Transistors.

There two types of transistor.

Bipolar Junction transistor (BJT).

Field effect transistor (FET).

BJT :-

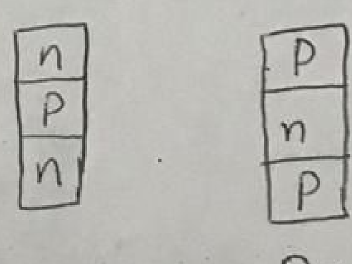
Applications: Amplifier

Electronic switch.

Transistor structure :-

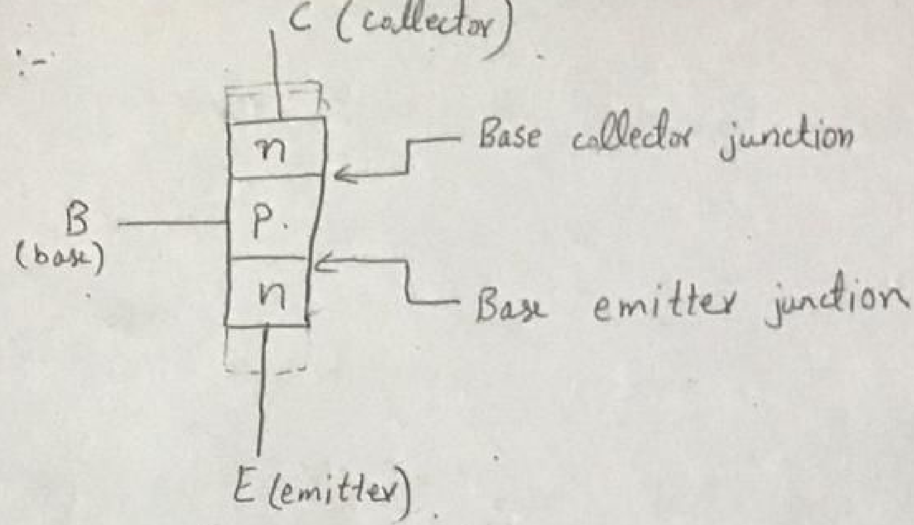
→ Three doped semiconductor regions.

→ Two Pn junctions.



npn PnP

npn :-



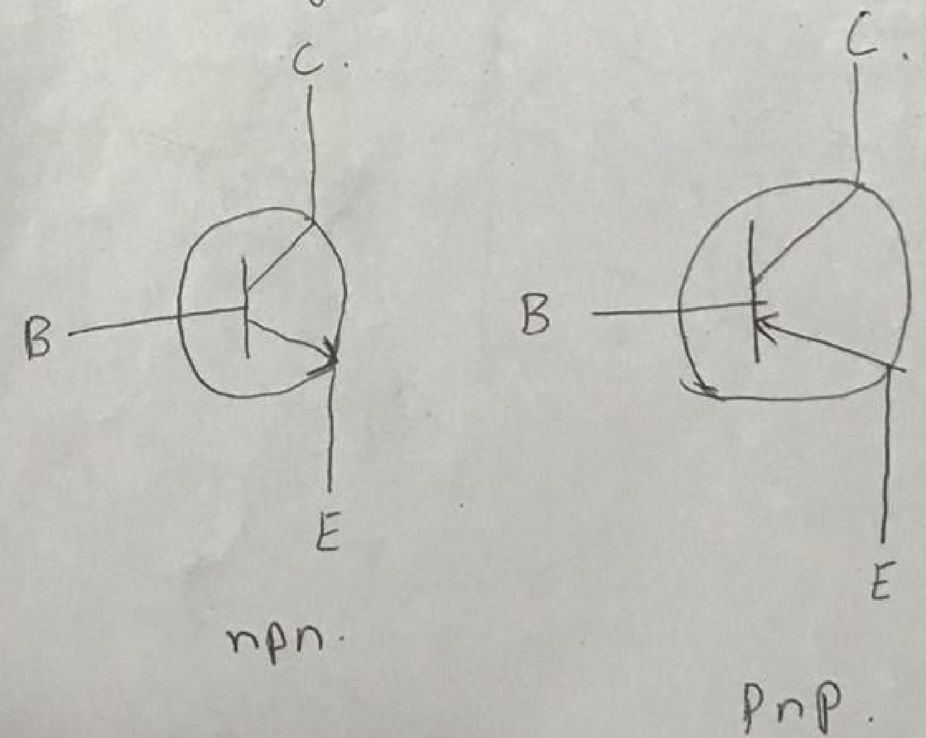
Physical Representation.

Base region is lightly doped (Thin)

Emitter region is heavily doped

collector region is moderately doped

Schematic Symbols :-

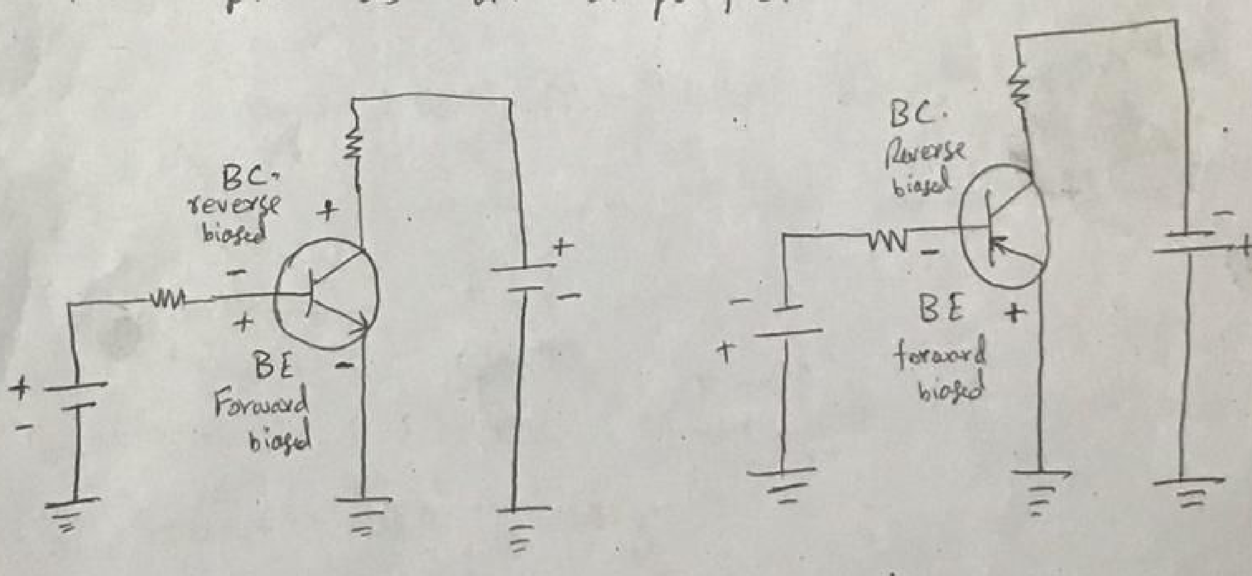


Bipolar refers to the use of both holes and electrons as carriers.

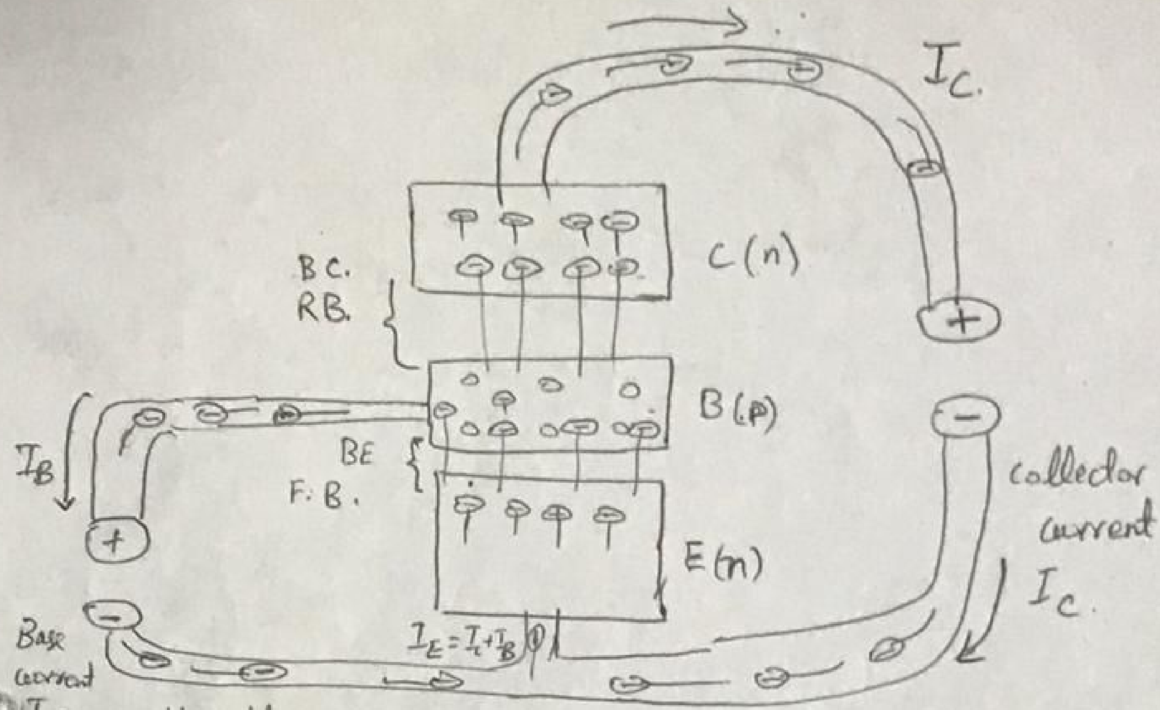
Basic Transistor operation :-

We will discuss npn. And pnp has the same operation except the role of electrons & holes, bias voltage polarities and the current directions are all reversed.

Bias for npn as an amplifier :-



npn   pnp.



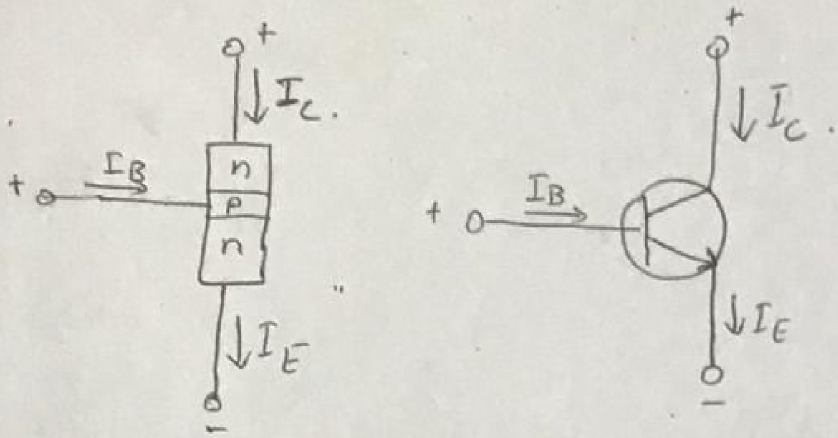
I_B. Heavily doped Emitter with electrons easily diffuses through the F.B BE junction into the P-type base region.

Base region has few holes. because its very thin. It combines very few electrons with holes coming from emitter.

Few Recombined electrons flow out of base which is called base current.

Remaining electrons diffuses into BC depletion region. these electrons are pulled towards collector +ve voltage.

Transistor currents :-



$$I_E = I_C + I_B.$$

I_B is very small compared to I_C, I_E.

Transistor parameters :-

We directly apply voltage source at collector. And voltage at base can be produced with a voltage divider.

DC Current gain :-

Ratio of the dc collector current (I_C) to the dc base current (I_B) is the dc beta (β_{DC}). which is ~~is~~ dc current gain of transistor.

$$\beta_{DC} = \frac{I_C}{I_B}$$

β_{DC} range 20 to 200 or higher.

DC alpha (α_{DC}) :-

Ratio of the dc collector current (I_C) to the dc emitter current (I_E) is the dc alpha (α_{DC}).

$$\alpha_{DC} = \frac{I_C}{I_E}$$

α_{DC} is always less than 1.

Range 0.95 to 0.99.

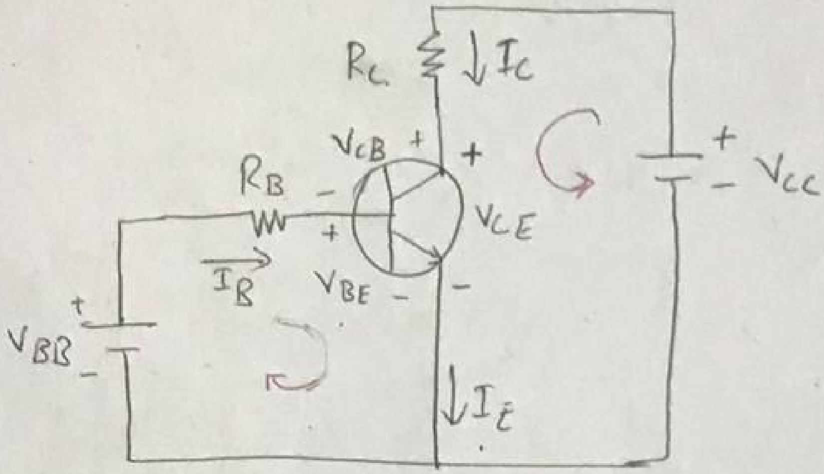
Example:

Determine β_{DC} and I_E for a transistor where $I_B = 50\mu A$ $I_C = 3.65mA$.

$$\beta_{DC} = \frac{I_C}{I_B} = \frac{3.65mA}{50\mu A} = 73.$$

$$I_E = I_B + I_C = 3.65mA + 50\mu A = 3.70mA.$$

Current and voltage Analysis :-



I_B : dc base current I_E : dc emitter current.

I_C : dc collector current.

V_{BE} : dc voltage at base with respect to emitter.

V_{CB} : dc voltage at collector with respect to base

V_{CE} : dc voltage at collector with respect to emitter.

V_{BB} forward biases base emitter junction.

It looks like forward biased diode and forward voltage drop $V_{BE} = 0.7V$

Apply KVL.

$$V_{R_B} = V_{BB} - V_{BE}$$

ohm's law $V_{R_B} = I_B R_B$.

$$I_B R_B = V_{BB} - V_{BE}$$

$$\boxed{I_B = \frac{V_{BB} - V_{BE}}{R_B}}$$

Apply KVL on other loop.

$$V_{CE} = V_{CC} - V_{RC}.$$

$$V_{RC} = I_C R_C.$$

voltage at the collector with respect to ground emitter.

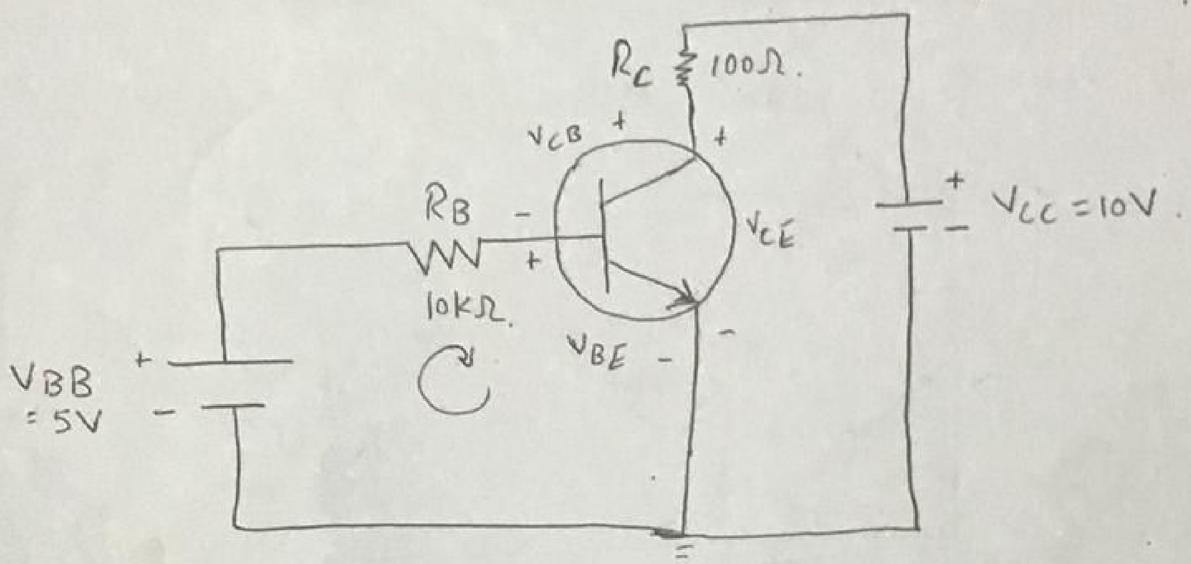
$\boxed{V_{CE} = V_{CC} - I_C R_C}$ where $\boxed{I_C = \beta_{DC} I_B}$

voltage across collector-base junction

$$\boxed{V_{CB} = V_{CE} - V_{BE}}$$

Example

Determine I_B, I_C, I_E, V_{BE}, V_{CE} & V_{CB} in the circuit. Transistor has $\beta_{DC} = 150$.



$$V_{BE} = 0.7V.$$

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5 - 0.7}{10k\Omega} = 430\mu A.$$

$$I_C = \beta_{DC} I_B = (150)(430\mu A) = 64.5mA$$

$$I_E = I_C + I_B = 64.5mA + 430\mu A = 64.9mA$$

for V_{CE} & V_{CB}.

$$V_{CE} = V_{CC} - V_{R_C} = V_{CC} - I_C R_C = 10 - (64.5mA)(100)$$

$$V_{CE} = 10 - 6.45 = 3.55V.$$

$$V_{CB} = V_{CE} - V_{BE} = 3.55 - 0.7 = 2.85V.$$