EE3331C/EE3331E Feedback Control Systems
Part II, Tutorial 1

Section 1

1. The transfer function of a dynamic system is $G(s) = \dfrac{16}{(s+1)(s+3)}$

What is the input applied to the system if the steady-state signal observed at the output is

$$y_{ss}(t) = 2\sin(5t).$$

[Exam, Sem 2, AY2012-13]

Solution:

$$G(j\omega) = \frac{16}{(1+j\omega)(3+j\omega)}$$

$$G(j5) = \frac{16}{(1+j5)(3+j5)} \quad \Rightarrow \quad |G(j5)| = \frac{16}{\sqrt{1+25}\sqrt{9+25}} = 0.54$$

$$\angle G(j5) = -\tan^{-1}(5) - \tan^{-1}\frac{5}{3} = -78.7 - 59.0 = -137.7^\circ$$

So the input signal,

$$u(t) = \frac{2}{0.54}\sin(5t + 137.7^\circ) = 3.7\sin(5t + 137.7^\circ)$$

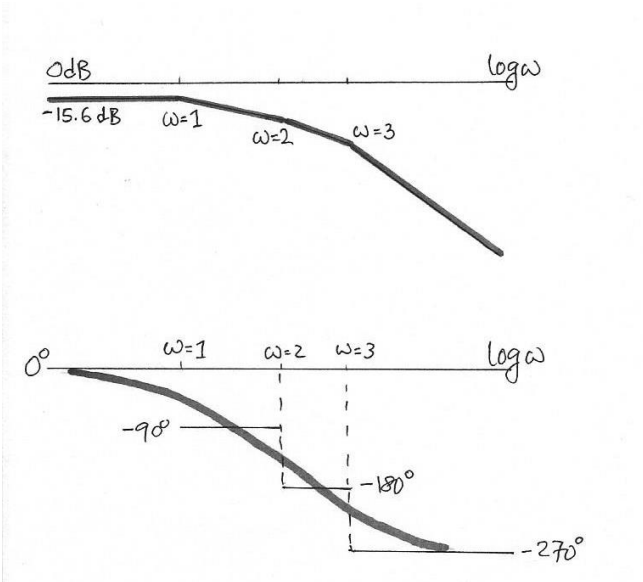
2. Sketch the Bode plot of $G(s) = \dfrac{1}{(s+1)(s+2)(s+3)}$

Solution:

Transfer function has no integrator. So low frequency gain ≈ DC gain.

$$|G(j0)| = \frac{1}{6}$$

$$|G(j0)|_{dB} = -15.6dB$$



3. Sketch the Bode plot of

$$G(s) = \frac{1}{s(s+2)(s+5)}$$

Solution:

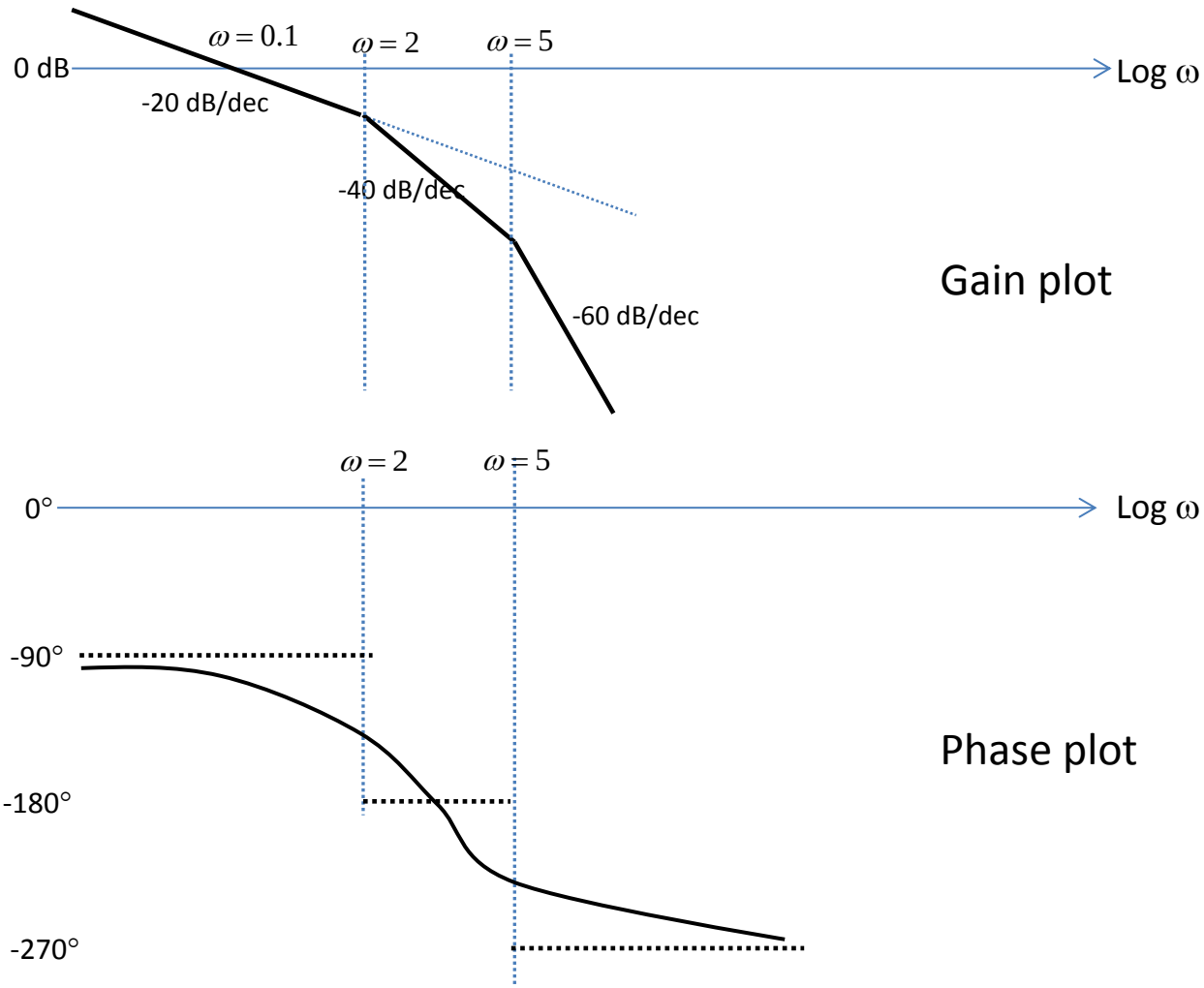
Transfer function has integrator. Let's express it in Bode form.

$$G(s) = \frac{1}{s \times 2(0.5s+1) \times 5(0.2s+1)}$$

$$= \frac{0.1}{s}\left(\frac{1}{0.5s+1}\right)\left(\frac{1}{0.2s+1}\right)$$

[Comment: in Bode form, the corner frequencies of the poles and zeros are not affected but dc-gain is unity for each pole and each zero.]

The integrator of the above transfer function (in Bode form) has gain plot with gradient of -20 dB/decade and intersects the 0-dB line at 0.1 rad/s.



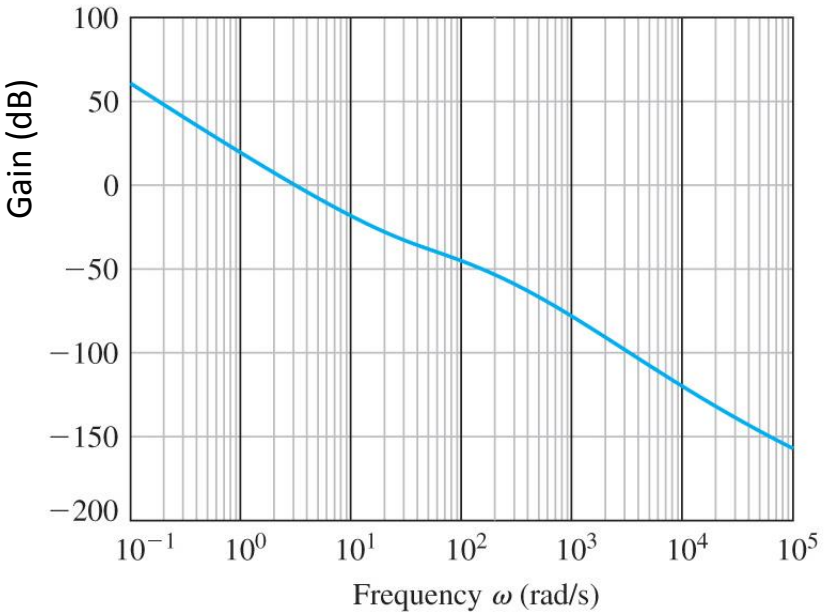
Section 2

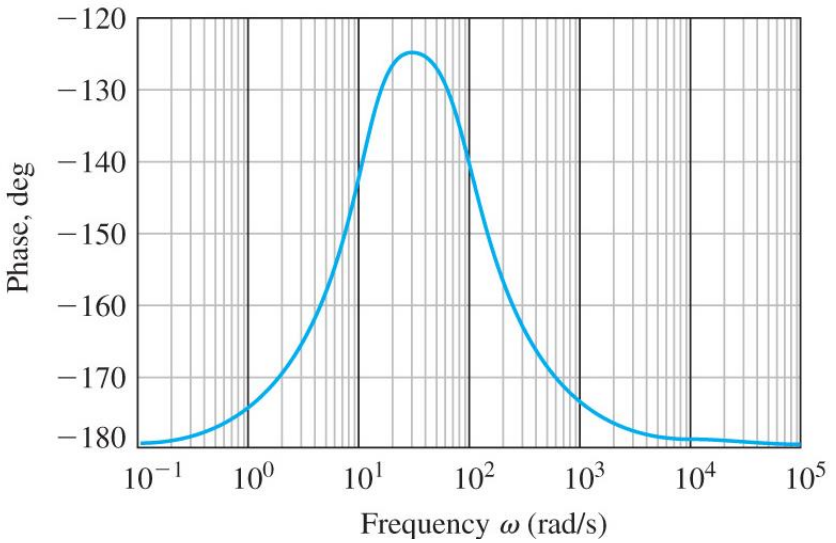
1. Sketch the Bode plot of

$$(i)\ G(s) = 50\frac{s(s+10)}{(s+1)(s+100)}$$

$$(ii)\ \frac{(s-10)}{s(s+1)(s+100)}$$

2. Estimate the transfer function from the Bode plot given

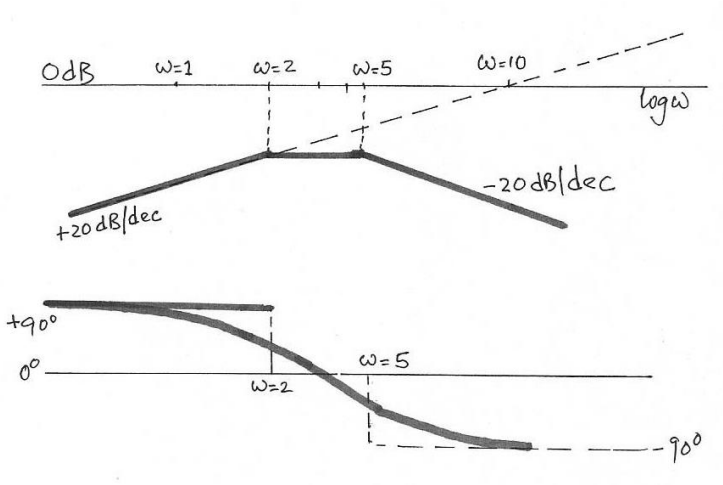




Section 3

1. Sketch the Bode plot of $G(s) = \dfrac{s}{(s+2)(s+5)}$

Answer:



2. Consider the transfer function $\dfrac{4(s+2)}{s(s+50)}$

Write another transfer function (without any delay element) that would have identical gain plot as of this transfer function but different phase plot.

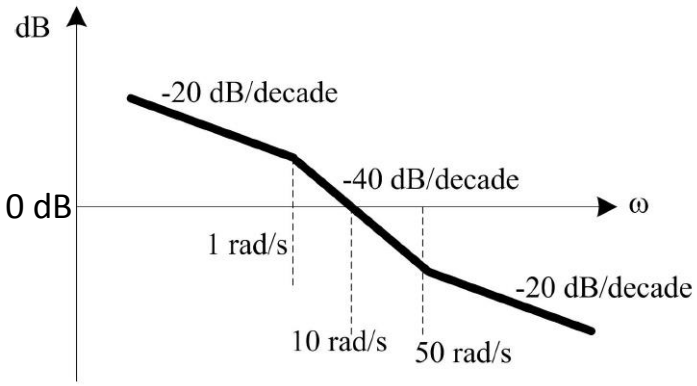
[Exam, Sem 1, AY2013-14]

Answer:

$$\frac{4(s-2)}{s(s+50)}$$

3. Write three distinct transfer functions that would have asymptotic Bode (gain) plot shown below.

[Exam, Sem 1, AY2014-15]



Answer:

$$a.\ \frac{2(s+50)}{s(s+1)} \quad b.\ \frac{2(s-50)}{s(s+1)} \quad c.\ \frac{2(s+50)}{s(s+1)}e^{-st_d}$$