BRCM College of Engineering & Technology

Bahal

Analog Electronics Laboratory

(PCC-EE – 207-G)

LAB MANUAL

III SEMESTER

Prepared By.

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BRCM College of Engineering & Technology

Bahal

Analog Electronics Laboratory

Class Work: 25
Exam : 25
Total : 50

Course Code	PCC-EE-207G	
Category	**Engineering Science Course**	
Course title	**Analog Electronics** (Laboratory)	
Scheme	**L**	**T** **P**
	-	**-** **2**

Notes:

(i)   At least 10 experiments are to be performed by students in the semester.
(ii)   At least 7 experiments should be performed from the list, remaining three experiments may either be performed from the above list or designed and set by the concerned institution as per the scope of the syllabus
(iii) Gruoup of students for practical should be 15 to 20 in number.

List of Experiments

1. To Study the following devices: (a) Analog & digital multimeters (b) Function/ Signal generators (c) Regulated d. c. power supplies (constant voltage and constant current operations) (d) Study of analog CRO, measurement of time period, amplitude, frequency & phase angle using Lissajous figures.

2. To Plot V-I characteristic of P-N junction diode & calculate cut-in voltage, reverse Saturation current and static & dynamic resistances.

3. To Plot V-I characteristic of zener diode and study of zener diode as voltage regulator. Observe the effect of load changes and determine load limits of the voltage regulator.

4. To Plot frequency response curve for single stage amplifier and to determine gain bandwidth product.

5. To Plot drain current - drain voltage and drain current – gate bias characteristics of field effect transistor and measure of I_{dss} & V_p

6. To Plot gain- frequency characteristic of emitter follower & find out its input and output resistances.

7. To Plot input and output characteristics of BJT in CB, CC and CE configurations. Find their h-parameters.

8. To Study half wave rectifier and effect of filters on wave. Also calculate theoretical & practical ripple factor.

10. To Study bridge rectifier and measure the effect of filter network on D.C. voltage output & ripple Factor.

11. To plot the characteristics of MOSFET.
12. To determine the following parameters of OP-AMP.a) Input Bias Current. b) Input Offset Current. c) Input Offset Voltage. d) CMRR

Note:

1. Each laboratory group shall not be more than about 20 students.
2. To allow fair opportunity of practical hands on experience to each student, each experiment may either done by each student individually or in group of not more than 3-4 students. Larger groups be strictly discouraged/disallowed.

Lab Session 01

OBJECTIVES

To study about Electrical variables and electrical symbols.
To study about Digital Multimeter.
To study about Digital Oscilloscope.
To study about Function Generator.
To study about Dual Track Power Supplies.

APPARATUS

Digital Multimeter.
Digital Oscilloscope. TDS-210
Function Generator.
Power supply unit mod. PS1-PSU/EV.

THEORY:

Electrical Symbols

Symbols of Some Electrical Components

Electrical Variables

Variables		Measurement Unit	Symbol
Current intensity	I	Ampere	A
Voltage o e.m.f.	V	Volt	V
Power	P	Watt	W
Frequency	f	Hertz	Hz
Pulse	w	Radiant / s	rd / s
Period	T	Second	s
Phase	ϕ	Degree or radiant	° or rd
Impedance	Z	Ohm	Ω
Admittance	Y	Ohm^{-1} or Mho	Ω^{-1}
Resistence	R	Ohm	Ω
Capacitance	C	Farad	F
Inductance	L	Henry	H

Digital Multimeter

Multimeter is the measuring instrument use to measure voltage, current and resistance of the electronics and electrical circuit. Multimeter is basically an integration of Ammeter, Voltmeter and Ohm-meter. Some of the modern digital Multimeter also contains Frequency meter.

Ammeter is used to measure the current. Since current flows through the component, the ammeter must go in series with the component. This makes sure the same current flows through the meter. Current is measured in Amperes (A). Often in electronics we use large resistors which only allow very small current to pass. Therefore we used two other small units.

mA (milliamperes)

μA (microamperes)
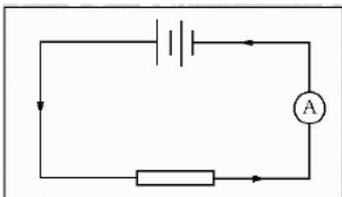
Voltmeter is used to measure the voltage and potential difference across the component. Therefore the

voltmeter must go in parallel. If the internal resistance of voltmeter is quite small then the loading effect causes the problem.
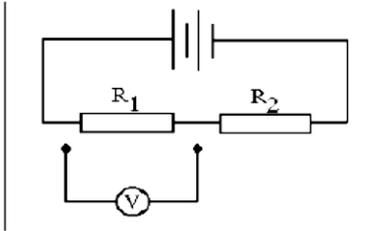
The unit for measuring the voltage is volt. Small signals such as bio-signals are generally measure in millivolts (mV).


The Cathode Ray Oscilloscope

We use CRO to visualize at the voltages that changes with the time such as AC voltages and signal waveforms from amplifiers. The voltage on the X-plate makes the electron beam sweep across the screen. This sets the time base. The spot on the screen shows how the Y-voltage varies with the time.
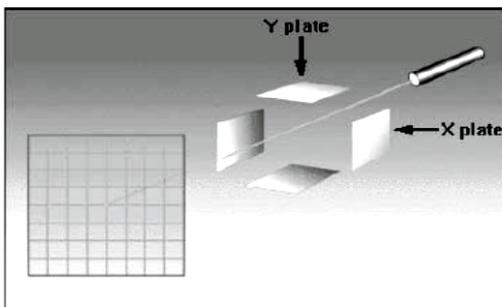
In this example the oscilloscope measures the sine wave with the peak amplitude of 5 V and the frequency of 50 Hz. The two properties we need to know about the sine wave is its amplitude and frequency.

Here we are using Digital Oscilloscope with LCD (Liquid Crystal Display) panel. Volts/div. and Time/div. are controlled digitally through Autoset button. Even other electrical calculations are done directly through this oscilloscope. There are several controlling knobs and buttons that are quite user friendly.
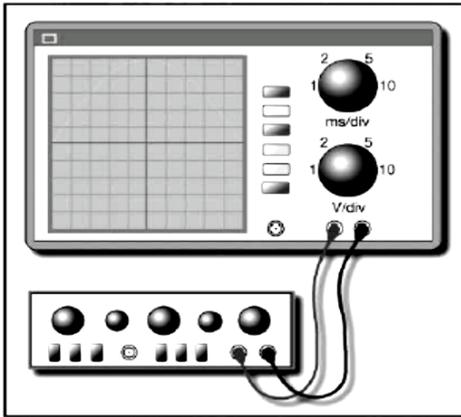
Using a CRO to measure amplitude and frequency.
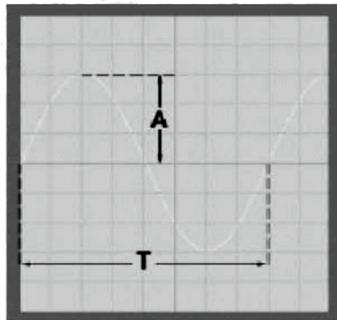
Time Base

= 5 ms/div

Vertical Sensitivity

= 2 V/div

Amplitude = 3 divisions = 3 x 2 = 6 V

Periodic Time T = 8 divisions = 8 x 5 = 40 ms

$$\text{Frequency} = \frac{1}{T} = \frac{1}{40\ ms} = \frac{1000}{40} = 25\ Hz$$

Digital Real-Time Oscilloscope

General Features

- 100MHz (TDS220 or TDS224) or 60MHz(TDS210)bandwidth with selectable 20 MHz bandwidth
- limit.

- 1GS/s sample rate and 2,500 point record length for each channel
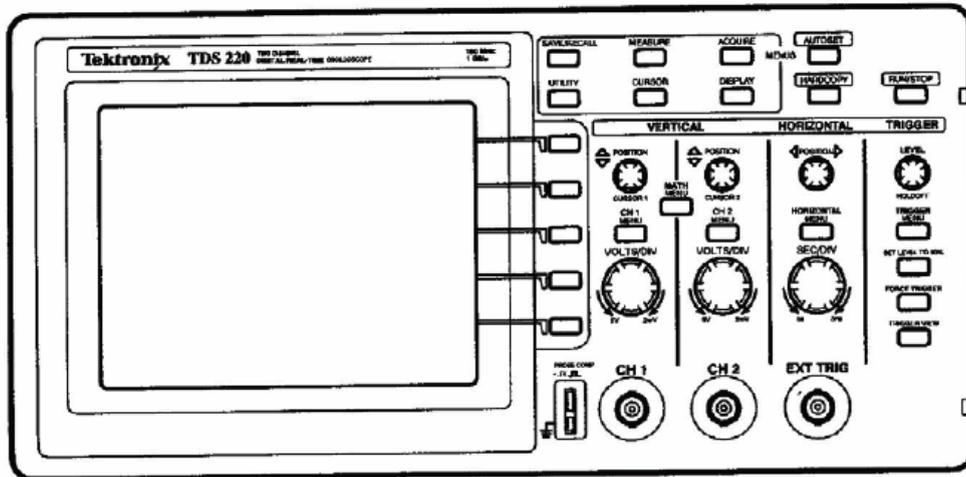- Cursors with readout
- Five automated measurements
- High-resolution, high-contrast LCD display with temperature compensation and replaceable back Light.
- Setup and waveform storage
- Autoset for quick setup
- Waveform averaging and peak detection
- Digital real-time oscilloscope
- Dual time base
- Video trigger capability
- RS-232, GPIB, and Centronics communication ports easily added with optional extension modules
- Variable persistence display
- User interface available in ten user-selectable languages

Functional Check

Perform this quick functional check to verify that your instrument is I operating correctly.

1. Turn on the instrument.

Wait until the display shows that all self tests passed. Push the SAVE/RECALL button, select Setups in the top menu box and push the Recall Factory menu box. The default Probe menu attenuation setting is 10X.

z is 10X.
ON/OFF
button

PASSED
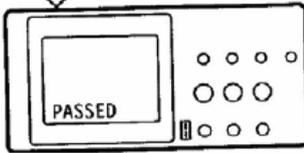
1   Set the switch to 10X on the P2100 probe and connect the probe to channel 1 on the oscilloscope. To do this, align the slot in probe connector with the key on the CH 1 BNC, push to connect, and twist to the right to lock the probe in place. Attach the probe tip and reference lead to the PROBE COMP connectors.

2   Push the AUTOSET button. Within a few seconds, you should see a square wave in the display (approximately 5 V at 1 kHz peak-to-peak). Push the CH 1 MENU button twice to turn off channel, push the CH 2 MENU button to turn on channel 2, repeat steps 2 .and 3. For TDS 224, repeat for CH 3 and CH 4.

PROBE COMP

CH 1
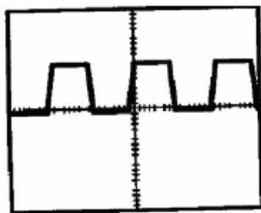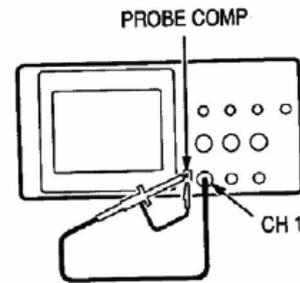
Using Autoset

The Autoset function obtains a stable waveform display for you. It automatically adjusts the vertical and horizontal scaling, as well as the trigger coupling, type, and position, slope, level and mode settings.

The Function Generator

This instrument is basically the frequency generator that can generate signals of different frequency, amplitude and shape. It is known as variable frequency source.

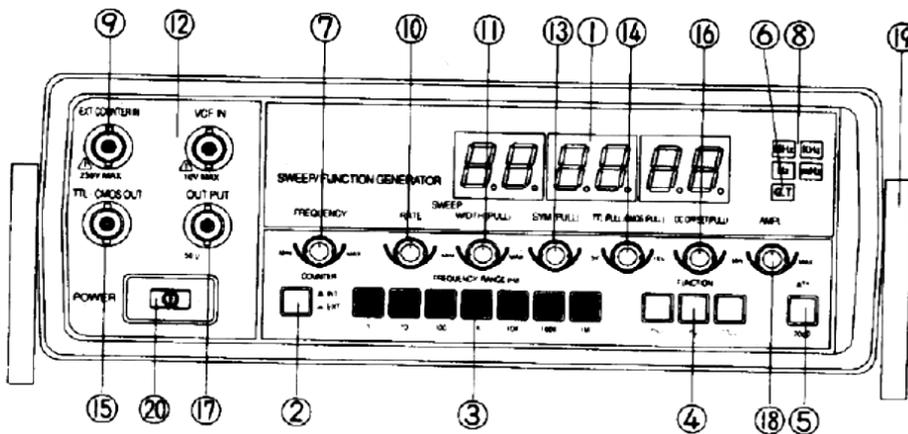| 1	LED DISPLAY.	Displays internal or external frequency.
2	INTERNAL EXTERNAL SWITCH. : PUSH IN	External Frequency Counter. PUSH OUT: Internal Frequency Counter
3	RANGE SWITCHES.	Frequency range Selector.
4	FUNCTION SWITCHES.	Select Sine wave, Triangle wave or Square wave output.
5	ATTENUATOR.	Selects Output Level by -20 dB.
6	GATE TIME INDICATOR.	Gate Time Is selected automatically by input signal.
7	FREQUENCY DIAL.	Controls Output frequency in selected range.
8	MHz, KHz, Hz, mHz INDICATOR.	Indicates unit of frequency.
9	EXTERNAL COUNTER INPUT BNC.	Used as an External Frequency Counter.
10	SWEEP RATE CONTROL.	On/Off Switch for Internal Sweep Generator, adjusts sweep rate of Internal Sweep Generator
11	SWEEP WIDTH CONTROL.	Pull out and adjusts Magnitude of Sweep.
12	VCF INPUT BNC.	Voltage controlled Frequency Input permits External Sweep. Frequency control sweep rate control should be off when applying External Voltage at this BNC.
13	SYMMETRY CONTROL.	Adjust Symmetry of Output Waveform 1:1 to 10:1 with Push/Pull Switch On.
14.	TTL/CMOS CONTROL.	Selects TTL or CMOS mode Pull-out: CMOS Level Control, Push-In: TTL Level.
15.	TTL/CMOS OUTPUT BNC.	TTL/CMOS Level Output.
16.	DC OFFSET CONTROLS.	Adds Positive or Negative DC Component to Output Signal .

17	MAIN OUTPUT BNC.	Impedance 50 Ohm.
18	AMPLITUDE CONTROL.	Adjusts Output Level from 0 to 20 dB.
19	TILT STAND.	PullOut to adjust tilt.
20	POWER SWITCH.	Push type switch. turning on the power when pressed.
21	FUSE HOLDER.	Replacing fuse with unscrewing
22	AC INLET.	For connection of the supplied AC power

Usually these are the shapes of the signal that can be generated using Function Generator.
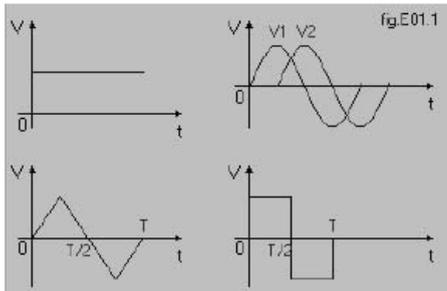
Lab Session 02

OBJECTIVES

- ☐   Identify diode schematic symbols.
- ☐   Describe Silicon based diode operating characteristics.
- ☐   Identify diode construction characteristics.
- ☐   Observe normal operations in a diode circuit.

EQUIPMENTS REQUIRED

- ☐   Base unit for the IPES system.
- ☐   Power supply module PSU/EV.
- ☐   Module holder structure MU/EV.
- ☐   Individual Control Unit module SIS3/EV.
- ☐   Experiment module MCM3/EV.
- ☐   Multimeter.
- ☐   Oscilloscope.

INTRODUCTION

Although the diode is a simple device, it forms the basis for an entire branch of electronics. Transistors, integrated circuits, and microprocessors are all based on its theory and technology. In today's world, semiconductors are found all around us. Cars, telephones, consumer electronics, and more depend upon solid state devices for proper operation.

PN Junction

Now, we are ready to build a diode. To do this, we need two blocks of material, one N type and one P type.
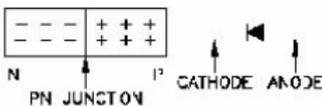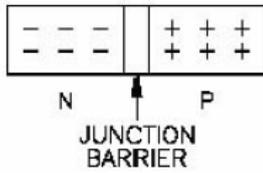

Figure 1. N and P Material

Figure 2. Diode

The resulting block of material is a diode. At the instant the two blocks are fused, their point of contact becomes the PN junction. Some of the electrons on the N side are attracted to the P side, while at the same

time, an equal number of hole charges are attracted to the N side.

Figure 3. PN Junction Diode

As a result, the PN junction becomes electrically neutral. The barrier in Figure 3 is greatly exaggerated. In some semiconductor devices, the PN junction barrier may only be a few atoms thick. The PN junction is an electrical condition, rather than a physical one. The junction has no charge; it is depleted of charges. Thus, another name for it is the **depletion zone**. Because of the existence of the depletion zone, there is no static current flow from the N material to the P material.

The diode consists of two parts or elements, the N material and the P material. Their proper names are cathode and anode. The cathode is the N material and the anode is the P material. Electron current flow is from the cathode to the anode. Figure 4 illustrates a PN junction diode.
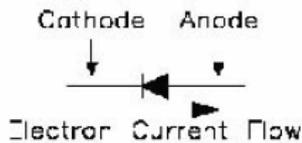
Figure 4. The Diode

Bias

Average DC level of current to set operating characteristics.

There are two types of bias in semiconductors, forward and reverse. Forward bias will eliminate the depletion zone and cause a diode to pass current. Reverse bias will increase the size of the depletion zone and in turn, block current. Figure 6 and 7 illustrates forward and reverse bias.

Figure 5. Bias

A diode is biased by placing a difference in potential across it. Figure 7 illustrates a forward biased diode. Because of the positive potential applied to the anode and the negative potential applied to the cathode, the depletion zone disappears. Current flows from the negative terminal of the battery through the N region, across the non-existent depletion zone, and through the P region to the positive terminal of the battery. It takes a specific value of voltage for a diode to begin conduction. Approximately .3 volts across a

germanium diode or .7 volts across a silicon diode are necessary to provide forward bias and conduction. A germanium diode requires a lower voltage due to its higher atomic number, which makes it more unstable Silicon is used far more extensively than
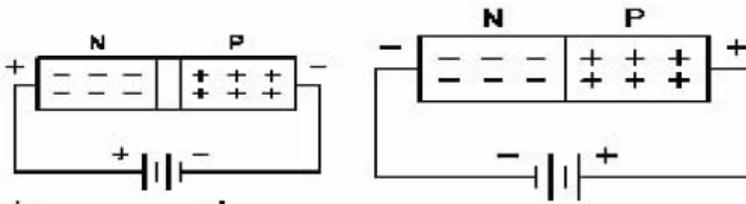
Figure 6. Reversed Biased Diode   Figure 7. Forward Biased Diode

Reverse bias is accomplished by applying a positive potential to the cathode and a negative potential to the anode as shown in Figure 6. The positive potential on the cathode will attract electrons from the depletion zone. At the same time, the negative potential on the anode will attract holes. The net result is that the depletion zone will increase in size.

A forward biased diode will conduct, with only a small voltage drop over it. The voltage drop for a forward biased germanium diode is .3 volts, while .7 volts is normal for a silicon diode. We can say that a forward biased conducting diode is almost a short. A reversed biased diode will not conduct. Therefore, it can be considered an open circuit. We call a reversed biased diode **cut off**. Cut off refers to the current flow through the diode being blocked, or cut off.

Diode characteristics

The diode consists of two elements, the anode and the cathode. The anode corresponds to the P material and the cathode to the N material. Current flow is from the cathode to the anode.
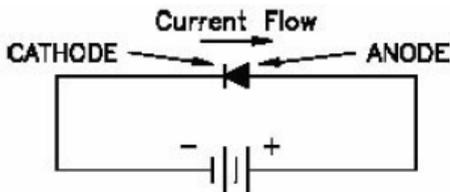
Figure 8. Forward Biased Diode

Figure 8 illustrates a forward biased diode with current flow and the diode elements labeled. The graph in Figure 9 depicts current flow through a diode with different values of forward and reverse bias.

Figure 9. Forward and Reverse Currents of a Semiconductor Diode

Let's examine forward bias first.

As the forward bias is gradually increased, current through the diode will increase. A small forward voltage (forward bias) will generate a very large forward current (cathode to anode). Typical values of forward current are in the r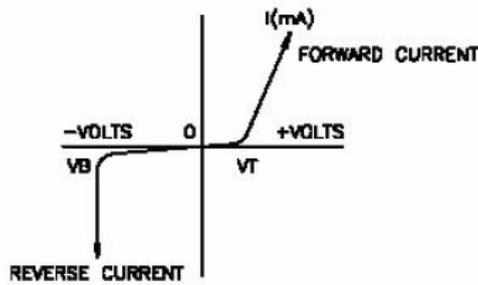ange of .2 to 20 amps. Of course, every diode has a maximum value of forward current that can be passed without damage. Typical low power diode current characteristics are:

I_f- the maximum forward current (upto 1 amp)
I_{fm}- maximum peak forward current (upto 5 amps, repetitive)
I_{fs}- maximum peak surge current (upto 35 amps, non-repetitive)

Reverse bias will effect diodes in a different manner. Figure 9 illustrates the point. As the reverse bias or voltage is increased, there will be a very small reverse current (anode to cathode). It will be in the range of 1 milliamp for a germanium (Ge) diode and 1 microampere for silicon (Si) diode. As the reverse voltage is gradually increased, the reverse current will stay at a constant low level until the junction breakdown voltage V_B is reached. At that point, the junction will cease to exist and the diode will conduct. As you can see in Figure 9, the current flow will be massive. Reverse current flow is so heavy that it is called **avalanche conduction**. When the diode is operated in the avalanche region, current flow becomes independent of voltage, and that point is called **avalanche breakdown**. Due to the massive electron flow, normal PN junction diodes are destroyed when operated in this manner.

The forward and reverse biased states of a diode can be compared to a variable resistor. Figure 10 illustrates the concept. A forward biased diode will drop only .3 or .7 V. That corresponds to an internal resistance in the anode that drops from several Kilo-ohms at the point where conduction begins to several ohms where a diode is conducting heavily. In the reverse bias state, resistance will be in the Mega-ohms until breakdown voltage is reached. At that point, internal resistance will drop rapidly.
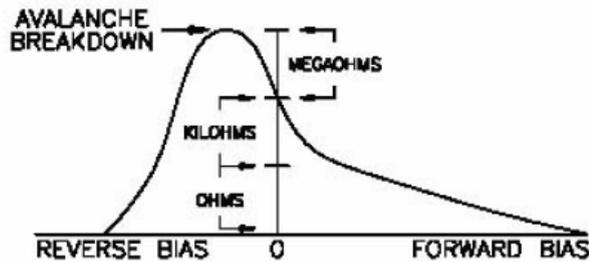
Figure 10. Diode Characteristics Expressed as a Resistance

The stripe on the body of the diode indicates the cathode. To test a diode, you will measure the resistance of the barrier junction.

PROCEDURE

- **Measurement of the forward and reverse resistance of diode**

1   Set the Multimeter for resistance measurement.
2   Measure the forward and reverse resistance of D1 (Silicon) and D2 (Germanium).
3   Record the values in the table.

	D1 (Si)	D2 (Ge)
Forward Resistance		
Reverse Resistance		

- **Measurement of diode current as function of applied voltage**

1   Connect jumpers J2, J8, J9 and J5 to produce the circuit shown in the figure.
2   Steadily increase the supply voltage and measure the voltage across the silicon diode D1.
3   Remove all the jumpers from the module.
4   With the result obtained plot the voltage current curves for D1.

OBSERVATIONS

S.No.	VOLTAGE (Volt) D1	CURRENT (mA) D1

CONCLUSION Current through Silicon based diode starts increasingly exponentially when potential across diode is approximately millivolts (Cut-in Voltage).
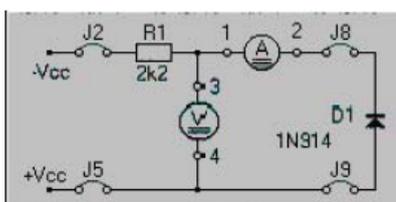
OBJECTIVES

☐ Identify diode schematic symbols.
☐ Describe Germanium based diode operating characteristics.
☐ Identify diode construction characteristics.
☐ Observe normal operations in a diode circuit.

EQUIPMENTS REQUIRED

☐ Base unit for the IPES system.
☐ Power supply module PSU/EV.
☐ Module holder structure MU/EV.
☐ Individual Control Unit module SIS3/EV.
☐ Experiment module MCM3/EV.
☐ Multimeter.
☐ Oscilloscope.

INTRODUCTION

A germanium diode requires a lower voltage due to its higher atomic number, which makes it
unstable. Silicon is used far more extensively than germanium in solid state devices because of its stabil

PROCEDURE

1   Connect jumpers J2, J10, J11 and J5 to produce the circuit shown in the figure.
2   Steadily increase the supply voltage and measure the voltage across the silicon diode D2.
3   Remove all the jumpers from the module.
4   With the result obtained plot the voltage current curves for D2.

OBSERVATIONS

S.No.	VOLTAGE (Volt) D2	CURRENT (mA) D2

CONCLUSION

Current through Silicon based diode starts increasingly exponentially when potential across diode is approximately   millivolts (Cut-in Voltage).

SUMMARY

- Semiconducting elements can act as conductors or insulators.
- Silicon and germanium are semiconductor elements most often used in electronics.
- N material is formed from silicon or germanium doped to add electrons. Most common doping agents are arsenic, antimony, or phosphorous.
  - • P Material
  - − is formed from silicon or germanium.
  - − is doped to add holes.
- The most common doping agents are aluminum, boron, or gallium.
  - • A PN Junction
  - − is formed from a block of P material fused with a block of N material.
  - − is also called a **junction barrier**.
  - − is electrically neutral (with no bias voltage to the device).
  - − is an electrical barrier rather than a physical one.
  - − requires 0.3 V to be overcome if the material is germanium, or 0.7 V if it is silicon.
  - − is also called the depletion zone.
  - − is called a diode.
  - • The diode consists of two parts:
    - The N material is called the cathode.
    - The P material is called the anode. Current flows from cathode to anode.
- Bias determines whether a diode conducts or is cut off.
- Forward bias allows a diode to conduct.
- Reverse bias blocks conduction, or cuts off a diode.
- With forward bias, current increases as the voltage increases.
- With reverse bias, reverse current is minimal until avalanche conduction is reached.
  - • Diode current flow
    - After leaving the negative source terminal, it enters the right end of the diode.
    - It travels through the N region as a free electron.
    - Near the junction, it recombines and becomes a valence electron.
    - It travels through the P region as a valence electron.
    - After leaving the left end of the diode, it flows into the positive source terminal.

OBJECTIVE

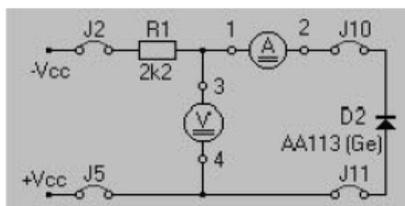- To study the half-wave rectifier.

EQUIPMENT REQUIRED

- ☐ Base unit for the IPES system.
- ☐ Power supply module PSU/EV.
- ☐ Module holder structure MU/EV.
- ☐ Individual Control Unit module SIS3/EV.
- ☐ Experiment module MCM3/EV.
- ☐ Multimeter.
- ☐ Oscilloscope.

BASIC THEORY

The rectifier circuit converts the AC voltage furnished by the utilities company into the DC voltage required to operate electronic equipment. Many common electrical products use voltages provided by a rectifier. Without the rectifier to convert the AC voltage to the DC voltage required to operate these electrical units, it would be virtually impossible to have the conveniences that we enjoy today. A television without a rectifier would require several extremely large batteries. These batteries would have to be large because of the current that is required. In other words, a television without the rectifier would be so large that it would occupy an entire room. The rectifier is the heart of the electronic unit.

Introduction

A rectifier system can be divided into five sections, each performing a separate function. Figure 1 is a block diagram of a rectifier system. This lesson deals with the input, rectifier, and filter sections.

```
┌────────┐   ┌──────────┐   ┌────────┐   ┌───────────┐   ┌──────────┐
│ INPUT  │──▶│ RECTIFIER│──▶│ FILTER │──▶│ REGULATOR │──▶│ VOLTAGE  │
│        │   │          │   │        │   │           │   │ DIVIDER  │
└────────┘   └──────────┘   └────────┘   └───────────┘   └──────────┘
```

Figure 1. Rectifier System

Input Block

The input block consists of a transformer, normally a power transformer that receives the AC input signal from some power source. The transformer transfers the electrical energy received to the rectifier section by electromagnetic induction or mutual inductance. The transformer performs the transfer of energy without any change in frequency, but it is able to change the voltage and current from the input source to the voltage and current required by the rectifier section. The phase relationship of the current in the secondary of the transformer is dependent upon the phase of the voltage in the primary winding and the direction of the winding in the secondary. If the secondary windings are wound in the same direction as the primary windings, the phase between the input signal and the output signal will be the same. If the secondary windings are wound in the opposite direction of the primary windings, the phase between the input signal

and the output signal will be 180 degrees out of phase. The schematic drawings of a transformer indicate the phase relationship between the primary and secondary with the use of dots. The dots on a schematic diagram indicate which windings are in phase. Figure 2 illustrates this relationship.

Figure 2. Transformer

Rectifier Block

The rectifier circuit is the most important part in the rectifier system. The rectifier circuit converts the AC waveform from the input block into a pulsating DC waveform. One of several different rectifier circuits may be utilized to perform this function. These circuits are the half-wave rectifier, the full-wave rectifier, the full-wave bridge rectifier, and the voltage doubler.
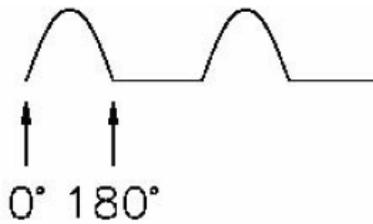
Half-Wave Rectifier

Figure 3 shows the schematic diagram for a half-wave rectifier. The half-wave rectifier is the simplest type of rectifier; it consists of only one diode. For explanation purposes, a load resistance must be placed in the circuit to complete the path for current flow and to develop the output signal.
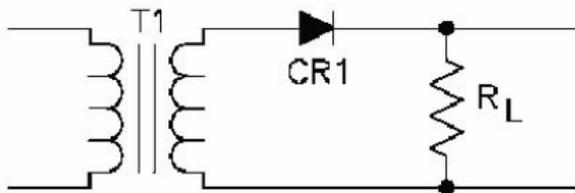
Figure 3. Half-Wave Rectifier

The half-wave rectifier in Figure 3 is a positive half-wave rectifier. It is called a positive half-wave rectifier because it only uses the positive portion of the input sine wave and produces a positive pulsating DC signal. During the positive alternation of the input voltage, the positive alternation of the sine wave causes the anode of the diode to become positive with respect to the cathode. The diode is now forward-biased and will conduct. Current will flow from the negative side of the transformer secondary, through the load resistor, through the diode, to the positive side of the transformer secondary. This path for current flow will exist during the complete positive alternation of the input waveform because the diode will remain forward-biased as long as the positive signal is applied to the anode. The resulting output of the rectifier will be developed across the load resistor and will be a positive pulse very similar to the positive alternation of the input waveform. Figure 4 illustrates the output waveform across the load resistor. During the negative alternation of the input sine wave, the anode is negative with respect to the cathode and the diode will become reverse-biased. As long as this condition exists, no current will flow in the circuit and an output

signal cannot be developed across the load. The circuit gives the appearance of producing a series of positive pulses. A negative half-wave rectifier operates very similar to a positive half-wave rectifier, except the output will be a series of negative pulses. (Refer to Figure 5.)

Figure4. Output Waveform of a Positive Half-WaveRectifier

During the positive alternation, the diode is reverse-biased; no current will flow through the circuit, and no signal will be developed across the load. This condition will exist any time a positive alternation is present on the cathode. When the negative alternation is present on the cathode, the diode is forward-biased; current flows from the negative side of the secondary through the diode, through the load resistance, to the positive side of the secondary. This condition allows a negative pulse to be developed across the load resistance and continues until the negative cycle is removed from the cathode. The output of a negative half-wave rectifier will be a series of negative pulses. The amplitude of the output is approximately the same as the peak voltage of the input signal if measured with the oscilloscope. If a multimeter is used to measure the pulsating DC voltage, it will indicate the average voltage. The average voltage of a sine wave is zero volts; however, if the negative portion of a sine wave is clipped off, the average value changes to some positive value. Since the waveform swings positive but never goes negative, the average voltage will be positive. To determine the average value of a pulsating DC signal using a half-wave rectifier, multiply the peak voltage by .318.

Example: Input peak value = 10 volts AC

        10 volts AC X .318 = 3.18 volts AC

        $E_{AVG} = E_{PEAK} \times .318$

The average value of a signal is the average of all the instantaneous values during one alternation. For one positive alternation, the voltage value increases from 0 volts to some maximum peak value and decreases back to 0 volts; the average value would be some value between the two limits. The instantaneous value of an alternating voltage or current is the value of voltage or current at one particular instant. The value may be zero if the particular instant is the time in the cycle at which the polarity is changing. It may also be the same as the peak value if the selected instant is the time in the cycle at which the voltage or current stops increasing and starts decreasing. There are actually an infinite number of instantaneous values between zero and peak value.The current flows in the circuit during the half cycle (duration of a half- wave) and produce a positive half-wave voltage across the load. The average value V_m of the rectified voltage is:

$$V_m = V_M / \pi = 0.318 \cdot V_M$$

The rms voltage is:

$$V_{rms} = V_M / 2$$

Ripple Frequency

The half-wave rectifier gets its name from the fact that it conducts during only half the input cycle. I output is a series of pulses with a frequency that is the same as the input frequency. Thus, when operation from a 60 hertz line source, the frequency of the pulses is 60 hertz. The frequency at which the puls appear is called ripple frequency.

Peak Inverse Voltage (PIV)

The largest reverse voltage that the diode must be able to withstand without breakdown is known as PIV. is the largest reverse voltage that is expected to appear across the diode.

PIV = V_M

PROCEDURE

☐   Connect jumpers J14, J24, J31, J27, J20 and the ammeter to produce the circuit shown below.
☐   Adjust RV_2 to obtain the minimum current in the circuit.
☐   Connect the Oscilloscope to display both the input voltage and the voltage across the load.
☐   Compare the two waveforms and determine at which time the diode conducts.
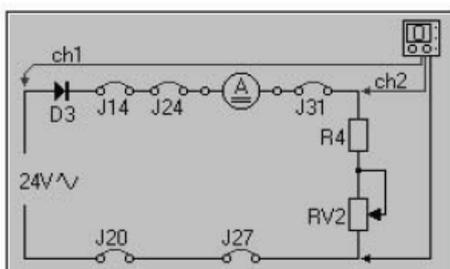
OBSERVATIONS AND CALCULATIONS

Write down the frequency of the input AC cycle?

Write down peak to peak, rms and mean value of input AC cycle?

Write down the frequency of the Half wave rectifier output?

Write down peak to peak, rms and mean value of Half wave rectifier output?

CONCLUSION

- In Half-wave rectifier the two signals are in phase but the load signal lacks the negative half w and the input one has slightly higher amplitude.

OBJECTIVE

• To study the Full-wave rectifier.

EQUIPMENT REQUIRED

☐ Base unit for the IPES system.
☐ Power supply module PSU/EV.
☐ Module holder structure MU/EV.
☐ Individual Control Unit module SIS3/EV.
☐ Experiment module MCM3/EV.
☐ Multimeter.
☐ Oscilloscope.

BASIC THEORY

Conventional Full-Wave Rectifier

A full-wave rectifier uses two diodes and a center-tapped transformer. Before we discuss a full-wave rectifier, let's consider these points about a center-tapped transformer. Refer to Figure 1. A center-tapped transformer is composed of two windings, one primary winding and one secondary winding which is divided by a ground connected to the center of the secondary winding. When a center tap of a transformer is grounded, the voltages at the opposite side of the secondary windings are 180 degrees out of phase. The amplitude of these two signals will be the same, because there is the same number of windings above the ground as there is below the ground. When the voltage at point A is positive with respect to the ground, the voltage at point B is negative with respect to the ground.
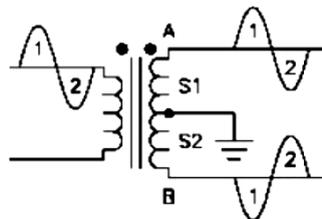

Figure 1. Center-tapped Transformer

Theory Of Operation Of A Full-Wave Rectifier

During the first half cycle, the anode of CR1 is positive with respect to the cathode, while the anode of CR2 is negative with respect to the cathode. Refer to Figure 2. Thus, CR1 is forward-biased, while CR2 is reverse-biased. During the second half cycle, the anode of CR1 is negative with respect to the cathode, while the anode of CR2 is positive with

respect to the cathode, causing CR1 to be reversed-biased and CR2 to be forward-biased.
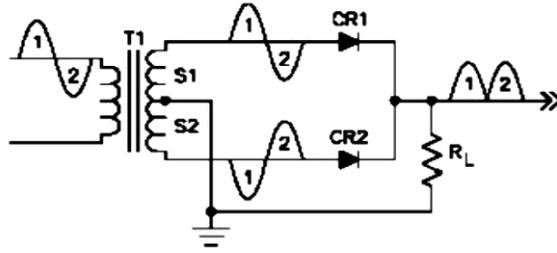
Figure 2. Full Wave Rectifier

When CR1 is forward-biased, current will flow from ground through the load resistor, through the diode CR1, to the upper half of T1, through T1 to the center tap, and back to the ground. As current flows through the load resistor, a positive signal is developed at the junction of RL and CR1. This signal is a positive DC pulse with amplitude approximately the same as the input signal. This signal is developed during the first half of the input cycle only. Refer to Figure 3.
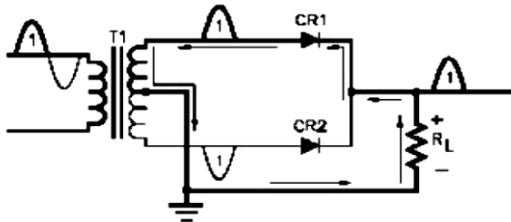
Figure 3. First Half Cycle Rectifier

During the second half cycle of the input signal, CR2 is forward-biased and will allow current to flow. CR1 is reversed-biased during this half cycle. Current will now flow from the ground through the load resistor, through CR2, up through the lower half of the transformer, to the center tap, and back to the ground. Current is still flowing in the same direction across the load resistor so that a positive signal will be developed at the junction of CR2 and RL. Refer to Figure 4.
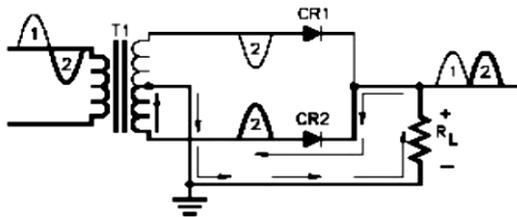
Figure 4. Second Half Cycle Rectifier

During this one cycle of the input sine wave, two positive DC pulses have been developed. With this

condition, the output frequency has doubled. If the input frequency is 60 hertz, the positive alternation will be present 60 times. After the full-wave rectification, there will be 120 positive pulses at the output. The amplitude, if measured with an oscilloscope, will be approximately the same as the peak input signal. If the DC output signal is measured with a multimeter, the indication will be the average value of the peak signal. To determine the average value of a full-wave rectified signal, multiply the peak value by .636. **Example:** $E_{AVG} = E_{PEAK}$ x .636

> Input peak value = 10 V AC
> 10 V AC x .636 = 6.36 V DC

Advantage of Full Wave Rectifier

The Half wave rectifier has too low an average (or rms) value of output voltage, as it uses only half the input cycle. This is inconvenient, especially if the load requires a lot of power. There are two alternatives to the simple rectifier, which rectify the whole of the input cycle, and so increase the average and rms value of the rectified voltage.

One circuit – the full-wave rectifier, uses two diodes, as seen in figure

fig. B04.1
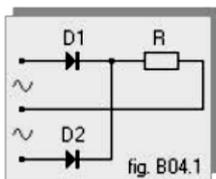
This dual diode rectifier requires two equal voltages, but 180' apart, on the anodes. The average value V_m of the rectified voltage is:

The rms voltage V_{eff} is:

$$V_m = 2 \cdot V_M / \pi = 0.636 \cdot V_M$$

$$V_{eff} = V_M / \sqrt{2} = 0.707 \cdot V_M$$

Peak Inverse Voltage (PIV)

The largest reverse voltage that the diode must be able to withstand without breakdown is known as PIV. It is the largest reverse voltage that is expected to appear across the diode. During the positive half cycle D1 is conducting and D2 is cut off. The voltage at the cathode of D2 is $V_O = V_M - 2V_{DO}$ and that at its anode is -V_M. Therefore,

PIV = 2V_M - V_{DO}

It is approximately for the case of half-wave rectifier.

PROCEDURE

- Connect jumpers J14, J18, J24, J31, J27, J20 and the ammeter to produce the circuit shown below.
- Connect the ground of the oscilloscope to the common point of the two ac input voltages. Connect the probes to display the voltage across the load and alternatively on the anodes of diodes D3 and D7.
- Adjust RV2 to obtain the maximum load current through the circuit.
- Set the ammeter to dc, disconnect jumper J18 and measure the current.
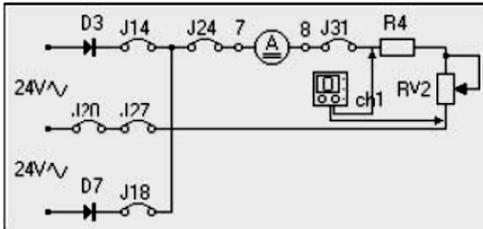
OBSERVATIONS AND CALCULATIONS

Write down the frequency of the input AC cycle?

Write down peak to peak, rms and mean value of input AC cycle?

Write down the frequency of the Full wave rectifier output?

Write down peak to peak, rms and mean value of Full wave rectifier output?

CONCLUSION

- In Full-wave rectifier D3 and D7 rectify the half wave with the help of center-tapped transformer. The voltage on the load consists only of positive pulses.

SUMMARY

- Rectification is the process of changing alternating current to direct current.
- A half-wave rectifier consists of one diode that changes AC voltages to DC voltages, using only one-half cycle of the applied AC voltage.
- A full-wave rectifier consists of two or four diodes connected to utilize both halves of the input AC cycle for producing a DC output.
- The average voltage output of a half-wave rectifier is equal to: $E_{AVG} = 0.318$ x E_{PEAK}.
- The average voltage output of a full-wave rectifier is: $E_{AVG} = 0.636$ x E_{PEAK}
- The average output voltage of a full-wave rectifier is higher than that of a half-wave rectifier. The current capability of the full-wave rectifier is higher than that of the half-wave rectifier.
- A full-wave rectifier is more efficient than a half wave rectifier, and its output is much better filtered, because it uses the entire cycle of the applied AC cycle.
- There are two main types of rectifiers: the half-wave and the full-wave.
- The half-wave rectifier uses only one diode and produces an output during one half of the input signal. The direction of current flow through the diode

Input & Output Characteristics of CE Configuration and h-Parameter Calculations

Objective:

To study the input and output characteristics of a transistor in Common Emitter configuration.

Components:

S.No.	Name	Quantity
1	Transistor BC 107	1(One) No.
2	Resistors (1KΩ, 100KΩ)	1(One) No. Each
3	Bread board	1(One) No.

Equipment:

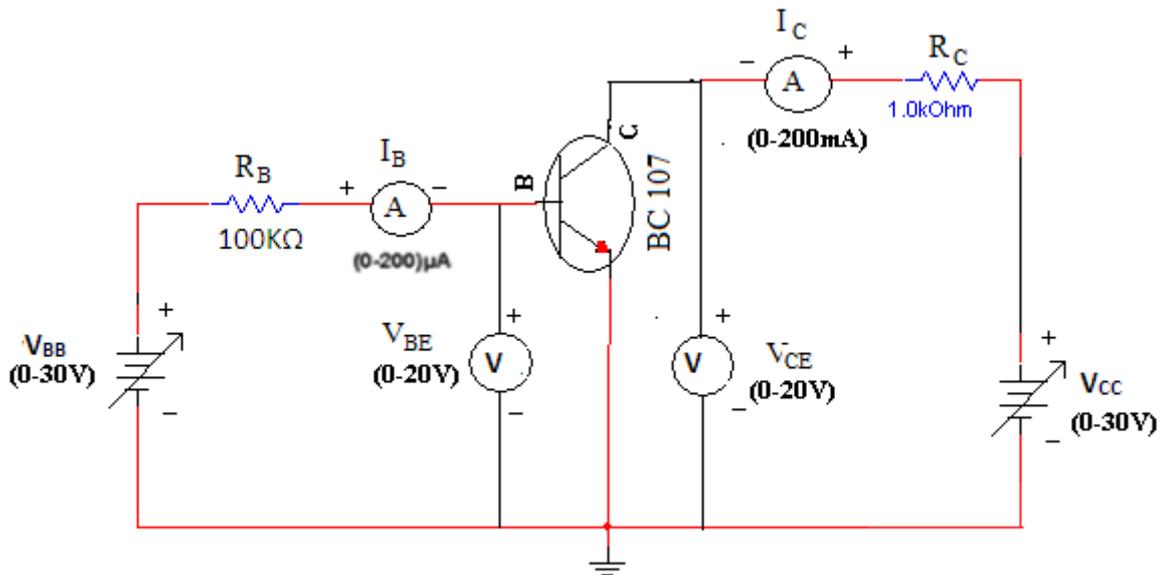| S.No.	Name	Quantity
1	Dual DC Regulated Power supply (0 - 30 V)	1(One) No.
2	Digital Ammeters (0 - 200 mA, 0-200 μA)	1(One) No. Each
3	Digital Voltmeter (0 - 20V)	2(Two) No.
4	Connecting wires (Single Strand)	

Specifications:

For Transistor BC 107:
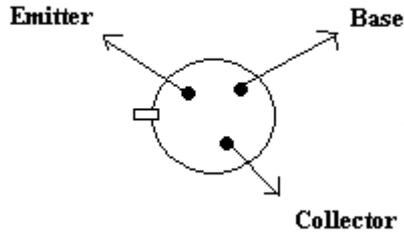
- Max Collector Current = 0.1A
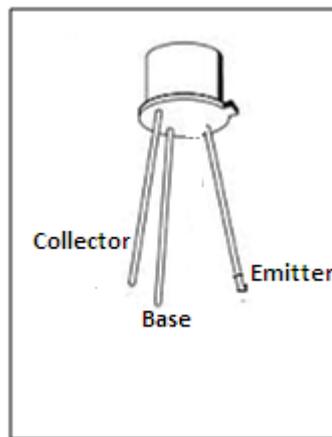- V_{CEO} max = 50V

Circuit Diagram:

h – Parameter model of CE transistor:
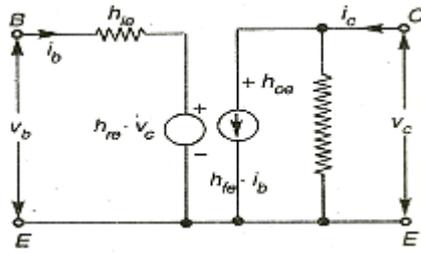
Pin assignment of Transistor:

View from side of pins

View from top of casing

Operation:

The basic circuit diagram for studying input characteristics is shown in the circuit diagram. The input is applied between base and emitter, the output is taken between collector and emitter. Here emitter of the transistor is common to both input and output and hence the name Common Emitter Configuration.

Input characteristics are obtained between the input current and input voltage at constant output voltage. It is plotted between V_{BE} and I_B at constant V_{CE} in CE configuration.

Output characteristics are obtained between the output voltage and output current at constant input current. It is plotted between V_{CE} and I_C at constant I_B in CE configuration.

Procedure:

Input Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. Keep output voltage V_{CE} = 0V by varying V_{CC}.
3. Varying V_{BB} gradually, note down base current I_B and base-emitter voltage V_{BE}.
4. Step size is not fixed because of non linear curve. Initially vary V_{BB} in steps of 0.1V. Once the current starts increasing vary V_{BB} in steps of 1V up to 12V.
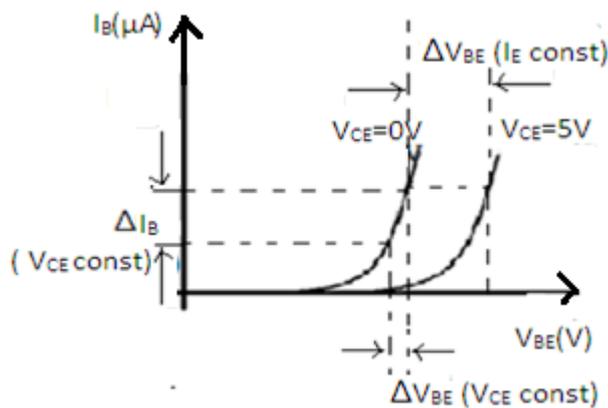5. Repeat above procedure (step 3) for V_{CE} = 5V.

Output Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. Keep emitter current I_B = 20μA by varying V_{BB}.
3. Varying V_{CC} gradually in steps of 1V up to 12V and note down collector current I_C and Collector-Emitter Voltage(V_{CE}).
4. Repeat above procedure (step 3) for I_B = 60µA, 0µA.

Observations:

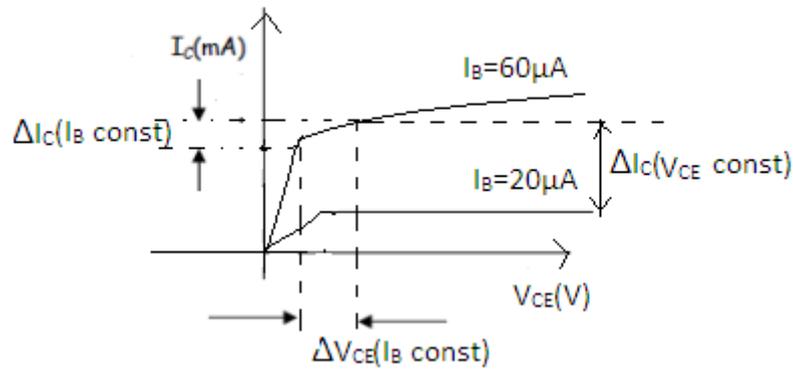| Input Characteristics Input Characteristics				
V_{BB} (Volts)	V_{CE} = 0V		V_{CE} = 5V	
	V_{BE} (Volts)	I_B (µA)	V_{BE} (Volts)	I_B (µA)

Output Characteristics						
V_{CC} (Volts)	I_B = 0 µA		I_B = 20 µA		I_B = 40 µA	
	V_{CE} (Volts)	I_C (mA)	V_{CE} (Volts)	I_C (mA)	V_{CE} (Volts)	I_C (mA)

Graph:

Input Characteristics

Output Characteristics

1. Plot the input characteristics by taking $\mathbf{V_{BE}}$ on X-axis and $\mathbf{I_B}$ on Y-axis at a constant $\mathbf{V_{CE}}$ as a constant parameter.
2. Plot the output characteristics by taking $\mathbf{V_{CE}}$ on X-axis and taking $\mathbf{I_C}$ on Y-axis taking $\mathbf{I_B}$ as a constant parameter.

Calculations from Graph:

1. **Input Characteristics:** To obtain input resistance find $\mathbf{\Delta V_{BE}}$ and $\mathbf{\Delta I_B}$ for a constant $\mathbf{V_{CE}}$ on one of the input characteristics.

   Input impedance = h_{ie} = R_i = $\mathbf{\Delta V_{BE}}$ / $\mathbf{\Delta I_B}$ ($\mathbf{V_{CE}}$ is constant)

   Reverse voltage gain = h_{re} = $\mathbf{\Delta V_{EB}}$ / $\mathbf{\Delta V_{CE}}$ ($\mathbf{I_B}$ = constant)

2. **Output Characteristics:** To obtain output resistance find $\mathbf{\Delta I_C}$ and $\mathbf{\Delta V_{CB}}$ at a constant $\mathbf{I_B}$.

   Output admittance 1/hoe = R_o = $\mathbf{\Delta I_C}$ / $\mathbf{\Delta V_{CE}}$ ($\mathbf{I_B}$ is constant)

   Forward current gain = hfe = $\mathbf{\Delta I_C}$ / $\mathbf{\Delta I_B}$ ($\mathbf{V_{CE}}$ = constant)

Inference:

1. Medium input and output resistances.
2. Smaller values if $\mathbf{V_{CE}}$, lower the cut-in-voltage.
3. Increase in the value of $\mathbf{I_E}$ causes saturation of the transistor of an earlier voltage.

Precautions:

1. While performing the experiment do not exceed the ratings of the transistor. This may lead to damage the transistor.
2. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
4. Make sure while selecting the emitter, base and collector terminals of the transistor.

Result:

Input and Output characteristics of a Transistor in Common Emitter Configuration are studied.

The h-parameters for a transistor in CE configuration are:

a. The Input Resistance (h_{ie}) _____Ohms.
b. The Reverse Voltage Gain (h_{re}) _____.
c. The Output Conductance (h_{oe}) _____ Mhos.
d. The Forward Current Gain (h_{fe}) _____.

Outcomes: Students are able to

1. Analyze the characteristics of BJT in Common Emitter and configuration.
2. Calculate h-parameters from the characteristics obtained.

AIM: To obtain the Voltage gain for two stage RC coupled Amplifier and also to observe the frequency Response.
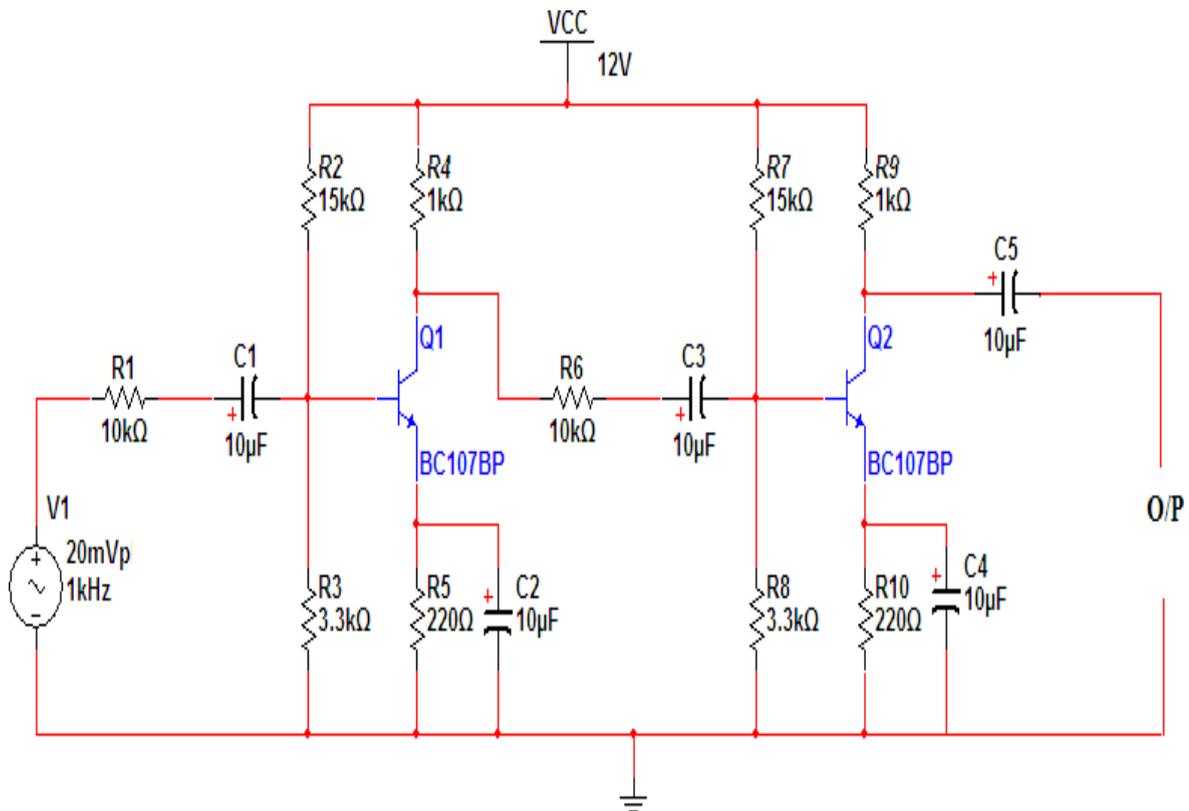
<u>EQUIPMENT REQUIRED</u>:

1. cathode ray oscilloscope   1No

2. Regulated power supply   1No

3. function generator   1No

4. bread board   1No

5. connecting wires

<u>COMPONENTS REQUIRED</u>:

1. Resistors:
    15k-2no
    10k-2no
    1k-2no
    3.3k-2no
    220Ω-2no
2. Transistor :BC107-2no
3. Capacitors-10µf -5no

<u>**CIRCUIT DIAGRAM**</u>:

THEORY: Whenever large amplification with very good impedance matching is required using an active device such as a transistor or a field effect transistor a single active device and its associated circuitry will not be able to cater to the needs. In such a case single stage amplifier is not sufficient and one requires more stages of amplification i.e., output of one stage is connected to the input of second stage of amplification circuit and the chain continues until the required characteristics of amplifier is achieved such an amplifier is called as multistage amplifier.In multistage amplifier, the output signal preceding stage is to be coupled to the input circuit of succeeding stage. For this interstage coupling different types of coupling can be employed. They are

1. RC coupling

2. Transformer coupling

3. Direct coupling

RC coupling is most popularly used type of coupling because it is cheap and provides excellent fidelity over a wide range of frequency .it is usually employed for voltage.

PROCEDURE:

1) Connect the circuit as shown in the figure.

2) Apply 1Khz frequencyand 20mv Vp-p Sine wave from function generator..

3) Observe input and output Waveforms simultaneously on C.R.O

4) Change the frequency of input signal from 10HZ to 1MHZ in steps and note amplitudes of input and output Waveforms(input signal should be maintained constant).

5) Calculate Voltage gain (A) for each (in db) verses frequency.

Observations:

S.No	Frequency (Hz)	Input Voltage	Output Voltage	Gain=(V_0/V_i)	Gain in db= $20 \times \log_{10} (V_0/V_i)$

PRECAUTIONS:

1. Check connections before switching ON power supply.

2. Don't apply over voltage

3. When you are not using the equipment switch them Off
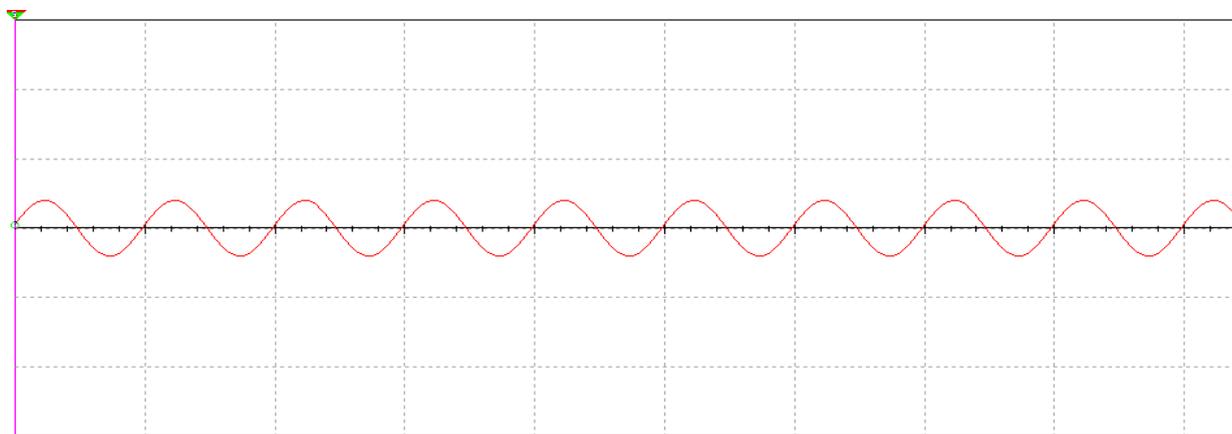
CALCULATIONS:

Maximum gain of the amp:

Upper cutoff frequency F2:

Lower cutoff frequency F1:
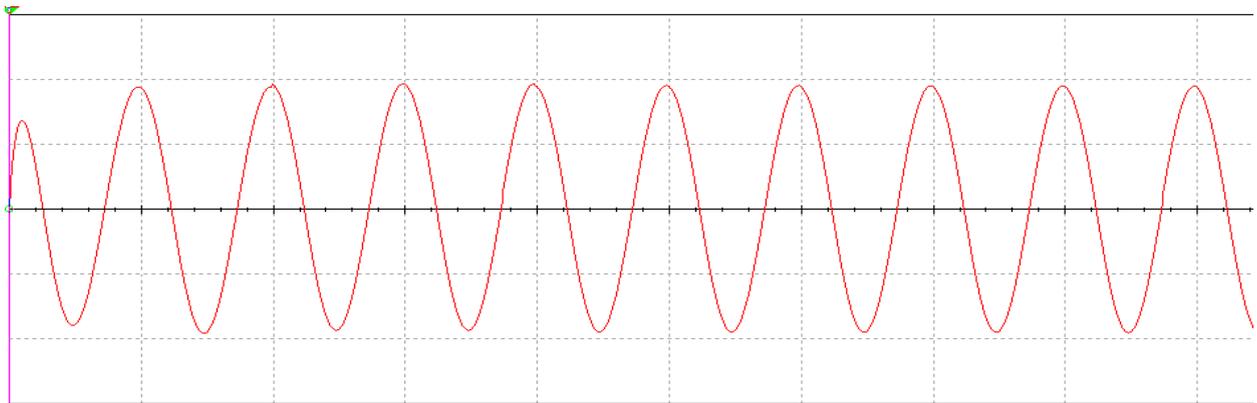
Band width=F2-F1:

EXPECTED GRAPH:

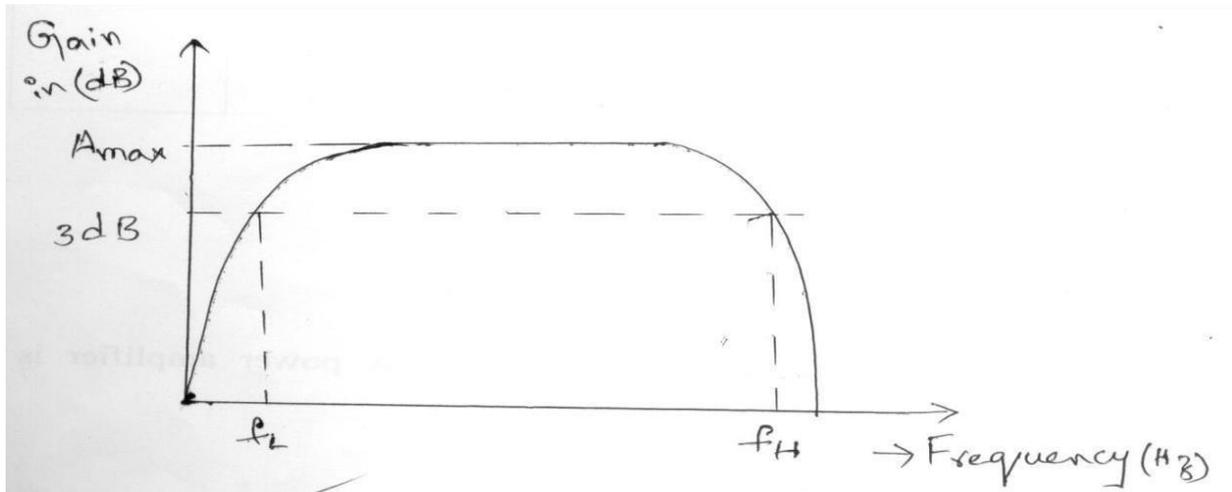### Input wave form

Output waveform

Frequeny response:

RESULT: -

1. Frequency response of Two stage RC coupled amplifier is plotted.
2. Gain =_____dB (maximum).
3. Bandwidth= fH--fL = _____ Hz. At stage 2

AIM: To calculate the frequency of the RC phase shift oscillator & to measure the phase angles at different RC sections.

APPARATUS:

       1. Transistor BC107

        2. Resistors: 10KΩ   -3Nos
                        8KΩ or 10KΩ
                        22KΩ
                        1.2KΩ
                        100KΩ
       3. Capacitors: 0.001µf – 3 Nos
                       10µF   – 2Nos
                       1µf
   4. Regulated power Supply
       5. CRO

THEORY:

       RC-Phase shift Oscillator has a CE amplifier followed by three sections of RC phase shift feedback Networks the output of the last stage is return to the input of the amplifier. The values of R and C are chosen such that the phase shift of each RC section is 60º.Thus The RC ladder network produces a total phase shift of 180º between its input and output voltage for the given frequencies. Since CE Amplifier produces 180 º phases shift the total phase shift from the base of the transistor around the circuit and back to the base will be exactly 360º or 0º. This satisfies the Barkhausen condition for sustaining oscillations and total loop gain of this circuit is greater than or equal to 1, this condition used to generate the sinusoidal oscillations.

  The frequency of oscillations of RC-Phase Shift Oscillator is,

$$f = \frac{1}{2\pi RC * \sqrt{6}}$$

CIRCUIT DIAGRAM:
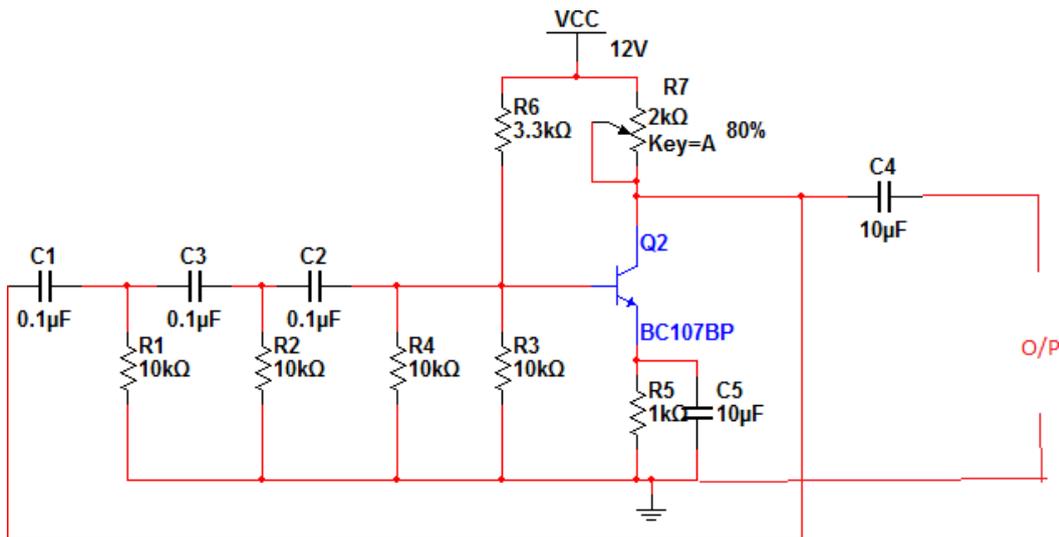
PROCEDURE:

1. Make the connection as per the circuit diagram as shown above.

2. Observe the output signal and note down the output amplitude and time period (T_d).

3. Calculate the frequency of oscillations theoretically and verify it practically ($f=1/T_d$).

4. Calculate the phase shift at each RC section by measuring the time shifts (T_p) between the final waveform and the waveform at that section by using the below formula.

OBSERVATIONS:

THEORITICAL CALCULATIONS: R = 10KΩ, C = 0.001 µf

$$f = \frac{1}{2\pi RC* \sqrt{6}} =$$

PRACTICAL CALCULATIONS:

$$T_d =$$

$$f = \frac{1}{T_d}$$

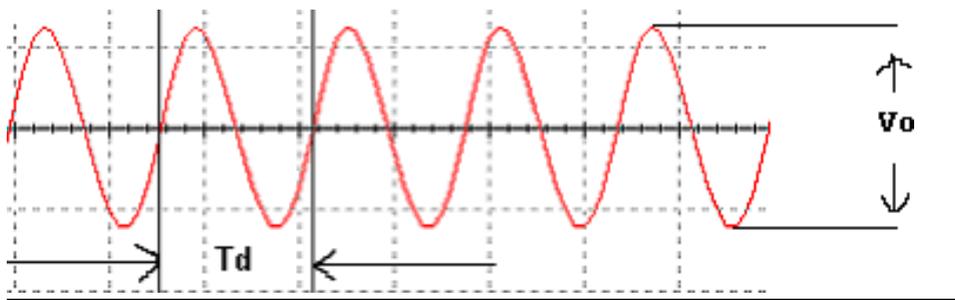$$(1). \ \theta_1 = \frac{Tp_1}{T_d} *360^0 =$$

$$(2).\ \theta_2 = \frac{Tp_2}{T_d} * 360^0 =$$
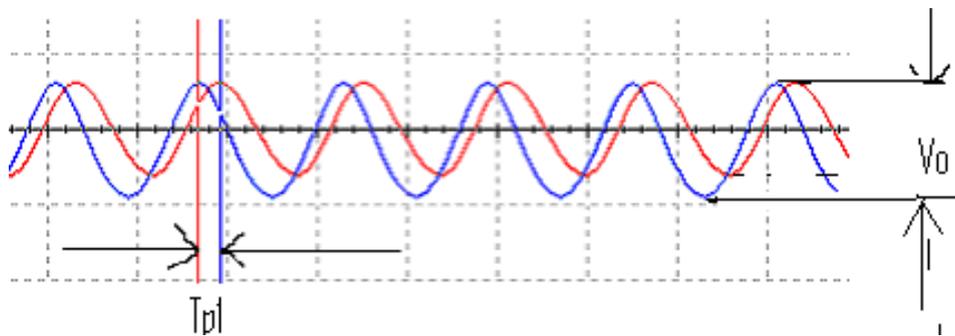
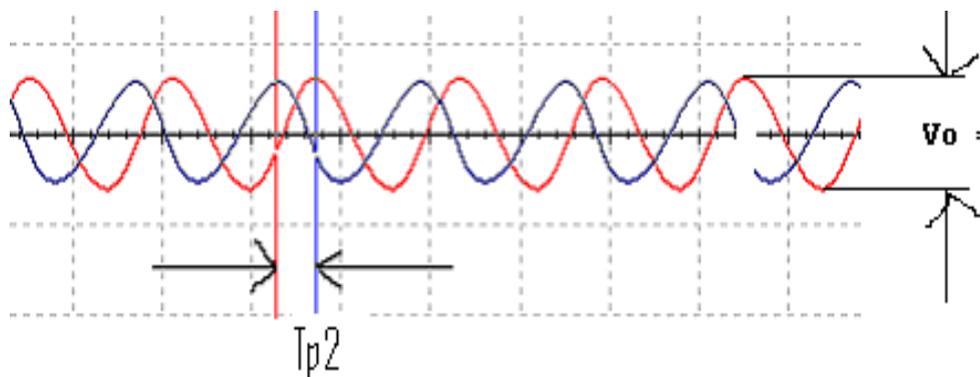$$(3).\ \theta_3 = \frac{Tp_3}{T_d} * 360^0 =$$
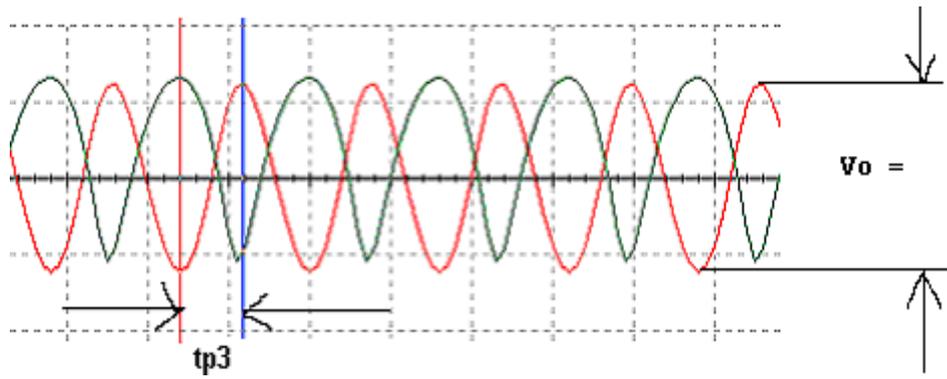
MODEL WAVE FORMS:

OUT PUT WAVE FORM :

OUT PUT WAVE FORM : $\theta = 60^0$

OUT PUT WAVE FORM : $\theta = 120^0$

OUT PUT WAVE FORM : $\theta = 180$

tp3

Vo =

RESULT: The frequency of RC phase shift oscillator is calculated and the phase shift at different RC sections is noted.
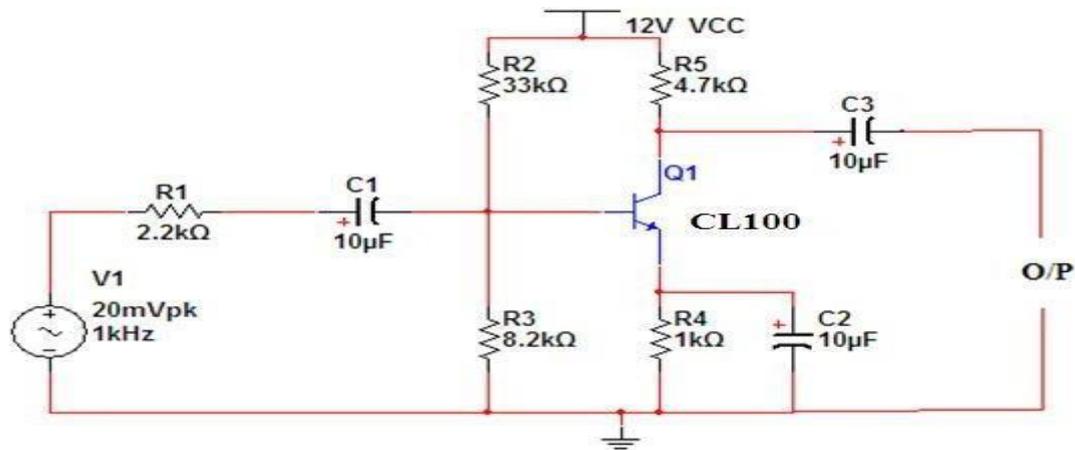
$F_T =$ $F_{P =}$

AIM: To design and test the class A power amplifier

APPARATUS:

    1. Class A power amplifier trainer kit
    2. Function Generator
    3. CRO
    4. BNC Probes and connecting wires

CIRCUIT DIAGRAM:

THEORY:

        The amplifier is said to be class A power amplifier if the q point and the input signal are selected such that the output signal is obtained for a full input cycle. For this class the position of q point is approximately y at the midpoint of the load line. For all the values of input signal the transistor remains in the active region and never entire into the cutoff or saturation region. The collector current flows for 3600 (life cycle) of the input signal in other words the angle of the collector current flow is 3600 the class a amplifiers or furthers classified as directly coupled and transformer coupled and transformer coupled amplifiers in directly coupled type .The load is directly connected in the collector circuit while in the transformer coupled type, the load is coupled to the collector using the transformer.

Advantages:

    1. Distortion analysis is very important

    2. It amplifies audio frequency signals faithfully hence they are called as audio amplifiers

Disadvantages:

    1. H parameter analysis is not applicable

    2. Due to large power handling the transistor is used power transistor which is large in size and having large power rating.

PROCEDURE:

1. Switch ON Class –A power amplifier trainer

2. Set Vs (say 250 to 300 mV), at 10 KHz using signal generator.

3. Connect milli ammeter to the ammeter terminals

4. By keeping the input voltage constant, vary the frequency from 0 to 1MHz in regular steps .

5. Note down the corresponding output voltage from CRO

6. Calculate the DC input power using the formula $Pdc = V_{cc}I_c$

7. Calculate the AC output power using the formula $Pac = V_o^2/8R_L$

8. Calculate the efficiency $\eta = Pac /Pdc$

9. Plot the graph between Gain (db) and frequency.

10. Calculate bandwidth from the graph.

PRECAUTIONS:

1. Check connections before switching ON power supply

2. Don't apply over voltage

3. When you are not using the equipment switch them OFF.

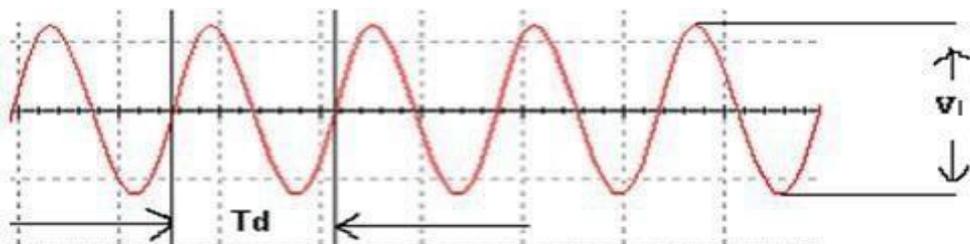4. Handle all equipment carefully.

CALCULATIONS:

Input power: $Pdc = V_{cc}I_c =$

Outpower: $Pac = V_{PP}^2/8R_L =$

η = Efficiency=output power/input power*100 = $Pac /Pdc*100 =$

EXPECTED GRAPH:

I/P:

O/P:
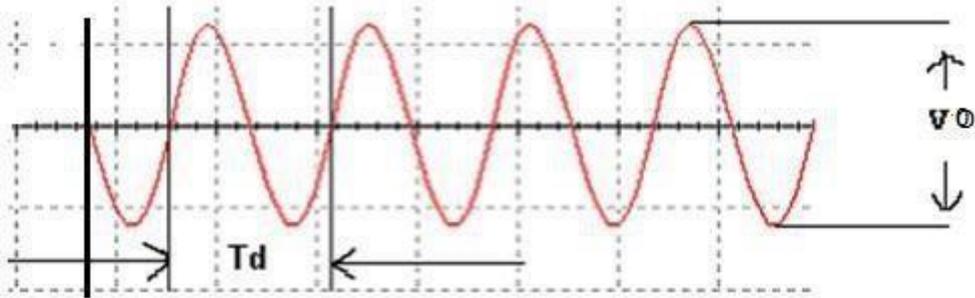
RESULT: Gain and frequency as observed of Class A power amplifier.

η = Efficiency=output power/input power*100 = Pac /Pdc

EXPERIMENT-10

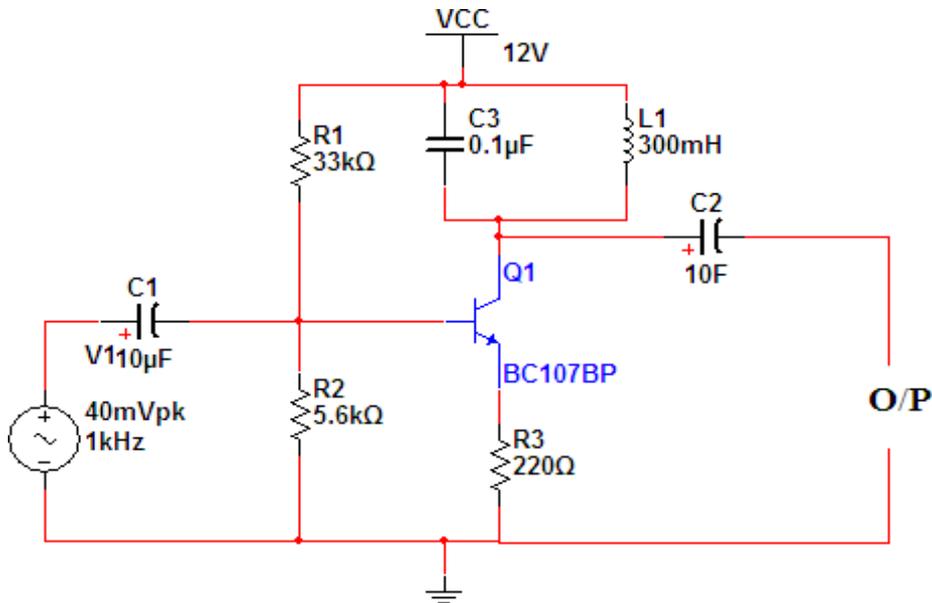**AIM:** To study single tuned voltage Amplifier and to calculate

       1. Resonant Frequency.
       2. Q factor.
       3. Bandwidth and

4. Impedance

APPARATUS:

1. Tuned RF Amplifier trainer Kit.
2. Function Generator.
3. CRO.
4. BNC probes and connecting wires

CIRCUIT DIAGRAM:

THEORY:

It is usually required to use a number of tuned amplifier stages in cascade in order to obtain large overall gain. These cascade tuned amplifiers may be put into the following three categories:

1. Single tuned amplifiers.
2. Double tuned amplifiers.
3. Stagger-tuned amplifiers.

Single tuned amplifiers use one parallel tuned circuit as the load impedance in each stage and all these tuned circuits in different stages are tuned to the same frequency.Double tuned amplifier uses two inductively coupled tuned circuits per stage, both the tuned circuits being tuned to the same frequency.Staggered tuned amplifier uses a number of single tuned stages in cascade, the successive tuned circuits being tuned to slightly different frequencies.

Single tuned amplifiers may again be put into following two categories:

a) Capacitance coupled single tuned amplifiers and

b) Transformer coupled or inductively coupled single tuned amplifiers

RESONANT FREQUENCY:

Depending upon the frequency of the source voltage Vs, the circuits may behave either as inductive or capacitive. However, at a particular frequency when the inductive reactance Xl equals the capacitive reactance Xc, then the circuit behaves as a purely resistive circuit. This phenomenon is called resonance: and the corresponding frequency is called resonant frequency. The resonant frequency (fr) can be found by equating the two reactance values.

PROCEDURE:

1. Connect ions should be made as per the circuit diagram.

2. Connect the AC signal source from function generator (above AF range) to input of the trainer kit.

3. Keep the input voltage constant , vary the frequency in regular steps and down the corresponding output voltage

4. Calculate the resonant frequency.

5. Plot the graph: gain (db) Vs frequency

6. Find the input and output impedance

7. Calculate the bandwidth and Q factor

PRECAUTIONS:

1. Check connections before switching ON power supply

2. Don't apply over voltage

3. When you are not using the equipment switch them OFF.

4. Handle all equipment carefully

EXPECTED GRAPH:
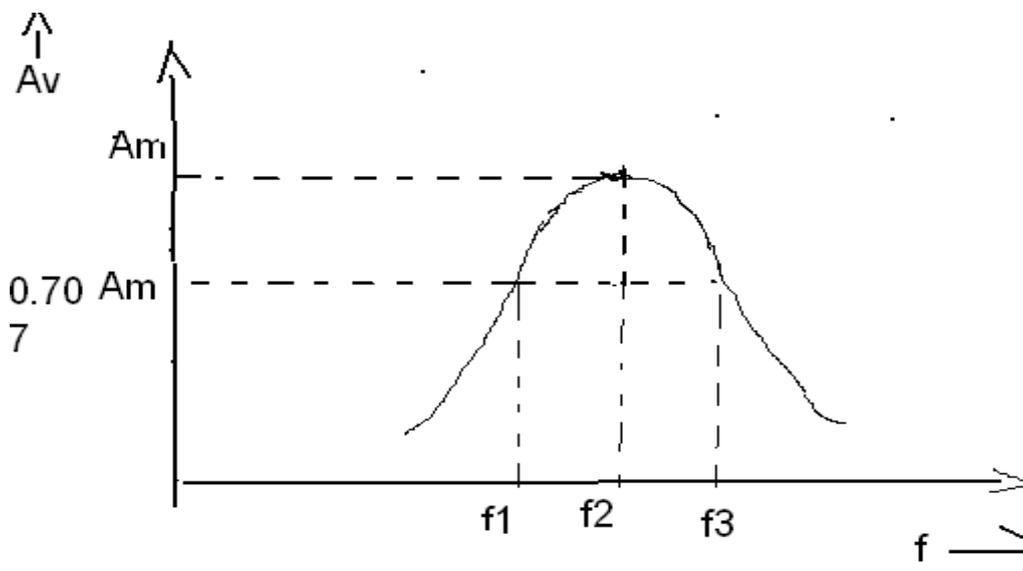
Observations:

Input Voltage=   (Constant)

S.NO	Input Frequency (Hz)	OutputVoltage(V_o)	Gain A = V_o/V_i	Gain in dB 20log(V_o/V_i)

RESULT: Gain and frequency as observed of single tuned voltage amplifier.

$F_T = F_P =$

AIM: To observe the input and output waveforms and to calculate the efficiency of Class B
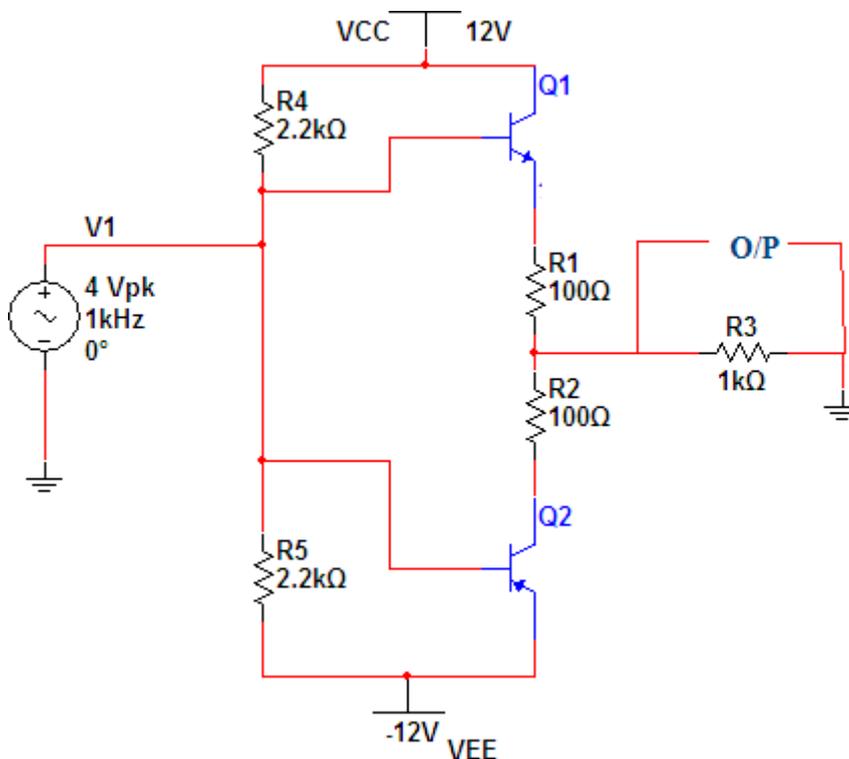Complimentary symmetry power amplifier.

APPARATUS:
EQUIPMENT REQUIRED:

Power supply 0-30V- 1 No.
CRO 20MHz - 1 No.
Digital multimeter - 1 No.
Signal generator 1Hz - 1MHz - 1 No.

COMPONENTS:
Resistors : 2.2KΩ - 2 Nos.
             100Ω   - 2 Nos.
             1KΩ   - 1 No
Transistors CL100- 1No , CK100 -1NO

CIRCUIT DIAGRAM:

THEORY:

An amplifying system consists of several stages in cascade. The input and the
intermediate stages amplify small signal excitations to a value large enough to drive the final
device .The out put stage feeds the final device .The output stage feeds a transducer such as a
CRO,loudspeaker or servomotor. Thus the final stage must be capable of delivering a large
voltage or current or appreciable amount of power. This requires an amplifier which is referred
as a power amplifier

In class B complimentary symmetry class _B amplifier one n-p-n and p-n-p is used. Hence the circuit is called class-B complimentary symmetry amplifier. This circuit ifis transformer less circuit .But with common emitter configuration it becomes power transfer without output impedance for maximum power transfer without an output transformers. Hence the matched pair of complementary transistors are used in common collector configuration This is because in common collector configuration has lowest output impedance and hence the impedance matching is possible.

PROCEDURE:

1. conncet the circuit s per the circuit diagram
2. apply 4v p-p with 1KHZ frequency using function generator
3. observe the output in CRO .
4. note the cross over distortion in output.(outputVp-p)
5. remove the collector connection and put ammeter.
6. note the Idc value in the ammeter.
7. using Pdc and Pac formulas find the efficiency.

OBSERVATION:

Pac=$V_m2/2R_L$ =

Pdc=Vcc*Idc = v_O

=

VCC = RL

=

EFFICIENCY: η =Pac/Pdc*100=

MODEL GRAPHS: I/P WAVEFORM

O/P WAVEFORM