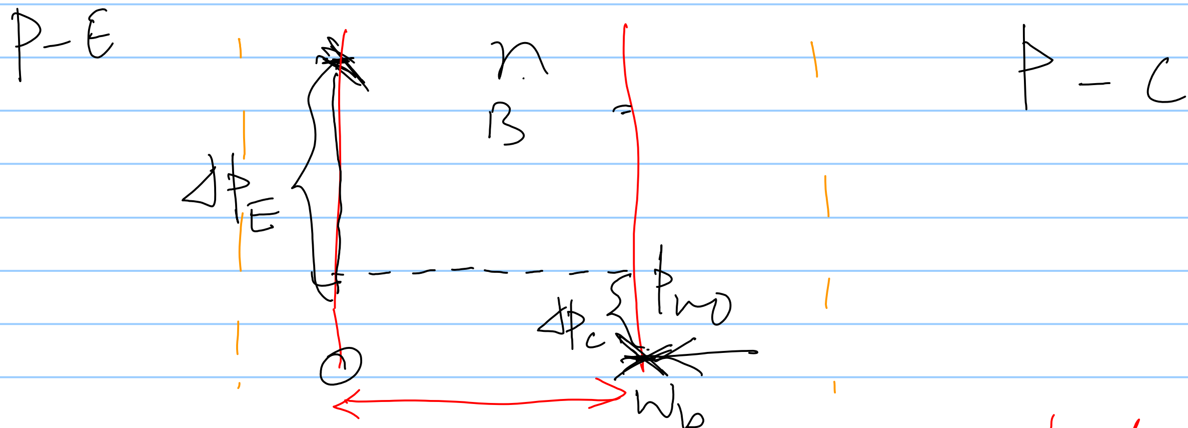
Currents in BJTs

17/10/2014



B-E forward biased

B-C reverse biased

$W_b \leftarrow$ width of neutral base region

$$\Delta p_E = p_{no}\left(\exp\left(V_{BE}/V_T\right) - 1\right)$$

$$\Delta p_C = p_{no}\left(\exp\left(\frac{V_{BC}}{V_T}\right) - 1\right) \approx -p_{no}$$

$$\frac{d^2}{dx^2}\delta p(x) = \frac{\delta p(x)}{L_p^2} \qquad x \in (0, W_b)$$

$$\Rightarrow \delta p(x) = C_1 e^{x/L_p} + C_2 e^{-x/L_p}$$

$$\delta p(x=0) = \underline{\Delta p_E} = C_1 + C_2 \longleftarrow$$

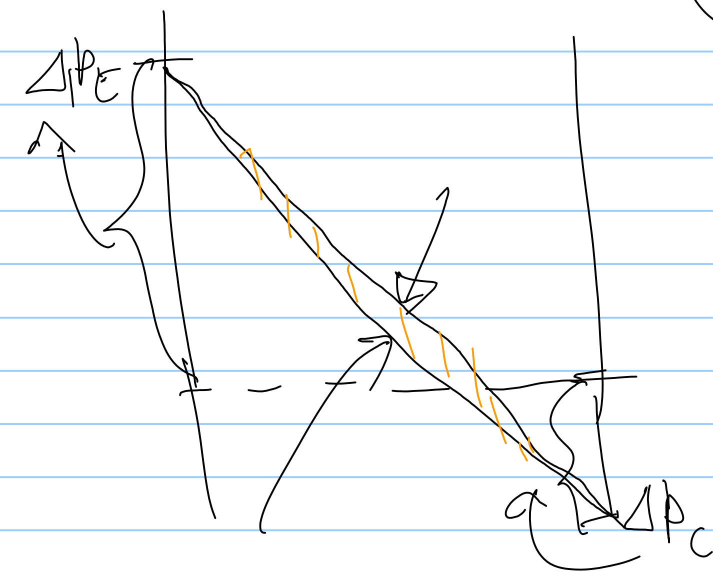
$$\delta p(x=W_b) = \underline{\Delta p_C} = C_1 e^{W_b/L_p} + C_2 e^{-W_b/L_p}$$

$$C_1 = \frac{\Delta p_C - \Delta p_E e^{-W_b/L_p}}{e^{W_b/L_p} - e^{-W_b/L_p}} \; ; \quad C_2 = \frac{\Delta p_E e^{W_b/L_p} - \Delta p_C}{e^{W_b/L_p} - e^{-W_b/L_p}}$$

$W_b << L_p$

$x \in (0, W_b)$

$$\Rightarrow \delta p(x) = \left(\frac{\Delta p_c - \Delta p_E e^{-W_b/L_p}}{e^{W_b/L_p} - e^{-W_b/L_p}}\right) e^{x/L_p} + \left(\frac{\Delta p_E e^{W_b/L_p} - \Delta p_c}{e^{W_b/L_p} - e^{-W_b/L_p}}\right) e^{-x/L_p}$$



$W_b/L_p << 1$

$x/L_p << 1$

$$\Rightarrow e^{W_b/L_p} \approx 1 + W_b/L_p$$

$$\Rightarrow e^{x/L_p} \approx 1 + x/L_p$$

$$\delta p(x) = \frac{\Delta p_C - \Delta p_E\left(1 - W_b/L_p\right)}{2W_b/L_p}\left(1 + x/L_p\right)$$

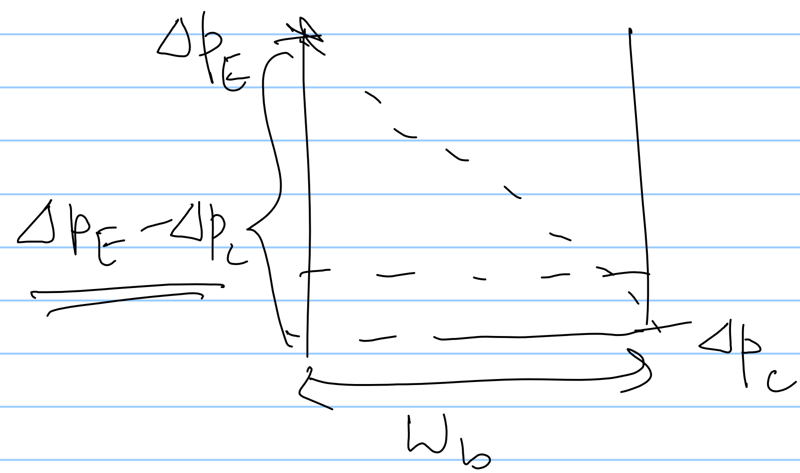
$$+ \frac{\Delta p_E\left(1 + W_b/L_p\right) - \Delta p_C}{2W_b/L_p}\left(1 - x/L_p\right)$$

$$= \frac{\cancel{\Delta p_C} - \cancel{\Delta p_E} + \cancel{2}\Delta p_E \cancel{W_b/L_p} + \cancel{\Delta p_E} - \cancel{\Delta p_C}}{\cancel{2}\cancel{W_b/L_p}}$$

$$+ \left(\frac{x}{\cancel{L_p}}\right)\left(\frac{\cancel{2}\Delta p_C - \cancel{2}\Delta p_E}{\cancel{2}W_b/\cancel{L_p}}\right)$$

$$\delta p(x) = \Delta p_E + \frac{\Delta p_c - \Delta p_E}{W_b}\, x.$$

$$y = c + mx$$



$$m = -\frac{\Delta p_E - \Delta p_c}{W_b}$$

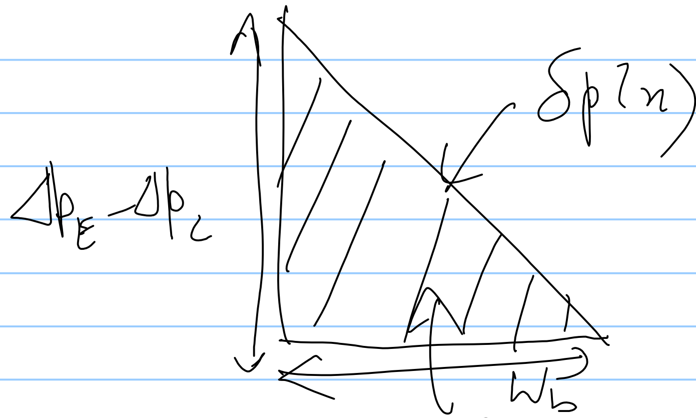
$$I_{Ep} = qA D_p \frac{d\,\delta p(x)}{dx} \Bigg|_{x=0}$$

for $\gamma = 1$, $I_{En} = 0$

$$I_E = I_{Ep}$$

$$I_C = qA D_p \frac{d\,\delta p(x)}{dx} \Bigg|_{x=W_b}$$

$$I_B = I_{Ep} - I_C$$



$\Delta p_c \in (0, -p_{n0})$

Q_p ← excess minority charge stored in the base

$$Q_p = qA \cdot \frac{1}{2} \cdot W_b (\Delta p_E - \Delta p_c)$$
$$\simeq qA \frac{1}{2} W_b \Delta p_E$$

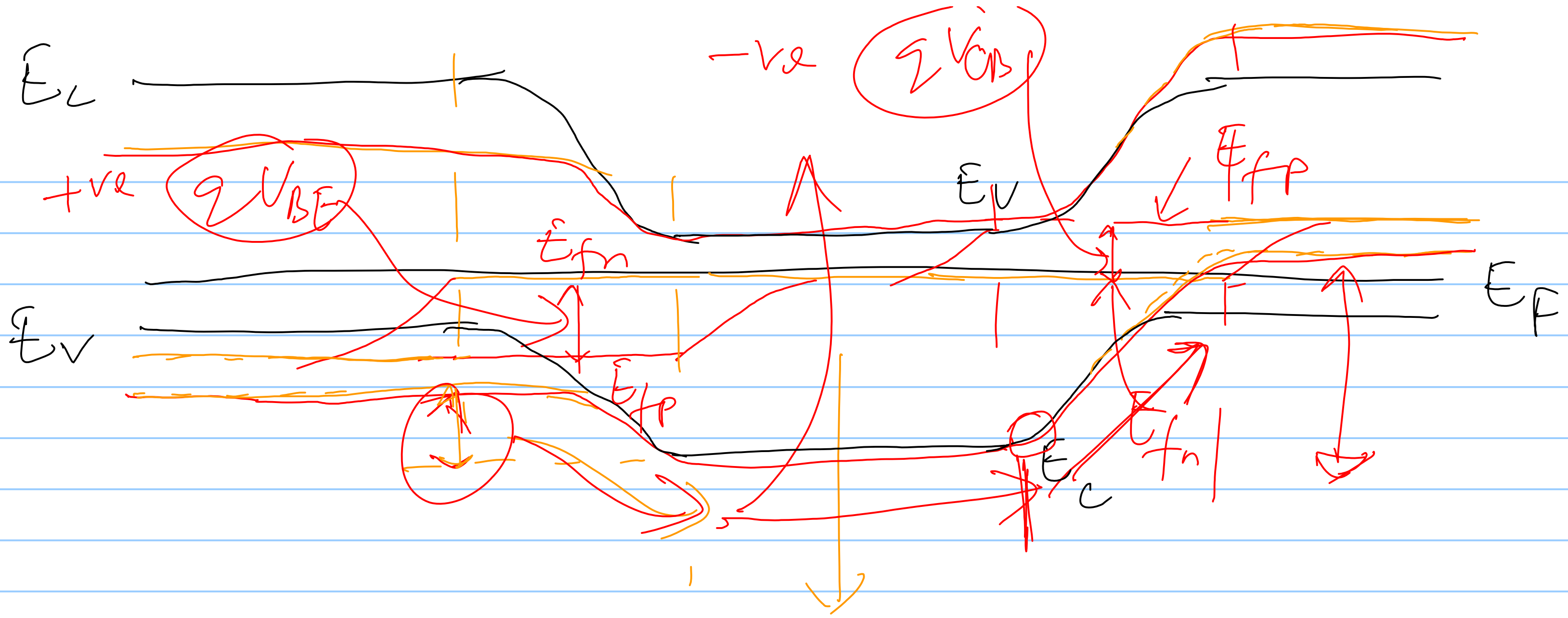
$$\boxed{I_B \downarrow = \frac{Q_p}{\tau_p \uparrow}}$$

$$I_C \uparrow = \frac{Q_p}{\tau_t \downarrow}$$

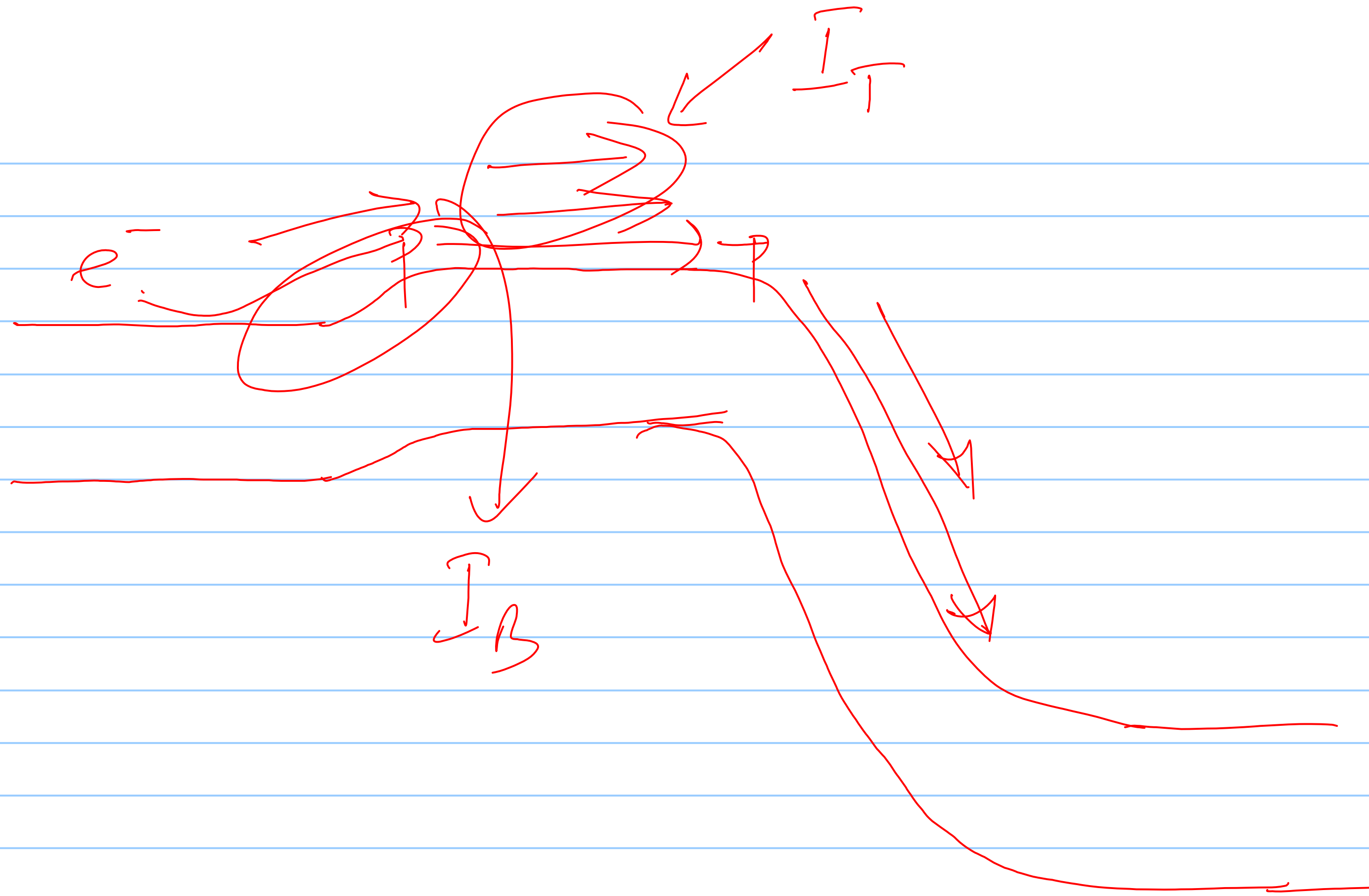
$$\tau_t = \frac{W_b^2}{2D_p}$$

$$\beta = \frac{I_C}{I_B} = \frac{\tau_p}{\tau_t}$$

$$I_E = I_C + I_B$$

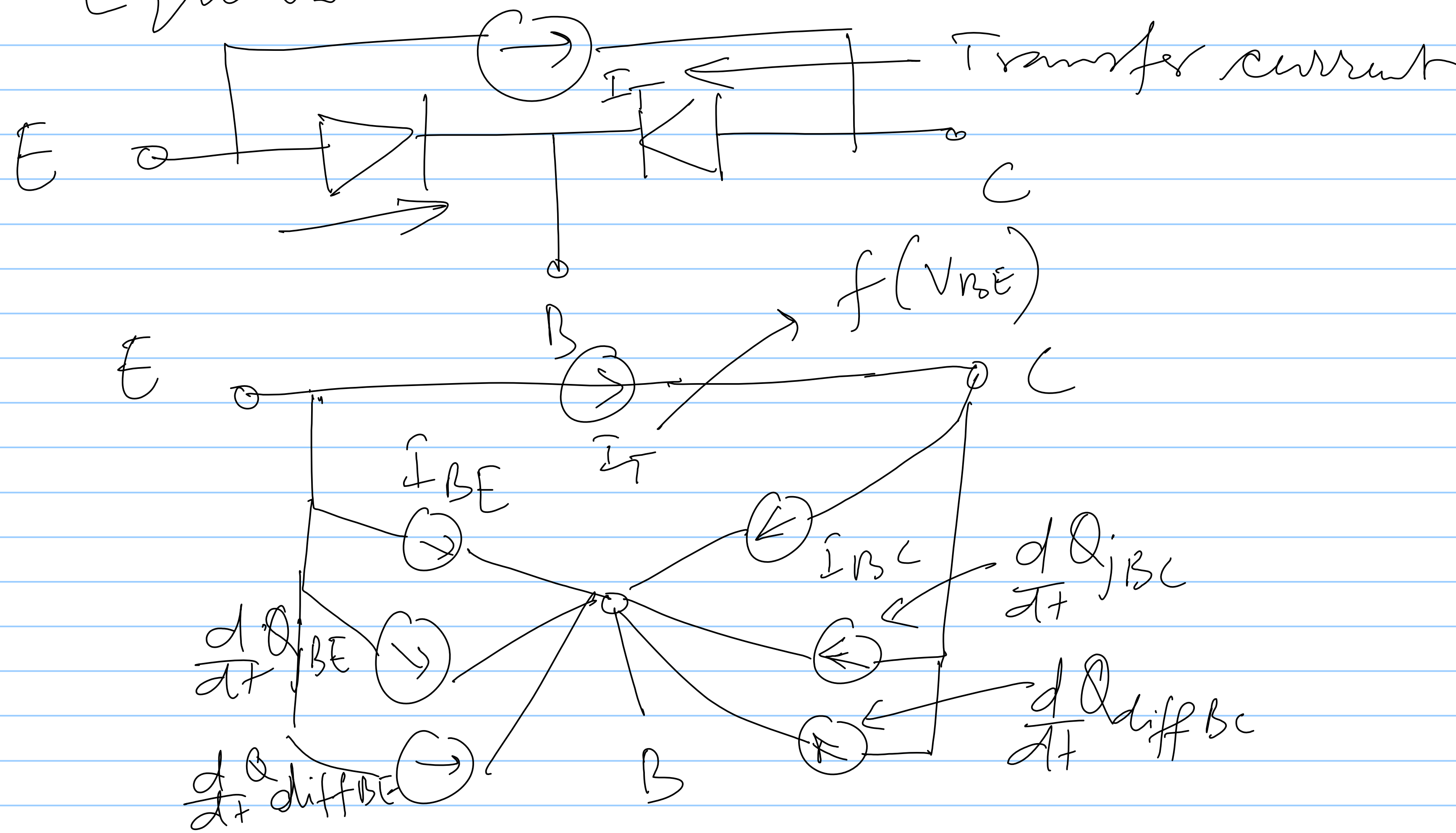


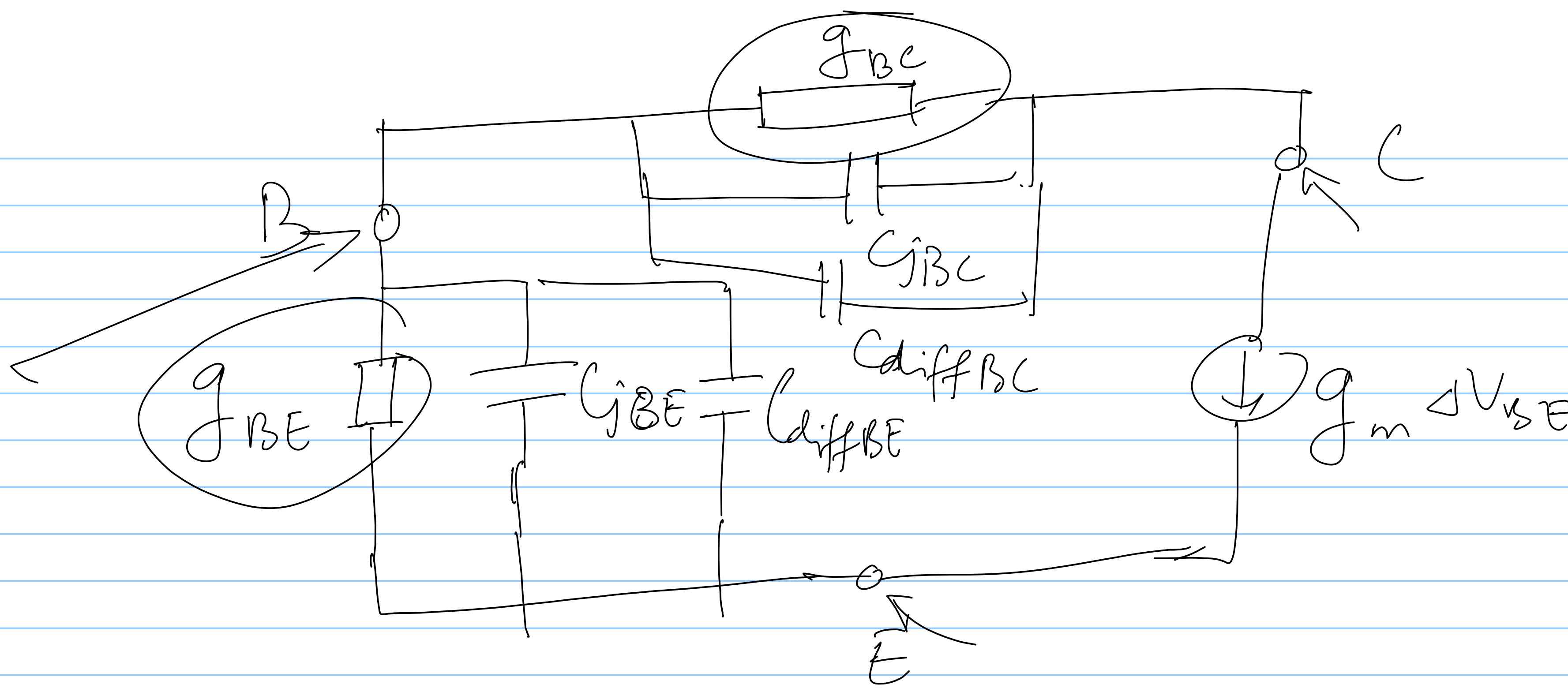
E_c
+ve
qV_{BE}
E_{fn}
E_v
E_{fp}
-ve
qV_{CB}
E_v
E_{fp}
E_F
E_c
E_{fn}



e⁻
I_T
I_B

Equivalent Ckt Model





B
C
E
gBC
CjBC
CdiffBC
gBE
CjBE
CdiffBE
gm dVBE