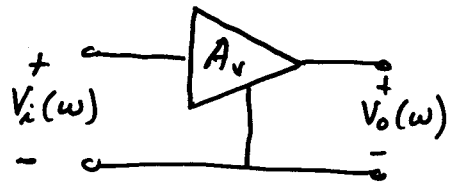
Frequency Domain Analysis of Amplifiers



$$A_v(\omega) = A_v(j\omega) = \frac{V_o(j\omega)}{V_i(j\omega)}$$

$$A_v(s) = \frac{V_o(s)}{V_i(s)} \quad \text{where } s = \sigma + j\omega$$

General frequency domain transfer function —

$$A_v(s) = \frac{N(s)}{D(s)} = \frac{a_m s^m + \cdots + a_1 s + a_0}{b_n s^n + \cdots + b_1 s + b_0} = K \frac{(s+z_1)(s+z_2)\cdots(s+z_m)}{(s+p_1)(s+p_2)\cdots(s+p_n)}$$

$m \le n$

Zeros : Values of s where $A_v(s) = 0$ i.e. $-z_1, -z_2, \cdots -z_m$

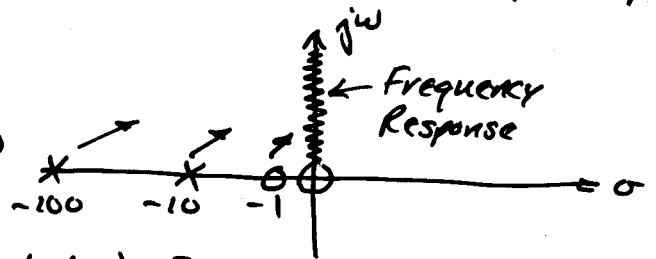
Poles : " " " " $A_v(s) = \infty$ i.e. $-p_1, -p_2, \cdots -p_n$

Example

$$A_v(s) = \frac{100\,s(s+1)}{(s+10)(s+100)}$$

$z_1 = 0$, $z_2 = -1$

$p_1 = -10$, $p_2 = -100$



$A_v(j\omega) = ?$

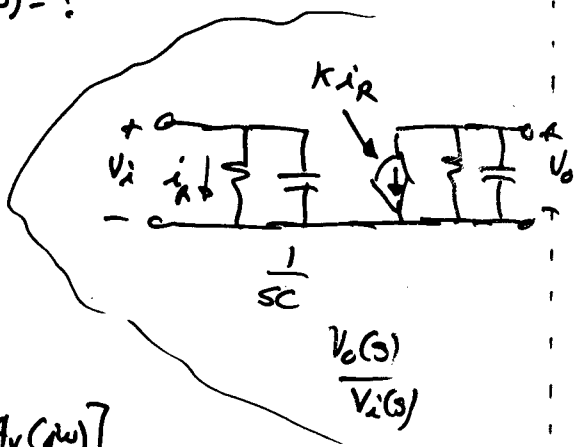
Frequency Response —

1.) Find $A_v(s)$

2.) Replace s by $j\omega$

3.) Magnitude of $A_v(j\omega)$ and the phase of $A_v(j\omega)$

4.) Plot $|A_v(j\omega)|$ and $\text{Arg}[A_v(j\omega)]$



Bode Plot —

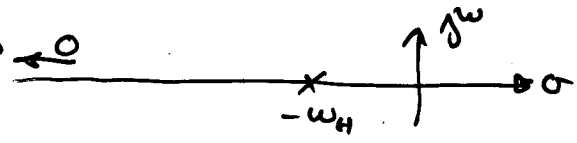
Plotting $A_v(j\omega)$ as

1.) $20\log_{10}[|A_v(j\omega)|$ as a function of $\log_{10}\omega$ or $\log_{10} f$

2.) $\text{Arg}[A_v(j\omega)]$ " " " " " " "

First-Order, Low-Pass Amplifier

$$A_v(s) = \frac{A_0 \omega_H}{s + \omega_H}$$



$s = j\omega$

$$A_v(j\omega) = \frac{A_0 \omega_H}{j\omega + \omega_H} = \frac{A_0}{1 + j\frac{\omega}{\omega_H}}$$

Magnitude:

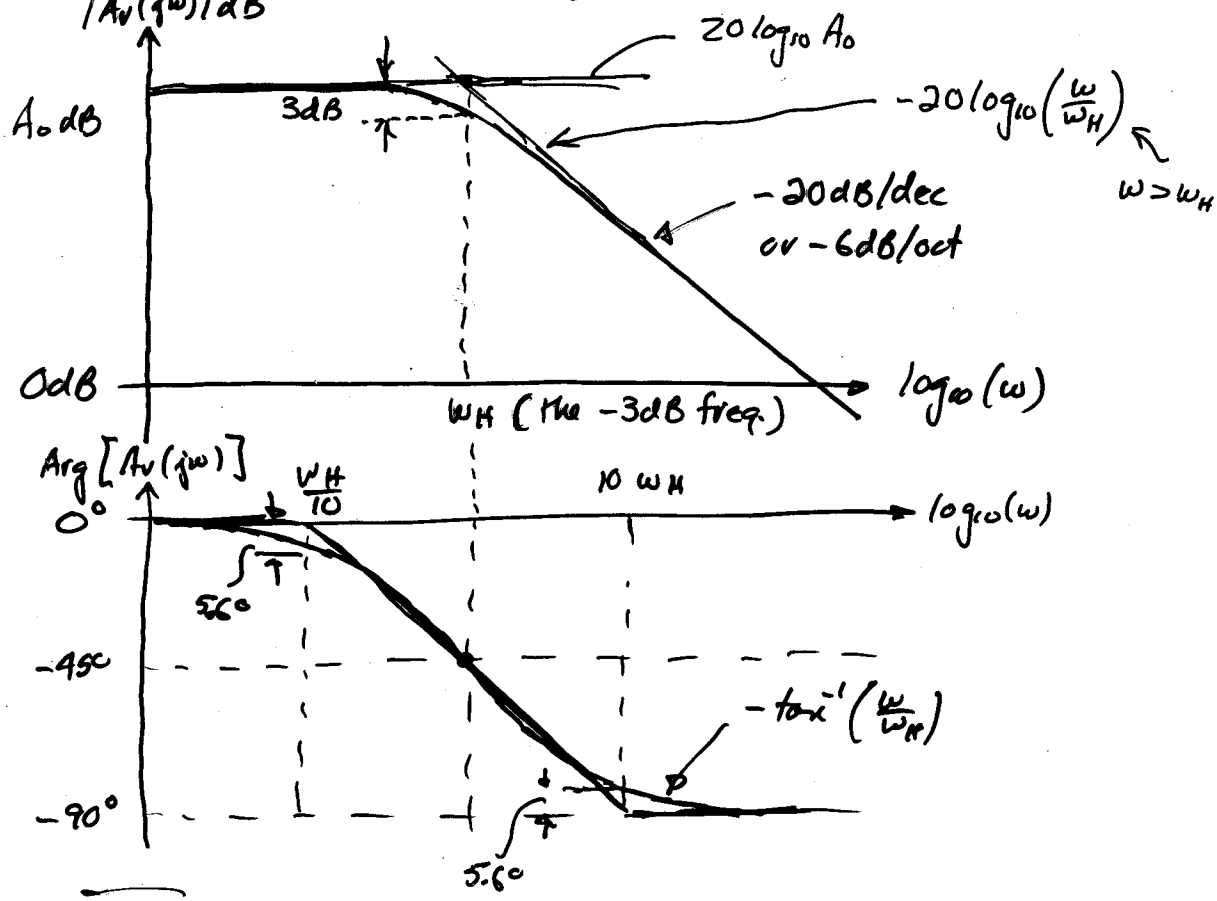
$$|A_v(j\omega)| = \frac{A_0}{\sqrt{1 + \left(\frac{\omega}{\omega_H}\right)^2}}$$

Phase:

$$\text{Arg}[A_v(j\omega)] = +\tan^{-1}\left(\frac{\omega}{\omega_H}\right)$$

Bode Plot:

$$|A_v(j\omega)|\ \text{dB} = 20\log_{10}\left[\frac{A_0}{\sqrt{1+(\omega/\omega_H)^2}}\right] = 20\log_{10} A_0 - 20\log_{10}\left[1+\left(\frac{\omega}{\omega_H}\right)^2\right]^{1/2}$$



$$A_v(s) = \frac{A_0 s}{s + \omega_L}$$ (High pass