Operation Sheet 1	Developing Basic Electronic System Design

Overview:

This provides the basic knowledge over the construction and functionality of the basic electronic devices such as diodes and transistors. It also provides the information about the uncontrollable and controllable electronic switches and the flow of current through these switches in different biasing conditions. This course is intended to describe the different configurations and modes of controllable switches and how these electronic devices can be configured to work as rectifiers, clippers, clampers, oscillators and amplifiers.

Upon the completion of Data Structures practical course, the trainees will be able to:

1. Analyze the diode and transistor characteristics.

2. Understand the principles of rectifier circuits using diodes and implement them using hardware.

3. Design the biasing circuits like self biasing.

4. Design various amplifiers like CE, CC, common source FET amplifiers and implement them using hardware and also observe their frequency responses.

5. Understand the concepts of SCR and observe its characteristics.

6. Understand the concepts of unipolar junction transistor and observe its characteristics.

Instructions to the Trainees

1. Students are required to attend all labs.

2. Students should work individually in the hardware and software laboratories.

3. Students have to bring the lab manual cum observation book, record etc along with them whenever they come for lab work.

4. Should take only the lab manual, calculator (if needed) and a pen or pencil to the work area.

5. Should learn the prelab questions. Read through the lab experiment to familiarize themselves with the components and assembly sequence.

6. Should utilize 3 hour's time properly to perform the experiment and to record the readings. Do the calculations, draw the graphs and take signature from the instructor.

7. If the experiment is not completed in the stipulated time, the pending work has to be carried out in the leisure hours or extended hours.

8. Should submit the completed record book according to the deadlines set up by the instructor.

9. For practical subjects there shall be a continuous evaluation during the semester for 25 seasonal marks and 50 end examination marks.

10. Out of 25 internal marks, 15 marks shall be awarded for day-to-day work and 10 marks to be awarded by conducting an internal laboratory test.

1: Identification, specifications, testing of R, L, C components (Color Codes), potentiometers, switches (SPDT, DPDT and DIP), coils, Gang condensers, relays, bread boards, PCBs, identification, specifications and testing of active devices, diodes, BJTs, Low power JFETs, MOSFETs, power transistors, LEDs, LCDs, optoelectronic devices, SCR, UJT,DIACs.
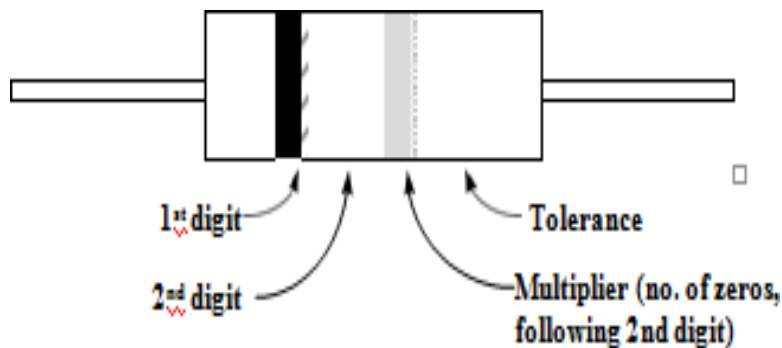
1. RESISTOR:

Resistor is an electronic component whose function is to limit the flow of current in an electric circuit. It is measured in units called ohms. The symbol for ohm is Ω(omega). They are available in different values, shapes and sizes.

Every material has some resistance. Some materials such as Rubber, Glass and air have very high opposition to current to flow .These materials are called insulators. Other materials such as Copper, Silver and Aluminum etc, has very low resistance, they are called Conductors.
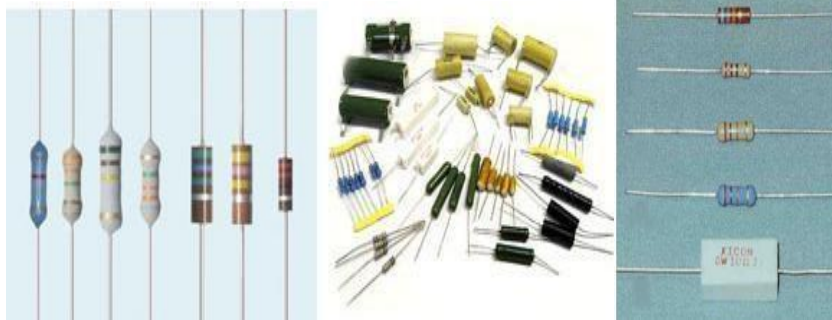
Resistor Color Codes

Colour-code bands on a resistor

| Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

Applications:

It is widely used in electronic circuits to limit the current

2. CAPACITOR

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electro statically in an electric field. By contrast, batteries store energy via chemical reactions. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film. Capacitors are widely used as parts of electrical circuits in many common electrical devices.

Capacitors are also very commonly used. A lot have their values printed on them, some are marked with 3-digit codes, and a few are color coded. The same resources listed above for resistors can also help you identify capacitor values. They are typically marked with an "C" on a circuit board.

Symbol:
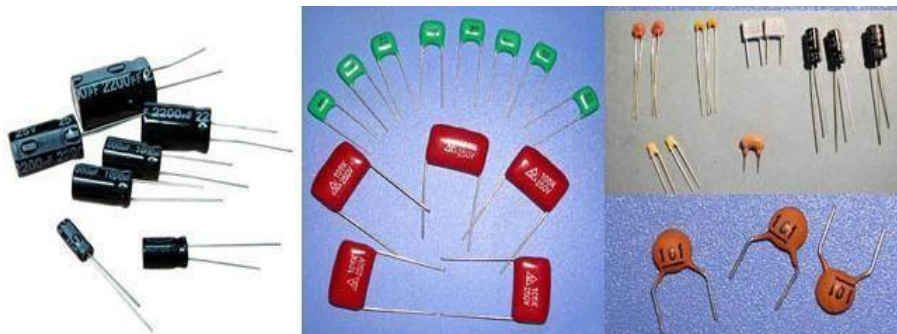
Applications:

1. In tuned circuits.
2. As bypass capacitors to by pass ac through it.
3. Blocking capacitor to block dc components.

3. INDUCTORS

An inductor, also called a coil or reactor, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored in a magnetic field in the coil. When the current flowing through an inductor changes, the time- varying magnetic field induces a voltage in the conductor, according to Faraday"s law of electromagnetic induction, which by Lenz's law opposes the change in current that created it.

Inductors, also called coils, can be a bit harder to figure out their values. If they are color coded, the resources listed for resistors can help, otherwise a good meter that can measure inductance will be needed. They are typically marked with an "L" on a circuit board.

Applications:

1. Filter chokes for smoothing and pulsating currents produced by rectifiers.
2. Audio frequency chokes, to provide high impedance at audio frequencies.

4. POTENTIOMETERS:

The variable resistors are usually called Rheostats and the smaller variable resistors commonly used in electronic circuits are called potentiometers called pot.

symbol

The arrow indicates a movable contact on a continuous resistance element. A potentiometer can be either linear or non-linear.

Applications:

Pots are used to change the volume of sound and brightness of picture.

5. SWITCHES:

A switch is a device which can connect two points in a circuit (or) disconnect two points. If the switch is acting so has to connect two points. It is said to be in ON position. If the switch is acting so has to disconnect two points. It is said to be in OFF position.

SPDT:- (Single Pole Double Throw):

If there are two independent circuits to be connected using two throws but still connecting one poll then it is called single pole double throw.

DPDT: (Double Pole Double Throw):

This switch is capable of connecting the receiver to either Antenna-I or Antenna-II at the same time and it connects two poles hence the DPDT switch.

6. GANGED CONDENSERS:

In tuning circuits it is desired to change the value of capacitance readily, this is done by means of variable capacitors. The most common variable capacitor is the air ganged capacitor. By rotating the shaft, we can change the distance between movable and fixed sets of plates like that capacitance value is changed.

Applications:

Used in tuning circuits

7. RELAYS:

Switches closes its contacts by the mechanical activation of its lever, the relay do this by an electromagnetic coil pulling its contacts current and wound over a core of soft magnet. The moving armature of core causes the contact closure.

Relays can have several poles and several contacts. Types of Relays are

1. Reed Relays
2. Solid State Relays
3. Over load relays etc.

Applications:

In telephone networks

8. BREAD BOARDS:

This is the platform (or chasis) on which any circuit can be ringed up to provide inter connections between electronics components and devices.

The advantage of bread board is, the components can be connected (or) disconnected easily. It has holes both horizontally and vertically as shown in the figure.

The horizontal holes at the top and bottom are having internal shorts where as in the remaining part vertical holes are shorted internally.
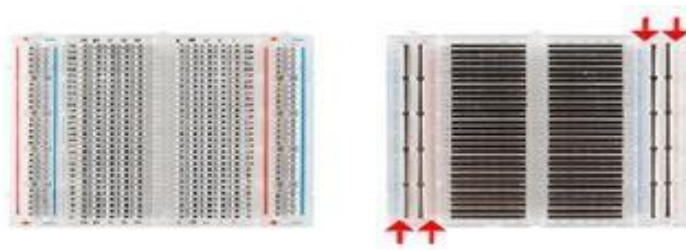
9. PCB (PRINTED CIRCUIT BOARD):

A printed **circuit board** (**PCB**) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. Components (e.g. capacitors, resistors or active devices) are generally soldered on the **PCB**.
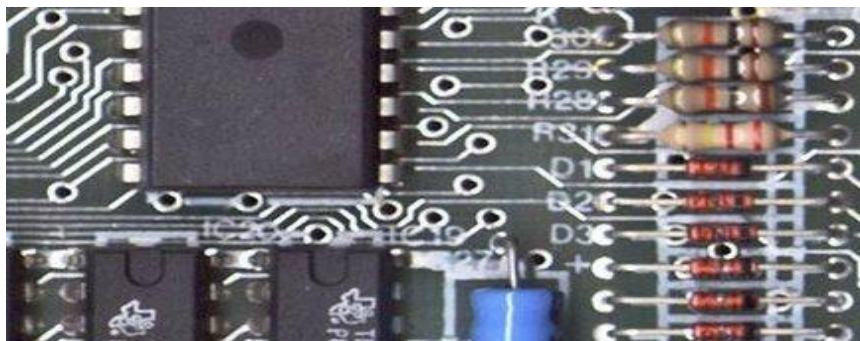
10. DIODE:

A popular semiconductor device called a diode is made by combining P & N type semiconductor materials. The doped regions meet to form a P-N junction. Diodes are unidirectional devices that allow current to flow through them in one direction only.

The schematic symbol for a semiconductor diode is shown in fig-1. The P-side of the diode is called the anode (A), while the N-side of the diode is called the cathode (K).
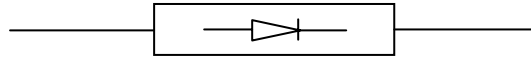

Figure : symbol of P-N diode.

Diode specifications:

Breakdown voltage rating VBR

The Breakdown voltage rating VBR is the voltage at which avalanche occurs. This rating can be designed by any of the following: Peak Inverse Voltage (PIV); Peak Reverse Voltage (PRV); Break down voltage rating VBR

Average forward – current rating, IF

This important rating indicates the maximum allowable average current that the diode can handle safely, the average forward current rating is usually designated as IF Maximum reverse current, IR1N4007 silicon diode specifies a typical IR of 0.05 A for a diode junction.

Temperature TJ of 250C and a reverse voltage VR of 100 V. The

maximum rating of a diode should never be exceeded.

Testing of diode:

Using an ohmmeter to check a diode: when using an ohm meter, check the resistance of the diode in one direction , then reverse the meter leads and measure the resistance of the diode in the other direction. If the diode is good it should measure a very high resistance in one direction, and a low resistance in the other direction. For a silicon diode the ratio of reverse resistance RR , to forward resistance RF should be very large, such as 1000:1 or more.

Note: If the diode is shorted it will measure a low resistance in both the directions. If the diode is open, it will measure a high resistance in both the directions.

Using a DMM to check a diode: Most digital multimeters provide a special range for testing the diodes. This range is called the diode range. This is the only range setting on the DMM that can provide the proper amount of forward bias for the diode being tested. It is important to note that when the digital multimeter forward biases the diode being tested, the digital display will indicate the forward voltage dropped across the diode rather that the forward resistance, RF.

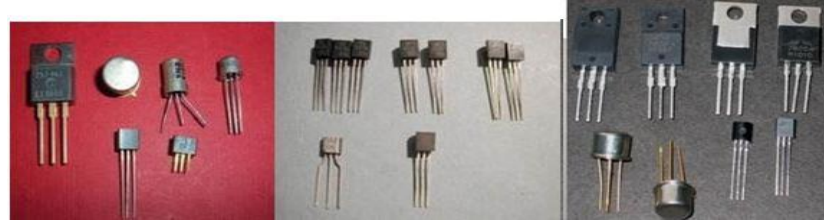A good silicon diode tested with the

Identification:

1N4007
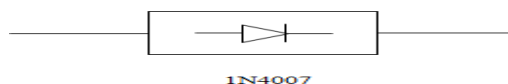
APPLICATIONS:

- Rectifiers, Clippers and Clampers.
- Signal detector.
- Digital logic gates.

11. BIPOLAR JUNCTION TRANSISTOR (BJT):

A transistor has three doped regions there are two types of transistors one is npn and other is pnp. Notice that for both types, the base is narrow region sandwiched between the larger collector and moderate emitter regions.

In npn transistors, the majority current carriers are free electrons in the emitter and collector, while the majority current carriers are holes in the base. The opposite is true in the pnp transistor where the majority current carriers are holes in the emitter and collector, and the majority current carriers are free electrons in the base.

1. Emitter 2. Base 3. Collector
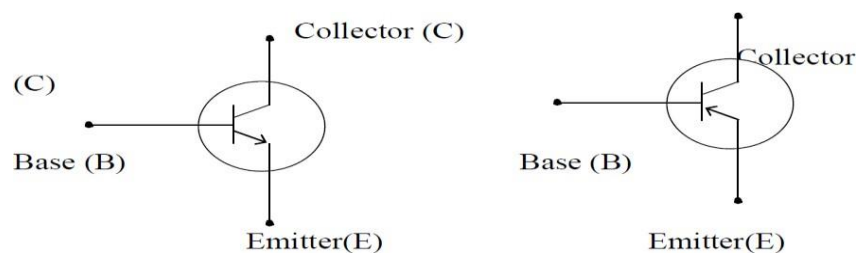
Schematic symbols for transistors (a) npn transistor (b) pnp transistor.

In order for a transistor to function properly as an amplifier, the emitter-base junction must be forward biased and the collector base junctions must be reverse biased.

Transistor lead Identification:

There are three leads in a Transistor called collector, emitter and base. When a transistor is to be connected in a circuit it is necessary to identify the leads of transistor before connecting in a circuit. The identification of the leads of transistor varies with manufacturer. There are three systems in general.
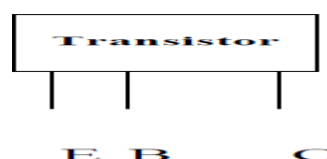
When the lead of a transistor is in the same plane and unevenly as in above fig., they are identified by the position and spacing of leads. The central lead is the base lead. The collector lead is identified by the large spacing existing between it and the base lead. The remaining is the emitter.

When the leads of a transistor are in the same plane but evenly spaced, the central lead is the base, the lead identified by dot is the collector and the remaining lead is the emitter.

BC 547
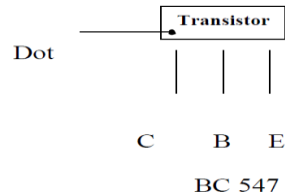
When the leads of a transistor are spaced around the circumference of a circle, the three leads are generally in E-B-C order clockwise from a notch.

BC 107
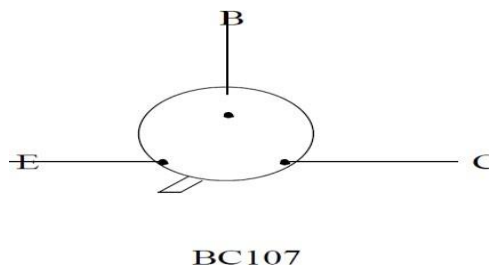
SPECIFICATIONS:

In all cases, the maximum ratings are given for collector-base voltage, collector emitter voltage, emitter base voltage, collector current and power dissipation.

Power dissipation rating P_d (Max):

The product of V_{CE} and I_C gives the power dissipation, P_d of the transistor. The product of V_{CE} x I_C must not exceed the maximum power dissipation rating, P_d (Max) of the transistor is nearly 1Watt.

Derating factor:

Manufacturers usually supply derating factors for determining the power dissipation rating at any temperature above 25 ^{0}C. The derating factor is specified in Watt/^{0}C. For example if a transistor has a derating factor of 2 mW/^{0}C, then for each 10^oC rise in junction temperature the power rating of the transistor is reduced by 2 mW.

Breakdown voltage ratings;

A data sheet lists the breakdown voltage ratings for the emitter- base, collector-base, and collector-emitter junctions. Exceeding these voltage ratings can destroy the transistor.

BVCBO is 60V, BVCEO is 40V and BVEBO is 6V.

Testing of BJTs:

Checking a transistor with an ohmmeter:

To check the base-emitter junction of an npn transistor, first connect the ohmmeter and then reverse the ohmmeter leads. The resistance indicated by the ohmmeter should be low since the base emitter junction is forward biased. The resistance indicated by the ohmmeter should read high because the base emitter junction is reverse biased. For a good pn junction made of silicon the ration RR/RF should be equal to or greater than 1000:1.

To check the collector-base junction, repeat the process described for the base-emitter junction.

Shorted and open junctions:

A low resistance across the junction in both directions implies that the emitter-base or collector-base junctions are shorted. If the ohmmeter indicates a high resistance in both directions, then the junctions are open. In both cases the transistor is defective and must be replace.Checking a transistor with a Digital Multimeter (DMM):

Insert the transistor in the provided slots, position the knob of DMM in hFE mode and check the hFE value.

Applications:

- Amplifiers.
- Oscillators.
- Switches.

12. FIELD EFFECT TRANSISTORS (FETS):

The field effect transistor (FET) is a three terminal device similar to the bipolar junction transistor. The FET, however, is a unipolar device, which depends on only one type of charge carriers; either electrons or holes. There are basically two types of FETs. The junction field effect transistor, abbreviated JFET, and the metal oxide semiconductor field effect transistor, abbreviated MOSFET.

A junction field effect Transistor is a three terminal semiconductor device in which current conduction is by one type of carriers i.e., electrons or holes.

There are two basic types of FET"s

1. Junction field effect transistor (JFET)
2. Metal oxide field effect transistor (MOSFET)

Schematic symbol of JFET

n-channel JFET   p-channel JFET
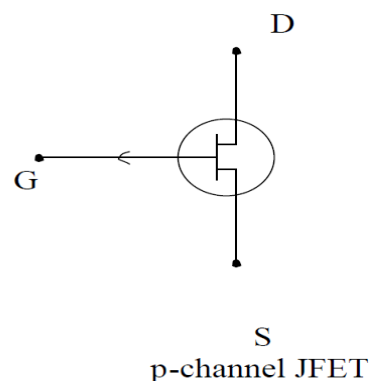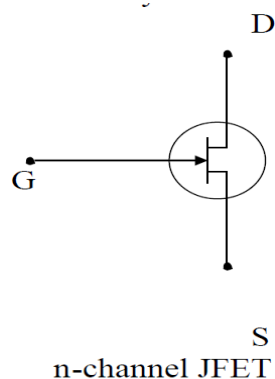
Specifications:

   i. A.C. drain resistance (rd): Drain resistance has a large value, ranging from 10kΩto 1MΩ

   ii. Transconductance (gm): It is expressed in mA/V

   iii. Amplification factor (μ): It is product of A.C drain resistance and transconductance.

S.No	Parameters	BFW10	BFW11
1	I_{DSS}	8-20mA	4-10mA
2	V_{GS}	4-8V	2-4V
3	g_m	3.2mA/V	3.2 mA/V

Pinch off voltage:

The value Vp is the start of the interval VP to VDS max during which ID remain constant. As VDS is increased from 0V to Vp called the pinch off voltage, ID increases from 0 to the maximum drain current that can be attained without destroying the JFET, the voltage IDSS. **VGS(off):** Maximum drain current flows when VGS = 0 and minimum drain current when VGS = VGS (off).

Testing:

In case of FET, drain to source should be a fixed resistance in either direction. Gate to drain or gate to source should be an open circuit or a very high resistance.

Applications:

Used in tuners of radio and TV receivers

Amplifiers and Voltage variable resistor.

13. MOSF

The metal ETs: oxide semiconductor field effect transistor has a gate, source and drain just like JFET. Like a JFET, the drain current in a MOSFET is controlled by the gate-source voltage VGS. There are two basic types of MOSFETs. The enhancement type and depletion type. The enhancement type MOSFET is usually referred to as an E-MOSFET and the depletion type MOSFET is referred to as a D-MOSFET.

The key difference between JFETs and MOSFETs is that the gate terminal in a MOSFET is insulated from the channel. Because of this, MOSFETs are sometimes referred to as insulated gate FETs or IGFETs. Because of the insulated gate, the input impedance of a MOSFET is many times higher t that of a JFET.

Types of MOSFET'S:

(a) n-channel D- MOSFET (b) P-channel D-MOSFET

(c)n-channel E-MOSFET (d) p-channel E-MOSFET

Specifications:

A typical MOSFET is the 3N200 made by BEL. It has two independent gates against only one in a common MOSFET. Its specifications are drain to source voltage VDS= 0.2V to 20 Gate 1 to source voltage V G1S = 0.6 V to +3 V

Gate 2 to source voltage V G2S = 0.6 V to +6 V Drain to gate 2 voltage VDG2 = +20V Drain current ID = 50 mA

Transistor dissipation PT = 330 mw Derating = 2.2 m2/0C

Testing:

1. In case of MOSFET, drain to source should be a fixed resistance in either direction
2. Gate to drain or gate to source should be an open circuit or a very high resistance (greater than FET).

The device under test in the given circuit is a depletion type N- channel JFET, with the gate circuit kept open, the magnitude of the drain current is sufficient to make the ID R2 drop large enough. So that the BJT is forward biased and driven into its ON state. Therefore the lamp glows. The switch SW is now closed. The bias on the FET gate then causes depletion of its channel.

This lowers the IDR2 drop to the point where conduction through the BJT output circuit fails to keep the bulb glowing. All this will happen if the FET is in good condition. On the other hand, a short circuited FET will deep the lamp On in either position of switch SW, while an open FET will fail to switch the indicator lamp ON.

Power Transistors:

The two types of power transistors made with of the alloy junction type and the silicon planar type. However, large power means a high current circulating through the device, requiring bigger areas for a given current density, the active emitter and collector areas can be over 10

Identification:

SL100
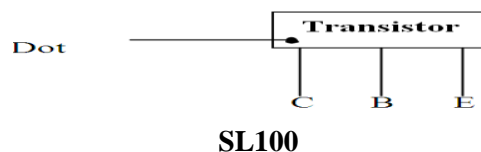
Specifications:

One way to distinguish transistors is by the number marked on them. Thus low frequency, low power transistors bears the numbers AC125, AC126, BC147 and BC148. An example of a high frequency, low power transistor is BF115; power transistors are BD138, AD149, 2N3055 etc. Similarly, germanium and silicon transistors are distinguished by the first letters A and B respectively.

Type	BVcbo	BVceo	BVebo	Ic	Maximum Collector Dissipation at 25° C	β	Vce	Ic	Icbo
2N696 Medium level	60	40	5	0.3	0.6	20-60	10	150	1

BVCEO : maximum value of voltage across collector-emitter circuit with base open. BVCBO : maximum value of voltage across collector-base circuit with emitter open. BVEBO : maximum value of voltage across emitter-base circuit with collector open. ICmax : maximum value of DC collector current.

PT : max. power dissipation in absence of heat sinks at ambient temperature. FT : gain bandwidth ICBO: leakage current.

Testing:
Follow the same procedure as the ordinary BJT-testing using multimeter.

The characteristics of a BJT under different configurations can be observed directly on a CRT screen. The transistors leads are simply inserted in the three sockets of a device called a curve tracer.

14. LIGHT EMITTING DIODES LEDS:

As opposed to other diodes that give off heat when conducting, LEDs emit light. In the latter, the recombination of charge carriers across the PN junction releases optical energy when the electrons fall from the conduction to the valence band. The heat emission is negligible in light emitting materials like gallium arsenic phosphide and gallium phosphoide.

LEDs must, of course, be covered in a transparent or translucent material. The wavelength of the radiation for a given colour is given by the relation = 1.23/Eg. Where Eg is the energy gap between conduction and valence bands. Its value is 1.45 ev for GaAs, 3 ev for GaAsP and 2.25 ev for Gap. The colours obtained from these materials are red, yellow and green respectively.
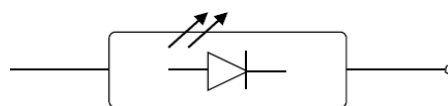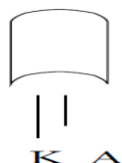

Figure: symbol of LED.

Identification:

Longer terminal is cathode and the other is Anode.

Specifications:

1. VF operating : 1.3 v to 2.5 v
2. Forward voltage(max): 5 v.
3. Forward current 5 mA to 15 mA
4. Reverse breakdown : 10 v to 12 V
5. Operating life : 100,000 hours.
6. Turn on time : 10-20 nsec.
7. Turn off time: 80-100 nsec.

Testing:

The diode is simply put across a multimeter to see if the reading is different when the polarity is reversed. The LED will glow and show a resistance between 30 ohms and 50 ohms when forward biased.

15. LIQUID CRYSTAL DISPLAY (LCD):

As the name implies, liquid crystals are materials which have the properties of both liquids and solids crystals. Instead of a melting poing, they have a temperature range called a mesophase with in which the molecules are mobile as in a liquid although remaining grouped as in a solid. **Identification:**
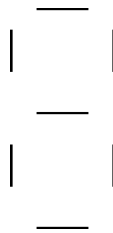
Specifications of a dynamic light scattering LCD:

1. Operating voltage: 15 V to 30 V
2. Frequency range: 50 Hz to 60 Hz
3. Current required: 60 ⬜ A.
4. Rise time = 25 x 10 3 S
5. Contrast ratio: 20 :1

Specification of twisted nematic field effect LCD:

1. Operating voltage: 3 V
2. Operating frequency: 30 Hz to 1500 Hz
3. Effective current : 5 ⬜ A to 6 ⬜ A
4. Rise time = 100 x 10 3 S

16. SCR

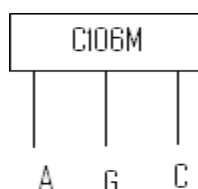The basic structure and circuit symbol of SCR is shown below. It is a four layer three terminal device in which the end P-layer acts as anode the end N-layer acts as cathode and P-layer nearer to cathode acts as a gate. As leakage current in silicon is very small compared to Germanium SCRs are made of silicon and not Germanium.

Identification:

```
┌──────────────┐
│    C106M     │
└──┬────┬────┬─┘
   │    │    │
   │    │    │
   A    G    C
```

When the leads of the SCR are in the same plane but evenly spaced the central lead is the Gate, left side of the gate is Anode and the other is Cathode.

Specifications:

The following is a list of some important SCR specifications:

1. **Latching Current (IL):**

   Latching current is the minimum current required to latch or trigger the device from its OFF-state to its ON-state.

2. **Holding Current (IH):**

   Holding current is the minimum value of current to hold the device in ON-state. For turning the device OFF, the anode current should be lowered below IH by increasing the external circuit resistance.

3. **Gate Current (Ig):**

Gate current is the current applied to the gate of the device for control purposes. The minimum gate current is the minimum value of current required at the gate for triggering the device the maximum gate current is the maximum value of current applied to the device without damaging the gate. Move the gate current earlier is the triggering of the device and vice versa. Voltage safety factor (Vf) voltage safety factor Vf is a ratio which is related to the PIV, the RMS value of the normal operating voltage.

Testing:

- The SCR should be switched on and voltage measured between anode and cathode, which should be approximately volt and the voltage between gate and cathode should be 0.7 volt.

- An ohmmeter can also be used to test SCR the gate –cathode of a thyristor has a similar characteristic to a diode with the gate positive with respect to the cathode,

a low resistance (typically below 100Ω) should be indicated on the other hand with the gate negative with respect to the cathode a high resistance (greater than 100kΩ) will be indicated. A high resistance is indicated in either direction for the anode to cathode connections.

Applications:

These are used in power control applications such as lamp dimmers motor speed control, temperature control and invertors. They are also employed for over voltage protection in DC power supplies.

17. UJT

Identification:

UJT is a three terminal semiconductor switching device. As it has only one PN junction and three leads it is commonly called as uni- junction transistors.

The basic structure of UJT is as shown below.

Picture
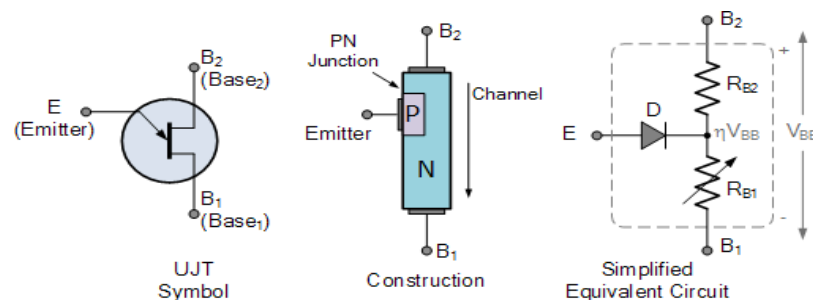
Specifications:(For UJT 2N2646)

- Peak emitter current (Ip) = 2A
- Continuous emitter current (IE) = 50mA
- Inter Base Voltage (VBB) = 35V
- Emitter Base Reverse Voltage (VEB2) = -30V
- Power dissipation at 25°C = 300mW

Testing:

- In case of UJT, emitter to base, (cont1) and emitter to base2 (confg2) should be exhibit a typical diode characteristics except that the diode resistance in forward and reverse cases is different for the two configurations.
- The resistance across base1 to base2 should be fixed resistance in either direction.

Applications:

UJT can be used as relaxation oscillator and phase control circuit.

18. DIAC

The **DIAC** is a full-wave or bi-directional semiconductor switch that can be turned on in both forward and reverse polarities. The **DIAC** gains its name from the contraction of the words DIode Alternating Current. The **DIAC** is widely used to assist even triggering of a TRIAC when used in AC switches.

Basic Structure — Schematic Symbols
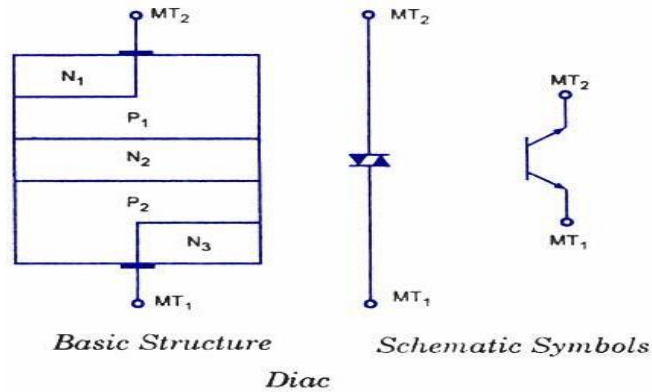
Diac

Application of Diac

It can be used mainly in the triac triggering circuit. The **diac** is connected in the gate terminal of the triac. When the voltage across the gate decreases below a predetermined value, the gate voltage will be zero and hence the triac will be turned off. The main applications are-

- It can be used in the lamp dimmer circuit.
- It is used in the heat control circuit.
- It is used in the speed control of a universal motor

Operation Sheet 2:	**Study and operation of Multimeters (analog and digital), Function generators, Regulated power supplies, CRO**

Operation Title:

MULTIMETRES

Aim: To accurately read voltages using analog voltmeter and DMM from Regulated power supply

Theory: Analog Voltmeter:

Although digital meters are used extensively through out the electronic industry. There are many analog meters also in use. The DC voltage scales on analog voltmeter are linear that is the distance between equal values (adjacent divisions) marked on the meter scale are of same length.

Ex:- If the scale is from 0V to 10V then there are 10 equally spaced divisions between these two values each division represents 0.2V.

Zero adjustment:-

Before use make any measurement with the voltmeter, be certain that the meter indication 0V. In analog voltmeter, control (screw) is placed on the front panel of the meter for the purpose of zeroing the meter.

Parallex error:

It results when the person making the measurement is not directly viewing the meter pointer.

Theory: Digital Multimeter:

A Multimeter is an electronic device that is used to make various electrical measurements, such as AC and DC voltage, AC and DC current, and resistance. It is called a Multimeter because it combines the functions of a voltmeter, ammeter, and ohmmeter. Multimeter may also have other functions, such as diode test, continuity test, transistor test, TTL logic test and frequency test.

Parts Of Multimeter

A Multimeter has three parts:

- Display
- Selection Knob
- Ports

The display usually has four digits and the ability to display a negative sign. A few multimeters have illuminated displays for better viewing in low light situations.

The selection knob allows the user to set the multimeter to read different things such as milliamps (mA) of current, voltage (V) and resistance (Ω). Two probes are plugged into two of the ports on the front of the unit. COM stands for common and is almost always connected to Ground or „-" of a circuit. The COM probe is conventionally black but there is no difference between the red probe and black probe other than color. 10A is the special port used when measuring large currents (greater than 200mA). mAVΩ is the port that the red probe is conventionally plugged in to. This port allows the measurement of current (up to 200mA), voltage (V), and resistance (Ω). The probes have a banana type connector on the end that plugs into the multimeter. Any probe with a banana plug will work with this meter.

Safety Measures

- Be sure the test leads and rotary switch are in the correct position for the desired measurement.
- Never use the meter if the meter or the test leads look damaged.
- Never measure resistance in a circuit when power is applied.
- Never touch the probes to a voltage source when a test lead is plugged into the 10 A or 300 mA input jack.
- To avoid damage or injury, never use the meter on circuits that exceed 4800 watts.
- Never apply more than the rated voltage between any input jack and earth ground.
- Be careful when working with voltages above 60 V DC or 30 V AC rms. Such voltages pose a shock hazard.
- Keep your fingers behind the finger guards on the test probes when making measurements.
- To avoid false readings, which could lead to possible electric shock or personal injury, replace the battery as soon as the battery indicator appears.

Input Jacks

The black lead is always plugged into the common terminal. The red lead is plugged into the 10 A jack when measuring currents greater than 300 mA, the 300 mA jack when measuring currents less than 300 mA, and the remaining jack (V-ohms-diode) for all other measurements.
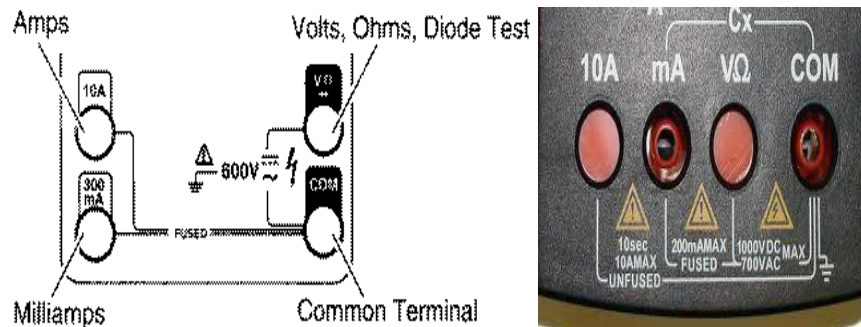
Range Fixing

The meter defaults to auto range when first turned on. You can choose a manual range in V AC, V DC, A AC, and A DC by pressing the button in the middle of the rotary dial. To return to autorange, press the button for one second.
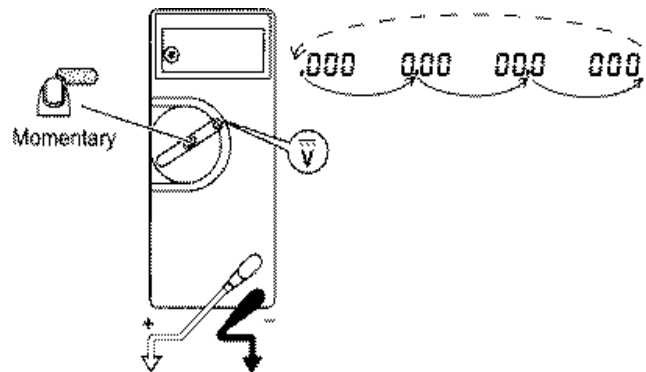
Procedure For Measurement Voltage Measurement

A.C. Voltage Measurment

1. Connect the positive(red) test lead to the „V/mA" jack socket and the negative(black) lead to the „COM" jack socket.
2. Set the selector switch to the desired mV D.C./D.C.V/A.C.V range.
3. Connect the test leads to the circuit to be measured.
4. Turn on the power to the circuit to be measured, the voltage value should appear on the digital display along with the voltage polarity(if reversed only).

Current Measurement

1. Connect the positive(red) test lead to the „V/mA" jack socket and the negative(black) lead to the „COM" jack socket(for measurements up to 200mA). For measurements between 200mA and 10A connect the red test lead to the „10mA" socket.

2. Set the selector switch to the desired uA/mA/A range.

3. Open the circuit to be measured and connect the test leads in **SERIES** with the load in which current is to be measured.

4. To avoid blowing an input fuse, use the 10A jack until you are sure that the current is less than 300 mA. Turn off power to the circuit. Break the circuit. (For circuits of more than 10 amps, use a current clamp.) Put the meter in series with the circuit and turn power on.

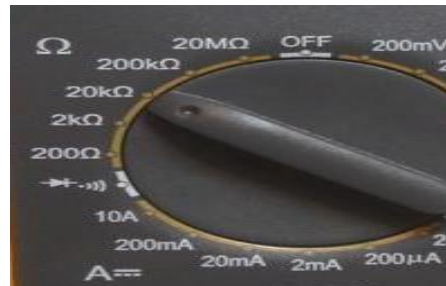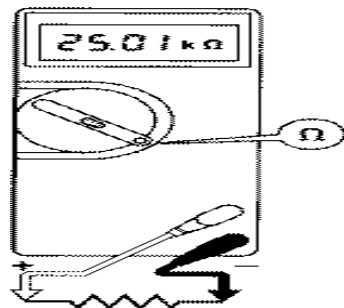**Resistance Measurement**

1. Connect the positive(red) test lead to the „V/mA" jack socket and the negative(black) lead to the „COM" jack socket.

2. Set the selector switch to the desired „OHM Ω".

3. If the resistance to be measured ia part of a circuit, turn off the power and discharge all capacitors before measurement.

4. Connect the test leads to the circuit to be measured.

5. The resistance value should now appear on the digital display.

6. If the resistance to be measured is part of a circuit, turn off the power and discharge all capacitors before measurement.

Continuity Test

This mode is used to check if two points are electrically connected. It is often used to verify connectors. If continuity exists (resistance less than 210 ohms), the beeper sounds continuously.

1. Connect the positive(red) test lead to the „V/mA" jack socket and the negative(black) lead to the „COM" jack socket.

2. Set the selector switch to the ⁞⁞⁞position.

3. Connect the test leads to two points of the circuit to be tested. If the resistence is Ohms the buzzer will sound.

4. If the resistance to be measured is part of a circuit, turn off the power and discharge all capacitors before measurement.

Diode Test

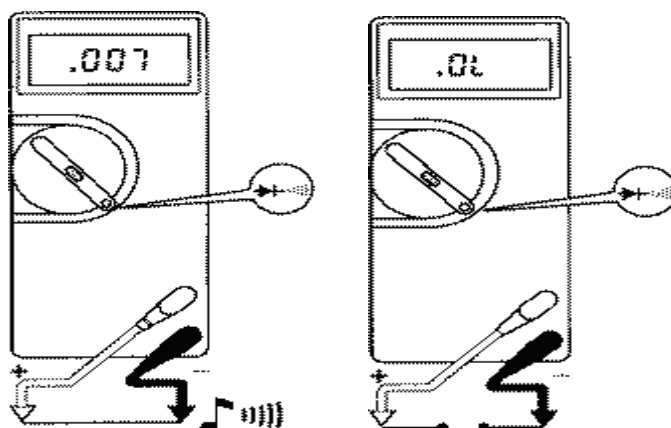1. Connect the positive (red) test lead to the „V/mA" jack socket and the negative(black) lead to the „COM" jack socket.
2. Set the selector switch to the ▸▸ position
3. Connect the test leads to be measured.
4. Turn on the power to the circuit to be measured and the voltage value should appear on the digital display.
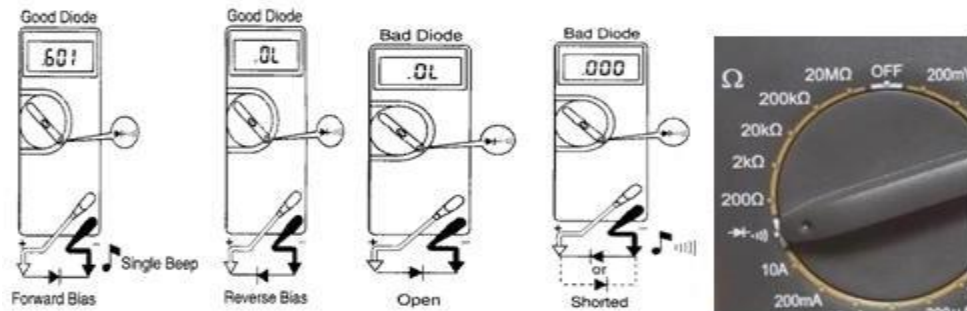
General Operation

Connection of Probes:

All multimeters come with two probes. They are to be connected to the terminals on the meter itself. The Black probe is to be connected to the COM terminal. Red probe is to be connected to terminal marked with :

- „V-Ω" for voltage measurement.
- „mA" or „20A" for current measurement (there are two terminals, one for 2A range and the other for 20A range)
- „V-Ω" for resistance measurement.

Setting of function:

The multimeter uses different circuits internally to measure different things. Therefore, you must select the correct function before using it.

Setting of Range:

- You can change the sensitivity of the meter by selecting different range for measurement. Set the range to the first range that is higher than the maximum value you expect to measure. This will give a more accurate reading. If you do not know what to expect, use the highest range first.
- After a reading is obtained, set the range to the appropriate one to get a better reading.
- When the value measured exceeds the existing range, the display will flash. When this happens, set the multimeter to a higher range until some values are displayed.

Precautions:

1. For current measurement, the maximum input current is 2A (if the RED mA and BLACK COM terminals are used) or 20A (if the RED 20A and BLACK COM terminals are used). Excessive current will blow the fuse on the 2A range, which must be replaced. The 20A range, however, is not protected by the fuse.

2. For voltage measurement (use the RED V- and BLACK COM terminals), the maximum input voltage on :

   - all DC ranges is 1200V DC or peak AC
   - the 20V, 200V and 1000V AC ranges is 1000V rms continuous
   - the 2V and 200mV AC ranges is 1000V rms for not more than 15 seconds.

3. To avoid electrical shock and/or instrument damage, do not connect the COM input terminals to any source of more than 500 volts DC or peak AC above earth ground.

Resistance measurement

Procedure

- Connect probes: black probe to COM terminal and red probe to terminal marked with
- Set function to resistance measurement
- Set to the appropriate range (refer to above)
- Connect the two probes" crocodile clips to the resistor (or to the resistor circuit via jumper wires) to make measurement
- Note the reading, adjust range if necessary
- Take the more accurate reading.

Voltage measurement

Procedure

1. Connect probes: black probe to COM terminal and red probe to terminal marked with „V"
2. Set function to voltage measurement
3. Set to the appropriate range (refer to above)
4. Set the AC-DC selection - depends on what type of signal you want to measure
5. Touch the two points where you want to make measurement
6. Note the reading, adjust range if necessary
7. Take the more accurate reading.

Note

Reading obtained is the voltage of where the red probe touch with reference to where the black probe touches. This may not indicate the voltage level from ground. To find the voltage level of a point from ground, black probe should be touching a ground point and the red probe on the point you want to measure.

Current measurement

Procedure

- Connect probes: black probe to COM terminal and red probe to terminal marked with „A"
- Set function to current measurement
- Set to the appropriate range
- Set AC-DC selection - depends on what type of signal you want to measure
- Off the power to the circuit
- Break the path which we want to make measurement
- Connect the path with the two probes so that current now flow through the multimeter
- On the power
- Note the reading, change range if necessary
- Take the more accurate reading.

Note

Use the 20A range if you are not sure of the current to be measured.

Connection Methods to Measure Voltage and Current

Voltage Measurement   Current Measurement
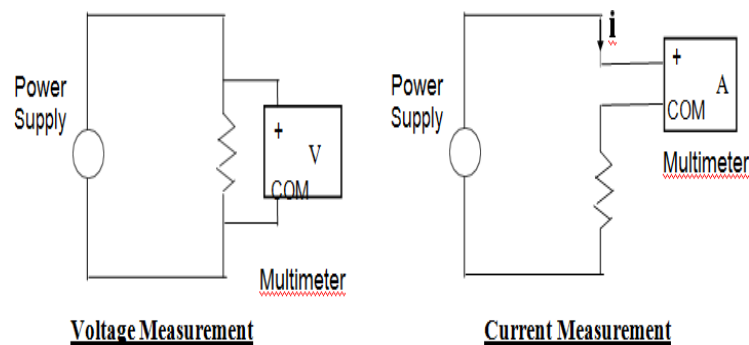
2) 2D FUNCTION GENERATOR

Objective

1. To get familiarization and study the operation of a function generator instrument
2. To identify key function generator specifications
3. To visualize the types of waveforms produced by a function generator

Equipment Required

1. Oscilloscope
2. Function Generator
3. BNC Connector Table

Theory

A **function generator** is electronic test equipment used to generate different types of waveforms over a wide range of frequencies. Function generators are capable of producing a variety of repetitive waveforms, generally from the list below

- *Sine wave:* A function generator will normally have the capability to produce a standard sine wave output. This is the standard waveform that oscillates between two levels with a standard sinusoidal shape.

- *Square wave:* A square wave is normally relatively easy for a function generator to produce. It consists of a signal moving directly between high and low levels.
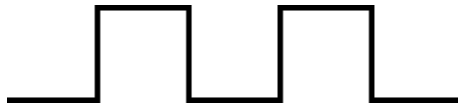
- *Pulse:* A pulse waveform is another type that can be produced by a function generator. It is effectively the same as a square wave, but with the mark space ratio very different to 1:1.

- *Triangular wave:* This form of signal produced by the function generator linearly moves between a high and low point.

- *Saw tooth wave:* Again, this is a triangular waveform, but with the rise edge of the waveform faster or slower than the fall, making a form of shape similar to a saw tooth.

These waveforms can be either repetitive or single-shot Function generators are used in the development, test and repair of electronic equipment.

Types of Function Generator

Procedure

- Turn on the oscilloscope
- Connect the function generator to one vertical channel of the oscilloscope using BNC Connector
- Select the type of wave form by pressing Function control button.
- Set the waveform at desired frequency by adjusting Frequency variable control button.
- Now adjust the amplitude control of the function generator to establish a 4 V peak-to-peak (p-p) sinusoidal waveform on the screen.
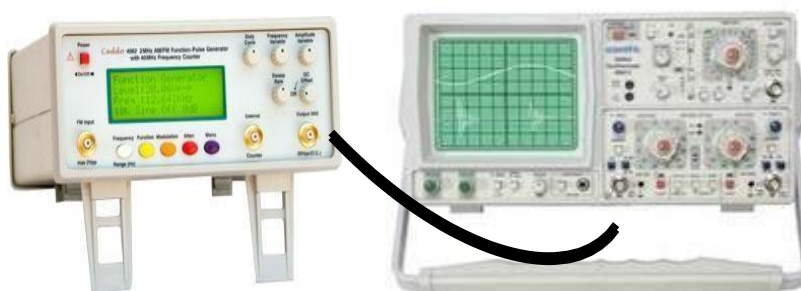
Function Generator connected

Function Generator Controls

Knobs Number	Control Name	Functions
1	Power	Push button switch to power ON the instrument.
2	LCD Display	20 x 4 Character bright back lit Liquid Crystal Display.
3	Frequency	Used for selection of frequency range step by step.

4	Function	Used for selection of Particular waveform. A total number of 6 different waveforms : ❖ *Sine* ❖ *Square* ❖ *Triangle* ❖ *Ramp* ❖ *Pulse*
5	Modulation	Used for selection of Frequency Modulation.
6	Attenuation	Used for Selection of 20dB or 40dB attenuation
7	Menu	Used for selection of Function Generator/Frequency counter mode.
8	Duty Cycle	When pulse output function is selected, this controls the pulse duty cycle from 15% to 85%.
9	Frequency	In conjunction with frequency range, selected by frequency key on front Panel.
10	Amplitude Variable	In conjunction with attenuators (6), this varies the level of output.
11	DC Offset	This control provides DC offset. Approximately ±5VDC is superimposed on the output. Keep the control off if DC offset is not required.
12	Output (BNC	Output of 10 MHz function generator i.e. 20Vpp (Open Circuit)
13	External Counter (BNC Connector)	Input BNC connector for measuring the frequency of external signal when External Counter mode is selected by Menu key on the LCD display.
14	Modulation Input	Maximum modulation Input i.e. 2Vpp.

3) 2B DC VARIABLE POWER SUPPLY

A power supply is a device that supplies electric power to an electrical load. The term is most commonly applied to electric power converters that convert one form of electrical energy to another, though it may also refer to devices that convert another form of energy (mechanical, chemical, solar) to electrical energy. A regulated power supply is one that controls the output voltage or current to a specific value; the controlled value is held nearly constant despite variations in either load current or the voltage supplied by the power supply's energy source.

A power supply may be implemented as a discrete, stand-alone device or as an integral device that is hardwired to its load. Examples of the latter case include the low voltage DC power supplies that are part of desktop computers and consumer electronics devices.

Commonly specified power supply attributes include:

- The amount of voltage and current it can supply to its load.

- How stable its output voltage or current is under varying line and load conditions.

Power Supplies Types

1. Battery
2. DC power supply
3. AC power supply
4. Linear regulated power supply
5. Switched mode power supply
6. Programmable power supply
7. Uninterruptible power supply
8. High voltage power supply
9. Voltage multipliers

Dc Power Supply Specification

a. Adjustable 0~30V/0~2A
b. The design is limit the voltage overload
c. The power supply input 220V, 230V, 240V AC
d. Output voltage: 0-30V DC
e. Work temperature: -10oC-40oC

Main Function

1. Output constant current adjustable.
2. Output constant voltage adjustable.
3. LCD voltage and current display.
4. Constant voltage and current operation in individual.
5. Over current protection.

Adjustable power supply

4) 2C CATHODE-RAY OSCILLOSCOPE (CRO)

The device consists mainly of a vacuum tube which contains a cathode; anode, grid, X&Y- plates, and a fluorescent screen (see Figure below). When the cathode is heated (by applying a small potential difference across its terminals), it emits electrons. Having a potential difference between the cathode and the anode (electrodes), accelerate the emitted electrons towards the anode, forming an electron beam, which passes to fall on the screen.

When the fast electron beam strikes the fluorescent screen, a bright visible spot is produced. The grid, which is situated between the electrodes, controls the amount of electrons passing through it thereby controlling the intensity of the electron beam. The X&Y- plates are responsible for deflecting the electron beam horizontally and vertically.

A sweep generator is connected to the X-plates, which moves the bright spot Horizontally across the screen and repeats that at a certain frequency as the source of the signal.

The voltage to be studied is applied to the Y-plates. The combined sweep and Y voltages produce a graph showing the variation of voltage with time.

Experimental Figures
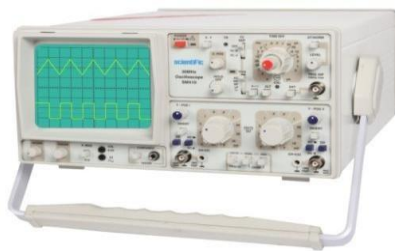
Fig 1. Cathode Ray tube Oscilloscope   Fig 2. Out Line Diagram of CRO
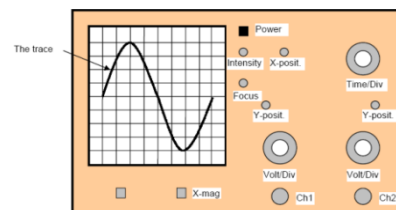
Procedure

- Turn on the Oscilloscope
- Adjust the intensity and the focus of the trace.
- Use the X & Y knobs to center the trace horizontally and vertically.
- Connect the cable from Ch1 of the CRO to Function generator.
- A signal will appear on the screen.
- Make sure that the inner red knobs of the Volt/Div and the Time/Div are locked clockwise.
- Set the frequency of the generator to 100 Hz.
- Adjust the Volt/Div and the Time/Div knobs so that you get a suitable size signal

- Count the number of vertical squares lying within the signal, then calculate the peak to peak value as:
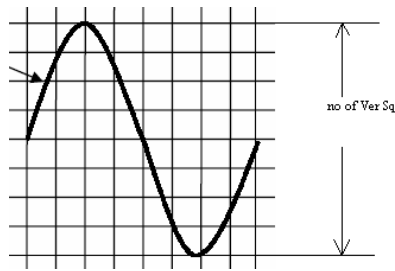
$$Vp\text{-}p = \text{No. vertical Div} * \square \text{ Volt/Divs}$$

- Count the number of horizontal squares lying within the one Duty Cycle, then calculate time value as:

$$\textbf{Time} = \text{No. Horizontal Div} * \square \text{ Time/Divs 11.}$$

- Calculate the Frequency of signal by using the formula:

$$\text{Freq} = 1 \ /\text{Time}$$

Lab Test 1:	PN JUNCTION DIODE CHARACTERISTICS

To plot the V-I characteristics of a PN junction diode in both forward and reverse directions. Find cut in voltage (knee voltage), static and dynamic resistance in forward direction at forward current of 2mA & 8mA respectively.Find static and dynamic resistance at 10V in reverse bias condition.

COMPONENTS & EQUIPMENT REQUIRED

S.No	Device	Range /Rating	Quantity (in No.s)
1.	Semiconductor diode trainer Board Containing		
	DC Power Supply	(0-15) V	1
	Diode (Silicon)	1N 4007	1
	Diode (Germanium)	OA79	1
	Carbon Film Resistor	1 KΩ, 1/2 W	1
2.	DC Voltmeter	(0-1) V	1
	DC Voltmeter	(0-20) V	1
3.	DC Ammeter	(0-200) μA	1
	DC Ammeter	(0-20) mA	1
4.	Connecting wires	5A	10

THEORY

A p-n junction diode conducts only in one direction. The V-I characteristics of the diode are curve between voltage across the diode and current through the diode. When external voltage is zero, circuit is open and the potential barrier does not allow the current to flow. Therefore, the circuit current is zero. When P-type (Anode is connected to +ve terminal and n- type (cathode) is connected to –ve terminal of the supply voltage, is known as forward bias. The potential barrier is reduced when diode is in the forward biased condition. At some forward voltage, the potential barrier altogether eliminated and current starts flowing through the diode and also in the circuit. The diode is said to be in ON state. The current increases with increasing forward voltage.When N-type (cathode) is connected to +ve terminal and P-type (Anode) is connected –ve terminal of the supply voltage is known as reverse bias and the potential barrier across the junction increases. Therefore, the junction resistance becomes very high and a very small current (reverse

saturation current) flows in the circuit. The diode is said to be in OFF state. The reverse bias current due to minority charge carriers

PROCEDURE

Forward Bias

1. Connect the circuit as shown in figure(1).
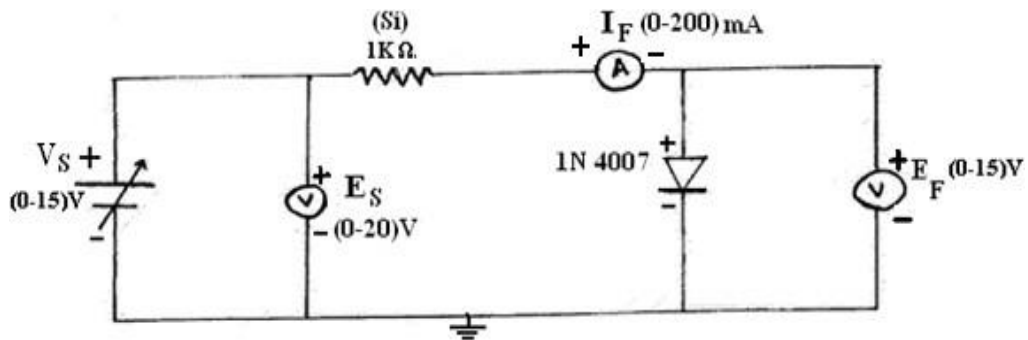2. Vary the supply voltage E_s in steps and note down the corresponding values of E_f and I_f as shown in the tabular column.
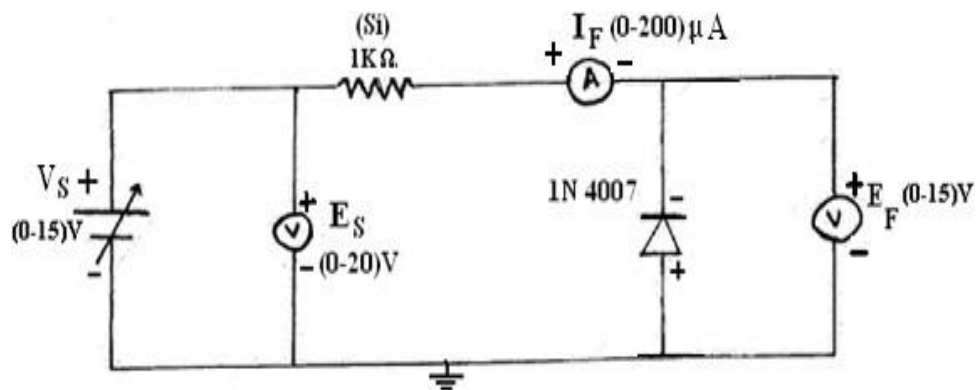
Reverse Bias

1. Connect the circuit as shown in figure (2).
2. Repeat the procedure as in forward bias and note down the corresponding Values of E_r and I_r as shown in the tabular column.

CIRCUIT DIAGRAMS

Forward Bias

Reverse Bias

EXPECTED GRAPHS

TABULAR COLUMN

Forward Bias				Reverse Bias		
E_s (volts)	E_f (volts)	I_f (mA)		E_s (volts)	E_r (volts)	I_r (µA)
0.1				0.1		
0.2				0.2		
0.3				0.3		
0.4				0.4		
0.5				0.5		
0.6				0.6		
0.7				0.7		
0.8				0.8		
0.9				0.9		
1				1		
2				2		
4				4		
6				6		
8				8		
10				10		
12				12		
14				14		

PRECAUTIONS

1. Ensure that the polarities of the power supply and the meters as per the circuit diagram.
2. Keep the input voltage knob of the regulated power supply in minimum position both when switching ON or switching OFF the power supply.
3. No loose contacts at the junctions.
4. Ensure that the ratings of the meters are as per the circuit design for precision.

CALCULATIONS

Forward Bias

Static Resistance at 8mA= E_f / I_f =

Static resistance at 2mA= E_f / I_f =

Dynamic resistance at 8mA= $\Delta E_f / \Delta I_f$ =

Dynamic resistance at 8mA= $\Delta E_f / \Delta I_f$ =

Reverse Bias

Static Resistance at (10V)= E_r / I_r =

Dynamic resistance at (10V)= $\Delta E_r / \Delta I_r$ =

PRE LAB QUESTIONS

1. Define depletion region of a diode?
2. What is meant by transition & space charge capacitance of a diode?
3. Is the V-I relationship of a diode Linear or Exponential?
4. Draw the ideal characteristics of P-N junction diode?
5. What is the diode equation?

LAB ASSIGNMENT

To plot the V-I characteristics of a PN junction (Germanium) diode in both forward and reverse directions by using multisim.

POST LAB QUESTIONS

1. Define cut-in voltage of a diode and specify the values for Si and Ge diodes?
2. What are the applications of a p-n diode?
3. What is PIV?
4. What is the break down voltage?
5. What is the effect of temperature on PN junction diodes?

RESULT

V-I characteristics of PN junction are plotted and verified in both forward and reverse directions.

Forward direction

(i) Cut-in-voltage=0.7V

(ii) a) Dynamic Resistance (at 8 mA) =

     b) Dynamic Resistance (at 2mA) =

(iii) a) Static Resistance(at 8mA) =

     b) Static Resistance (at 2mA) =

Reverse Direction

 (i) Static Resistance (at 10V) =

 (ii) Dynamic Resistance (at 10 V) =

Lab Test 2:	Zener Diode Characteristics And Voltage Regulator

Plot the V-I characteristics of a Zener diode, find zener breakdown voltage in reverse bias condition, find static and dynamic resistance in both forward and reverse bias conditions and perform zener diode voltage regulator.

COMPONENTS & EQUIPMENT REQUIRED

S.NO	DEVICES	RANGE /RATING	QUANTITY (in No.s)
1	Zener diode trainer Board Containing		
	a) DC Power Supply.	(0-15) V	1
	b) Zener Diode	4.7 V	1
	c) Zener Diode	6.2 V	1
	d) Carbon Film Resistor	1 KΩ, 1/2 W	1
2	DC Voltmeter	(0-1) V	1
	DC Voltmeter	(0-20) V	1
3	a) DC Ammeter	(0-200) μA	1
	b) DC Ammeter	(0-20) mA	1
4	Connecting wires	5A	10

THEORY

A zener diode is heavily doped p-n junction diode, specially made to operate in the break down region. A p-n junction diode normally does not conduct when reverse biased. But if the reverse bias is increased, at a particular voltage it starts conducting heavily. This voltage is called Break down Voltage. High current through the diode can permanently damage the device.

To avoid high current, we connect a resistor in series with zener diode. Once the diode starts conducting it maintains almost constant voltage across the terminals whatever may be the current through it, i.e., it has very low dynamic resistance. It is used in voltage regulators.

PROCEDURE

Forward Bias

1. Connect the circuit as shown in figures (1)

2. Vary the supply voltage E_s in steps and note down the corresponding values of E_f and I_f as shown in the tabular column.
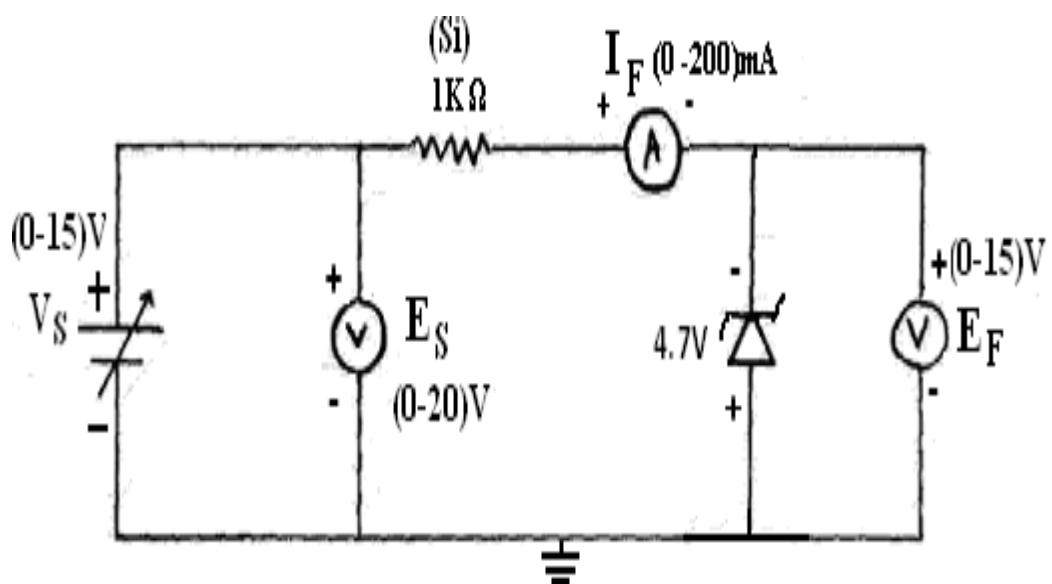
Reverse Bias

1. Connect the circuit as shown in figure (2).

2. Repeat the procedure as in forward bias and note down the corresponding values of E_r and I_r as shown in the tabular column.

CIRCUIT DIAGRAMS
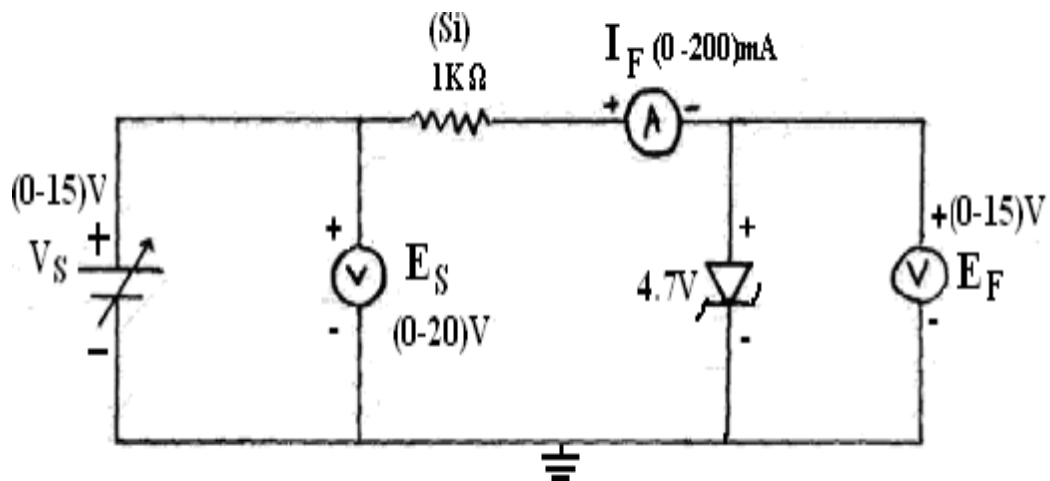
Forward Bias

Reverse Bias

Zener Doide As Voltage Regulator
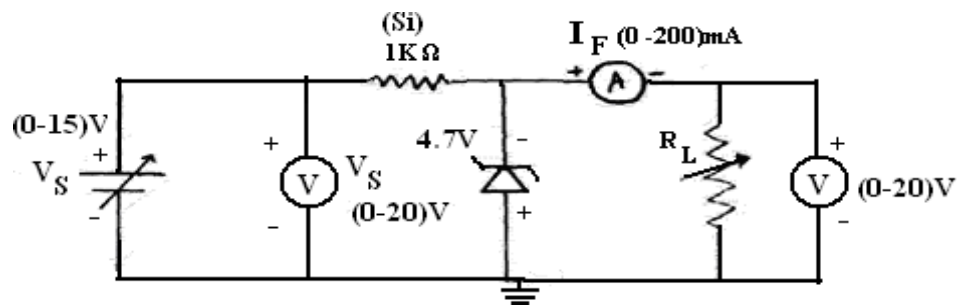
EXPECTED GRAPH

TABULAR COLUMN

Forward Bias   Reverse Bias
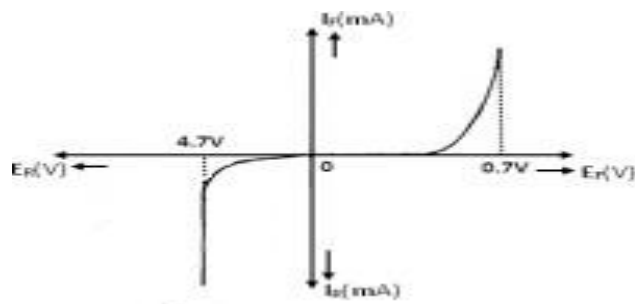
E_s (volts)	E_f (volts)	I_f (mA)
0.1		
0.2		
0.3		
0.4		
0.5		
0.6		
0.7		
0.8		
0.9		
1		
2		
4		
6		
8		
10		
12		
14		

E_s (volts)	E_r (volts)	I_r (mA)
0.1		
0.2		
0.3		
0.4		
0.5		
0.6		
0.7		
0.8		
0.9		
1		
2		
4		
6		
8		
10		
12		
14		

Zener Doide As Voltage Regulator:

V_{in}=15V , V_{NL}=_____ R_L=15K

$R_L(\Omega)$	V_{FL}(volts)	I_L (mA)	%Regulation
100			
200			
500			
1K			
2K			
5K			
10K			
20K			

E_s (volts)	E_{FL} (volts)	I_L (mA)
1		
2		
4		
6		
8		
10		
12		
14		

PRECAUTIONS

1. Ensure that the polarities of the power supply and the meters as per the circuit diagram.
2. Keep the input voltage knob of the regulated power supply in minimum position both when switching ON or switching OFF the power supply.
3. No loose contacts at the junctions.
4. Ensure that the ratings of the meters are as per the circuit design for precision.

CALCULATIONS

1. Forward Static resistance at 6 mA= Ef/ If

2. Forward Dynamic resistance at 6mA=Δ Ef / Δ If

3. Reverse Static resistance at 6 mA= Ef/ If

4. Reverse Dynamic resistance at 6mA=Δ Ef / Δ I

PRE LAB QUESTIONS

1. What type of temperature Coefficient does the zener diode have?
2. If the impurity concentration is increased, how the depletion width effected?
3. How the breakdown voltage of a particular diode can be controlled?
4. What type of temperature coefficient does the Avalanche breakdown has?

LAB ASSIGNMENT

To plot the V-I characteristics of a Zener diode (6.1V) in both forward and reverse directions by using multisim.

POST LAB QUESTIONS

1. Explain briefly about avalanche and zener breakdowns?
2. Draw the zener equivalent circuit?
3. Differentiate between line regulation & load regulation?
4. In which region zener diode can be used as a regulator?

RESULT

1. V-I characteristics of Zener diode are plotted and verified in both forward and reverse directions.
2. Zener breakdown voltage for 4.7V zener diode = 4.7V.
3. (i) Forward Bias:

   a) Static resistance at 6 mA =

   b) Dynamic resistance at 6 mA=

   (ii) Reverse Bias:

   a) Static resistance at 6 mA=

   b) Dynamic resistance at 6 mA=

Lab Test 3:	Halfwave Rectifiers With/Without Filters

Examine the input and output waveforms of a half wave rectifier without and with filters. Calculate the ripple factor with load resistance of 500Ω, 1 KΩ and 10 KΩ respectively. Calculate ripple factor with a filter capacitor of 100μF and the load of 1KΩ, 2KΩ and 10KΩ respectively.

COMPONENTS & EQUIPMENT REQUIRED

S.No	Device	Range/Rating	Quantity in No.
1	Rectifier and Filter trainer Board Containing		
	a) AC Supply.	(9-0-9) V	1
	b) Silicon Diodes	1N 4007	1
	c) Capacitor	0.47μF	1
2	a) DC Voltmeter	(0-20) V	1
	b) AC Voltmeter	(0-20) V	1
3	DC Ammeter	(0-50) mA	1
4	Cathode Ray Oscilloscope	(0-20) MHz	1
5	Decade Resistance Box	10Ω-100KΩ	1
6	Connecting wires	5A	12

THEORY

During positive half-cycle of the input voltage, the diode D1 is in forward bias and conducts through the load resistor R1. Hence the current produces an output voltage across the load resistor R1, which has the same shape as the +ve half cycle of the input voltage.

During the negative half-cycle of the input voltage, the diode is reverse biased and there is no current through the circuit. i.e, the voltage across R1 is zero. The net result is that only the +ve half cycle of the input voltage appears across the load. The average value of the half wave rectified o/p voltage is the value measured on dc voltmeter.

For practical circuits, transformer coupling is usually provided for two reasons.

1. The voltage can be stepped-up or stepped-down, as needed.
2. The ac source is electrically isolated from the rectifier. Thus preventing shock hazards in the secondary circuit.

PROCEDURE

Half Wave Rectifier without filter

1. Connect the circuit as shown in figure (a).

2. Adjust the load resistance, R_L to 500Ω, and note down the readings of input and output voltages through oscilloscope.

3. Note the readings of dc current, dc voltage and ac voltage.

4. Now, change the resistance the load resistance, RL to 1 KΩ and repeat the procedure as above. Also repeat for 10 KΩ.

5. Readings are tabulated as per the tabular column.

Half Wave Rectifier with filter

1. Connect the circuit as shown in figure (b) and repeat the procedure as for half wave rectifier without filter.

CIRCUIT DIAGRAMS
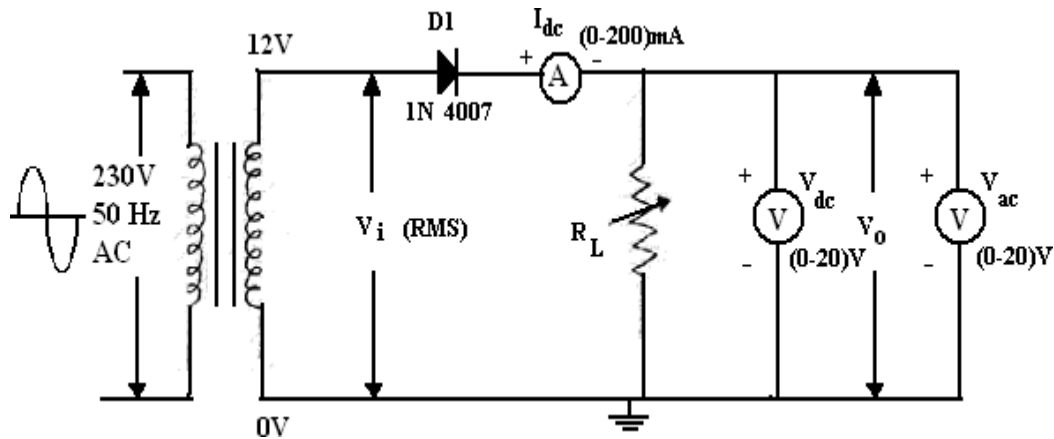
Figure (a) :Half Wave Rectifier without Filter
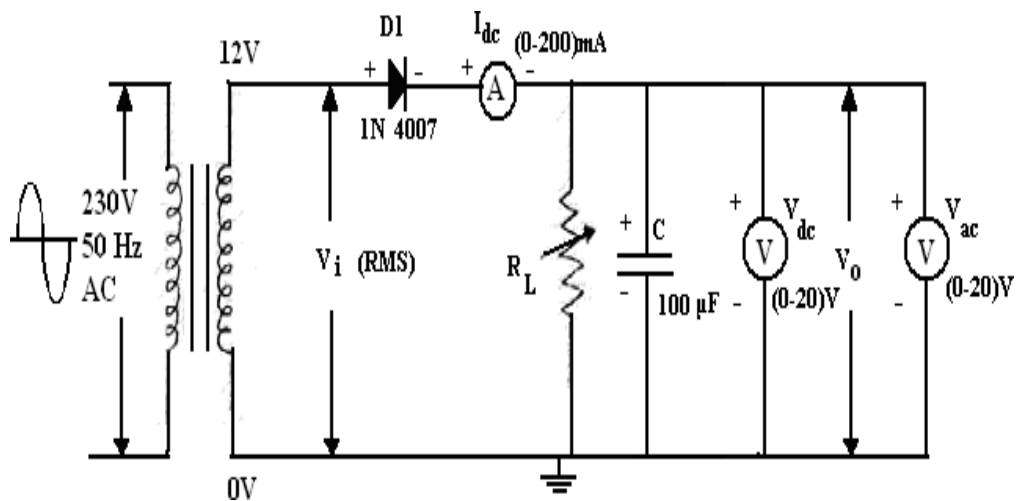
Figure (b):Half Wave Rectifier with Filter

EXPECTED GRAPHS
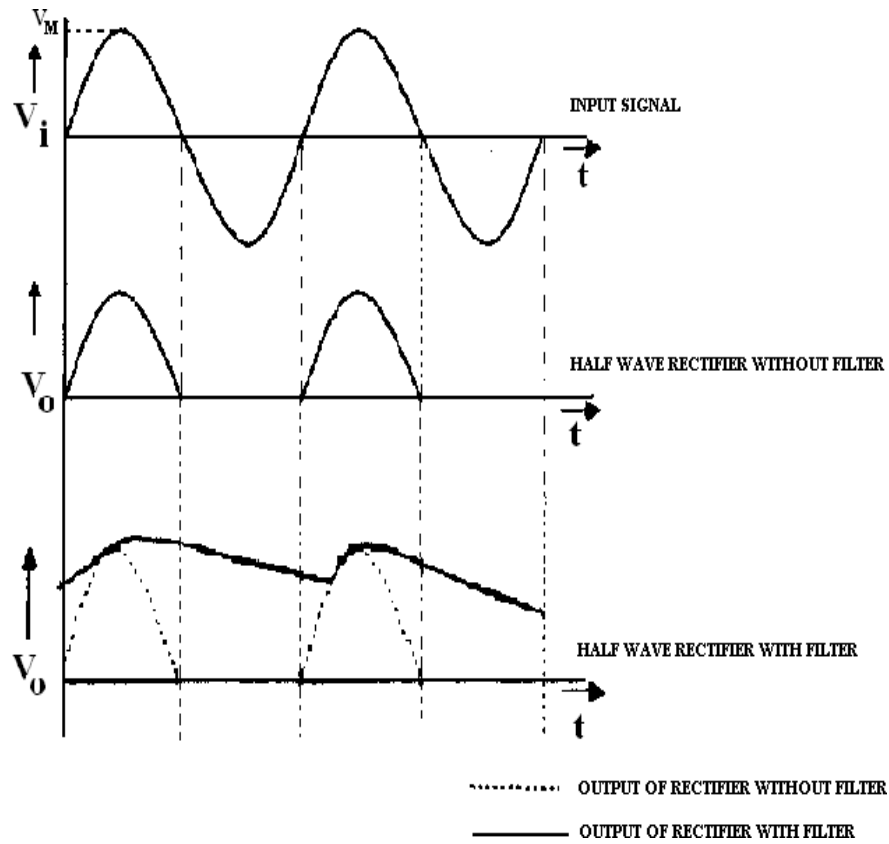
PRECAUTIONS

1. No loose contacts at the junctions.
2. Meters of correct ranges must be used for precision

TABULAR COLUMNS

Half Wave Rectifier without Filter

S. No	Load Resistance (R_L)	Input Voltage Peak (V_m)	Output Voltage Peak (V_o)	Average dc current (I_{dc})	Average Dc voltage (V_{dc})	RMS Voltage (V_{ac})	Ripple Factor $\gamma = \dfrac{V_{ac}}{V_{dc}}$
1.	500Ω						
2.	1KΩ						
3.	10KΩ						

Half Wave Rectifier with Filter   C=10μF

S. No	Load Resistance (R$_L$)	Input Voltage Peak (V$_m$)	Output Voltage Peak (V$_o$)	Average dc current (I$_{dc}$)	Average Dc voltage (V$_{dc}$)	RMS Voltage (V$_{ac}$)	Ripple Factor $\gamma = \dfrac{V_{ac}}{V_{dc}}$
1.	1KΩ						
2.	2KΩ						
3.	10KΩ						

PRE LAB QUESTIONS

1. What is a rectifier?
2. How Diode acts as a rectifier?
3. What is the significance of PIV? What is the condition imposed on PIV?
4. What is meant by regulation?
5. What is meant by time constant?

LAB ASSIGNMENT

Plot the wave forms of Half wave rectifier with RL=5000 ohms, C = 680μF.

POST LAB QUESTIONS

1. Draw the o/p wave form without filter?
2. Draw the o/p wave form with filter?
3. What is meant by ripple factor? For a good filter whether ripple factor should be high or low?
4. What happens to the o/p wave form if we increase the capacitor value?
5. What happens if we increase the capacitor value?

RESULT

1. Input and Output waveforms of a half-wave with /without filter are observed and plotted.
2. For Half-wave rectifier without filter-

   γ, Ripple factor at 500Ω=

            1KΩ=
           10 KΩ=

3. For Half-wave rectifier with filter:-

   γ, Ripple factor at 1KΩ, 100μF =

           2KΩ, 100μF =
           10 KΩ, 100μF =

Lab Test 4:	Full wave Rectifiers With/Without Filter

Examine the input and output waveforms of a full wave (center tapped) rectifier without and with filters.Calculate the ripple factor with load resistance of 500Ω, 1 KΩ and 10 KΩ respectively.

Calculate ripple factor with a filter capacitor of 100μF and the load of 1KΩ, 2KΩ and 10KΩ respectively.

COMPNENTS& EQUIPMENTS REQUIRED

S.No	Device	Range /Rating	Quantity (in No.s)
1	Rectifier and Filter trainer Board Containing		
	a) AC Supply.	(9-0-9) V	1
	b) Silicon Diodes	1N 4007	2
	c) Capacitor	0.47μF	1
2	a) DC Voltmeter	(0-20) V	1
	b) AC Voltmeter	(0-20) V	1
3	DC Ammeter	(0-50) mA	1
4	Cathode Ray Oscilloscope	(0-20) MHz	1
5	Decade Resistance Box	10Ω-100KΩ	1
6	Electrolytic Capacitor	100μF	1
7	Connecting wires	5A	12

THEORY

The circuit of a center-tapped full wave rectifier uses two diodes D1&D2. During positive half cycle of secondary voltage (input voltage), the diode D1 is forward biased and D2is reverse biased.

The diode D1 conducts and current flows through load resistor R_L. During negative half cycle, diode D2 becomes forward biased and D1 reverse biased. Now, D2 conducts and current flows through the load resistor R_L in the same direction. There is a continuous current flow through the load resistor R_L, during both the half cycles and will get unidirectional current as show in the model graph. The difference between full wave and half wave rectification is that a full

wave rectifier allows unidirectional (one way) current to the load during the entire 360 degrees of the input signal and half-wave rectifier allows this only during one half cycle (180 degree).

PROCEDURE

Full-wave Rectifier without filter

1. Connect the circuit as shown in the figure (a).
2. Adjust the load resistance R_L to 500Ωand connect a capacitor of 100μF value in parallel with the load and note the readings of input and output voltages through Oscilloscope.
3. Note the readings of DC current, DC voltage and AC voltage.
4. Now change the load resistance RL to 2000Ω and repeat the procedure as the above.
5. Readings are tabulate as per the tabular column.

Full-wave Rectifier with filter

1. Connect the circuit as shown in the figure (b).
2. Adjust the load resistance R_L to 1KΩand connect a capacitor of 100μF values in parallel with the load and note the readings of input and output voltages through Oscilloscope.
3. Note the readings of DC current, DC voltage and AC voltage.
4. Now change the load resistance R_L to 2KΩ and repeat the procedure as the above. Also
5. repeat for 10K, 100μF values.
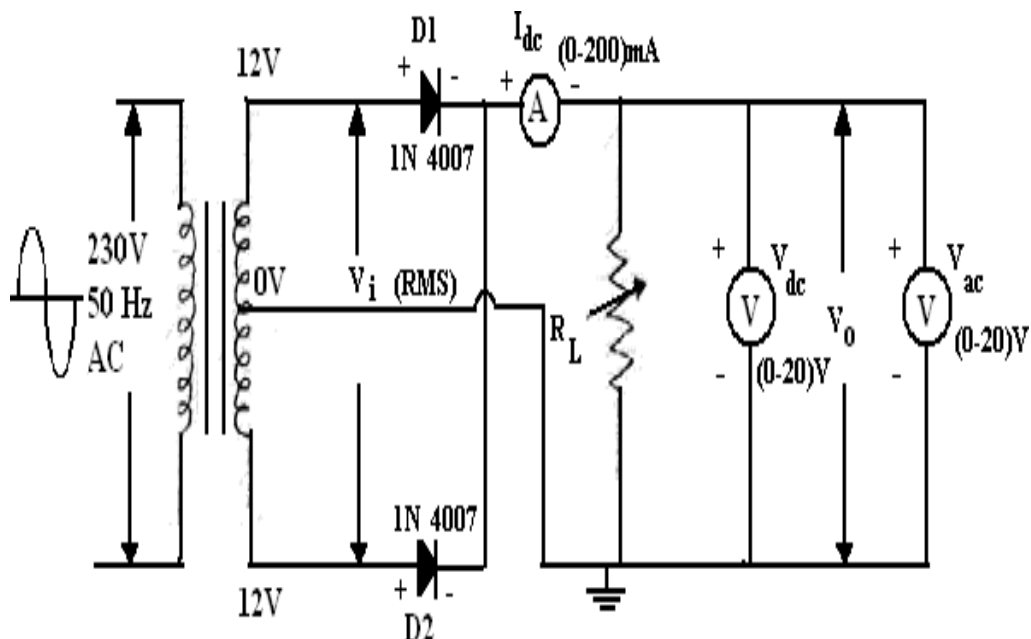6. Readings are tabulate as per the tabular column.

CIRCUIT DIAGRAMS

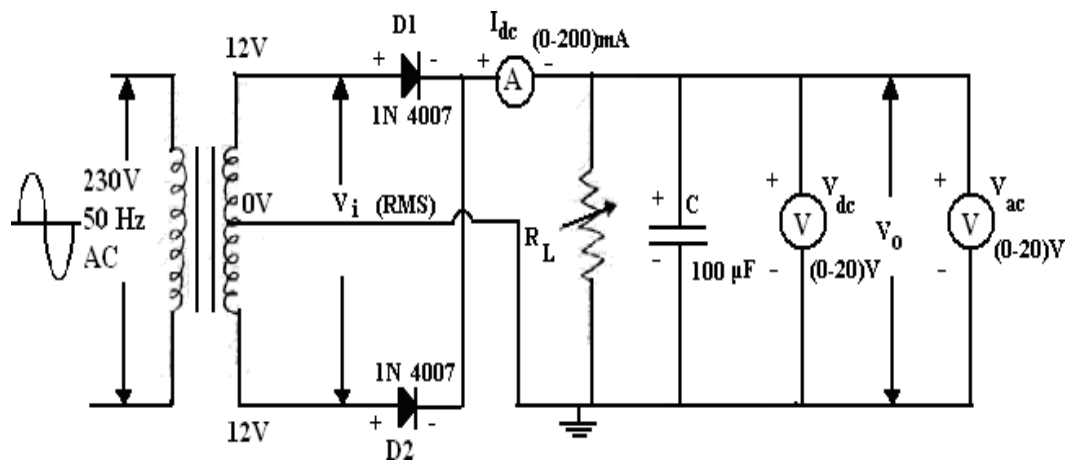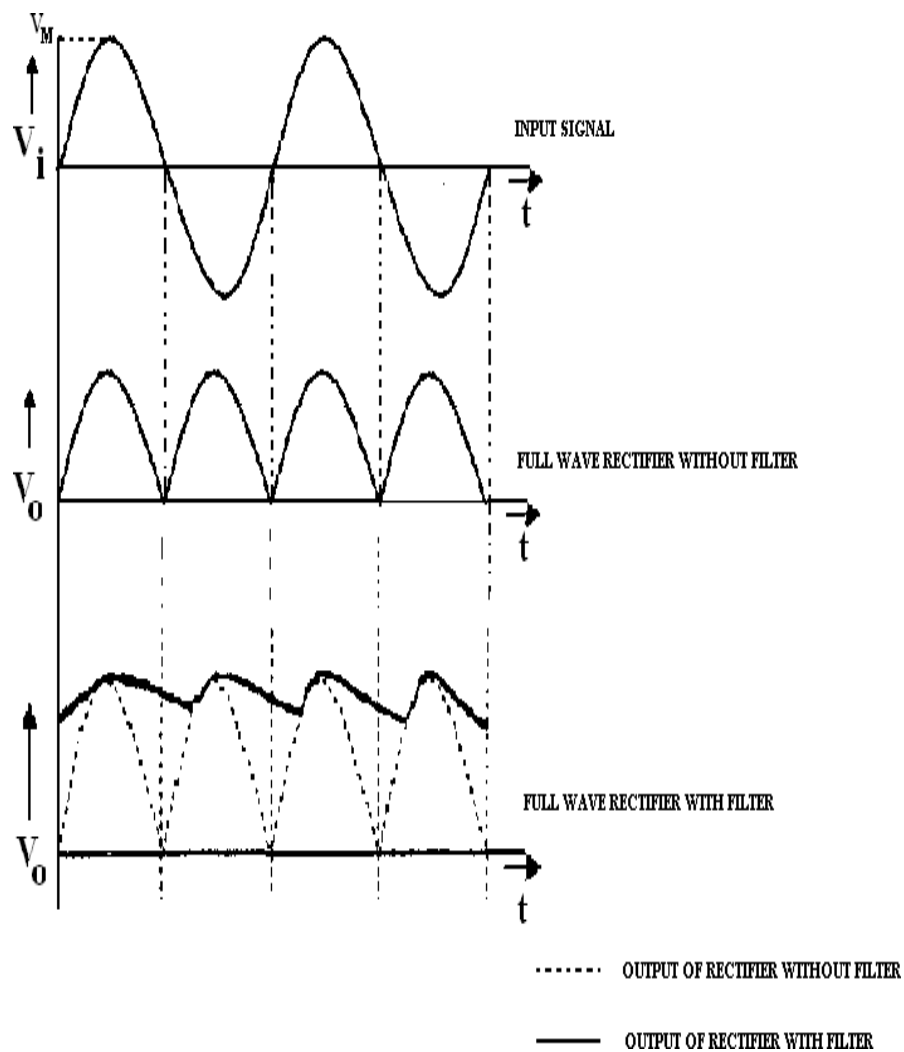Figure (a): Full Wave Rectifier (Center-tap) Without Filter

Figure (b): Full Wave Rectifier (center-tap) With Filter

EXPECTED GRAPHS

OUTPUT OF RECTIFIER WITHOUT FILTER

OUTPUT OF RECTIFIER WITH FILTER

1. No loose contacts at the junctions.
2. Meters of correct range must be used for precision.

TABULAR COLUMNS

Full wave Rectifier (Center-tap) Without Filter

S. No	Load Resistance (R_L)	Input Voltage Peak (V_m)	Output Voltage Peak (V_o)	Average dc current (I_{dc})	Average Dc voltage (V_{dc})	RMS Voltage (V_{ac})	Ripple Factor $\gamma = \dfrac{V_{ac}}{V_{dc}}$
1	500Ω						
2	1KΩ						
3	10KΩ						

Full wave Rectifier (Center-tap) With Filter   C = --- μF

S.No	Load Resistance (R_L)	Input Voltage Peak (V_m)	Output Voltage Peak (V_o)	Average dc current (I_{dc})	Average Dc voltage (V_{dc})	RMS Voltage (V_{ac})	Ripple Factor $\gamma = \dfrac{V_{ac}}{V_{dc}}$
1	500Ω						
2	1KΩ						
3	10K						

PRE LAB QUESTIONS

1. What is a full wave rectifier?
2. How Diode acts as a rectifier?
3. What is the significance of PIV requirement of Diode in full-wave rectifier?
4. Compare capacitor filter with an inductor filter?
5. What is the theoretical maximum value of ripple factor for a full wave rectifier?

LAB ASSIGNMENT

Plot the wave forms of fulle wave rectifier with RL=500 ohms, C = 470μF.

POST LAB QUESTIONS

1. Draw the o/p wave form without filter? Draw the O/P? What is wave form with filter?

2. What is meant by ripple factor? For a good filter whether ripple factor should be high or low? What happens to the ripple factor if we insert the filter?

3. What is meant by regulation? Why regulation is poor in the case of inductor filter?

4. What is meant by time constant?

5. What happens to the o/p wave form if we increase the capacitor value? What happens if we increase the capacitor value?

RESULT

1. Input and Output waveforms of a full-wave (center tapped) and bridge rectifier with /without filters are observed and plotted.

2. For Full-wave rectifier(center tapped) without filter-
    - i. γ, Ripple factor at 500Ω, 100μF =
        - a. 2KΩ, 100μF =

3. For full-wave rectifier (Center tapped) with filter-
    - i. γ, Ripple factor at 500Ω, 100μF =
        - a. 2KΩ, 100μF =

	Transistor CB Characteristics
Lab Test 5:	

Plot the input and output characteristics of a transistor connected in Common Base configuration. Calculate the input resistance R_i at I_e= 12 mA, output resistance R_o at V_{CB}=8V and current gain at V_{CB} =6V.

COMPONENTS & EQUIPMENT REQUIRED

S.No	Device	Range /Rating	Quantity (in No.s)
1.	Transistor CB trainer Board Containing		
	a) DC Power Supply.	(0-12) V	2
	b) PNP Transistor	CK100	1
	c) Carbon Film Resistor	470Ω, 1/2 W	2
2.	a) DC Voltmeter	(0-1) V	1
	b) DC Voltmeter	(0-20) V	1
3.	DC Ammeter	(0-50) mA	2
4.	Connecting wires	5A	12

THEORY

A transistor is a three terminal active device. T he terminals are emitter, base, collector. In CB configuration, the base is common to both input (emitter) and output (collector). For normal operation, the E-B junction is forward biased and C-B junction is reverse biased.

In CB configuration, I_E is +ve, I_C is –ve and I_B is –ve.

So, $V_{EB=}f1 (V_{CB},I_E)$ and $I_{C=}f2 (V_{CB},I_B)$

With an increasing the reverse collector voltage, the space-charge width at the output junction increases and the effective base width „W" decreases. This phenomenon is known as "Early effect". Then, there will be less chance for recombination within the base region. With increase of charge gradient within the base region, the current of minority carriers injected across the emitter junction increases. The current amplification factor of CB configuration is given by,

$$\alpha= \Delta I_C/ \Delta I_E$$

PROCEDURE Input

Characteristics:

1. Connect the transistor as shown in figure.
2. Keep the V_{CB} constant at 4V and 8V.Vary the V_{EB} in steps and note corresponding I_E values as per tabular form.

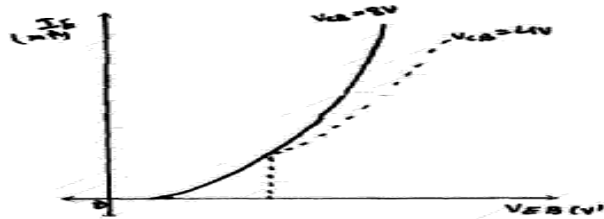### Output Characteristics:

1. Keep the I_E constant at 4mA and 8mA.Vary the V_{CB} in steps and note corresponding I_C values.
2. Readings are tabulated as shown in tabular column.

CIRCUIT DIAGRAM

EXPECTED GRAPHS

Input Characteristics

Output characteristics

TABULAR COLUMN

Input Characteristics

V_{CB} = -4V		V_{CB} = -8V	
V_{EB} (Volts)	I_E (mA)	V_{EB} (Volts)	I_E (mA)

Output Characteristics

I_E = 8mA		I_E = 4mA	
V_{CB} (Volts)	I_C (mA)	V_{CB}(Volts)	I_C(mA)

CALCULATIONS

Input Resistance (I_E =12 mA) = $\Delta V_{EB}/\Delta I_E$ =

At V_{EB} = 4V

Input Resistance (I_E =12 mA) = $\Delta V_{EB}/\Delta I_E$ =

At V_{EB} = 8V

Output resistance (I_E =8mA) = $\Delta V_{CB}/\Delta I_C$ =

At V_{CB} = -8V.

Output resistance (I_E =4mA) = $\Delta V_{CB}/\Delta I_C$ =

At V_{CB} = -8V.

Current Amplification Factor „α" = $\Delta I_C/\Delta I_E$ =

H-parameter calculations

$h_{ib} = \Delta V_{eb} / \Delta I_e =$

$h_{ob} = \Delta I_c / \Delta V_{cb} =$

$h_{fb} = \Delta I_c / \Delta I_e =$

$h_{rb} = \Delta V_{eb} / \Delta V_{cb} =$

PRE LAB QUESTIONS

1. What is the range of α for the transistor?
2. Draw the input and output characteristics of the transistor in CB configuration?
3. Identify various regions in output characteristics?
4. What is the relation between α and β?

LAB ASSIGNMENT

Plot the I/O characteristics of CB configuration for Vcc = 12V, VEE = 6V, RE= 100K ohms, Rc = 1K ohms, α =0.98, Vbe = 0.7V.

POST LAB QUESTIONS

1. What are the applications of CB configuration?
2. What are the input and output impedances of CB configuration?
3. Define α(alpha)?
4. What is EARLY effect?
5. What is the power gain of CB configuration

RESULT

Input and output curves are plotted.

1. R_i Input Resistance:
   - (i) V_{EB} = 4V and I_E =12 mA, R_i =
   - (ii) V_{EB} = 8V and I_E =12 mA, R_i =
2. R_o Output Resistance:
   - (i) V_{CB} = 8V and I_E = 8 mA, R_o =
   - (ii) V_{CB} = 8V and I_E = 4 mA, R_o =
3. Current Amplification factor

   „α" =

   (at V_{CB} =6V)

Lab Test 6:	**Transistor CE Characteristics**

Plot the input and output characteristics of a transistor connected in Common Emitter configuration. Calculate the input resistance R_i at I_B= 20 μA, output resistance R_o at V_{CE}=10V and current gain at V_{CE} =10V.

COMPONENTS & EQUIPMENT REQUIRED

S.No	Device	Range /Rating	Quantity (in No.s)
1.	Transistor CE trainer Board Containing a) DC Power Supply. b) PNP Transistor c) Carbon Film Resistor	(0-12) V BC 107 470Ω, 1/2 W 100KΩ,1/2 W	2 1 1 1
2.	a) DC Voltmeter b)DC Voltmeter	(0-1) V (0-20) V	1 1
3.	DC Ammeter	(0-50) mA (0-200) μA	1 1
4.	Connecting wires	5A	12

THEORY

A transistor is a three terminal device. The terminals are emitter, base, collector. In common emitter configuration, input voltage is applied between base and emitter terminals and output is taken across the collector and emitter terminals.

Therefore the emitter terminal is common to both input and output.

The input characteristics resemble that of a forward biased diode curve. This is expected since the Base-Emitter junction of the transistor is forward biased. As compared to CB arrangement I_B increases less rapidly with V_{BE}. Therefore input resistance of CE circuit is higher than that of CB circuit.

The output characteristics are drawn between I_c and V_{CE} at constant I_B. the collector current varies with V_{CE} unto few volts only. After this the collector current becomes almost constant, and

independent of V_{CE}. The value of V_{CE} up to which the collector current changes with V_{CE} is known as Knee voltage. The transistor always operated in the region above Knee voltage, I_C is always constant and is approximately equal to I_B.

The current amplification factor of CE configuration is given by

$$B = \Delta I_C / \Delta I_B$$

PROCEDURE

Input Characteristics:

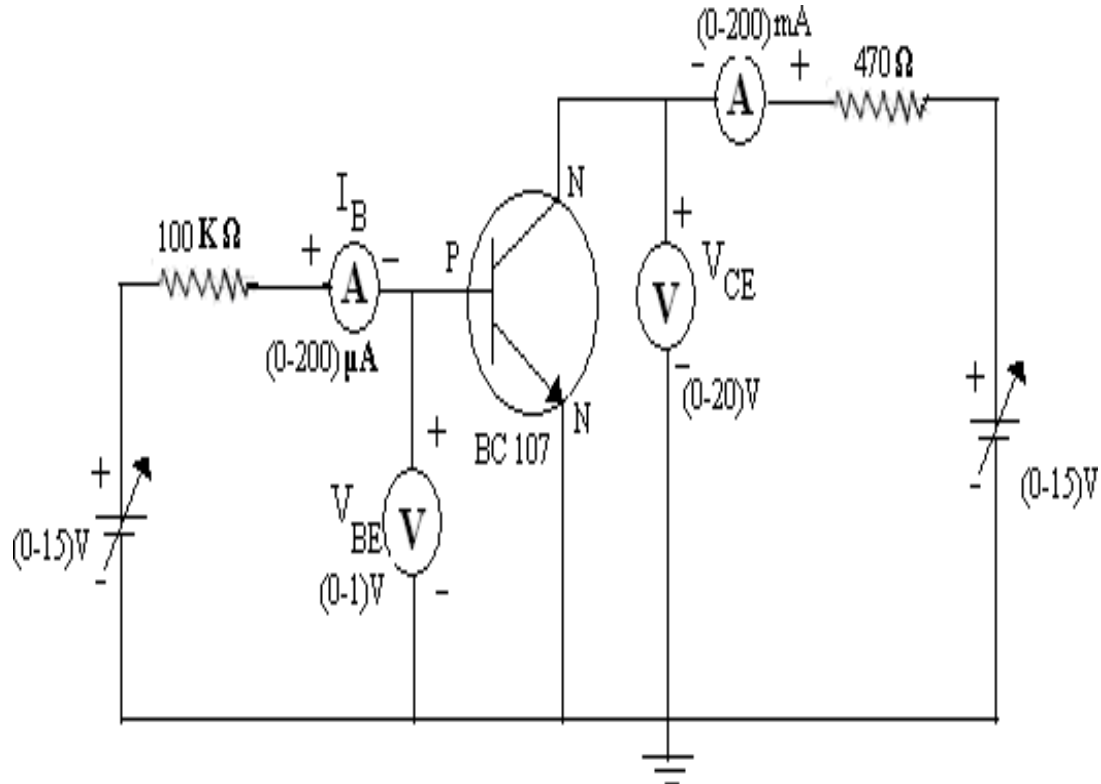1. Connect the transistor as shown in figure.
2. Keep the V_{CE} constant at 2V and 6V.
3. Vary the I_B in steps and note down the corresponding V_{EB} values as per tabular column.

Output Characteristics:

1. Keep the I_B constant at 20 µA and 40 µA.
2. Vary the V_{CE} in steps and note corresponding I_C values.
3. Readings are tabulated as shown in tabular column.

CIRCUIT DIAGRAM

EXPECTED GRAPHS
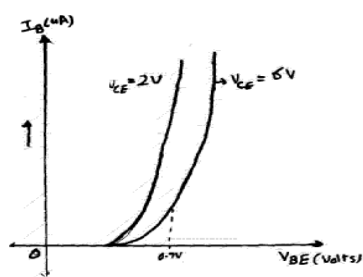
<table>
<tr><td align="center">**Input Characteristics**</td><td align="center">**Output Characteristics**</td></tr>
</table>
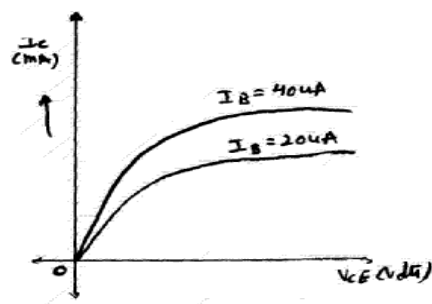
PRECAUTIONS

1. Keep the knobs of supply voltages V_{BE} & V_{CE} at minimum positions when switching ON or switching OFF the power supply.
2. No loose contacts at the junctions.
3. Do not overload the meters above its rated ranges.

TABULAR COLUMN

<table>
<tr><td align="center" colspan="4">**Input Characteristics**</td><td align="center" colspan="4">**Output Characteristics**</td></tr>
</table>

$V_{CB} = 2V$		$V_{CB} = 6V$		$I_B = 20\mu A$		$I_B = 40\mu A$	
V_{BE} (Volts)	I_B (μA)	V_{BE} (Volts)	I_B (μA)	V_{CE} (Volts)	I_C (mA)	V_{CE} (Volts)	I_C (mA)

CALCULATIONS

Input Resistance (I_B=20µA) = $\Delta V_{BE}/\Delta I_B$ =

At V_{CE} = 2V

Input Resistance (I_B =20µA) = $\Delta V_{BE}/\Delta I_B$ =

At V_{CE}= 6V

Output resistance (V_{CE}=10V) = $\Delta V_{CE}/\Delta I_C$ =

At I_B=20µA

Output resistance (V_{CE}=10V) = $\Delta V_{CE}/\Delta I_C$ =

At I_B=20µA

Current Amplification Factor „β" = $\Delta I_C/\Delta I_B$ =

H-PARAMETER CALCULATIONS

$h_{ie} = \Delta V_{be} / \Delta I_b$ =

$h_{oe} = \Delta I_c / \Delta V_{ce}$ =

$h_{fe} = \Delta I_c / \Delta I_b$ =

$h_{re} = \Delta V_{be} / \Delta V_{ce}$

PRE LAB QUESTIONS

1. What is the range of ß for the transistor?
2. What are the input and output impedances of CE configuration?
3. Identify various regions in the output characteristics?
4. what is the relation between α *and* ß

LAB ASSIGNMENT

Plot the I/O characteristics of CE configuration for Vcc = 10V, VBB = 4V, Rb= 200K ohms, Rc = 2K ohms, β = 200, Vbe = 0.7V.

POST LAB QUESTIONS

1. Define current gain in CE configuration?
2. Why CE configuration is preferred for amplification?
3. What is the phase relation between input and output?
4. Draw diagram of CE configuration for PNP transistor?
5. What is the power gain of CE configuration?
6. What are the applications of CE configuration?

RESULT

1. Input and Output curves are plotted.

2. R_i, Input Resistance:

    a. $V_{CE} = 2V$ and $I_B = 20\ \mu A$, $R_i =$

    b. $V_{CE} = 6V$ and $I_B = 20\ \mu A$, $R_i =$

3. R_o, Output Resistance:

    a. $V_{CE} = 10V$ and $I_B = 20\mu A$, $R_o =$

    b. $V_{CE} = 10V$ and $I_B = 40\mu A$, $R_o =$

4. Current Amplification factor

    „β" =   (at $V_{CE} = 10V$)

Lab Test 6:	**Frequency Response CE Amplifier**

Plot the frequency response of CE amplifier and calculate gain bandwidth.

COMPONENTS & EQUIPMENTS REQUIRED

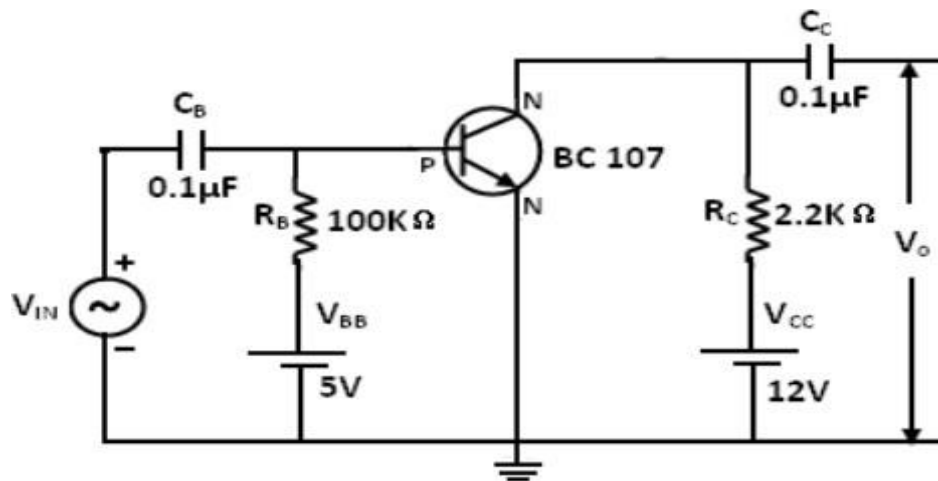| S.No	Device	Range/Rating	Quantity (in No.s)
1	CE Amplifier trainer Board with		
	(a) DC power supply	12V	1
	(b) DC power supply	5V	1
	(c) NPN transistor	BC 107	1
	(d) Carbon film resistor	100KΩ, 1/2W	1
	(e) Carbon film resistor	2.2KΩ, 1/2W	1
	(f) Capacitor	0.1μF	2
2	Function Generator	0.l Hz- 1MHz	1
3	Dual trace C.R.O	0-20MHz	1
4	Connecting Wires	5A	4

THEORY

The CE amplifier provides high gain &wide frequency response. The emitter lead is common to both input & output circuits and is grounded. The emitter-base circuit is forward biased. The collector current is controlled by the base current rather than emitter current. The input signal is applied to base terminal of the transistor and amplifier output is taken across collector terminal. A very small change in base current produces a much larger change in collector current. When +VE half-cycle is fed to the input circuit, it opposes the forward bias of the circuit which causes the collector current to decrease, it decreases the voltage more –VE. Thus when input cycle varies through a -VE half-cycle, increases the forward bias of the circuit, which causes the collector current to increases thus the output signal is common emitter amplifier is in out of phase with the input signal.

$$Bandwidth = f_H - f_L$$

PROCEDURE

1. Connect the circuit diagram as shown in figure.
2. Adjust input signal amplitude in the function generator and observe an amplified voltage at the output without distortion.
3. By keeping input signal voltages at 50mV, vary the input signal frequency from 0 to 1MHz in steps as shown in tabular column and note the corresponding output voltage

CIRCUIT DIAGRAM

EXPECTED GRAPH

PRECAUTIONS

1. Oscilloscope probes negative terminal should be at equipotential points (i.e. ground voltage= 0), because both terminals are internally shorted in dual trace oscilloscope.
2. Ensure that output voltage is exactly an amplified version of input voltage without any distortion (adjust input voltage amplitude to that extent).
3. No loose connections at the junctions.

TABULAR COLUMN

Input voltage: $V_i = 50mV$

Frequency (in Hz)	Output (V_o) (Peak to Peak)	Gain $A_V = V_0/Vi$	Gain (in dB) = $20 \log_{10} V_O/ V_i$
20			
600			
1K			
2K			
4K			
8K			
10K			
20K			
30K			
40K			
50K			
60K			
80K			
100K			
250K			
500K			
750K			
1000K			

PRE LAB QUESTIONS

1. What is an Amplifier?
2. How many types of an Amplifier?
3. What is meant Band width, Lower cut-off and Upper cut-off frequency?

LAB ASSIGNMENT

Draw the frequency response of CE amplifier using R_B =1000 ohms , R_{CE} = 4000 ohms.

POST LAB QUESTIONS

1. How much phase shift for CE Amplifier?
2. What are the applications?
3. Draw the Equivalent circuit for low frequencies?

RESULT

Frequency response of CE amplifier is plotted.

Gain, A_V =_____dB.

Bandwidth= f_H- f_L =_____

Lab Test 8:	**Frequency Response Of CC Amplifier**

Plot the frequency response of CC amplifier and calculate gain bandwidth.

COMPONENTS & EQUIPMENTS REQUIRED

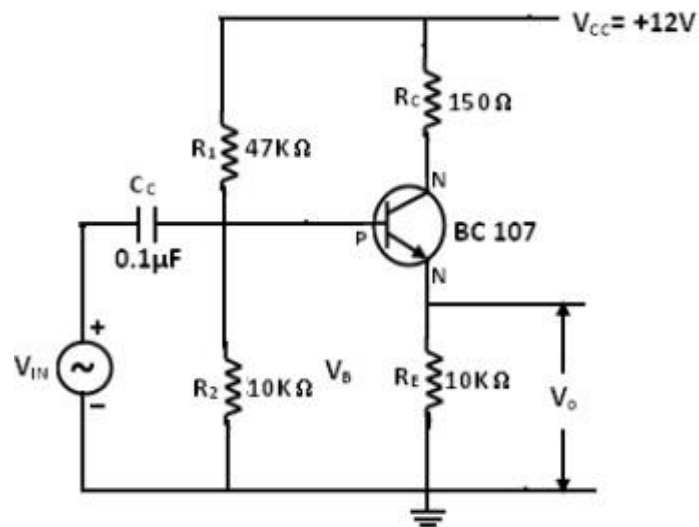| S.No	Device	Range/Rating	Quantity(in No.s)
1	CC Amplifier trainer Board with		
	a) DC power supply	12V	1
	b) DC power supply	5V	1
	c) NPN transistor	CL100	1
	d) Carbon film resistor	100KΩ, 1/2W	1
	e) Carbon film resistor	2.2KΩ, 1/2W	1
	f) Capacitor	0.1μF	2
2	Function Generator	0.1 Hz- 1MHz	1
3	Dual trace C.R.O	0-20MHz	1
4	Connecting Wires	5A	4

THEORY

In common-collector amplifier the input is given at the base and the output is taken at the emitter. In this amplifier, there is no phase inversion between input and output. The input impedance of the CC amplifier is very high and output impedance is low. The voltage gain is less than unity. Here the collector is at ac ground and the capacitors used must have a negligible reactance at the frequency of operation. This amplifier is used for impedance matching and as a buffer amplifier. This circuit is also known as emitter follower.

PROCEDURE

1. Connect the circuit diagram as shown in figure.
2. Adjust input signal amplitude in the function generator and observe an amplified voltage at the output without distortion.
3. By keeping input signal voltages at 50mV, vary the input signal frequency from 0 to 1MHz in steps as shown in tabular column and note the corresponding output voltages.

CIRCUIT DIAGRAM

EXPECTED GRAPH

PRECATIONS

1. Oscilloscope probes negative terminal should be at equipotential points (i.e. ground voltage= 0), because both terminals are internally shorted in dual trace oscilloscope.
2. Ensure that output voltage is exactly an amplified version of input voltage without any distortion (adjust input voltage amplitude to that extent)
3. No loose connections at the junctions.

TABULAR COLUMN

Input voltage: $V_i = 50mV$

Frequency (in Hz)	Output (V_o) (Peak to Peak)	Gain $A_V = V_0/Vi$	Gain (in dB) = $20 \log_{10} V_O/V_i$
20			
600			
1K			
2K			
4K			
8K			
10K			
20K			
30K			
40K			
50K			
60K			
80K			
100K			
250K			
500K			
750K			
1000K			

PRE LAB QUESTIONS

    a. What is the other name for CC Amplifier?

    b. What are the uses of CC Amplifier?

LAB ASSIGNMENT

Draw the frequency response of CC amplifier using R_s =900 ohms , R_l = 2000 ohms.

POST LAB QUESTIONS

    1. Why this amplifier has got the name Emitter Follower?

    2. What is the maximum Voltage gain of an Emitter Follower?

    3. Why it is used as a Buffer amplifier?

RESULT

Frequency response of CE amplifier is plotted.

Gain, A_V =_____dB.

Bandwidth= f_H-f_L =_____Hz.

Lab Test 9:	UJT Characteristics

Demonstrate the Volt-ampere characteristics of silicon-controlled rectifier.

EQUIPMENT/COMPONENTS REQUIRED

S. No.	Device	Range/ Rating	Quantity
1	UJT Trainer Board Containing		1
	a) DC Power Supply	0-30V	2
	b) Resistor	100Ω	1
		100KΩ	1
	c) UJT		1
2	DC voltmeter	(0-20) V	2
3	DC ammeter	(0-200) mA	1
		(0-200)µA	1
4	Connecting wires	5A	10

THEORY

A Unijunction Transistor (UJT) is an electronic semiconductor device that has only one junction. The UJT Unijunction Transistor (UJT) has three terminals an emitter (E) and two bases (B1 and B2). The base is formed by lightly doped n-type bar of silicon. Two ohmic contacts B1 and B2 are attached at its ends. The emitter is of p-type and it is heavily doped. The resistance between B1 and B2, when the emitter is open-circuit is called interbase resistance. The original unijunction transistor, or UJT, is a simple device that is essentially a bar of N type semiconductor material into which P type material has been diffused somewhere along its length. The 2N2646 is the most commonly used version of the UJT.
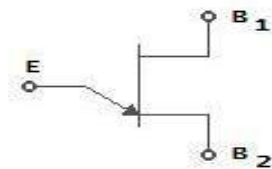

Circuit symbol

The UJT is biased with a positive voltage between the two bases. This causes a potential drop along the length of the device. When the emitter voltage is driven approximately one diode voltage above the voltage at the point where the P diffusion (emitter) is, current will begin to flow from the emitter into the base region. Because the base region is very lightly doped, the additional current (actually charges in the base region) causes (conductivity modulation) which reduces the resistance of the portion of the base between the emitter junction and the B2 terminal. This reduction in resistance means that the emitter junction is more forward biased, and so even more current is injected. Overall, the effect is a negative resistance at the emitter terminal. This is what makes the UJT useful, especially in simple oscillator circuits. When the emitter voltage reaches V_p, the current starts to increase and the emitter voltage starts to decrease. This is represented by negative slope of the characteristics which is referred to as the negative resistance region, beyond the valley point, RB1 reaches minimum value and this region, VEB proportional to I_E.

PROCEDURE

    a. Connection is made as per circuit diagram.

    b. Output voltage is fixed at a constant level and by varying input voltage corresponding emitter current values are noted down.

    c. This procedure is repeated for different values of output voltages.

    d. All the readings are tabulated and Intrinsic Stand-Off ratio is calculated using

        i. $\eta = (V_p - V_D) / V_{BB}$

    e. A graph is plotted between V_{EE} and I_E for different values of V_{BE}.

CIRCUIT DIAGRAM
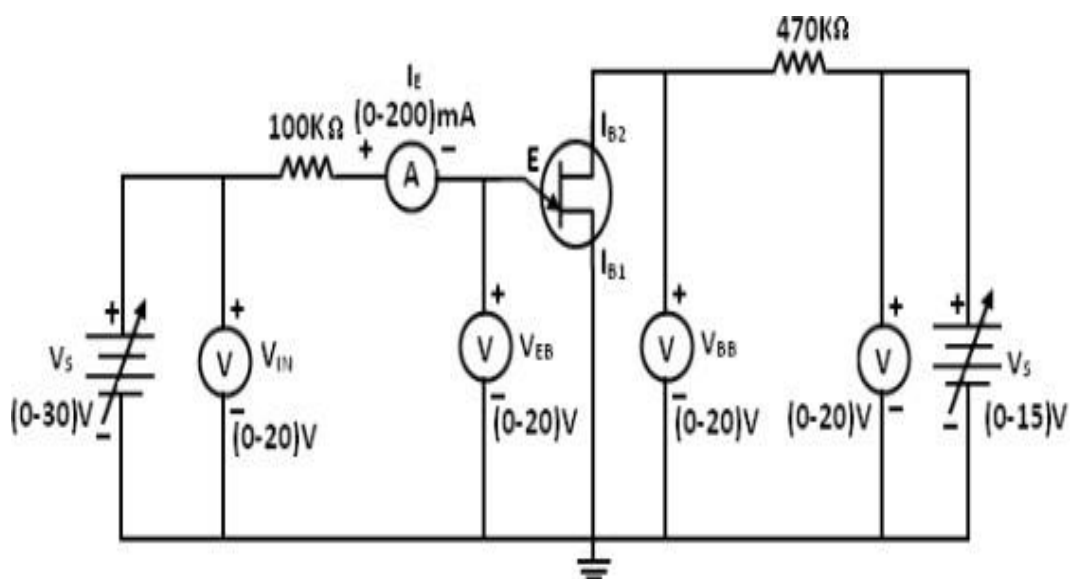
EXPECTED GRAPH
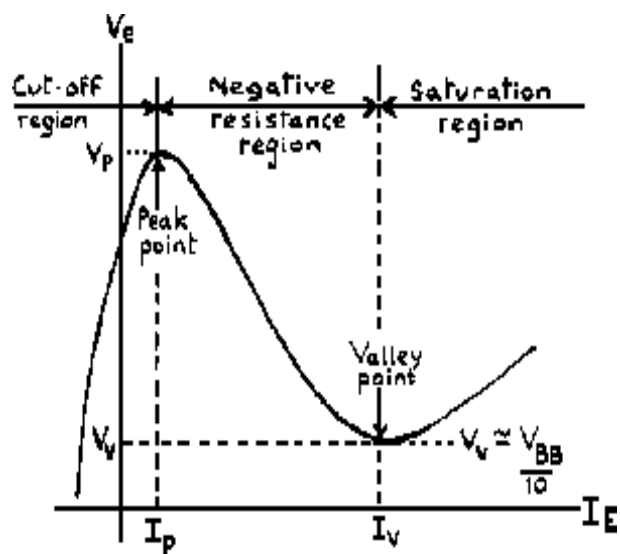
TABULAR COLUMN

$V_{BB}=1V$		$V_{BB}=2V$		$V_{BB}=3V$	
$V_{EB}(V)$	$I_E(mA)$	$V_{EB}(V)$	$I_E(mA)$	$V_{EB}(V)$	$I_E(mA)$

CALCULATIONS

1. $V_P = \eta V_{BB} + V_D$

2. $\eta = (V_P - V_D) / V_{BB}$

3. $\eta = (\eta 1 + \eta_2 + \eta 3) / 3$

PRE LAB QUESTIONS

1. What is the symbol of UJT?
2. Draw the equivalent circuit of UJT?
3. What are the applications of UJT?
4. Formula for the intrinsic standoff ratio?
5. What does it indicates the direction of arrow in the UJT?

LAB ASSIGNMENT

Plot the characteristics of UJT has a firing potential of 20V , it is connectec across the capacitor of a series RC circuit with R = 100k ohms and C = 1000Pfarads supply by a source of 40V Dc by using multisim.

POST LAB QUESTIONS

1. What is the difference between FET and UJT?
2. Is UJT is used an oscillator? Why?
3. What is the Resistance between B_1 and B_2 is called as?
4. What is its value of resistance between B_1 and $B_{2?}$
5. Draw the characteristics of UJT?

RESULT

The characteristics of UJT are observed and the values of Intrinsic Stand-Off Ratio are calculated.

	Silicon Controlled Rectifier Characteristics
Lab Test 10:	

Demonstrate the Volt-ampere characteristics of silicon-controlled rectifier.

EQUIPMENT/COMPONENTS REQUIRED

S. No.	Device	Range/Rating	Quantity
1	SCR Trainer Board Containing		1
	a) DC Power Supply	0-30V	2
	b) Resistor	100Ω	1
		100KΩ	1
	c) SCR		1
2	DC voltmeter	(0-20) V	2
3	DC ammeter	(0-200) mA	1
		(0-200)µA	1
4	Connecting wires	5A	10

THEORY

It is a four layer semiconductor device being alternate of P-type and N-type silicon. It consists os 3 junctions J_1, J_2, J_3 the J_1 and J_3 operate in forward direction and J_2 operates in reverse direction and three terminals called anode A, cathode K , and a gate G. The operation of SCR can be studied when the gate is open and when the gate is positive with respect to cathode.
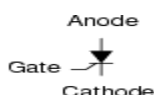

Schematic symbol

When gate is open, no voltage is applied at the gate due to reverse bias of the junction J_2 no current flows through R_2 and hence SCR is at cut off. When anode voltage is increased J_2 tends to breakdown.

When the gate positive, with respect to cathode J_3 junction is forward biased and J_2 is reverse biased .Electrons from N-type material move across junction J_3 towards gate while holes from P-type material moves across junction J_3 towards cathode. So gate current starts flowing, anode current increase is in extremely small current junction J_2 break down and SCR conducts heavily.

When gate is open thee break over voltage is determined on the minimum forward voltage at which SCR conducts heavily. Now most of the supply voltage appears across the load resistance. The holding current is the maximum anode current gate being open, when break over occurs.

PROCEDURE

1. Connections are made as per the circuit diagram.

2. Set the both voltage sources to zero volts.

3. Switch on the SCR trainer kit.

4. Set the gate current of SCR at 60 μA in the ammeter b varying the gate power supply.

5. Now slowly vary the Anode voltage from 0 to 30 volts. Measure the voltage in the voltmeter, which is connected between anode and cathode.

6. Once SCR has fired for a particular gate current, note down anode to cathode voltage and down the gate current of SCR

7. Now increase the anode to cathode supply voltage and note down the Anode current.

8. Now repeat the steps 5 to 7 for gate currents 70 and 80μA

9. Draw the graph between Anode and Cathode voltages and the anode current for various gate currents.

10. Note down the latching and holding currents from the plot.

CIRCUIT DIAGRAM

EXPECTED GRAPH

TABULAR COLOUMN

S.No.	Gate current=_____µA		Gate current=_____µA	
	Anode to cathode voltage	Anode current	Anode to cathode voltage	Anode current
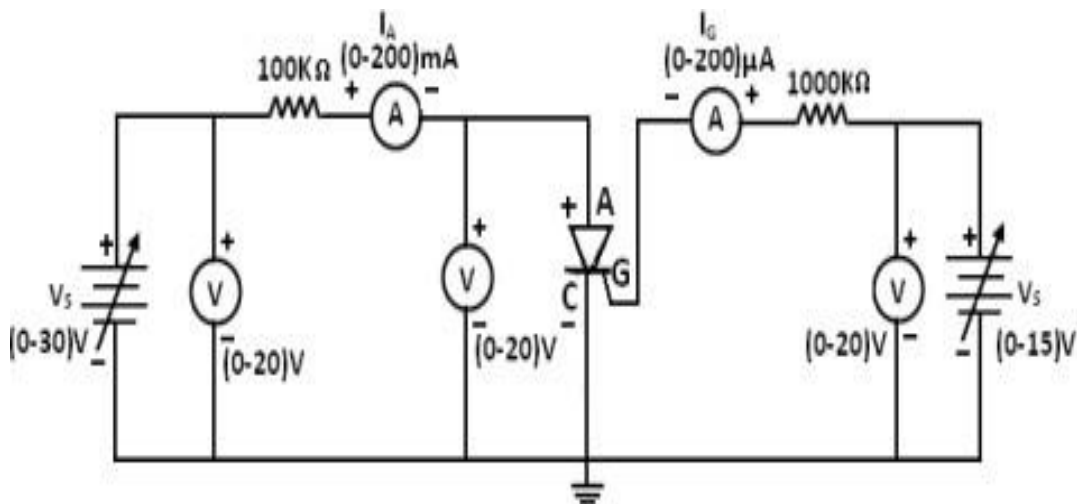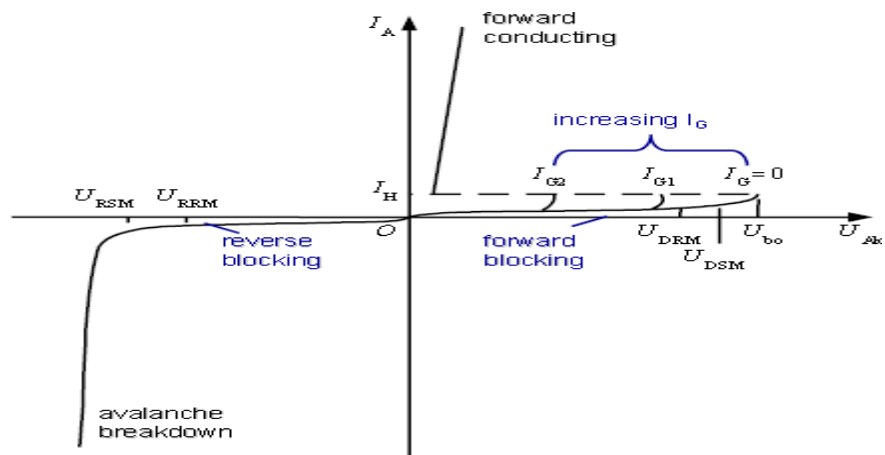
PRE LAB QUESTIONS

1. What the symbol of SCR?

2. IN which state SCR turns of conducting state to blocking state?

3. What is the value of forward resistance offered by SCR?

4. What is the condition for making from conducting state to non conducting state?

LAB ASSIGNMENT

Plot the reverse bias characteristics of SCR by using Multisim

POST LAB QUESTIONS

1. What are the applications of SCR?

2. What is holding current?

3. What are the important type"s thyristors?

4. How many numbers of junctions are involved in SCR?

5. What is the function of gate in SCR?

6. When gate is open, what happens when anode voltage is increased?

RESULT

1. For Gate current= 60μA Latching Current=Holding Current=

2. For Gate current= 60μA Latching Current =Holding Current=

3. For Gate current= 60μA Latching Current= Holding Current=

Lab Test 11:	FET Characteristics

Find drain resistance at V_{DS}=3V for V_{GS}= 0.5V, 0V, -1V. Find Trans

conductance at V_{GS}= -1.0V for V_{DS}= 1V, 2V, 3V.

COMPONENTS & EQUIPMENTS REQUIRED:

S.No.	Device	Range /Rating	Quantity (In No.s)
1	FET Characteristics trainer board containing		
	(a) DC power supply	0-12V	1
	(b) DC power supply	0-5V	1
	(c) FET	BFW 11	1
	(d) Carbon film resistor	1KΩ, 1/2W	1
	(e) Carbon film resistor	470KΩ, 1/2W	1
2	DC Voltmeter	0-20V	2
3	(a) DC Ammeter	0-200μA	1
	(b) DC Ammeter	0-20mA	1
4	Connecting wires		12

THEORY:

A FET is a three terminal device, having the characteristics of high input impedance and less noise, the Gate to Source junction of the FET s always reverse biased. In response to small applied voltage from drain to source, the n-type bar acts as sample resistor, and the drain current increases linearly with V_{DS}. With increase in I_D the ohmic voltage drop between the source and the channel region reverse biases the junction and the conducting position of the channel begins to remain constant. The V_{DS} at this instant is called "pinch of voltage".

If the gate to source voltage (V_{GS}) is applied in the direction to provide additional reverse bias, the pinch off voltage ill is decreased.

In amplifier application, the FET is always used in the region beyond the pinch-off.

$$F_{DS}=I_{DSS}(1-V_{GS}/V_P)^2$$

PROCEDURE: -

Drain characteristics:

1. Connect the circuit as shown in figure (1)

2. Set the gate source voltage, V_{GS} in 0V position.

3. Increase drain source voltage, V_{DS} in steps and note corresponding I_D values as Shown in the tabular column.

4. Now change V_{GS} to +0.5Vand –1V and repeat the above procedure.

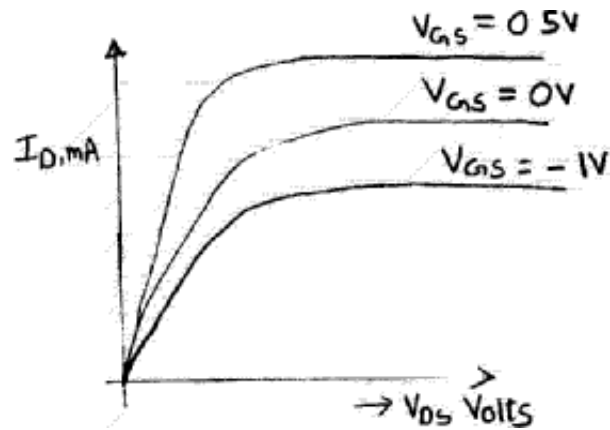Transfer characteristics:

5. Connect the circuit as shown in figure (1).

6. Keep the drain source voltage, V_{DS} at 1V.

7. Vary the gate source voltage, V_{GS} in steps and note corresponding I_D values as shown in the tabular column.

8. Now change V_{DS} to 2Vand 3V and repeat the above procedure.
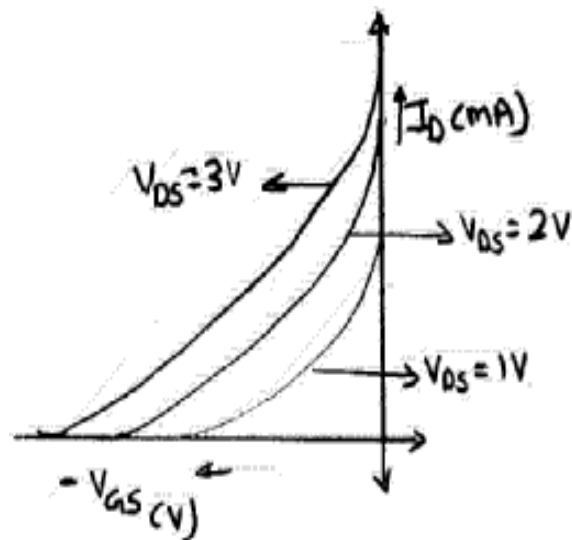
CIRCUIT DIAGRAM:
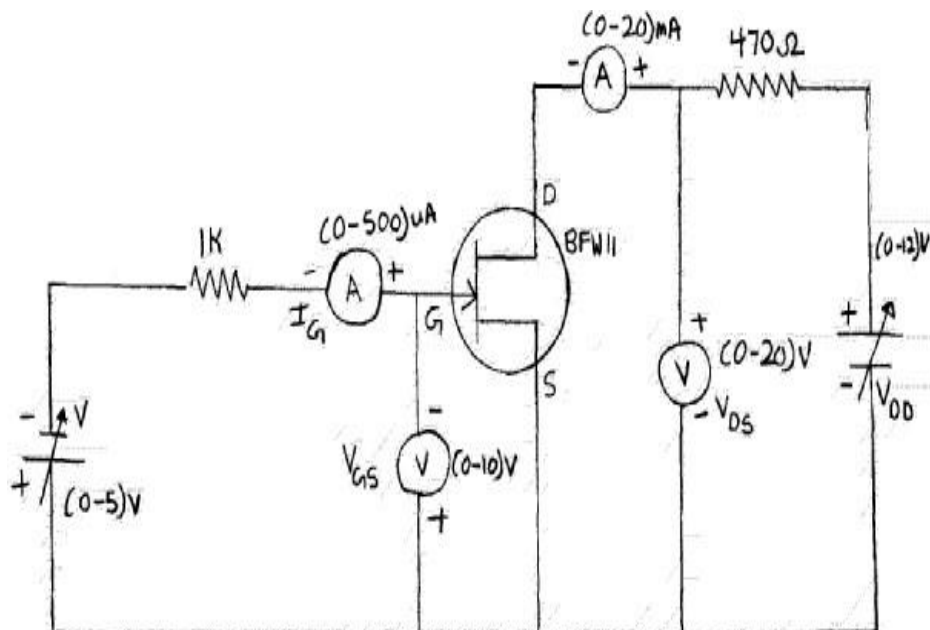
EXPECTED GRAPHS:

Drain Characteristics:

Transfer Characteristics:

PRECAUTIONS:

1. Knobs of the supply must be kept at minimum position while switching on and off the supply.

2. Loose connections at junction must be avoided.

3. Device and meter of correct rating and range must be used.

TABULATIONS:

Drain characteristics:

	$V_{GS}=0V$	$V_{GS}= 0.5V$	$V_{GS}= 1.0V$
V_{DS} (v)	I_D (mA)	I_D (mA)	I_D (mA)
0			
0.2			
0.4			
0.6			
0.8			
1.0			
2.0			
3.0			
4.0			
5.0			
6.0			
7.0			
8.0			
9.0			
10.0			

Transfer characteristics:

	$V_{DS}=0V$	$V_{DS}=2V$	$V_{DS}= 3V$
V_{GS} (v)	I_D (mA)	I_D (mA)	I_D (mA)
0			
-0.2			
-0.4			
-0.6			
-0.8			
-1.0			
-1.2			
-1.4			

-1.6			
-1.8			
-2.0			
-2.2			
-2.4			
-2.6			
-2.8			

CALCULATIONS:

a. AC drain resistance at $V_{DS}=3V$ of $V_{GS}= 0.5V$

       i. $= \Delta V_{DS}/ \Delta I_D$

       ii. $=$

b. AC drain resistance at $V_{DS}=3V$ of $V_{GS}= 0V$

       i. $= \Delta V_{DS}/ \Delta I_D$

       ii. $=$

c. AC drain resistance at $V_{DS}=3V$ of $V_{GS}= -1V$

       i. $= \Delta V_{DS}/ \Delta I_D$

       ii. $=$

d. Transconductance at $V_{GS} = -1V$ of $V_{DS}=1V$

       i. $= \Delta I_D / \Delta V_{GS}$

       ii. $=$

e. Transconductance at $V_{GS} = -1V$ of $V_{DS}=2V$

       i. $= \Delta I_D / \Delta V_{GS}$

f. Transconductance at $V_{GS} = -1V$ of $V_{DS}=3V$

       i. $= \Delta I_D / \Delta V_{GS}$

POST LAB QUESTIONS::

1. What are the advantages of FET over transistor?

2. Is FET a current controlled device? Explain?

3. What is the operation of a N-channel JFET?

4. Can you compare JFET and a MOSFET?

RESULT:

1. At V_{DS}=3V

        Drain Resistance for V_{GS}=0.5V is

        Drain Resistance for V_{GS}=0V is

        Drain Resistance for V_{GS}=0.5V is

2. At V_{GS}=-1V

        Trans Conductance for V_{DS} = 1V is

        Trans Conductance for V_{DS}= 2V is

        Trans Conductance for V_{DS}= 3V is

Lab Test 12:	Frequency Response Of CS Amplifier

Plot the frequency response of a FET amplifier.

Calculate gain.

Calculate bandwidth.

COMPONENTS & EQUIPMENTS REQUIRED: -

S.No	Device	Range/Rating	Quantity (in No.s)
1.	FET amplifier Trainer Board with (a) DC supply voltage (b) FET (c) Capacitors (d) Resistors	12V BFW 11 0.1µF 47µF 1.5KΩ 4.7 KΩ 1MΩ	1 1 2 1 1 1 1
2.	Signal generator	0.1Hz-1MHz	1
3.	CRO	0Hz-20MHz	1
4.	Connecting wires	5A	4

THEORY:-

A field-effect transistor (FET) is a type of transistor commonly used for weak-signal amplification (for example, for amplifying wireless (signals). The device can amplify analog or digital signals. It can also switch DC or function as an oscillator. In the FET, current flows along a semiconductor path called the channel. At one end of the channel, there is an electrode called the source. At the other end of the channel, there is an electrode called the drain. The physical diameter of the channel is fixed, but its effective electrical diameter can be varied by the application of a voltage to a control electrode called the gate. Field-effect transistors exist in two major classifications. These are known as the junction FET (JFET) *and the* metal-oxide semiconductor FET (MOSFET). The junction FET has a channel consisting of N-type semiconductor (N-channel) or P-type semiconductor (P-channel) material; the gate is made of the opposite semiconductor type. In P-type material, electric charges are carried mainly in the form of electron deficiencies called holes. In N-type material, the charge carriers are primarily electrons. In a JFET, the junction is the boundary between the channel and the gate. Normally, this P-N junction is reverse-biased (a DC voltage is applied to it) so that no current flows between the channel

and the gate. However, under some conditions there is a small current through the junction during part of the input signal cycle. The FET has some advantages and some disadvantages relative to the bipolar transistor. Field-effect transistors are preferred for weak-signal work, for example in wireless, communications and broadcast receivers. They are also preferred in circuits and systems requiring high impedance. The FET is not, in general, used for high-power amplification, such as is required in large wireless communications and broadcast transmitters.

PROCEDURE: -

Connect the circuit diagram as shown in figure.

1. Adjust input signal amplitude in the function generator and observe an amplified voltage at the output without distortion.

2. By keeping input signal voltage, say at 50mV, vary the input signal frequency from 0 to 1MHz insteps as shown in tabular column and note the corresponding output voltages.

CIRCUIT DIAGRAM:
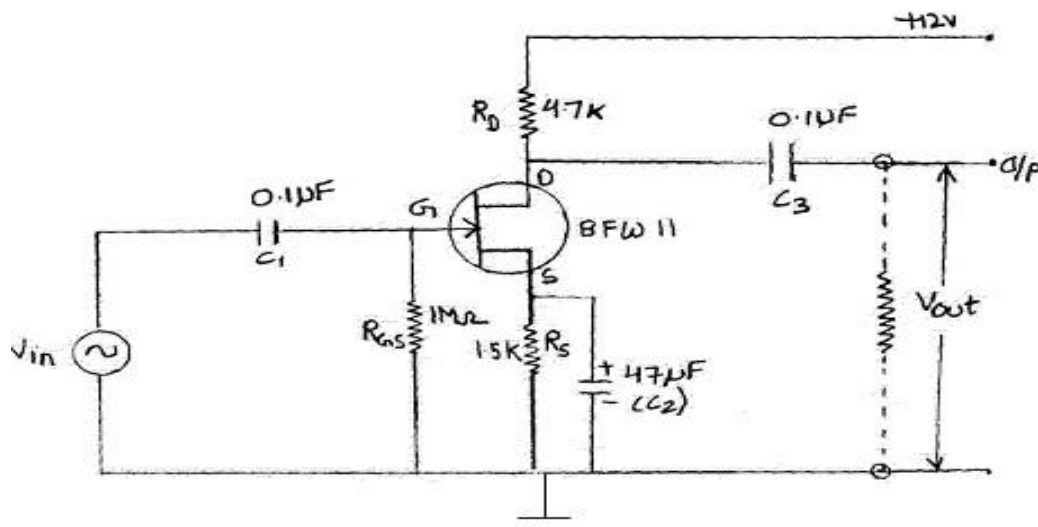
EXPECTED GRAPH:
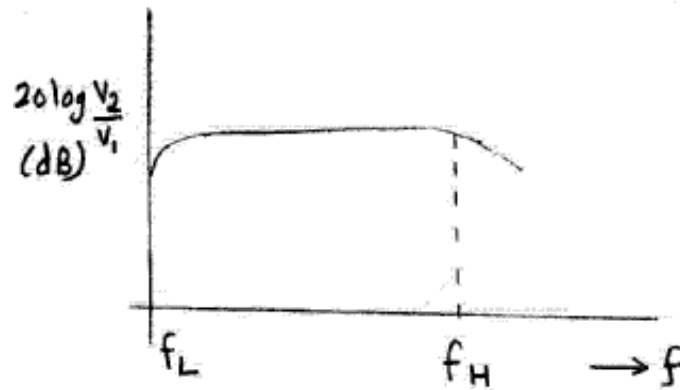
PRECAUTIONS:

1. Oscilloscopes probes negative terminal should be at equipotential points (i.e. ground voltage is zero) because both terminals are internally shorted in dual trace oscilloscope.

TABULAR COLUMN:

Input = 50mV

Frequency (in Hz)	Output Voltage (V_o)	Gain $A_v = V_o/V_i$	Gain (in dB) = $20\log_{10}(V_o/V_i)$
20			
40			
80			
100			
500			
1000			
5000			
10K			
50K			
100K			
200K			
400K			
600K			
800K			

LAB ASSIGNMENT

Draw the frequency response of CS amplifier using Multisim.

POST LAB QUESTIONS:

1. What are the advantages of JFET over BJT?

2. Why input resistance in FET amplifier is more than the BJT amplifier?

3. What is a uni-polar device?

4. What is pinch off voltage?

5. What are various FETs?

6. What is Enhancement mode and Depletion mode?

7. Draw the Equivalent circuit of JFET for low frequencies?

8. Write the mathematical equation for g_m in terms of g_{mo}?

9. Write equation of FET I_D in terms of V_{GS} and V_p?

RESULT: -

1. Frequency response of FET amplifier is plotted.

2. Gain =_____dB (maximum).

3. Bandwidth= f_H-f_L =_____Hz.

Lab Test 13:	Frequency Response Of CD Amplifier

To obtain the frequency response of a Common Drain Field Effect Transistor Amplifier and also to find its voltage gain, Output Resistance and Bandwidth.

COMPONENTS & EQUIPMENTS REQUIRED: -

S.	Nam	Range / Value	Quan
1	Dual Regulated D.C Power supply	0–30 Volts	1
2	JFET	BFW10 or 11	1
3	Resistors	2.2M□ , 4.7K□	Each 2
4	Resistors	1K□	1
5	Capacitors	47□ f ,0.001□ f	Each 1
6	Signal Generator	(0 – 1MHz)	1
7	Bread Board and connecting wires	-	1 Set
8	Dual Trace CRO	20MHz	1 No

THEORY:-

The common drain FET amplifier is similar to the common collector configuration of the bipolar transistor. A general common drain JFET amplifier, self-biased, is shown in the circuit diagram below.This configuration, which is sometimes known as a source follower, is characterized by a voltage gain of less than unity, and features a large current gain as a result of having a very large input impedance and a small output impedance.

PROCEDURE: -

Frequency Response:

1. Connect the circuit as per the Fig.1. Apply VDD of 15 V
2. Give a signal Vs of 100 mV (P-P) at 1 KHz on the I/P side and observe the O/P on CRO.
3. Vary the frequency from 50 Hz to 1MHz with proper intervals on the input side and observe the output Vo on CRO
4. Draw a graph between frequency Vs Gain on Semi-log Graph Sheet and find its Mid frequency Gain Amid
5. Draw a horizontal line across the graph at 0.707 Amid and find the Bandwidth

To Find R0:

1. Keep Vs = 100mV (P-P) 1KHz Signal and find Corresponding output Vo.
2. Now with out disturbing Vs Connect potentiometer across output and observe the output on CRO.
3. Adjust the value of Potentiometer Such that the output falls to the Vo/2 value.

Note the value of the potentiometer resistance is the Ro of the JFET CD Amplifier.

CIRCUIT DIAGRAM:

Common Drain JFET Amplifier
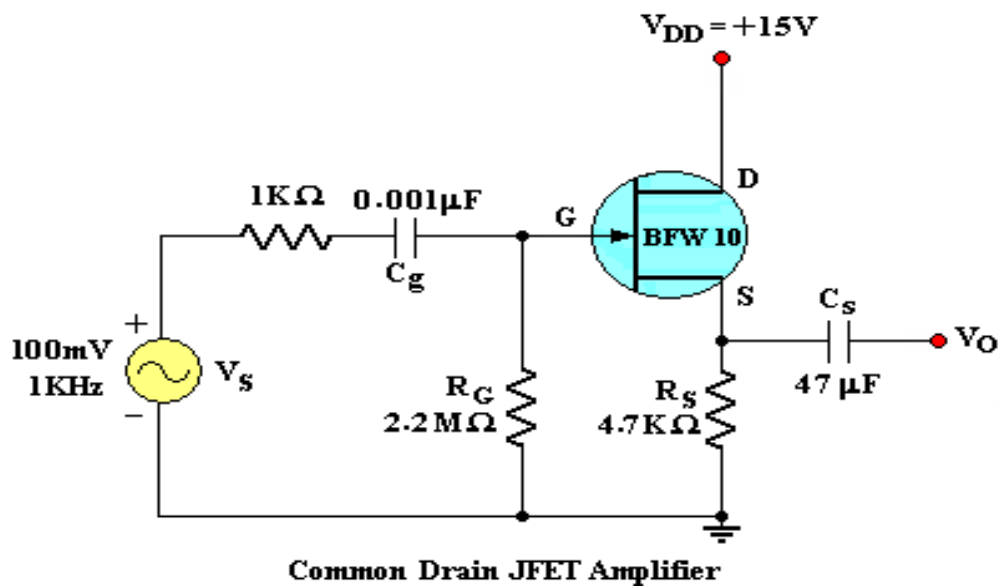
EXPECTED GRAPH:
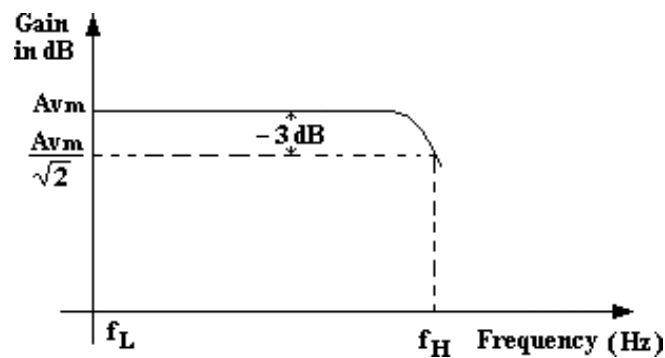
PRECAUTIONS:

1. Check the wires for continuity before use.

2. Keep the power supply at Zero volts before Start

3. All the contacts must be intact

4. For a good JFET we will get a gain of 0.9 to 1.0 at 1KHz. If not change the JFET.

TABULAR COLUMN:

S.No		O/P Voltage, Vo (V)	Voltage Gain Frequency	Av in dB = 20 log (Av)
1	100			
2	200			
3	300			
4	500			
5	700			
6	1K			
7	3K			
8	5K			
9	7K			
10	10K			
11	30K			
12	50K			
13	70K			
14	100K			
15	300K			
16	500K			
17	700K			
18	1M			

LAB ASSIGNMENT

Draw the frequency response of CD amplifier using Multisim.

POST LAB QUESTIONS:

1. What are the advantages of JFET over BJT?

2. Why input resistance in FET amplifier is more than BJT amplifier

3. What is a Uni-polar Device?

4. What is Pinch off Voltage?

5. What are the various FETs?

6. What is Enhancement mode and depletion mode?

7. Draw the equivalent circuit of JFET for Low frequencies

8. Write the mathematical equation for gm in terms of gmo.

9. Write equation of FET ID in terms of VGS and VP.

RESULT: -

BandWidth	B. W	= f2 – f1 =	H
Mid band Gain	A Mi	=	
Output Resistance	Ro	= ohms	