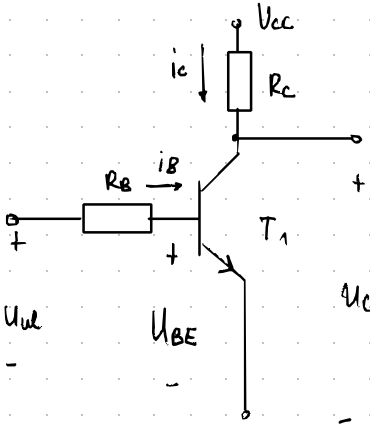
8.4 BipT kao sklopka

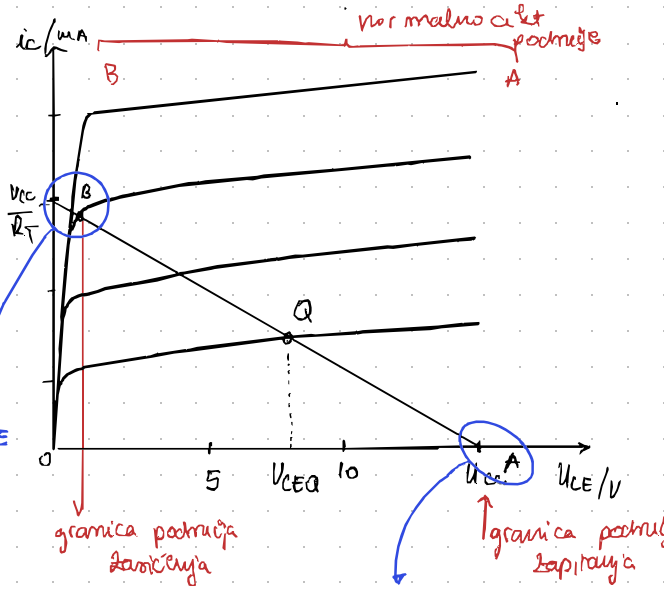


$U_{CE} = U_{iz}$

$U_{iz} = U_{CE}$

$= U_{CE\,zas.}$

UKLJUČENA SKLOPKA



$i_C = 0$

ISKLJUČENA SKLOPKA

$\Rightarrow$ UVJET ZASIĆENJA: $I_{B\,zas} \geq \frac{I_{C\,zas}}{\beta}$

$I_{C\,zas} = \frac{U_{CC} - U_{CE\,zas}}{R_C}$

$I_{B\,zas} = \frac{U_{ul} - U_{BE\,zas}}{R_B}$

Primjer 8.14.)

$V_{CC} = 5V$ $\quad U_{UL} = U_{CC}$

$R_C = 1k\Omega$

$R_{B\,max} = ? \rightarrow$ zasićenje $\quad \beta \in [50, 150]$

$U_{CE\,zas} = 0{,}2V$ $\quad U_{BE\,zas} = 0.8V$

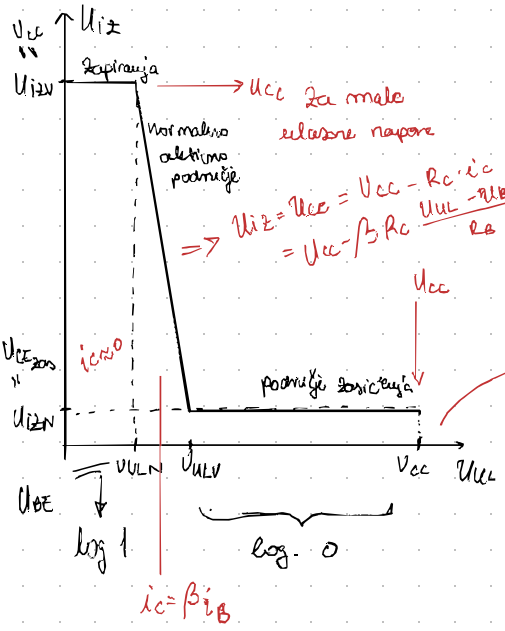
$I_{C\,zas} = \frac{5 - 0.2}{1000} \rightarrow$ ($I_{C\,zas} = 4{,}8\,mA$)

$I_{B\,zas} = \frac{U_{ul} - U_{BE\,zas}}{R_B} \geq \frac{I_{C\,zas}}{\beta} \rightarrow \frac{U_{ul} - U_{BE\,zas}}{I_{C\,zas}} \cdot \beta \geq R_B$

$\rightarrow R_{B\,min} = 43.75k\Omega$

$\rightarrow R_{B\,max} = 131.25k\Omega$

Naponska prijenosna karakt.



$$I_B = \frac{U_{ULV} - U_{BE}}{R_B} = \frac{I_{C\,zas}}{\beta} = \frac{U_{cc} - U_{CE\,zas}}{\beta \cdot R_C}$$

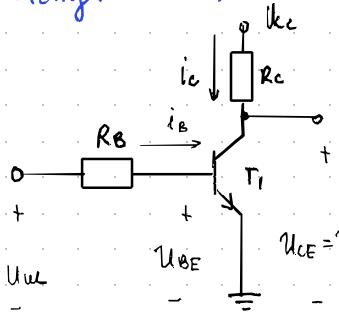
$$\Rightarrow U_{iz} = U_{CE} = U_{cc} - R_C \cdot i_C = U_{cc} - \beta R_C \frac{U_{UL} - U_{BE}}{R_B}$$

$$I_C = I_{C\,zas} = \frac{U_{cc} - U_{CE\,zas}}{R_C}$$

$$I_{B\,zas} \geq \frac{I_{C\,zas}}{\beta}$$

$$U_{iz} = U_{CE\,zas} = U_{izN} = U_0$$

Primjer 8.15.)



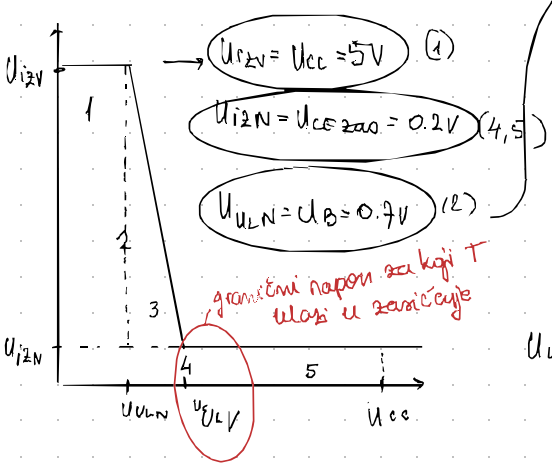
$U_{cc} = 5V$ $\quad U_{CE\,zas} = 0.2V$

$R_B = 10k\Omega$ $\quad U_{BE} = 0.7V$

$R_C = 1k\Omega$

$\beta = 100$

granice naponskih smetnji?



$$I_B = \frac{U_{ULV} - U_{BE}}{R_B} = \frac{I_{C\,zas}}{\beta} = \frac{U_{cc} - U_{CE\,zas}}{\beta \cdot R_C}$$

$$\frac{U_{ULV}}{R_B} = \frac{U_{cc} - U_{CE\,zas}}{\beta R_C} + \frac{U_{BE}}{R_B} \quad / \cdot R_B$$

$$U_{ULV} = \frac{U_{cc} - U_{CE\,zas}}{\beta} \cdot \frac{R_B}{R_C} + U_{BE}$$

$$U_{ULV} = \frac{5 - 0.2}{10} + 0.7 \rightarrow \boxed{U_{ULV} = 1,18\,V} \quad (3,4)$$

(5) $\rightarrow U_{UL} > U_{ULV} \rightarrow U_{iz} = konst = U_{izN} = U_{CE\,zas}$

Za invertor za slike log 0 i 1 vrijedi: $U_0 = (0) = U_{iz} = U_{CE\,zas}$

$U_1 = (1) = U_{iz} = U_{cc}$

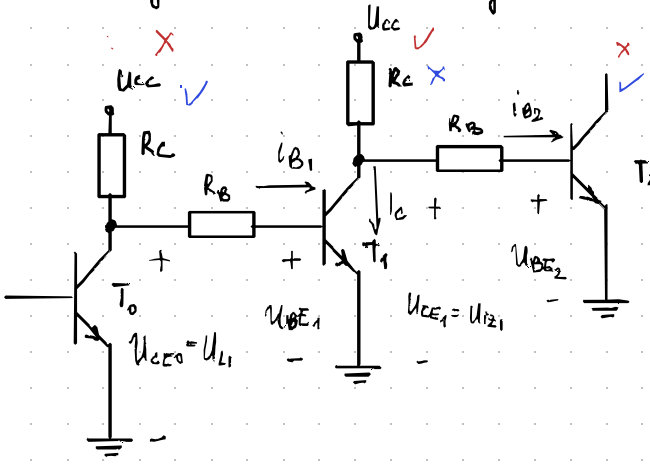
Granice smetnji invertora:

$GSN = U_{ULN} - U_{izN} = 0.7 - 0.2 = 0,5\,V$

$GSV = U_{izV} - U_{ULV} = 5V - 1.18 = 3,82\,V$

Utjecaj opterećenja na napone logičkih razina

Analiziraju se stacionarna stanja invertora s tranzistorom T_1



① T_0 u zapiranju → $i_{C_{T_0}} = 0$

↳ T_1 u zasićenju

↳ T_2 u zapiranju $i_{B_2} = 0$

zas //

$$I_{B_1 zas} = \frac{U_{cc} - U_{BE\,zas}}{R_c + R_B}$$ ← mora biti dovoljno velik

$$I_{B_1 zas} \geq \frac{I_{C_1 zas}}{\beta} = \frac{U_{cc} - U_{CE\,zas}}{\beta R_c}$$

$$U_{i2_1} = U_{CE_1} = U_{CE\,zas} = U_0$$

② T_0 u zasićenju

↳ T_1 u zapiranju

↳ T_2 u zasićenju

$$U_{iL_1} = U_{CE_0} = U_{CE\,zas}$$

$$U_{i2} = U_{cc} - R_c I_{B_2 zas} = U_{cc} - R_c \frac{U_{cc} - U_{BE\,zas}}{R_c + R_B} = U_1$$

↳ $i_{B_2} - I_{B_2 zas}$

U_1 visoki napon Log 1!

- Ako je T_1 opterećen s N invertora ↳ $U_1 = U_{cc} - N R_c \frac{U_{cc} - U_{BE\,zas}}{N R_c + R_B}$
- sa što više invertora je opterećen T_1 to je lošija situacija bit za log 1

Primjer 16.) →

$U_{cc} = 5V$

$R_B = 20k\Omega$

$R_c = 1k\Omega$

$\beta = 100$

$U_{CE\,zas} = 0.2V$

$U_{BE\,zas} = 0.8V$

radi li ispravno invertni?

U_0 i U_1 =?

LOGIČKA 0 T_0 zap → T_1 zas → T_2 zap

$$I_{B_1} = \frac{U_{cc} - U_{BE\,zas}}{R_c + R_B} \geq \frac{U_{cc} - U_{CE\,zas}}{\beta R_c} = U_0$$

$$I_{B_1 zas} = \frac{15 - 0.8}{21 \times 10^3} \rightarrow I_{B_1 zas} = 0.2\,mA$$

$$I_{C_1 zas} = \frac{U_{cc} - U_{CE\,zas}}{R_c} \rightarrow I_{C_1 zas} = 4{,}8\,mA$$

$U_{CE\,zas} = U_0 \Rightarrow 0.2V$ * nije 0V

LOGIČKA 1

$$U_1 = U_{cc} - R_c \frac{U_{cc} - U_{BE\,zas}}{R_c + R_B} \rightarrow U_1 = 4.8V$$ * nije 5V

što je veća kaskada više je odstupanje

⇒ IMPULSNI ODZIV - skripta 373-374. str

Uključivanje tranzistora

$t < 0 \longrightarrow$ napon $u_{UL} = -U_{UL2}$ zaporno polarizira spoj EB $\longrightarrow$ $i_B \approx 0$, $u_{BE} = -U_{UL2}$

$\longrightarrow$ napon U_{CC} zaporno pol. spoj CB $\longrightarrow i_C \approx 0$

$\hookrightarrow$ područje zapiranja

$t = 0 \longrightarrow$ trenutačna promjena napona $u_{UL}: -U_{UL2} \longrightarrow U_{UL1} \Rightarrow$ trenutačna promjena struje i_B

$\hookrightarrow$ spoj EB postupno se polarizira

$\hookrightarrow$ postupno raste $i_C \longrightarrow$ tranzistor prolazi kroz normalno aktivno područje

uz $i_{B_1} = \dfrac{U_{UL1} - U_{BE\,zas}}{R_B} > \dfrac{I_{C\,zas}}{\beta} = \dfrac{U_{CC} - U_{CE\,zas}}{\beta \cdot R_C}$

$\hookrightarrow$ prelazi u područje zasićenja

- impulsna vremena:

vrijeme zakašnjenja $t_d \longrightarrow$ od $t=0$ do $i_C = 0.1 \cdot I_{C\,zas}$

vrijeme porasta $t_r \longrightarrow$ od $i_C = 0.1 \cdot I_{C\,zas}$ do $i_C = 0.9 \cdot I_{C\,zas}$

vrijeme uključivanja $t_{on} \longrightarrow \underline{t_{on} = t_d + t_r}$

Isključivanje tranzistora

$t = t_1 \longrightarrow$ trenutačna promjena s $U_{UL1} \longrightarrow -U_{UL2}$

$\hookrightarrow$ trenutačna promjena struje i_B na $-I_{B_2} = \dfrac{-U_{UL2} - U_{BE\,zas}}{R_B}$

- zbog injektiranog naboja manjinskih nosilaca spoj EB ostaje u početku propisno polariziran $\longrightarrow$ struja baze $-I_{B_2}$ odstranjuje višak naboja u području zasićenja!

$\longrightarrow$ prolazom kroz normalno akt. područje tranzistor prelazi u područje zapiranja

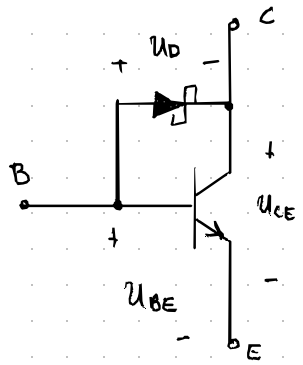
- impulsna vremena:

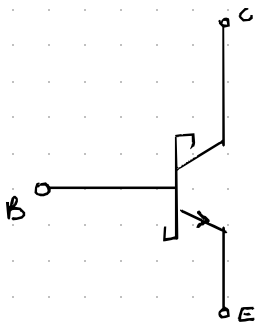
vrijeme zadržavanja $t_s \longrightarrow$ od t_1 do $i_C = 0.9 \cdot I_{C\,zas}$

vrijeme pada $t_f \longrightarrow$ od $i_C = 0.9 \cdot I_{C\,zas}$ do $i_C = 0.1 \cdot I_{C\,zas}$

vrijeme isključivanja $t_{off} = t_s + t_f$

Skraćivanje vremena zadržavanja → Schottkeyev tranzistor





→ u impulsnom radu bip T sklopke u praviliu je najduže vrijeme zadržavanja t_s kao rezultat odstranjivanja velikog naboja manjinskih nosilaca nakupljenog za vrijeme rada T u području zasićenja

Schottkeyev T → njegovom primjenom se skraćuje t_s — Schott. dioda

→ područje zapiranja ili norm. akt. područje ($\varphi_C > \varphi_B$) → spoj CB i SD u zaporno pol.

↳ prelaskom postaje propusno

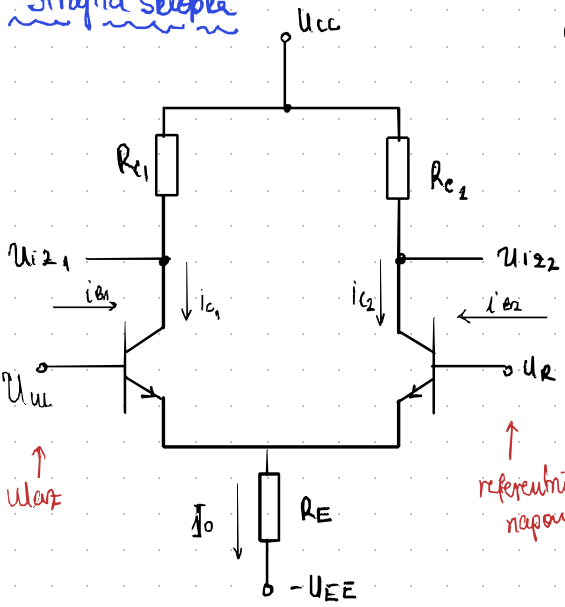
↳ S.D ograniči napon U_{BC} na kolj. diode → spriječi ulazak tranz. u dublje zasićenje

napon U_{CE} tranzistora u zasićenju $\Rightarrow U_{CE} = U_{BE} - U_D \approx 0.7 - 0,4 = 0,3V$

Skupina ECL (emiter coupled logic)

→ skupina emiterski vezane logike

Strujna sklopka



Odnos kolektorskih struja

$$\frac{i_{C1}}{i_{C2}} = exp\left(\frac{U_{BE1} - U_{BE2}}{U_T}\right) = exp\left(\frac{U_{UL} - U_R}{U_T}\right)$$

ako zanemarimo I_{B1} i I_{B2}

$$\downarrow$$

$$I_{C1} + I_{C2} \approx I_0$$

$$\frac{i_{C1}}{I_0} \approx \frac{1}{1 + exp\left(\frac{U_R - U_{UL}}{U_T}\right)}$$

$$\frac{i_{C2}}{I_0} \approx \frac{1}{1 + exp\left(\frac{U_{UL} - U_R}{U_T}\right)}$$