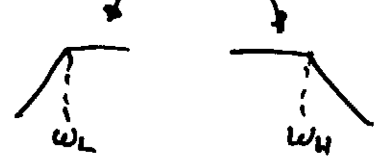
Bandpass Amplifiers – Wideband ($\omega_H >> \omega_L$)

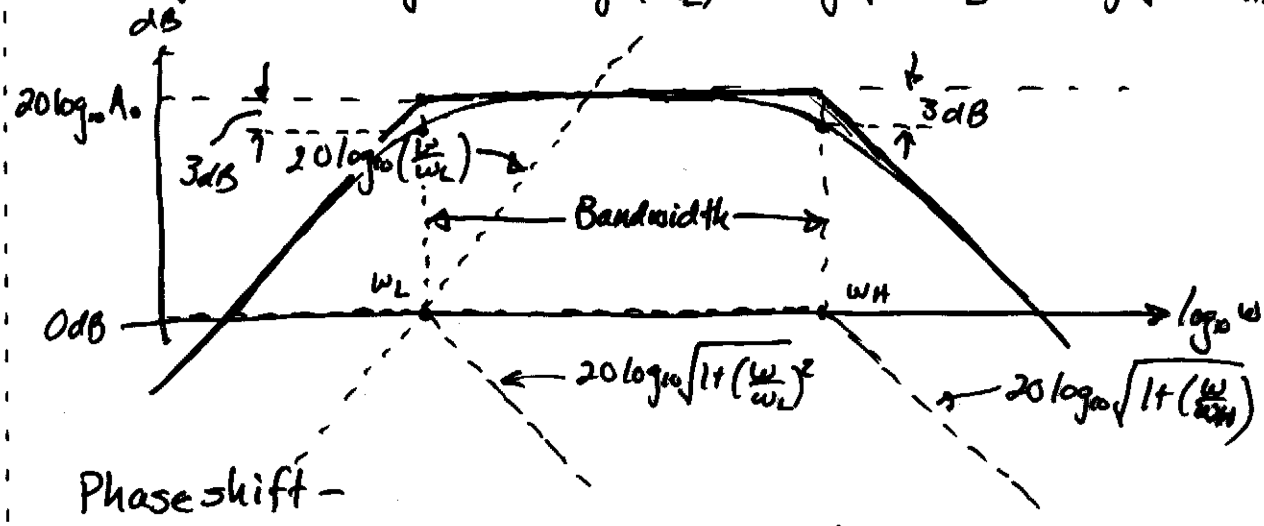
The simplest transfer function for a BP amp. $= A_v(s) = \pm A_0 \left(\frac{s}{s+\omega_L}\right)\left(\frac{\omega_H}{s+\omega_H}\right)$

$$A_v(j\omega) = \pm A_0 \left(\frac{j\frac{\omega}{\omega_L}}{1+j\frac{\omega}{\omega_L}}\right)\left(\frac{1}{1+j\frac{\omega}{\omega_H}}\right)$$



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

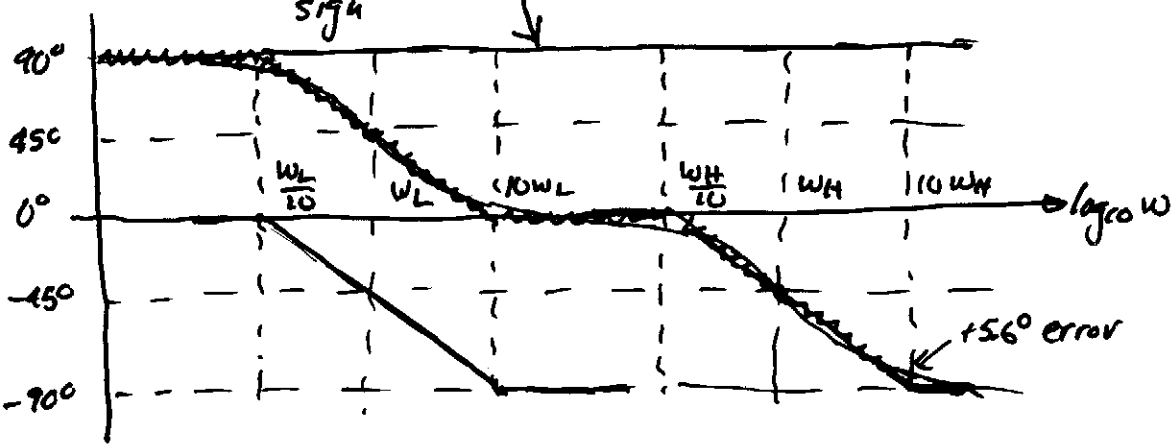
$$|A_v(j\omega)|\,dB = 20\log_{10} A_0 + 20\log_{10}\left(\frac{\omega}{\omega_L}\right) - 20\log_{10}\sqrt{1+\left(\frac{\omega}{\omega_L}\right)^2} - 20\log_{10}\sqrt{1+\left(\frac{\omega}{\omega_H}\right)^2}$$



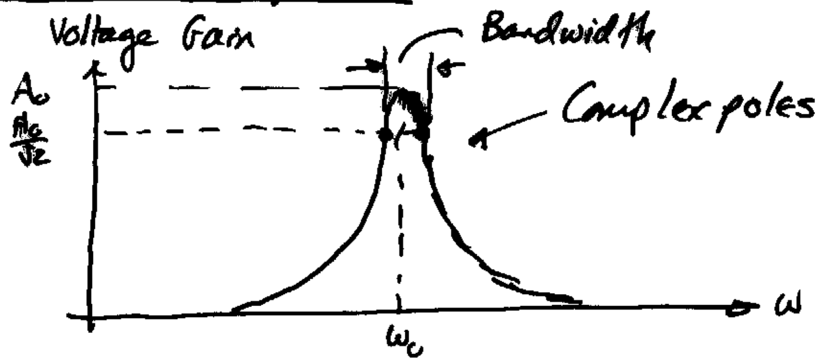
Phaseshift –

$$Arg[A_v(j\omega)] = \pm 180^\circ + 90^\circ - \tan^{-1}\left(\frac{\omega}{\omega_L}\right) - \tan^{-1}\left(\frac{\omega}{\omega_H}\right)$$

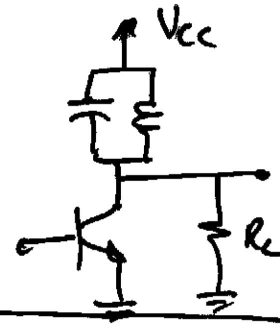
If minus sign



Narrowband Amplifiers

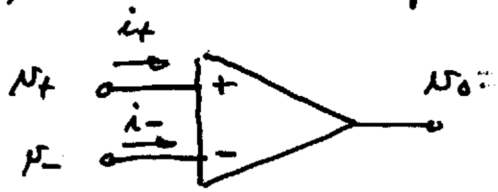


Complex poles → L's & C's



CHAPTER 12 – Operational Amplifiers (Op Amp)

1.) Differential Amplifier



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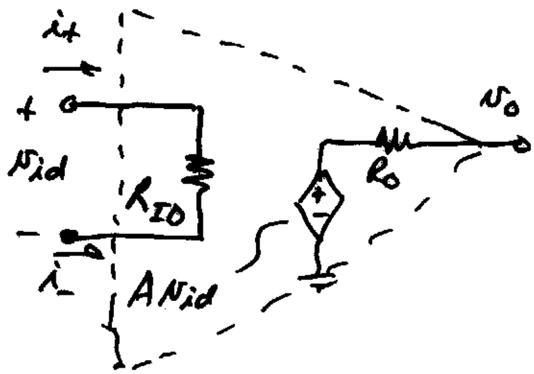
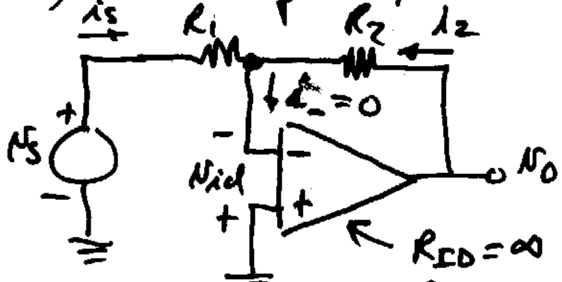


$v_{id} = v_+ - v_-$

2.) Ideal Op Amp

1.) $v_{id} = 0$, $i_+ = i_- = 0$ } Assume some form of negative feedback from the output back to the input.

3.) Inverting Amplifier – Assume op amp is ideal.



$R_{ID} = \infty$

$R_o = 0$

Gain = A = Large

$i_s = \frac{v_s + v_{id}}{R_1} \approx \frac{v_s}{R_1}$

$i_2 = \frac{v_o + v_{id}}{R_2} \approx \frac{v_o}{R_2}$

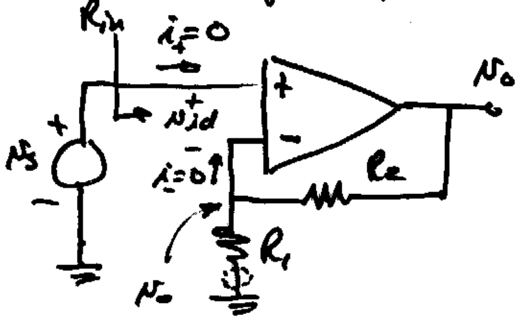
$i_s + i_2 = 0$

$\therefore \frac{v_o}{R_2} = -\frac{v_s}{R_1} \rightarrow \boxed{\frac{v_o}{v_s} = -\frac{R_2}{R_1}}$

$R_{in} = \frac{v_s}{i_s} = R_1$

$R_{out} = 0$

4.) Noninverting Amplifier



$$v_- = v_o \frac{R_1}{R_1+R_2}$$

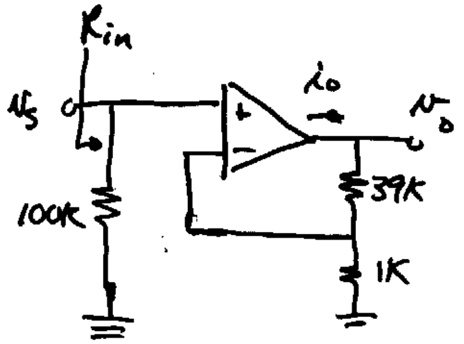
$$v_{id} = v_s - v_- = 0$$

$$v_s = v_o \frac{R_1}{R_1+R_2} \rightarrow \boxed{\frac{v_o}{v_s} = \frac{R_1+R_2}{R_1}}$$

$$\underline{\underline{R_{in} = \frac{v_s}{i_+} = \infty}} \qquad \underline{\underline{R_{out} = 0}}$$

5.) Example -

What is the voltage gain in dB and R_{in}? If $v_s = 0.25V$ what is v_o and i_o?



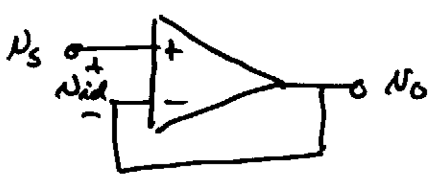
$$\frac{v_o}{v_s} = \frac{R_1+R_2}{R_1} = \frac{1K+39K}{1K} = 40 \rightarrow 10 \cdot 2 \cdot 2 \rightarrow \underline{\underline{32\,dB}}$$

$$R_{in} = 100K \| \infty = \underline{\underline{100K}}$$

$$\text{If } v_s = \tfrac{1}{4}V \rightarrow v_o = 10V \rightarrow i_o = \frac{v_o}{R_1+R_2} = \frac{10V}{40K} = \underline{\underline{0.25mA}}$$

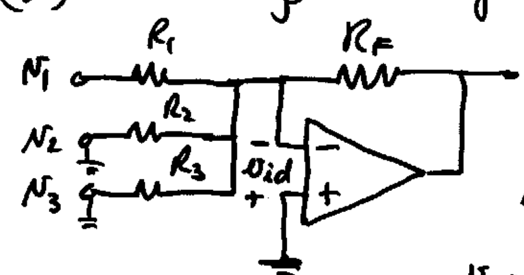
6.) Op Amp Circuits

(a.) +1 gain or buffer (voltage)



$$v_{id} = v_s - v_o = 0 \rightarrow \underline{\underline{v_o = v_s}}$$

(b.) Summing, inverting amplifier

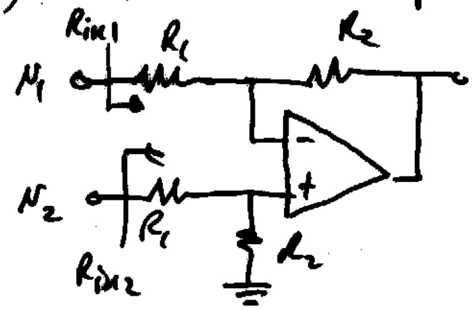


$$v_o = v_o\Big|_{v_2=v_3=0} + v_o\Big|_{v_1=v_3=0} + v_o\Big|_{v_2=v_3=0}$$

$$v_o = -\frac{R_F}{R_1}v_1 - \frac{R_F}{R_2}v_2 - \frac{R_F}{R_3}v_3$$

$$v_o = -R_F\left(\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3}\right)$$

(c.) Difference Amplifier



$$v_o = \frac{R_2}{R_1}(v_1 - v_2)$$

$R_{in1} = R_1$

$R_{in2} = R_1 + R_2$