ELECTRICAL MACHINE LAB MANUAL

Subject: Electrical Machine-I

Subject Code: ELPC 353

B.Tech 3rd Semester

Department of Electrical Engineering
J. C. Bose University of Science and Technology
YMCA, Faridabad-121 006

DEPARTMENT OF ELECTRICAL ENGINEERING

VISION OF THE DEPARTMENT

Electrical Engineering Department congregates the challenges of new technological advancements to provide comprehensively trained, career-focused, morally strong accomplished graduates, cutting-edge researchers by experimental learning which contribute to ever-changing global society and serve as competent engineers.

MISSION OF THE DEPARTMENT

- To commit excellence in imparting knowledge through incubation and execution of high-quality innovative educational programs.
- To develop the Research-oriented culture to build national capabilities for excellent power management.
- To inculcate and harvest the moral values and ethical behavior in the students through exposure of self -discipline and personal integrity.
- To develop a Centre of Research and Education generating knowledge and technologies which lay ground work in shaping the future in the field of electrical engineering.

PROGRAM OUTCOMES (POs)

Graduates of the Electrical Engineering program at JCBUST, YMCA will be able to:

PO1. Apply knowledge of mathematics, science, engineering fundamentals, and electrical engineering specialization to the solution of engineering problems.

PO2. Identify, formulate, review literature, and analyze electrical engineering problems to design, conduct experiments, analyze data, and interpret data.

PO3. Design solutions for electrical engineering problems and design system components of processes that meet the desired needs with appropriate consideration for public health and safety and cultural, societal, and environmental considerations.

PO4. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions in electrical engineering.

PO5. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to electrical engineering activities with an understanding of the limitations.

PO6. Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7. Understand the impact of electrical engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development.

PO8. Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communicate effectively on complex engineering activities with the engineering committee and with society at large, such as being able to comprehend and write effective reports and design documentation, and make effective presentations in electrical engineering.

PO11. Demonstrate knowledge and understanding of the engineering principles and management principles and apply these to one‘s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Recognize the need for, and the preparation and ability to engage in independent research and lifelong learning in the broadest context of technological changes in electrical engineering.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1. To apply state-of-the-art knowledge in analysis design and complex problem solving with effective implementation in the multidisciplinary area of Electrical Engineering with due regard to environmental and social concerns.

PSO2. To prepare graduates for continuous self-learning to apply technical knowledge and pursue research in advanced areas in the field of Electrical Engineering for a successful professional career to serve society ethically.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1. To produce competent electrical engineering graduates with a strong foundation design, analytics and problem-solving skills for successful professional careers in industry, research and public service.

PEO2. To provide a stimulating research environment so as to motivate the students for higher studies and innovation in the specific and allied domains of electrical engineering.

PEO3. To encourage the graduates to practice the profession following ethical codes, social responsibility and accountability.

PEO4. To train students to communicate effectively in multidisciplinary environment.

PEO5. To imbibe an attitude in the graduates for life-long learning process.

Syllabus

Electrical Machines Lab-I (ELPC-353)

L-T-P **Internal Marks-15**
0-0-2 **ExternalMarks-35**
Total-50

List of Experiments

1. To study the constructional details of DC machine.
2. To perform Load test on DC shunt motor.
3. To study the construction and working of three-point DC machine starter.
4. To obtain the internal characteristics of DC shunt generator.
5. To obtain external characteristics of DC shunt generator.
6. To obtain the magnetization Characteristics of separately excited D.C Generator.
7. To obtain the external Characteristics of D.C. Series Generator.
8. Speed control of DC shunt motor by armature voltage control method.
9. Speed control of DC shunt motor by field control method.
10. To obtain the efficiency of DC machine using Swinburne's test.
11. To determine transformer parameters by short circuit and open circuit test.
12. To determine transformer losses by Sumpner's Test.
13. To perform parallel operation on two single phase transformers.
14. To convert three phase system in to two phase by Scott connection.

COURSE OBJECTIVES & OUTCOMES

Course Objectives:

1. To conduct various tests on single phase transformer to determine its parameters.
2. To conduct tests on single phase transformer to determine performance characteristics.
3. To conduct test on DC generator to determine the performance characteristics.
4. To conduct test on DC motor to draw the performance curves.

Course Outcomes:

At the end of the course the student will be able to:

CO1. Students will be able to Perform various tests on single phase transformer to assess its performance

CO2. Students will be able to Perform tests on DC generators to determine magnetization characteristics.

CO3. Students will be able to Conduct tests on DC generators to determine internal and external characteristics.

CO4. Students will be able to Conduct test on DC motor to draw the performance curves.

Mapping of Course Outcomes (COs) with POs and PSOs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3	1	1	1	2	2	2	2	3	2
CO2	3	3	2	3	3	1	1	1	2	2	2	2	3	2
CO3	3	3	2	3	3	1	1	1	2	2	2	2	3	2
CO4	3	3	2	3	3	1	1	1	2	2	2	2	3	2

Justification:

CO1: Perform various tests on single-phase transformers to assess their performance.

- **PO1 (3):** Strongly related as it requires applying knowledge of electrical engineering fundamentals.
- **PO2 (3):** Strongly related as it involves analyzing data from transformer tests.
- **PO3 (2):** Moderately related as designing test setups involves some design considerations.
- **PO4 (3):** Strongly related due to the need for experimental data analysis.
- **PO5 (3):** Strongly related because modern tools are used for testing and analysis.
- **PO6 (1):** Weakly related as societal and ethical considerations are less directly involved.
- **PO7 (1):** Weakly related since sustainability aspects are not the primary focus.
- **PO8 (1):** Weakly related as ethical principles are not the primary concern in performing tests.
- **PO9 (2):** Moderately related as tests can be performed individually or in teams.
- **PO10 (2):** Moderately related as results need to be reported effectively.
- **PO11 (2):** Moderately related due to project management in testing setups.
- **PO12 (2):** Moderately related due to the need for ongoing learning of test methods.
- **PSO1 (3):** Strongly related as it involves state-of-the-art knowledge in electrical testing.
- **PSO2 (2):** Moderately related as it supports learning and research in transformer performance.

CO2: Perform tests on DC generators to determine magnetization characteristics.

- **PO1 (3):** Strongly related as it requires applying foundational knowledge.
- **PO2 (3):** Strongly related as it involves analyzing generator characteristics.
- **PO3 (2):** Moderately related as testing requires some design of experiments.
- **PO4 (3):** Strongly related due to the necessity of data interpretation and analysis.
- **PO5 (3):** Strongly related because modern testing techniques and tools are used.
- **PO6 (1):** Weakly related to societal, health, or safety aspects.
- **PO7 (1):** Weakly related to environmental sustainability concerns.

- **PO8 (1):** Weakly related as ethical considerations are minimal in testing procedures.
- **PO9 (2):** Moderately related as teamwork may be involved in testing processes.
- **PO10 (2):** Moderately related as communication of findings is important.
- **PO11 (2):** Moderately related as it involves managing testing projects.
- **PO12 (2):** Moderately related to continuous learning in electrical testing.
- **PSO1 (3):** Strongly related as it involves application of complex problem-solving skills.
- **PSO2 (2):** Moderately related to fostering ongoing learning and ethical practices.

CO3: Conduct tests on DC generators to determine internal and external characteristics.

- **PO1 (3):** Strongly related to the application of electrical engineering principles.
- **PO2 (3):** Strongly related as it involves problem analysis and data interpretation.
- **PO3 (2):** Moderately related due to experimental design elements.
- **PO4 (3):** Strongly related for analysis and synthesis of test results.
- **PO5 (3):** Strongly related with the use of modern tools and techniques.
- **PO6 (1):** Weakly related to societal and safety implications.
- **PO7 (1):** Weakly related as environmental impacts are minimal.
- **PO8 (1):** Weakly related to professional ethics in this context.
- **PO9 (2):** Moderately related as testing may involve collaboration.
- **PO10 (2):** Moderately related to effective communication of results.
- **PO11 (2):** Moderately related as it includes aspects of project management.
- **PO12 (2):** Moderately related due to continuous engagement in learning test methodologies.
- **PSO1 (3):** Strongly related to complex problem-solving in generator performance testing.
- **PSO2 (2):** Moderately related to ongoing technical development and research skills.

CO4: Conduct tests on DC motor to draw performance curves.

- **PO1 (3):** Strongly related through application of electrical engineering knowledge.
- **PO2 (3):** Strongly related as it involves analysis of motor performance data.
- **PO3 (2):** Moderately related due to design considerations in testing setups.
- **PO4 (3):** Strongly related because of the need for experimental research and data synthesis.
- **PO5 (3):** Strongly related through the application of modern testing tools.
- **PO6 (1):** Weakly related to societal, health, and safety considerations.
- **PO7 (1):** Weakly related since environmental impact is minimal.
- **PO8 (1):** Weakly related to ethical principles in testing.
- **PO9 (2):** Moderately related as teamwork can enhance the testing process.
- **PO10 (2):** Moderately related due to the need for clear communication of test results.

- **PO11 (2):** Moderately related as it involves managing testing and results reporting.
- **PO12 (2):** Moderately related through the necessity for ongoing learning in motor testing.
- **PSO1 (3):** Strongly related to practical application of advanced knowledge and skills.
- **PSO2 (2):** Moderately related to fostering self-learning and research in electrical engineering.

||General Instructions||

1. Students should come well-prepared for the experiment they will be conducting.
2. Usage of mobile phones in the laboratory is strictly prohibited.
3. In the lab, wear shoes and avoid loose-fitting clothes.
4. Read and understand the experiment manual thoroughly before starting the experiment. Know the objectives, procedures, and safety precautions.
5. Before starting the experiment, check the condition of the equipment, wiring, and connections. Report any damaged or malfunctioning equipment to the lab instructor immediately.
6. Ensure all connections are made as per the circuit diagram. Double-check all connections before powering the equipment.
7. Do not switch on the power supply until the instructor has approved your setup. Always start with the minimum voltage/current required and gradually increase as needed.
8. Do not overload machines beyond their rated capacity. Overloading can damage the equipment and pose safety risks.
9. Familiarize yourself with the lab's emergency shutdown procedures, including the location of emergency switches and fire extinguishers.
10. Do not bring food or drinks into the lab to avoid accidental spills, which can lead to electrical hazards.
11. Stay attentive during the experiment. Avoid distractions like mobile phones, and do not engage in unnecessary conversation during lab work.
12. Accurately record all measurements and observations during the experiment. Ensure that all data is properly noted in your lab report.
13. If you are unsure about any procedure or face difficulties during the experiment, do not hesitate to ask the lab instructor for guidance.
14. After completing the experiment, switch off the power supply, disconnect the setup, and return all equipment to its proper place. Ensure the workspace is clean and organized.

Electrical Machines-I Lab
(ELPC-353)
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Experiment No. 1

Aim: To study the constructional details of DC machine**.**

Apparatus Required:

S No.	Apparatus	Range	Type	Quantity

Theory:

Rotating Electrical Machines are used for Electro-mechanical energy conversion i.e. Generators convert Mechanical Energy to Electrical Energy and Motors convert Electrical Energy to Mechanical Energy. All the Rotating Electrical Machines have same basic construction that is they have two parts: Stator, the part of the machine which remains stationery and Rotor, the part of machine to which mechanical energy is associated by virtue of its rotation.

Similarly, In DC motor there are two types of windings as in all other Rotating Machines, Field Winding which is responsible for production of flux and Armature Winding which carries high current from the supply in motors and to the load in case of Generators.

When energy is converted from Electrical Energy to Mechanical Energy, then it is first converted to Magnetic Energy and then to Mechanical Energy and hence Magnetic Energy acts an intermediate stage between Electrical and Mechanical Energy. Flux is required to be produced in machines in order to store energy in Magnetic Domain and this requires consumption of Reactive Power and hence Reactive Power is indispensable when it comes to Electrical Machines as all machines require a flux to work upon.

Construction Details of DC Machines:

DC Machine has two parts Stator and Rotor. The field winding if DC Machines is wound on the Stator and Armature Winding is wound on the Rotor. Different parts of Stator and Rotor have been explained below:

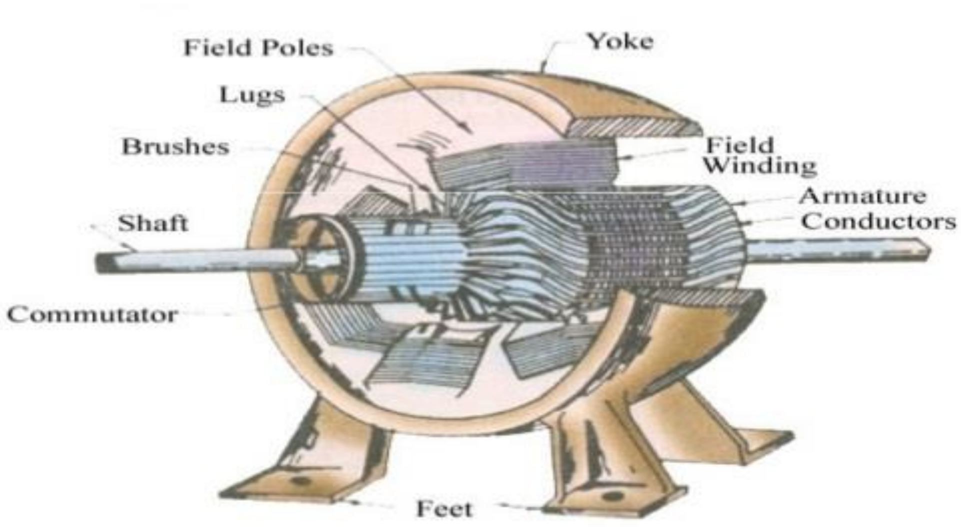


Fig: Cut Section View of the DC Machine

Yoke:

It provides path for pole flux and carries half of it. It provides mechanical support to whole machine. Cast iron is used for small DC machines and fabricated steel for large dc machines. If DCmachine is operated through power electronic converter, then yoke is laminated else not.

Field Poles:

It consists of pole core and pole shoe. Pole core is made of cast steel but pole shoe is laminated and fixed to pole core appropriately. At present both pole shoe and pole core are laminated.

Field Winding:

The pole excited by a winding wound around pole core. The winding is made from copper. Number of turns and cross-section of field winding depend on type of DC machine. For DC shunt machine, large number of turns and small cross-section because field winding has entire terminal voltage across it so large number of turns and larger length of conductor which implies high resistance so field current is small. For DC series machine, number of turns and large cross section as the field winding carries armature current so which is high so larger cross section area which implies low resistance so less voltage drop and hence a smaller number of turns. For DC compound machines, both windings are employed.

Interpoles:

Fixed to Yoke in between main poles of DC machine. Tapered with sufficient cross-sectional area and wider at bottom to avoid magnetic saturation. Inter pole winding consists of a few turns of thick wire is connected in series to armature. So, a MMF is directly proportional to armature current.

Compensating winding:

Placed in slots cut in poles of a DC machine. These are Connected in series with armature and are used in large dc machines only.

Brushes:

Housed in box type brush holders attached to stator end cover or yoke. A small spring keeps them pressed to commutator. Made of carbon in small DC machines, electro graphite for all and copper graphite for low-voltage, high current dc machines.

Armature core:
Serves purpose of having armature coil in slots and providing low reluctance path to magnetic flux and is Made of 0.35mm to 0.50 mm, thick lamination of Si – steel to keep down iron losses.

Result:
The study of construction of DC motor is done successfully.

Viva Questions

Q.1 What are the main parts of a DC machine?
Q.2 What is the function of the yoke in a DC machine?
Q.3 What material is commonly used for the yoke and why?
Q.4 Describe the role of the armature core in a DC machine.
Q.5 What is the purpose of the commutator in a DC machine?
Q.6 How do brushes function in a DC machine?
Q.7 What is the significance of pole shoes in a DC machine?
Q.8 Why are the armature windings of a DC machine laminated?
Q.9 What is the role of the poles and pole shoes?
Q.10 Why are the poles and pole shoes laminated?
Q.11 What is the armature core made of?
Q.12 What is the purpose of the commutator in a DC machine?
Q.13 What materials are used for brushes in a DC machine?
Q.14 What is the function of the bearings in a DC machine?
Q.15 How does the armature winding contribute to the operation of a DC machine?

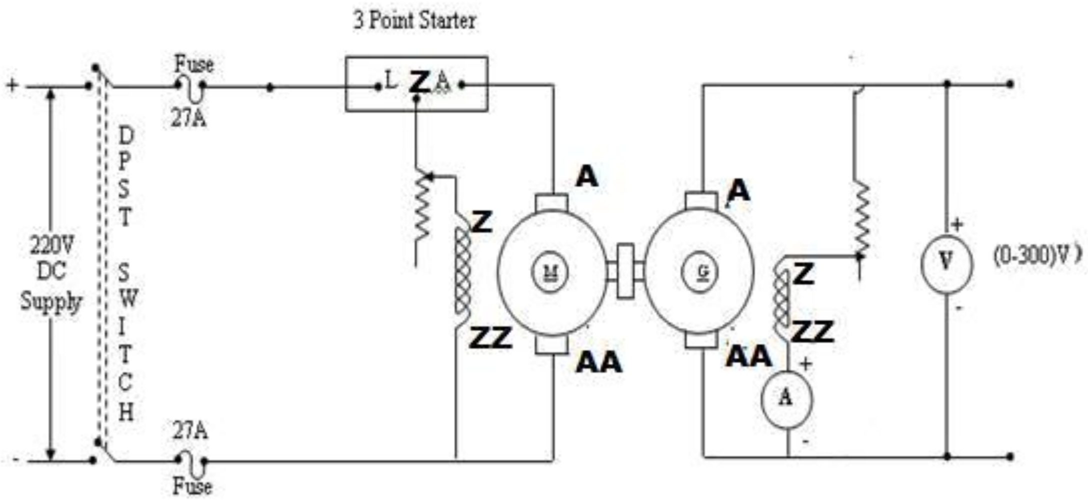
Experiment No. 2

Aim: To perform Load test on DC shunt motor.

Apparatus Required:

S No.	Apparatus	Range	Type	Quantity

Circuit Diagram:



Theory:

The speed torque curve of a dc motor is an important characteristic. At the rated output torque, the armature is at its rated value and so is the speed. Now, suppose that the load torque is reduced. The armature current becomes correspondingly smaller. This results in higher speed. The extent to which speed increases depends upon how large the drop I_aR_a is in comparison to the terminal voltage V.

Procedure:

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, and minimum field rheostat position, DPST switch isclosed and starter resistance is gradually removed.
3. The motor is brought to its rated speed by adjusting the field rheostat.
4. Ammeter, Voltmeter readings, speed and spring balance readings are noted under no load condition.
5. The load is then added to the motor gradually and for each load, voltmeter, ammeter, springbalance readings and speed of the motor are noted.
6. The motor is then brought to no load condition and field rheostat to minimum position, thenDPST switch is opened.

Observation Table:

S No.	VoltageV_L (Volts)	Current I_L(Amps)

Result: The load test on the given D.C shunt motor has been completed successfully.

Precautions:

1. DC shunt motor should be started and stopped under no load condition.

2. Field rheostat should be kept in the minimum position.

Viva Questions:

Q.1 Why should the field rheostat be kept in the position of minimum resistance?
Q.2 How can the direction of rotation of a DC shunt motor be reversed?
Q.3 What are the mechanical and electrical characteristics of a DC shunt motor?
Q.4 What are the applications of a DC shunt motor?
Q.5 What is the purpose of a load test on a DC shunt motor?
Q.6 Why should the DC shunt motor be started and stopped under no-load conditions?
Q.7 What precautions should be taken during the load test?
Q.8 What happens to the speed of a DC shunt motor as the load increases?

Q.9 Which motor is called a constant speed dc motor?

Q.10 Why starter is used to start dc motor?

Experiment No. 3

Aim: To study about the construction and working of three-point DC machine starter.

Necessity of Starters:

The current drawn by the armature is given by the relation
I = (V-E)/R

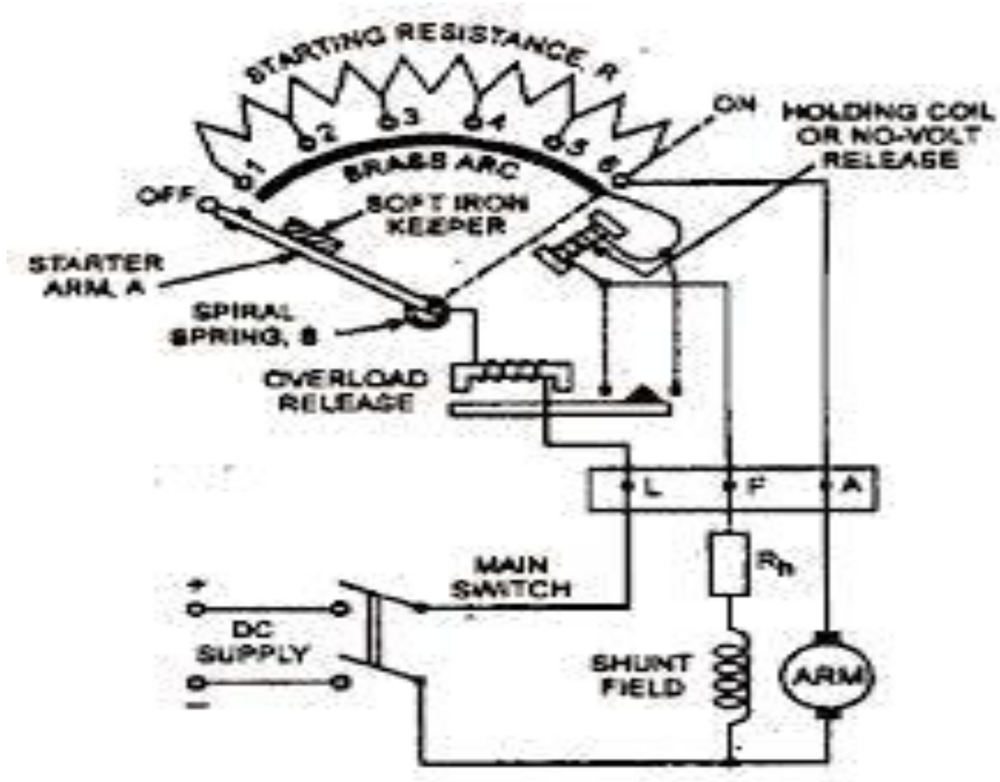
Where V is the supply voltage, E is the back EMF and R is the armature resistance.
When the motor is at rest, there is obviously a back the EMF developed in the armature. If now full supply voltage is developed across the stationary armature, it will draw a very large amount of current since the armature resistance is relatively small. Consider the case of a 44V, 5HP (373 KW) motor having a cold armature resistance of 0.25 and a full load current of 50A. If this motor is started from the line directly, it will draw a starting current of 400/0.25=1760A which is 1760/50=35.2 times its full load current. This excessive current will blow out the fuses and prior to that, it will damage the commutator and brushes. To avoid this happening a resistance is introduced in series with the armature (for the duration of starting period only, say 5 to 10 seconds) which limits the starting current to a safe value. The starting resistance is gradually cut out as the motor gains speed and develops the back emf which then regulates the speed.
Very small motor may, however be started from rest by connecting them directly to the supply lines. It does not result in any harm to the motor for the following reasons:

1. Such motors have a relatively high armature resistance than large motors, hence their startingis not so high.
2. Being small, they have low moment of inertia, hence they speed up quickly
3. The momentary large starting current taken by them is not sufficient to produce a large disturbance in the voltage regulation of the supply lines.

In fig.1 is shown the resistance R used for starting a shunt motor. It will be seen that the starting resistance R is in series with the armature and does not with the motor as a whole.

The field winding is connected directly across the lines. Hence shunt field current is independent of the resistance R. If R were introduced in the motor circuit, then Ish will be small at the start hence starting torque Tst would be small and there would be some difficulty in starting a motor.

Working of Three- Point Starter



The internal wiring for such a starter is shown in the fig and it is seen that basically the connections are the same as in the fig except for the additional protective devices used here. The three terminals of the starting box are marked as A, B, C. One line is directly connected to one armature terminal and one field terminal which are tied together. The other line is connected to point A which is further connected to the starting arm L, through the over–current (or over load) release M.

To start the motor, the main switch is first closed and then the starting arm is slowly move to the right. As soon as the arm makes contact with stud no.1, the field circuit is directly connected across the line and at the same time full starting resistance Rs is placed in series with the armature. The starting current drawn by the armature=V/(Ra+Rs) where Rs is the startingresistance. As the arm is further moved, the starting resistance is gradually cut out till, when the arm reaches the running position, the resistance is all cut out. The arm moved over the various studs against a strong spring which tends to restore it to OFF position. There is a soft iron piece Sattached and held by an electromagnet E energized by the shunt current. It is variously known as “HOLD-ON” coil, LOW-VOLTAGE (or NO-VOLTAGE) realize. It will be seen that as the arm is moved from stud 1 to the last stud, the field current has to travel back through that portion of the starting resistance that has been cut out of the armature circuit. This results in slight decrease of shunt current. But as the value of starting resistance is very small as compared to shunt field resistance, this slight decrease in I is negligible. This defect can, however, be remedied by usinga brass are which is connected to stud.

The normal function of HOLD-ON coil is to hold the arm in the full running position when the motor is in running position. But, in case of failure or disconnecting of the supply or break in the field circuit, it is de-energized thereby releasing the arm which is pulled back by the spring to the OFF position. This prevents the stationary armature from being put across the lines again when the supply when the supply is restored after temporary shutdown. This would have happened if the arm were left in the full null position. One great advantage of connecting the HOLD-ON coil in series with the shunt field is that, should the field circuit become open, the starting arm immediately springs back to the OFF position thereby preventing the motor from running away.

The over-current release consists of electromagnet connected in the supply line. If the motor becomes over-loaded beyond a certain predetermined value, then D is lifted and short-circuits the electromagnet. Hence, the arm is released and returns to OFF position.

The form of over-load protection described above is becoming obsolete, because it cannot be made either as accurate or as reliable as a separate well-designed circuit breaker with a suitable time element attachment. Many a times a separate magnetic contractor with an overload relay is also used.

Often the motors are protected by thermal overload relays in which a bimetallic strip is heated by the motor is itself heating up. Above a certain temperature, this relay trips and opens the line contractor thereby isolating the motor from the supply. It is desired to control the speed the motor in addition, then a field rheostat is connected in the field circuit as shown in the fig. The motor speed can be increased by weakening the flux. Obviously, there is a limit to the speed increase obtained in this way, although speed ranges of three or four are possible. If too much resistance is „cut-in‟ by the field rheostat, then field current is reduced very much so that it is unable to create enough electromagnetic pull to overcome the spring tension. Hence, the arm is pulled back to OFF position. It is this undesirable feature of a three-point starter which it makes it unsuitable for use with variable speed motors.

Result:

Thus, the construction and operation of DC machine starter is studied.

Viva Questions:

Q.1 What are the main components of a three-point starter?
Q.2 What is the purpose of the starting resistance in a three-point starter?
Q.3 What protective devices are included in a three-point starter?

Q.4 What happens when the starter handle is moved to the first stud?

Q.5 What role does the no-volt release (NVR) play during normal operation?

Q.6 What are the advantages of using a three-point starter?

Q.7 What is the purpose of the overload release (OLR)?

Q.8 What is the function of the no-volt release (NVR) coil?

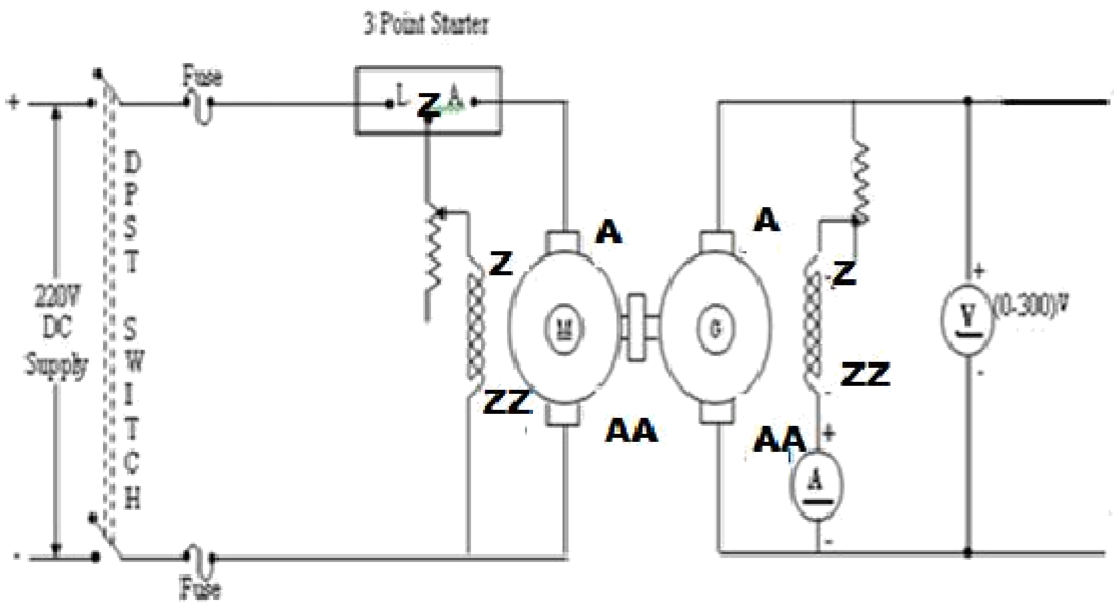
Experiment No. 4

Aim-: To obtain the internal characteristics of DC shunt generator.

Apparatus Required:

S.No.	Apparatus	Range	Type	Quantity

Circuit Diagram:



Theory:

The internal load characteristics of DC shunt generator is plotted between V and IL. In this we consider only drop due to armature reaction only. Drop due to ohmic losses are not considered in the internal characteristics.

Basically, the internal characteristics of DC shunt generator can be easily obtained by computing these equations.

Eg = V + Ia Ra (Volts)

Ia = IL + If (Amps)

Eg : Generated emf in Volts

V : Terminal Voltage in Volts

Ia : Armature Current in Amps

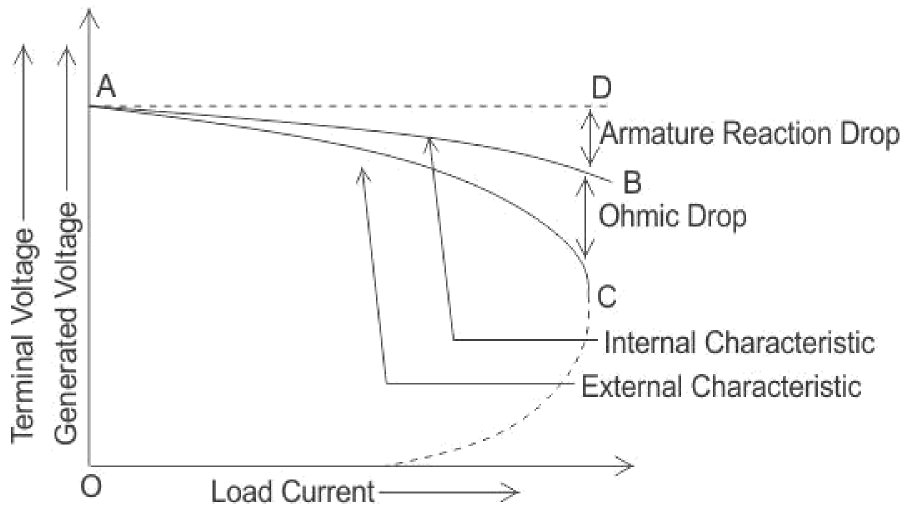
IL : Line Current in Amps

If : Field Current in Amps

Ra : Armature Resistance in Ohms

Procedure (obtain load characteristic):

1. Connections are made as per the circuit diagram.
2. After checking minimum position of DC shunt motor field rheostat and maximum position of DCshunt generator field rheostat, DPST switch is closed and starting resistance is gradually removed.
3. Under no load condition, Ammeter and Voltmeter readings are noted, after bringing the



voltage to rated voltage by adjusting the field rheostat of generator.

4. Load is varied gradually and for each load, voltmeter and ammeter readings are noted.
5. Then the generator is unloaded and the field rheostat of DC shunt generator is brought to maximumposition and the field rheostat of DC shunt motor to minimum position, DPST switch is opened.

S.No.	Voltage VL (Volts)	Load Current IL (Amps)

Result: Thus, the load characteristics of DC shunt generator is determined.

Precautions:

1. The field rheostat of motor should be at minimum position.

2. The field rheostat of generator should be at maximum position.

3. No load should be connected to generator at the time of starting and stopping

Viva Questions:

Q.1 What is the internal characteristic of a DC shunt generator?

Q.2 Why does the generated voltage decrease under load in a DC shunt generator?

Q.3 What is the effect of armature reaction on the internal characteristics of a DC shunt generator?

Q.4 How does the internal characteristic curve differ from the open circuit characteristic (O.C.C.)?

Q.5 What is the difference between internal and external characteristics of a DC shunt generator?

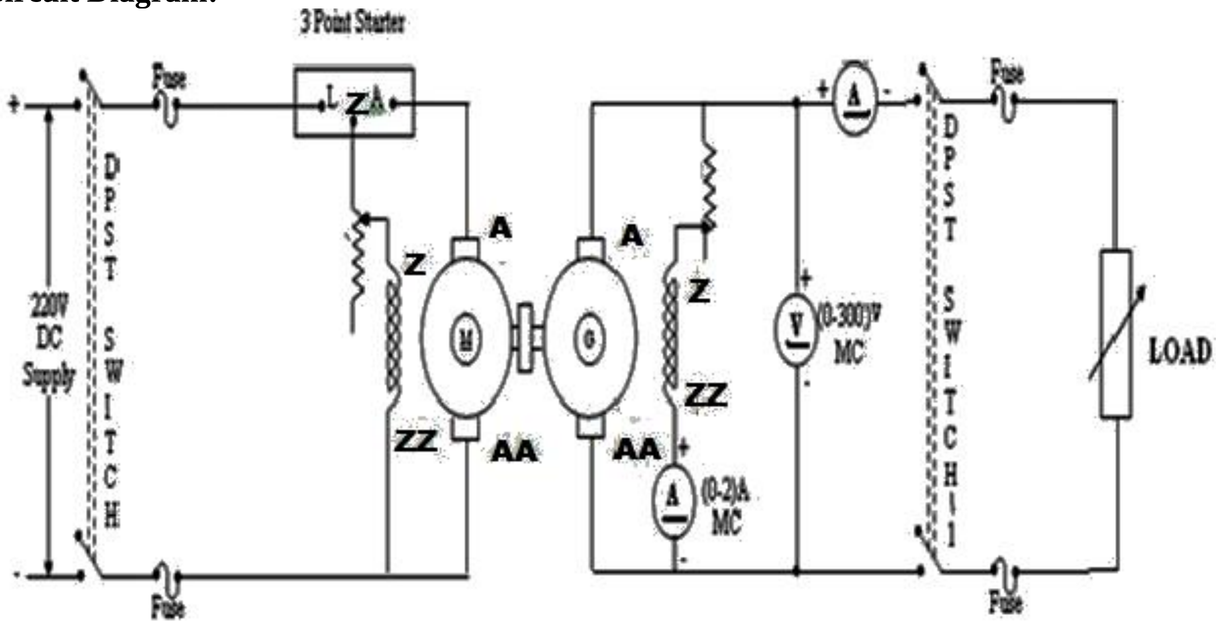
Experiment No. 5

Aim-: To obtain the external characteristics of DC shunt generator.

Apparatus Required:

S.No.	Apparatus	Range	Type	Quantity

Circuit Diagram:



Theory:

The external load characteristics of DC shunt generator is plotted between V and IL. In this we consider the drop due to armature reaction and drop due to ohmic losses both the drops are considered in the external characteristics.

Basically, the external characteristics of DC shunt generator can be easily obtained by computing these equations:

Eg = V + Ia Ra (Volts)

Ia = IL + If (Amps)

Eg : Generated emf in Volts

V: Terminal Voltage in Volts

Ia : Armature Current in Amps

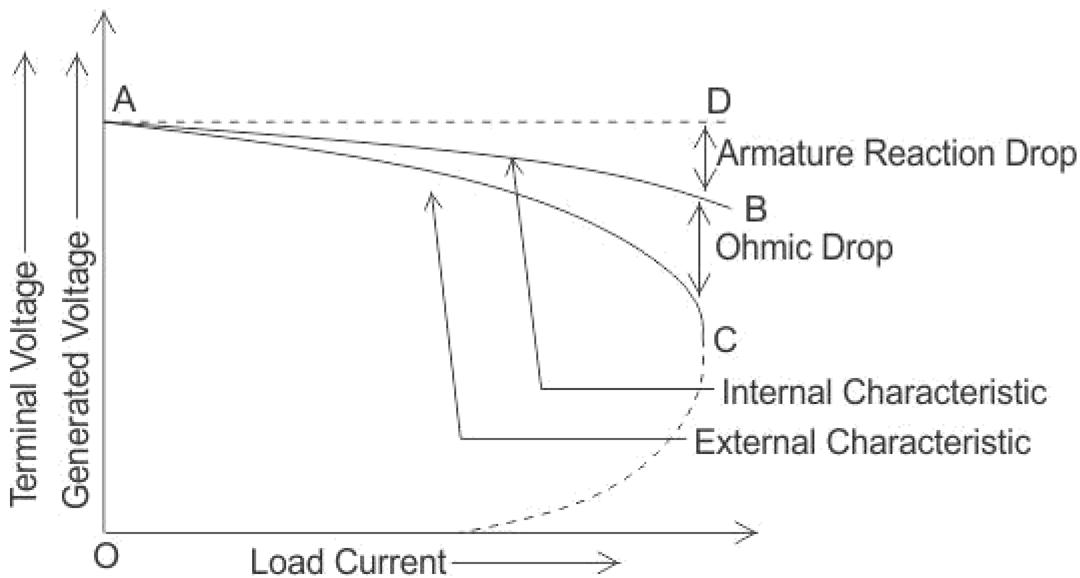
IL : Line Current in Amps

If : Field Current in Amps

Ra : Armature Resistance in Ohms

Procedure (obtain external characteristic):

1. Connections are made as per the circuit diagram.
2. After checking minimum position of DC shunt motor field rheostat and maximum position of DC shunt generator field rheostat, DPST switch is closed and starting resistance is gradually removed.
3. Under no load condition, Ammeter and Voltmeter readings are noted, after bringing the voltage to rated voltage by adjusting the field rheostat of generator.
4. Load is varied gradually and for each load, voltmeter and ammeter readings are noted.
5. Then the generator is unloaded and the field rheostat of DC shunt generator is brought to maximum position and the field rheostat of DC shunt motor to minimum position, DPST switch is opened.



Observation Table:

S.No.	Voltage V_L (Volts)	Load Current I_L (Amps)

Result:

Thus, the external characteristics of DC shunt generator is determined.

Precautions:

1. The field rheostat of motor should be at minimum position.

2. The field rheostat of generator should be at maximum position.

3. No load should be connected to generator at the time of starting and stopping

Viva Questions

Q1. What are the external characteristics of a DC shunt generator?

Q.2 Why does the terminal voltage of a DC shunt generator drop with an increase in load current?

Q.3 What factors affect the external characteristics of a DC shunt generator?

Q.4 How does armature reaction affect the external characteristics of a DC shunt generator?

Q.5 How can the external characteristics of a DC shunt generator be improved?

Q.6 How can the external characteristics curve of a DC shunt generator be experimentally determined?

Q.7 Why does the terminal voltage of a DC shunt generator drop more sharply at higher loads?

Q.8 What is the impact of armature resistance on the external characteristics of a DC shunt generator?

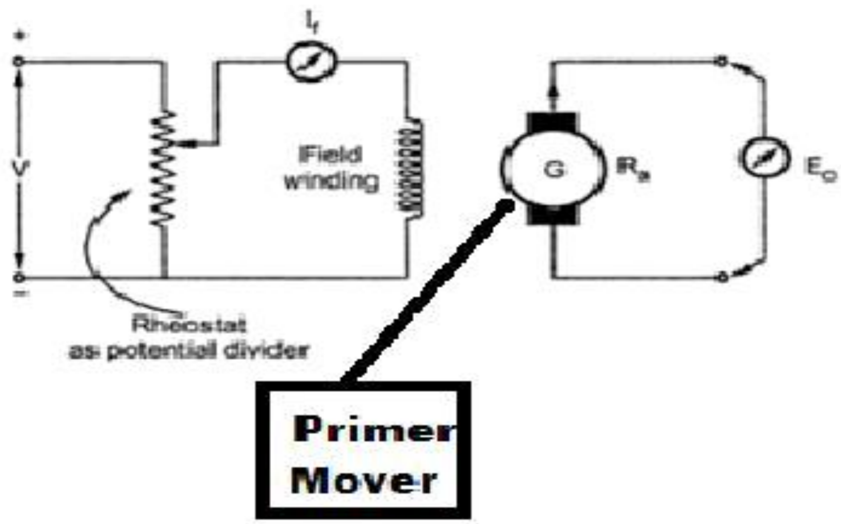
Experiment No. 6

Aim-: To obtain the Magnetization Characteristics of separately excited D.C Generator.

Apparatus Required:

S.No.	Apparatus	Range	Type	Quantity

Circuit Diagram:

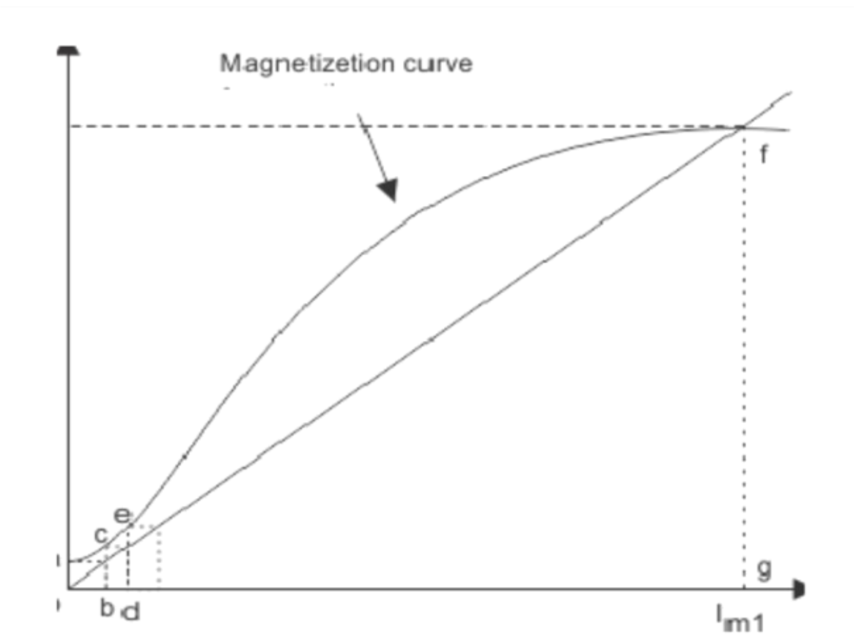


Theory:

The magnetic circuit of a dc machine consists of both linear (airgap) and non-linear (magnetic material of the stator and rotor) parts. Hence, Kf changes (it decreases as the magnetic circuit gets saturated) with the change in flux density in the machine. The relationship between E and If can be determined by measuring the open circuit voltage (voltage across armature terminals) at different values of If at a constant speed. This curve is known as open circuit characteristics (O.C.C). This variation is shown in Fig.10. Since E is an indirect measure of air gap flux (at constant speed of rotation), the curve is similar to the B-H curve (or φ Vs If) of the magnetic material. For this reason, O.C.C. can also be referred to as the magnetization curve. It should be noted that E does not start at zero when the field current is zero but at some value (of the order of 8-10 V). This is due to residual magnetism

Procedure :

1. Connect the circuit diagram as shown in fig.
2. Switch on main power supply to induction motor so as to run dc generator.
3. Note down the readings.
4. Now increase the field current gradually.
5. Reapeat steps 3 and 4 for different speeds of rotation.
6. Plot the complete hysteresis loop.
7. Now again reverse the voltmeter and ammeter connections and increase current till saturation is reached.
8. Plot a graph between E and If.



Observation Table:

S.NO	**ArmatureVoltage (Ef)**	**Field Current(I_f)**

Result: Thus, the magnetization characteristic curve of Separately excited DCGenerator is obtained

Precautions:

1. All connections should be tight and neat.
2. The field current should not be increased to cross the rated value.

Viva Questions:

Q.1 What is residual magnetism in the context of a D.C. generator?

Q.2 How does armature reaction affect the magnetization characteristics?

Q.3 How is the magnetization characteristic curve obtained?

Q.4 What is residual magnetism?

Q.5 What happens to the generated voltage when the generator is loaded?

Q.6 Can the magnetization characteristic be used to determine the critical field resistance of a D.C. generator?

Q.7 Why is it important to maintain the generator speed constant while measuring the magnetization characteristic?

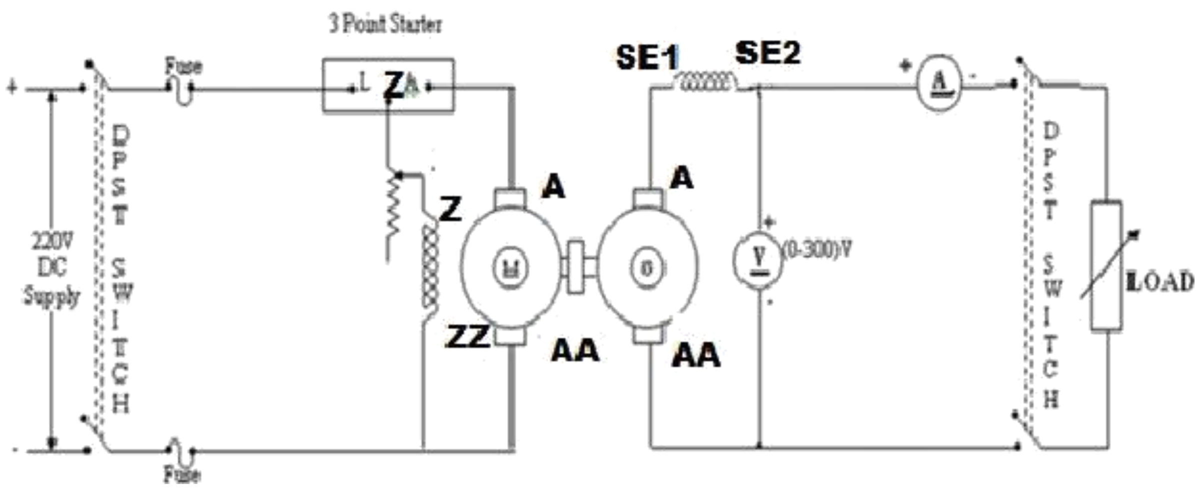
Experiment No. 7

Aim-: Obtain the external characteristics of D.C. Series Generator.

Apparatus Required:

S.No.	Apparatus	Range	Type	Quantity

Circuit Diagram:



Theory:

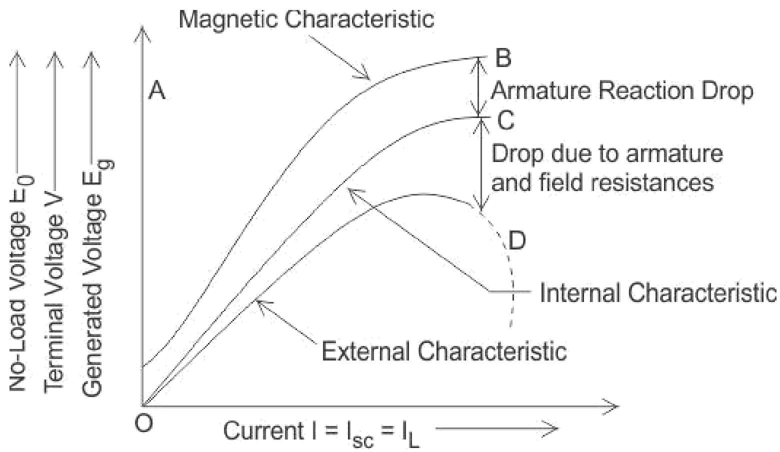
As Load Resistance is reduced, Armature Current increases and since it is same as field current also increases which leads to increase in flux and hence induced voltage also increases.

Now, the terminal voltage ,V = Ea –Ia(Ra+RSe)increases until breakdown point is reached and after that machine enters saturation and flux becomes constant, so Ea becomes constant and due to increase in armature current terminal voltage reduces. In this only drop due to armaturereaction is and drop due to ohmic losses both are considered in external characteristics

Procedure:

1. Connections are given as shown in the circuit diagram.
2. The DC supply is switched ON and the DC shunt motor (prime mover) is started using the 3-point starter
3. The motor is brought to its rated speed by adjusting its field rheostat and the same is checked with the help of a tachometer.
4. The load DPST is now closed and the loading rheostat is switched on in steps and at each step the motor speed is maintained constant by adjusting the motor field rheostat and then the terminal voltage (VL) and the load current (IL) are noted down.

5. The procedure is continued until the load current is equal to 120% of the rated current of the generator.
6. After the experiment is completed the load on the generator is gradually decreased tominimum and then the main supply is switched OFF.
7. The resistances of the armature and the series field winding of the generator are found by giving low voltage supply and connecting a voltmeter and ammeter.
8. The external characteristics of the given DC series generator are plotted



Observation Table:

S.NO	Load Voltage V_L	Load Current I_L

Result:

Thus, the external load characteristic curve of DC Series Generator is drawn.

Precautions:

1. The Starter handle should be kept in OFF position at the time of switching ON the supply tothe DC motor.
2. The field rheostat of the DC shunt motor (prime mover) should be kept in the minimum resistance position.

Viva Questions:

Q.1 What is the external characteristic of a D.C. Series Generator?

Q.2 How does the terminal voltage change with load current in a D.C. Series Generator?

Q.3 How does armature reaction affect the external characteristics of a D.C. Series Generator?

Q.4 How does the external characteristic of a DC series generator differ from that of a DC shunt generator?

Q.5 Can a DC series generator operate at no load? Explain why or why not.

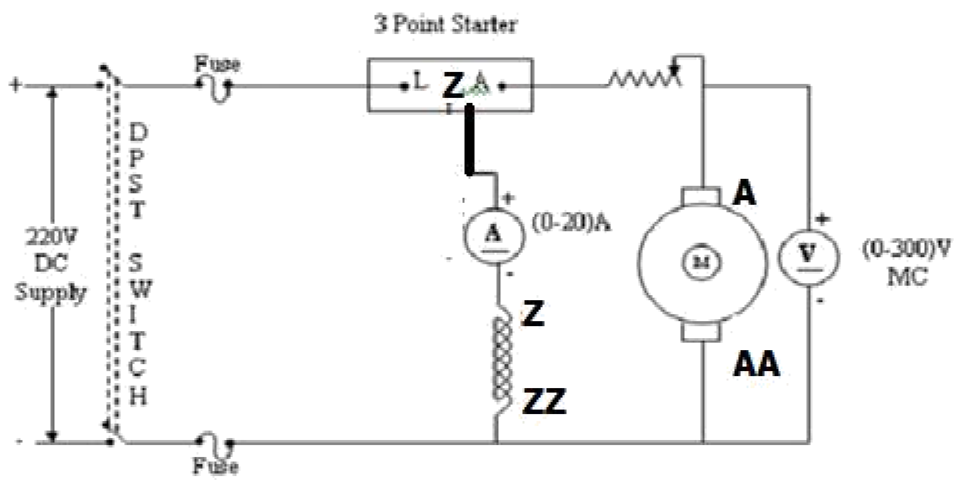
Experiment No. 8

Aim-: Speed control of DC shunt motor by armature voltage control method.

Apparatus Required:

S.No.	Apparatus	Range	Type	Quantity

Circuit Diagram:



Theory:

This armature voltage control method of speed control of DC shunt motor is used for controlling speed below base speed. As its used for below base speed hence it's also called as constant torque control method as our torque remains constant in this region. This method is used when speeds below the no-load speed are required. As the supply voltage is normally constant, the voltage across the armature is varied by inserting a variable rheostat in series with the armature circuit. As controller resistance is increased, voltage across the armature is decreased, thereby decreasingthe armature speed. For a load constant torque, speed is approximately proportional to the voltage across the armature

Procedure:

1. Connections are made as per the circuit diagram.
2. After checking the maximum position of armature rheostat and minimum position of field rheostat, DPST switch is closed.
3. Field current is fixed to various values and for each fixed value by varying the armature

rheostat, speed is noted for various voltages across the armature.

Observation Table:

S.NO	If =	
	Armature Voltage V_a	**Speed N (rpm)**

Result:

Thus, the speed control characteristic curve of DC Shunt motor is obtained.

Precautions:

1. Field Rheostat should be kept in the minimum resistance position at the time of starting andstopping the motor.
2. Armature Rheostat should be kept in the maximum resistance position at the time of startingand stopping the motor

Viva Questions

Q1. What is the armature voltage control method in DC shunt motors?
Q.2 How does changing the armature voltage affect the speed of a DC shunt motor?
Q.3 What are the advantages of using the armature voltage control method?
Q.4 Are there any disadvantages to the armature voltage control method?
Q.5 Can the armature voltage control method be used for both increasing and decreasing the speed of the motor?
Q.6 How does the armature voltage control method affect the speed of a DC shunt motor?
Q.7 What are the typical applications of armature voltage control in DC shunt motors?

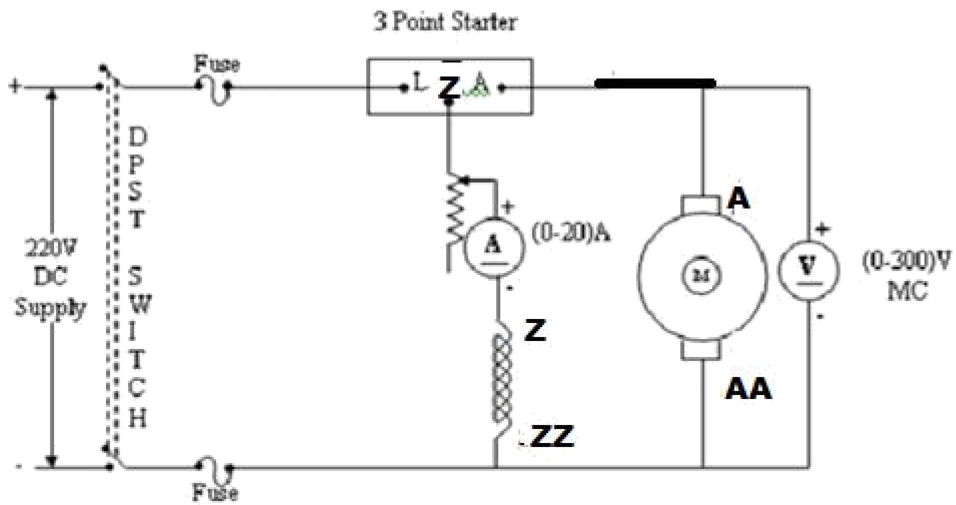
Experiment No. 9

Aim-: Speed control of DC shunt motor by field control method.

Apparatus Required:

S.No.	Apparatus	Range	Type	Quantity

Circuit Diagram:



Theory:

Speed control of DC shunt motor by the help of field flux control is carried out above the base speed. As its used for above base speed hence it's also called as constant power control method as our power remains constant in this region by decreasing the flux, the speed can be increased and vice versa. The flux of a dc motor can be changed by changing Ish with help of a shunt field rheostat. Since Ish is relatively small, shunt field rheostat has to carry only a small current, which means IshR loss is small, so that rheostat is small in size.

Procedure:

1. Connections are made as per the circuit diagram.
2. After checking the maximum position of armature rheostat and minimum position of fieldrheostat, DPST switch is closed.
3. Armature voltage is fixed to various values and for each fixed value; by adjusting the fieldrheostat, speed is noted for various field currents.
4. Bringing field rheostat to minimum position and armature rheostat to maximum positionDPST switch is opened.

Observation Table:

S.NO	Va =	
	Field Current If	**Speed N (rpm)**

Result:

Thus, the speed control characteristic curve of DC Shunt motor is obtained.

Precautions:

1. Field rheostat should be kept in the minimum resistance position at the time of starting and stopping the motor.
2. Armature rheostat should be kept in the maximum resistance position at the time of startingand stopping the motor

Viva Questions

Q.1 How does the speed of a DC shunt motor vary with armature voltage and field current?

Q.2 Compare the resistance of the armature and field winding.

Q.3 What is the importance of speed control of DC motor in industrial applications?

Q.4 What are the applications of a DC shunt motor?

Q.5 Which is of the two methods of speed control is better and why?

Q.6 Why is the speed of DC shunt motor practically constant under normal load condition?

Q.7 What are the factors affecting the speed of a DC shunt motor?

Q.8 What is the field control method for speed control of a DC shunt motor?

Q.9 How does changing the field resistance affect the speed of a DC shunt motor?

Q.10 What are the advantages of using the field control method for speed control?

Q.11 What are the limitations of the field control method?

Q.12 Can the field control method be used for both increasing and decreasing the speed of a DC shunt motor?

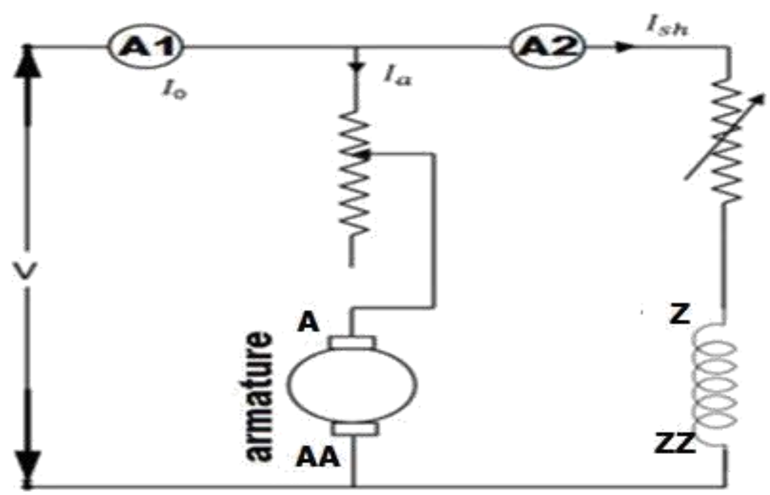
Experiment No. 9

Aim-: To obtain the efficiency of D.C machine using Swinburne's test.

Apparatus Required:

S.No.	Apparatus	Range	Type	Quantity

Circuit Diagram:



Theory:

Testing of D.C. machines can be divided into three methods: (a) direct, (b) regenerative, and (c) indirect. Swinburne's Test is an indirect method of testing a D.C. machine.

In this method, the constant losses of the D.C. machine are calculated at no-load. Hence, its efficiency either as a motor or as a generator can be determined. In this method, the power requirement is very small. Hence, this method can be used to pre-determine the efficiency of higher capacity D.C. machines as a motor and as a generator.

Power input at No-load = Constant losses + Armature copper losses

Power input at No-load = Constant losses

Power input = $V_aI_a + V_fI_f$

Losses in a D.C. Machine:

The losses in a D.C. machine can be divided as 1) Constant losses, 2) Variable losses, which changes with the load.

Constant losses:

Mechanical Losses: Friction and Windage losses are called mechanical losses. They depend upon the speed. A D.C. shunt machine is basically a constant speed machine both as a generator and as a motor. Thus, the mechanical losses are constant.
Iron Losses: For a D.C. shunt machine, the field current hence the flux. Hence, hysteresis and eddy current losses (which are also called as iron losses) remain constant.
Field Copper Losses: Under normal operating conditions of a D.C. shunt machine, the field current remains constant. Thus, power received by the field circuit (which is consumed as field copper losses) is constant.
Constant losses in a D.C. shunt machine = Mechanical losses + Iron Losses + Filed copper losses

Variable Losses:

The power lost in the armature circuit of s D.C. machine increases with the increase in load.
Thus, the armature copper losses are called as variable losses.

Efficiency of a D.C. machine:

% Efficiency = (Output Power/ Input Power) x100
As a generator Input power, P in = (P_{out}) + (constant losses) + (armature copper losses at a given load $I_a^2R_a$.
$P_{out} = V_L.I_L$
where, $I_a = I_L + I_f$ for self-excited generator (V_fI_f is not encountered for P_{in})
$I_a = I_L$ for separately excited motor.

Note: While calculating the armature copper losses on load condition, the hot resistance of the armature = 1.2*Ra (normal temperature) is considered

Procedure:

1. Keep the field voltage control auto transformer at maximum position.
2. Keep the D.C. drive potentiometers at zero position.
3. Connect the circuit as shown in the circuit diagram.
4. Run the machine as a motor at no-load.
5. Adjust the voltage applied to the armature to get rated voltage.
6. Adjust the field auto transformer till the motor attains the rated speed.
7. Measure the field voltage and current.
8. Measure the field resistance and armature resistance

Observation Table:

Sl. No.	Load Current IL	Power Input	Copper Loss	Total Loss	Power Output	Efficiency

Conclusion:

The power required to conduct the test is very less as compared to the direct loading test. Moreover, Constant losses are calculated from this method are used to compute the efficiency of a D.C. machine as agenerator and as a motor without actually loading it. Hence this is an economic method.

Result: Thus, the no load losses and hence the efficiency can be computed easily by this test

Viva Questions:

Q.1 What is the purpose of Swinburne's test?

Q.2 What are the constant losses in a DC machine?

Q.3 What are the assumptions made in Swinburne's test?

Q.4 Why is the indirect method preferred to the direct loading test?

Q.5 The efficiency of DC machine is generally higher when it works as a generator than when it works as a motor. Is this statement true or false? Justify your answer with proper reasons.

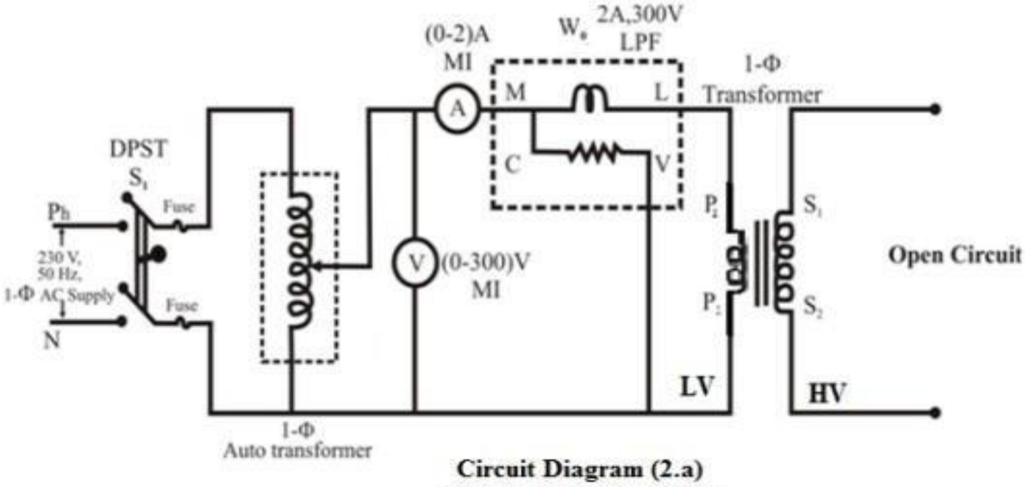
Experiment No.: 10

Aim: By conducting Open circuit and Short Circuit tests on a given 1-Φ transformer to predetermine efficiency, voltage regulation and to draw its equivalent circuit.

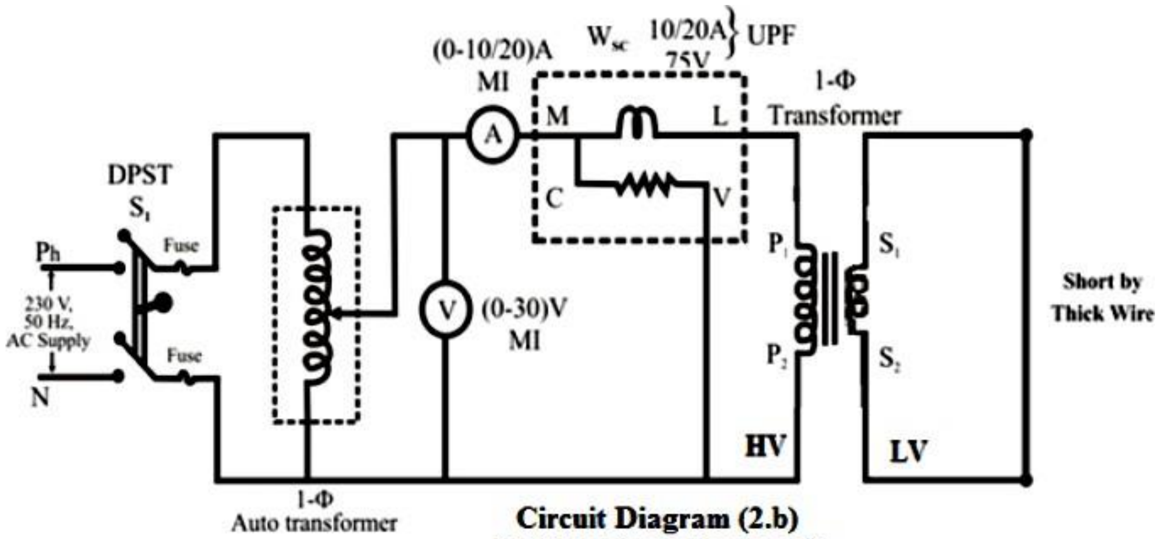
Apparatus Required:

S No.	Apparatus	Range	Type	Quantity

Circuit Diagram:



Circuit Diagram (2.a)
OPEN CIRCUIT TEST



Circuit Diagram (2.b)
SHORT CIRCUIT TEST

Theory: -

Open – Circuit (OC) or No-Load Test

The purpose of this test is to determine the shunt branch parameters of the equivalent circuit of the transformer. One of the windings is connected to supply at rated voltage, while the other winding is kept open - circuited. From the point of view of convenience and availability of supply the test is usually performed from the LV side, while the HV side is kept open circuited.
Voltage = V_1; Current = I_0 and power input = P_0

Indeed, the no-load current, I_0 is so small (it is usually 2-6% of the rated current) and R_{01} and X_{01} are also small, that V_1 can be regarded as = E_1 by neglecting the series impedance. This means that for all practical purposes the power input on no-load equals the core (iron) loss

Short Circuit (SC) Test

This test serves the purpose of determining the series parameters of a transformer. For convenience of supply arrangement and voltage and current to be handled, the test is usually conducted from the HV side of the transformer while the LV side is short-circuited. Since the transformer resistance and leakage reactance are very small, the voltage V_{sc} needed to circulate the full load current under short circuit is as low as 5-8% of the rated voltage. The exciting current under these conditions is only about 0.1to 0.5% of the full load current Thus the shunt branch of the equivalent circuit can be altogether neglected. While conducting the SC test, the supply voltage is gradually raised from zero till the transformer draws full load current. The meter readings under these conditions are: Since the transformer is excited at very low voltage, the iron loss is negligible (that is why shunt branch is left out), the power input corresponds only to the copper loss, i.e.
V_{sc} =Voltage, I_{sc} = Current , P_{sc} = Power (Copper loss)

$$Z_{01} = V_{sc}/I_{sc} = \sqrt{R_{01}^2 + X_{01}^2}$$

Equivalent resistance, $R_{01}= P_{SC} / (I_{SC})^2$ Equivalent reactance,

$$X_{01} = \sqrt{Z_{01}^2 + R_{01}^2}$$

Procedure:

Open Circuit Test

1. Connections are made as shown in the circuit diagram (2.a).
2. By keeping auto-transformer voltage in zero out-put position, the supply switch (S1) is closed.
3. Vary the auto transformer voltage gradually and apply rated voltage to the LV side of the transformer and keep the HV side open.
4. The readings of all the meters are noted down.
5. The auto-transformer is brought back to its initial zero output position, the supply switch(S1)

is opened.

Short Circuit Test

1. Connections are made as shown in the circuit diagram (2.b).
2. Keeping auto-transformer voltage in zero out-put position, the supply switch (S1) is closed
3. By varying the 1-Φ auto transformer, a low voltage is applied to HV side of the transformer such that the rated current flows through it and short the LV side of the transformer.
4. The Primary rated current is given by :

   I_1 = (kVA * 1000) / Rated Primary voltage (V1).
5. The readings of all the meters are noted down.
6. The auto-transformer is brought back to its initial zero output position, the supply switch (S1) is opened.

Observation Table

1. Open Circuit Test

OC TEST:

V_o Volts	I_o Amps	W_o Watts

SC TEST:

V_{sc} Volts	I_{sc} Amps	W_{sc} Watts

Precautions:

1. Open circuit test is performed on LV side i.e. meters are connected LV side and HV side willbe open circuited.
2. For short circuit test is connect meters on HV side and LV side will be short circuited
3. Rated voltage and rated current must be maintained in OC test and SC test respectively
4. All the connections must be tight

Viva Questions

Q.1 What is the purpose of OC and SC tests?
Q.2 Why is the core of a transformer laminated?
Q.3 What is meant by regulation?
Q.4 Define the term transformation ratio?
Q.5 What are the components of no-load current?
Q.6 What are the parameters of the equivalent circuit?

Q.7 How are the parameters referred to the HV or LV side? Explain with an example.

Experiment No. 11

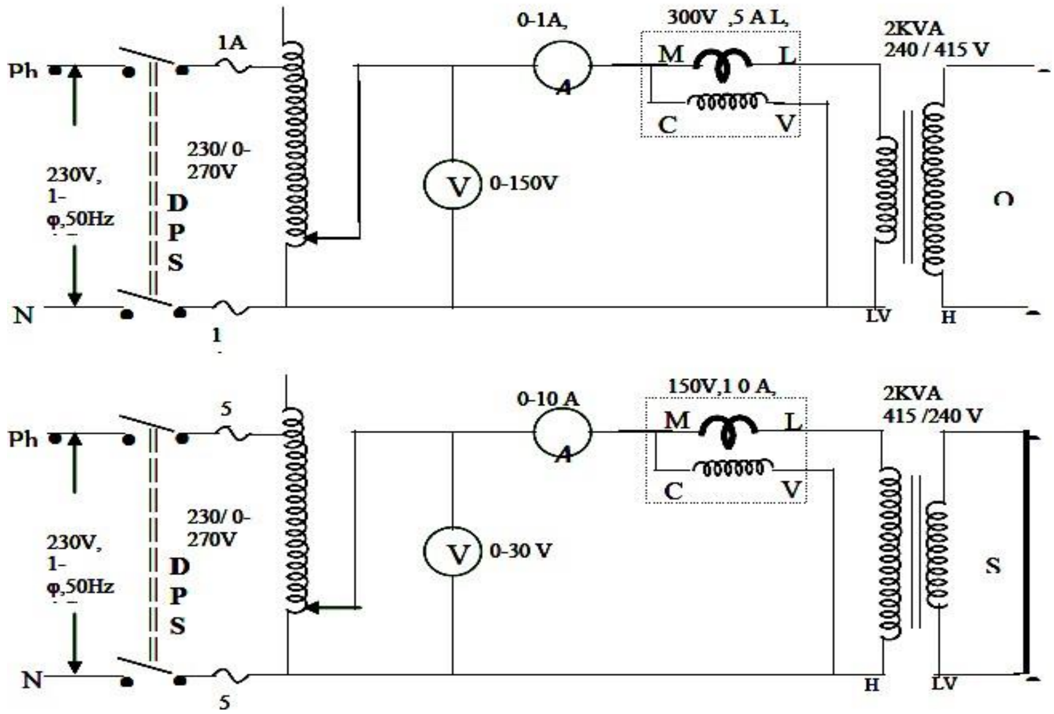
Aim : Sumpners test on two single-phase transformers

Apparatus Required:

SL.NO	Name of the Apparatus	Type	Range	Quantity

Circuit Diagram

CIRCUIT DIAGRAM: OC AND SC TESTS ON A SINGLE PHASE



Theory:-

Without conducting any actual loading test is the Sumpner's test which can only be conducted simultaneously on two identical transformers. In conducting the Sumpner's test the primaries of the two transformers are connected in parallel across the rated voltage supply(V_1), while the two secondaries are connected in phase opposition. As per the superposition theorem, if V_2 source is assumed shorted, the two transformers appear in open-circuit to source V_1 as their secondaries are in phase opposition and therefore no current can flow in them. The current drawn from source V_1 is thus $2I_0$ (twice the no-load current of each transformer) and power is $2P_0$ (= $2P_i$), twice the core loss of each transformer). When V_1 is regarded as shorted, the transformers are series-connected across V_2 and are short-circuited on the side of primaries. Therefore, the impedance seen at V_2 is 2Z and whenV_2 is adjusted to circulate full-load current (I_{fl}), the power fed in is $2P_c$ (twice the full-load copper-loss of each transformer). Thus in the Sumpner's test while the transformers are not supplying any load, full iron-loss occurs in their core and full copper-loss occurs in their windings; net power input to the transformers being($2P_o$+$2P_c$). The heat run test could , therefore, be conducted on the two transformers, while only losses are supplied.

For each trans former the results are

Voltage =V_1 , Current = I_0 /2 , Core losses = P_0 /2 Voltage =V_{sc} /2 ,
Current = I_{sc} , Copper losses = P_{sc} /2
P_0 = P_i (iron-loss) P_0
= V_1 $I_0 \cos\varphi_0$ $\cos\varphi_0$
= P_0 / V_1 I_0

$I_w = I_0\cos\varphi_0$, $I\mu = I_0\sin\varphi_0 R_0 = V_1/ I_w$, $X_0 = V_1 / I_\mu$.

V_{sc} =Voltage, I_{sc} = Current , P_{sc} = Power (Copper loss)

$$Z_{01} = V_{sc}/2 * I_{sc} = \sqrt{R_{01}^2 + X_{01}^2}$$

Equivalent resistance, $R_{01}= P_{sc} / (I_{SC})^2$

Equivalent reactance, $X_{01} = \sqrt{Z_{01}^2 - X_{01}^2}$

Procedure :

1. Connections are done as per the circuit diagram.
2. By using the variac rated voltage is 240V is made to apply across the low voltage sideof the transformer.
3. Before closing the DPST switch the reading of the voltmeter connected across DPST switch must be zero.
4. By using the variac in H.V side rated current is made to flow in the circuit.
5. At this instant note down all the meter readings.
6. By using above tabulated readings the efficiency and regulation of the transformersare calculated.

Precautions:

1. The Dimmer stat should be kept at minimum O/P position initially.
2. The Dimmer stat should be varied slowly & uniformly.

Observations:

Primary Side:

V_o Volts	$2I_o$ Amps	$2W_o$ Watts

Secondary Side:

$2V_{sc}$ Volts	I_{SC} Amps	$2W_{sc}$ Watts

Result: Sumpners test on two single-phase transformers is performed.

Viva Questions:

Q.1 What is the purpose of conducting the Sumpner's test?
Q.2 What are the losses in a transformer?
Q.3 Why LPF wattmeter is used in OC test?
Q.4 Why UPF wattmeter is used in SC test?
Q.5 How is the Sumpner's test different from the open-circuit and short-circuit tests?
Q.6 What are the advantages of the Sumpner's test?
Q.7 What are the limitations of the Sumpner's test?
Q.8 How is efficiency calculated in the Sumpner's test?
Q.9 How are the transformers connected in the Sumpner's test?

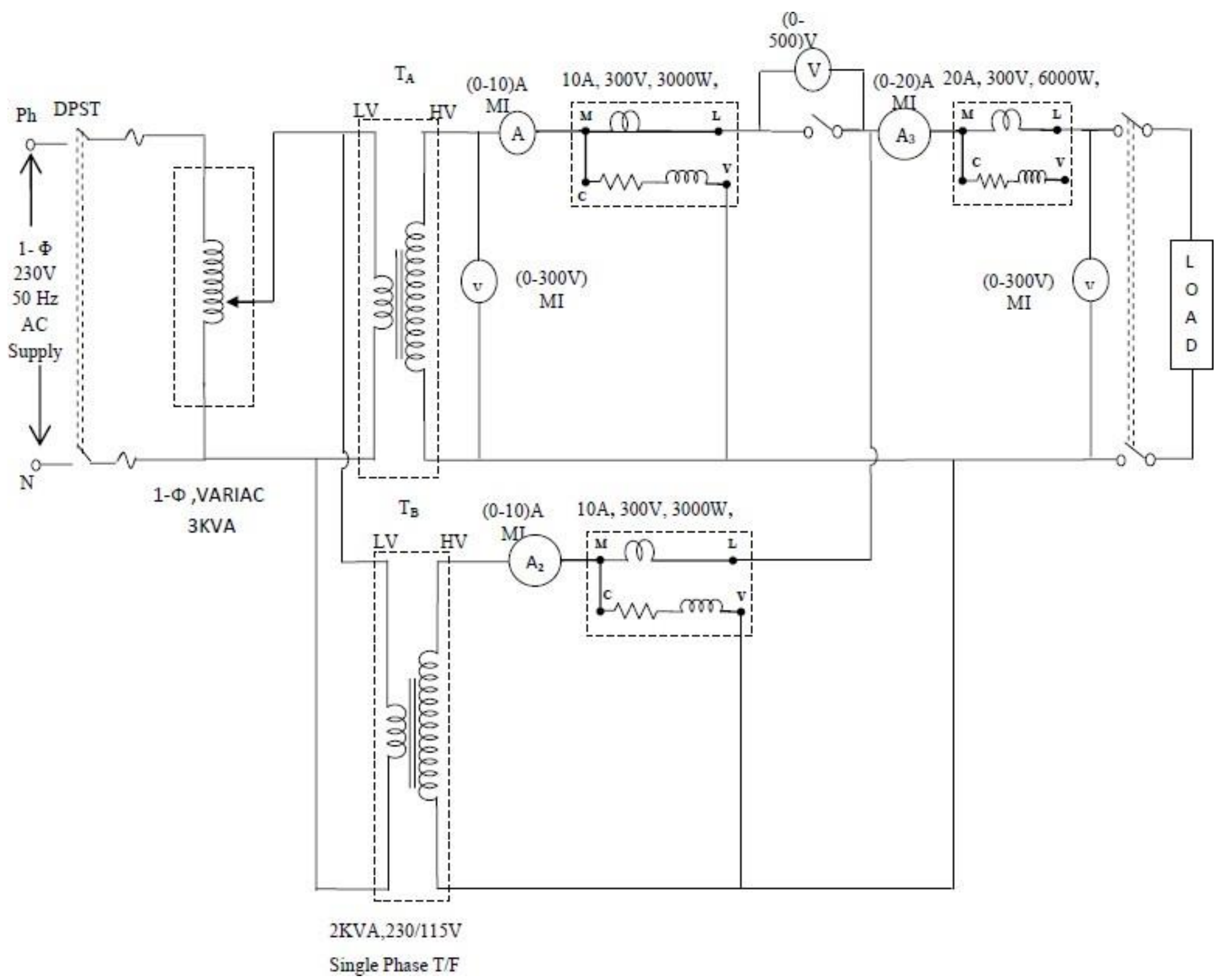
Experiment No. 12

Aim-: To study the parallel operation of single-phase transformers.

Apparatus Required:

S.No.	Apparatus	Range	Type	Quantity

Circuit Diagram:



Theory:

A power transformer is one of the most vital and an equally expensive components in a power system. It may so happen that, over time, due to load growth in its service area, an existing transformer may not be able to withstand the demand during peak-hours without exceeding its long-term MVA rating. Operating a transformer in such a fashion would cause overheating and degrade its expected life. In most cases, instead of commissioning an entirely new higher capacity unit, a more viable alternative exists in adding a smaller unit in parallel to complement the existing one. In other words, a new smaller capacity transformer can now be connected in parallel to the existing one such that the two share a large peak load in a specific proportion and the one operating near limits is relieved of the burden. Also, during light load conditions, the additive capacity can be kept offline, if desired. To successfully operate the transformers in parallel, while commissioning, certain rules must be followed. We state them below, as applied to the single-phase transformers used in the experiment.

Procedure :

1. Connect the circuit as shown in the diagram.
2. Note down the readings of all wattmeter's, ammeters and voltmeters for given load.
3. Repeat the above test for different values of load
4. Take at least three readings.

Observation Table:

S.NO.	I_1 (AMPS)	W_1(WATTS)	I_2(AMPS)	W_2(WATTS)	$I_L=I_1+I_2$ (AMPS)	$W_L=W_1+W_2$ (WATTS)
1.						

Result:

The two transformers connected in parallel share the load equally**.**

Precautions:

1. Transformers should be connected in such a way that they have same polarity.
2. All connections should be neat and tight.
3. Connecting leads should be perfectly insulated

Viva Questions:

Q1. Why is parallel operation of transformers necessary?

Q.2 What are the conditions for the parallel operation of single-phase transformers?

Q.3 What happens if transformers with different impedances are connected in parallel?

Q.4 How do you ensure the correct polarity when connecting transformers in parallel?

Q.5 What are the advantages of parallel operation?

Q.6 What could happen if the polarity of one transformer is reversed during parallel operation?

Q.7 What are the essential conditions for parallel operation of single-phase transformers?

Q.8 Why must transformers have the same voltage ratio for parallel operation?

Q.9 What happens if transformers with different voltage ratios are connected in parallel?

Q.10 Can two transformers of different types (e.g., core type and shell type) be connected in parallel?

Experiment No. 13

Aim: To convert three phase system to two phase system with the help of Scott Connection

Apparatus Required:

Sno.	Name of the Apparatus	Type	Range	Quantity

Theory:-

Phase conversion from three to two phase is needed in special cases, such as in supplying 2-phase electric arc furnaces. The concept of 3/2-phase conversion follows from the voltage phasor diagram of balanced 3-phase supply shown in Fig 1. If the point M midway V_{BC} could be located, then V_{AM} leads V_{BC} by 90^o. A 2-phase supply could thus be obtained by means of transformers; one connected across AM, called the teaser transformer and the other connected across the lines B and C. since $V_{AM}= (\sqrt{3}/2)V_{BC}$, the transformer primaries must have $\sqrt{3}\, N_1/2$ (teaser) and N_1 turns; this would mean equal voltage/turn in each transformer. A balanced 2-phase supply could then be easily obtained by having both secondaries with equal number of turns, N_2. The point M is located midway on the primary of the transformer connected across the lines B and C. The connection of two such transformers, known as the Scott connection, is shown in Fig. 1(a), while the phasor diagram of the 2-phase supply on the secondary side is shown in Fig. 1(c).

The neutral point on the 3-phase side, if required, could be located at the point N which divides the primary winding of the tertiary in the ratio 1: 2 (refer Fig.).

Load Analysis:-

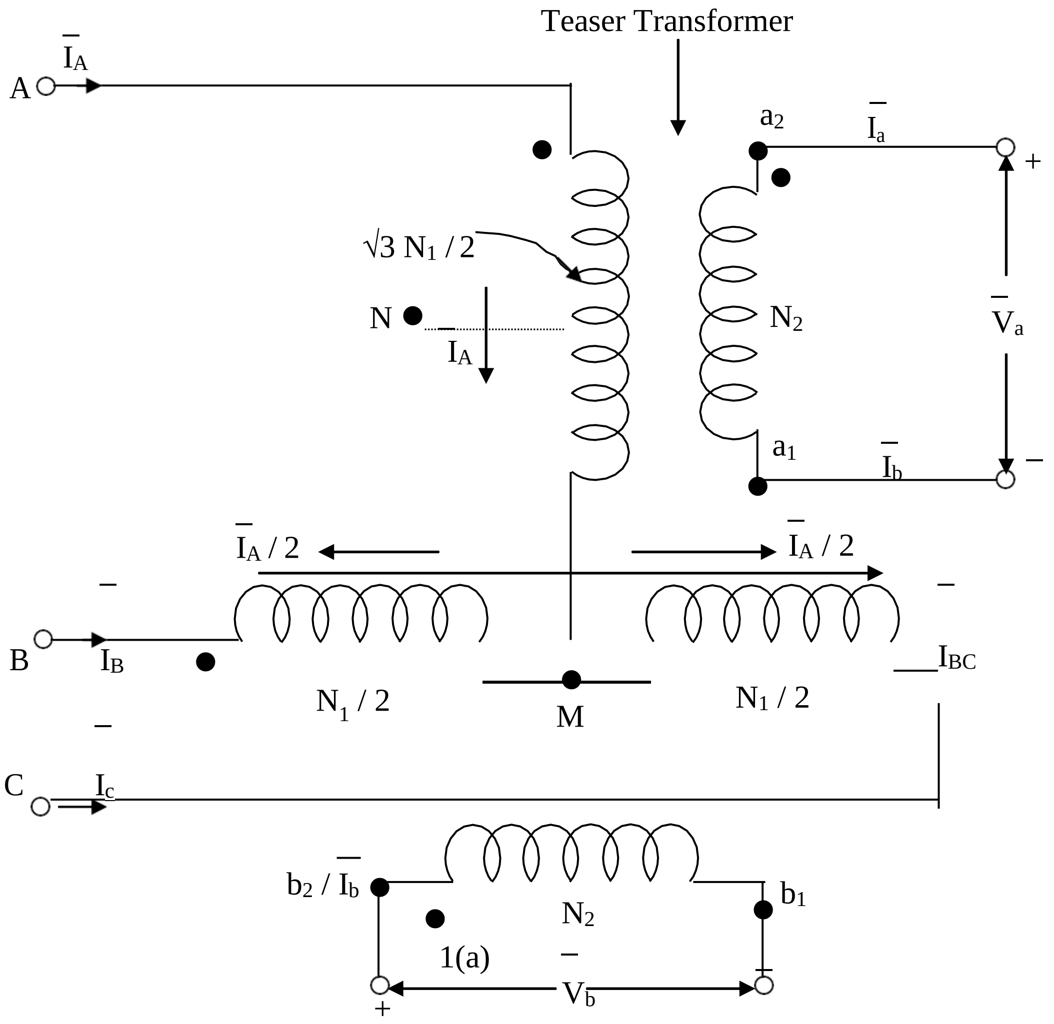
If the secondary load currents are I_A and I_B , the currents can be easily found onthe 3-phase side fig.1(a).

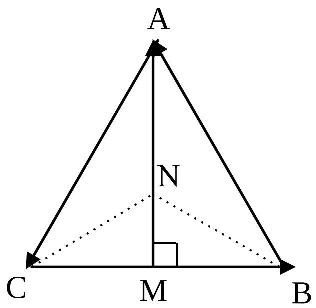
$$\bar{I}_A = (2N_2 / \sqrt{3}N_1) \times \bar{I}_a = (2\, I_a / \sqrt{3}) \text{ (for } N_1 / N_2 = 1)$$

$$I_{BC} = N_2 / N1\, \bar{I}_b = \quad I_b \text{ (for } \bar{N}_1 / \bar{N}_2 = 1)$$

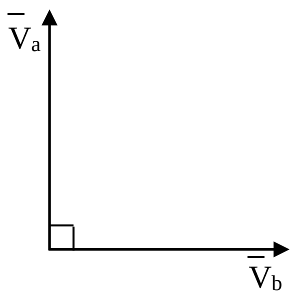
$$\bar{I}_B = \bar{I}_{BC} - \bar{I}_A / 2$$

$$\bar{I}_c = - \bar{I}_{BC} - \bar{I}_A / 2$$


Teaser Transformer
A
B
C
N
M
$\bar{I}_A$
$\sqrt{3}\, N_1 / 2$
a_2
a_1
$\bar{I}_a$
$\bar{I}_b$
N_2
$\bar{V}_a$
+
–
$\bar{I}_A / 2$
$\bar{I}_A / 2$
$\bar{I}_B$
$\bar{I}_{BC}$
$N_1 / 2$
$N_1 / 2$
$\bar{I}_c$
$b_2 / \bar{I}_b$
b_1
N_2
1(a)
$\bar{V}_b$
+

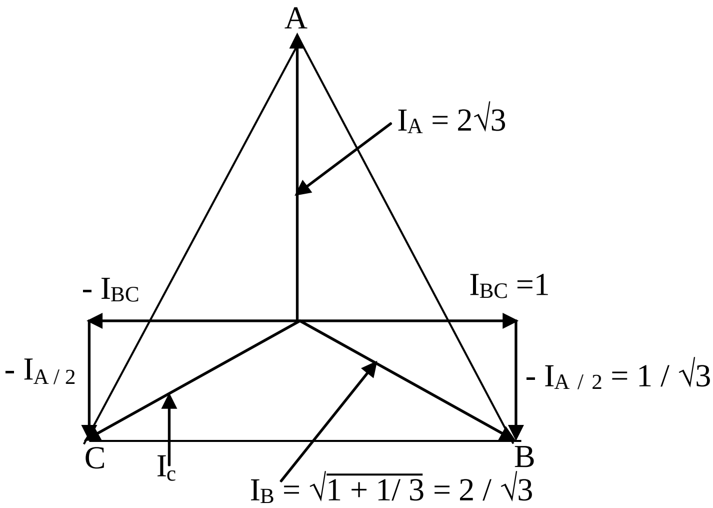

A
N
C
M
B

(b)


$\bar{V}_a$
$\bar{V}_b$

(c)

The corresponding phasor diagram for balanced secondary side load of unity power factor is drawn in fig. (2) from which it is obvious that the currents drawn from the 3- phase system are balanced and cophasal with the star voltages. The phasor diagram for thecase of an unbalanced 2-phase load is drawn in fig (3)



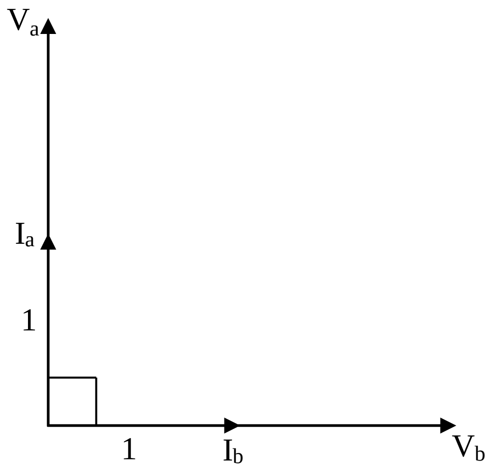
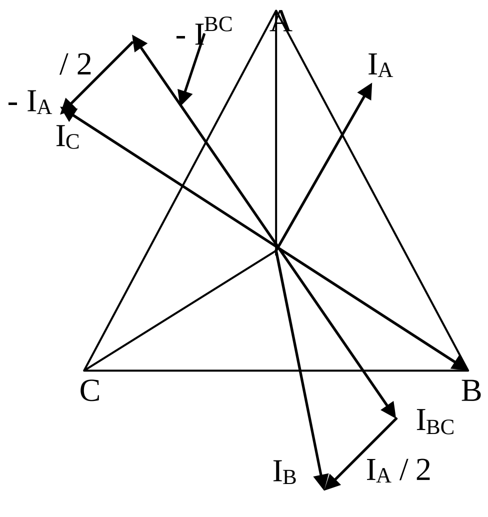


Fig.(2)



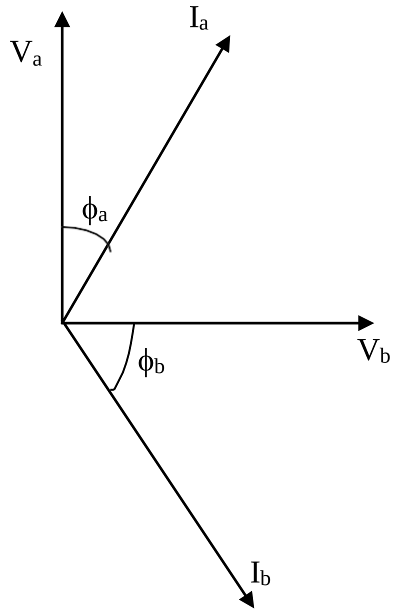
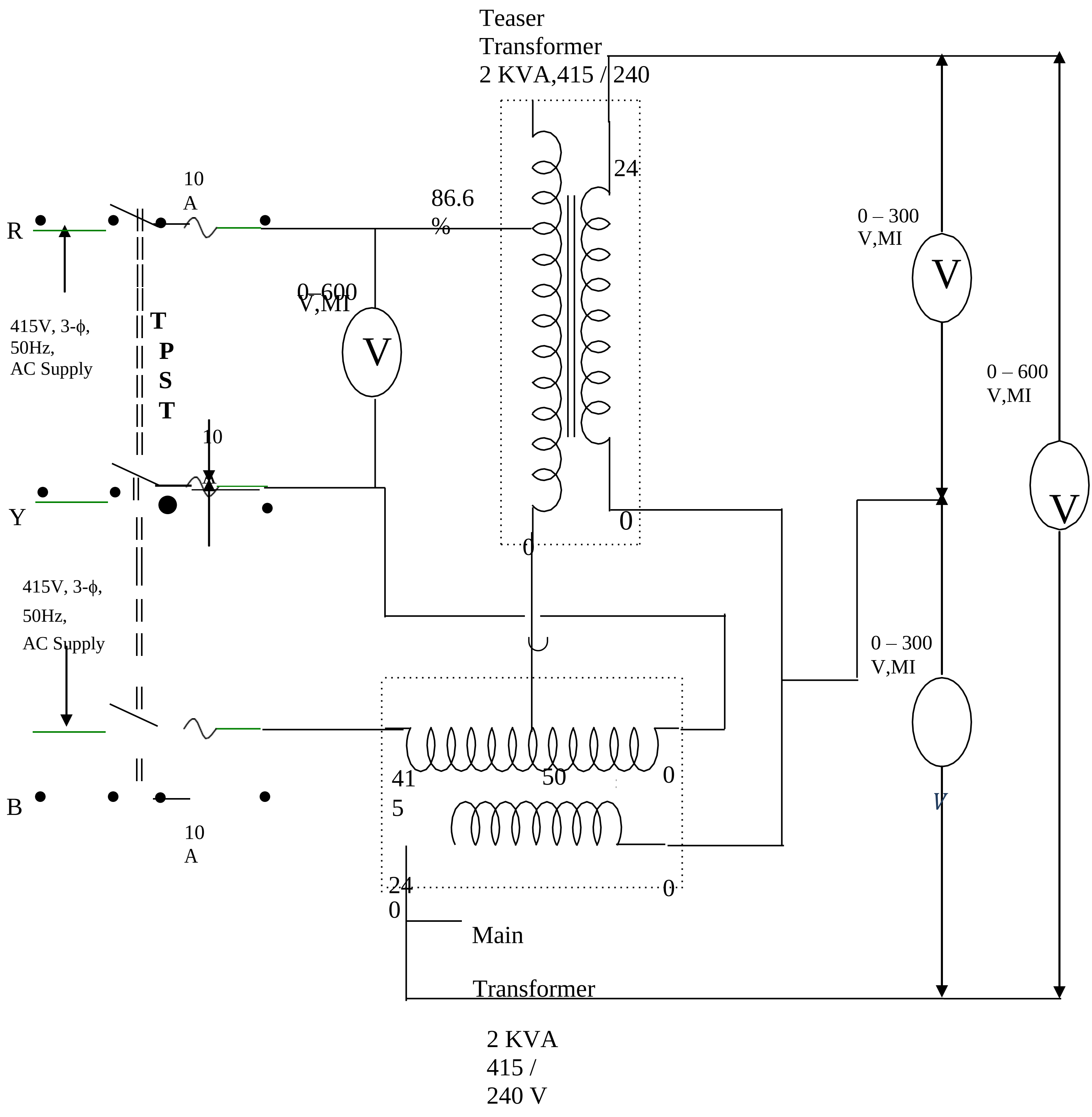


Fig.(3)

Circuit Diagram: Scott Connection



Procedure:

1. Connections are done as per the circuit diagram.
2. By using 3-ϕ auto transformer apply different voltages to the circuit.
3. Note down the all the meter readings.
4. Observe different meter readings.

Tabular Form:

S.NO	3 - ϕ SUPPLY			2 - ϕ SUPPLY		
	V_{RY} in volts	V_{YB} in volts	V_{BR} in volts	V_{Ph} in volts	V_{Ph} in volts	V_L in volts

Result: Hence, the three-phase system is converted to two phase system with the help of Scott Connection

Viva Questions

Q.1 What is the primary purpose of using a Scott-T connection in electrical systems?

Q.2 How are the main and teaser transformers connected in a Scott-T connection?

Q.3 What are some practical applications of the Scott-T connection in modern electrical systems?

Q.4 Why is the Scott Connection used?

Q.5 What are the advantages of using the Scott Connection?

Q.6 Can the Scott Connection handle unbalanced loads?