GANDHI SCHOOL OF ENGINEERING

Chidananda Hills, Bhabandha, Berhampur, Ganjam

DCMT LABORATORY EXPERIMENTS

EXPERIMENT NO. 01

Aim of the Experiment

To safely dismantle a DC machine, identify its internal structural components, study their functions and materials, and reassemble the machine.

Apparatus Required

- DC machine (motor or generator)
- Tool kit: Spanner set, socket wrench set, mallet, screwdriver, insulated pliers.
- Safety gear: Insulated hand gloves, safety goggles, safety shoes.
- Consumables: Cleaning cloth, marking chalk / punch, fine sandpaper.

Construction Overview

A standard DC machine fundamentally consists of two primary divisions:

1. Stator (Stationary Part): Yoke, field poles, field windings, and brush holder assembly.
2. Rotor (Rotating Part): Armature core, armature winding, commutator, shaft, and bearings.

Safety Precautions

- **Isolate Electrical Supply:** Ensure the machine is completely disconnected from any live mains supply.
- **Isolate Mechanical Load:** Decouple any external pulleys or mechanical loads from the shaft.
- **Avoid Force:** Never strike the commutator, shaft, or windings with a heavy steel hammer; use a soft rubber or wooden mallet.
- **Watch for Arcs:** Ensure the capacitors (if present) are discharged to prevent arcing.

Step-by-Step Dismantling Procedure

(1) Record Nameplate Details: Copy down all machine specifications (kW, voltage, current, RPM, insulation class).

(2) Make Alignment Marks: Use chalk or a punch to mark the relative positioning of the end covers and the main frame (yoke). This ensures proper alignment during reassembly.

(3) Remove the Pulley / Fan Cover: Loosen the securing screws to detach any shaft pulley, external cooling fan, or protective fan guard.

(4) Remove Terminal Cover and Connections: Unscrew the terminal box plate. Document or take a picture of the internal wire connections, then disconnect the leads.

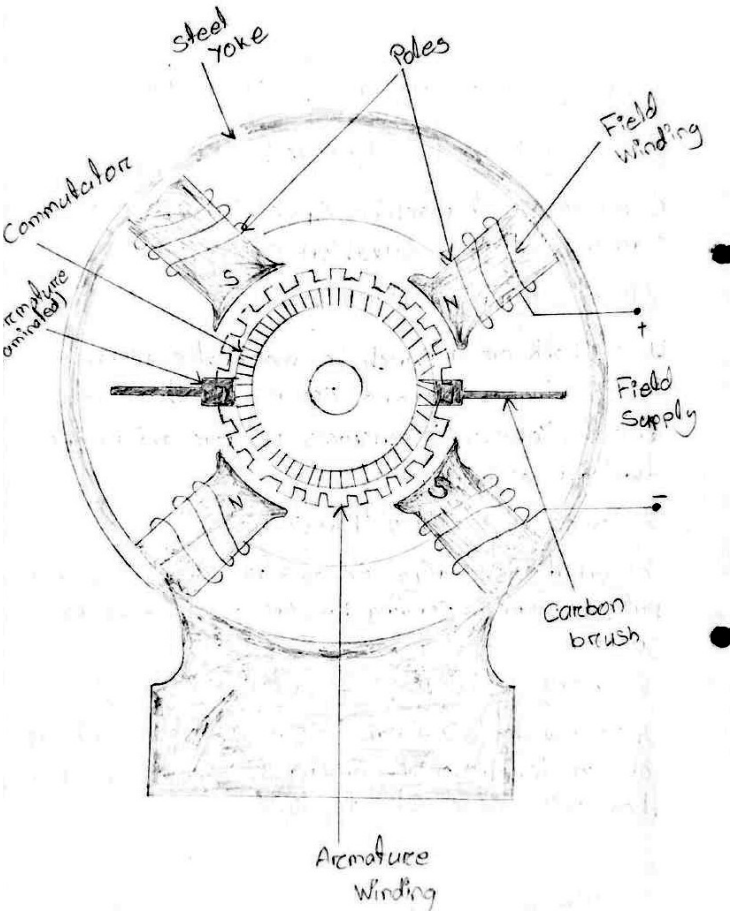


Fig.: Constructional details of a DC machine

(5) Lift the Carbon Brushes: Release the spring tension on the brush holders and slide the carbon brushes out so they do not catch or scratch the commutator during rotor removal.

(6) Detach End Shields: Unscrew the bolts holding the front and rear end covers (end shields) to the yoke frame. Gently tap the covers free using a mallet.

(7) Extract the Armature (Rotor): Carefully slide the armature assembly straight out of the stator bore. Do not drag the armature core or windings against the field poles to avoid structural / insulation damage.

(8) Inspect Bearings: Check the condition of the ball / sleeve bearings resting on the shaft ends.

Observation Table

While dismantled, clean each component with a dry cloth and document your findings below:

Sl. No.	Component Name	Material Used	Primary Function
01	Yoke (Frame)	Cast iron / Cast steel	Provides outer protective covering and a low-reluctance magnetic path.
02	Field Poles	Laminated steel	Produce the core magnetic flux within the machine.

Sl. No.	Component Name	Material Used	Primary Function
03	Field Windings	Copper wire	Carries excitation current to magnetize the poles.
04	Armature Core	Laminated silicon steel	Holds the armature winding; laminated to minimize eddy current losses.
05	Armature Winding	Insulated copper	Conductor slots where EMF is induced (generator) or torque is developed (motor).
06	Commutator	Hard-drawn copper segments	Converts AC generated internally to external DC (or vice-versa); isolated via mica.
07	Carbon Brushes	Carbon / Graphite	Collects or delivers current by sliding over the rotating commutator.
08	Shaft & Bearings	High-grade steel	Transfers rotational mechanical energy and ensures smooth, low-friction rotation.

Reassembly Procedure

1. Clean all internal dust and grit using a dry cloth or light blower.
2. Slide the armature back into the stator centre point, taking care not to rub the poles.
3. Align the end plates perfectly, matching your initial punch / chalk markings. Tighten the end shield bolts uniformly.
4. Re-insert the carbon brushes into their holders and snap the tension springs back into position.
5. Fix the external fan and pulley securely to the shaft.
6. Rotate the shaft by hand to verify it turns freely without any binding or noise.

Result

The structural assembly of the given DC machine was successfully dismantled, its constituent components were identified and evaluated, and the machine was fully reassembled.

EXPERIMENT NO. 02

Aim of the Experiment

To connect and run a DC shunt motor with a 3-point starter and change the direction of rotation (D.O.R.).

Apparatus Required

Sl. No.	Name of the Components	Range	Quantity
01	Insulated Combination Plier	150 mm	01
02	Screwdriver	200 mm	01
03	Electrician's Knife	50 mm	01
04	D.C. Shunt Motor	2 HP, 220 V	01
05	3-Point Starter	2 HP	01
06	D.C. Voltmeter	0–300 V	01
07	D.C. Ammeter	0–20 A	01
08	P.V.C. Cable	2.5 mm^2	As required

Theory

The D.O.R. of a D.C. shunt motor reverses either by changing the direction of current in the armature winding or in the shunt field winding.

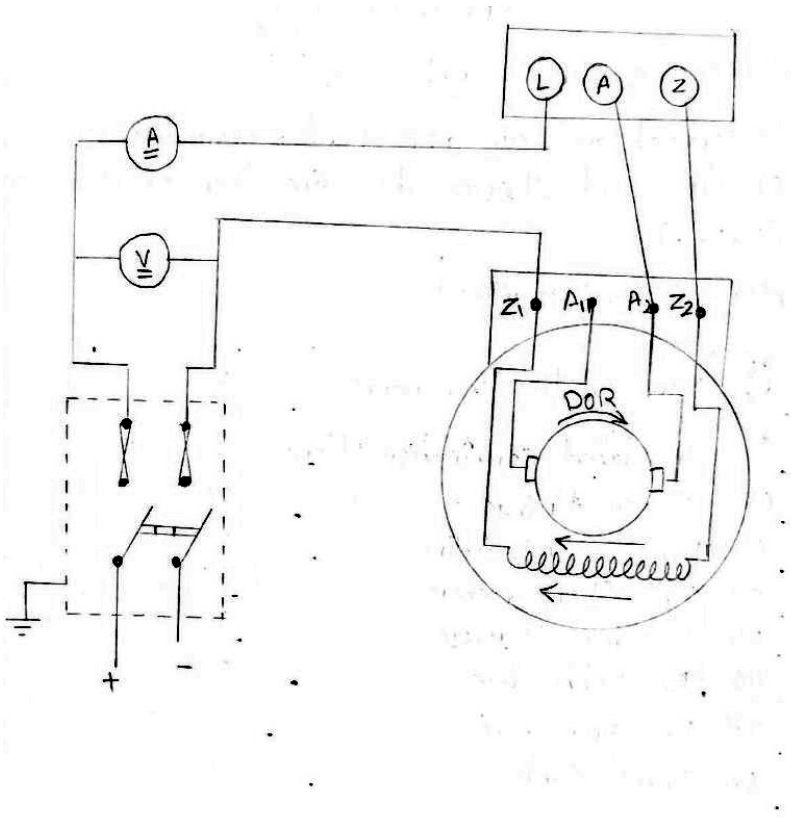


Fig. (a): Connection of DC shunt motor with 3-point starter

Procedure

1. Disconnect the supply of the 3-point starter.
2. Find out the terminals of the starter and motor by series testing board.
3. Make the connection as per the circuit diagram.
4. Switch on the power supply.
5. Now operate the handle of the starter towards the 'ON' position.
6. Move the handle gradually till the N.V.C. (No-Volt Coil) attracts the handle.
7. Observe the D.O.R. of the motor.
8. Stop the motor by operating the handle to the 'OFF' position.
9. Make the connection as per circuit diagram (b).
10. Again run the motor and observe the D.O.R. of the motor.
11. Stop the motor and make the connection as per circuit diagram (c). Again run the motor and observe the D.O.R. of the motor.
12. In this way, the D.O.R. of the motor is reversed.

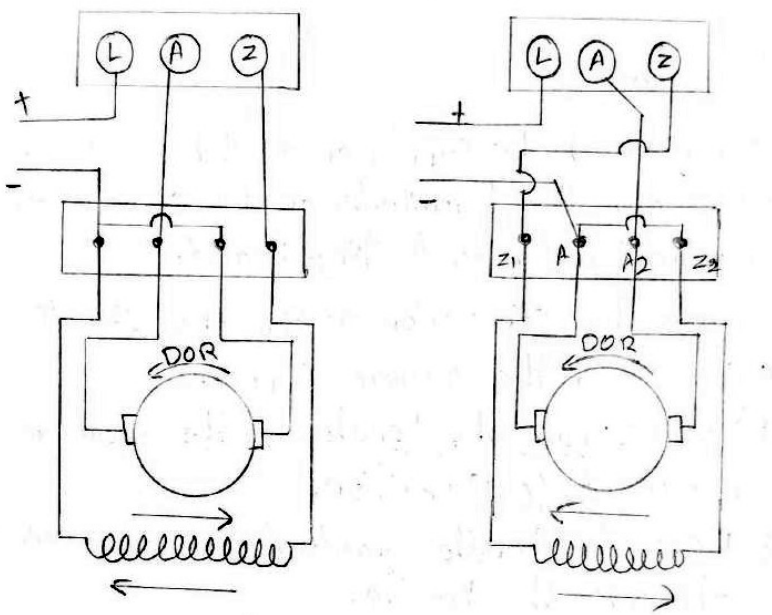


Fig. (b) and (c): Reversal of D.O.R. by changing armature / field connections

Conclusion

From the above experiment, I learnt how to reverse the D.O.R. of a shunt motor by changing the direction of current either in the armature winding or in the field winding.

EXPERIMENT NO. 03

Aim of the Experiment

To check the functioning of a single-phase transformer.

Apparatus Required

Sl. No.	Name of the Components	Range	Quantity
01	Insulated Combination Plier	150 mm	01 No.
02	Screwdriver	200 mm	01 No.
03	Electrician's Knife	50 mm	01 No.
04	Line Tester	500 V	01 No.
05	Single-Phase Variac	0–270 V	01 No.
06	Single-Phase Transformer	2 kVA, 230/115 V	01 No.
07	Voltmeter (M.I. Type)	0–300 V	02 Nos.
08	P.V.C. Cable	1.5 mm^2	As required

Theory

Transformer

A transformer is a static device which transfers power from one circuit to another circuit without changing the frequency.

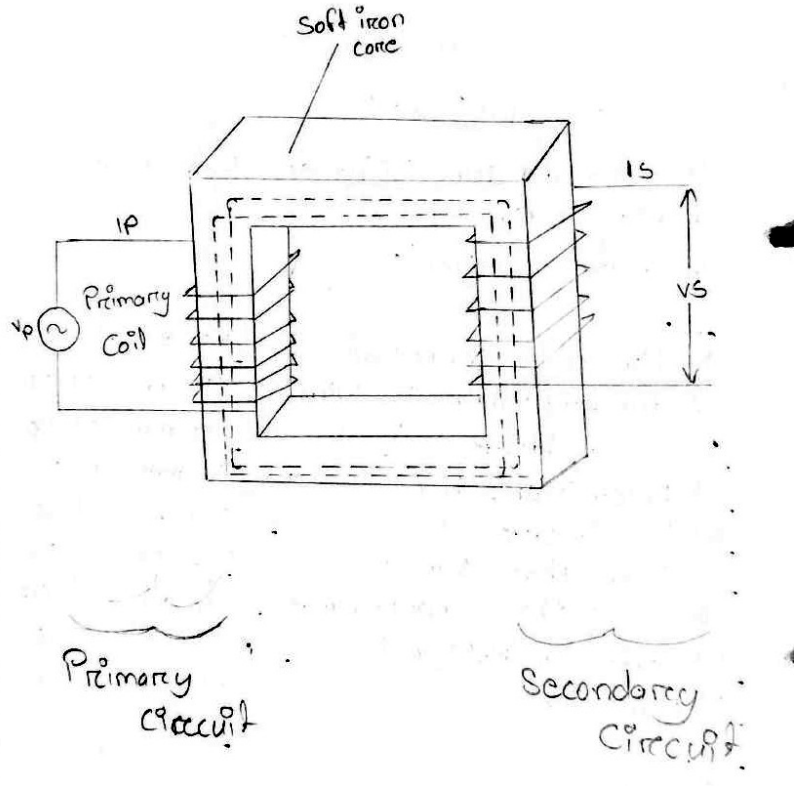


Fig.: Single-phase transformer

Functioning of Transformer

1. An alternating voltage (V1) is applied to the input coil known as the primary winding.
2. This alternating current generates a continuously changing magnetic field and alternating magnetic flux within the core.
3. The changing magnetic flux passes through the secondary winding with the help of the iron core.
4. It induces an E.M.F. across the secondary winding on the principle of mutual induction.
5. When a load is connected to the secondary winding, an alternating current flows through the secondary circuit, successfully transferring power.

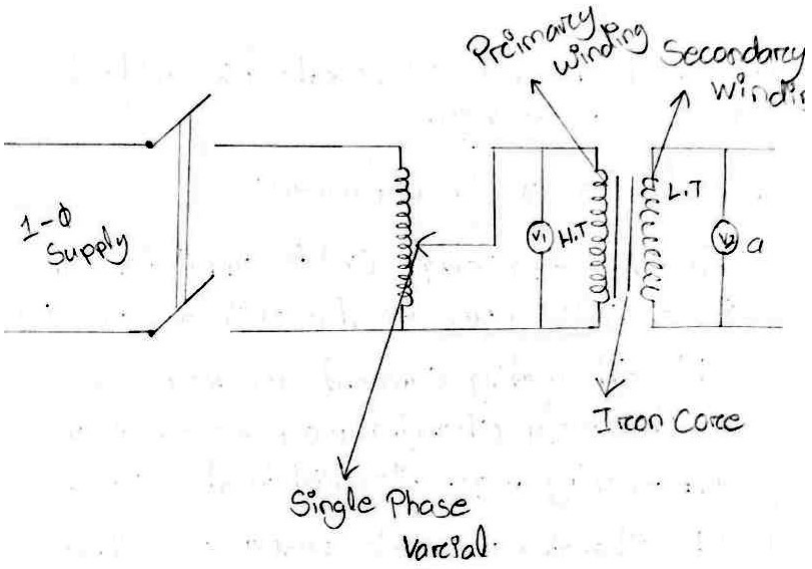


Fig.: Circuit diagram for checking the functioning of a single-phase transformer

Procedure

1. Connect the 1-φ variac, 1-φ transformer, voltmeters V1 and V2 as per the circuit diagram.
2. Switch on the power supply.
3. Vary the 1-φ variac.
4. Observe the primary voltage V1 and secondary voltage V2.

Observation Table

Sl. No.	Primary Voltage (V1) in Volts	Secondary Voltage (V2) in Volts
01	224	113
02	200	102
03	190	96
04	180	93
05	160	78
06	140	70
07	120	60
08	100	50
09	80	40
10	60	32
11	40	21
12	20	11

Conclusion

From the above experiment, I came to know how to check the functioning of a 1-φ transformer.

EXPERIMENT NO. 04

Aim of the Experiment

To perform the open circuit test and short circuit test to determine the equivalent circuit parameters and efficiency.

Apparatus Required

Sl. No.	Components Required	Range	Quantity
01	Insulated Combination Plier	150 mm	1 No.
02	Screwdriver	200 mm	1 No.
03	Wire Stripper	100 mm	1 No.
04	Line Tester	0–500 V	1 No.
05	Ammeter (M.I. Type)	0–5 A	1 No.
06	Ammeter (M.I. Type)	0–10 A	1 No.
07	Voltmeter	0–300 V	1 No.
08	1-φ Variac	0–270 V	1 No.
09	1-φ Transformer	220 V/115 V, 1 kVA	1 No.
10	Wattmeter	5 A, 0–1000 W	1 No.
11	P.V.C. Wire	1.5 mm^2, 650 V grade	As required

Theory

Open Circuit Test

1. The open circuit test is performed to determine the iron loss of the transformer.
2. In the open circuit test, the high voltage side is kept open.
3. Wattmeter, ammeter, voltmeter and 1-φ variac are connected on the low voltage side.
4. In this test, rated voltage is applied to the L.V. side through the 1-φ variac.
5. The wattmeter reading shows the iron loss of the transformer.

Short Circuit Test

1. The short circuit test is performed to determine the copper loss of the transformer.
2. In this test, the L.V. side is short-circuited.
3. Instruments like the 1-φ variac, wattmeter, voltmeter and ammeter are connected to the H.V. side of the transformer.
4. The H.V. side voltage is gradually increased with the help of the 1-φ variac until full load current flows through the H.V. side.
5. Then the wattmeter shows the copper loss of the transformer.

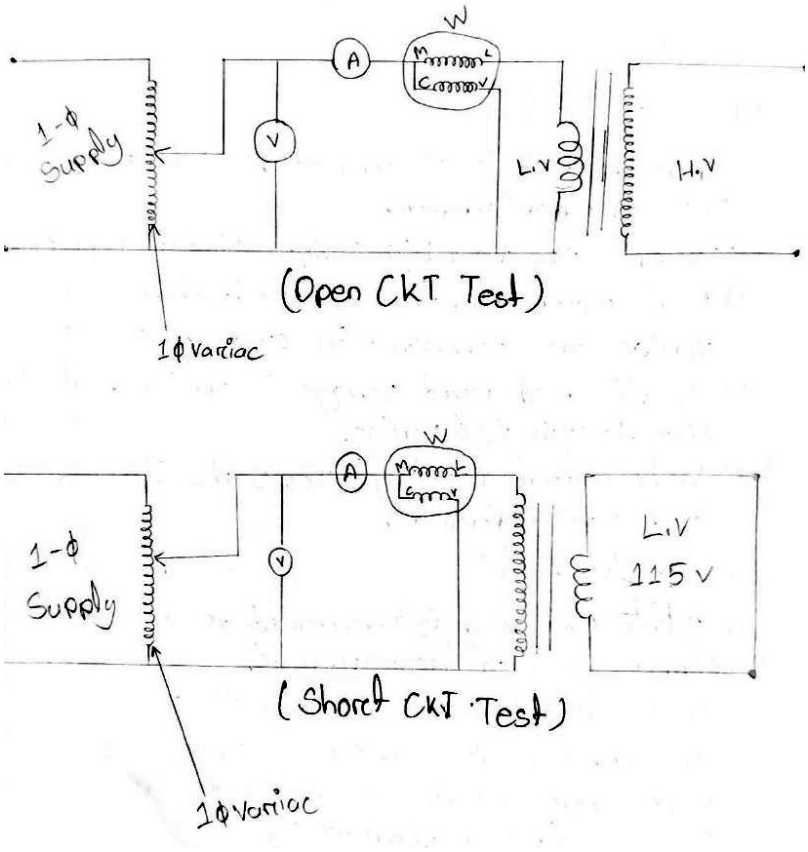


Fig.: Circuit diagrams for open circuit test and short circuit test

Procedure for Open Circuit Test

1. Open the high voltage side of the transformer.
2. Connect the 1-φ variac, ammeter, voltmeter and wattmeter as per the circuit diagram on the low voltage side.
3. Switch on the power supply through the 1-φ variac.
4. Gradually increase the voltage with the help of the 1-φ variac until it reaches the rated voltage of the low voltage side.
5. After that, note down the readings of the ammeter, voltmeter and wattmeter in the observation table.
6. The wattmeter will indicate the iron loss of the transformer.

Procedure for Short Circuit Test

1. Short-circuit the low voltage side of the 1-φ transformer with a thick copper wire.
2. Connect the 1-φ variac, ammeter, voltmeter and wattmeter on the high voltage side.
3. Keep the variac at the '0' position.
4. Switch on the power supply.
5. Gradually increase the voltage of the H.V. side with the help of the 1-φ variac until full load current flows through the H.V. side.
6. After that, note down the readings of the ammeter, voltmeter and wattmeter in the observation table.

7. The wattmeter will indicate the copper loss of the transformer.

Observation Table

Open Circuit Test

Ammeter Reading (I0) in Ampere	Voltmeter Reading (V0) in Volts	Wattmeter Reading (W0) in Watts (Iron Loss)
0.6 A	115 V (rated L.V.)	24 W (core loss, Pi)

Short Circuit Test

Ammeter Reading (Isc) in Ampere	Voltmeter Reading (Vsc) in Volts	Wattmeter Reading (Wsc) in Watts (Copper Loss)
8.7 A	18 V	98 W (copper loss, Pcu)

Calculation

No-load power factor:

$$\cos \varphi 0 = W0 / (V0 \times I0) = 24 / (115 \times 0.6) = 0.348$$

Magnetizing current:

$$Im = I0 \sin \varphi 0 \ \ (\varphi 0 = \cos^{-1} 0.348) = 0.6 \times 0.937 = 0.5 \ A$$

Core loss current:

$$Iw = I0 \cos \varphi 0 = 0.6 \times 0.348 = 0.20 \ A$$

Equivalent core resistance:

$$R0 = V0 / Iw = 115 / 0.209 \approx 550.2 \ \Omega$$

Magnetizing reactance:

$$X0 = V0 / Im = 115 / 0.562 \approx 204.6 \ \Omega$$

Equivalent impedance:

$$Z01 = Vsc / Isc = 18 / 8.7 \approx 2.07 \ \Omega$$

Equivalent resistance:

$$R01 = Wsc / Isc^2 = 98 / 8.7^2 = 1.30 \ \Omega$$

Equivalent reactance:

$$X01 = \sqrt{(Z01^2 - R01^2)} = 1.61 \ \Omega$$

Efficiency:

$$\% \eta = Output / (Output + Total losses) \times 100$$
$$= (kVA \times \cos \varphi) / (kVA \times \cos \varphi + Total losses) \times 100$$
$$= (2000 \times 0.8) / [2000 \times 0.8 + (Pi + Pcu)] \times 100$$
$$= 800 / [800 + (24 + 98)] \times 100 = 86.76\%$$

Conclusion

From the above experiment, I learnt how to determine the copper loss, iron loss and efficiency of a 1-φ transformer.

EXPERIMENT NO. 05

Aim of the Experiment

To connect an auto-transformer in step-up and step-down modes, note the input and output voltages, and compare the performance with that of a two-winding transformer.

Apparatus Required

Sl. No.	Name of the Components	Range	Quantity
01	Insulated Combination Plier	150 mm	1 No.
02	Screwdriver	200 mm	1 No.
03	Electrician's Knife	50 mm	1 No.
04	1-φ Transformer	230/115 V	1 No.
05	1-φ Variac or Auto-transformer	0–270 V	1 No.
06	Line Tester	0–500 V	1 No.
07	A.C. Voltmeter	0–300 V	2 Nos.
08	Connecting Wires	1.5 mm^2	As required

Theory

An auto-transformer has a single winding, part of which is common to both the primary and secondary circuits. Power is therefore transferred partly by induction and partly by direct conduction through the common portion.

Auto-transformers are lower in cost and smaller in size. They have lower losses, higher efficiency and better voltage regulation.

The main disadvantage is that the primary and secondary are electrically connected, so there is no isolation. If the common portion becomes open-circuited, the full primary voltage appears across the load. For this reason, they are not used where the ratio is large or where isolation is required.

They are used for starting induction motors, for interconnecting systems of nearly equal voltage, and as laboratory variacs.

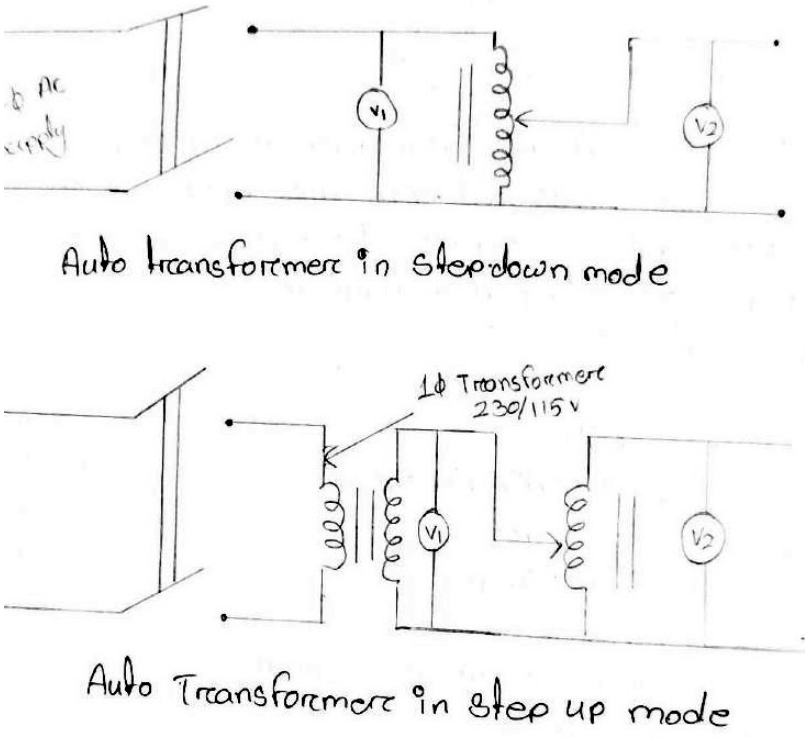


Fig.: Auto-transformer in step-down mode and step-up mode

Procedure

1. Note the nameplate details of the auto-transformer.
2. Step-down mode: Connect the supply across the full winding and take the output from the tapping point, with meters on both sides.
3. Switch on the power supply, set the input to the rated value and note V1 and V2.
4. Switch off the power supply.
5. Step-up mode: Connect the supply across the tapped portion and take the output across the full winding, and repeat the same set of measurements.
6. Tabulate the results and compare the two modes.

Observation Table

Step-Down Mode

Sl. No.	V1 in Volts	V2 in Volts	K = V2 / V1
01	230 V	115 V	0.5
02	230 V	180 V	0.78
03	230 V	200 V	0.86

Step-Up Mode

Sl. No.	V1	V2	K = V2 / V1
01	115	230	2

Sl. No.	V1	V2	K = V2 / V1
02	115	200	1.73
03	115	180	

Conclusion

From the above experiment, I learnt how to connect an auto-transformer in step-up and step-down mode.

EXPERIMENT NO. 06

Aim of the Experiment

To control the speed of a DC shunt motor by the field flux control method and by the armature voltage control method.

Apparatus Required

Sl. No.	Name of the Components	Range	Quantity
01	Insulated Combination Plier	150 mm	01 No.
02	Screwdriver	200 mm	1 No.
03	Electrician's Knife	50 mm	1 No.
04	Line Tester	0–500 V	1 No.
05	DC Shunt Motor with 3-Point Starter	3 HP, 220 V	1 No.
06	Field Rheostat	0–100 Ω	1 No.
07	Armature Rheostat	0–50 Ω	1 No.
08	DC Voltmeter	0–300 V	1 No.
09	DC Ammeter	0–2 A	1 No.
10	DC Ammeter	0–10 A	1 No.
11	Tachometer	—	1 No.
12	Connecting Wires	2.5 mm²	As required

Theory

For a DC shunt motor, the speed is given by:

$$N = (V - Ia\,Ra) / (K\,\varphi)$$

So, the speed can be varied by changing either the flux φ or the voltage applied to the armature.

Field Flux Control Method

In this method, a field rheostat is connected in series with the shunt field, which reduces the field current and hence the flux, so the speed rises above the rated value. This method is simple, economical and gives smooth control with little loss because the field current is small, but speeds below rated speed cannot be obtained, and at a very weak field the machine becomes unstable and commutation deteriorates. It is a constant power method.

Armature Voltage Control Method

In this method, a rheostat in series with the armature reduces the voltage available at the armature, and hence the speed falls below the rated value. It gives speeds below rated speed only, and is wasteful because the Ia^2R loss in the rheostat is large, and the speed regulation is also poor. It is a constant torque method.

Procedure

1. Connect the motor circuit with the field rheostat in series with the shunt field and the armature rheostat in series with the armature, along with the starter and meters.
2. Keep the field rheostat at minimum resistance and the armature rheostat at zero (0), switch on the supply and start the motor.
3. **Field Control:** Keeping the armature voltage constant at the rated value, increase the field rheostat resistance in steps. At each step, record the field current and speed until the maximum permissible speed is reached.
4. Restore the field rheostat to minimum resistance.
5. **Armature Control:** Keeping the field current constant at its rated value, increase the armature rheostat resistance in steps. At each step, record the armature voltage and speed.
6. Bring the motor back to rated conditions and switch off through the starter.

Observation Table

Field Flux Control Method

Sl. No.	Field Current (If) in Ampere	Speed in R.P.M.

Armature Voltage Control Method

Sl. No.	Armature Voltage (Va) in Volts	Speed in R.P.M.

Conclusion

From the above experiment, I learnt how to control the speed of a DC shunt motor by the field flux control method and the armature voltage control method.

EXPERIMENT NO. 07

Aim of the Experiment

To perform the brake test on a DC series motor and determine its performance characteristics.

Apparatus Required

Sl. No.	Name of the Components	Range	Quantity
01	DC Series Motor with Brake Drum	3 HP, 220 V	1 No.
02	2-Point Starter	3 HP	1 No.
03	DC Voltmeter	0–300 V	1 No.
04	DC Ammeter	0–20 A	1 No.
05	Spring Balances	0–25 kg	2 Nos.
06	Tachometer	0–3000 RPM	1 No.
07	DPST Switch	32 A	1 No.
08	Connecting Wires	2.5 mm^2	As required

Theory

The brake test is a direct method of testing a DC motor. A belt is wound over the brake drum fixed to the motor shaft, and its two ends are attached to spring balances S1 and S2. The load on the motor is varied by tightening the belt.

$$Torque\ T = (S1 - S2) \times 9.81 \times r \quad (N\text{-}m)$$

where S1 and S2 are the spring balance readings in kg and r is the radius of the brake drum in metres.

$$Output\ power = 2\pi NT / 60 \quad (W)$$

$$Input\ power = V \times I \quad (W)$$

$$Efficiency\ \eta = (Output / Input) \times 100$$

Note: A DC series motor must never be started or run without load, because at no load its speed becomes dangerously high. The brake belt must be kept tight before starting.

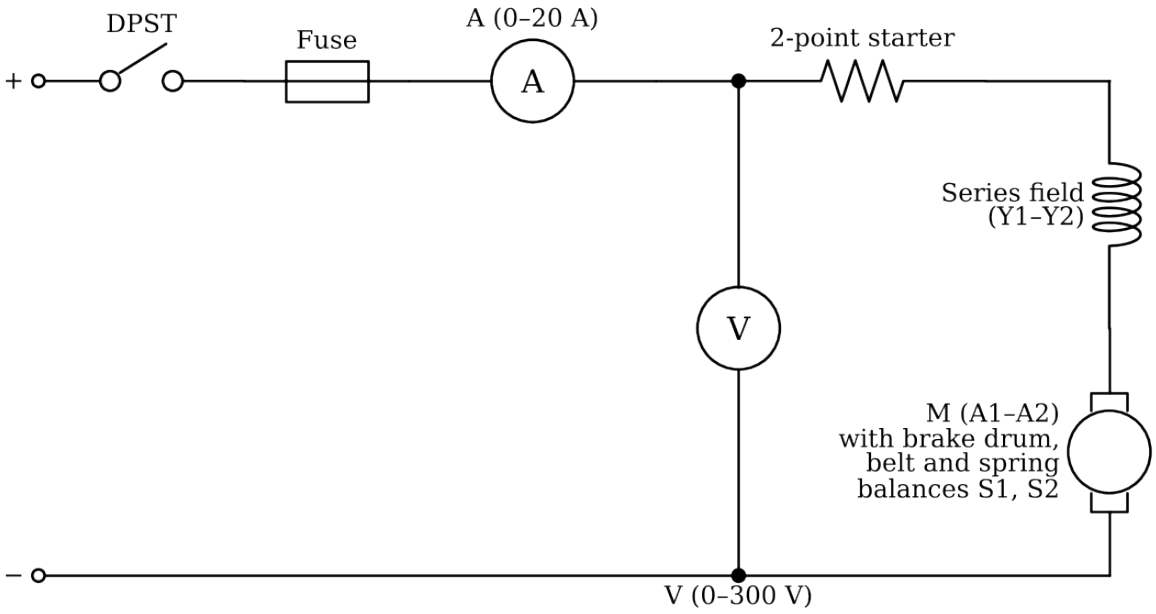


Fig.: Brake test on DC series motor

Procedure

1. Note the nameplate details of the motor and measure the radius of the brake drum.
2. Connect the circuit as per the circuit diagram.
3. Tighten the brake belt so that the motor starts with some load.
4. Switch on the DPST switch and start the motor slowly using the starter.
5. Note the readings of the voltmeter, ammeter, spring balances S1 and S2, and the speed.
6. Increase the load in steps by tightening the belt, and note all readings for each step until the rated current is reached.
7. Pour water inside the brake drum to keep it cool during the test.
8. Reduce the load (but do not remove it fully) and switch off the supply.

Observation Table

Radius of brake drum r = _____ m

Sl. No.	V (V)	I (A)	S1 (kg)	S2 (kg)	Speed N (RPM)	Torque T (N-m)	Output (W)	Input (W)	η (%)
01									
02									
03									
04									

Precautions

1. Never start or run the DC series motor without load.
2. The brake drum should be cooled with water.
3. Connections should be tight.

Result

The brake test on the DC series motor was performed, and its torque, output and efficiency were determined at different loads.

EXPERIMENT NO. 08

Aim of the Experiment

To determine the voltage regulation and efficiency of a single-phase transformer by direct loading.

Apparatus Required

Sl. No.	Name of the Components	Range	Quantity
01	1-φ Transformer	1 kVA, 230/115 V	1 No.
02	1-φ Variac	0–270 V	1 No.
03	Wattmeter	10 A, 300 V	1 No.
04	Ammeter (M.I. Type)	0–5 A	1 No.
05	Ammeter (M.I. Type)	0–10 A	1 No.
06	Voltmeter (M.I. Type)	0–300 V	2 Nos.
07	Lamp Load	1 kW, 230 V	1 No.
08	DPST Switch	16 A	1 No.
09	P.V.C. Wire	1.5 mm²	As required

Theory

In the direct loading test, the transformer is loaded with the actual load, and the input and output are measured directly.

Voltage regulation: When a load is connected, the secondary terminal voltage falls because of the voltage drop in the winding resistance and leakage reactance. The change in secondary voltage from no load to full load, expressed as a percentage of the no-load voltage, is called the voltage regulation.

$$\% \text{ Regulation} = [(V0 - V2) / V0] \times 100$$

where V0 is the secondary voltage at no load and V2 is the secondary voltage on load.

Efficiency:

$$\text{Output power} = V2 \times I2 \quad (\text{for resistive lamp load, } \cos\varphi = 1)$$

$$\text{Input power} = W \text{ (wattmeter reading)}$$

$$\text{Efficiency } \eta = (\text{Output} / \text{Input}) \times 100$$

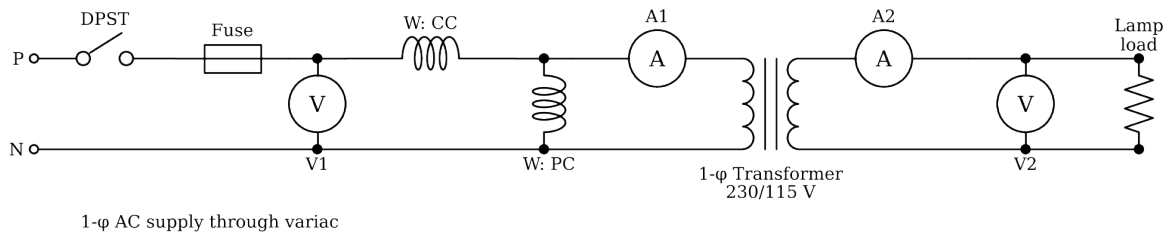


Fig.: Direct loading of single-phase transformer

Procedure

1. Connect the circuit as per the circuit diagram.
2. Keep the variac at the zero position and the load switched off.
3. Switch on the supply and increase the primary voltage to the rated value (230 V).
4. With no load, note the secondary voltage V0.
5. Switch on the load in steps and, at each step, note V1, I1, W, V2 and I2. Keep the primary voltage constant at the rated value.
6. Continue until the rated (full-load) current flows.
7. Switch off the load, reduce the variac to zero and switch off the supply.

Observation Table

No-load secondary voltage V0 = _____ V

Sl. No.	V1 (V)	I1 (A)	W (W)	V2 (V)	I2 (A)	Output V2 × I2 (W)	η (%)	% Regulation
01								
02								
03								
04								

Precautions

1. The primary voltage should be kept constant at the rated value.
2. The transformer should not be loaded beyond its rated current.
3. Connections should be tight.

Result

The voltage regulation and efficiency of the single-phase transformer were determined by direct loading.