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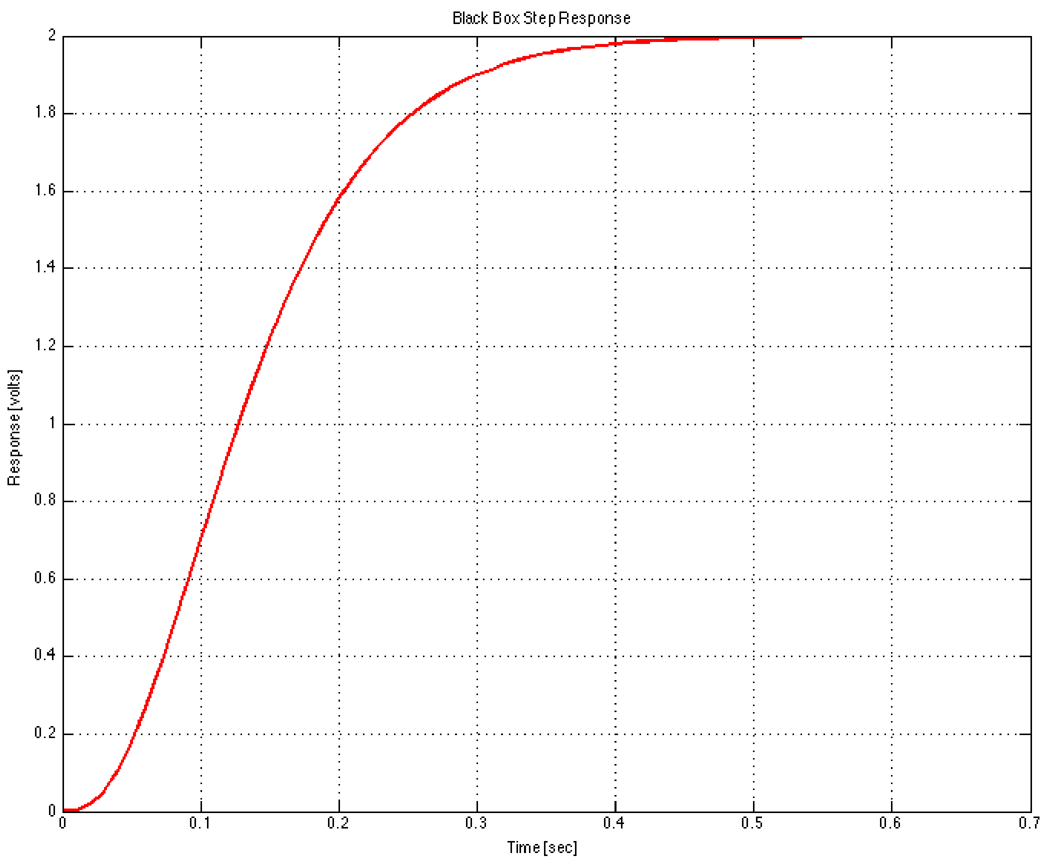
ESE 505 Homework 3

1 Step Response

Below is a picture of the step response for the transfer function described in the homework

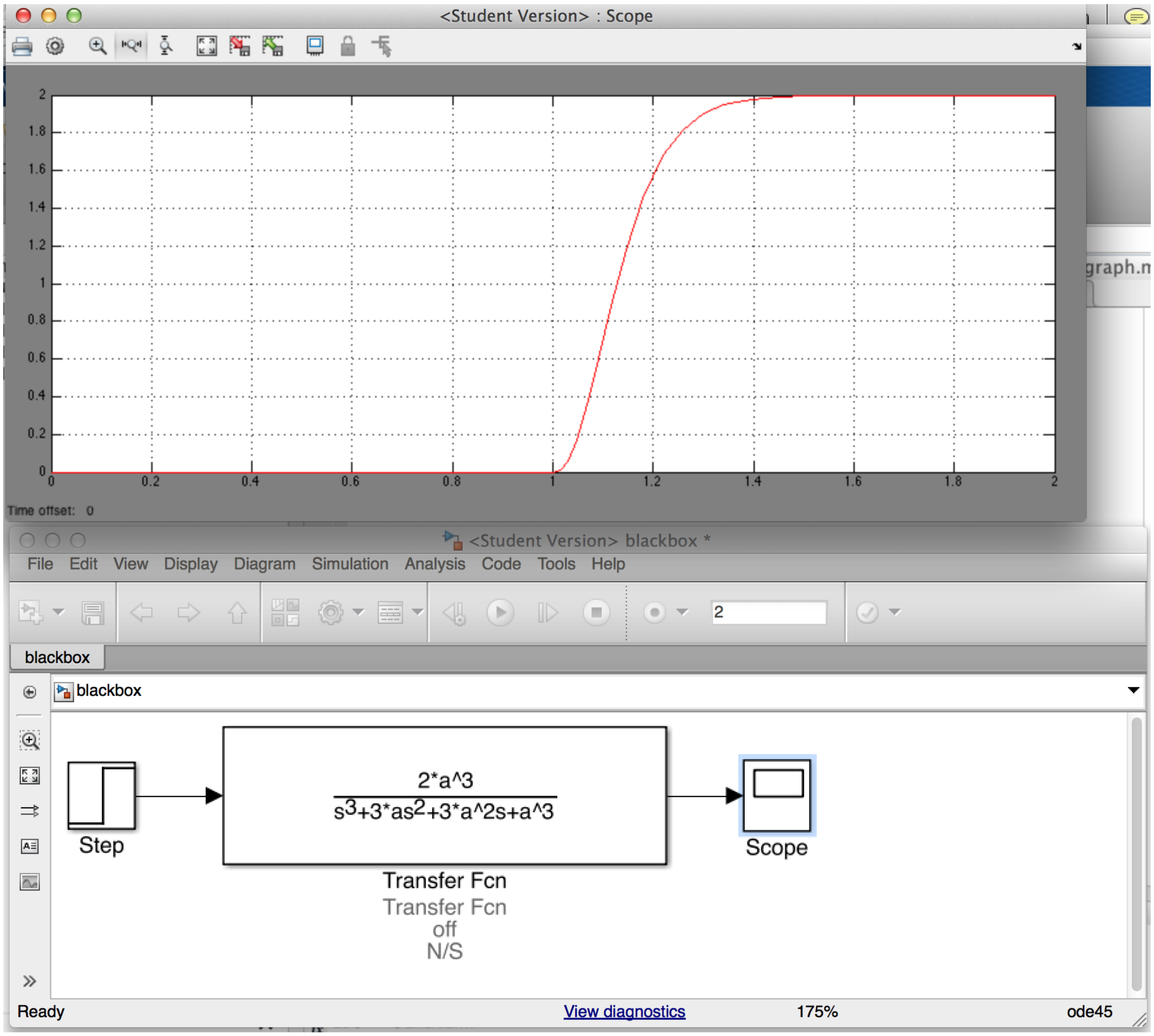
$$\frac{2a^3}{s^3 + 3as^2 + 3a^2 s + a^3}$$

Figure 1: Step response



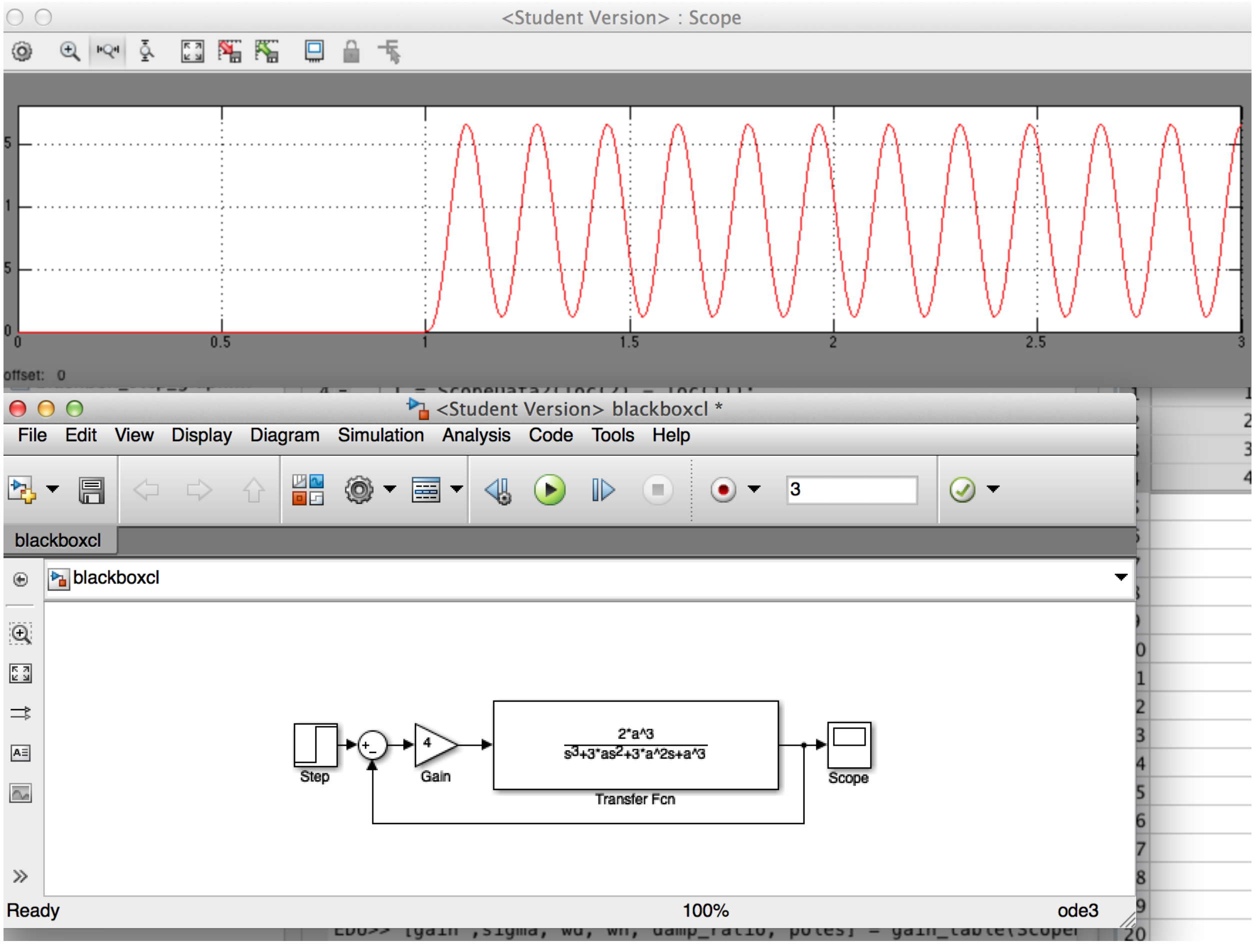
generated using Matlab built in transfer funcition

Figure 2: Simulink step response



Generated using Simulink model

Figure 3: Simulink Proportional Gain (K =4)

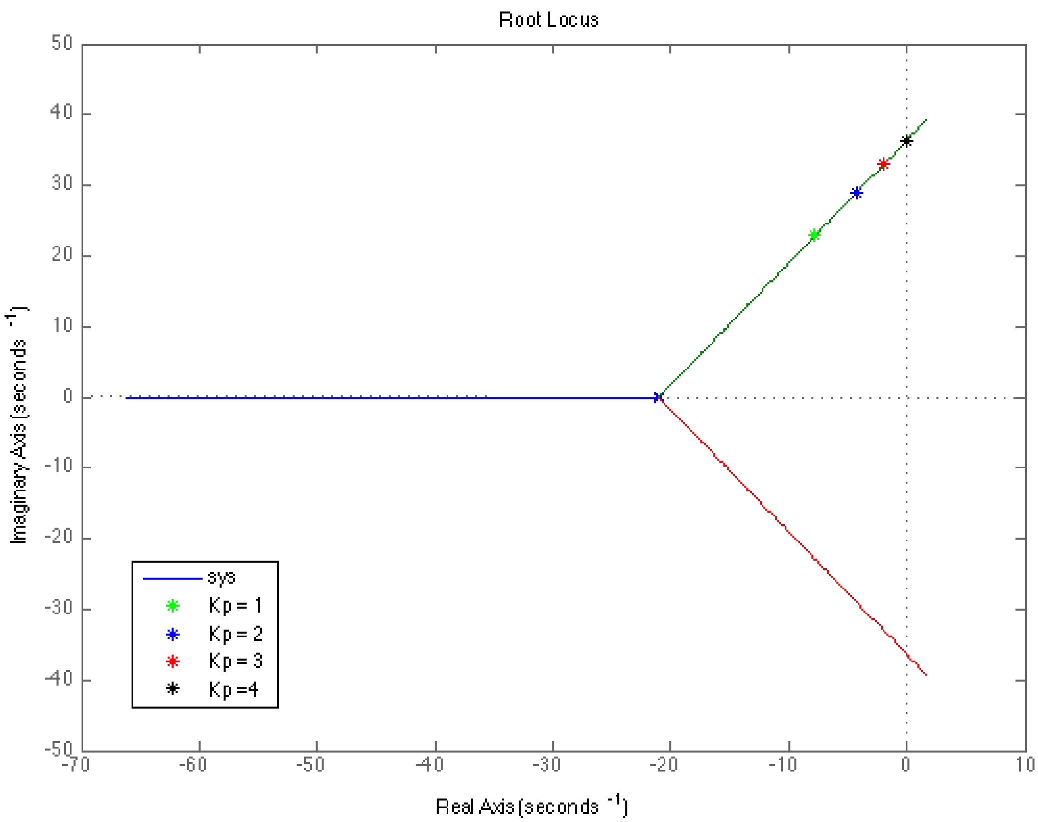


Generated using Simulink model

2 Root Locus and Poles

K	σ	ω_d	ω_n	ζ
1	-7.7756	22.9313	24.2138	0.3211
2	-4.324	28.822	29.1446	0.14838
3	-1.9209	33.069	33.1251	0.05799
4	0.0010	36.319	36.319	-2.788021e-05

Figure 4: Root Locus for Transfer Function

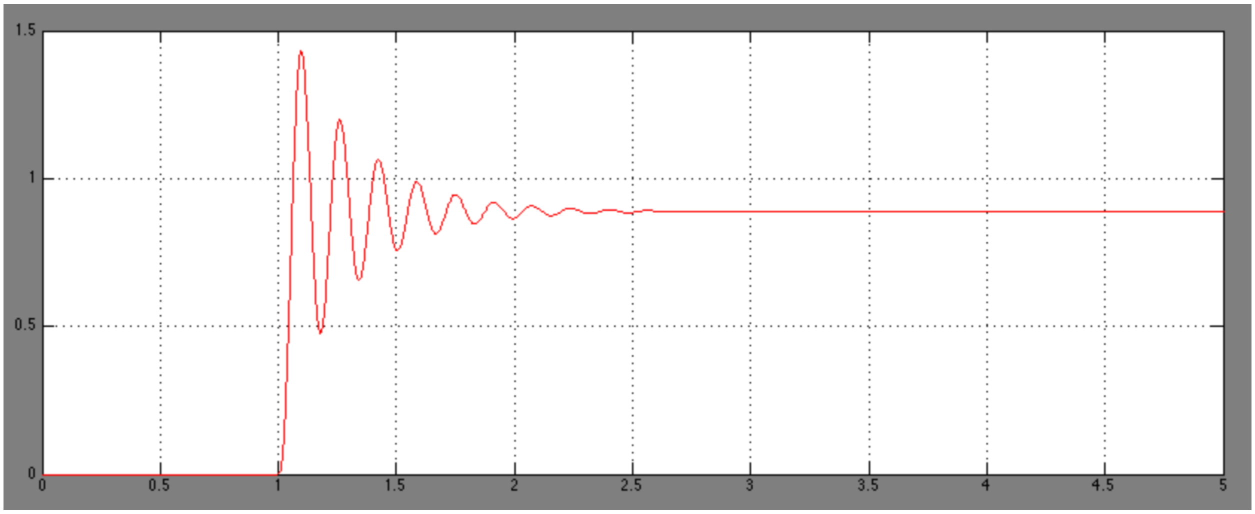


Using different Gains to see effect on pole position

3 Closed loop control with Derivative Gain

Kd = .0257 To obtain this I used the damping ratio from my table as as well as my natural frequency to find kd. I found Kd using sgrid and rlocfind. S grid to locate the point on the root locust curve that corresponded to damping my proportional gains. I noticed that it is slightly off from the recommended gain of .0257, I think this is due to some errors I might have in finding my damping ratio.

Figure 5: Simulink Proportional Gain (K =4) and Derivative Gain (Kd = .0257)



Generated using Simulink model

4 Adding an Integral Term

Initial damp ratio = .0904 withK_I set to 0. For this part of the assignment I used the form

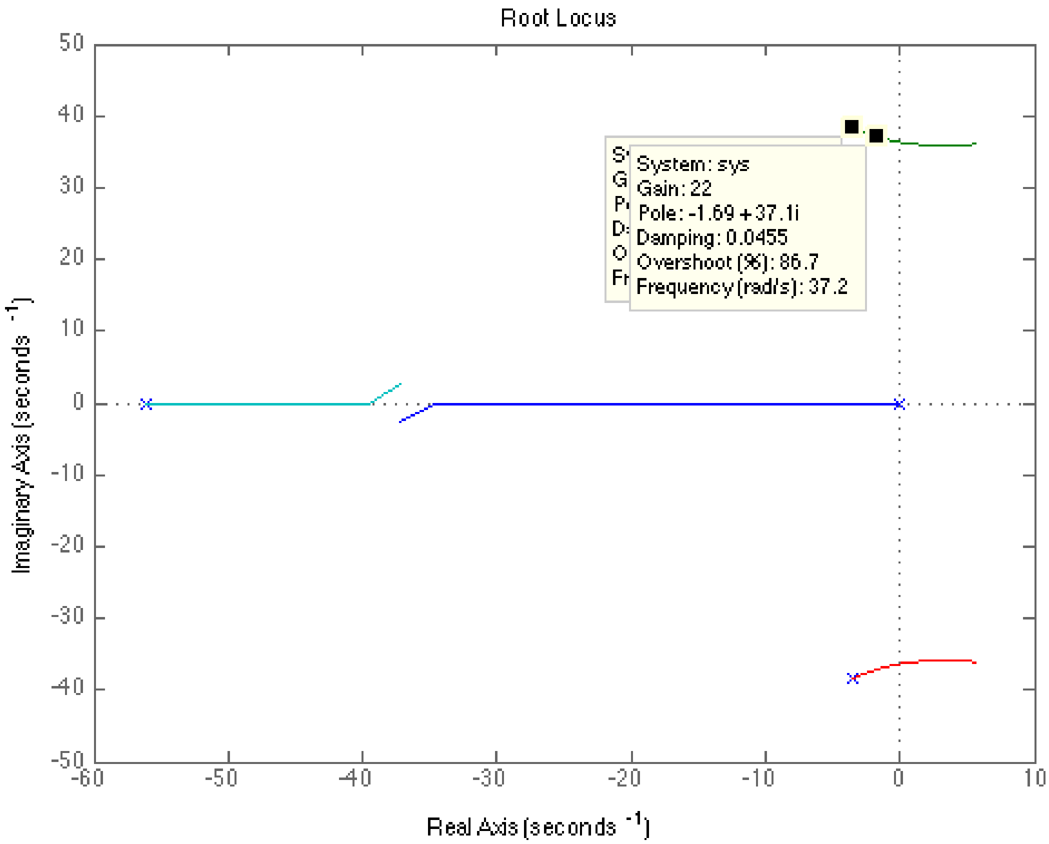
$$D_p + K_p N(s) + sK_d N(s) + \frac{1}{s} K_I N(S) = 0$$

Where

$$A(s) = D_P + s^2 K_d N(s) + sK_p N(s)$$
$$B(s) = N(s)$$

After generating a range of K_I values I go this root locus graph

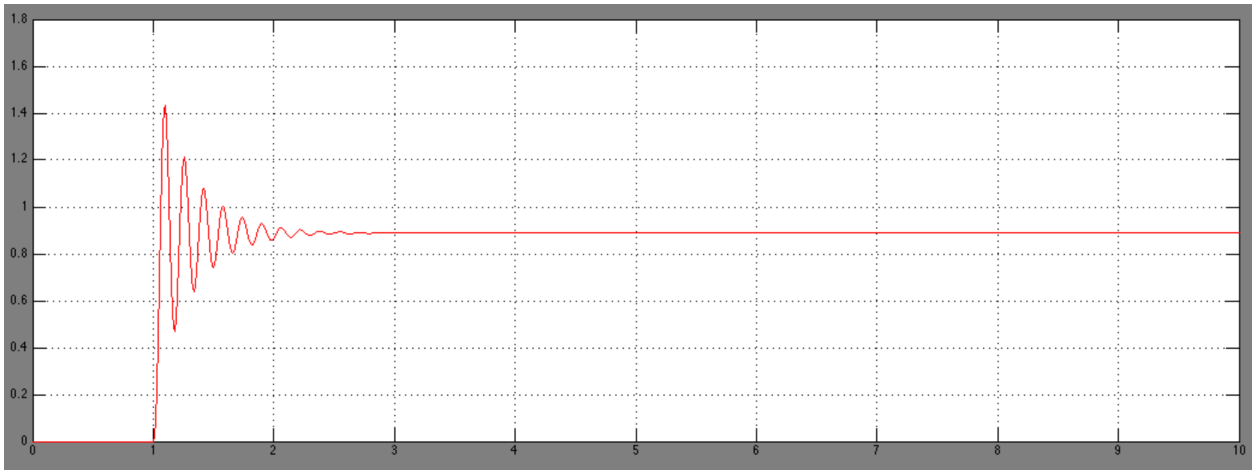
Figure 6: PID transfer function



Generated using Transfer function

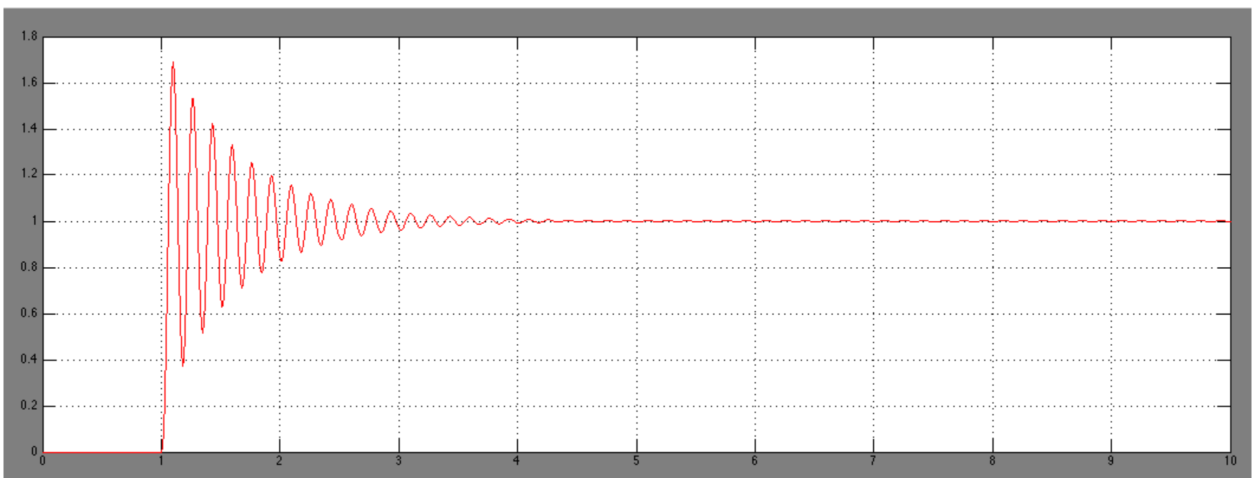
I was able to extract a K_I of 22 and a damping constant of .0455

Figure 7: step response with $K_I = 0$



Generated using Simulink

Figure 8: step response with K_I of 22

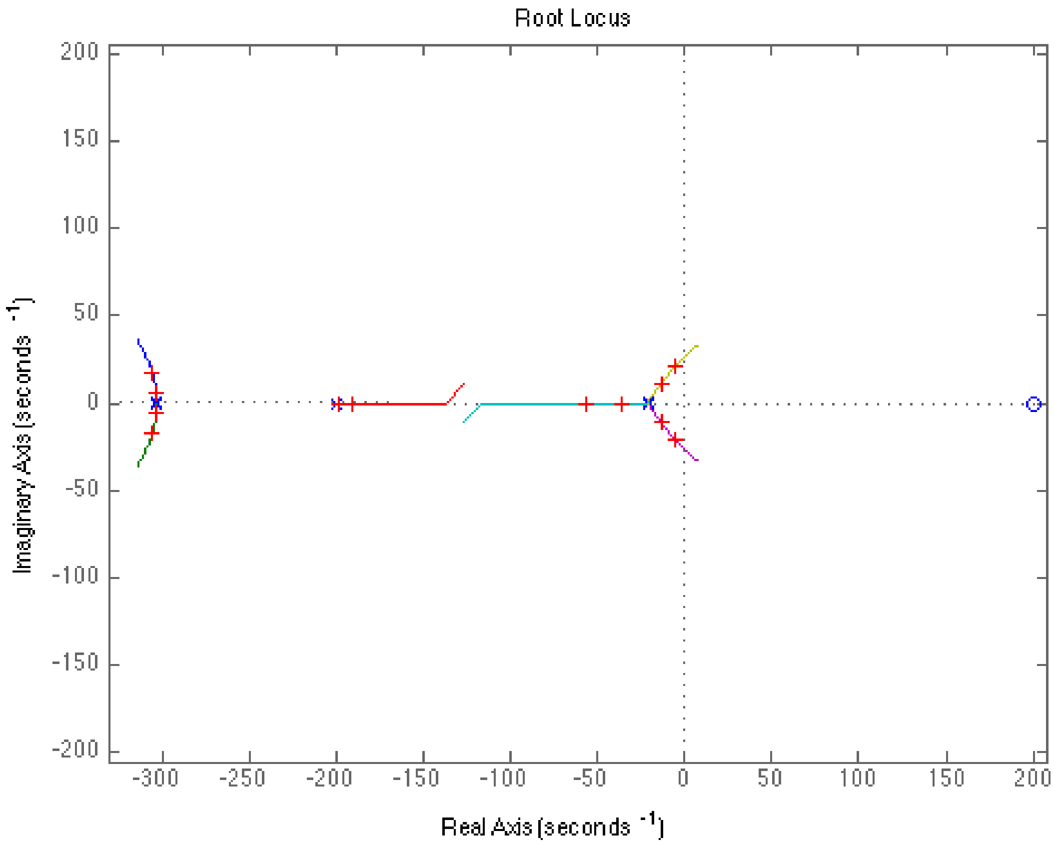


Generated using Simulink

5 Neutral Stablilty using Simulink

I started this section by modelling in Simulink the black box system with the time delay. I added the transfer equation and formed a root locus graph. I noticed that it seemd that any value that I chose that stayed to the left of the real axis and was on the plot would result in a stable system for this function.

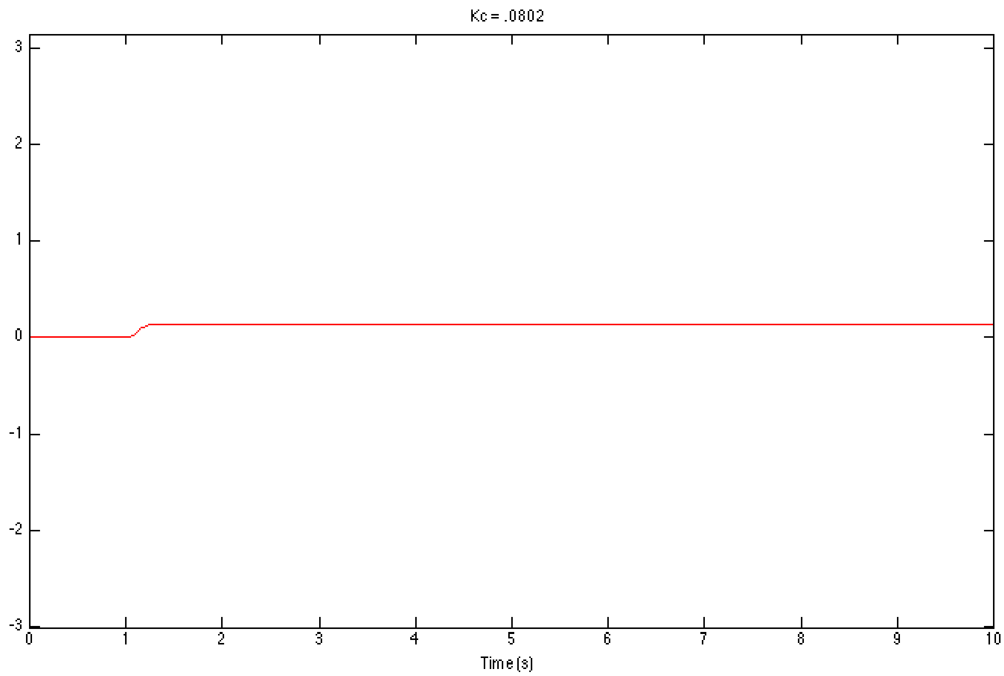
Figure 9: Time delayed function



Generated using Transfer functionl

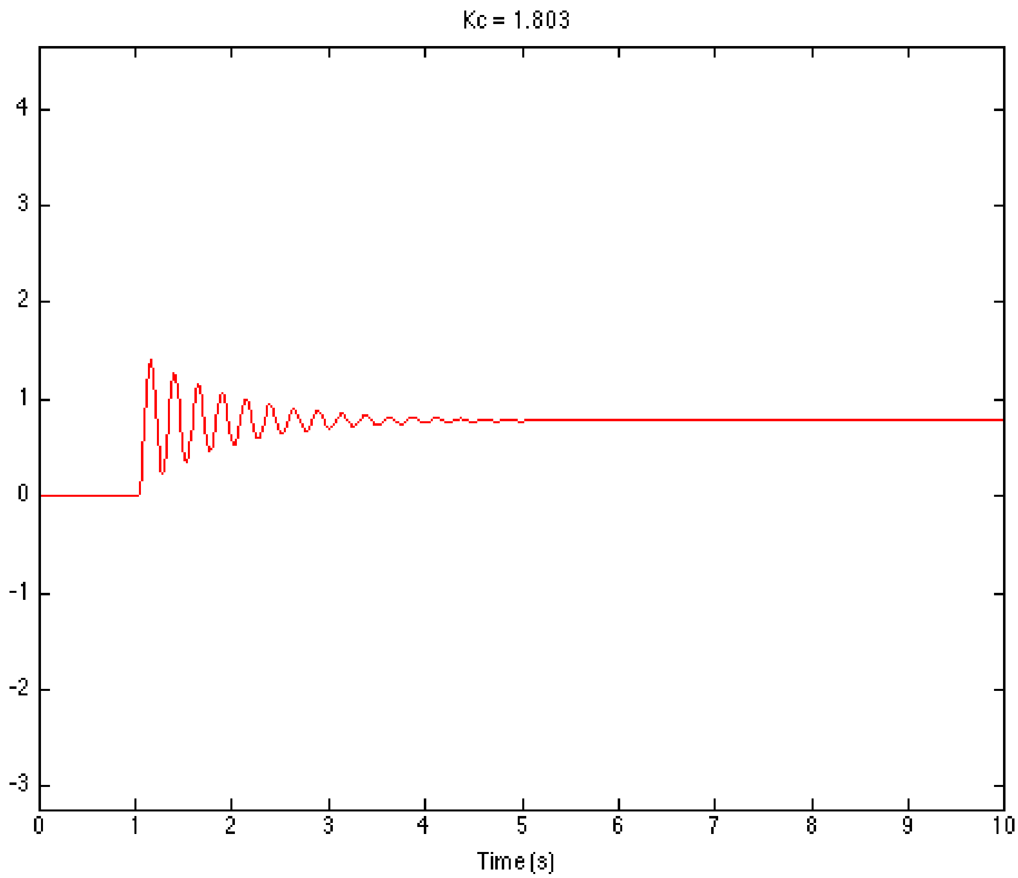
I noticed the signal was stable at lower values for K, but as long as it was left of the real axis and on the plot I was able to produce a stable graph for K values from .0802 up until 2

Figure 10: Time delayed function with K = .0802



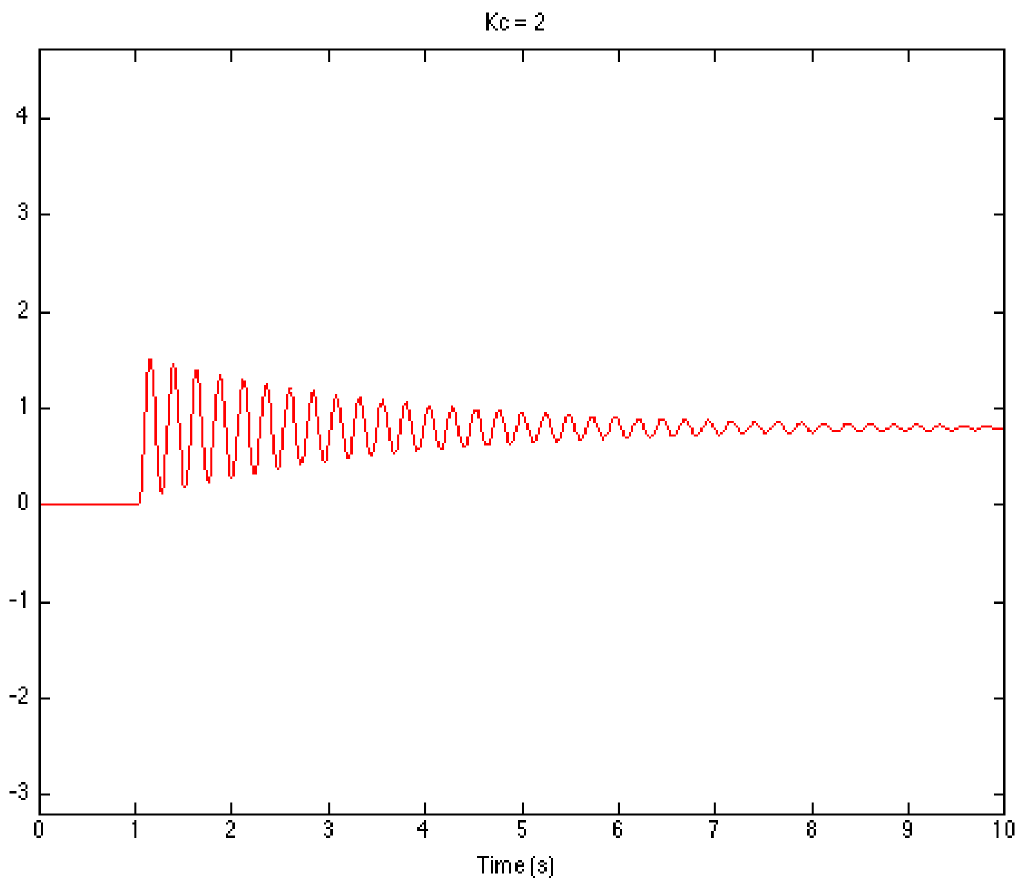
Generated using Transfer functionl

Figure 11: Time delayed function with K = 1.803



Generated using Transfer functionl

Figure 12: Time delayed function with K = 2



Generated using Transfer functionl