ECE 3510 Bode Plot Notes

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Steps to make Bode Plots

Sample transfer function: $$P(s) = K \cdot \frac{(s+z_1)\cdot(s+z_2)\cdot(s+z_3)}{s^2\cdot(s+p_1)\cdot(s+p_2)\cdot(s^2+2\cdot\zeta\cdot\omega_n+\omega_n^2)}$$

1. a) Rewrite, replacing all s's with blanks:

$$P(s) = K \cdot \frac{(\_+z_1)\cdot(\_+z_2)\cdot(\_+z_3)}{\_\_\cdot(\_+p_1)\cdot(\_+p_2)\cdot(\_+\omega_n)\cdot(\_+\omega_n)}$$

notice that you also simplify the complex poles for now

b) Use what's left to find the initial magnitude. Plot a point on the $\omega = 1$ frequency line at this magnitude.

$20\cdot\log(|P(s)|)$ --> dB

2. a) Replace all the poles and zeros at zero, but use $j\omega$ instead of s:

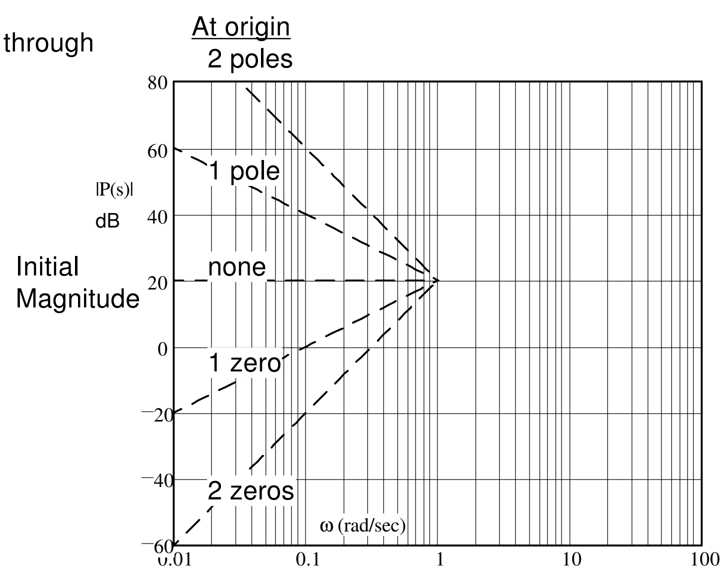
$$P(s) = K \cdot \frac{(\_+z_1)\cdot(\_+z_2)\cdot(\_+z_3)}{(j\cdot\omega)^2\cdot(\_+p_1)\cdot(\_+p_2)\cdot(\_+\omega_n)\cdot(\_+\omega_n)}$$

b) Use this to find the initial slope. Lightly plot a line through the point on the $\omega = 1$ frequency line at this slope.

ω's in the numerator, each --> $+20$dB/decade

ω's in the denominator, each --> -20dB/decade

c) Use this $P(s)$ to find the initial phase angle.



3. a) Extend the line to the first pole or zero. (If the first pole or zero less than 1, intercept the line.)

b) Replace that pole or zero with $j\omega$ and cross out the value of the pole:

$$P(s) = K \cdot \frac{(j\omega+z_1)\cdot(\_+z_2)\cdot(\_+z_3)}{(j\omega)^2\cdot(\_+p_1)\cdot(\_+p_2)\cdot(\_+\omega_n)\cdot(\_+\omega_n)}$$

c) Use this to find the new slope and phase angle. Unless you replaced what was once a $-s$ or crossed out a negative value:

zeros turn up the slope --> $+20$dB/decade   zeros increase the phase angle --> $+90$deg

poles turn down the slope --> -20dB/decade   poles decrease the phase angle --> -90deg

4. Repeat step 3 for each successive pole or zero.

After the last one you may want to check the magnitude or slope and phase again.

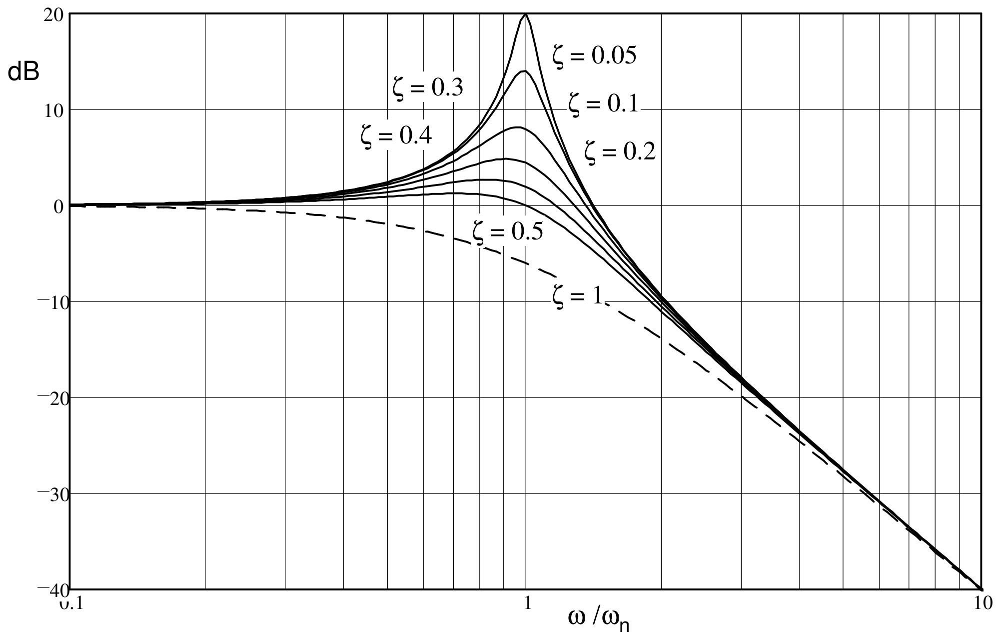
5. Correct the plot at the complex poles by scaling what you see here.

   You may have to use a mirror image of these plots

   At ω_n the actual magnitude is:

$$\frac{1}{2 \cdot \zeta}$$

To correct the plot at complex zeros, use these plots upside-down

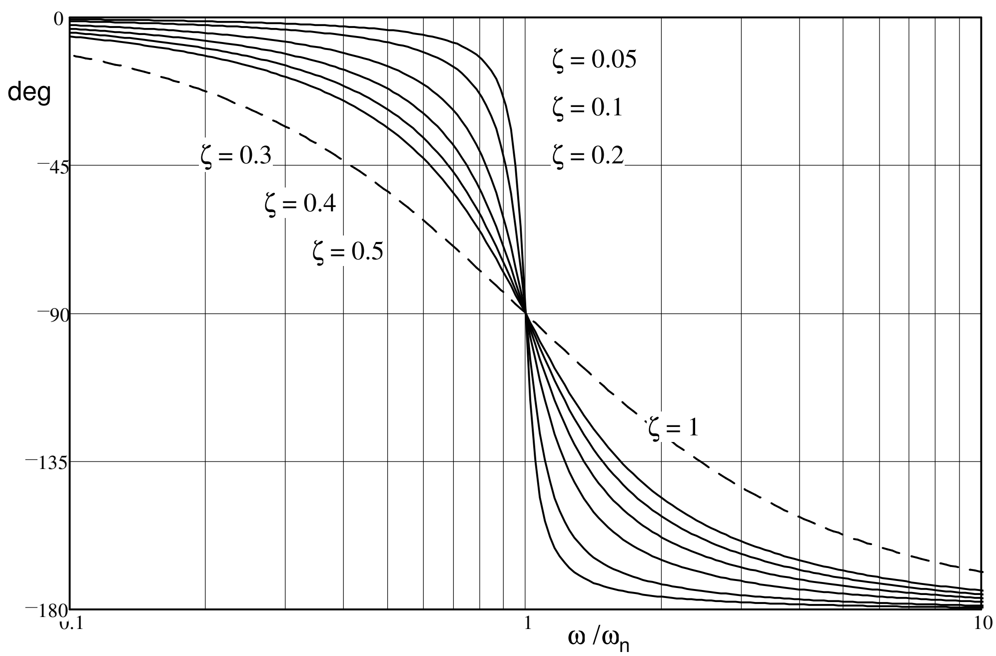


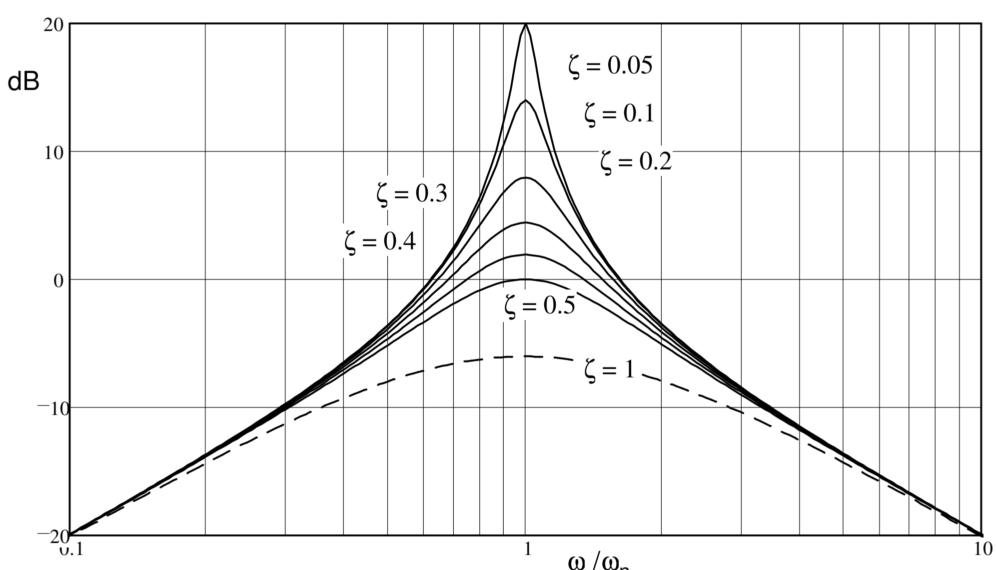
natural frequency

$$\omega_n = \sqrt{a^2 + b^2}$$

damping factor

$$\zeta = \frac{a}{\omega_n}$$





6. Draw a smooth line through the bode plots to estimate the actual magnitude and phase.