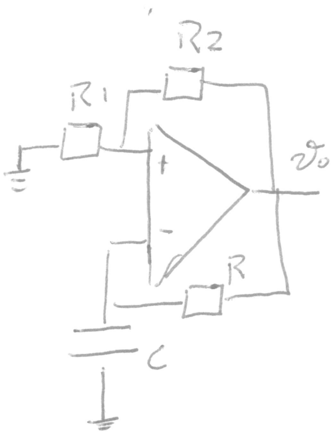
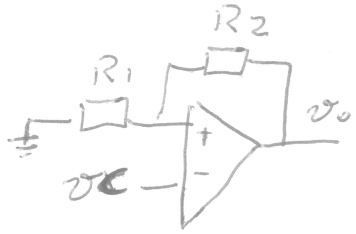
• Multivibrador astável



⇒ Baseado no comparador com histerese



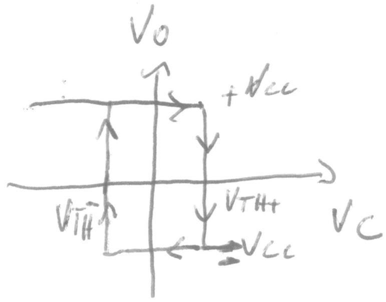
• $v_o = +V_{cc}$

$$\Rightarrow V_{TH+} = \frac{v_o}{R2+R_1} \cdot R_1$$

$$\boxed{V_{TH+} = \frac{+V_{cc} \cdot R_1}{R2+R_1}}$$

• $v_o = -V_{cc}$

$$\Rightarrow V_{TH-} = \frac{v_o}{R2+R_1} \cdot R_1 \rightarrow \boxed{V_{TH-} = \frac{-V_{cc}\, R_1}{R2+R_1}}$$



$$\therefore \begin{cases} v_C > V_{TH+} \Rightarrow v_o = -V_{cc} \\ v_C < V_{TH-} \Rightarrow v_o = +V_{cc} \end{cases}$$

① • Supondo que quando liga o oscilador $v_o = +V_{cc}$, o capacitor se carrega com $V_C(t) = V_{cc} \cdot \left[1 - \exp\left(-\frac{t}{\tau}\right)\right] + V_{C0} \cdot \exp^{-t/\tau}$, até $\tau \to RC$

$V_C(t)$ atingir V_{TH+} e $v_o = -V_{cc}$.

② • Portanto, o capacitor se carrega com o valor negativo

$$V_C(t) = -V_{cc}\left(1 - \exp -\frac{t}{\tau}\right) + \underbrace{V_{TH+}}_{V_{C0}} \cdot \exp -\frac{t}{\tau}$$ até $V_C(t)$ atigir

V_{TH-} e $v_o = -V_{cc}$.

③ • Portanto $V_C(t) = +V_{cc}\left(1 - \exp -\frac{t}{\tau}\right) + \underbrace{V_{TH-}}_{V_{C0}} \cdot \exp -\frac{t}{\tau}$

④ • Em regime os passos 2 e 3 se repetem

⑤ O período de oscilação é igual ao dobro do tempo que ~~o~~ ~~Vcc~~ o capacitor leva para se carregar de $-V_{TH}$ a $+V_{TH}$

• $V_c(t) = V_{cc}\cdot\left(1-\exp -\frac{t}{\tau}\right) + \overset{\nearrow V_{c0}}{V_{TH-}}\cdot\exp -\frac{t}{\tau}$

$$V_c\left(\frac{T}{2}\right) = V_{cc}\left(1-\exp -\frac{T/2}{\tau}\right) + V_{TH-}\exp -\frac{T/2}{\tau}$$

$$V_{TH+} = V_{cc} - V_{cc}\exp -\frac{T/2}{\tau} + V_{TH-}\cdot\exp -\frac{T/2}{\tau}$$

$$V_{TH+} - V_{cc} = -\exp\left(\frac{-T/2}{\tau}\right)\cdot\left(-V_{TH-}+V_{cc}\right)$$

$$\left(-V_{TH-}+V_{cc}\right)\exp -\frac{T/2}{\tau} = V_{cc}-V_{TH+}$$

$$T = -2\cdot\tau\cdot\ln\frac{V_{cc}-V_{TH+}}{-V_{TH-}+V_{cc}}$$

$$\boxed{T = 2\tau\ln\frac{V_{cc}-\overset{\nearrow LTP}{V_{TH-}}}{V_{cc}-\underset{\searrow UTP}{V_{TH+}}}}$$

$$V_{TH+} = \overbrace{\frac{V_{cc}}{R_2+R_1}\cdot R_1}^{\beta} \Rightarrow V_{TH+} = \beta V_{cc}$$

$$V_{TH-} = \frac{-V_{cc}}{R_2+R_1}\cdot R_1 \Rightarrow V_{TH-} = -\beta V_{cc}$$

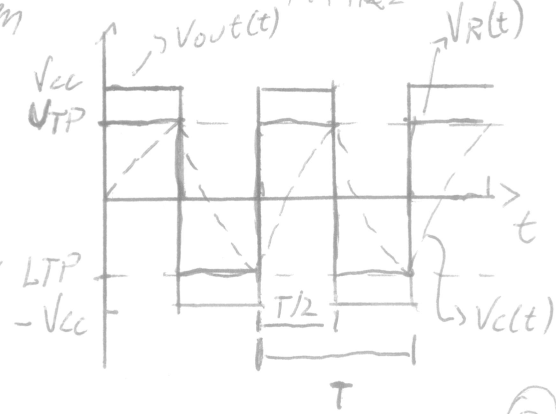
$$\therefore T = 2\cdot\tau\ln = \frac{V_{cc}-(-\beta V_{cc})}{V_{cc}-\beta V_{cc}} =$$

$$\boxed{T = 2\cdot\tau\cdot\ln = \frac{\boxed{1+\beta}}{\boxed{1-\beta}}}$$

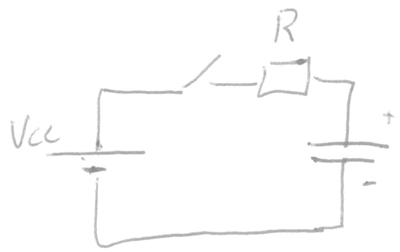
$1+\beta \rightarrow 1 + \frac{R_1}{R_1+R_2} = \frac{2R_1+R_2}{R_1+R_2}$

$1-\beta \rightarrow 1 - \frac{R_1}{R_1+R_2} = \frac{R_2}{R_1+R_2}$

$$\boxed{T = 2\cdot\tau\ln\left(1+\frac{2R_1}{R_1+R_2}\right)}$$



obs: Carga Capacitor



$$i = C\frac{dV_c}{dt}$$

$$V_{cc} - Ri - V_c = \emptyset$$

$$V_{cc} - RC\frac{dV_c}{dt} - V_c = \emptyset$$

$$RC\frac{dV_c}{dt} + V_c = V_{cc}$$

• Res. Homogêneo: $RC\frac{dV_c}{dt} + V_c = \emptyset$

Eq. Característica

$$RC\lambda + 1 = \emptyset \Rightarrow \lambda = -\frac{1}{\underbrace{\tau}_{\hookrightarrow RC}} \Rightarrow \boxed{V_{c_{Homog}} = A_\circ \exp\frac{-t}{RC}}$$

• Resp. Particular

$$RC\frac{dV_c}{dt} + V_c = V_{cc}$$

$$\Rightarrow V_{cp} = B \Rightarrow RC\circ\emptyset + B = V_{cc} \Rightarrow B = V_{cc}$$

$$\boxed{V_{cp} = V_{cc}}$$

• Res. Geral

$$V_c = V_{cH} + V_{cp} = A\exp\frac{-t}{RC} + V_{cc}$$

• Cond. inicial $\Rightarrow V_c(\emptyset) = V_{c\emptyset}$

$$V_c(\emptyset) = A\exp\frac{-\emptyset}{RC} + V_{cc}$$

$$V_{c\emptyset} = A + V_{cc}$$

$$\boxed{A = -V_{cc} + V_{c\emptyset}}$$

$$\Rightarrow V_c(t) = (-V_{cc} + V_{c\emptyset})\exp\frac{-t}{RC} + V_{cc}$$

$$\boxed{V_c(t) = V_{cc}\left(1 - \exp\frac{-t}{RC}\right) + V_{c0}\exp\frac{-t}{RC}}$$