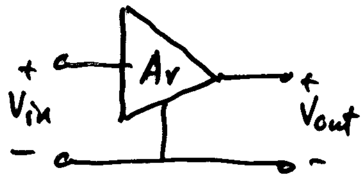
Bode Plots and Frequency Response

First-Order, High-Pass Amplifier



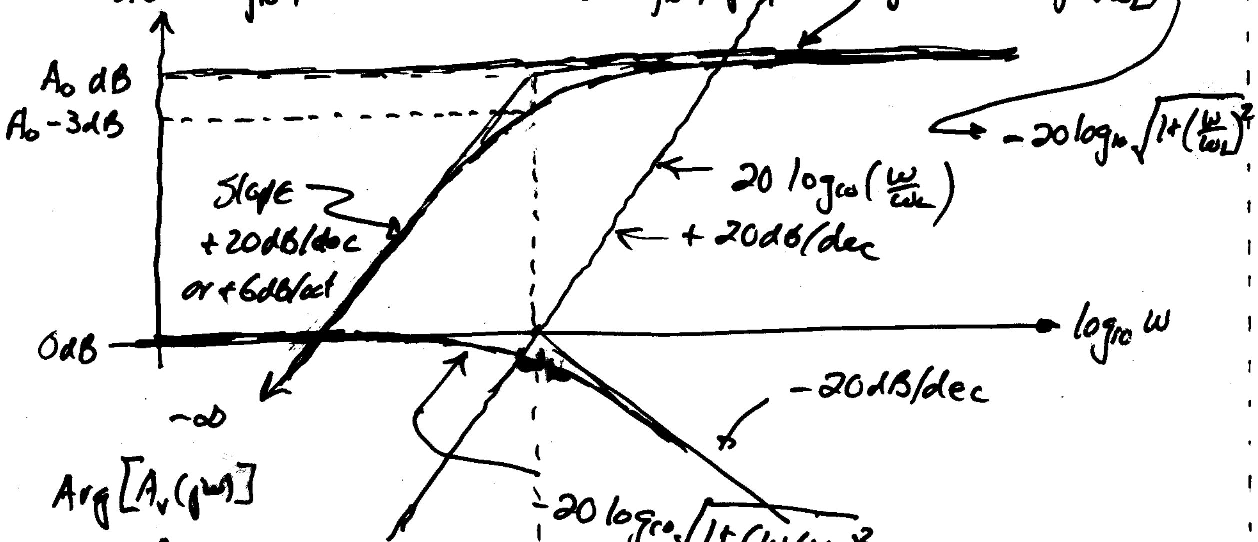
$$A_v(s) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{A_0\, s}{s+\omega_L}$$

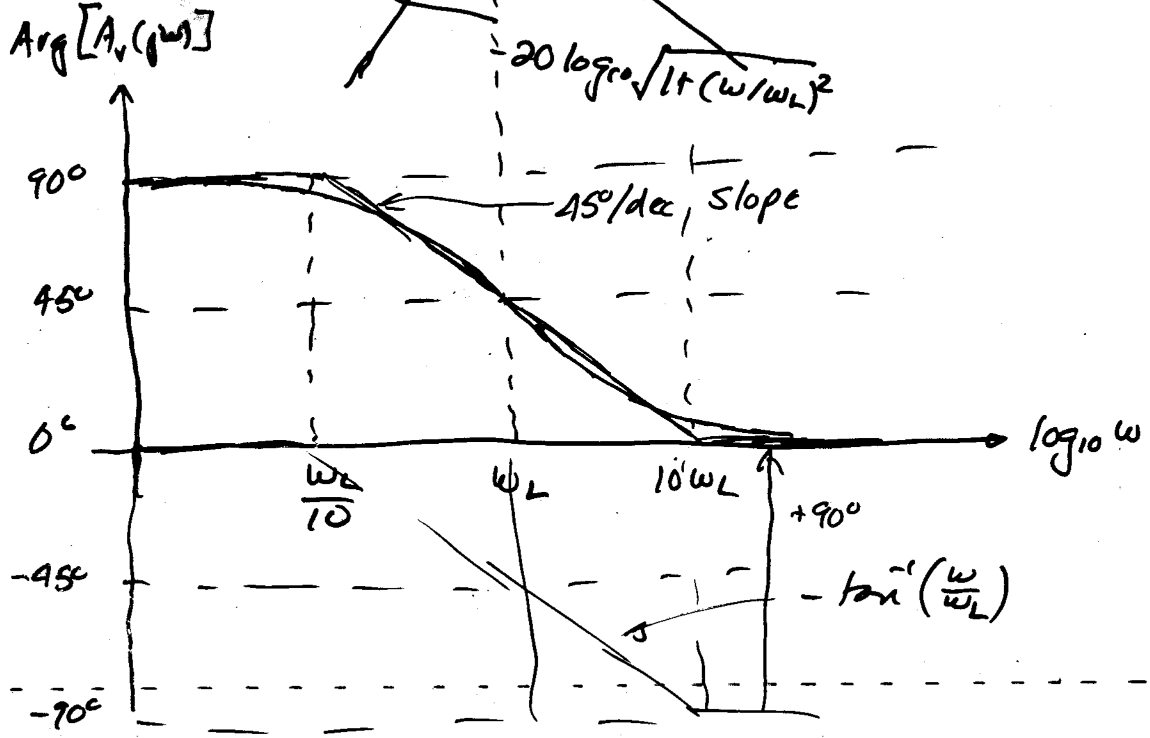
$$s \to j\omega \;\therefore\; A(j\omega) = \frac{A_0\, j\omega}{j\omega+\omega_L} = \frac{A_0\, j\frac{\omega}{\omega_L}}{1+j\frac{\omega}{\omega_L}}$$

$$|A(j\omega)| = \frac{A_0 \frac{\omega}{\omega_L}}{\sqrt{1+\left(\frac{\omega}{\omega_L}\right)^2}} \qquad \mathrm{Arg}\left[A(j\omega)\right] = 90^\circ - \tan^{-1}\left(\frac{\omega}{\omega_L}\right)$$

$$\to 20\log_{10}|A(j\omega)| = 20\log_{10} A_0 + 20\log_{10}\left(\frac{\omega}{\omega_L}\right) - 20\log_{10}\sqrt{1+\left(\frac{\omega}{\omega_L}\right)^2}$$

$dB = 20\log_{10} A$



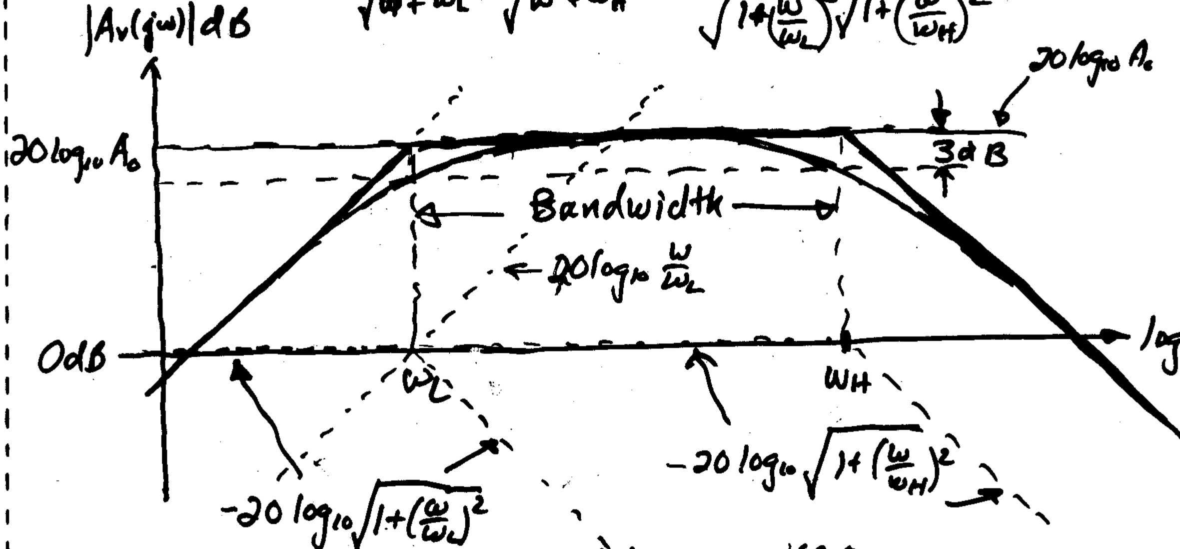


Bandpass Amplifier

$$A_v(s) = \left(\frac{A_o s}{(s+\omega_L)}\right)\left(\frac{\omega_H}{s+\omega_H}\right) = \frac{A_o s\,\omega_H}{(s+\omega_L)(s+\omega_H)} \rightarrow \frac{A_o s}{(s+\omega_L)\left(\frac{s}{\omega_H}+1\right)} = \frac{A_o \frac{s}{\omega_L}}{\left(\frac{s}{\omega_L}+1\right)\left(\frac{s}{\omega_H}+1\right)}$$

$\omega_H >> \omega_L$

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



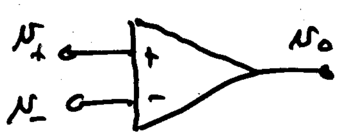
Practice Bode Plots?!!

$$\frac{1000\,s}{(s+1)(s+100)} = 10\left(\frac{s}{s+1}\right)\left(\frac{100}{s+100}\right)$$

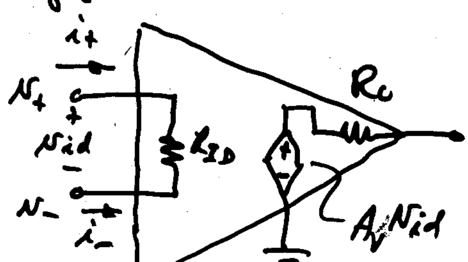
OP AMPS (operational amplifiers)

Def.– An op amp is a high gain amplifier intended to be used with negative feedback to define the transfer function.

Characteristics of an op amp:

1.) 

$\Rightarrow$

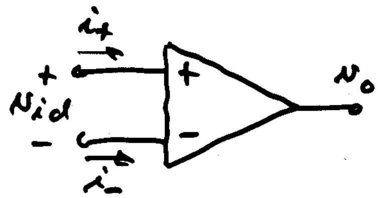


$= A\,v_{id}$

$(A \rightarrow \infty)$

2.) $A_v = A \rightarrow \infty$

Ideal Op Amp



An ideal op amp has

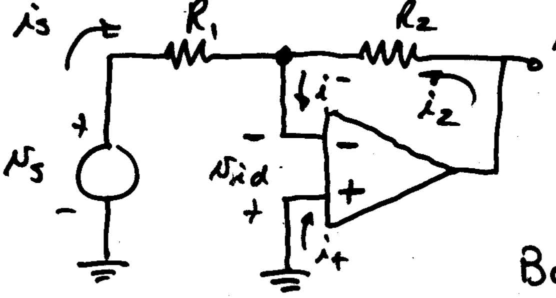
$v_{id} = 0$
and
$i_+ = i_- = 0$

All this happens because of 2 reasons,

1.) $A_v \rightarrow \infty$

2.) There is some form of −fb. from output back to input.

Inverting Voltage Amplifier



$v_o = -\frac{R_2}{R_1} v_s$

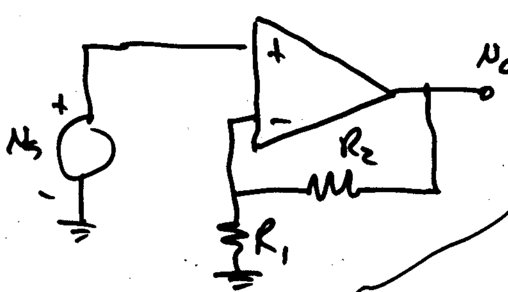
$\sum i \rightarrow i_s + i_2 = i^- = 0$

$\therefore i_s = -i_2$

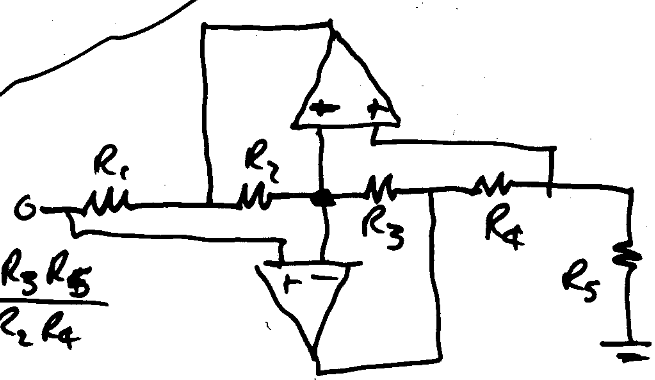
But, $i_s = \frac{v_s + \overset{0}{\cancel{v_{id}}}}{R_1} = \frac{v_s}{R_1}$

$i_2 = \frac{v_o + \overset{0}{\cancel{v_{id}}}}{R_2} = \frac{v_o}{R_2} \quad \therefore \quad \frac{v_s}{R_1} = -\frac{v_o}{R_2} \Rightarrow \boxed{v_o = -\frac{R_2}{R_1} v_s}$

Noninverting Voltage Amp.



$v_o = \left(\frac{R_1 + R_2}{R_1}\right) v_s$



$R_{in} = \frac{R_1 R_3 R_5}{R_2 R_4}$