Unit IV

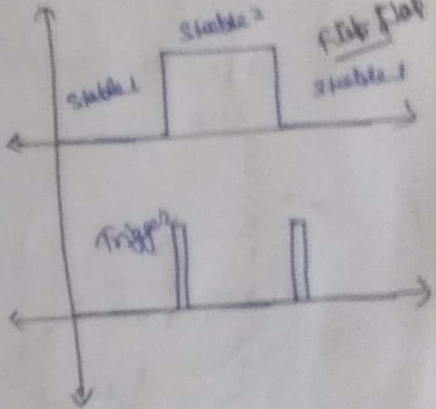
Multivibrators and Time base Generators.

A circuit which can oscillate at a number of frequencies is called a multivibrator. It has three types:

(i) Bistable multivibrator
(ii) Monostable "
(iii) Astable "

* **Bi-stable multivibrator:**

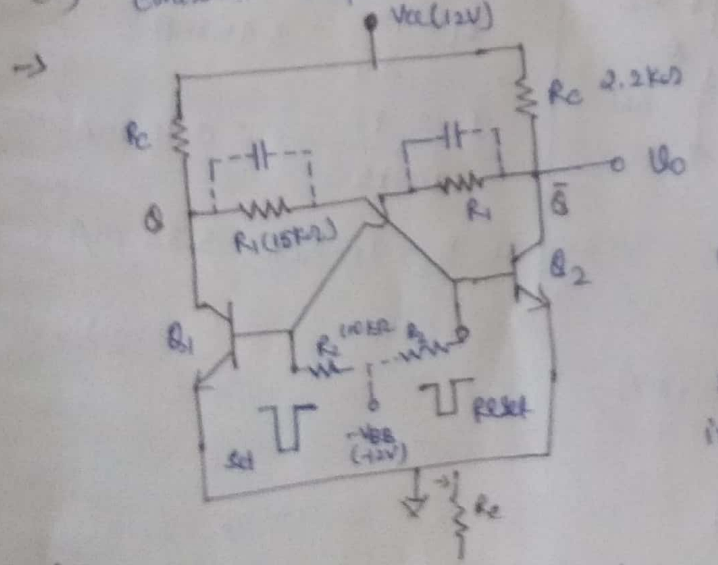
It has two stable states and it make transition from one state to another state by external excitation. It is used as flip-flop.



Types:

(i) Collector coupled bistable multivibrator
 (a) fixed bias bistable multivibrator
 (b) self-bias " "
(ii) Emitter coupled bistable multivibrator

→



Let consider that transistor Q_1 draws more current in compare to Q_2. i.e. $Q_1 \rightarrow ON$ & $Q_2 \rightarrow OFF$. Transistor behave as inverter.

Operation:

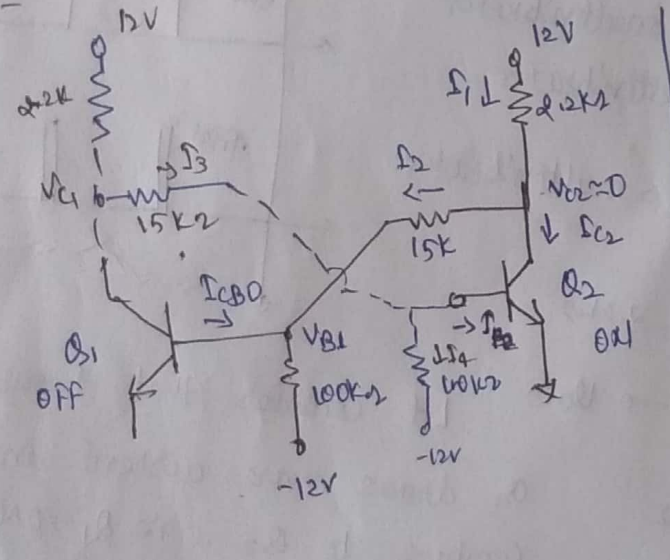
→ When Q_1 is ON then collector vge is $V_{cc} - I_cR_c$ i.e. less which is given to base of Q_2 and it is not sufficient to switch Q_2 ON. as Q_2 collector vge is +Vcc (high), which is given to base of Q_1. So, Q_1 will be in saturation. output remains in same state.

→ When small trigger pulse is given to base of Q_1 to set it into off, then Q is +Vcc & Q_2 will be ON & $\bar{Q}$ is $V_{cc} - I_cR_c$. i.e. state has been changed. Same o/p is given to Q_1. So, still it would be OFF,

→ To change the state again, small trigger pulse is given to base of Q_2 to reset. i.e. Q_2 will be OFF & $\bar{Q}$ is equal to V_{cc}, which is given to Q_1. So, Q_1 will turn ON.

→ So, when-when trigger pulse occur then there is transition in o/p. It is required that there should be change of state as soon as abrupt trigger pulse is applied.
The transition time can be reduced by connecting small capacitance in shunt with R_1. It is known as commutating transpose or speed up capacitors.

e.g. $h_{fe} = 20$, calculate current & voltage.



→ we neglect I_{CBO}.

$$V_{B1} = \frac{-12 \times 15}{(15+100)} = -1.56V$$

$$I_1 = \frac{12}{2.2} = 5.45\,mA$$

$$I_2 = \frac{12}{100+15} = 0.10\,mA$$

So, $I_{C2} = I_1 - I_2 = 5.35\,mA$

$$(I_{B2})_{min} = \frac{I_{C2}}{h_{fe}} = \frac{5.35}{20} = 0.27\,mA$$

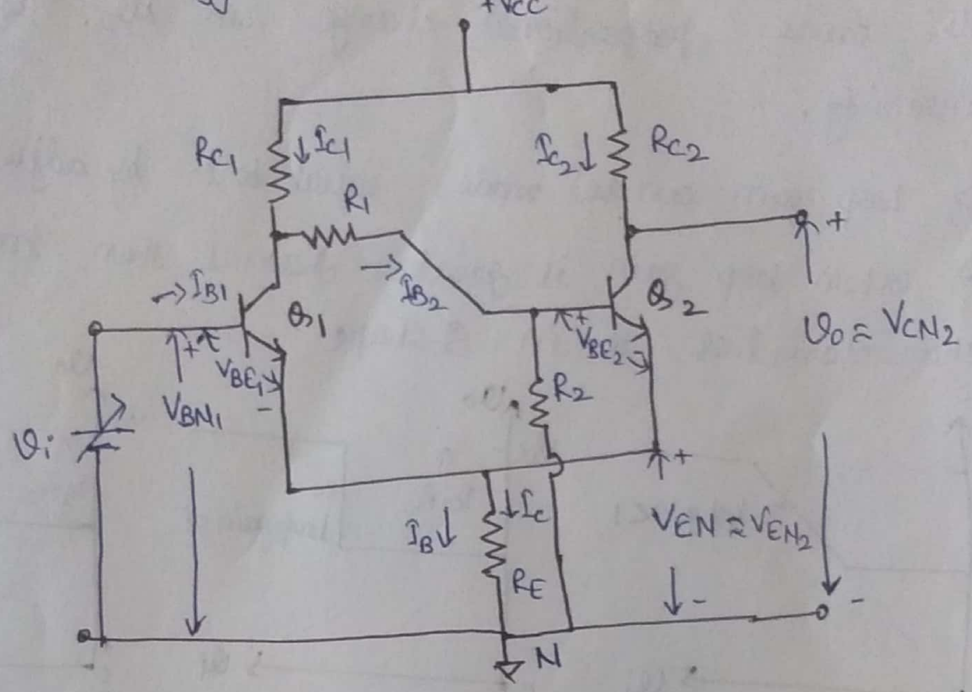
→ $I_3 = \frac{12}{2.2+15} = 0.70\,mA$

$I_4 = \frac{12}{100} = 0.12\,mA$

So, $I_{B2} = I_3 - I_4 = 0.58\,mA$.

* Schmitt Trigger:

An emitter-coupled bistable multivibrator is called as schmitt trigger.



→ The I/P voltage v_i is variable. R_{C_1}, R_1 & R_2 are voltage divider.

case-I:

when $v_i < (V_{BN_1}$ ie. $V_{BE_1} + V_{EN})$ then transistor Q_1 is OFF.

The O/P at collector of Q_1 is high (Vcc), which is given to I/P to Q_2. The voltage at base of Q_2 is given as,

$$V_{BN_2} = \frac{V_{CC} \cdot R_2}{R_{C_1} + R_1 + R_2}$$

Due to this Q_2 turn ON & O/P voltage v_o is equal to $V_{CC} - I_{C_2} R_{C_2}$. The current I_{B_2} & I_{C_2} flow through the resistance R_E. Let assume that Q_2 is in active region.

case-II:

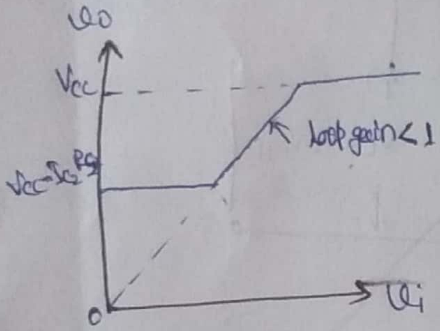
when v_i is increased, then at $v_i = V_{EN_2} + V_{\gamma_1}$, Q_1 begins to conduct. So, voltage at base of Q_2 decreases.

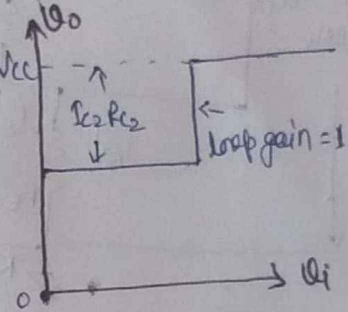
→ If V_i increased further then Q_1 is ON & Q_2 is OFF. The O/P voltage is equal to V_{cc}.

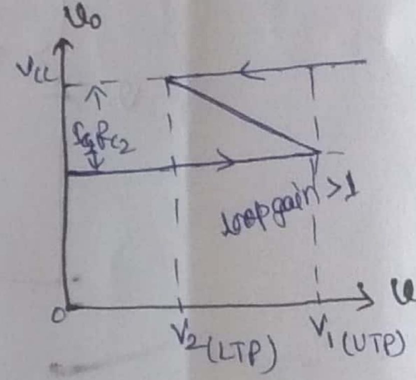
→ If loop gain is less than unity then incremental change ΔV_i cause proportional change in ΔV_o. i.e. it has linearity.

→ Loop gain can be made equal to 1 by adjusting R_{C1} & R_{C2}.

→ when loop gain is greater than 1 then transfer characteristics is in S-shape.





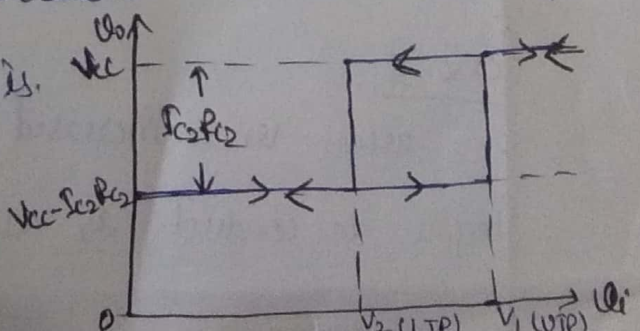


→ The voltage (at which) $V_i = V_1$, when O/P voltage changes suddenly from $V_{cc} - I_{C2}R_{C2}$ to V_{cc} is known as upper trip point (UTP).

Case-III:

when I/P voltage V_i is decreased & at voltage $V_i = V_2$, O/P voltage falls from V_{cc} to $V_{cc} - I_{C2}R_{C2}$ is known as lower trip point (LTP). The hysteresis voltage is given as, $V_H = V_1 - V_2$.

when V_i is increased to V_1, it has to pass the pt. V_2. Similarly when V_i is decreased to V_2, it has to pass the pt V_1. This is called hysteresis.



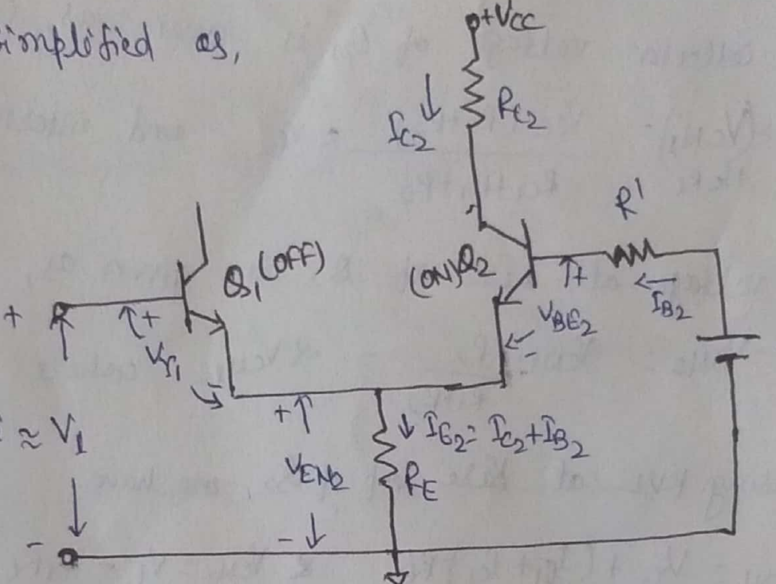
→ Calculation of UTP & LTP i.e. V_1 & V_2:

→ UTP (V_1): The Q_1 switches into ON and Q_2 switches into OFF

The voltage at the base of Q_2 is given as,

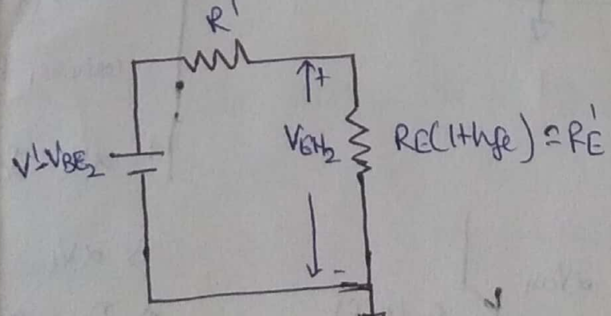
$$V' = V_{BN_2} = \frac{V_{CC} \times R_2}{R_{C1} + R_1 + R_2}.$$

& internal resistance $R' = R_2 \,||\, (R_{C1} + R_1)$.. so, circuit can be simplified as,



The emitter current $I_{E_2} = I_{B_2} + I_{C_2} = I_{B2}\left(1 + \frac{I_{C_2}}{I_{B2}}\right) = I_{B_2}(1 + h_{fe})$.

The net voltage in base loop is $V' - V_{BE2}$. This base loop is simplified as,



$$V_{EN_2} = \frac{(V' - V_{BE_2}) \times R_E'}{R' + R_E'}$$

$\ast$ $R' << R_E'$

so, $V_{EN_2} = V' - V_{BE2}$.

& we have, $V_1 = V_{\gamma_1} + V_{EN_2}$.

we assume that Q_1 is in active region.

we have,

$V_{CB2} = V_{CE2} - V_{BE2}$ & $V_{CE2} + V_{EN2} = V_{CC} - I_{C_2} R_{C_2}$

so, $V_{CB2} = V_{CC} - I_{C_2} R_{C_2} - V_{EN2} - V_{BE2}$

and $V_{EN2} = (I_{B2}+I_{E2})R_E = I_{C2}\left(1+\frac{I_{B2}}{I_{C2}}\right)R_E = I_{C2}\left(1+\frac{1}{h_{fe}}\right)R_E$

$\Rightarrow V_{EN2} = I_{C2}\cdot R_E''$, where $R_E'' = (1+1/h_{fe})R_E$.

Hence, $\boxed{V_1 = I_{C2}R_E'' + V_{\gamma_1}}$

→ **LTP(V_2)**: Q_1 switches in to OFF & Q_2 switches in to ON.

The collector voltage of Q_1 is given as, (ie. Thevenin's vge source)

$V_t = (V_{CN1}) = \frac{V_{CC}(R_1+R_2)}{R_{C1}+R_1+R_2} \approx V_t$ and internal resistance
$+I_{C1}R_t$

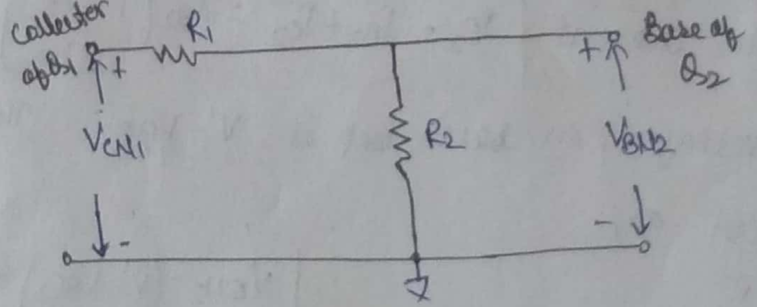
$R_t = R_{C1} \| (R_1+R_2)$

The voltage at base of Q_2 is given as,

$V_{BN2} = V_{CN1}\cdot\frac{R_2}{R_1+R_2} = \alpha V_{CN1}$. where $\alpha = \frac{R_2}{R_1+R_2}$

By using KVL at base loop of Q_2, we have

$\alpha V_{CN1} = V_{\gamma_2} + (I_{B1}+I_{C1})R_E$ & $V_{CN1} = V_t - I_{C1}R_t$

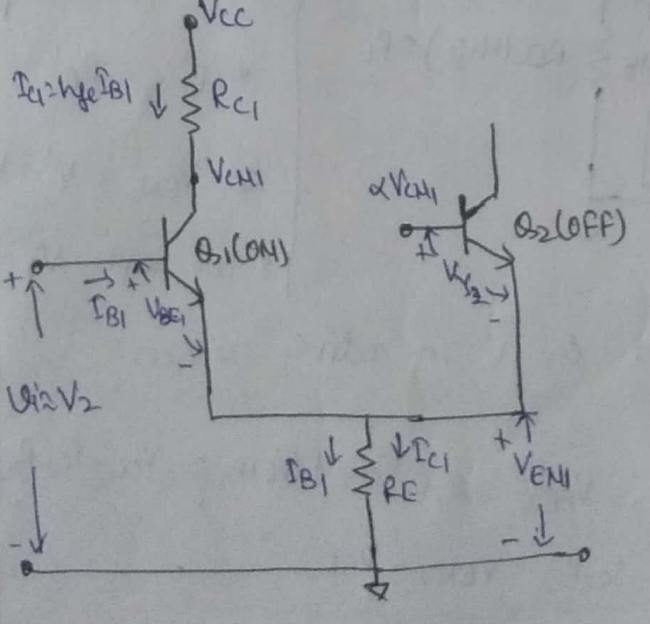


so, $\alpha(V_t - I_{C1}R_t)$
$= V_{\gamma_2} + I_{C1}\left(1+\frac{I_{B1}}{I_{C1}}\right)R_E$
$= V_{\gamma_2} + I_{C1}\left(1+\frac{1}{h_{fe}}\right)R_E$
$= V_{\gamma_2} + I_{C1}\cdot R_E''$
where, $R_E'' = (1+1/h_{fe})R_E$

So $\alpha V_t - I_{C1}\alpha R_t = V_{\gamma_2} + I_{C1}R_E''$

$\Rightarrow \alpha V_t = I_{C1}(\alpha R_t + R_E'') + V_{\gamma_2}$

$\Rightarrow I_{C1} = \frac{\alpha V_t - V_{\gamma_2}}{\alpha R_t + R_E''}$



we have,

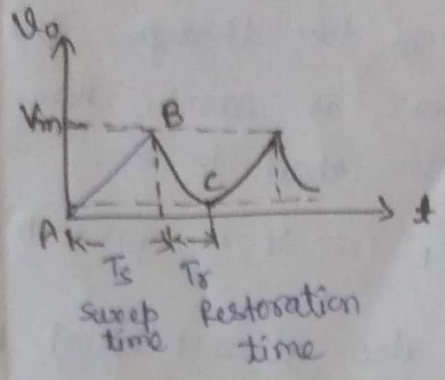
$\alpha V_t = \frac{V_{CC}\cdot(R_1+R_2)}{R_{C1}+R_1+R_2} \times \frac{R_2}{R_1+R_2} = V'$

So $I_{C1} = \frac{V' - V_{\gamma_2}}{(\alpha R_t + R_E'')}$

Hence $\boxed{V_2 = V_{BE1} + I_{C1}R_E''}$

* Timebase generator or sweep generator:

→ It is basically a function generator that generate waveform.
→ It produce o/p voltage / current which is linear w.r.t time.
→ It is used in CRO to sweep electron beam & in T.V Rx.

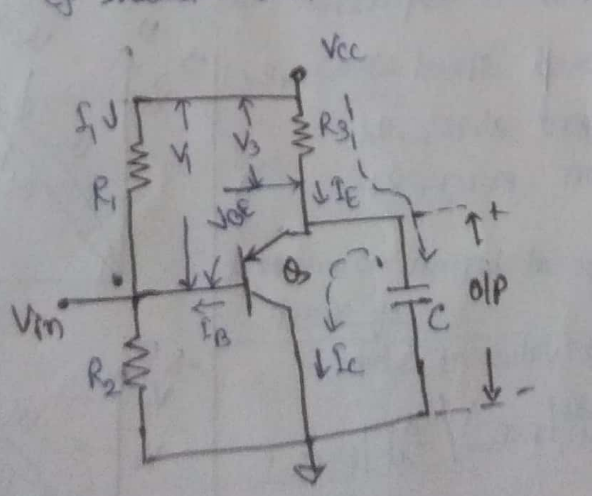


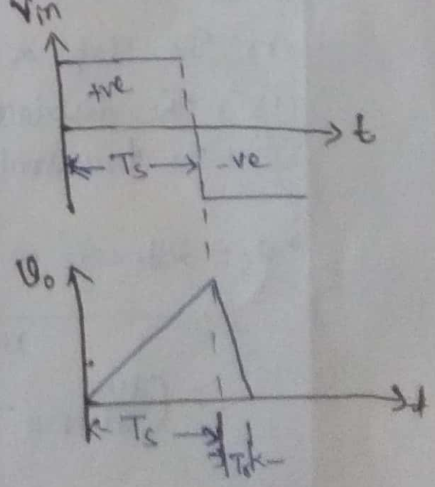
So, Time period, $T = T_s + T_r$.

→ Types:
(i) free running Time base generator : without trigger
(ii) Triggered Time base generator : required trigger signal

→ Methods to generate Time base generator:
(i) Exponential charging : UJT relaxation osc.
(ii) Miller integration : Miller sweep ckt
(iii) Bootstrap : Bootstrap time base generator
(iv) Constant current charging : current time base generator

* Constant current Ramp generator:
e.g. Inductor ckt, Transistor ckt, sweep ckt





→ Resistance R_1 & R_2 provide voltage V_1 to the base of transistor. The voltage across R_3 is equal to $V_1 - V_{BE}$.

→ Case-I:

→ Initially when $+V_{CC}$ is given then pnp transistor Q is OFF due to reverse biasing of i/p junction. During this time capacitor C charges up to $+V_{CC}$ through the resistance R_3, linearly. So, output appear as ramp. Here current is constant. The o/p increases about to V_{CC}.

The current across 'R_E' i.e. I_E is given by $\frac{V_1 - V_{BE}}{R_E}$.

The collector current I_C is also almost equal to I_E.

→ Case-II:

When transistor Q base has negative supply voltage then it will turn Q on to ON condition. So, capacitor C, which was charged. Now, it will discharge through the path emitter & collector of transistor. So, o/p decreases.

Application:

It is used in TV, RADAR & computer to provide magnetic deflection.

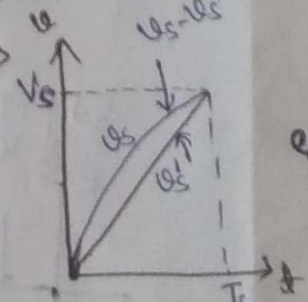
* **Deviation from linearity:**

It is difficult to generate linear sweep signals by time base generator. It is expressed as:

(i) The slope or sweep speed error, e_s

(ii) The displacement error, e_d

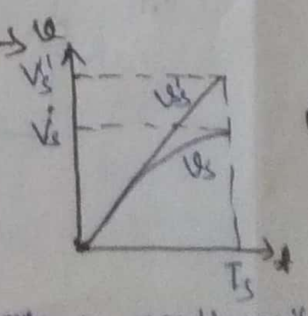
(iii) The transmission error, e_t

→ 

$$e_d = \frac{(v_s - v_s')_{max}}{V_s}$$

→ $e_s = \dfrac{\text{difference in slope at beginning and end of sweep}}{\text{initial value of slope}}$

$$= \left(\frac{dv_o}{dt}\Big|_{t=0} - \frac{dv_o}{dt}\Big|_{t=T_s}\right) \Big/ \frac{dv_o}{dt}\Big|_{t=0}$$

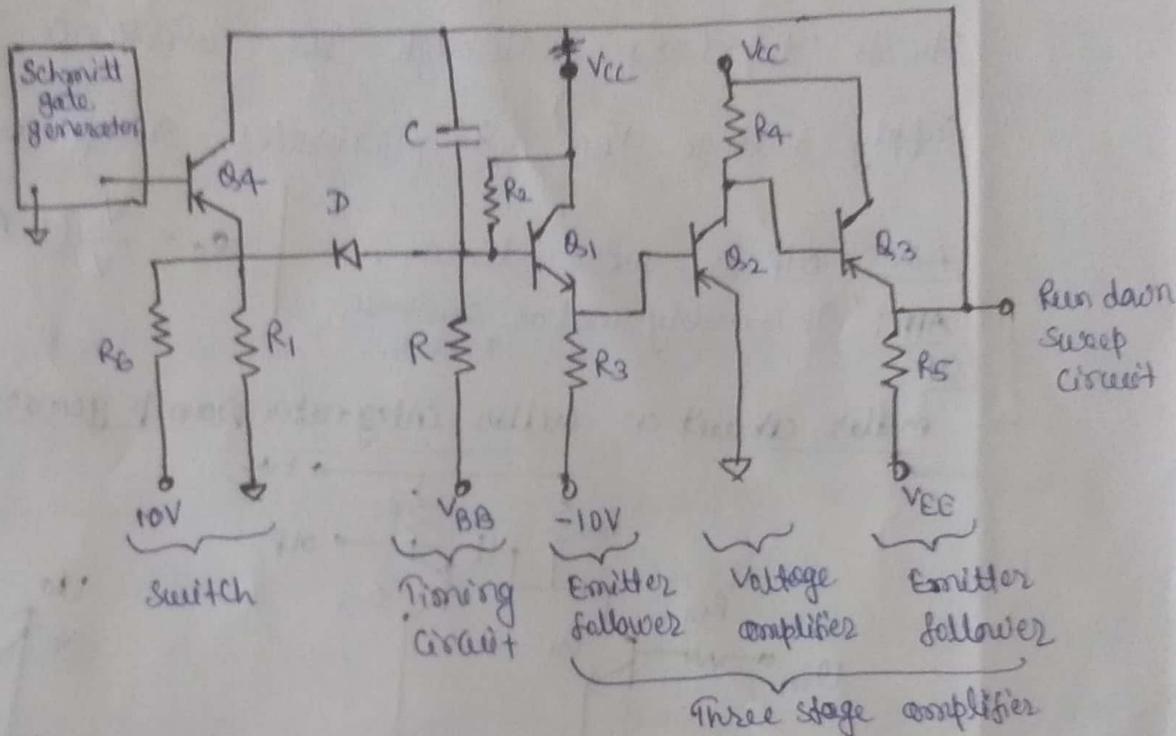
→ 

$$e_t = \frac{V_s' - V_s}{V_s'}$$

→ By reducing these errors, we can improve non linearity.

* Miller sweep generator:

The transistor Miller time base generator circuit is popular miller integrator circuit that produces sweep waveform. It is mostly used in horizontal deflection circuit.



Construction:

It consist of transistor Q_4 as switch. It has three stage amplifier. In which Q_1 acts as emitter follower, Q_2 acts as voltage amplifier & Q_3 acts as emitter follower. The capacitor C is connected b/w base of Q_1 & emitter of Q_3. The combination of C & R acts as timing circuit. The Q_1 provides high I/P impedance.

Operation:

Case-I: when there is negative pulse at base of Q_4 then Q_4 turn ON and current flow through the resistance R_1. It makes diode D in forward bias. The capacitor C appear in parallel with Q_4. So, it doesn't charge during this period. i.e. Voltage across capacitor is zero.

case-II

when positive pulse is available at the base of Q_4, then it turns OFF. So, positive voltage appear across the resistance R_1 due to 10V supply voltage. Due to this diode gets reverse bias and capacitor C starts to charge through the resistance R due to supply voltage V_{BB}. It generates sweep voltage at o/p.

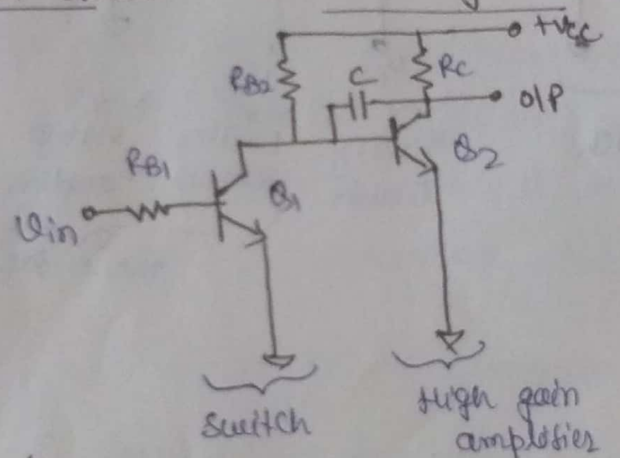
Adv: o/p is more linear.

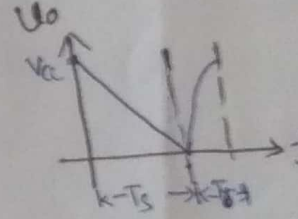
App.: It is widely used as sawtooth generator.

$$e_s = \frac{V_s}{V}\left(1 - A + \frac{R}{R_i} + \frac{C}{C_i}\right)$$

OR

→ Miller circuit or Miller integrator ramp generator:





Construction:

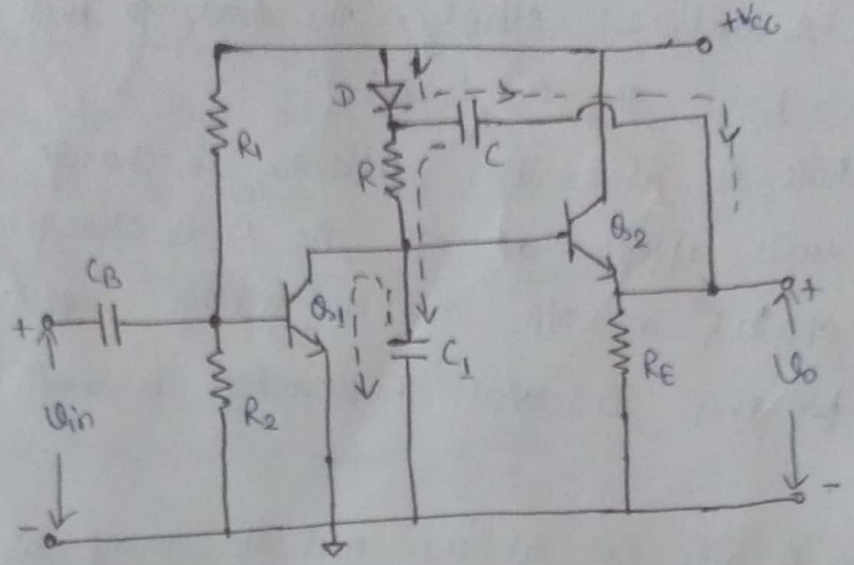
It consist of transistor Q_1 as switch & Q_2 as high gain amplifier. The capacitor 'C' is connected b/w jn of collector of Q_1 & base of Q_2 and collector terminal of Q_2.

Operation:

→ When +ve voltage appear at base of Q_1 due to Vin then it turns ON. So, Q_2 is OFF and o/p voltage is equal to Vcc. During this capacitor C charges through the Rc. So, charging time constant is equal to $C \cdot R_C$.

→ when Vin is removed then Q_1 turns OFF. So, Q_2 is ON. The o/p voltage decreases, which depends on discharging of capacitor 'C' through R_{B2}. If discharging time constant $C \cdot R_{B2}$ is large then it provide constant discharge current. The o/p vge decreases linearly. It has excellent ramp linearity.

* Boot strap (circuit) Time base generator :



Construction:

It consist of two transistors Q_1 & Q_2. The Q_1 act as switch & Q_2 act as emitter follower. The capacitor C_B is blocking capacitor. The capacitor C is connected b/w cathode of diode & emitter terminal of Q_2. The capacitor C_1 is connected to junction of collector of Q_1 & base of Q_2 and ground. The capacitance of $C >> C_1$.

Operation:

Case-I:

Before applying gating waveform Vin at $t=0$, the Q_1 is ON due to biasing voltage at base terminal. which is obtained from +Vcc & combination of R_1 & R_2. Since Q_1 is ON, there is no sufficient voltage at base of Q_2 to switch it in to ON. i.e. Q_2 is OFF.

So, capacitor 'C' will charge up to +Vcc through the diode 'D'. The O/P voltage V_o is zero.

Case-II:

Now negative trigger pulse from gating waveform of monostable multivibrator is applied to base of Q_1.

So, Q_1 turn OFF. The capacitor C discharge and capacitor C_1 charge through R. Since capacitance of $C >> C_1$, so, C charges & discharges slowly. The diode D will be in reverse bias. The Q_2 is ON.

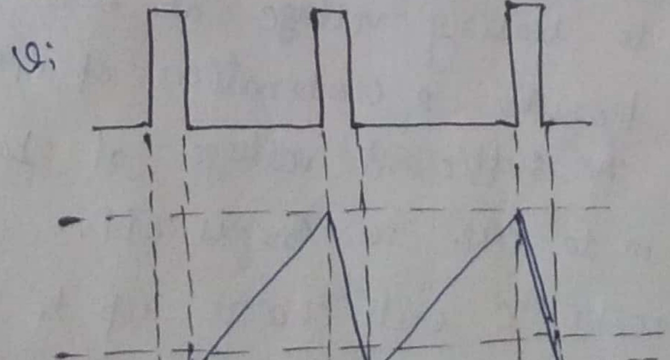
Since Q_2 is emitter follower, so, change at the base of Q_2 will appear at O/P. As C_1 is charging that voltage appears as O/P.. The O/P voltage appear as ramp signal for this interval. The O/P voltage is max^m about V_{CC}.

Case - III :

When Q_1 gets ON at the end of ramp signal then capacitor C_1 discharges rapidly to its initial value through Q_1. The diode again become forward bias and capacitor C will start to charge again. Again circuit produce next ramp signal.

The capacitor 'C' provides feedback current to C_1, it is known as boot strapping capacitor.

Output waveform :



Adv :

The O/P voltage ramp is very linear and amplitude reaches to supply voltage.