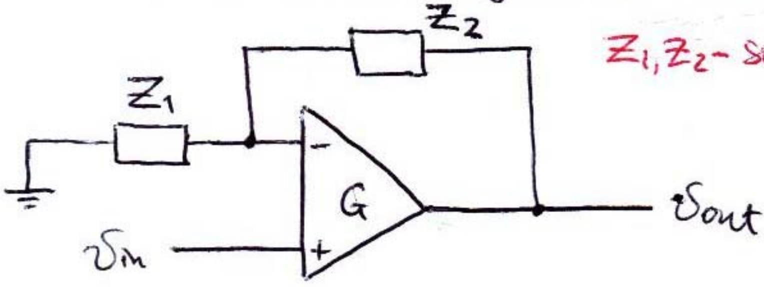
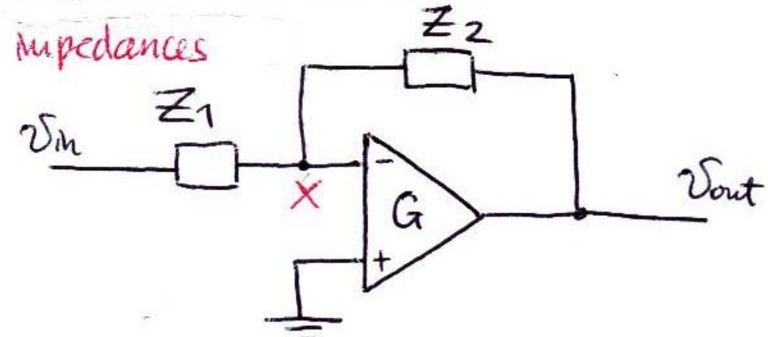
P3360/AEP 3630

Lecture 11

Two basic configurations with negative feedback

Z_1, Z_2 - some impedances





"noninverting" $v_{in} = v_+$

Same as what we looked @ during last lecture.

"closed loop gain": $G_{CL} \equiv \dfrac{v_{out}}{v_{in}}$

$$G_{CL} = \frac{G}{1+GH} = \frac{1}{H}\,\frac{1}{1+\frac{1}{GH}}$$

$$G_{CL} \approx \frac{1}{H} \text{ if } |GH| \gg 1$$

"neg. F.B. transfer fcn": $H = \dfrac{v_-}{v_{out}}$

$$H = \frac{Z_1}{Z_1+Z_2}$$

"loop gain": gain for signal going around a closed loop

GH - very important for stability (next lecture)

"inverting", $v_{in} \rightarrow v_-$

1) $$v_x = v_{in}\frac{Z_2}{Z_1+Z_2} + v_{out}\frac{Z_1}{Z_1+Z_2}$$

(superposition)

2) $$v_{out} = G(v_+ - v_-) = G(0 - v_x)$$

3) $$\Rightarrow G_{CL} = \frac{v_{out}}{v_{in}} = -\frac{GZ_2}{GZ_1+Z_1+Z_2}$$

4) introduce

$$H' = \frac{Z_1}{Z_2},\ \Rightarrow G_{CL} = -\frac{1}{H'}\,\frac{1}{1+\frac{1}{GH}}$$

"closed loop gain"

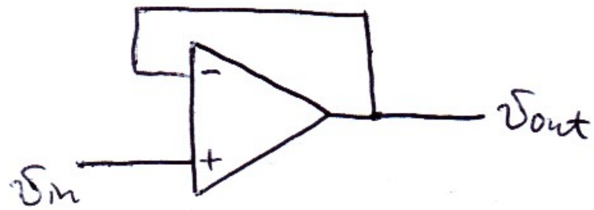
$$G_{CL} = -\frac{1}{H'}\,\frac{1}{1+\frac{1}{GH}}$$

$$G_{CL} \approx -\frac{1}{H'} \text{ if } |GH| \gg 1$$

"loop gain" GH

Applications of neg. feedback

1 voltage follower (amplifying buffer)



$\xrightarrow{\text{volt. rule}}$ v_{in} ——— v_{out}

alt. method $G_{CL} = \dfrac{G}{1+GH} \approx 1$, $G \gg 1$

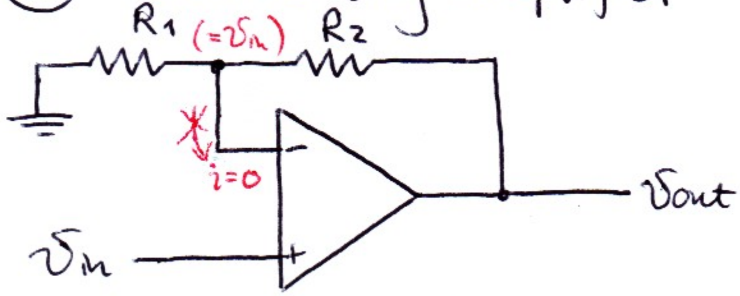
741: $G \sim 10^5$, $R_{in} \sim M\Omega$, $R_{out} \sim 80\Omega$

$$R_{in,CL} = R_{in}(1+(1)G) \approx 10^{11}\Omega$$

$$R_{out,CL} = \frac{R_{out}}{1+(1)G} \approx 10^{-3}\Omega$$

- draws no current (no loading)
- drive low Z load with high Z source (power gain)

2 noninverting amplifier



$v_- = v_{in}$ (volt. rule)

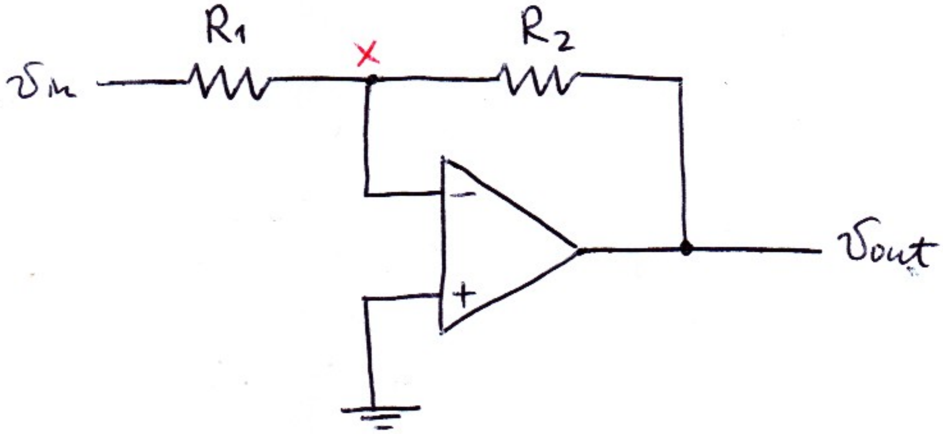
$H = \dfrac{R_1}{R_1+R_2}$, $\Rightarrow$

$$\boxed{G_{CL} = \frac{R_1+R_2}{R_1}}$$

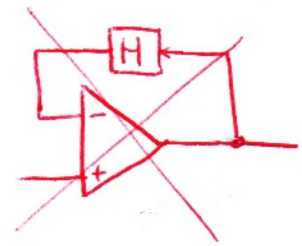
$R_{in,CL} = R_{in}(1+GH)$ is large

$R_{out,CL} = \dfrac{R_{out}}{1+GH}$ is very small

③ inverting amplifier



Note: cannot use



"x" - virtual ground (0V, by volt. rule); $H' = \frac{R_1}{R_2}$

$$\Rightarrow \boxed{G_{CL} = -\frac{1}{H'} = -\frac{R_2}{R_1}}$$

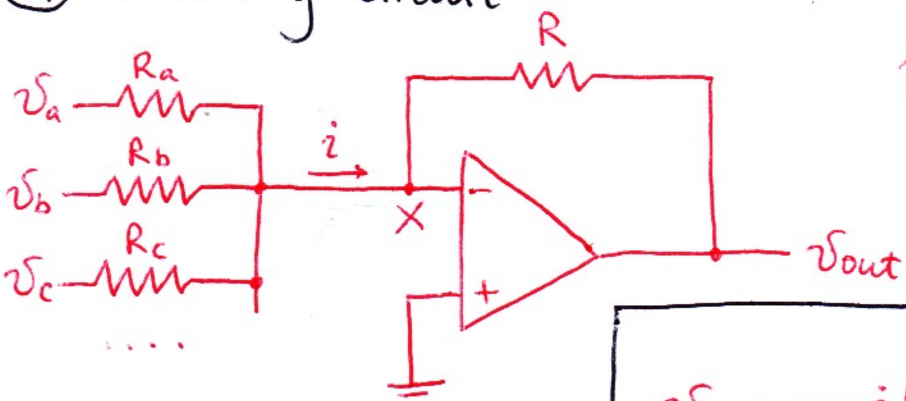
Q: input impedance ?

A: $R_{in,CL} \equiv \frac{v_{in}}{i_{in}}$; $i_{in} = \frac{v_{in} - 0V}{R_1}$ (0V: virt. ground), $\Rightarrow \boxed{R_{in,CL} = R_1}$

Q: output impedance ?

⇒ HW problem (it's small)

④ summing circuit



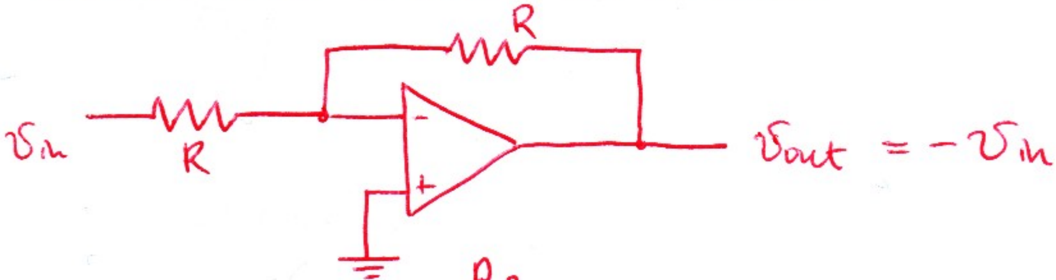
"X" - virtual ground

$$i = i_a + i_b + i_c + \ldots$$
$$= \frac{v_a}{R_a} + \frac{v_b}{R_b} + \frac{v_c}{R_c} + \ldots$$

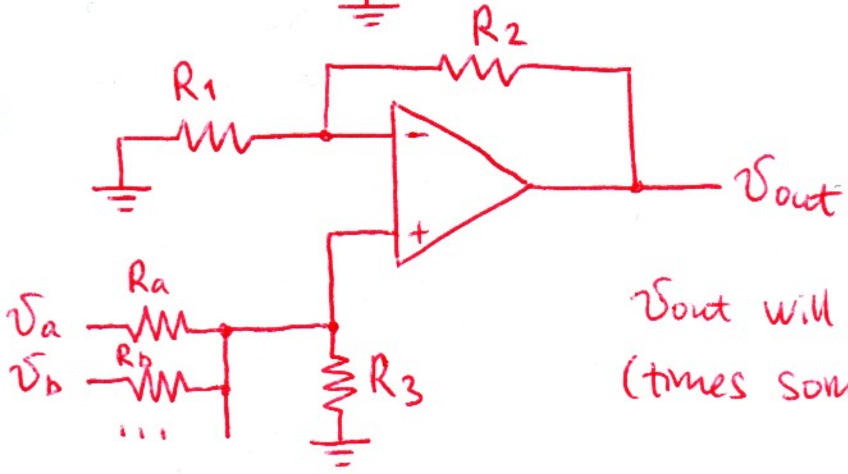
$$\boxed{v_{out} = -iR = -R\left(\frac{v_a}{R_a} + \frac{v_b}{R_b} + \ldots\right)}$$

Q: How to add without inversion (i.e. w/o "−" sign)?

A1: add another inverter at the end



A2:



v_{out} will be sum of $v_a, v_b, \ldots$ (times some coeff.) w/o inversion.

Active filters (next lecture)

Feedback network contains $Z(\omega)$ (RLC-network)

Pros:

- gain can be > 1
- Z_{out} can be made very low
- can design high Q filters without inductors (i.e. bulky coils) HW

Cons:

- can go unstable

Q: ideal integrator & differentiator : poles & zeros of $G(s)$?

A: $\underbrace{\text{ideal integrator}}_{\text{pole @ origin}}$ & $\underbrace{\text{differentiator}}_{\text{zero @ origin}}$ (more next time)