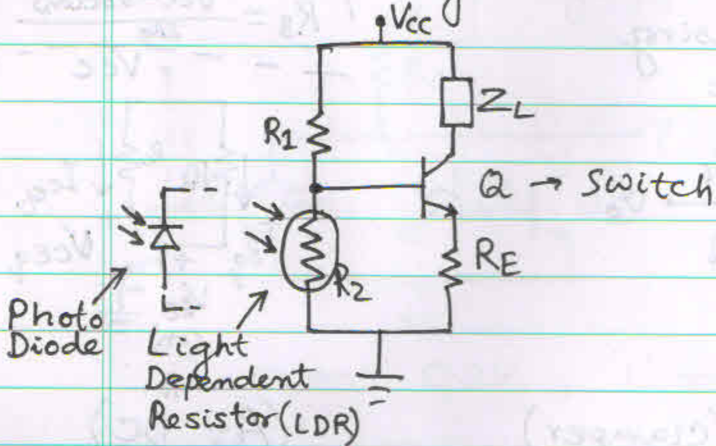
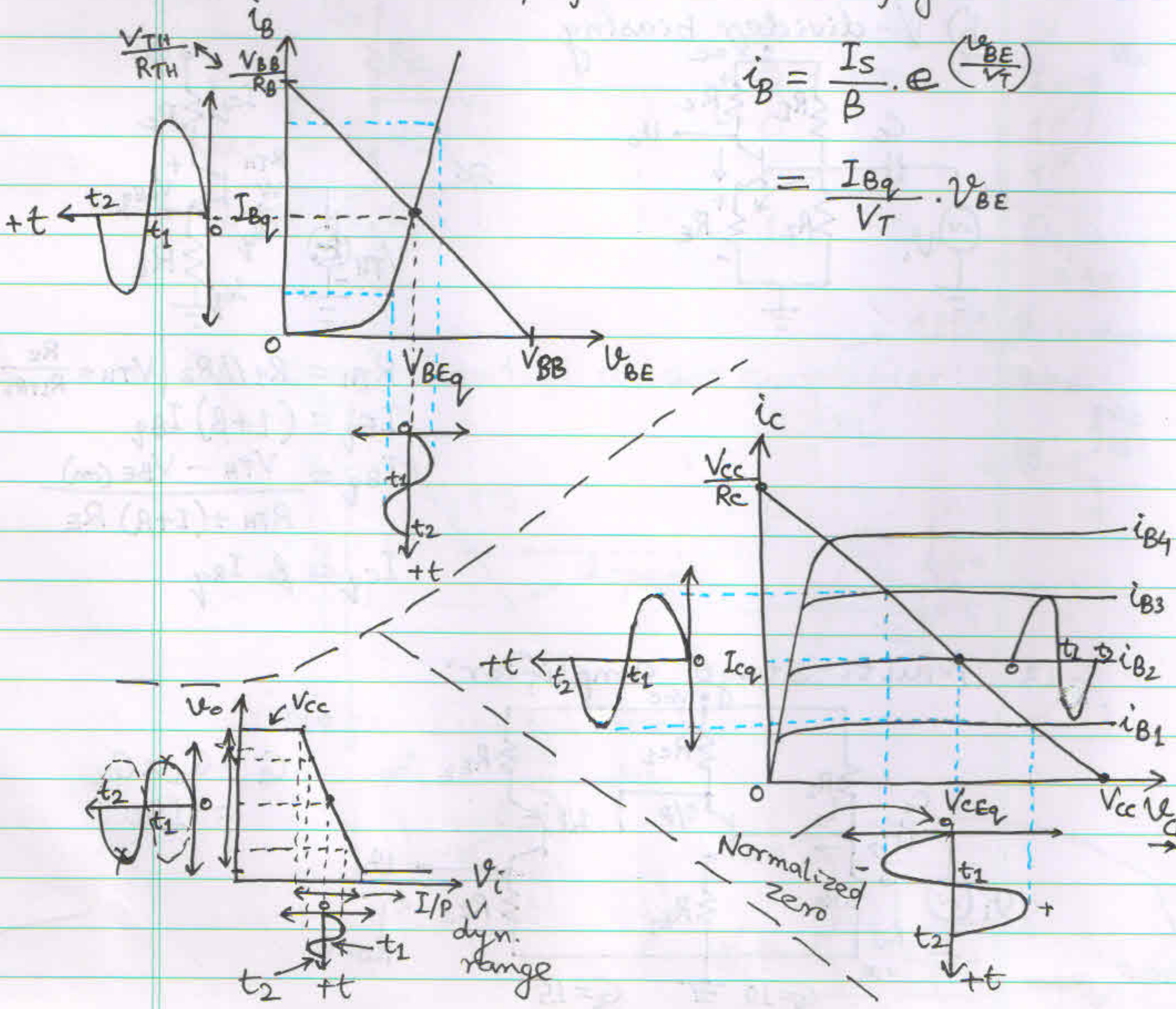
14. BJT as a Light controlled switch ↳ Digital




15. BJT as an amplifier : CE config.

$$i_B = \frac{I_S}{\beta} \cdot e^{\left(\frac{v_{BE}}{V_T}\right)}$$

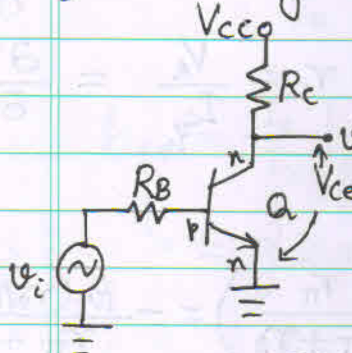
$$= \frac{I_{Bq}}{V_T} \cdot v_{BE}$$



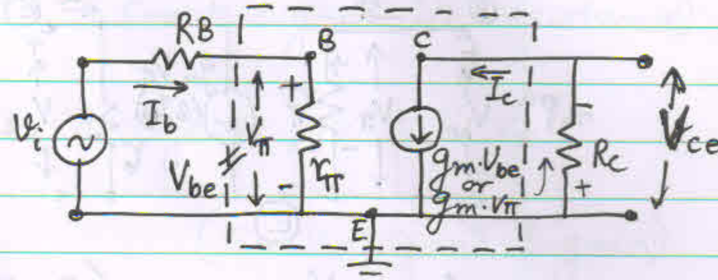
$\overset{npn}{BC548}$ / $\overset{pnp}{BC549}$

CE amp.

16. a) Small signal hybrid-$\pi$ equivalent circuit : AC + DC




$\cong$




$r_\pi \Rightarrow$ Diffusion R (B-E I/P R)

$g_m \Rightarrow$ Transconductance

$V_\pi \Rightarrow$ V across B-E junction.

$$r_\pi = \frac{V_{be}}{i_b} = \frac{V_T}{I_{Bq}} = \frac{\beta \cdot V_T}{I_{Cq}} = \frac{\beta}{g_m}$$

$$V_\pi = \left(\frac{r_\pi}{r_\pi + R_B}\right) v_i$$

$$g_m = \frac{I_{Cq}}{V_T}$$

$$v_o = V_{ce} = -[g_m \cdot V_\pi] \cdot R_C$$

Gain $\rightarrow$ $A_v = \frac{v_o}{v_i} = -(g_m \cdot R_C) \cdot \left(\frac{r_\pi}{r_\pi + R_B}\right)$

V-gain of an amplifier (BJT in CE config.)
(Small-signal)

$$i_b = \frac{v_i}{r_\pi + R_B} \quad ; \quad i_c = \beta \cdot i_b = I_S \cdot e^{\left(\frac{v_{BE}}{V_T}\right)}$$

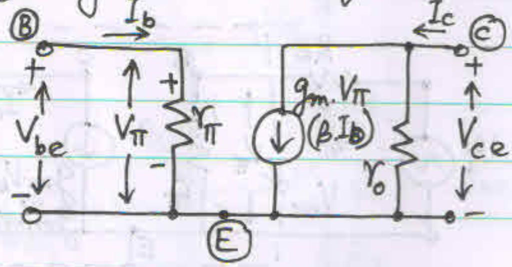
$$V_{ce} = -i_c \cdot R_C$$

$\hookrightarrow v_o$

→ Time varying characteristics

b) Hybrid-Π equivalent circuit with Early Effect:

npn




$$r_o = \frac{V_A}{I_{c_q}} = \frac{\partial v_{CE}}{\partial i_c}\bigg|_{q\text{-pt}}$$

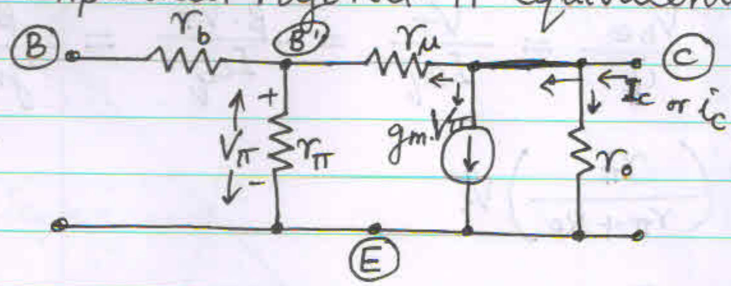
$$A_V = \frac{V_o}{V_i} = -g_m\,(R_C /\!/ r_o)\left(\frac{r_\pi}{r_\pi + r_B}\right) = -\frac{\beta\cdot(r_o /\!/ R_C)}{r_\pi + R_B}$$

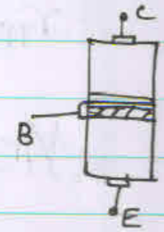
↑ V-Gain

$$V_o = g_m \cdot V_\pi\,(r_o /\!/ R_C)$$

c) Expanded hybrid-Π equivalent circuit:

npn




$r_b$ : Series resistance in 'Base' region of S-C (10s of Ω)

$r_b \ll r_\pi$ $\qquad$ $r_b \approx 0$ at low frequencies.

$r_\mu$ : Reverse-biased diffusion resistance (C-B junc$^n$)

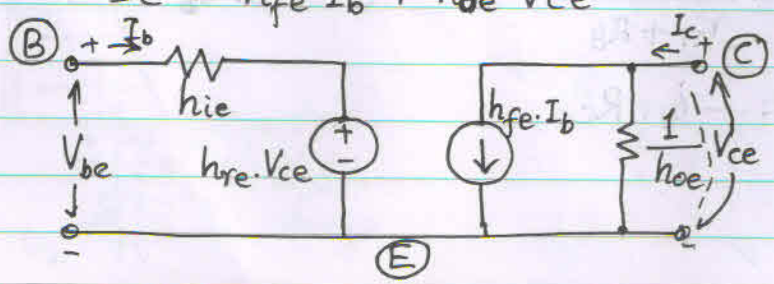
(MΩ normally).

→ Feedback is realized. → $I_b \to f(V_{ce})$

(O/P → I/P) → 'f/b' in short → $f(i_c)$

17. h-parameters:

$$V_{be} = h_{ie}\, I_b + h_{re}\, V_{ce}$$
$$I_c = h_{fe}\, I_b + h_{oe}\, V_{ce}$$



$$h_{ie} = \frac{V_{be}}{I_b}\bigg|_{V_{ce}=0} = r_b + (r_\pi \,//\, r_\mu) \;;\; h_{ie} \approx r_\pi$$

(Small-signal I/P resistance)

$$h_{fe} = \frac{I_c}{I_b}\bigg|_{V_{ce}=0} \;;\; I_c = g_m . V_\pi \;;\; V_\pi = I_b . r_\pi$$

$$= g_m . r_\pi = \beta$$

(Small-signal I-gain)

$$h_{re} = \frac{V_{be}}{V_{ce}}\bigg|_{I_b=0} \;;\; V_{be} = V_\pi = \frac{r_\pi}{r_\pi + r_\mu} . V_{ce}$$

$$= \frac{r_\pi}{r_\pi + r_\mu} \approx \frac{r_\pi}{r_\mu} \;;\; \because r_\pi \ll r_\mu$$

(Voltage f/b ratio)

$$h_{oe} = \frac{I_c}{V_{ce}}\bigg|_{I_b=0} \;;\; I_c = g_m . V_\pi + \frac{V_{ce}}{r_o} + \frac{V_{ce}}{r_\pi + r_\mu}$$

$$= \frac{1+\beta}{r_\mu} + \frac{1}{r_o}$$

(Small-signal O/P admittance) $\rightarrow \frac{1}{Z}$

18. T-model