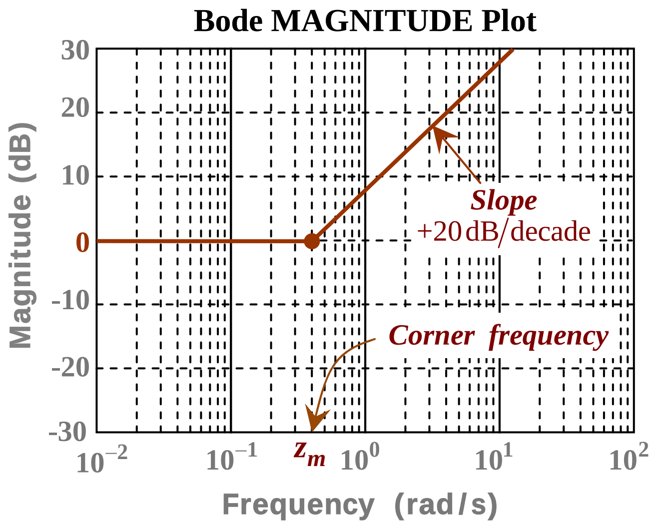
Question:

In almost all of the Bode plot questions, you always taught us that when there was change of 20 dB up then there is zero. How can we know whether the zero is on the left- or right-half of the s-plane?

Answer:

Foremost, frequency response (i.e. Bode plots) is meaningful only if the system is stable or marginally stable because the Fourier transform of the impulse response of an unstable system does not exist. Therefore, all the poles extracted from the Bode MAGNITUDE plot must NOT lie on the right-half of the s-plane. As for zeros, they can lie on both sides of the s-plane because they do not affect stability. In order to determine the location of the zero, with the corner frequency known, the Bode PHASE plot or the ZERO factor must be given. Without either of these it is not possible to determine the location of the zeros by just knowing the corner frequency.

The corner frequency z_m extracted from the Bode plot is always a positive value.



ZERO lying on the Left-Half of the s-plane

If the zero factor is given as

$$G_z(s) = \left(\frac{s}{z_m} + 1\right)$$

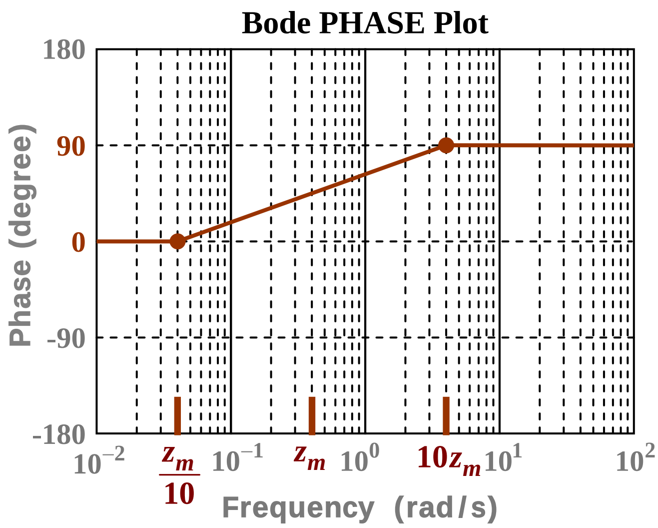
then the zero is located at

$$\underbrace{s = -z_m}_{\text{left-half of the s-plane}}$$

and the Bode phase plot is as shown in the figure on the right with

Low frequency asymptote: $\lim_{\omega \to 0} \tan^{-1}\left(\frac{\omega}{z_m}\right) = 0°$

High frequency asymptote: $\lim_{\omega \to \infty} \tan^{-1}\left(\frac{\omega}{z_m}\right) = 90°$



ZERO lying on the Right-Half of the s-plane

If the zero factor is given as

$$G_z(s) = \left(-\frac{s}{z_m} + 1\right)$$

then the zero is located at

$$\underbrace{s = z_m}_{\text{right-half of the s-plane}}$$

and the Bode phase plot is as shown in the figure on the right with

Low frequency asymptote: $\lim_{\omega \to 0} \tan^{-1}\left(-\frac{\omega}{z_m}\right) = 0°$

High frequency asymptote: $\lim_{\omega \to \infty} \tan^{-1}\left(-\frac{\omega}{z_m}\right) = -90°$