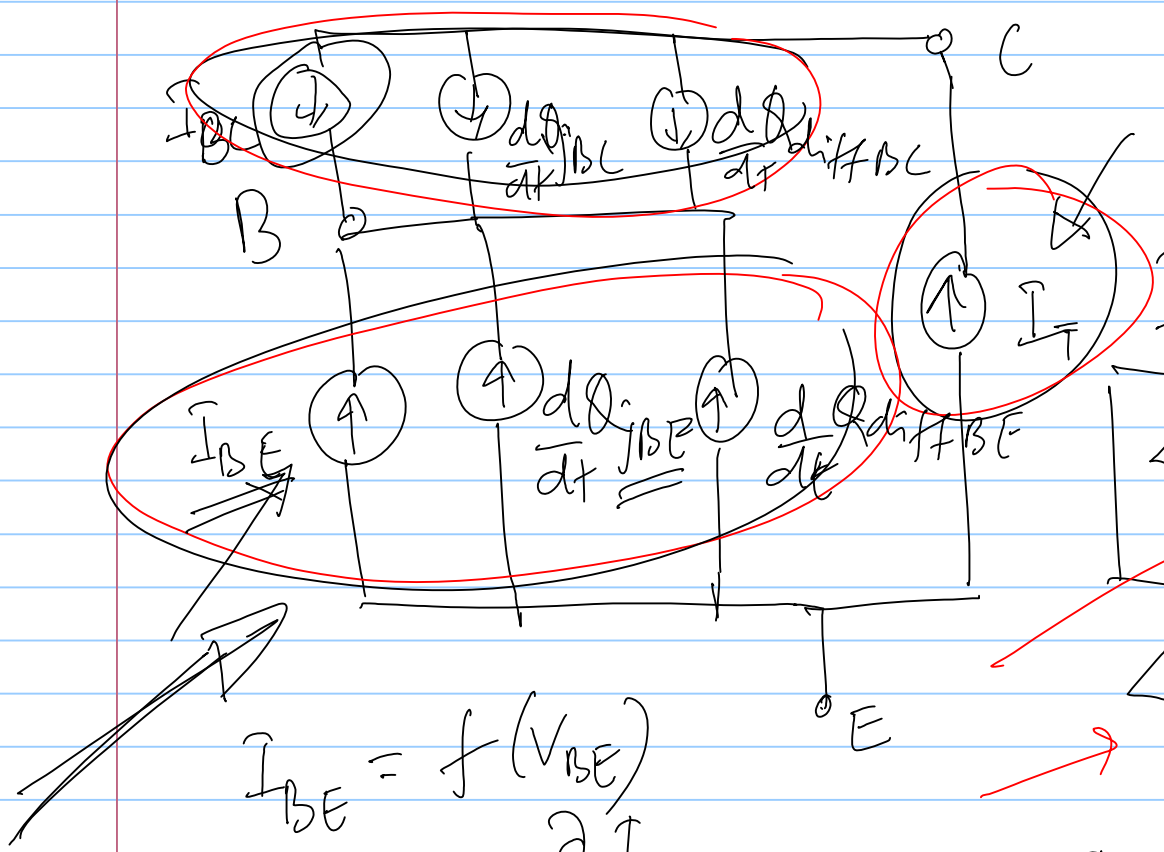
Equivalent Circuit Model.

20/10/2014



$V \rightarrow I, Q$

$\Delta V \rightarrow \Delta I, \Delta Q$

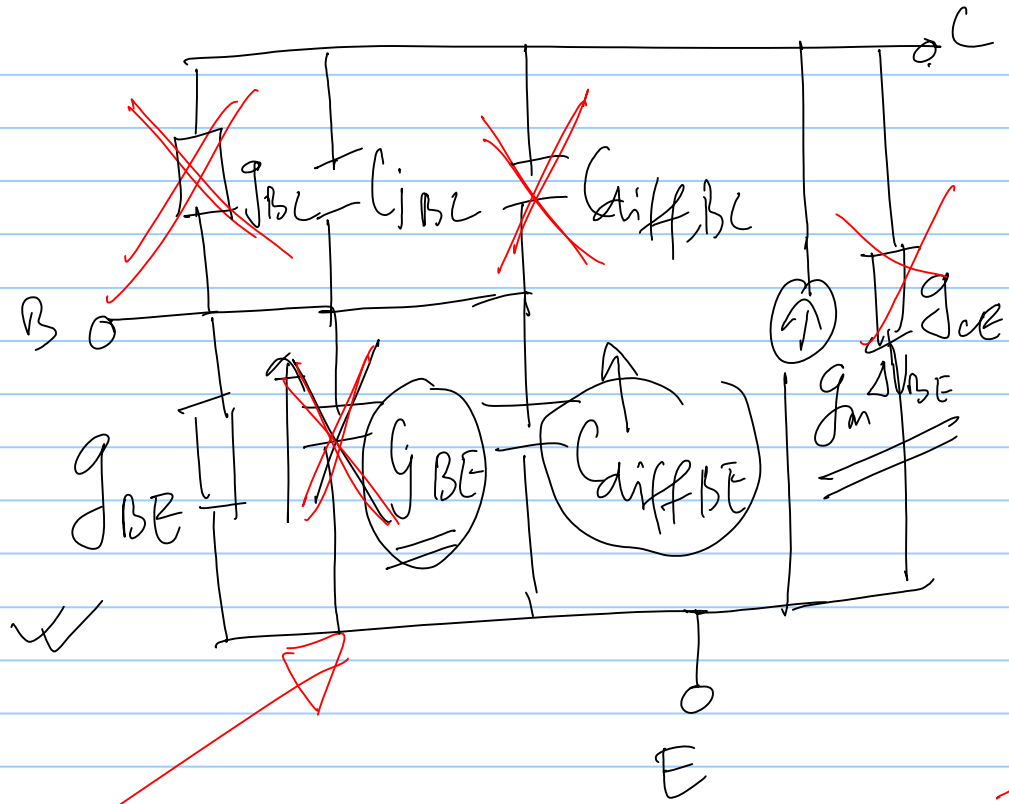
$I, Q = f(V_1, V_2)$

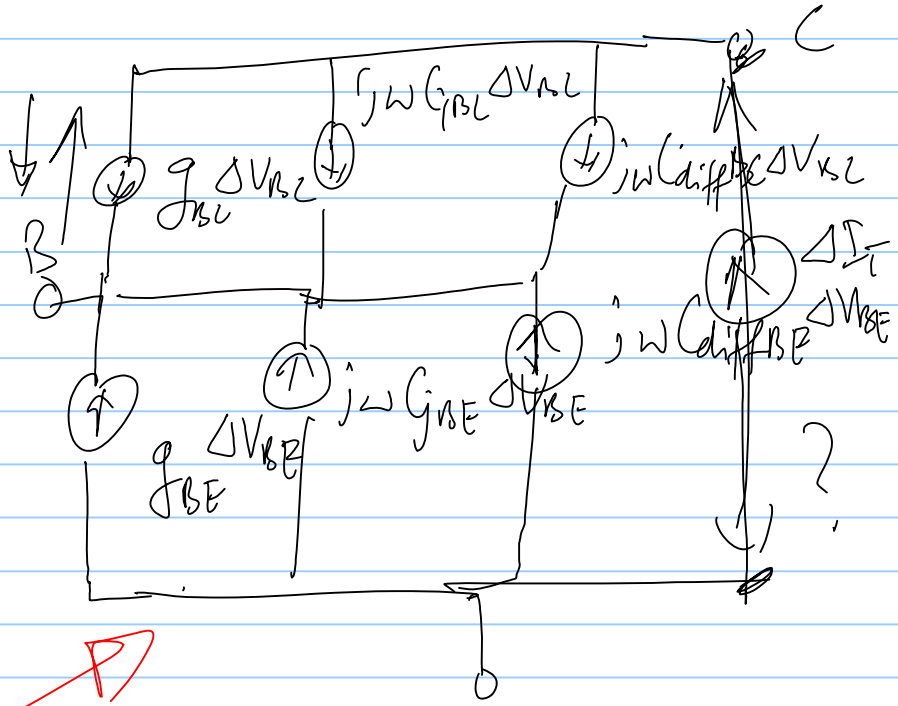
$$\Delta I = \left.\frac{\partial f_1}{\partial V_1}\right|_{V_2} \Delta V_1 + \left.\frac{\partial f_1}{\partial V_2}\right|_{V_1} \Delta V_2$$

$$\Delta Q = \left.\frac{\partial f_2}{\partial V_1}\right|_{V_2} \Delta V_1 + \left.\frac{\partial f_2}{\partial V_2}\right|_{V_1} \Delta V_2$$

$I_{BE} = f(V_{BE})$

$$\Delta I_{BE} = \frac{\partial I_{BE}}{\partial V_{BE}} \Delta V_{BE} = g_{BE} \Delta V_{BE} = \left(\frac{I_{BE}}{V_T}\right) \Delta V_{BE}$$





$$\frac{d}{dt} Q \rightarrow j\omega \Delta Q = j\omega C \cdot \Delta V$$

$$\Delta I_T = \left.\frac{\partial I_T}{\partial V_{BE}}\right|_{V_{BC}} \Delta V_{BE} + \left.\frac{\partial I_T}{\partial V_{BC}}\right|_{V_{BE}} \Delta V_{BC}$$

$$C_j(V) = \frac{\varepsilon_{Si} A}{W(V)}$$

$$\int_0^V C_j \, dV = Q_j(V)$$

$$V_{BE} = V_{BC} + V_{CE}$$

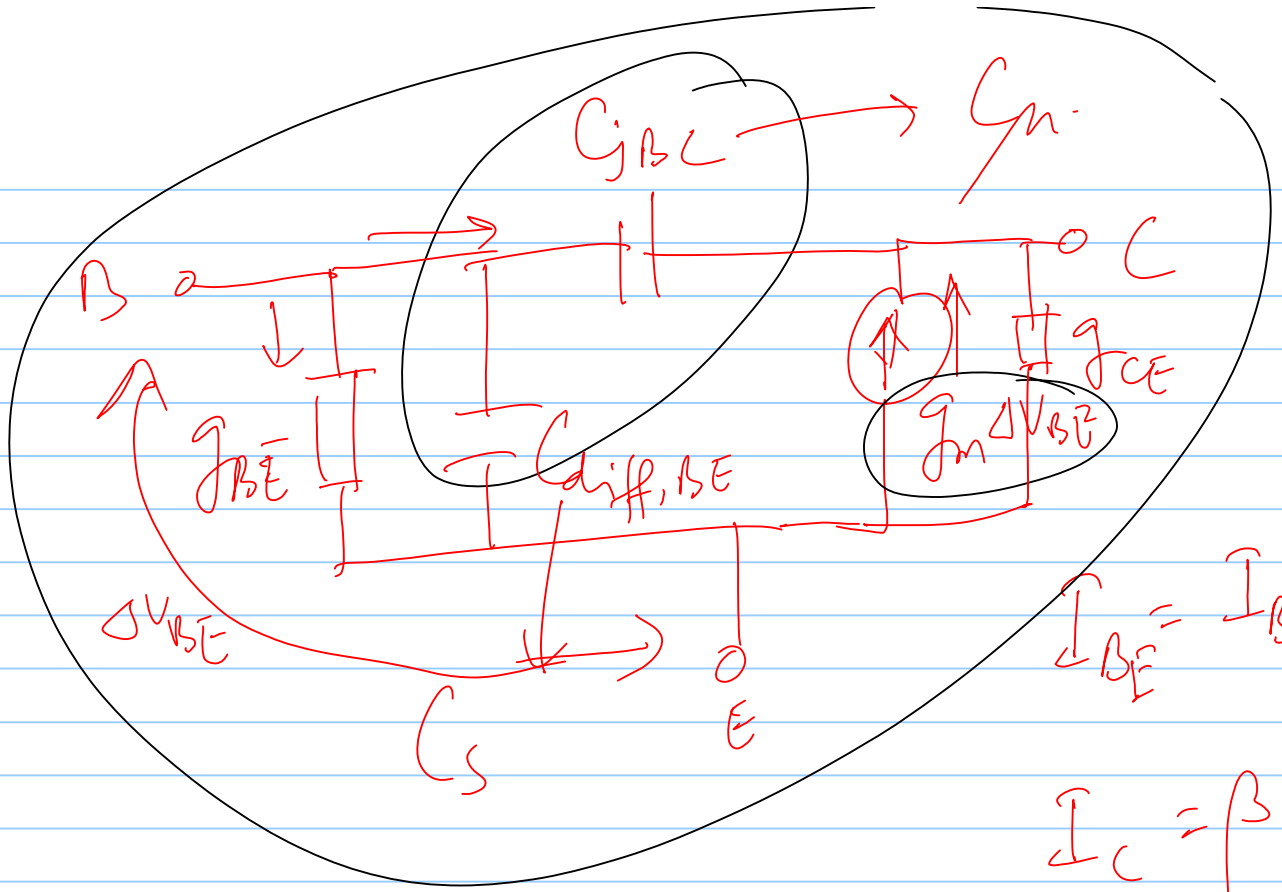
$$= V_B - V_C + V_C - V_E$$

$$= V_{BE}$$

$$dV_{BC} = -dV_{CE} \quad \text{when } V_{BE} = \text{Const}$$

$$\left.\frac{\partial i_T}{\partial V_{BC}}\right|_{V_{BE}} \Delta V_{BC} = \left.\frac{\partial i_T}{\partial V_{CE}}\right|_{V_{BE}} \Delta V_{CE}$$

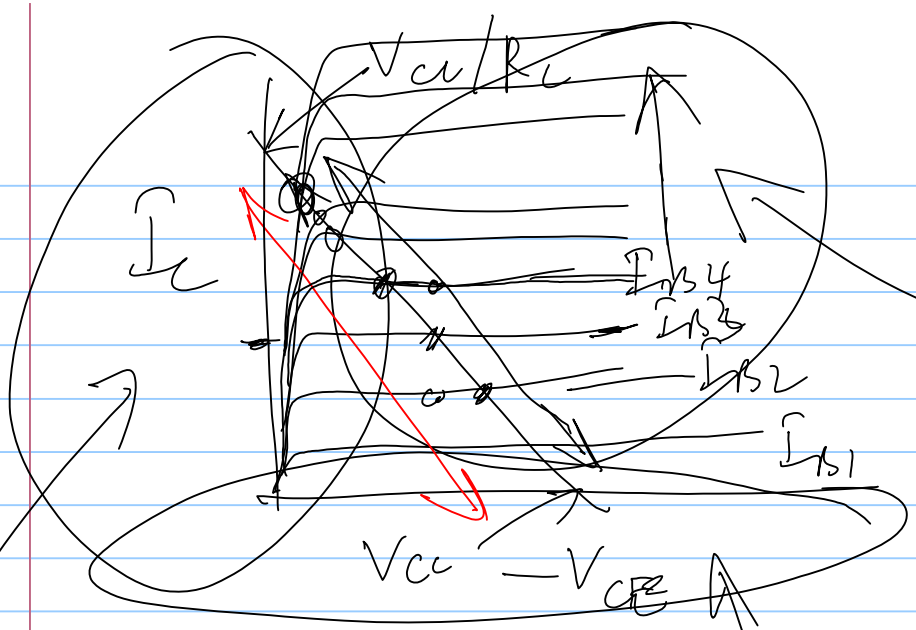
g_{CE}



$$I_{BE} = I_{BES}\left(e^{V_{BE}/V_T} - 1\right)$$

$$I_C = \beta I_{BE} = \beta I_{BES}\left(e^{V_{BE}/V_T} - 1\right)$$

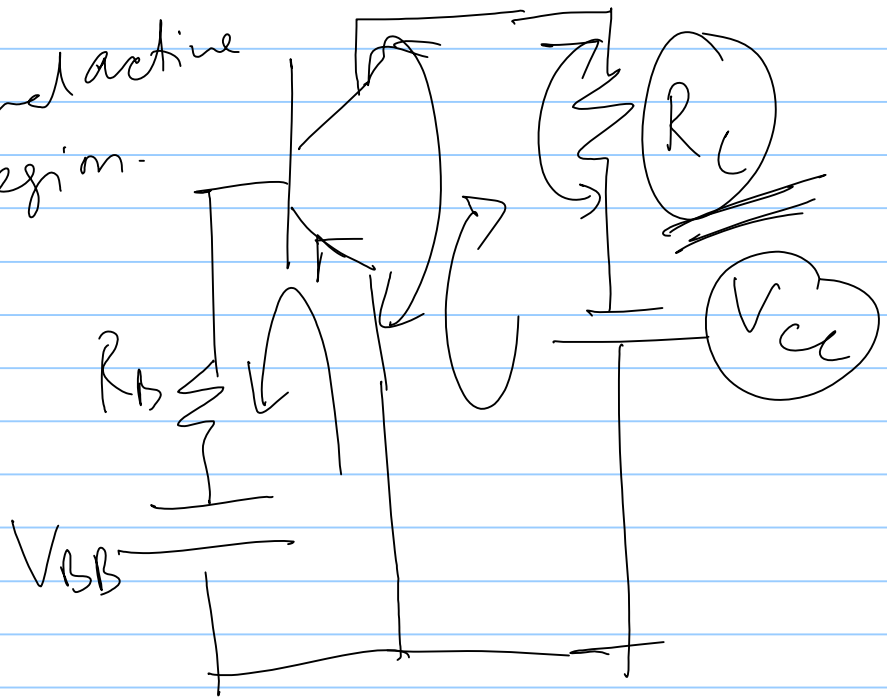
$$g_m = \frac{dI_C}{dV_{BE}} = \boxed{\frac{I_C}{V_T}}$$



Saturation region

p-n-p transistor

Normal active region



Cutoff region $V_{cc} = -V_{CE} + I_C R_C$