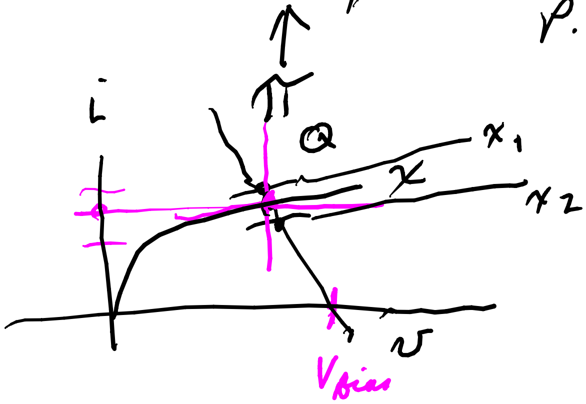
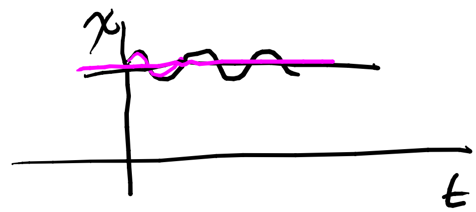
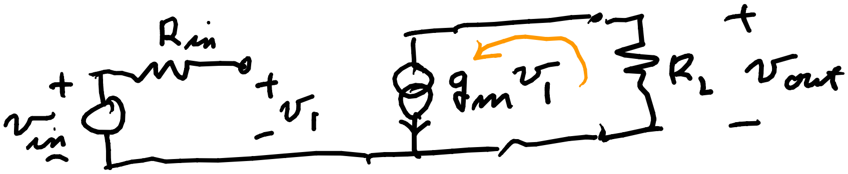
BJT & MOS equivalent circuits

p. 557 Table 7.A.3

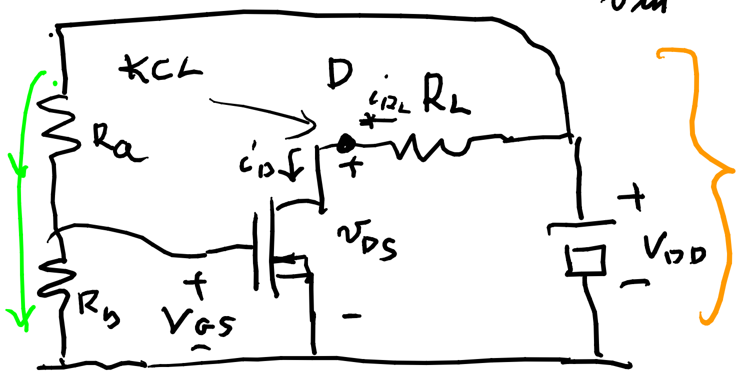




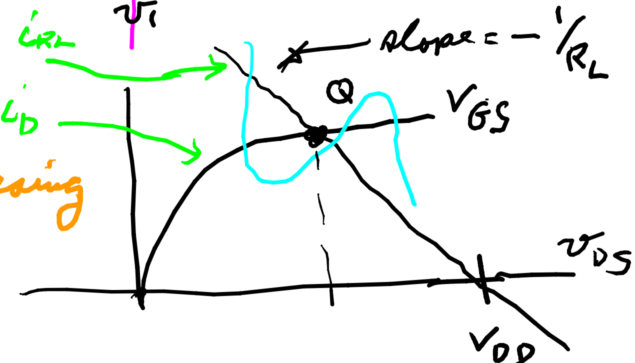


} small signals

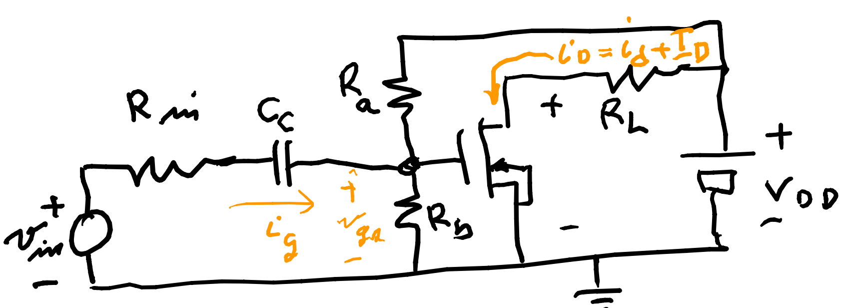
$$v_1 = v_{in} \qquad \frac{v_{out}}{v_{in}} \approx -R_L g_m \frac{v_1}{v_1} = A_v = -g_m R_L$$

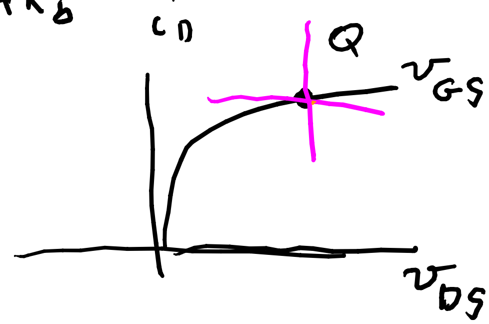


} biasing



$$V_{GS} = \frac{R_b}{R_a + R_b} \cdot V_{DD}$$





$$i_D = f(v_{GS}, v_{DS}) = i_d + I_D$$

$$y_X = y_x + Y_X$$

total ↑ signal ↑ DC bias ↑

$i_D \rightarrow$ expansion (power series)

$$i_D = f(V_{GS}, V_{DS}) + \frac{\partial f}{\partial v_{GS}}\bigg|_Q (v_{GS} - V_{GS}) + \frac{\partial f}{\partial v_{DS}}\bigg|_Q (v_{DS} - V_{DS})$$

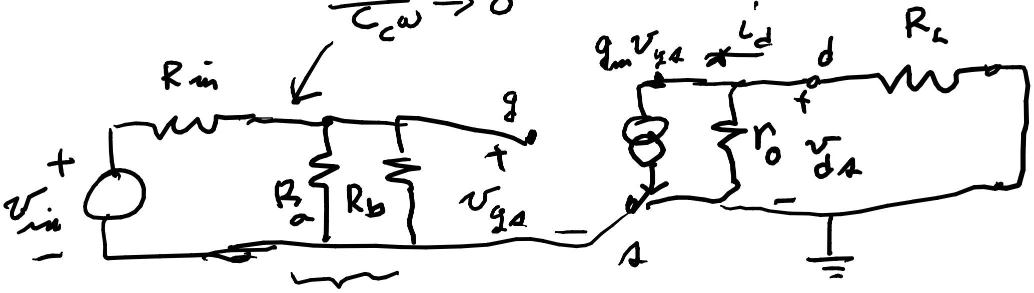
Q = V_{GS}, V_{DS}

+ higher order (ignore for small signal)

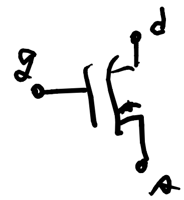
$$i_D = I_D + g_m v_{gs} + g_o v_{ds}$$

$$i_D - I_D = i_d = g_m v_{gs} + g_o v_{ds}$$

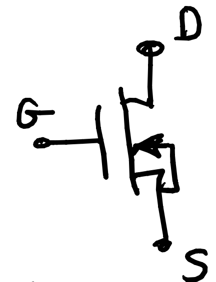
$$r_o = \frac{1}{g_o} = \text{output}$$



choose large R_s'



small signal



total

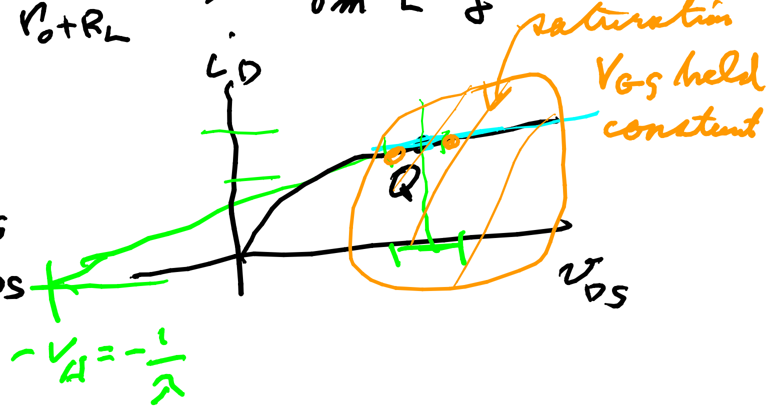
$$\frac{v_o}{v_{in}} = -g_m \frac{r_o R_L}{r_o + R_L} \Rightarrow -g_m R_L \text{ if } r_o \rightarrow \infty$$

$$r_o = \frac{1}{g_o} \; ; \; g_o = \frac{\partial i_D}{\partial v_{DS}}\bigg|$$

$v_{GS} = V_{GS}$

$v_{DS} = V_{DS}$

$\Rightarrow Q$

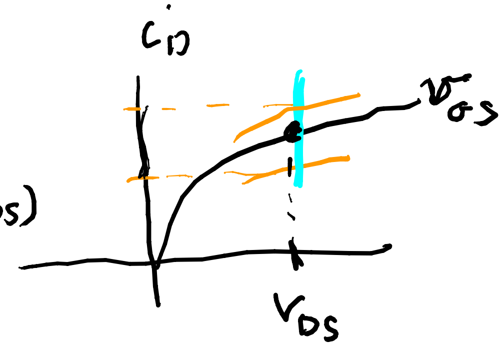


$\therefore$ g_o = slope of i_D line when v_{GS} = Q point value is held constant

if in <u>saturation</u> $i_D = \frac{KP}{2}\frac{W}{L}(v_{GS} - VTO)^2(1 + \lambda v_{DS})$

$$\left.\frac{\partial i_D}{\partial v_{DS}}\right|_Q = \frac{KP}{2}\frac{W}{L}(V_{GS} - VTO)^2 \cdot \lambda \approx I_D \cdot \lambda$$

$$= \frac{I_D}{(1+\lambda V_{DS})} = g_o$$



$$g_m = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_{\substack{Q \\ v_{DS} = V_{DS}}} = 2 \cdot \frac{KP}{2}\frac{W}{L}(V_{GS} - V_{TO})(1 + \lambda V_{DS})$$

$$= \frac{I_D}{(V_{GS} - V_{TO})} = \frac{I_D}{V_{ov}}$$

V_{ov} " over drive voltage