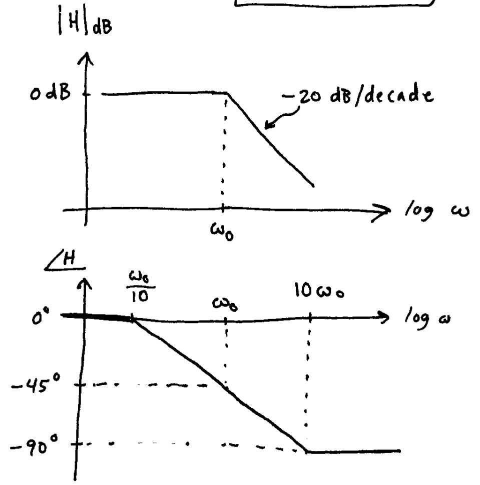
Bode plot guide — ECE 3110

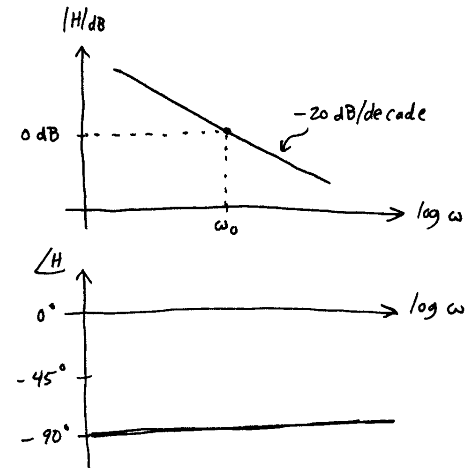
Pole at $s = \omega_0$

$$\boxed{H(s) = \frac{1}{\frac{s}{\omega_0} + 1}}$$



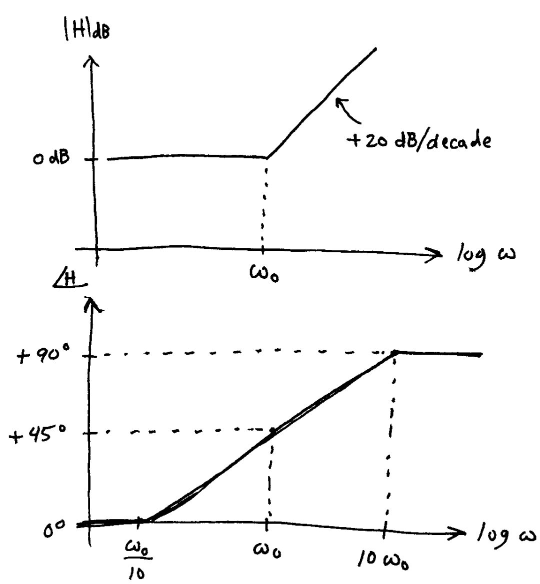
Pole at $s = 0$

$$\boxed{H(s) = \frac{1}{\frac{s}{\omega_0}} = \frac{\omega_0}{s}}$$



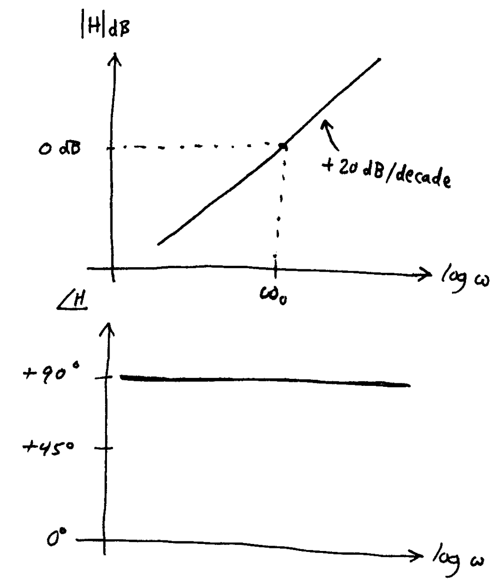
Zero at $s = \omega_0$

$$\boxed{H(s) = \frac{s}{\omega_0} + 1}$$



Zero at $s = 0$

$$\boxed{H(s) = \frac{s}{\omega_0}}$$

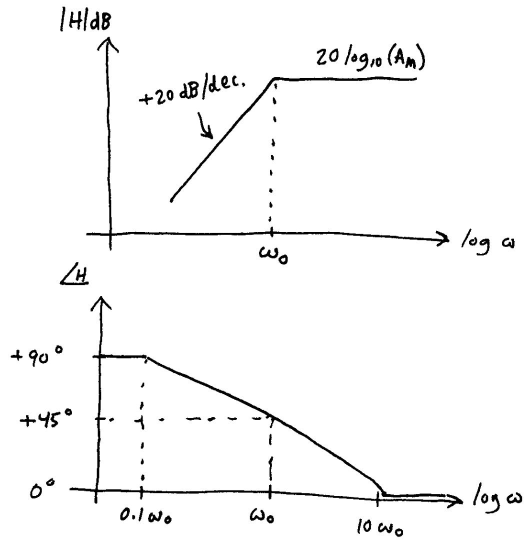


"Inverted" Poles and Zeros – ECE 3110

- "High-pass" or "ac coupled" circuits often yield transfer functions of the following form:

$$H(s) = A_M \frac{s}{s+\omega_0} = A_M \frac{\frac{s}{\omega_0}}{\frac{s}{\omega_0}+1} \quad \begin{array}{l} \leftarrow \text{zero at } s=0 \\ \leftarrow \text{pole at } s=\omega_0 \end{array}$$

where A_M is the midband gain. If we draw a Bode plot for this transfer function, we see:

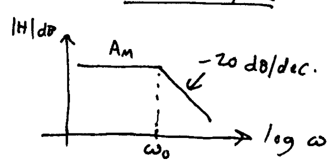


← Notice that this looks like the plot for a pole at $s=\omega_0$ if the plot is <u>inverted</u> on the frequency axis!

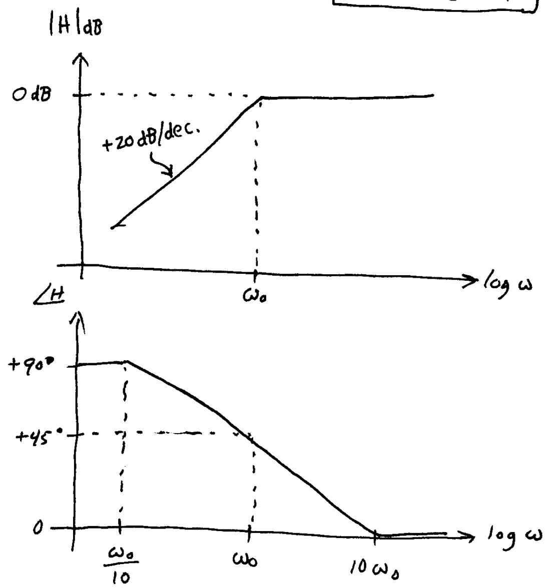
- Note that we can rewrite $H(s)$ as follows:

$$H(s) = A_M \frac{s}{s+\omega_0} \cdot \frac{\frac{\omega_0}{s}}{\frac{\omega_0}{s}} = \frac{A_M}{\underbrace{\frac{\omega_0}{s}+1}_{\text{we'll call this an inverted pole}}}$$

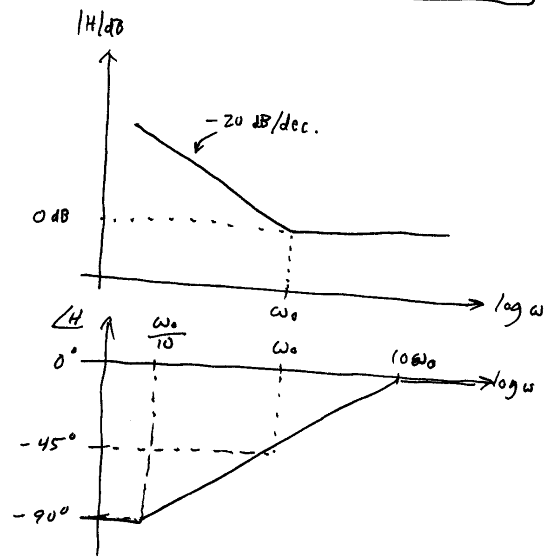
- Remember, a <u>normal pole</u> is: $H(s) = \dfrac{A_M}{\frac{s}{\omega_0}+1} \Rightarrow$



Inverted pole at $s = \omega_0$ $\boxed{H(s) = \frac{1}{\frac{\omega_0}{s} + 1}}$



Inverted zero at $s = \omega_0$ $\boxed{H(s) = \frac{\omega_0}{s} + 1}$



Example: $H(s) = \dfrac{s(s+10)\ \left(1 + \frac{s}{100{,}000}\right)}{\underbrace{(s+100)(s+25)}_{\text{troublesome part}}\underbrace{\left(1 + \frac{s}{10{,}000}\right)\left(1 + \frac{s}{40{,}000}\right)}_{\text{normal poles + zeros}}}$

Solution: Divide numerator + denominator by s^2:

$$H(s) = \frac{\left(1 + \frac{10}{s}\right) \qquad \left(1 + \frac{s}{100{,}000}\right)}{\underbrace{\left(1 + \frac{100}{s}\right)\left(1 + \frac{25}{s}\right)}_{\text{inverted poles + zeros!}}\ \underbrace{\left(1 + \frac{s}{10{,}000}\right)\left(1 + \frac{s}{40{,}000}\right)}_{\text{normal poles + zeros unchanged.}}}$$

← By inspection, $A_M = 1$