TRANSISTOR CURRENTS

Transistor current components

The various current components which flow across the forward-biased emitter junction and the reverse-biased collector junction.

The emitter current IE consists of hole current IPE (holes crossing from emitter into base) and electron current IC (electrons crossing from base into the emitter).

The ratio of hole to electron currents IPE/INE, crossing the emitter junction is proportional to the ratio of the conductivity of the P material to that of the N material.

In a commercial transistor the doping of the emitter is made much larger than the doping of the base. Because of this type of fabrication, there is one advantage.

That is, (in PNP transistor) the emitter current consists almost entirely of holes. Such a situation is a required one.

Because the current which results from electrons crossing the emitter junction from base to emitter does not contribute carriers which can reach he collector.

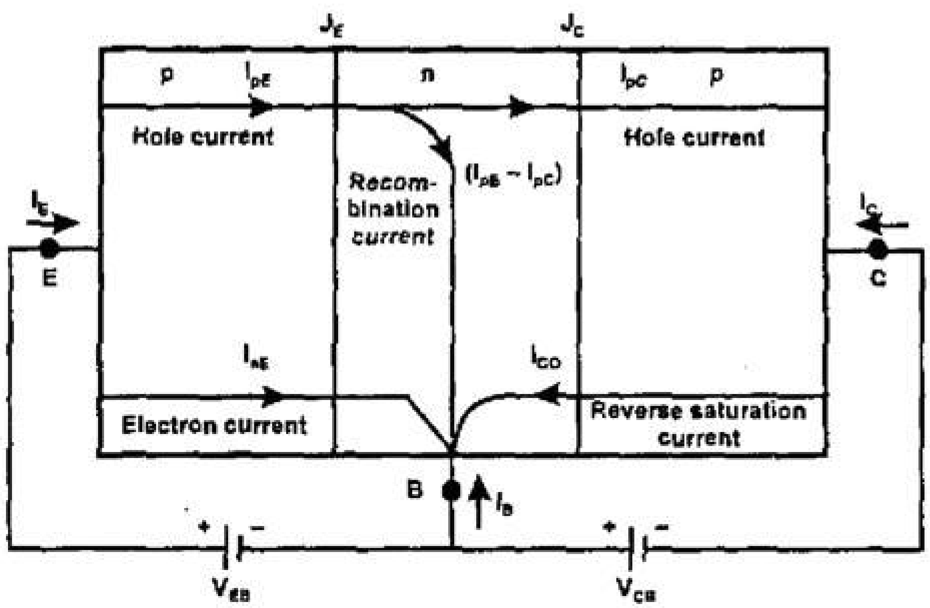

Fig.2.9. Transistor current components

All the holes crossing the emitter junction JE does not reach the collector junction JC because some of them combine with the electrons in the N-type base. If IFC is the hole current at JC there must be a bulk recombination current IPE-IPC leaving the base.

If the emitter were open-circuited so that IE= 0, then IPC would be zero. Under these circumstances, the base and collector would act as a reverse- biased diode.

The collector current IC would equal the reverse saturation current ICO, If IE not equal to zero then IC=ICO-IPC

For a PNP transistor, ICO consists of holes moving across JC from left to right (base to collector) and electrons crossing JC in the opposite direction.

Since the assumed reference direction for ICO, is from right to left, then for a PNP transistor, is negative. For an NPN transistor, ICO is positive. The various parameters which relate the current components discussed below.

EMITTER EFFICIENCY Y

The emitter, or injection, efficiency is defined as

$$\gamma \equiv \frac{\text{current of injected carriers at } J_E}{\text{total emitter current}}$$

In the case of a PNP transistor,

$$\gamma = \frac{I_{pE}}{I_{nE} + I_{nE}} = \frac{I_{pE}}{I_E}$$

where IPE is the injected hole diffusion current at emitter junction and is the injected electron diffusion current at emitter junction.

TRANSPORT FACTOR

The transport factor is defined as

$$\beta = \frac{\text{injected carrier current reaching } J_C}{\text{injected carrier current at } J_E}$$

In the case of a PNP transistor,

= IPC/IPE

LARGE SIGNAL CURRENT GAIN

It is a ratio of the negative of the collector-current increment to the emitter- current change from zero (cutoff) to as the large-signal current gain of a common- base transistor, or

$$\alpha = \frac{I_C - I_{CO}}{I_E}$$

Since IC and IE have opposite signs, then a, as defined, is always positive. Typical numerical values of a lie in the range of 0.90 to 0.995.

$$\alpha = \frac{I_{pC}}{I_E} = \frac{I_{pC}}{I_{pE}} \frac{I_{pE}}{I_E}$$

$$\alpha = \beta\gamma$$

The transistor alpha is the product of the transport factor and the emitter efficiency. This statement assumes that the collector multiplication ratio2 is unity.

is the ratio of the total current crossing JC to the hole current (for PNP transistor) arriving at the junction. For most transistors, = 1.

It should be pointed out that is not a constant, but varies with emitter current ‘F’ collector voltage V and temperature.

If the transistor is in its active region (that is, if the emitter is forward-biased and the collector is reverse-biased), the collector current is given by Eq. (2.4), or

$$I_C = -\alpha I_E + I_{CO}$$

In the active region the collector current is essentially independent of collector voltage and depends only upon the emitter current.

If the above eqn is generalized then it is applied to the reverse biased collector junction and for any voltage across J. To achieve this generalization ICO is replaced by the current in a PN diode.

This current is given by the volt-ampere relationship of Eq. I=IO(eVn/VT-1), with IC replaced by ICO and V by VC where the symbol VC represents the drop across JC from the P to the N side. The complete expression for IC for any VC and IE is

Source : http://mediatoget.blogspot.in/2011/09/transistor-currents.html