HW1 - grading

Lab1 - issues?

up next:

linearization: large signal, operating point, small signal

device physics

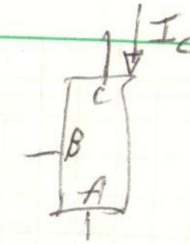
frequency response

many 3 terminal devices where

I_C is a strong function of V_{BA}

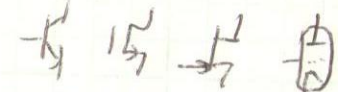
weak fn of V_{CA}

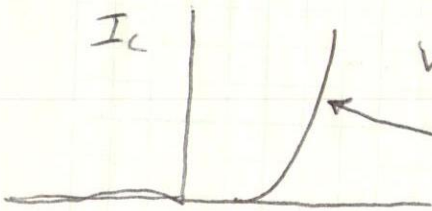
other currents are "small" (I_B)



BJT, JFET, Vacuum tube, MOSFET, ...

BBS 1947 | Nishizawa Watanabe 1950 | de Forest ~1911 | Lillienfield 1927



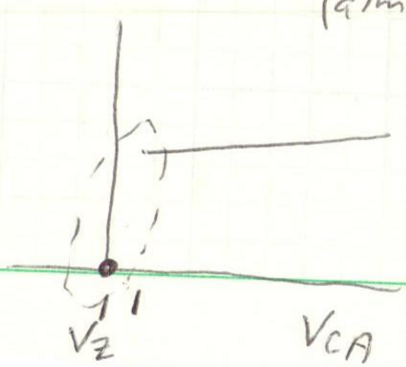


V_{CA} const.

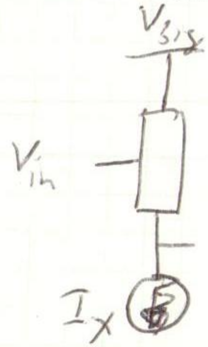
{exponential, quadratic, $V_{BA}^{3/2}$} + combinations

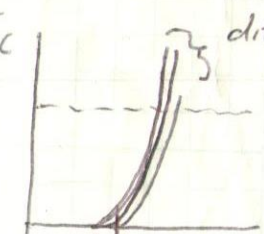
V_X ~ some kind of turn-on voltage (almost never sharp)

sometimes negative



V_{BA} const





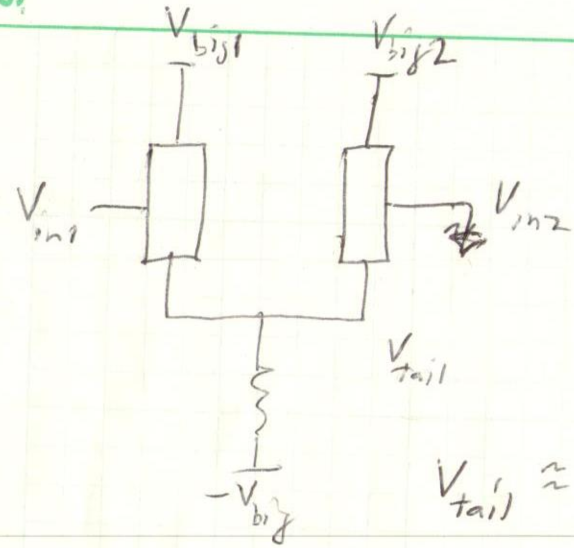
to pass I_X, $V_{BA} \approx$ const

therefore $V_{out} = V_{in} - V_{BA}$

$\approx V_{in} - (V_X + \quad)$

source follower, emitter follower, cathode follower

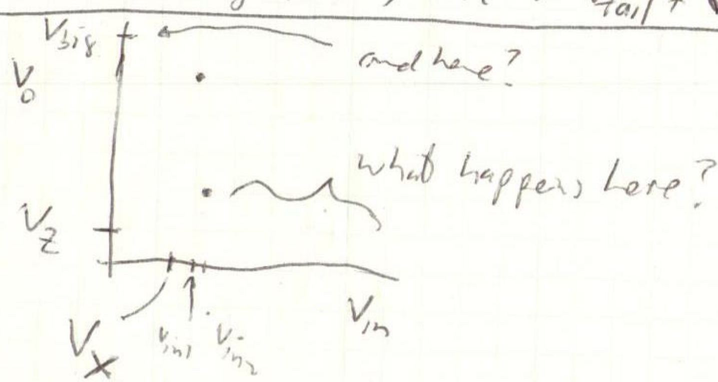
W1L2 18S04 140204



$V_{tail} \approx \max(V_{in1}, V_{in2}) - V_X$

Do V_{bis1} and V_{bis2} matter much?

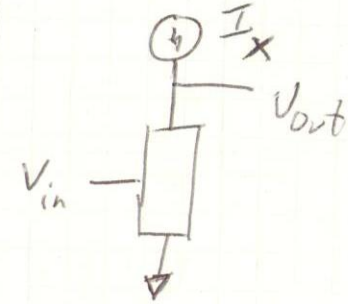
not as long as they are $> V_{tail} + V_Z$

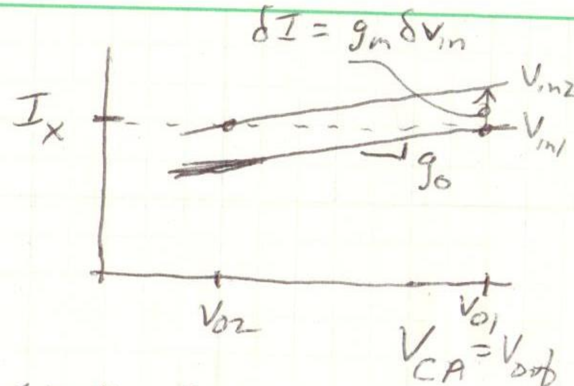


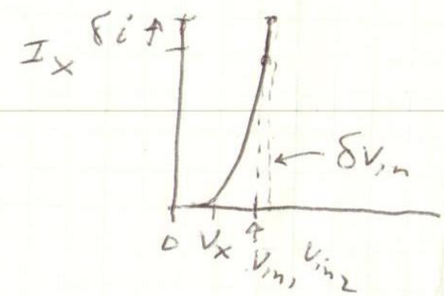
what's the gain? $\delta i = g_m \delta v$

but I_X is constant, so $\delta i = 0$, so must have

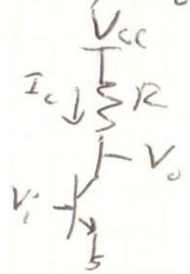
$$g_o \delta V_{out} = -\delta i = -g_m \delta V_i \qquad \frac{\delta V_{out}}{\partial V_{in}} = -\frac{g_m}{g_o} = -g_m r_o$$







why not just calculate it directly?



$V_o = V_{CC} - I_C R$

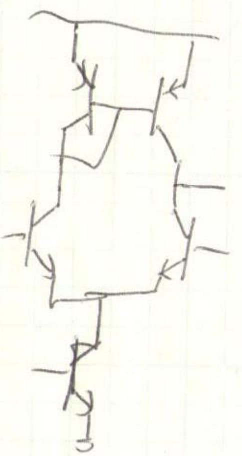
$$\boxed{I_C = I_S\left(e^{\frac{V_{BE}}{V_{TH}}} - 1\right)\left(1 + \frac{V_{CE}}{V_A}\right)}$$

simple BJT model

$$V_o = V_{CC} - R I_S\left(e^{\frac{V_{in}}{V_{TH}}} - 1\right)\left(1 + \frac{V_{out}}{V_A}\right)$$

painful to solve by hand

easy for computers



Lab 3

closed form equations
$\approx$ unsolvable by hand.
(easy for computer : DC sweep)

linearization gives very accurate answer as long as you get the Region of Operation right.

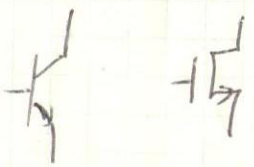
Linearization. (Taylor)

$f(x,y)$ continuous. $f(X_0, Y_0) = F_0$

best approx to f near X_0, Y_0 is?

$$f(X_0+\delta x, Y_0+\delta y) = F(X_0, Y_0) + \frac{\partial f}{\partial x}\bigg|_{X_0 Y_0} \delta x + \frac{\partial f}{\partial y}\bigg| \delta y + \ldots$$

$$= F_0 + (x \text{ slope})\delta x + (y \text{ slope})\delta y + \text{h.o.t}$$



$$I_D = \begin{cases} 0 \\ \frac{\mu_n C_{ox}}{2} \frac{W}{L}(V_{GS}-V_t)^2(1+\lambda V_{DS}) \\ \ldots \end{cases}$$

$I_d(V_{GS}, V_{DS})$

at some point V_{GS}, V_{DS} $\quad I_d(V_{GS}, V_{DS}) = I_D$

near that point

$$I_d(V_{GS}+v_{gs}, V_{DS}+v_{ds}) = I_D + \frac{\partial I_D}{\partial V_{GS}}\bigg| v_{gs} + \frac{\partial I_D}{\partial V_{DS}}\bigg| v_{ds}$$

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

$$\begin{pmatrix}\text{full nonlinear}\\ \text{dynamics}\end{pmatrix} = \underbrace{\begin{pmatrix}\text{single}\\ \text{point}\\ \text{solution}\end{pmatrix}}_{\text{one nonlinear solution}} + \underbrace{\begin{pmatrix}\text{small}\\ \text{signal}\\ \text{model}\end{pmatrix} + \text{h.o.t.}}_{\text{Taylor}}$$

local derivatives