Assignment 2:

EEE3088F – Engineering design principles

Prepared By:

Ronak Mehta - MHTRON001

Vikyle Naidoo - NDXVIK005

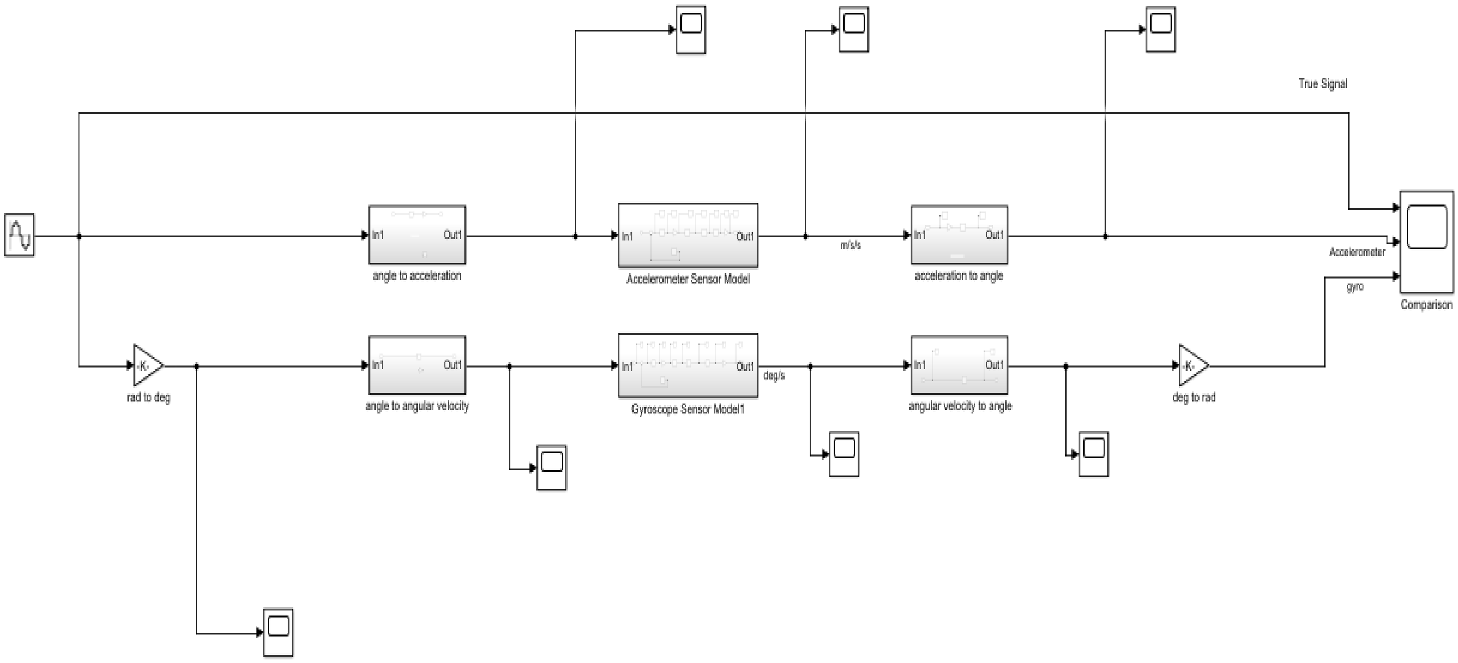
Faculty of Engineering and the Built Environment

12th April 2019

Questions:

1) Block Diagrams for Gyroscope and accelerometer.

i) *Combined diagram:*

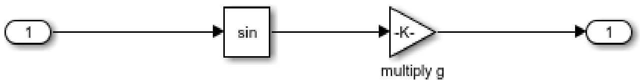


ii) *For Accelerometer:*

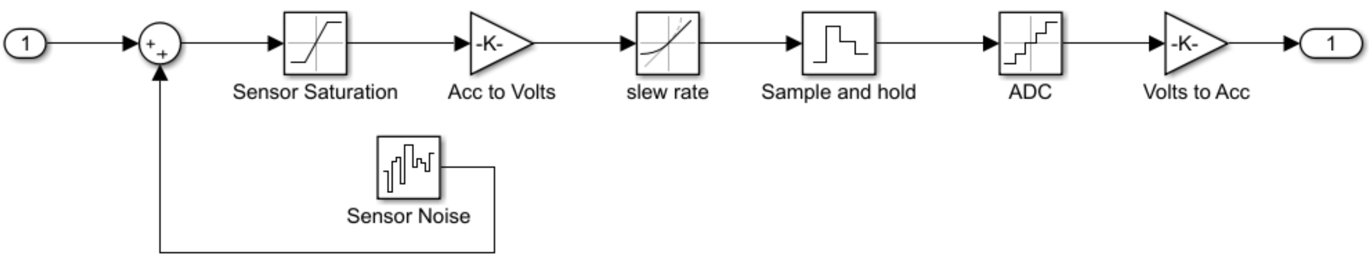
Three sub-blocks were used, namely:

Angle to acceleration, Accelerometer sensor model and Acceleration to angle

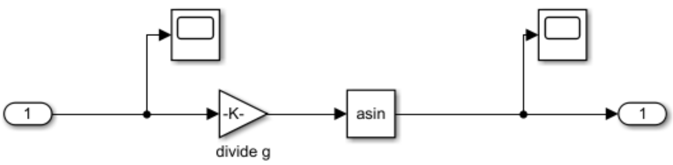
1. Angle to acceleration:
a = gsin(theta)



Accelerometer sensor model:

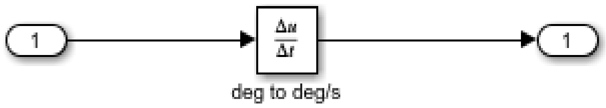


3. Acceleration to angle:
theta = asin(az)/g

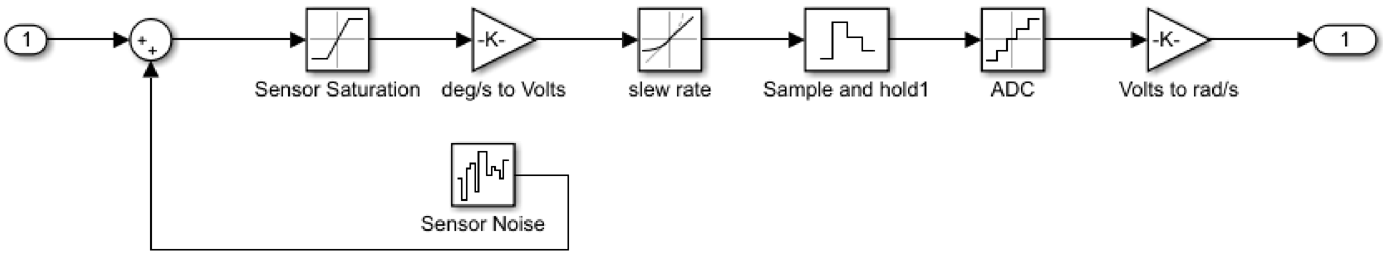


iii) *For Gyroscope:*
Three sub-blocks were used, namely:
Angle to angular velocity, Gyroscope sensor model and Angular velocity to angle

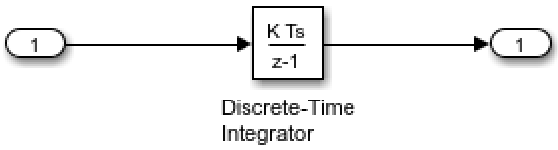
1. Angle to angular velocity



2. Gyroscope sensor model:



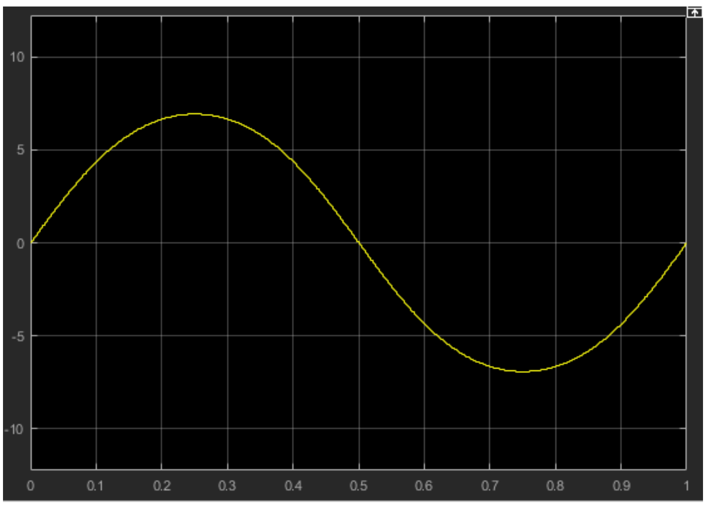
3. Angular velocity to angle:



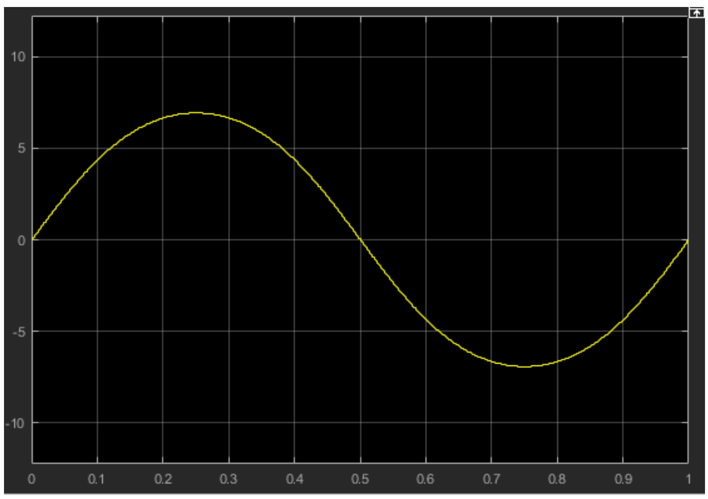
2) (a) and (b)

For Accelerometer:

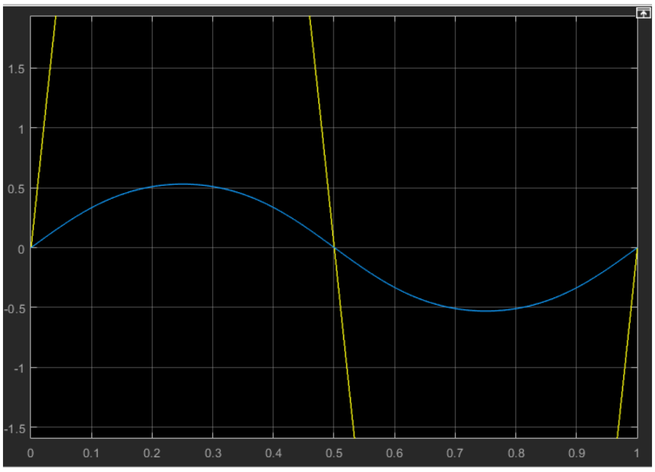
i) Sensor Noise:
Model block: Band-limited white noise power:
9.62E-9 ms^{-2} = (10E-6*9.81*sqrt(50))^2 *0.02



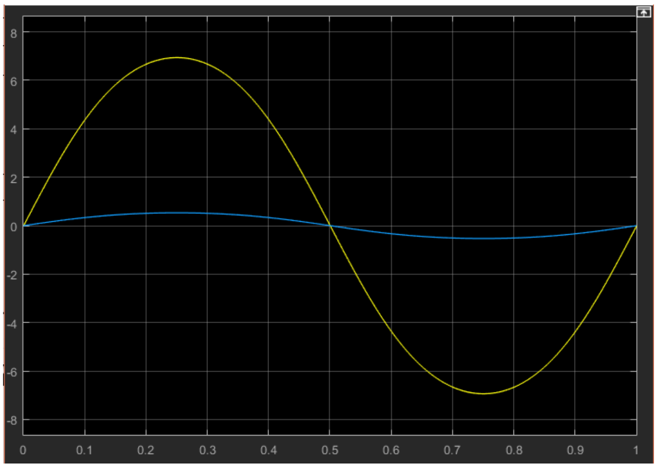
ii) Range:
Model block: Sensor Saturation:
Upper Limit = 4*9.81 = 39.24 ms^{-2}
Lower Limit = - 4*9.81 = -39.24 ms^{-2}



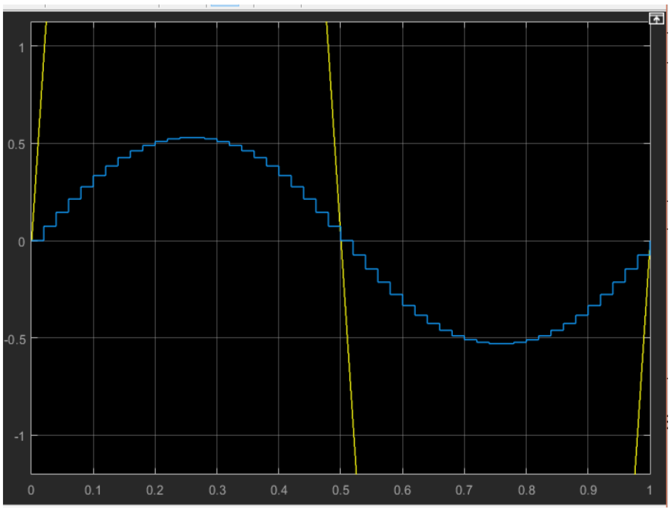
iii) <u>Acceleration-Voltage conversion:</u>
Gain: 0.0765 $Vm^{-1}s^{2}$ = 3/4/9.81



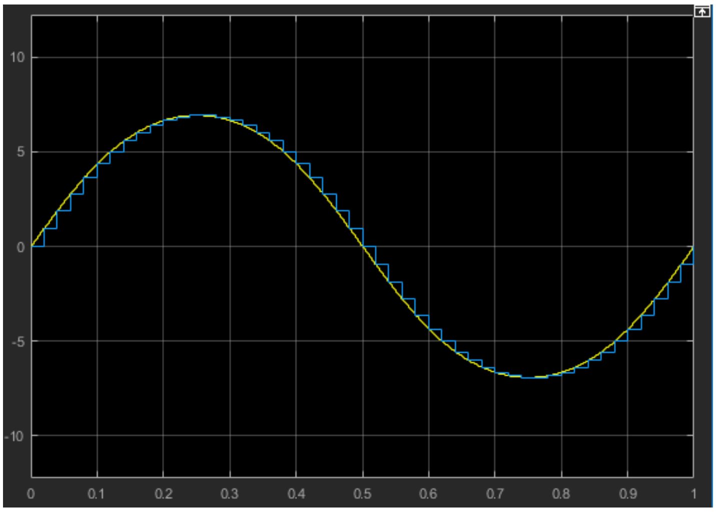
iv) *<u>Slew rate:</u>*
Rate Limiter:
Rising slew rate = 10 V/µs
Falling slew rate = - 10 V/µs



v) <u>ADC:</u>
Quantization level: 0.0007 volts per bit = $3/((2^{12})-1)$

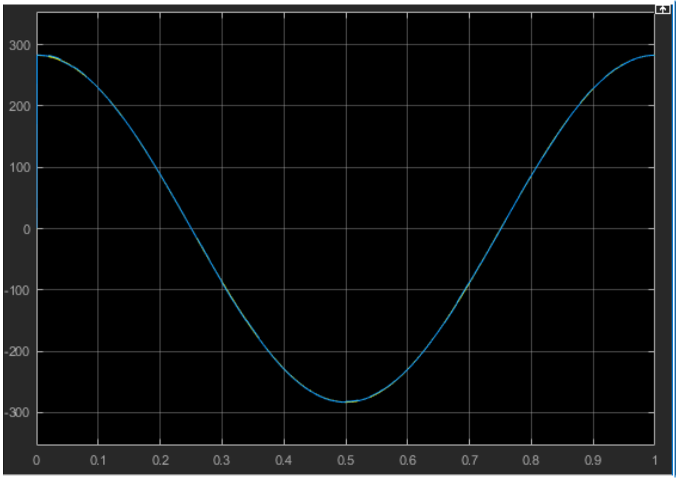


vi) <u>Voltage-acceleration conversion:</u>
Gain: 13.08 $ms^{-2}V^{-1}$ = (4*9.81)/3

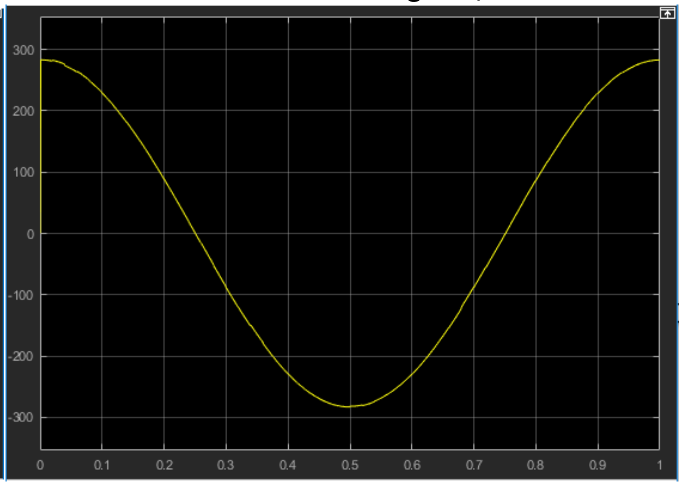


For Gyroscope:

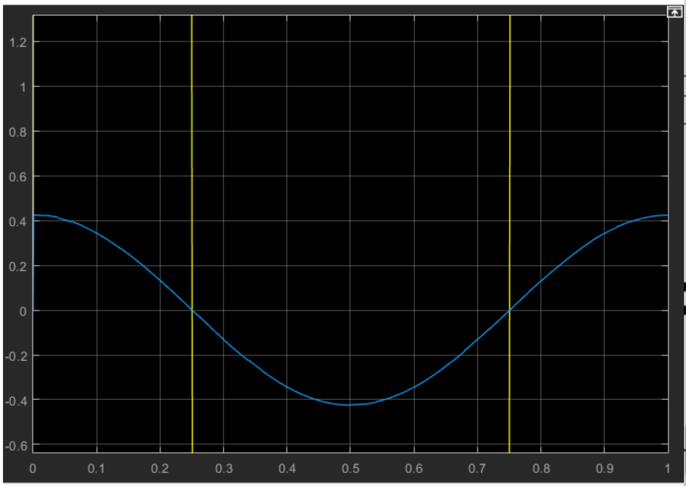
i) Sensor Noise:
Model block: Band-limited white noise power:
0.01 degrees/sec = (0.1*sqrt(50))^2*0.02



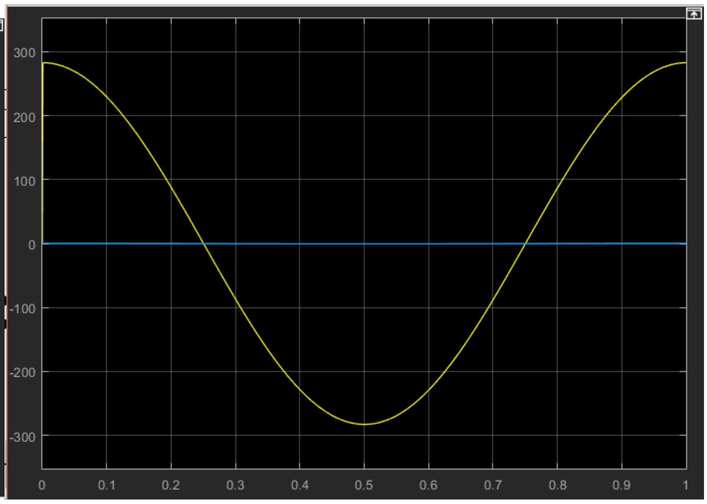
ii) Range:
Model block: Sensor Saturation:
Upper Limit = 2000 degrees/sec
Lower Limit = - 2000 degrees/sec



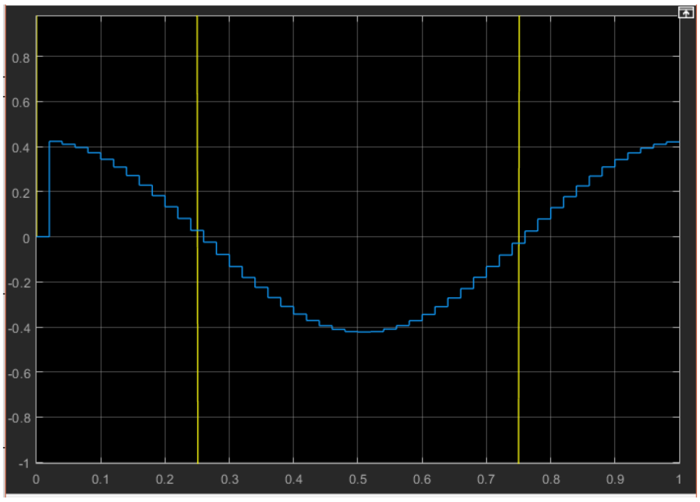
iii) Angular velocity-Voltage conversion:
Gain: 0.0015 Vs/degree = 3/(2000)



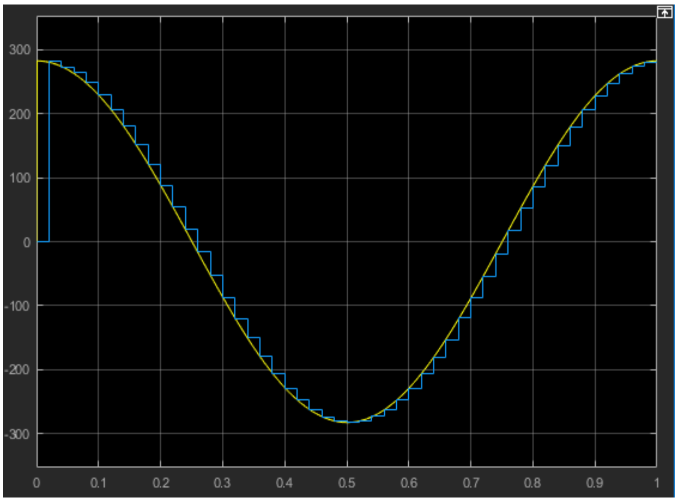
iv) *Slew rate:*
Rate Limiter:
Rising slew rate = 16 V/µs
Falling slew rate = - 16 V/µs



v) <u>ADC:</u>
Quantization level: 45.8E-6 volts per bit = 3/((2^16)-1)



vi) <u>Voltage-angular velocity conversion:</u>
Gain: 666.67 degree/s/V = (2000)/3



2.(c)

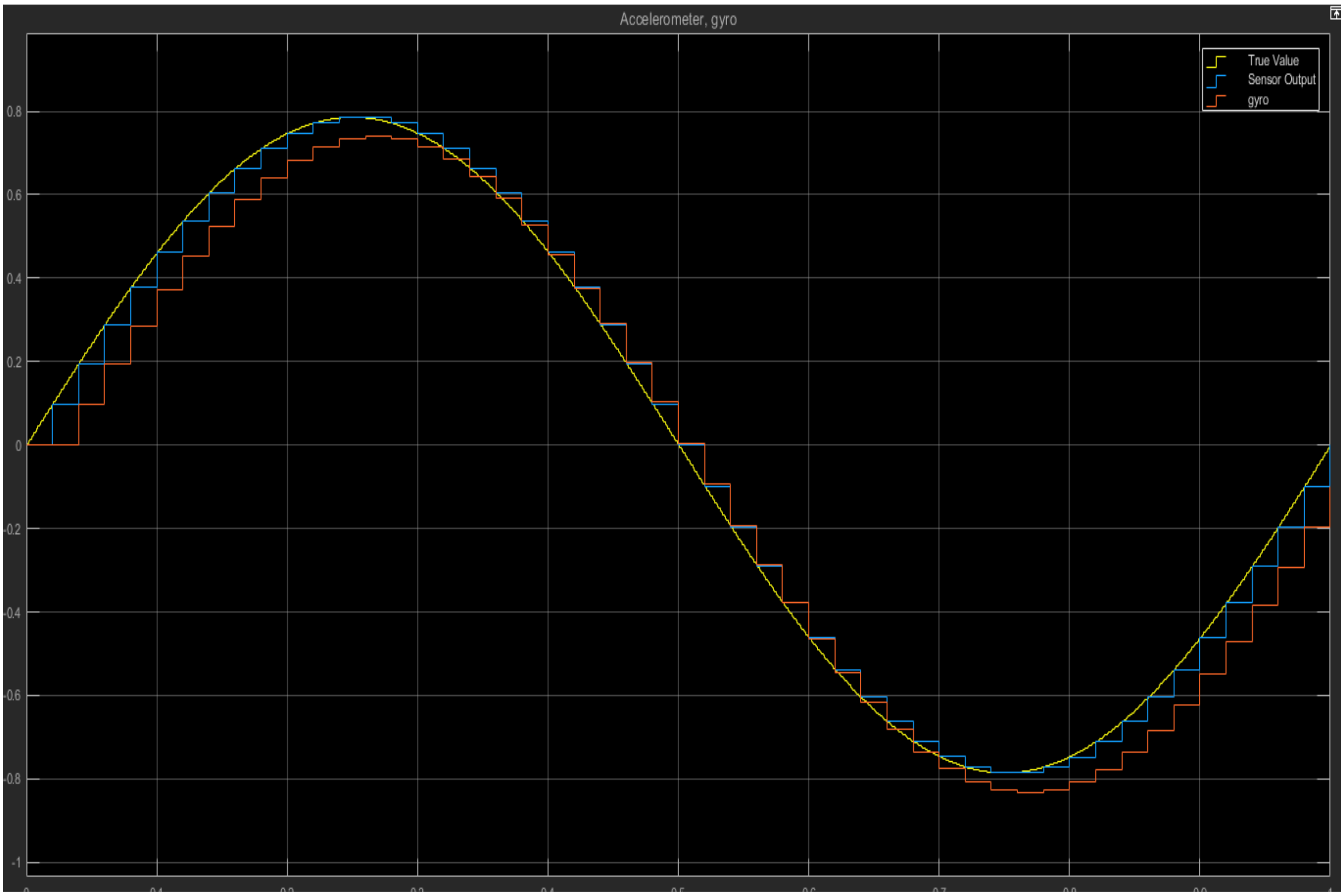
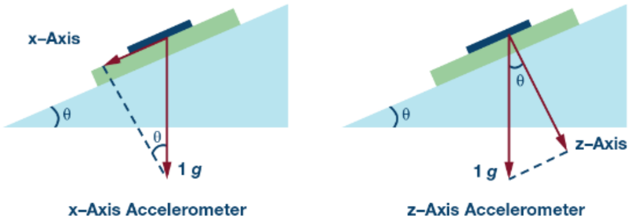


Figure 1 Comparison of output
yellow : input
blue: accelerometer
red: gyro

3)

The specifications in assignment 1 was that this device needs to be capable of measuring any angle in a 360deg range around a single axis with an accuracy of 0.5deg and provide the user with feedback.



For the gyroscope we chose the axis of measurement to be the x axis. Hence ax = gsinθ

For an accuracy of 0.5 deg ➔ 0.0087 rad = 0.87e-2

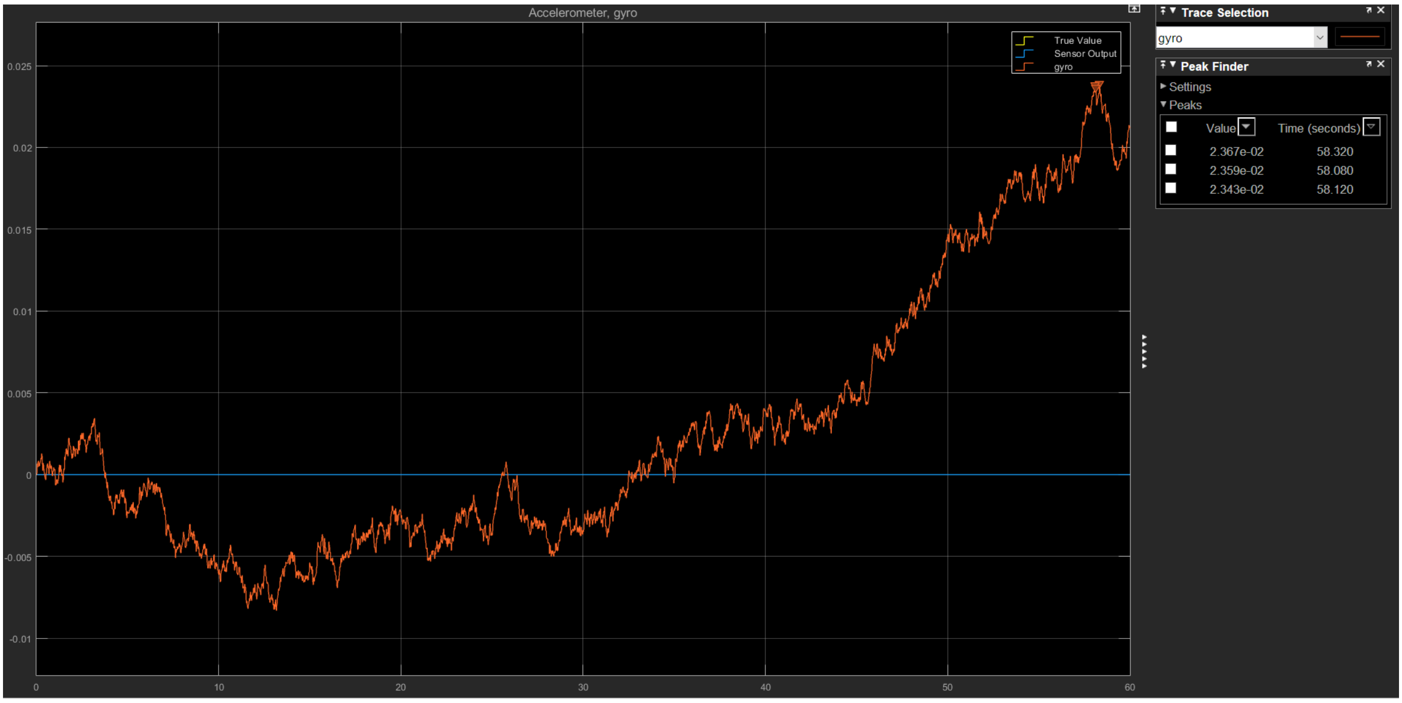


Figure 2 output of sensors when input is held constant
yellow : input
blue: accelerometer
red: gyro

From the above graph it is apparent that the input (yellow) and the accelerometer(blue) are both at the same value (ie 0 rad). Hence blue is masking yellow since they are the same value ➔ there is minimal or zero error in this scenario.

It is apparent that the gyro output (red) is differing from the input by a max error = 2.367e-2 rad

from the specs we have 2.367e-2>0.87e-2 hence the gyro does not pass the specifications.

In conclusion the accelerometer is most accurate, and the gyroscope does not meet the specifications