Multi-Vibrator (MV)
Lecture – 2

TDC PART – I
Paper - II (Group - B)

Chapter - 3

by:

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Transistor Astable Multivibrator (AMV)

- A **multivibrator** which **generates square waves of its own** (i.e. **without** any **external triggering pulse**) is known as an **astable** or free **running multivibrator.**

- Its is also called **free-running relaxation oscillator**. It has **no stable state** but only **two quasi-stable (half-stable)** states between which it **keeps oscillating continuously** of its own without any **external excitation.**

- It is also called free-running relaxation oscillator. It has no stable state but only two quasi-stable (half-stable) states between which it keeps oscillating continuously of its own without any external excitation. Thus it is just an oscillator since it requires no external pulse for its operation. Of course, it does require a source of d.c. power. Because it continuously produces the square-wave output it is often referred to as a free running multivibrator. In this circuit, neither of the two transistors reaches a stable state. When one is ON, the other is OFF and they continuously switch back and forth at a rate depending on the RC time constant in the circuit. Hence, it oscillates and produces pulses of certain mark-to-space ratio. Moreover, two outputs (180° out of phase with each other) are available. **It has two energy-storing elements i.e. two capacitors.**

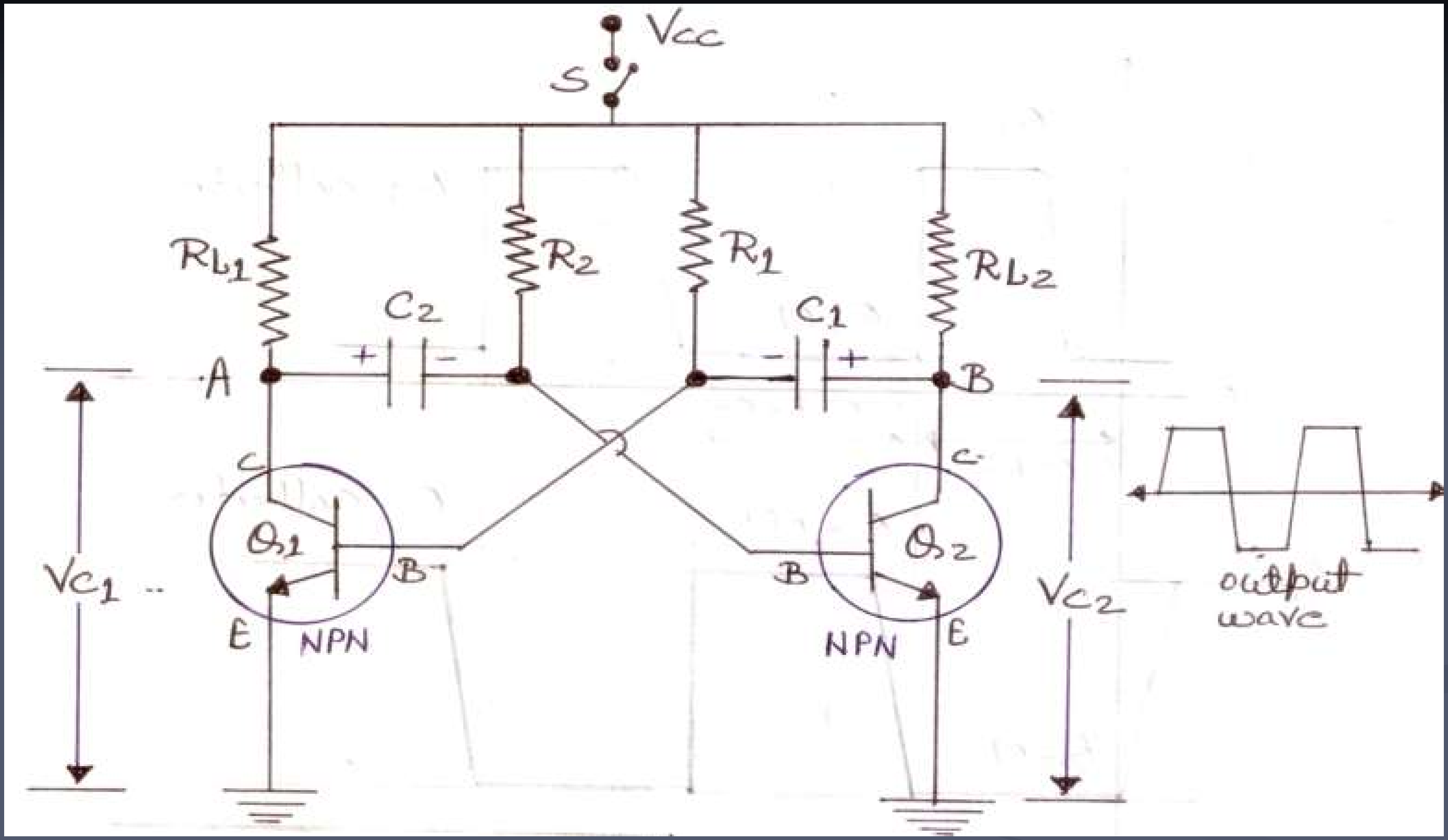
- An **Astable Multivibrator** or a **Free Running Multivibrator** is the multivibrator which has **no stable states**. Its **output oscillates** continuously between its **two unstable states** without the aid of **external triggering**. The **time period** of each states are **determined** by **Resistor Capacitor (RC) time constant**. It **switches back and forth** from **one state** to the **other,** remaining in each state for a time determined by **circuit constants**. In other words, at **first one transistor conducts (i.e. ON state)** and the **other stays in the OFF state** for **some time**. After **this period of time**, the **second transistor** is automatically **turned ON** and the **first transistor** is **turned OFF.** Thus the **multivibrator** will **generate** a **square wave output** of its **own**. The **width** of the **square wave** and its **frequency** will **depend upon the circuit constants**.

- **Fig (7)** shows in slide no. 5, the **circuit of a symmetrical collector-coupled AMV** using **two similar transistors**. It is **consists** of **two CE amplifier stages, each providing** a **100% positive feedback** to the **other.** The **feedback ratio is unity** and **positive** because of **180° phase shift** in each stage. **Hence, the circuit oscillates**. Because of the **very strong positive feedback signal**, the **transistors** are **driven** either to **saturation** or to **cut-off** region **(they do not work on the linear region also called active region of their characteristics).**

AMV Circuit Details

- **Fig (7)** shows in slide no 5, the circuit of a typical **transistor astable multivibrator** using two identical **transistors Q1** and **Q2**. The circuit essentially consists of **two symmetrical CE amplifier stages**, each providing a **feedback to the other**. Thus **collector loads of the two stages** are equal i.e. **RL1 = RL2** and the **biasing resistors are also equal** i.e. **R2 = R1.** The output of **transistor Q1** is coupled to the input of **Q2** through **C2** while the output of **Q2** is feed to the input of **Q1** through **C1**. The **square wave output** can be taken from **Q1 or Q2** at **Point A or B.**

- The transistor **Q1** is forward-biased by **VCC** and **R1** whereas **Q2** is forward-biased by **VCC** and **R2.** The **collector-emitter voltages** of **Q1** and **Q2** are determined respectively by **RL1** and **RL2** together with **VCC**. The output of **Q1** is coupled to the input of **Q2** by **C2** whereas output of **Q2** is coupled to **Q1** by **C1.** The **output can be taken** either from **point A or B** though these would be **phase-reversed 180°** with respect to each other as shown in **Fig (7).**



- **Fig (7)** shown a Typical circuit Diagram of Transistor Astable Multivibrator

- **Note that** it is not essential to draw the coupling leads at 45° to the vertical as **shown in Fig (7)** but it is usually done because it helps to identify the circuit immediately as MV.

AMV Circuit Operation

- In the circuit diagram shown in **Fig (7)** we can find two transistors which is wired as a switch. **Please do read the article Transistor as a Switch.** When a transistor is **ON,** its **collector and emitter** act as a **short circuit**. But when it is **OFF** they acts as **open circuit**. So in the above circuit when a **transistor** is in **OFF** state its **collector** will have the **voltage Vcc** and when it is **ON** its **collector** will be **grounded or zero**. When one transistor is **ON** the other will be **OFF.** The **OFF** time of transistor is determined by **RC time constant**.

- The circuit operation would be easy to understand if it is remembered that due to feedback

  (1) when Q1 is ON, Q2 is OFF and

  (2) when Q2 is ON, Q1 is OFF.

- When the power is switched on by closing **Switch S**, one of the **transistors** will **start conducting** before the other does (or slightly faster than the other). It is so because characteristics of no **two** seemingly similar **transistors can be exactly alike**. Suppose that **Q1 starts conducting** before **Q2** does. The positive feedback system is such that **Q1** will be very rapidly driven to **saturation** and **Q2** to **cut-off.**

The following sequence of events will occur :-

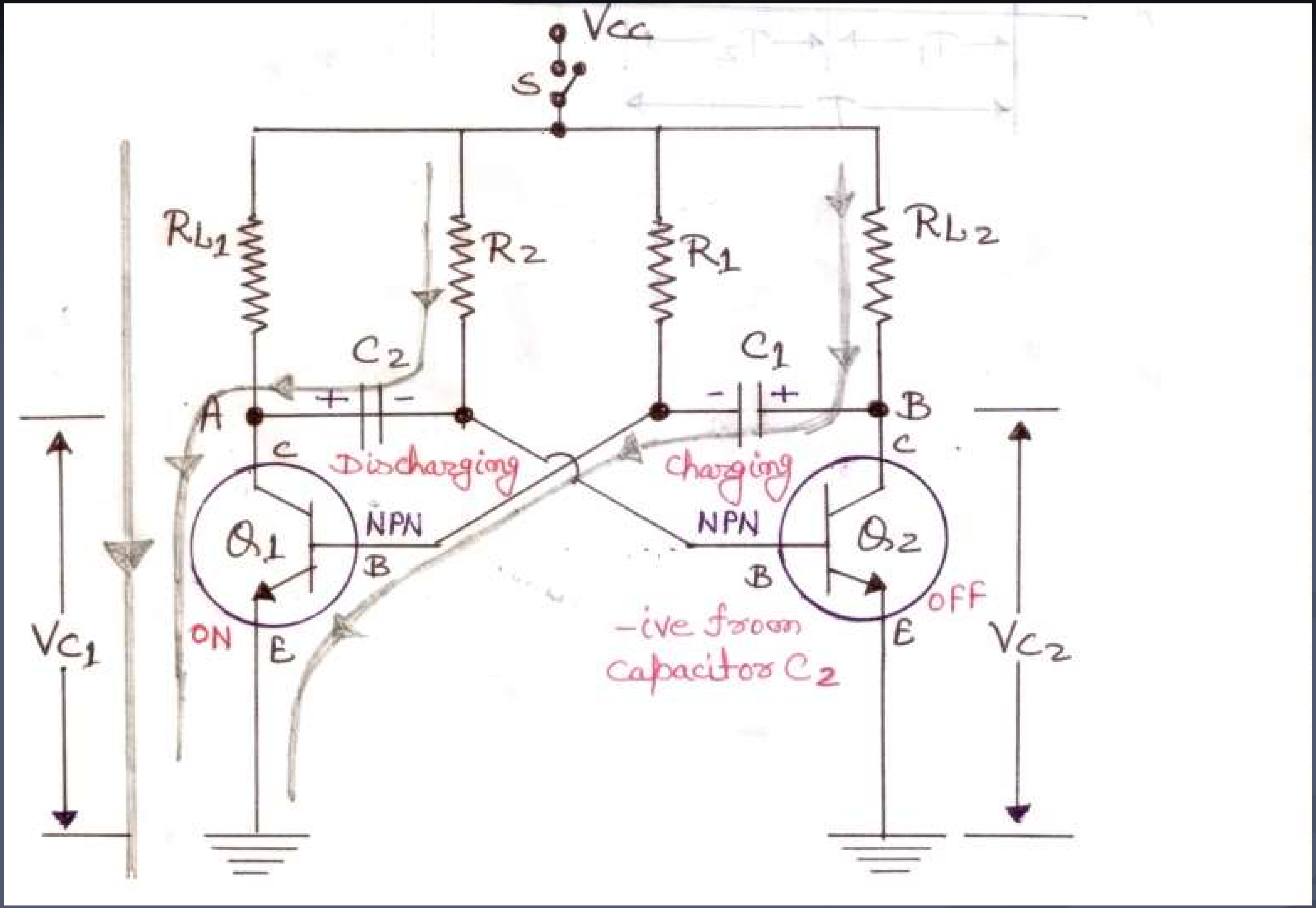
(1) When the circuit is switched **ON** by closing **Switch S** one transistor will driven to **saturation (ON)** and other will driven to **cut-off (OFF)**. Consider **Q1** is **ON** and **Q2** is **OFF.**

(2) Since **Q1** is in saturation, whole of **VCC** drops across **RL1**. Hence, **VC1 = 0** and **point A** is at **zero or ground potential**.

(3) Since **Q2** is in **cut-off** i.e. it conducts no current, there is no drop across **RL2.** Hence, **point B** is at **VCC.**

(4) During this time **Capacitor C1** is charging to **Vcc** through resistor **RL2.**

(5) **Q2** is **OFF** due to the **Negative** (**-ive) voltage** from the discharging **capacitor C2** which is charged during the previous cycle. So the **OFF** time of **Q2** is determined by **R2C2** time constant which is shown in **Fig (8)** below.



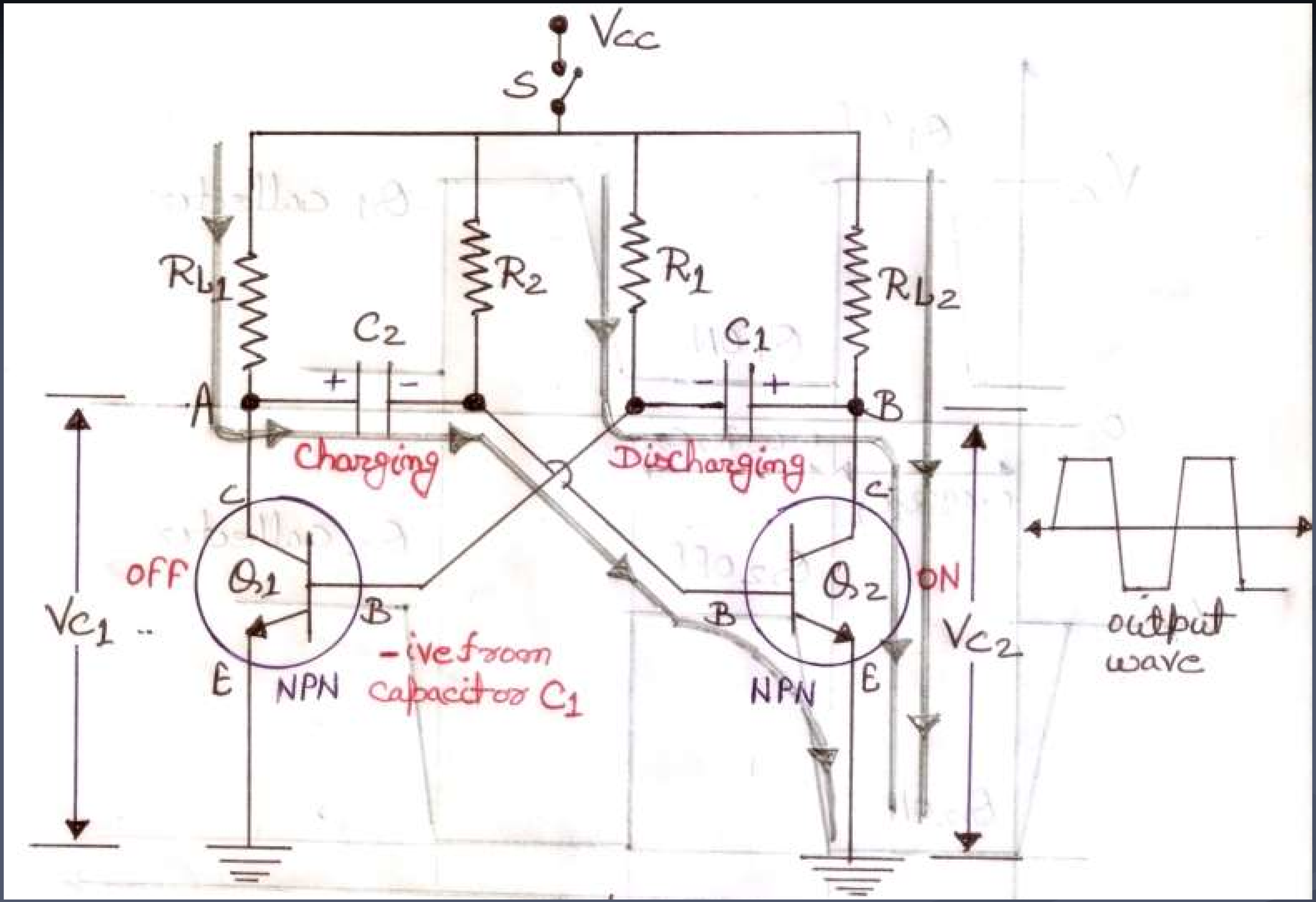
- **Fig (8)** shown a circuit Diagram of Typical Transistor Astable Multivibrator when Transistor Q1 ON and Transistor Q2 OFF

(6) After a time period determined by **R2C2** time constant the **capacitor C2** discharges completely. Since **point A** is at **0 V**, **C2** starts to charging in reverse direction through **R2** towards **VCC**.

(7) When the **capacitor C2** charges and voltage across **C2** rises sufficiently i.e. more than **0.7 V,** it provide base emitter voltage of **0.7V** to the **transistor Q2** in the forward direction so that it starts conducting and is soon **transistor Q2** driven to saturation then **Q2 turn ON** and capacitor **C1** starts discharging shown in **Fig (9**) in slide no 11 .

(8) From **Fig (9)** shown above **VC2 decreases** and becomes almost **zero** when **Q2** gets saturated and **turn ON**. The potential of point B decreases from **VCC** to **almost 0 V**. This potential **decrease (negative swing)** is applied to the base of **Q1** through and from capacitor **C1**. Consequently, **Q1** is pulled out of **saturation (ON state)** and is soon driven to **cut-off (turn OFF).**

(9) The negative voltage from the **capacitor C1** turns **OFF** the **transistor Q1** and the **capacitor C2** starts charging from **Vcc** through **resistor RL1.**



- **Fig (9)** shown a circuit Diagram of Typical Transistor Astable Multivibrator when Transistor Q1 OFF and Transistor Q2 ON.

(10) When the **capacitor C2** charges and voltage across **C2** raises sufficiently i.e. more than **0.7 V,** it provides base emitter voltage of **0.7V** to the **transistor Q2** in the forward direction so that it starts conducting. Thus the **transistor Q2** remains in **ON state.**

(11) As in the previous state, when the **capacitor C1** discharges completely it starts **charging towards opposite direction** through **R1.**

(12) Since, now **point B** is at **0 V**, **C1 starts charging** through **RL2** towards the target **voltage VCC.**

(13) Again when the voltage across the **capacitor C1** increases sufficiently, i.e. more than **0.7 V**, it provides **base emitter voltage of 0.7V** to the **transistor Q1** then **Q1 becomes forward-biased**. It is sufficient to **turn ON transistor Q1.** Hence **Q1** will turn **ON** and again **capacitor C2 starts discharging**. **In this way, the whole cycle is repeated.**

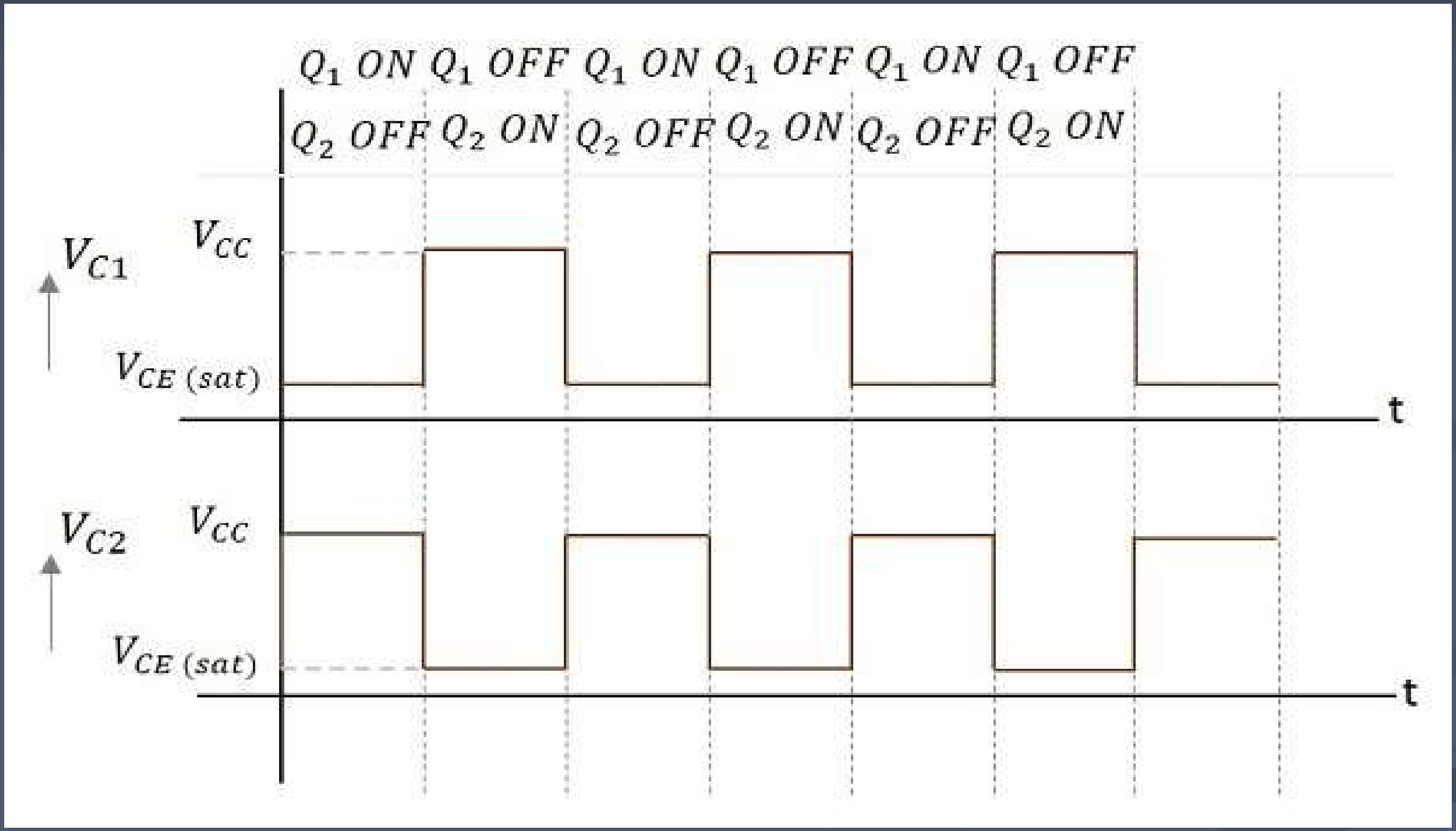
(14) This process continuous and produces rectangular waves at the collector of each transistor.

- **Note:** Charging time is very less compared to discharging time.

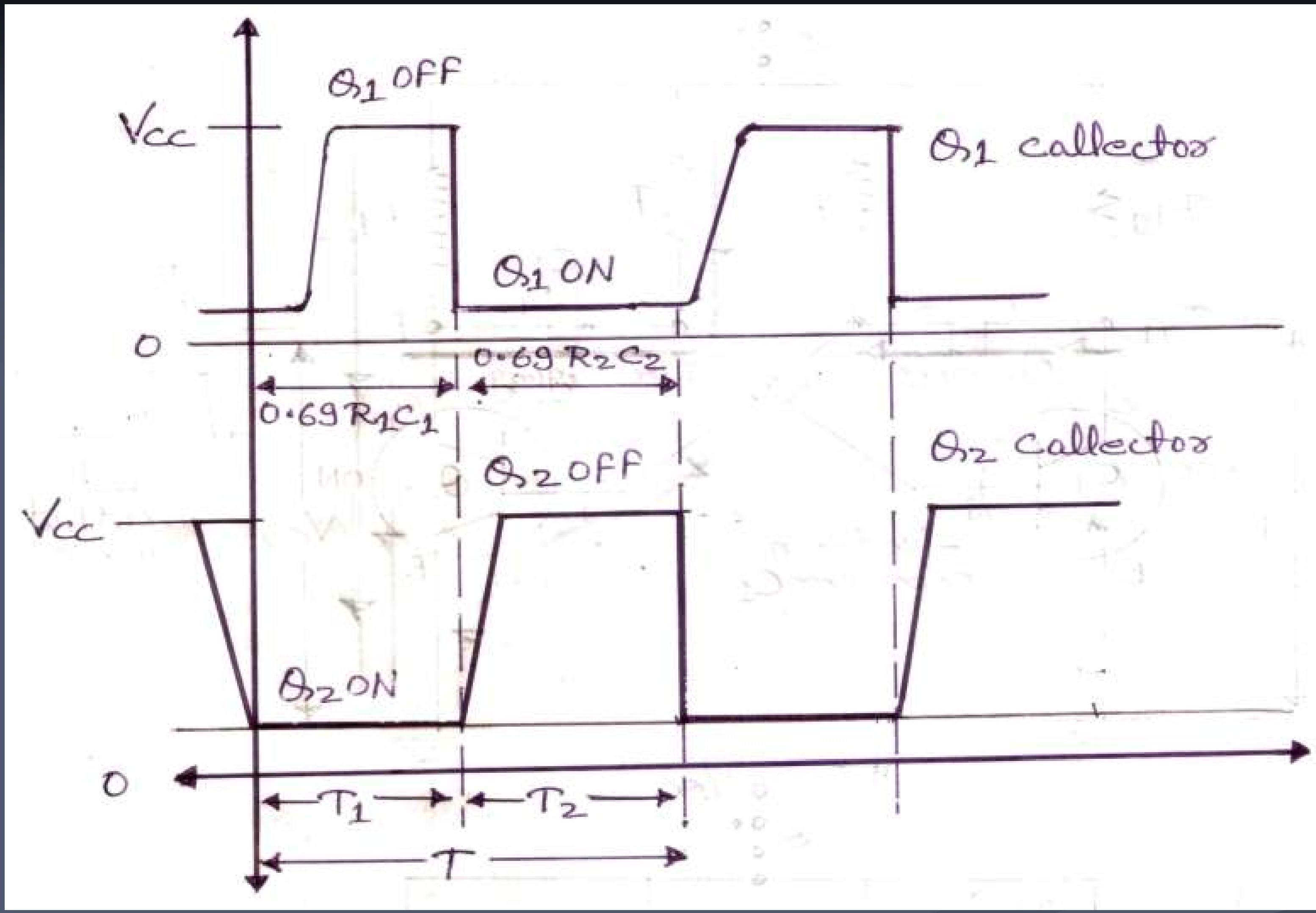
- It is seen from above, that the circuit alternates between a state in which Q1 is ON and Q2 is OFF and a state in which Q1 is OFF and Q2 is ON. Hence the output voltage and the output waveform are formed by the alternate switching of the transistors Q1 and Q2. The time period of these ON/OFF states depends upon the values of biasing resistors and capacitors used, i.e., on the RC values used. Hence the time in each state depends on RC values. Since each transistor is driven alternately into saturation and cut-off the voltage waveform at either transistor collector points A and B shown in **Fig (7), (8)** and **(9),** is essentially a **square waveform** with a peak **amplitude equal to VCC** shown in **Fig (8) and Fig (9)** below.

AMV Output Waveforms

- The output waveforms at the collectors of Q1 and Q2 are shown in the **Fig (10)** and **Fig (11)** below :-



- **Fig (10)** Shown The output waveforms at the collectors of Transistor Q1 and Q2.



- **Fig (11)** Shown The output waveforms at the collectors of Transistor Q1 and Q2.

AMV Transistor ON or OFF time and Its Frequency

- The time for which either transistor remains ON or OFF is given by :-
- The **ON time** of **transistor Q1** or the **OFF time** of **transistor Q2** is given by

$$T1 = 0.694\ R2\ C2$$

- Similarly, the **OFF time** of **transistor Q1** or **ON time** of **transistor Q2** is given by

$$T2 = 0.694\ R1\ C1$$

- Total time period of the square wave is

$$T = T1 + T2 = 0.694\ (R2\ C2 + R1\ C1)$$

As

$R1 = R2 = R$ and

$C1 = C2 = C$,

- i.e. the two stages are symmetrical, then **Total Time Period (T)** is given by

$$\therefore \quad T = 0.694\,(RC + RC)$$

$$\text{or} \quad T = 2 * 0.694\, RC \;\; \text{seconds}$$

$$\therefore \quad T = 1.388\, RC \;\; \text{seconds}$$

- **Hence Frequency of the Square Wave will be**

$$\therefore \quad f = 1 / T$$

$$\text{or} \quad f = 1 / 1.388\, RC$$

$$\therefore \quad f = 0.72 / RC$$

- **It may be noted that in these expressions, R is in ohms and C in farad.**

Minimum Values of β

- To ensure oscillations, the transistors must saturate for which minimum values of β are as under :

$\beta 1 = R1 / RL1$ and

$\beta 2 = R2 / RL2$

If $R1 = R2 = R$ **and**

$RL1 = RL2 = RL$ then,

$\beta min = R / RL$

AMV Advantages

- The advantages of using an astable multivibrator are as follows :-

  (1) No external triggering required.

  (2) Circuit design is simple

  (3) Inexpensive

  (4) Can function continuously

AMV Disadvantages

- The drawbacks/disadvantages of using an astable multivibrator are as follows :-

(1) Using more components

(2) Energy absorption is more within the circuit.

(3) Output signal is of low energy.

(4) Duty cycle less than or equal to 50% can't be achieved.

(5) Difficulty in obtaining proper operating conditions

AMV Applications

- Astable Multivibrators are used in many applications such as

  (1) Amateur radio equipment
  (2) Morse code generators
  (3) Timer circuits
  (4) Analog circuits
  (5) TV systems
  (6) Square wave generator
  (7) Pules wave generator
  (8) Specialised uses in Radar

to be continued ....