NOTES

The basic connections of the transistor in amplifier circuits

The common base configuration .

The common base configuration is shown in Fig (68) . The input and output of the circuit have a common Base . The current relationships (from section) can be written as follows :

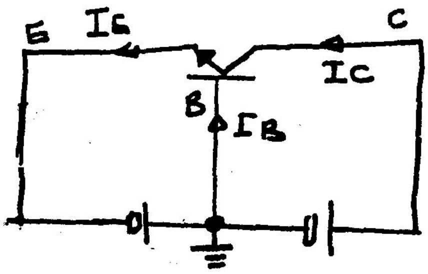
$I_C = \alpha I_E + I_{CBO}$;

I_{CBO} being the leakage current , due to the fact that the emitter/base junction is open circuited ---> reverse biased , and ,

$I_B = (1-\alpha) I_E$

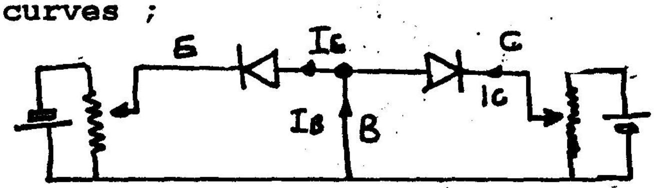
and ,

$I_C = \alpha I_E$



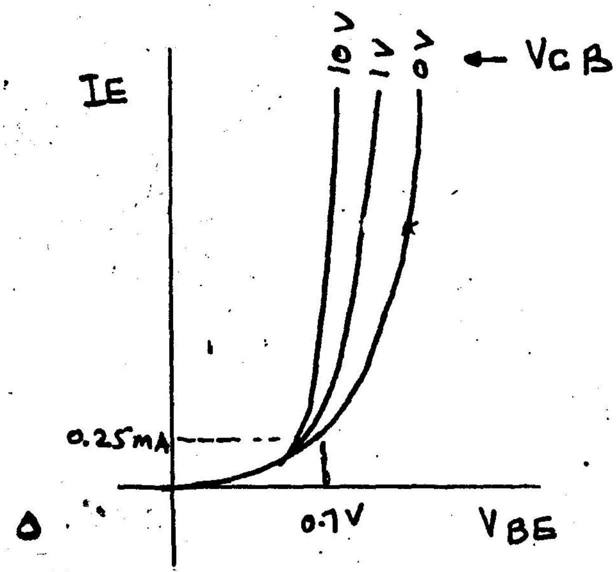
Fig(68)

5.4.1.1 The common base static characteristic curves :
(a) The input characteristic curves ;



Fig(69)

referring to Fig (69) ,The input characteristic curves are found by determining the relationship (curves) between I_E and V_{BE} (input circuit) , for a given set of values of V_{BC} . Such curves are shown in Fig (70) . With V_{CB} open circuited , the base/emitter junction behaves as forward biased . As V_{CB} is increased , the depletion layer of the base/collector junction increases , causing a reduction of the effective base layer width (The early effect ---- see reference book for more details) , causing an increase in the value of



Fig(70)

IE and intern , an increase in the IE for a given VBE .
It should be pointed at this stage ,that the gradient of the an input characteristic curve , at a given operating point defined by I_{EQ} and V_{CBQ} , has a dimension of resistance , i.e.

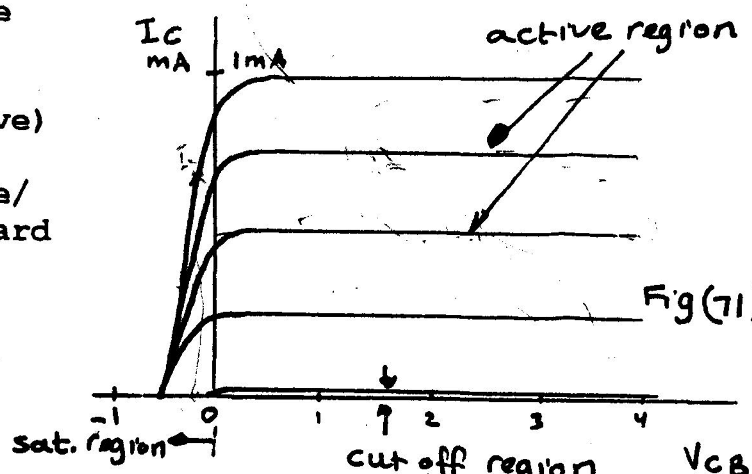
$\Delta V_{EB} / \Delta I_E$ | at Q point

This is known as the input resistance h_{ib} (b denotes the common base configuration).

(B) The output characteristics

In obtaining these curves , relationships between I_C and V_{CB} for given values of I_E are obtained as shown in Fig (71) .

Such curves depicts three distinct regions :



Fig(71)

(1) The operating (Active) region.
In this region , the base/ emitter junction is forward biased , while the base/ collector junction is reversed biased , i.e.

$I_C = I_E$ (approximetely

(2) The saturation region
As a negative V_{CB} is applied , the collector/base junction become forward biased, injection current as shown , fig (72),i.e.the resultant I_C drops to zero .

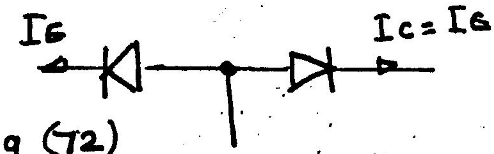


Fig (72)

(3) the cutoff region
In this region , both transistor junctions are reversed biased , i.e. no current flow , except for the leakage current I_{CBO} .

As in the case of the input circuit , the gradient at a particular operating point (I_C , V_{CB}) is given by ;

$\Delta I_C / \Delta V_{BC}$ | at Q point ,
This is known as the output conductance of the transistor and is denoted by h_{ob} (b denotes the common base connection) , i.e. , the output resistance = 1 / h_{ob}

i.e. the CB Transistor configuration has low input resistance (impedance) and a high output resistance , which makes coupling between stages difficult .

~~5~~4.3.2 The common emitter configuration

In this configuration , shown in Fig (73) ,, the base of the transistor is arranged as the input terminal and the collector as the output terminal , with the emitter being common to both input and output of the circuit .

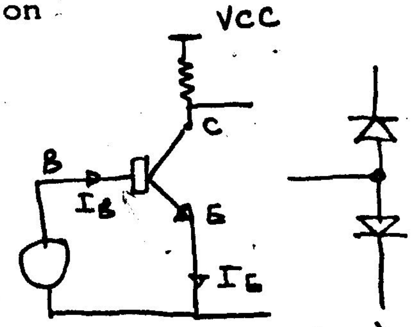


Fig (73)

Using similar procedures to that outlined in the common base configuration , we have ,

$I_B = (1 - \alpha)/\alpha \; * \; I_C$

or ,

$I_B = I_C / \beta = I_C / H_{FE}$

and since $I_E = I_C + I_B$ then , from simple manupilation of the above equation and adding the component of the leakage current derived for the common base confoguration (from $I_C = \alpha I_E + I_{CBO}$), would yield ;

$I_C = \alpha (I_C + I_B) + I_{CBO} \quad \therefore \quad I_C[1-\alpha] = \alpha I_B + I_{CBO}$

$I_C = \alpha I_B / (1-\alpha) + I_{CBO} / (1-\alpha)$

the term $I_{CBO} /(1-\alpha)$ is called the leakage current in the common emitter mode with I_B set equal to zero) and is denoted by I_{CEO}

It ie clear that $I_{CBO} /(1-\alpha)$ approximately equals $\beta * I_{CBO}$, for $\alpha == 1$.

i.e. the leakage current in the common emitter case is much larger that the common base case , by a factor of β .

5.4.2.1 The common emitter static characteristics

(a) The input characteristics ;

considering the following curves, Fig (74) , (V_{BE} abainst I_B), then we observe that for V_{CE} =0 and V_{BE}=0 then I_B=0 , since both diodes are reversed biased . If V_{CE} is kept at zero level and

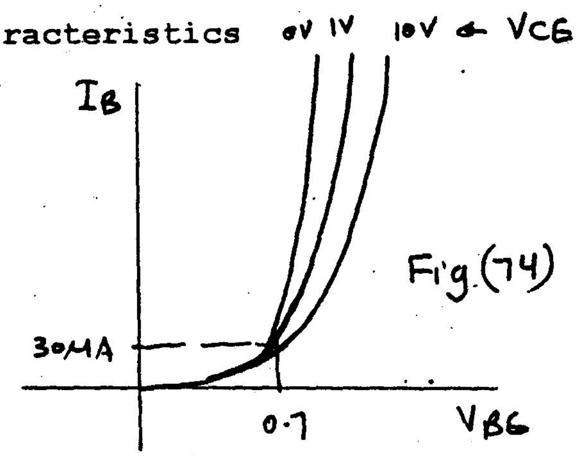
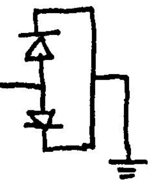


Fig (74)

V_{BE} is increased then rapid increase in the I_B occurs and the combined diode behaves as a simple forward biased diode , as shown in Fig (75) .As V_{CE} is further increased (with VBE remains constant) the value of IB decreases (because one diode , BC , is reversed biased and the other diode , BE , is forward biased).
The static input resistance of the transistor in this configuration = $V_{BE} / I_B |$ at any point on the curve .This value would vary very widley , depending on which part of the curve the quantity is evaluated . On the other hand , the small signal dynamic (operating) resistance is important and is given by :

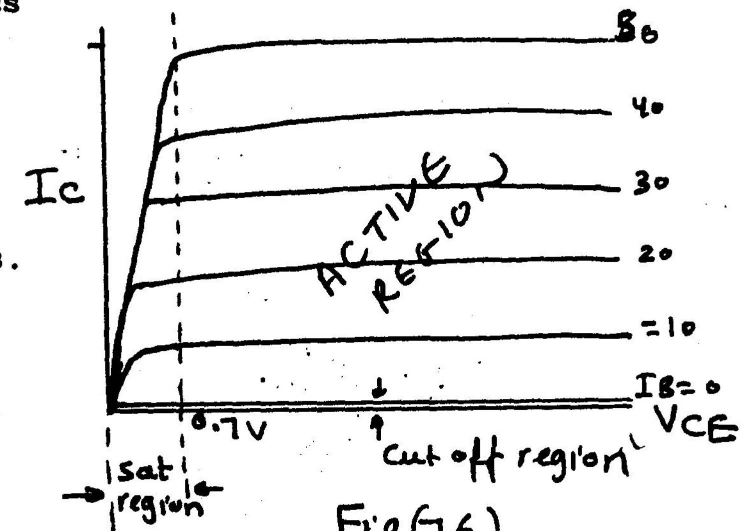
Fig(15)



$\Delta V_{BE} / \Delta I_B \;|_{\text{at Q point}} = h_{ie}$
$= V_T / I_B \;|_{\text{at Q point}}$
$= 26\text{ mv} / I_B$, at room temperature , see reference book on how these equations were derived .

(b) The output characteristics

The following set of curves , Fig (76), illustrate the way in which the collector current Ic varies with the collector voltage , for a given values of base currents. Such curves are called the output characteristic curves of the transistor in the common emitter configuration. The curves display three distinct regions :



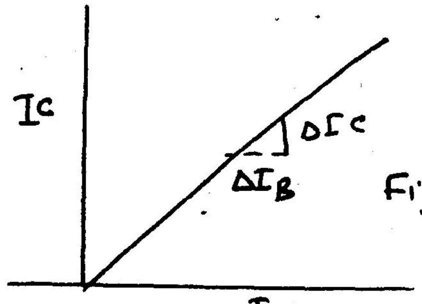
Fig(76)

(1) The Active region .
In this region , the collector /emitter voltage exert little control on the collectcurrent , due to the fact that , the collector/base junction is reversed biased and thus does not contribute to the Ic and I_E current which result from the forward bias of the base/emitter junction .

If the transistor is to be used as a linear amplifier , it must be used in this region (the equations relating the currents of the transistor and which were presented at the bigining of this section , are applicaple in this region).
IN this region , three parameters are of interest ;
[1.1] The gradient of a particular curve , for a given I_B and V_{CE} is given by :

$\Delta I_C / \Delta V_{CE} = h_{oe}$ = the ouput conductance of the transitor in the common emitter configuration , thus the output resistance = 1 / h_{oe} (the e denotes the common emitter connection)

[1.2] If we construct a plot of Ic against I_B ,Fig (77), using the output characteristic curves , then the gradient of the resulting curve would yield a quantity given by :

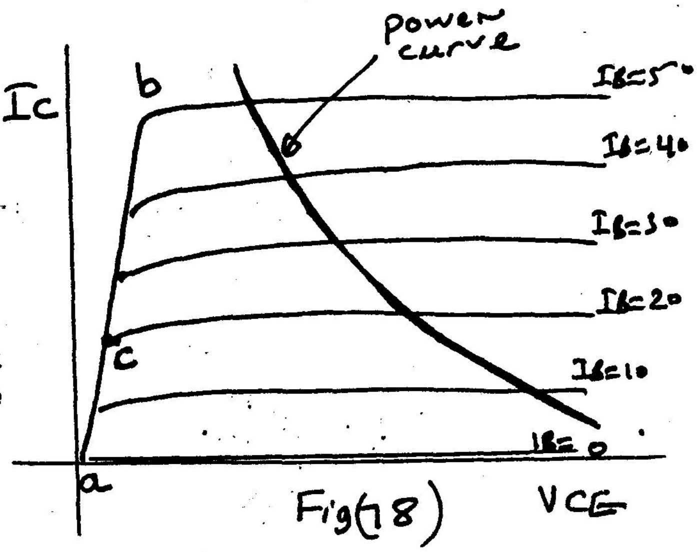


Fig(77)

$\Delta I_c / \Delta I_B \mid V_{CE}$ = constant
= h_{fe}
= the dynamic operating current gain of the transistor (not to be confused with the static current gain H_{FE}).

[1.3] The safe power operating range

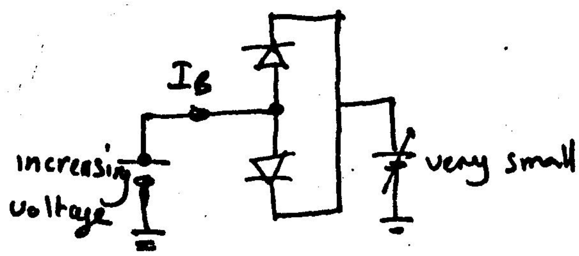
In using the transistor , the maximum power dissipated (as specified by the manufacturers) should not be exceeded . A maximum power curve ,Fig (78), for variable V_{CE} and Ic , can be constructed on the same set of output characteristics curves (hyperobola $V_{CE} . I_c$ = constant). In order that the power is not exceded , the transistor must be operated to the left of the power curve .



Fig(78)

(2) The saturation region .

Point C on the curve Fig (76), corrosponds to a base current equals or greater than 20 mA . It follows that the collector current does not increase in value with any increase in base current . Such analogy applies to the A B portion of the curves and is identified as the saturation region of the common emitter configuration .In this region both the base/emitter and base/collector diodes are forward biased as shown in Fig (79).



Fig(79)

(3) The cut off region .

When the base current is zero , virually no collector current willflow . This part of the output characteristic curves is called the cut off region and both diodes (junctions) of the transistor are reversed biased as shown in Fig (80) .

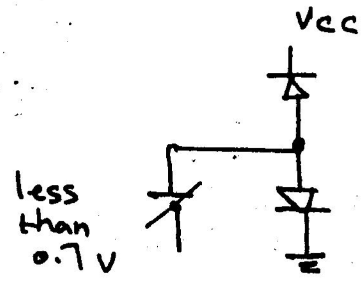
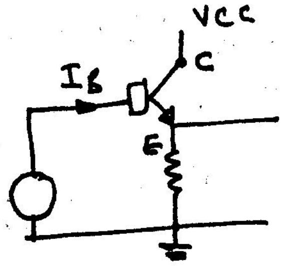


Fig (80)

~~5.4~~ 4.Y.3 The common collector configuration (Emitter follower)

Referring to Fig (81) which shows a typical common collector circuit . Such circuit is essentially the same as the common emitter circuit , except that the load resistor is in the emitter lead rather than in the collector lead . If we continue to specify the operation of the ciruit in terms of currents which flow in it , then the operation will be tha same as that of the common emitter configuration . When no base current flows in the circuit (except for leakage) then the emitter current will also be zero and thus no current will flow in the load . As IB is increased from zero value , the transistor will pass through the active stage and evantually reach saturation . In this case , most of VCC will appear across the load resistor (- 0.2 V) .



Fig(81)