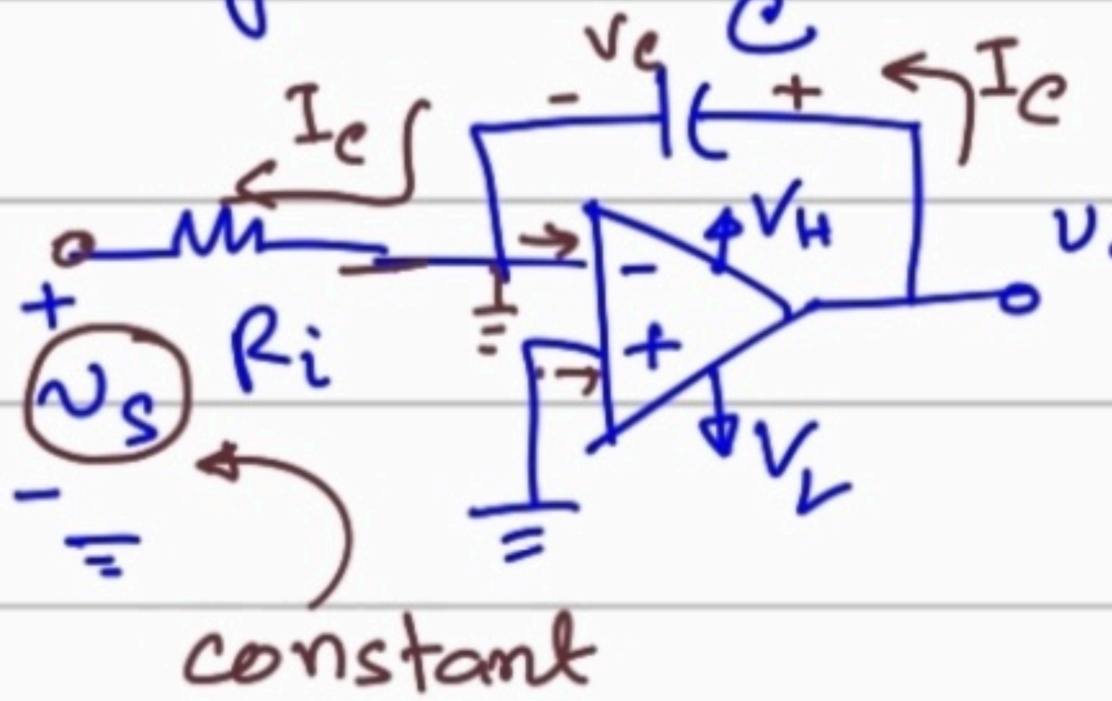
Triangular Wave Generator:

Integrator:



We are assuming virtual ground is present here.

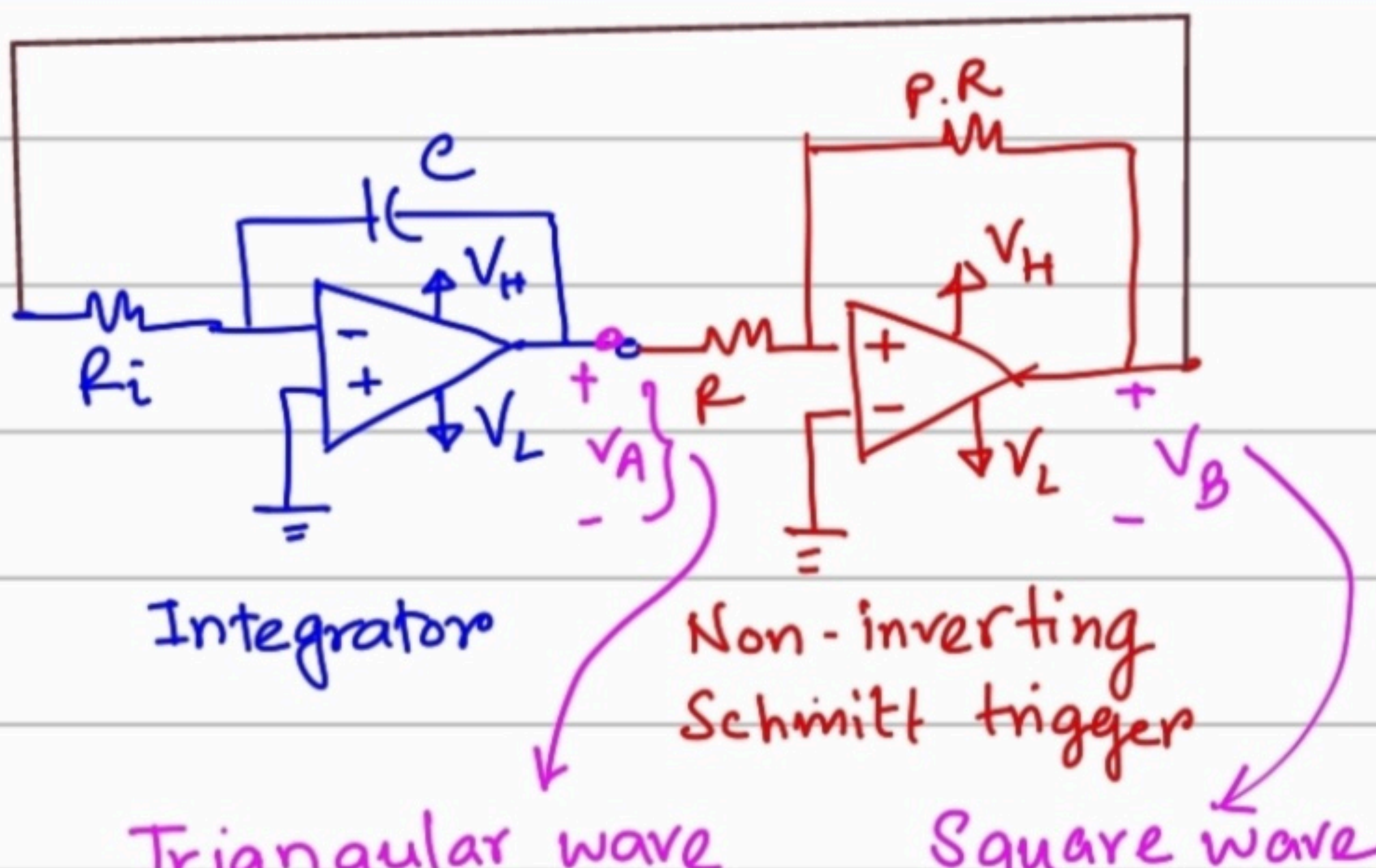
$$I_c = C\frac{dv_c}{dt} = \frac{0 - v_s}{R_i}$$

$$\Rightarrow \int_{v_c(t_1)}^{v_c(t)} dv_c = -\frac{v_s}{R_iC}\int_{t_1}^{t} dt$$

$$\Rightarrow v_c(t) - v_c(t_1) = -\frac{v_s}{R_iC}(t - t_1)$$

$$\Rightarrow \boxed{v_c(t) = v_c(t_1) - \frac{v_s}{R_iC}(t - t_1)}$$

$v_c(t_1) = V_{initial}$



$$V_{TL} = V_H\left(-\frac{R}{pR}\right)$$

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

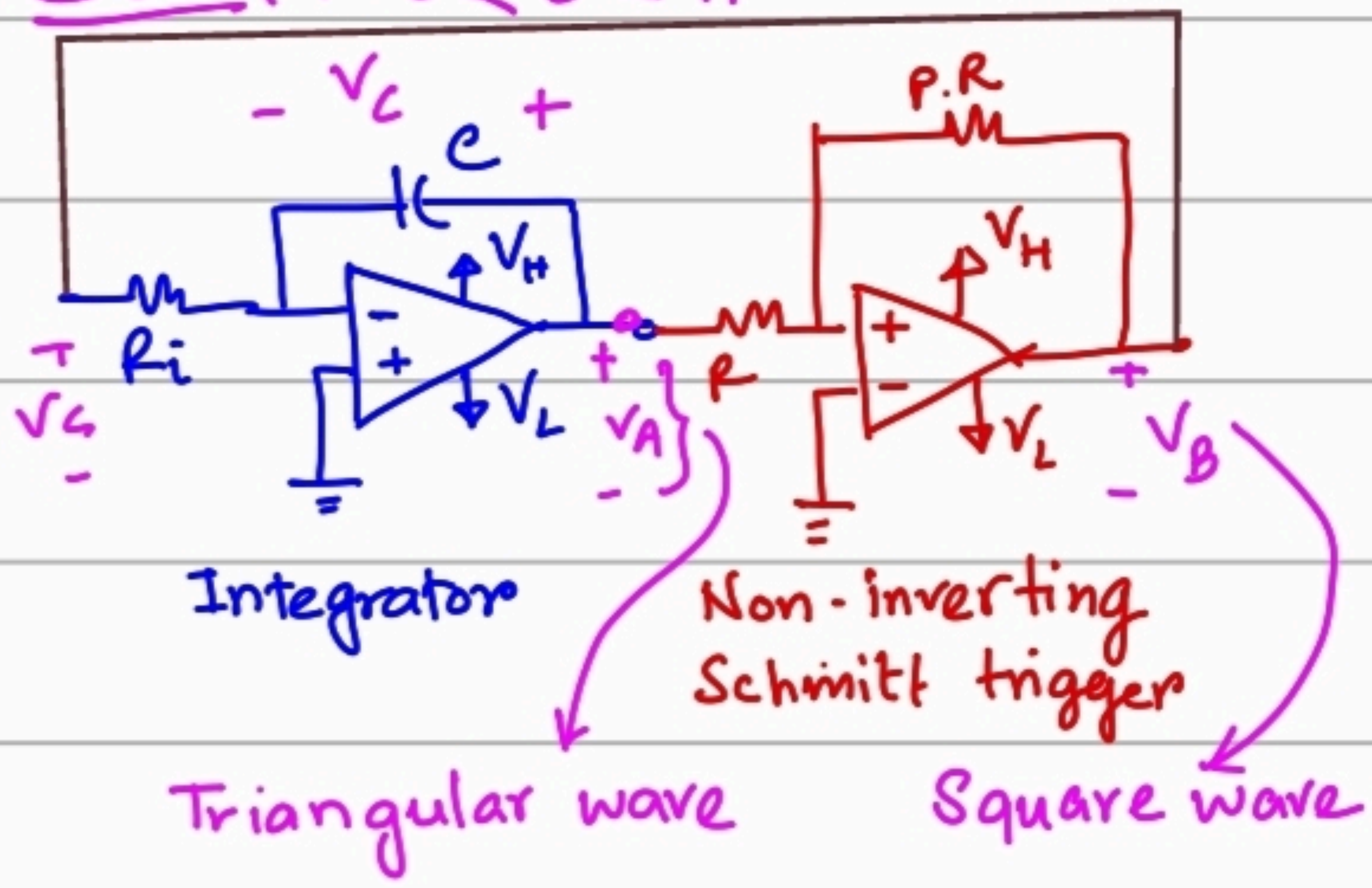
$$V_{TH} = -\frac{V_L}{p}$$

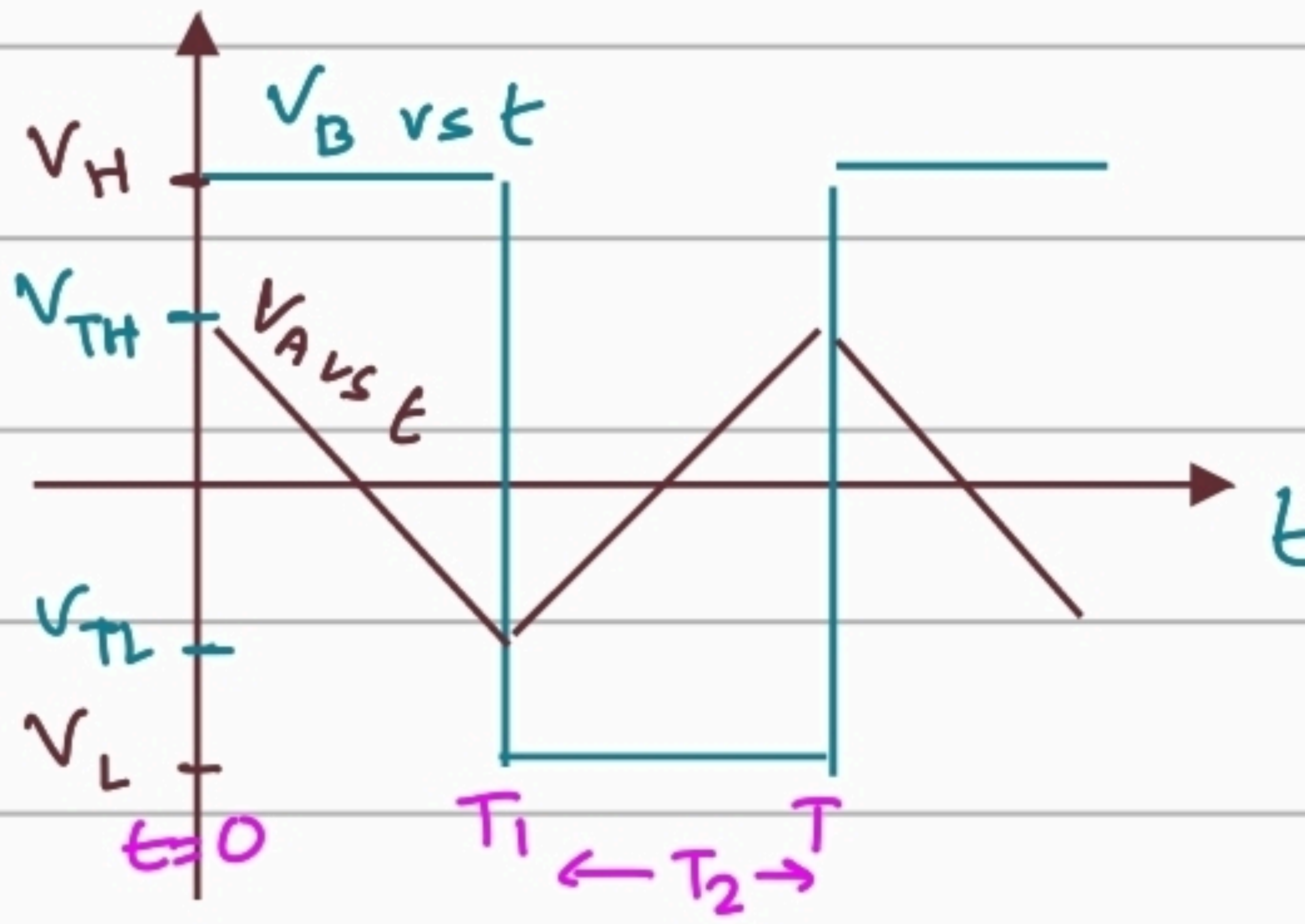
$V_{UT} = V_{TH} \rightarrow$ upper or higher Threshold ✱

$V_{LT} = V_{TL} \rightarrow$ lower Threshold ✱

✱

Case 1 : $0 < t < T_1$





Initial condition: $v_B = V_H$ and $V_A = V_{TH}$, $t_{initial} = 0$

$$v_C(t) = v_A(t) = v_{initial} - \frac{v_s}{R_i C}(t - t_{initial}) \quad [V_S = V_B = V_H]$$

$$\Rightarrow V_A(t) = V_{TH} - \frac{V_H}{R_i C}(t - 0)$$

Because $V_A(T_1) = V_{TL}$. we can find.

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

Case 2: $T_1 < t < T$. Using similar analysis like square wave we can desire,

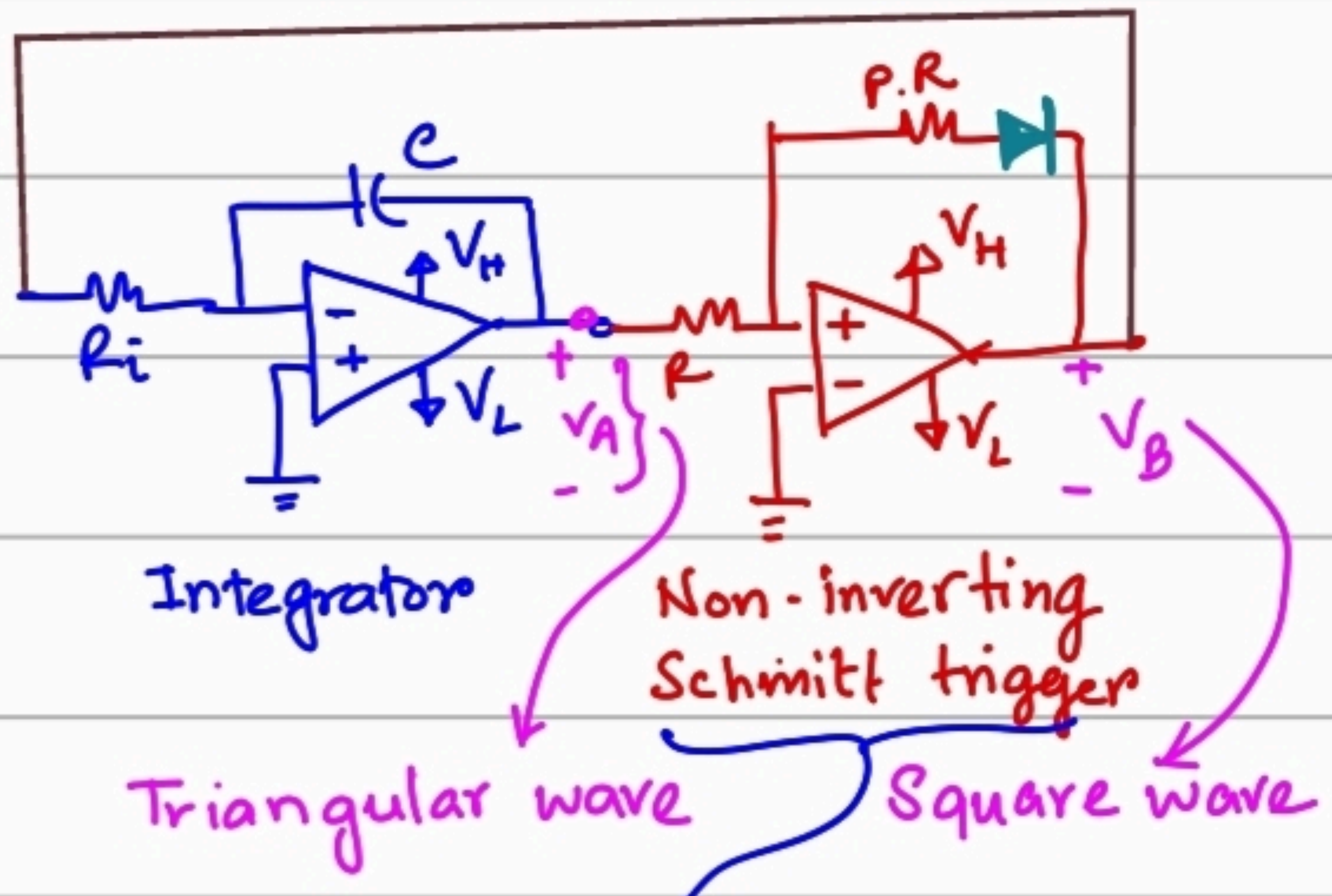
$$\boxed{T_2 = R_i C\left(\frac{V_{TL} - V_{TH}}{V_L}\right)} \qquad H \leftrightarrow L$$

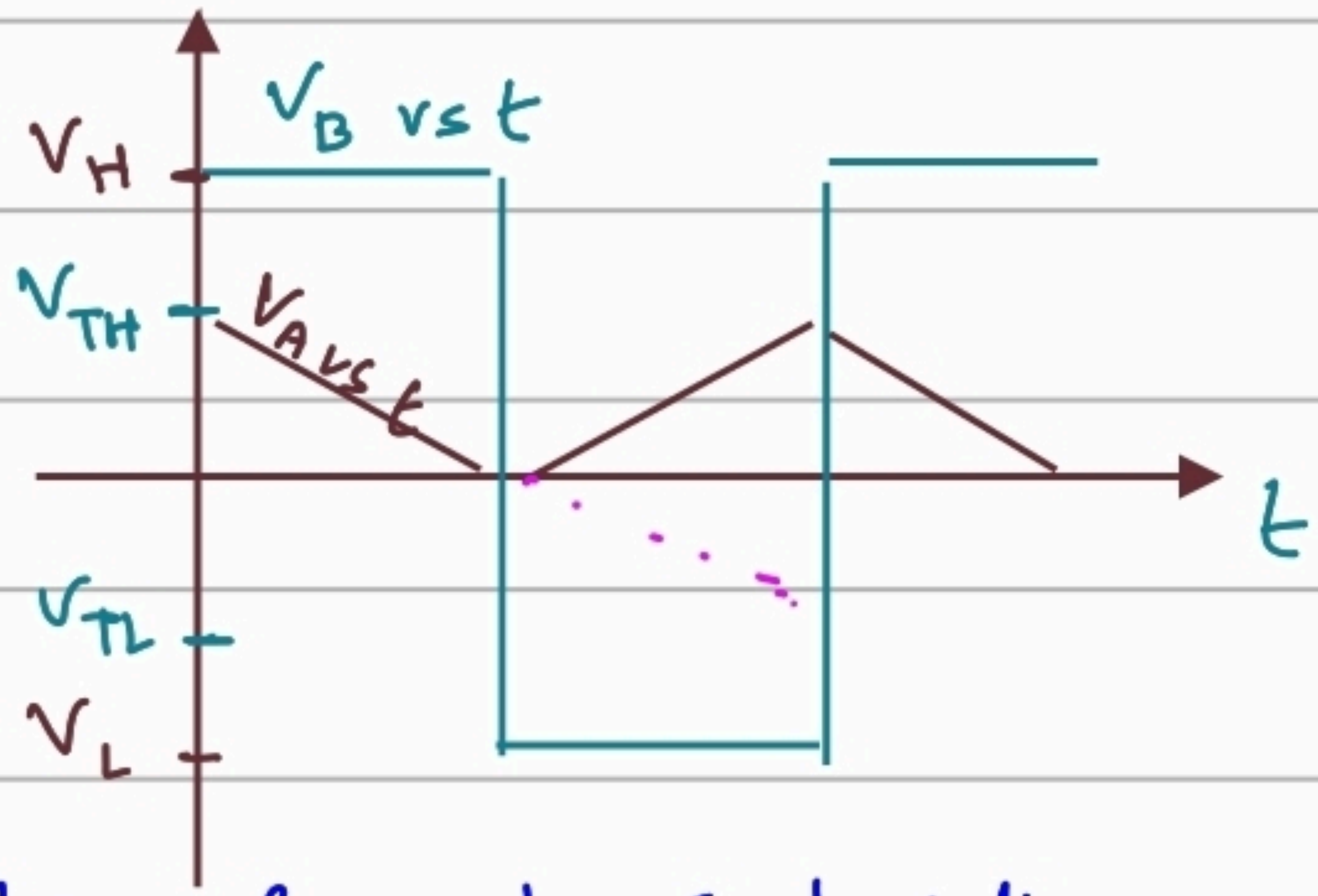
Total time period, $T = T_1 + T_2$. frequency, $f = \frac{1}{T}$

Special case: $\boxed{V_L = -V_H}$ $\quad V_{TH} = -\frac{V_L}{P}$, $V_{TL} = -\frac{V_H}{P}$

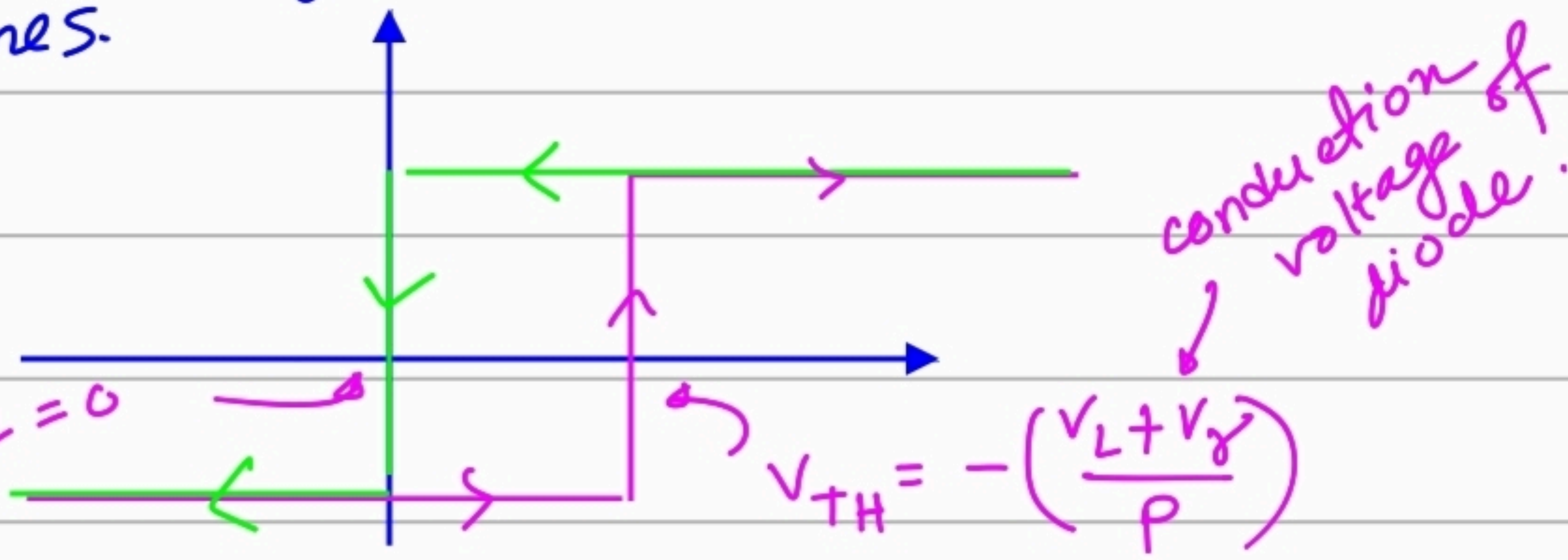
$$\boxed{f = \frac{P}{4 R_i C}}$$

Unipolar Triangular Wave Generator





After putting this diode the transfer characteristics becomes.



$$V_{TH} = -\left(\frac{V_L + V_\gamma}{P}\right)$$

Assuming $V_H = -V_L$, we will get

$$\boxed{f = \frac{P}{2RC}}$$