

Rules for Drawing Bode Diagrams

The table below summarizes what to do for each type of term in a Bode Plot. This is also available as a [Word Document](#) or [PDF](#).
The table assumes $\omega_0>0$. If $\omega_0<0$, magnitude is unchanged, but phase is reversed.

Term	Magnitude	Phase
Constant: K	$20\log_{10}(K)$	K>0: 0° K<0: ±180°
Pole at Origin (Integrator) $\frac{1}{s}$	-20 dB/decade passing through 0 dB at $\omega=1$	-90°
Zero at Origin (Differentiator) s	+20 dB/decade passing through 0 dB at $\omega=1$ <i>(Mirror image, around x axis, of Integrator)</i>	+90° <i>(Mirror image, around x axis, of Integrator about)</i>
Real Pole $\frac{1}{\frac{s}{\omega_0} + 1}$	1. Draw low frequency asymptote at 0 dB. 2. Draw high frequency asymptote at -20 dB/decade. 3. Connect lines at ω_0 .	1. Draw low frequency asymptote at 0° 2. Draw high frequency asymptote at -90° 3. Connect with a straight line from $0.1\cdot\omega_0$ to $10\cdot\omega_0$
Real Zero $\frac{s}{\omega_0} + 1$	1. Draw low frequency asymptote at 0 dB. 2. Draw high frequency asymptote at +20 dB/decade. 3. Connect lines at ω_0 . <i>(Mirror image, around x-axis, of Real Pole)</i>	1. Draw low frequency asymptote at 0° 2. Draw high frequency asymptote at +90° 3. Connect with a straight line from $0.1\cdot\omega_0$ to $10\cdot\omega_0$ <i>(Mirror image, around x-axis, of Real Pole about 0°)</i>
Underdamped Poles (Complex conjugate poles) $\frac{1}{\left(\frac{s}{\omega_0}\right)^2 + 2\zeta\left(\frac{s}{\omega_0}\right) + 1}$ $0 < \zeta < 1$	1. Draw low frequency asymptote at 0 dB. 2. Draw high frequency asymptote at -40 dB/decade. 3. Connect lines at ω_0 . 4. If $\zeta<0.5$, then draw peak at ω_0 with amplitude H(j ω_0) =-20·log ₁₀ (2 ζ), else don't draw peak (it is very small).	1. Draw low frequency asymptote at 0° 2. Draw high frequency asymptote at -180° 3. Connect with straight line from $\omega = \frac{\omega_0}{10^\zeta}$ to $\omega_0 \cdot 10^\zeta$ <i>You can also look in a textbook for examples</i>
Underdamped Zeros (Complex conjugate zeros) $\left(\frac{s}{\omega_0}\right)^2 + 2\zeta\left(\frac{s}{\omega_0}\right) + 1$ $0 < \zeta < 1$	1. Draw low frequency asymptote at 0 dB. 2. Draw high frequency asymptote at +40 dB/decade. 3. Connect lines at ω_0 . 4. If $\zeta<0.5$, then draw peak at ω_0 with amplitude H(j ω_0) =+20·log ₁₀ (2 ζ), else don't draw peak (it is very small). <i>(Mirror image, around x-axis, of Underdamped Pole)</i>	1. Draw low frequency asymptote at 0° 2. Draw high frequency asymptote at +180° 3. Connect with straight line from $\omega = \frac{\omega_0}{10^\zeta}$ to $\omega_0 \cdot 10^\zeta$ <i>You can also look in a textbook for examples.</i> <i>(Mirror image, around x-axis, of Underdamped Pole)</i>

For multiple order poles and zeros, simply multiply the slope of the magnitude plot by the order of the pole (or zero) and multiply the high and low frequency asymptotes of the phase by the order of the system.

For example:

Second Order Real Pole $\frac{1}{\left(\frac{s}{\omega_0} + 1\right)^2}$	1. Draw low frequency asymptote at 0 dB 2. Draw high frequency asymptote at <i>-40</i> dB/decade 3. Connect lines at break frequency. <i>-40 db/dec is used because of order of pole=2. For a third order pole, asymptote is -60 db/dec</i>	1. Draw low frequency asymptote at 0° 2. Draw high frequency asymptote at <i>-180°</i> 3. Connect with a straight line from $0.1\cdot\omega_0$ to $10\cdot\omega_0$ <i>-180° is used because order of pole=2. For a third order pole, high frequency asymptote is at -270°.</i>
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