Breakdown voltage considerations of a transistor:

In a transistor switch, the voltage change which occurs at the collector with the switching is nominally equal to the collector supply voltage V_{CC}. since this voltage change will be used to operate other circuits and devices, then for the sake of reliability of operation, V_{CC} should be made as large as possible.

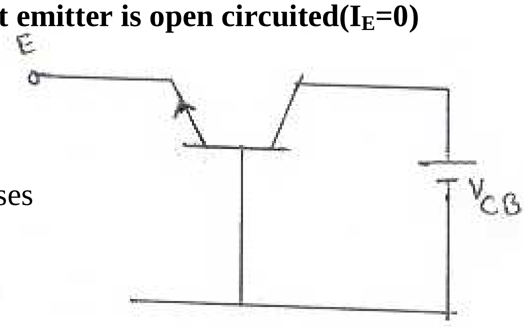
But if V_{CC} is high , reverse biased voltage across the collector junction is also high (since $V_{CB} = V_{CE} - V_{BE}$). due to this breakdown is attained.

Relation between BV_{CBO} & BV_{CEO} :

Assume that BV_{CBO} is collector to base breakdown voltage when emitter is open circuited

And BV_{CEO} is collector to emitter breakdown voltage when base is open circuited.

Consider a **transistor in CB configuration and assume that emitter is open circuited(I_E=0)** as shown in figure.



Here Due to V_{CB} , $I_C = I_{CO}$ since collector junction is in

Reverse biased condition. if V_{CB} increases I_{CO} is also increases

Due to the avalanche multiplication of charge carriers.

So $I_C = M I_{CO}$, where M is avalanche multiplication factor.

If V_{CB} is further increases ,at a high enough voltage ,

Namely BV_{CBO} , the multiplication factor M becomes nominally infinite and the region

of breakdown is attained.

The avalanche multiplication factor depends on the voltage V_{CB} between collector and base. We shall consider that

$$M = \frac{1}{1-\left(\frac{V_{CB}}{BV_{CBO}}\right)^n} \text{--------(1)}$$

Where n is an integer .it is in the range of 2 to 10.

If emitter is not open circuited ($I_E \neq 0$):

Current gain of a transistor in CB configuration is $\alpha = \frac{I_C}{I_E}$

So $I_C = \alpha I_E$

Taking avalanche multiplication into account , $I_C = M\alpha I_E$

Consequently, it appears that , in the presence of avalanche multiplication ,

the transistor behaves as though its common-base current gain were α^* , where

$\alpha^* = M\alpha$

Transistor in CE configuration :

Current gain of a transistor in CE configuration is $h_{FE} = \dfrac{\alpha}{1-\alpha}$

In the presence of avalanche multiplication the CE current gain is $h_{FE}{}^*$, where

$$h_{FE}{}^* = \frac{\alpha^*}{1-\alpha^*} = \frac{M\alpha}{1-M\alpha}$$

if $M\alpha = 1$ ----(2) , then current gain in CE configuration is infinite .this means breakdown is attained.

From equations (1) &(2) ,

$$\frac{1}{\alpha} = \frac{1}{1-\left(\dfrac{V_{CB}}{BV_{CBO}}\right)^n}$$

$$V_{CB} = BV_{CBO}\sqrt[n]{1-\alpha}$$

Since V_{CB} at break down is much larger than the small forward base-to -emitter voltage V_{BE} , we may replace V_{CB} by V_{BE} in the above equation.

Also $1-\alpha = \dfrac{\alpha}{h_{FE}} \approx \dfrac{1}{h_{FE}}$

Therefore $V_{CE} = BV_{CBO}\sqrt[n]{\dfrac{1}{h_{FE}}}$ -----(3)

Finally we note that the condition imposed above that the base current be fixed implies a current generator at the base, that is, source of infinite impedance. Equation (3) consequently gives the breakdown voltage under the condition that the base is open circuited (with respect to signal or ac variations).

So in equation (3) , we can replace V_{CE} with BV_{CEO}

Therefore $$BV_{CEO} = BV_{CBO}\sqrt[n]{\frac{1}{h_{FE}}}$$

Breakdown voltage with base not open circuited:

Assume that the base is returned to the emitter through a resistor R_B and a DC voltage source V_{BB} as shown in figure.

We may expect that the breakdown voltage , designated BV_{CEX} , will lie between BV_{CEO} and BV_{CBO}.