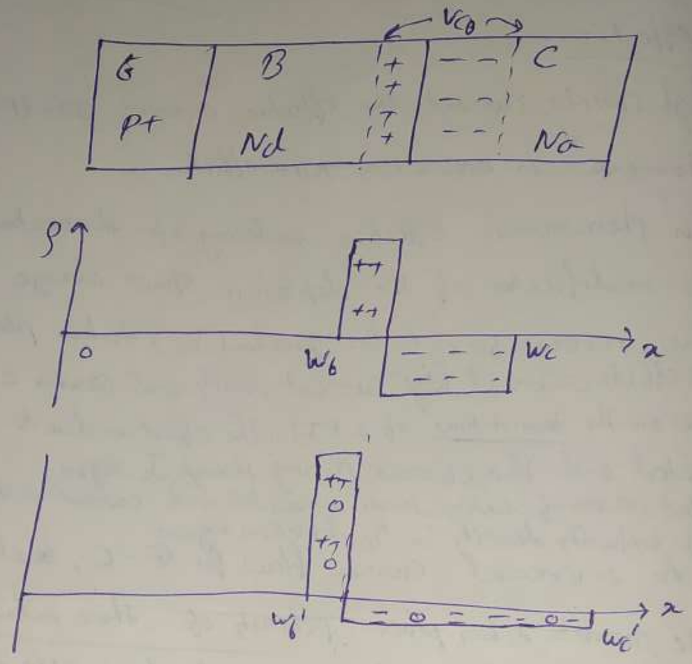
Kirk Effect:-

- At high collector current the effective current gain (β) dropped. This phenomenon is known as kirk effect.
- In this phenomenon effective widening of the neutral base due to modification of the depletion space charge distribution at the reverse biased B-C junction (J_C) takes place.
- The kirk effects occur at high current density and causes a dramatic increase in the transit time of a BJT. The effect is due to charge density associated with the current passing through J_C region.
- This effect occurs if charge density associated with current is larger than the ionised impurity density in J_C depletion region.
- Due to increased current flow for E-C, buildup of mobile carrier takes place. Polarity of these mobile charges adds to fixed donor charges on the base side of B-C depletion region and substracts from the fixed acceptor charges on the collector side of junc^n.
- Hence, fewer uncompensated donors (Smaller depletion width) are needed to maintain reverse bias V_{CB} across the junc^n. Also due to that neutral base width increases.
- Due to this phenomenon effective widening of the neutral base region in collector region takes place. Also a drop of current gain and increase of base transit time take place.



(a) Cross section of PNP BJT

(b) Space charge distribution in Jc reverse biases for very low current

(c) Space charge distribution in Jc reverse bias for high current.

The electric field at Jc from poisson's eq^n is given by.

$$\frac{d\mathcal{E}}{dx} = \frac{1}{\epsilon}\left[q(N_d^+ - N_a^-) + \frac{I_c}{A v_d}\right]$$

v_d — drift vel.

$\frac{I_c}{A v_d}$ — mobile carrier charge concentration.

V_{CB} & Electric field E is related by.

$$V_{CB} = -\int_{W_b}^{W_c} \mathcal{E}\, dx$$

- Assuming V_{CB} ~~&~~ ~~const~~ is fixed and I_C increases.

- In poission's eqn the extra holes injected into the depletion region have same effect if doping level on base side were increased and that on collector side decreased.

- The base widening can extend at even higher current levels all the way through the lightly doped collector region to the heavily doped buried sub-collector.

High freqⁿ Transistor :-

MOD-4 GD-19

Basic requirement of high freqⁿ Transistor are as below

- Physical size should be small.
- Base width must be narrow to reduce transit time.
- Emitter and collector areas must be small to reduce junction capacitance.
- Effective resistance associated with each region should be minᵐ so that RC charging time should be minᵐ.

A tradeoff betⁿ power and size is present for high freqⁿ transistor. Method of enterdigitation provides a means of increasing the useful emitter edge length while keeping overall area to a minimum. To minimise the effective resistance between E, B & C, hence RC time will be effected accordingly.

- Reduction of base resistance by heavy doping of the base requires the use of a heterojunction to maintain γ at an acceptable value.
- Collector depletion region must be kept as small as possible to reduce transit time of carrier drifting through collector juncⁿ. This can be accomplished by making lightly doped collector region narrower.
- The packaging of transistor should be perfect to reduce the parasitic resistance, inductance or capacitance at high freqⁿ.