MULTIVIBRATOR

- Electronic ckt which is used to implement 2 state devices like oscillator, timer and flip flop.
- It is nothing but a switching circuit.
- It generates non-sinusoidal waves such as Square waves, Rectangular waves and Saw tooth waves etc.
- Used as frequency generators, frequency dividers and generators of time delays and also as memory elements in computers etc.

- 2 states refer to 2 voltage levels of multivibrator (high and low).
- In digital electronics, 1 & 0.

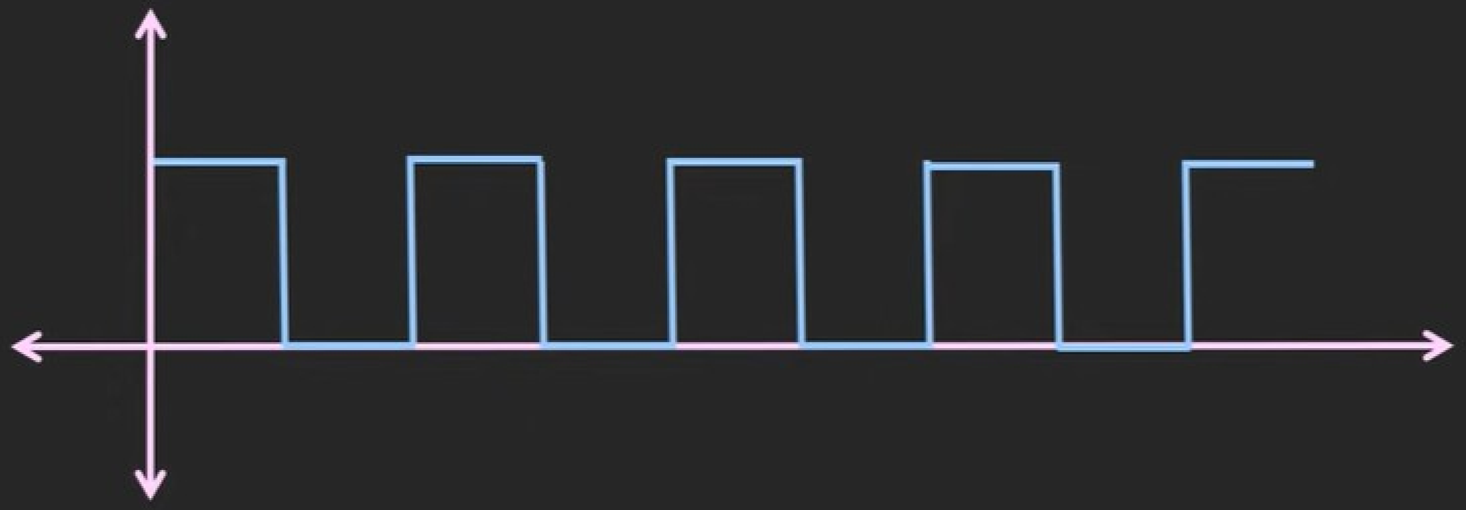
- Depending upon the no. of stages, MV can be divided into 3 types:

1. Astable MV
2. Monostable MV
3. Bistable MV

Astable Multivibrator

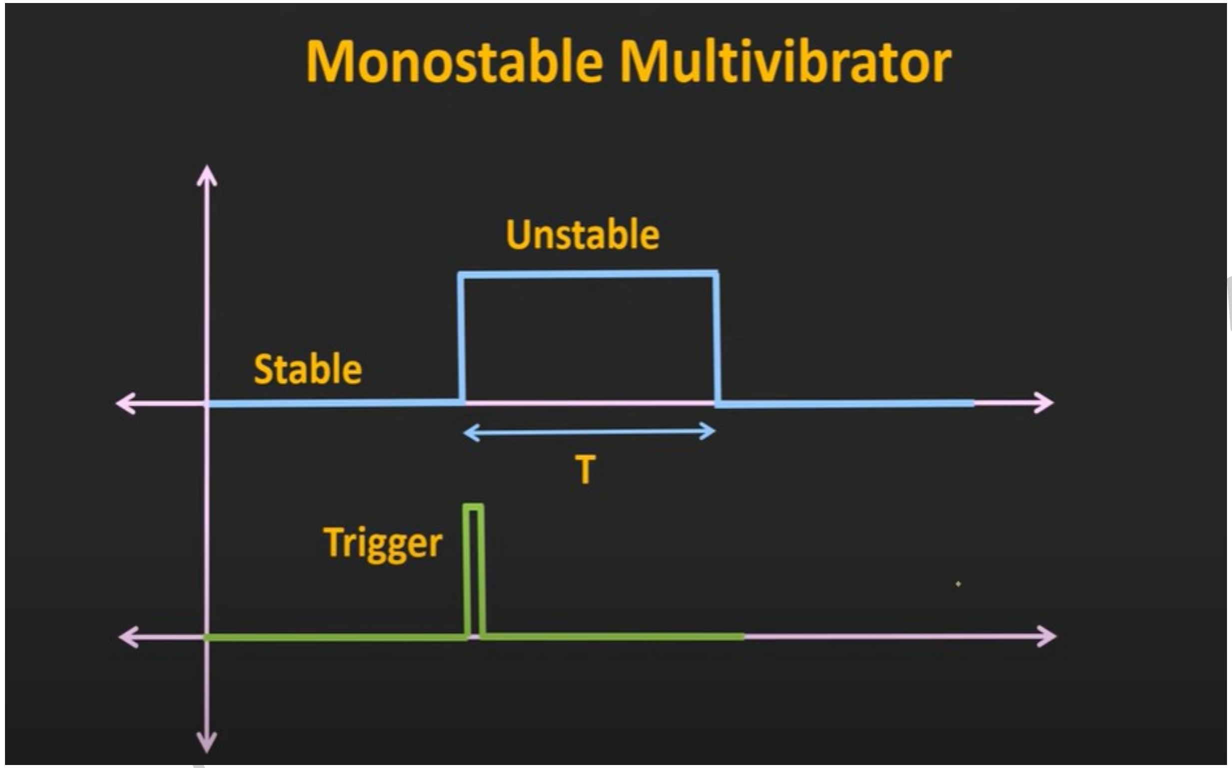
- Astable multivibrator does not remain stable in any of the two states.
- And the output of the multivibrator continuously changes between the two states.
- This type of multivibrator is used in the design of a relaxation oscillator.
- Time for which o/p remains in the particular state can be determined by the passive components like R and C.

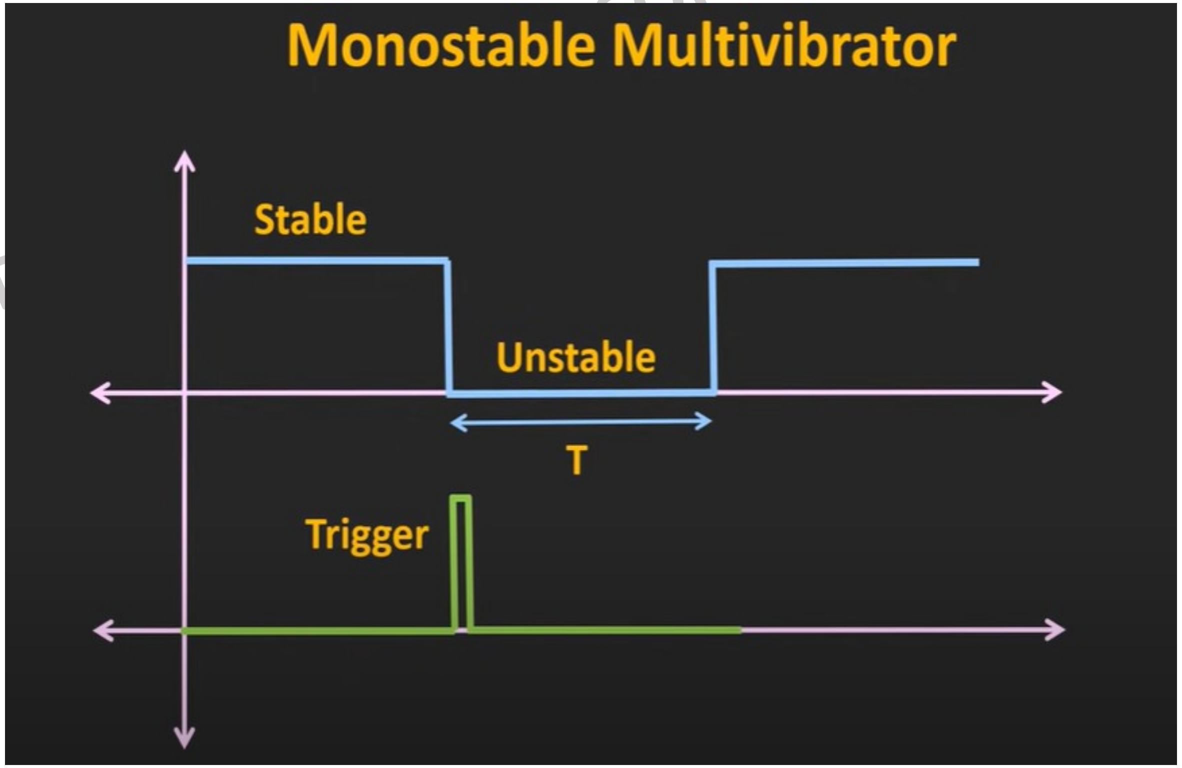
Astable Multivibrator



Monostable Multivibrator (One shot MV)

- In this, there is one stable state and one astable state.
- The MV o/p remains in the stable state but whenever an external trigger signal is applied, the output momentarily goes into the astable state. And after some time it comes back into the stable state.
- The time required to come back into the stable state depends on the passive components like R and C.
- Used as a timer in many applications.

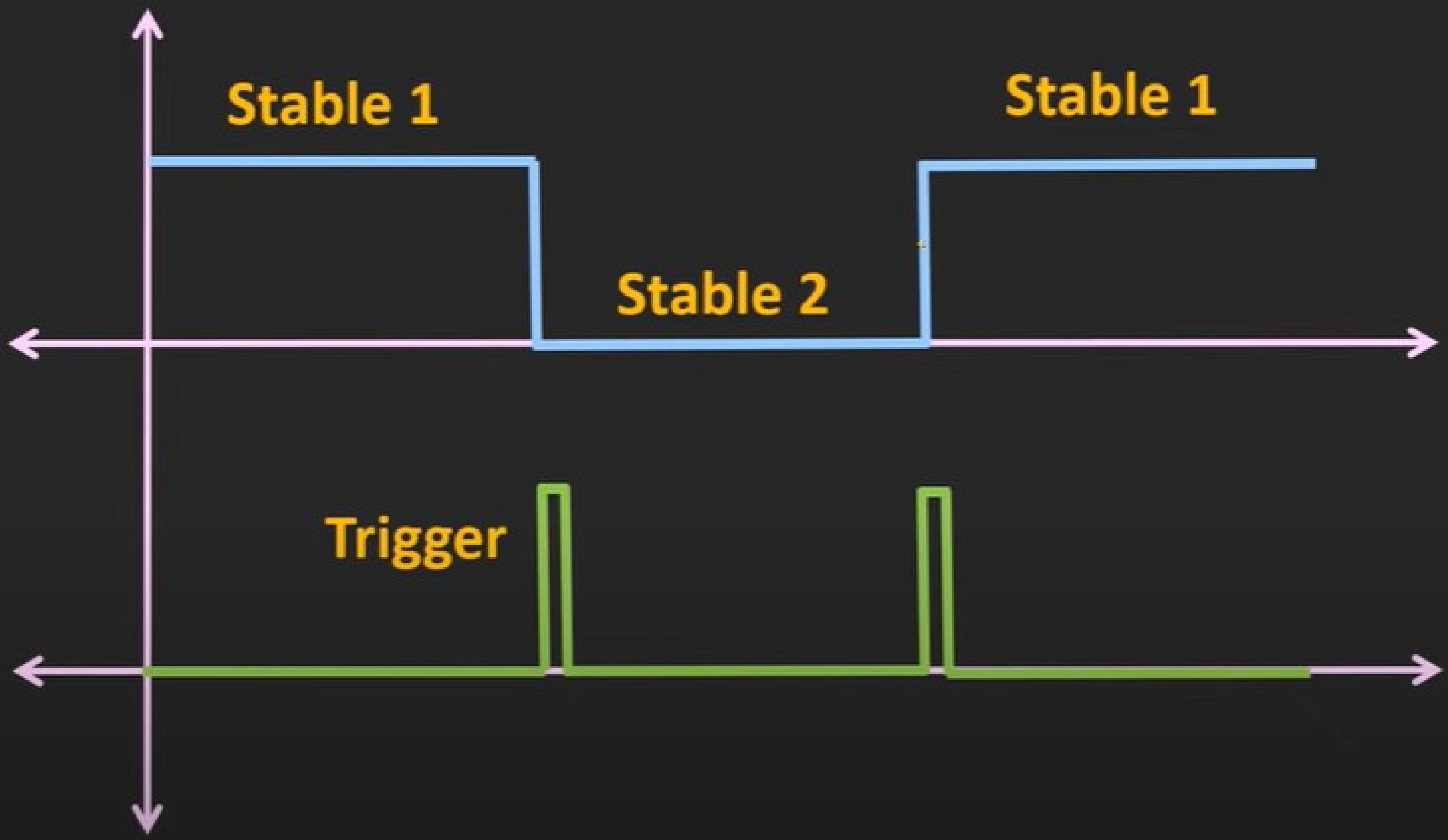

Monostable Multivibrator
Unstable
Stable
T
Trigger


Monostable Multivibrator
Stable
Unstable
T
Trigger

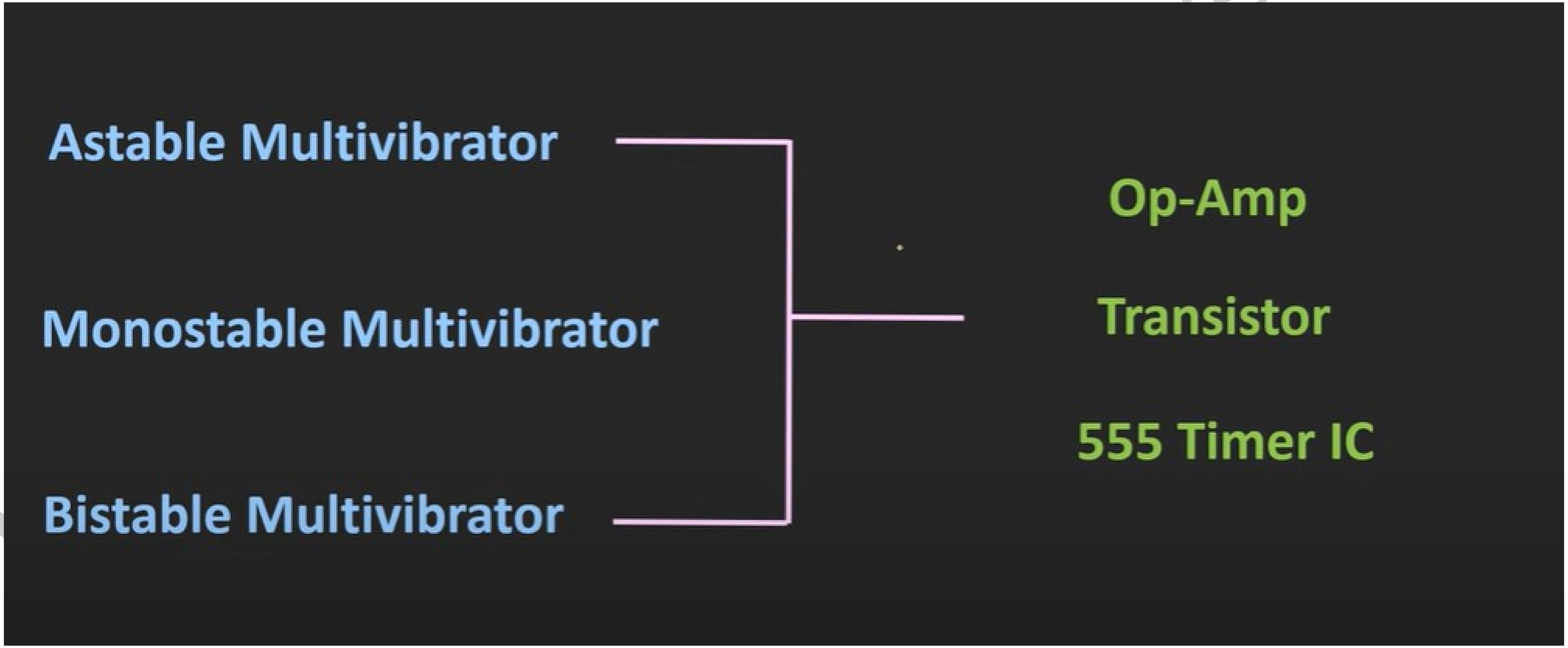
Bistable Multivibrator

- Has two stable states.
- The output used to be in any one of the two stable states.
- Whenever an external trigger signal is applied, the output goes from one stable state to another stable state.
- If no triggering action is applied thereafter, then it remains in the new stable state.
- The bistable multivibrator is one kind of flip-flop circuit.

Bistable Multivibrator

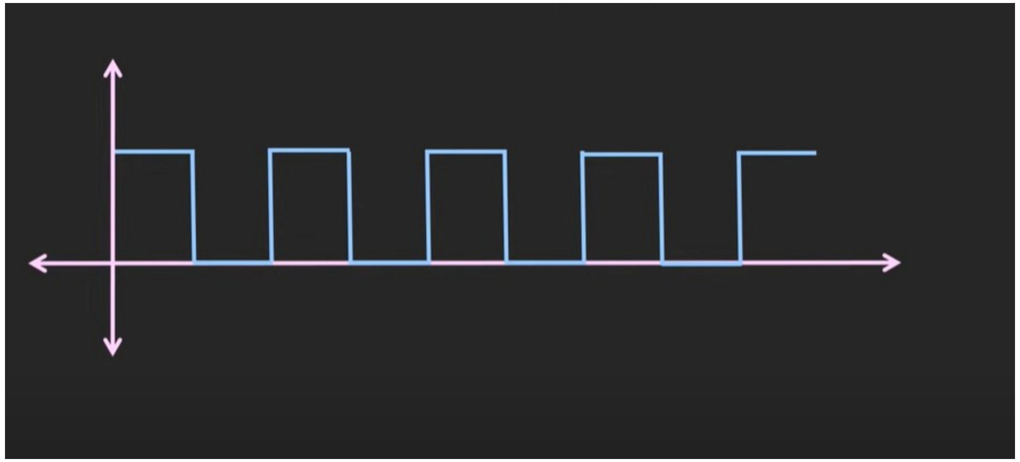


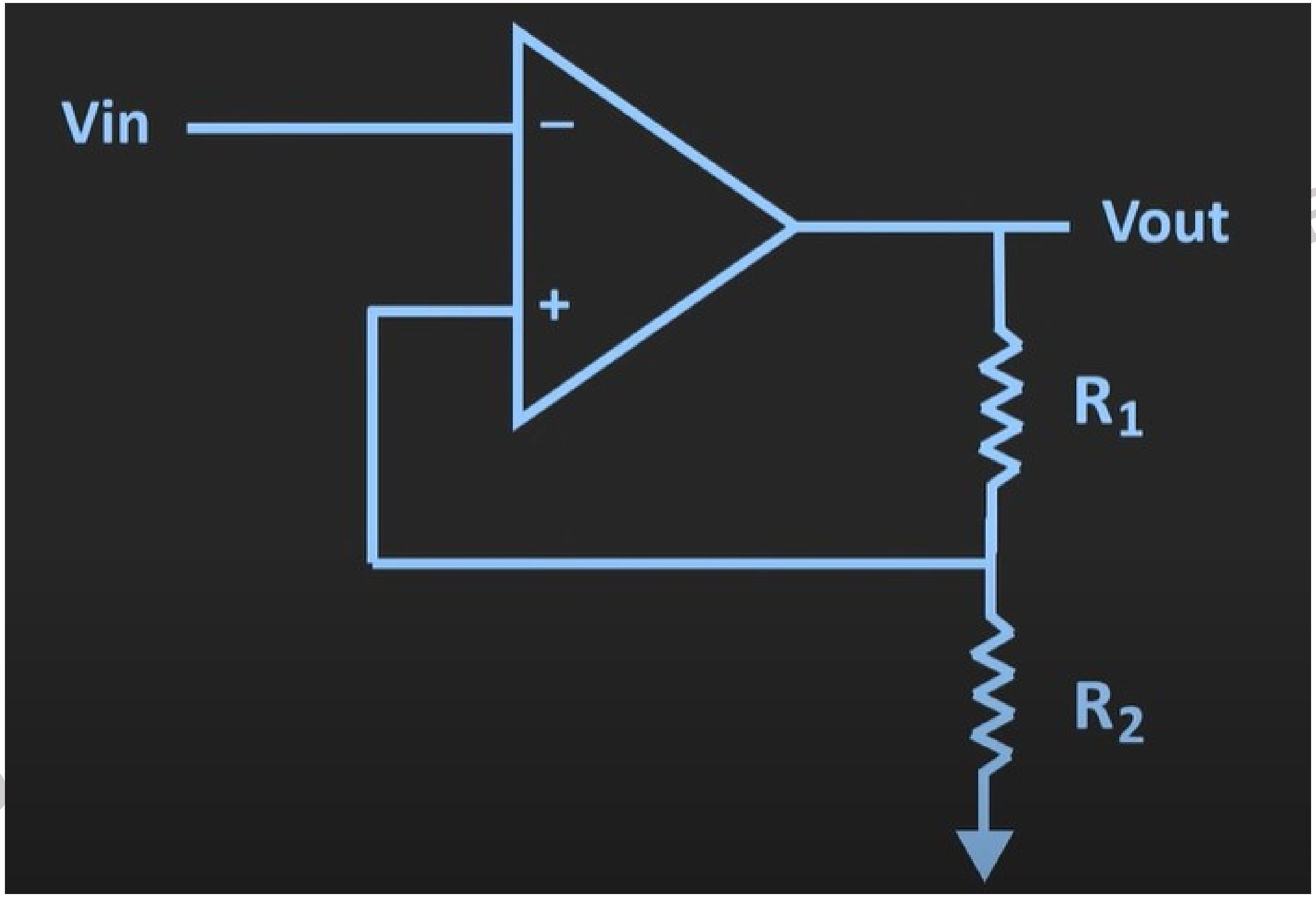
- All the three types of multivibrators can be designed using either op-amp, transistor pairs or 555 timer IC.



SQUARE WAVE GENERATOR (ASTABLE MULTIVIBRATOR)

- Both states are astable state and output used to change continuously between the two states.
- Used to design relaxation oscr (o/p is non sinusoidal). A relaxation oscillator is an oscillator based upon the behavior of a physical system's return to equilibrium after being disturbed.
- Op amp used with +ve f/b.



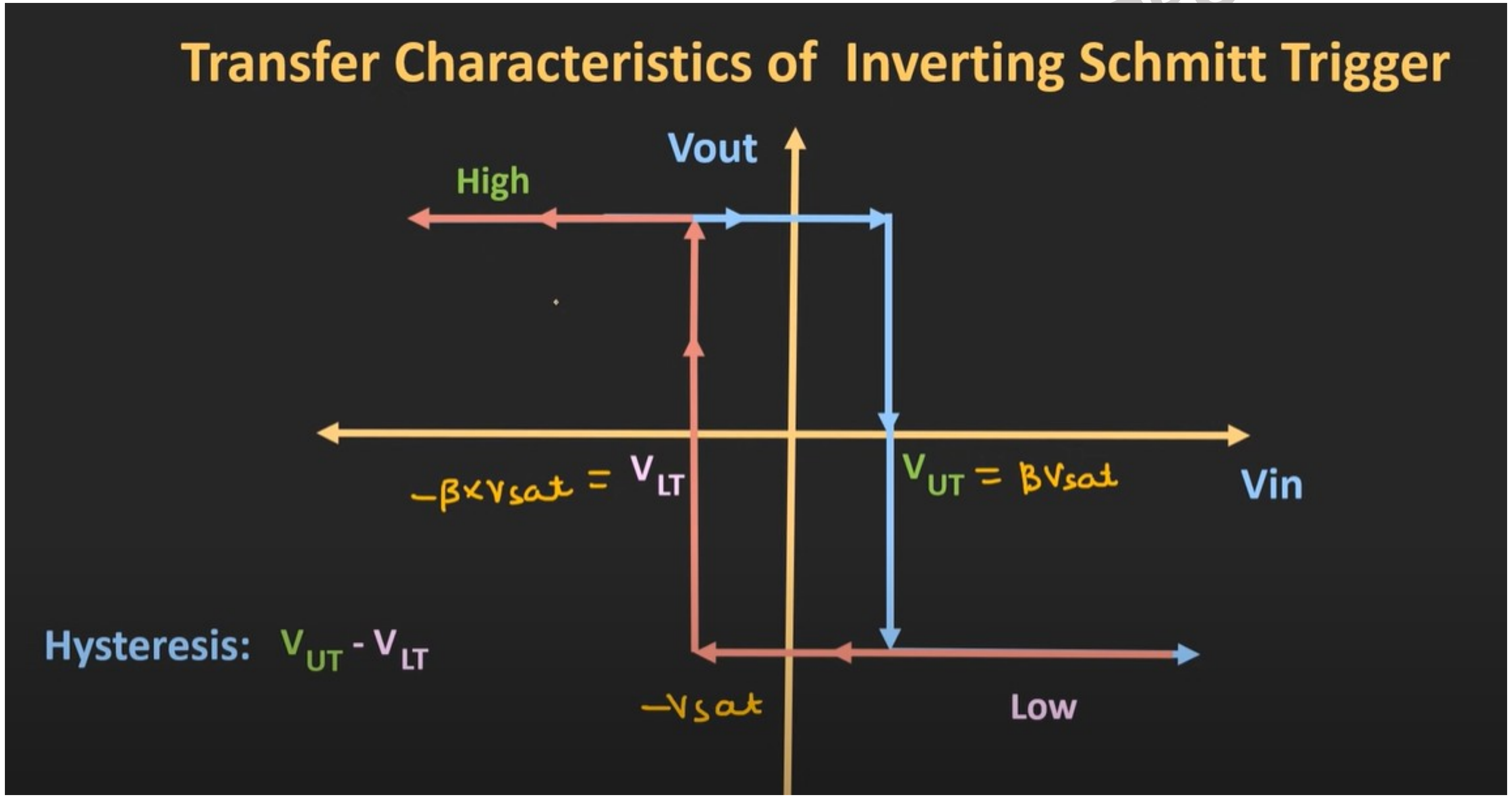


Vin
−
+
Vout
R_1
R_2

Schmitt trigger

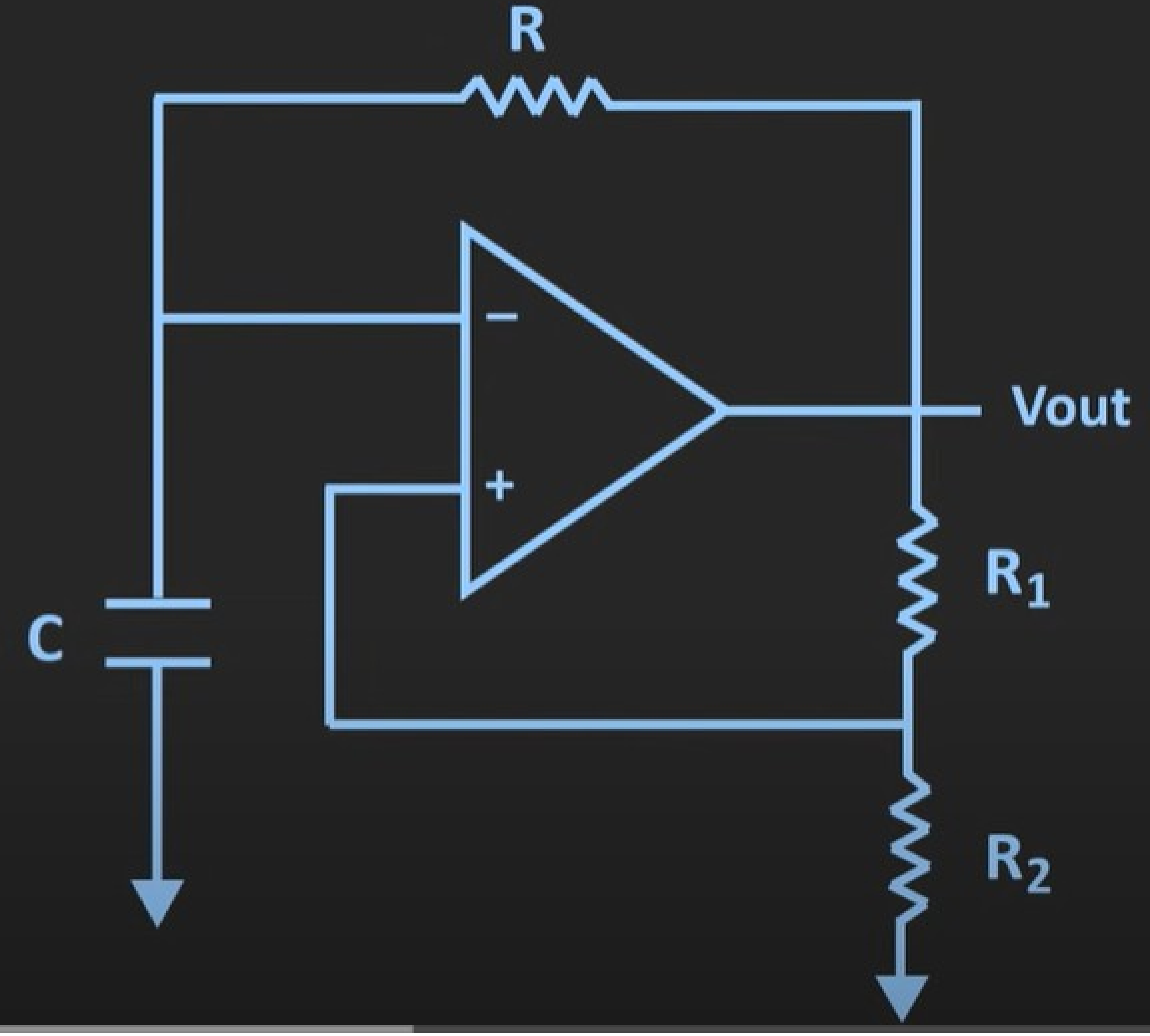
- Fraction of o/p is fed back to i/p.
- Bcoz of +ve f/b, o/p shud grow continuously.
- But its not possible as already discussed.
- Restricted by supply voltages.
- Let initially o/p of Schmitt trigger is +Vsat.
- Then $V^{+} = V_{sat} = \beta V_{sat}$
- When $V_{in} < V^{+}$ ---------- o/p $+V_{sat}$
- When $V_{in} > V^{+}$ ---------- o/p $-V_{sat}$

- Now $V^+ = -V_{sat} = -\beta V_{sat}$
- This again changes when $V_{in} < V^+$



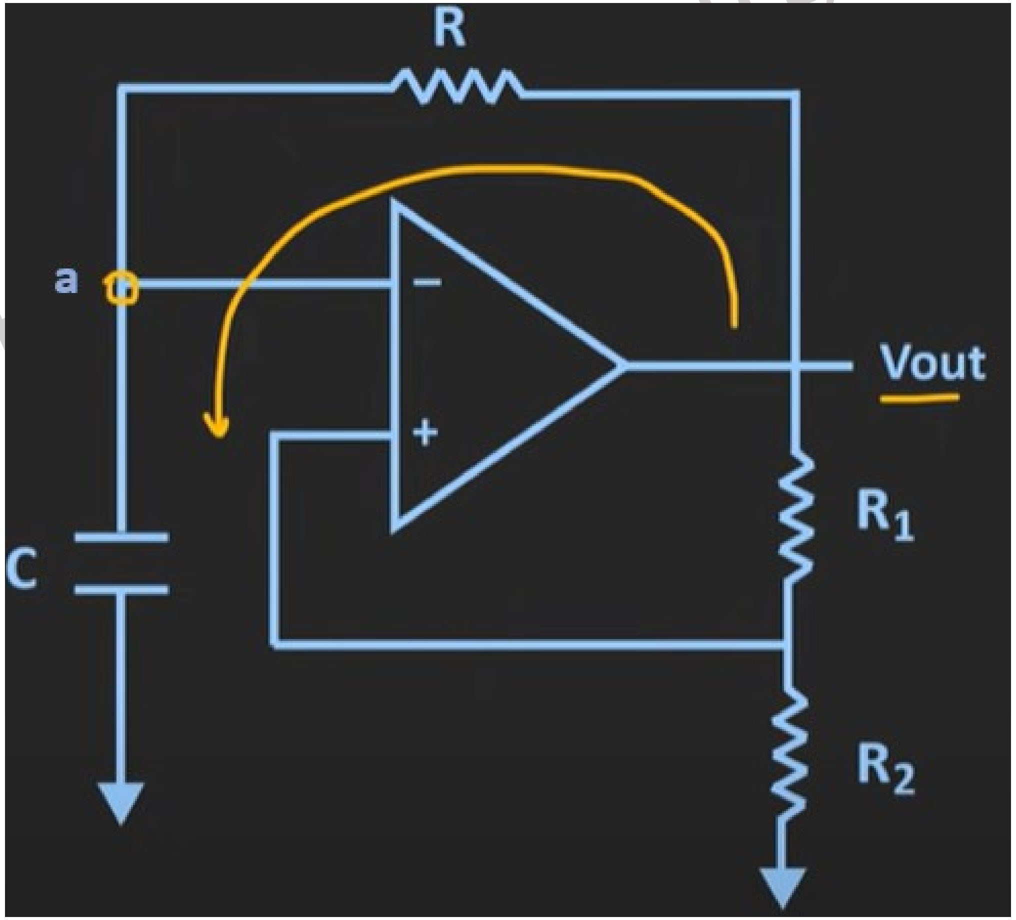
- In the Schmitt trigger, i/p is applied externally.
- But if we provide f/b from o/p to i/p via R and C, then the same ckt can be used as an astable MV.

Astable Multivibrator



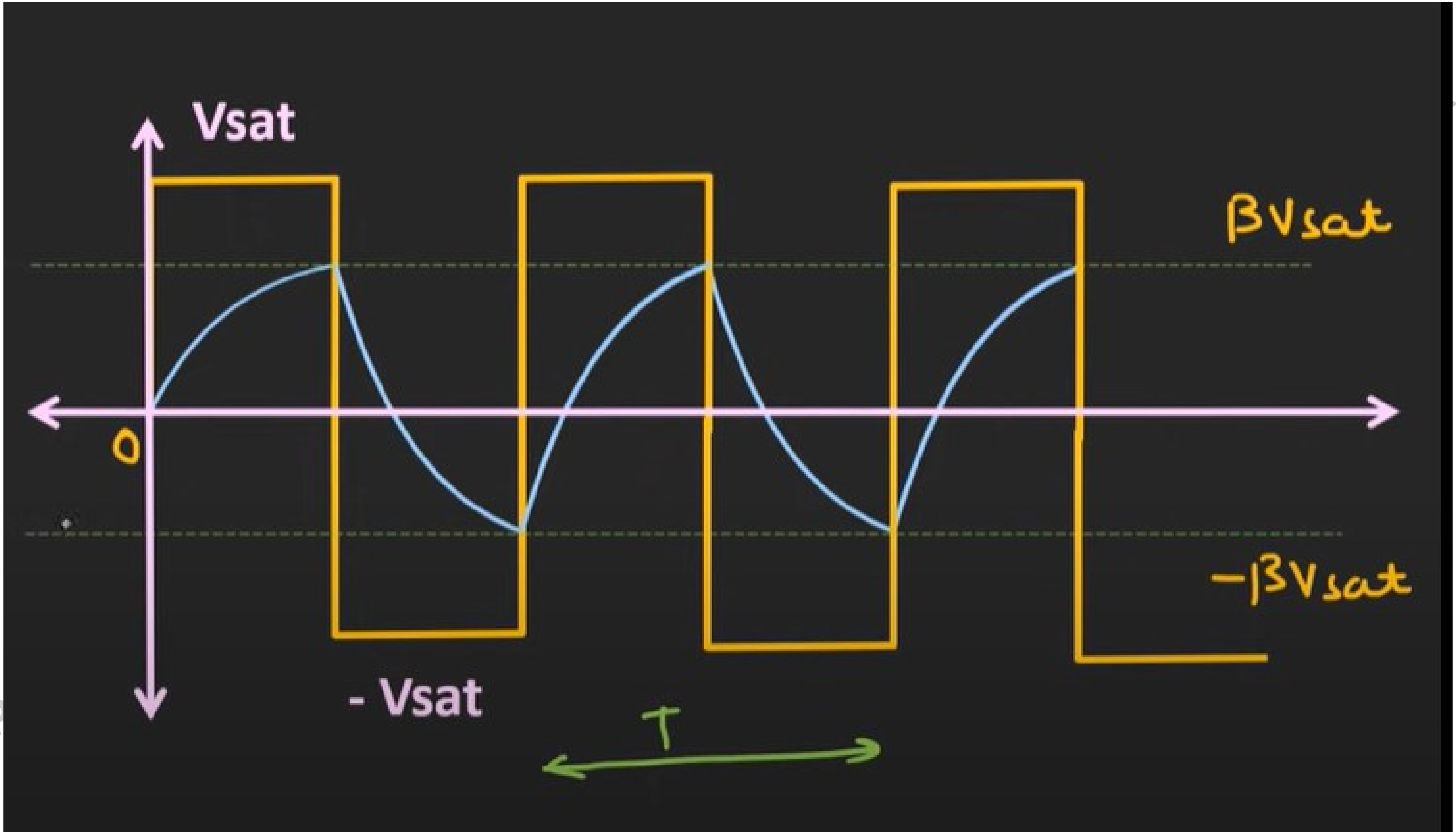
Working

- Lets assume initial voltage across this ckt is $+V_{sat}$.
- So capacitor starts charging thru this path.
- Assume ideal op amp. So no current flow into op amp.
- As soon as cap starts charging, the V will get build up across this capr.



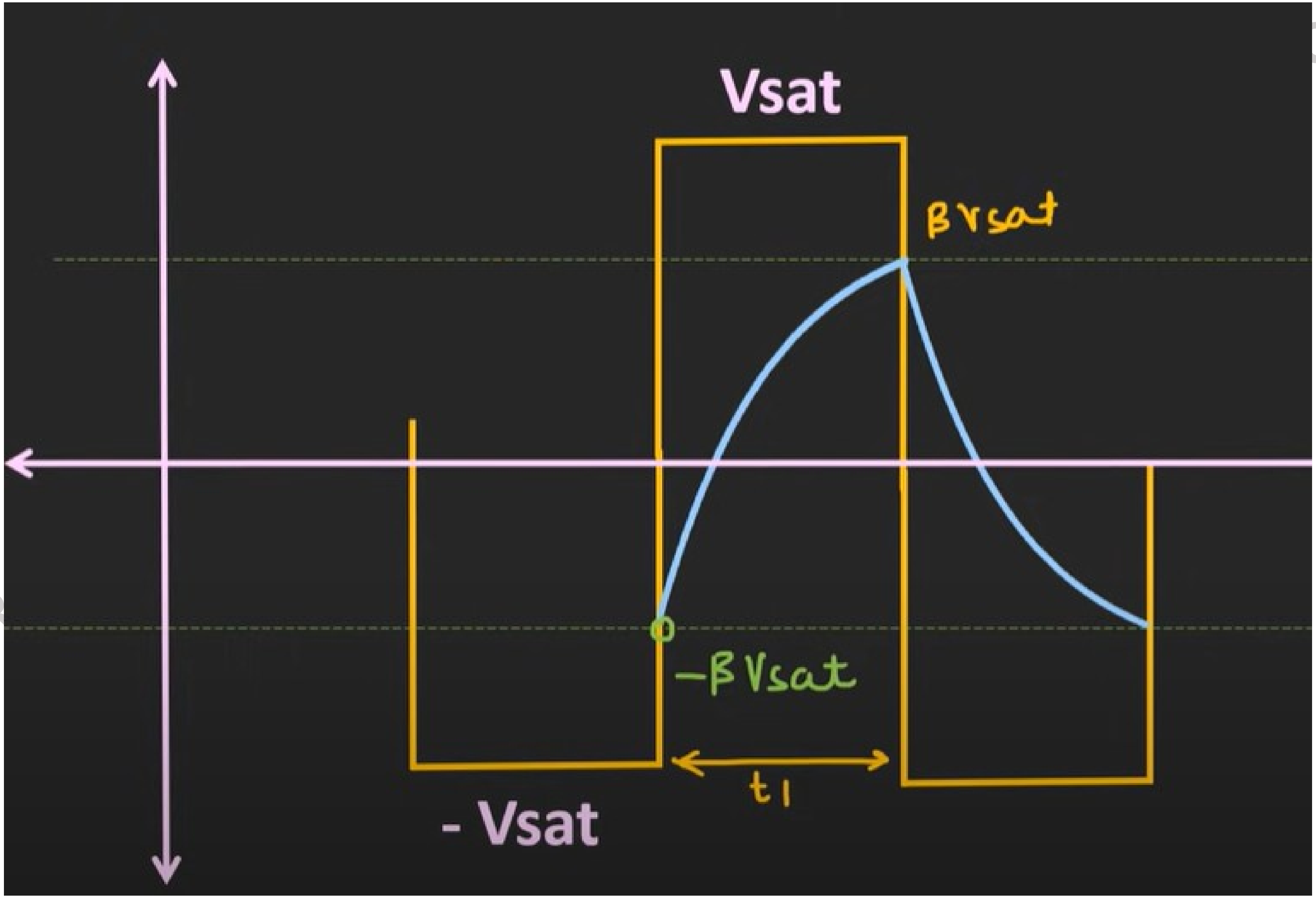
- V at node a will also build up.
- Whenever V_a reaches V_{UT} or in this case lets say equal to $\beta\ V_{sat}$, then V at inv node will be slightly > that at non inv node.
- So o/p changes to $-V_{sat}$.
- Now capr starts charging to the –ve saturation voltage.
- As soon as the voltage jz goes below $-V_{sat}$, at that time V at non inv terminal is slightly > that of inv terminal.
- Once again o/p switch from $-V_{sat}$ to $+V_{sat}$.

- In this way, by charging and discharging of capacitor, we will get a square wave at o/p.
- Time period of astable MV depends on the value of this R and C.
- It also depends on the value of the upper & lower threshold voltage.
- So eventually we can say that it depends on R1 and R2.



Vsat
βVsat
0
-βVsat
- Vsat
T

Derivation



- Assume V initially across cap = $- \beta V_{sat}$
- and it is charging towards $+V_{sat}$.
- V across capacitor

$$V_c(t) = V_{final} + [V_{initial} - V_{final}]$$

- V_{final} is the V towards which the capacitor is charging.

$V_{final} = +V_{sat}$

$V_{initial} = - \beta V_{sat}$

We need to find time t_1 which is required by capr to charge from $- \beta V_{sat}$ to $+ \beta V_{sat}$.

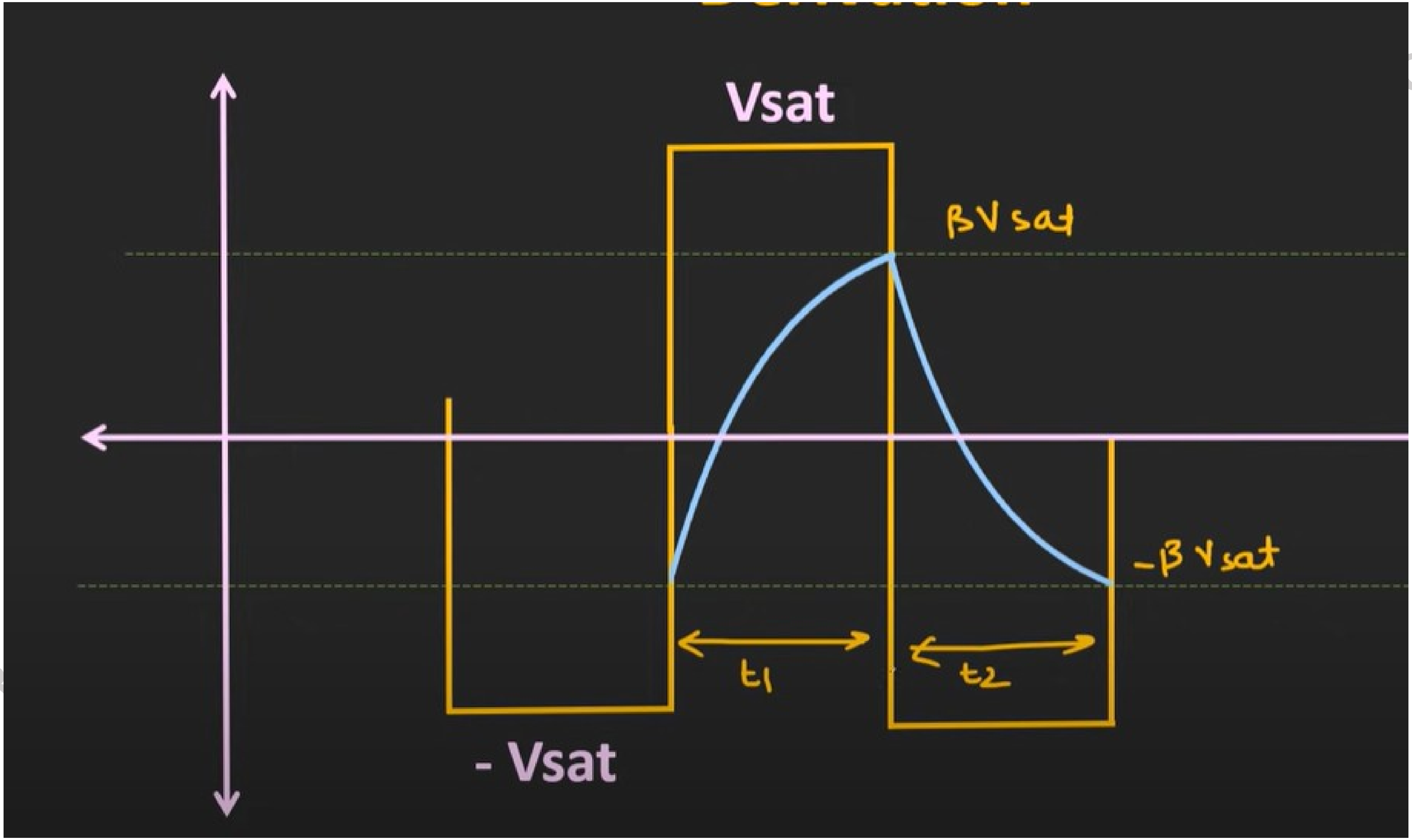
$$V_c(t_1) = V_{sat} + [- \beta V_{sat} - V_{sat}]$$

$$\beta V_{sat} = V_{sat} + [- \beta V_{sat} - V_{sat}]$$

$$\beta - 1 = - [1+\beta]$$

$$=$$

t_1 = RC ln


Vsat
βVsat
-βVsat
t1
t2
- Vsat

- Here as the +ve and –ve saturation voltages are equal, duty cycle of square wave will be 50%.
- If upper and lower threshold V are different, then duty cycle will be > or < 50%.
- Here as duty cycle is 50% , we can say that $t_1 = t_2$.

$V_{initial} = \beta\, V_{sat}$

$V_{final} = -V_{sat}$

$$V_c(t_2) = -V_{sat} + [\beta V_{sat} + V_{sat}]$$

$$-\beta V_{sat} = -V_{sat} + [\beta V_{sat} + V_{sat}]$$

$$1- \beta = [1+\beta]$$

$$=$$

$$t_2 = RC \ln$$

Time period of square wave $T = t_1 + t_2$

$T = 2RC \ln$

o/p swings from $+V_{sat}$ to $-V_{sat}$.

So V_{0ut} (peak to peak) = $2V_{sat}$.

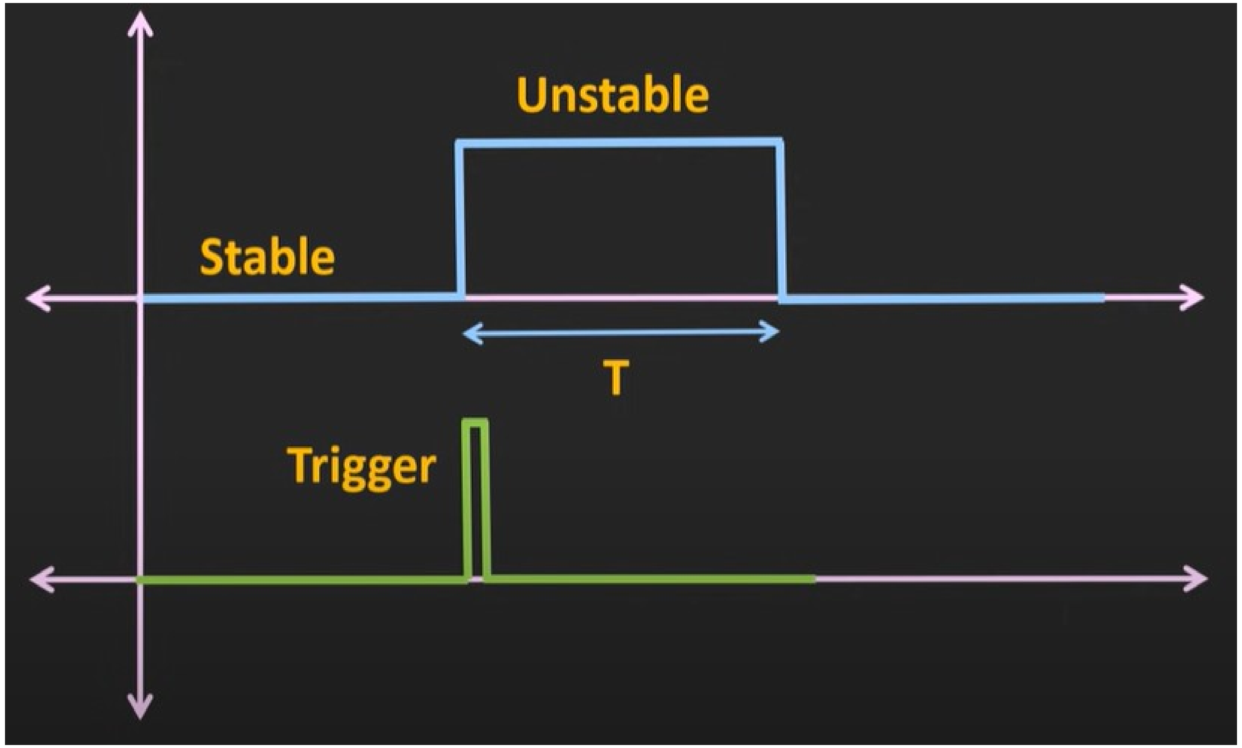
For $R_1 = 1.16R_2$, we get $T = 2RC$ and $f_0 = 1/2RC$.

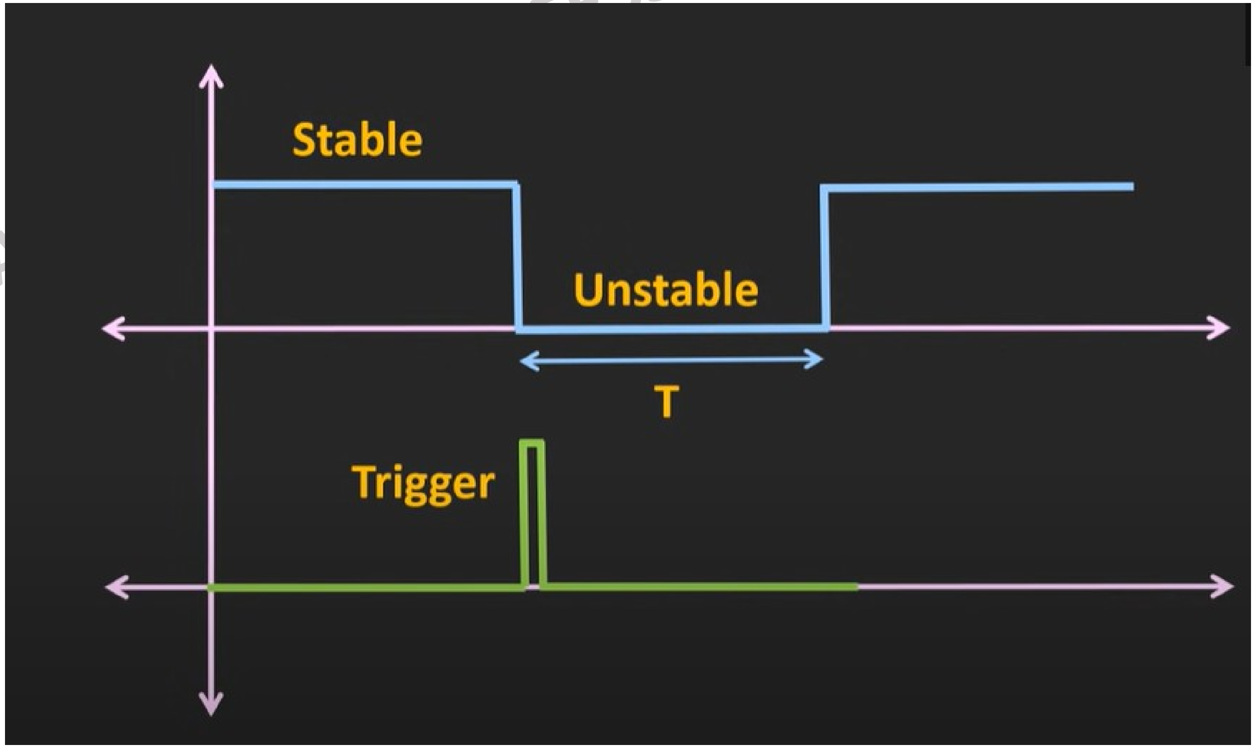
Q: Design astable MV having freq of 1 KHz.

- R1=R2
- T=1ms
- β = ?
- C = 0.1 μF
- R=4.5 K
- R1=R2=10 K

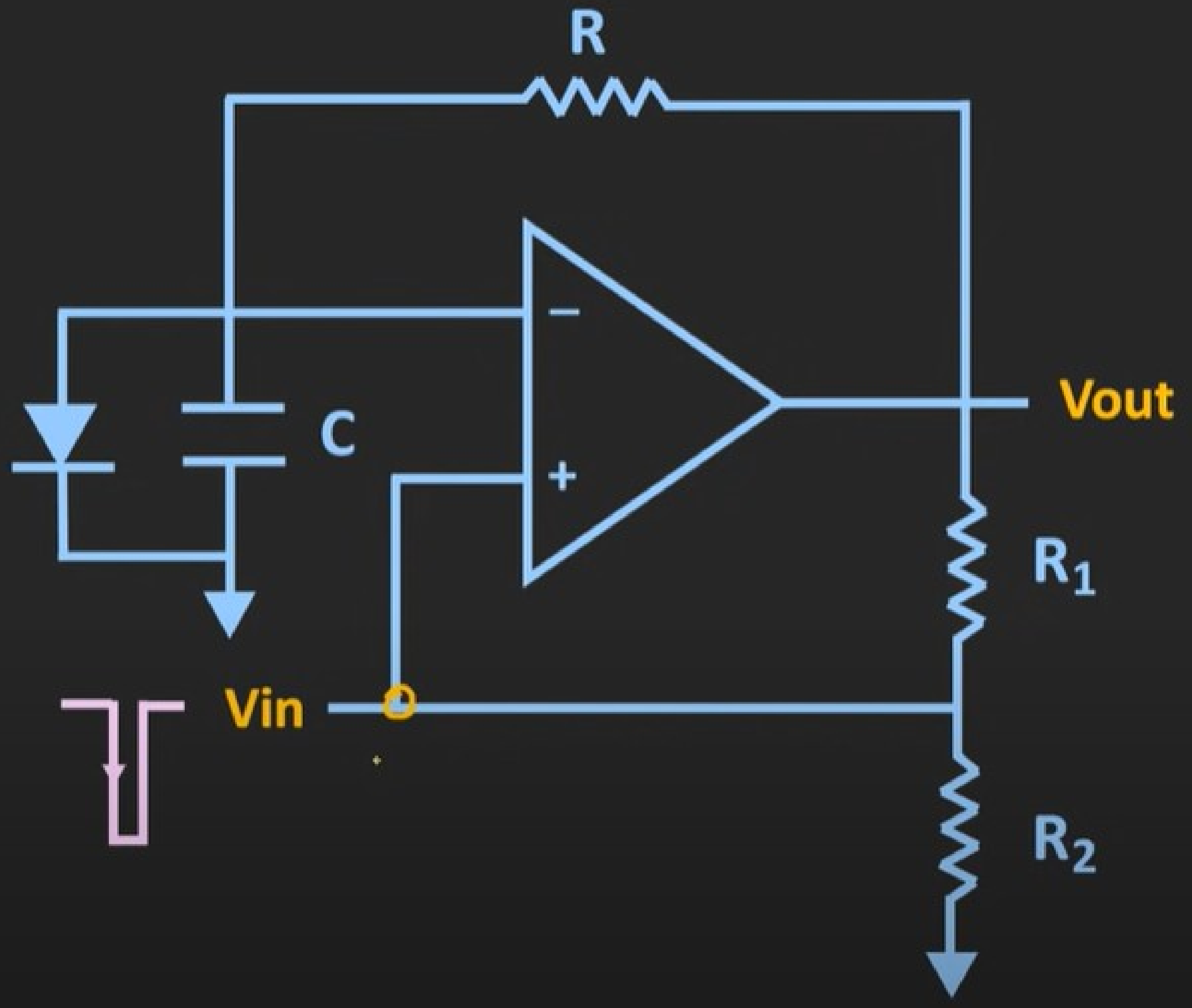
Monostable Multivibrator

- There is one stable state.
- When the trigger signal is applied then momentarily the output goes into the unstable state and once again comes back into the stable state.


Unstable
Stable
T
Trigger

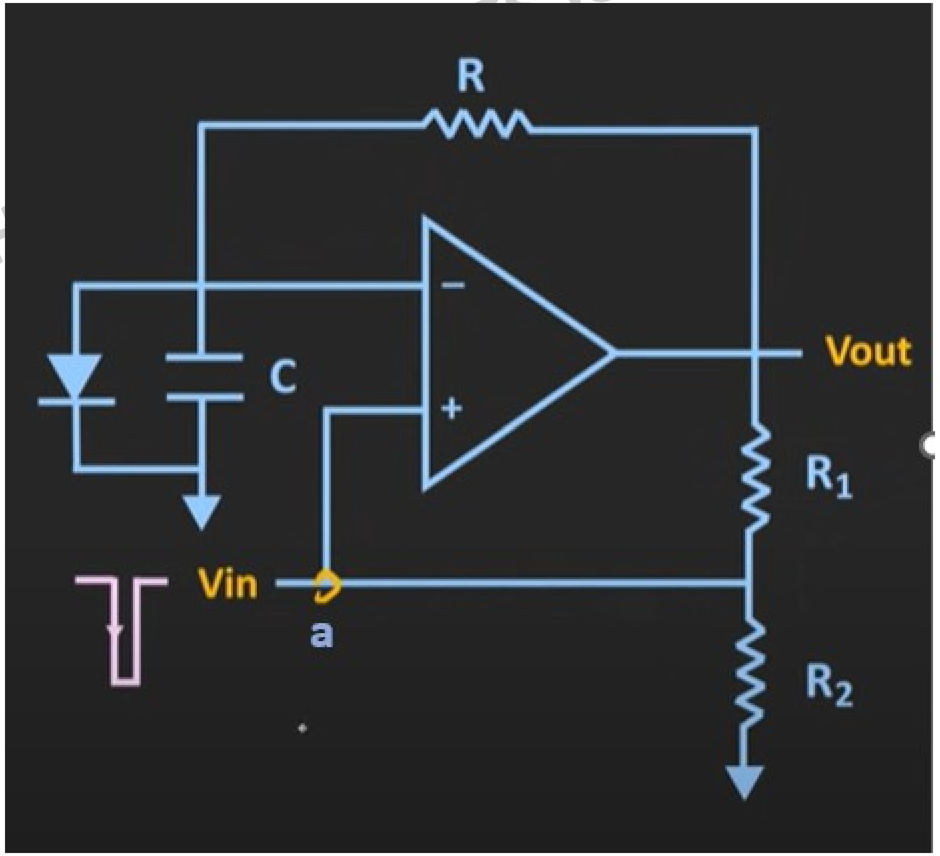

Stable
Unstable
T
Trigger

Monostable Multivibrator



Working Principle

- Diode parallel to capr.
- Trigger s/g is applied at node a.
- Initially lets assume o/p of ckt $+V_{sat}$ and it is a stable state of the ckt.
- $V_a = V_{sat} = \beta V_{sat}$

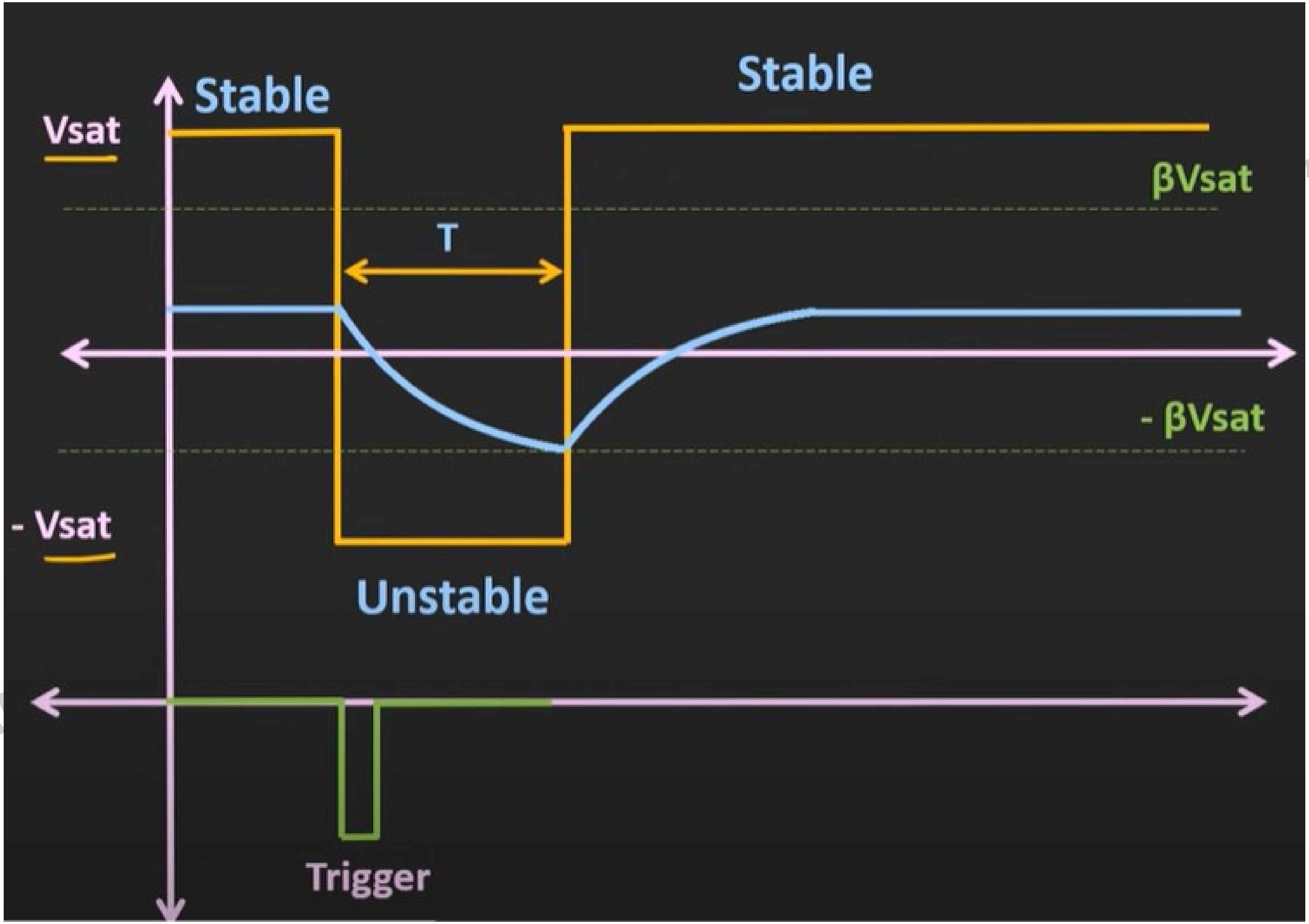


- Whenever o/p is $+V_{sat}$, diode is FB.
- V across capr will be forward V drop of diode.
- So inv node V = forward V drop of diode.
- As $\beta\ V_{sat}$ > forward V drop of diode, o/p remains at $+V_{sat}$.
- Now, lets say after a certain time the trigger s/g is applied at this node.
- When a –ve trigger is applied, then momentarily o/p at non inv node will be less than V at inv node.

- So o/p of op amp will now switch from +ve to –ve sat voltage.
- The ckt goes into unstable state.

$$V_a = -V_{sat} = -\beta V_{sat}$$

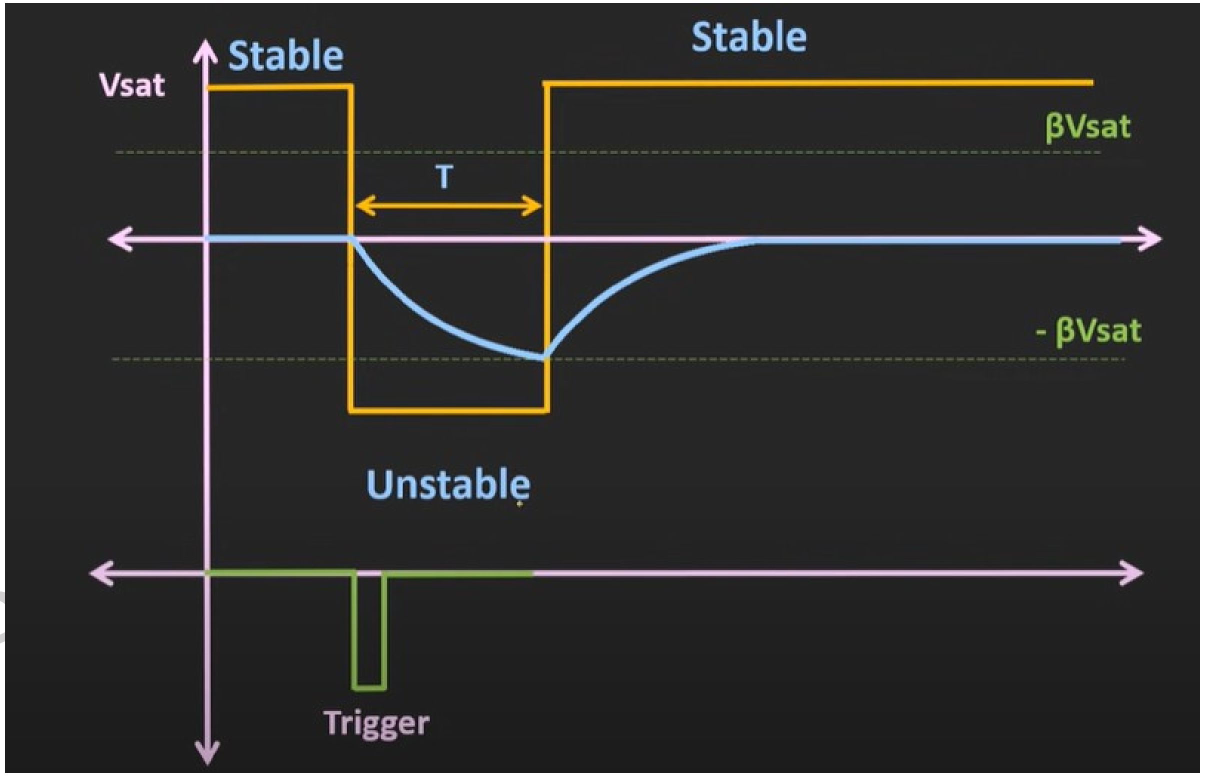
- Diode RB.
- Cap starts charging to $-V_{sat}$.
- Whenever the voltage at inv node goes below this $-\beta V_{sat}$, o/p of op amp will go to $+V_{sat}$.


Stable
Vsat
Stable
βVsat
T
- βVsat
- Vsat
Unstable
Trigger

- Only for this time T, the o/p will remain in unstable state.
- Now again in stable state. Capr voltage = forward V drop of diode.
- Here T is only time duration of pulse (Not a time period).

Derivation

- Assumed that diode which is used in the ckt is an ideal diode.
- So drop across diode =0V
- So whenever the –ve trigger is applied to MMV, cap starts charging from 0 to $-V_{sat}$.



$$V_c(t) = V_{final} + [\, V_{initial} - V_{final} \,]$$

$V_{final} = -V_{sat}$

$V_{initial} = 0\ V$

- We need to find time T required to reach $-\beta V_{sat}$ from 0.

$V_c(T) = -V_{sat} + [\,0 + V_{sat}\,]$

$-\beta V_{sat} = V_{sat}\,[\,-1]$

$1 - \beta =$

$T = RC \ln()$

- If $R_1 = R_2$, $T = 0.693RC$

- If drop across diode = V_D, then $\mathbf{V_{initial} = V_D}$.

$T = RC \ln()$

$1- \ = \quad ($ from $1- \beta =$

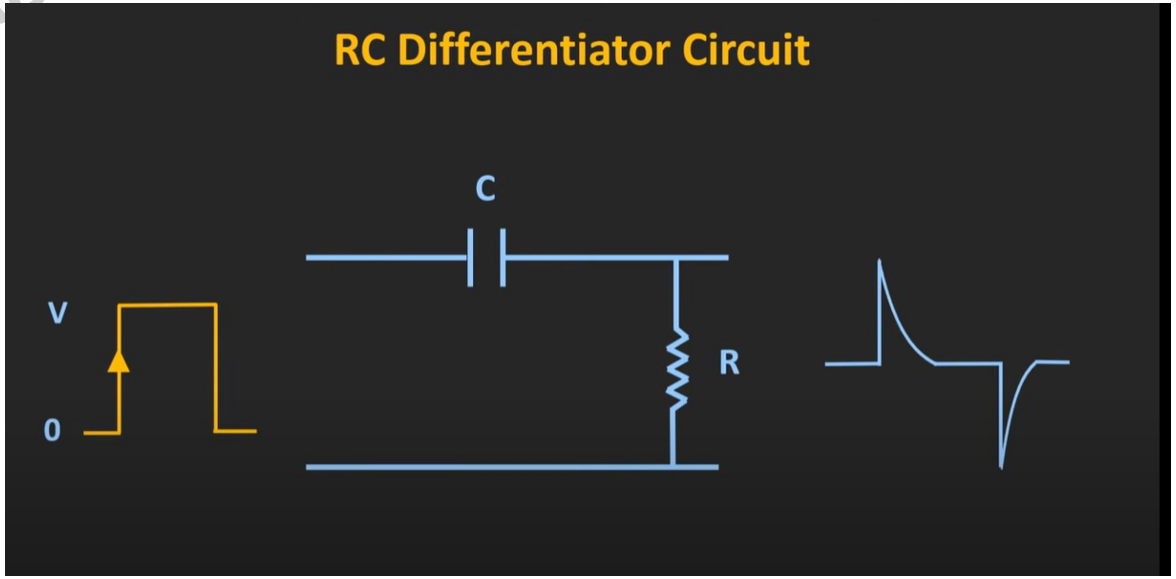
$=$

$$T = -RC \ln []$$

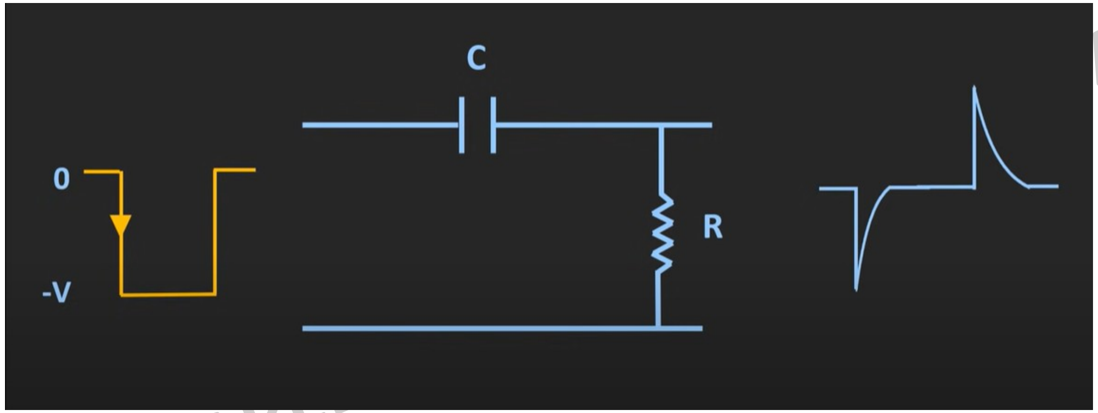
$$T = RC \ln []$$

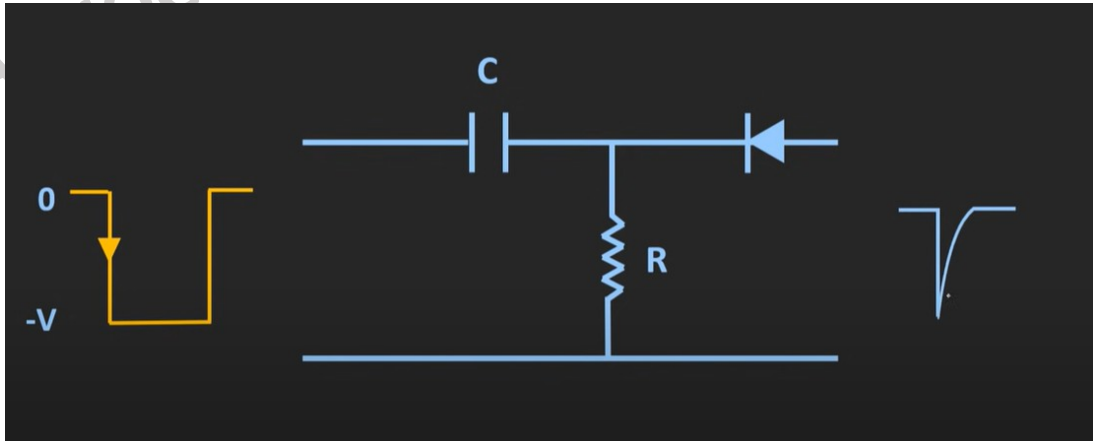
This is the time for which o/p becomes unstable.

- Trigger s/g required to change the state of MMV.
- Duration of trigger s/g shud be much < time period for which MMV to go into unstable state.
- One way to get this trigger s/g is using differentiator ckt .
  - When we give a pulse going from 0 to V, we get 2 spikes like this. But we need only (–ve) spike. So we go for next fig.

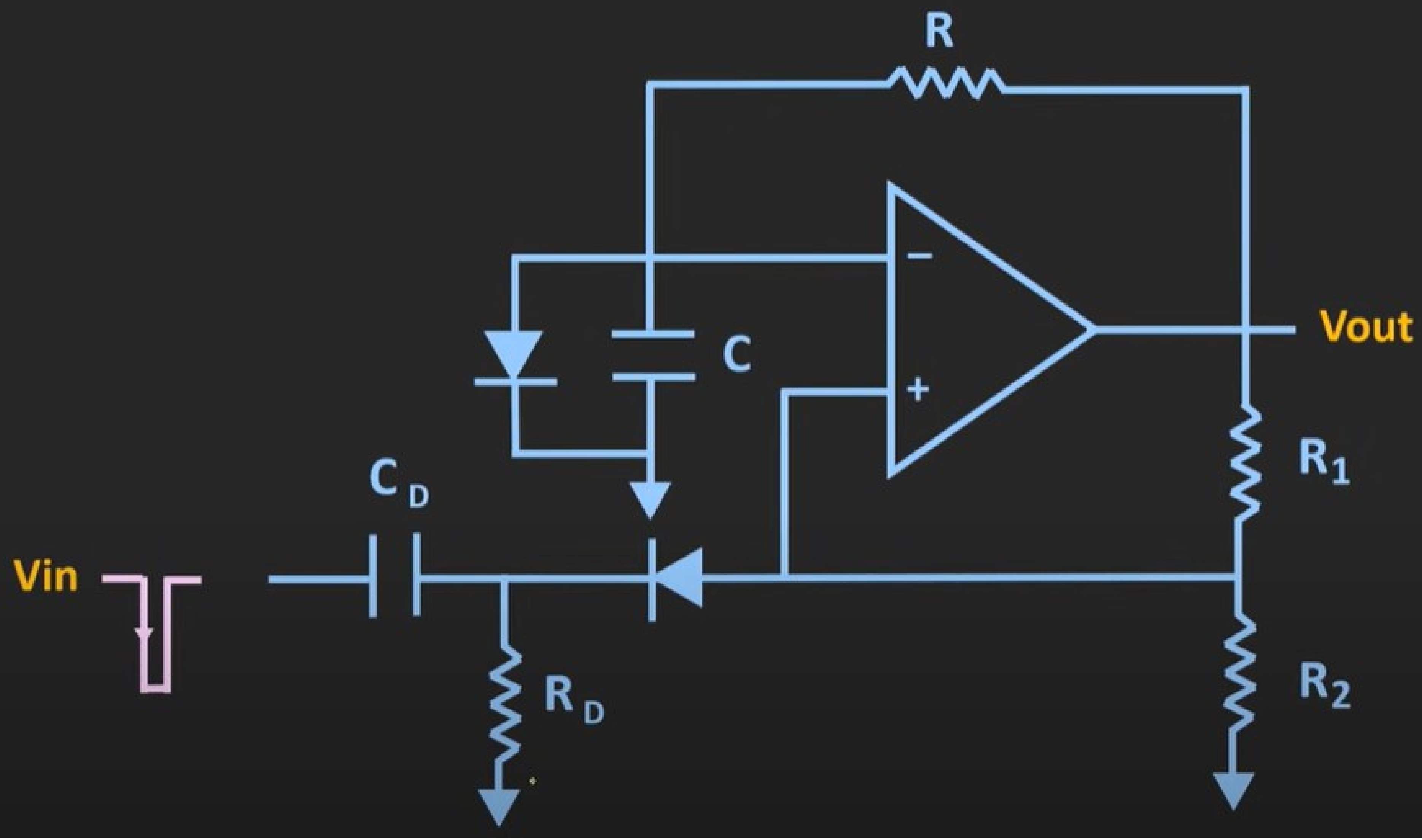


To get only the –ve spike as trigger s/g, use the following ckt with a diode (to eliminate +ve spike).





Monostable Multivibrator



Q: Design a monostable MV which has time T =10ms.

- R1=R2=10K
- T =0.693 RC
- Let C=1μF
- R= 14.4k
- Tune a 20K potentiometer to this value.
- If not available, use 10 k pot. in series with 10K resistor and tune pot.to 4.4k value.