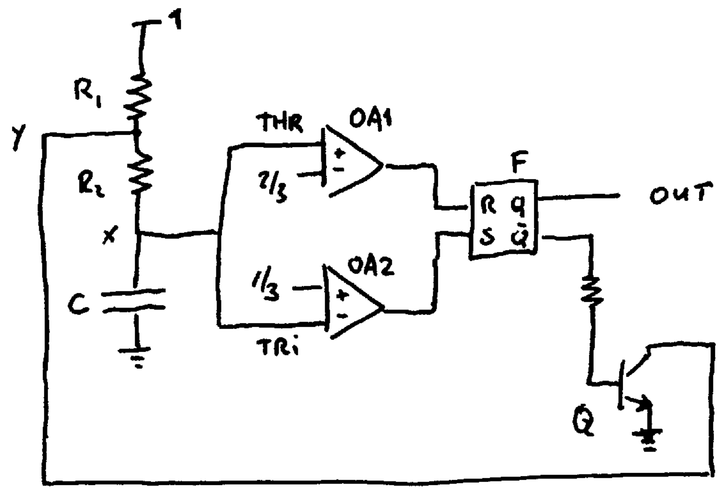
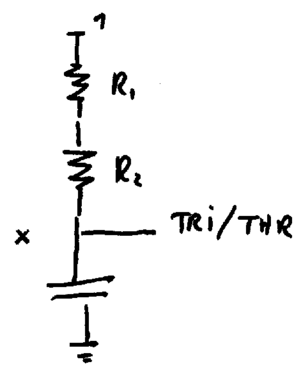
NE555 Oscillator solution



All voltages divided by Vcc

($2/3 \Rightarrow 2/3\, V_{cc}$, etc)

Charging cycle (Q open circuit) $\bar{Q}$ is low, OUT = high (1)



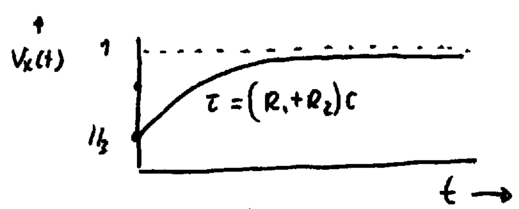
note: no current enters in the opamps

← This is an RC circuit that shows exponential behavior.

$t = \infty \Rightarrow V_x = 1$ (no current through R1 and R2)

$t = 0 \Rightarrow V_x = 1/3$ (see note later)

$\tau = (R_1 + R_2)C$



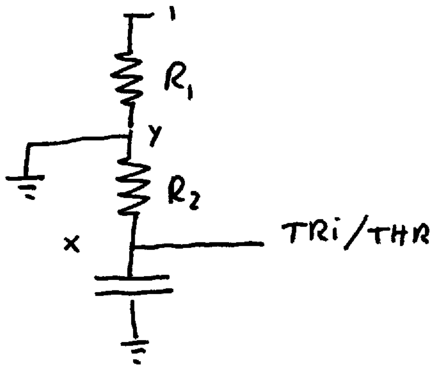
$V_x(t) = 1 - 2/3 \exp(-t/\tau)$

When V_x reaches $2/3$, the top op-amp (OA1) goes from low to high. Or, in other words a reset of the flip flop F occurs, OUT ↓ and $\bar{Q}$ ↑. Transistor Q opens, shorting point y to ground.

When does this occur? $V_x(t) = 2/3 \Rightarrow$

$$t_1 = (R_1 + R_2)C \ln 2$$

Now we have

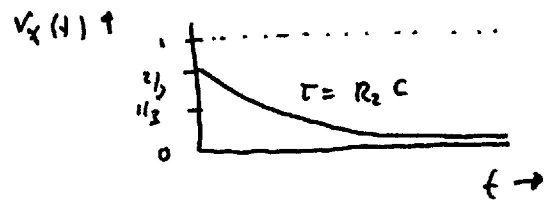


This is an RC circuit that shows exponential behavior

$t = \infty$, $V_x = 0$

$t = 0$, $V_x = 2/3$ (see prev. page)

$\tau = R_2 C$ (R_1 does nothing!)

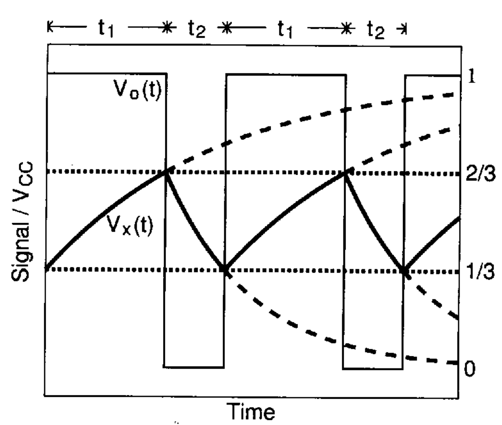


$$V_x(t) = \tfrac{2}{3} \exp(-t/\tau)$$

When V_x reaches 1/3, the bottom op-amp (OA2) goes from low to high ↑. Or, in other word, a <u>set</u> of the flip-flop occurs, OUT ↑, $\bar{Q}$ ↓. Transistor Q closes (open circuit), removing the ground from point y.

When does this occur? $V_x(t) = 1/3$ ⇒

$$t_2 = R_2 C \ln 2$$



$$T = t_1 + t_2 = C(R_1 + 2R_2) \ln 2$$

$f = 1$ kHz ⇒ $T = 1$ ms, $C = 100$ nF, ⇒ $R_1 + 2R_2 = 10$ kΩ

example $R_2 = 3.9$ kΩ, $R_1 = 2.2$ kΩ