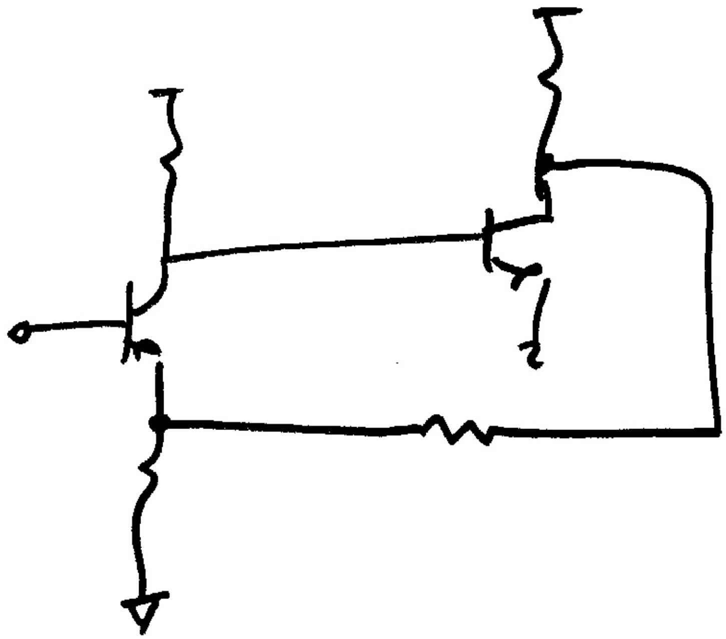
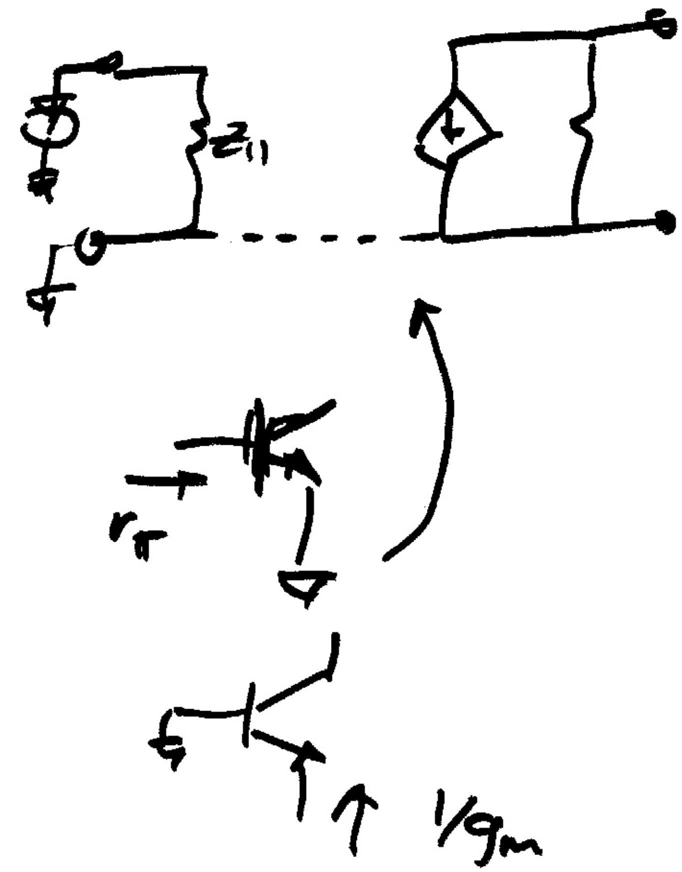
LECT 14

EX





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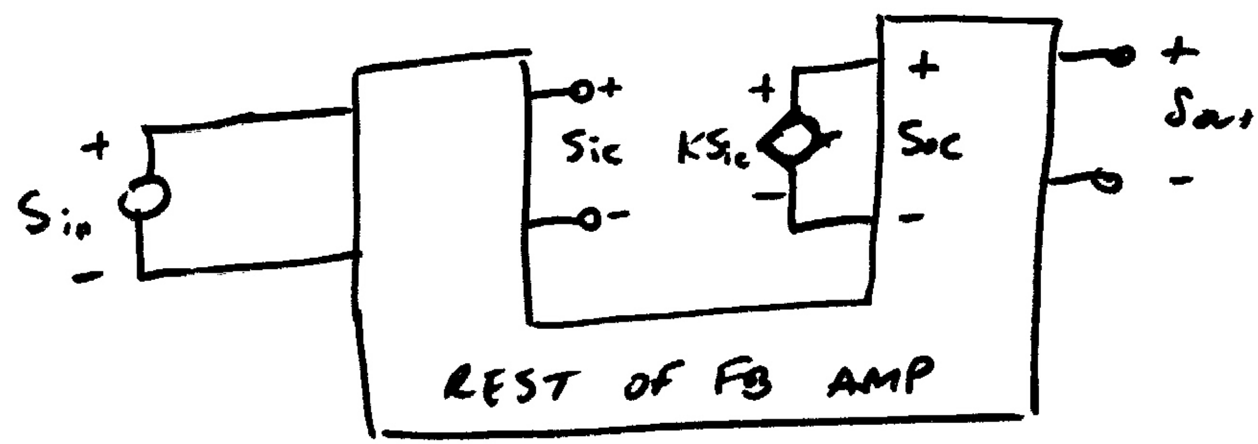
RETURN RATIO ANALYSIS



$(K = g_m)$

(A) $\quad S_{oc} = K S_{ic}$

(B) $\quad S_{ic} = B_1 S_{in} - H S_{oc}$

(C) $\quad S_{out} = d S_{in} + B_2 S_{oc}$

(D) $\quad B_1 = \left.\dfrac{S_{ic}}{S_{in}}\right|_{S_{oc}=0} = \left.\dfrac{S_{ic}}{S_{in}}\right|_{K=0}$

GAIN INPUT → CONTROL NODE FOR K=0

(E) $H = -\left.\frac{S_{ic}}{S_{oc}}\right|_{S_{in}=0}$ REVERSE GAIN

(F) $d = \left.\frac{S_{out}}{S_{in}}\right|_{S_{oc}=0} = \left.\frac{S_{out}}{S_{in}}\right|_{k=0}$

DIRECT FEEDTHRU

(G) $B_2 = \left.\frac{S_{out}}{S_{oc}}\right|_{S_{in}=0}$ PARTIAL GAIN FROM GEN → O/P FOR INPUT SHORTED

(A) & (B)

$$S_{ic} + H \underbrace{S_{oc}}_{k S_{ic}} = B_1 S_{in}$$

$$S_{ic} (1 + kH) = B_1 S_{in}$$

$$\frac{S_{ic}}{S_{in}} = \left(\frac{B_1}{1 + kH} \right)$$

(C)

$$\frac{S_{out}}{S_{in}} = d \cancel{S_{in}} + B_2 \frac{S_{oc}}{S_{in}}$$

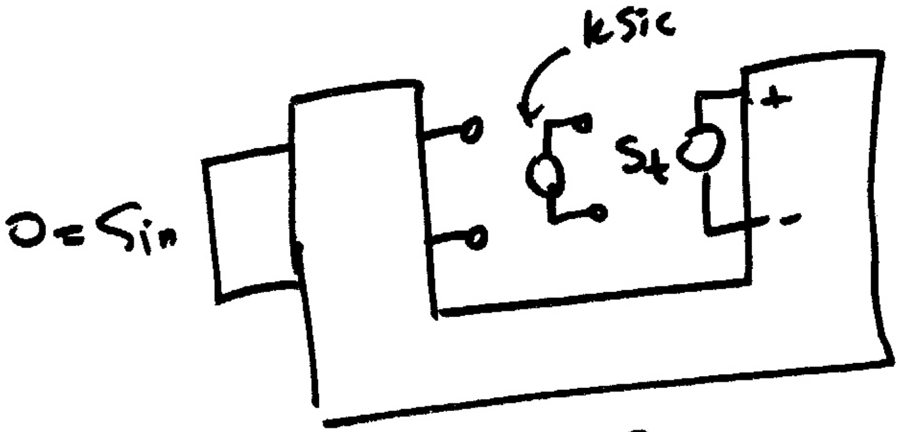
$$= d + B_2 K \left(\frac{S_{ic}}{S_{in}} \right)$$

$$\boxed{A = d + \frac{B_1 K B_2}{1 + kH}}$$ CLOSED LOOP GAIN

WHAT IS KH?

$KH = R$

LOOP GAIN OR RETURN RATIO



$$S_{ic} = \cancelto{0}{B_1 S_{in}} - H S_{oc}$$

$$= -H S_{oc}$$

$$S_r = -KH S_{oc} = -KH S_t$$

$$R = -\frac{S_r}{S_t} = \underline{\underline{KH}}$$

$$A = d + \frac{B_1 K B_2}{1 + R}$$

$$g \triangleq B_1 K B_2$$

$$A = d + \frac{g}{1+R} = \frac{d + dR + g}{1 + R}$$

$$\cancel{= \frac{R}{1+R}\left(d + \frac{g}{R}\right)}$$

$$= \frac{d(1+R) + g}{1+R}$$

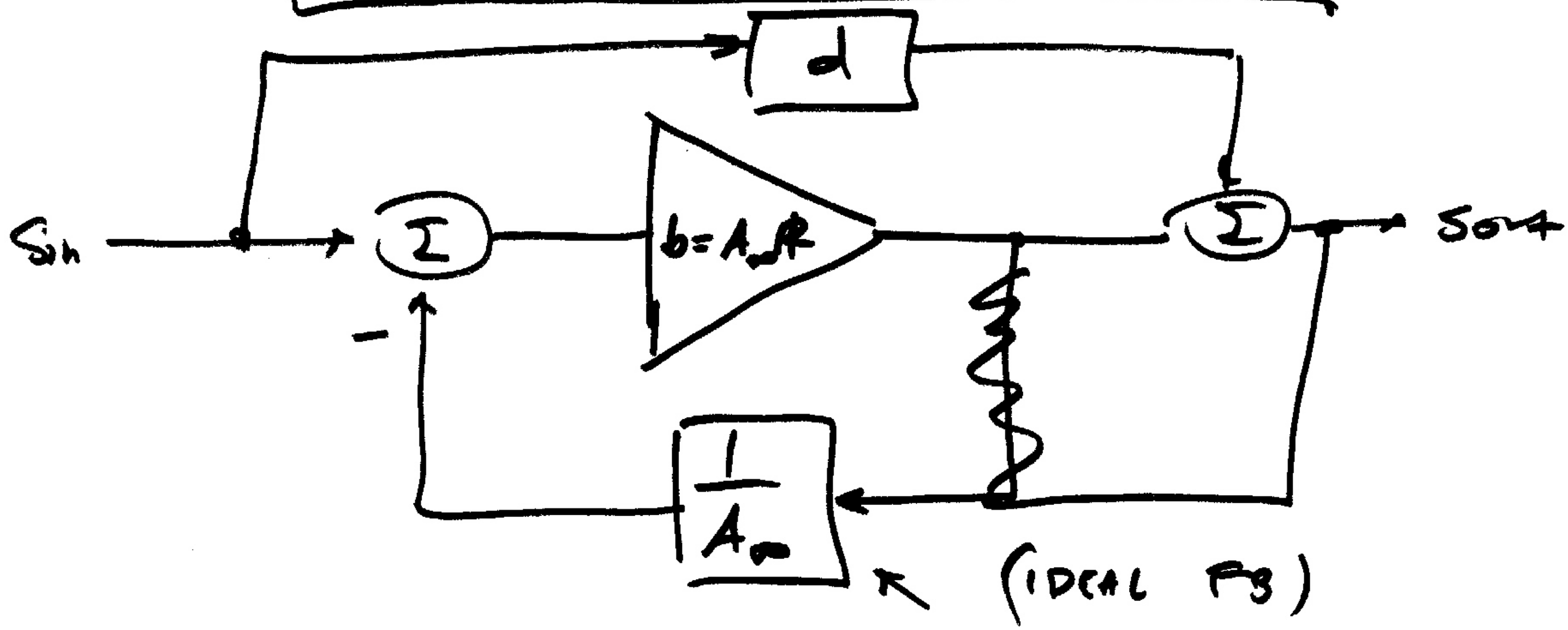
$$= \frac{R}{1+R}\left(d + \frac{g}{R}\right) + \frac{d}{1+R}$$

$$A_\infty = \frac{g}{R} + d$$

CLOSED LOOP GAIN FOR VERY LARGE R

LET $R \to \infty$

$$\boxed{A = A_\infty \frac{R}{1+R} + \frac{d}{1+R}}$$



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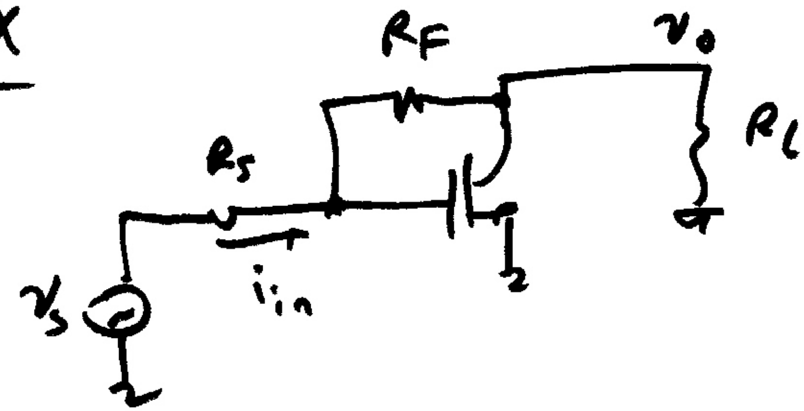


CALC A_∞

d

R

A_∞ : GAIN AS $R \to \infty$ OR $k \to \infty$

$g_m \to \infty$

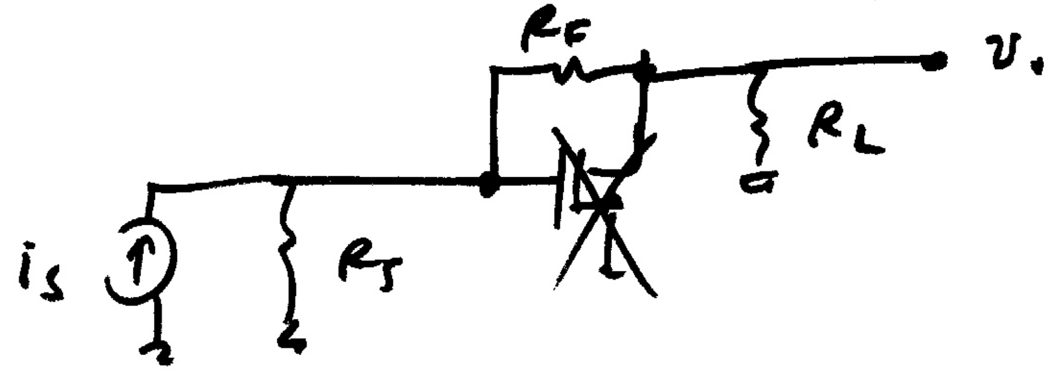
$v_{gs} \to 0$

$\frac{v_s}{R_S} = i_{in}$

$v_o = - i_{in} \cdot R_F$

$$\boxed{A_\infty = \frac{v_o}{i_{in}} = -R_F}$$

$\underline{d}$: DIRECT FEEDTHRU FOR $K = g_m = 0$

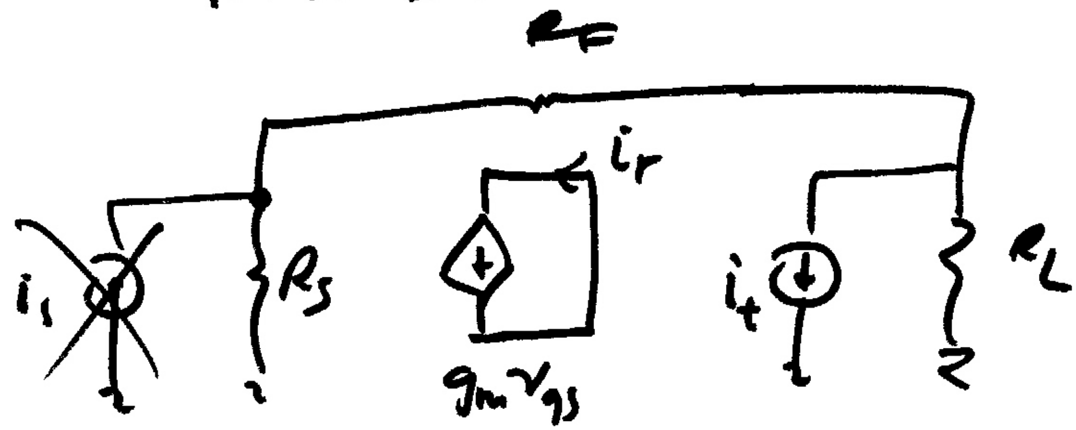


$$\frac{v_o}{i_s} = \frac{R_S}{R_S + R_F + R_L} \cdot R_L$$

$$\boxed{d = \frac{R_S R_L}{R_S + R_F + R_L}}$$

$\mathcal{R}$ RETURN RATIO

BREAK GENERATOR INPUT $\Rightarrow$



$$v_{gs} = -i_t \cdot \frac{R_L}{R_L + R_F + R_S} \cdot R_S$$

$$i_r = g_m v_{gs} = -\frac{g_m R_L R_S}{R_L + R_F + R_S} i_t$$

$$\boxed{\mathcal{R} = \frac{-i_r}{i_t} = \frac{g_m R_L R_S}{R_L + R_F + R_S}}$$

$$A = A_\infty \frac{\mathcal{R}}{1+\mathcal{R}} + \frac{d}{1+\mathcal{R}}$$

$$= \left(-R_F\right) \frac{g_m R_L R_S}{(R_L + R_F + R_S) + g_m R_L R_S} +$$

$$\frac{R_S R_L}{R_S + R_F + R_L + g_m R_L R_S}$$

$$\boxed{A = \frac{(1 - g_m R_F)\, R_S R_L}{R_F + R_L + (1 + g_m R_L) R_S}}$$

$g_m R_F \to \infty$

$g_m R_L \to \infty$

$$A = \frac{-\cancel{g_m} R_F \cancel{R_S} \cancel{R_L}}{\cancel{g_m} \cancel{R_L} \cancel{R_S}} = -R_F$$

$$= A_\infty$$

DIRECT $\quad b = A_\infty \cdot R$

$$b = \left(\frac{g}{R} + d\right) R = g + d R$$

$$= B_1 K B_2 + d R$$

$$= B_1 K B_2 + d K H$$

$$b = \underbrace{\left(B_1 + \frac{dH}{B_2}\right)}_{\left.\frac{S_{ic}}{S_{in}}\right|_{S_{out}=0}} K \underbrace{B_2}_{\left.\frac{S_{out}}{S_{oc}}\right|_{S_{in}=0}}$$

IF $S_{out} = 0$

$$0 = S_{out} = \alpha S_{in} + B_2 S_{oc}$$

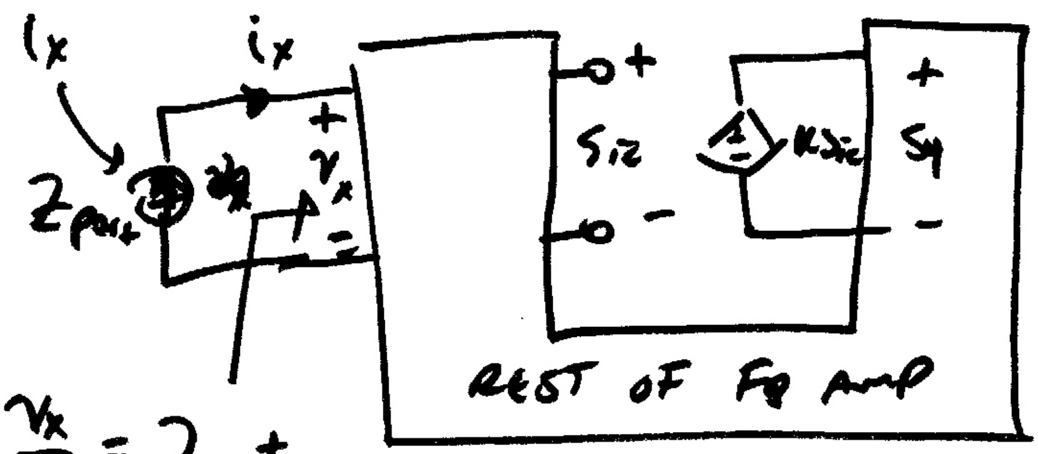
$$B_2 S_{oc} = -\alpha S_{in}$$

$$S_{ic} = B_1 S_{in} - H S_{oc}$$

$$= B_1 S_{in} - H \left(-\frac{\alpha}{B_2}\right) S_{in}$$

$$\boxed{\left.\frac{S_{ic}}{S_{in}}\right|_{S_{out}=0} = \left(B_1 + \frac{\alpha H}{B_2}\right)}$$

CLOSED LOOP IMPEDANCES



$$\frac{v_x}{i_x} = Z_{port}$$

$$v_x = a_1 i_x + a_2 S_y$$

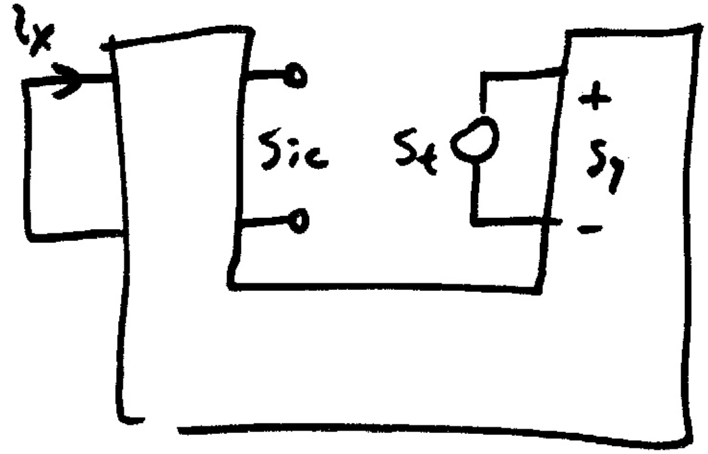
$$S_{ic} = a_3 i_x + a_4 S_y$$

SET $k = 0 \Rightarrow S_y = 0$

$$\boxed{\frac{v_x}{i_x} = a_1 = Z_{port}\,(k=0)}$$

LET PORT X = SHORT CIRCUIT

$\rightarrow v_x = 0$



$S_t = S_y \qquad i_x = -\frac{a_2}{a_1} S_t$

$$S_{ic} = a_3\left(-\frac{a_2}{a_1} S_t\right) + a_4 S_t$$

$\cancel{S_r = K S_{ic} =}$

$$\frac{S_{ic}}{S_t} = a_4 - \frac{a_3 a_2}{a_1}$$

$$S_r = K S_{ic} = K\left(a_4 - \frac{a_3 a_2}{a_1}\right)$$

$$\boxed{R_{SHORT} = -K(\quad)}$$

$$R_{SHUNT} = -k\left(a_4 - \frac{a_3 a_2}{a_1}\right)$$

$$Z_x = \frac{v_x}{i_x} = a_1 + a_2 \frac{s_y}{i_x}$$

$$= a_1 + a_2 \frac{k\, s_{ic}}{i_x}$$

$$\frac{s_{ic}}{i_x} = a_3 + a_4 \cdot \frac{k\, s_{ic}}{i_x}$$

$$\frac{s_{ic}}{i_x}\left(1 - k a_4\right) = a_3$$

LET PORT X = OPEN CIRCUIT $i_x = 0$

CALC $\mathcal{R}$ $\quad s_y = s_t$

$$s_{ic} = a_y s_y$$

$$s_r = k s_{ic} = k a_y s_t$$

$$\boxed{\mathcal{R}_{OPEN} = -k a_y}$$

$$\boxed{Z_x = a_1 + \frac{a_2 k a_3}{1 - k a_4}}$$

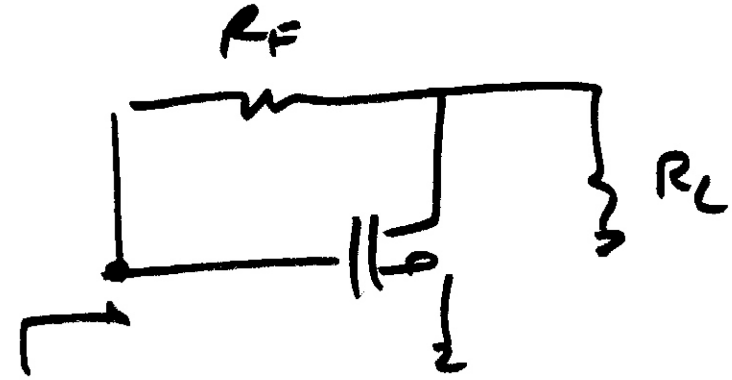
$$= \frac{a_1 - k a_1 a_4 + a_2 k a_3}{1 - k a_4}$$

$$= a_1 \frac{\left(1 - k\left(a_4 - \frac{a_2 a_3}{a_1}\right)\right)}{1 - k a_4}$$

$$\boxed{Z_x = Z_{port}(k=0)\,\frac{(1 + R_{short})}{(1 + R_{open})}}$$

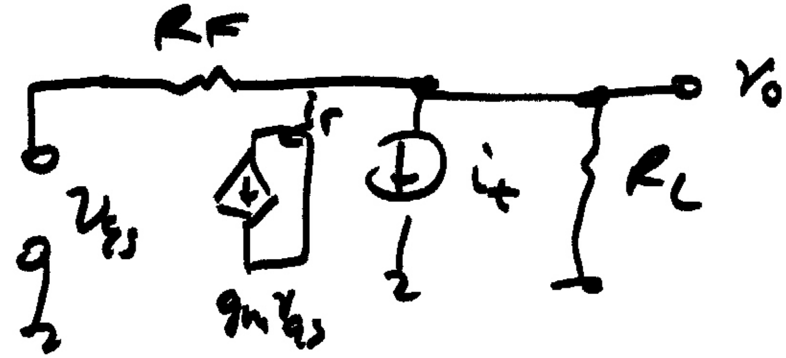
BLACKMAN'S IMPEDANCE FORMULA

EX



$Z_{in} = ?$

$Z(K=0) = R_F + R_L$



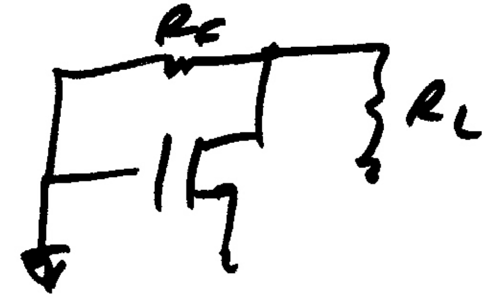
R_{OPEN}

$$v_{gs} = v_o = -i_t \cdot R_L$$

$$v_r = g_m v_{gs} = -g_m R_L \quad i_t$$

$$R_{OPEN} = +g_m R_L$$

R_{SHORT}

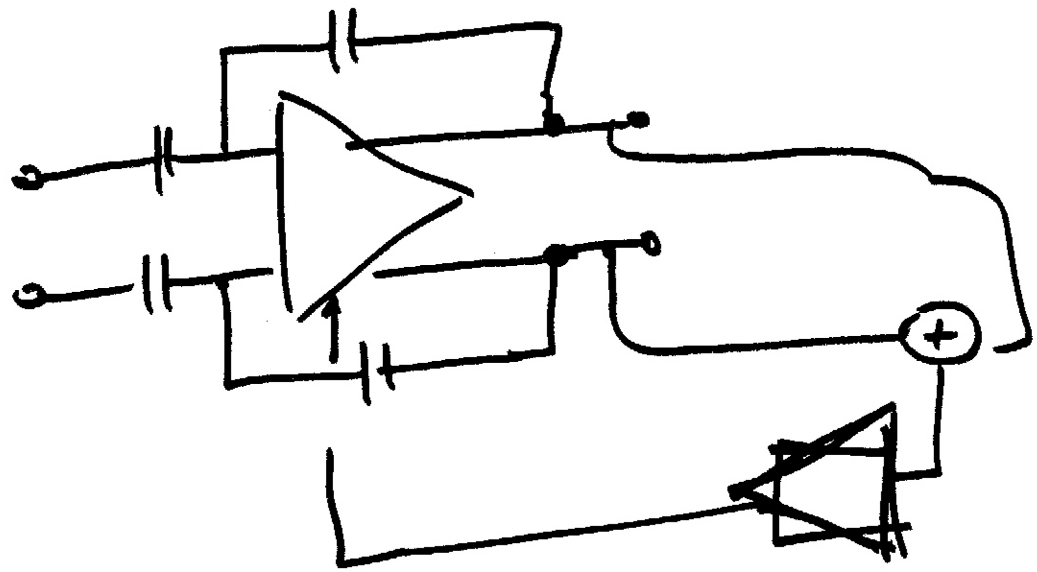


$v_{gs} = 0 \qquad i_r \equiv 0$

$R_{SHORT} = 0$

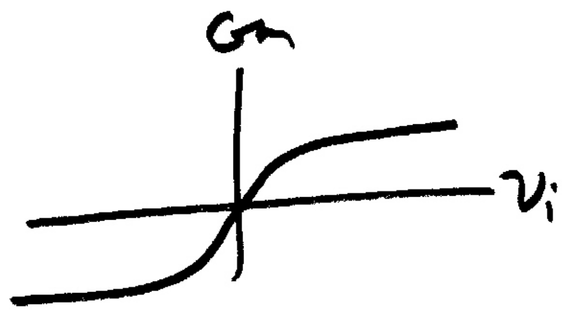
$$Z = Z(u=0)\,\frac{\left(1 + R_{\cancel{open}}^{\;SHORT}\right)}{\left(1 + R_{\cancel{SHORT}\;OPEN}\right)}$$

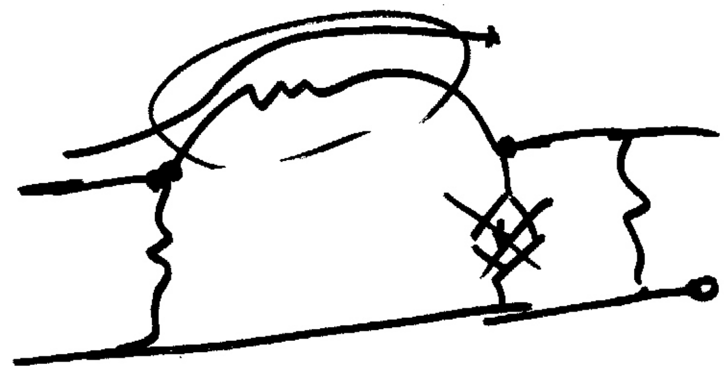
$$Z = \frac{(R_F + R_L)}{1 + g_m R_L} \simeq \frac{1}{g_m}\left(\frac{R_F + R_L}{R_L}\right)$$



COMMON MODE LOOP &

DIFF MODE LOOP DECOUPLED





$y_{12} = 0 \Rightarrow$ STOPS FB

$y_{21} = 0 \Rightarrow ?$