MULTIVIBRATORS

A multivibrator is a switching ckt that can generate non-sinusoidal waves (acts a relaxation oscillator) consisting of two amplifier stages in such a manner that the output of first stage is coupled to the input of second stage and output of second stage is coupled to the input of first stage with positive feedback. A basic block diagram of a multivibrator is shown in fig-1 & 2.

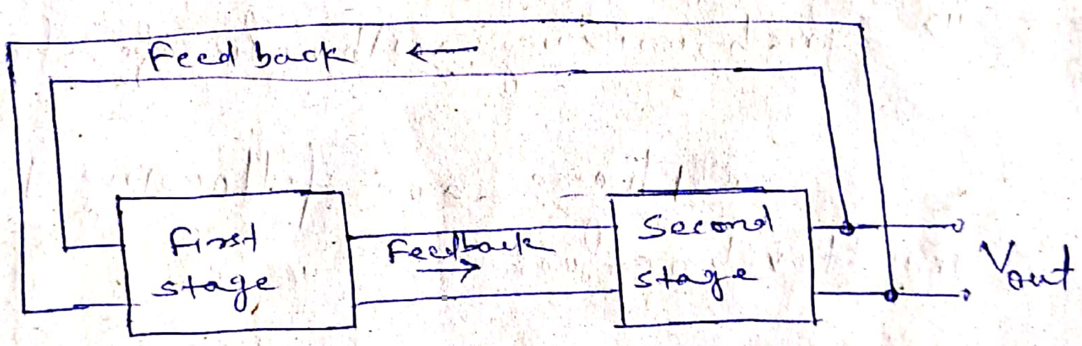


Fig-1

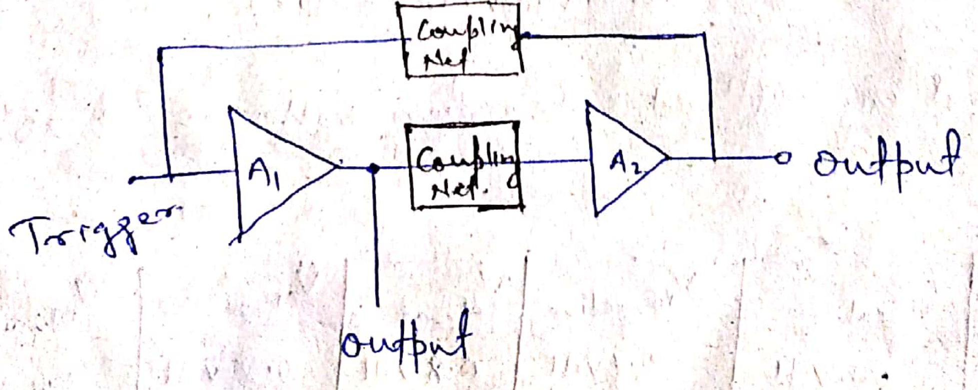


Fig-2

Here the transistor of one stage is drives at saturation then transistor of other stage is kept at cut-off and vice-versa during its operation. The condition in which a multivibrator may remain indefinitely until the ckt is triggered by external signal, is known as stable state.

Application of Multivibrator.

i) For storing binary number
ii) Counting pulses
iii) Synchronizing arithmetic operation

There are following basic multivibrators —

a) Astable or free running multivibrator
b) Monostable multivibrator
c) Bistable multivibrator.

Typical cut-off and saturation voltages at 25°c —

Material	$V_{BE,cut-in}$	$V_{BE,active}$	$V_{BE,sat}$	$V_{CE,sat}$	$V_{BE,cut-off}$
Si	0.5 volt	0.7 volt	0.8 volt	0.2 volt	0.0 volt
Ge	0.1 v	0.2 V	0.3 V	0.1 v	-0.1 v

ASTABLE MULTIVIBRATOR

A multi-vibrator which has no stable state but two quasi-stable (temporary) states and circuit changes automatically from one quasi-stable to another quasi-stable state without any triggering, is called Astable-multi-vibrator. The rate of change of quasi-stable state depends upon RC-time constant of ckt. This ckt is just similar to an oscillator as there is no need of external input signal. Astable-multi-vibrator is also called "free-running oscillator". Fig-3 shows astable-multivibrator.

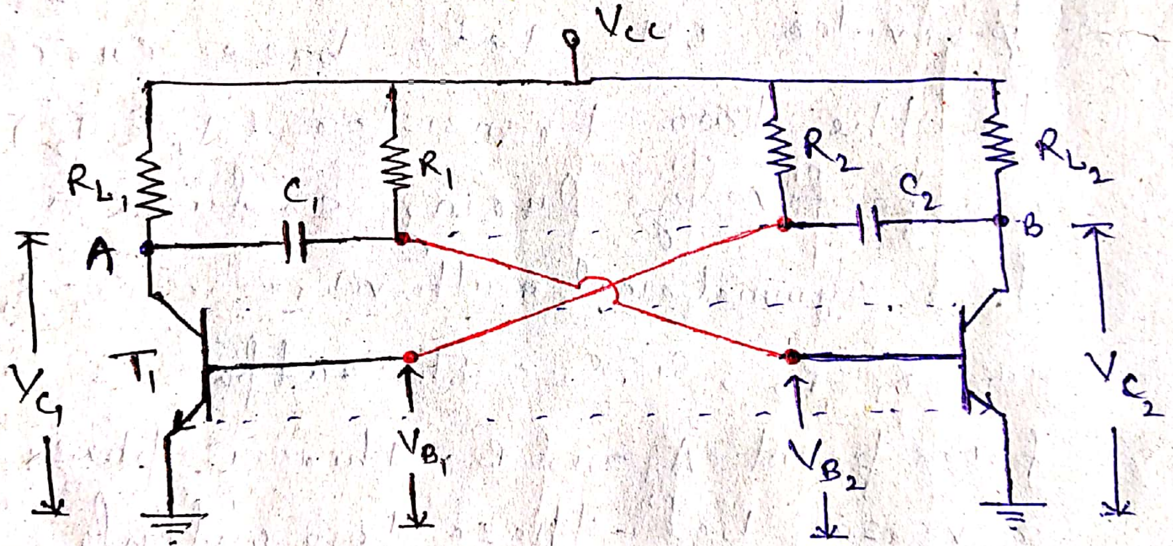


Fig-3.

Construction:

Astable multi-vibrator shown in fig-3 consist of two identical transistors T_1 and T_2 in CE configured amplifier and each transistor provide a feedback to other.

The feedback ratio is unity and positive because of 180° phase-shift in each stage. In circuit R_{L_1} and R_{L_2} are collector load of respective transistors T_1 and T_2. C_1 and C_2 are coupling capacitors. Here the output of T_1 is coupled to the input of T_2 through C_1 while the output of T_2 is coupled to the input of T_1 through C_2 as shown in fig-3. R_1 and R_2 provides ON state base current to the two transistors (T_1 & T_2) respectively during saturation. In a symmetrical multi-vibrator, $R_{L_1} = R_{L_2}$ and $R_1 = R_2$, $C_1 = C_2$. The output is taken from point A and B. There is phase reversal betn these two outputs.

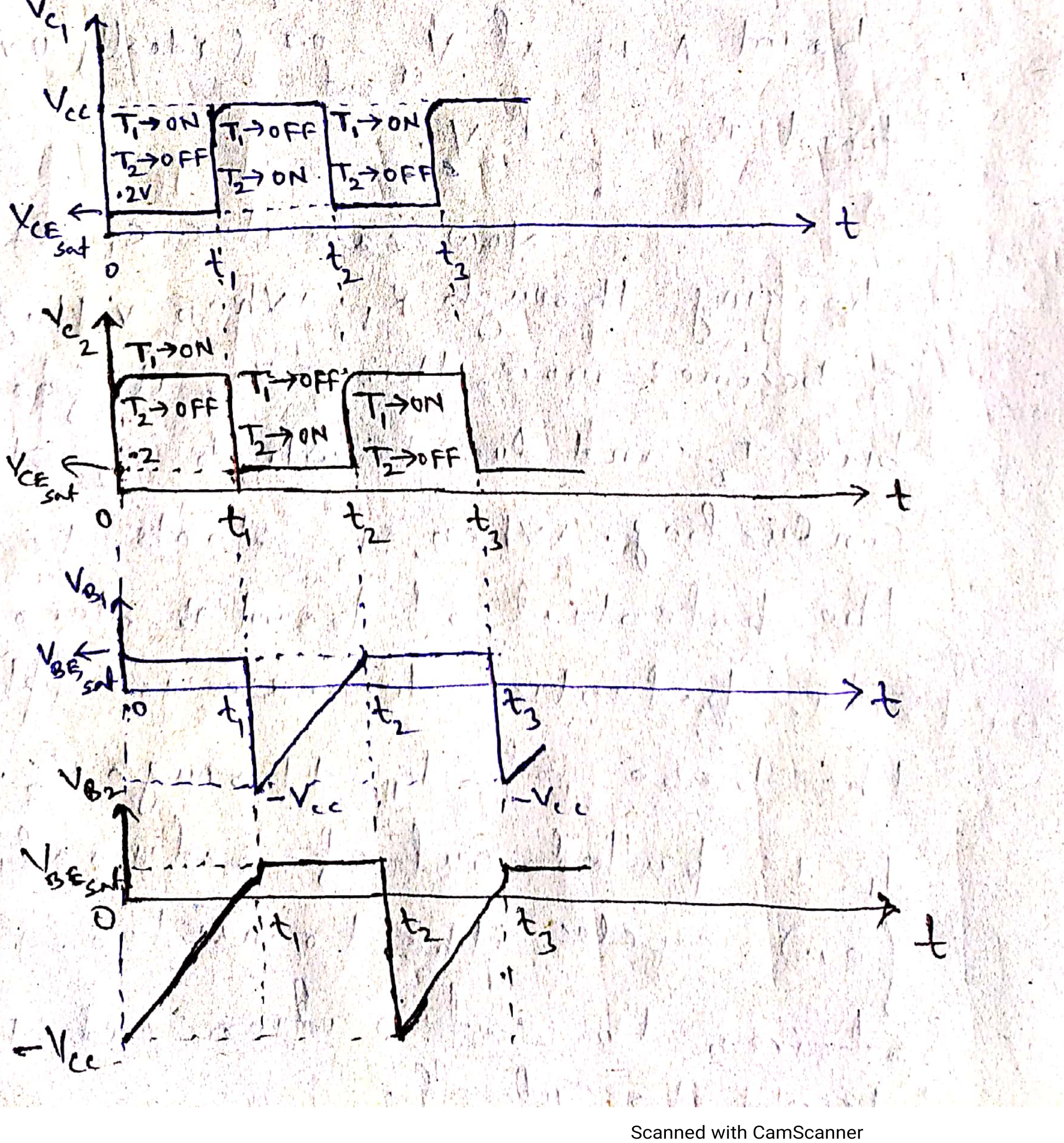
Working operation:

When power is switch ON, let due to some circuit imbalance (because characteristics of two transistors are not exactly same) either T_1 conducts more than T_2 or T_2 conducts more than T_1. The rising collector current of T_1 drives its collector more and more negative.

This is applied to the base of T_2 through capacitor C_1. This establishes a reverse bias on T_2 and thus its collector current starts decreasing. This is connected to the base of T_1 through C_2. Thus, T_1 is more forward biased. The further increase in collector current of T_1 causes a further decrease of collector current of T_2. The series action continues untill T_1 is driven to saturat^n and T_2 to cut-off. When T_1 is driven is saturation and T_2 in cut-off, the point A is at $V_{CE,sat} = 0.2$ (ideally 0 volt) and point B is at V_{cc}.

Now, capacitor C_1 starts charging through R_1. When, voltage across C_1 becomes more than 0.7 V, it forward biases T_2 and due to which T_2 starts conducting. When, T_2 starts to conduct, the potential at point B decreases. This potential decrease is applied to the base of T_1 through C_2. Consequently T_1 is pulled out of saturation. After few cycles, the transistor T_2 is driven to saturation and T_1 is driven to cut-off.

In this situation, point B goes to $V_{CE,sat}$ and point A to V_{cc}. The whole cycle is repeated continuosly and generates a square wave. Thus, we see that, circuit alternates between a state in which T_1 is ON, T_2 is OFF and T_1 is OFF, T_2 is ON. The time in each state depends upon value of RC = ℓ. In this entire operation, the waveform of collector and base signals are shown in fig-4.



Voltage across a capacitor is given by ——

$$V_c = V(1-e^{-t/RC}) \quad \text{——} \; (1)$$

Since, T_1 conducts for half-cycle and T_2 conducts for another half-cycle, the coupling capacitor (C_1 or C_2) charges upto half of supply voltages V_{cc} and compels the respective transistor to conduct. i.e at $V_c = \frac{1}{2} V_{cc}$, respective transistor starts to conduct.

Now, at $V_c = \frac{1}{2} V_{cc}$, from eqn (1)

$$\frac{1}{2} V_{cc} = V_{cc}(1-e^{-t_1/R_1C_1}) \; ; \; [\text{For transistor } T_1]$$

or, $\frac{1}{2} = 1 - e^{-t_1/R_1C_1}$

or, $e^{-t_1/R_1C_1} = 1 - \frac{1}{2} = \frac{1}{2}$

or, $\log_e(e^{-t/R_1C_1}) = \log_e(1/2)$

or, $-\frac{t}{R_1C_1} = -\log(0.5)$ or $\boxed{t_1 = 0.693 R_1C_1}$

Similarly, for transistor T_2,

$t_2 = 0.693 R_2C_2$

$\therefore$ total time period, $t = T$,

$T = t_1 + t_2 \Rightarrow \boxed{T = 0.693(R_1C_1 + R_2C_2)}$

If, $R_1 = R_2$, $C_1 = C_2$, then

$$T = 0.693(RC + RC) = 0.693 \times 2RC$$

or $\boxed{T = 1.386RC}$ ← This is the time period of wave generat

$\therefore f = \frac{1}{T} \Rightarrow \boxed{f = \frac{1}{1.38RC}}$

Application

i> It is used as square wave generator

ii> Voltage-to-frequency converter

iii> Clock signal generator for binary logic.

iv> It is used in construction of digital voltmeter and SMPS (Switch-Mode-Power Supply).