Basic Rules of Developing a Bode Plot Using a Straight Line Approximation Method

Magnitude Plot

Given a term $(s+\alpha)$, where $s = j\omega$ and α is the corner frequency associated with that term:

- If the frequency of interest (ω) is less than the corner frequency (α), then you may approximate the magnitude of the term $(s+\alpha)$ by the corner frequency α.
- If the frequency of interest (ω) exceeds the corner frequency (α), then you may approximate the magnitude of the term $(s+\alpha)$ by the value of ω.
    - Example: given a term (s+300) that is part of an overall transfer function, if you are attempting to determine the magnitude of the Bode plot for any frequency below 300 rad/s, you may approximate the magnitude of the term (s+300) by 300. Once you begin determining the magnitude of the Bode plot for frequencies above 300 rad/s, then you would approximate the magnitude of the term (s+300) by whatever ω is when you are evaluating the magnitude of the Bode plot at that frequency. So, if you are evaluating the magnitude of the Bode plot at 1000 rad/s, you would approximate the value of the (s+300) term by 1000.
- Note that the magnitude of the function at the corner frequency can either be approximated by ω or α, since their values are the same. The maximum error in the approximation occurs here (at the corner frequency), with an error of 0.707 (3 dB).

Phase Plot

Given a term $(s+\alpha)$, where $s = j\omega$ and α is the corner frequency associated with that term:

- If the frequency of interest (ω) is <u>less than or equal to a decade below</u> the corner frequency (α), then the phase angle contribution of the term $(s+\alpha)$ is 0°.
- If the frequency of interest (ω) is <u>greater than or equal to a decade above</u> the corner frequency (α), then the phase angle contribution of the term $(s+\alpha)$ is 90°.
- If the frequency of interest (ω) is <u>within a decade below or a decade above</u> the corner frequency (α), then the phase angle contribution of the term $(s+\alpha)$ must be calculated.
    - Example: given a term (s+300) that is part of an overall transfer function, if you are attempting to determine the phase angle of the Bode plot for any frequency below or equal to 30 rad/s, you may approximate the phase angle of the term (s+300) by 0°. Once you begin determining the magnitude of the Bode plot for frequencies above 30 rad/s and below 3000 rad/s, then you would calculate the exact phase angle of the term (s+300).
        - If you are evaluating the phase angle of the Bode plot at 100 rad/s, the phase angle contribution of the (s+300) term is $\tan^{-1}(100/300) = 18.43^\circ$.
        - If you are evaluating the phase angle of the Bode plot at 300 rad/s, the phase angle contribution of the (s+300) term is $\tan^{-1}(300/300) = 45^\circ$.
        - If you are evaluating the phase angle of the Bode plot at 1000 rad/s, the phase angle contribution of the (s+300) term is $\tan^{-1}(1000/300) = 73.3^\circ$.

      Once the frequency reaches one decade above the corner frequency (in this case 3000 rad/s) or beyond, then the phase angle contribution of the (s+300) term is 90°. This is the "final" phase contribution of this term.