EE302 - Bode Plots, Gain & Phase Margins – DePiero

Bode Plots depict the frequency response of a transfer function, using s = jw. The plots include magnitude (on a dB scale) and phase. We will use Bode Plots for several purposes, which include finding Gain Margin and Phase Margin – these are measures of relative stability. Bode Plots are also helpful for compensator design. We will make Bode Plots of the open loop transfer function, KGH(s). Semilog paper is available on another handout.

A few general notes, regarding the construction of Bode Plots:

- Frequency (radians/sec) is plotted on the horizontal axis, with a log scale.
- An origin (0, 0) is never plotted on a Bode Plot because of the log-frequency axis.
- Before plotting, individual factors need to be put into 'leading 1's" form. This will generally effect the constant gain term.
- Because the magnitude is plotted in dB, the overall transfer function maybe found by adding the contribution of individual factors.

Type	**Factor**	**Corner Freq.**	**Zero Cross**	**Slope dB/decade**	**Angle Degrees**
Constant	Constant			0, all w	0, all w
Integrator	1/jw		1	-20, all w	-90, all w
Differentiator	jw		1	+20, all w	+90, all w
1st Order Pole	1/(1 + jw/wc)	wc		0, w < wc -20, w > wc	0, w < wc/10 -90 deg/decade, wc/10 > w > 10 wc -90, w > 10 wc
1st Order Zero	1 + jw/wc	wc		0, w < wc +20, w > wc	0, w < wc/10 +90 deg/decade, wc/10 > w > 10 wc +90, w > 10 wc
2nd Order Pole	$\frac{1}{1+(j2\zeta/w_n)+(jw/w_n)^2}$	$\sim w_n$		0, w < wc -40, w > wc	0, w < wc/10 -180 deg/decade, wc/10 > w > 10 wc -180, w > 10 wc
2nd Order Zero	$1+(j2\zeta/w_n)+(jw/w_n)^2$	$\sim w_n$		0, w < wc +40, w > wc	0, w < wc/10 +180 deg/decade, wc/10 > w > 10 wc +180, w > 10 wc

Also, regarding 2nd order systems, a better approximation to the corner frequency is the resonant frequency which is $w_n\sqrt{1-\zeta^2}$. Furthermore, a resonant peak occurs for smaller values of the damping ratio. Recall that for 1st order systems the actual curve drops by 3dB at the corner frequency, -6dB for 2nd order.