Name	Urwa Maryam, Umar Hayyat, Mateen Abbas
Roll no.	2019-EE-352, 2019-EE-360, 2019-EE-384
Marks	

Lab Manual # 9

QUBE Servo Filtering

Objectives

In this lab, we will learn

- using the LabVIEW™ to interact with Quanser@ QUBE-Servo rotary hardware,
- using an encoder to measure the speed and filtrate it.

Introduction

DC Motor:

Direct-current motors are used in a variety of applications.

Encoders:

Similar to rotary potentiometers, encoders can also be used to measure angular position. There are many types of encoders but one of the most common is the rotary incremental optical encoder, shown in Figure. Unlike potentiometers, encoders are relative. The angle they measure depends on the last position and when it was last powered. It should be noted, however, that absolute encoders are available. The encoder in this lab has a resolution on 2048 counts i.e., for a complete rotation of motor it will generate a count of 2048.

Exercise 1:

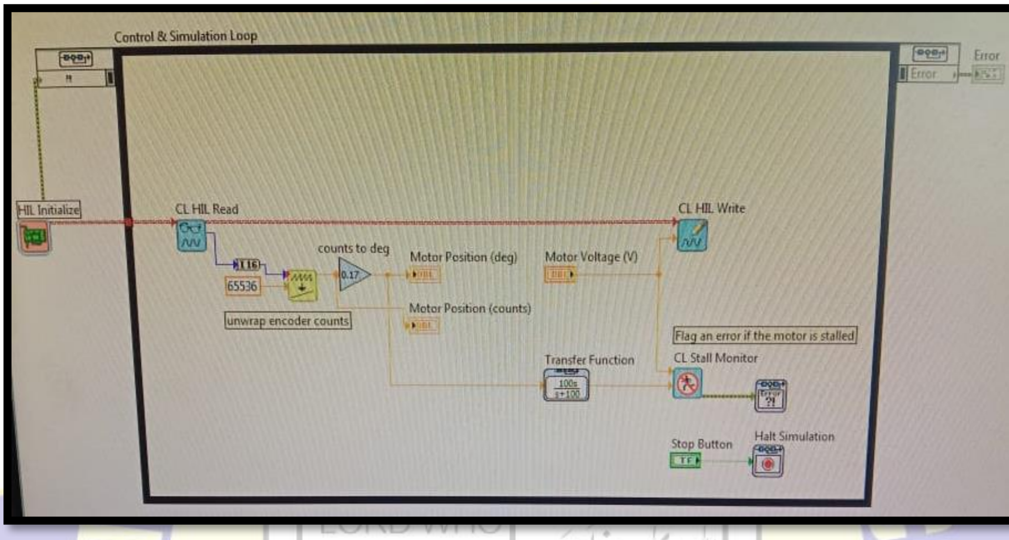
- Simulate the VI with the disk at the 0-degree position marked on the QUBE-Servo, rotate it one full rotation, and verify that the encoder output reads 2048 counts.
- Now using a sensor gain block in block diagram, convert these number of counts into degrees. Now after inserting the sensor gain, simulate the VI again to verify that the encoder outputs 360 degrees for one complete rotation.

Calculations for degree conversion (sensor gain):

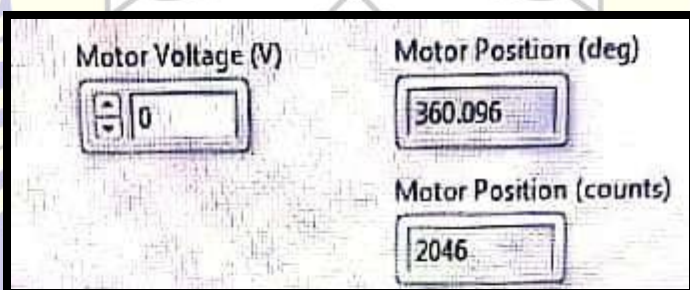
Counts per revolution (360º) = 2048 counts

Rev. in one count = rev. per count = 360º / 2048 = 0.1758º

Block Diagram:



Front Panel:



Filter:

A filter can be used to block out the unwanted-frequency components of a signal. For example, a first-order low-pass filter transfer function has the form

$$G(s) = \frac{\omega_f}{s + \omega_f}$$

where ω_f is the cut-off frequency of the filter in radians per seconds (rad/s). All higher frequency components of the signal will be attenuated by at least −3 dB ≈ 50%.

In the VI file of filtering, you may observe that there is a derivative block connected which converts the position of the servomotor to speed (in rad/s). Before the derivative block, you can see the gain block, whose purpose it to convert the position from 2048 counts to radians.

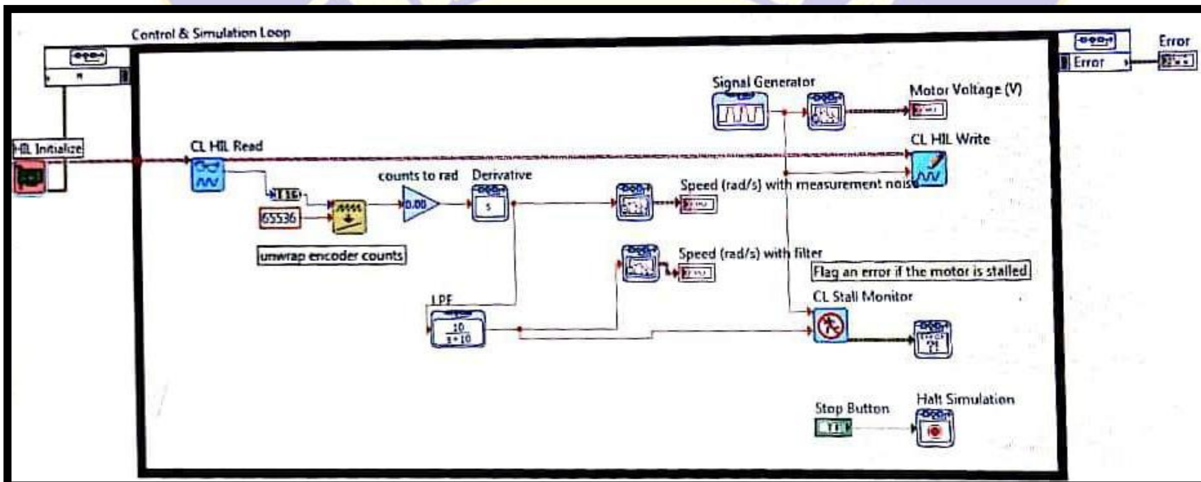
Exercise 2:

- Using the VI file of filtering, first change the encoder calibration (sensor) gain in the VI file so that the output of the gear position comes out in radians instead of degrees.
- Set the frequency of the Signal Generator as 0.4 Hz, input the waveform of square voltage varying from 1 to 3 V. Now simulate the VI file and attach the front panel and block diagram pictures to your report.

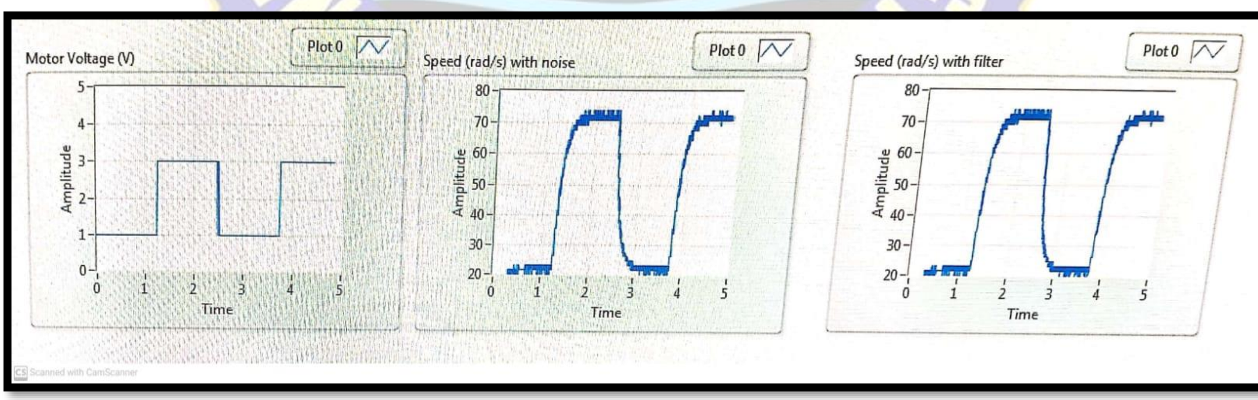
Calculations for conversion to radians (sensor gain):

Counts per revolution (2π) = 2048 counts
Rev. in one count = rev. per count = $2\pi/2048 = 0.003$ rad/s

Block Diagram:



Front Panel (input voltage and encoder-based measured servo speed):

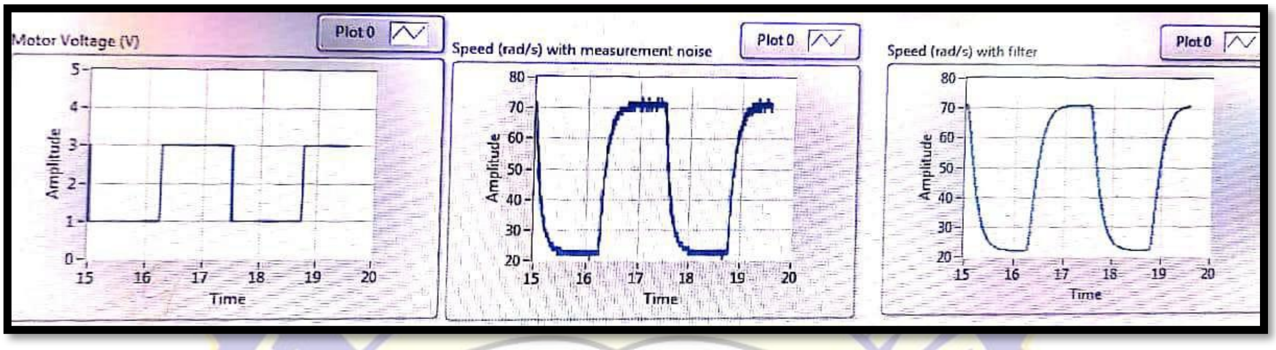


Q: Why is there a noise in the waveform of motor speed?

The main source of motor noise is the commutator brushes, which **can bounce as the motor shaft rotates**. Though the system keeps the motor running, occasional spark occurs between brushes and commutator at the timing of the commutation. The spark is one of the causes of the electrical noise.

- Now double click on the transfer function block placed after the derivative block to add the cutoff frequency of the filter. The purpose of the filter is to remove the noise in the measured speed.
- Mention the cutoff frequency in rad/s **10** and in Hz **1.59**.

Front Panel diagram (filtered encoder-based speed response and the motor voltage):



Conclusion:

In this lab, we have performed filtering and integration of servo motor. We measured the counts of servo motor by rotation it 360o and then we inserted the value in degree per count and verified the result that total count is 2048 per revolution. We measured the motor speed with and without filter. There is noise in motor speed waveform (without filter) then we inserted the low pass filter and adjusted its cur off frequency to remove the noise.