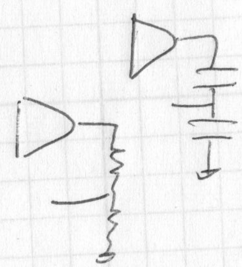
Project Presn #2

Feedback

e.g. real circuits

→ have loading effects

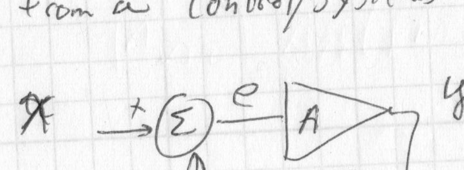


→ don't always fit cleanly into two boxes

→ have multiple feedback loops (e.g. C_{gd})

→ are not "one way" (unilateral) (e.g. C_{gd})

from a control/systems theory perspective:



$$H(s) = \frac{Y}{X} = \frac{A}{1+Af}$$

be careful of $Af = -1$!

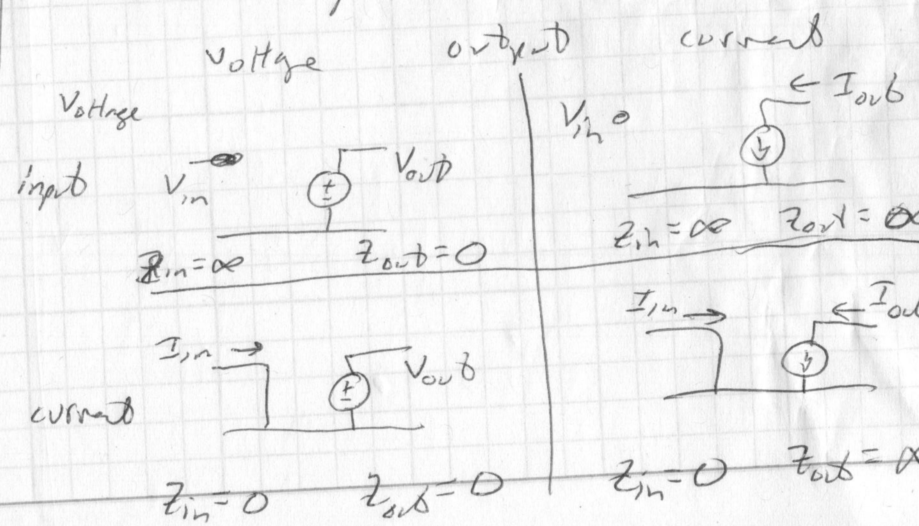
True & wonderful, <u>but</u>

doesn't capture richness of real circuits.

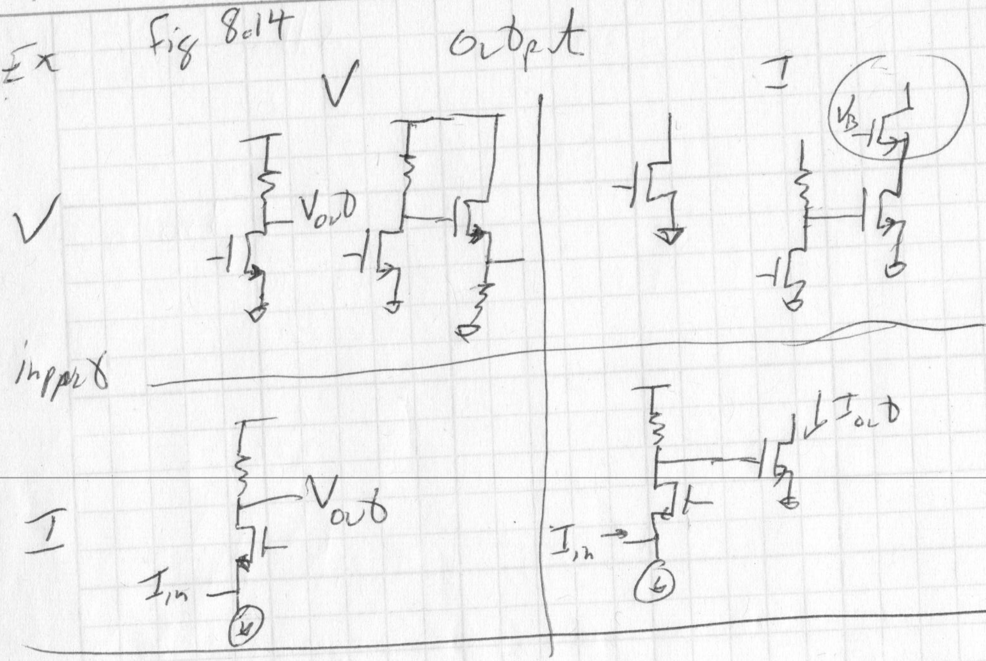
nonetheless, there are some important truths

2 Kinds of inputs: I, V

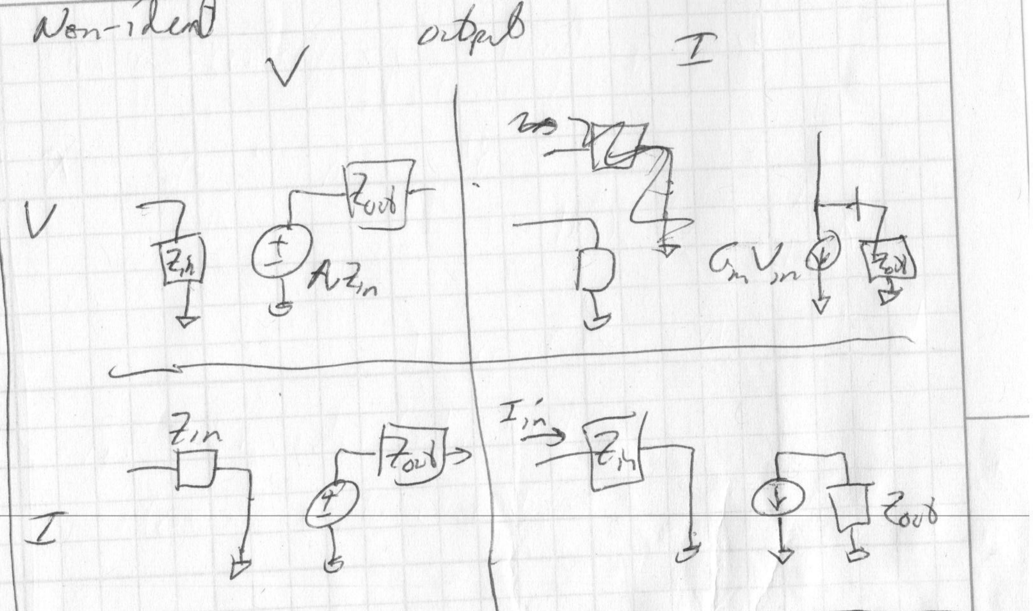
2 kinds of outputs: I, V

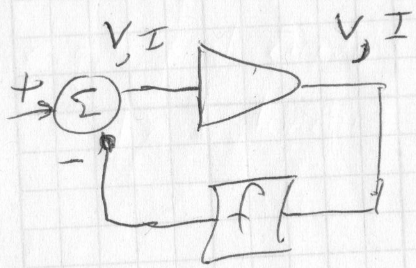


Ex fig 8.14



Non-ideal





to feed back a

Voltage: add in <u>series</u>

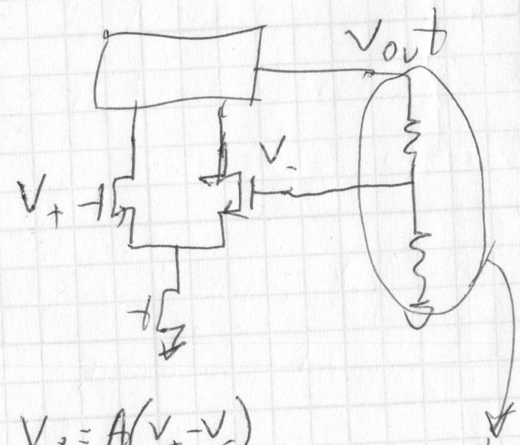
current add in <u>shunt</u>

to sense a

Voltage: meter across (<u>shunt</u>)

current: meter in <u>series</u>

Ex: fig 8.19

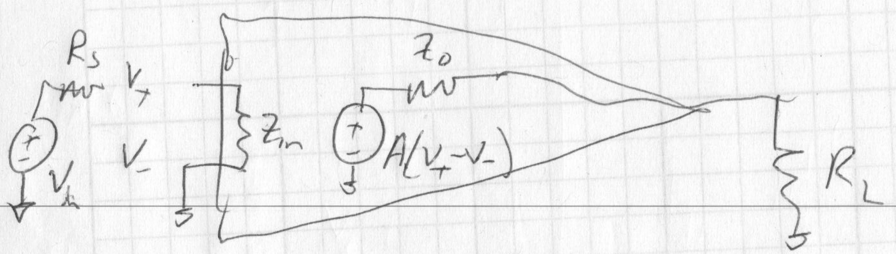


$V_{out} = A(V_+ - V_-)$

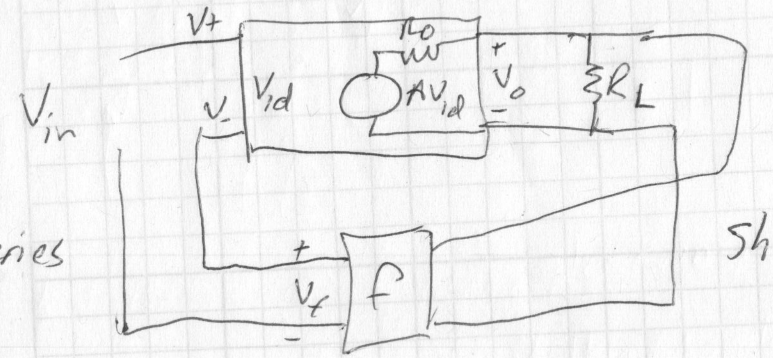
series feedback

shunt sensing

In general, feedback multiplies or divides the input and output impedances by $1+Af$ to improve them



$$V_o = \left(V_{in}\frac{R_{in}}{R_{in}+R_s}\right)A\,\frac{R_L}{R_L+R_o} = AV_{in} \text{ if } \begin{matrix} R_o=0 \\ R_{in}=\infty \end{matrix}$$



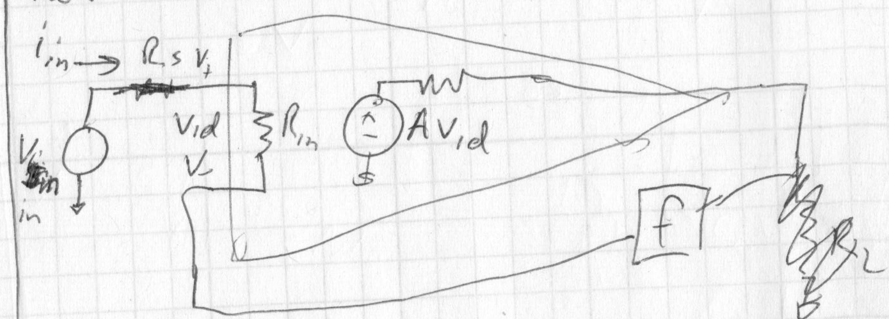
Series

Shunt

$$\cancel{V_f = fV_o}$$
$$\cancel{V_{id} = V_f = V_{in} - V_f = -fV_o}$$

$$V_{in} = V_{id} + V_f = V_{id} + fV_o$$

now in feedback



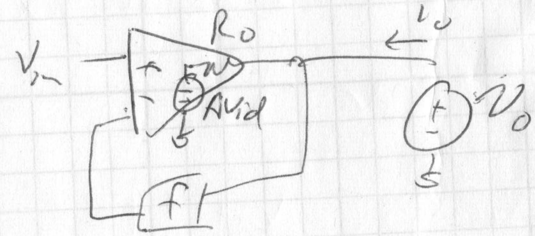
$V_{in} = \cancel{i_{in}(R_s+R_{in})}$

$v_{id} = i_{in}R_{in}$

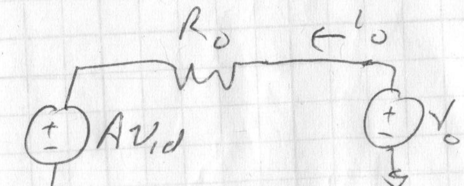
$v_- = fA_o i_{in}R_{in}$

$v_{id} = v_{in} - v_- = v_{in} - fA_o i_{in}R_{in}$

$i_{in}R_{in} + fA_o i_{in}R_{in} = v_{in}$ $R_{in,fb} = \frac{v_{in}}{i_{in}} = (1+A_of)R_{in}$



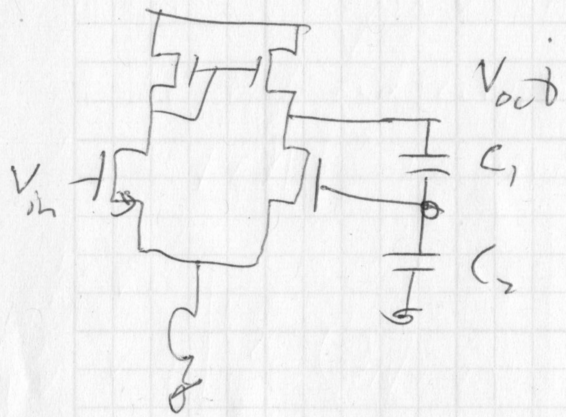
$$R_{out} = \frac{v_o}{i_o}$$



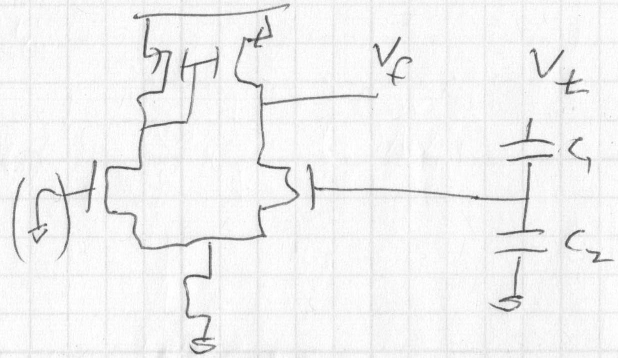
$V_{in} = 0$

$V_{id} = -fv_o$

$$v_o = AV_{id} + i_oR_o$$
$$= A(-fv_o) + i_oR_o$$
$$(1+Af)v_o = i_oR_o$$
$$R_{out,fb} = \frac{v_o}{i_o} = \frac{R_o}{1+Af}$$

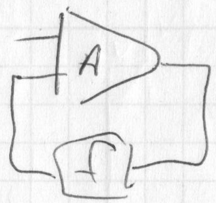


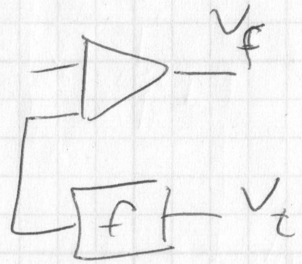
break loop at V_{out} to calc loop gain



$$V_- = V_t \frac{C_1}{C_1+C_2}$$

$$V_f = A V_{id} = g_m R_o \frac{C_1}{C_1+C_2} V_t$$





loop gain $Af = \frac{V_f}{V_t} = g_m R_o \frac{C_1}{C_1+C_2}$

$$R_{out,fb} = \frac{R_o}{1+Af} = \frac{R_o}{1 + g_m R_o \frac{C_1}{C_1+C_2}}$$

$$\approx \frac{1}{g_m} \frac{1}{f} \quad \text{if} \quad g_m R_o \frac{C_1}{C_1+C_2} \gg 1$$

$Z_{in,fb} = (1+Af) Z_{in}$ $\quad Z_{in} = \frac{1}{\omega (2 C_{gs})}$

but not the other parasitics