JHARKHAND
Rai University
RANCHI

MINING ENGINEERING

LAB MANUAL

BASIC ELECTRICAL ENGINEERING

(B.TECH)

SEMESTER I

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LIST OF LABORATORY EXPERIMENTS/DEMONSTRATIONS:

1. Basic safety precautions. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.
2. To determine the characteristics of PN junction diode.
3. Verification of The venin’s Theorem.
4. Verification of Norton’s Theorem
5. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.
6. To determine the equivalent resistance in series and parallel.
7. Verification of KVL and KCL.
8. To verify ohm’s law.
9. Verification of Superposition theorem.

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EXPERIMENT NO. -1

AIM: Basic safety precautions. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.

Apparatus Required:

S.No.	Name of apparatus	type	Range	Quality
1.	Ammeter	MI,MC	(0-2)A AC, (0-1) A DC	As required
2.	Voltmeter	MI,MC	(0-300)V AC, (0-20) V DC	As required
3.	Multimeter	DIGITAL	-	1
4.	Resistors	Fixed, Variable	-	As required
5.	Capacitors	Fixed, Variable	-	As required
6	Inductors	Fixed, Variable		As required

Basics Safety Protections:

1. Remove Jewelry , metal watches, or other metal accessories while performing any experiments , as these can be dangerous in the vicinity of rotation machinery and electrical connection.
2. Do not wear loose apparel , shorts , or short skirts as they expose skin to electrical connections and rotation machinery
3. Have a pen ,calculators, lab notebook , and experiment description prepared and ready.
4. Avoids loose wires ,cables , and connection
5. Turn off all equipment before leaving the lab.
6. Familiarize oneself with all ON/OFF buttons on equipments, circuit breakers, and disconnect the switches of bench.

Ammeter: - Ammeter is an electronic instruments device used to determine the electric current flowing through a circuit.Ammeters measuring current in milli-ampere range is known as milli-ammeters. Common types of ammeters are moving-coil ammeter and moving-iron ammeter. Ammeters are connected in series to the circuit whose current is to be measured. Hence this electronic instruments are designed to have as minimum resistance/loading as possible.

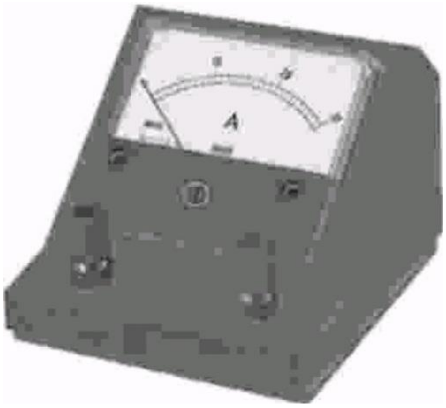
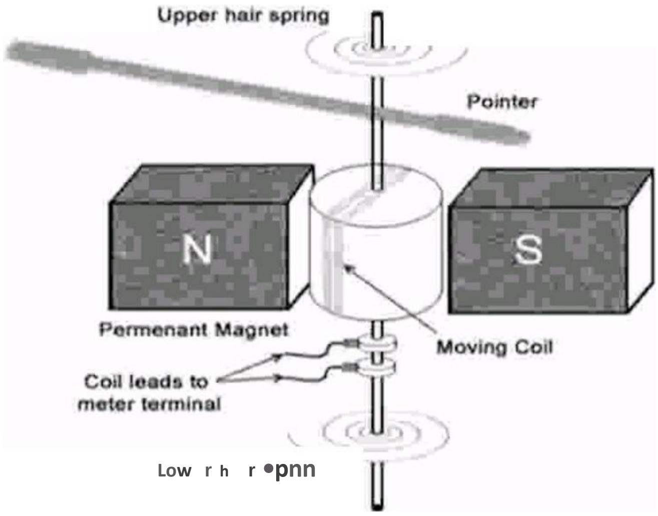


Fig. l(a).1 Ammeter- Electronic Instruments

Moving Coil Ammeter:

Moving coil ammeters are used to measure DC Currents. This electronic instruments consists of a coil suspended by two hair springs. This coil is placed in a magnetic field created by a fixed permanent magnet. A torque is experienced when current passes through this coil which is proportional to the current. When the coil turns, the springs will exert a restoring force proportional to the angle turned.



By these two forces, the coil willstop at some point and the angular deflection will be proportional to the current.

Moving Iron Ammeter:

Moving iron ammeters as electronic instruments can be used for measuring both direct and alternating currents in electronics lab. In this type of ammeter, a piece of soft iron is used. This iron piece constitutes of amoving vane and a fixed vane. Current to be checked flows through a fixed coil placed around the iron piece. This coil produces a magnetic field proportional to the current. So the iron pieces will get magnetized with the same polarity. The movable vane turns away from the fixed vane due to magnetic repulsion. As the iron turns,the spring of the electronic instruments will exert a restoring force and stop the vane, when both the forces become equal. The pointer of the ammeter is attached to the movable vane, which will point to the proper current reading using a calibrated scale.

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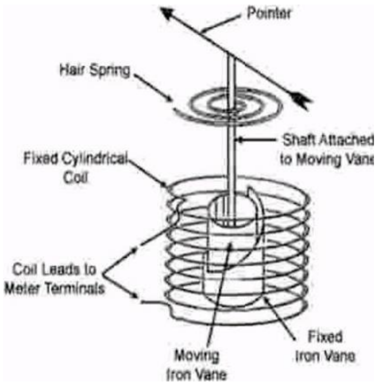

Voltmeter:

Voltmeter is an electronic instruments used in an electric circuit to determine the potential difference or voltagebetween two different points. Digital and analog voltmeters are available in electronics lab. They are usually connected in parallel (shunt) to the circuit. Hence they are designed to have maximum resistance as possibleto reduce the loading effect. This device is also common in electronics lab.

Fig.1 (a).4 (i) Analog Voltmeter (ii) Digital Voltmeter

Analog Voltmeter:

Analog voltmeter is a type of voltmeter and electronic instruments with an extra connection of a series resistor (high resistance). It consists of a movable coil placed in a magnetic field. The coil ends are connected to themeasuring terminals. As current flows across the coil, it will start turning due to magnetic force excreted on thecoil and thus the hair spring will stop the coil by an equal and opposite restoring force. Angular rotation will be proportional to the voltage in this electronic instruments.

Digital Voltmeter

Digital voltmeters can measure both AC and DC measurements with high accuracy as an electronics instrument. It can measure a high voltage up to 1 kV. Main component of a digital voltmeter is an Analog to Digital Converter (ADC). Voltage to be measured is amplified or attenuated properly by the circuit and the output is sent to an Analog to Digital Converter (ADC) IC. This IC will convert the analog signal input to digital signal output. Adigital display driven by this IC will display the proper voltage value.

Digital Multi Meter (DMM)

A multimeter or a multitester, also known as a VOM (Volt-Ohm meter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter would include basic features such as the ability to measure voltage, current, and resistance. Analog multimeters use a micro ammeter whose pointer moves over a scale calibrated for all the different measurements that can be made. Digital multimeters (DMM, DVOM) display the measured value in numerals, and may also display a bar of a length proportional to the quantity being measured. Digital multimeters are now far more common than analog ones, but analog multimeters are still preferable in some cases, for example when monitoring a rapidly-varying value.

A multimeter can be a hand-held device useful for basic fault finding and field service work, or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls,Domestic appliances, power supplies, and wiring systems.

Operation:

A multimeter is a combination of a multi range DC voltmeter, multi range AC voltmeter, multi range ammeter, and multi range ohmmeter. An un-amplified analog multimeter combines a meter movement, range resistors and switches.

For an analog meter movement, DC voltage is measured with a series resistor connected between the meter movement and the circuit under test. A set of switches allows greater resistance to be inserted for higher voltage ranges. The product of the basic full-scale deflection current of the movement, and the sum of the series resistance and the movement's own resistance, gives the full-scale voltage of the range. As an example, a meter movement that required 1 mill ampere for full scale deflection, with an internal resistance of 500 ohms, would, on a 10-volt range of the multimeter, have 9,500 ohms of series resistance. For analog current ranges, low-resistance shunts are connected in parallel with the meter movement to divert most of the current around the coil. Again for the case of a hypothetical 1 mA, 500 ohm movement on a 1 Ampere range,the shunt resistance would be just over 0.5ohms.

Moving coil instruments respond only to the average value of the current through them. To measure alternating current, a rectifier diode is inserted in the circuit so that the average value of current is non-zero. Since the rectified average value and the root-mean-square value of a waveform need not be the same, simple rectifier-type circuits may only be accurate for sinusoidal waveforms. Other wave shapes require a different calibrationfactor to relate RMS and average value. Since practical rectifiers have non-zero voltage drop, accuracy andsensitivity is poor at low values.

To measure resistance, a small battery within the instrument passes a current through the device under test and the meter coil. Since the current available depends on the state of charge of the battery, a multimeter usually has an adjustment for the ohms scale to zero it. In the usual circuit found in analog multimeters, the meter deflection is inversely proportional to the resistance; so full-scale is O ohms, and high resistance corresponds to smaller deflections. The ohms scale is compressed, so resolution is better at lower resistance values.Amplified instruments simplify the design of the series and shunt resistor networks.

The internal resistance of the coil is decoupled from the selection of the series and shunt range resistors; the series network becomes a voltage divider. Where AC measurements are required, the rectifier can be placed after the amplifier stage,improving precision at low range.

Fig l(a).5 Digital Multi meter

Digital instruments, which necessarily incorporate amplifiers, use the same principles as analog instruments for range resistors. For resistance measurements, usually a small constant current is passed through the device under test and the digital multimeter reads the resultant voltage drop; this eliminates the scale compression found in analog meters, but requires a source of significant current. An auto ranging digital multimeter can automatically adjust the scaling network so that the measurement uses the full precision of the *AID* converter.

In all types of multimeters, the quality of the switching elements is critical to stable and accurate measurements. Stability of the resistors is a limiting factor in the long-term accuracy and precision of the instrument.

Quantities measured

Contemporary multimeters can measure many quantities. The common ones are:

- Voltage, alternating and direct, in volts.
- Current alternating and direct in amperes

The frequency range for which AC measurements are accurate must be specified.

- Resistance in ohms.
- Duty cycle as a percentage.
- Frequency in hertz.
- Inductance in henrys.

Temperature in degrees Celsius or Fahrenheit, with an appropriate temperature test probe, often a thermocouple.

Digital multimeters may also include circuits for:

- Continuity tester; sounds when a circuit conducts.
- Diodes (measuring forward drop of diode junctions), and transistors (measuring current gain and other parameters).
- Battery checking for simple 1.5 volt and 9 volt batteries. This is a current loaded voltage scale Which simulates in-use voltage measurement.

RESISTANCE & RESISTOR

The electrical resistance of an electrical element measures its opposition to the passage of an electric current; the inverse quantity is electrical conductance, measuring how easily electricity flows along a certain path. Electrical resistance shares some conceptual parallels with the mechanical notion of friction. The SI unit ofelectrical resistance is the ohm (.Q), while electrical conductance is measured in Siemens (S).An object of uniform cross section has a resistance proportional to its resistivity and length and inversely proportional to its cross-sectional area. All materials show some resistance, except for superconductors, which have a resistance of zero.

The resistance of an object is defined as the ratio of voltage across it to current through it:

I

Such materials are called Ohmic materials. For objects made of ohmic materials the definition of the resistance, with R being a constant for that resistor, is known as Ohm's law.In the case of a nonlinear conductor (not obeying Ohm's law), this ratio can change as current or voltage changes; the inverse slope of a chord to an I-V curve is sometimes referred to as a "chordal resistance" or "static resistance".

Fig. l(a).6 Resistor

DC resistance

The resistance of a given resistor or conductor grows with the length of conductor and specific resistivity of the material, and decreases for larger cross-sectional area. The resistance **R** and conductance G of a conductorof uniform cross section, therefore, can be computed as

$$R = \rho \frac{L}{A}$$

$$G = \sigma \frac{A}{L}$$

AC resistance

A wire carrying alternating current has a reduced effective cross sectional area because of the skin effect.

Adjacent conductors carrying alternating current have a higher resistance than they would in isolation or when carrying direct current, due to the proximity effect. At commercial power frequency, these effects significant for large conductors carrying large currents, such as bus bars in an electrical substation, or large power cablescarrying more than a few hundred amperes.

When an alternating current flows through the circuit, its flow is not opposed only by the circuit resistance, but also by the opposition of electric and magnetic fields to the current change. That effect is measured by electrical reactance. The combined effects of reactance and resistance are expressed by electrical impedance.

Measuring resistance

An instrument for measuring resistance is called an ohmmeter. Simple ohmmeters cannot measure low resistances accurately because the resistance of their measuring leads causes a voltage drop that interferes with the measurement, so more accurate devices use four-terminal sensing.

Temperature dependence

Near room temperature, the electric resistance of a typical metal increases linearly with nsmg temperature, while the electrical resistance of a typical semiconductor decreases with rising temperature. The amount of that change in resistance can be calculated using the temperature coefficient of resistivity of the material usingthe following formula:

$$R(T) = R_0[1 + \alpha(T)$$

Where Tis its temperature, TO is a reference temperature (usually room temperature), RO is the resistance at TO, and a is the percentage change in resistivity per unit temperature. The constant a depends only on thematerial being considered. The relationship stated is actually only an approximate one, the true physics being somewhat non-linear, or looking at it another way, a itself varies with temperature. For this reason it is usual tospecify the temperature that a was measured at with a suffix, such as al5 and the relationship only holds in arange of temperatures around the reference.

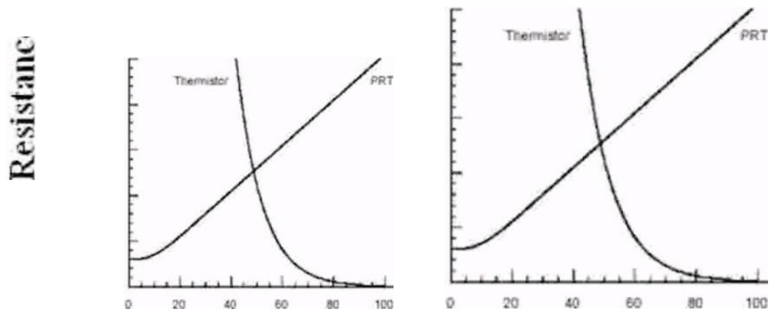

Fig. l(a).7: Temperature characteristics of resistance

INDUCTANCE AND INDUCTOR

I. Elementary Characteristics

The coil in the figure simulates an inductor. The main issue is how the magnetic field lines go across the inductor (lines with arrows). There is some magnetic field at the top bottom of the coil too.

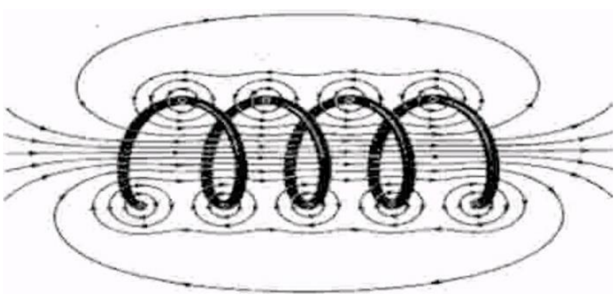

Fig. l(a).8 Elementary characteristics

The current I going through the inductor generate a magnetic field which is perpendicular to I. The Magnetic Field His given by the loops that surround the current I. The direction of the Magnetic Field is given by the arrows around the loops. If the current was to flow in the opposite direction the Magnetic.

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Fig. l(a).8 Magnetic field on wire

Field arrows wouldbe reversed. For a practical display of this phenomena see: Magnetic field on wire.

CAPACITOR

A capacitor is a passiveelectrical component that can store energy in the electric field between a pair of conductors (called "plates"). The process of storing energy in the capacitor is known as "charging", and involves electric charges of equal magnitude, but opposite polarity, building up on each plate. A capacitor'sability to store charge is measured by its capacitance, in units of farads. Capacitors are often used in electric and electronic circuits as energy-storage devices. They can also be used to differentiate between high-frequency and low-frequency signals.

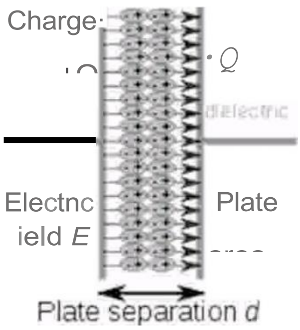

Fig l(a).11 Parallel-Plate capacitor

Charge separation m a parallel-plate capacitor causes an internal electric field. A dielectric (orange) reducesthe field and increases the capacitance. A capacitor consists of two conductors separated by a non-conductive region. The non-conductive region is called the dielectric or sometimes the dielectric medium. In simpler terms, the dielectric is just an electrical insulator. Examples of dielectric mediums are glass, air, paper, vacuum, and even a semiconductor depletion region chemically identical to the conductors. A capacitor is assumed to be self- contained and isolated, with no net electric charge and no influence from any external electric field. The conductors thus hold equal and opposite charges on their facing surfaces, and the dielectric develops an electric field. In SI units, a capacitance of one farad means that one coulomb of charge on each conductor causes a voltage of one volt across the device

The capacitor is a reasonably general model for electric fields within electric circuits. An ideal capacitor is wholly characterized by a constant capacitance C, defined as the ratio of charge ±Q on each conductor to the voltage V between them:

Sometimes charge build-up affects the capacitor mechanically, causing its capacitance to vary. In this case,capacitance is defined in terms of incremental changes:

Energy storage

Work must be done by an external influence to "move" charge between the conductors in a capacitor. When the external influence is removed the charge separation persists in the electric field and energy is stored to be released when the charge is allowed to return to its equilibrium position. The work done in establishing the electric field, and hence the amount of energy stored, is given by:

$$W = \int_{q=0}^{Q} V\,dq = \int_{q=0}^{Q} \frac{q}{C}\,dq = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}VQ$$

OBSERVATION TABLE:

S.No.	Components for identification/Testing	Type	Measured Value		Quality
			By multimeter	By Color Coding	
1.	Resistors	1.			
		11.			
2.	Capacitors	1.			
		11.			
3.	Inductors	1.			
		11.			

PROCEDURE

For Resistors

1. Identify the type of element and write in observation table.
2. Find different vale of resistor using color coding and multi meter, note down in observation table
3. Using multi meter test given resistor for open and short conditions.

For Inductors

1. Identify the type of element and write in observation table.
2. Find different vale of resistor using color coding and multi meter, note down in observation table.
3. Using multi meter test given resistor for open and short conditions.

For Capacitor

1. Identify the type of element and write in observation table.
2. Find different vale of resistor using color coding and multi meter, note down in observation table

3. Using multi meter test given resistor for open and short conditions

RESULT:

Study of various passive components viz. resistor, capacitor, inductor and their testing and identification hasdone.

PRECAUTIONS

1. All connection must be tight.
2. Get the circuit connections checked by the teacher before performing the experiment.
3. Power to the circuit must be switched on in the presence of the teacher.
4. Get the experimental readings checked by the teacher.
5. Don't touch directly the live parts of equipment and circuit.
6. Wear leather shoes in the lab.

VIVA VOICE:

1) What are the various uses of multimeter?
2) What is a capacitor?
3) Which device is use to measure ac current?
4) What is a voltmeter?

OBJECTIVE:

Introduction and use of oscilloscope.

APPARATUS REQUIRED:

S.No	Name of the equipment	Quantities	Type
1.	Function Generator	1	
2.	C R O	1	
3.	Connecting Probe	As Required	

THEORY:

CATHODE RAY OSCILLOSCOPE

The cathode-ray oscilloscope (CRO) is a common laboratory instrument that provides accurate time and amplitude measurements of voltage signals over a wide range of frequencies. Its reliability, stability, and ease of operation make it suitable as a general purpose laboratory instrument. The heart of the CRO is a cathode-ray tube.

The cathode ray is a beam of electrons which are emitted by the heated cathode (negative electrode) and accelerated toward the fluorescent screen. The assembly of the cathode, intensity grid, focus grid, and accelerating anode (positive electrode) is called an electron gun. Its purpose is to generate the electron beam and control its intensity and focus. Between the electron gun and the fluorescent screen are two pair of metalplates - one oriented to provide horizontal deflection of the beam and one pair oriented to give vertical deflection to the beam.

These plates are thus referred to as the horizontal and vertical deflection plates. The combination of these two deflections allows the beam to reach any portion of the fluorescent screen. Wherever the electron beam hitsthe screen, the phosphor is excited and light is emitted from that point. This conversion of electron energy into light allows us to write with points or lines oflight on an otherwise darkened screen.

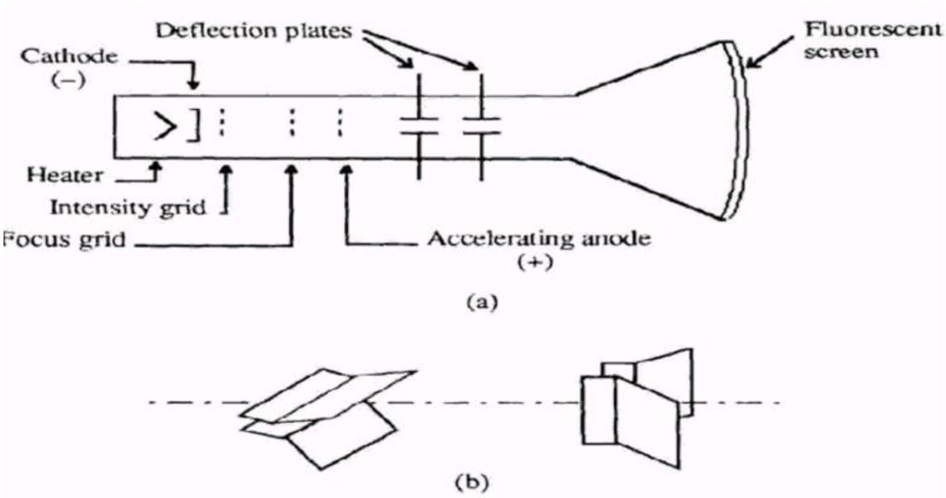

Fig: l(b).1 Cathode-ray oscilloscopes (CRO) (a) Schematic (b) Details of deflection Plate

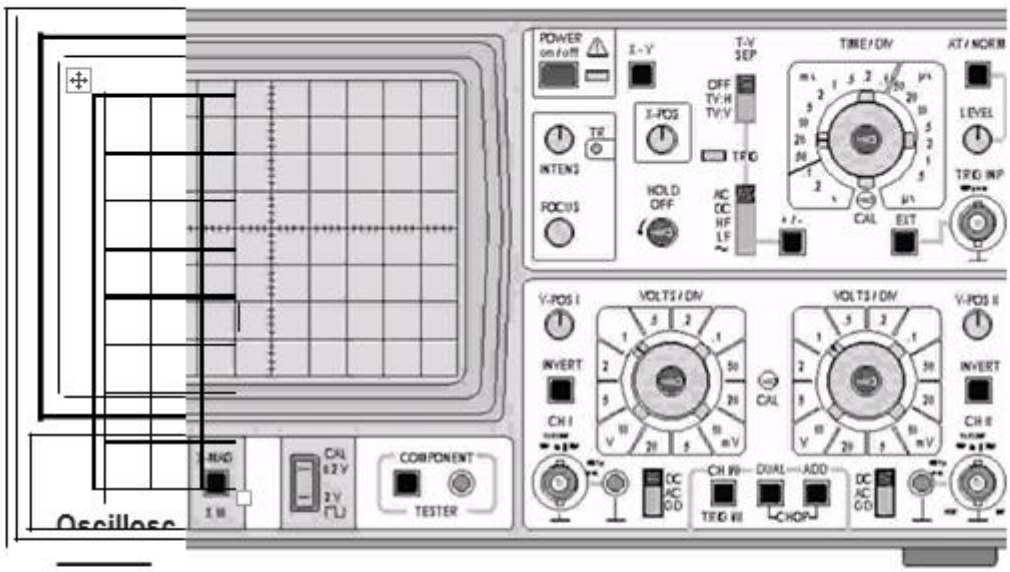

Fig l(b).3 Cathode Ray Oscilloscope

Accuracy of the vertical deflection is + 3%. Sensitivity is variable.

Horizontal sweep should be accurate to within 3%. Range of sweep is variable

Operating Instructions: Before plugging the oscilloscope into a wall receptacle, set the controls as follows:

Power switch at off

Intensity fully counters clockwise

Vertical centering in the center of range

Horizontal centering in the center of range

Vertical at 0.2

Sweep times 1

WARNING: Never advance the Intensity Control so far that an excessively bright spot appears. Bright spot simply burning of the screen. A sharp focused spot of high intensity (great brightness) should never be allowed to remain fixed in one position on the screen for any length of time as damage to the screen may occur.

PROCEDURE:

I. Set the signal generator to a frequency of 1000 cycles per second. Connect the output from the generator to the vertical input of the oscilloscope. Establish a steady trace of this input signal on the scope. Adjust (play with) all of the scope and signal generator controls until you become familiar with the function of each.

II. Measurements of Voltage: By adjusting the Horizontal Sweep time/cm and trigger, a steady trace of the Sme wave may be displayed on the screen. The trace represents a plot of voltage vs. time, where the vertical deflection of the trace about the line of symmetry CD is proportional to the magnitude of the voltage at any instant of time.

The relationship between the magnitude of the peak voltage displayed on the scope and the effective or RMS voltage (VRMS) read on the AC voltmeter is

VRMS = 0.707 Vm (for a sine or cosine wave).

Ill. Frequency Measurements: When the horizontal sweep voltage is applied, voltage measurements can still be taken from the vertical deflection. Moreover, the signal is displayed as a function of time. time base (i.e. sweep) is calibrated, such measurements as pulse duration or signal period can be made. Frequencies can then be determined as reciprocal of the periods.

IV. Lissajous Figures: When sine-wave signals of different frequencies are input to the horizontal and Vertical amplifiers a stationary pattern is formed on the CRT when the ratio of the two frequencies is an integral fraction such as 1/2, 2/3, 4/3, 1/5, etc. These stationary patterns are known as Lissajous figures and can be used for comparison measurement of frequencies.

Use two oscillators to generate some simple Lissajous figures like those shown in Fig. You will find it difficult to maintain the Lissajous figures in a fixed configuration because the two oscillators are not phase and frequency locked. Their frequencies and phase drift slowly causing the two different signals to change slightly with respect to each other.

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EXPERIMENT NO. 2

AIM: To determine the characteristics of PN junction diode.

Components:

Name	Qty
Diodes IN 4007(Si)	1
Resistor 1KΩ, 10KΩ	1

Equipment:

Name	Range	Qty
Bread Board	-	1
Regulated Power Supply	0-30V DC	1
Digital Ammeter	0-200□A/20mA	1
Digital Voltmeter	0-2V/20V DC	1
Connecting Wires		

Theory:

Donor impurities (pentavalent) are introduced into one-side and acceptor impurities into the other side of a single crystal of an intrinsic semiconductor to form a p-n diode with a Junction called depletion region (this region is depleted off the charge carriers). This Region gives rise to a potential barrier V□ called ***Cut- in Voltage***. This is the voltage across the diode at which it starts conducting. It can conduct beyond this Potential.

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to anode (P-side) and –ve terminal of the input supply is connected to cathode (N- side) then diode is said to be forward biased. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from p-side and electrons from n-side cross the junction simultaneously and constitute a forward current (***injected minority current*** – due to holes crossing the junction and entering N-side of the diode, due to electrons crossing the junction and entering P-side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short-circuited switch.

If –ve terminal of the input supply is connected to anode (p-side) and +ve terminal of the input supply is connected to cathode (n-side) then the diode is said to be reverse biased. In this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction. Both the holes on p-side and electrons on n-side tend to move away from the junction thereby increasing the depleted region. However the process cannot continue indefinitely, thus a small current called ***reverse saturation current*** continues to flow in the diode. This small current is due to thermally generated carriers. Assuming current flowing through the diode to be negligible, the diode can be approximated as an open circuited switch.

The volt-ampere characteristics of a diode explained by following equation:

$I = I_0 (e^{v/(\eta V_T)} - 1)$ where

I=current flowing in the diode I_0=reverse saturation current

V=voltage applied to the diode

V_T=volt-equivalent of temperature=kT/q=T/11,600=26mV (@ room temp).

η=1 (for Ge) and 2 (for Si)

It is observed that Ge diode has smaller cut-in-voltage when compared to Si diode. The reverse saturation current in Ge diode is larger in magnitude when compared to silicon diode.

Circuit Diagram:

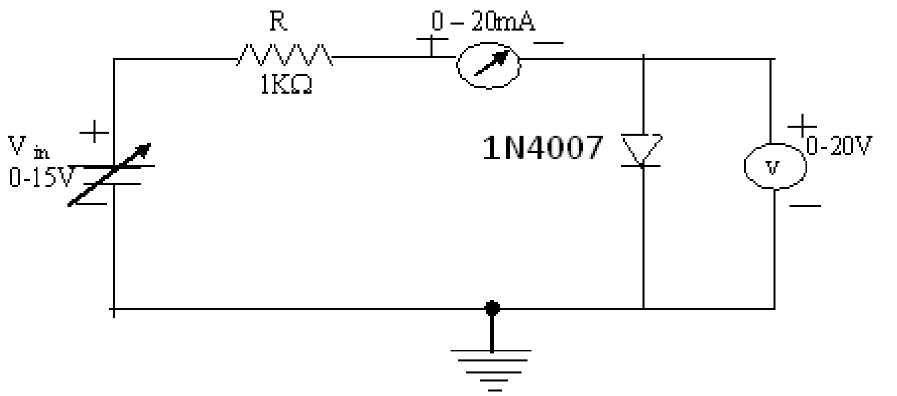
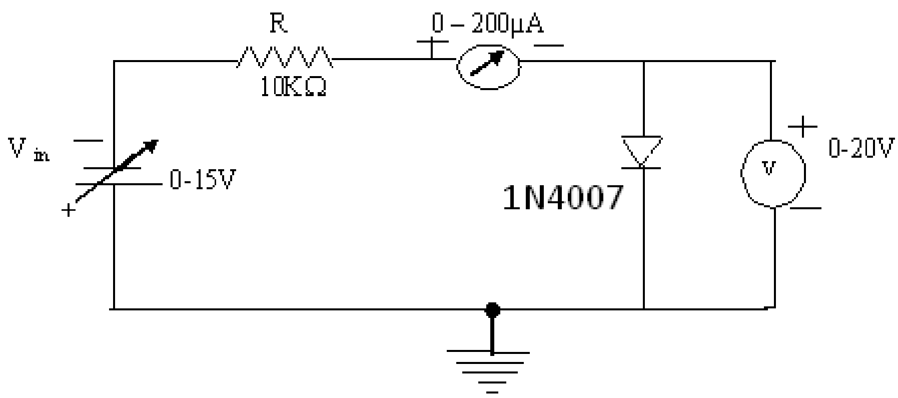


Fig (2) - <u>Reverse Biased condition:</u>



Procedure:

Forward Biased Condition:

1. Connect the circuit as shown in figure (1) using silicon PN Junction diode.
2. Vary V_f gradually in steps of 0.1 volts upto 5volts and note down the corresponding readings of I_f .
3. Step Size is not fixed because of non linear curve and vary the X-axis variable (i.e. if output variation is more, decrease input step size and vice versa).
4. Tabulate different forward currents obtained for different forward voltages.

Reverse biased condition:

1. Connect the circuit as shown in figure (2) using silicon PN Junction diode.
2. Vary V_r gradually in steps of 0.5 volts upto 8 volts and note down the corresponding readings of I_r.
3. Tabulate different reverse currents obtained for different reverse voltages. ($I_r = V_R$ / R, where V_R is the Voltage across 10K Resistor).

Observations

Si diode in forward biased conditions:

Sl. No	RPS Voltage	Forward Voltage across the diode V_f (volts)	Forward current through the diode I_f (mA)

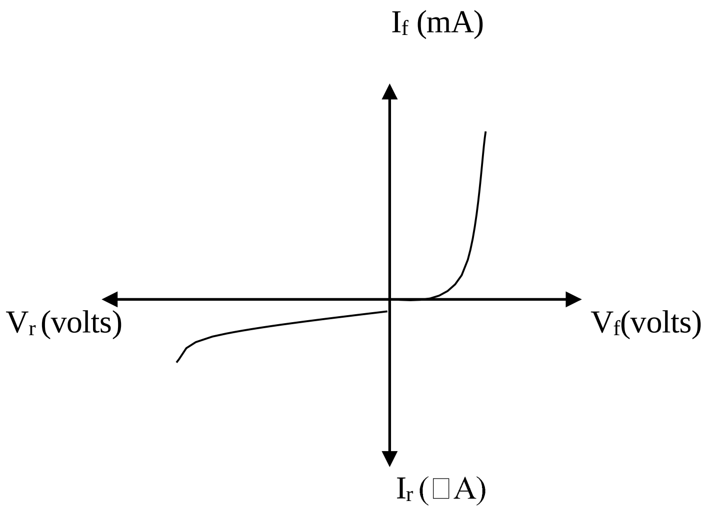
Si diode in reverse biased conditions:

Sl. No	RPS Voltage	Reverse Voltage across the diode V_r (volts)	Reverse current through the diode I_r (□A)

Graph (Instructions):

1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Now mark + ve x-axis as V_f
   - Ve x-axis as V_r
   + Ve y-axis as I_f
   - ve y-axis as I_r.
3. Mark the readings tabulated for Si forward biased condition in first Quadrant and Si reverse biased condition in third Quadrant.

Calculations from Graph:



Static forward Resistance $R_{dc} = V_f / I_f$ Ω

Dynamic forward Resistance r_{ac} = □V_f/□I_f

Ω Static Reverse Resistance $R_{dc} = V_r / I_r$ Ω

Dynamic Reverse Resistance $r_{ac} = \Delta V_r / \Delta I_r\ \Omega$

Precautions:

1. While doing the experiment do not exceed the ratings of the diode. This may lead to damage the diode.
2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch **ON** the power supply unless you have checked the circuit connections as per the circuit diagram.

Result:

1. Cut in voltage = ……… V
2. Static forward resistance =.................. □
3. Dynamic forward resistance =................ □

EXPERIMENT NO 3

AIM: Verification of The venin's Theorem.

APPARATUS REQUIRED:

S.NO.	Name of the Apparatus	Range	Quantity
1	Bread Board	-	1
2	Resistor	1 KΩ	3
3	Resistor	2.2 KΩ	2
4	Resistor	4.7 KΩ	1
5	Ammeter	0-100 mA	1
6	Voltmeter	0-30 V	1
7	RPS	0-30 V	1

THEORY:

Thevenin's theorem states that any two terminal linear network having a number of voltage current sources and resistances can be replaced by a simple equivalent circuit consisting of a single voltage source in series with a resistance, where the value of the voltage source is equal to the open circuit voltage across the two terminals of the network, and resistance is equal to the equivalent resistance measured between the terminals with all the energy sources are replaced by their internal resistances.

PROCEDURE:

1. Connection are made as per the circuit diagram shown in figure 2.1
2. Vary the supply voltage V_1 and take the corresponding reading I_3 from the ammeter.
3. Now connect the circuit diagram in figure 2.2 in bread board (Removing the load resistor R_6).
4. Vary the supply voltage V_1 in the same way as done in step 2 and note down the corresponding V_{AB} or V_{TH} from the voltmeter.
5. Find out the R_{TH} and draw the Thevenin equivalent ciruit.

6. Now connect the circuit diagram in figure 2.3 in bread board and note down the I_L value by varying V_{TH} (fix the values of V_{TH} got from step 4).

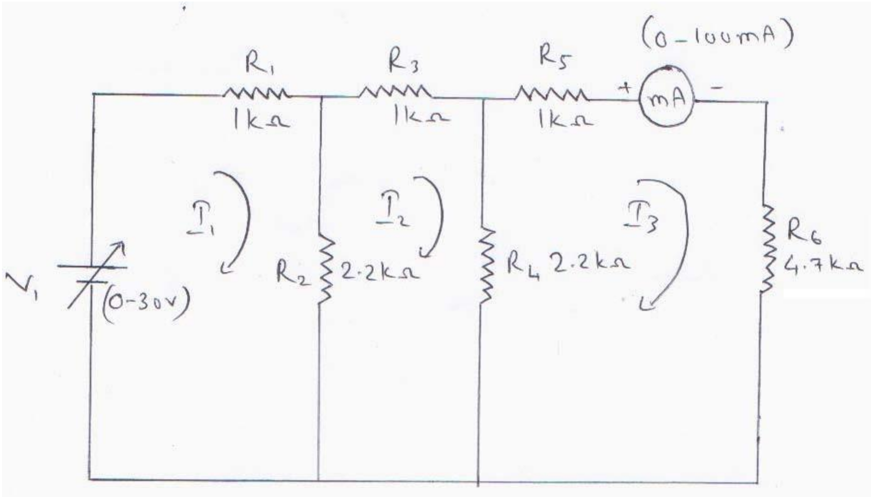


Figure 2.1

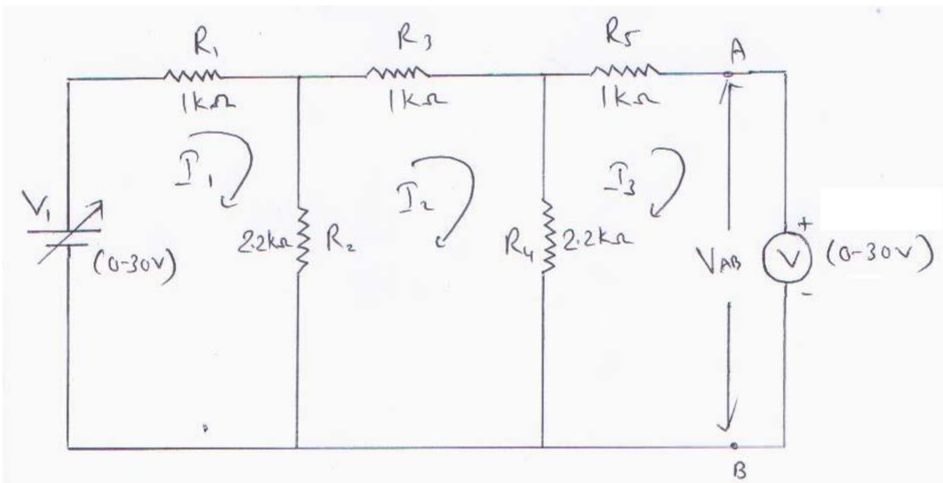


Figure 2.2

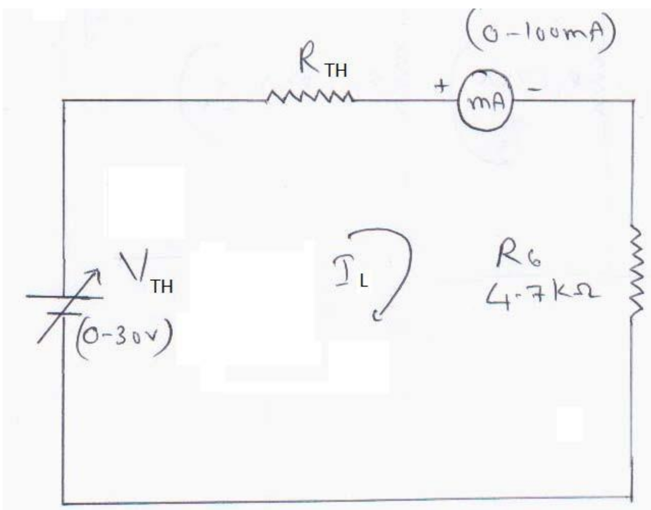


Figure 2.3

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Tabulation:

Table 1(for I_3 & V_{TH} or V_{AB}):

V1 (v)	I_3 (mA)		V_{TH} (v)	
	Theoretical	Practical	Theoretical	Practical

Table 2 (for I_L):

V_{TH} (v) (practical)	I_L (mA)	
	Theoretical	Practical

Note: *All theoretical values can be found by using either mesh analysis or nodal analysis and also using voltage division rule and current division rule where it is applicable.*

RESULT :

EXPERIMENT NO . 4

AIM: Verification of Norton's Theorem.

APPARATUS REQUIRED:

S.NO.	Name of the Apparatus	Range	Quantity
1	Bread Board	-	1
2	Resistor	1 KΩ	3
3	Resistor	2.2 KΩ	2
4	Resistor	4.7 KΩ	1
5	Ammeter	0-100 mA	1
6	Voltmeter	0-30 V	1
7	RPS	0-30 V	1

THEORY:

Norton's theorem states that any two terminal linear network with current sources, voltage sources and resistances can be replaced by an equivalent circuit consisting of a current source in parallel with a resistance. The value of the current source is the short circuit current between the two terminals of the network and the resistance is equal to the equivalent resistance measured between the terminals with all the energy sources are replaced by their internal resistances.

PROCEDURE:

1. Connection are made as per the circuit diagram shown in figure 3.1
2. Vary the supply voltage V_1 and take the corresponding reading I_3 from the ammeter.
3. Now connect the circuit diagram in figure 3.2 in bread board (Removing the load resistor R_6 and shorting the terminals).
4. Vary the supply voltage V_1 in the same way as done in step 2 and note down the corresponding I_N from the ammeter.
5. Find out the R_N and draw the Norton's Equivalent circuit

6. Now apply source transformation in the circuit diagram as shown in figure 3.3 and obtain the circuit as shown in figure 3.4.
7. Connect the circuit as shown in figure 3.4 in bread board and vary the supply voltage and note down the corresponding I_L from the ammeter.

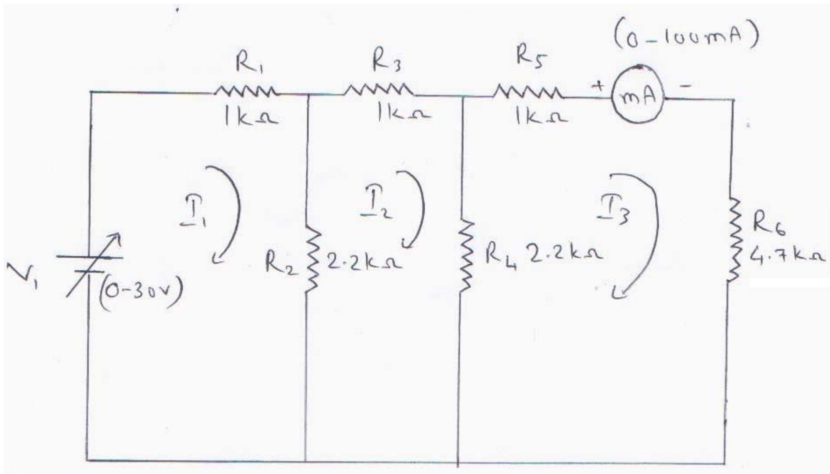


Figure 3.1

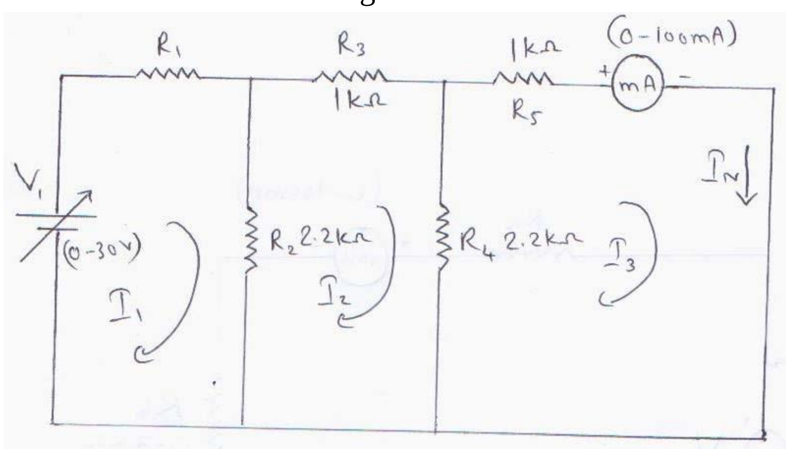


Figure 3.2

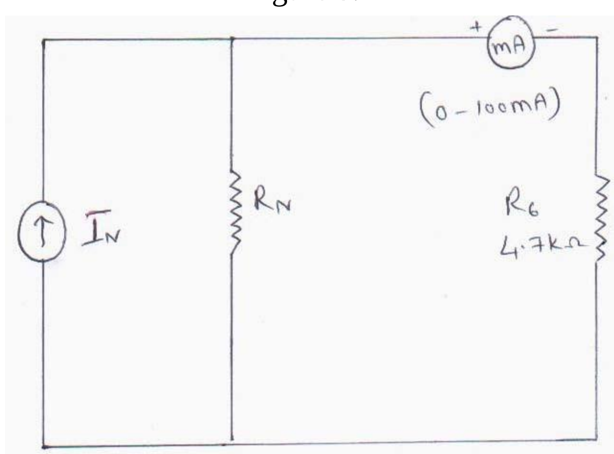


Figure 3.3

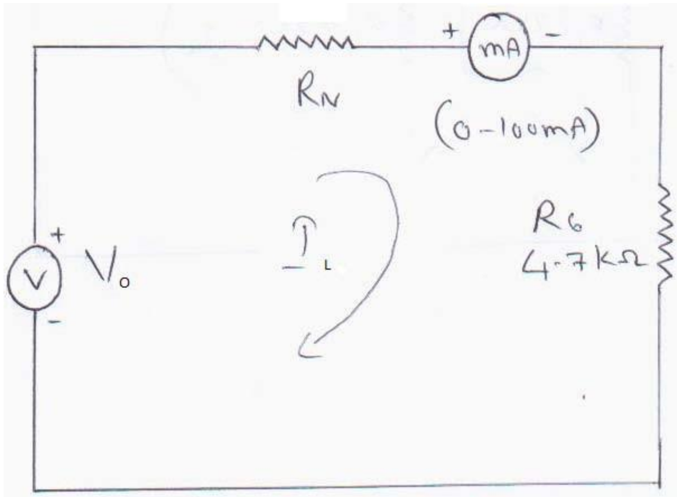


Figure 3.4

Tabulation:

Table 1(for I_3 & I_N):

V1 (v)	I_3 (mA)		I_N (mA)	
	Theoretical	Practical	Theoretical	Practical

Table 2 (for I_L):

V_o (v)	I_L (mA)	
	Theoretical	Practical

<u>Note:</u> *All theoretical values can be found by using either mesh analysis or nodal analysis and also using voltage division rule and current division rule where it is applicable.*

RESULT :

EXPERIMENT NO 5

AIM: Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.

DC Machine: Construction and their Applications

The DC machine can be classified into two types namely DC motors as well as DC generators. Most of the DC machines are equivalent to AC machines because they include AC currents as well as AC voltages in them. The output of the DC machine is DC output because they convert AC voltage to DC voltage. The conversion of this mechanism is known as the commutator, thus these machines are also named as commutating machines. DC machine is most frequently used for a motor. The main benefits of this machine include torque regulation as well as easy speed. The applications of the DC machine is limited to trains, mills, and mines. As examples, underground subway cars, as well as trolleys, may utilize DC motors. In the past, automobiles were designed with DC dynamos for charging their batteries.

What is a DC Machine?

A DC machine is an electromechanical energy alteration device. The working principle of a DC machine is when electric current flows through a coil within a magnetic field, and then the magnetic force generates a torque which rotates the de motor. The DC machines are classified into two types such as DC generator as well as DC motor. The main function of the DC generator is to convert mechanical power to DC electrical power, whereas a DC motor converts DC power to mechanical power. The AC motor is frequently used in the industrial applications for altering electrical energy to mechanical energy. However, a DC motor is applicable where the good speed regulation & ample range of speeds are necessary like in electric-transaction systems

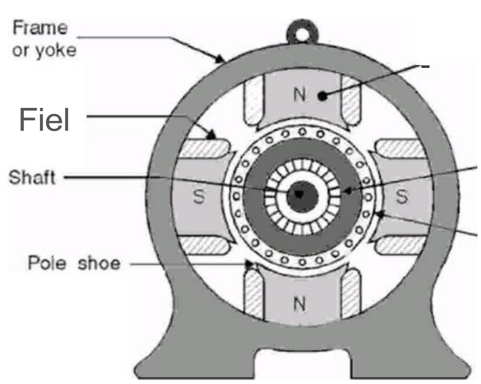


Fig 4.1 : parts of de machine

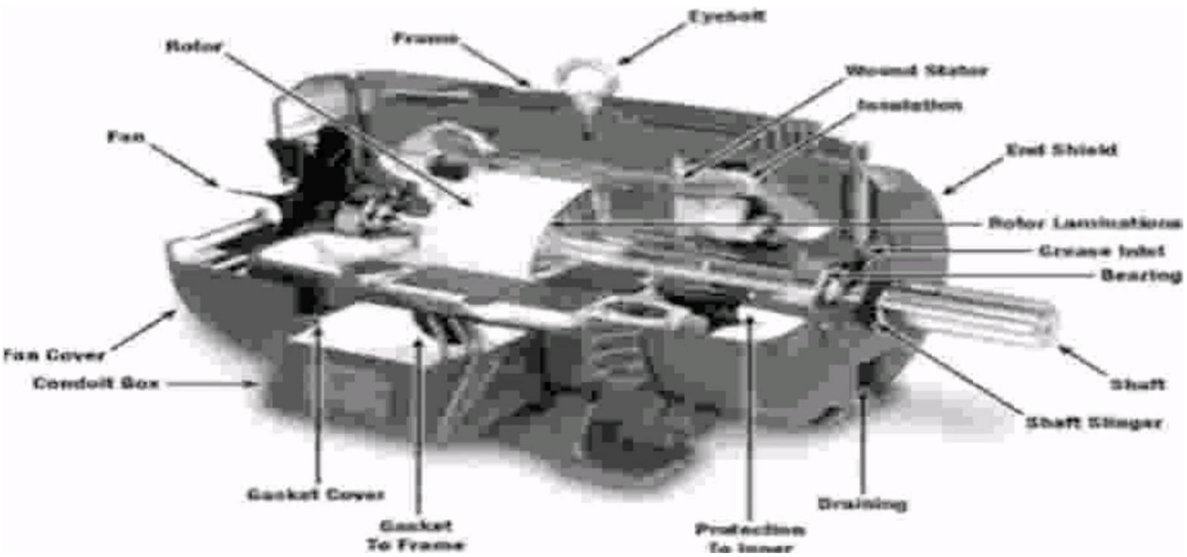


Fig 4.2: DC machine

Construction of DC Machine

The construction of DC machine can be done using some of the essential parts like Yoke, Pole core & poleshoes, Pole coil & field coil, Armature core, Armature winding otherwise conductor, commutator, brushes &bearings. Some of the parts of the DC machine is discussed below.

Yoke

Another name of a yoke is the frame. The main function of the yoke m the machine is to offer mechanical support intended for poles and protects the entire machine from the moisture, dust, etc. The materials used in the yoke are designed with cast iron, cast steel otherwise rolled steel.

Pole and Pole Core

The pole of the DC machine is an electromagnet and the field winding is winding among pole. Whenever field winding is energized then the pole gives magnetic flux. The materials used for this are cast steel, cast iron otherwise pole core. It can be built with the annealed steel laminations for reducing the power drop because of the eddy currents.

Pole Shoe

Pole shoe in DC machine is an extensive part as well as enlarge the region of the pole. Because of this region, flux can be spread out within the air-gap as well as extra flux can be passed through the air space toward armature. The materials used to build pole shoe is cast iron otherwise cast steed, and also used annealed steel lamination to reduce the loss of power because of eddy currents.

Field Windings

In this, the windings are wounded in the region of pole core & named as field coil. Whenever current is supplied through field winding then it electromagnetics the poles which generate required flux. The material used forfield windings is copper.

Armature Core

Armature core includes the huge number of slots within its edge. Armature conductor is located in these slots.It provides the low-reluctance path toward the flux generated with field winding. The materials used in this core are permeability low-reluctance materials like iron otherwise cast. The lamination is used to decrease the loss because of the eddy current.

Armature Winding:

The armature winding can be formed by interconnecting the armature conductor. Whenever an armature winding is turned with the help of prime mover then the voltage, as well as magnetic flux, gets induced within it. This winding is allied to an exterior circuit. The materials used for this winding are conducting material like copper.

Commutator

The main function of the commutator in the DC machine is to collect the current from the armature conductor as well as supplies the current to the load using brushes. And also provides uni-directional torque for DC- motor. The commutator can be built with a huge number of segments in the edge form of hard drawn copper .The Segments in the commutator are protected from thin mica layer.

Brushes

Brushes in the DC machine gather the current from commutator and supplies it to exterior load. Brushes wear with time to inspect frequently. The materials used in brushes are graphite otherwise carbon which is in rectangular form.

AC Machine: Construction and working of squirrel cage induction motor.

A 3 phase squirrel cage induction motor is a type of three phase induction motor which functions based on the principle of electromagnetism. It is called a 'squirrel cage' motor because the rotor inside of it - known as a'squirrel cage rotor' - looks like a squirrel cage.

This rotor is a cylinder of steel laminations, with highly conductive metal (typically aluminum or copper) embedded into its surface. When an alternating current is run through the stator windings, a rotating magnetic field is produced.

This induces a current in the rotor winding, which produces its own magnetic field. The interaction of the magnetic fields produced by the stator and rotor windings produces a torque on the squirrel cage rotor.

One big advantage of a squirrel cage motor is how easily you can change its speed-torque characteristics.

This can be done by simply adjusting the shape of the bars in the rotor. Squirrel cage induction motors are used a lot in industry- as they are reliable, self-starting, and easy to adjust.

Squirrel Cage Induction Motor Working Principle

When a 3 phase supply is given to the stator winding it sets up a rotating magnetic field in space. This rotating magnetic field has a speed which is known as the synchronous speed.

This rotating magnetic field induces the voltage in rotor bars and hence short-circuit currents start flowing
m

the rotor bars. These rotor currents generate their self-magnetic field which will interact with the field of the stator. Now the rotor field will try to oppose its cause, and hence rotor starts following the rotating magnetic field.

The moment rotor catches the rotating magnetic field the rotor current drops to zero as there is no more
relative motion between the rotating magnetic field and rotor. Hence, at that moment the rotor experiences zero tangential force hence the rotor decelerates for the moment

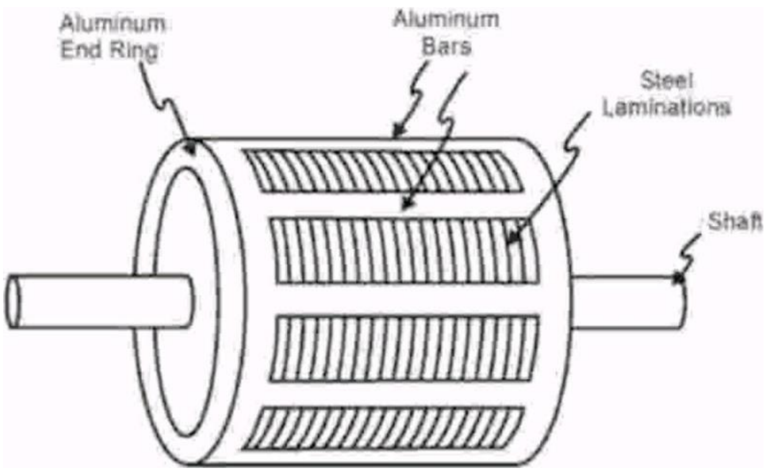


Fig 4.3 rotor

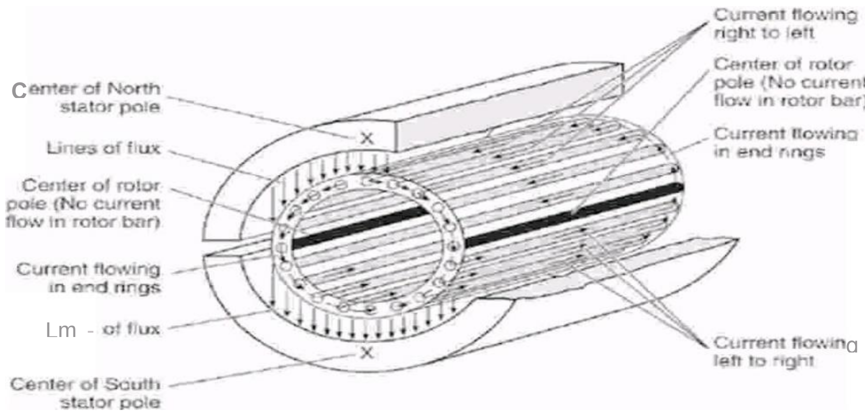
After deceleration of the rotor, the relative motion between the rotor and the rotating magnetic field are establishes hence rotor current again being induced. So again, the tangential force for rotation of the rotor is restored, and therefore again the rotor starts_following rotating mag netic field, and in this way, the rotor maintains a constant speed which is just less than the speed of rotating magnetic field or synchronous speed. Slip is a measure of the difference between the speed of the rotating magnetic field and rotor speed. The frequency of the rotor current= slip x supply frequency

Squirrel Cage Induction Motor Construction

A squirrel cage induction motor consists of the following parts:

- Stator
- Rotor
- Fan

Bearings



Stator

It consists of a 3 phase winding with a core and metal housing. Windings are such placed that they are electrically and mechanically 1200 apart from in space. The winding is mounted on the laminated iron core to provide low reluctance path for generated flux by AC currents.

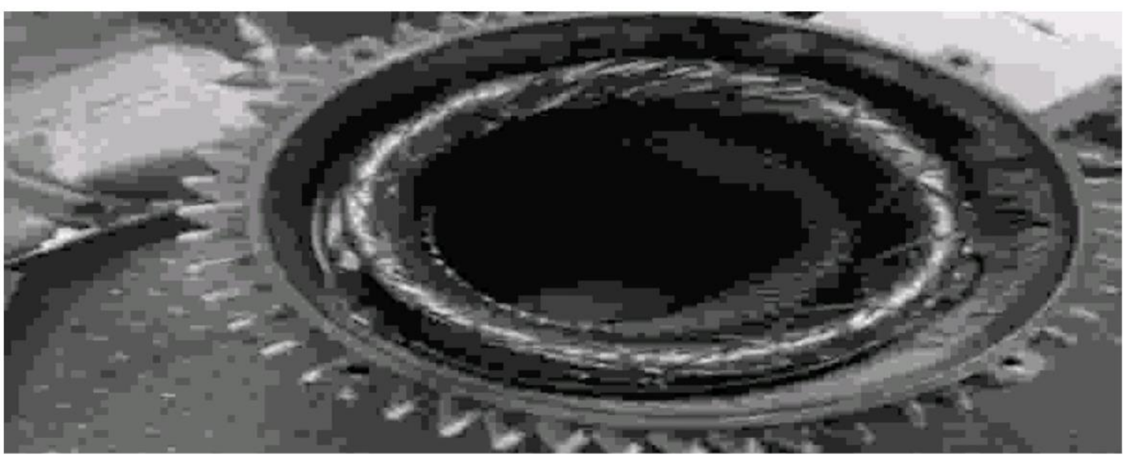


Fig 4.5:stator

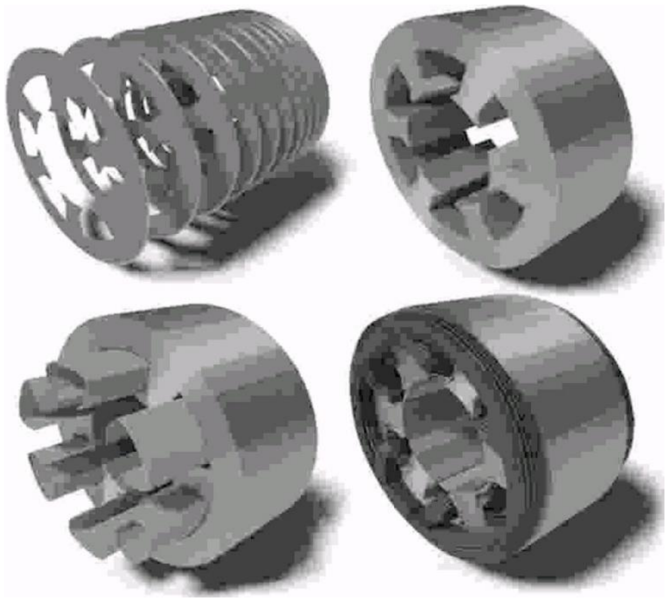
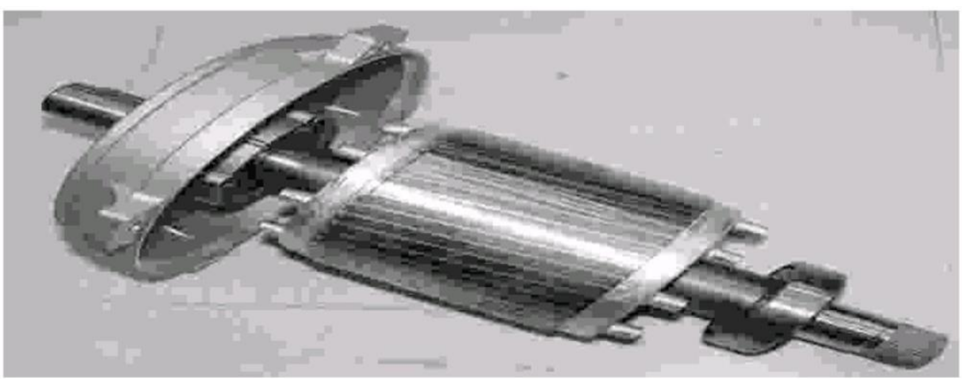


Fig 4.6:stator

Rotor It is the part of the motor which will be in a rotation to give mechanical output for a given amount of electricalenergy. The rated output of the motor is mentioned on the nameplate in horsepower. It consists of a shaft, short-circuited copper/aluminum bars, and a core.



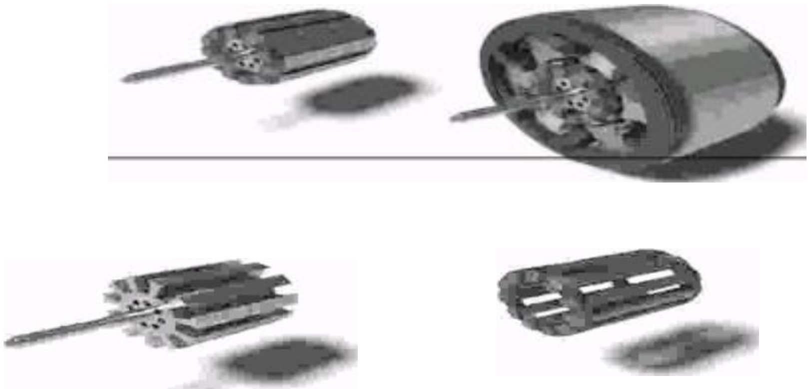


Fig 4.6:Rotor

The rotor core is laminated to avoid power loss from eddy currents and hysteresis. Conductors are skewed toprevent cogging during starting operation and gives better transformation ratio between stator and rotor.

Fan

A fan is attached to the back side of the rotor to provide heat exchange, and hence it maintains the temperatureof the motor under a limit.

Bearings

Bearings are provided as the base for rotor motion, and the bearings keep the smooth rotation of the motor.

Application of Squirrel Cage Induction Motor

Squirrel cage induction motors are commonly used in many industrial applications. They are particularly suited for applications where the motor must maintain a constant speed, be self-starting, or there is a desire forlow maintenance.

These motors are commonly used in:

- Centrifugal pumps
- Industrial drives (e.g. to run conveyor belts)
- Large blowers and fans
- Machine tools
- Lathes and other turning equipment

Advantages of Squirrel Cage Induction Motor

Some advantages of squirrel cage induction motors are:

- They are low cost

- Require less maintenance (as there are no slip rings or brushes)
- Good speed regulation (they are able to maintain a constant speed)
- High efficiency in converting electrical energy to mechanical energy (while running, not during startup)
- Have better heat regulation (i.e. don't get as hot)
- Small and lightweight
- Explosion proof (as there are no brushes which eliminate the risks of sparking)

Disadvantages of Squirrel Cage Induction Motor

Although squirrel cage motors are very popular and have many advantages - they also have somedownsides. Some disadvantages of squirrel cage induction motors are:

- Very poor speed control
- Although they are energy efficient while running at full load current, they consume a lot of energy onstartup
- They are more sensitive to fluctuations in the supply voltage. When the supply voltage is reduced, induction motor draws more current. During voltage surges, increase in voltage saturates the magneticcomponents of the squirrel cage induction motor
- They have high starting current and poor starting torque (the starting current can be 5-9 times the Full load current; the starting torque can be 1.5-2 times the full load torque)

Construction of Synchronous Machines

Synchronous machines run at synchronous speed. The synchronous speed is given by

$$\frac{120f}{p}$$

Where, Ns = synchronous speed, f = supply frequency and p = number of poles. As we can see from the equation, the synchronous speed depends on the frequency of the supply and the number of poles.

The construction of a synchronous machine is very similar to the construction of an alternator. Both are synchronous machines where one we use as a motor and the other as a generator. Just like any other motor, the synchronous motor also has a stator and a rotor. We will look into the construction details of the variouspart in one detail.

Fig 4.8: Stator frame of Synchronous Motor

Stator Core:

The stator core is made up of thin silicon laminations. It is insulated by a surface coating to minimize hysteresis and eddy current losses. Its main purpose is to provide a path of low reluctance for the magnetic lines of force and accommodate the stator windings.

Fig 4.9: Stator core of Synchronous Motor

Stator Winding

The stator core has cuts on the inner periphery to accommodate the stator windings. The stator windings could be either three-phase windings or single phase windings.

Fig 4.10: Stator winding of Synchronous Motor

Enamelled copper is used as the winding material. In the case of 3 phase windings, the windings are distributed over several slots. This is done to produce a sinusoidal distribution of EMF.

Rotor of Synchronous Motor

The rotor is the moving part of the machine. Rotors are available in two types:

- Salient Pole Type
- Cylindrical Rotor Type

The salient pole type rotor consists of poles projecting out from the rotor surface. It is made up of steel laminations to reduce eddy current losses.

Fig 4.11: Rotor of Synchronous Motor

A salient pole machine has a non-uniform air gap. The gap is maximum between the poles and is minimum at the pole centres. They are generally used for medium and low-speed operations as they have a large number of poles. They contain damper windings which are used for starting the motor.

A cylindrical rotor is made from solid forgings of high-grade nickel chrome molybdenum steel forgings of high-grade nickel chrome molybdenum steel. The poles are created by the current flowing through the windings .They are used for high-speed applications as they have less number of poles. They also produce less noise and windage losses as they have a uniform air gap. DC supply is given to the rotor windings via slip-rings. Once the rotor windings are excited, they act like poles.

Single Phase Induction Motor

We use the single-phase power system more widely than three phase system for domestic purposes, commercial purposes and some extent in industrial uses. Because, the single-phase system is more economical than a three-phase system and the power requirement in most of the houses, shops, offices are small, which can be easily met by a single phase system.The single phase motors are simple in construction, cheap in cost, reliable and easy to repair and maintain.

Due to all these advantages, the single phase motor finds its application in vacuum cleaners, fans, washing machines, centrifugal pumps, blowers, washing machines, etc.
The single phase AC motors are further classified as:

1. Single phase induction motors or asynchronous motors.
2. Single phase synchronous motors.
3. Commutator motors.

This article will provide fundamentals, description and working principle of single phase induction motor. Construction of Single Phase Induction Motor
Like any other electrical motor asynchronous motor also have two main parts namely rotor and stator.

Stator: As its name indicates stator is a stationary part of induction motor. A single phase AC supply is given to the stator of single phase induction motor.

Rotor:

The rotor is a rotating part of an induction motor. The rotor connects the mechanical load through the shaft. The rotor in the single-phase induction motor is of squirrel cage rotor type.
The construction of single phase induction motor is almost similar to the squirrel cage three-phase induction
motor. But in case of a single phase induction motor, the stator has two windings instead of one three- phase winding in three phase induction motor.

$$\frac{120f}{P}$$

Stator of Single Phase Induction Motor

The stator of the single-phase induction motor has laminated stamping to reduce eddy current losses on itsperiphery. The slots are provided on its stamping to carry stator or main winding. Stampings are made up of silicon steel to reduce the hysteresis losses.

When we apply a single phase AC supply to the stator winding, the magnetic field gets produced, and the motor rotates at speed slightly less than the synchronous speed Ns.

Synchronous speed Ns is given by

Where,f = supply voltage frequency, P=No. of poles of the motor.

The construction of the stator of the single-phase induction motor is similar to that of three phase induction motor except there are two dissimilarities in the winding part of the single phase induction motor.

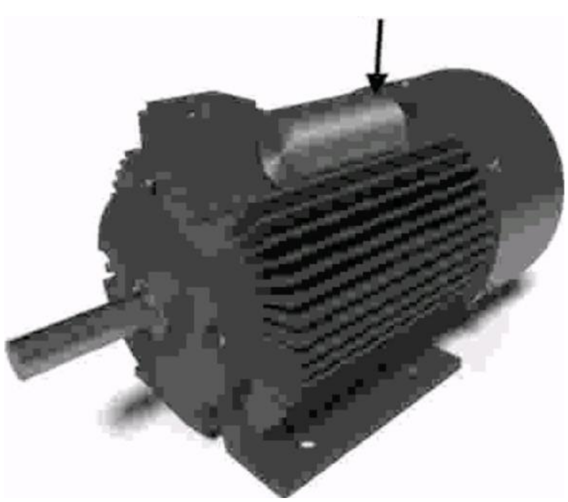
1. Firstly, the single-phase induction motors are mostly provided with concentric coils. We can easily adjust
   the number of turns per coil can with the help of concentric coils. The mmf distribution is almost sinusoidal.
2. Except for shaded pole motor, the asynchronous motor has two stator windings namely the main winding
   and the auxiliary winding. These two windings are placed in space quadrature to each other.

Rotor of Single Phase Induction Motor

The construction of the rotor of the single-phase induction motor is similar to the squirrel cage three- phase induction motor. The rotor is cylindrical and has slots all over its periphery. The slots are not made parallel toeach other but are a little bit skewed as the skewing prevents magnetic locking of stator and rotor teeth andmakes the working of induction motor more smooth and quieter (i.e. less noisy).

The squirrel cage rotor consists of aluminum, brass or copper bars. These aluminum or copper bars are called
rotor conductors and placed in the slots on the periphery of the rotor. The copper or aluminum rings permanently short the rotor conductors called the end rings.

To provide mechanical strength, these rotor conductors are braced to the end ring and hence form a complete
closed circuit resembling a cage and hence got its name as squirrel cage induction motor. As end rings permanently short the bars, the rotor electrical resistance is very small and it is not possible to add



external resistance as the bars get permanently shorted. The absence of slip ring and brushes make the construction of single phase induction motor very simple and robust.

RESULT:

We have studied about DC machines, Squirrel cage induction motor, Synchronous machines, 1-ph induction motor

EXPERIMENT NO 6

RESISTANCE IN SERIES AND PARALLEL

AIM: To determine the equivalent resistance of two resistors when connected in series.

Materials Required:

- Two resistors of different values
- A battery of 6 volts
- Ammeter
- Plug key
- Connecting wires
- A piece of sandpaper
- Voltmeter
- Rheostat

Theory:

The resistance can be increased or decreased depending on the combination and connections in a circuit. The difference between the series and parallel circuit is based on the arrangement of the resistors. Resistors are said to be connected in series if their ends are joined. The potential difference across each resistor would be different, but the current would be the same.

If two resistors are connected in series, then;

Resistance, $R = R_1+R_2$

Current, I = constant

Potential difference, $V = V_1+V_2$

On applying Ohm's law, we get,

$V_1 = IR_1$

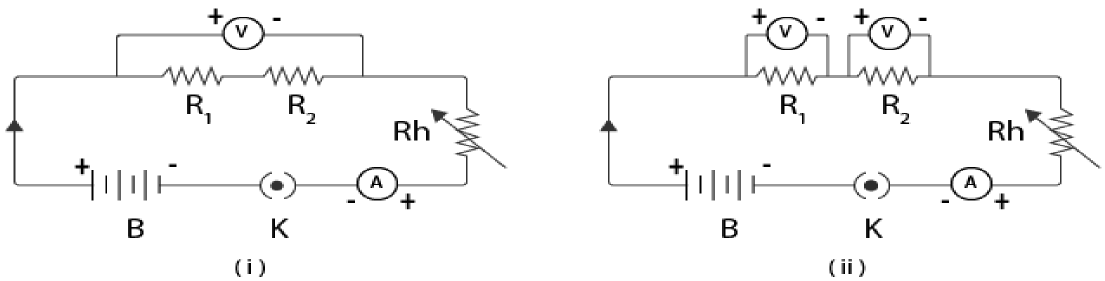
$V_2 +IR_2$

$V = V_1+V_2$

$V = I(R_1+R_2)$

$\therefore R = R_1+R_2$

Circuit Diagram



B = battery (6V)	K = Key
A= Ammeter	V= Voltmeter
R1 = 1Ω	R2 = 2Ω
Rh = Rheostat	V1, V2 = Voltmeter readings for individual resistors

Procedure

1. With the help of a circuit diagram, make the connections.
2. Do not switch on the key.
3. The ammeter should be connected in series, the voltmeter in parallel, and the rheostat in series.
4. Make the connections as shown in the experimental setup and check of +ve and -ve terminals of the battery.
5. By inserting the key, record the ammeter and voltmeter readings.
6. Note three readings by adjusting the rheostat.
7. Note down the readings of a voltmeter by connecting it to each resistor.
8. Measure the potential difference, V_1 across the first resistor by plugging in the key.
9. Measure the potential difference, V_2 across the second resistor by plugging in the key.
10. Calculate the relationship between V, V_1, and V_2.

Observation Table

Resistor used	No.of observations	Voltmeter reading in Volts (V)	Ammeter reading in Ampere (I)	R = V/I (in ohm)	Mean value of resistance (ohm)
R_1 (first resistor)					
R_2 (second resistor)					

$R_s=R_1+R_2$ (series combination)					

Result

The calculated value of R_s	$R_s=R_1+R_2=$
The experimental value of R_s	

Hence, it is verified that $R_s=R_1+R_2$.

Precautions

1. Voltmeter and resistor should always be in parallel.
2. The least count of voltmeter and ammeter should be calculated properly.
3. Connections should be as per the experimental setup.
4. When no current flows through the ammeter and voltmeter, the pointers should be at zero.
5. The connecting wires that are used should be thick copper wire and using sandpaper the insulation at the end of the wires should be removed.
6. The connections should be tight to avoid introducing external resistance.
7. To avoid heating and change the resistor's resistance value, the current should flow while taking the readings.
8. **Aim**

To determine the equivalent resistance of two resistors when connected in parallel.

Materials Required

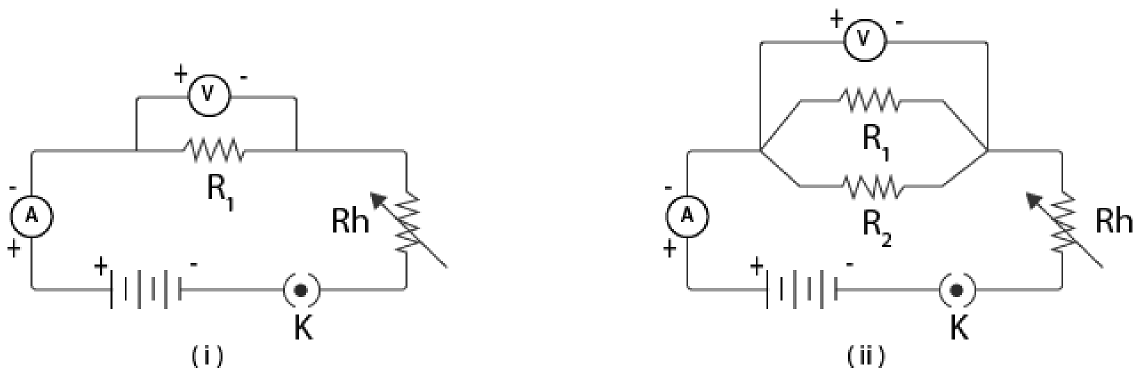
1. A battery
2. A plug key
3. Connecting wires
4. An ammeter

5. A voltmeter
6. Rheostat
7. A piece of sandpaper
8. Two resistors of different values

Theory

If the resistors are connected in parallel along with a battery, then the total current I is calculated as a sum of the separate value of current through each branch. It is given as:

$I = I_1+I_2+I_3+\ldots$



Circuit Diagrams

Procedure

1. Make all the connections as shown in the experimental setup I by keeping the key off.
2. Insert the key when the circuit is connected appropriately.
3. For resistors R_1 and R_2, note three readings of ammeter and voltmeter.
4. Connect the circuit as shown in the experimental setup II.
5. Resistors and voltmeter both are connected in parallel.
6. Record three readings of ammeter and voltmeter and use a rheostat.
7. Remove the key.
8. With the help of the observation table, do the calculations.

Observation Table

Resistor used	No.of observations	Voltmeter reading in Volts (V)	Ammeter reading in Ampere (I)	R=V/I (in Ohm)	Mean value of resistance (Ohm)

R_1 (first resistor)	A				R_1 =
	B				
	C				
R_2 (second resistor)	A				R_2 =
	B				
	C				
$1/R_p=(1/R_1)+(1/R_2)$ Parallel combination	A				R_p= $1/R_p$=

Result

The calculated value of	
The experimental value of	
The equivalent resistance R_p is less than the individual resistance.	

Precautions

1. The connecting wires used should be thick copper wire and using sandpaper, the insulation at the end of the wires should be removed.
2. The connections should be tight to avoid introducing external resistance.
3. To make connections, the circuit diagram should be referred to.
4. To make the current entry from the positive terminal and exit from the negative terminal, the ammeter should be connected in series.
5. Resistor and voltmeter should be connected in parallel.
6. The least count of ammeter and voltmeter should be calculated properly.
7. When there is no current flow, the ammeter and voltmeter should be at zero.

8. To avoid heating and change the resistor's resistance value, the current should flow while taking the readings.

EXPERIMENT NO .7

AIM: Verification of KVL and KCL.

APPARATUS REQUIRED:

S.NO.	Name of the Apparatus	Range	Quantity
1	Bread Board	-	1
2	Resistor	1 KΩ	3
3	Ammeter	0-25 mA	3
4	Voltmeter	0-30 V	2
5	RPS	0-30 V	1

THEORY:

Kirchhoff's Voltage Law (KVL) states that the algebraic sum of all branch voltages around any closed path in a circuit is always zero at all instants of time. In the figure 1.1, if KVL is applied then the equation is

$$V_s = V_1+V_2+V_3$$

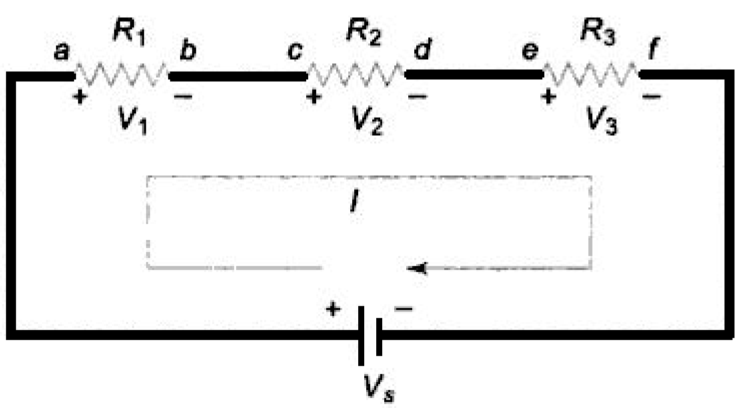


Figure 1.1

Kirchhoff's Current Law (KCL) states that the sum of the currents entering into any node/point/junction is equal to the sum of the currents leaving that node/point/junction. In the figure 1.2, if KCL is applied then the equation is

$$I_T = I_1 + I_2 + I_3$$

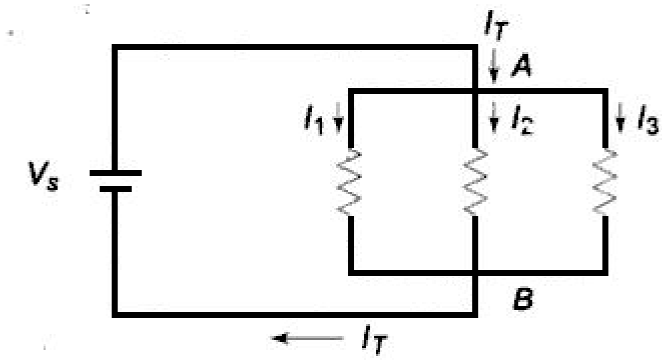


Figure 1.2

PROCEDURE:

a. Verification of KCL

1. Give the connection according to circuit shown in figure 1.3
2. Vary the supply voltage and take the corresponding readings of & I_2 I_L, I_1 from the ammeter.
3. Verify the reading.

b. Verification of KVL

1. Connection are made as per the circuit diagram shown in figure 1.4
2. he supply voltage and take the corresponding readings V_1 & from the voltmeter.
3. Verify the reading.

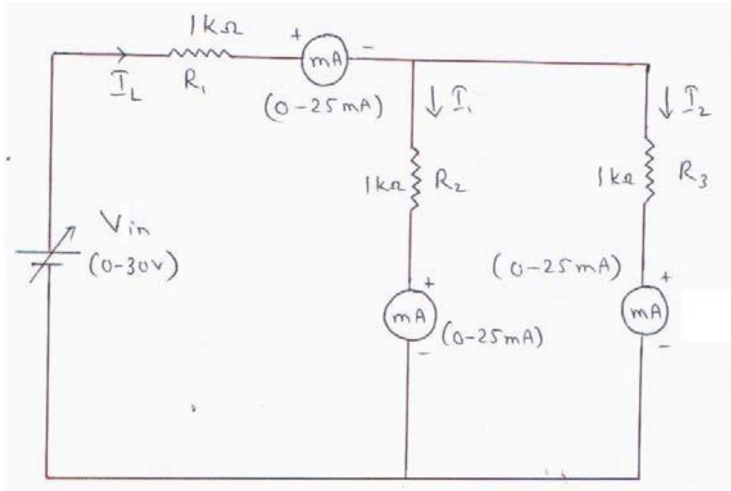


Figure 1.3

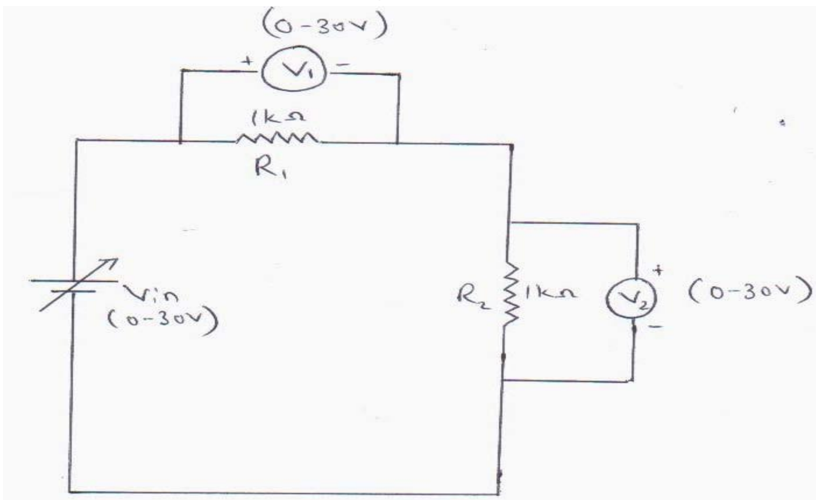


Figure 1.4

Tabulation:

Table 1(for KCL):

Vin (v)	I_1 (mA)		I_2 (mA)		$I_L = I_1 + I_2$ (mA)	
	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical

Table 2 (for KVL):

Vin (v)	V_1 (v)		V_2 (v)		$V_{in} = V_1 + V_2$ (v)	
	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical

Note: *All theoretical values can be found by using either mesh analysis or nodal analysis and also using voltage division rule and current division rule where it is applicable.*

RESULT :

EXPERIMENT NO 8

AIM: To Verify Ohm's Law.

APPARATUS REQUIRED:

S. No	Name of the apparatus	Range	Type	Quantity
1	Regulated power supply	(0 – 30)V/2A	Digital	01
2	Voltmeter	(0-30)V	MC	01
3	Ammeter	(0-1)A	MC	01
4	Rheostat	50 Ω	Tubular	01
5	Connecting wires	---	----	Required number

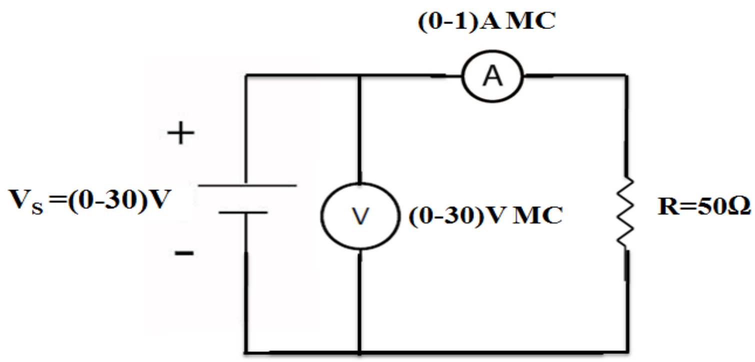
PRECAUTIONS:

1. Initially keep the RPS output voltage knob in zero volt position.
2. Set the ammeter pointer at zero position.
3. Take the readings without parallax error.
4. Avoid loose connections.
5. Avoid short circuit of RPS output terminals

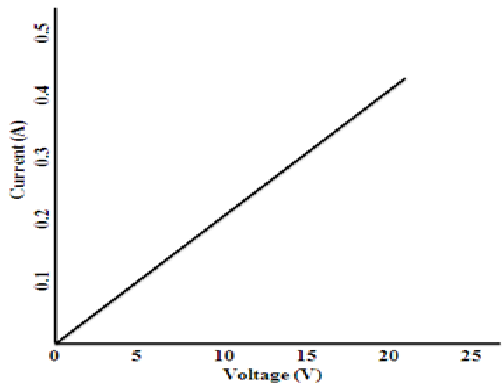
PROCEDURE:

1. Make the connections as per circuit diagram. All connections must be neat and tight.
2. Determine the zero error and least count of the ammeter and voltmeter and record them.
3. Adjust the rheostat to pass a low current (R=50Ω).
4. Vary the regulated power supply to an appropriate value (Say 30V) in steps, and note down the current and voltage through the load for each step (voltmeter & ammeter reading).
5. Take atleast six sets of readings by adjusting the regulated power supply gradually.
6. Reduce the output voltage of the regulated power supply to 0V and switch-off the supply.
7. Plot a graph with V along x-axis and I along y-axis.
8. The graph will be a straight line which verifies Ohm's law.

CIRCUIT DIAGRAM:



MODEL GRAPH:



OBSERVATIONS:

$$I \propto V \text{ i.e. } V \propto I \Rightarrow V = RI$$

S.NO	VOLTAGE(V)	CURRENT(A)

RESULT:

PRE LAB QUESTION:

1. State Ohms Law
2. Define Voltage And Current
3. Define Resistance

POST LAB QUESTIONS:

Write down the relation between voltage ,current and resistance

EXPERIMENT NO 9

AIM: Verification of Superposition theorem.

APPARATUS REQUIRED:

S.NO.	Name of the Apparatus	Range	Quantity
1	Bread Board	-	1
2	Resistor	1 KΩ	2
3	Resistor	2.2 KΩ	2
4	Ammeter	0-25 mA	1
5	Voltmeter	0-30 V	1
6	RPS	0-30 V	1

THEORY:

The superposition theorem states that in any linear network containing two or more sources, the response in any element is equal to the algebraic sum of the responses caused by individual sources acting alone, while the other sources are non- operative; that is, while considering the effect of individual sources, other ideal voltage sources and ideal current sources in the network are replaced by short circuit and open circuit across their terminals.

PROCEDURE:

1. Connection are made as per the circuit diagram shown in figure 4.1
2. Vary the supply voltage V_{S1} & V_{S2} and take the corresponding reading I_2 from the ammeter.
3. Now V_{S2} is short circuited. Vary V_{S1} & take the corresponding reading I_2^1 from the ammeter as shown in figure 4.2
4. Now V_{S1} is short circuited. Vary V_{S2} & take the corresponding reading I_2^{11} from the ammeter as shown in figure 4.3
5. Finally Verify whether $I_2 = I_2^1 + I_2^{11}$

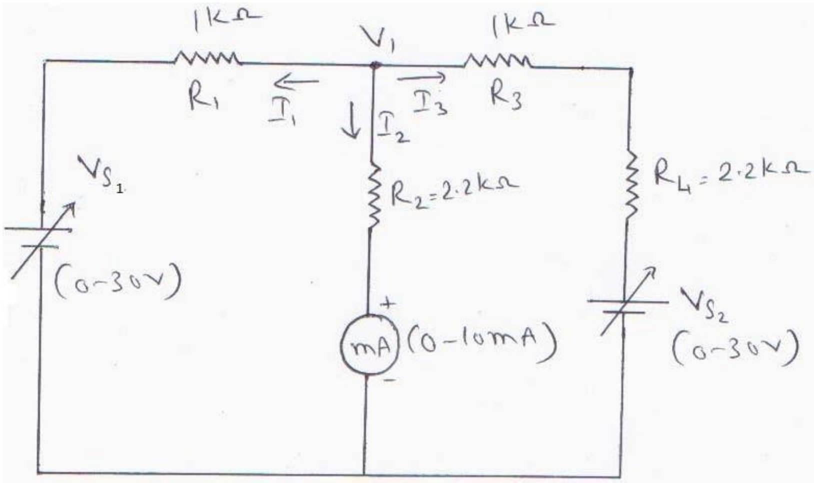


Figure 4.1

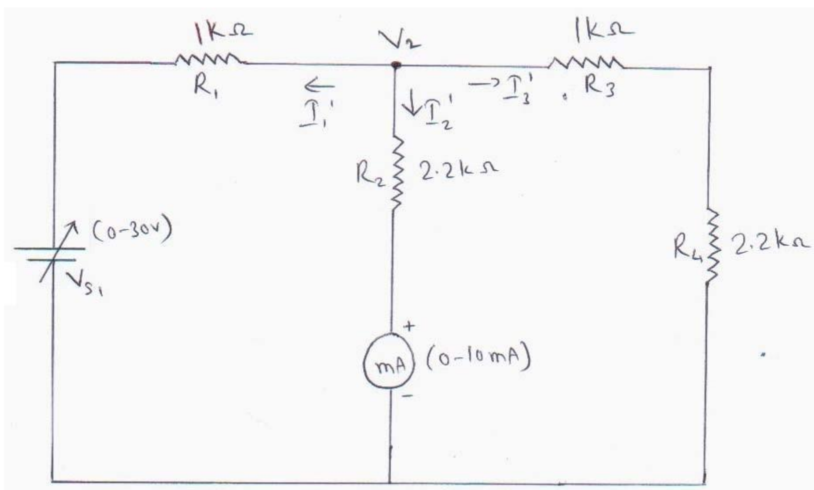


Figure 4.2

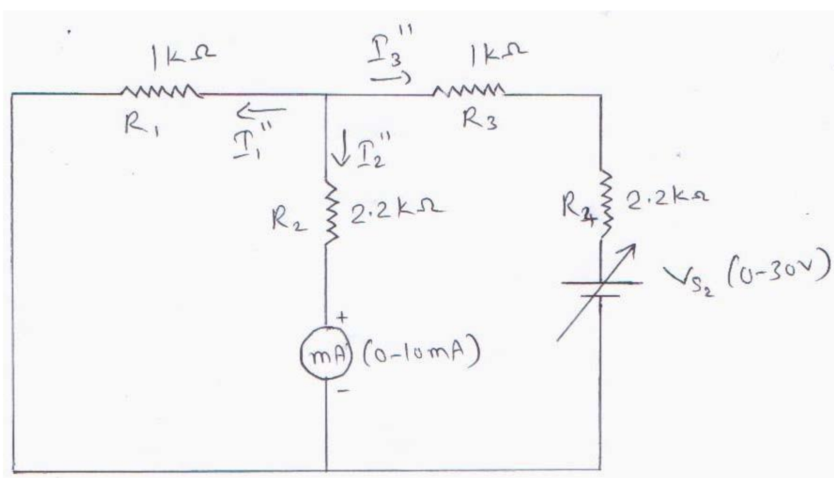


Figure 4.3

Tabulation:

Table 1(for I_2):

V_{S1} (v)	V_{S2} (v)	I_2 (mA)	
		Theoretical	Practical

Table 2 (for I_2^{1} & I_2^{11}):

V_{S1} acting alone, V_{S2} replaced by internal Resistance (v)			V_{S2} acting alone, V_{S1} replaced by internal Resistance (v)			Total I_2 (mA) $I_2 = I_2^{1} + I_2^{11}$	
V_{S1}(v)	I_2^{1} (mA)		V_{S2}(v)	I_2^{11} (mA)		Theoretical	Practical
	Theoretical	Practical		Theoretical	Practical		

Note: *All theoretical values can be found by using either mesh analysis or nodal analysis and also using voltage division rule and current division rule where it is applicable.*

RESULT :