ECE 3510 Final Exam Information

This sheet and the Information sheets from Exams 1 - 3 are the only reference materials allowed at exam. Bring this page. You **may add** whatever you want to this sheet (both sides).

Bode Plots

See also Exam 3 Information sheet

b) At complex poles and zeroes.

if complex pole is expressed:

$$\left(s^2 + 2\cdot\zeta\cdot\omega_n\cdot s + \omega_n^{\,2}\right)$$

natural frequency $\omega_n = \sqrt{\omega_n^{\,2}}$

damping factor: $\zeta = \dfrac{2\cdot\zeta\cdot\omega_n}{2\cdot\omega_n}$

if complex pole is expressed:

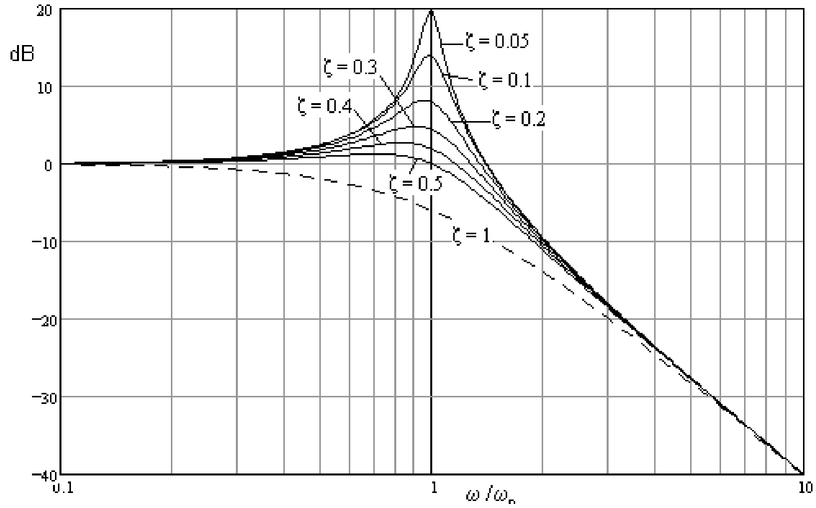
$$\left[(s+a)^2 + b^2\right] = s^2 + 2\cdot a\cdot s + \left(a^2 + b^2\right)$$

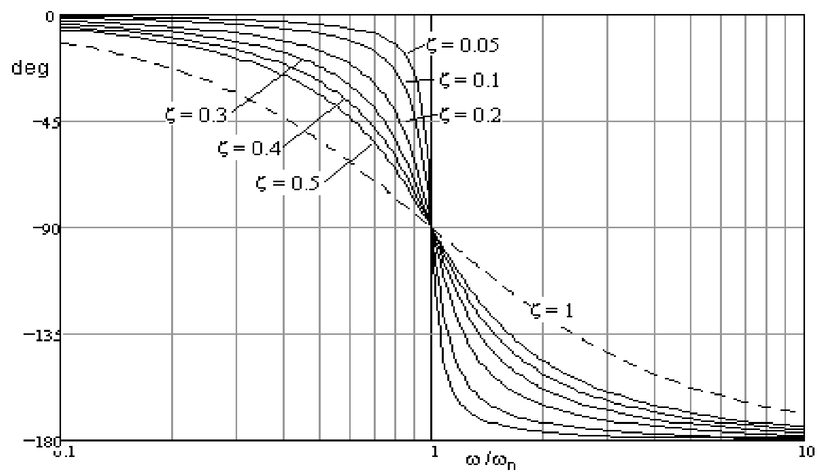
natural frequency $\omega_n = \sqrt{a^2 + b^2}$

damping factor $\zeta = \dfrac{a}{\omega_n}$

Near ω_n, the difference between peak & straight lines is: $\dfrac{1}{2\cdot\zeta}$ in dB: $20\cdot\log\left(\dfrac{1}{2\cdot\zeta}\right)$

For angles, see drawing at right.





GM, PM, & DM Gain Margin (GM):
Find where angle plot crosses 180^o .
GM is -dB of mag plot at same freq.

Phase Margin (PM): Find where mag plot crosses 0dB. PM is 180^o + phase angle at same freq.

Delay Margin (DM): $T = \dfrac{2\cdot\pi}{\omega_{PM}}$ OR $\dfrac{1}{f_{PM}}$ $\qquad DM = \left(\dfrac{PM}{360\cdot deg}\right)\cdot T$

Bode Plot to Transfer Function

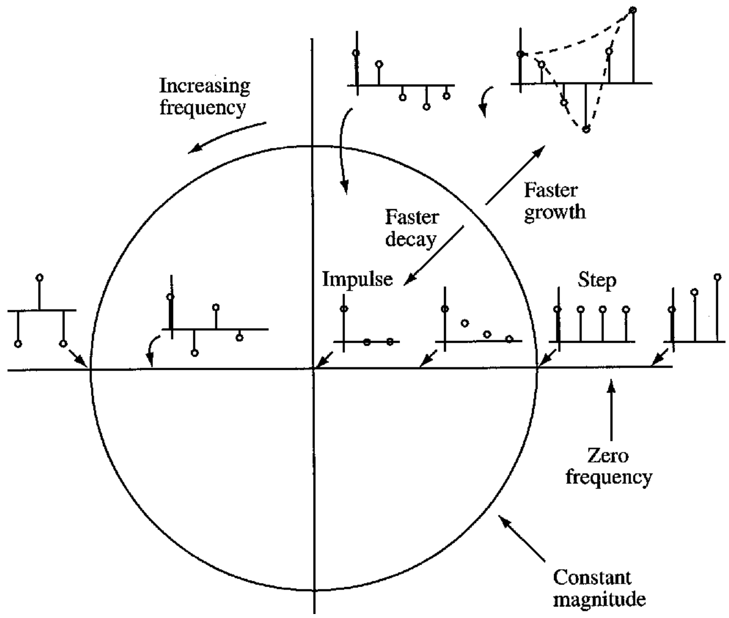
Draw best-fit straight lines at slopes of 0dB/dec, $\pm$20dB/dec, $\pm$40dB/dec, $\pm$60dB/dec, etc..

Essentially reverse the plot procedure.

Find the magnitude at some part of the plot (usually a flat part) & find any multiplying constant needed.

Discrete Signals, Systems and z-transforms

Finite-length signals have all poles at zero



$$f(k) \qquad F(z) = \sum_{k=0}^{\infty} f(k)\cdot z^{-k}$$

f(k)	**F(z)**
$\delta(k)$	1
$u(k)$	$\frac{z}{z-1}$
p^k	$\frac{z}{z-p}$
$(\lvert p\rvert)^k\cdot\cos(\theta_p\cdot k)$	$\frac{z\cdot\left(z-\lvert p\rvert\cdot\cos(\theta_p)\right)}{z^2-2\cdot\lvert p\rvert\cdot\cos(\theta_p)\cdot z+(\lvert p\rvert)^2}$
$(\lvert p\rvert)^k\cdot\sin(\theta_p\cdot k)$	$\frac{z\cdot\left(\lvert p\rvert\cdot\sin(\theta_p)\right)}{z^2-2\cdot\lvert p\rvert\cdot\cos(\theta_p)\cdot z+(\lvert p\rvert)^2}$

Inverse z-transforms (partial fractions & long division)

Divide by z first: $\frac{F(z)}{z}$

	F(z)	**f(k)**
	A	$A\cdot\delta(k)$
Poles on real axis (not at zero):	$\frac{B\cdot z}{(z-p)}$	$B\cdot p^k$
	$\frac{B\cdot p\cdot z}{(z-p)^2}$	$k\cdot p^k$
Complex poles:	$\frac{B\cdot z}{(z-p)}+\frac{\overline{B}\cdot z}{\left(z-\overline{p}\right)}$	$2\cdot\lvert B\rvert\cdot(\lvert p\rvert)^k\cdot\cos\left(\theta_p\cdot k+\theta_B\right)$

Properties of the z-transform

- linear
- Right-shift = delay = multiply by $z^{-1} = \frac{1}{z}$
- Left-shift = advance = multiply by z
- Initial value = $f(0) = F(\infty)$ Final value (DC) = $f(\infty) = (z-1)\cdot F(z)\Big|_{z=1}$

Signals are bounded if all poles in inside unit circle, no double poles on unit circle

Converge to 0 if all poles inside unit circle. Converge to a non-zero value if a single pole is at 1

Difference equations, be able to get $H(z)$

Discrete-time systems, FIR (all poles at zero), IIR (some poles not at zero)

BIBO Stability, all poles inside unit circle.

Step & Sinusoidal responses, effects of poles & zeros, etc.

DC gain = $H(1)$ sinusoidal: $H\left(e^{j\cdot\Omega_o}\right) = \lvert H\rvert \angle\theta_H$ multiply magnitudes and add angles

Same Feedback system as in continuous-time and Root locus works the same but is interpreted very differently.