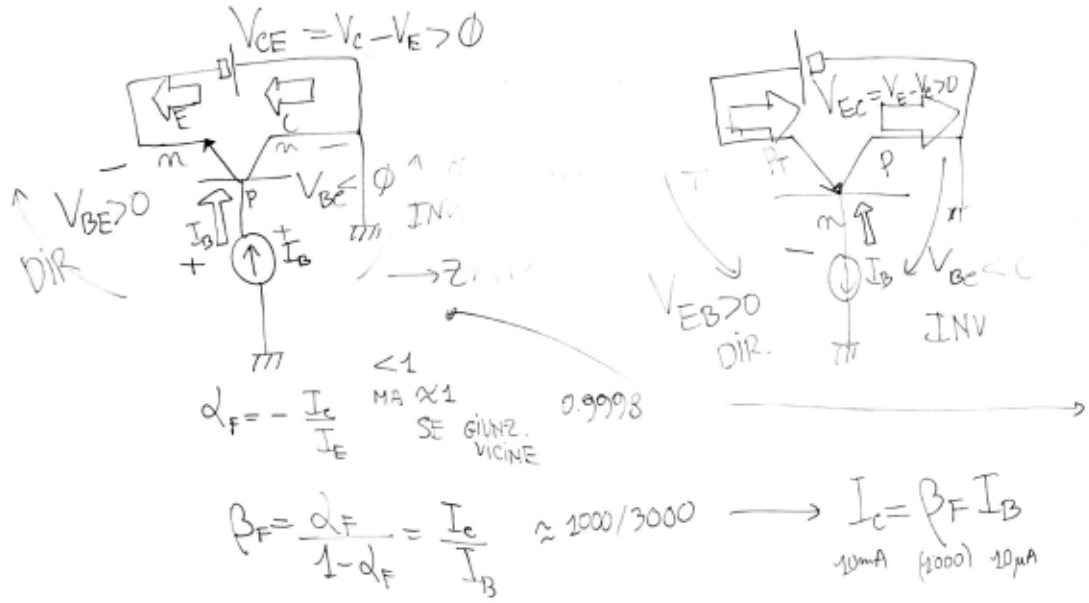
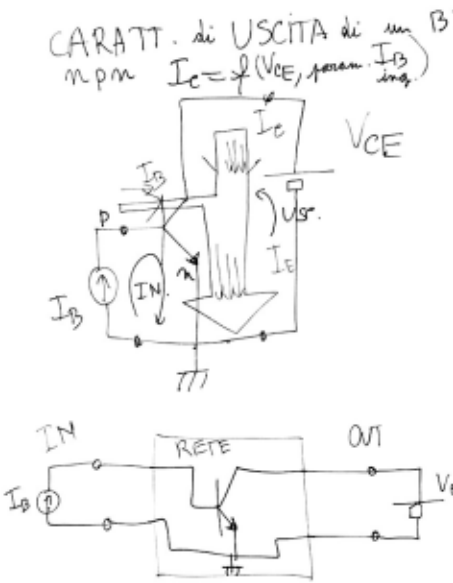
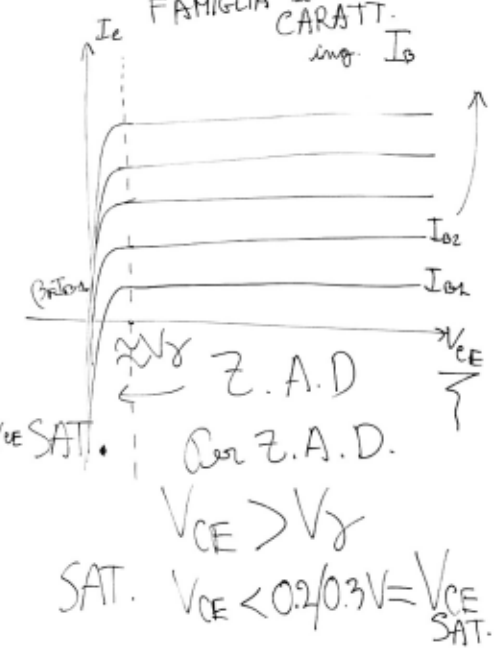
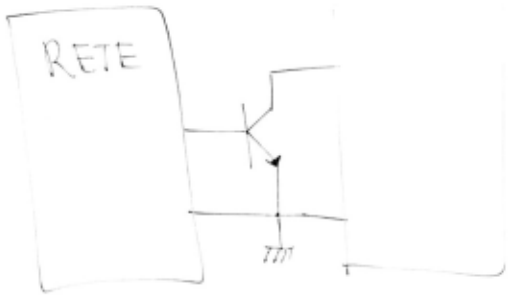

$V_{CE} = V_C - V_E > 0$
E
B
C
n
p
n
$V_{BE} > 0$
DIR
I_B
I_B
$V_{BC} < 0$
IN.
$\alpha_F = -\frac{I_c}{I_E}$
< 1
MA ≈ 1
SE GIUNZ. VICINE
0.9998
$\beta_F = \frac{\alpha_F}{1-\alpha_F} = \frac{I_c}{I_B} \approx 1000/3000 \longrightarrow I_c = \beta_F I_B$
1mA (1000) 1μA

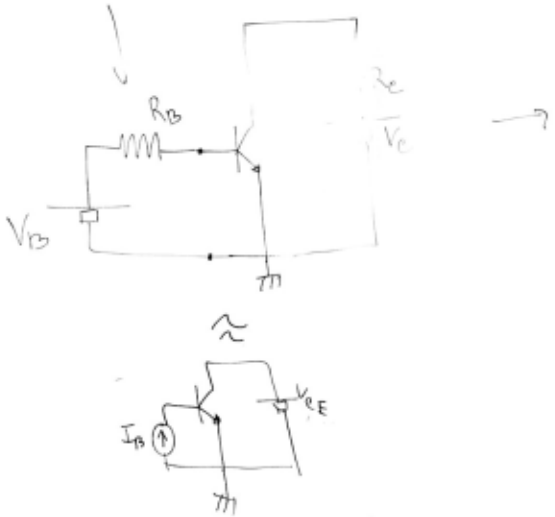
$V_{EC} = V_E - V_C > 0$
P
n
p
I_B
$V_{BC} < 0$
$V_{EB} > 0$
DIR.
INV


CARATT. di USCITA di un BJT
npn
$I_C = f(V_{CE}, \text{param. } I_B \text{ ing.})$
I_C
V_{CE}
I_B
p
n
IN.
I_E
I_B
IN
RETE
OUT
I_B
V_{CE} SAT.

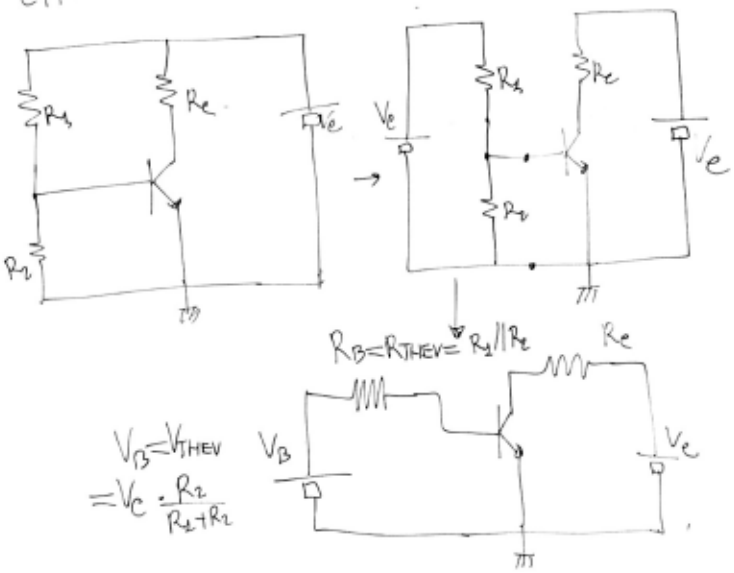

FAMIGLIA di CARATT.
ing. I_B
I_C
I_{B2}
I_{B1}
$I_{B1<I_{B2}}$
$2V_\gamma$
Z.A.D
V_{CE}
Per Z.A.D.
$V_{CE} > V_\gamma$
SAT. $V_{CE} < 0.2/0.3V = V_{CE\,SAT.}$

POLARIZZ. → I_{BQ}, I_{CQ}, V_{CEQ}
BATTERIA



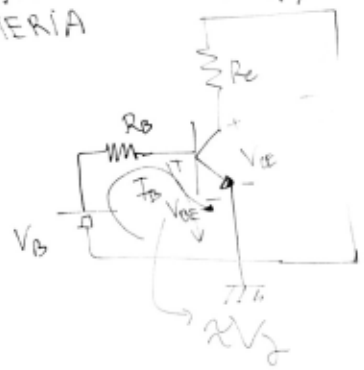


CIRC. di AUTOPOLARIZZ. del TRANSISTORE



POLARIZZ. → $I_{B\phi}$, $I_{C\phi}$, $V_{CE\phi}$, $V_{BE\phi}$

BATTERIA



ING. $V_B = R_B I_B + V_{BE}$

SC. $V_C = \beta_F I_C + V_{CE}$

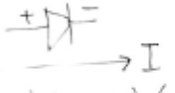
$I_C = \beta_F I_B$

$I_B = \dfrac{V_B - V_{BE}}{R_B} \cong \dfrac{V_B - V_\gamma}{R_B} = I_{B\phi}$

$I_C = \beta_F I_{B\phi} = I_{C\phi}$

$V_C = R_e I_{C\phi} + V_{CE} \rightarrow V_{CE\phi} = V_C - R_e I_{C\phi}$

B-E dir.



$V_{D\,on} \cong V_\gamma$ (0.6/0.7)

$V_C, R_e \rightarrow V_B, R_B$ "ESTERNE"

IMPONIAMO → $I_{B\phi}$, $I_{C\phi}$, $V_{CE\phi}$

$V_{BE\phi} \cong V_\gamma$

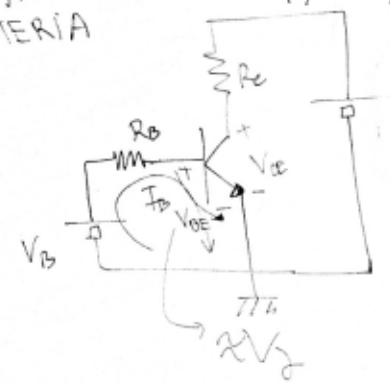
$I_{B\phi} = \dfrac{V_B - V_\gamma}{R_B}$

$I_{C\phi} = \beta_F I_{B\phi}$

$V_{CE\phi} = V_C - R_e I_{C\phi}$

POLARIZZ. → $I_{B\Phi}$, $I_{C\Phi}$, $V_{CE\Phi}$, $V_{BE\Phi}$

BATTERIA

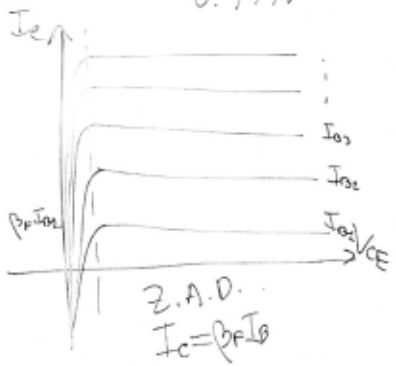


$\beta_F = \frac{\alpha_F}{1-\alpha_F}$ 5000 10000

0.9998
0.9999
0.9997

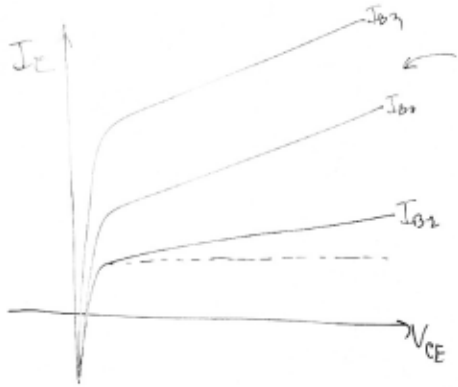
β_F ↑ MAL CONDIZ.ⁿ

↓ FUGA TERMICA.



Z.A.D.

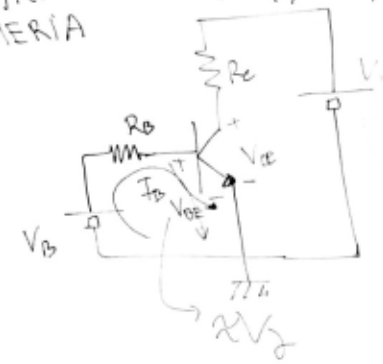
$I_C = \beta_F I_B$



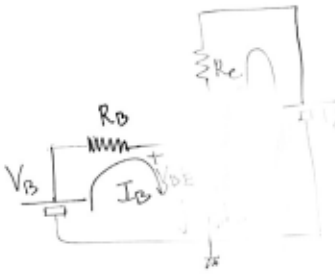
← EFFETTO EARLY

POLARIZZ. → I_{BQ}, I_{CQ}, V_{CEQ}, V_{BEQ}

BATTERIA

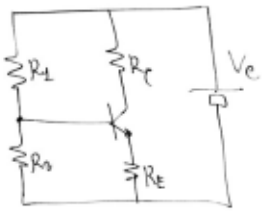


... di
AUTOPOLARIZZ.
con RESISTENZA R_E



$V_B = V_{th} \cdot \frac{R_2}{R_1+R_2}$

$R_B = R_1 // R_2$



ING. $V_B = R_B I_B + V_{BE} + R_E (I_B + I_C)$

USC. $V_C = R_C I_C + R_E (I_B + I_C)$

$\hookrightarrow V_{BE} \cong V_\gamma$

$V_B - V_\gamma = R_B I_B + R_E (I_B + I_C)$

$I_C = \beta_F I_B$

$V_B - V_\gamma = R_B I_B + R_E (I_B + \beta_F I_B)$

$V_B - V_\gamma = R_B I_B + R_E (\beta_F + 1) I_B$

$$I_B = \frac{V_B - V_\gamma}{R_B + R_E (\beta_F + 1)}$$

$$I_C = \beta_F I_B = \frac{\beta_F (V_B - V_\gamma)}{R_B + R_E (\beta_F + 1)}$$

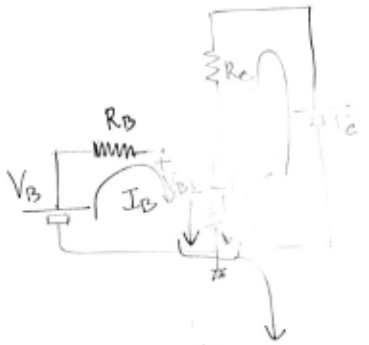
POLARIZZ. $\longrightarrow I_{B\phi}, I_{E\phi}, V_{CE\phi}, V_{BE\phi}$
BATTERIA

$$I_E = \frac{(\beta_F+1)}{R_B + R_E(\beta_F+1)}$$

R_B e R_E SONO PARI $\approx$ KΩ
β_F GRANDE

$\lim_{\beta_F \to +\infty} I_E \longrightarrow I_E = \frac{\beta_F+1}{R_E(\beta_F+1)} \; V_B - V_\gamma$

$I_B = \frac{V_B - V_\gamma}{R_E} \longrightarrow I_{E\phi} \longrightarrow I_{C\phi} = \alpha_F I_{E\phi} \simeq I_{E\phi}$



$I_E = I_B + I_C$

$I_E = I_B + \beta_F I_B = I_B(\beta_F+1)$

ING. $V_B = R_B I_B + V_{BE} + R_E(I_B + I_C)$

USC. $V_C = R_C I_C + R_E(I_B + I_C)$

$\rightarrow V_{BE} \simeq V_\gamma$

$V_B - V_\gamma = R_B I_B + R_E(I_B + I_C)$

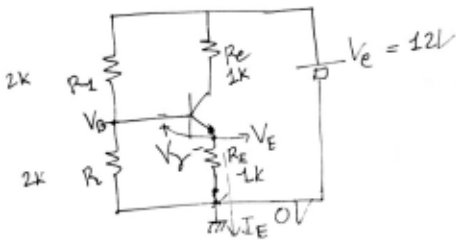
$I_C = \beta_F I_B$

$V_B - V_\gamma = R_B I_B + R_E(I_B + \beta_F I_B)$

$V_B - V_\gamma = R_B I_B + R_E(\beta_F+1) I_B$

$$I_B = \frac{V_B - V_\gamma}{R_B + R_E(\beta_F+1)}$$

$$I_C = \beta_F I_B = \frac{\beta_F (V_B - V_\gamma)}{R_B + R_E(\beta_F+1)}$$



$I_{C\phi}$, $V_{CE\phi}$, $I_{E\phi}$, $V_{BE\phi}$, V_γ

5.3mA

$\Delta V_{RE} = V_E - \phi$

$V_B = V_e \cdot \frac{R_2}{R_1} = 12 \cdot \frac{2}{4} = 6V$

$\rightarrow V_E = 6 - V_\gamma = 6 - 0.7 = 5.3\ V$

$V_E - \phi = R_E I_E$

$V_E = R_E I_E \quad I_E = \frac{V_E}{R_E} = \frac{5.3V}{1k} = 5.3\ mA$

$\hookrightarrow I_{E\phi} = 5.3mA \cong I_{C\phi}$

ERRORE $1/\beta_F$

$\sim 1/300$

BJT in Z.A.D.? Si se $V_{CE\phi} > 0.2/0.3V$

USC. $V_e = R_e I_{C\phi} + V_{BE\phi} + R_E I_{E\phi}$

$V_{CE\phi} = V_e - \underset{1k \cdot 5.3m}{R_e I_{C\phi}} - \underset{1k \cdot 5.3m}{R_E I_{E\phi}} = 12 - 5.3 - 5.3 = 1.4V$

OK!

Z.A.D.

POLARIZZ. $\longrightarrow I_{B\phi}, I_{C\phi}, V_{CE\phi}, V_{BE\phi}$

BATTERIA

$$I_E = \frac{(\beta_F+1)}{R_B+R_E}$$

R_B e R_E SONO

β_F GRANDE

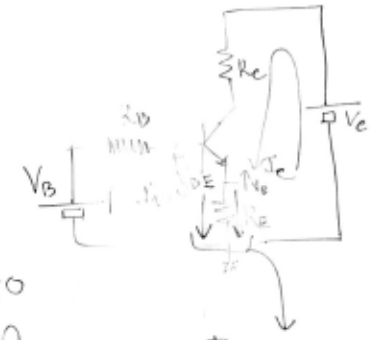
RAGIONEVOLI ($\approx K\Omega$)

SPECIFICHE (DATA SHEET del TR.)

$\longrightarrow \beta_F$ MINIMO GARANTITO > 300

$$\lim_{\beta_F \to +\infty} I_E \longrightarrow I_E = \frac{\beta_F+1}{R_E(\beta_F+1)}(V_B - V_\gamma)$$

$$I_B = \frac{V_B - V_\gamma}{R_E} \longrightarrow I_{E\phi} \longrightarrow I_{C\phi} = \alpha_F I_{E\phi} \simeq I_{E\phi}$$



$$I_E = I_B + I_C$$

$$I_E = I_B + \beta_F I_B = I_B(\beta_F+1)$$

INS. $V_B = R_B I_B + V_{BE} + R_E(I_B + I_C)$

USC. $V_C = R_C I_C + R_E(I_B + I_C)$

$\hookrightarrow V_{BE} \simeq V_\gamma$

$$V_B - V_\gamma = R_B I_B + R_E(I_B + I_C)$$

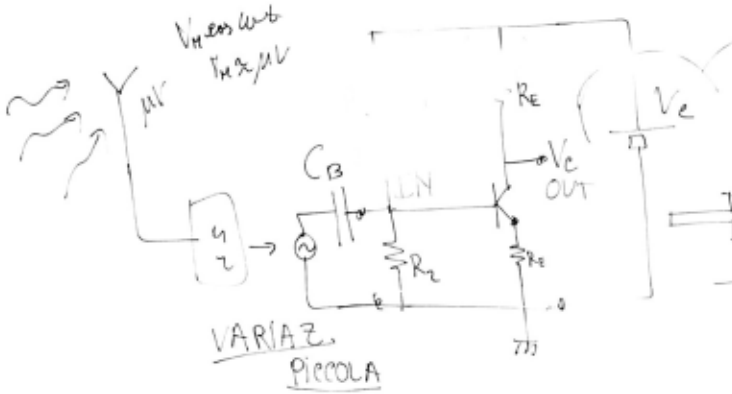
$$I_C = \beta_F I_B$$

$$V_B - V_\gamma = R_B I_B + R_E(I_B + \beta_F I_B)$$

$$V_B - V_\gamma = R_B I_B + R_E(\beta_F+1) I_B$$

$$I_B = \frac{V_B - V_\gamma}{R_B + R_E(\beta_F+1)}$$

$$I_C = \beta_F I_B = \frac{\beta_F (V_B - V_\gamma)}{R_B + R_E(\beta_F+1)}$$



→ SEGNALE

PUNTO DI RIPOSO

I_{CQ}, V_{CEQ}, I_{BQ}

→ piccola variaz. in INGRESSO

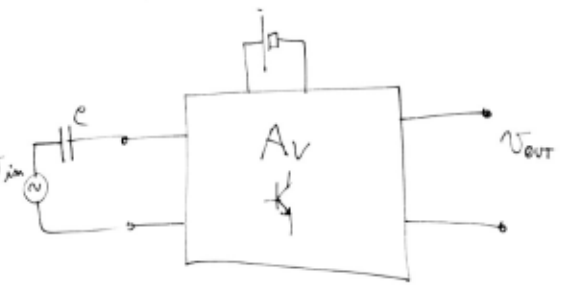
→ GRANDE var. in USCITA

(MODULO. la V_e GRANDE con SEGNALE PICCOLO)

AMPLIF. di TENSIONE →

$v_{OUT} = A_V \, v_{in}$

↳ $A_V(j\omega) = \dfrac{V_{in}(j\omega)}{V_{in}(j\omega)}$



↳ $H(j\omega) = \dfrac{V_{in}(j\omega)}{V_{in}(j\omega)}$