Experiment BI-4: Filter Frequency Response

Equipment Required

PC or Mac Computer

IX-TA data acquisition unit and power supply

USB cable

C-DIN-BB: Din to Breadboard cable

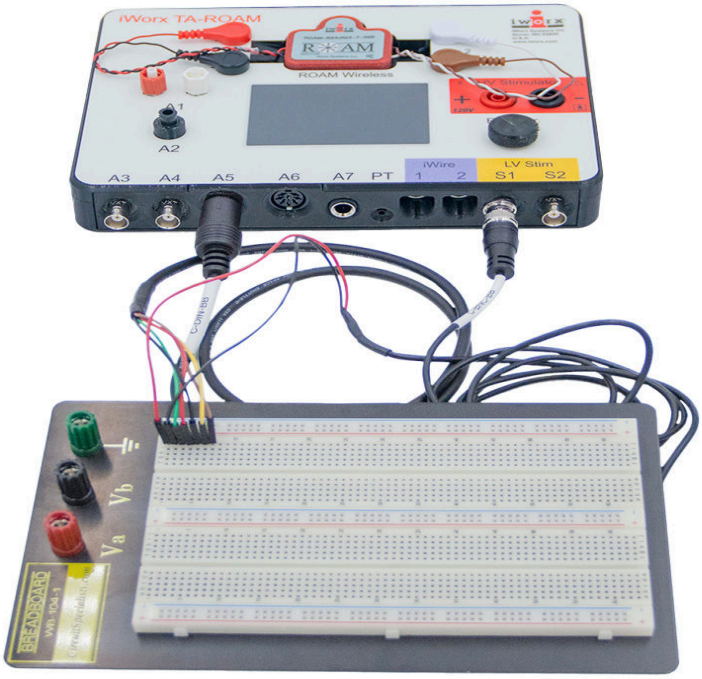
C-BNC-BB: BNC to Breadboard cable

A-BREADBOARD: Breadboard.

Electronic components to build a filter on the breadboard.

Breadboard Setup

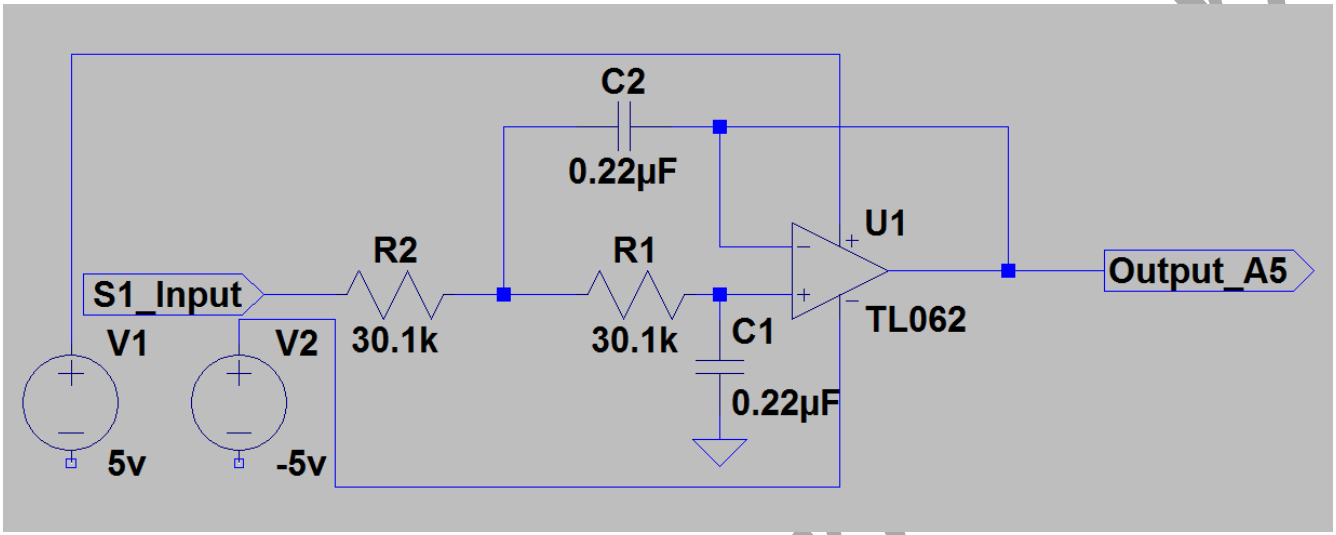
1. Insert the BNC connector on the end of the C-BNC-BB cable into the S1 stimulator port of the TA.
2. Connect the other end of the C-BNC-BB cable to the breadboard.
3. Insert the DIN8 connector of the C-DIN-BB cable into the A5 port of the TA.
4. Connect the other end of the C-DIN-BB cable to the breadboard.



Design the Filter Circuit

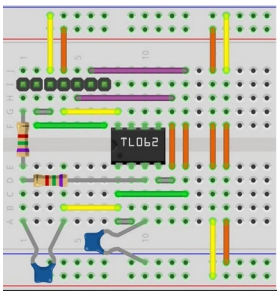
Here is an example of a filter circuit for a 2 pole low pass filter.

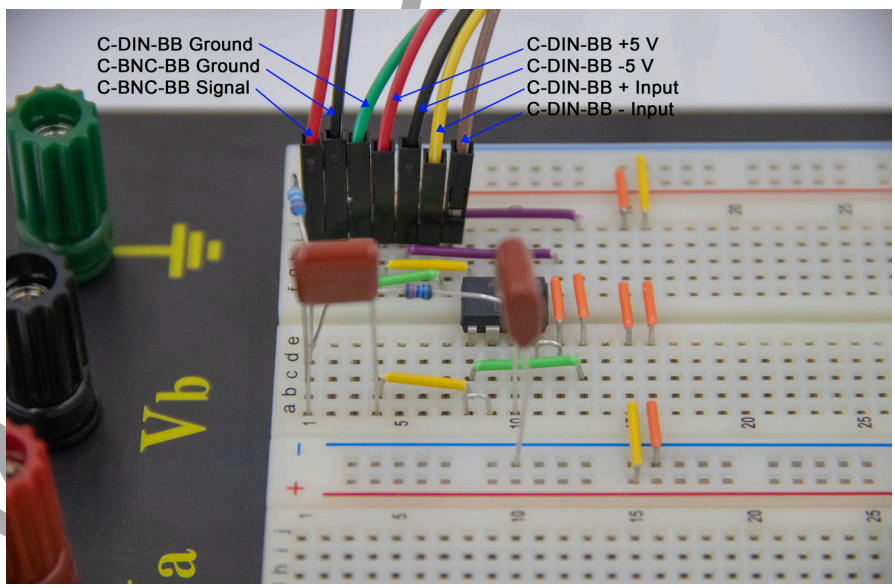
Circuit



The Filter is a Sallen Key 2-pole low pass filter. Its job is to remove 60Hz electrical noise picked up from fluorescent lights, computers and AC power lines.

It is implemented here on the breadboard.



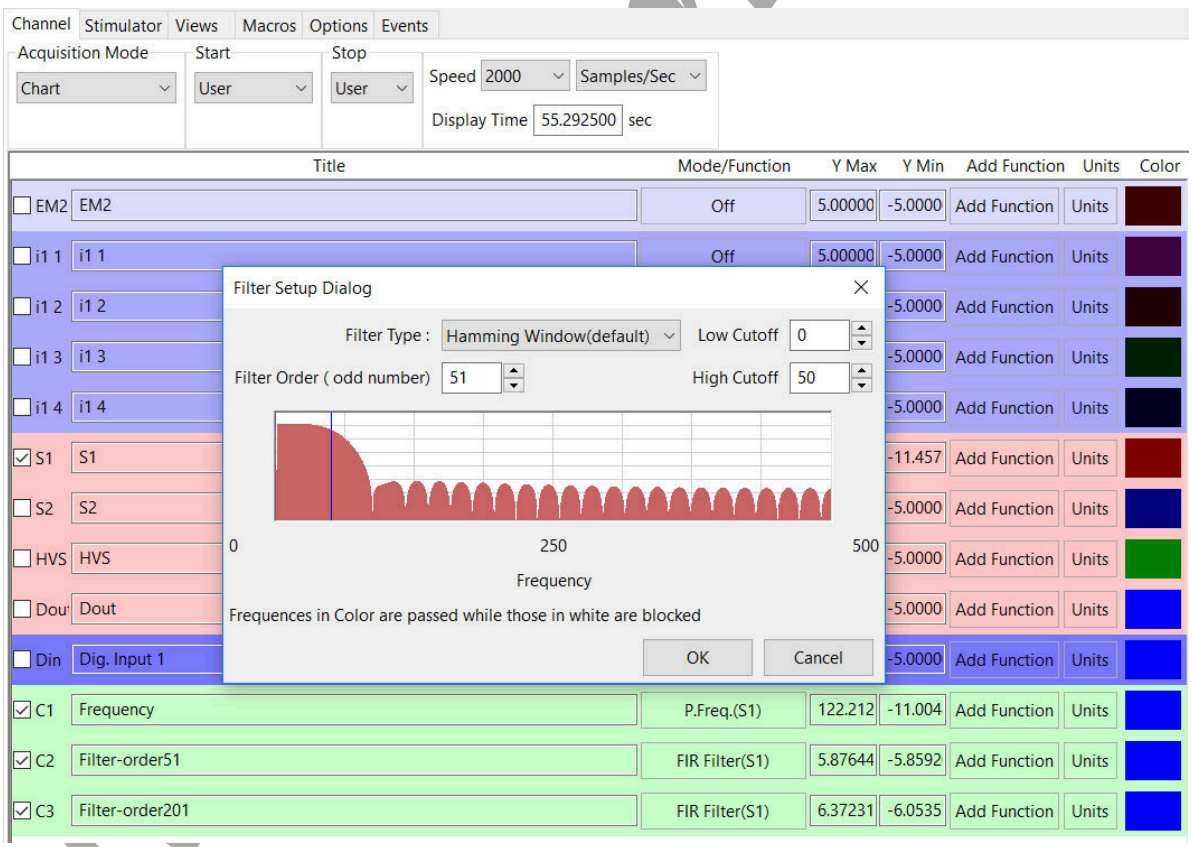


Setting up LabScribe

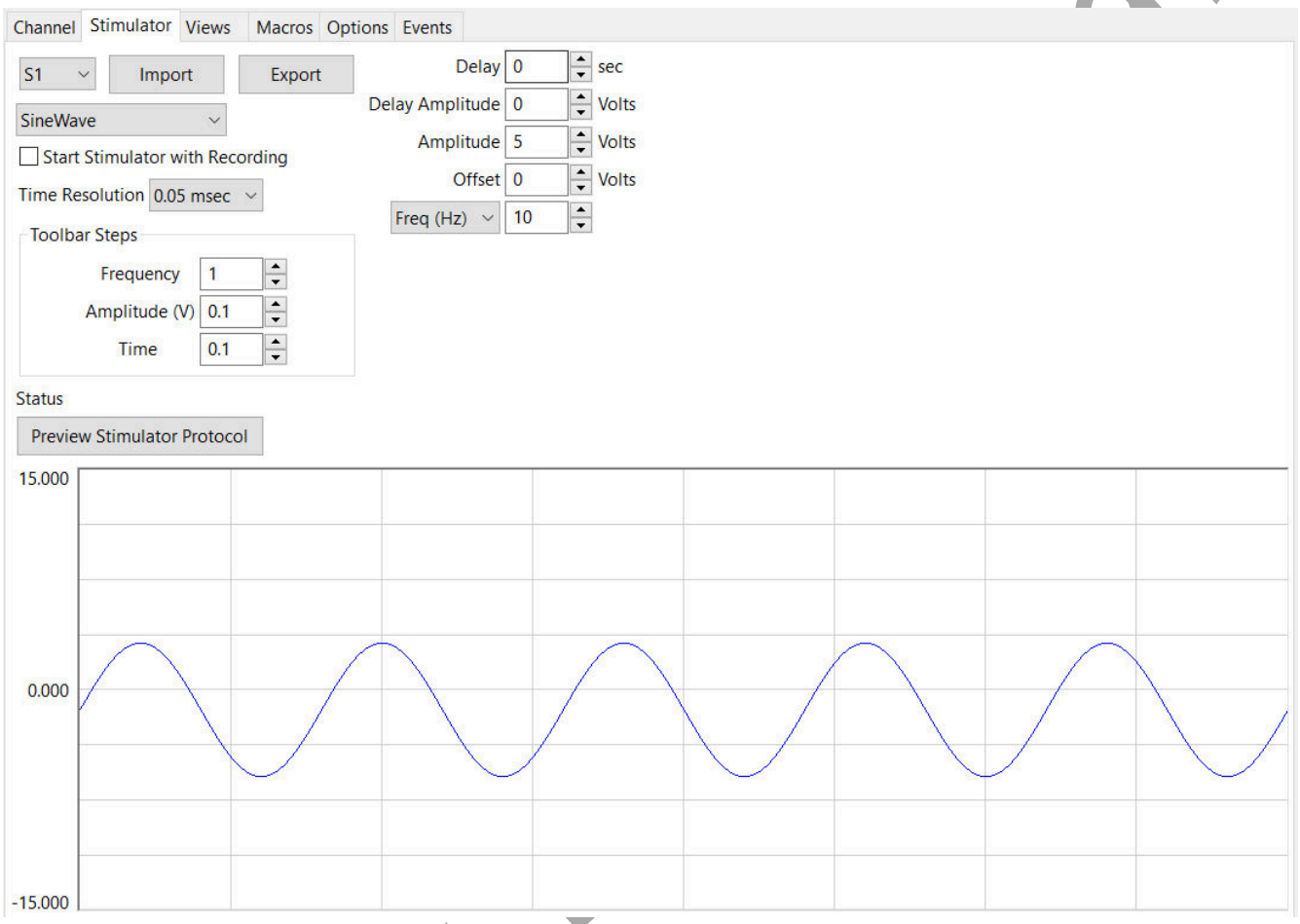
The provided Filter Frequency-Response LabScribe setting file has been preset with the following settings. The instructions here are for your information and to help you modify other iWorx lab experiments to add the option for additional signal conditioning.

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 (Filter Output): This is the output of the Filter
    - S1 (Stimulator): This is what the Stimulator is outputing, This is the input to the filter circuit.
    - C1 (Frequency): This measures the frequency of the sine wave
    - C2 (Filter-order 51): This is a digital FIR filter using a Hamming Window set for a 50Hz low pass and order 51.
    - C3 (Filter-order 201): This is a digital FIR filter using a Hamming Window set for a 50Hz low pass and order 201.



- ***Stimulator Tab***
  - Choose S1 stimulator
  - Set the mode to Sinewave
  - Set the Amplitude to 5V and the Frequency to 10 Hz.



Experiment BI-4: Filter Frequency Response

Exercise 1: Filter Frequency Response

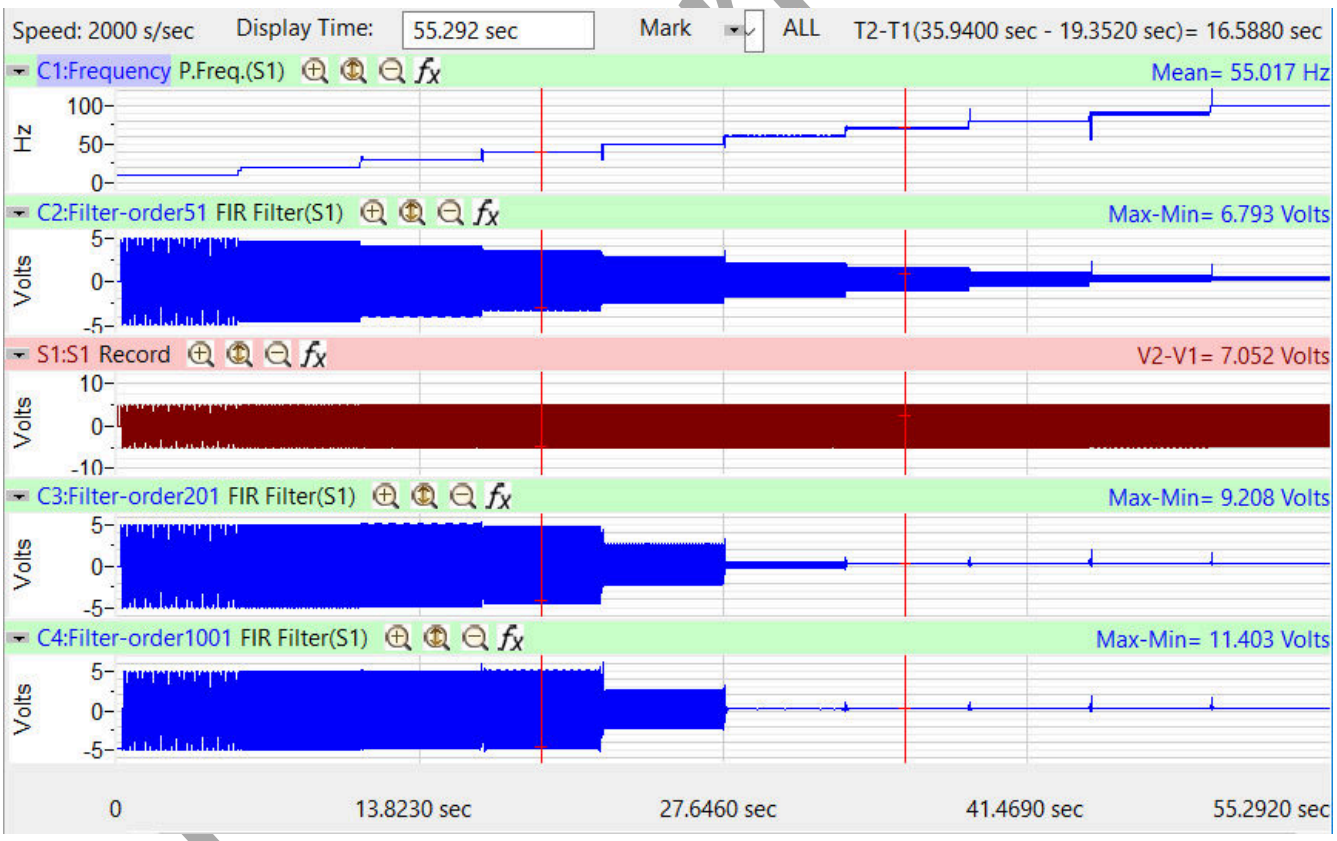
Aim: To record frequency response of a low pass filter.

Procedure

1. Click on the Freq Response Macro button, located on the upper right side of the LabScribe Main window. The signal should begin scrolling across the screen. The Macro will automatically start recording the data and changing the stimulator output.

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 from the LabScribe Tools menu.*

2. The recording will stop after about 1 minute.
3. Click on the AutoScale All button on the LabScribe toolbar, to Autoscale all the channels.



Analysis

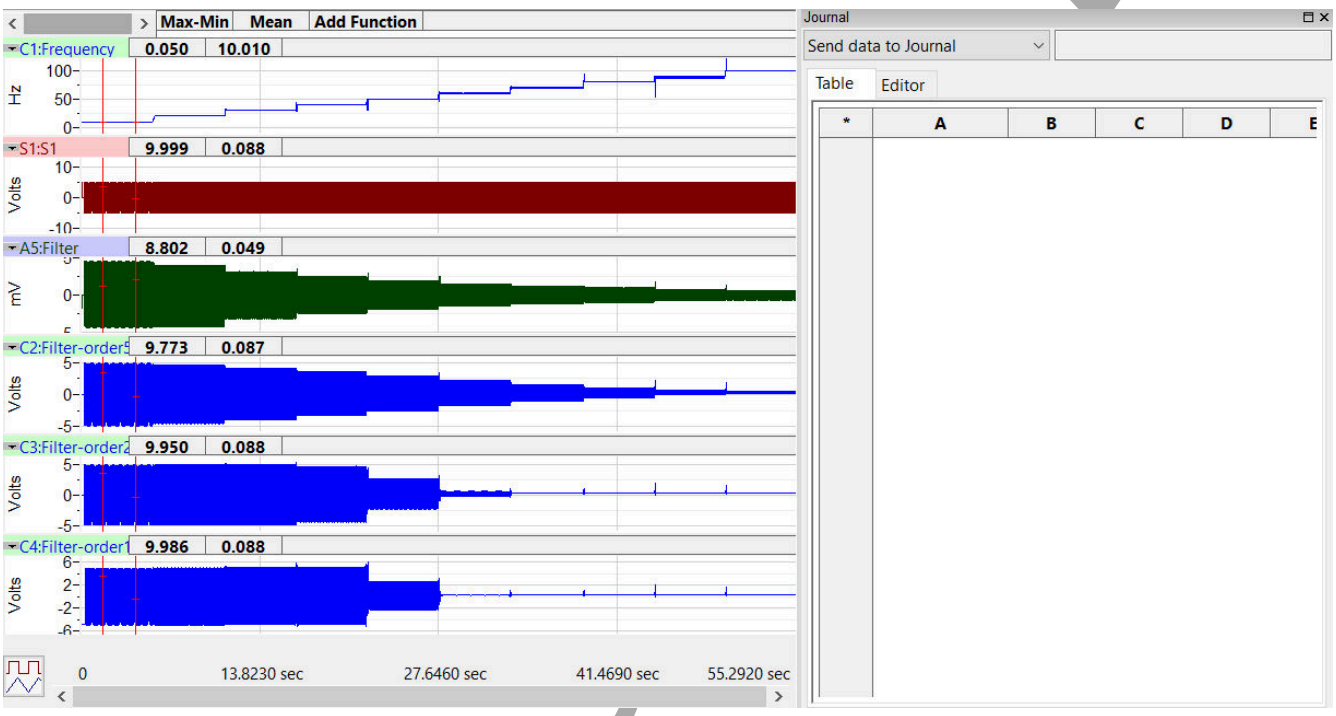
Click on the  Analysis button on the toolbar, to switch to the Analysis window.

The Analysis window has been setup to calculate the Max-Min and the Mean value between cursors:

Max-Min	Mean	Add Function
0.050	10.010	

When you move the 2 cursors on the screen the Max-Min and the Mean value will be calculated and displayed on the channel bar.

Click on the journal  button on the toolbar to show the built-in journal.



As you can see in the image above, the first graph show the input frequency. Place the 2 cursors on the flat portion so that you can see that the Mean frequency in the first graph is 10 Hz. The Max-Min of the rest of the channels shows the amplitude of the filter, which is about 10V.

Right-Click on the channel and select “Add Title to Journal”.

This will add the current measurement titles to the journal. “Title, Max-Min, Mean”.

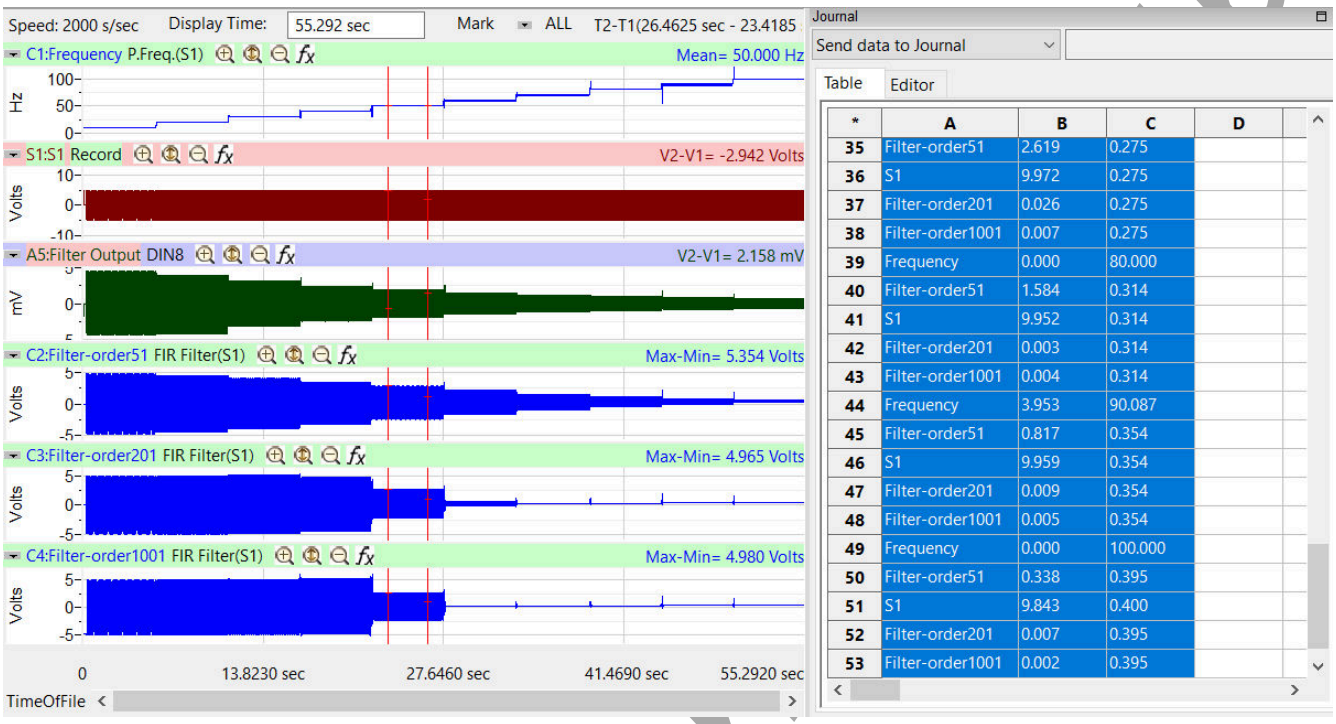
Then Right Click on the channel and select “Add All Data to Journal”.

This will add the measurement from all the channels to the journal.

Move the 2 cursors so that they are in the flat region corresponding to 20Hz frequency.

Right-click on the channel and select “Add All Data to Journal”.

Repeat this for all the other frequencies.



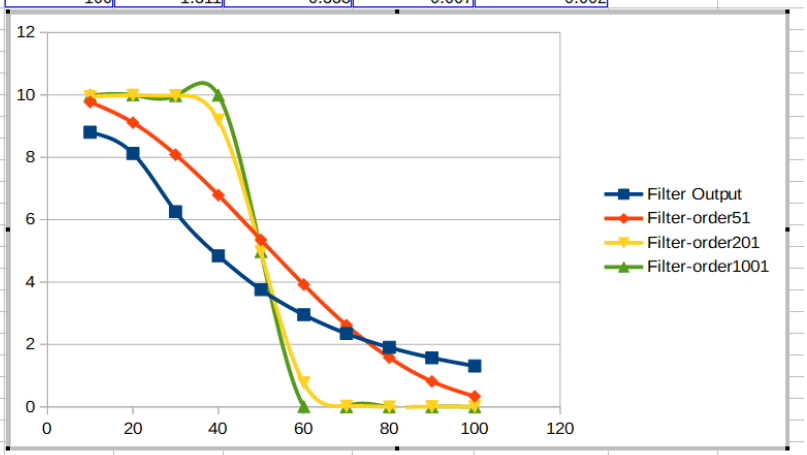
*	A	B	C	D
35	Filter-order51	2.619	0.275	
36	S1	9.972	0.275	
37	Filter-order201	0.026	0.275	
38	Filter-order1001	0.007	0.275	
39	Frequency	0.000	80.000	
40	Filter-order51	1.584	0.314	
41	S1	9.952	0.314	
42	Filter-order201	0.003	0.314	
43	Filter-order1001	0.004	0.314	
44	Frequency	3.953	90.087	
45	Filter-order51	0.817	0.354	
46	S1	9.959	0.354	
47	Filter-order201	0.009	0.354	
48	Filter-order1001	0.005	0.354	
49	Frequency	0.000	100.000	
50	Filter-order51	0.338	0.395	
51	S1	9.843	0.400	
52	Filter-order201	0.007	0.395	
53	Filter-order1001	0.002	0.395	

The journal now has the measurements from all the channels.

Select all the values in the journal, Right-Click and choose **Copy Selection.**

These values can now be pasted into a spreadsheet program, where we can plot the bode plot for the different filters.

	A	B	C	D	E	F	G	H	I	J	K
1	Title	Max-Min	Mean		Frequency	Filter Output	Filter-order51	Filter-order201	Filter-order1001		
2	Frequency	0.05	10.01		10	8.802	9.773	9.95	9.986		
3	S1	9.999	0.088		20	8.126	9.113	9.991	9.998		
4	Filter Output	8.802	0.049		30	6.257	8.085	9.979	9.977		
5	Filter-order51	9.773	0.087		40	4.842	6.792	9.195	9.994		
6	Filter-order201	9.95	0.088		50	3.757	5.354	4.965	4.98		
7	Filter-order1001	9.986	0.088		60	2.955	3.923	0.768	0.011		
8	Frequency	0.202	20.018		70	2.351	2.619	0.026	0.007		
9	S1	9.998	0.076		80	1.908	1.584	0.003	0.004		
10	Filter Output	8.126	-0.034		90	1.573	0.817	0.009	0.005		
11	Filter-order51	9.113	0.076		100	1.311	0.338	0.007	0.002		
12	Filter-order201	9.991	0.076								
13	Filter-order1001	9.998	0.076								
14	Frequency	0.452	30.032								
15	S1	9.995	0.11								
16	Filter Output	6.257	-0.015								
17	Filter-order51	8.085	0.111								
18	Filter-order201	9.979	0.11								
19	Filter-order1001	9.977	0.11								
20	Frequency	0	40								
21	S1	9.99	0.154								
22	Filter Output	4.842	-0.001								
23	Filter-order51	6.792	0.154								
24	Filter-order201	9.195	0.154								
25	Filter-order1001	9.994	0.154								
26	Frequency	0	50								
27	S1	9.969	0.195								
28	Filter Output	3.757	-0.004								
29	Filter-order51	5.354	0.195								
30	Filter-order201	4.965	0.195								
31	Filter-order1001	4.98	0.195								
32	Frequency	1.783	60.059								
33	S1	9.984	0.235								
34	Filter Output	2.955	-0.006								
35	Filter-order51	3.923	0.235								
36	Filter-order201	0.768	0.234								



Optional Exercises: Frequency response of a high pass filter.

Extend the first exercise to test the frequency response of a high pass filter. Create an analog high pass filter and set up the digital filters to perform a high pass filter.

For example:

1) What happens if you use a 4 pole filter instead of a 2 pole filter?

2) What happens if you use a different topology for the filter?

3) What happens if you use a high pass filter?

4) What happens if you use a band pass filter?

5) What happens when you change the windowing function in the digital FIR filter?