**Control Systems Laboratory**

**Control Freeks**

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ECE 4115 – Controls Systems Laboratory I

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1 Experimentation

1.

(a, b, & c)

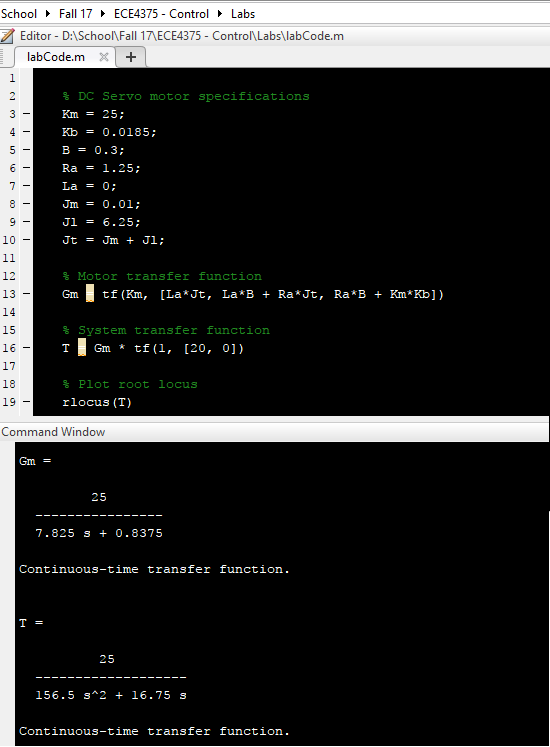


Figure 1 MATLAB calculation of transfer functions

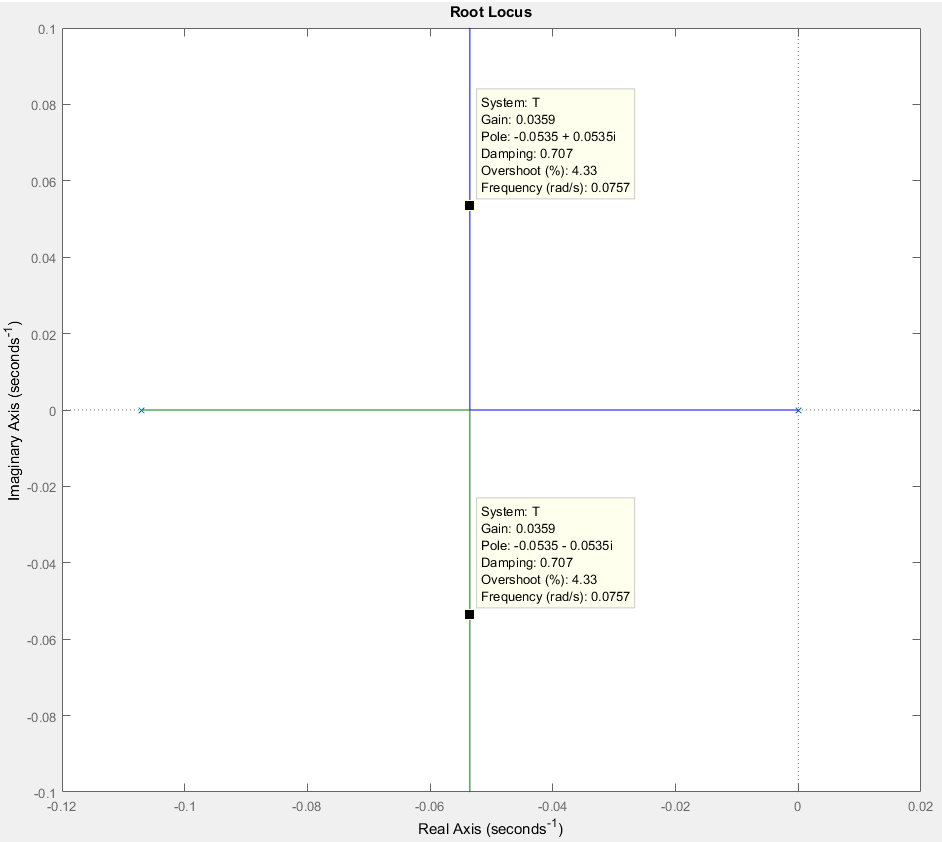


Figure 2 MATLAB Root Locus Plot

(d) KP = 0.0359 as determined from the root locus plot shown in Figure 2.

(e)

For

(f)

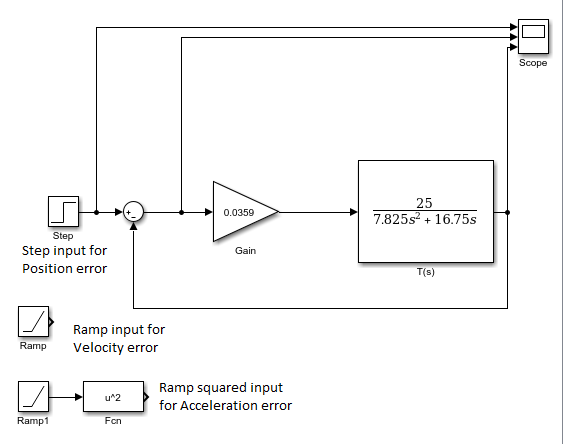


Figure 3 Simulink Block Diagram for plotting static errors

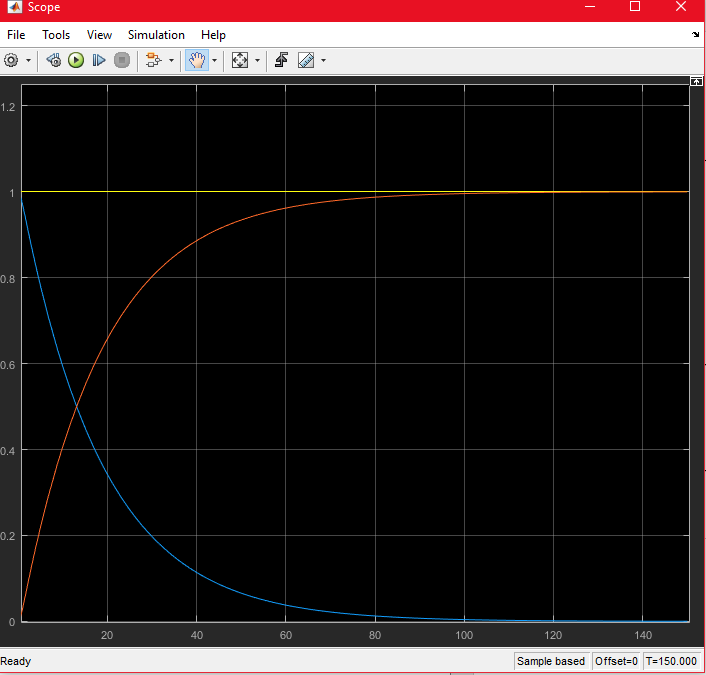


Figure 4 Static Position error. Yellow: Input, Orange: Output, Blue: Error.

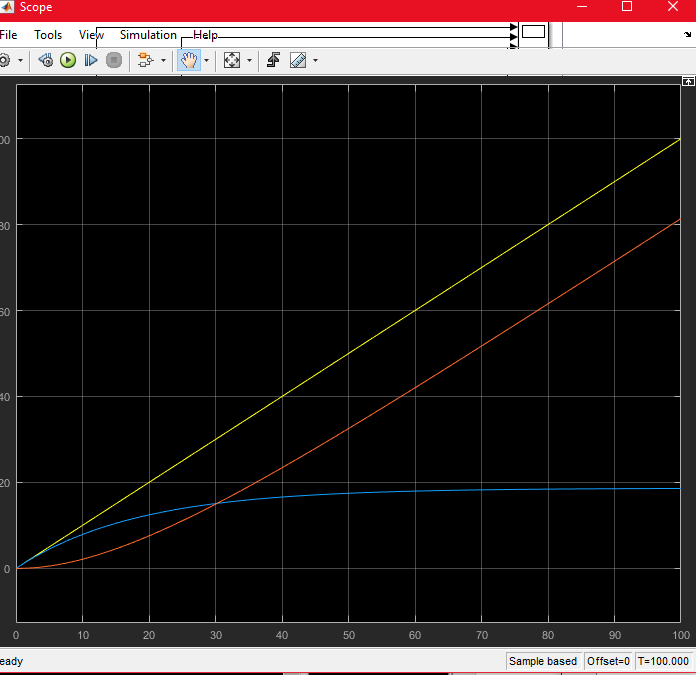


Figure 5 Static Velocity Error. Yellow: Input, Orange: Output, Blue: Error

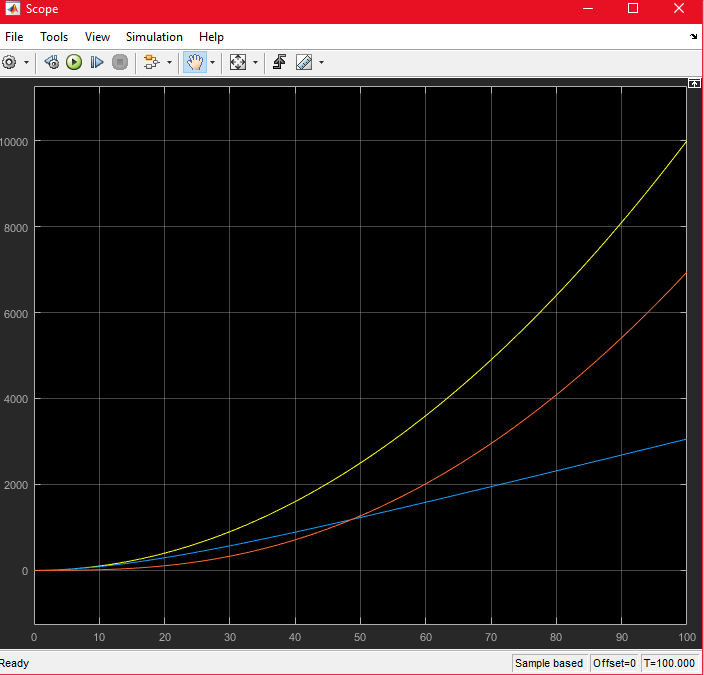


Figure 6 Static Acceleration Error. Yellow: Input, Orange: Output, Blue: Error.

**1.1 Discussion**

These questions are the same as the first three questions in part 3.1 and will be answered there.

**2 Analysis**

1.

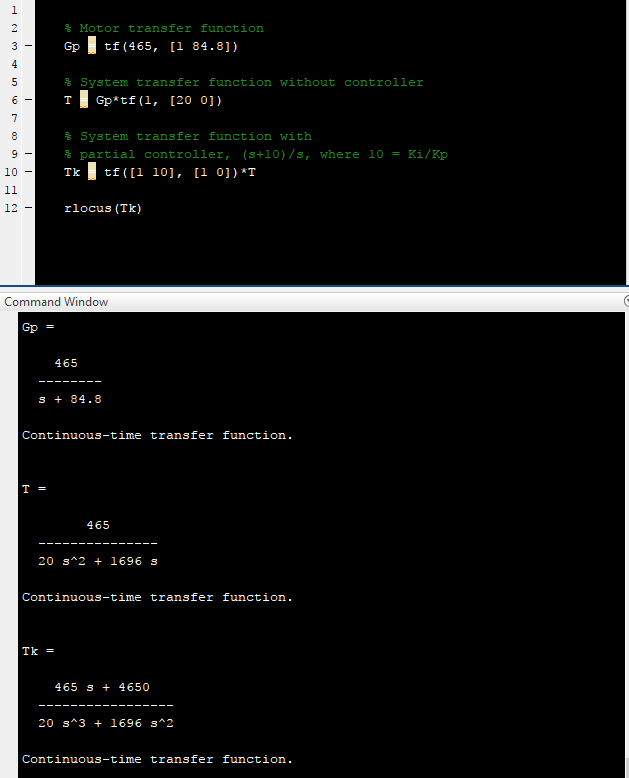


Figure 7 MATLAB code for transfer functions

(a)

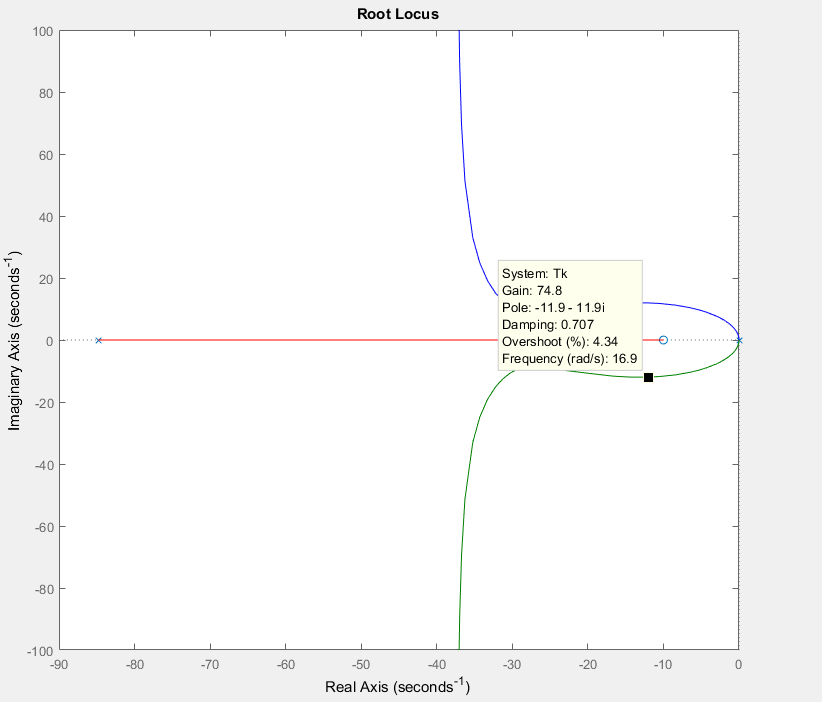


Figure 8 Root Locus Plot for finding gain

was chosen to be 10, resulting in:

(from root locus plot, shown in Figure 8), and

So

(b)

For

For :

So

(c)

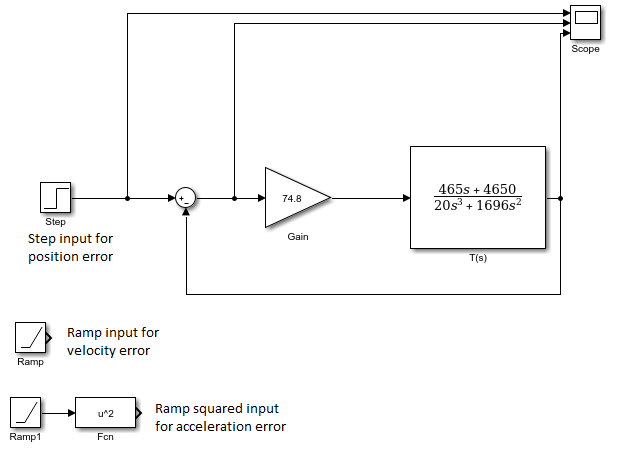


Figure 9 Simulink diagram for static error plots

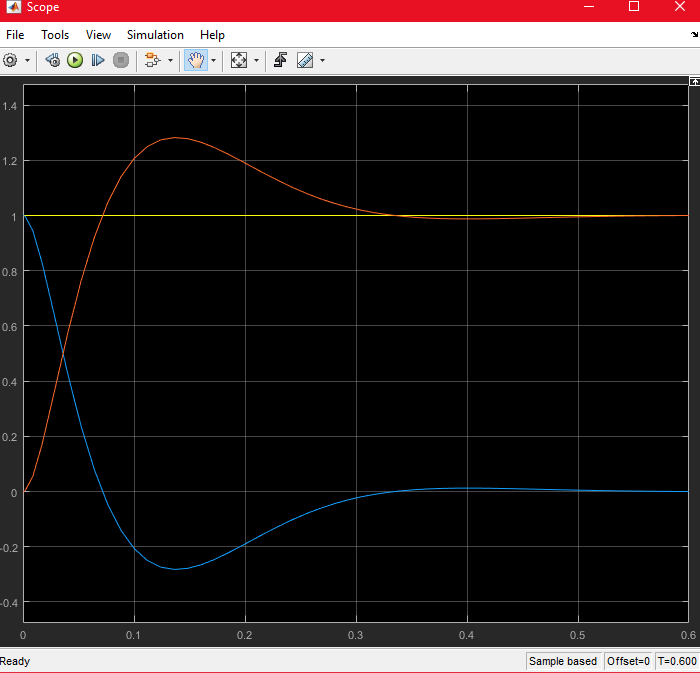


Figure 10 Static Position error. Yellow: Input, Orange: Output, Blue: Error.

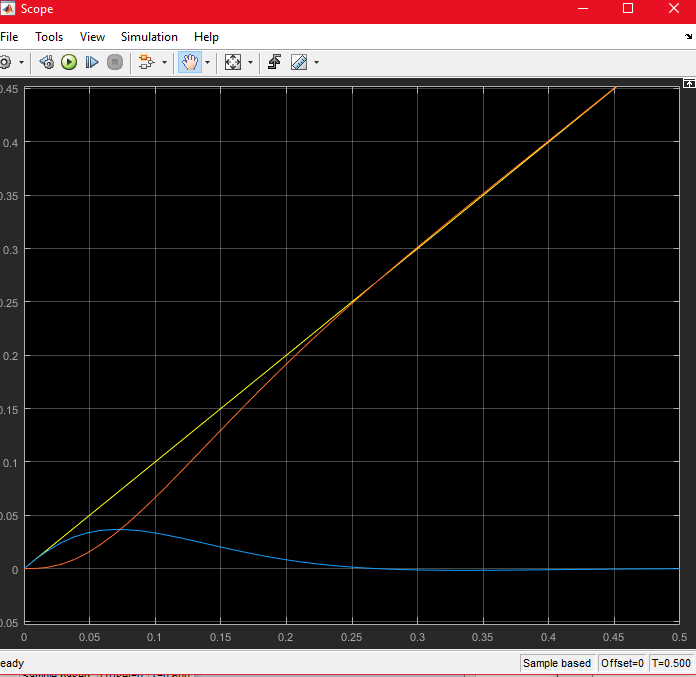


Figure 11 Static Velocity Error. Yellow: Input, Orange: Output, Blue: Error



Figure 12 Static Acceleration Error. Yellow: Input, Orange: Output, Blue: Error.

**3 Design**

1.

(a)

For and :

and

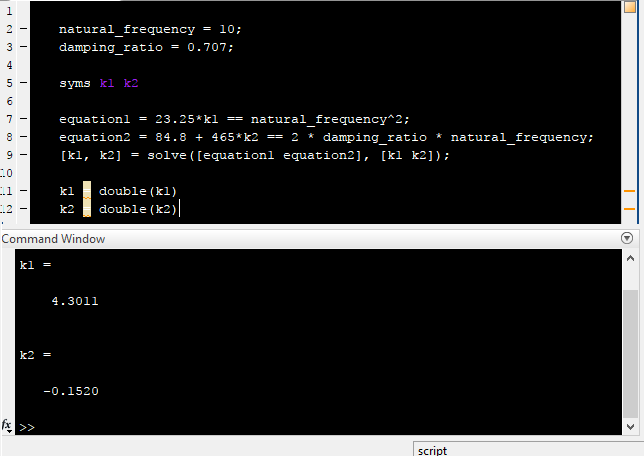


Figure 13 Calculation of K1 and K2

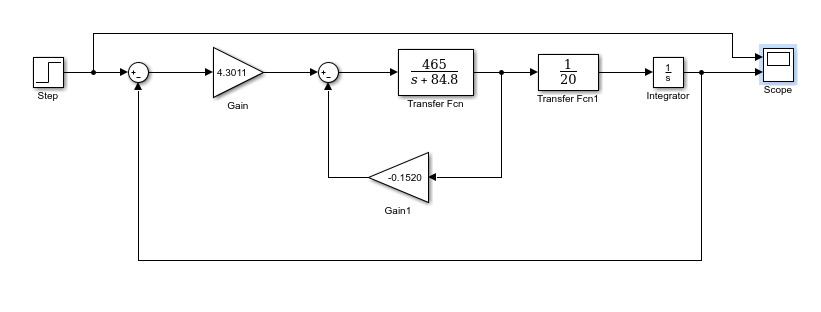
(b)

Figure 14 Simulink setup for finding the desired information

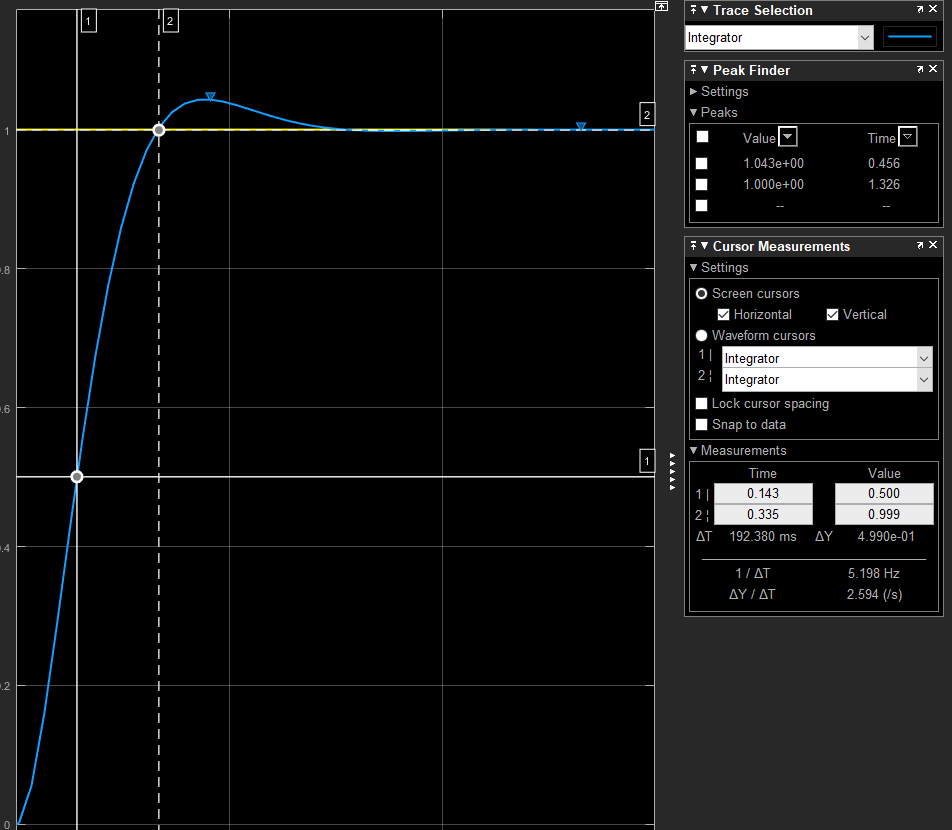


Figure 15 Simulink graph with td, tr, tp, Mp and ωd measurements

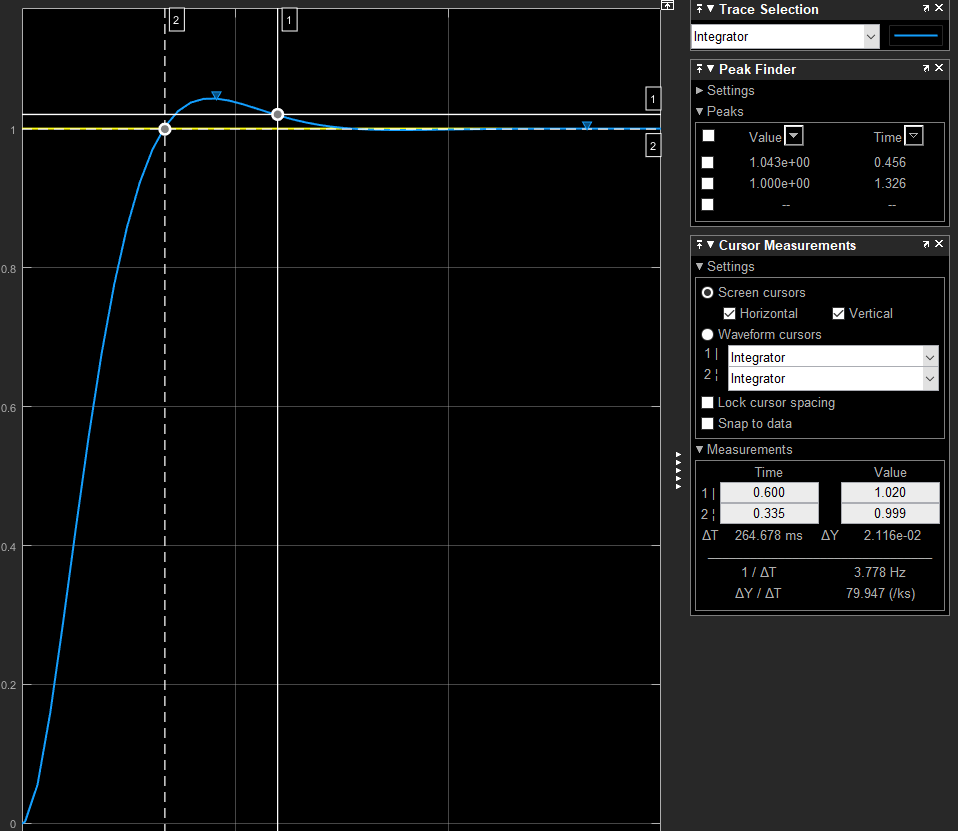


Figure 16 Simulink Graph showing ts measurement

From in Figures 15 & 16:

i. td = 0.143 s

ii. tr = 0.335 s

iii. tp = 0.456 s

iv. ts (2%) = 0.6 s

v. rad/s

vi. Mp% = (1.043-1)×100% = 4.3%

(c)

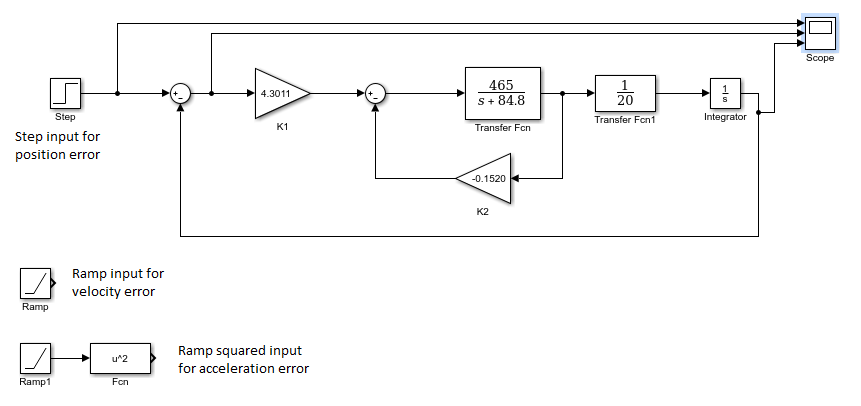


Figure 17 Simulink diagram for static error plots

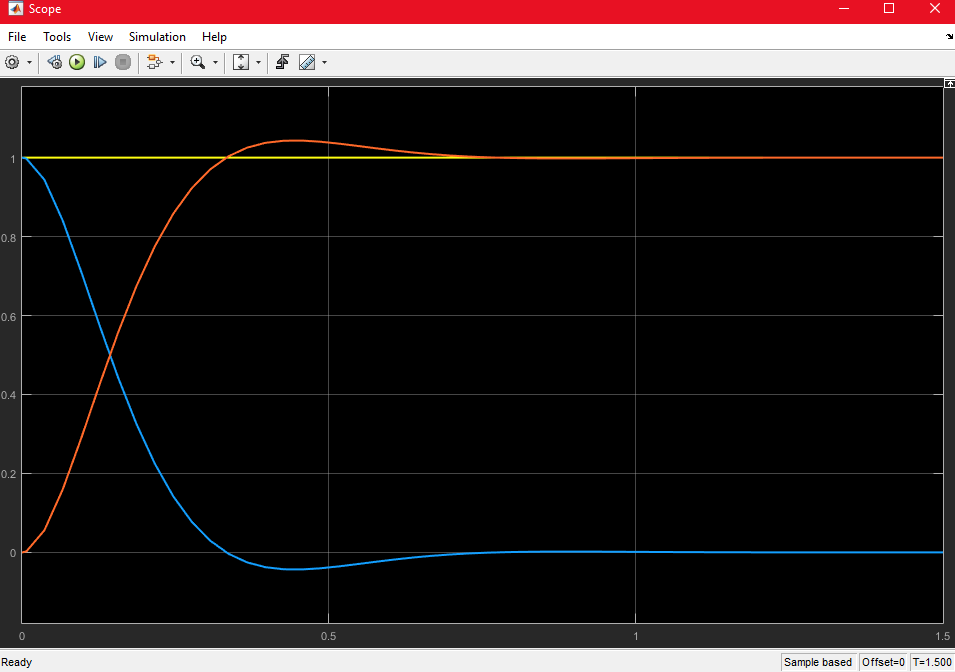


Figure 18 Static Position error. Yellow: Input, Orange: Output, Blue: Error.

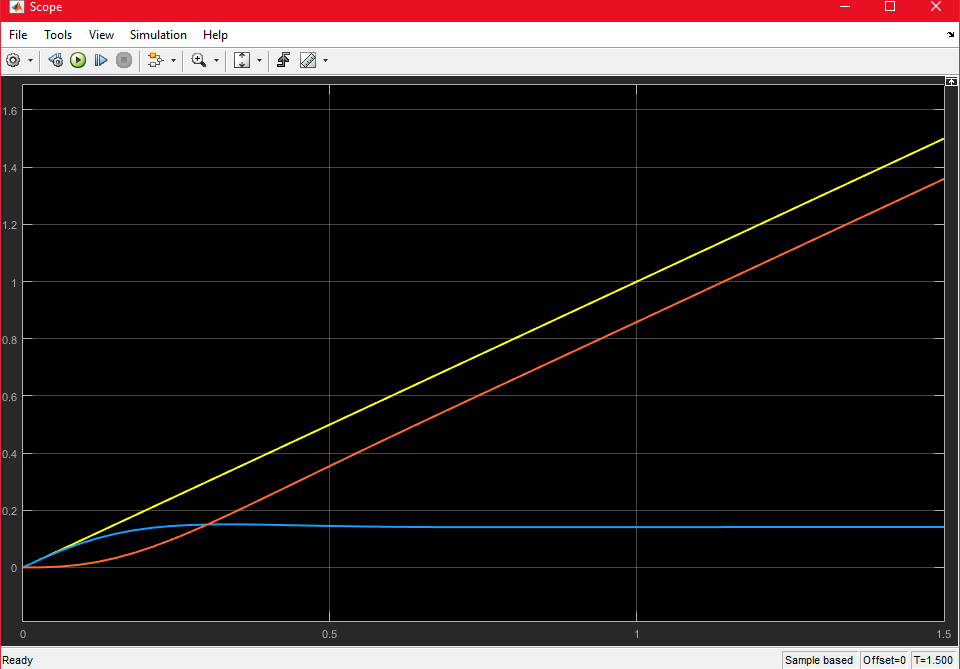


Figure 19 Static Velocity error. Yellow: Input, Orange: Output, Blue: Error.

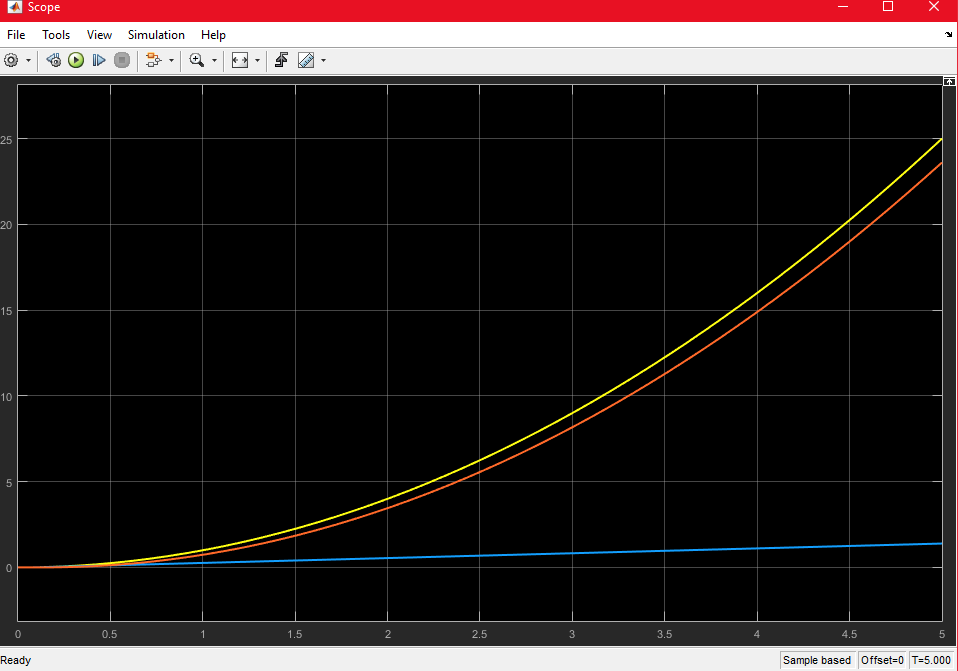


Figure 20 Static Acceleration error. Yellow: Input, Orange: Output, Blue: Error.

**3.1 Discussion**

1. The controller in (1d) has less overshoot and less oscillation than the controller in (1e), so unless you want the system to reach a target value quicker, the controller in (1d) performs better.

2. The gearbox reduces the motor output by a factor of 20

3. The output of the system oscillates at the same frequency as the input, but experiences greater attenuation at higher frequencies.

4.

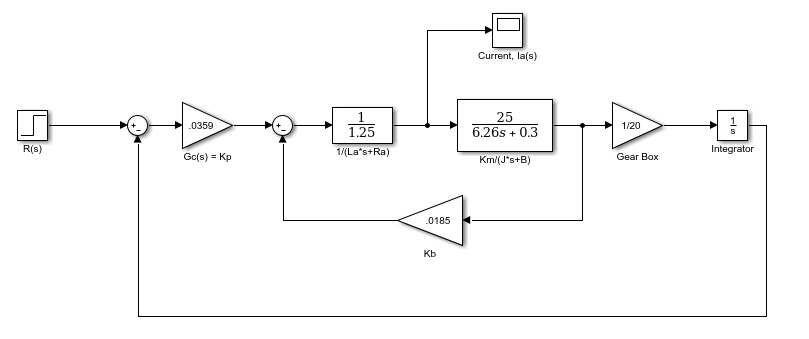


Figure 21 Simulink setup for current measurements

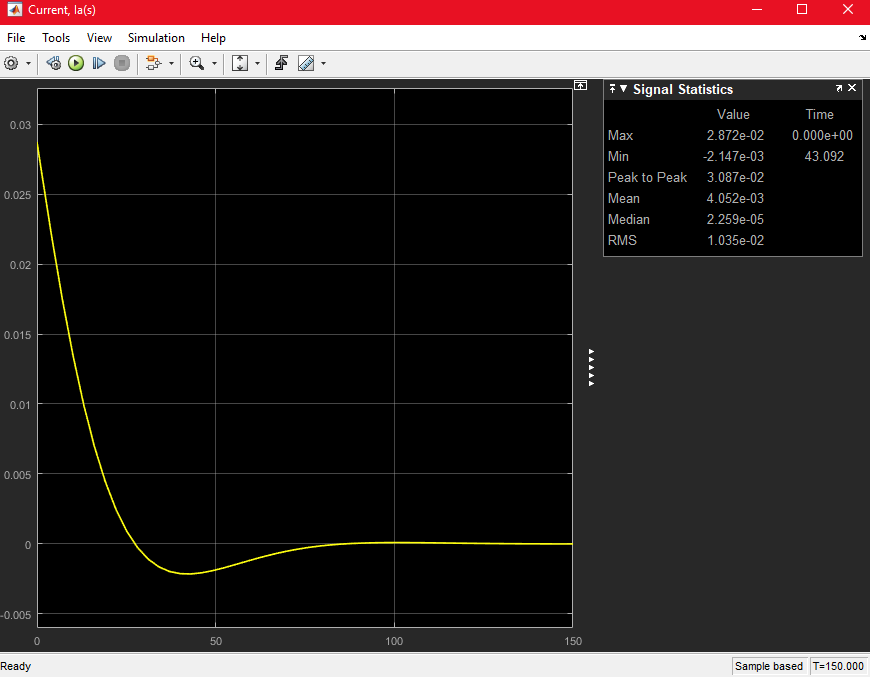


Figure 22 Motor current for the controller in part 1d, Kp=0.0359. Max current is 28.72 mA.

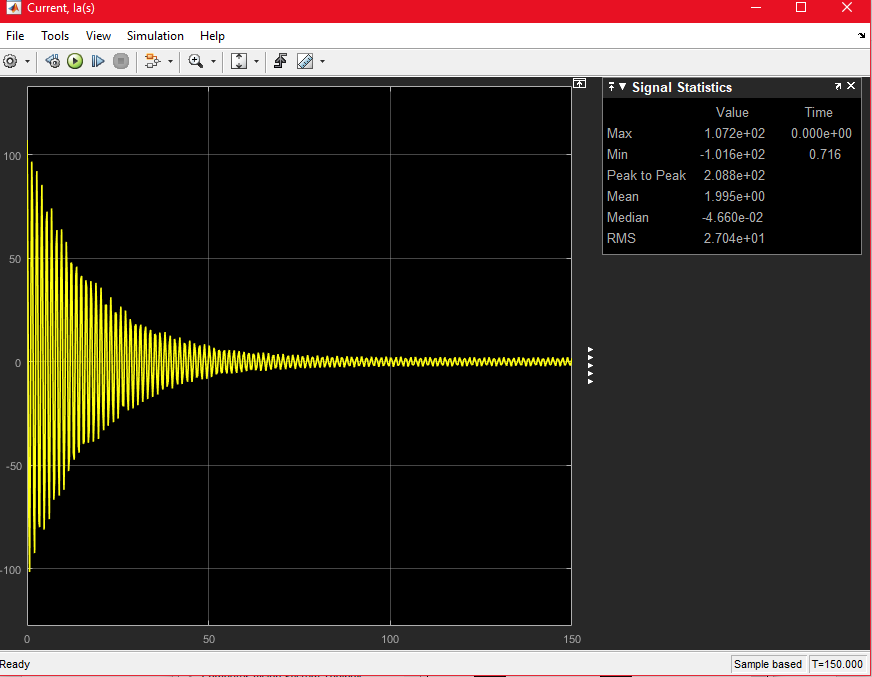


Figure 23 Motor current for the controller in part 1e, Kp=134. Max Current is 107.2 A.

Currents were only measured for part 1 controllers, because not enough information was given about the motor in parts 2 and 3 to be able to plot the currents.