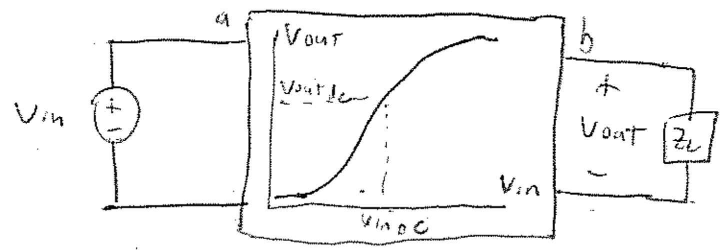
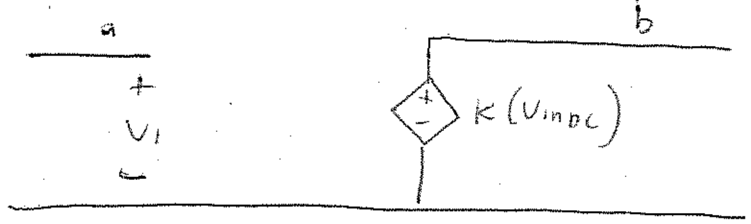
# LECTURE 2:

SLIDE 9) CREATE TWO PORT MODEL:

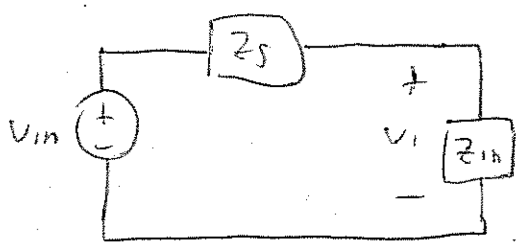


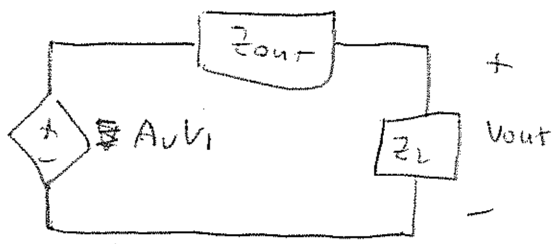

DEFINE $K(V_{in\,DC})$ AS THE SLOPE $\left.\frac{V_{out}}{V_{in}}\right|_{V_{in} = V_{in\,DC}}$

TWO PORT:



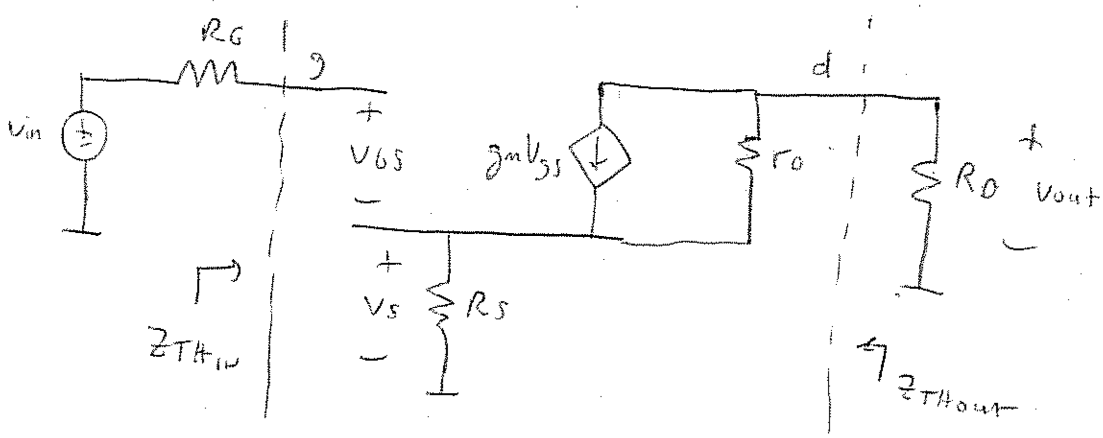

SLIDE 10)



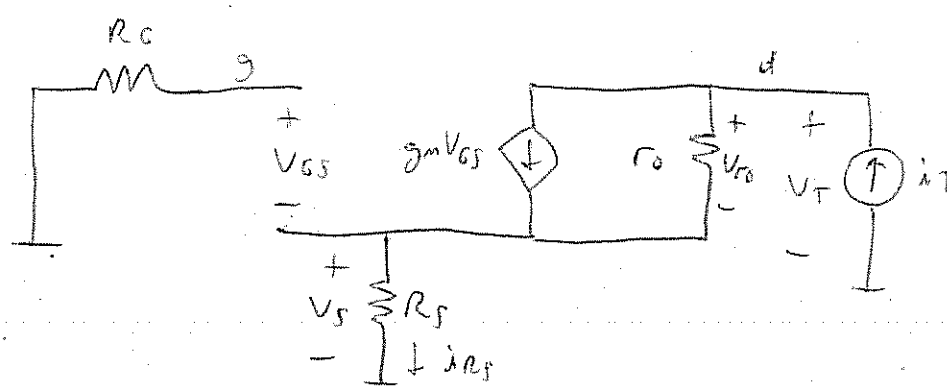

$$V_{out} = \frac{Z_L}{Z_{out} + Z_L} A_v V_1 = \boxed{\frac{Z_L}{Z_{out} + Z_L}\left(\frac{Z_{in}}{Z_s + Z_{in}}\right) V_{in} = V_{out}}$$

SLIDE 11) WITH $r_{\pi} = \infty$, $g_{mb} = 0$ WE HAVE:




$Z_{TH_{IN}} = \infty$ SINCE NO CURRENT FLOW INTO TERMINAL g

$Z_{TH_{out}}$ ⇒ MUST CALCULATE → EASIER TO USE TEST CURRENT




$i_{RS} = i_T$ BY KCL ⇒ $V_S = i_T R_S$

$\Rightarrow V_{GS} = 0 - i_T R_S = -i_T R_S$

$\Rightarrow g_m V_{GS} = -g_m i_T R_S$

$\Rightarrow V_{Ro} = ~~(g_m i_T R_S) r_o~~ (g_m i_T R_S + i_T) r_o$

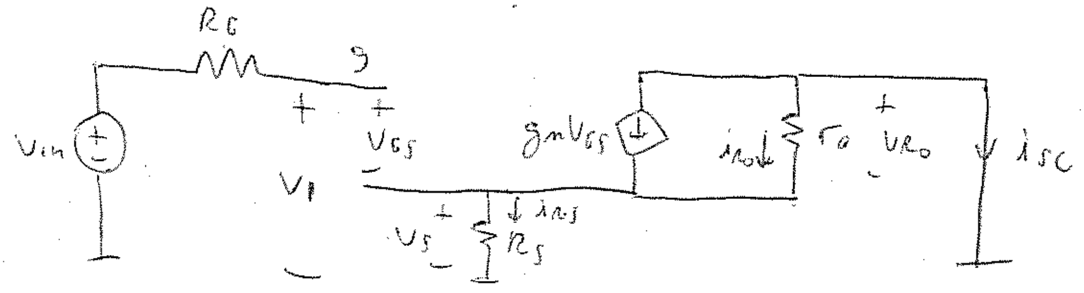
$\Rightarrow V_T = V_S + V_{Ro} = i_T R_S + g_m i_T R_S r_o + i_T r_o$

$= i_T (R_S + g_m R_S r_o + r_o)$

$\Rightarrow \boxed{Z_{TH_{out}} = \frac{V_T}{i_T} = R_S(1 + g_m r_o) + r_o}$

TO BE CLEAR: $Z_{TH_{out}} = R_S(1 + g_m r_o) + r_o$

SLIDE 11) DETERMINE $G_m$ BY LOOKING AT SHORT CIRCUIT CURRENT:




NOTE: $i_{RS} = -i_{SC} \Rightarrow V_S = -i_{SC} R_S$

$$\Rightarrow V_{GS} = V_1 - V_S = V_1 + R_S i_{SC}$$

NOTE: $V_{Ro} + V_S = 0 \Rightarrow V_{Ro} = -V_S = i_{SC} R_S$

$$\Rightarrow i_{Ro} = \frac{V_{Ro}}{r_o} = i_{SC} \frac{R_S}{r_o}$$

FINALLY: $i_{SC} = -i_{Ro} - g_m V_{GS}$

$$= -i_{SC} \frac{R_S}{r_o} - g_m (V_1 + R_S i_{SC})$$

$$\Rightarrow i_{SC}\left(1 + \frac{R_S}{r_o} + g_m R_S\right) = -g_m V_1$$

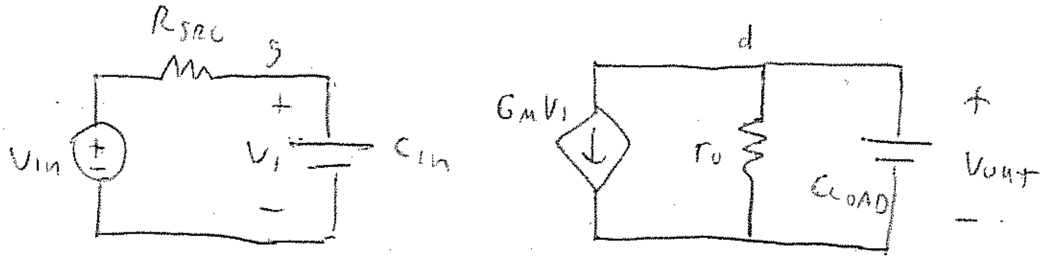
$$\Rightarrow i_{SC} = \frac{-g_m}{1 + g_m R_S\left(1 + \frac{1}{g_m r_o}\right)} V_1$$

NOTE THAT $G_m = -i_{SC}$

$$\Rightarrow \boxed{G_m = \frac{g_m}{1 + g_m R_S\left(1 + \frac{1}{g_m r_o}\right)}}$$

LECTURE 2:

SLIDE 13)




$$V_{out}(s) = -G_m V_1(s) \frac{1}{sC_{LOAD}} \parallel r_o$$

$$= -G_m \frac{\frac{1}{sC_{LOAD}} r_o}{\frac{1}{sC_{LOAD}} + r_o} V_1(s)$$

$$= -G_m \frac{r_o}{1 + sC_{LOAD} r_o} V_1(s)$$

AND $$V_1(s) = V_{in}(s) \frac{\frac{1}{sC_{in}}}{R_{src} + \frac{1}{sC_{in}}} = \frac{1}{1 + sR_{src}C_{in}} V_{in}(s)$$

$$\Rightarrow V_{out}(s) = -G_m \frac{r_o}{1 + sC_{LOAD} r_o} \left( \frac{1}{1 + sR_{src}C_{in}} \right) V_{in}(s)$$

$$\Rightarrow \boxed{\frac{V_{out}(s)}{V_{in}(s)} = -G_m \frac{r_o}{1 + sC_{LOAD} r_o} \left( \frac{1}{1 + sR_{src}C_{in}} \right)}$$

~~NO ZEROS~~

NO ZEROS

POLES AT $\frac{1}{C_{LOAD} r_o}$ AND $\frac{1}{C_{in} R_{src}}$

SLIDE 14)

$$\boxed{\frac{V_{out}(f)}{V_{in}(f)} = \frac{-G_m r_o}{1 + j2\pi f C_{LOAD} r_o} \left( \frac{1}{1 + j2\pi f C_{in} R_{src}} \right)}$$