Experiment BI-2: EMG Signal Conditioning and Analysis

Equipment Required

PC or Mac Computer

IX-TA-220 data acquisition unit and power supply

USB cable

iWire-B3G EMG cable and electrode lead wires

C-DIN-BB: Din to Breadboard cable

C-BNC-BB: BNC to Breadboard cable

A-BREADBOARD: Breadboard.

Alcohol swabs

Disposable ECG/EMG electrodes

Start the Software

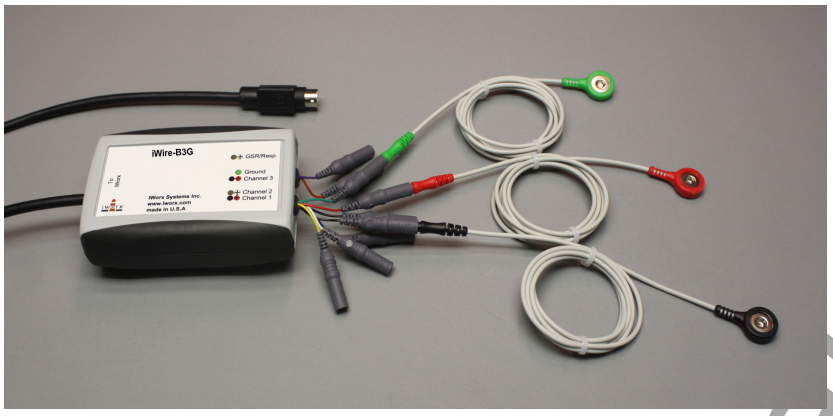
1. Click on LabScribe
2. Click Settings → BioInstrumentation → EMGFilter
3. Once the settings file has been loaded, click the **Experiment** button on the toolbar to open any of the following documents:
    1. Appendix
    2. Background
    3. Labs
    4. Setup (opens automatically)

ECG Cable Setup

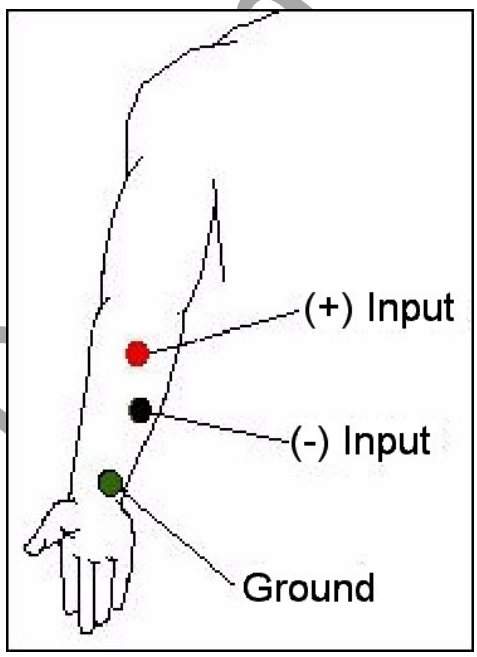
1. Insert the connector on the end of the iWire-B3G EMG cable into the iWire 1 input on the front of the IXTA.

Note - Connect the iWire-B3G to the IXTA prior to turning it on.

2. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets on the EMG cable.
3. Use an alcohol swab to clean and scrub three regions on the inside of the subject's dominant forearm where the electrodes will be placed. One area is near the wrist, the second is in the middle of the forearm, and the third area is about 2 inches from the elbow.

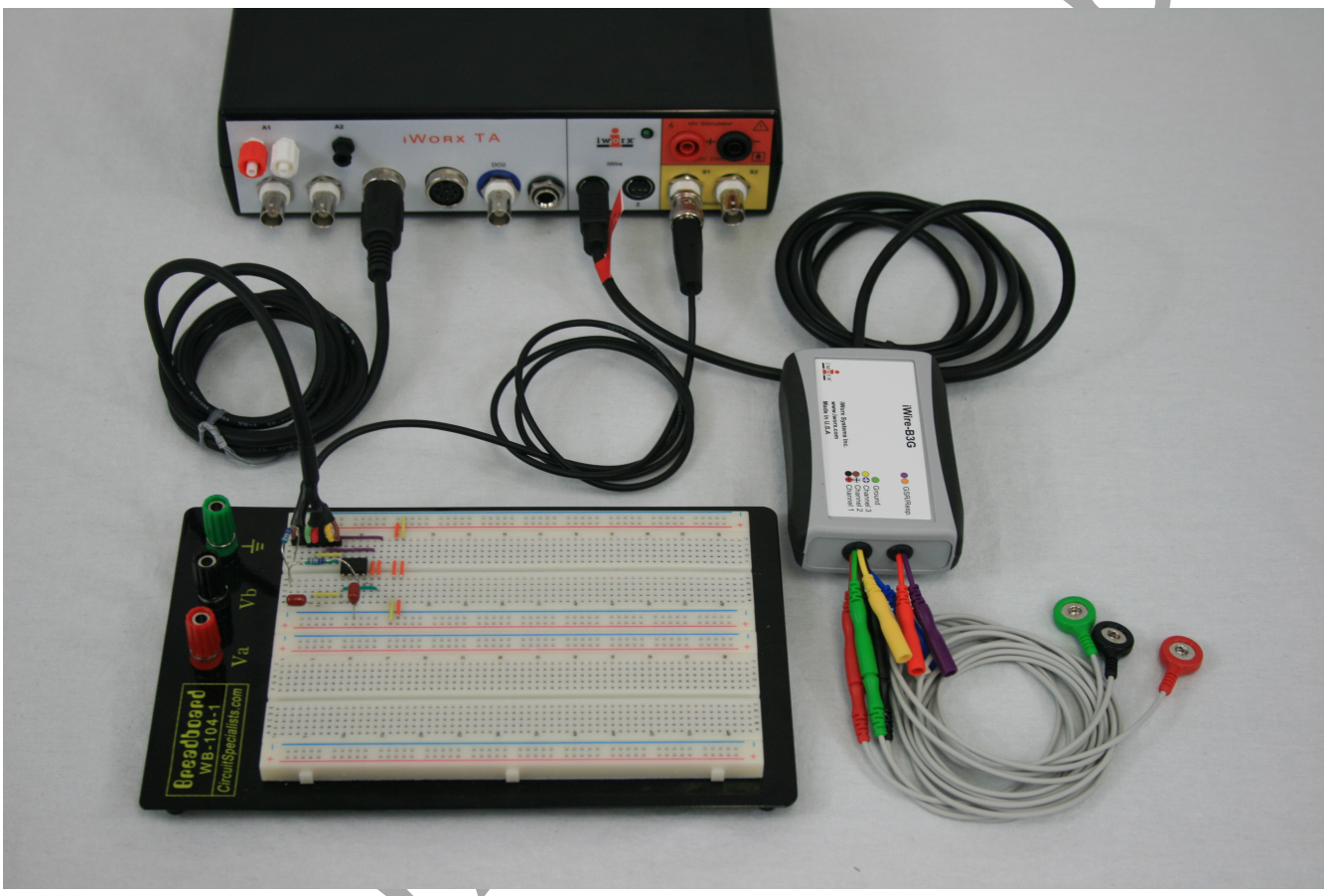


4. Let the areas dry before attaching the electrodes.
5. Remove the plastic disk from a disposable electrode and apply it to one of the scrubbed areas. Repeat for the other two areas.
6. Snap the lead wires onto the electrodes, so that:
    - the red "+1" lead is attached to the electrode near the elbow.
    - the black "-1" lead is attached to the electrode in the middle of the forearm.
    - the green "C" lead (the ground) is attached to the electrode on the wrist.



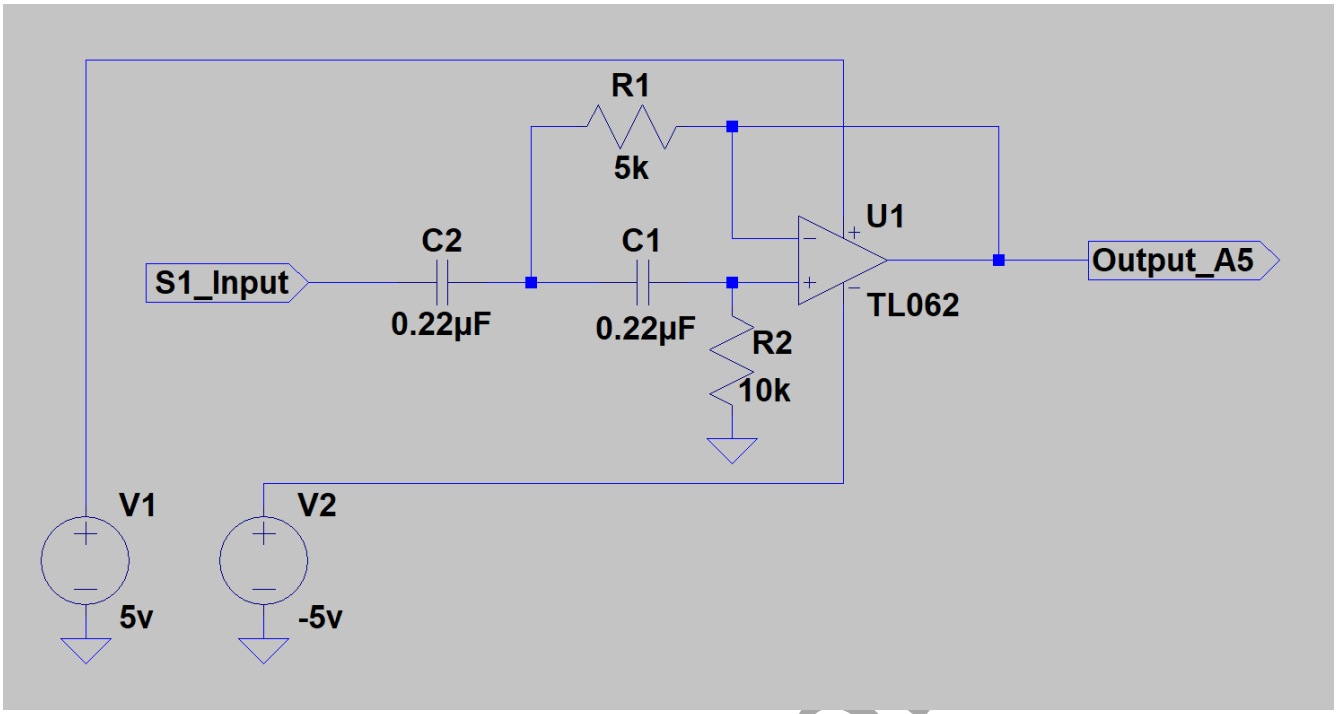
Breadboard Setup

1. Insert the BNC connector on the end of the C-BNC-BB cable into the S1 stimulator port of the IX-TA-220
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 IX-TA-220.
4. Connect the other end of the C-DIN-BB cable to the breadboard.



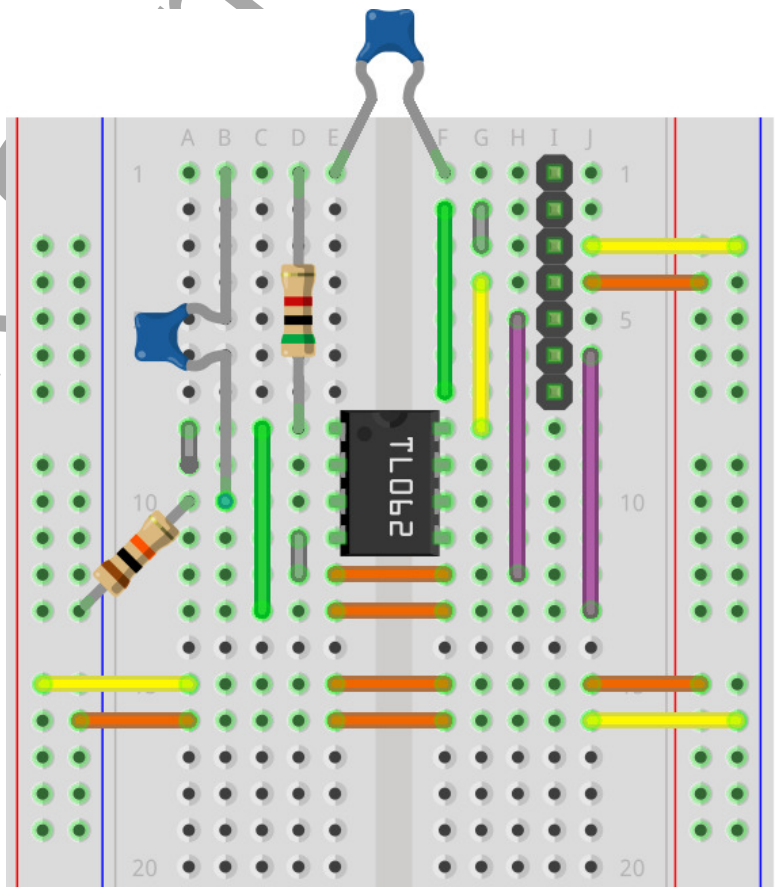
Design the Filter Circuit

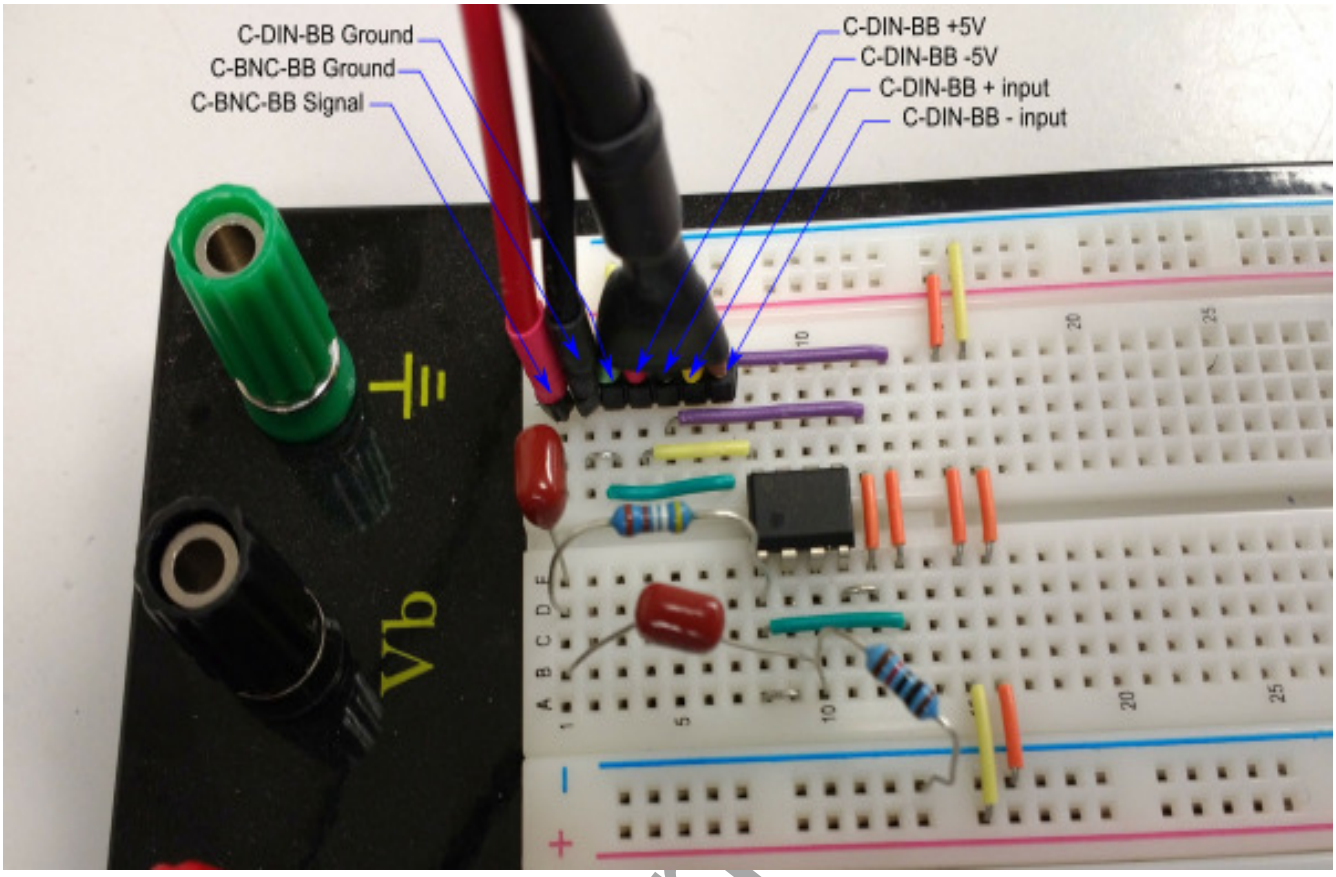
Here is an example of a filter circuit for a 2 pole high pass filter.
The Filter is a Sallen Key 2-pole high pass filter set for 100Hz. Its job is to remove 60Hz electrical noise picked up from fluorescent lights, computers and AC power lines.



Circuit

It is implemented here on the breadboard.



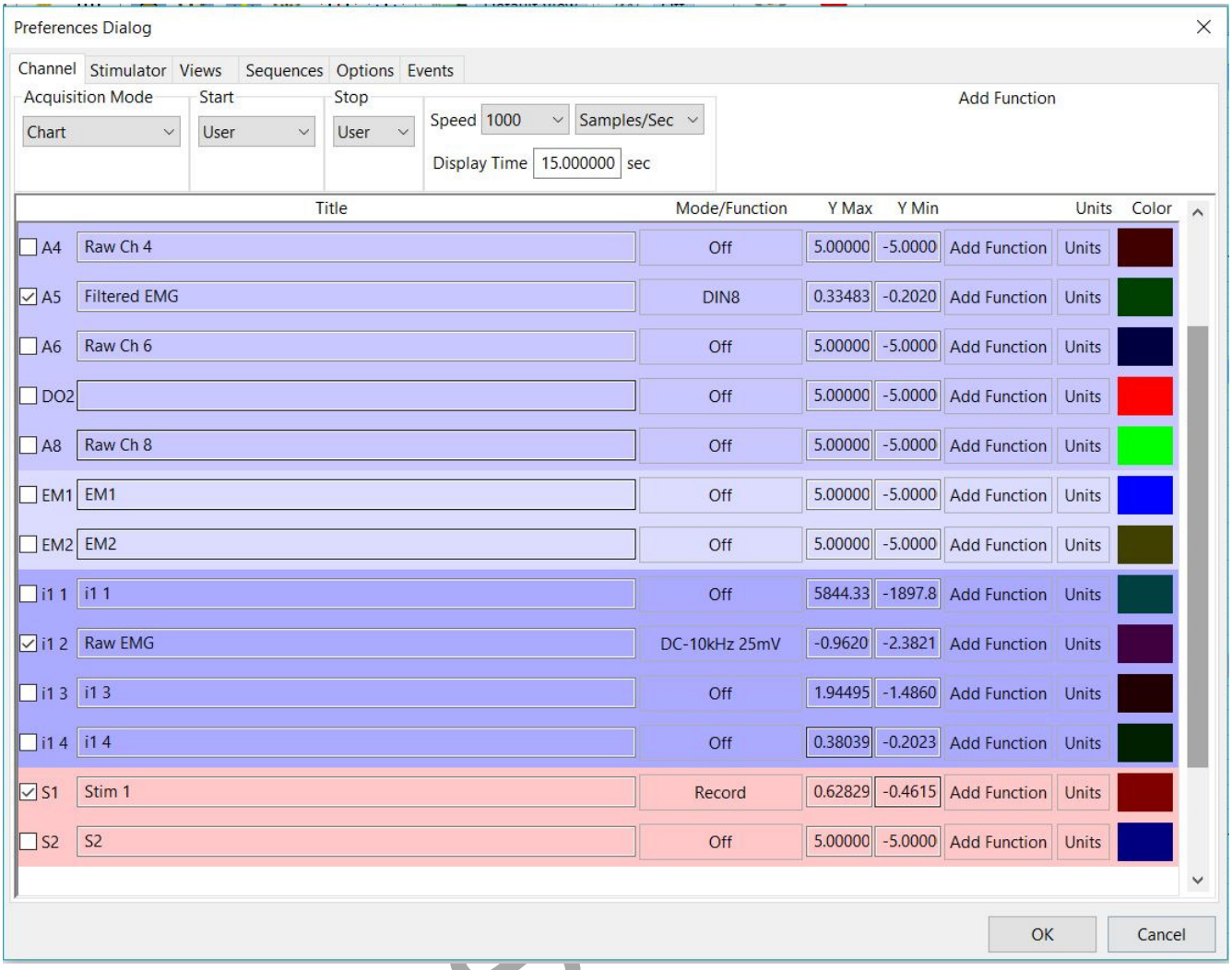


Setting up LabScribe

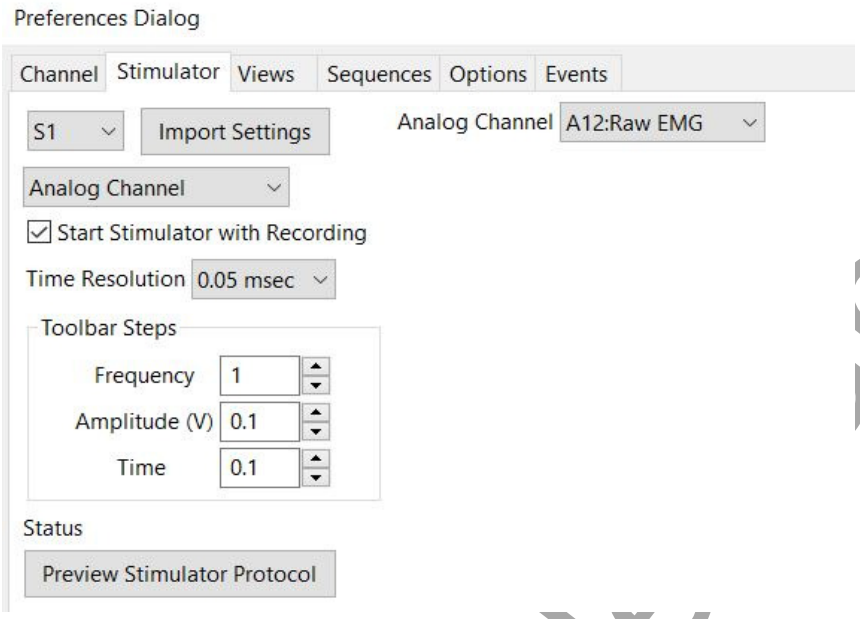
The provided EMGFilter LabScribe setting file has been preset with the following settings. The instructions here are for your information and to help you modify other iWorx lab experiments to add the option for additional signal conditioning.

Open the Preferences dialog, by choosing Edit→Preferences from the Main Menu.

- ***Channels Tab***.
  - Enable the Channels to be recorded and Label them. These channels will be used:
    - A5 (Filtered EMG): This is the output of the Filter
    - i1 2 (Raw EMG): This is the EMG measured by the iWire-B3G
    - S1 (Stimulator): This is what the Stimulator is outputing, which is same as the Raw EMG Channel. You do not have to enable this channel.



- ***Stimulator Tab***
  - Choose S1 stimulator
  - Set the mode to Analog Channel
  - Choose A12: Raw EMG as the analog channel to be send to the Stimulator output
  - Enable Start Stimulator with Recording.



Experiment BI-2: EMG Signal Conditioning and Analysis

Exercise 1: The EMG and High Pass filter

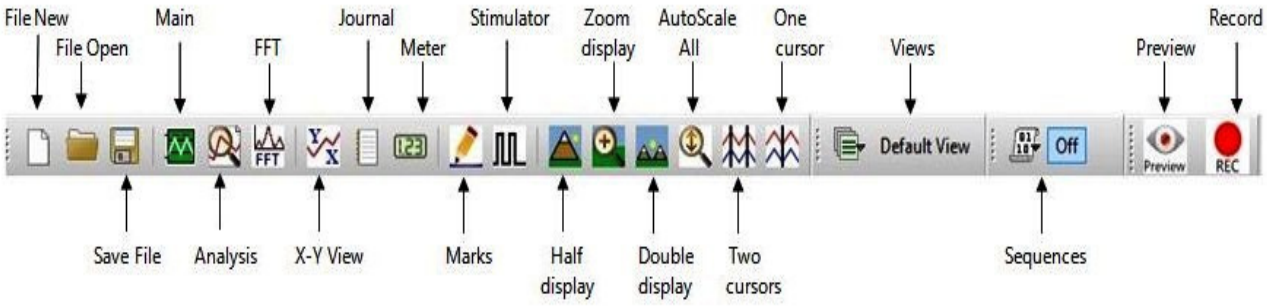
Aim: To record an EMG and high pass filter the signal to reduce 60 Hz noise.

Procedure

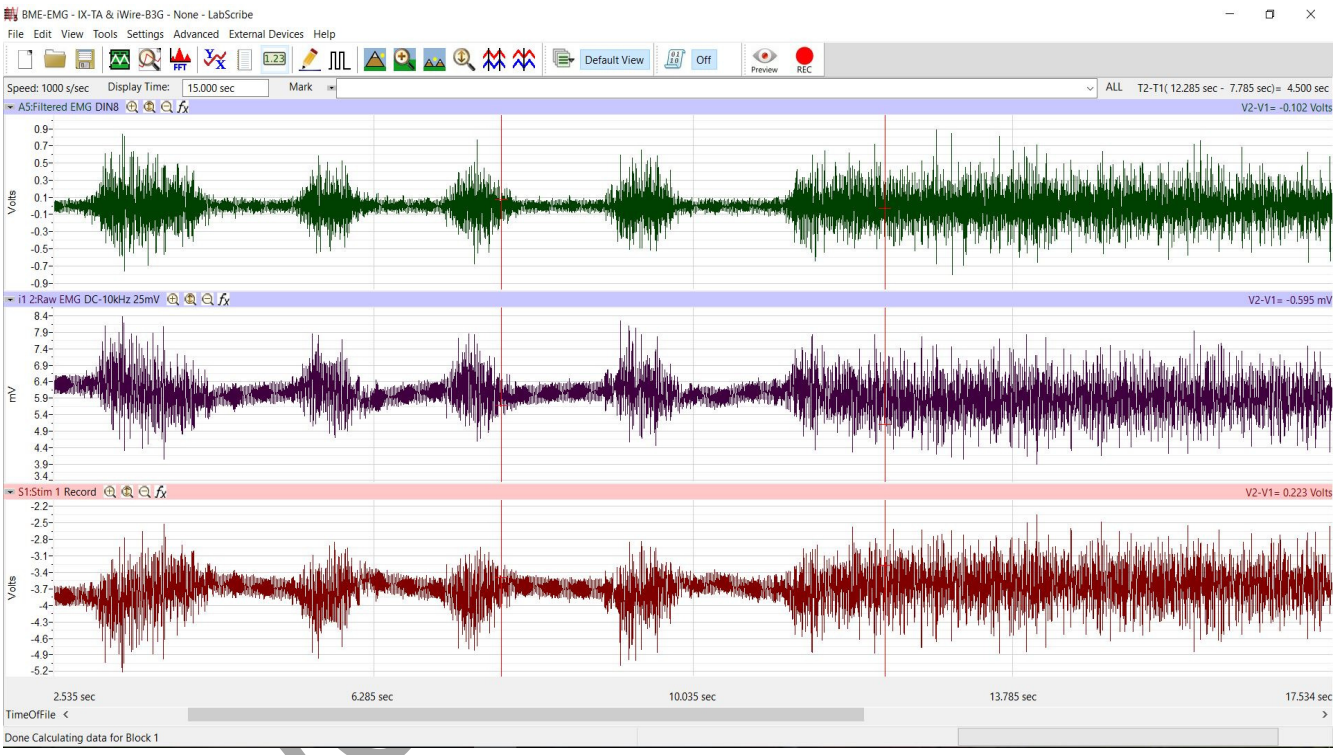
1. Click on the Record button, located on the upper right side of the LabScribe Main window. The signal should begin scrolling across the screen.

   Note: *If the user clicks the Record button and 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. Make sure BOTH the IXTA and iWire-B3G are recognized by the software.*

2. Click on the AutoScale All button on the LabScribe toolbar, to Autoscale all the channels.



3. The subject should sit quietly with his or her dominant forearm resting on the table top. Explain the procedure to the subject.
    1. The subject will squeeze his or her fist around a tennis ball five times, each contraction is two seconds long followed by two seconds of relaxation.
    2. Each successive contraction should be approximately two, three, and four times stronger than the first contraction; the final contraction should be full strength.
4. In the relaxation period after the last contraction, click the Stop button.
5. Click the AutoScale buttons for the EMG and Muscle Force channels. The recording should be similar to the image below.
6. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.
7. Click Stop to halt the recording and click File → Save As to save your data file.



Note:

- *Channel A12: Raw EMG is the Raw EMG signal recorded by the iWire-B3G.*
- *Channel S1: Stim 1 is the output of the Stimulator that is send to the breadboard*
- *Channel A5: Filtered EMG is the Filtered output of the EMG signal, after signal conditioning on the Breadboard.*

- *The signals on A12 and S1 are the same, and have some 60Hz noise.*
- *The Filtered Signal is recorded on Channel A5. The 60 Hz noise has been filtered out with the 2 pole high pass filter, as set according to the Setup PDF document.*

Optional Exercises: The EMG and Signal Conditioning

Extend the first exercise to test other signal conditioning that can be performed on the EMG signal.

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?

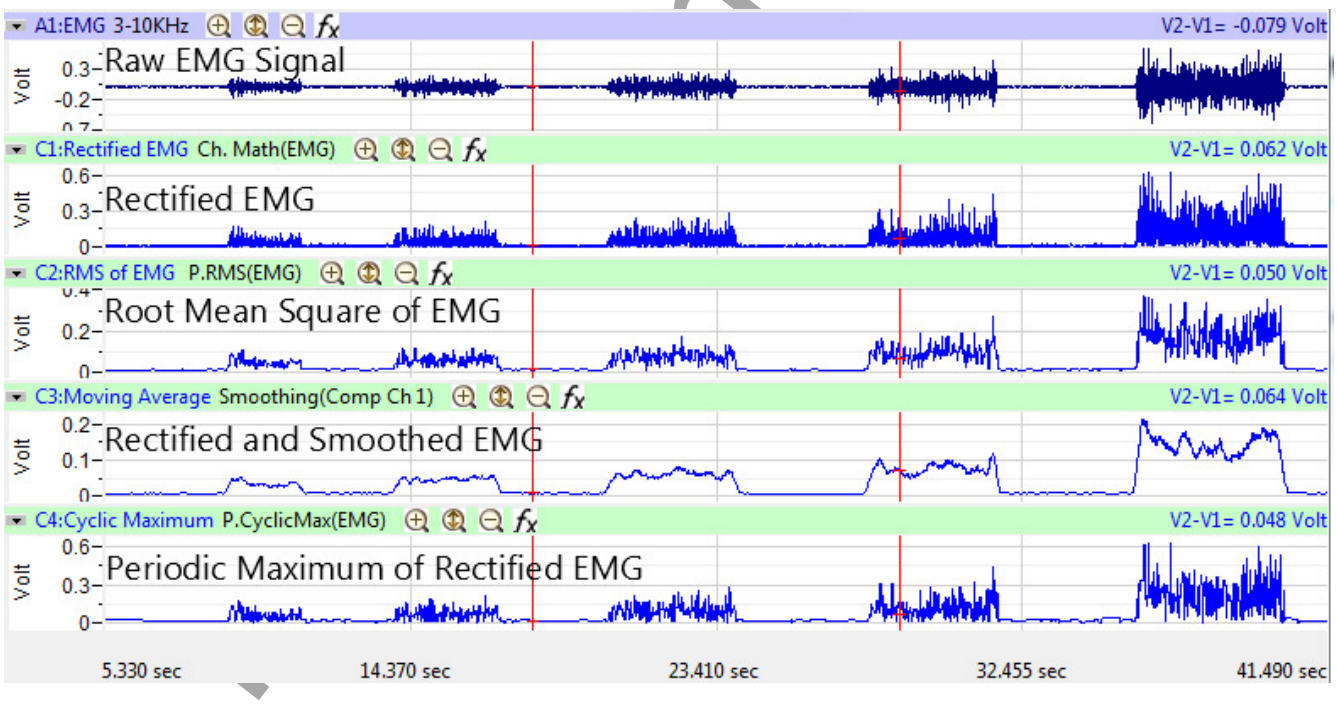
3) What happens if you use a low pass filter?

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

5) What filter cutoffs are best at reducing the noise but still maintain the signal?

EMG Analysis Routines

Perform the following EMG analyses and determine the best possible use for each and comment on their advantages and disadvantages.



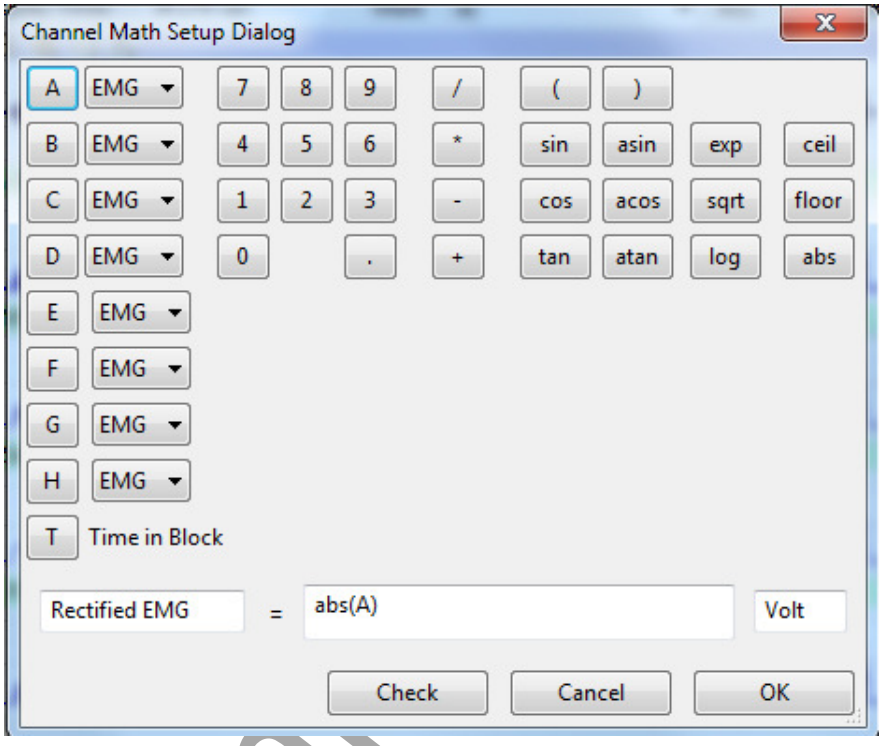
Time Domain Analysis

Rectified EMG Data:

To rectify a channel, click on the channel's **Add Function** button,  . Choose Channel Math.

Choose the Channel to be rectified, as the A channel.

Type in *abs(A)* in the function text area. Then click OK.



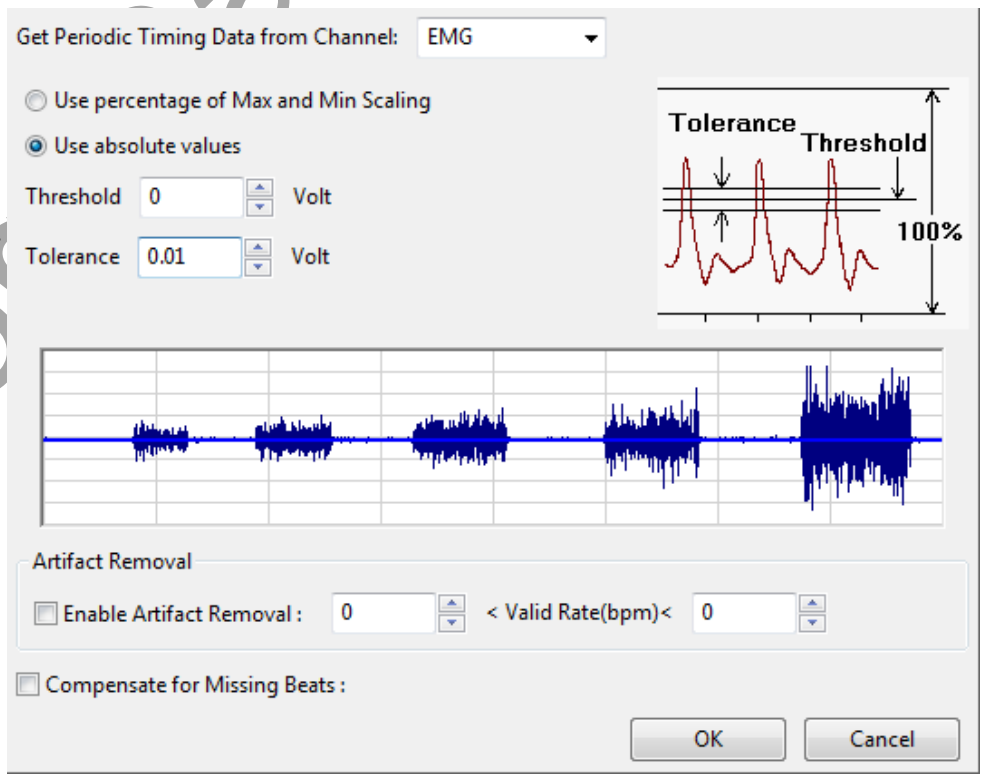
RMS (Root Mean Square):

To calculate the RMS of a channel, click on the channel's **Add Function** button,  .

Choose Periodic, choose RMS.

Set the Threshold and Tolerance. Since EMG data is AC coupled, we can use Absolute values for the threshold and tolerance. Also we can set the Threshold at Zero.

The raw EMG data values are squared and then the square root is calculated.



Envelope EMG Data:

There are 2 options to calculate the Envelope of the EMG signal:

1) Smoothing the Rectified Data

2) Calculating the Periodic (cyclic) maximum for each cycle of the EMG

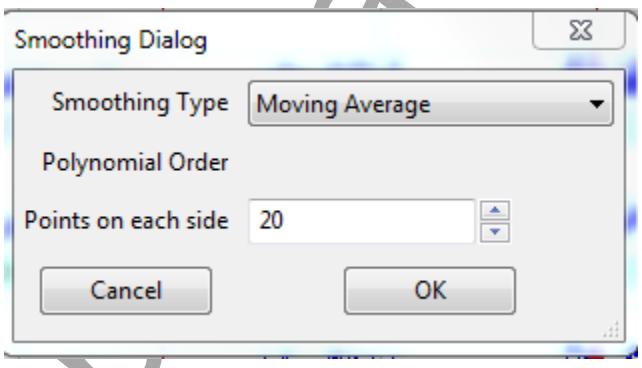
Smoothing the Rectified Data:

To Smooth the rectified EMG signal. Click on the **Add Function** button f_x of the Rectified EMG channel.

Choose Smoothing

Choose the smoothing type: Moving Average.

Choose the number of points for the moving average.



Cyclic Maximum of EMG:

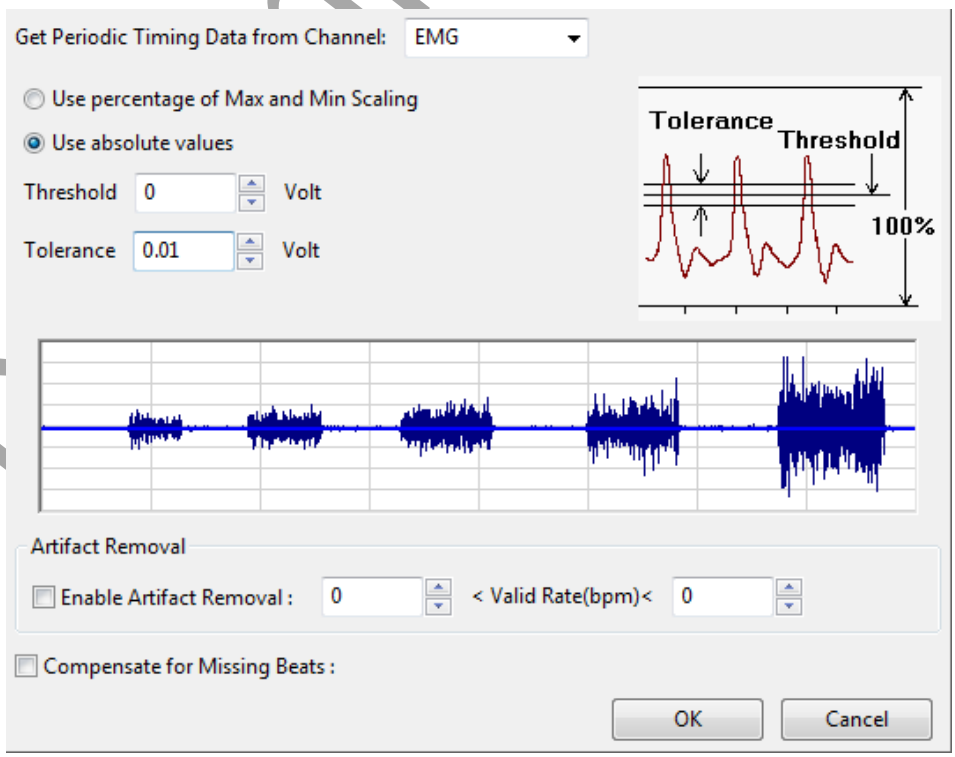
To Smooth the Rectified EMG signal,

Click on the EMG channel's

Add Function button, f_x.

Choose Periodic, then Cyclic Maximum.

Set the Threshold and Tolerance as in the RMS setup.



Filtering:

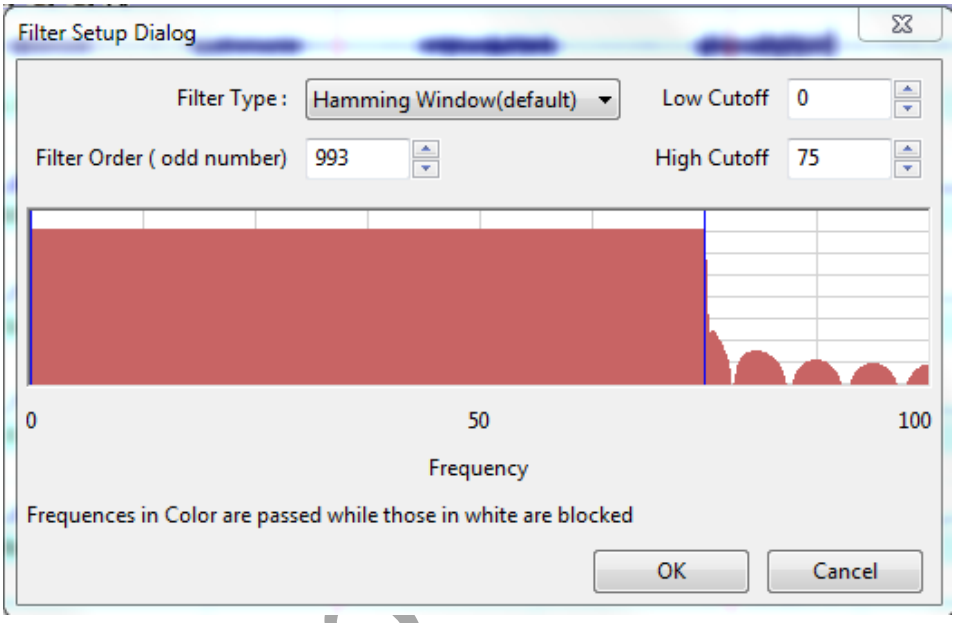
A User Defined Filter can also be applied to the Rectified EMG signal.

To Filter the Rectified EMG signal, click on the EMG channel's **Add Function** button, f_x.

Choose Filter.

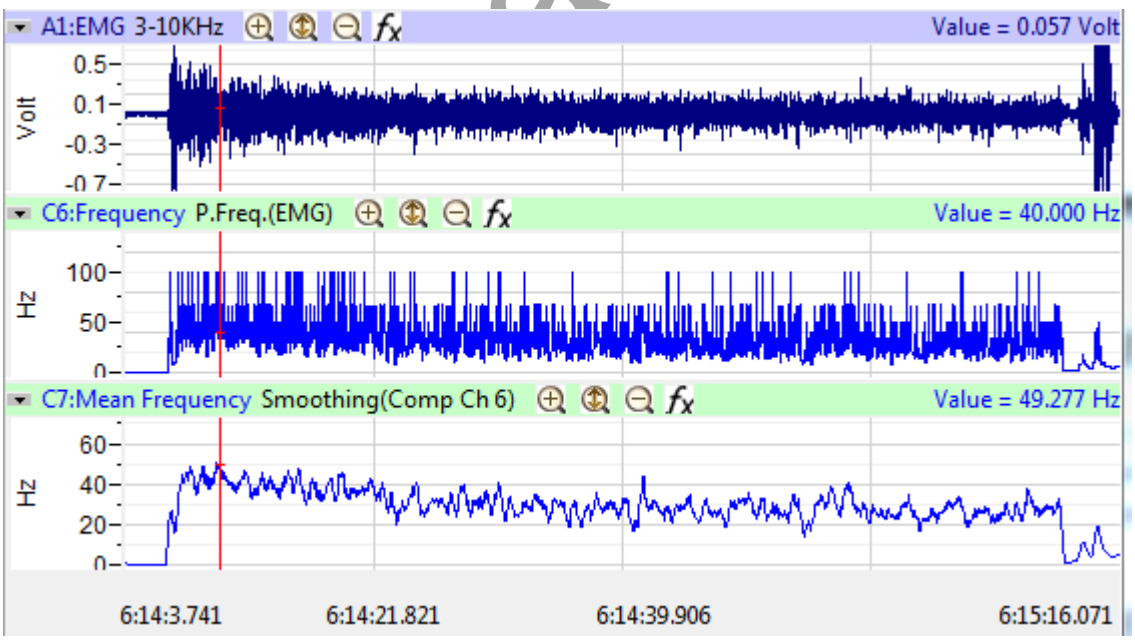
Choose FIR Filter.

Set the type of filter and filter cutoffs.



Mean Frequency:

Mean Frequency of the EMG signal decreases with time during the task that induces Fatigue.



To calculate the Mean Frequency, first calculate the Frequency of the EMG signal.

Click on the EMG channel's **Add Function** button, f_x.

Choose Periodic, then Frequency.

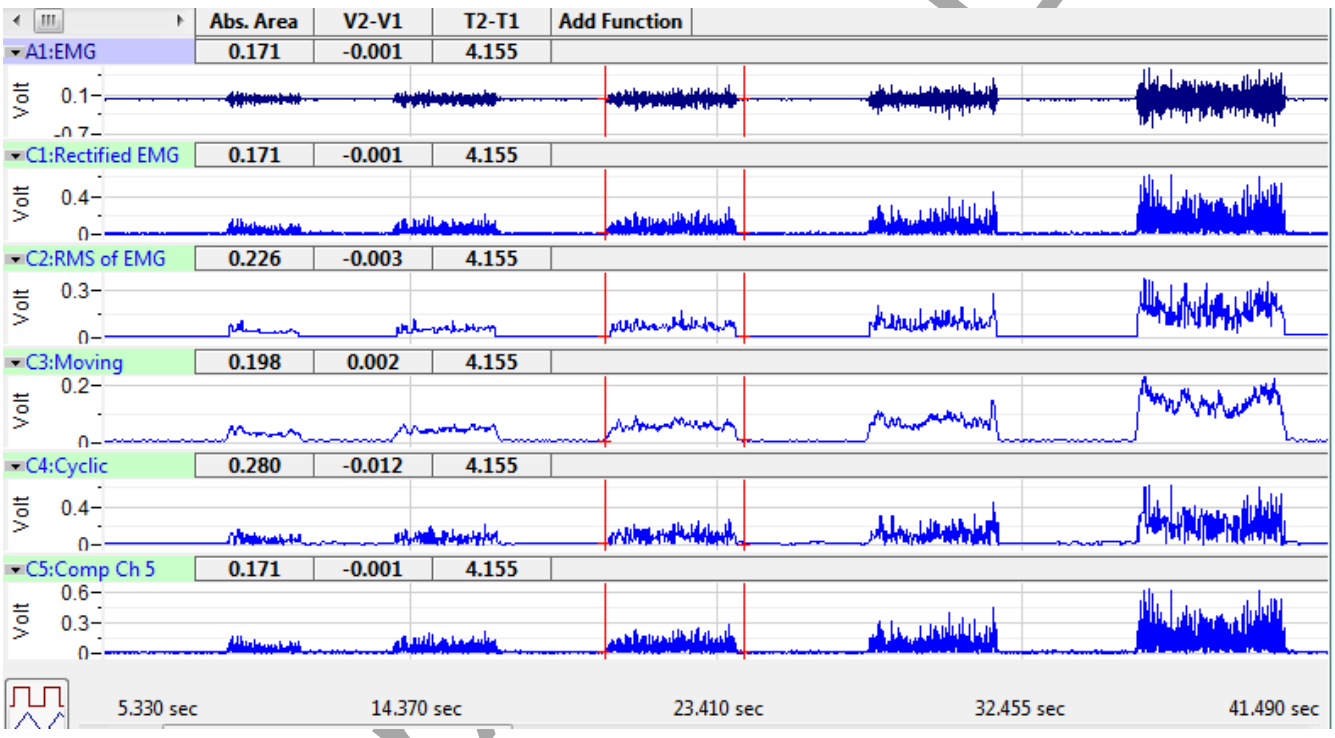
- The Periodic frequency dialog setup is similar to the RMS setup.

Then click on the Periodic Frequency channel's **Add Function** button, f_x.

Choose Smoothing and set up the smoothing channel.

We now have a channel that is the mean Frequency of the EMG signal.

Absolute Integral Under The Curve:



In the Analysis window various measurements can be performed on EMG data as well. Such as calculating the Absolute Integral under the curve between the 2 cursors.

Frequency Domain Analysis

LabScribe can perform Spectral Analysis of the EMG signal.

Power Spectral Density can be calculated by squaring the Fourier Transfiorm of the selected segment.

This gives a measure of the power that each frequency contributes to the EMG signal.