D/o
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Asst Prof

5 Voltage Time Base Generators

B. Bhaskar 18-H25

The time base generator is an electronic circuit which generates an output voltage (or) current that varies linearly with tim Ideally the output waveform should be a ramp (or) sweep.

There are mainly 2 types of time base generators. They are

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1. Voltage time base generators
2. Current time base generators

If the output waveform linearly Increases with voltage then it is called voltage time base generators.

If the output waveform linearly Increases with current then it is called current time base generators.

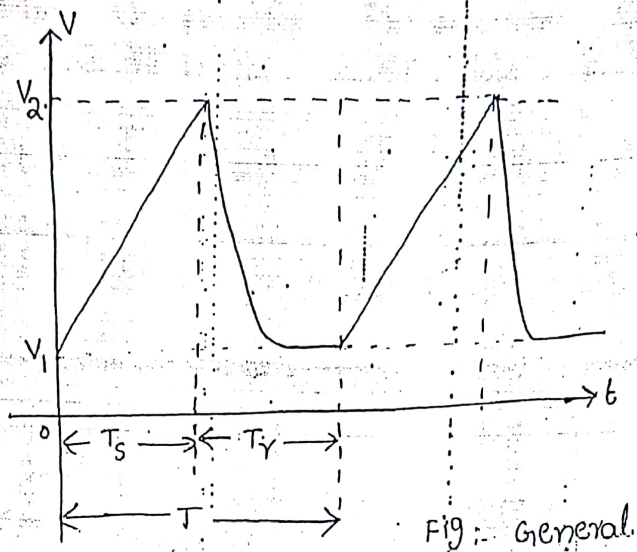
Time base generators used in CRO, Radar, Television, cathode ray oscilloscopes and Analog to digital converters.

General features of a time base (or sweep) signal :-

The voltage starting from some Initial value Increases linearly with time to a maximum value after which it returns again to its Initial value.

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The time during which the output increases i
called "sweep time" and the time taken by the signa
return to its Initial value is called "restoration time'
The sweep and restoration time is shown in fig. below



T_s → sweep tin
T_r → Restorat

Fig:- General sweep voltage

In some cases the ~~return~~ restoration time is very small comp
with sweep time. If the restoration time is almost zero, th
voltage returns to the Initial value instantaneously, the
waveform should be sawtooth wave as shown in fig. below

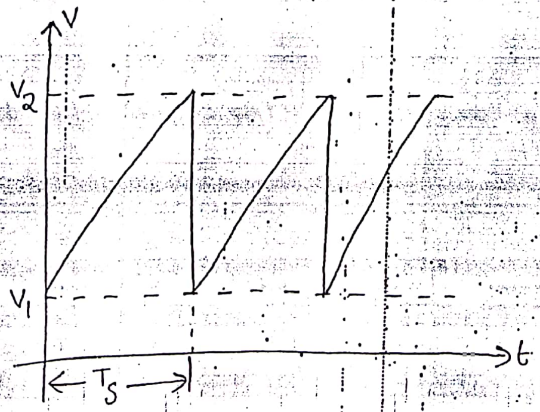
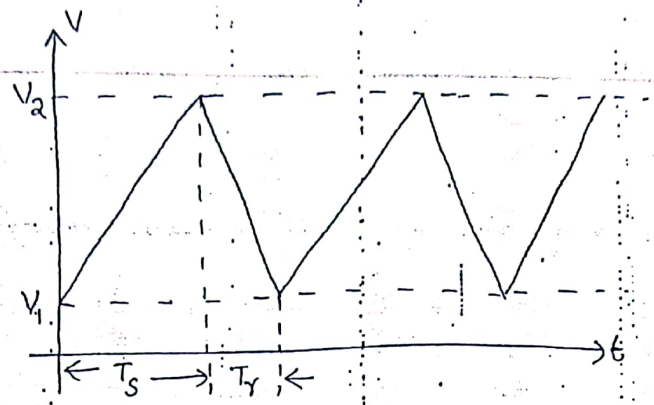


Fig:- saw-tooth voltage waveform

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A sweep voltage may also be a triangular wave,



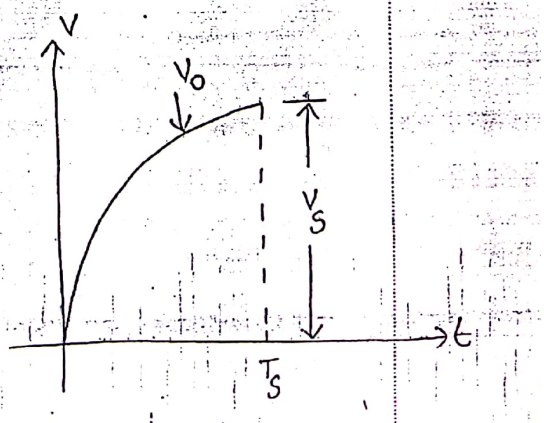
The signals generated by time-base circuits are not perfectly linear. even if the signals are linear, they suffer distortion when transmitted through coupling networks.

The deviation of a signal from linearity is expressed in 3 ways. They are

1. Sweep error (or) Slope error (or) Slope-Speed error (or) Speed error (or) Sweep-Speed error
2. Transmission error
3. Displacement error

1. Slope error (e_S) :-

It is defined as the difference between Initial slope (i.e slope at $t=0$) and final slope (i.e slope at $t=T_S$) expressed as a



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$$\text{Slope error } (e_s) = \frac{\text{Initial slope} - \text{final slope}}{\text{Initial slope}}$$

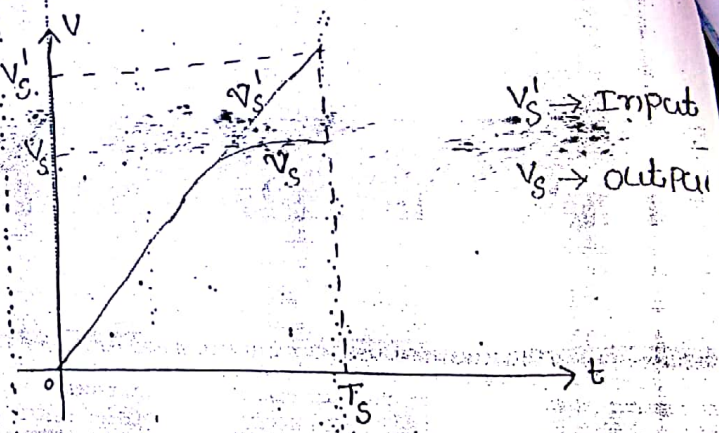
$$= \frac{\left.\frac{dV_o}{dt}\right|_{t=0} - \left.\frac{dV_o}{dt}\right|_{t=T_s}}{\left.\frac{dV_o}{dt}\right|_{t=0}}$$

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

2. Transmission error (e_t) :-

When a ramp signal is transmitted through a high-pass RC circuit, the output falls away from the input.

The transmission error is defined as the difference between input and output divided by the input at the end of the sweep.



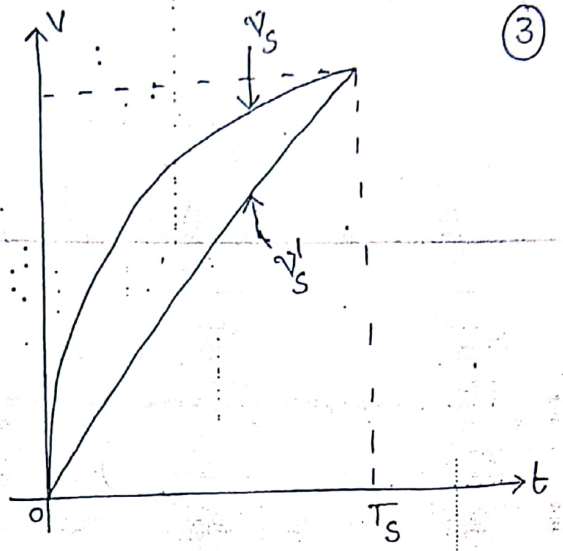
$$\therefore \text{Transmission error } (e_t) = \frac{V_s' - V_s}{V_s'}$$

3. Displacement error (e_d) :-

It is defined as the maximum difference between the actual sweep voltage and the linear sweep which passes through the beginning and end points of the actual sweep.

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



e_d = max. difference between actual sweep voltage and linear sweep / Amplitude of the sweep voltage

Methods of generating a time-base waveform :-

A sweep linearity is achieved by the one of the following methods

1. Exponential charging :-

In this method, capacitor is charged through a resistor to a voltage which is quite small as compared to the charging voltage.

2. constant current charging :-

In this method, a capacitor is charged from a constant current source. since the charging current is constant the voltage across the capacitor is a ramp voltage.

3. miller circuit :-

In this method, a step voltage is converted into [illegible] like a miller integrator.

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4. Boot strap circuit :-

In this method, a constant current is passed through a capacitor and voltage across the capacitor is a ramp. Constant current is obtained by maintaining a constant voltage across a fixed resistor in series with the capacitor.

5. compensating Networks :-

To Improve the linearity of miller and Boot strap time-base generators.

Exponential sweep circuit :-

The exponential sweep circuit as shown in fig (a)

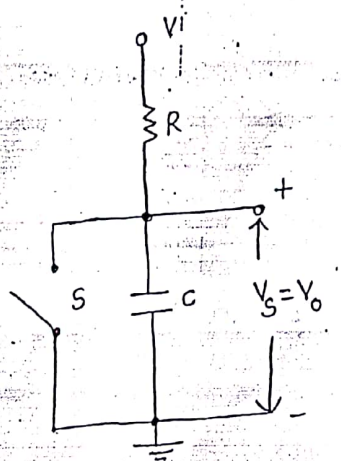


Fig (a)

The switch 'S' is normally closed and open at $t=0$. so for $t>0$, the capacitor charges towards supply voltage with time constant RC.

The output across the capacitor 'C' is given by

$$V_o(t) = V(1-e^{-t/RC})$$

After an Interval of time T_S when the sweep amplitude attains the value V_S, switch again closes. The resultant sweep

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waveform is shown in fig (b).

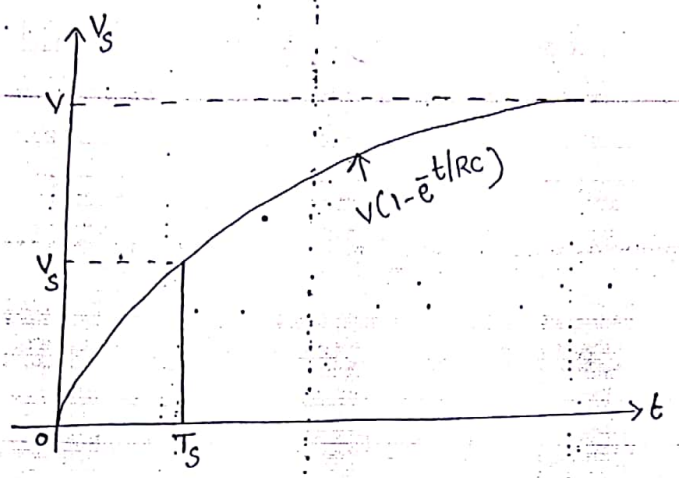


Fig (b) : The resultant exponential waveform across the capacitor

Slope (or) sweep speed error (e_s) :-

we know that for an exponential sweep circuit,

$$V_0(t) = V(1 - e^{-t/RC})$$

$$e_s = \frac{\left.\frac{dV_0}{dt}\right|_{t=0} - \left.\frac{dV_0}{dt}\right|_{t=T_s}}{\left.\frac{dV_0}{dt}\right|_{t=0}}$$

$$\left[\because \frac{dV_0}{dt} = 0 - Ve^{-t/RC}\left(\frac{-1}{RC}\right) = \frac{Ve^{-t/RC}}{RC}\right.$$

$$= \frac{\left.\frac{Ve^{-t/RC}}{RC}\right|_{t=0} - \left.\frac{Ve^{-t/RC}}{RC}\right|_{t=T_s}}{\left.\frac{Ve^{-t/RC}}{RC}\right|_{t=0}}$$

$$= 1 - \frac{\frac{V}{RC} - \frac{Ve^{-T_s/RC}}{RC}}{\frac{V}{RC}}$$

$$\therefore e_s = 1 - e^{-T_s/RC}$$

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$$= 1 - \left\{ 1 - \frac{T_s}{RC} + \left(\frac{-T_s}{RC}\right)^2 \frac{1}{2!} + \cdots \right\}$$

Neglect second and higher order terms

$$e_s = 1 - 1 + \frac{T_s}{RC}$$

$$\boxed{e_s = \frac{T_s}{RC}}$$

Transmission error (e_t) :-

From fig (b), $V_s = V(1 - e^{-t/RC})$

At $t = T_s$,

$$V_s = V(1 - e^{-T_s/RC})$$

$$= V\left[1 - \left(1 - \frac{T_s}{RC} + \left(\frac{-T_s}{RC}\right)^2 \frac{1}{2!} + \cdots\right)\right]$$

$$V_s = V\left(1 - 1 + \frac{T_s}{RC} - \frac{T_s^2}{2R^2C^2}\right)$$

$$= V\left(\frac{T_s}{RC} - \frac{T_s^2}{2R^2C^2}\right)$$

$$= \frac{VT_s}{RC}\left(1 - \frac{T_s}{2RC}\right)$$

Input is a ramp, i.e $V_s' = \alpha t$, where $\alpha \rightarrow$ slope

Here, $\alpha = \frac{V}{RC}$, $V_s' = \frac{Vt}{RC}$

But $t = T_s$

$\therefore V_c' = \underline{VT_s}$

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$$\therefore e_t = \frac{\frac{VT_s}{RC} - \frac{VT_s}{RC}\left(1-\frac{T_s}{2RC}\right)}{\frac{VT_s}{RC}} = \frac{\frac{VT_s}{RC}\left(1-\left(1-\frac{T_s}{2RC}\right)\right)}{\frac{VT_s}{RC}}$$

$$= 1-1+\frac{T_s}{2RC} = \frac{T_s}{2RC}$$

$$\boxed{e_t = \frac{T_s}{2RC}}$$

Displacement error, (e_d):-

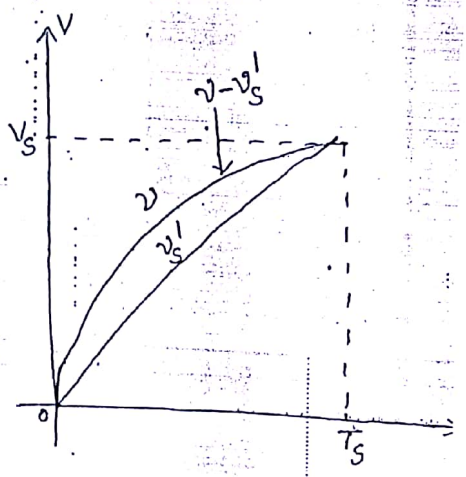
w.k.T

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

$$= V\left[1-\left(1-\frac{t}{RC}+\left(\frac{-t}{RC}\right)^2\frac{1}{2!}+\cdots\right)\right]$$

$$= V\left(1-1+\frac{t}{RC}-\frac{t^2}{2R^2C^2}\right)$$

$$= V\left(\frac{t}{RC}-\frac{t^2}{2R^2C^2}\right) = \frac{Vt}{RC}\left(1-\frac{t}{2RC}\right)$$



Input is a ramp, i.e $V_s' = \alpha t$; where $\alpha \rightarrow$ slope

Here $\alpha = \frac{V}{RC}$

$$\therefore V_s' = \frac{Vt}{RC}$$

$$\therefore \text{Deviation} = |V_s - V_s'| = \frac{Vt}{RC}\left(1-\frac{t}{2RC}\right) - \frac{Vt}{RC}$$

$$= \frac{Vt}{RC}\left[1-\frac{t}{2RC}-1\right] = \frac{Vt}{RC}\left(\frac{t}{2RC}\right)$$

max. Deviation occur at $t = \frac{T_s}{2}$

$$\therefore |V_s - V_s'|_{max} = \frac{VT_s}{2RC}\left(\frac{T_s}{2\times 2RC}\right)$$

w.k.T $V_s' = \frac{Vt}{RC}$, consider $t = \frac{T_s}{2}$ $\therefore V_s' = \frac{VT_s}{4RC}$

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$$\therefore \text{Displacement error } e_d = \frac{\text{max. deviation}}{\text{sweep Amplitude}}$$

$$= \frac{|V_S - V_S'|_{max}}{V_S}$$

$$= \frac{\left(\frac{VT_S}{RC}\right)\left(\frac{T_S}{4RC}\right)}{\frac{VT_S}{2RC}}$$

$$\boxed{e_d = \frac{T_S}{8RC}}$$

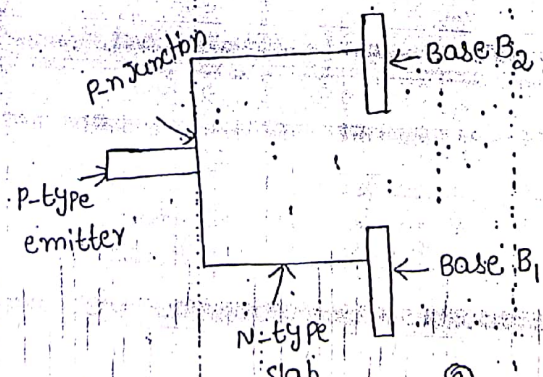
Relation ship between e_d, e_s, e_t :

w.k.T $e_d = \frac{T_S}{8RC}$, $e_s = \frac{T_S}{RC}$, $e_t = \frac{T_S}{2RC}$

$$\therefore \boxed{e_d = \frac{1}{8} e_s} \quad (\text{or}) \quad \boxed{e_d = \frac{1}{4} e_t}$$

Unijunction transistor (or) UJT sweep generator :-

It has only one P-n Junction. P-type material is heavily doped considered as emitter and n-type material is lightly doped material and it divided into 2 equally spaced, base B_1 and base B_2.



(a)

Fig :- construction of UJT

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The equivalent circuit of UJT as shown in fig. below

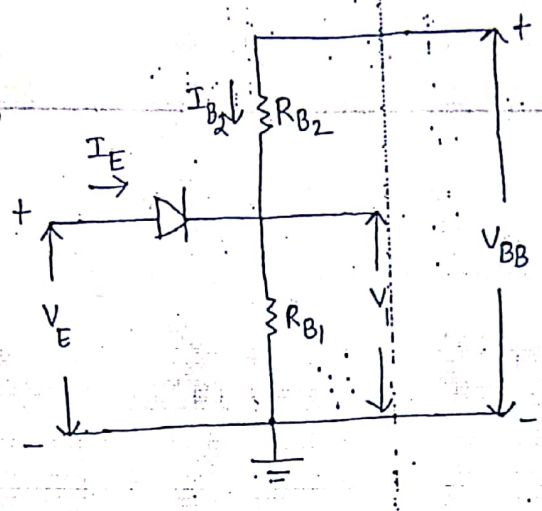


Fig ⓑ:- equivalent circuit of UJT

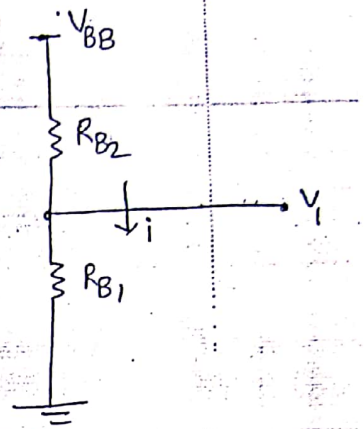


Fig ⓒ:- when $i_E = 0$

From equivalent circuit,

R_{B_1} is the resistance between Base B_1 and emitter and it is basically a variable resistance, its value dependent on emitter current I_E.

R_{B_2} is the resistance between Base B_2 and emitter, its value is fixed.

If $I_E = 0$, then $i = \dfrac{V_{BB}}{R_{B_1} + R_{B_2}}$ (fig ⓒ)

$$\therefore V_1 = i R_{B_1} = \frac{V_{BB}}{R_{B_1} + R_{B_2}} R_{B_1} = \left(\frac{R_{B_1}}{R_{B_1} + R_{B_2}}\right) V_{BB}$$

The ratio $\dfrac{R_{B_1}}{R_{B_1} + R_{B_2}}$ is called Intrinsic stand off ratio and it is denoted by η.

$$\therefore \eta = \frac{R_{B_1}}{R_{B_1} + R_{B_2}}$$

$$\therefore \boxed{V_1 = \eta V_{BB}}$$

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From equivalent circuit, diode current cutback

emitter voltage

$$V_E = V_\gamma + V_1$$

$V_\gamma \rightarrow$ cut-in voltage of the

This value of emitter voltage which makes the diode conduct called peak voltage and denoted by V_p.

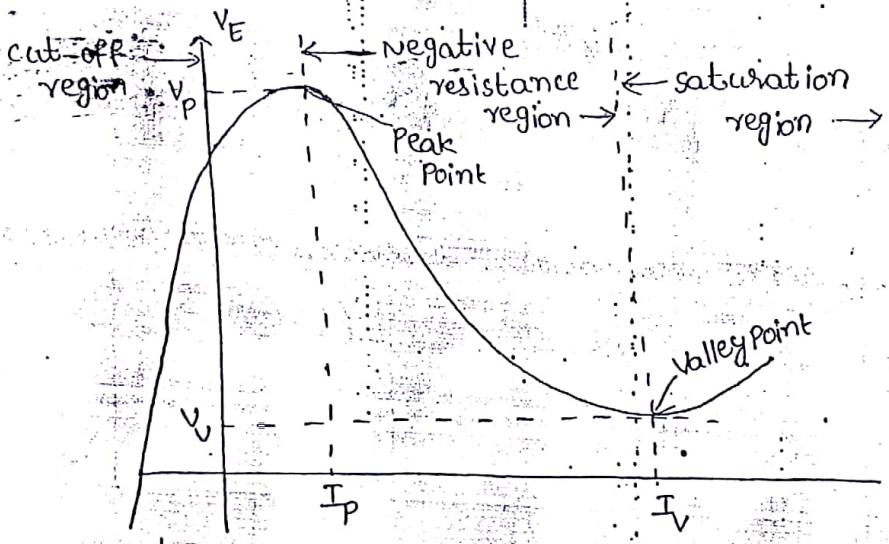
$$\therefore V_p = V_\gamma + V_1$$

$$V_p = V_\gamma + \eta V_{BB} \qquad (\because V_1 = \eta V_{BB})$$

If $V_E < V_p$ the UJT is OFF

If $V_E > V_p$ the UJT is ON.

Characteristics of UJT :-



Application

The main Application of UJT is in switching circuits where in rapid discharge of capacitors is very essential. UJT sweep circuit is called a relaxation oscillator.

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UJT sweep circuit (or) working of UJT relaxation oscillator :-

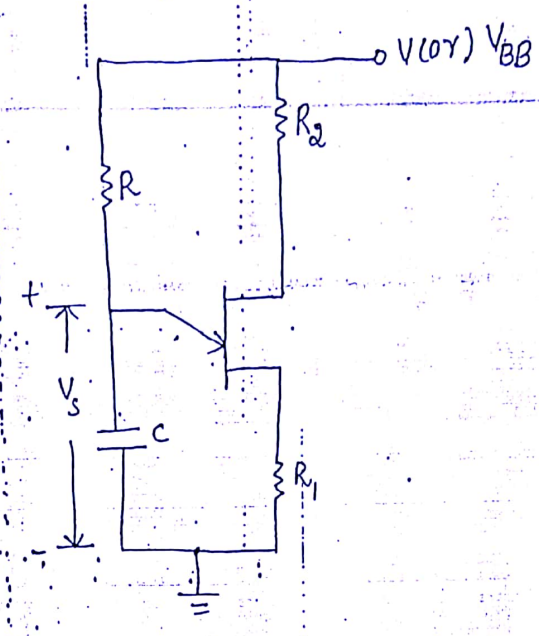


Fig :- UJT sweep circuit

when the capacitor voltage V_s rises to the V_p, UJT readily conducts.

when the UJT becomes ON, the capacitor discharges and voltage falls.

when the voltage falls to valley point V_v, UJT becomes OFF, again capacitor starts charges.

The output waveform for capacitor charging and discharging as shown in figure.

→ charging of capacitor when the UJT OFF

→ Discharging of capacitor when the UJT is ON.

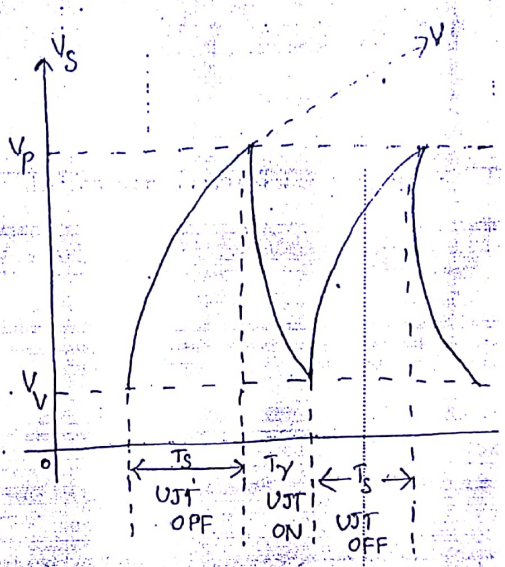


Fig :- output waveform across cap

During the Interval T_s, UJT is OFF, capacitor charges & V_s Increases exponentially.

i.e $V_s = V_f - (V_f - V_{in})\, e^{-t/Rc}$ — (1)

consider $V_f = V$, $V_{in} = V_v$

$V_f = V_p$

∴ eq ① becomes,

$$V_p = V - (V - V_v)\, e^{-T_s/RC} \Rightarrow (V - V_v)\, e^{-T_s/RC} = V - V_p$$

$$\Rightarrow e^{-T_s/RC} = \frac{V - V_p}{V - V_v}$$

$$\Rightarrow e^{T_s/RC} = \frac{V - V_v}{V - V_p}$$

$$\Rightarrow T_s/RC = \ln\left(\frac{V - V_v}{V - V_p}\right)$$

$$\Rightarrow \boxed{T_s = RC \ln\left(\frac{V - V_v}{V - V_p}\right)}$$

$$\therefore f = \frac{1}{T_s} = \frac{1}{RC \ln\left(\frac{V - V_v}{V - V_p}\right)}$$

$$= \frac{1}{RC \ln\left(\frac{V}{V - V_p}\right)} \quad [\because V_v << V]$$

$$= \frac{1}{RC \ln\left(\frac{1}{1 - \frac{V_p}{V}}\right)} = \frac{1}{RC \ln\left(\frac{1}{1 - \frac{V_p}{V_{BB}}}\right)} \quad (\because V =$$

we know that, $V_p = V_\gamma + \eta V_{BB}$

$$:= V_\gamma + \eta V_{BB}$$

$$= \eta V_{BB} \quad [\because V_\gamma << V_{BB}]$$

$$\Rightarrow \frac{V_p}{V_{BB}} = \eta \quad \text{---} ③$$

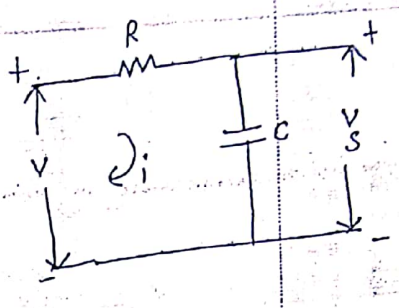
substitute eq ③ in eq ②

$$\boxed{f = \frac{1}{RC \ln\left(\frac{1}{1 - \eta}\right)}}$$

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Transistor constant - current sweep (or) constant current voltage sweep :-

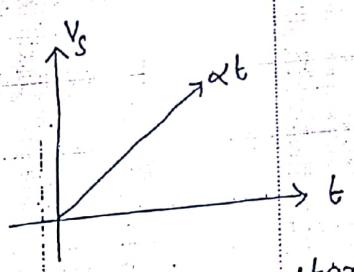
In RC circuit, voltage across the capacitor is rising exponentially.



$$V_s = \frac{1}{C}\int i\,dt$$

$$= \left(\frac{I}{C}\right)t$$

Let $I/C = \alpha \Rightarrow \boxed{V_s = \alpha t}$



From above graph, if the capacitor current is keep constant, the voltage developing across the capacitor is a ramp voltage.

The circuit diagram of constant-current sweep as shown in fig. below.

$$I_E = \frac{V_{EE} - V_{EB}}{R_E}$$

Switch 'S' is open at $t=0$.

The collector current is

$$I_C = h_{fb} I_E$$

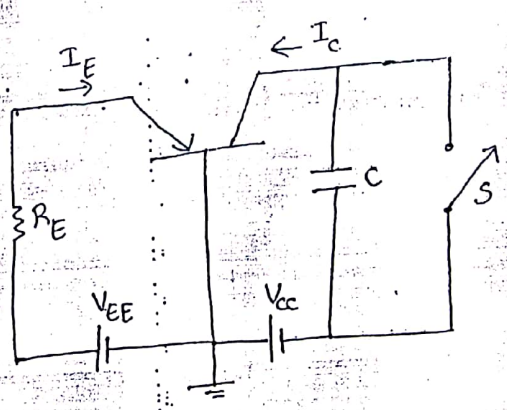


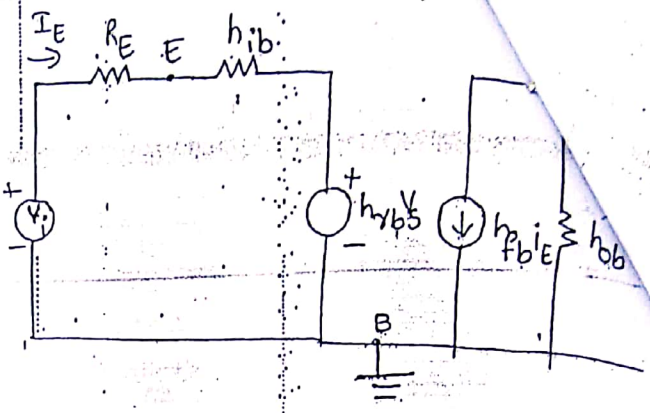
Fig:- constant current sweep circuit

The equivalent circuit is shown in fig. below

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Apply KVL to Input Loop

$$V_i = i_e(R_E + h_{ib}) + h_{rb} V_S \quad \text{—①}$$



Apply KCL at output node 'c'

$$I_c = h_{fb} i_E + h_{ob} V_S = -C \frac{dV_S}{dt} \quad \text{—②}$$

Fig:- Small signal model

[∵ $V_S = -i$

$\Rightarrow i =$

From eq ①, $i_e = \dfrac{V_i - h_{rb} V_S}{R_E + h_{ib}}$ —③

substitute eq ③ in eq ②,

$$I = h_{fb}\left[\frac{V_i - h_{rb} V_S}{R_E + h_{ib}}\right] + h_{ob} V_S = -C \frac{dV_S}{dt}$$

$$\frac{h_{fb} V_i}{R_E + h_{ib}} - \frac{h_{fb} h_{rb} V_S}{R_E + h_{ib}} + h_{ob} V_S = -C \frac{dV_S}{dt}$$

$$\Rightarrow C \frac{dV_S}{dt} - \frac{h_{fb} h_{rb} V_S}{R_E + h_{ib}} + h_{ob} V_S = -\frac{h_{fb} V_i}{R_E + h_{ib}}$$

Let $-h_{fb} = \alpha$

$$\Rightarrow C \frac{dV_S}{dt} + \frac{\alpha h_{rb} V_S}{R_E + h_{ib}} + h_{ob} V_S = \frac{\alpha V_i}{R_E + h_{ib}}$$

$$\Rightarrow \frac{dV_S}{dt} + \frac{\alpha h_{rb} V_S}{C(R_E + h_{ib})} + \frac{h_{ob} V_S}{C} = \frac{\alpha V_i}{C(R_E + h_{ib})}$$

$$\Rightarrow \frac{dV_S}{dt} + \frac{V_S}{C}\left[\frac{\alpha h_{rb}}{R_E + h_{ib}} + h_{ob}\right] = \frac{\alpha V_i}{C(R_E + h_{ib})}$$

Let $\frac{1}{C}\left[\frac{\alpha h_{rb}}{\quad} + h_{ob}\right] = \frac{1}{\quad}$

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$$\frac{dV_S}{dt} + \frac{V_S}{\tau} = \frac{\alpha V_i}{c(R_E + h_{ib})}$$

At $t=0$, $V_S=0$ then the solution of this equation is

$$V_S = \frac{\alpha\tau V_i}{c(R_E+h_{ib})}\left(1-e^{-t/\tau}\right)$$

$$= \frac{V_i \alpha\tau}{c(R_E+h_{ib})}\left(1-\left(1-\frac{t}{\tau}+\frac{t^2}{2\tau^2}+\cdots\right)\right)$$

$$= \frac{V_i \alpha\tau}{c(R_E+h_{ib})}\left(1-1+\frac{t}{\tau}\right) \quad (\because \text{neglect all higher order terms})$$

$$= \frac{V_i \alpha\tau}{c(R_E+h_{ib})}\left(\frac{t}{\tau}\right) = \frac{V_i \alpha t}{c(R_E+h_{ib})}$$

The emitter current, $i_E = \frac{V_i}{R_E+h_{ib}}$

$$V_S = \frac{\alpha i_E t}{c}$$

At $t=T_S$, $V_S = \frac{\alpha V_i T_S}{c(R_E+h_{ib})} \Rightarrow T_S = \frac{V_S c (R_E+h_{ib})}{\alpha V_i}$

$\therefore$ slope error $e_S = \frac{T_S}{\tau}$

$$= \frac{V_S c (R_E+h_{ib})}{\alpha V_i} \Big/ \frac{1}{c}\left(h_{ob} + \frac{\alpha h_{rb}}{R_E+h_{ib}}\right)$$

$$= V_S \frac{h_{ob}(R_E+h_{ib})}{\alpha V_i} + V_S \frac{(R_E+h_{ib})\alpha h_{rb}}{\alpha V_i (R_E+h_{ib})}$$

$$\boxed{e_S = \frac{V_S}{V_i}\left[h_{rb} + \frac{h_{ob}}{\alpha}(R_E+h_{ib})\right]}$$

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Miller and Boot strap Time base generators :-

Miller sweep circuit (or) miller Integrator (or) miller Time base g

Boot strap time base generator:-

An RC Network with exponential charging rate as shown in figure(a).

If we now add another voltage source 'V' such that V has at all times a magnitude equal to V_c but opposite polarity to that of capacitor voltage V_c, then charging current of capacitor is constan

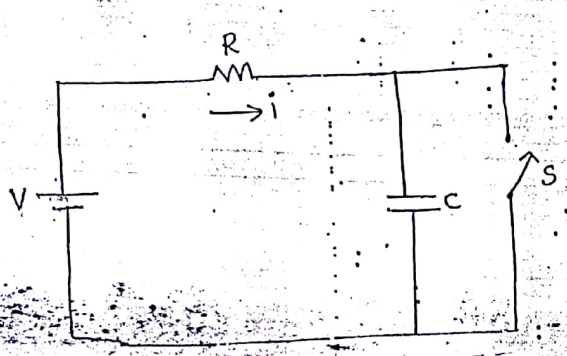
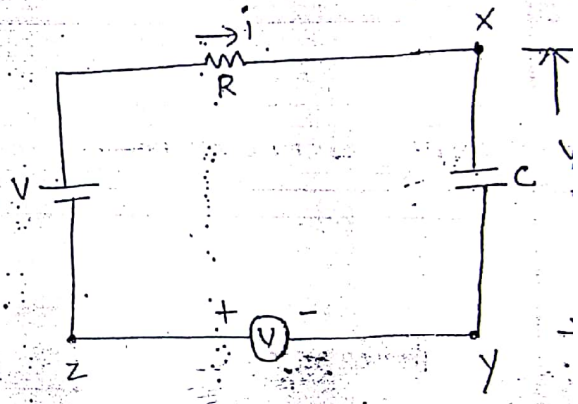


Fig a) RC exponential sweep circuit



b) R-C Sweep with auxilary voltag

From fig (b),

$$-V + iR + V_c - V = 0 \quad \text{as } V_c = V$$

$$V = iR \Rightarrow i = \frac{V}{R} = \text{constant}$$

There are 2 methods used for simulating the fictitious (imaginary) generator by an Amplifier. They are known as miller and Boot strap time base generators.

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In miller time base generator the point z in fig(b) is grounded and the output is taken between x and y, which will be a negative going ramp.

On other hand if point y is grounded and output is taken between z and x, which will be a positive going ramp. This is a Boot Strap time base generator.

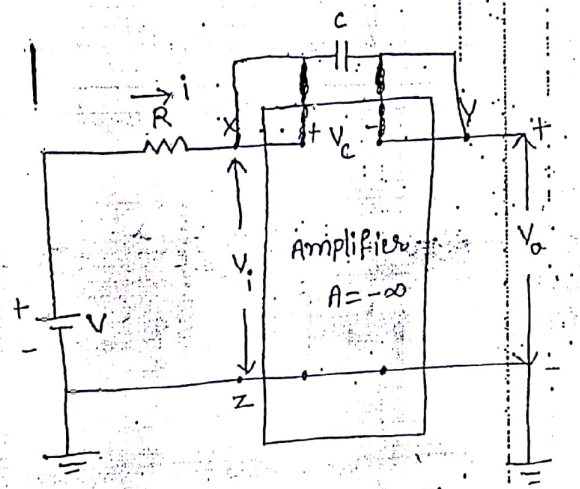


Fig:- c) Miller Integrator circuit

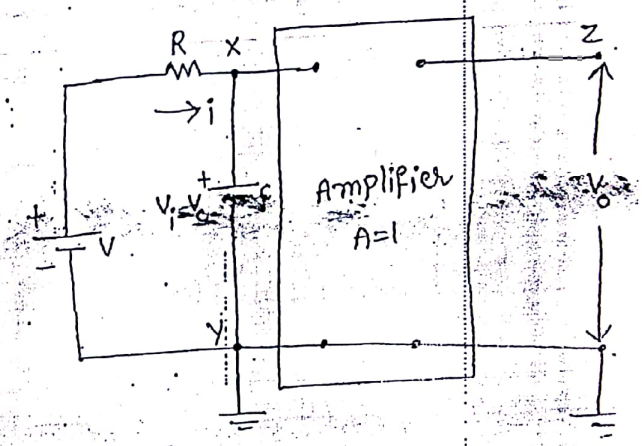


Fig:- d) Boot Strap circuit

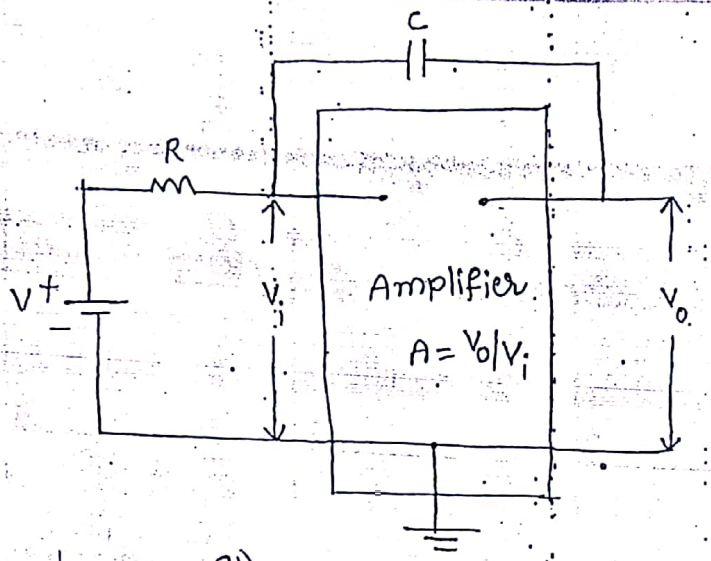
From fig (c), the miller Integrator, we assumed $|V_c| = |V_D|$ at every Instant of time, then Input V_i to the Amplifier must be zero. This means the gain of the Amplifier should be Infinity.

From fig (d), we assumed $V_D = V_c$; then $\frac{V_o}{V} = 1$ which means the Amplifier voltage gain A must be equal to unity for Boot strap time base generator.

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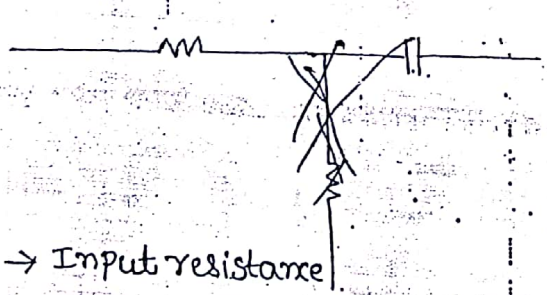
Expression for sweep-speed error in miller sweep circuit

The general miller sweep generator is shown in fig(a)



Fig(a) :- General miller sweep generator

The above circuit can be replaced by an its equivalent circuit the circuit modifies shown in fig(b)



R_i → Input resistance

R_o → output resistance

A → open loop voltage gain

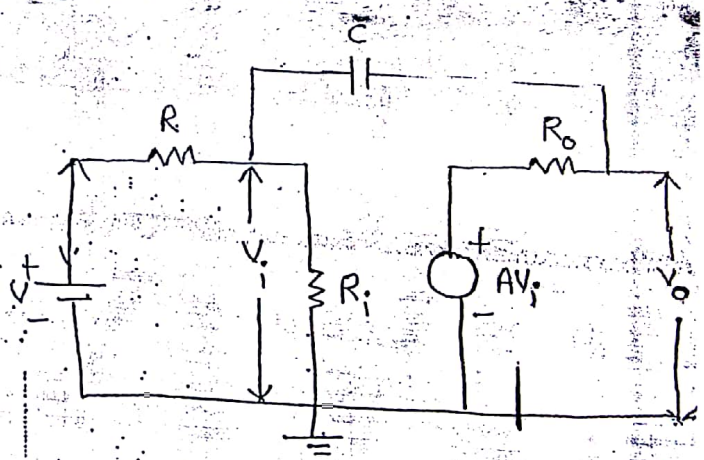


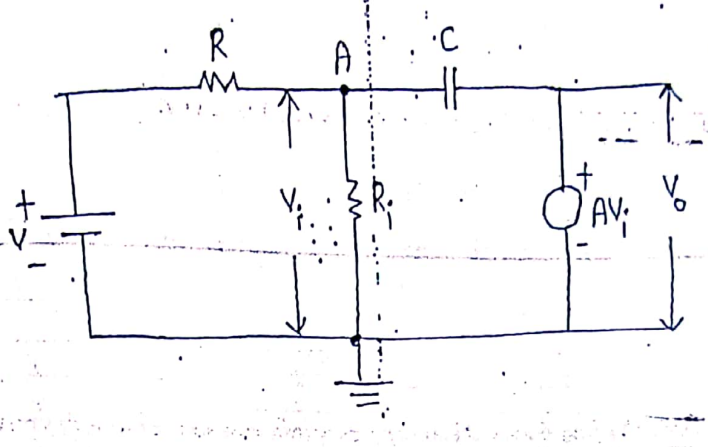
Fig (b)

$$\text{Gain, } A = \frac{V_o}{V_i} \Rightarrow V_o = AV_i$$

There is no voltage drop across R_o, Hence $R_o = 0$.

The above circuit can be modified as

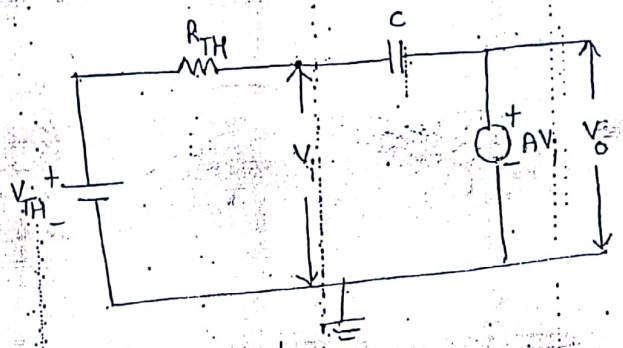
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The Thevenin's voltage and resistance at node 'A' is

$$V_{TH} = \frac{V \cdot R_i}{R + R_i} \quad , \quad R_{TH} = R \| R_i = \frac{R R_i}{R + R_i}$$

The above circuit can be further modified as

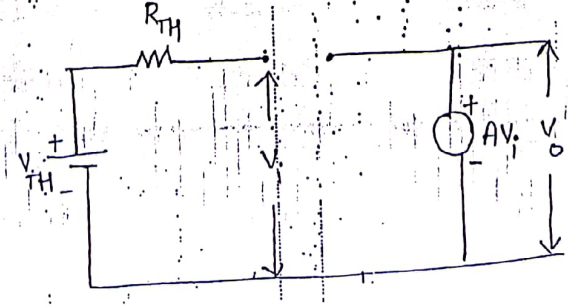


$$\text{Sweep error, } e_s = \frac{\text{sweep Amplitude}}{\text{maximum output (Peak-Peak)}}$$

$$= \frac{V_s}{V_o(t=\infty)}$$

At $t=\infty$, i.e. Low frequencies capacitor act as open circu

then the above circuit modified as



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From circuit, $V_o = AV_i$

$= AV_{TH}$

$\therefore V_o = A \cdot \frac{VR_i}{R+R_i}$ at $t=\infty$

But, $e_s = \frac{V_s}{V_o(t=\infty)} = \frac{V_s}{\frac{AVR_i}{R+R_i}}$

$= \frac{V_s(R+R_i)}{AVR_i}$

$\therefore e_s = \frac{V_s}{AV} \cdot \left(\frac{R+R_i}{R_i}\right)$

$$\boxed{e_s = \frac{V_s}{AV}\left(1+\frac{R}{R_i}\right)}$$

Expression for sweep error in Bootstrap sweep circuit :-

The general circuit diagram of Bootstrap sweep circuit as shown in fig(a)

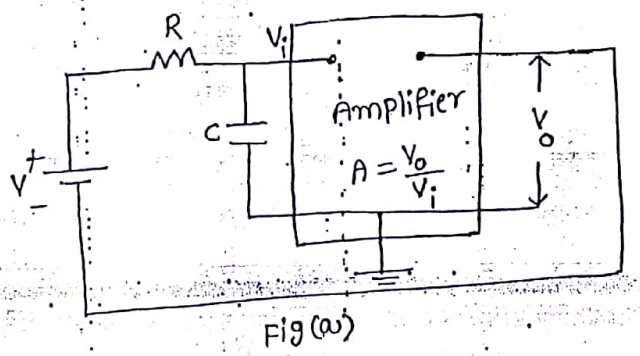


Fig (a)

The equivalent circuit of above fig. can be modified as

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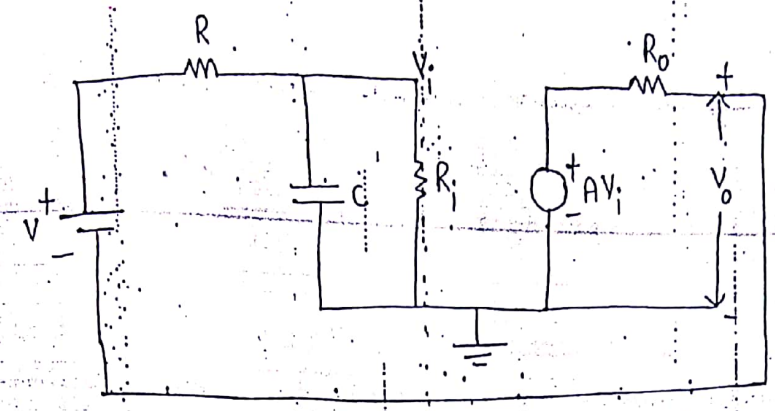


Fig (b)

Sweep error, e_s = $\frac{\text{Sweep Amplitude}}{\text{max. output (or) value of } V_o \text{ at } t=\infty}$

At $t=\infty$, capacitor act as open circuit. Then fig (b) can be modified as,

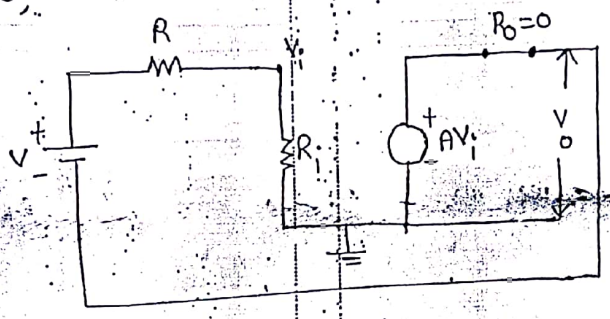


Fig (c)

The equivalent circuit of fig (c) can be drawn as fig (d).

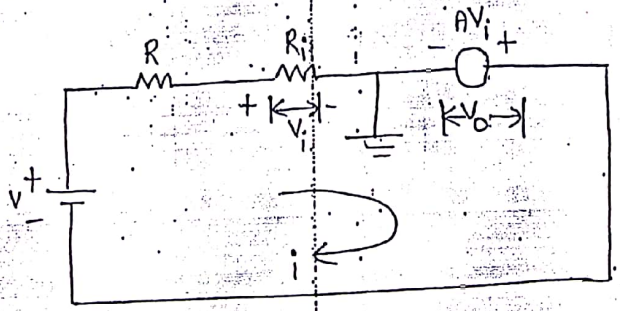


Fig (d)

From above circuit,

$$V_o = AV_i$$

$$= A(IR_i) \quad \text{—①} \quad [\because V_i = IR_i]$$

Apply KVL,

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$V + V_o = iR + iR_i$

$\Rightarrow V - iR - iR_i + V_o = 0$

$\Rightarrow V - i(R+R_i) + V_o = 0 \Rightarrow i = \frac{V+V_o}{R+R_i}$ —(2)

sub. eq (2) in eq (1)

$V_o = A(iR_i)$

$= AR_i\left(\frac{V+V_o}{R+R_i}\right) \Rightarrow \frac{AR_i V}{R+R_i} + \frac{AR_i V_o}{R+R_i}$

$V_o - \frac{AR_i V_o}{R+R_i} = \frac{AR_i V}{R+R_i}$

$\Rightarrow V_o\left[1 - \frac{AR_i}{R+R_i}\right] = \frac{AR_i V}{R+R_i}$

$\Rightarrow V_o\left[\frac{R+R_i - AR_i}{R+R_i}\right] = \frac{AR_i V}{R+R_i}$

$\Rightarrow V_o(R+R_i(1-A)) = AR_i V$

$\Rightarrow V_o = \frac{AR_i V}{R+R_i(1-A)}$ —(3)

But $e_s = \frac{V_s}{V_o} = \frac{V_s}{\frac{AR_i V}{R+R_i(1-A)}} = \frac{V_s(R+R_i(1-A))}{AR_i V}$

$= \frac{V_s}{AV}\left(\frac{R+R_i(1-A)}{R_i}\right)$

$$\boxed{e_s = \frac{V_s}{AV}\left(\frac{R}{R_i} + (1-A)\right)} \quad —(4)$$

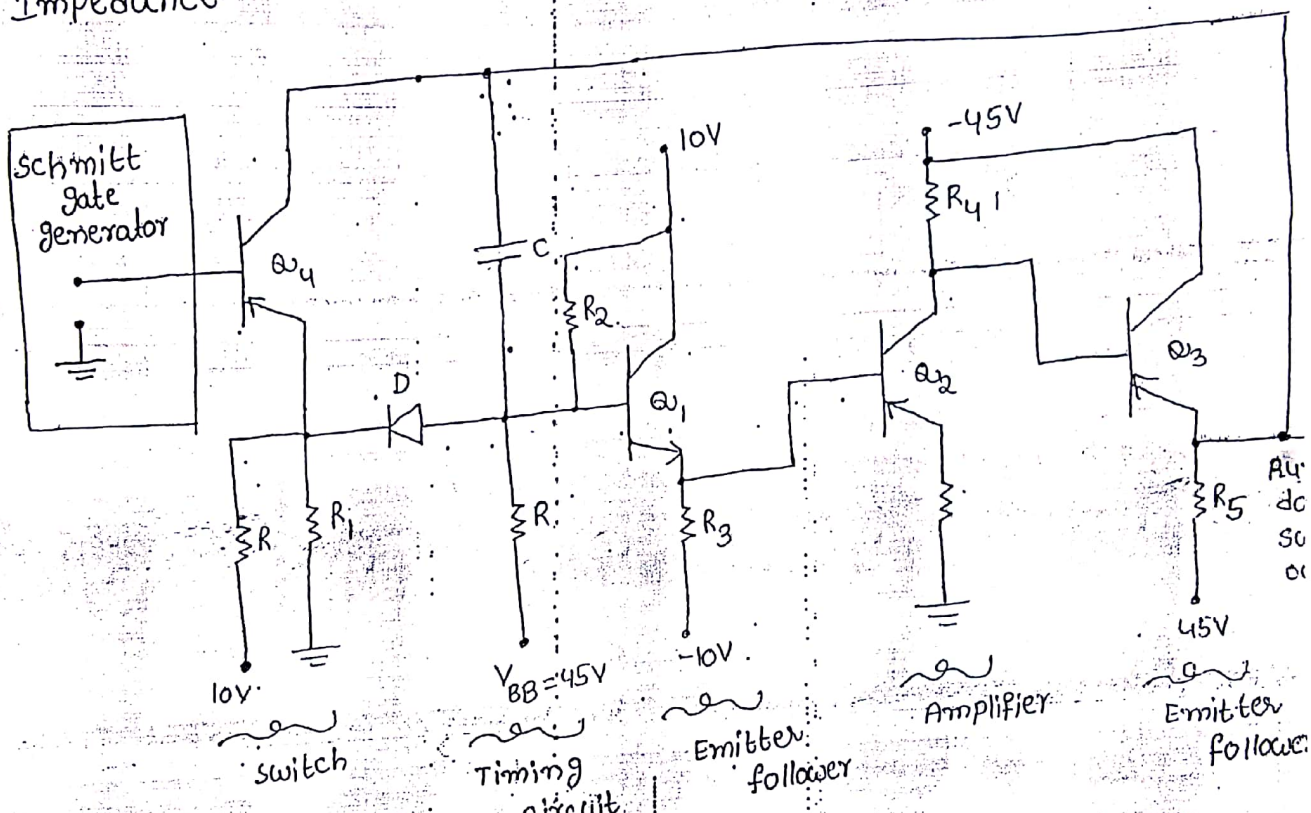
If open loop gain of Amplifier is unity i.e $A=1$, then

$$\boxed{e_s = \frac{V_s}{V}\left[\frac{R_i}{R_i} + (1-A)\right]} \quad —(5)$$

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Transistor miller time base generator :-

To obtain high degree of linearity the input Impedance of miller time base generator should have a high Input Impedance.



From fig. Transistor Q_1 act as an emitter follower. Transistor Q_2 provides voltage Amplification. Transistor Q_3 act as an emitter follower. Q_3 is used to prevent the loading of the voltage Amplifier Q_2 and provides low output Impedance so that the circuit can drive heavy loads.

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The capacitor C placed between base of Q_1 and emitter Q_3 is the timing capacitor. The sweep speed is changed fro range to range by switching R and C and may be varied continuously by varying V_{BB}.

under quiescent condition, the output of schmitt gate is at lower level. So transistor, Q_4 is ON. The emitter current of Q_4 flows through R_1 hence emitter is at negative potential. so, diode D conducts. The current through R flows through diode D and transistor Q_4. The capacitor C is bypasse and hence prevent from charging.

When a triggering signal is applied, the output of schmitt gate goes to higher level. So the base voltage of Q_4 rises and hence transistor Q_4 goes OFF. A current flows from 10V source through R_1. A positive signal is applied, diode D is reverse biased. At this time upper terminal of C is connected to collector of Q_4 which is in cut-off. The capacitor charged from V_{BB} and hence a rundown sweep output is obtained at emitter of Q_3. At end of sweep, capa C discharges through D and Q_4.

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Transistor Bootstrap time-base generator :-

The Input to transistor Q_1 is the gating waveform from a monostable multivibrator.

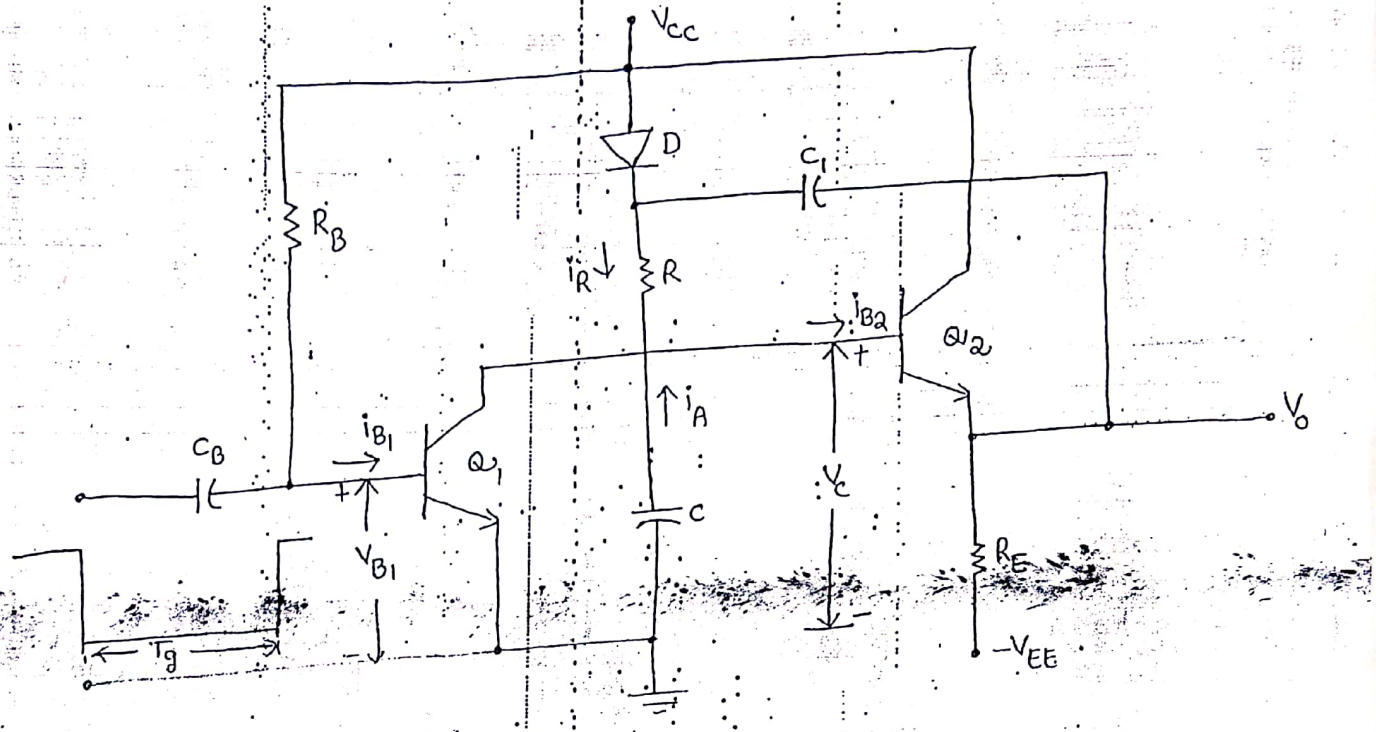


Fig :- Voltage time-base generator.

Quiescent conditions :-

under Quiescent conditions, i.e before the application of gating waveform. at $t=0$, Q_1 is in saturation because it gets enough base drive from V_{cc} through R_B. The voltage across the capacitor which is also voltage at collector of Q_1 and base of Q_2 is $V_{CE(sat)}$. Q_2 conducting and act as emitter follower.

The output voltage $V_o = V_{CE(sat)} - V_{BE2}$

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The current i_R at Resistor R is $\frac{V_{cc}}{R}$.

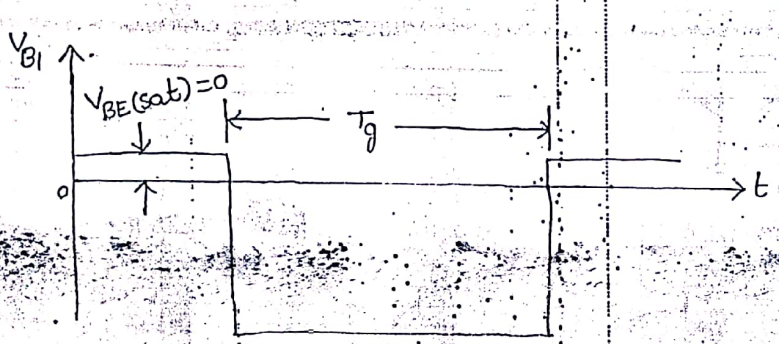
The base current Q_2 is smaller than the collector current of

$$i_{c1} = i_R = \frac{V_{cc}}{R} \quad \text{and} \quad i_{b1} = \frac{V_{cc}}{R_B}$$

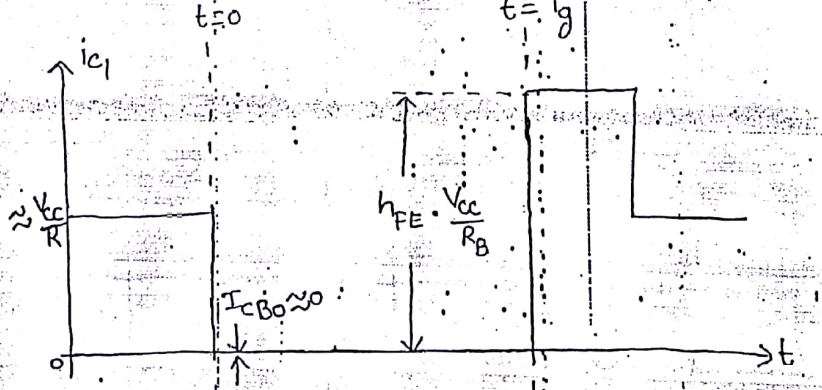
For Q_1 to be in saturation, $i_{b1(sat)} > i_{b1(active)}$

$$\frac{V_{cc}}{R_B} > \frac{V_{cc}}{h_{fe} R} \quad \text{(or)} \quad R_B < h_{fe} R$$

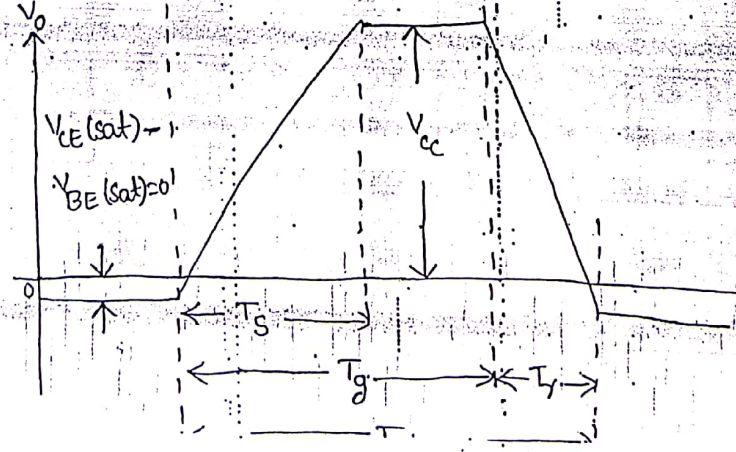
The output waveform of an Boot strap time base generator as shown in fig. below



a) Base voltage of Q_1



b) The collector curren of Q_1



c) The output vo at emitter of

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current

Formation of Sweep:-

At $t=0$, when voltage at base of Q_1 goes negative, Q_1 is OFF

So, There is current flows through capacitor C_1.

The voltage across the capacitor,

$$V_c = \frac{1}{C}\int i_{c_1}\, dt = \frac{1}{C}\int \frac{V_{cc}}{R}\, dt = \frac{V_{cc}}{RC}\int dt$$

$$= \frac{V_{cc}\, t}{RC}$$

The output $V_o = V_c = \frac{V_{cc}\, t}{RC}$

The voltage across C_1 is constant and equal to V_{cc}, when sweep circuit starts, diode is reverse biased & current through R is suppli. by C_1.

- when output V_o varies linearly only when the duration of gate signal (T_g) is small so, V_o does not exceed V_{cc}. however, T_g is large, the output V_o may reach V_{cc} even before T_g.

when $V_b = V_{cc}$, the voltage V_{CE2} of Q_2 is practically zero. Then Q_2 no longer behaves as an emitter follower. hence V_o remains constant at V_{cc}. The current $\frac{V_{cc}}{R}$ through C_1 and R now flows from base to emitter of Q_2.

If $T_s < T_g$, V_o reaches V_{cc}

$$V_{cc} = \frac{V_{cc}\, T_s}{RC} \quad (\text{or}) \quad T_s = RC$$

If $V_s < V_{cc}$, The max. ramp voltage is

$$V_s = \frac{V_{cc}\, T_g}{RC}$$

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Calculation of Retrace time, T_r :-

At $t = T_g$, Q_1 goes to conduction, current $i_{b1} = \frac{V_{cc}}{R_B}$ flows to base of Q_1. current $i_{c_1} = h_{fe} \cdot i_{b1}$ flows into collector of Q_1.

The collector current, C_1 remains constant at

$$i_{c_1} = h_{fe} \cdot \frac{V_{cc}}{R_B}$$

Apply KVL at collector of Q_1 and neglect i_{b2},

$$i_{c_1} = i_R + i_A \Rightarrow i_A = i_{c_1} - i_R$$

$$= \frac{V_{cc}}{R_B} h_{fe} - \frac{V_{cc}}{R}$$

The retrace time T_r, then charge large by capacitor $= i_A T_r$

$$V_S = \frac{i_A T_r}{C} \Rightarrow T_r = \frac{C V_S}{i_A}$$

$$= \frac{C V_S}{V_{cc}\left(\frac{h_{fe}}{R_B} - \frac{1}{R}\right)} = \frac{C \frac{V_S}{V_{cc}}}{\frac{h_{fe}}{R_B} - \frac{1}{R}}$$

The retrace time can be reduced by choosing small value of R_B.

If R_B is reduced, collector current $i_{c_1} = h_{fe} \cdot \frac{V_{cc}}{R_B}$ may Increase

Recovery Process :- The Interval $T = T_g + T_r$, capacitor C_1 discharges at a constant rate because the current $i = \frac{V_{cc}}{R}$ through it remains constant.

charge lost by capacitor $C_1 \rightarrow \frac{V_{cc}}{R} T$ at time T

charge gained by capacitor $C_1 \rightarrow \frac{V_{EE}}{R_E} T_1$ at time T_1

$$\frac{V_{cc}}{R} T = \frac{V_{EE}}{R_E} T_1 \quad (\because \text{charge} = \text{discharge})$$

$\rightarrow$ [illegible]