DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY
COURSE NO. : EEE 264/274
EXPT. NO.-01

NAME OF THE EXPERIMENT: STUDY OF DIODE CHARACTERISTICS

OBJECTIVE

To study the I-V characteristics of silicon p-n junction diodes.

MATERIALS REQUIRED

p-n junction diode(1N4003)	one piece
5V Zener diode	one piece
resistor (1K)	one piece
dc power suply	one piece
signal generator	one piece
oscilloscope	one unit
chords and wire	lot

THEORY

A p-n junction diode is a two-terminal device that acts as an one-way conductor. When a diode is forward biased as shown in Fig. 1(a), current I_D flows through the diode and current is given by

$$I_D = I_S\left[e^{\frac{V_a}{nV_T}} - 1\right] \qquad (1)$$

where, n is the ideality factor and $1 \geq n \geq 2$. I_S is the reverse-saturation current and $V_T = kT/q$ is the thermal voltage. V_T is about 0.026V at room temperature.

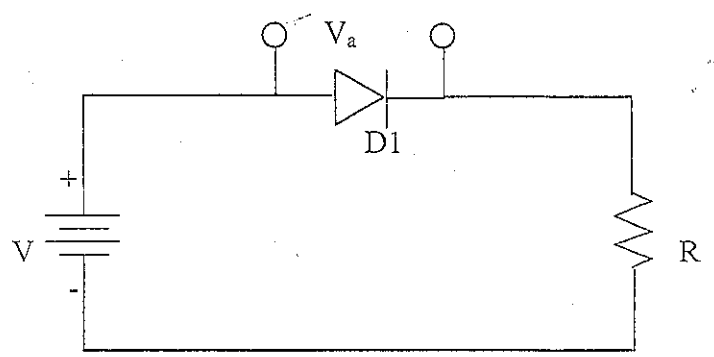

Fig.1(a)

When it is reverse biased as shown in Fig. 1(b), $I_D = -I_S$ (for see eqn. (2)). As it is generally in pA (pico-amp) range, in many applications this current is neglected and diode is considered open.

$$I_D = I_S\left[e^{-V_R/V_T} - 1\right] = -I_S \quad \text{for } |V| >> V_T \qquad (2)$$

The material for p-n junction diode is silicon semiconductor. Semiconductors are a group of materials having electrical conductivity intermediate between metals and insulators.
Metals: Al (aluminum), Cu(copper),Au(gold).
Insulators: Ceramic, Wood , rubber.
Semiconductor: Si (silicon), Ge (germanium), GaAs (gallium-arsenide).

P-type Silicon:

When an intrinsic silicon semiconductor is doped with Al impurities, it becomes p-type. At thermal equilibrium,

$$p_o = N_A \quad \text{and } n_o = n_i^2/N_A$$

where, p_o is the hole concentration , n_o is the electron concentration , N_A is the doping density of impurities(acceptor atoms), n_i is the intrinsic concentration. $n_i = 1.5 \times 10^{10} cm^{-3}$ for Si at room temperature .

N-type silicon:

When an intrinsic silicon semiconductor is doped with P(phosphorous) impurities it becomes n-type . At thermal equilibrium, $n_o = N_D$ and $P_o = n_i^2/N_D$. Here, N_D is the doping density of impurities (donor atoms).

In semiconductor both holes and electrons contribute to current.

Current-Voltage Characteristics

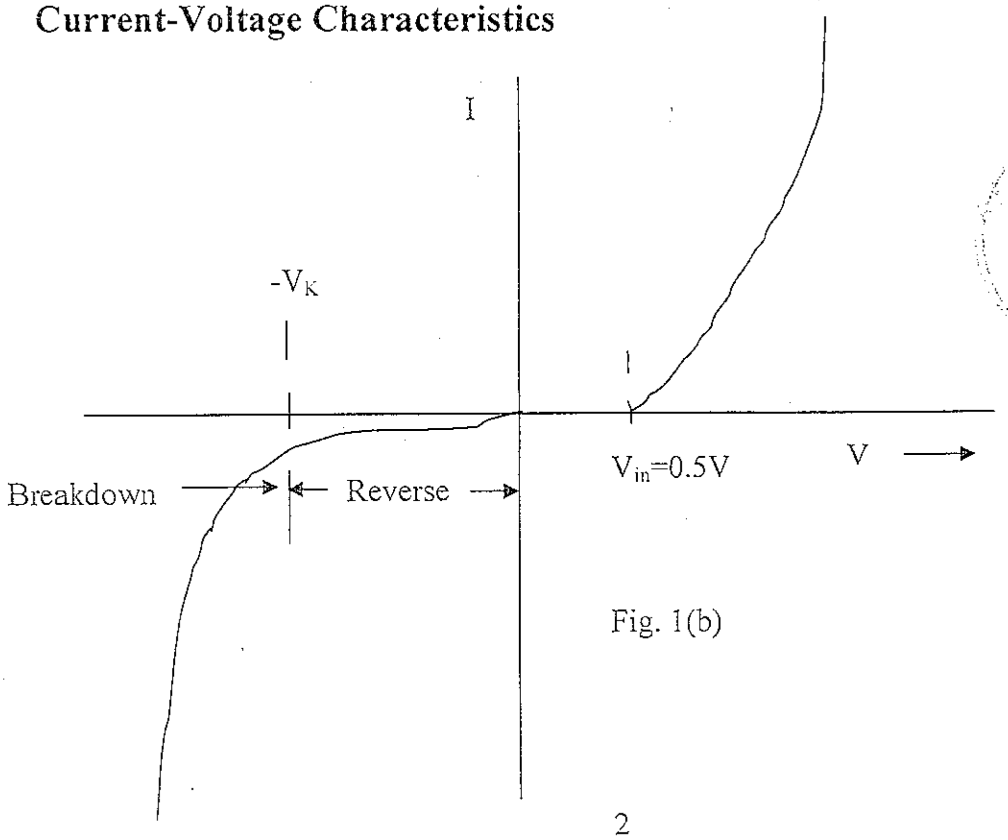

Fig. 1(b)

V_{in} is the cut-in voltage. Its value is usually 0.5V. At this voltage, diode is forward biased but even then I is very small and it is usually neglected. When diode is reverse biased and $V< V_K$, diode drives into breakdown and a large current will flow. The current can be limited by using resistor in diode circuit. If the slope (dI/dV) is very steep, the breakdown mechanism is called Zener breakdown. Zener diode can be used in regulator circuit.

Small Signal

Consider the circuit shown in Fig. 1(c). For ac voltage V_d<10 mV, we can write

$$i_d = [I_D/nV_T] * v_d = v_d/r_d$$

where, $r_d = nV_T/I_D$ is the diode small-signal (dynamic) resistance and I_D is the dc current. Dc resistance is given by $r_D = V_D/I_D$ where V_D is the dc voltage across the diode .

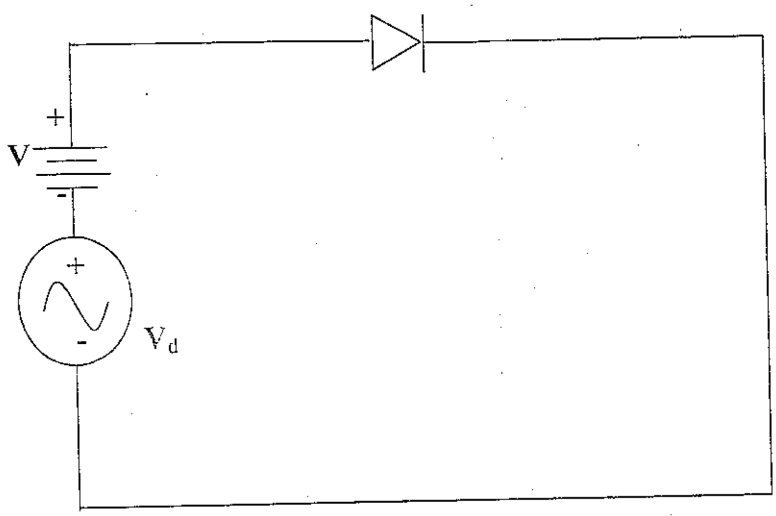

Fig. 1 (c)

CIRCUIT DIAGRAMS FOR EXPERIMENTS

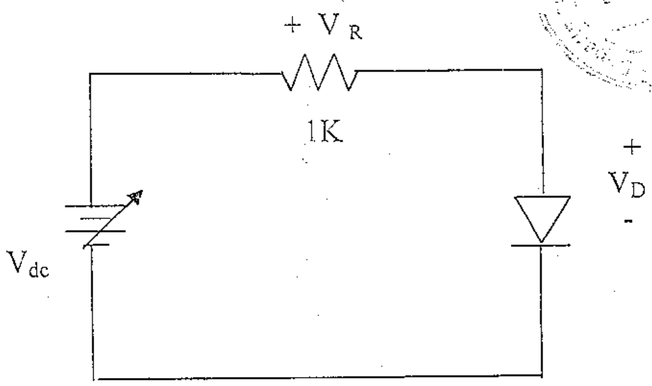

Fig. 2

(Circuit diagram for diode characteristics.)

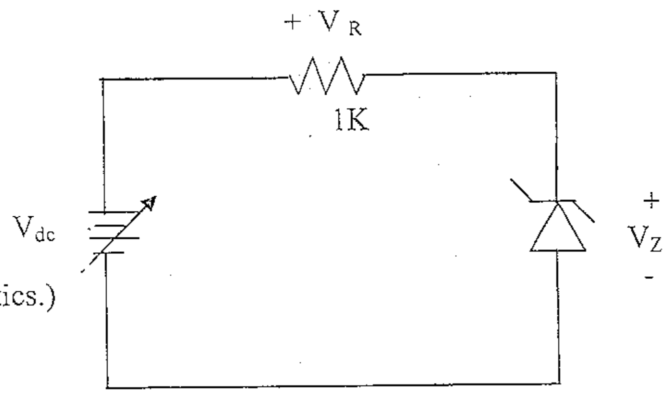

Fig. 3

(Circuit diagram for zenner diode characteristics.)

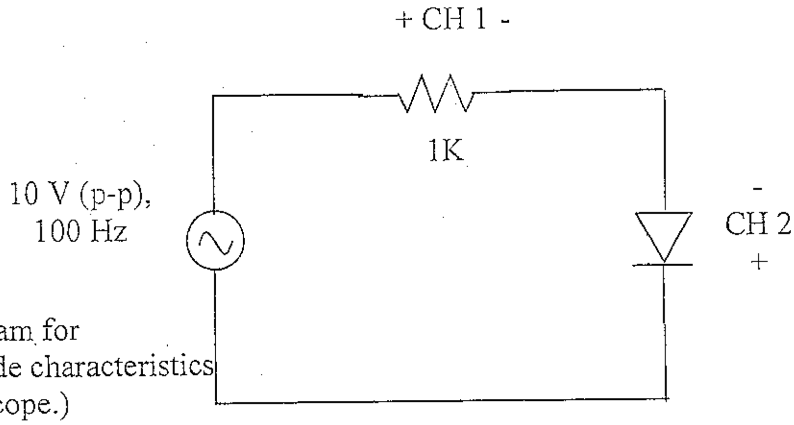

Fig. 4

(Circuit diagram for obtaining diode characteristics from oscilloscope.)

PROCEDURE

1. Measure resistance accurately using multimeter. Construct the circuit as shown in Fig. 2. Vary input voltage (V_{dc}) and measure V_D, V_R for values of V_D=0.1V, 0.2V, 0.3V, 0.4V, 0.5V, 0.6V, 0.7V and so on. Obtain maximum value of V_D without increasing V_{dc} beyond 25 V (Note that $I_D=V_R/R$).

2. Repeat step1 for the values at V_z =0.5V, 1.0V, 1.5V, 2.0V, 2.5V, 3V and so on up to the maximum value obtainable without increasing V_{dc} beyond 25V. Apply circuit in Fig. 3 for this step.

3. Construct the circuit as shown in the Fig. 4. Set the oscilloscope in X-Y mode and locate the zero point on oscilloscope display. Make proper connection (according to Fig. 4) and observe the output.

4. Repeat step3 by increasing supply frequency to 5 kHz.

REPORT

1. Plot diode I-V characteristics for different readings obtained in this experiment.

2. Calculate static and dynamic resistance for I_D=5 mA, 10 mA and also for V_D=0.6 V, 0.72 V for circuit in Fig. 2.

3. Determine the Q-point for the circuit in Fig. 2 when V_{dc}=15 V.

4. Explain the result obtained in step 4.

5. What is the Zener voltage of the diode of Fig. 3?

6. What is the dynamic resistance of the Zener diode at Zener voltage?

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COURSE NO. : EEE 264/274
EXPT. NO.-02

NAME OF THE EXPERIMENT: STUDY OF DIODE RECTIFIER CIRCUITS

OBJECTIVE

To understand principle of diode in converting ac into dc and to study different diode rectifier circuits.

MATERIALS REQUIRED

Trainer board
Multimeter
Resistor 10kΩ
Capacitor 1μF,47μF
Diode 4 pieces.

THEORY

The diode rectifier converts the input sinusoidal voltage V_s to a unipolar output V_o. There are two types of rectifier circuits: (i) Half-wave rectifier and (ii) Full-wave rectifier.

Half-wave rectifier

The circuit of a half-wave rectifier is shown in Fig. 1.

CIRCUIT DIAGRAM

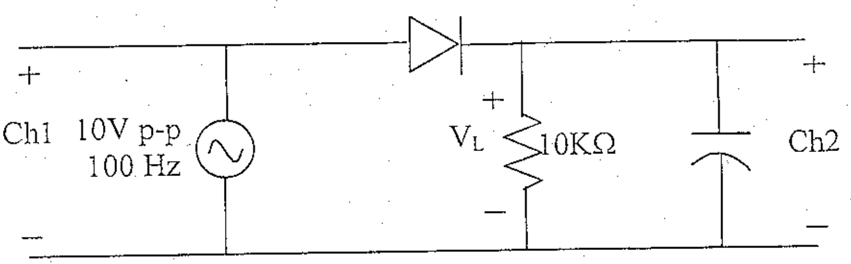

Fig. 1 Circuit diagram for half wave Rectifier

The input and output of the rectifier are drawn in Fig. 2. Diode conducts only when it is forward biased. For $V_s = V_m \sin\omega t$, DC voltage and current of a half wave rectifier are as follows

$$V_{DC}= V_m/\pi - (1/2)V_{DO}$$
$$I_{DC}=(V_m/\pi - (1/2)V_{DO})/R$$

where, $V_{DO} \approx 0.7$ V.

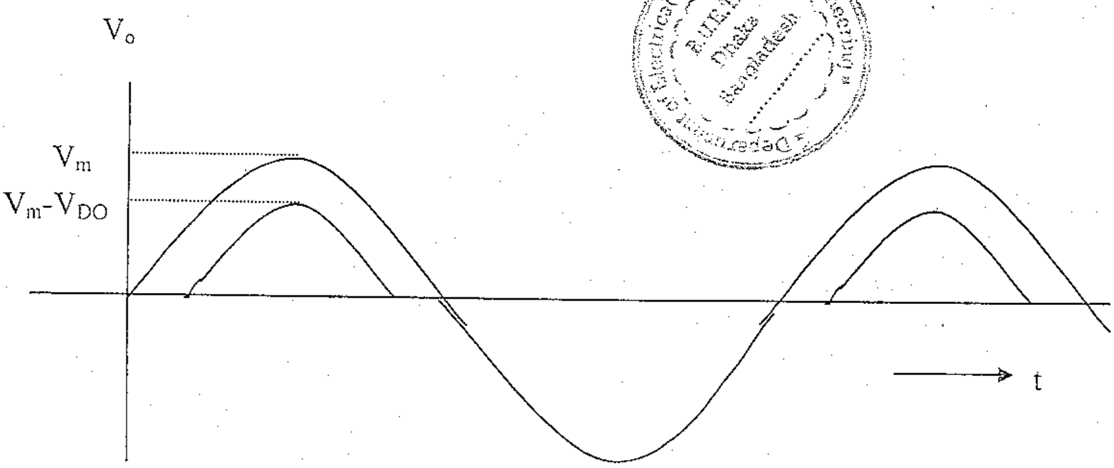

Fig. 2

PIV(Peak Inverse Voltage)

PIV is the peak reverse voltage that appears across the diode when it is reverse-biased.

$$PIV = V_m$$

Full-wave rectifier

The bridge rectifier circuit is shown in Fig. 3.

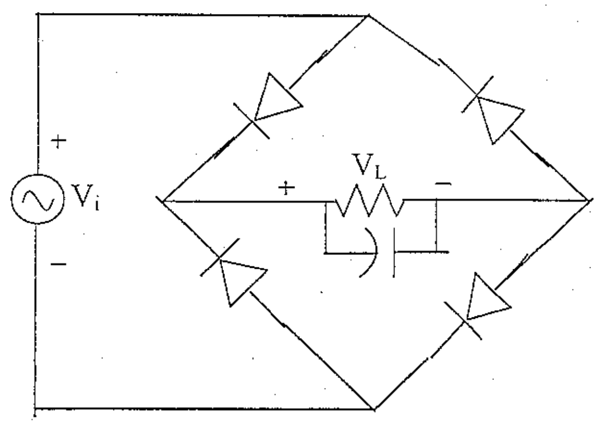

Fig. 3 Circuit diagram for bridge rectifier

Fig. 4 shows the input and output voltage as a function of time. Peak voltage across each diode when it is reverse-biased.

$$PIV = V_m - V_{DO}$$

DC voltage, $V_{DC} = 2V_m/\pi - 2V_{DO}$

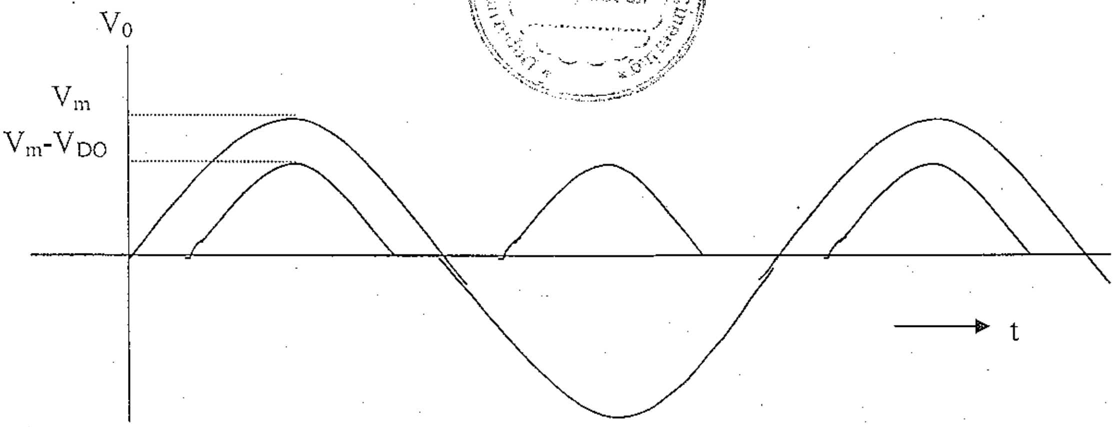

Fig. 4

Ripple factor

A rectifier converts alternating currents into a unidirectional current, periodically fluctuating components still remaining in the output wave. A measure of the fluctuating component is given by the ripple factor r, which is defined as

$$r = \frac{\text{rms value of alternating components of wave}}{\text{average value of wave}}$$

$$= I'_{rms}/I_{dc} = V'_{rms}/V_{dc}$$

where, I'_{rms} and V'_{rms} denote the rms value of the ac components of the current and voltage, respectively .

For a half-wave rectifier, $r = 1.21$

and for a full wave rectifier $r = 0.482$

Filter

The rectifier with a filter is shown in Fig 1. When capacitor charges to V_p (10V p-p), input voltage decreases immediately but capacitor will not charge its voltage instantaneously. As a result diode will be reverse biased and stop conducting. The stored charges on the capacitor will be released through R.

For RC >> T

The ripple voltage is given by

$V_r = (1/fC)V_p/R = (1/fC)I_L$ where $V_p/R \approx I_L$ (constant , an assumption).

DC current

$i_{Dav} = I_L\,[1 + \pi\,\sqrt{(2\,V_p/V_r)}]$

Maximum diode current

$i_{Dmax} = I_L\,[1 + 2\,\pi\,\sqrt{(2\,V_p/V_r)}]$

For full-wave rectifier

$$V_r = Vp/(2fCR)$$
$$i_{Dav} = I_L\,[1 + \pi \sqrt{(V_p/2V_r)}]$$
$$i_{Dmax} = I_L\,[1 + 2\,\pi \sqrt{(V_p/2V_r)}]$$

PROCEDURE

1. Construct circuit of Fig.1 without the capacitor. Observe V_i and V_o simultaneously on the oscilloscope. Sketch input and output waveforms. Measures V_o with multimeter in dc and ac mode.

2. Connect 1μF capacitor across the load resistor. **BE CAREFUL** about the polarity of the capacitor. Sketch input and output waveforms. Measure V_o with multimeter.

3. Replace 1μF Capacitor with 47μF and repeat step 2.

4. Construct the circuit of Fig.2 without the capacitor. Observe and sketche V_i, V_o. **DO NOT TRY** to observe V_i, V_o simultaneously. Measure ac and dc components of V_o with multimeter.

5. Connect 1μF capacitor as shown in Fig.2 and repeat step 4.

6. Replace 1 μF capacitor by 47μF for Fig.2 and repeat step 4.

REPORT

1. Calculate the average and effective values of the load voltages in circuits of Fig.1 and Fig. 2 without capacitor. Compare these values with those obtained with the multimeter.

2. Calculate the ripple factors for the two circuits for each of the three cases and compare with the ideal values.

3. Which capacitor acts as a better filter? Explain your answer.

4. What are the advantages and disadvantages of the full wave center tapped and bridge rectifier circuit?

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COURSE NO. : EEE 264/274
EXPT. NO.-03

NAME OF THE EXPERIMENT: STUDY OF DIODE CLIPPING AND CLAMPING CIRCUITS.

OBJECTIVE

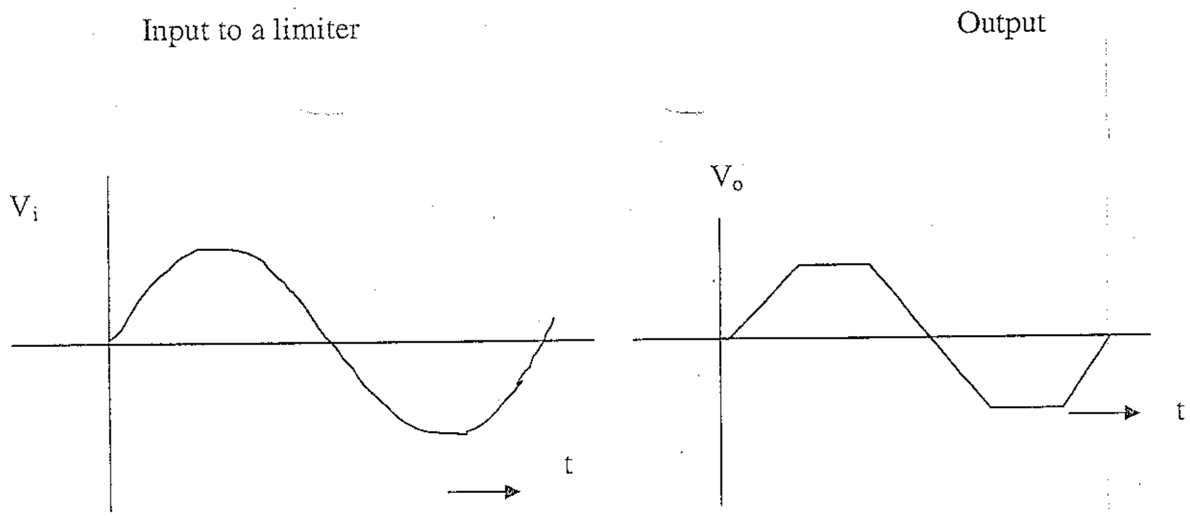
To study the application of diodes in different clipping and clamping circuits.

MATERIALS REQUIRED

p-n junction diode(1N4003)	one piece
5V zenner diode	one piece
resistor (1K)	one piece
capacitor (10μF)	one piece
dc power suply	one piece
signal generator	one piece
oscilloscope	one piece
multimeter	one piece
chords and wire	lot

THEORY

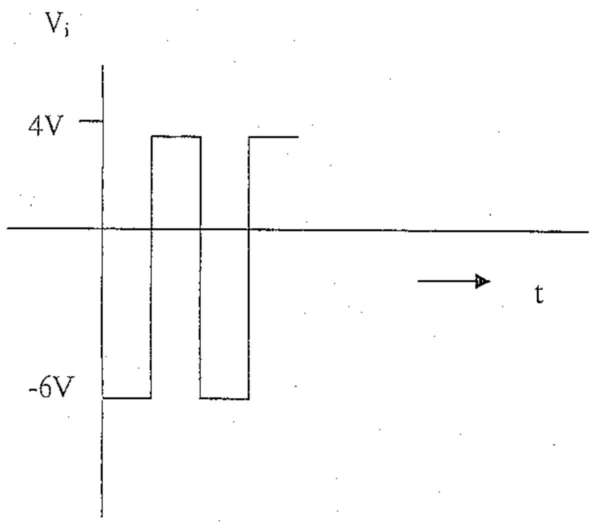
Limiter or clippers are used to cut-off or eliminate a portion of an ac signal. A limiter can be realized by using diode and resistor as shown in Fig 1.



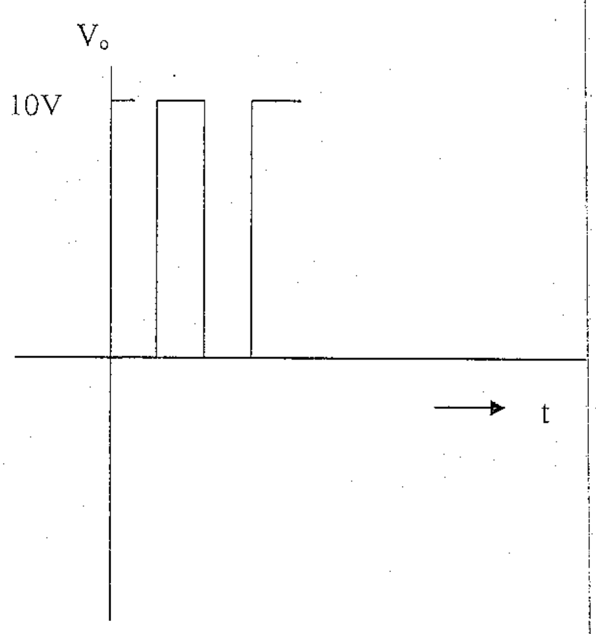
Clampers

The clamper circuit is one that will clamp a signal to a different dc level.

Input to a clamper



Output



CIRCUIT DIAGRAMS

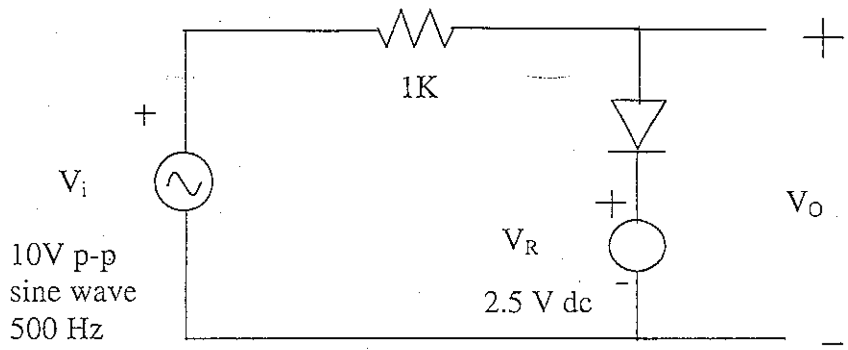


Fig. 1

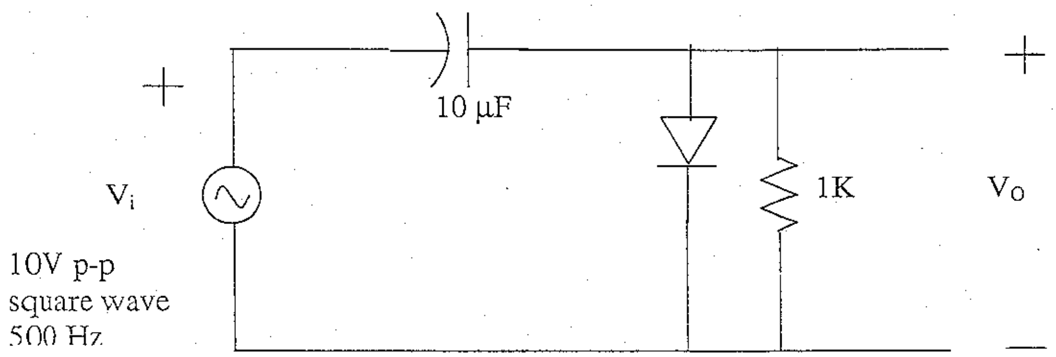

+
10 μF
V_i
1K
V_O
10V p-p
square wave
500 Hz
+
—

Fig. 2

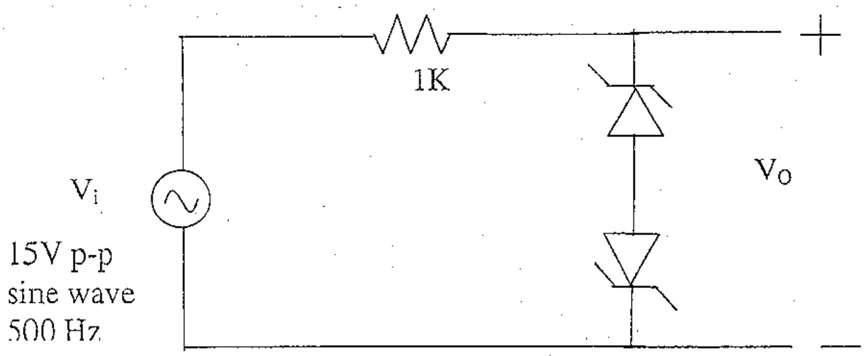

1K
+
V_O
V_i
15V p-p
sine wave
500 Hz
—

Fig. 3

PROCEDURE

1. Construct the circuit shown in Fig.1. Observe V_i and V_o simultaneously on the oscilloscope and sketch the waveforms. Set the oscilloscope in XY mode. Observe and record the transfer characteristic of the circuit. Make sure that V_i is fed to the X channel.

2. Reverse the polarity of the diode in Fig.1 and repeat step 1.

3. Construct the circuit shown in Fig. 2 and repeat the procedure in step 1.

4. Construct the circuit shown in Fig. 3 and repeat the procedure in step 1.

REPORT

1. What is a clipping circuit? Explain the operation of the circuit in Fig. 1.

2. Design a circuit in which the input voltage $V_i = 5 \sin \omega t$ and the output should be limited between + 2.5 V and – 3.5 V. Assumes that the diodes are ideal.

3. What is a clamping circuit? Explain the operation of the circuit in Fig. 2.

4. Sketch the output voltage of the circuit of Fig. 2 if $V_i = 5 \sin(2\pi 1000t)$.

5. Explain the operation of circuit in Fig. 3. How will V_o change if the polarities of the two Zener diodes in the circuit of Fig. 3 are reversed?

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COURSE NO. : EEE 264/274
EXPT. NO.-04

NAME OF THE EXPERIMENT: STUDY OF N-P-N CE AND CB TRANSISTOR CHARACTERISTICS.

OBJECTIVE

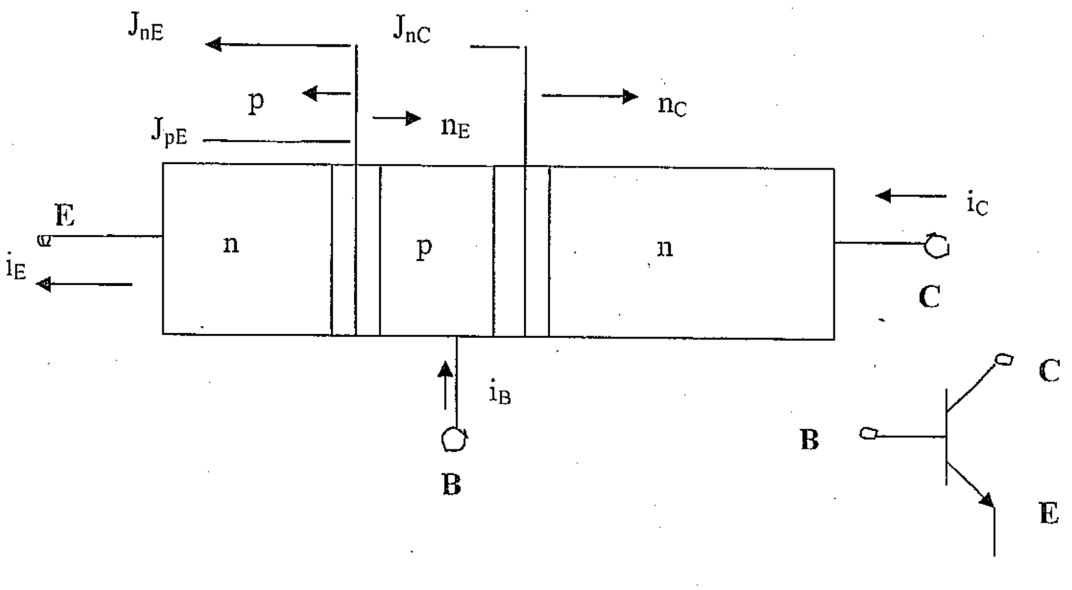
To determine the CE and CB characteristics of a transistor.

MATERIALS REQUIRED

n-p-n transistor (C829)	one piece
resistors 2k,1k,500Ω,100Ω	one piece each
multimeter	two pieces
bread board	

THEORY

Transistor has two p-n junctions (see figure below). One junction is called emitter junction and other is called collector junction. When transistor is used as an amplifier, it is operated in active mode. In active mode, emitter junction is forward biased and collector junction is reverse biased.



Emitter current is given by

$$I_E = I_{nE} + I_{pE}$$

we can also write

$$I_E = I_C + I_B = [(1 + \beta)/\beta]I_C$$

Where $\beta = I_C / I_B$ is called common emitter current gain.

In good transistor $I_C >> I_B$ i.e. $\beta >> 1$. I_C can also be expressed as $I_C = \alpha\ I_E$. where $\alpha = \beta/(1+\beta)$. α is called common base current gain. For good transistor, α is close to unity.

Proper dc biasing of a transistor is a prerequisite for proper operation as an amplifier. The purpose of the biasing is to fix the I_C (dc) and V_{CE} (dc) . But I_C is a function of temperature, V_{BE} and β. It is always desirable to design a biasing circuit where I_C is insensitive to change in β.

When E-B junction is forward biased and C-B junction is reverse biased, the transistor operates in active mode. For saturation mode of operation, both junction are forward-biased. Cut-off region operation requires that both E-B and C-B junctions be reverse biased. The inverted active operation occurs when E-b is reverse-biased and C-B is forward biased.

CIRCUIT DIAGRAMS

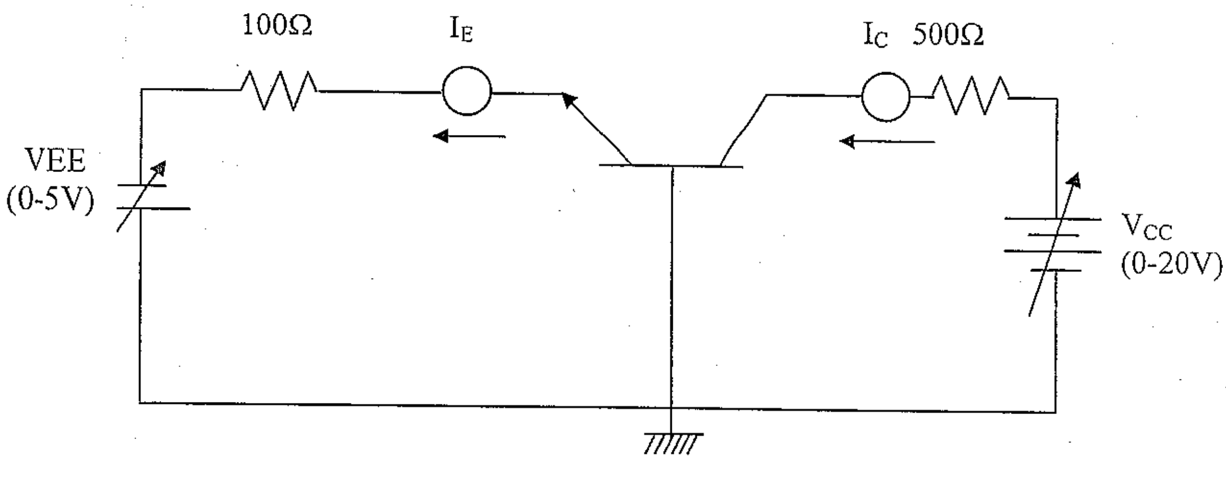


Fig. 1(a) Common base configeration

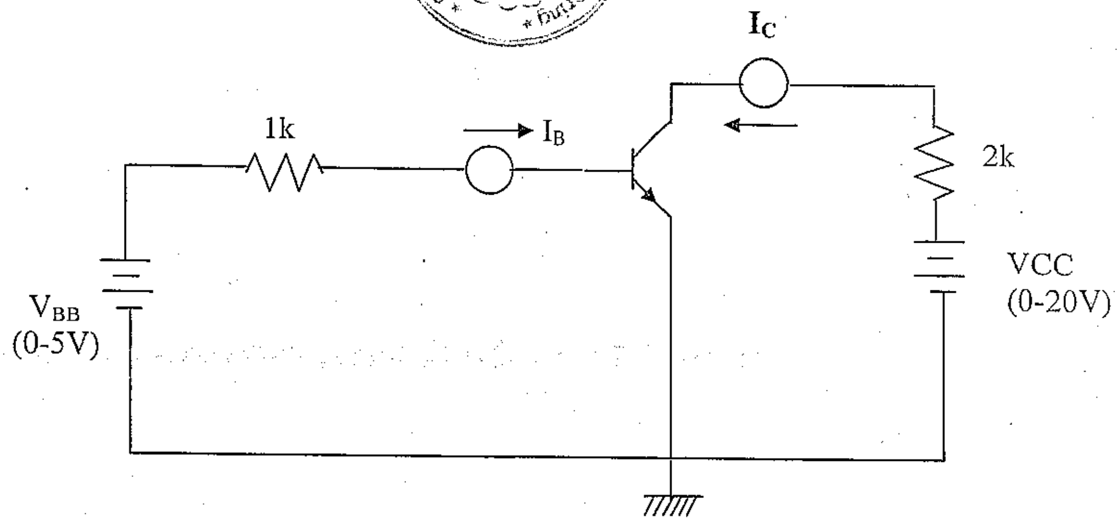


Fig. 1(b) Common-emitter configeration

PROCEDURE

For CB Configuration refer to Fig. 1(a)

1. Construct the circuit shown in Fig. 1(a)

2. Set V_{CC} to 10V. vary V_{EE} so that I_E is around 2 mA. Adjust V_{CC} to get V_{CB} as zero. Measure the value of V_{BE}

3. Keeping V_{CB}=0, vary I_E by changing V_{EE} and measure the value of V_{BE} and I_E

4. Set I_E=3mA. Adjust V_{CC} to get V_{CB}=1V. Repeat step 3.

5. Adjust V_{EE} so that I_E is zero. Vary V_{CC} from zero to a suitable value and measure V_{CB} and I_C.

6. Vary V_{EE} so that I_E = 1mA. Repeat step 5.

7. Repeat step 5 for I_E=2mA.

8. Assemble the circuit shown in Fig. 1(b).

9. First set V_{CC}=10V. Apply voltage to B-E junction. Adjust the value of V_{CC} so that V_{CE} is zero. Vary V_{BB} and measure V_{BE} for different values of I_B.

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COURSE NO. : EEE 264
EXPT. NO.-05

NAME OF THE EXPERIMENT: STUDY OF BJT BIASING CIRCUITS.

OBJECTIVE

To establish the proper operating point and to study the stability of the operating point with respect to changing β in different biasing circuits.

EQUIPMENTS

n-p-n transistor (C828,BC108)	one piece each
500k potentiometer	one piece
resistors	470Ω 560Ω 10KΩ
DC micrometer	0-100μA
multimeter	one unit
Trainer board	one unit

CIRCUIT DIAGRAMS

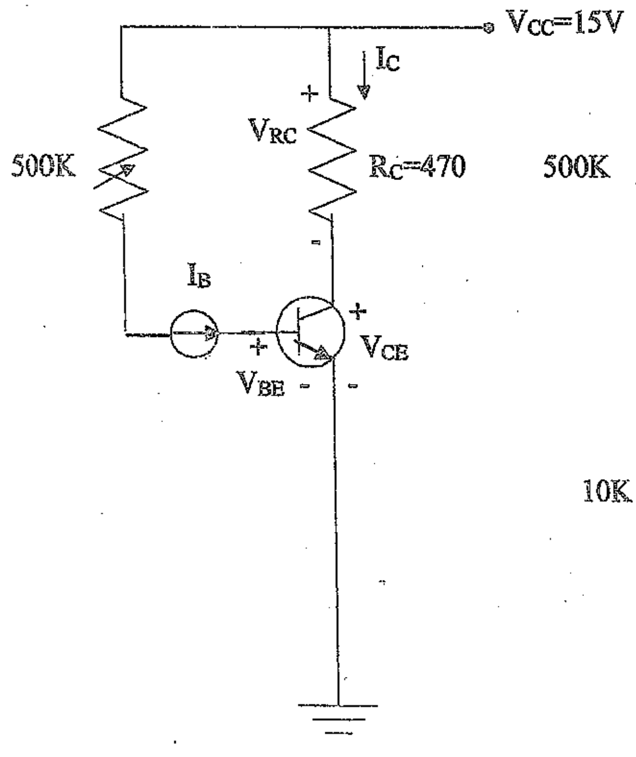


Fig. 1(a)

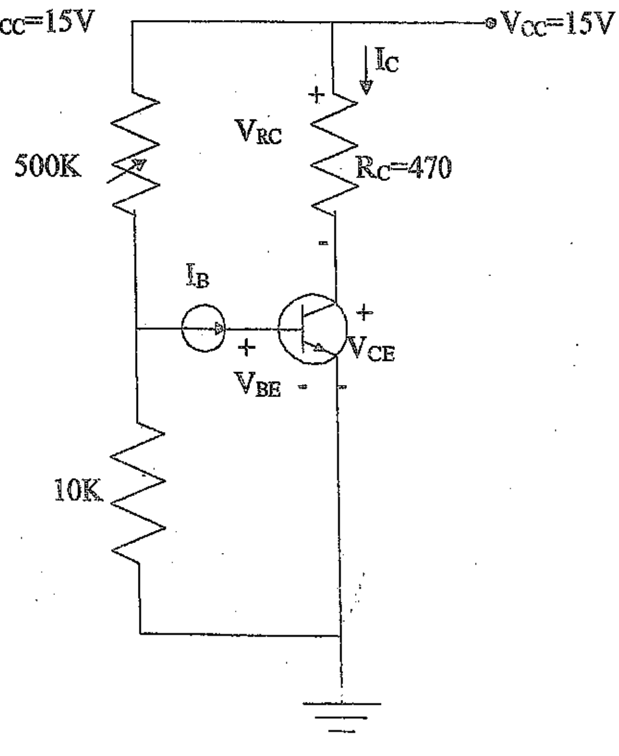
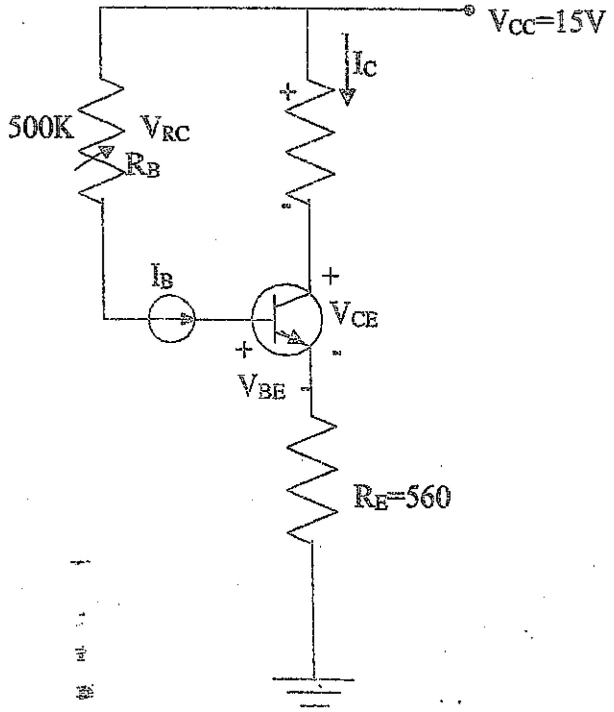


Fig. 1(b)

Fixed bias circuits



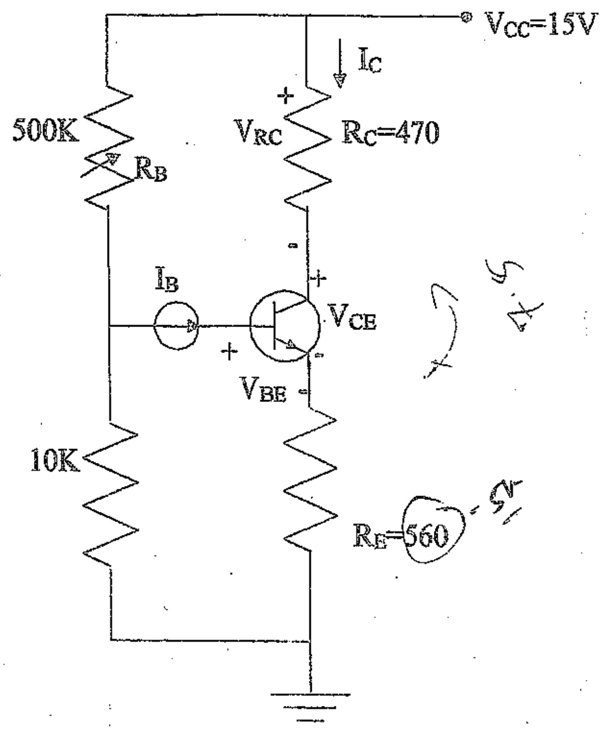


Fig. 2(a) Self bias circuits Fig. 2(b)

PRELAB WORK

Student must perform the following calculations before coming to the lab

1. For the circuit shown in Fig. 1(a) and 2(a), find expressions for I_{CQ} and V_{CQ}.

PROCEDURE

1. Measure the value of R_c with multimeter and record.
2. Construct the fixed bias circuit with C828 transistors as shown in Fig. 1(a). Adjust 500K potentiometer until V_{CE} is approximately equal to $V_{CC}/2$. Measure V_{CE}, V_{BE}, V_{RC} and I_B. I_C can be calculated from V_{RC} and R_C.
3. Replace C828 by C829 keeping V_{CC} and 500K potentiometer fixed at values set in step1. Measure V_{CE} V_{BE} V_{RC} and I_B.

4. Construct the fixed bias circuit with C828 transistors as shown in Fig. 1(b). Repeat step 2 and 3.

5. Construct the self bias circuit with C828 transistors as shown in Fig. 2(a). Repeat step 2 and 3.

6. Construct the self bias circuit with C828 transistors as shown in Fig. 2(b). Repeat step 2 and 3.

REPORT

1. Compare the circuits of Fig. 1(a) and 1(b) with respect to stability against variation in β and justify your answer.

2. Compare the circuits of Fig. 2(a) and 2(b) with respect to stability against variation in β and justify your answer.

3. Compare the stability of fixed bias circuits with that of self bias circuits.

4. Discuss the stability of fixed bias and self bias circuits against variation in temperature.

5. Determine β from the measured values of currents. Using this value for β and measured value of PB, calculate V_{CEQ} and I_{CQ} for prelab expressions. Compare had calculated values with experimental ones.

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COURSE NO. : EEE 264
EXPT. NO.-06

NAME OF THE EXPERIMENT: STUDY OF COMMON EMITTER(CE)) AMPLIFIER.

OBJECTIVE

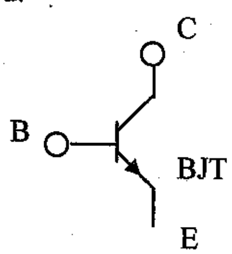
To know the effect of the frequency on the gain of a common emitter amplifier and also to measure the input impedance , output impedance and phase relationships of a CE amplifier.

MATERIALS REQUIRED

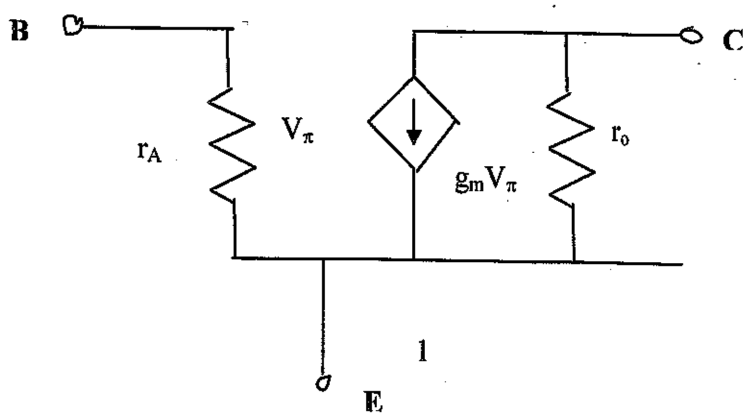
n-p-n transistor C828	one piece
10k potentiometer	two piece
resistors	100Ω ,470Ω, 560Ω,5KΩ,33KΩ
capacitors	10μF,10μF,47μF
multimeter	one piece
bread board	one piece
power supply	one piece
signal generator	one piece
oscilloscope	one piece

THEORY

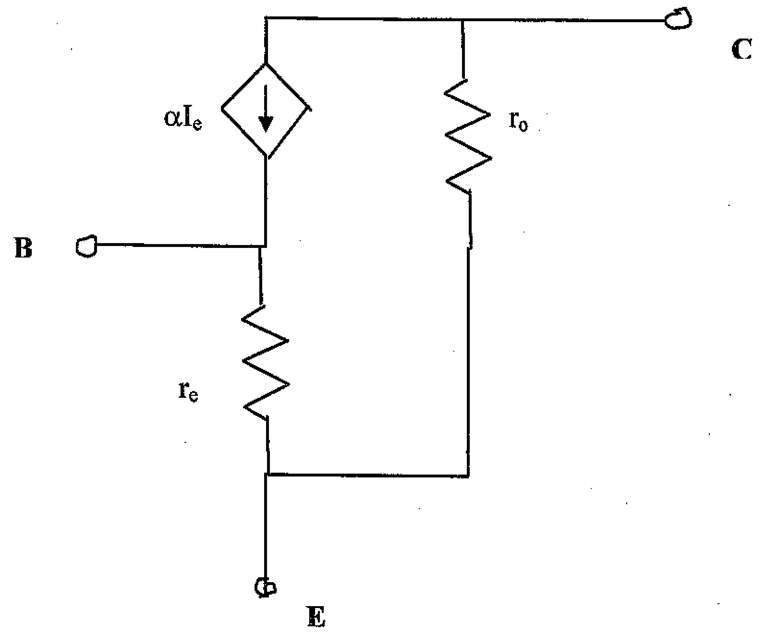
When a bipolar transistor operates in linear region, then principle of superposition can be applied. As a result, ac circuit can be separated from dc circuit. For small ac signal analysis, π or T model is used.



Small-signal π-model



Small-signal T-model



For π-model ,

$$r_\pi = V_t/I_B \text{ and } g_m = \beta/r_\pi \text{ and } r_o = V_A/|I_C|$$

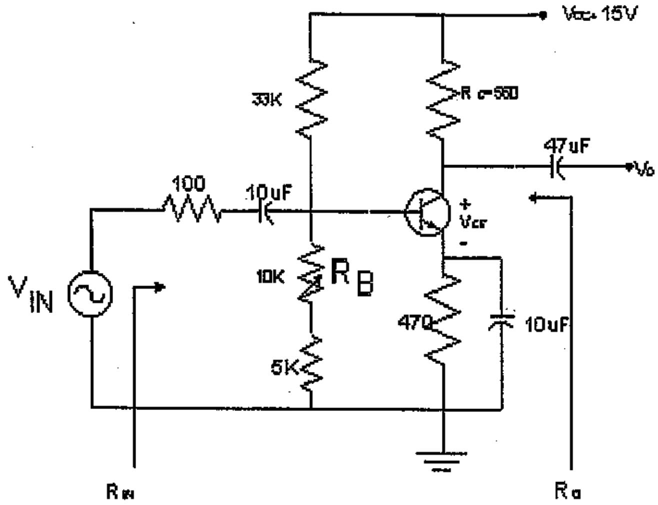
For T-model ,

$$r_e = V_t / I_E$$

V_A is the early voltage and V_t=kT/q is thermal voltage.

We know that a p-n junction diode is associated with two types of capacitance, (i) junction capacitance and (ii) diffusion capacitance. A bipolar transistor consists of two junctions , emitter- base and collector-base junctions. At high frequency we cannot neglect the effect of capacitances on the performance of the transistor. At low and mid band frequencies , their effects can be neglected.

CIRCUIT DIAGRAM



CE Emitter Amplifier

PRELAB WORK

Students must perform the following Calculations before coming to the lab.

1. Draw the small signal equivalent Circuits of the CE Amplifier Circuit.
2. Obtain an expression for the voltage gain (V_0/V_{in}).
3. Remove $C_E = 10\mu F$ and obtain voltage gain.
4. Obtain an expression for output resistance R_0.

PROCEDURE

1. Construct the circuit as shown in the circuit diagram for CE amplifier. Adjust 10K potentiometer until V_{CE} is approximately equal to $V_{CC}/2$ by multimeter.
2. Set the signal generator frequency at 5KHz. Ch.2 is connected to V_O. Apply and increase input signal until you see distorted output signal. Set V_{in} below this value 100mV. Connect V_{IN} to ch.1. Measure peak value of both V_{in} and V_O.
3. Set the oscilloscope in dual mode. Observe the phase relationship between input and output.
4. Connect the 10KΩ potentiometer from V_O to ground. Adjust the 10 KΩ potentiometer until V_O is half the open circuit value. Measure the output impedance from potentiometer.

5. Disconnect ch.2 and connect ch.1 across 100Ω and measure peak value.
6. Disconnect the bypass capacitor and observe the effect on gain.
7. Reconstruct the circuit as shown in Fig. 1. Set the signal frequency at 50 Hz. Measure the input and output.
8. Repeat step 7 for frequency 100Hz, 200Hz, 500Hz, 800Hz, 1KHz, 2KHz etc., until higher cut-off frequency is found ensuring constant input for all steps.
9. Observe the phase relationships between input and output below lower cutoff and higher cutoff frequency.

REPORT

1. Plot the gain in dB as a function of frequency in a semi-log paper.
2. From the graph paper determine the lower cutoff frequency, higher cutoff frequency and mid-band gain for this common emitter amplifier.
3. What is the input impedance, output impedance and phase relationship between input and output for CE amplifier and comment on them?
4. What is the function of bypass capacitor and dc blocking capacitor?
5. What is the advantage and disadvantage of common emitter amplifier?
6. Using measured value of R_B, Calculate voltage gain from prelab expressions for $\beta = 75$. If value of g_m and r_π required, determine g_m and r_π from dc analysis for the circuit.

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COURSE NO. : EEE 264
EXPT. NO.-07

NAME OF THE EXPERIMENT: STUDY OF AN EMITTER FOLLOWER

OBJECTIVE

To measure the input impedance, output impedance, phase relationship and gain of an emitter follower.

MATERIALS REQUIRED

n-p-n transistor C828	one piece
10K,100K potentiometer	one piece each
resistors	100Ω ,10KΩ,100KΩ
capacitors	10μF,10μF
multimeter	one piece
bread board	one piece
power supply	one piece
signal generator	one piece
oscilloscope	one piece

CIRCUIT DIAGRAM

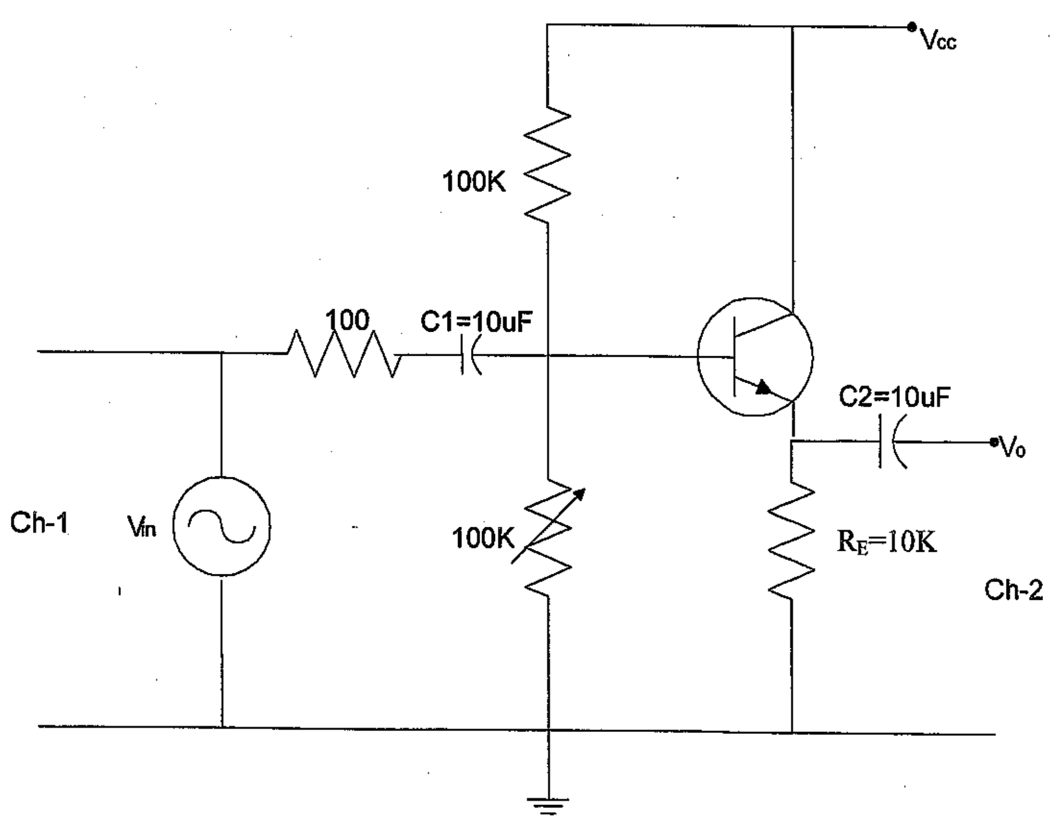

Fig. 1

PROCEDURE

1. Construct the circuit as shown in Fig. 1. Adjust 100K potentiometer to fix the Q point at the middle of the output characteristics.

2. Set the signal generator frequency at 5KHz. Apply the input signal to 0.5V (p-p). Observe the wave shape in dual mode.

3. Measure the peak value of both V_{in} and V_O.

4. Connect the 10KΩ potentiometer from V_O to ground. Adjust the 100 KΩ potentiometer until V_O is half the open circuit value. Measure the potentiometer resistance.

5. Disconnect ch.2 & potentiometer and connect ch.1 across 100Ω. Measure the peak value.

6. Change the input frequency to 50 Hz and measure voltage gain. Measure voltage gains at different frequencies. Take sufficient readings around lower cutoff frequency, in mid-band and upper cutoff frequency.

REPORT

1. Plot the frequency response of the circuit on semilog graph paper.

2. What is the input impedance , output impedance, phase relationship and gain of the emitter follower circuit. How do these quantities compare with those of a CE amplifier?

3. What is the application of the emitter follower circuit.

4. What are advantages and disadvantages of emitter follower circuit.

5. Explain the reason why voltage gain is less than unity.

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COURSE NO. : EEE 264
EXPT. NO.-08

NAME OF THE EXPERIMENT: STUDY OF A RC COUPLED TWO STAGE AMPLIFIERS.

OBJECTIVE

To know the effect of the frequency on the gain of a RC coupled amplifier and also to measure the input impedance, output impedance and phase relationships of the amplifier.

MATERIALS REQUIRED

n-p-n transistor C828	two pieces
potentiometer	1KΩ
resistors	100Ω ,470Ω(2), 560Ω(2),33KΩ(2),68KΩ(2)
capacitors	10μF(4)
multimeter	one piece
bread board	one piece
power supply	one piece
signal generator	one piece
oscilloscope	one piece

CIRCUIT DIAGRAM

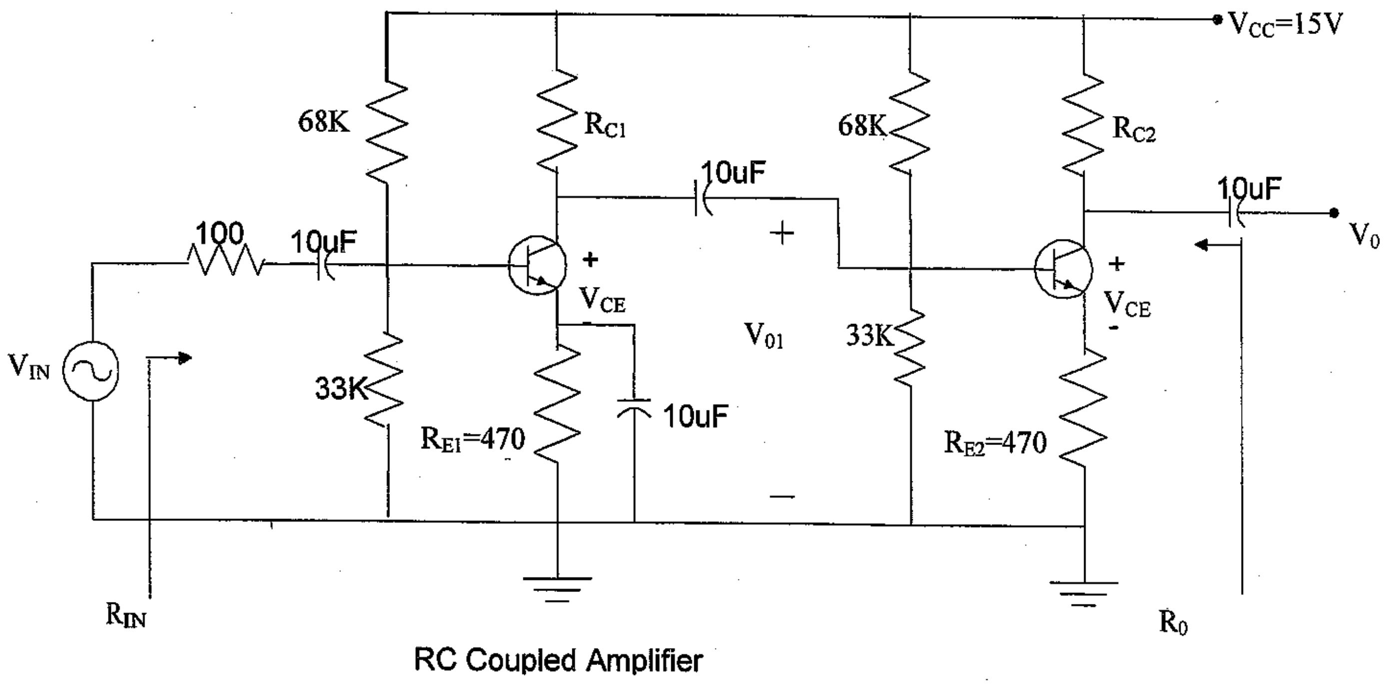

Fig. 1

PROCEDURE

1. Construct the circuit as shown in fig. 1. Verify that both the transistors are properly biased in the active region.

2. Set the signal generator frequency at 5KHz. Increase input signal until output is not distorted.

3. Set the oscilloscope in dual mode. Observe the phase relationships of both input and output. Measure peak value of Vin , V_{01} and Vo.

4. Connect the 1KΩ potentiometer from V_O to ground. Adjust the 1KΩ potentiometer until V_O is half the open circuit value. Measure the potentiometer resistance.

5. Disconnect ch.2 and connect ch.1 across 100Ω and measure peak value.

6. Change the input frequency to 50 Hz. Measure input and output from the oscilloscope to calculate gain. Measure the gain at different frequency. Take sufficient reading in the lower cutoff region, in mid-band and in the upper cutoff region.

REPORT:

1. Plot the frequency response of the circuit on the semilog graph paper.

2. What is the input impedance, output impedance and mid band gain of the RC coupled common emitter amplifier.

3. Calculate the mid band gain of each stage. How are these values compared with the overall gain?

4. Discuss the phase relationships of the two stages.

5. What are the advantage and disadvantage of RC coupled common emitter amplifier?

6. Why does the gain decrease at higher frequency?

7. What is the effect of bypass capacitor on frequency response?

8. Why is bypass capacitor omitted from the second stage?

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COURSE NO. : EEE 264
EXPT. NO.-09

NAME OF THE EXPERIMENT: MATHEMATICAL OPERATIONS USING OP-AMP

OBJECTIVE

Any kind of mathematical operations can be done using OP-AMP. In this experiment only three i.e. addition, differentiation and integration operations will be performed.

THEORY

The property of infinite impedance and infinite gain of an operational amplifier results in a situation of zero voltage between the two input terminals. The effect is known as a virtual ground. Due to this effect, the op-amp can be used to perform some mathematical operations.

Addition: Using the concept of inverting amplifier, the op-amp can be used as an adder (actually inverting adder) to sum up some input signals. In Fig.1 the output of the op-amp is

$$V_0 = -(E_1 + E_2 + E_3)$$

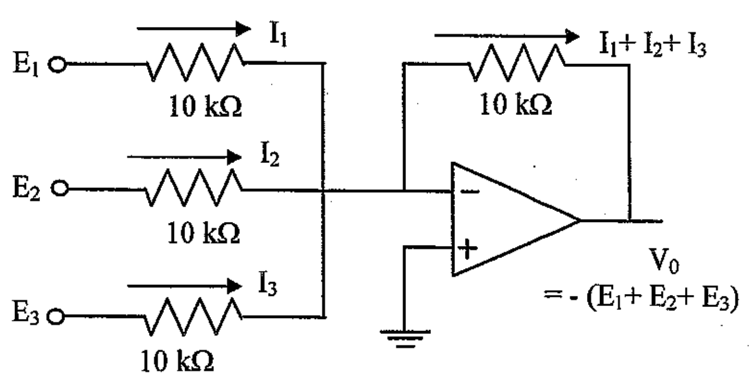

Fig. 1 Adder circuit

Integration and Differentiation: The circuit in Fig. 2 acts as an integrator where the output voltage is given as:

$$v_0(t) = -\frac{1}{RC}\int v_i(t)dt$$

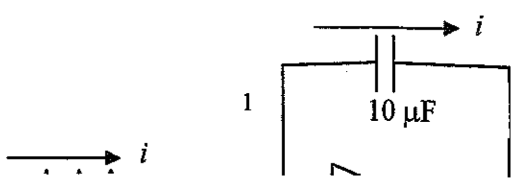

Fig. 2 Integrator circuit

Similarly, the circuit in Fig. 3 acts as a differentiator and the output voltage is given as:

$$v_0(t) = -RC\frac{dv_i(t)}{dt}$$

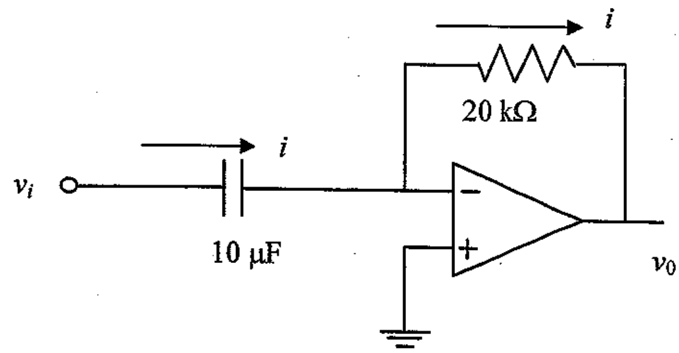

Fig. 3 Differentiator circuit

APPARATUS

Trainer board	1 Capacitor 10μF
OP-AMP (741)	1 Oscilloscope
Resistance	50kΩ, 10kΩ, 20kΩ

PROCEDURE

1. Implement the adder circuit as shown in Fig.1. Apply the supply voltages as +12V and -12V at pin no. 7 and 4 respectively. Apply the input voltages E_1= 2V, E_2= 3V and E_3= 4V , and measure the output voltage.
2. Implement the integrator circuit as in Fig. 2.
3. Apply a sinusoidal waveform of 5 volt p-p in the input. Observe the output.
4. Change the resistance to 50kΩ and observe the output voltage waveshape.
5. Repeat step 3 and 4 for a square wave input signal.
6. Repeat step 3 and 4 for a sawtooth input signal.

7. Implement the differentiator circuit in Fig. 3.
8. Repeat steps 3 to 6.

REPORT

1. Draw the input and output waveforms of the integrator and differentiator circuit.
2. Design a circuit which will take two inputs $v_1(t)$ and $v_2(t)$; producing an output of $v_O(t) = 0.5v_1(t) + 20 \int v_2(t)dt$.

10. Repeat the above experiment for V_{CE}=1Volt.

11. Vary V_{BB} so that I_B is about 10μA. Vary V_{CE} in steps of 2.5 volts and measure V_{CE} and I_C.

12. Repeat the experiment for I_B=20μA and 30μA.

REPORT

1. (a) Plot output and input characteristics of the n-p-n CB transistors.

   (b) Indicate active, linear/saturation and cut-off regions of the characteristics.

2. (a) Plot output and input characteristics of CE transistor.

   (b) Calculate the early voltage from the output characteristic.

   (c) Discuss the effect of changing β on the output characteristics.

   (d) Discuss the effect of changing V_{CE} on the input characteristics

3. What are the role of the 2K and 1K fixed resistors in the circuits?

4. Plot $\beta(=I_c/I_B)$ as a function of I_C for V_{CE}=7.5V.