Experiment: 2

TRANSISTOR CHARACTERISTICS

AIM: To study the input and output characteristics of the given npn transistor in common emitter configuration and hence to determine β, α, input resistance and the knee voltage.

APPARATUS: Transistor, variable DC power supplies, micro-ammeter, milli-ammeter, digital voltmeter and resistor.

INTRODUCTION: The transistor is an active device. A bipolar transistor has three separately doped regions and two p-n junctions. Typical impurity concentrations in the emitter, base and collector are of the order of 10^{19}, 10^{17} & 10^{15} cm^{-3} respectively.

There are three modes of operation.

• Forward-active (Base-Emitter Forward Bias, Base-Collector Reverse Bias)

• Cut-off (Base-Emitter Reverse Bias, Base-Collector Reverse Bias)

• Saturation (Base-Emitter Forward Bias, Base-Collector Forward Bias)

When a transistor is in the fully-off state (like an open switch), it is said to be *cutoff*. Conversely, when it is fully conductive between emitter and collector (passing as much current through the collector as the collector power supply and load will allow), it is said to be *saturated*. These are the two modes of operation explored thus far in using the transistor as a switch.

However, bipolar transistors don't have to be restricted to these two extreme modes of operation. If the collector current is greater than zero but less than the maximum allowed by the power supply and load circuit, the transistor will "throttle" the collector current in a mode somewhere between cutoff and saturation. This mode of operation is called the *active* mode.

In active operation mode, input circuit is forward biased and output circuit is reverse biased. In cut-off mode, both the Input & output circuits are forward biased.

Common emitter configuration: Here emitter is common to both input and output terminals. The basic amplifying action is produced by transferring the source current from a low to a high resistance circuit.

There are three major types of transistor

• Bipolar junction transistor or BJT

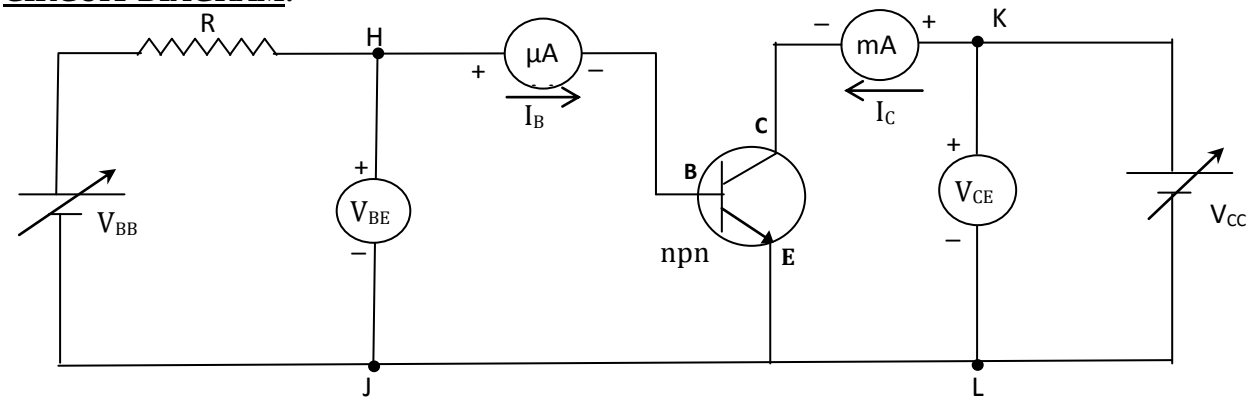
• Metal-oxide field effect transistor or MOSFET

• Junction FET or JFET

Amplification: A signal is actually a small variation in input voltage. When a small voltage difference is given to the input circuit the current I_E will be very high because the resistance in the B-E junction (R_{in}) is low. As the base is very thin and doped in a low level it cannot handle this electron flow. Therefore most of

the electrons (almost all the electrons) slip to the collector which means $I_C \approx I_E$. But as mentioned above the resistance in the B-C junction (Rout) is very high. Therefore the voltage difference in the output circuit which is equal to $I_C R_{out}$ will be greater than the original voltage difference of $I_E R_{in}$.

CIRCUIT DIAGRAM:



FORMULAE:

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

Where β is the current gain in the common emitter configuration

ΔI_c is the change in collector current in A

ΔI_B is the change in base current in A

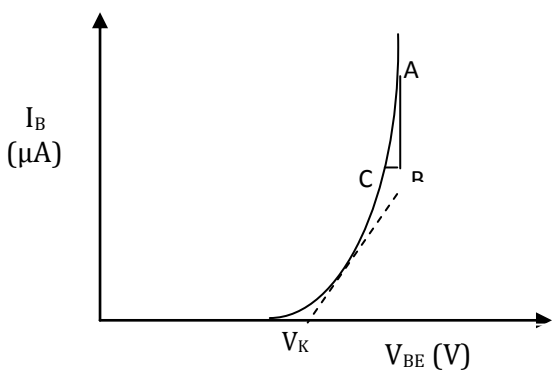
$$\alpha = \frac{\beta}{1+\beta}$$

Where α is the current gain in the common base configuration.

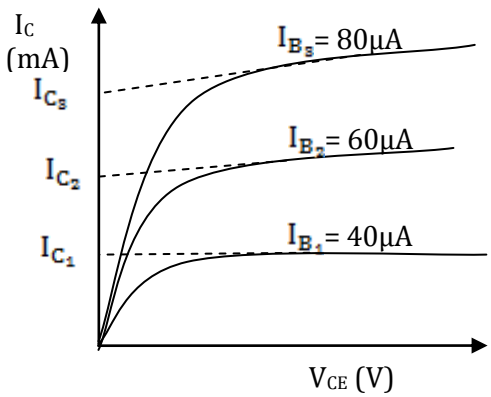
Input resistance, $R_{in} = \frac{1}{Slope} = \frac{V_{BE}}{I_B}\ \Omega$

NATURE OF GRAPH:

Input characteristics



Output characteristics



PROCEDURE:

1. Make the circuit connections as shown in the circuit diagram.
2. To study input characteristics, V_{CE} is set to 2V.
3. V_{BE} is increased from zero to 0.8V in steps mentioned in the table and the corresponding I_B values are noted from micro ammeter.
4. For output characteristics I_B is set at 40μA by varying V_{BE} and V_{CE} is varied as given by varying V_{CC}.
5. Corresponding readings of current are noted from milliammeter and this process is repeated for I_B=60 μA and I_B=80 μA.
6. Now a graph of I_B vs V_{BE} is plotted and input resistance and the knee voltage are calculated.
7. I_C vs V_{CE} is plotted and current amplification factors α and β are calculated.

CALCULATIONS:

$$\beta_1 = \frac{I_{C_2} - I_{C_1}}{I_{B_2} - I_{B_1}} =$$

$$\beta_2 = \frac{I_{C_3} - I_{C_2}}{I_{B_3} - I_{B_2}} =$$

$$\beta_3 = \frac{I_{C_3} - I_{C_1}}{I_{B_3} - I_{B_1}} =$$

$$\beta = \frac{\beta_1 + \beta_2 + \beta_3}{3} =$$

$$\alpha = \frac{\beta}{1+\beta} =$$

TABULAR COLUMN & OBSERVATION:

Input characteristics

V_{CE}=2V constant	
V_{BE} (V)	I_B (μA)
0	
0.1	
0.2	
0.3	
0.4	
0.5	
0.55	
0.6	
0.65	
0.7	
0.75	
0.8	

Output characteristics

V_{CE} (V)	I_B=40μA	I_B=60μA	I_B=80μA
	I_C (mA)	I_C (mA)	I_C (mA)
0			
0.05			
0.10			
0.15			
0.20			
0.25			
0.30			
0.40			
0.50			
0.60			
0.70			
0.80			
0.90			
1.0			

RESULT:

The input and output characteristics of the given npn transistor in common emitter configuration are studied.

1. The knee voltage V_K is ……V
2. The value of β …….
3. The value of α …….
4. Input resistance R_{in} ……..Ω

References:

1. Semiconductor devices, Kannan Kano,1998,PHI,Indian Edn, (page 220 – 228)
2. Basic principles of Electronics,V K Mehta,1988,S Chand Publn, (Page 174-181)
3. Electronic Devices and Circuit Theory, Robert Boylestad, PHI publn,1998, (Page 114 - 128).