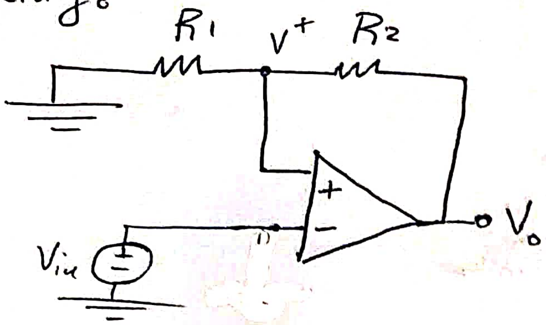
Bistable Multivibrator :

* Inverting :

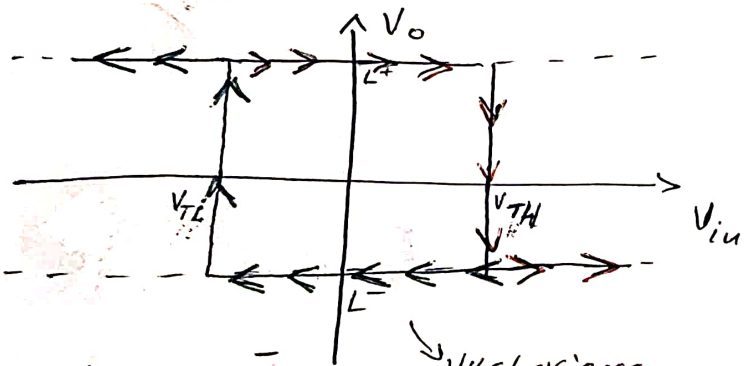


$\Rightarrow V^+ = V_o \underbrace{\left(\frac{R_1}{R_1 + R_2} \right)}_{\beta}$

$= V_o \beta$

if $V_o = \underset{(High)}{L^+} \Rightarrow \underline{V^+ = \beta L^+ = V_{TH}}$ different threshold

if $V_o = \underset{(Low)}{L^-} \Rightarrow \underline{V^- = \beta L^- = V_{TL}}$

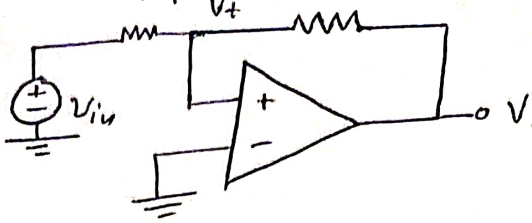


Hysterises

$\Rightarrow V_{TL} = \beta L^-$

$V_{TH} = \beta L^+$

* non-inverting :



$\Rightarrow V_+ = V_{in} \frac{R_2}{R_1+R_2} + V_o \frac{R_1}{R_1+R_2}$

if $V_o = L^+$:

$\Rightarrow V_+ = V_{in} \frac{R_2}{R_1+R_2} + L^+ \frac{R_1}{R_1+R_2}$

↳ To get V_{TL} : $V_+ = 0$

$\Rightarrow V_{in} R_2 + L^+ R_1 = 0$

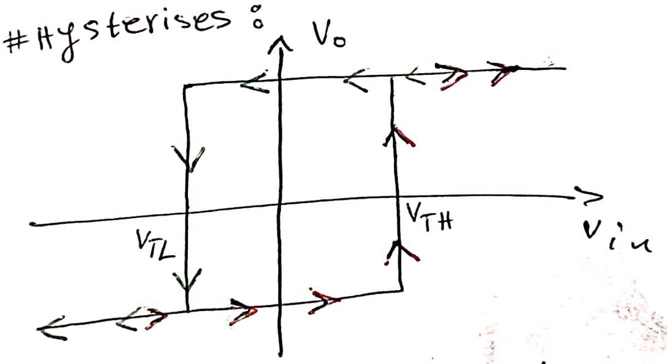
$\Rightarrow V_{TL} R_2 + L^+ R_1 = 0$

$\boxed{V_{TL} = -L^+ \frac{R_1}{R_2}}$

if $V_o = L^-$:

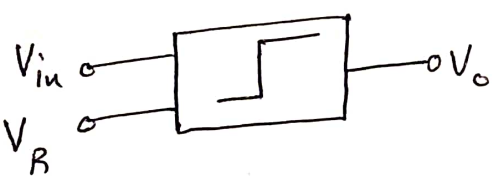
$\Rightarrow$ similary : $\boxed{V_{TH} = -L^- \frac{R_1}{R_2}}$

Hysterises :

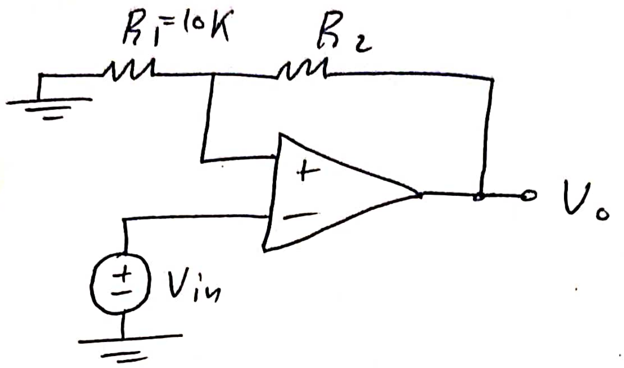


$\Rightarrow$ Bistable circuits can be used as comparators

↳ called schmitt triggers. $\Rightarrow$ It prevents the signal that have fast changing noise from switching the comparator o/p between L^+ & L^- back & forth when fluctuating at the threshold voltage.



Q1 : The op-amp in the shown bistable ct. has o/p saturation voltages of ± 13 V. Design the ct. to obtain threshold voltages of ± 5 V. for $R_1 = 10$ find the value of R_2.



sol :

∵ $V_{TH} = \beta L^{+}$, $V_{TL} = \beta L^{-}$

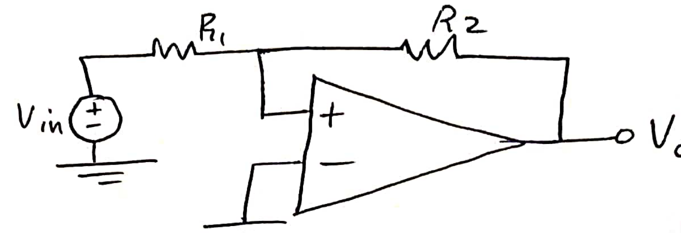
$$\Rightarrow 5 = \left(\frac{R_1}{R_1 + R_2}\right)(13)$$

$$\Rightarrow 5(10 + R_2) = 130$$

$$\Rightarrow 50 + 5R_2 = 130$$

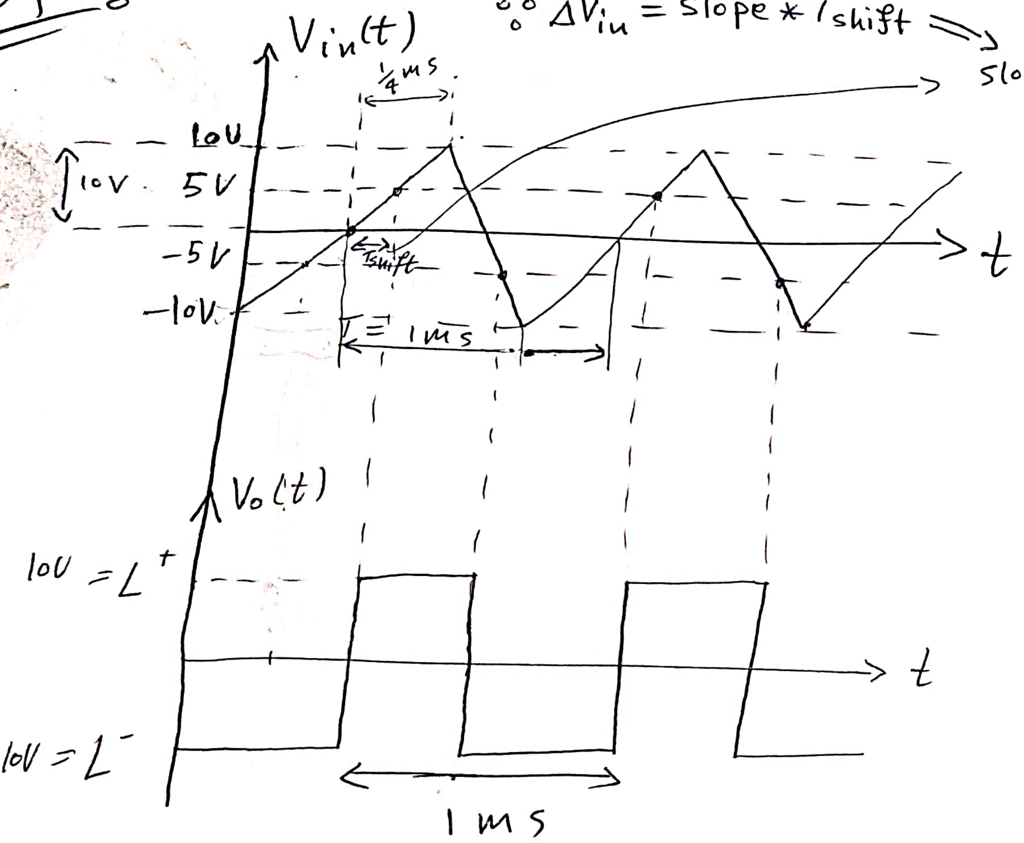
$$\boxed{R_2 = 16\ K\Omega}$$

Q_2: Consider the shown bistable circuit, let $L_+ = -L_- = 10\,V$ & $V_{TH} = -V_{TL} = 5\,V$. if V_i is a triangular wave with 0V average & 10V peak amplitude & 1ms period. sketch the o/P waveform. find the time interval between the zero crossing of V_{in} & V_o.



Sol:

$\because \Delta V_{in} = \text{slope} * T_{shift} \Rightarrow$



ΔV in $\frac{1}{4}$ cycle

$\text{slope} = \dfrac{10}{0.125 * 10^{-3}}$ it takes $\frac{1}{4}$ cycle to reach 10V

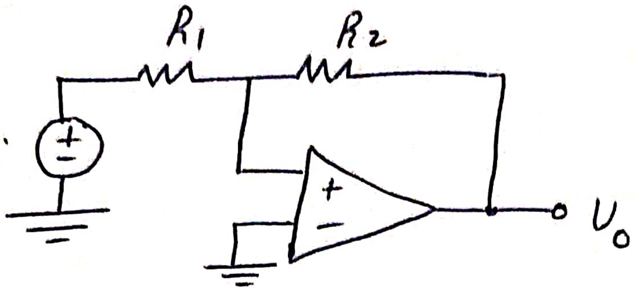
$\Rightarrow (T_{shift}) \cdot \left(\dfrac{10}{0.25 \times 10^{-3}}\right) = 5$

$\Rightarrow T_{shift} = \dfrac{5}{10} * 0.25 \times 10^{-3}$

$\boxed{T_{shift} = 0.125\,ms}$

interval between zero crossing of V_{in} & V_o

Q3 : For shown circuit. if the op amp has ±10V output saturation levels, design the ct. to obtain ±5V thresholds.



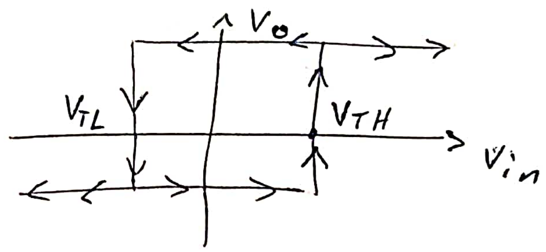
sol :

∵ the given ct. is a non-inverting bistable multivibrator.

$$\Rightarrow \quad V_{TL} = -L^{+}\frac{R_1}{R_2} \quad , \quad V_{TH} = -L^{-}\frac{R_1}{R_2}$$

∵ $L^{+} = 10$, $L^{-} = -10$

$V_{TL} = -5$, $V_{TH} = +5$

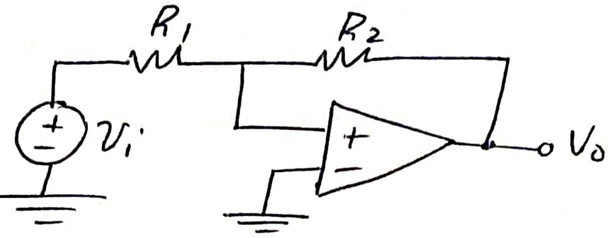


let $\boxed{R_1 = 10K\Omega}$

$$\Rightarrow 5 = 10\left(\frac{10K}{R_2}\right)$$

$$\Rightarrow \quad \boxed{R_2 = 20K\Omega}$$

Q_4: For the shown circuit. if $L_+ = -L_- = 10V$ & $R_1 = 1K\Omega$. Find the value of R_2 that gives a hysteresis of 100 mV width.

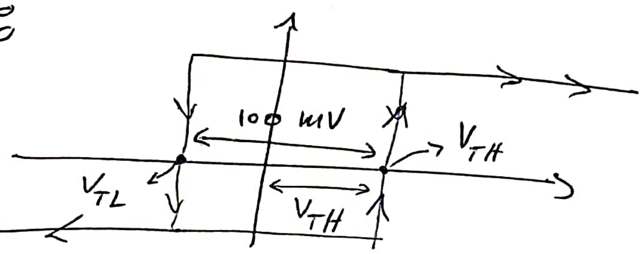


Sol:

$L_+ = -L_- = 10V$

$R_1 = 1K\Omega$

∵ the ct. is a non-inverting bistable multivibrator with the hysteresis:



∵ hysteresis width = 100mV

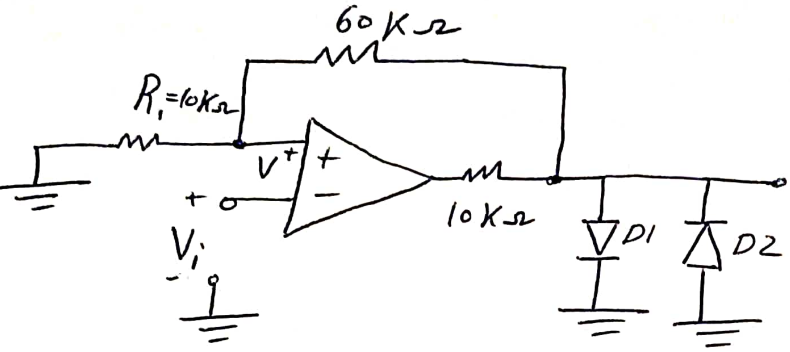
$$\Rightarrow \quad V_{TH} = -V_{TL} = \frac{100\,mV}{2} = 50\,mV$$

$$\because \quad V_{TH} = -L^-\left(\frac{R_1}{R_2}\right)$$

$$\Rightarrow \quad V_{TH} = 50 * 10^{-3} = (10)\left(\frac{1K}{R_2}\right)$$

$$\Rightarrow \quad \boxed{R_2 = 200\,K\Omega}$$

Q_5: For the shown circuit. sketch & Label the transfer characteristic $V_o - V_I$. The diodes are assumed to have a Constant 0.7-drop when conducting, & the op-amp saturates at ±12 V. what is the maximum diode current?



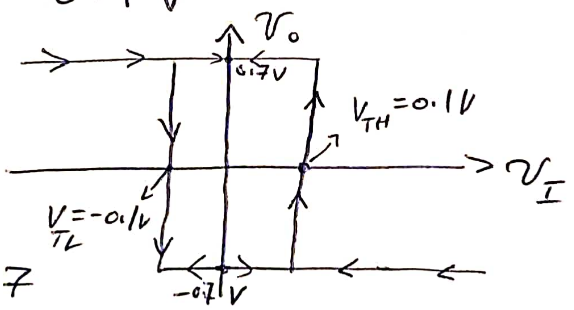
sol:

- Because of the two diodes (D1 - D2) at the o/p node $\Rightarrow V_o = \pm 0.7$

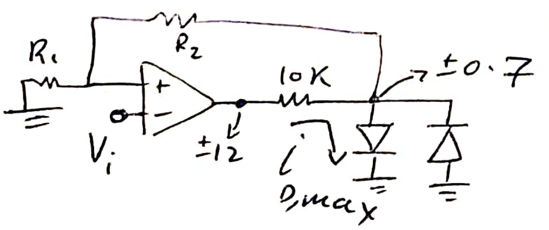
+0.7 (if D1 → ON)   -0.7 (if D2 → ON)

* So, $V^+ = \pm 0.7 \left(\dfrac{10K}{(10K + 60K)} \right) = \pm 0.1\,V$

$\Rightarrow V_{TH} = 0.1\,V$, $V_{TL} = -0.1\,V$



* Max diode current:



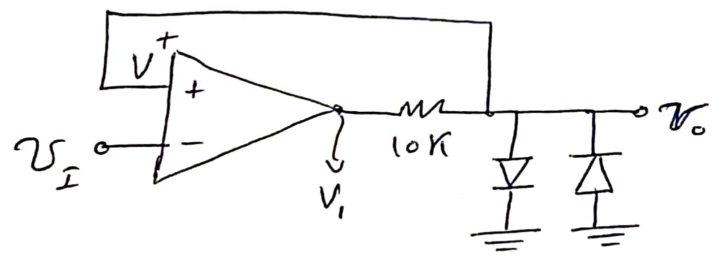
$\Rightarrow i_{D\,max} = \dfrac{12 - 0.7}{10K} = 1.12\,mA$

Q6: Considering the same circuit of the last question (Q5). if R_1 is eliminated & R_2 is short circuited. sketch & label the transfer characteristic. Assume the diodes have a constant 0.7 V drop when conducting & the op-amp saturates at ±12 V.

sol:

$L_+ = 12V$

$L_- = -12V$



$\Rightarrow v_o = \pm 0.7 \Rightarrow$ depending on whether $V_1 = +12$ or $-12\,V$.

$\because V^+ = v_o = \pm 0.7$

$\Rightarrow V_{TH} = 0.7, \quad V_{TL} = -0.7$