EE 320 Intro to Electronics

5/1/13 Lecture 25

	MOSFET	BJT
logic	great	good - doesn't scale well also has stored charge
Analog	lower g But high input R ← good	high g low input R - not good

* Digital

Analog

BiCMOS → BJTs

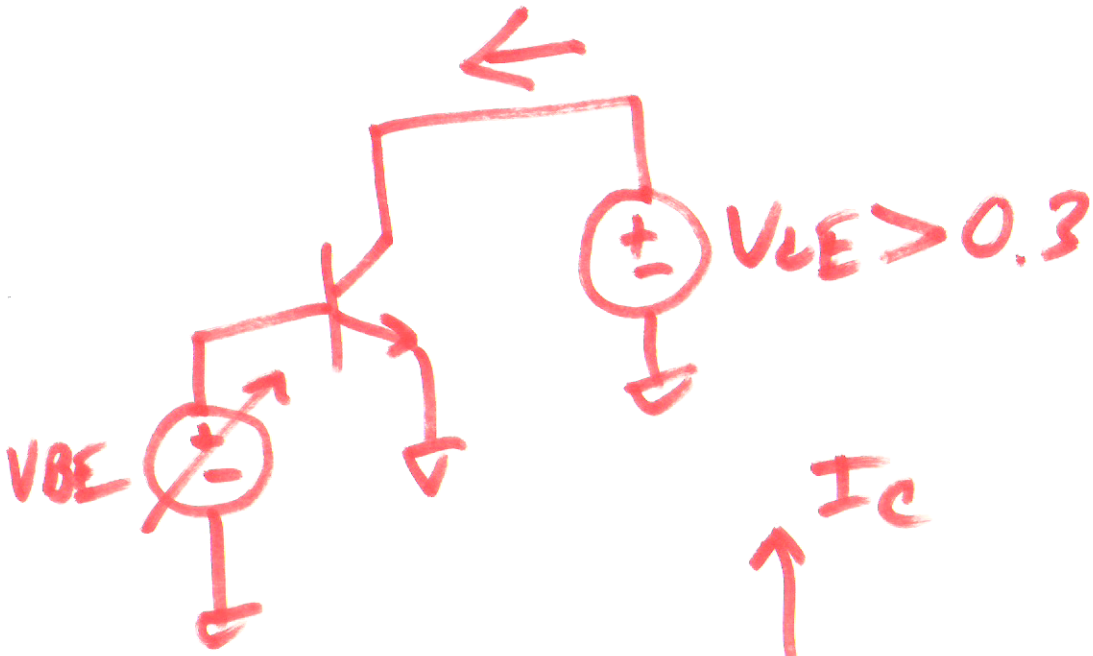
COST ↑

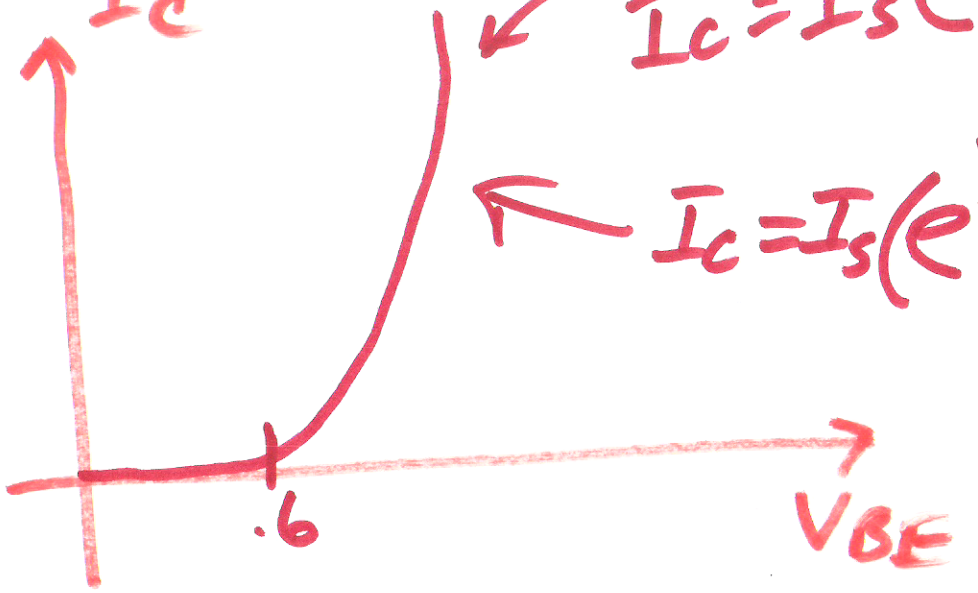
CMOS → Complementary MOS

p - and n

CMOS

1)





turned on

$I_C = I_S e^{V_{BE}/nV_T}$

$I_C = I_S\left(e^{\frac{V_{BE}}{nV_T}} - 1\right)$

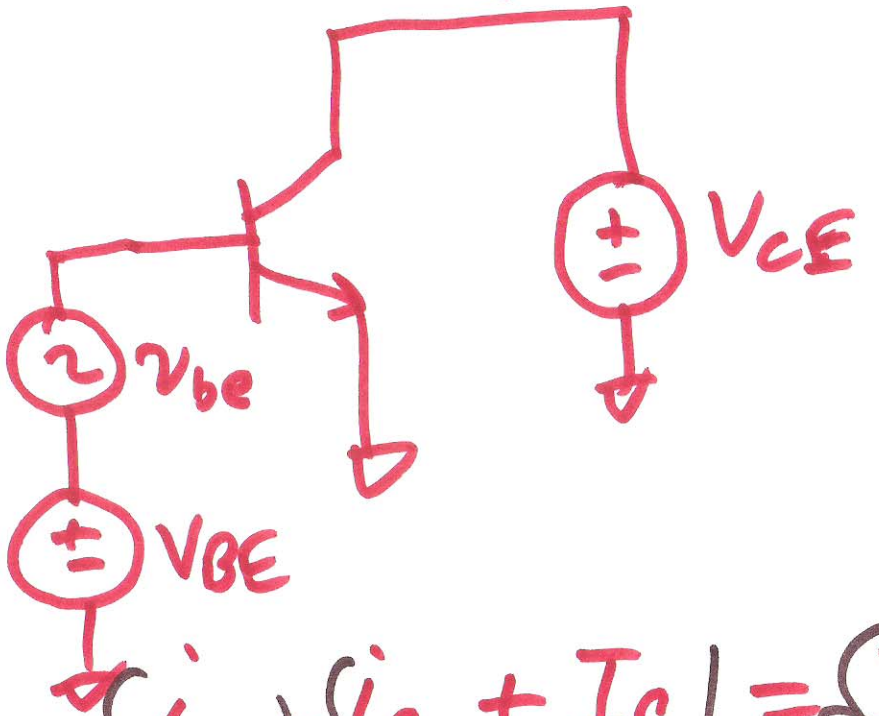
$V_T = \frac{kT}{q}$

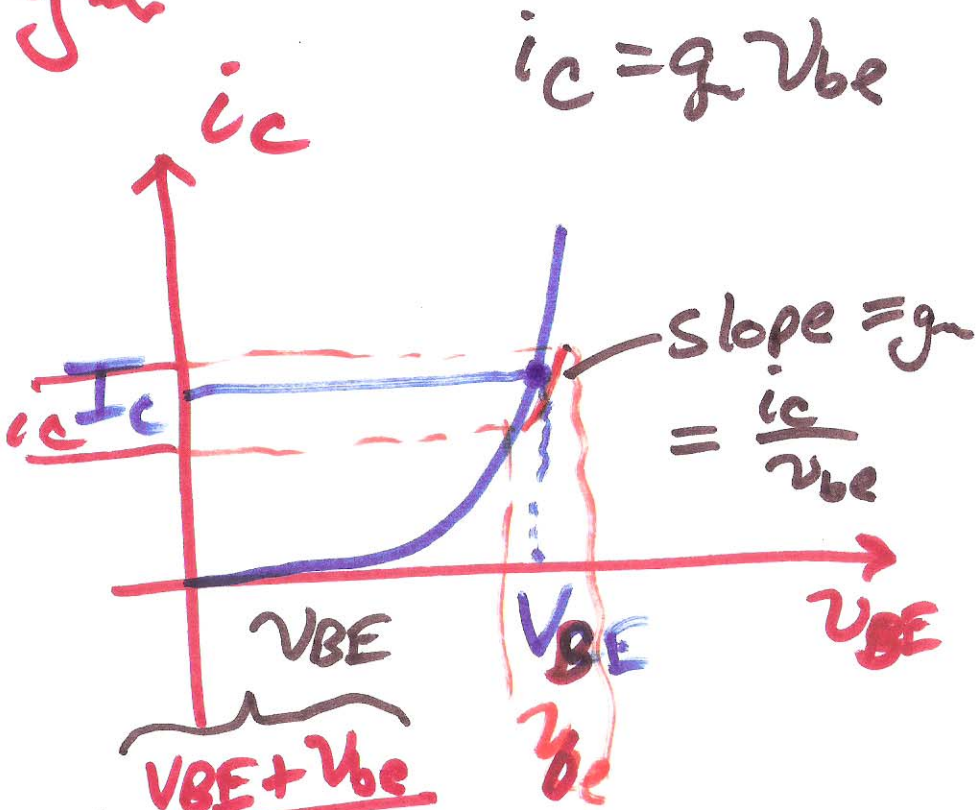
$= 25\,mV$ @ room temp

2)

derive g_m

$I_C + i_c$





$$g_m = \frac{\delta i_C}{\delta v_{BE}} = \frac{\delta i_c + I_C}{\delta v_{BE}} = \frac{\delta I_S}{\delta v_{BE}} \Big|_{\substack{I_C = \text{CONST} \\ V_{BE} = \text{CONST}}}$$

$$\left.\frac{\delta i_C}{\delta V_{BE}}\right|_{\substack{I_C=\text{CONST}\\ V_{BE}=\text{CONST}}} = \frac{\delta}{\delta V_{BE}} I_S e^{V_{BE}/nV_T}$$

$$= \frac{I_S}{nV_T} e^{V_{BE}/nV_T} \frac{\delta V_{BE}'}{\delta V_{BE}}$$

$$= \frac{i_C}{nV_T} \approx \frac{I_C}{nV_T}$$

i_C ← AC+DC

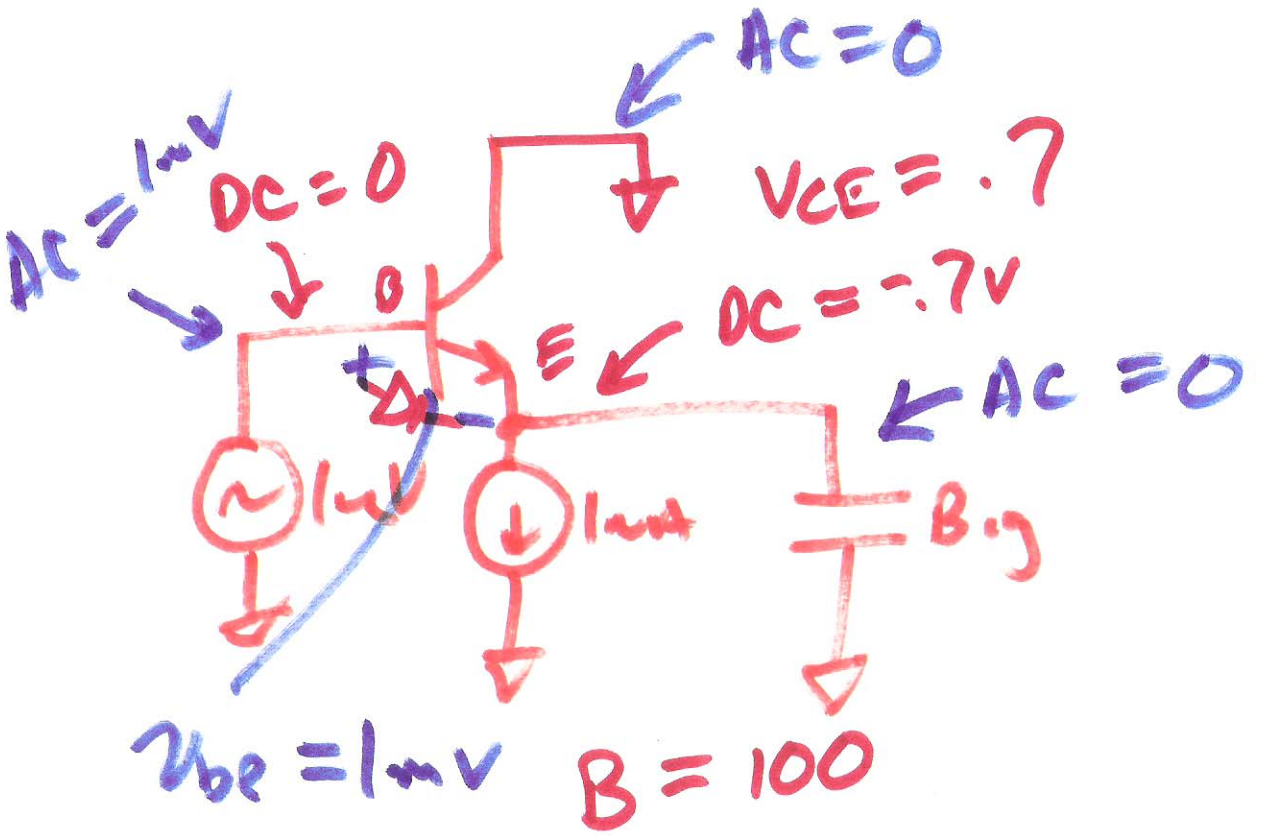
I_C ← DC

$$g_m = \frac{I_C}{nV_T}$$

$i_C \ll I_C$

AC DC

final exam :)



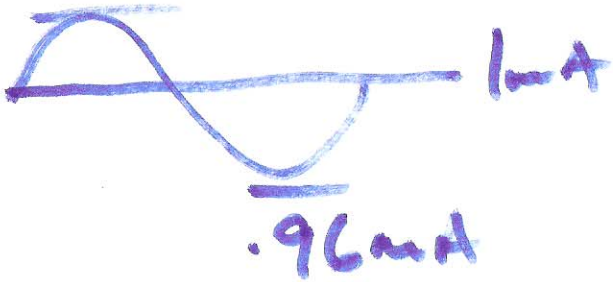
$$g = \frac{I_C}{nV_T} = \frac{1mA}{25mV}$$

$$I_C \simeq I_E = 1mA$$

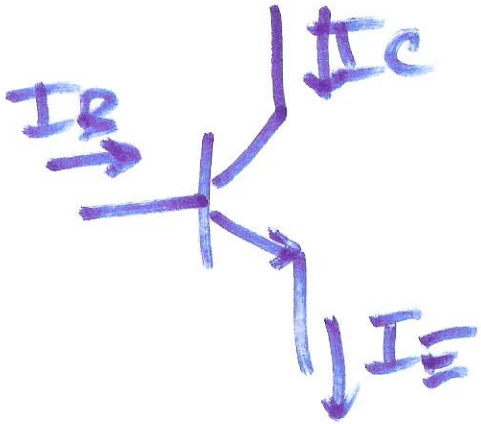
$$40mV = 40\frac{mA}{V}$$

$$i_c = g\,v_{be} = g \cdot 1mV$$

$$\boxed{i_c = 40\mu}$$



5)



$$\alpha I_E = I_C$$

$$I_C + I_B = I_E$$

$$\alpha I_C + \alpha I_B = I_C$$

$$\frac{\alpha}{1-\alpha} \cdot I_B = I_C$$

$$\beta \cdot I_B = I_C$$

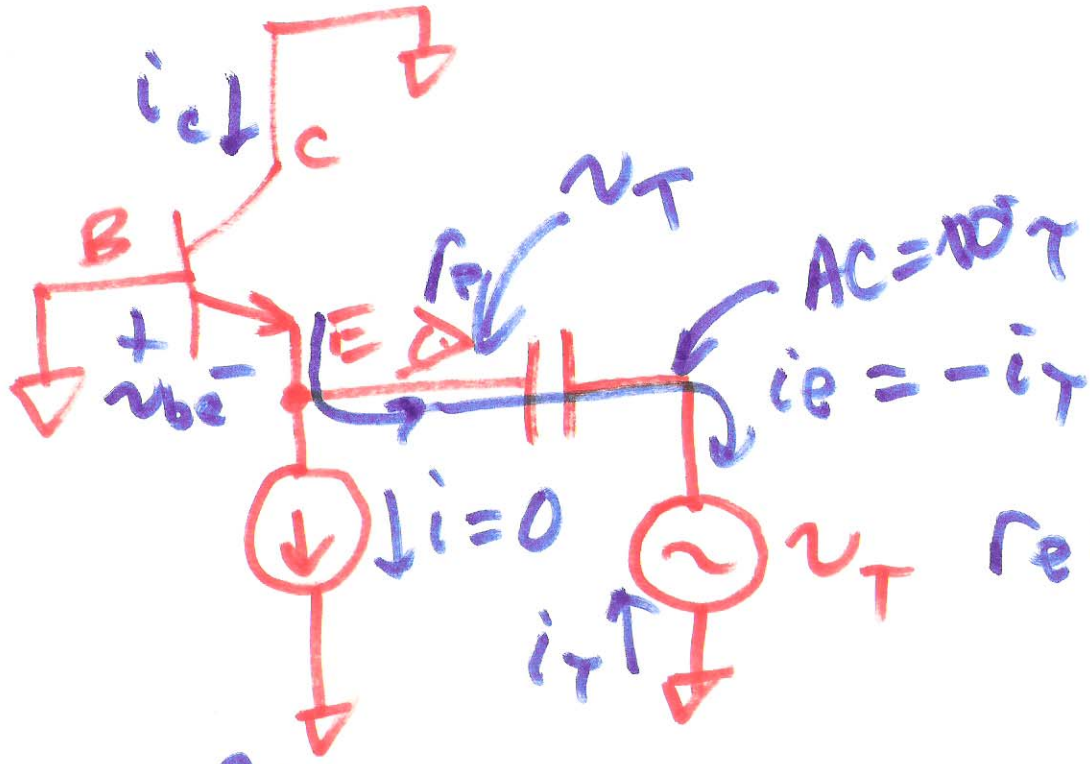
100

$$\beta = \frac{\alpha}{1-\alpha}$$

$$100 - 100\alpha = \alpha$$

$$\alpha = \frac{100}{101} = .99$$

6)



$$r_e = \frac{v_T}{i_T} = \frac{-v_{be}}{-\frac{I_E}{NV_T}\cdot v_{be}}$$

$$\boxed{r_e = \frac{NV_T}{I_E}}$$

$$v_{be} = -v_T$$

$$i_c = g_m(-v_T) = g_m v_{be}$$

$$g_m = \frac{I_c}{NV_T}$$

$$i_e \cdot \alpha = i_c \;,\; I_E \alpha = I_c$$

$$\alpha i_e = g_m v_{be} \rightarrow i_e = -i_T = \frac{g_m}{\alpha}\cdot v_{be}$$

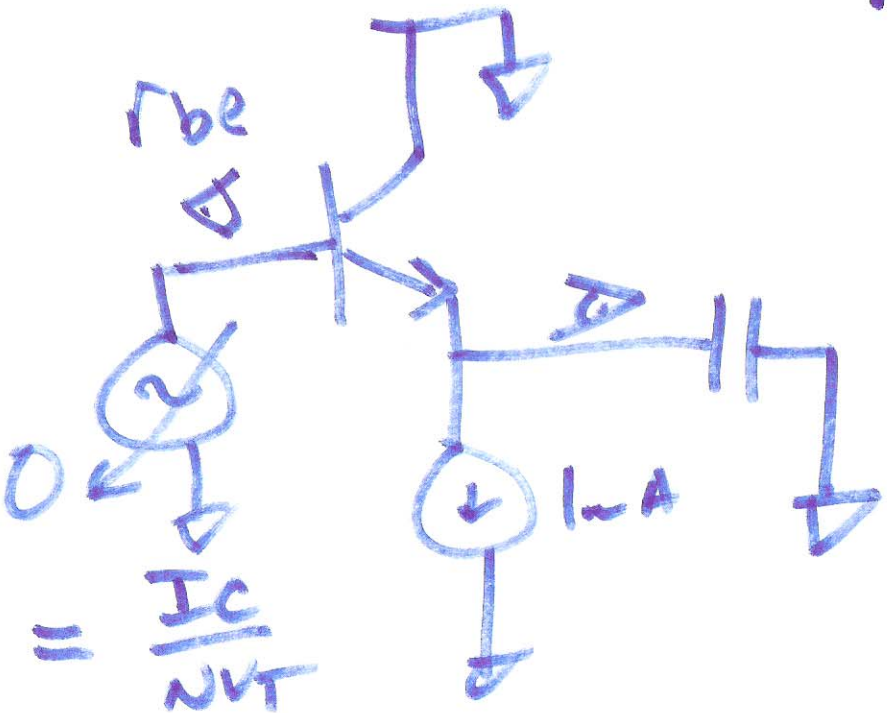
$$v_{be}\,\frac{I_E}{NV_T} \Leftarrow \frac{I_c}{\alpha \cdot NV_T}\cdot v_{be}$$

$$r_e = \frac{nV_T}{I_E} = \frac{25mV}{1mA} = 25\Omega$$

$$101 \cdot 25\Omega = 2525$$

$$r_e \simeq \frac{1}{g_m}$$

$$\frac{nV_T}{I_E} \simeq \frac{nV_T}{I_C}$$



$$r_{be} = \frac{nV_T}{I_B}$$

$$= (\beta+1) \cdot r_e$$

$$g_m = \frac{I_C}{nV_T}$$

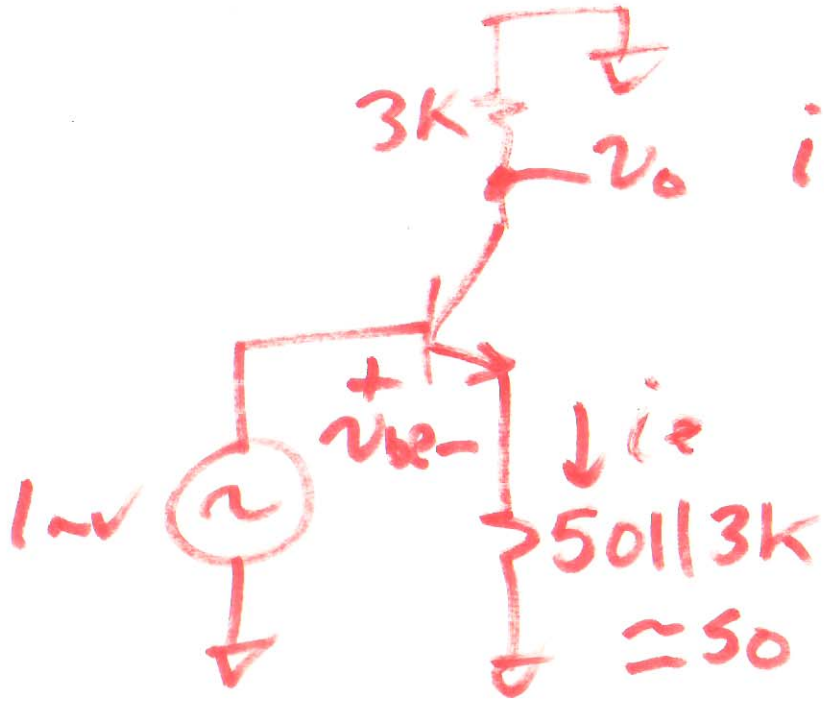
$$r_e = \frac{nV_T}{I_E}$$

$$r_{be} = \frac{nV_T}{I_B}$$

$$I_B \cdot \beta = I_C \qquad I_B \cdot \beta + I_B$$

$$I_B(\beta+1) = I_E = I_C + I_B$$

5)



$i_c = g_m v_{be}$

$v_o = -i_c \cdot 3k$

$1mV = v_{be} + i_e \cdot 50$

$i_e \approx \frac{i_c}{g_m}$

CE Amp

$$\frac{v_o}{v_i} = \frac{-3k}{\frac{1}{g_m} + 50} = \frac{-3k}{75} \approx \boxed{40}$$

$g_m = 40 \frac{+}{V}$

$\frac{1}{g_m} = 25\Omega$

9)