Continue Chapter 11

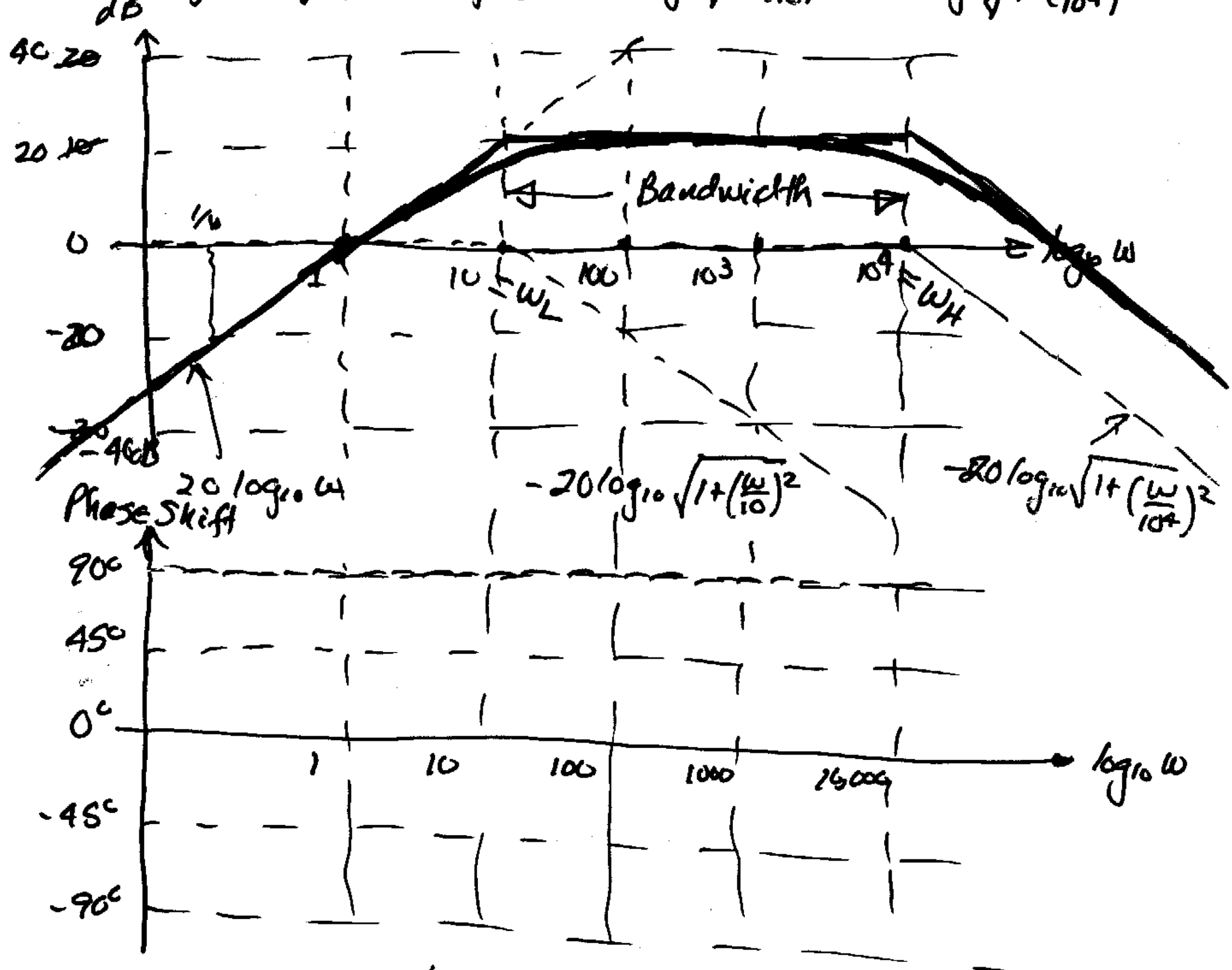
1.) Bandpass

$$A_v(s) = \frac{A_o s}{s+\omega_L} \times \frac{\omega_H}{s+\omega_H} \xrightarrow{\text{Assume}} A_v(s) = \frac{-10\, s\, 10^4}{(s+10)(s+10^4)}$$

Plot the magnitude and phase -

$$A_v(j\omega) = \frac{-10^5\, j\omega}{(j\omega+10)(j\omega+10^4)} = \frac{j\frac{\omega}{1}}{\left(1+j\frac{\omega}{10}\right)\left(1+j\frac{\omega}{10^4}\right)} k$$

$$20\log_{10}|A_v(j\omega)| = 20\log_{10}(\omega) - 20\log_{10}\sqrt{1+\left(\frac{\omega}{10}\right)^2} - 20\log_{10}\sqrt{1+\left(\frac{\omega}{10^4}\right)^2}$$

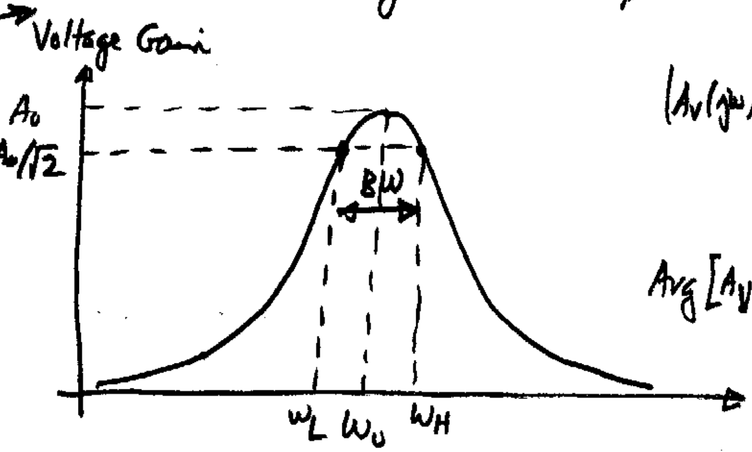


$$Arg[A_v(j\omega)] = \pm\cancel{180}^\circ + 90^\circ - \tan^{-1}\left(\frac{\omega}{10}\right) - \tan^{-1}\left(\frac{\omega}{10^4}\right)$$

9/04/02

Lecture 6 – Frequency Response Continued

1.) Narrow-Band or High-Q Bandpass Amplifier



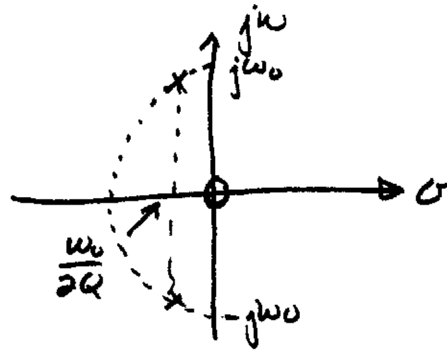
$$|A_v(j\omega)| = \frac{\frac{1}{Q}\frac{\omega}{\omega_0}}{\sqrt{\left[1-\left(\frac{\omega}{\omega_0}\right)^2\right]^2+\left(\frac{\omega}{Q\omega_0}\right)^2}}$$

$$\mathrm{Arg}\left[A_v(j\omega)\right] = \pm 180^\circ + 90^\circ - \tan^{-1}\left[\frac{\omega\omega_0}{Q(\omega_0^2-\omega^2)}\right]$$

$$= \pm 180^\circ + 90^\circ - \tan^{-1}\left[\frac{\omega/\omega_0 Q}{1-\left(\frac{\omega}{\omega_0}\right)^2}\right]$$

Complex Poles –

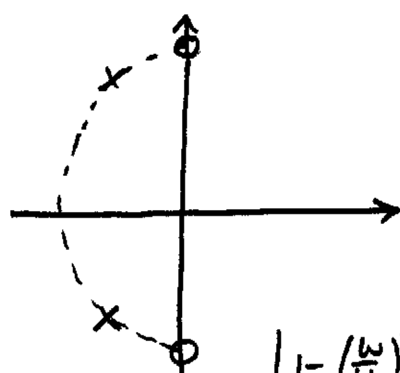
$$A_v(s) = A_0 \frac{s\frac{\omega_0}{Q}}{s^2+\frac{\omega_0}{Q}s+\omega_0^2}$$

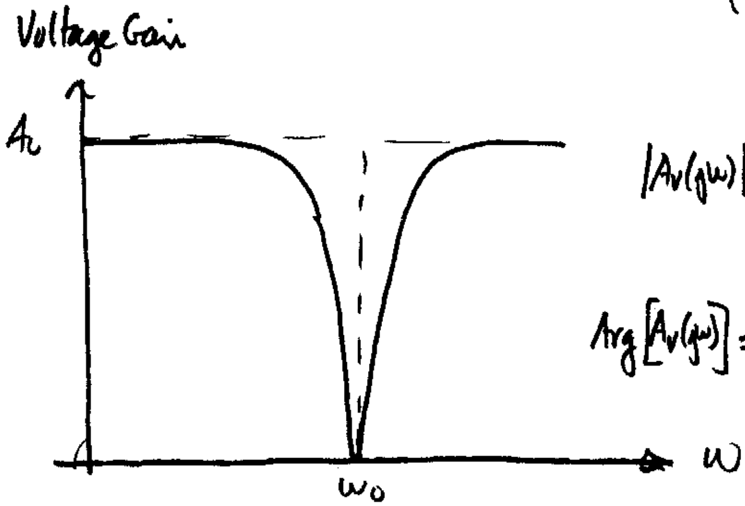


2.) Band-Rejection Amplifiers

$j\omega$ axis zeros

$$A_v(s) = A_0 \frac{s^2+\omega_0^2}{s^2+\frac{\omega}{Q}s+\omega_0^2}$$





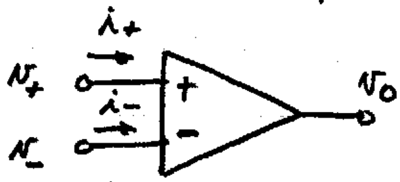
$$|A_v(j\omega)| = \frac{\left|1-\left(\frac{\omega}{\omega_0}\right)^2\right|}{\sqrt{\left(1-\left(\frac{\omega}{\omega_0}\right)^2\right)^2+\left(\frac{\omega}{\omega_0 Q}\right)^2}}$$

$$\mathrm{Arg}\left[A_v(j\omega)\right] = \angle A_0 + \angle(\omega_0^2-\omega^2) - \tan^{-1}\left[\frac{\frac{\omega}{\omega_0 Q}}{1-\left(\frac{\omega}{\omega_0}\right)^2}\right]$$

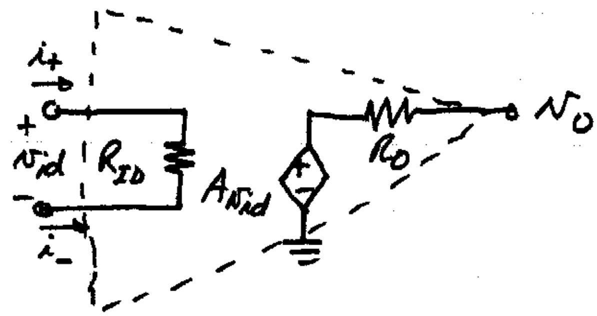
9/4/02

LECTURE 7 – OPERATIONAL AMPLIFIERS (OP AMPS)

1.) Differential Amplifier



$\Longrightarrow$



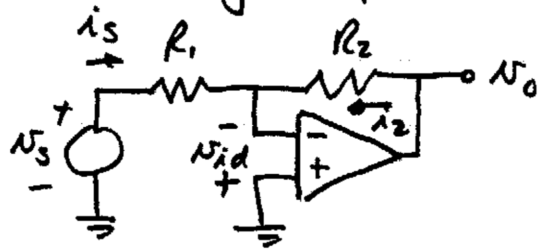
$v_{id} = v_+ - v_-$

2.) Ideal Op Amp

1.) $v_{id} = 0$

2.) $i_+ = i_- = 0$

3.) Inverting Amplifier



$i_s = \dfrac{v_s + v_{id}}{R_1} = \dfrac{v_s}{R_1}$

$i_2 = \dfrac{v_o + v_{id}}{R_2} = \dfrac{v_o}{R_2}$

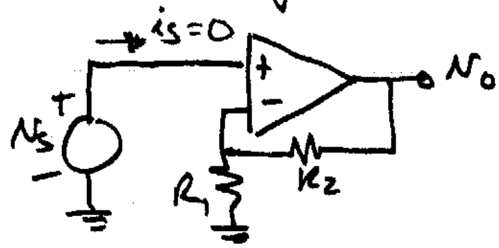
$i_s + i_2 = 0$

$R_{in} = \dfrac{v_s}{i_s} = \dfrac{v_s}{v_s/R_1} = \underline{R_1}$

$\therefore \quad \dfrac{v_o}{R_2} = -\dfrac{v_s}{R_1} \rightarrow \underline{\dfrac{v_o}{v_s} = -\dfrac{R_2}{R_1}}$

$R_{out} = \underline{0}$ (because $R_o = 0$)

4.) Noninverting Amplifier

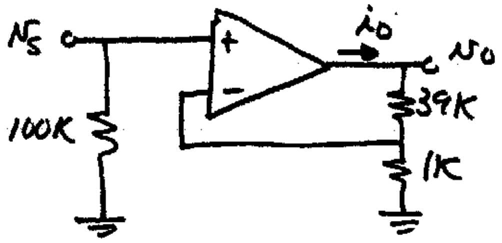


$v_+ = v_s$ & $v_- = v_o \dfrac{R_1}{R_1 + R_2}$

but $v_+ = v_-$ so $\underline{v_o = \dfrac{R_1 + R_2}{R_1} v_s}$

$R_{in} = \dfrac{v_s}{i_s} = \underline{\infty}$ $\quad R_{out} = \underline{0}$

5.) Example – What is the voltage gain in dB and R_{in}?
If $v_S = 0.25V$, what is v_o and i_o?



$v_o = \frac{R_1+R_2}{R_1} v_S = 40\, v_S$

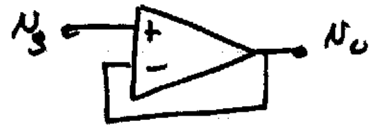
$A_V = 40 \rightarrow$ <u>32dB</u>

$R_{in} =$ <u>100KΩ</u>

$v_S = \frac{1}{4}V \rightarrow v_o =$ <u>10V</u> and $i_o = \frac{10}{40K} =$ <u>0.25mA</u>

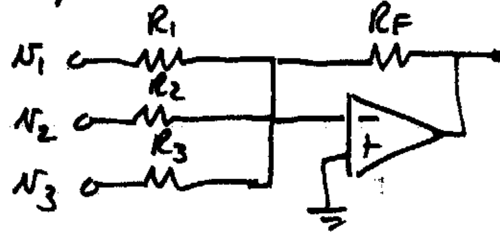
6.) Op Amp Circuits

a.) Buffer



$\frac{v_o}{v_S} = 1$

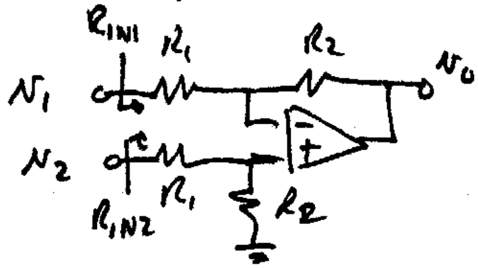
b.) Summing Amplifier



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

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

c.) Difference Amplifier



$v_+ = \frac{v_2 R_2}{R_1+R_2}$

$v_- = \frac{v_1 R_2}{R_1+R_2} + v_o \frac{R_1}{R_1+R_2}$

$\therefore \quad v_o \frac{R_1}{R_1+R_2} = \frac{v_2 R_2}{R_1+R_2} - \frac{v_1 R_2}{R_1+R_2} \rightarrow$ <u>$v_o = \frac{R_2}{R_1}(v_2 - v_1)$</u>

$R_{IN1} = R_1$ and $R_{IN2} = R_1 + R_2$