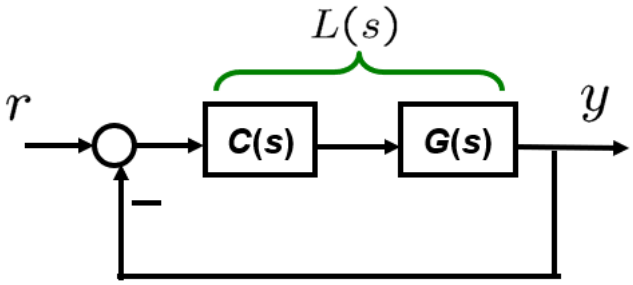
Assignment 20 (ELEC 341 L20_FreqDomSpec)

Problem 1:

Given the unity feedback system below, use frequency response methods to determine the value of gain, *C*(*s*), to yield a step response with a 20% overshoot. Use Matlab to graph the step response.



$$G(s) = \frac{(s+4)}{s(s+8)(s+10)(s+15)}$$

Solution:

Assignment 20, problem 1:

$$L(s)=\frac{(s+4)}{s(s+8)(s+10)(s+15)}$$

Find C(s) (gain controller compensator) for PO=20%

$$\zeta=\frac{\left|\ln\frac{PO}{100}\right|}{\sqrt{\pi^2+\left(\ln\frac{PO}{100}\right)^2}}=\frac{\left|\ln\frac{20}{100}\right|}{\sqrt{\pi^2+\left(\ln\frac{20}{100}\right)^2}}\rightarrow \underline{\zeta=0.455}\ ;\ PM=100\zeta\rightarrow \underline{PM=45.59^\circ}$$

We must reduce the PM to 45.59°, i.e., the Bode magnitude must be 0 dB when the Bode plot is: $-180^\circ+PM_{compen.}=-180^\circ+45.59^\circ=\underline{-134.41^\circ}$

Find ω^* at which $\angle L(j\omega^*)=-134.41^\circ\rightarrow$

$$\angle L(j\omega^*)=\tan^{-1}\left(\frac{\omega^*}{4}\right)-\left\{\tan^{-1}\left(\frac{\omega^*}{0}\right)+\tan^{-1}\left(\frac{\omega^*}{8}\right)+\tan^{-1}\left(\frac{\omega^*}{10}\right)+\tan^{-1}\left(\frac{\omega^*}{15}\right)\right\}=-134.41^\circ$$

90°

$\rightarrow \underline{\omega^*=7.5}$

At $\omega^*=7.5\rightarrow$ gain=? $\rightarrow |L(j7.5)|=\dfrac{\sqrt{7.5^2+4^2}}{75\sqrt{2.5^2+8^2}\sqrt{7.5^2+10^2}\sqrt{7.5^2+15^2}}$

$\rightarrow |L(j7.5)|=4.930\times10^{-4}$;

$$C(s)=\frac{1}{|L(j7.5)|}\rightarrow \boxed{C_{compen.}=C(s)=2028}$$

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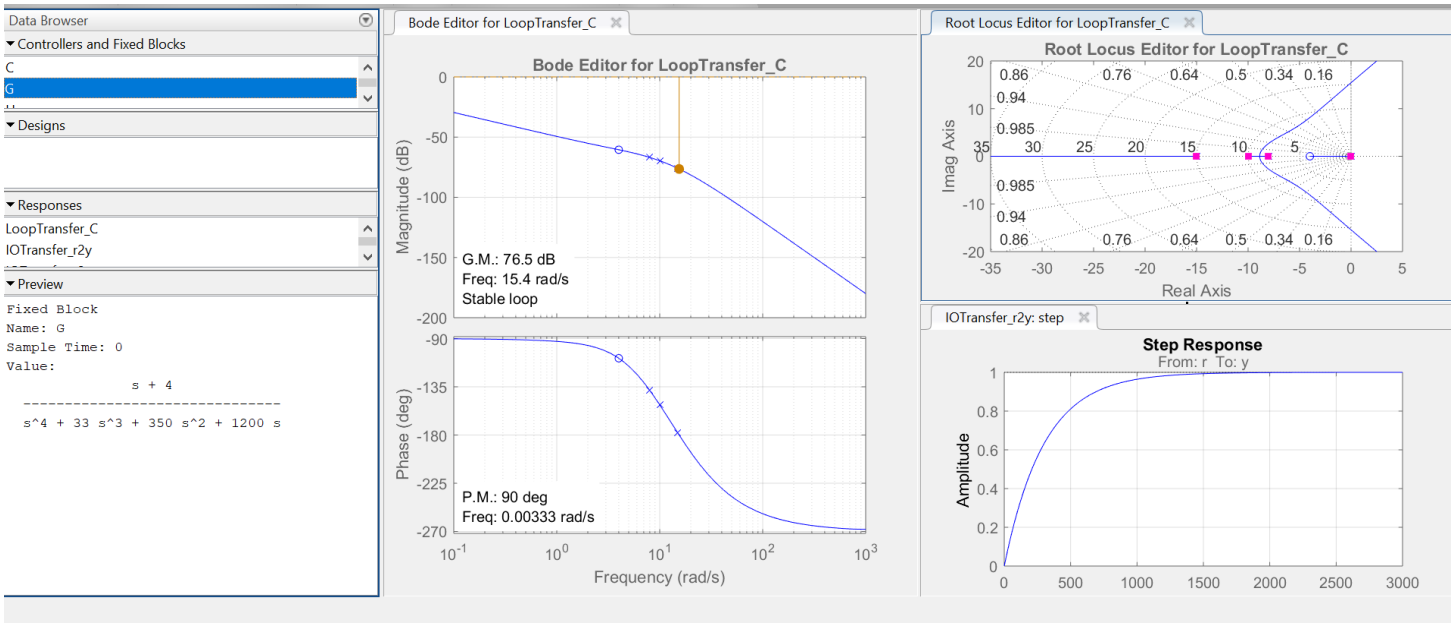
The following graph is for C(s) =1:



Using Bode plot in Matlab, try to put PM at around the requested value of 45.59 degrees. Below, you will see the results for a PM of 47.2 deg, which is close enough. You should get the following graph, which corresponds to C(s) = 1944.1. This is close enough to C(s) = 2028: