EMG SIGNAL PROCESSING

1 Background

1.1 EMG Signals

The signal acquired from the EMG sensor and amplified through the on-board QNET circuit is shown in the first two blocks of Figure 1.1. This signal is in the ± 10 V range but still includes a lot of noise. The signal must be processed further, using either an analog circuit or digitally through a PC, in order for it to be used. A signal processing method knows as linear envelope is used to do this. As illustrated in Figure 1.1, this involves rectifying the signal and passing it through a low-pass filter. A high-pass filter (HPF) may also be used to remove any low-frequency components. Choosing the filter cutoff frequency of the high-pass and low-pass filter is important.

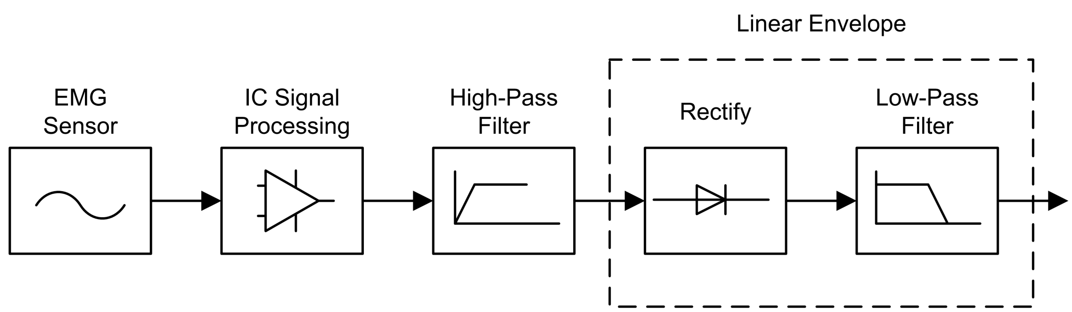

Figure 1.1: EMG signal processing

The result when the measured EMG signal is passed through a high-pass filter is shown in the second plot in Figure 1.2. For the QNET Myoelectric Trainer, choose a low HPF cutoff (e.g. around 0.25 Hz) to ensure only the DC component is removed and the remainder of the signals are kept. Setting the cutoff too high can make the signal too noisy.

In order to take a *running average* of the EMG the signal is passed through a linear envelope. Rectifying the signal means taking its absolute value. In electronics, a full-wave rectifier circuit is used. As illustrated in the third plot in Figure 1.2, the obtained signal is always positive.

The low-pass filter makes the signal smooth and generates the *envelope* of the signal, as shown in the last plot of Figure 1.2. There is a tradeoff when setting its cutoff frequency. If the cutoff is too low, the envelop will be too slow. If its set too high, then the envelope will be less smooth. The resulting signal from the linear envelope can potentially be used to check for muscular failure, rehabilitation, myoelectric prosthesis, and so on.

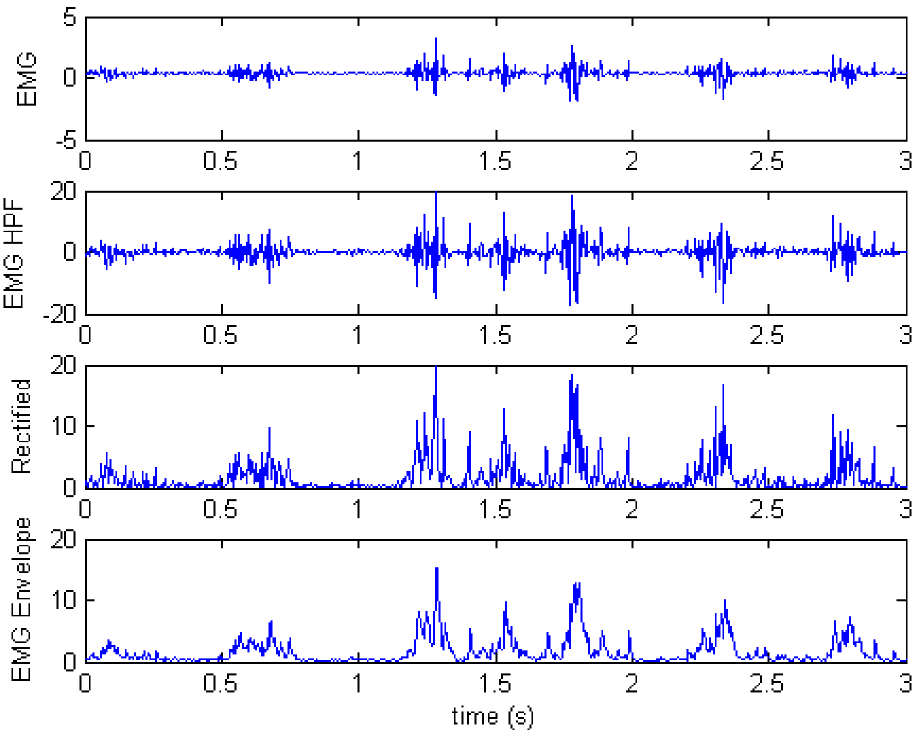

Figure 1.2: Measured and processed EMG signal

1.2 EMG Signal Processing Virtual Instrument

The virtual instrument used to view EMG sensor measurements, and the output of the linear envelope is shown in Figure 1.3 and Figure 1.4.

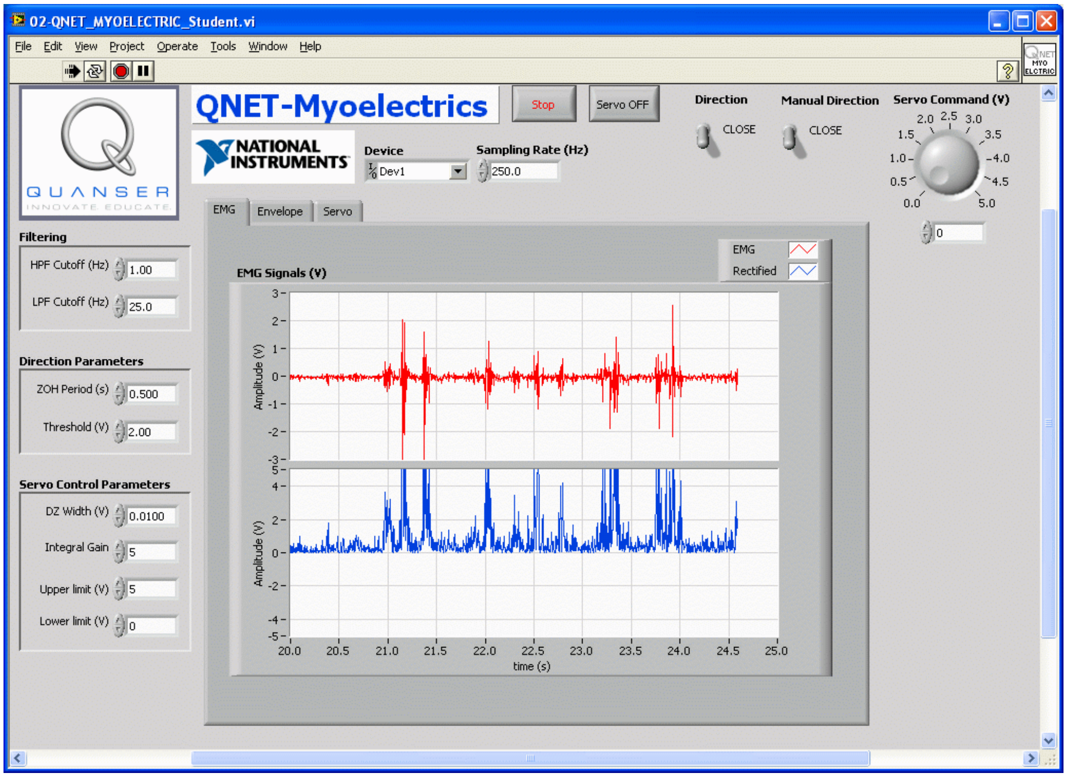

Figure 1.3: QNET Myoelectric VI: EMG Signal tab

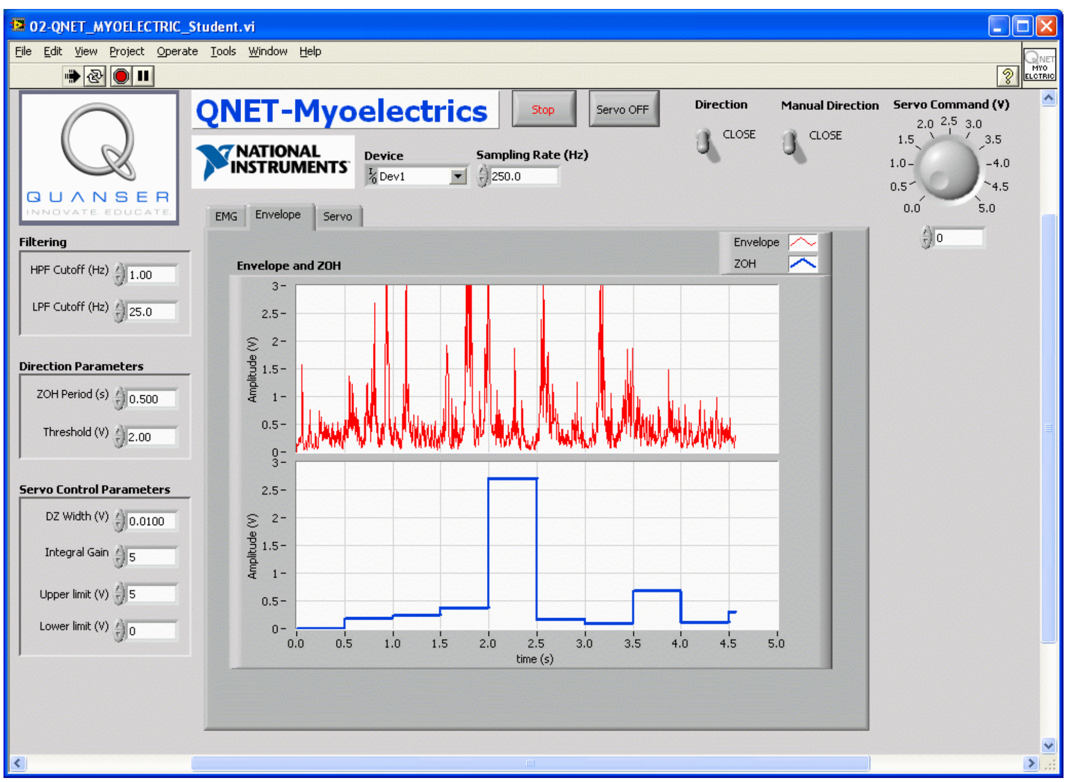

Figure 1.4: QNET Myoelectric VI: Envelope and ZOH tab

2 In-Lab Exercise

2.1 Signal Analysis

1. Go through the steps in laboratory experiment on the EMG Sensor Setup to ensure the EMG sensor is working properly and that you have the Dynamic Signal Analyzer instrument up and running.

2. Take a screen capture, similar to Figure 2.1, of when the forearm muscles are contracted.

   Note: To do this, select the instrument window and press on the ALT and PRTSCN keys and the image will be saved on the clipboard.

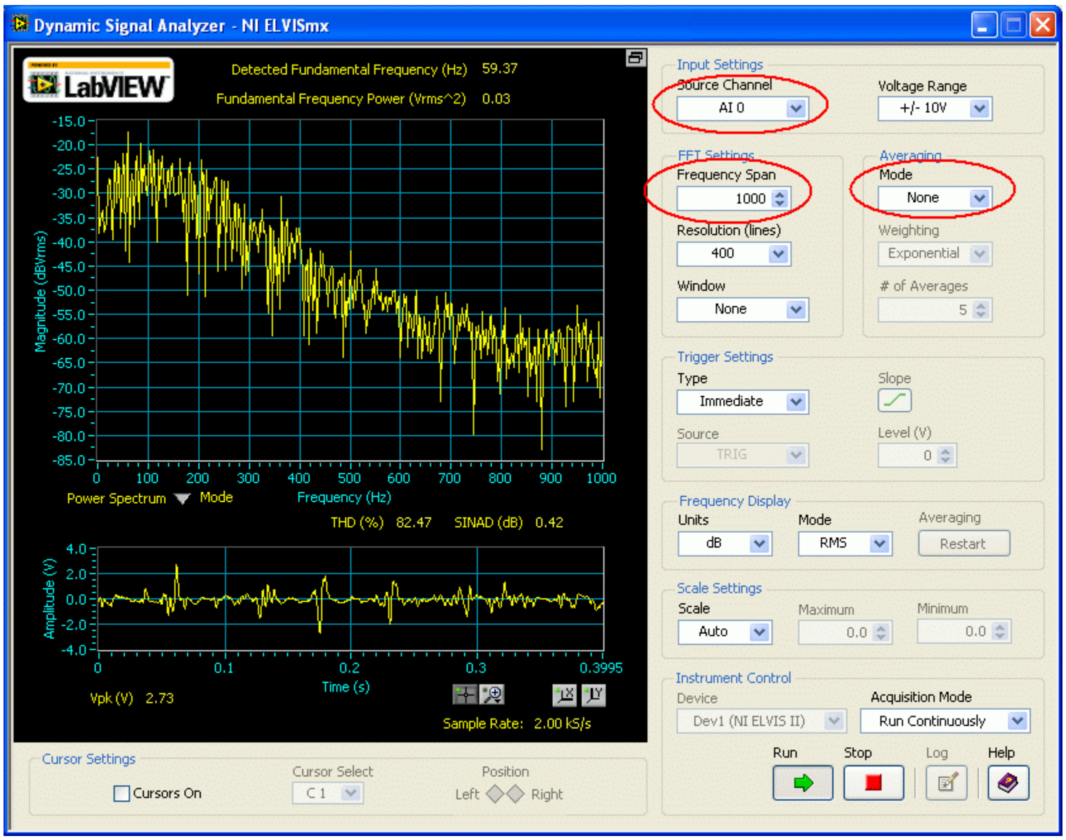

Figure 2.1: Setting up the Dynamic Signal Analyzer instrument

3. Relax the muscle in your forearm and take a second screen capture.

4. Comment on the difference between the power spectrum response when the muscles are contracted and relaxed. Enter the absolute peak voltage of the measured EMG signal (i.e. large positive or negative value attained) and the frequency range where the power spectrum amplitude is above -40 dB.

5. If completed, click on the Stop button and close the Dynamic Signal Analyzer instrument.

2.2 Linear Envelope

1. Go through the steps in EMG Sensor Setup laboratory experiment to ensure the EMG sensor is working properly.

2. Open the `QNET_MYOELECTRIC_Student.vi`. **Make sure the correct Device is chosen.**

3. Run the VI.
4. Select the EMG tab, as shown in Figure 1.3. The top plot in the EMG Signal (V) scope is the measured EMG signal (after on-board signal processing) and the bottom plot is the high-pass filtered and rectified signal.
5. Adjust the high-pass filter cutoff frequency, HPF Cutoff, such that the rectified signal has less noise. As a guideline, the peaks of the rectified signal should not be much more than double the peaks of the EMG signal. Attach a capture of the response.
6. Select the Envelope tab, as shown in Figure 1.4, the top plot is the linear envelope of the EMG signal and the bottom plot is the zero-order hold of the envelope.
7. Adjust the low-pass filter cutoff frequency, LPF Cutoff, so the envelope is smoother. What happens when the cutoff is set too low? Summarize the tradeoff and attach the envelope response.
8. Click on the Stop button to stop running the VI.

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