LECTURE 6-Design of via Frequency Response- Gain Adjustment

Example 6.1

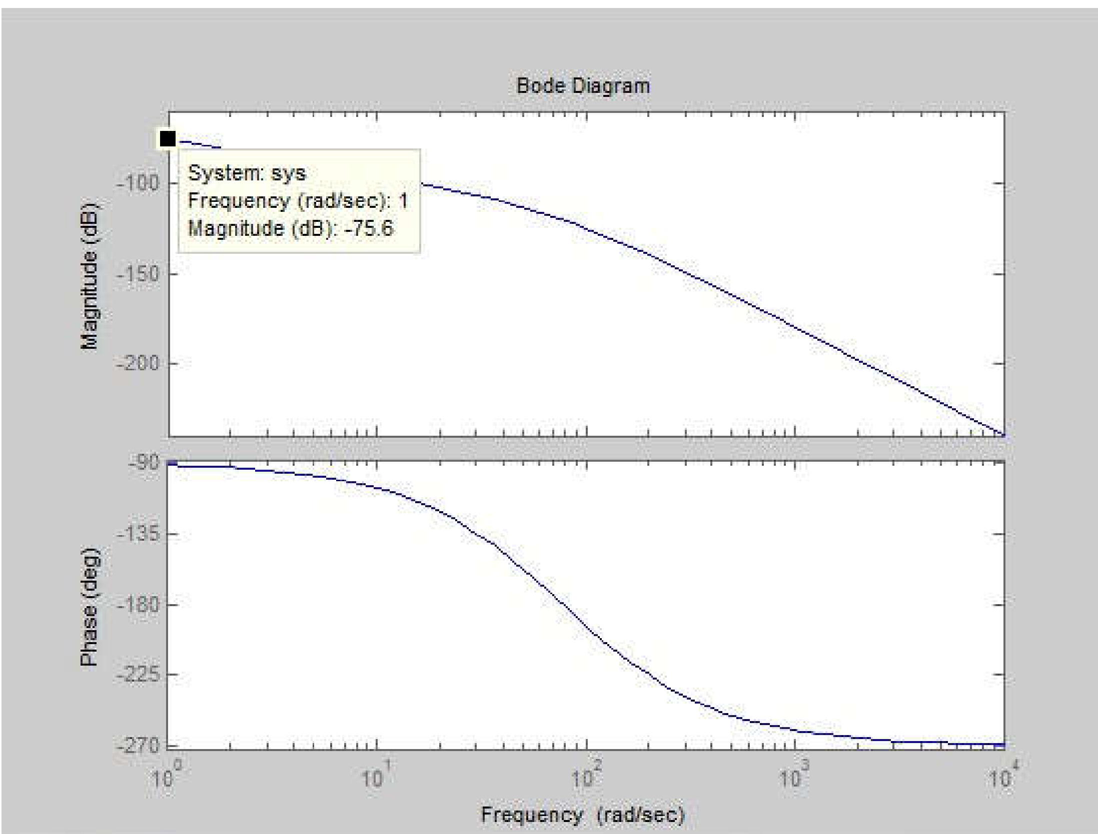
For a unity feedback system with a forward transfer function;

$$G(s) = \frac{K}{s(s+50)(s+120)}$$

Use frequency response techniques to find the value of gain K, to yield a closed-loop step response with 20% overshoot.

Matlab Code

```
n=[1];
d=[1,170,6000,0];
sys=tf(n,d);
bode(sys) ;
```



In order to start at magnitude 0 db, we need to increase the magnitude plot by 75.6db

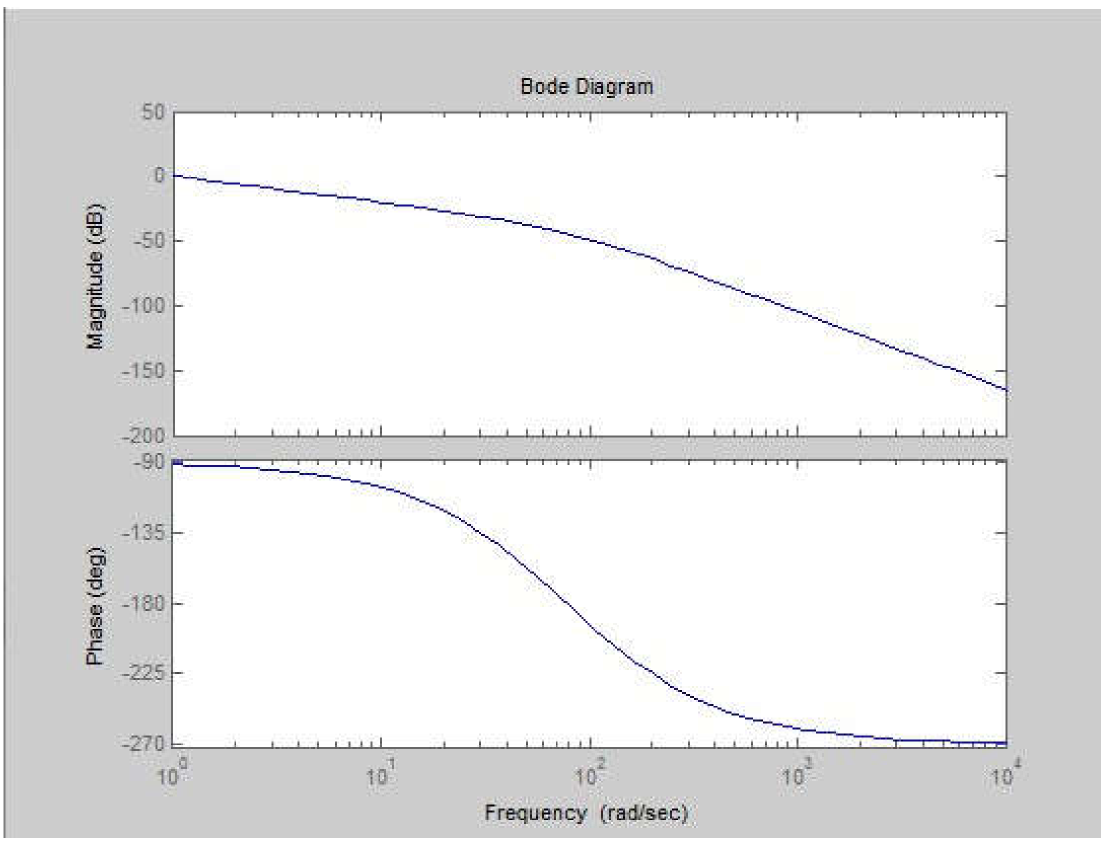
20 log k= 75.6

K=6025.6

We need to start with K=6025.6

Matlab Code

```
n=[6025.6];
d=[1,170,6000,0];
sys=tf(n,d);
bode(sys);
```



From the following equations we find damping ratio and phase margin;

$$\xi = \frac{-ln(\%M_p/100)}{\sqrt{\pi^2 + ln^2(\%M_p/100)}}$$

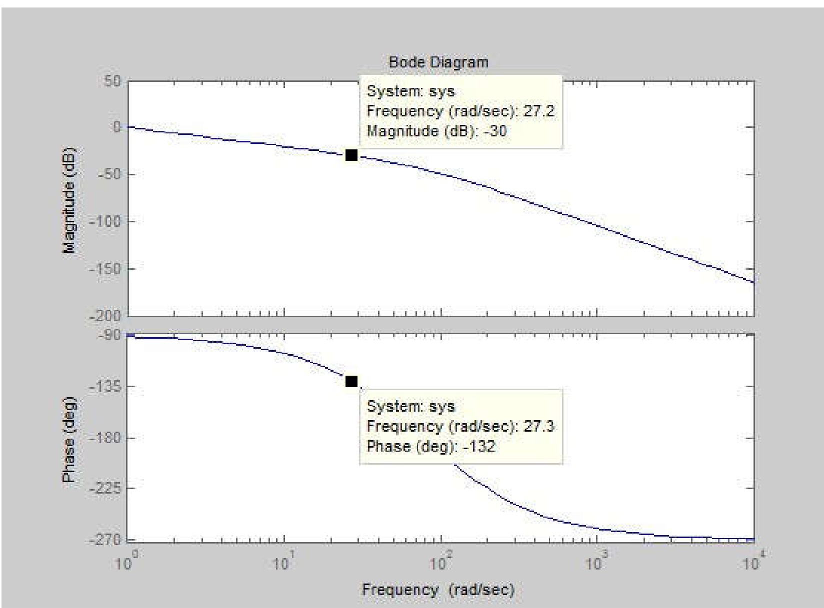
$$\phi_M = tan^{-1}\left(\frac{2\xi}{\sqrt{-2\xi^2 + \sqrt{1 + 4\xi^4}}}\right)$$

$$\xi = 0.456$$

$$\phi_M = 48.152^0$$

$$180^0 - \phi = 48.152^0$$

$$\phi = -131.8^0$$

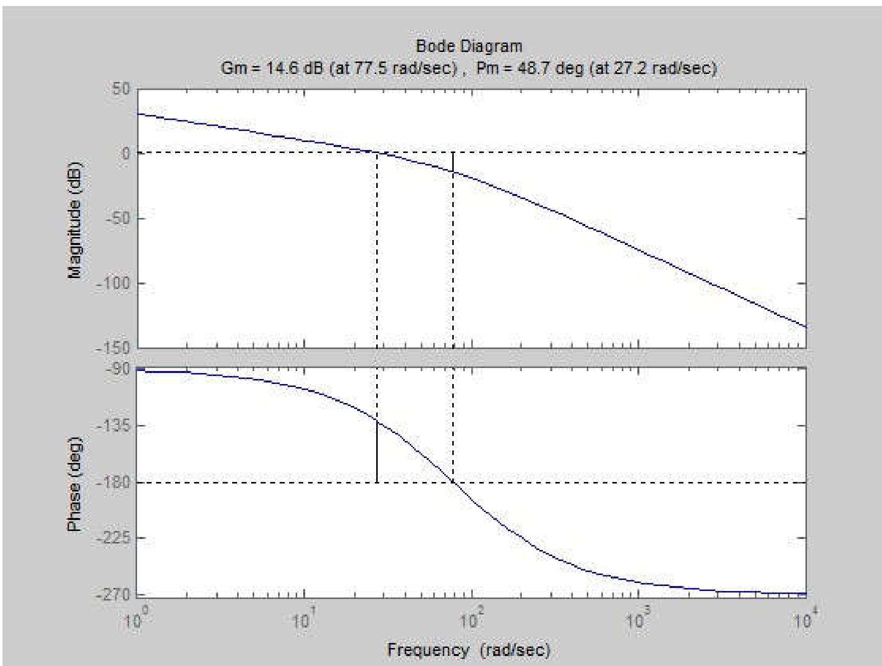


At phase -131.8 the magnitude is -30db with a frequency 27.3 rad /sec. we need to adjust the gain to force the magnitude curve to go through 0db at this frequency. So the additional gain is 20log k=30db so K=31.62. However we started with a gain k=6025.2 so the overall gain is K=31.62 *6025.6=190546.2.

So the gain –adjusted open-loop transfer function is;

$$G(s) = \frac{190546.2}{s(s+50)(s+120)}$$

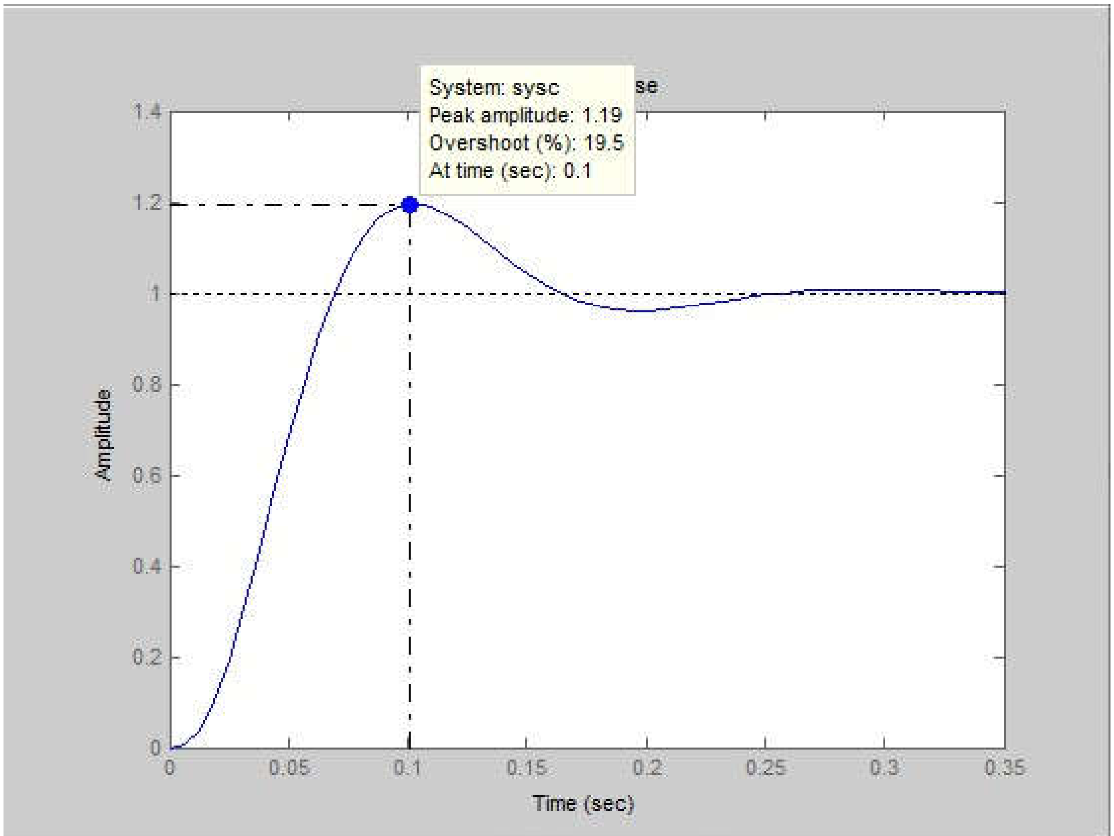
The bode plot of the new system is;



To insure that our design meets the required specifications we shall draw the step response of the closed loop system.

Matlab code:

```
Sysc= feedback(sys,1)
step(sysc)
```



As you can see the overshooting is as required so our design is correct.