NELSON EBIMIEDEI JACOB
ND/ELECT/ 20/045

ELETRONICS 1

BY
ENGR. EBIMOBOWEI YABEFA

CamScanner

NELSON EBIMUBDEI JACOB
ND/ELECT/20/045

ELECTRONICS 1

BY

ENGR. EBIMOBOWEI YABEFA

CS CamScanner

Experiment 1

BIASING A DIODE

Materials Required

Components

- Potentometer Linear 2KΩ
- Resistor, 100Ω, 2W
- Silicon diode, IN 4148 or equivalent

Equipment

- 0 - 50V voltmeter d,c
- 0 - 10mA ammeter, d.c
- 0 - 100A ammeter, d.c
- Stabilized Power supply unit 0-60V

PROCEDURE

(A) Forward Biasing

(i) Set up the circuit shown in Fig. 1 for the silicon diode and switch on the power supply set at 5V.

(ii) Turn the potentiometer R1 gradually so that the applied voltage, V (measured by the 0-5V voltmeter) varies gradually in steps of 0.1V, starting from zero volt and stopping at a maximum of 0.8V. Measure the corresponding current I for each value of applied voltage, and record your readings as shown in Table 1 below.

(iii) Repeat steps (i) and (ii) for the germanium diode, except that the maximum applied voltage should not exceed 0.5V. Record your results as shown also in Table 1.

(iv) Switch off the power supply

(B) Reverse biasing

(v) Set up the circuit shown in Fig. 2 for the silicon diode.

(vi) Switch on the power supply and set it to read 50V.

(vii) Measure the current (using the 0-100mA ammeter) as you gradually turn the potentiometer R1 to produce varying reverse applied voltage

CamScanner

NAME : NELSON EBIMOKUEI JACOB

in steps of -2V, starting from zero volt to – 10 volts and subsequently in steps of -5V up to -30V, as shown in Table 2.

(viii) Repeat steps (v) to (vii) for the germanium diode.

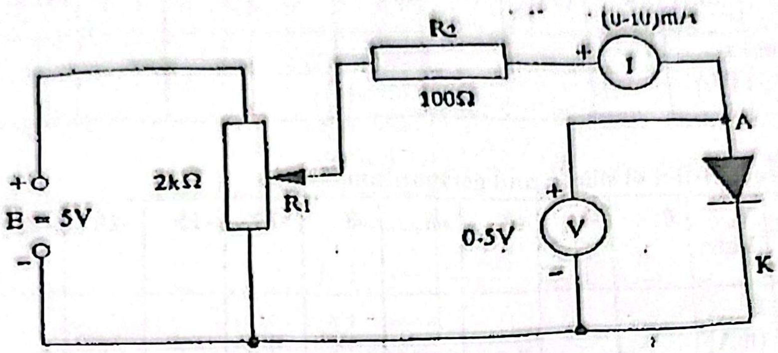


Fig. 1. Forward-biasing mode of the diode

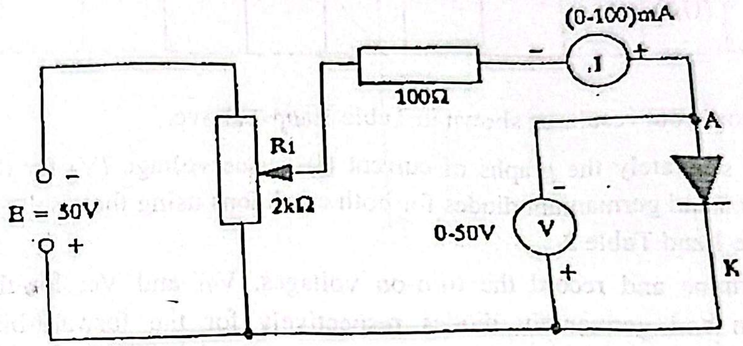


Fig. 2 Reverse-biasing mode of the diode

N.B. Only negative voltages and currents are implied in this step. The change in connection to the terminals of the micro-ammeter and voltmeter make the readings appear positive (see Table 2).

RESULT ANALYSIS

Table 1: Forward characteristics of silicon and germanium diodes

CamScanner

Type	V, Volts	0	0.1 0.025	0.2 0.05	0.3 0.125	0.4 0.25	0.5 4.	0.6	0.7 0.625	0.8 0.1
Silicon diode	I (mA)	0	0.	0	0	0	4.5	9.9	11.4	60
Germanium diode	I (UA)									

Table 2: Reverse characteristics of silicon and germanium diodes

Type	V, Volts	0	-2	-4	-6	-8	-10	-15	-20	-25	-30
Silicon diode	I (mA)										
Germanium diode	I (UA)										

1. Record your results as shown in Table 1 and 2 above.
2. Plot separately the graphs of current (I) versus voltage (V) for the silicon and germanium diodes for both conditions using the results in Table 1 and Table 2.
3. Determine and record the turn-on voltages. V_{01} and V_{02} for the silicon and germanium diodes respectively for the forward-bias condition from the graphs obtained in step 2.

4. Determine and record the saturation current (Io) and breakdown voltage V_B for both silicon and germanium diodes, (for the reverse-biased condition) from the graphs obtained in step 2.

……………………………………………………………………………

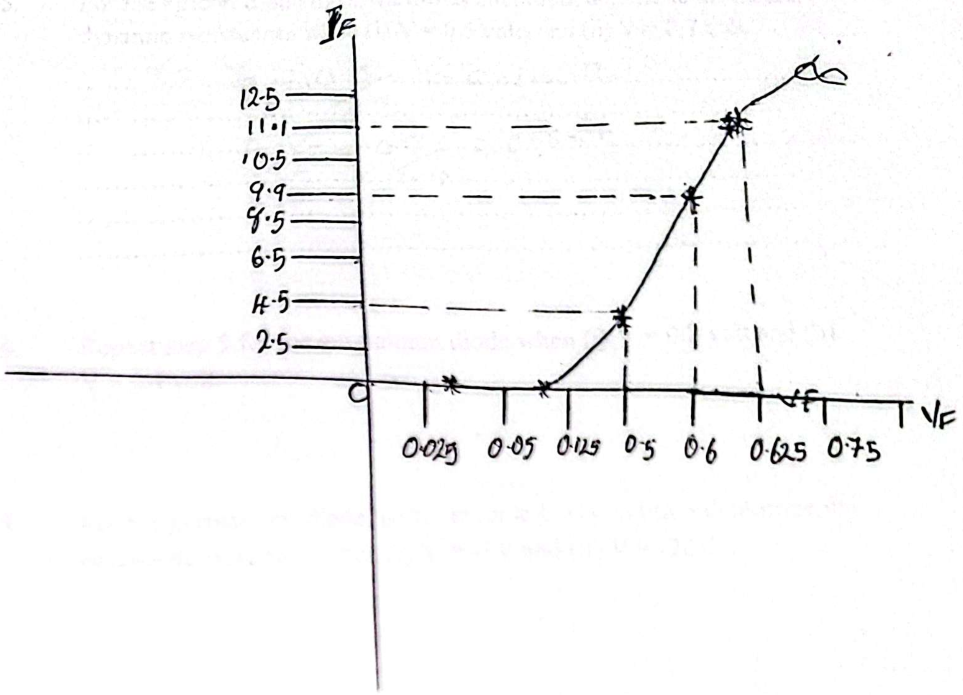
……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

CamScanner

NAME : NELSON EBIMIKDEI JACOB
DEPT : ELECT/ELECT
DATE : 04/11/21
MATRIC : ND/ELECT/20/045



……………………………………………………………………………

……………………………………………………………………………

5. For the silicon diode in forward-bias condition, determine the dc and dynamic resistances when (i) V = 0.5 volts and (ii) V = 0.7 volt.

$$r = \frac{V}{I} = \frac{0.5}{4.5} = 0.1 m\Omega$$

$$r_2 = \frac{V}{I} = \frac{0.7}{11.4} = 0.6 m\Omega$$

……………………………………………………………………………

……………………………………………………………………………

6. Repeat step 5 for the germanium diode when (i) V = 0.2 volt and (ii) V = 0.4 volt.

7. For the germanium diode, under reverse-bias condition determine the reverse dc resistance when (i) V = -5V and (ii) V = -20V

QUESTIONS

(a) Do the static characteristic curves plotted in step 2 resemble in shape those shown in Fig. 1? Explain briefly the differences, if any.

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

(b) What difference do you notice in values between the dynamic resistances for a germanium diode under forward-bias and reverse-bias conditions?

Hint: In answering this question you may use your results in steps 6 and 7

....

....

....

....

....

(c) DO the turn-on voltages determined for silicon and germanium diode in step 3 agree with the expected results? Explain the differences, if any.

Experiment 2
Zener Diode Characteristics

Materials Required

Components

- (Linear) Potentiometer, 2 kilo ohms
- Resistor 470Ω (2W rated)
- Zener diode, BZY 488, 6.8V, 500mW at 25^0C.

N.B. Any other zener diode of different breakdown voltage Vz may also be used.

Equipment

- Power supply, d.c., variable,.
- Electronic voltmeter.
- 0.10v, dc voltmeter
- 0-5, mA meter, d.c
- 0-10, mA meter, d.c.
- 0-30, mA meter, d.c (2Nos)
- 0-50, mA meter d.c
- Connection Leads or wires.

CS CamScanner

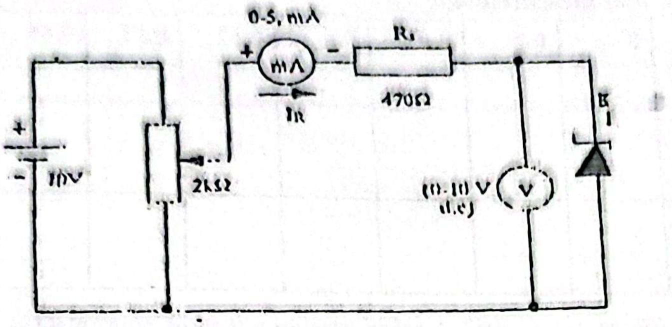


Fig. 3: Circuit showing zener diode in forward biasing condition.

Procedure

(A) Forward bias

(i) Connect the circuit of Fig. 3, keeping the power supply at 4V and the range of the voltmeter at 5v, max.

(ii) Measure and record in Table 1, the forward current IF in the diode at each level of applied voltage VF shown in the table.

(iii) Switch off the d.c power supply.

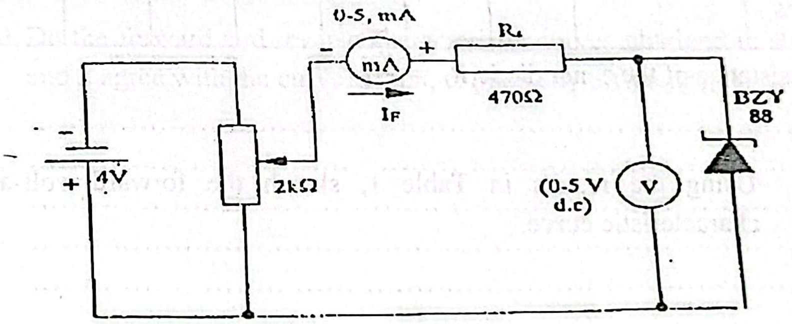


Fig. 4: Circuit showing zener diode in reverse-biasing condition.

Reverse bias

(iv) Connect the circuit of Fig.4, keeping the power supply and those of the miliammetre, compared with the connection of Fig. 3.

(v) Measure and record in Table 2, the reverse current IR in the diode at each level of applied voltage V shown in the table.

(vi) Meanwhile, switch off the d.c. power supply.

RESULT ANALYSIS

Table 1: Forward-bias measurements

V_f (Volts)	0	0.2	0.4	0.6	0.62	0.64	0.65	0.66	0.67
I_f (mA)									
R_f, ohms									

N.B. Forward resistance, $R_f = \frac{V_f}{I_f}$

Table 2: Reverse-bias measurements

V_r (Volts)	1	2	3	4	5	6	6.5	6.6	6.7	6.8	6.9
I_r (mA)											
R_r ohms											

N.B. Reverse resistance of the zener diode, $R_r = \frac{V_r}{I_r}$

1. Using the results in Table 1, sketch the forward volt-ampere characteristic curve.

2. Using the results in table 1, sketch the reverse volt-ampere characteristic curve.

CS CamScanner

3. **Determine from the reverse characteristic curve obtained in step 2 above, approximate the values of the following parameters: Io, Vzmin, I_{ZM} and I_{ZT}.**

....

....

....

....

....

....

QUESTIONS

(a) Do the forward and reverse characteristic curves obtained in steps 1 and 2 agree with the curve? If not, explain any difference(s)?

....

....

....

....

....

....

(b) Explain the reason for the changing values of R_F and R_Z obtained from Table 1 and Table 2 respectively.

....

....

....

....

....

....

....

(c) Given that the power and voltage ratings of the zener diode BZY 88 are P= 500mW and Vz = 6.8V respectively, determine the maximum permissible current through the diode.

....

....

....

....

....

....

Experiment 3

ZENER DIODE AS A VOLTAGE REGULATOR

Material Required

- * Linear potentiometer, 2kΩ
- * Resistor, 1 kΩ (1w), (2Nos)
- * Resistor, 100Ω (2w)
- * Zener diode BZY 88, 6.8V, 500mW at 25^{0}C or any other type, preferably with Vz< 10v.
    - ➢ Power supply, dc, variable unit.
    - ➢ Electronic voltmeter: (0-10)V dc voltmeter
    - ➢ (0-20)mA (dc) meter
    - ➢ (0-30) mA (dc) meters (2 Nos)

PROCEDURE

(A) Fixed V_i Variable R_L

(i) Connect the circuit of Fig. 1 with Vi = 20V fixed and load, Rl = 1kΩ connected (by linking A to X).

(ii) Measure Iz, Il and VL, record as specified in Table 1.

(iii) Disconnect the 1kΩ - load resistor and replace with RL = 470Ω. Repeat step (ii)

(iv) Disconnect the 470Ω - load resistor and replace with RL = 100Ω. Repeat step (ii).

NB: Use (0-50) mA meter to measure IL in this case.

(v) Meanwhile, switch off the dc power supply. Do not disconnect the whole circuit of Fig. 1. Replace only the (0-50) mA meter with the (0-10) mA meter.

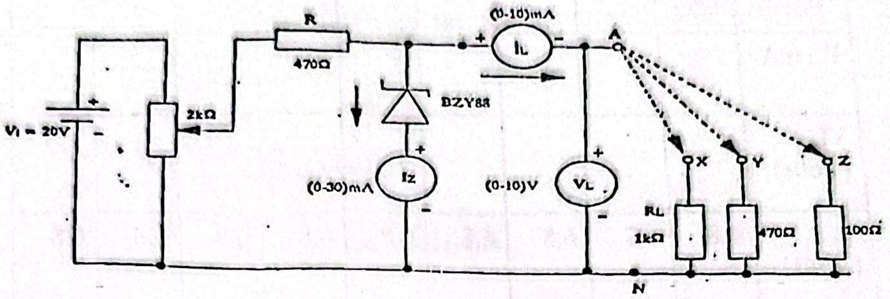


Fig. 1: Voltage regulator circuit using zener diode.

(B) Fixed R_L Variable Vi

(i) Connect the same circuit shown in Fig. 1 with R_L = 1kΩ

(ii) set the dc power supply initially to Vi = 10v

(iii) Measure and record Iz, I_L and Vz as specified in Table 2

(iv) Slowly increase Vi in steps of 1V until Vi = 20v, and repeat step (iii).

Table 1: Zener diode regulator with different loads. Fixed Vi = 20v, variable R_L.

	R_L = 1kΩ	R_L = 470Ω	R_L = 100Ω
I_L, mA			
Iz, mA			
Ii = (IL + Iz)mA			
V_L (Volts)			
Vz (Volts)	6.8	6.8	6.8
Vi (Volts)	20	20	20

N.B. If the Zener diode BZY 88 is not used in this experiment, then write down the voltage rating of the zener diode you used (instead of the 6.8V).

Table 2: Zener – regulator with Vi variable, fixed R_L = 1kΩ, variable V_i.

Vi(Volts	10	11	12	1	14	15	16	17	18	19	20
Iz, mA											
IL, mA											
VL, (Volts)											
Vz, (Volts)	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8

QUESTIONS

(a) Using Equation 3, determine the minimum value of load resistance R_L, min suitable for this experiment if Vi = 20V, Vz = 6.8v and R = 470Ω.

(b) How would you use your result in (i) to justify why Vi = 6.8v when the 100Ω - load was used (as recorded in Table 10.1)?

(c) Determine from Table 2 the range of values of Vi for which V_L differs from Vz by 0.1v.

(d) (i) Determine from Table 2 the least in the value of Vi when V_L begins to be equal to Vz. Regard this value of Vi as Vi,min (as illustrated in Fig. 3)? If yes, why?

....

....

....

....

....

....

....

....

(i) Is it possible to determine Vi,max in this experiment? If not, why?

....

CS CamScanner

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

(c) Given that the manufacturer's specification of the Zener diode (BZY 88) used in this experiment are as follows: P = 500mW and Vx = 6.8V, determine the maximum permissible current through the diode.

Experiment 4

Transistor characteristics

Materials Required

Components

- Linear potentiometer, 1 Megaohm
- Linear potentiometer, 25 kilo ohm
- Linear potentiometer, 500ohm
- PNP transistor, type OC71 or other suitable PNP silicon PNP transistor e.g can be used.

Equipment

- Stabilized d.c power supply (0-60v)
- (0-10)v d.c voltmeter
- (0-10)mA d.c ammeter (2Nos)
- Digital voltmeter
- Connection leads

Procedure

(A) Output characteristics (I_C versus V_{CB} for I_E = constant.)

(i) Connect the circuit of Fig.3 and turn R1 and R2 appropriately to set and keep I_E = 2mA initially.

CamScanner

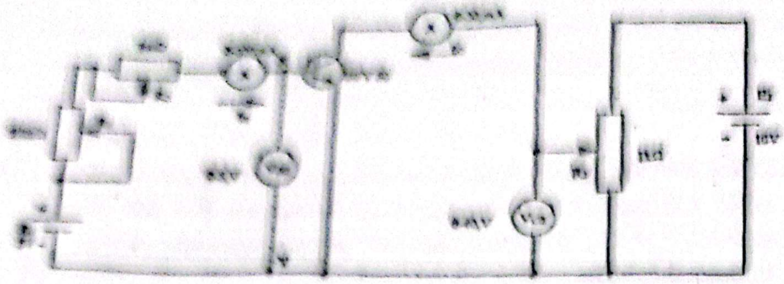


Fig. 3 Circuit connection for investigating static characteristics PNP transistor in CB

(ii) Next, vary V_{CB} from V to – 10V; (moving in steps of –1V) and obtain the corresponding value of IC for each value of VCB. Record your readings as shown in Table 1

(iii) Repeat step (ii) for IE = 4mA, 6mA, 8mA and 10mA.

Input Characteristics (I_E versus V_{EB}, for V_{CB} = constant)

(iv) Connect the circuit of Fig.3 with the voltmeter measuring V_{EB} connected but the milliammeter measuring I_c removed and replaced by a connection lead.

(v) Adjust R so that V_{CB} = OV. For this fixed value of V_{CB}, vary R_1 and R_2 (appropriately) in order to obtain varying value of I_E, starting from 0mA and moving in step of 1mA until 10mA is reached. For each value of I_E, record as shown in Table 2 the corresponding value of V_{EB} (measured by using the digital voltmeter set to maximum 2V d.c range).

(vi) Repeat step (v) for V_{CB} = -4v.

Transfer Characteristics (IC versus I_E, for V_{CB} – constant).

(vii) Connect the circuit of Fig. 3 with V_{EB} measuring (digital) voltmeter removed but the Ic measuring &milliammeter connected.

(viii) As before, set V_{CB} = OV and gradually vary I_E from 0 (zero) mA until 10mA is reached, moving in step 2mA. For each value of I_E record the corresponding value of Ic. Record your results as shown in Table 3.

(ix) Repeat step (viii) for V_{CB} = -8v.

RESULT ANALYSIS

Table 1 Measurements on output characteristics.

IE (mA) Vcb(V)	2 Ic (mA)	4 Ic (mA)	6 Ic (mA)	8 Ic (mA)	10 Ic (mA)
-0					
-1					
-2					
-3					
-4					
-5					
-6					
-7					
-8					
-9					
-10					

Table 2 Measurements on input characteristic.

	I_E, mA	0	1	2	3	4	5	6	7	8	9	10
V_{CB} = 0V	V_{EB}, V											
V_{CB} = -4V	V_{EB}, V											

Table 3 Measurements on transfer characteristics.

	I_E, mA	0	1	2	3	4	5	6	7	8	9	1
V_{CB} = 0V	I_C,mA											
V_{CB} = -8V	I_C,mA											

1. Using the results in Table 1 plot the output characteristic curve

CS CamScanner

2. Using the results in Table 2 plot the input characteristic curves

3. Using the results in table 3 plot the transfer characteristic curves

4. Determine the output impendence Ro of the transistor in CB configuration for I_E = 4mA, and IE = 8mA, using your plot in step 1.

....

....

....

....

....

....

5. Using your plot in step 2, determine the input impedance Ri for V_{CB} = -4V, when IC = 5mA

....

....

....

....

6. Using your plot in step 3, determine the current gain hFB for V_{CB} = 0v.

QUESTIONS

(a) Do your plots in steps 1 – 3 agree with the theoretical sketches? Explain briefly the difference(s), if any.

....

....

....

....

....

....

....

CS CamScanner

Experiment 5

STATIC CHARACTERISTICS OF A NPN TRANSISTOR IN COMMONEMITTER CONFIGURATION

OBJECTIVE

To investigate the output, input and current gain static characteristics of a NPN transistor in common-emitter (CE) configuration.

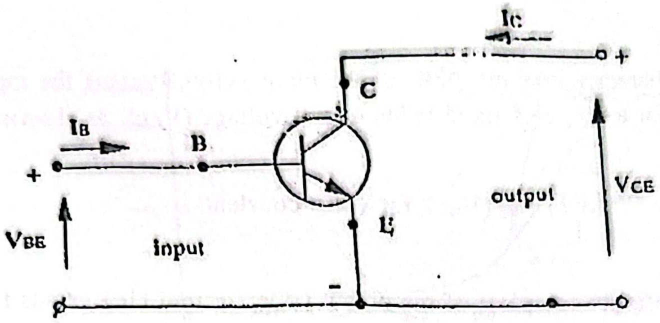


Fig. 1: Symbol of an NPN transistor in CE configuration

As expected of all bipolar junction transistor circuits in CE configuration the (base-emitter) side is forward-biased and the output (collector-emitter) side is reverse-biased. In particular for the NPN transistor in common-emitter connection (in the active region) the base-emitter junction is forward-biased, while the collector junction is reverse biased as shown in Fig.2.

For the transistor in common-emitter configuration, we note that: output (collector) characteristics are plots of the output current (IC) versus output voltage (VCE) for a range of fixed values of input current (IB) as shown in Fig. 3(a).

i.e $I_C = f_1 (V_{CE})$, for constant values of I_B

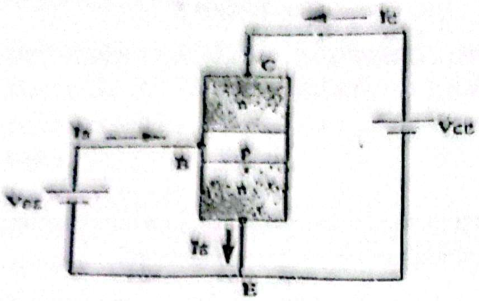


Fig. 2: Notation of an NPN transistor in CE

Input (Base) characteristics are plots of the input current versus the input voltage (V_{BE}) for a range of fixed value output voltage (V_{CE}), as shown in Fig. 3(b).

$$\text{i.e } I_B = f_2 (V_{BE}), \text{ for } V_{CE} = \text{constant}$$

Transfer characteristics are plots of the output collector rent (I_C) versus the input base current (I_B) for a rate fixed constant values of output voltage (V_{CE}), as shown in Fig. 3(c)

$$\text{i.e } I_C = f_3 (I_B), \text{ for } V_{CE} = \text{constant}$$

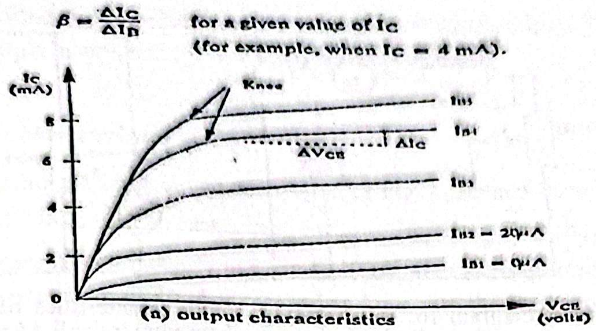
The output impedance Ro for any fixed I_B = constant can be determined as

$$R_o = \frac{\Delta V_{BE}}{\Delta I_B} \quad \text{for } I_B = I_{B4} = \text{constant}$$

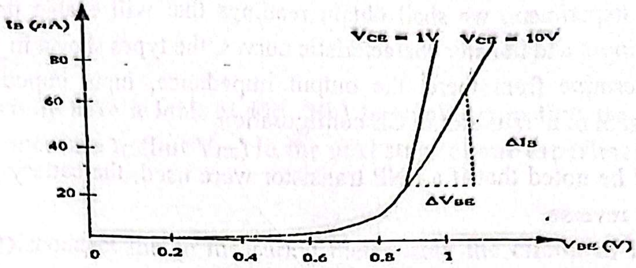
From the transfer characteristic graph, for a fixed V_{CE} (say, V_{CE} = 4V) the current gain, β can be determined as the slope of the line,

$$\beta = \frac{\Delta I_C}{\Delta I_B} \quad \text{for a given value of } I_C \text{(for example, when } I_C = 4\text{mA)}$$

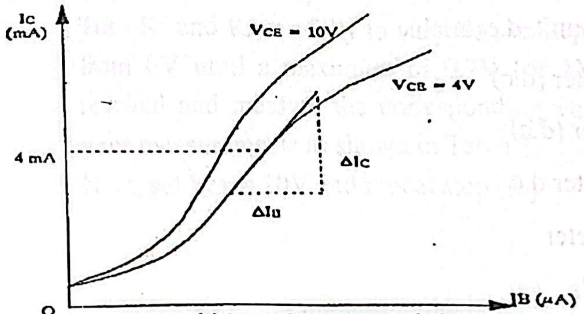
CamScanner



(a) output characteristics



(b) input characteristics



(c) Transfer characteristics

Fig.3: Characteristic curves of an NPN transistor in the CE configuration:

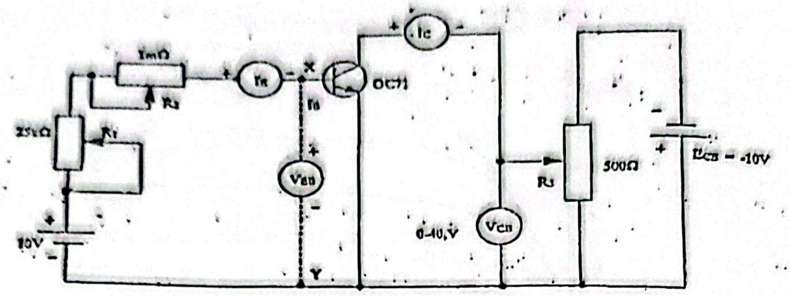


Fig. 4 Circuit diagram for investigating static characteristics of an NPN transistor in CE

In this experiment, we shall obtain readings that will enable us plot the output, input and transfer characteristic curves, the types shown in Fig. 13.3, and determine from there, the output impedance, input impedance and current gain of a transistor in CE configuration.

It should be noted that if a PNP transistor were used, the battery polarities would be reverse.

MATERIALS REQUIRED

Equipment

- Power supply unit, d.cvariable
- 0-100, uA, meter (d.c)
- 0-30, mA meter (d.c)
- 0-30, V voltmeter d.c
- 0-5V, dc voltmeter
- Connection leads

PROCEDURE

Output Characteristics

(i) Connect the circuit of Fig. 4, and turn R₁ and R₂ appropriately to set $I_B = 0\ \mu A$initially.

(ii) Next, turn R₃ to increase Vce in steps of 1V, starting from 0V until a maximum of 10V is reached, and measure the corresponding Ic in each case. Record your readings as shown in Table 1.

(iii) Follow the procedure in step (i) and set $I_B = 20\mu A, 40\mu A, 60\mu A$ and $80\mu A$ in turn, and for each fixed I_B repeat step (ii).

Transfer characteristics

(iv) Using the same circuit connection of Fig. 4, set and keep $V_{CE} = 2V$ initially.

(v) Vary IB continuously in steps of $20\mu A$, after starting from $0\mu A$ until a maximum of $80\mu A$ is reached and measure the corresponding I_C in mA). Record your readings as shown in Table 2.

(vi) Next, set $V_{CE} = 8V$ and repeat step (v).

Input Characteristics

N.B. Briefly have a look at Fig. 3(b) to remind you that we wouldn't need to measure I_C (but V_{CE}) in the next stage of our experiment.

(vii) Disconnect the I_C measuring meter from the circuit of Fig. 4, and link up the gap by using aa connection lead. Connect a 0-5, V dc voltmeter between terminals X and Y to measure (V_{BE}).

(viii) Set $V_{CE} = 1V$ initially

(ix) Turn R_1 and R_2 carefully to vary V_{BE} in steps o 0.1V starting from 0V until a maximum of 0.7V (or 1V, if possible) is reached and measure the corresponding value of IB. record your measurements as shown in Table 3.

(x) Next, set $V_{CE} = 10V$ and repeat step (ix)

RESULT ANALYSIS

Table 1: Measurement on output characteristics.

I_B, (μA)	0	20	40	60	80
V_{CE}, (V)					
0					

CS CamScanner

1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Table 2: Measurements on Transfer characteristics

	I_B,µA	0	20	40	60	80
V_{CE} = 2V	IC, mA					
V_{CE} = 10V						

Table 3: Measurements on input characteristics

	Vbe	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
$V_{CE} = 1$	$I_B(\mu A)$									
$V_{CE} = 10$	$I_B(\mu A)$									

Result Analysis

1. Using the results in table 1, plot the output characteristic curves.
2. Using the results in Table 2, plot the transfer characteristics curves
3. Using the results in Table 3, plot the input characteristic curves
4. Determine the output impedance Ro of the transistor in CE for I_B = 20µA and I_B = 80µA, using your plot in step 1 (N.B. see Fig. 3(a) for a hint on how to determine Ro)

5. Using your plot in step 2, determine the current gain for V_{CE} = 1V, when I_C =

5mA

6. Use your plot in step 3 to determine the input impedance R_I for V_{CE} = 2V, when

I_B = 20μA.

QUESTIONS

(a) Do your characteristic curves in steps 1 – 3 agree with the sketches shown in Fig. 3? Explain briefly the differences you notice, if any.

(b) Explain briefly how the transistor characteristic curve in Fig. 3(c) could be obtained by using the output characteristic curves of Fig. 3(a) for a fixed value of Vce.

(c) Compute the value of β from one end of the curve to the other?

(d) Explain briefly what change(s) you would expect in the circuit of Fig. 4 if a PNP transistor were used?

(e) Using the characteristic cuves in steps 1 and 3, find the value of Ic corresponding to

V_{BE} = +600mv and V_{CE} = +5v.