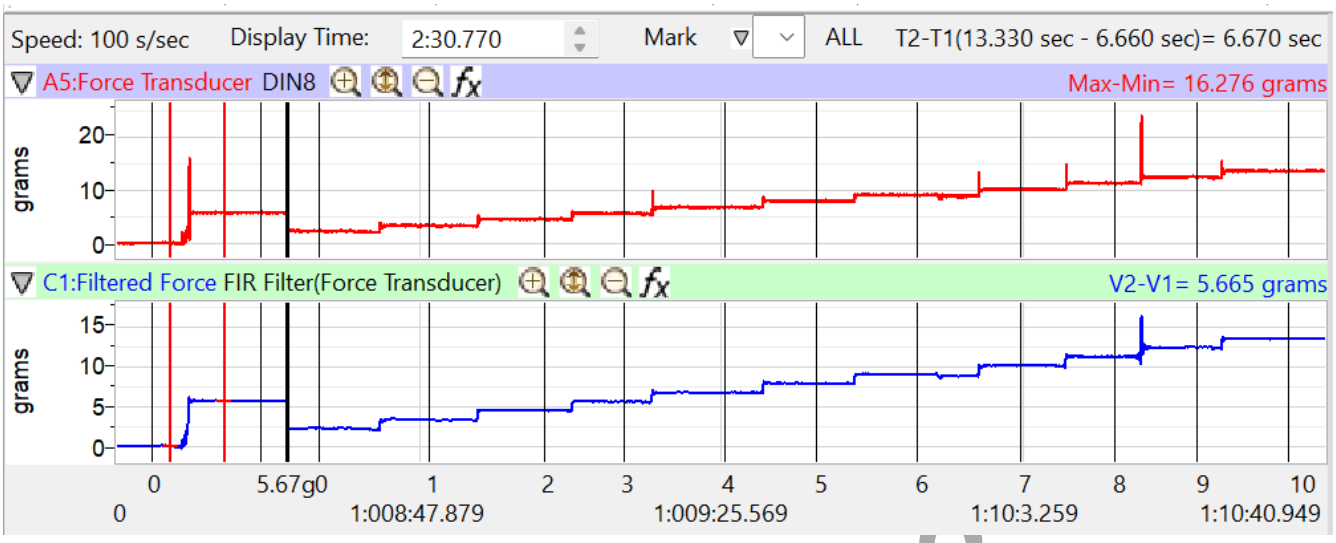
You will need about 10 small weights that are the same. The A-BYFT-Kit includes 10 nuts, which can be used as weights.

1. Remove all weights from the basket
2. Click on the Main window icon to switch to the main window.
3. Click on the Record button. The signal should begin scrolling across the screen.
4. Type the text "0" in the mark text box and click enter. This will mark the record with the text "0".
5. Wait a few seconds.
6. Place 1 weight in the basket. Type the text "1" in the mark text box and click enter.
7. Wait few seconds.
8. Every few seconds place a weight in the basket and mark the record with the number of the weight added, until 10 weights have been placed in the basket.
9. Click Stop to halt the recording and click File → Save As to save your data file.

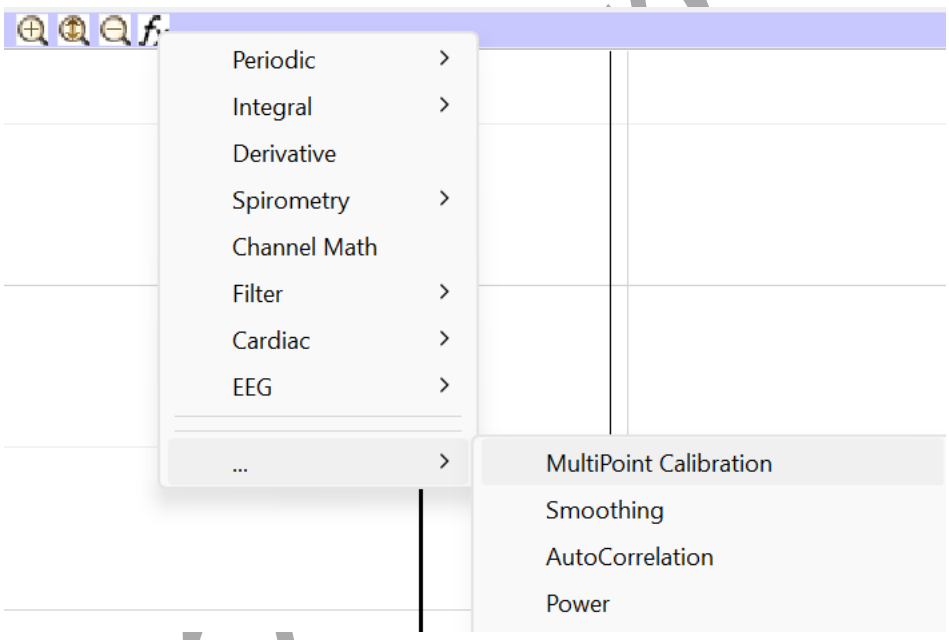
Analysis

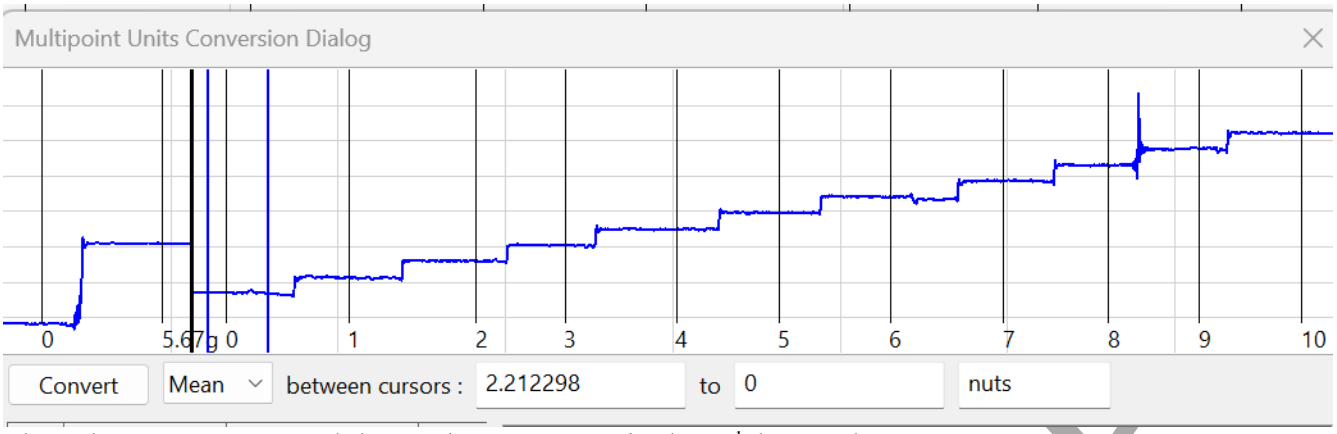
Click on the Double display time to see the complete file.

Click on the Autoscale All button to autoscale all channels.



Click on the f_x button on the Force transducer channel, and choose the Multipoint Calibration function.





Place the 2 cursors around the mark “0”, enter 0 in the 2nd box and set the units to “nuts” Click on the Convert Button

Move the cursor around the mark “1”, enter “1” in the 2nd box Click on the Convert button.

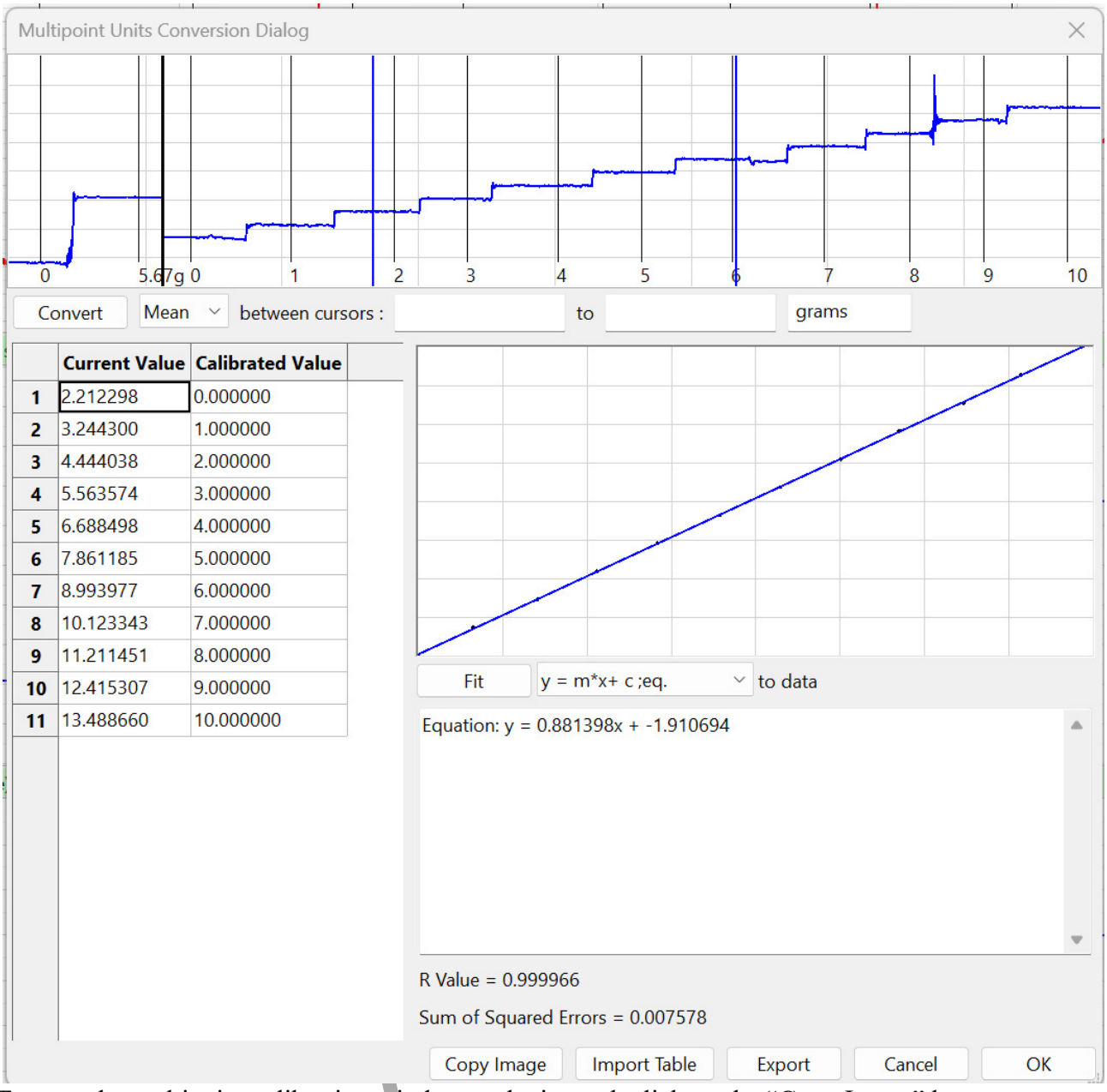
Move the cursors around the mark “2”, enter “2” in the 2nd box Click on the Convert button.

Repeat this for all 10 weights.

	Current Value	Calibrated Value
1	2.212298	0
2	3.244300	1
3	4.444038	2
4	5.563574	3
5	6.688498	4
6	7.861185	5
7	8.993977	6
8	10.123343	7
9	11.211451	8
10	12.415307	9
11	13.488660	10

Click on the “Fit” button to fit the data to “y = mx + c”

The R value is “0.999966” showing that the force transducer is very linear.



To copy the multipoint calibration window to the journal, click on the "Copy Image" button.

Then click OK.

Go to the Editor of the Journal and right click and choose Paste.

The image of the multipoint cal window will be pasted in the Journal.

You can use the Journal to write your report.