Lecture 6, Sep 27, 2023

Bode Plots

- Motivation: we need a good tool to predict what a circuit will do to a wide range of signal frequencies
- Example: $H(s) = \dfrac{1}{Ts+1}$ with $y(t) = A\sin(\omega t)$
  - We will always get a sine wave of the same frequency
  - However the phase and the amplitude of the output will be different
  - In general, all LTI systems have this property
- A Bode plot shows, for different frequencies in logarithmic scale, how a system changes the phase and amplitude of an input sinusoid
  - The information from both parts of the Bode plot are equivalent to all the information from the transfer function/pole-zero plot

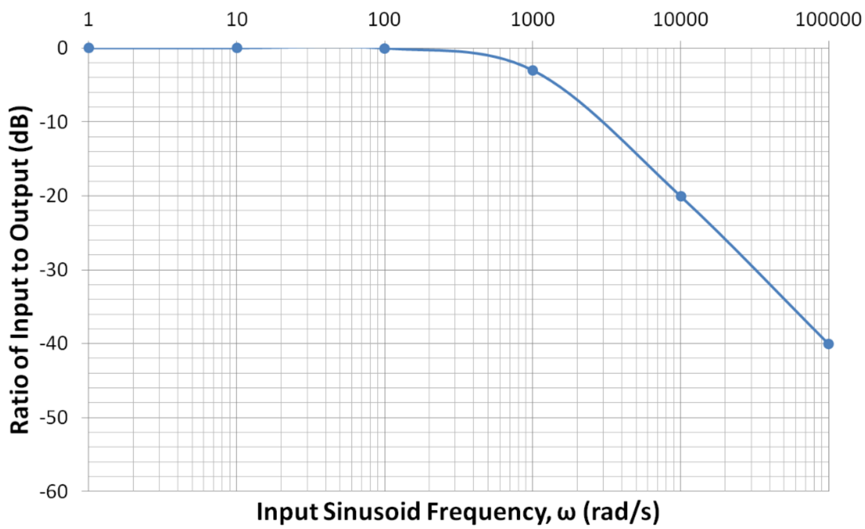

Figure 1: Magnitude Bode plot for the example transfer function.

- For the magnitude plot, a Bode plot shows the ratio of output amplitude over input amplitude in decibels – $\text{dB} = 20\log_{10}\dfrac{A_{out}}{A_{in}}$
  - At -3dB, we consider the output amplitude to have started deviating considerably
  - A typical Bode plot for a single pole looks similar to the example figure, with a horizontal segment where frequency has little effect, and a diagonal segment where increasing frequency significantly affects the output
    - The inflection point is the location of the pole; this is known as the *cutoff frequency* or *corner frequency*
    - After the pole location, each decade of increase in frequency leads to about -20dB of amplitude difference
- For the phase plot, the phase shift angle in degrees is shown
  - The phase plot can be approximated by 3 segments, with 2 horizontal ones and a diagonal one
  - In the diagonal segment, the phase decreases by $-45°$ per decade
  - The pole location is at the center of the diagonal segment of the phase plot; it has a phase shift of $-45°$
- A complete Bode plot requires both a magnitude and a phase plot

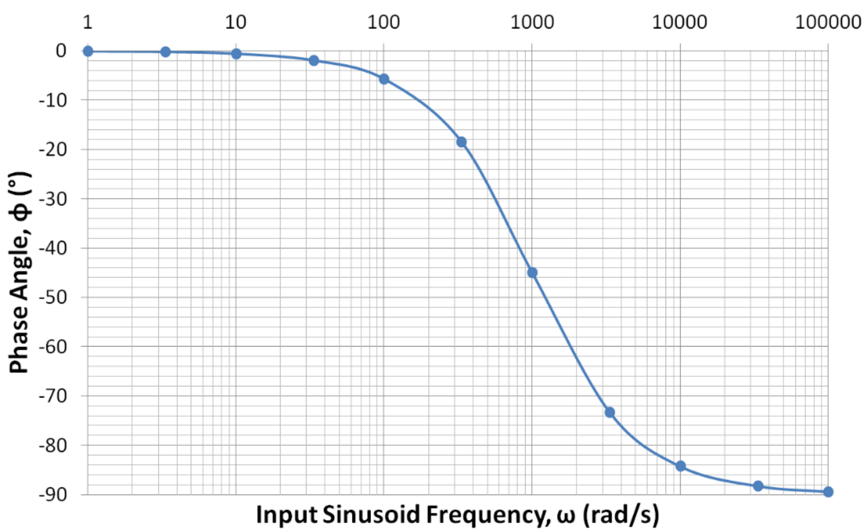

Figure 2: Phase Bode plot for the example transfer function.