LAB #5 report. MAE 106. UCI. Winter 2005

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1 Answer 1.

a) $\tau = K_p(\theta_d - \theta) + K_d\left(\dot{\theta}_d - \dot{\theta}\right)$

The output is θ and the input is θ_d

But $\tau = J\ddot{\theta}$

Take Laplace transform we get

$$\begin{aligned} Js^2\theta(s) &= K_p\theta_d(s) - K_p\theta(s) + K_d(s\theta_d(s) - s\theta(s)) \\ Js^2\theta(s) + K_p\theta(s) + K_d s\theta(s) &= K_p\theta_d(s) + K_d s\theta_d(s) \\ \theta(s)\left[Js^2 + sK_d + K_p\ \right] &= \theta_d(s)\left[K_p + K_d s\right] \end{aligned}$$

Hence the transfer function

$$G(s) = \frac{\theta(s)}{\theta_d(s)} = \frac{K_p + K_d s}{Js^2 + sK_d + K_p}$$

Compare this transfer function with

$$G_1(s) = \frac{\theta(s)}{\theta_d(s)} = \frac{K_p}{Js^2 + sK_d + K_p}$$

the one we used in the Lab. We see that new $G(s)$ has a zero at $s = -\frac{K_p}{K_d}$ while $G_1(s)$ has no zero. This controller will perform better as it tracks speed error as well as position error. This will make it more sensitive to changes.

2 Answer 2.

For p1, we are asked to plot the predicted response of $G(s) = \frac{K_p}{Js^2 + K_d s + K_p}$ for a step input for $\zeta = 0.1, 1, 2$

Write the equation in standard form, we get $G(s) = \frac{\frac{K_p}{J}}{s^2 + \frac{K_d}{J}s + \frac{K_p}{J}} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n\ s + \omega_n^2}$

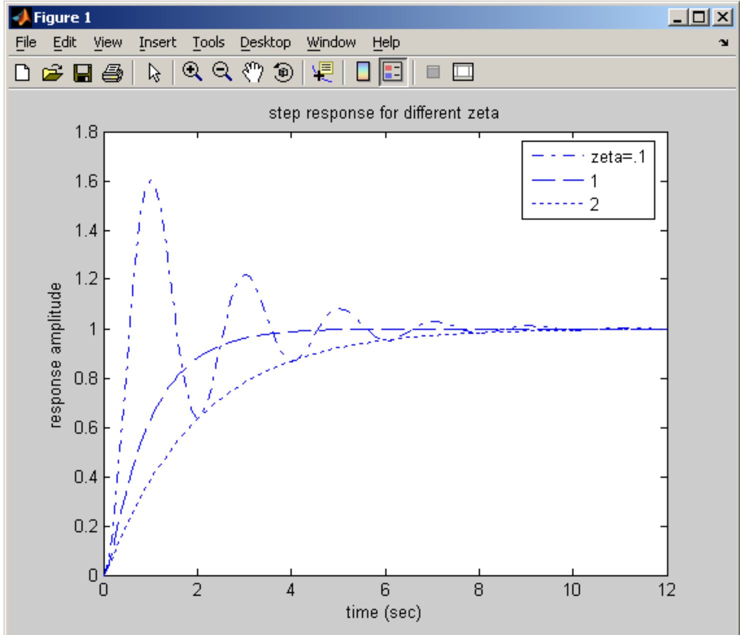
Hence $\omega_n = \sqrt{\frac{K_p}{J}}$ and $\xi = \frac{K_d}{2\sqrt{JK_p}}$

Where $K_p = \frac{R_2}{R_1} = \frac{10k}{1k} = 10$ and $K_d = R_2 C = 10 \times 10^3 \times 1 \times 10^{-3} = 10$

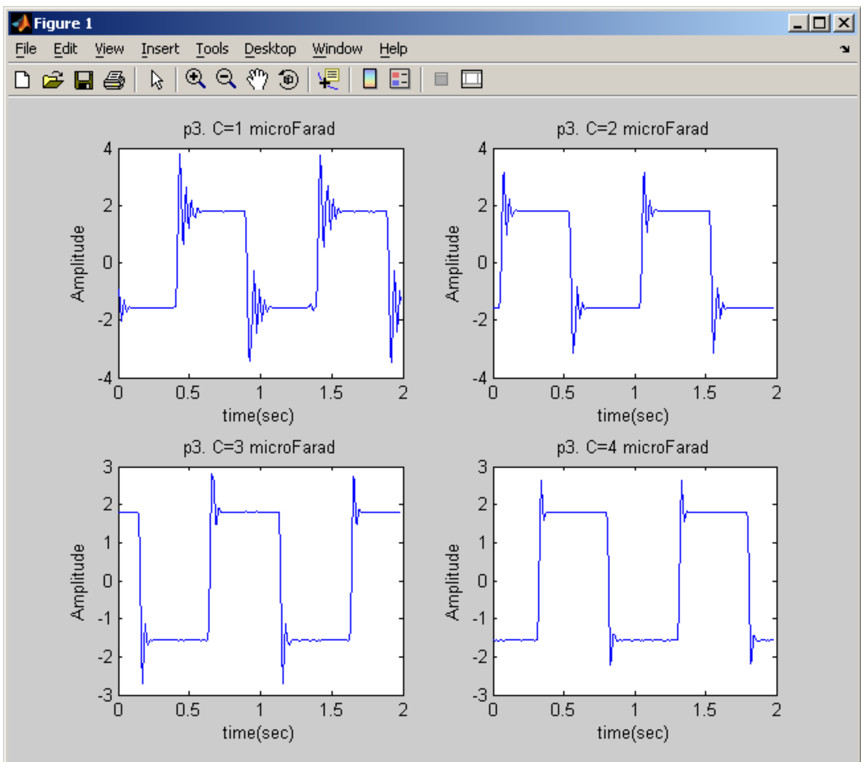
I will use $J = 1$ hence the transfer function becomes

$$G(s) = \frac{10}{s^2 + 20\ \xi\ s + 10}$$

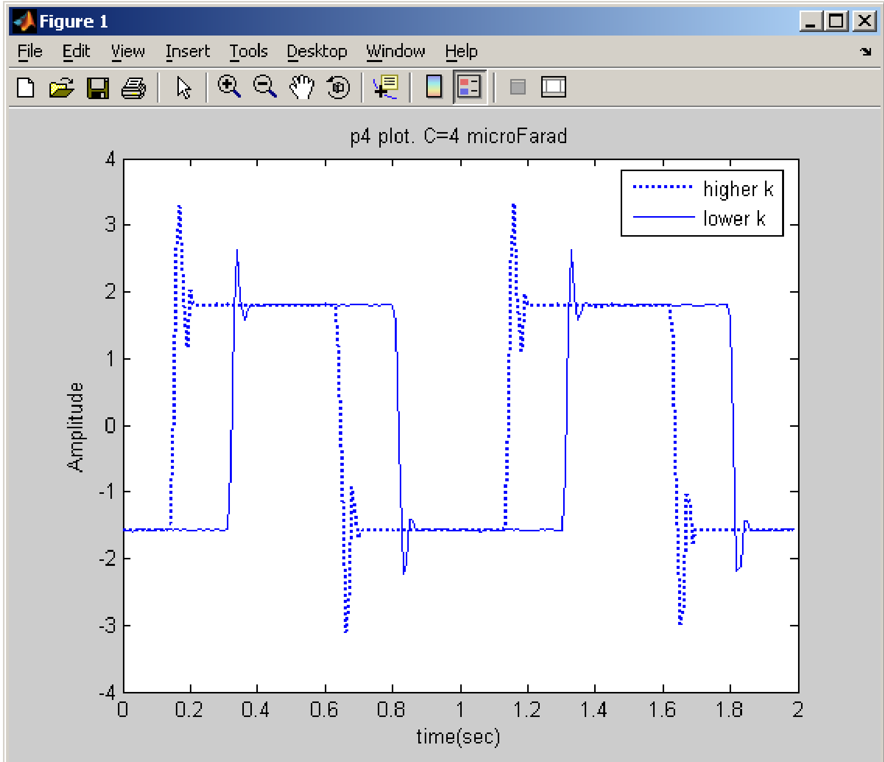
The following are the plots generated by a small program



For p3, we are asked to show plots for step input response for $C = 1, 2, 3, 4\mu F$ These are plots:



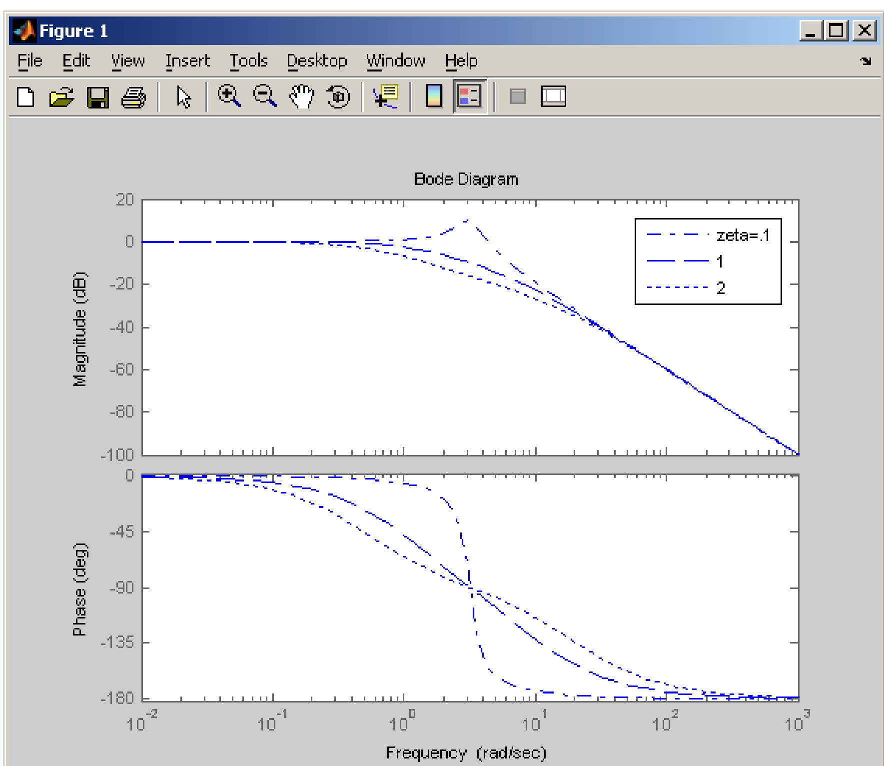
for p4, we are asked to plot the step response with higher k on top of the step response using original gain. this is the result



We see that with higher k, then the system responded more quickly.

3 Answer 3

Here we are asked to plot the frequency response for the predicted response. p2:



This is the result for p5

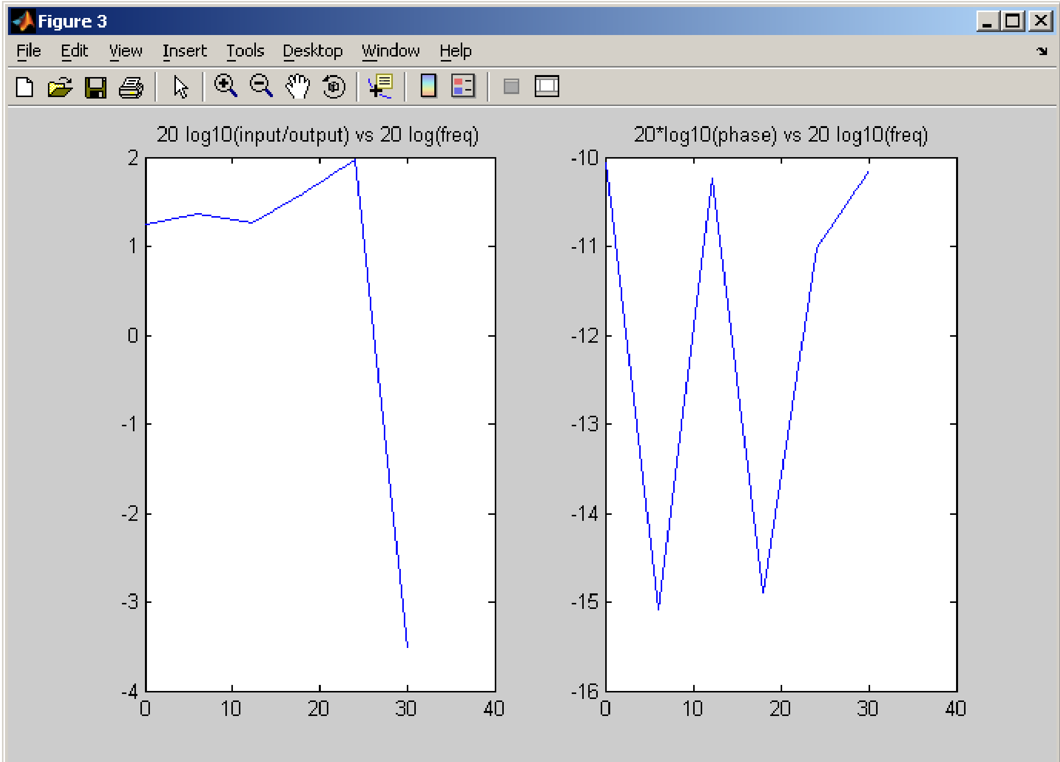


Figure 3
File Edit View Insert Tools Desktop Window Help
20 log10(input/output) vs 20 log(freq)
20*log10(phase) vs 20 log10(freq)