Kathmandu University
Department of Electrical and Electronics Engineering
ANALOG ELECTRONICS LABORATORY WORK

EXPERIMENT 6: Bipolar Junction Transistor Characteristics

Objectives: To understand transistor action and design a simple inverter and amplifier using a Bipolar Junction Transistor.

Materials and Equipment:
Resistor: 1K [2] Oscilloscope Probe: [3] Transistor: 2N222A [1]

Theory:
For a normal transistor action emitter diode is always forward biased ($V_{EB} > V\gamma$) and collector diode is always reversed biased. If it is the case then $I_C = \alpha I_E$.

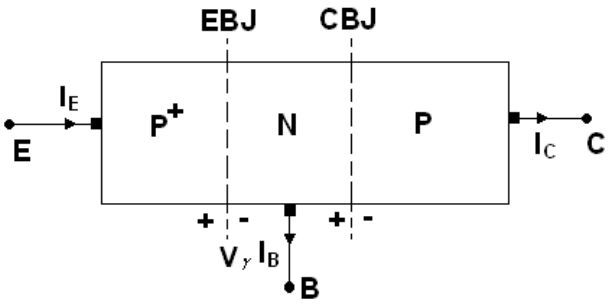

Fig: 1

The emitter current is given by $I_E = I_{EO} \exp\left(\frac{V_{EB}}{V_T}\right) \cong I_C$. Thus we have seen that collector current is not the function of reverse collector potential but it is solely the exponent function of base-emitter potential. This is valid as long as transistor is in the active region of operation. The collector current is related to base current by a very large factor β, where $I_C = \beta I_B$. With this view transistor is actually CCCS.
If you think collector current is controlled by base emitter potential then transistor is VCCS☺.

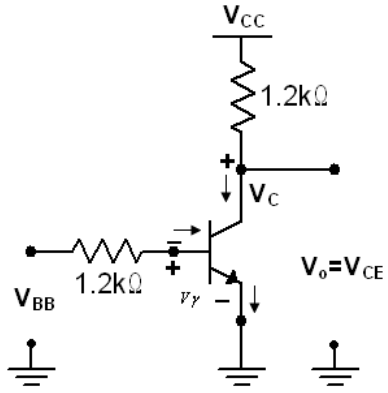

Fig: 2

In fig 2, V_{CC} is required to make the collector potential higher than the base potential. The collector resistor converts the collector current into the voltage and also establishes a desired DC bias voltage at collector. In the quiescent state, base (input) is at V_{BEQ} potential and collector (output) is at V_{CEQ} potential. The transfer function of the circuit in fig 2 can be found from the following relation.

$$V_O = V_{CE} = V_{CC} - I_C R_C$$

$$V_O = V_{CC} - \alpha I_{EO} \exp\left(\frac{V_i}{V_T}\right) R_C$$

This shows that when the input is very low (less then V_γ), output is at $V_{CC.}$ This is called cut-off region. When input voltage increases beyond V_γ then output voltage falls rapidly (exponentially). Then the collector current saturates at the value $I_{C(SAT)}$ (*please note that this is from circuit perspective)*. The collector potential no longer drops. We called this situation as transistor saturation. Between cut-off and saturation $(0.5 \geq V\gamma \leq 0.75)$ transistor has active region and acts as an amplifier in this region only. The complete Voltage Transfer Characteristics (VTC) of the circuit in fig 2 is shown in fig 3.

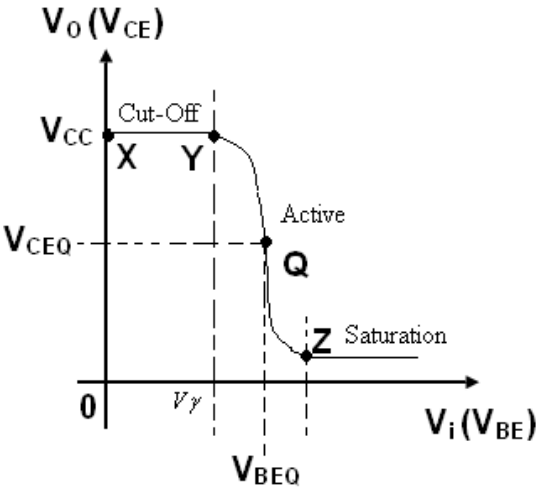

Fig: 3

To operate the transistor in the active region and to achieve linear amplification, V_{be} should be less then 26mV around the quiescent. When the input is below point Y, output is high. When the input is above point Z, output is always low. This is the inverter characteristics.

Procedure

1. Connect the circuit as shown in fig 2.
2. Fix V_{CC} @ 5V DC.
3. Apply V_{BB} by using another DC power supply arrangement.
4. Complete table 1.*Take current reading from multimeter.*

V_{BB} (Volts)	V_{CE} (Volts)	V_{CB} (Volts)	I_B (uA)	I_C (mA)
0.1				
0.2				
0.3				
0.4				
0.5				
0.6				
0.7				
0.8				
0.9				
1				
1.1				
1.2				
1.3				
1.4				
1.5				

Table: 1

5. Find the value of saturated collector emitter voltage ($V_{CE(SAT)}$).
6. Find the value of $I_{C(SAT)}$.

V_{CE} vs. I_C Characteristics @ Constant I_B

Procedure

1. Set V_{BB} @ 0.6V.
2. Measure the base current using multimeter.
3. Complete table 2.

V_{CC} (Volts)	V_{CE} (Volts)	V_{RC} (Volts) ($V_{CC} - V_{CE}$)	$I_C=(V_{RC} / 1.2)$ mA
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
15			

Table: 2

Voltage Transfer characteristics

Procedure

1. Remove the V_{BB} supply and set V_{CC} @ 5V DC.
2. Connect 100Hz sine @ 1V peak amplitude across the base resistor through the function generator.
3. Connect CHX of oscilloscope across the input and CHY across the collector. (Oscilloscope setting: *DC mode, Dual display position).*
4. See the output in YT mode by suitably adjusting the scale (V/Div).
5. Remember NOT gate ☺ and YT mode output.
6. See the output in XY mode by suitably adjusting the ground position. *Use DC mode.*
7. Compare the output with fig 3.
8. Adjust the offset and amplitude in the FG until you get linear amplification in CHY. *Remember small signal <<26mV. Use AC mode in the scope. Use YT display mode.*
9. See the phase inversion between the input and the output.
10. Check the DC voltage across the base.
11. See the linear amplifier characteristics in XY mode.
12. In YT mode see the effect on CHY output by changing V_{CC} from 5V to 15V in step of 2V.

Linear Amplifier ☺
Non-Linear Amplifier ☹