Transistor Construction

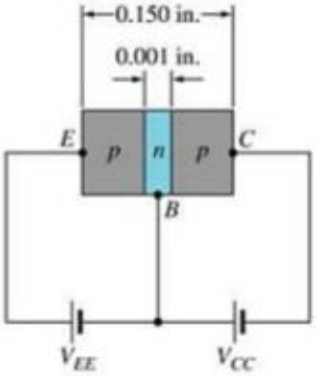
There are two types of transistors:

- ***pnp***
- ***npn***

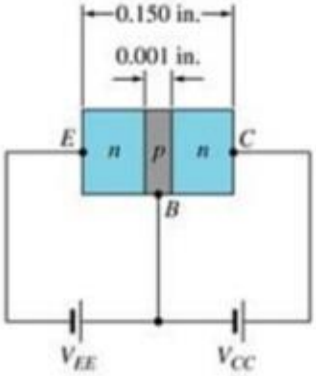
The terminals are labeled:

- **E - Emitter**
- **B - Base**
- **C - Collector**

pnp



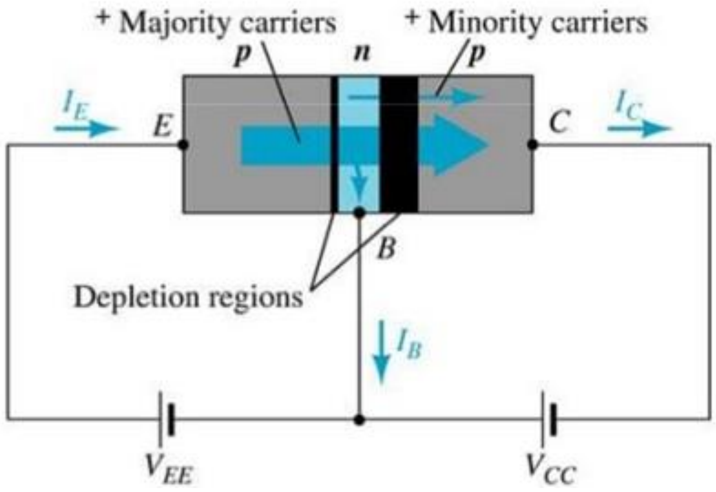
npn



Transistor Operation

With the external sources, V_{EE} and V_{CC}, connected as shown:

- **The emitter-base junction is forward biased**
- **The base-collector junction is reverse biased**



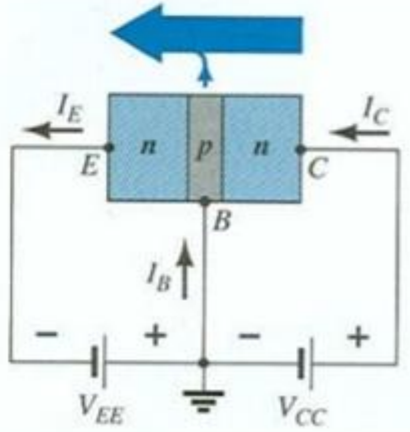
Currents in a Transistor

Emitter current is the sum of the collector and base currents:

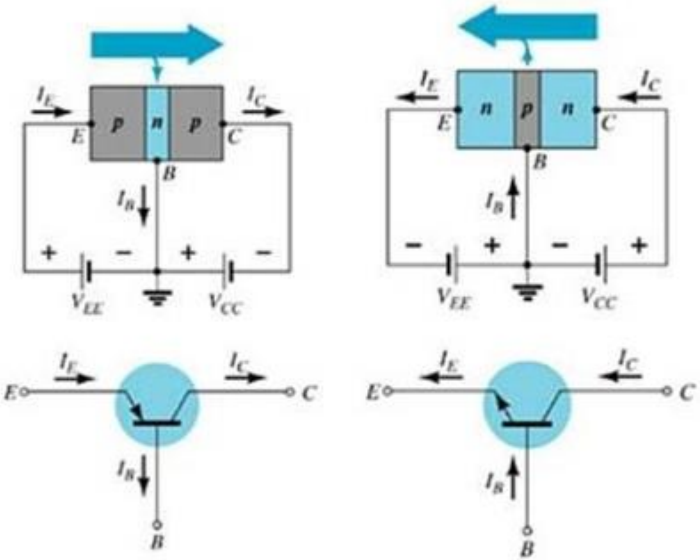
$$I_E = I_C + I_B$$

The collector current is comprised of two currents:

$$I_C = I_{C_{\text{majority}}} + I_{CO_{\text{minority}}}$$



Common-Base Configuration



The base is common to both input (emitter–base) and output (collector–base) of the transistor.

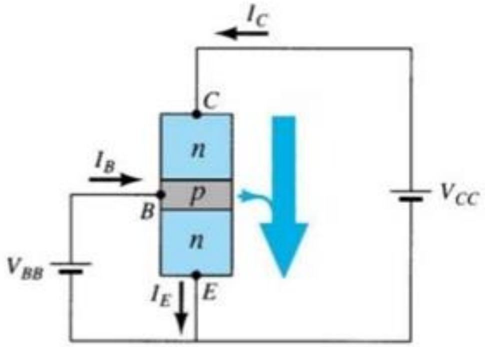
Operating Regions

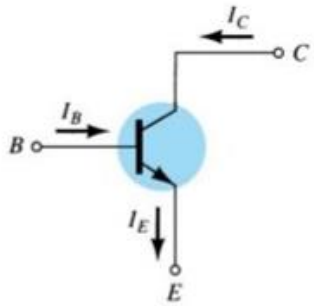
- Active – Operating range of the amplifier.
- Cutoff – The amplifier is basically off. There is voltage, but little current.
- Saturation – The amplifier is full on. There is current, but little voltage.

Common–Emitter Configuration

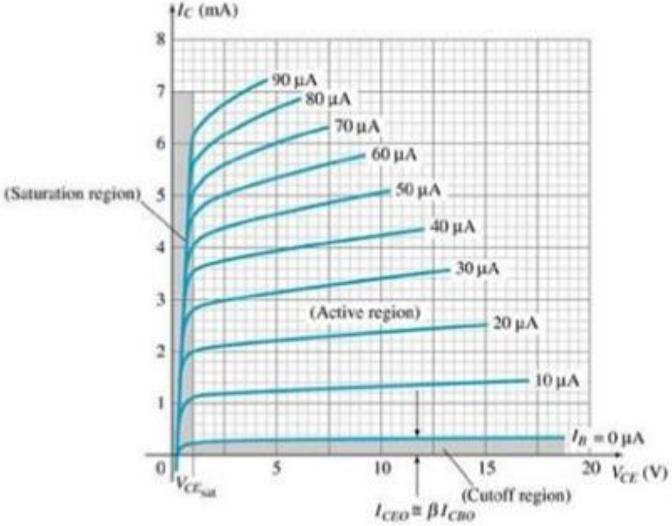
The emitter is common to both input (base-emitter) and output (collector-emitter).

The input is on the base and the output is on the collector.

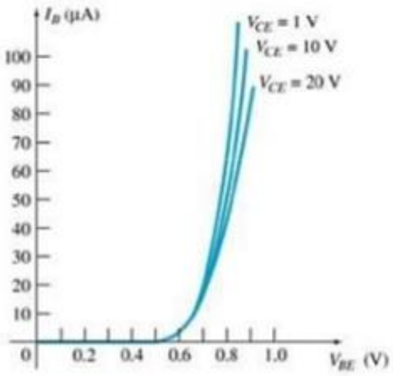




Common-Emitter Characteristics



Collector Characteristics



Base Characteristics

Common-Emitter Amplifier Currents

Ideal Currents

$$I_E = I_C + I_B \qquad\qquad I_C = \alpha I_E$$

Actual Currents

$I_C = \alpha I_E + I_{CBO}$ where I_{CBO} = minority collector current

I_{CBO} is usually so small that it can be ignored, except in high power transistors and in high temperature environments.

When $I_B = 0\ \mu A$ the transistor is in cutoff, but there is some minority current flowing called I_{CEO}.

$$I_{CEO} = \left.\frac{I_{CBO}}{1-\alpha}\right|_{I_B = 0\mu A}$$

Beta (β)

Relationship between amplification factors β and α

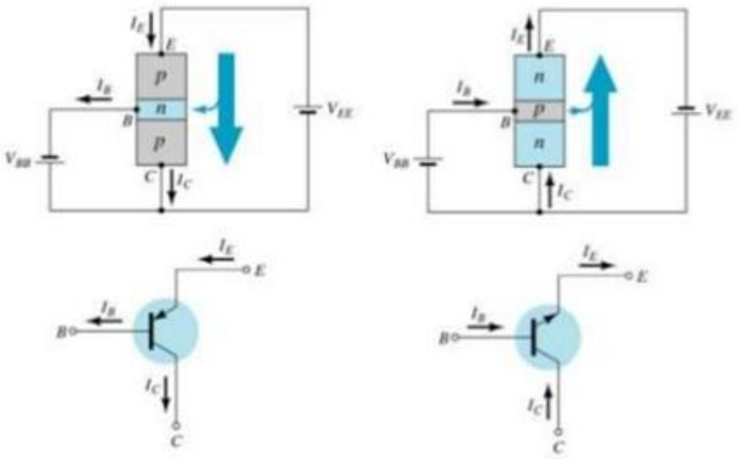
$$\alpha = \frac{\beta}{\beta + 1} \qquad \beta = \frac{\alpha}{\alpha - 1}$$

Relationship Between Currents

$$I_C = \beta I_B \qquad I_E = (\beta + 1) I_B$$

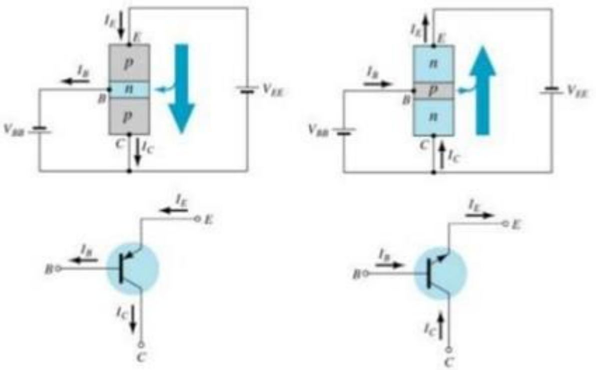
Common–Collector Configuration

The input is on the base and the output is on the emitter.



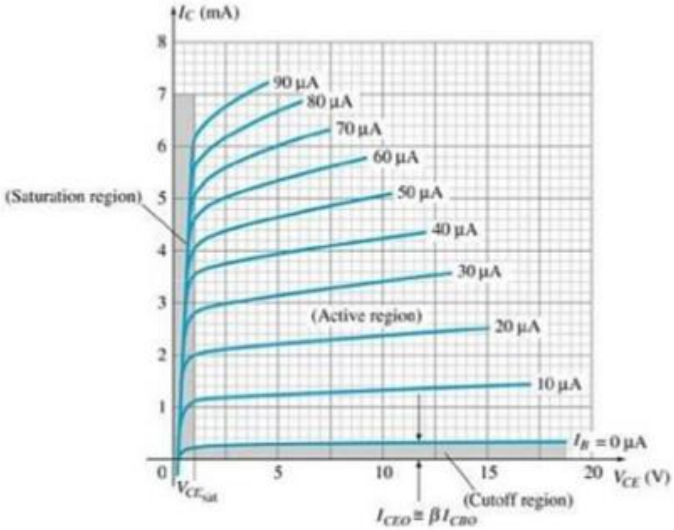
Common–Collector Configuration

The input is on the base and the output is on the emitter.



Common–Collector Configuration

The characteristics are similar to those of the common-emitter configuration, except the vertical axis is I_E.



Power Dissipation

Common-base:

$$P_{Cmax} = V_{CB} I_C$$

Common-emitter:

$$P_{Cmax} = V_{CE} I_C$$

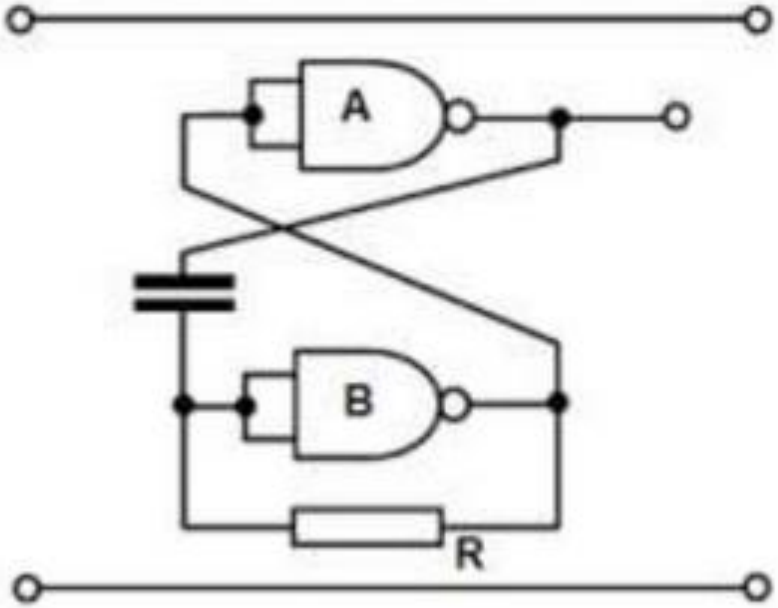
Common-collector:

$$P_{Cmax} = V_{CE} I_E$$

multivibrator

- A **MULTIVIBRATOR** is an electronic circuit used to implement a variety of simple two-state systems such as oscillators, timers and flip-flops.
- It is characterized by two amplifying devices (transistors, electron tubes or other devices)
- cross-coupled by resistors and capacitors.
- It has two states low “0” & high “1”

Diagram



Basic types

There are three types of multivibrator circuit

- Astable
- Bistable
- Monostable

Astable multivibrator

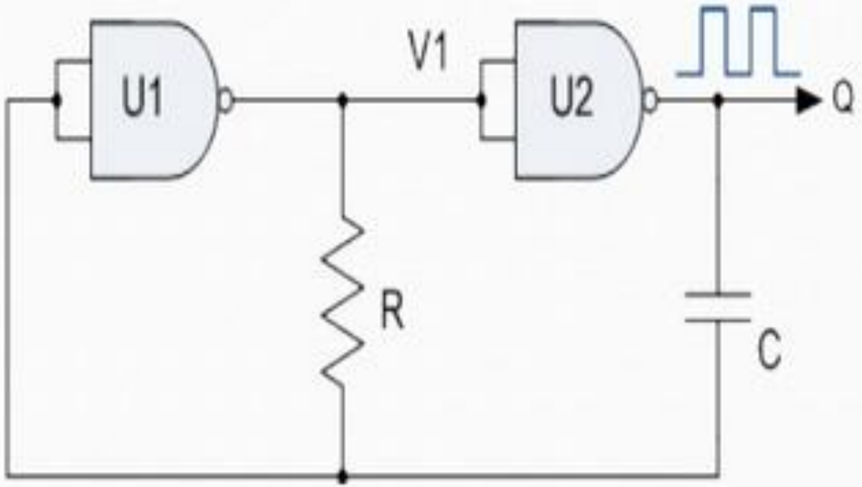
Astable, in which the circuit is not stable in either state—it continuously oscillates from one state to the other. Due to this, it does not require an input (Clock pulse or other).

Continue...

Astable Multivibrators are a type of "free running oscillator" that have no permanent "Meta" or "Steady" state but are continually changing there output from one state ("LOW") to the other state ("HIGH") and then back again to its original state. This continual switching action from "HIGH" to "LOW" and "LOW" to "HIGH" produces a continuous square wave output whose timing cycle is determined by the time constant of the Resistor-Capacitor, (*RC Network*) connected to it.

Astable multivibrator

NAND Gate Astable Multivibrators



Bistable Multivibrator

Bistable Multivibrators circuit, both states are stable, and the circuit will remain in either state indefinitely.

This type of Multivibrator circuit passes from one state to the other "Only" when a suitable external trigger pulse T is applied and to go through a full "SET-RESET" cycle **two** triggering pulses are required.

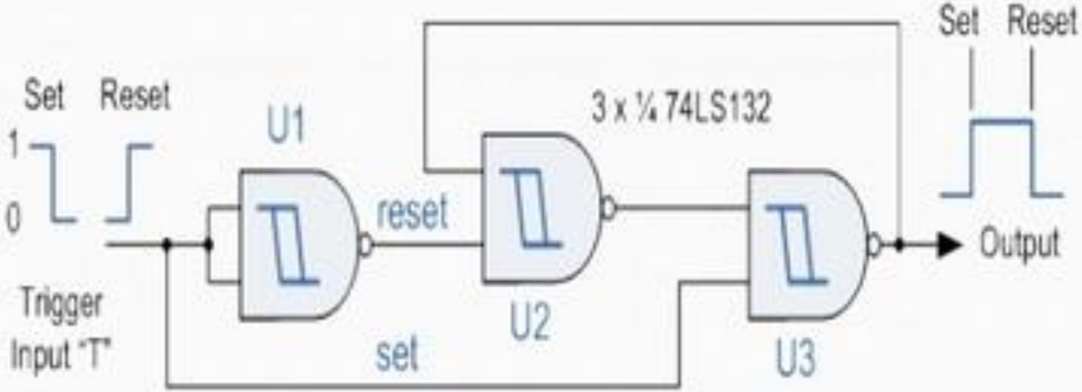
This type of circuit is also known as a "**Bistable Latch**", "**Toggle Latch**" or simply "**T-latch”**, “**flip-flop”**.

Such a circuit is important as the fundamental building block of a register or memory device.

Then a **Bistable Latch** or "Toggle Latch" is a two-state device in which both states either positive or negative, (logic "1" or logic "0") are stable.

Bistable Multivibrator

NAND Gate Bistable Multivibrator.



Application

Bistable Multivibrators have many applications such as frequency dividers, counters or as a storage device in computer memories but they are best used in circuits such as Latches and Counters.

Monostable multivibrator

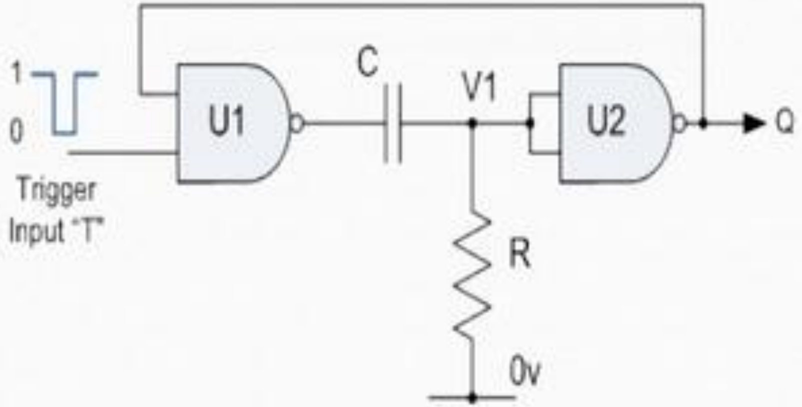
Monostable - has only **ONE** stable state and is triggered externally with it returning back to its first stable state

Monostable Multivibrators or "One-Shot" pulse generators are used to generate a single output pulse, either "High" or "Low", when a suitable external trigger signal or pulse T is applied.

Time constant is T = 0.8RC + Trigger in seconds

Monostable multivibrator

NAND Gate Monostable Circuit.



Applications

Monostable multivibrators are used in a number of applications and can be found wherever a square wave or timed interval is necessary for the success of a system. For example, monostable multivibrators were once used in analog systems to control an output signal's frequency, synchronize the line and frame rate of television broadcasts, and even moderate the tunes of different octaves with electronic organs. Additionally, before the integrated circuit's invention, monostable multivibrators were connected together in a series to divide frequencies.

Disadvantage

One main disadvantage of Monostable Multivibrators is that the time between the application of the next trigger pulse T has to be greater than the RC time constant of the circuit.