$R_1 = 8k$ $V_{CC} = 5V$

$R_2 = 500$

$R_3 = 4k$ $? \to$ margine immunità disturbi

$R_4 = 5k$

$\to$ modelli a soglia , $\beta_F = 100$ $V_\gamma = 0.2$

$\to$ riconoscere su caratteristica statica i punti caratteristici

   $\to$ guadagno , derivata $= -1$

   $\to$ potrebbe non esistere punto a pendenza -1, ma si vuole ambiente

$\to$ legame fra regione funzionamento T_1 e diodo

$$I_D = I_{E1}$$

$$T_1 \text{ ON} \Leftrightarrow D \text{ ON}$$

per accendere transistor?   ⊽ $]V_\delta$ ⊼ V_γ $\Rightarrow$ $V_i = 2V_\gamma$

SUPPONIAMO CHE D e T_1 SIANO SPENTI

$$V_i < 2V_\delta$$

$\to$ uscita? T_2 non è spento

HP: T_2 OFF

   $\to V_{BE2} < V_\gamma$

   $\to I_{B2}, I_{C2}, I_{E2} = 0$ ∫ $\to$ kirkhoff

         $V_{CC} - R_2 (\underset{=0}{\cancel{I_{C1}}} + \underset{=0}{\cancel{I_{B2}}}) - V_{BE2} - \cancel{R_3 I_{E2}} = 0$

         $\underset{T_1 \text{ OFF}}{} \underset{T_2 \text{ OFF}}{}$ $\underset{=0}{} \atop T_2 \text{ OFF}$

         $\to V_{CC} = V_{BE2} \to$ ASSURDO

<u>HP</u>: T_2 RN (normale)

→ $V_{BE2} = V_\gamma$
→ $V_{CE2} > V_{CE \, SAT}$
→ $I_{C2} = \beta_F I_{B2}$

→ RIPPECCIO CONDIZIONE

$$\begin{cases} V_{CC} - R_2 \left(\underbrace{I_{C1}}_{=0} + I_{B2} \right) - \underbrace{V_{BE2}}_{=V_\gamma} - R_3 I_{E2} = 0 \\ \\ I_{E2} = I_{C2} + I_{B2} = \left(\beta_F + 1 \right) I_{B2} \\ \qquad\qquad \overset{\shortparallel}{\beta_F I_{B2}} \end{cases}$$

$$V_{CC} - R_2 I_{B2} - V_\gamma - \left(\beta_F + 1 \right) R_3 I_{B2} = 0 \qquad \longrightarrow \qquad I_{B2} = \frac{V_{CC} - V_\gamma}{R_2 (\beta_F + 1) R_3} = 19.3 \, \mu A$$

$$\longrightarrow V_U = R_3 \cdot (\beta_F + 1) I_{B2} = 4.24 \, V$$

→ verifichiamo ipotesi

$$V_{C2} = V_{CC} - \underbrace{R_4 I_{C2}}_{\beta_F I_{B2}} = \underbrace{-0.25 \, V}_{??} \qquad\qquad V_{CE} = V_{C2} - V_U = -4.49 \begin{array}{l} < V_{CE \, SAT} \\ \underline{NO} \\ \underline{ASSURDO} \, ! \end{array}$$

<u>HP</u>: T_2 SAT

$V_{BE} = V_\gamma$
$V_{CE} = V_{CE \, SAT}$
$I_C < \beta_F I_B$

→ SI CONOSCE UN PEZZO DI CARATTERISTICA:

3.26
$T_1 \, OFF$
$D \, OFF$
$T_2 \, ON$

$T_1 \, ON \, (RN), \, D \, ON$
$T_2 \, SAT$

$2V_\gamma$

$V_U = R_3 \cdot I_{B2} \qquad \rightarrow I_{E2} = \dfrac{V_U}{R_3}$

$I_{E2} = I_{B2} + I_{C2}$

$I_{B2} = \dfrac{V_{CC} - (V_U + V_\gamma)}{R_2}$

$I_{C2} = \dfrac{V_{CC} - V_U + V_{CE \, SAT}}{R_4}$

$$\left. \begin{array}{l} \\ \\ \\ \end{array} \right\} \quad \frac{V_U}{R_3} = \frac{V_{CC} - V_U - V_\gamma}{R_2} + \frac{V_{CC} - V_U - V_{CE \, SAT}}{R_4}$$

$\rightarrow V_U = 3.86 \, V$

$I_C < \beta_F I_B \quad \underline{OK}$

→ T_1 va in regime normale

$$V_u = R_3 \, I_{E2}$$

$$I_{E2} = I_{C2} + I_{B2}$$

$$I_{C2} = \frac{V_{cc} - (V_u + V_{ce\,sat})}{R_4}$$

$$I_{E2} = I_{B2} + I_{C1}$$

$$I_{C1} = \beta_F \, I_{B1}$$

$$I_{B1} = \frac{V_i - 2V_\gamma}{R_1}$$

$$I_{E2} = \frac{V_{cc} - (V_u + V_\gamma)}{R_2}$$

$\Bigg\}$ $V_u = 11.51 - 5.1 \, V_i$:

↳ CURVA LINEARE
DECRESCENTE
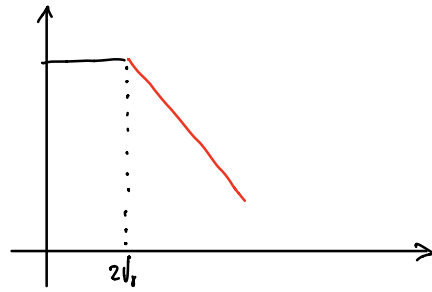
$\Big[T_2 : SAT \to RN$

$I_{C2} = \beta_F \, I_{B2} = -1.37 \cdot 10^{-3} - 1.07 \cdot 10^{-3} V_i$

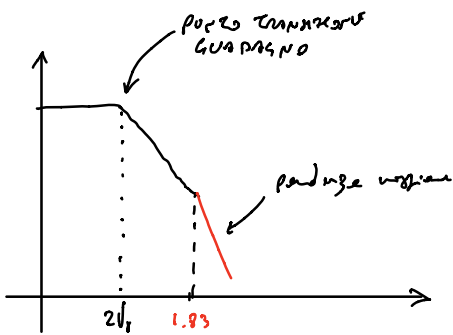$I_{B2} = 4.72 \cdot 10^{-5} - 2.3 \cdot 10^{-5} V_i$

$\Big\} \to V_i = 1.83 \, V$

⟵ QUALE ACCADE PRIMA?

$T_1 : RN \to SAT$

$\ldots$

$\Big\} \to V_i = 2 \ldots$

PUNTO TRANSIZIONE
GUADAGNO

PENDENZA MAGGIORE

$2V_\gamma$ 1.83

V_K STA CALANDO $\to T_1 \, SAT$
$\to T_2 \, OFF$ $\Big\}$ QUALE PRIMA?

$T_1 \, ON$
$D \, ON$
$T_2 \, RN$

$V_u = R_3 \, I_{E2}$
$I_{E2} = (\beta_F + 1) \, I_{B2}$ $\Big\}$ $V_u = 13.6 - 6.2 \, V_i$
$I \ldots$

$T_1 \, SAT :$ $V_{CE1} = V_{CE\,sat}$
$V_{CE1} = V_u + \cancel{V_\gamma} - \cancel{V_\gamma}$ $\Big\}$ $V_u = V_{CE\,sat}$
$\to V_i = 2.14 \, V$

↑ RAGGIUNTO PRIMA

$T_2 \, OFF : \to V_u = 0$
$\to V_i = 2.18 \, V$

V_{ILMAX}
V_{OHMIN}

T_1 RN
T_2SAT
D ON

T_1, T_2 RN
D ON

V_{IHMIN}
V_{OLMAX}

V_{CESAT}

$2V_\gamma$ 1.83 2.14

T_1 SAT
D ON
T_2 RN

$$V_0 = V_Y$$
$$V_X = V_0 + V_{CESAT} \left.\right\} V_0 = V_{CESAT}$$
$$V_U = V_X - V_\gamma$$

$\hookrightarrow$ PENDENZA $= 0$

$\hookrightarrow$ PENDENZA $= -6.2\zeta$

$\rightarrow$ MARGINE IMMUNITÀ DISTURBI

$$N_{ML} = V_{ILMAX} - V_{OLMAX} = 1.3 \, V$$
$$\quad \quad \underset{2V_\gamma}{\|} \quad \quad \underset{V_{CESAT}}{\|}$$

$$N_{MH} = V_{OHMIN} - V_{IHMIN} = 1.72 \, V$$
$$\quad \quad \underset{3.86}{\|} \quad \quad \underset{2.14}{\|}$$

$\left.\right\}$ min $\rightarrow$ $\boxed{N_M = 1.3 \, V}$