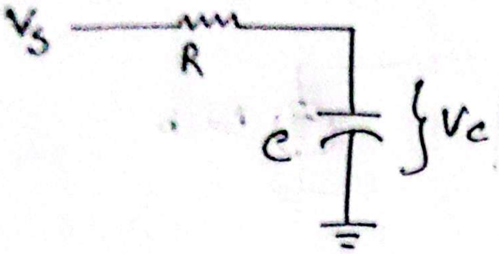
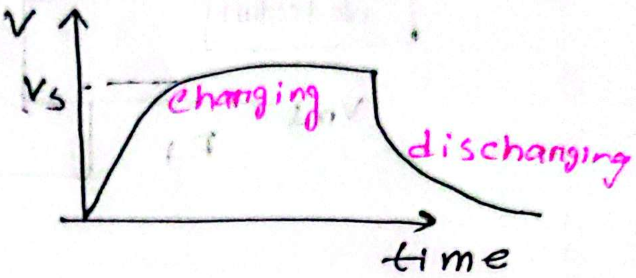
Square wave generator

Signal Generator





Charging $\Rightarrow$ $V = V_s(1 - e^{-t/RC})$

$$\boxed{RC = \tau}$$

Discharging $\Rightarrow$ $V = V_s e^{-t/RC}$

t_1 = initial time

t_2 = final time

$$V_c(t_2) = V_c(t_1)\, e^{-\overset{t_2-t_1}{t}/RC} + V_s\left(1 - e^{-\overset{t_2-t_1}{t}/RC}\right)$$

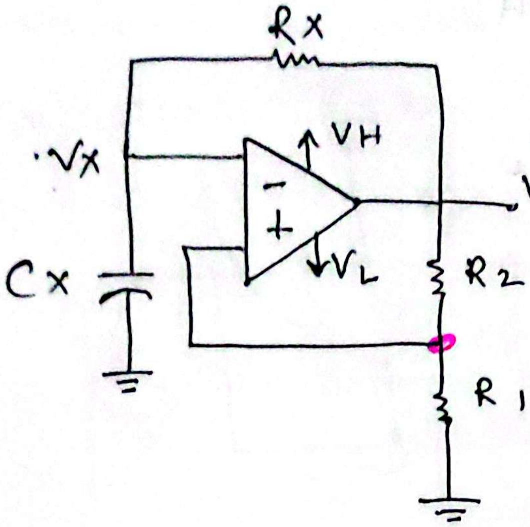
$$= V_c(t_1)\, e^{-\frac{t_2-t_1}{RC}} + V_s\left(1 - e^{-\frac{t_2-t_1}{RC}}\right)$$

$$= V_c(t_1)\, e^{-\frac{t_2-t_1}{RC}} + V_s - V_s e^{-\frac{t_2-t_1}{RC}}$$

$$\boxed{V_c(t_2) = V_s + \left(V_c(t_1) - V_s\right) e^{-\frac{t_2-t_1}{RC}}}$$

$$V_c(t_2) = V_{final} + \left(V_{initial} - V_{final}\right) \exp\left(-\frac{t_2-t_1}{RC}\right)$$

Square wave Generator

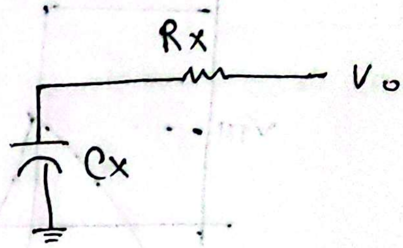


$V_+ > V_- \rightarrow V_0 = High = V_H$

$V_+ < V_- \rightarrow V_0 = Low = V_L$

$V_H = +$ Saturation voltage

$V_L = -$ Saturation voltage



$$\overset{\nearrow V_x}{V_c(t_2)} = V_0 + (V_{initial} - \underset{\searrow V_0}{V_{final}}) \exp\left(-\frac{t_2 - t_1}{R_x C_x}\right)$$

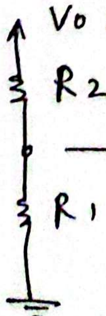
$$\Rightarrow \frac{V_c(t_2) - V_0}{V_c(t_1) - V_0} = \exp\left(-\frac{t_2 - t_1}{R_x C_x}\right)$$

$$\Rightarrow \ln\left(\frac{V_c(t_2) - V_0}{V_c(t_1) - V_0}\right) = \ln \cdot \exp\left(-\frac{t_2 - t_1}{R_x C_x}\right)$$

$$\Rightarrow t_2 - t_1 = -R_x C_x \ln\left(\frac{V_c(t_2) - V_0}{V_c(t_1) - V_0}\right)$$

$$\Rightarrow t_2 - t_1 = R_x C_x \ln\left(\frac{V_c(t_1) - V_0}{V_c(t_2) - V_0}\right)$$

$V_0 = V_H$ or V_L



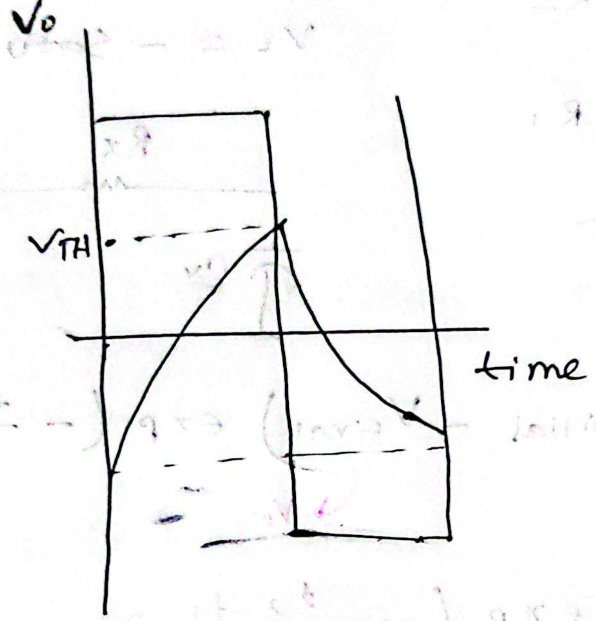
$$\longrightarrow V_+ = \frac{R_1}{R_1 + R_2} V_H + 0$$

$$V_+ = \frac{R_1}{R_1 + R_2} V_L$$

↑ground, তাই 0 add, অন্যকিছু থাকলে সেটা add হতো

$$V_{TH} = \frac{R_1}{R_1+R_2} V_H$$

$$V_{TL} = \frac{R_1}{R_1+R_2} V_L$$



$v_+ > v_- \Rightarrow V_0 = V_H$

$\frac{R_1}{R_1+R_2} V_H > V_x$

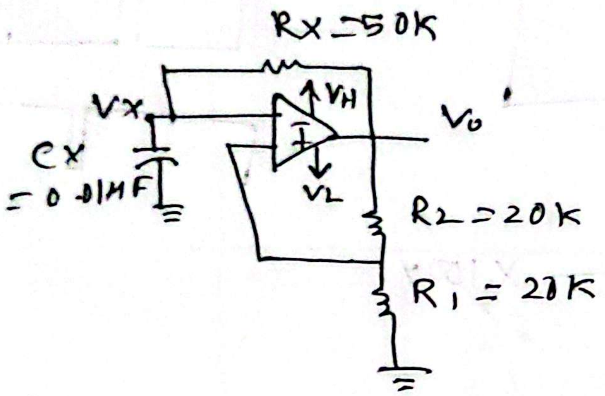
$V_{TH} < V_x \rightarrow$ output shift

$V_- > V_+ \Rightarrow V_0 = V_L$

$V_x > V_{TL} \rightarrow \frac{R_1}{R_1+R_2} V_L$

$\hookrightarrow V_x < V_{TL}$

* For the schmitt Trigger Oscillator, the saturation output voltages are +10V and -5V. $R_1 = R_2 = 20\,k\Omega$, $R_x = 50\,k\Omega$, $C_x = 0.01\mu F$ Determine the frequency of oscillation and duty cycle.



$$V_{TH} = \frac{V_H R_1}{R_1+R_2} = \frac{10\times 20}{20+20} = 5\,V$$

$$V_{TL} = \frac{V_L R_1}{R_1+R_2} = \frac{-5\times 20}{20+20} = -2.5\,V$$

$$\tau = R_x C_x = 50\times 10^3 \times 0.01\times 10^{-6} = 0.5\,ms$$

T_1 = voltage high time duration.

$$= \tau \ln\left(\frac{V_H - V_{TL}}{V_H - V_{TH}}\right)$$

$$= 0.5 \ln\left(\frac{10-(-2.5)}{10-5}\right) = 0.5 \ln(2.5)$$

T_2 = voltage low time duration.

$$= \tau \ln\left(\frac{V_L - V_{TH}}{V_L - V_{TL}}\right)$$

$$= 0.5\ln\left(\frac{-5-5}{-5-2.5}\right) = 0.5\ln 4$$

Total period, $T = T_1 + T_2 = 0.5\ln(2.5 \times 4)$
$= 0.5\ln(10)$

Frequency $= \frac{1}{T} = \frac{1}{0.5\ln(10)} = 868\ Hz$

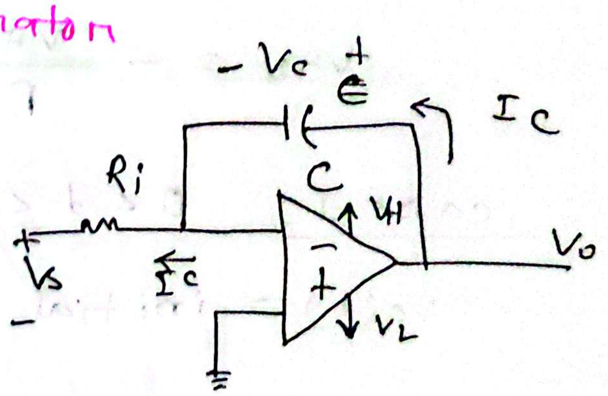
Duty cycle $=$ % of time voltage is high

$$\Rightarrow \frac{T_1}{T} \times 100\% = \frac{\ln 2.5}{\ln 10} \times 100\%$$

$$= 39.1\%$$

Triangular Wave Generator

Integrator:



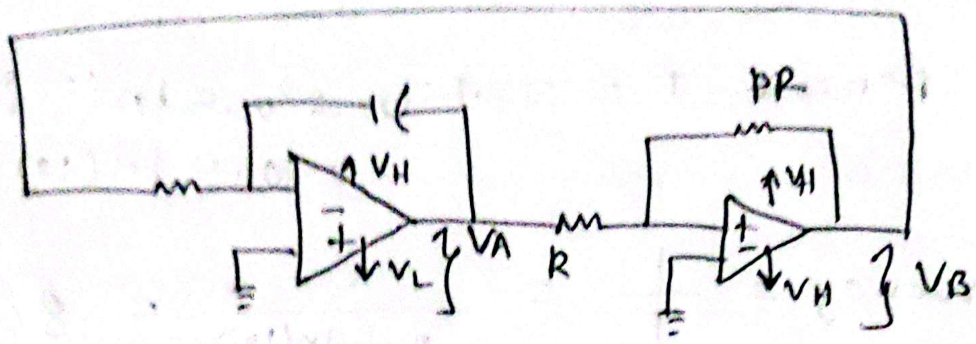
$$I_c = C\frac{dV_c}{dt} = \frac{0 - V_s}{R_i}$$

$$\Rightarrow \int_{V_{initial}}^{V_c(t)} \frac{dV_c}{V_c} = -\int_{t_1}^{t} \frac{dt}{R_iC}$$

$$\Rightarrow \frac{V_c(t) - V_{initial}}{V_s} = -\frac{t - t_1}{R_i C}$$

$$\boxed{V_c(t) = V_{initial} - \frac{V_s}{R_i C}(t - t_1)}$$

circuit of Triangular wave generator.

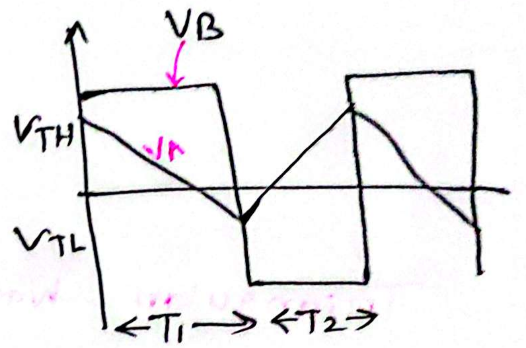


Triangular wave

$$V_{TH} = -\left(\frac{R}{P.R}\right)V_L$$

$$\Rightarrow V_{TH} = -\frac{V_L}{P}$$

$$V_{TL} = -\frac{V_H}{P}$$



case 1: $0 < t < T$

$$v_c(t) = \text{initial} - \frac{V_s}{R_iC}(t - 0)$$

$V_c(T_1) = V_{TL}$ and $V_c(0) = V_{TH}$

$v_c(T_1) = V_{TL}$, $V_{initial} = V_{TH}$,

$$\boxed{T_1 = (R_iC)\left(\frac{V_{TH} - V_{TL}}{V_H}\right)}$$

$$\boxed{T_2 = R_i C \cdot \frac{V_{TL} - V_{TH}}{V_L}}$$

Therefore, total time period becomes

$$T = T_1 + T_2$$

$$\boxed{T = \left(\frac{V_{TH} - V_{TL}}{V_H} + \frac{V_{TL} - V_{TH}}{V_L} \right) \times R_i C}$$

$f = \frac{1}{T}$. suppose $\left[V_H = -V_L \text{ and } V_{TH} = -\frac{V_L}{P} \right]$

$$V_{TL} = -\frac{V_H}{P}$$

$$\boxed{f = \frac{P}{4 R_i C}}$$

Unipolar triangular wave generator.

(same circuit, only add a diode)

$$f = \frac{P}{2 R_i C}$$