EMG CONTROL

1 Background

1.1 Myoelectric Control

In this section, the EMG envelope signal is used in the control algorithm shown in Figure 1.1 to open and close the clamp on the servo. The servo is driven by the on-board PWM amplifier.

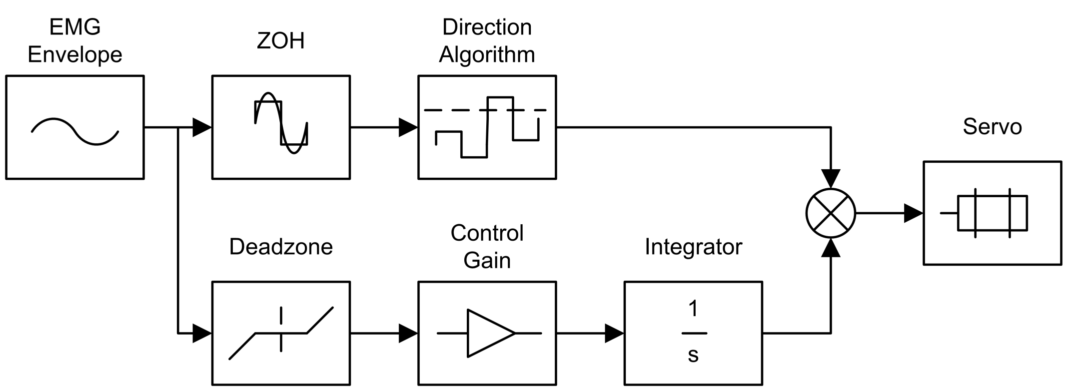

Figure 1.1: Myoelectric servo control algorithm

In order to open/close the clamps at different positions, this task-based control system has two parts: direction control and position control.

1.1.1 Servo Direction Control

The direction algorithm uses the EMG envelope signal to choose when to open or close the clamps and is illustrated in the top portion of Figure 1.1. To change the direction of the servo, i.e. from open to close or close to open, the signal must exceed a set threshold value for a certain time. Thus when the muscle is contracted more than usual, it should trigger a direction change. For example, if the signal is above the pre-defined threshold value of 0.5 V for at least 0.1 seconds then the servo direction should change.

Zero-order hold (ZOH) is typically used to reconstruct digital signals. It holds its input signal for a specified sampling period. The equation is defined as

$$y(t) = \begin{cases} u(t_i), & t - t_i < 0 \text{and} t_i - t \leq 0 \\ u(t_k), & t_k - t \leq 0 \text{and} t - t_{k+1} < 0 \end{cases} \tag{1.1}$$

where t is the current simulation time, t_i is the initial simulation time. For $k = 0, 1, 2, \ldots$ the ZOH sampling time T_s,

$$Figure 1.2 t_k = t_i + kT_s. \tag{1.2}$$

shows how the EMG envelope in sampled when passed through a ZOH with a sampling period of 0.1 seconds. If the ZOH signal exceeds a specified threshold, then the current servo direction is reversed.

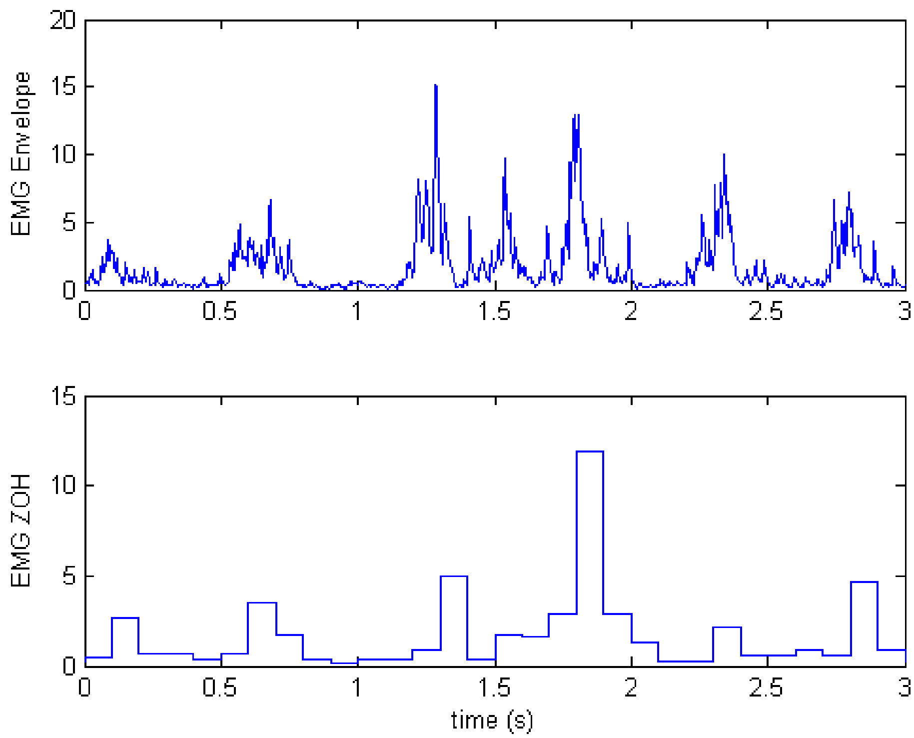

Figure 1.2: Zero-order hold of EMG envelope

The direction function is then

$$\text{dir} = \begin{cases} 1, & \epsilon < y_{\text{env}}(t) \\ -1, & y_{\text{env}}(t) \leq \epsilon \end{cases} \tag{1.3}$$

where ϵ is the threshold and $y_{\text{env}}(t)$ is the envelope of the EMG signal.

1.1.2 Servo Position Control

The position of the servo/clamp is proportional to the voltage fed to the PWM amplifier that drives it (i.e. no feedback design required). As shown in Figure 1.1, a dead zone is used to remove any small amplitude signals from the EMG envelope that may cause the servo to move from minor muscle contractions. Basically this prevents the servo from drifting when the muscles are at rest.

As shown in Figure 1.1, the envelope of the EMG signal is amplified by a control gain and passed through an integrator. This generates a voltage that controls the position of the servo. The gain has to be tuned according to the EMG signal. Saturation limits on the integrator ensure the clamp does not close or open passed its limits. The voltage command to the servo can be defined as

$$u(t) = \begin{cases} V_{\text{high}}, & V_{\text{high}} < u \\ V_{\text{low}}, & u < V_{\text{low}} \\ \dfrac{dir k_i y_{\text{env}}}{s}, & \text{otherwise} \end{cases} \tag{1.4}$$

were the upper integrator saturation is V_{high}, the lower integrator limit is V_{low}, the integral gain is k_i, the EMG envelope signal is $y_{\text{env}}(t)$, and the dir function is defined in Equation 1.3.

1.2 EMG Control Virtual Instrument

The virtual instrument used to configure the ZOH, and control the servo position is shown in Figure 1.3 and Figure 1.4.

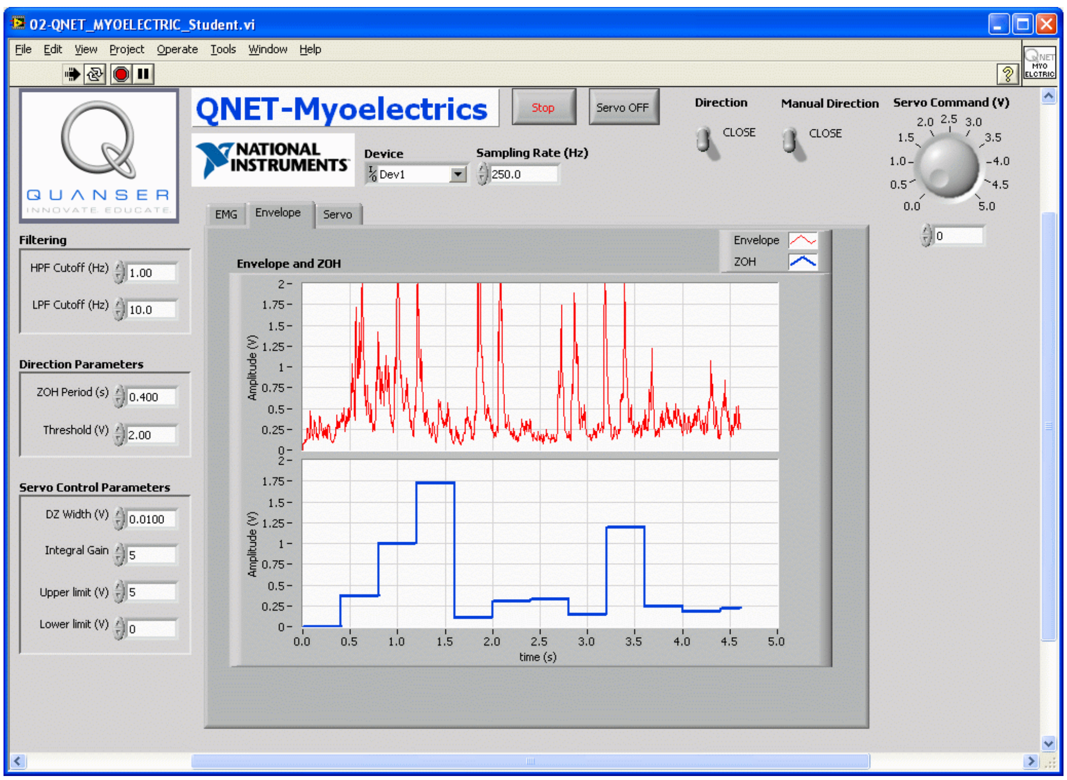

Figure 1.3: QNET Myoelectric VI: Configure the ZOH

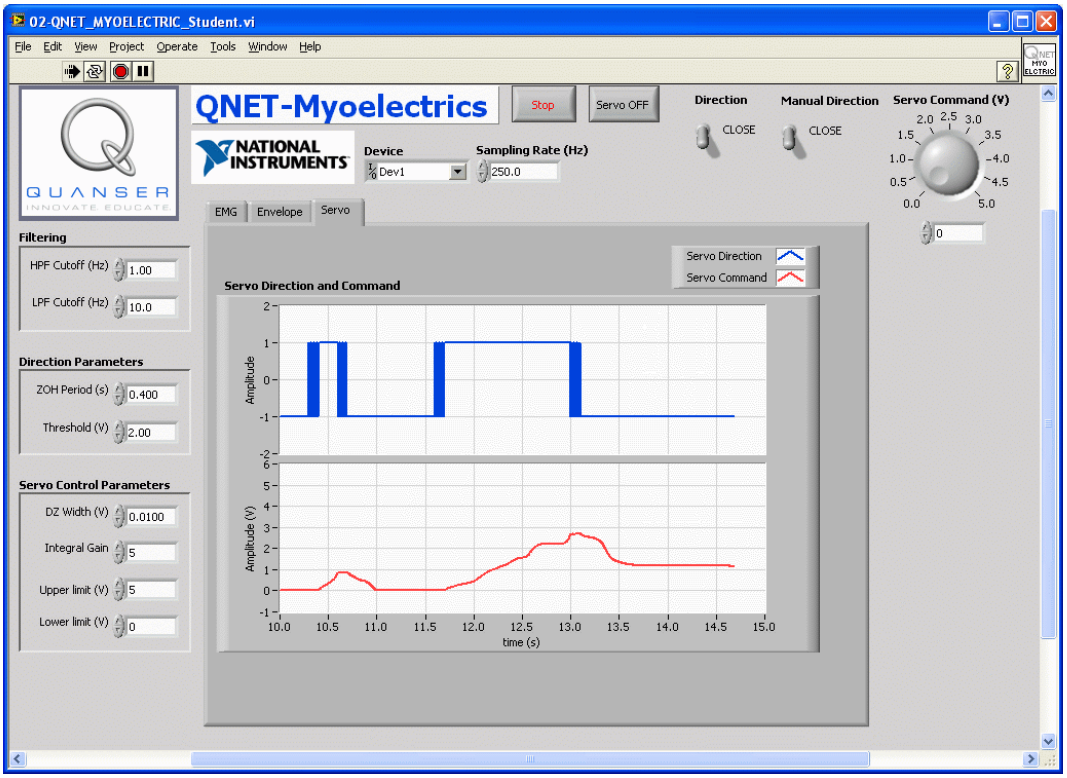

Figure 1.4: QNET Myoelectric VI: Servo tab

2 In-Lab Exercise

2.1 Full Servo Control

1. Make sure you have gone completed the laboratory experiments on Servo Direction Change and Servo Position Control before starting this laboratory experiment.
2. Open the `QNET_MYOELECTRIC_Student.vi`.
3. Open the VI block diagram.
4. Combine the direction algorithm with the servo position control designed in the laboratory exercises on Servo Direction Change and Servo Position Control, respectively. Attach an image of the block diagram.
5. **Make sure the correct Device is chosen.**
6. Run the VI.
7. Press the Servo OFF button to enable the servo. The button should be bright green and read *Servo ON*.
8. Test out the full servo control. You may have to tune the envelope and control parameters. Once you can easily open and close the position of the clamps using your muscles, record the parameters in Table 2.1.

Parameters	Value	Units
HPF Cutoff		
LPF Cutoff		
ZOH Period		
Threshold		
DZ Width		
Integral Gain		
Upper Limit		
Lower Limit		

Table 2.1: QNET Myoelectric Trainerfilter and control parameters

9. Record the response when using the full servo control to open and close the clamps. Give the results from both the Envelop and ZOH scope and the Servo Direction and Command scope. Based on your test results, could the system be used to control a myoelectric prosthesis?
10. Click on the Stop button to stop running the VI.

Quanser Inc.
119 Spy Court
Markham, Ontario
L3R 5H6
Canada
info@quanser.com
Phone: 1-905-940-3575
Fax: 1-905-940-3576

Printed in Markham, Ontario.

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