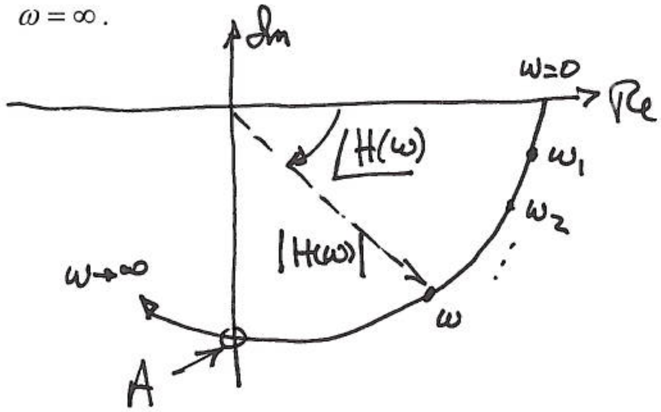
Assignment #17

ECSE-2410 Signals & Systems - Fall 2013 — Due Fri 11/08/13

1(20). Another useful frequency representation is the polar plot $H(\omega)=|H(\omega)|e^{\angle H(\omega)}$ as frequency is swept from $\omega=0$ to $\omega=\infty$.

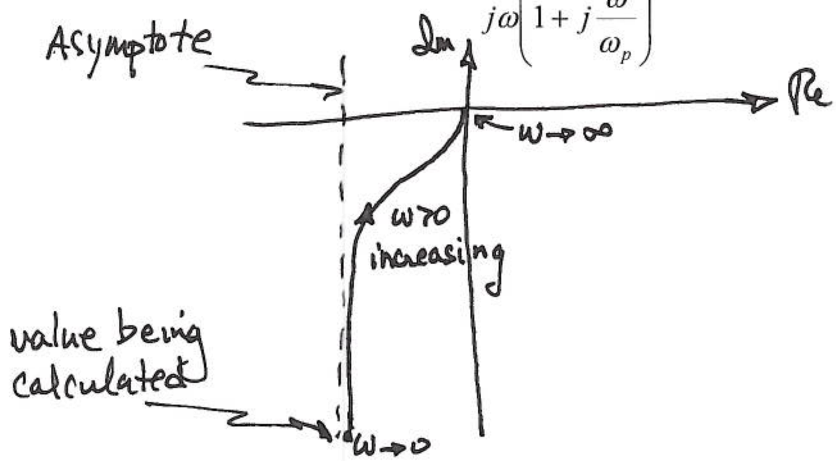


We can easily sketch such plots from the Bode magnitude and phase plots which are nothing more than individual plots of $|H(\omega)|$ and $\angle H(\omega)$. Note that the values at key frequencies like point A in the figure above can be found from the Bode phase plot as occurring at a frequency $\omega=\omega_0$ where $\angle H(\omega_0)=-90^\circ$. Using Bode plots as a guide (either sketch or use Matlab™) plot the polar frequency plots for

(a) $H(\omega)=\dfrac{10}{1+j\dfrac{\omega}{10}}$ (b) $H(\omega)=\dfrac{10}{\left(1+j\dfrac{\omega}{10}\right)\left(1+j\dfrac{\omega}{100}\right)}$

Scale your plots.

2(15). The polar plot shown for $H(\omega)=\dfrac{K\left(1+j\dfrac{\omega}{\omega_z}\right)}{j\omega\left(1+j\dfrac{\omega}{\omega_p}\right)}$, which has a pole at $s=0$, is:

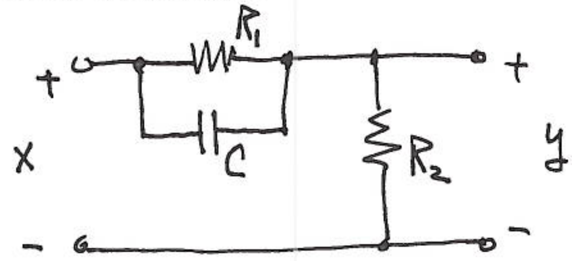


Show that the vertical asymptote (dotted in figure) at $\omega\to 0$ is

$$\lim_{\omega\to 0} H(\omega)=\lim_{\omega\to 0}[\mathrm{Re}(\omega)+j\mathrm{Im}(\omega)]=K\left(-\frac{1}{\omega_p}+\frac{1}{\omega_z}\right)-j\infty,$$

where Re and Im are the real and imaginary parts of $H(\omega)$.

3(15). For the circuit shown



(a) Find $H(\omega)$ in terms of R_1, R_2, C.
(b) Sketch the straight-line Bode magnitude plot and the 'curved' phase plot. Locate the break frequencies on your plot.
(c) Find the frequency ω_0, in terms of R_1, R_2, C, at which the phase is largest.

4(20). Sketch the Bode phase plot for $H(\omega) = \dfrac{10e^{-j\omega T}}{j\omega(1+j\omega)}$. Find the time delay, *T*, such that $\angle H(\omega) = -180^\circ$ at $\omega = 1$. Use exact calculations. Consequently, you will have to write a root-searching computer program to calculate your answer.

5(10). Consider the first and second order systems, $H_1(s) = \dfrac{1.5}{s+1.5}$ and $H_2(s) = \dfrac{16}{(s+2)(s+8)}$, respectively. Use the 'step(num, den)' Matlab™ command along with 'hold on' to plot the step response of both systems on one plot. Can you tell from the plot which curve represents which system order? Now calculate $\left.\dfrac{d}{dt} y_{step}(t)\right|_{t=0}$ for each system.

6(20). For a general second-order system $H(s) = \dfrac{K}{s^2 + as + K}$
(a) find the pole locations such that the system step response exhibits a $\%OS = 10\%$ and a settling time, and plot the pole-zero diagram.
(b) Use the Matlab™ 'step' command to plot the step response. Then verify from the plot that your response satisfies the given overshoot and settling time.