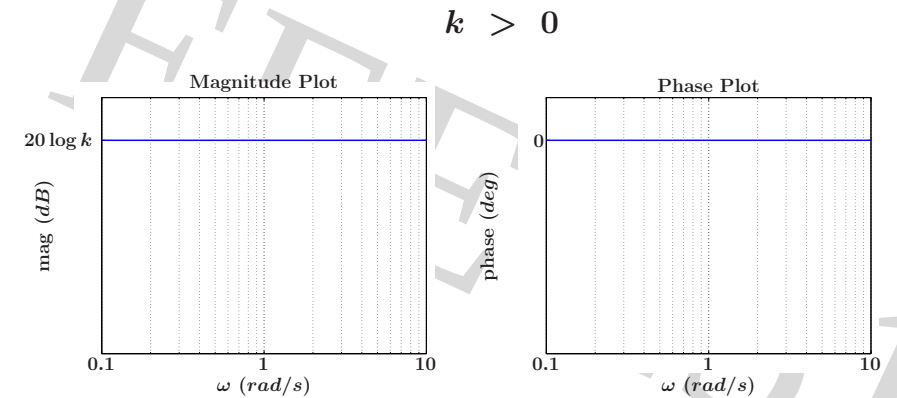


- Review of standard Bode plots.
 - pure gain.
 - poles and zeros at the origin.
 - poles and zeros on the real axis.
 - complex conjugate pairs poles / zeros.
- Building an asymptotic Bode plot.
- Identifying a transfer function from a Bode plot.
- Summary.

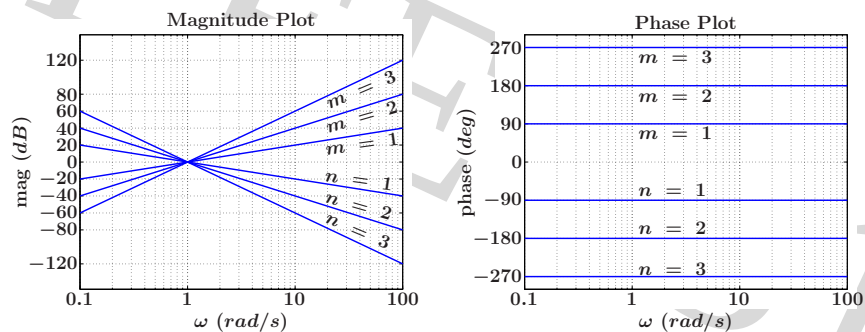
- Pure gain.



- Poles and zeros at the origin.

poles : $\frac{1}{s^n}$

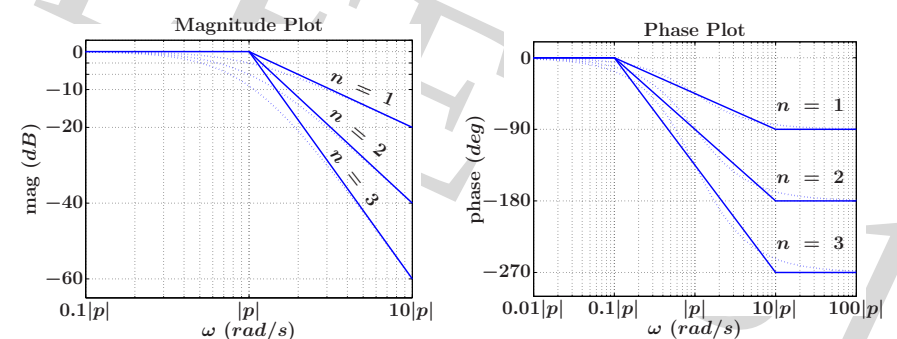
zeros : s^m



- Poles on the real axis.

$\frac{(-p)^n}{(s - p)^n}$

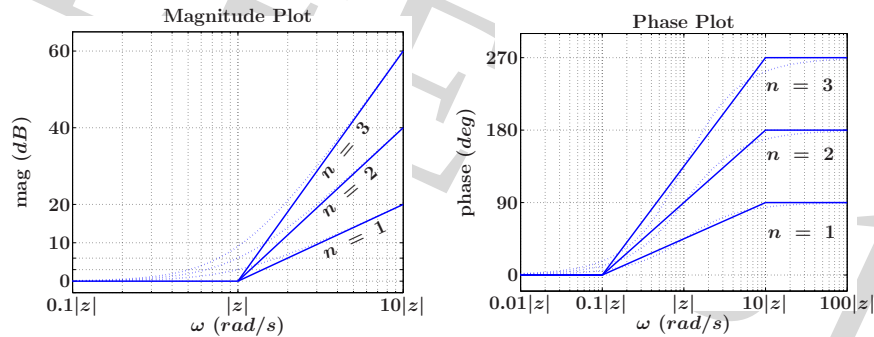
$p < 0$



Standard Bode Plots

- Zeros on the real axis.

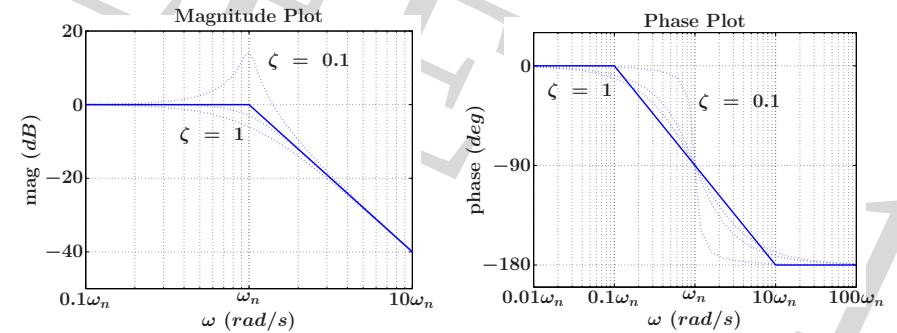
$$\frac{(s - z)^n}{(-z)^n}, \quad z < 0$$



Standard Bode Plots

- Complex conjugate poles.

$$\frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}, \quad \omega_n > 0 \text{ and } 0 \leq \zeta \leq 1$$



Standard Bode Plots

- Example. Consider the following transfer function.

$$G(s) = \frac{100s^2(s + 10^2)(s + 10^6)^2}{(s + 10)^2(s + 10^3)(s + 10^5)^3}$$

- Moving some factors around, we have

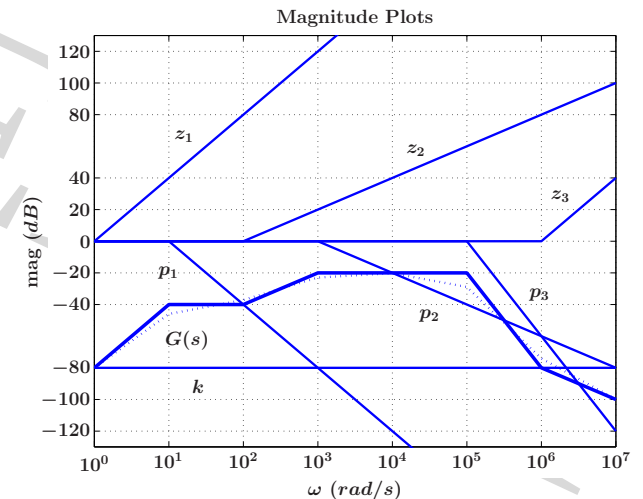
$$G(s) = \frac{10^{16}}{10^{20}} \cdot \frac{s^2 \left(\frac{s}{10^2} + 1\right) \left(\frac{s}{10^6} + 1\right)^2}{\left(\frac{s}{10} + 1\right)^2 \left(\frac{s}{10^3} + 1\right) \left(\frac{s}{10^5} + 1\right)^3}$$

Standard Bode Plots

- Asymptotic magnitude plots.

Let

$$\begin{aligned} k &= 10^{-4} \\ z_1 &= 0 \text{ (m2)} \\ z_2 &= -10^2 \\ z_3 &= -10^6 \text{ (m2)} \\ p_1 &= -10 \text{ (m2)} \\ p_2 &= -10^3 \\ p_3 &= -10^5 \text{ (m3)} \end{aligned}$$



Standard Bode Plots

- Asymptotic phase plots.

Let

$$k = 10^{-4}$$

$$z_1 = 0 \text{ (m2)}$$

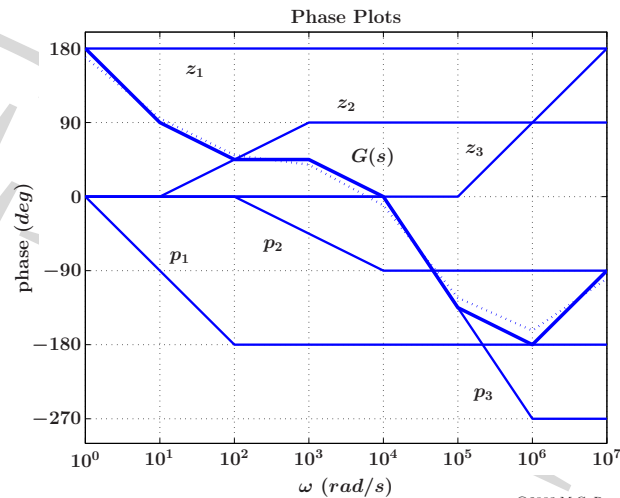
$$z_2 = -10^2$$

$$z_3 = -10^6 \text{ (m2)}$$

$$p_1 = -10 \text{ (m2)}$$

$$p_2 = -10^3$$

$$p_3 = -10^5 \text{ (m3)}$$



Identifying the TF from the Bode Plots

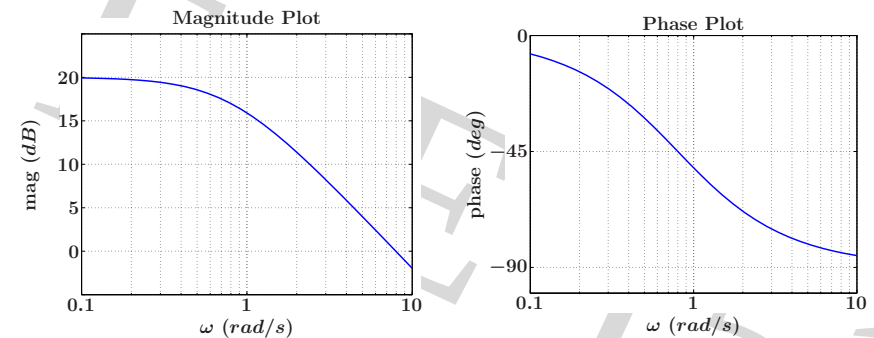
- Determine the general form of the transfer function.
 - trace the Bode plots and identify poles and zeros.
 - write out the general form and check.
- Compute for the system parameters.
 - use the magnitude plot to determine the gain, and the locations of poles and zeros.
 - use the phase plot to verify the locations, and possibly increase the accuracy.

Identifying the TF from the Bode Plots

- Learn and familiarize with 'standard' Bode plots.
- Identify the system type.
 - look at the slope of the magnitude plot at $\omega = 1$.
 - look at the phase angle as for small ω .
- Find the asymptotes and the corner frequencies.
 - find the transitions or bends in the Bode plots.
 - extend the asymptotes to determine the corner frequencies.

Identifying the TF from the Bode Plots

- Example. Consider the following Bode plots.



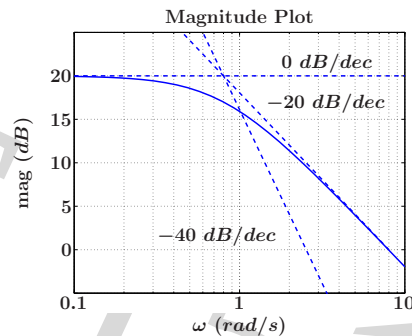
- Looking at the low frequencies,
 $\Rightarrow$ system type 0.

Identifying the TF from the Bode Plots

- What are the asymptotes?

At $\omega \rightarrow 0$, horizontal asymptote line at 20 dB.

At large ω , -20 dB/dec asymptote line.



- The magnitude plot only has one transition (or bend).
 $\Rightarrow$ the transfer function has one pole.

Identifying the TF from the Bode Plots

- We can see from the magnitude plot that the magnitude approaches 20 dB as $\omega \rightarrow 0$.

Using the general form of the transfer function for $\omega = 0$, the logarithmic gain is

$$20 \log \left| \frac{k}{-p} \right| = 20 \text{ dB}$$

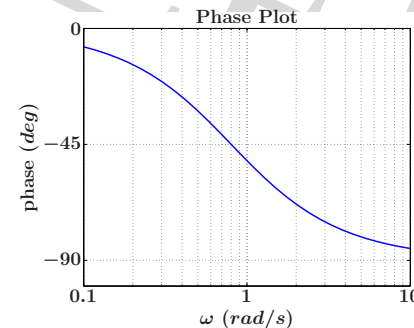
Since $p < 0$ and $k > 0$,

$$\frac{k}{-p} = 10$$

Identifying the TF from the Bode Plots

- The general form of the TF is

$$G(s) = \frac{k}{s - p} \Rightarrow G(j\omega) = \frac{k}{j\omega - p}$$



Looking at $\omega \rightarrow 0$, we can see that $\phi(\omega) \rightarrow 0$.

Thus, assuming $k > 0$, the pole must be located in the LHP, i.e.,

$$p < 0$$

Identifying the TF from the Bode Plots

- Using the general form, the phase angle at the corner frequency is

$$\phi(\omega) = -\tan^{-1} \left[\frac{\omega}{-p} \right] \Rightarrow \phi(\omega_c) = -\tan^{-1} \left[\frac{\omega_c}{-p} \right]$$

- From the standard Bode plots we know that corner frequency is located at $\omega_c = |p|$. Thus,

$$\phi(\omega_c) = -\tan^{-1} \left[\frac{\mp p}{-p} \right] = -45^\circ, -135^\circ$$

Use this equation to determine the location of ω_c (and consequently the pole p).

- From the plot we see that

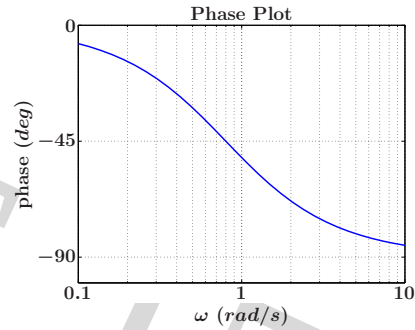
$$\omega_c = 0.8 \text{ rad/s}.$$

Since $p < 0$ and

$$\omega_c = |p|,$$

$$p = -0.8$$

$$\text{Also, } k = (-p)(10) = 8.$$



- Thus, the transfer function is

$$G(s) = \frac{8}{s - (-0.8)} = \frac{8}{s + 0.8}$$

- Learning typical Bode plots are important to
 - constructing the Bode plots for a given TF.
 - identifying the transfer function if the magnitude and phase plots are available.
- Why identify the transfer function from the Bode plots?
- Network analyzer does this automatically.