## LAB MANUALS

## BASIC ELECTRICAL ENGINEERING LAB



# SANT LONGOWAL INSTITUTE OF ENGINEERING AND TECHNOLOGY LONGOWAL

## **GENERAL INSTRUCTIONS**

- i. Students should switch on the power supply after getting the connections checked by the lab technician / teacher.
- ii. Be caution while designing the circuits and while handling the Transformers.
- iii. If a problem is observed in any hardware equipment, please report to the lab staff immediately; do no attempt to fix the problem yourself.
- iv. Please be considerate of those around you, especially in terms of noise level. While labs are a natural place for conversations regarding designing the circuit, kindly keep the volume low.
- v. Avoid parallax errors while calculating the values.
- vi. After completion of the experiment, components must be submitted properly to the lab Faculty.
- vii. Submission related to lab work has to be completed by the next lab session.

## INDEX

- i. To study the dependence of current on the potential difference across a resistor and determine its resistance. Also plot a graph between V and I.
- ii. To study the properties of series connection.
- iii. To study the properties of parallel connection.
- iv. To verify the Kirchhoff's voltage law for the given circuit.
- v. To verify the Kirchhoff's current law for the given circuit.
- vi. To observe sine wave, square wave, triangular wave on the CRO, and to measure amplitude and frequency of the wave form.
- vii. Measurement of power in a three phase system by two wattmeter method.
- viii. To perform short circuit test on a single phase transformer to calculate the copper loss of the transformer.
  - ix. To perform open circuit test on a single phase transformer to calculate the equivalent circuit parameters with respect to primary side of the transformer and the open circuit loss or core loss/iron loss of the transformer.
  - x. To know the construction of practical DC, AC machines and identify the parts.

## 1. VERFICATION OF OHM'S LAW

AIM: To study the dependence of current on the potential difference across a resistor and determine its resistance. Also plot a graph between V and I.

#### APPARATUS REQUIRED:

S. No.	Name of the equipment	Range	Туре	Quantity
1	Rheostat	-	-	1
2	Regulated Power Supply	-	-	1
3	Multimeter	-	Digital	1
4	Connecting Wires		-	Required No.

#### CIRCUIT DIAGRAMS:



#### THEORY:

The Ohm's law states that the direct current flowing in a conductor is directly proportional to the potential difference between its ends. It is usually formulated as V = IR, where V is the potential difference, or voltage, I is the current, and R is the resistance of the conductor.

#### PROCEDURE

- 1. Before doing the connection, check all the components and equipment.
- 2. Make the connection as shown in the circuit diagram
- 3. Keep value of Rheostat 1 K  $\Omega$  and start first set of ten trials.

4. Vary voltage applied across R from 1V to 10V and record corresponding values of current from the ammeter.

5. Also calculate theoretical values of current using ohm's law and record in the data table.

S. No.	Voltmeter Reading (V)	Ammeter Readings (A)	Resistance = V/I

6. Observe the difference between theoretical and practical values of current.

7. Repeat from step 3 by keeping value of Rheostat to 2 K Ohm.

#### **RESULTS:**

The study of dependence of current on the potential difference across a resistor has been determined. Also plot a graph between V and I.



## 2. & 3. SERIES AND PARALLEL CONNECTION

#### AIM: To study the properties of series and parallel connection.

#### APPARATUS REQUIRED:

S. No.	Name of the equipment	Range	Туре	Quantity
1	DC circuit training system	-	-	1
2	DC Power Supply	-	-	1
3	Digital A.V.O. meter	-	Digital	1
4	Connecting Wires		-	Required No.

#### CIRCUIT DIAGRAMS:

#### GIVEN CIRCUIT:



Fig.(1)



Fig.(2)



Fig.(3)









THEORY:

a) The Series Circuit: A Series Circuit or "series-connected circuit" is a circuit having just one current path. Thus, Fig.(1) is an example of a "series circuit" in which a battery of constant potential difference V volts, and three resistances, are all connected "in series." Since a series circuit has just one current path, it follows that all the components in a series circuit carry the same current I, a fact evident from inspection of Fig.(1). The current I is assumed to be a flow of positive charge, and thus flows out of the positive terminal of the battery and around through the external circuit, reentering the battery at the negative terminal. This is indicated by the arrows in Fig.(1). In a series circuit, the Total resistance, RT, that the battery sees is equal to the Sum of the individual resistances. Thus, in the particular case of Fig.(1) the battery sees a total resistance, RT = R1 + R2 + R3, while in the general case of "n" resistances connected in series the battery sees a total resistance of : RT = R1 + R2 + R3 +.....Rn.

By Ohm's law, it follows that the current I in a series circuit is equal to

$$I = \frac{V}{R_{\mathrm{T}}} = \frac{V}{R_{\mathrm{1}} + R_{\mathrm{2}} + \dots + R_{\mathrm{n}}}$$

Resistance, on the other hand, consumes electrical energy, removing it from the circuit in the form of heat. Since resistance does not produce or generate electrical energy, it is a non-active or Passive type of circuit element. The potential difference between the terminals of a resistor is called the Voltage Drop across the resistor, and, is equal to the current I times the resistance R; that is, the "voltage drop" across a resistance of R ohms carrying a current of I amperes is I·R volts.

$$V = IR_{T}$$
$$V = I(R_{1} + R_{2} + \dots + R_{n})$$
$$V = IR_{1} + IR_{2} + \dots + IR_{n}$$

In a series circuit, the applied voltage is equal to the sum of the voltage drops. It should be pointed out that the voltage drop across a resistor is always from plus to minus in the direction of the current flow, a fact illustrated in Fig.(2).

b) The Parallel Circuit: A parallel circuit is one in which the battery current divides into a number of "parallel paths." This is shown in Fig.(3), in which a battery, of constant V volts, delivers a current of I amperes to a load consisting of any number of n resistances connected "in parallel." The currents in the individual resistances are called the "branch currents," and the battery current I is often called the "line current." From inspection of Fig.(3) we see that, in a parallel circuit, the battery current I is equal to the sum of the branch currents.

$$I=I_1+I_2+I_3+\cdots+I_n$$

If the battery voltage V is applied equally to all n resistances; that is, the same voltage V is applied to all the parallel branches. Hence, by Ohm's law, the individual branch currents in Fig.(3) have the values:

$$I_1 = V/R_1, \qquad I_2 = V/R_2, \dots, I_n = V/R_n$$

Then, we have:

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}\right)$$

Now let RT be the total resistance as seen by the battery in Fig.(3). Then, by Ohm's law, it has to be true that:

Since the left-hand sides of the last two equations are equal, the two right hand sides are also equal. Setting the two right-hand sides equal, then cancelling the Vs, gives

$$\frac{1}{R_{\rm T}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$$

Procedure:

1. Using the DC circuit trainer, connect the circuit Shown in Fig. (4), take VT =10V, and R1=82 $\Omega$ , R2 = 100 $\Omega$  and R3 =150 $\Omega$ .

2. Measured the voltage and current of "R1 , R2 & R3", then record it in table below

	<mark>82Ω</mark>	100Ω	150Ω	
V(volt)				V <sub>T</sub> =
I(mA)				$I_T =$

3. By using ohm's law, Calculate the RT.

4. Disconnect the DC power supply, and then measured the equivalent resistance by using the AVO meter only.

5. Using the DC circuit trainer, connect the circuit Shown in Fig.(5), and take VT =10V, and R1=82 $\Omega$ , R2 = 100 $\Omega$  and R3 =150 $\Omega$ .

6. Measured the voltage and current of "R1 , R2 & R3", then record it in table below

	82Ω	100Ω	150Ω	
I (mA)				I <sub>T</sub> =
V(volt)				V <sub>T</sub> =

7. Disconnect the DC power supply, and then measured the equivalent resistance by using the AVO meter only.

## 4. & 5. VERIFICATION OF KIRCHOFF'S LAWS

AIM: To verify the Kirchhoff's voltage law and Kirchhoff's current law for the given circuit.

#### APPARATUS REQUIRED:

S. No.	Name of the equipment	Range	Туре	Quantity
1	RPS	0-30 V	-	1
2	Voltmeter	0-20 V	Digital	4
3	Ammeter	0-20 mA	Digital	4
4	Bread Board	-	-	1
5	Connecting Wires	-	-	Required No.
6	Resistors	470		2
		1k		1
		680		1

CIRCUIT DIAGRAMS:

GIVEN CIRCUIT:



Fig (1)

1. KVL:



#### PRACTICAL CIRCUIT:





2. KCL:



Fig(1b)

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PRACTICAL CIRCUIT:
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#### THEORY:

a) Kirchhoff's Voltage law states that the algebraic sum of the voltage around any closed path in a given circuit is always zero. In any circuit, voltage drops across the resistors always have polarities opposite to the source polarity. When the current passes through the resistor, there is a loss in energy and therefore a voltage drop. In any element, the current flows from a higher potential to lower potential. Consider the fig (1a) shown above in which there are 3 resistors are in series. According to kickoff's voltage law....

#### V = V1 + V2 + V3

b) Kirchhoff's current law states that the sum of the currents entering a node equal to the sum of the currents leaving the same node. Consider the fig (1b) shown above in which there are 3 parallel paths. According to Kirchhoff's current law...

#### | = |1 + |2 + |3|

#### PROCEDURE:

- 1. Kirchhoff's Voltage law:
  - 1. Connect the circuit as shown in fig (2a).
  - 2. Measure the voltages across the resistors.
  - 3. Observe that the algebraic sum of voltages in a closed loop is zero.
- 2. Kirchhoff's current law:
  - 1. Connect the circuit as shown in fig (2b).
  - 2. Measure the currents through the resistors.
  - 3. Observe that the algebraic sum of the currents at a node is zero.

#### OBSERVATION TABLE:

KVL:

S. No.	Voltage Across Resistor	Theoretical	Practical

KCL:

S. No.	Current Across Resistor	Theoretical	Practical

#### PRECAUTIONS:

- 1. Avoid loose connections.
- 2. Keep all the knobs in minimum position while switch on and off of the supply.

## **6. AMPLITUDE TIME PERIOD FREQUENCY**

AIM: To observe sine wave, square wave, triangular wave on the CRO, and to measure amplitude and frequency of the wave form.

#### APPARATUS REQUIRED:

S. No.	Name of the equipment	Range	Туре	Quantity
1	CRO	-	-	1
2	Function generator	-	-	1

#### THEORY:

C.R.O. (Cathode Ray Oscilloscope) is the instrument which is used to observe signal waveforms. Signals are displayed in time domain i.e. variation in amplitude of the signal with respect to time is plotted on the CRO screen. X-axis represents time and Y-axis represents amplitude. It is used to measure amplitude, frequency and phase of the waveforms. It is also used to observe shape of the waveform. C.R.O. is useful for troubleshooting purpose. It helps us to find out gain of amplifier, test oscillator circuits. We can measure amplitude and frequency of the waveforms at the different test points in our circuit. Thus, it helps us for fault finding procedure. In dual channel C.R.O. X-Y mode is available which is used to create Lissajous patterns.

Latest digital storage oscilloscope displays voltage and frequency directly on the LCD and does not require any calculations. It can also store waveform for further analysis. In this practical, we will measure amplitude and frequency of the different waveforms like sine wave, square wave, triangular wave and ramp wave.

#### PROCEDURE:

1. Connect function generator output at the input of C.R.O. at channel 1 or at channel 2.

2. Select proper channel i.e. if signal is connected to channel 1 select CH1 and if signal is connected to channel 2 select CH2

3. Adjust Time/ Div knob to get sufficient time period displacement of the wave on the CRO screen.

4. With fine tuning of time/ Div make the waveform steady on screen.

5. Use triggering controls if waveform is not stable.

6. Keep volt/ div knob such that waveform is visible on the screen without clipping.

7. Measure P-P reading along y-axis. This reading multiplied with volt/ div gives peak to peak amplitude of the ac i/ p wave.

8. Measure horizontal division of one complete cycle. This division multiplied by time/ div gives time period of the i/ p wave.

9. Calculate frequency using formula f = 1/T.

10. Note down your readings in the table below.

Function	Vertical	Volt/Div	Amplitude	Horizontal	Time/div	Time	Freq
	Division		(p-p)	Div			
Sine							
Wave							
Square							
Wave							
Triangular							
Wave							
Ramp							
Wave							

## 7. TWO WATTMETER METHOD

AIM: Measurement of power in a three phase system by two wattmeter method

#### APPARATUS REQUIRED:

S. No.	Name of the equipment	Range	Туре	Quantity
1	3 Phase Variable load	-	-	1
2	Voltmeter	0-300 V	Digital	1
3	Ammeter	0-10 A	Digital	2
4	Wattmeter	0-5 A	Digital	2

#### CIRCUIT DIAGRAM:



#### THEORY:

Surprisingly, only two single phase wattmeter are sufficient to measure the total power consumed by a three phase balanced circuit. The two wattmeter are connected as shown in figure. The current coils are connected in series with two of the lines. The pressure (or voltage) coils of the two wattmeter's are connected between that line and reference.

#### PROCEDURE:

- 1. Connect the circuit as shown in figure.
- 2. Keep the three phase variac at its zero position .
- 3. Switch on the main supply.

4. Increase the voltage supplied to the circuit by changing the positions of variac so that all the meters give readable deflection.

5. Note down readings of all the meters in the table below

S. No.	V	1	W1	W2	P = W1+W2

PRECAUTIONS:

- 1. Connections should be tight.
- 2. Take the readings carefully.
- 3. Switch off the circuit when not in use.

### 8. SHORT CIRCUIT TEST

AIM: To perform short circuit test on a single phase transformer to calculate the copper loss of the transformer.

#### APPARATUS REQUIRED:

S. No.	Name of the equipment	Range	Туре	Quantity
1	Transformer	1 Phase, 50 Hz	-	1
2	AC Voltmeter	0-300 V	Digital	1
3	AC Ammeter	0-25 A	Digital	1
4	AC Wattmeter	0-75 W	Digital	1
5	Variac	230V, 10A, 50 Hz 1 Phase		1
6.	Connecting Wires			As required

#### CIRCUIT DIAGRAM:



THEORY:

$$R_{01} = \frac{W_{sc}}{I_{sc}^2}$$
$$Z_{01} = \frac{V_{sc}}{I_{sc}}$$
$$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$$

#### PROCEDURE:

- 1. Make the connections as per the circuit diagram.
- 2. Make sure that the secondary side of transformer is shorted.
- 3. Keep the variac at zero position before switch on the supply.
- 4. Switch on A.C supply.

5. By varying the variac apply full load current to the transformer and note the reading of voltmeter, wattmeter and ammeter in the table below:

S. No.	Voltmeter Reading(V)	Ammeter Reading(A)	Wattmeter Reading (W)

6. Keep the variac at zero position and switch of supply.

CALCULATION:

Calculate the multiplying factor (M.F) of the wattermeter.

M.F= ((Rating of C.C)\*(Rating of P.C)\*cos $\phi$ )/(Wattmeter Ratingin)

Copper loss = Wsc (in Watts) = Wattmeter Reading\*M.F

Short circuit current=Ammeter reading= Isc

Voltmeter Reading = Vsc

Copper loss = Wattmeter Reading =Wsc

Calculate the values of R01, X01, Z01.

PRECAUTIONS:

1. All the connections should be tight and clean.

2. Special care should be taken while selecting the ranges of the meters for conducting shortcircuit test.

3. While conducting the short-circuit test, the voltage applied should be initially set at zero, and then increase slowly. If a little higher voltage than the required voltage be applied (by mistake), there is a danger of transformer being damaged.

### 9. OPEN CIRCUIT TEST

AIM: To perform open circuit test on a single phase transformer to calculate the equivalent circuit parameters with respect to primary side of the transformer and the open circuit loss or core loss/iron loss of the transformer.

#### APPARATUS REQUIRED:

S. No.	Name of the equipment	Range	Туре	Quantity
1	Transformer	1 Phase, 50 Hz	-	1
2	AC Voltmeter	0-300 V	Digital	1
3	AC Ammeter	0-25 A	Digital	1
4	AC Wattmeter	0-75 W	Digital	1
5	Variac	230V, 10A, 50 Hz 1 Phase		1
6.	Connecting Wires			As required

CIRCUIT DIAGRAM:



THEORY:

$$W=V_1I_0\cos\phi_0\qquad\qquad\cos\phi_0=W/(V_1I_0)$$

PROCEDURE:

1. Make the connections as per the circuit diagram.

2. Make sure that the secondary side of transformer is open.

3. Keep the variac at zero position before switch on the supply.

4. Switch on A.C supply.

5. By varying the variac apply full supply voltage i.e. 230V to the primary of the transformer and note the reading of voltmeter, wattmeter and ammeter in the table below:

S. No.	Voltmeter Reading(V)	Ammeter Reading(A)	Wattmeter Reading (W)

6. Keep the variac at zero position and switch of supply.

#### CALCULATION:

Calculate the multiplying factor (M.F) of the wattermeter.

M.F= ((Rating of C.C)\*(Rating of P.C)\*cos $\phi$ )/(Wattmeter Ratingin)

Iron loss = W (in Watts) = Wattmeter Reading\*M.F

No load current=Ammeter reading= I0

Supply Voltage =Voltmeter Reading = V1

#### PRECAUTIONS:

1. All the connections should be tight and clean.

2. Special care should be taken while selecting the ranges of the meters for conducting opencircuit test.

### **10. AC DC MACHINE PARTS**

AIM: To know the construction of practical DC, AC machines and identify the parts.

#### DC Generator:

A dc generator is an electrical machine which converts mechanical energy into direct current electricity. This energy conversion is based on the principle of production of dynamically induced emf. The following section outlines basic construction and working of a DC generator.

#### Construction of a DC Machine:

Note: A DC generator can be used as a DC motor without any constructional changes and vice versa is also possible. Thus, a DC generator or a DC motor can be broadly termed as a DC machine. These basic constructional details are also valid for the construction of a DC motor. Hence, let's call this point as construction of a DC machine instead of just 'construction of a dc generator'.





Armature core (rotor)

The above figure shows constructional details of a simple 4-pole DC machine. A DC machine consists of two basic parts; stator and rotor. Basic constructional parts of a DC machine are described below.

- 1. Yoke: The outer frame of a dc machine is called as yoke. It is made up of cast iron or steel. It not only provides mechanical strength to the whole assembly but also carries the magnetic flux produced by the field winding
- Poles and pole shoes: Poles are joined to the yoke with the help of bolts or welding. They carry field winding and pole shoes are fastened to them. Pole shoes serve two purposes;
  (i) they support field coils and (ii) spread out the flux in air gap uniformly.
- 3. Field winding: They are usually made of copper. Field coils are former wound and placed on each pole and are connected in series. They are wound in such a way that, when energized, they form alternate North and South poles
- 4. Armature core: Armature core is the rotor of a dc machine. It is cylindrical in shape with slots to carry armature winding. The armature is built up of thin laminated circular steel disks for reducing eddy current losses. It may be provided with air ducts for the axial air flow for cooling purposes. Armature is keyed to the shaft.
- 5. Armature winding: It is usually a former wound copper coil which rests in armature slots. The armature conductors are insulated from each other and also from the armature core. Armature winding can be wound by one of the two methods; lap winding or wave winding. Double layer lap or wave windings are generally used. A double layer winding means that each armature slot will carry two different coils.
- 6. Commutator and brushes: Physical connection to the armature winding is made through a commutator-brush arrangement. The function of a commutator, in a dc generator, is to collect the current generated in armature conductors. Whereas, in case of a dc motor, commutator helps in providing current to the armature conductors. A commutator consists of a set of copper segments which are insulated from each other. The number of segments is equal to the number of armature coils. Each segment is connected to an armature coil and the commutator is keyed to the shaft. Brushes are usually made from

carbon or graphite. They rest on commutator segments and slide on the segments when the commutator rotates keeping the physical contact to collect or supply the current.

#### CONSTRUCTION OF AC MACHINES (THREE PHASE INDUCTION MOTOR):

The three phase induction motor is the most widely used electrical motor. Almost 80% of the mechanical power used by industries is provided by three phase induction motors because of its simple and rugged construction, low cost, good operating characteristics, the absence of commutator and good speed regulation. In three phase induction motor, the power is transferred from stator to rotor winding through induction. The induction motor is also called a synchronous motor as it runs at a speed other than the synchronous speed. Like any other electrical motor induction motor also have two main parts namely rotor and stator.

Stator: As its name indicates stator is a stationary part of induction motor. A stator winding is placed in the stator of induction motor and the three phase supply is given to it.

Rotor: The rotor is a rotating part of induction motor. The rotor is connected to the mechanical load through the shaft.

The rotor of the three phase induction motor are further classified as

- Squirrel cage rotor,
- Slip ring rotor or wound rotor or phase wound rotor.

#### STATOR OF THREE PHASE INDUCTION MOTOR

The stator of the three-phase induction motor consists of three main parts :

- 1. Stator frame
- 2. Stator core
- 3. Stator winding or field winding

#### PARTS OF AC MOTOR (3-PHASE INDUCTION MOTOR):









STATOR WINDING OR FIELD WINDING



SQUIRREL CAGE THREE PHASE INDUCTION MOTOR



SLIP RING OR WOUND ROTOR THREE PHASE INDUCTION MOTOR