Quiz 2 - Friday, Sept. 3

Topics: Two port parameters, s-domain analysis, Bode plots

IDEAL OP AMP CIRCUITS ($A_{vd} = A_o \to \infty$)

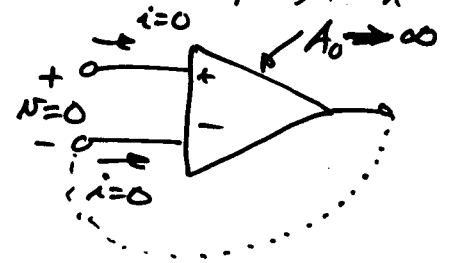
Nonideal aspects of an op amp

1.) $A_v \neq \infty$

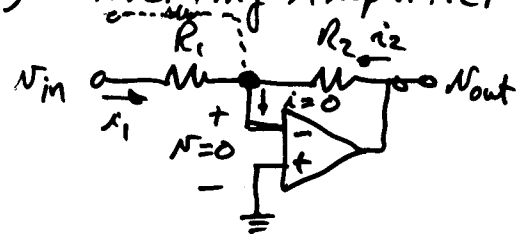
2.) $BW \neq \infty$

3.) $R_{id} \neq \infty$ and $R_o \neq 0$

If $A \to \infty$, and if a signal path exists from the output back to the input, then



1.) Inverting Amplifier



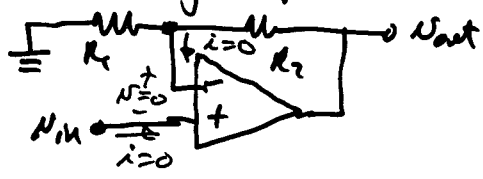
$$i_1 = \frac{v_{in} - v}{R_1} = \frac{v_{in} - 0}{R_1} = \frac{v_{in}}{R_1} \quad \to \quad R_{in} = \frac{v_1}{i_1} = R_1$$

$$i_2 = \frac{v_{out} - v}{R_2} = \frac{v_{out} - 0}{R_2} = \frac{v_{out}}{R_2}$$

$$i_1 + i_2 + i = 0 \quad \to \quad i_1 + i_2 + 0 = 0 \quad \to \quad i_1 = -i_2$$

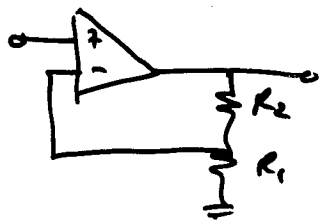
$$\frac{v_{in}}{R_1} = -\frac{v_{out}}{R_2} \quad \to \quad \boxed{\frac{v_{out}}{v_{in}} = -\frac{R_2}{R_1} = -\frac{Z_2(s)}{Z_1(s)}}$$

2.) Noninverting Amplifier

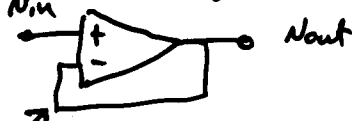


$$v = v_{in} - \frac{R_1}{R_1 + R_2} v_{out} = 0$$

$$\boxed{\frac{v_{out}}{v_{in}} = \frac{R_1 + R_2}{R_1} = \frac{Z_1 + Z_2}{Z_1}}$$

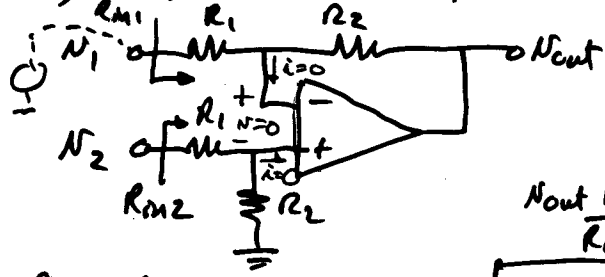


$R_2 = 0$ & $R_1 = \infty$



"Buffer" $\quad \frac{v_{out}}{v_{in}} = 1$

3.) Difference Amplifier

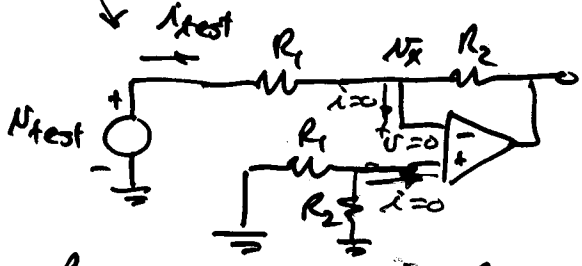


$$V = \left(V_{out}\frac{R_1}{R_1+R_2} + \frac{R_2}{R_1+R_2}V_1\right) - \frac{R_2}{R_1+R_2}V_2 = 0$$

$$V_{out}\frac{R_1}{R_1+R_2} = \frac{R_2}{R_1+R_2}V_2 - \frac{R_2}{R_1+R_2}V_1$$

$R_{in1} = R_1$

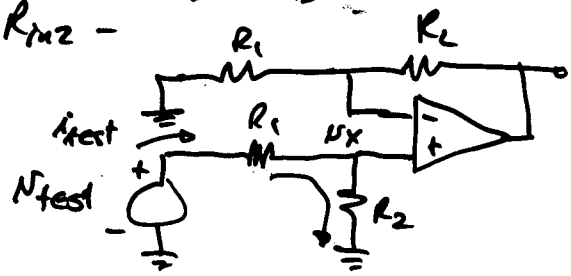
$$\therefore \boxed{V_{out} = \frac{R_2}{R_1}(V_2 - V_1)}$$



$$i_{test} = \frac{V_{test} - V_x}{R_1} = \frac{V_{test}}{R_1} \quad (V_x \to 0)$$

$$R_i = \frac{V_{test}}{i_{test}} = R_1$$

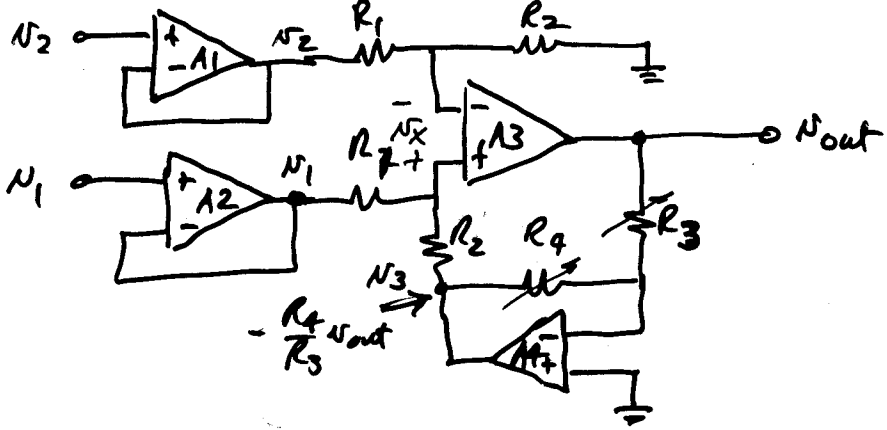
R_{in2} –



$$V_{test} = i_{test}(R_1 + R_2)$$

$$\therefore R_{in2} = R_1 + R_2$$

4.) Instrumentation Amplifier



$$V_x = V_1\frac{R_2}{R_1+R_2} + V_3\frac{R_1}{R_1+R_2} - V_2\frac{R_2}{R_1+R_2} = 0$$

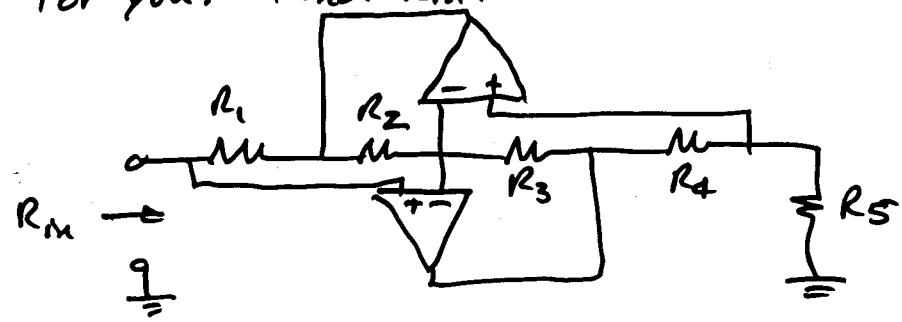
$$V_3\frac{R_1}{R_1+R_2} = \frac{R_2}{R_1+R_2}V_2 - \frac{R_2}{R_1+R_2}V_1 = \frac{R_2}{R_1+R_2}(V_2 - V_1)$$

Cont'd

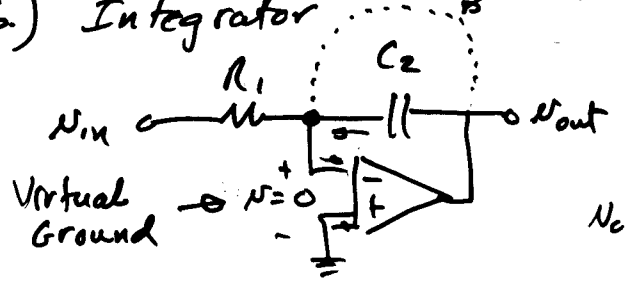
$$V_3 = \frac{R_2}{R_1}(V_2 - V_1) \rightarrow V_{out} = -\frac{R_4}{R_3}V_3 = -\frac{R_4}{R_3}\frac{R_2}{R_1}(V_2 - V_1)$$

$$\boxed{V_{out} = +\frac{R_2 R_4}{R_1 R_3}(V_1 - V_2)} = K(V_1 - V_2)$$

5) For you. Find R_{in}.



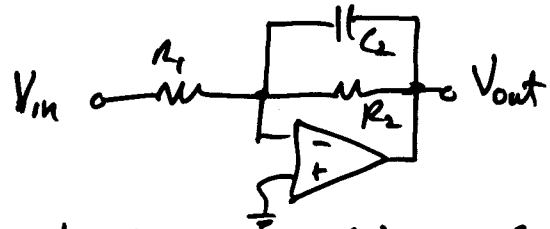
6) Integrator ..... DC problems



$$\frac{V_{in}}{R_1} + C_2\frac{dV_{out}}{dt} = 0$$

$$V_{out} = -\frac{1}{R_1 C_2}\int V_{in}\,dt$$

7.) Low pass filter



$$Z_2(s) = \frac{R_2\frac{1}{sC_2}}{R_2 + \frac{1}{sC_2}} = \frac{R_2}{sR_2C_2 + 1}$$

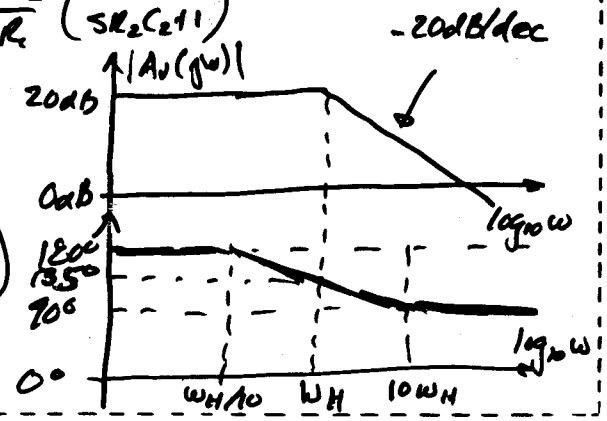
$$Z_1(s) = R_1$$

$$\frac{V_{out}(s)}{V_{in}(s)} = -\frac{Z_2(s)}{Z_1(s)} = -\frac{R_2}{R_1}\left(\frac{1}{sR_2C_2 + 1}\right)$$

If $\omega_H = \frac{1}{R_2C_2}$

then

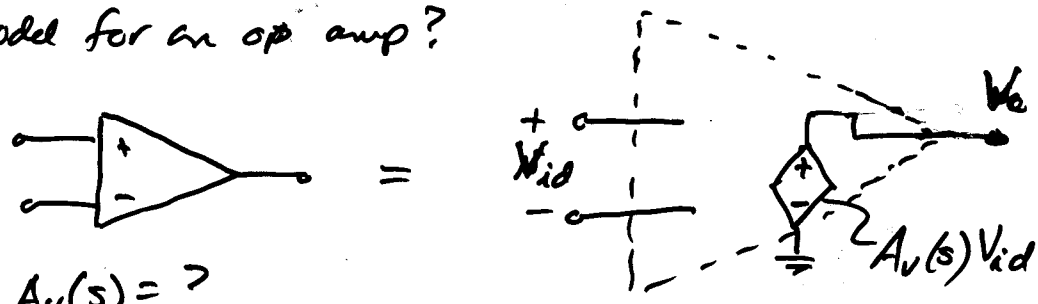
$$\frac{V_{out}(s)}{V_{in}(s)} = A_v(s) = -\frac{R_2}{R_1}\left(\frac{1}{\frac{s}{\omega_H} + 1}\right)$$



NONIDEAL OP AMPS

1.) $A_0 \neq \infty$ } 3050
2.) $BW \neq \infty$ }
3.) Resistances not ideal

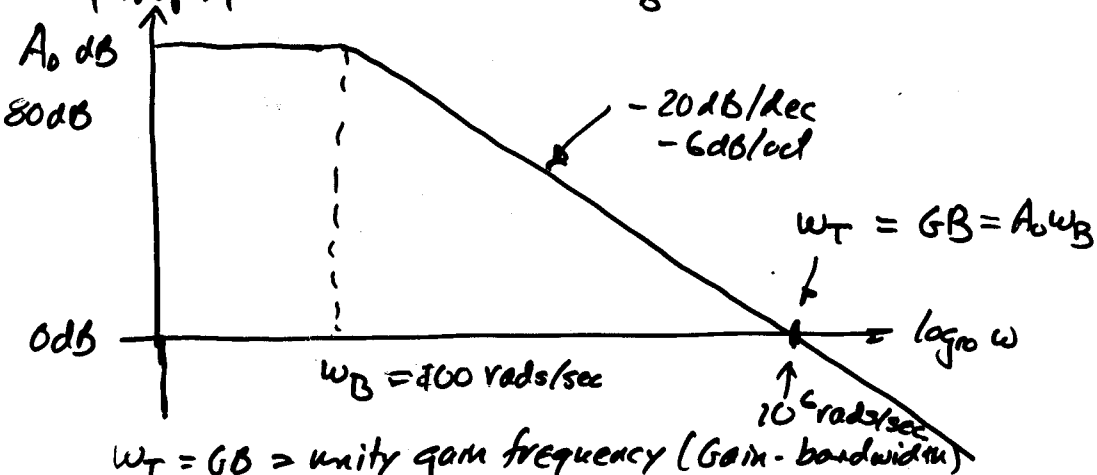
Model for an op amp?



$A_V(s) = ?$

1.) $A_V(s) = A_0$

2.) $A_V(s) = A_0 \frac{\omega_B}{s + \omega_B} = \frac{A_0}{\frac{s}{\omega_B} + 1}$



$\omega_T = GB$ = unity gain frequency (Gain-bandwidth)

1.) The noninverting amplifier when $A_V(s) = \frac{A_0}{\frac{s}{\omega_B} + 1}$

(To be continued)