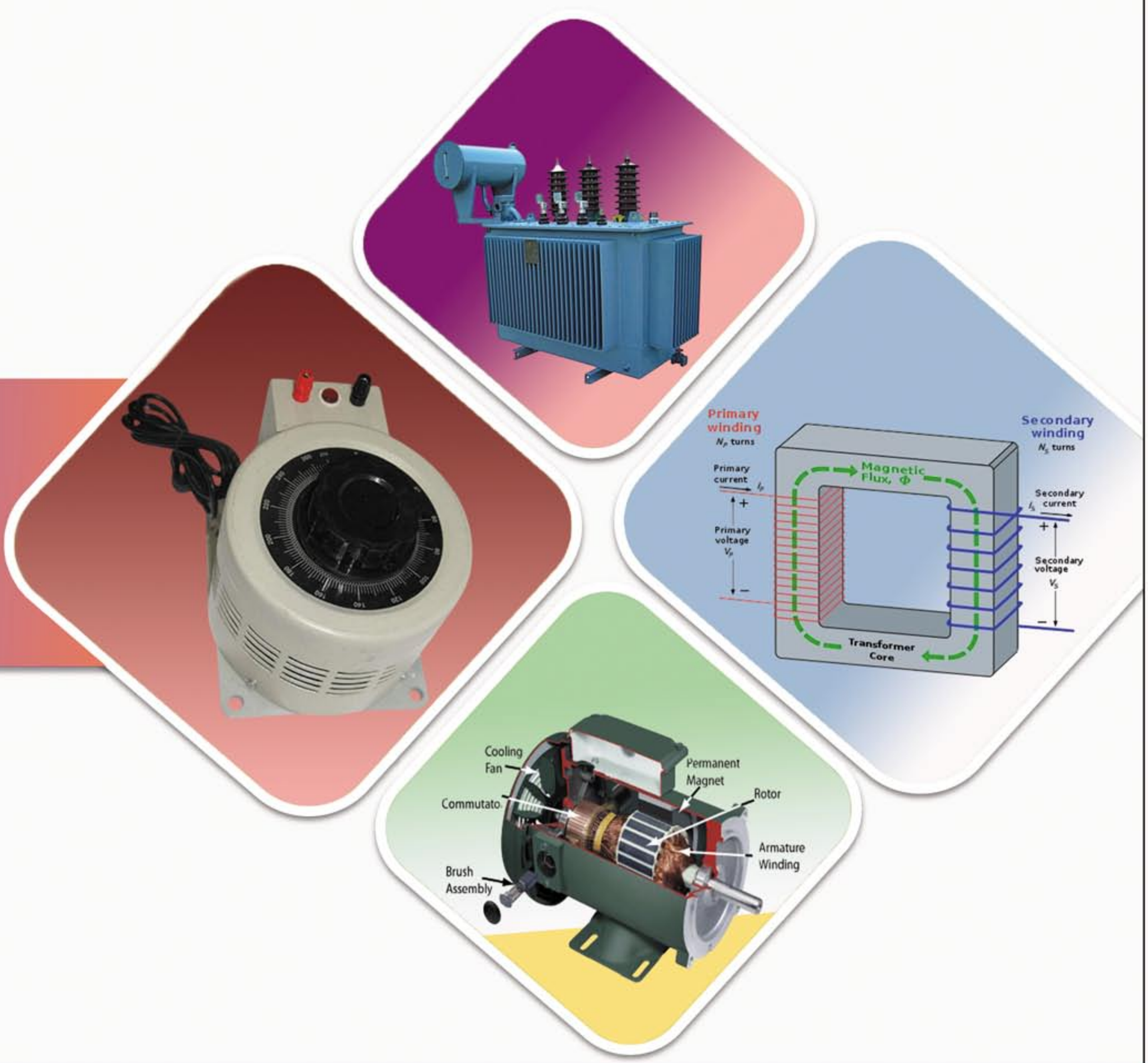
SCHEME : K

Name : ____________________________
Roll No. : ______________ Year : 20___ 20___
Exam Seat No. : ______________________

LABORATORY MANUAL FOR

D.C. MACHINES AND TRANSFORMERS (314322)



ELECTRICAL ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous) (ISO 9001: 2015) (ISO/IEC 27001:2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the following:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual For

D.C. MACHINES AND TRANSFORMERS

(314322)

Semester – IV

(EE/EK/EP)

Maharashtra State

Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

4th Floor, Government Polytechnic Building, 49, Kherwadi, Bandra (East), Mumbai- 400051.

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr. /Ms.……………………………………………

Roll No. ……………………………of fourth Semester of Diploma in …..…………………………..…………………………of Institute ………………………………………………………………………… (Code : ………) has completed the term work satisfactorily in course **D.C. Machine and Transformers (314322)** for the academic year 20…….to 20…….. as prescribed in the curriculum.

Place: …………….. **Enrollment No: ……………….**

Date: ………………. **Exam Seat No: …………………**

Subject Teacher Head of department Principal

Seal of Institute

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'T' Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher, instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through "chalk and duster" activity in the classroom situation. Accordingly, the "I scheme laboratory manual development team designed the practical to focus on the outcomes, rather than the traditional age old practice of conducting practical to 'verify the theory" (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected. from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

The basic aim of this course is that, the student must learn the basic concepts, rules and laws of electric and magnetic circuits and practical thereof. The basic concepts of electrical engineering in this course will be very useful for understanding electrical circuits.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Program Outcomes (POs)

- **PO 1. Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, sciences and engineering fundamentals and engineering specialization to solve the engineering problems.
- **PO 2. Problem analysis:** Identify and analyse well-defined engineering problems using codified standard methods.
- **PO 3. Design/ development of solutions:** Design solutions for well-defined technical problems and assist with the design of system components or processes to meet specified needs.
- **PO 4. Engineering tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.
- **PO 5. Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.
- **PO 6. Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
- **PO 7. Life-long learning:** Ability to analyse individual needs and engage in updating in the context of technological changes.

Program Specific Outcomes (PSOs):

- **PSO 1.** Maintain various types of static and rotating electrical equipment and power system with **its** control.
- **PSO 2.** Install and maintain all types of illumination and utilization system in residential, commercial and industrial sector considering conservation of electrical energy.

List of Relevant expected psychomotor domain Skills

The following relevant expected psychomotor domain Skills of the competency "Maintain electrical systems applying AC and DC circuit fundamentals" are expected to be developed in student by undertaking the practical's of this laboratory manual.

1. Ability to make connections.
2. Ability to test / plot / Verify and Investigate characteristics.
3. Ability to select proper ranges of meters.

Practical-Course outcome matrix

COURSE LEVEL LEARNING OUTCOMES (COS)

1. CO1 – Test the performance of D.C. Generators.
2. CO2 - Test the performance of D.C. Motors.
3. CO3 - Test the performance of Single phase transformers.
4. CO4 – Use three phase transformer for different applications.
5. CO5 - Use relevant special purpose transformers for different applications.

Sr.No.	Title of the Practical	CO1	CO2	CO3	CO4	CO5
1	Dismantling of a D.C. machine.	✓	-	-	-	-
2	Measurement of D.C. Shunt Generator voltage by changing flux and speed.	✓	-	-	-	-
3	Load test on D.C. Shunt Generator.	✓	-	-	-	-
4	Load test on D.C. Compound Generator.	✓	-	-	-	-
5	Testing the performance of D.C. Shunt generator by Hopkinson's Test.	✓	-	-	-	-
6	Reversal of rotation of D.C. shunt motor.	-	✓	-	-	-
7	Speed torque characteristics of D.C. shunt motor.	-	✓	-	-	-
8	Speed control of D.C. shunt motor using Armature control & flux control method.	-	✓	-	-	-
9	Reversal of rotation of D.C. series motor.	-	✓	-	-	-
10	Speed control of D.C. series motor using Armature control & flux control method.	-	✓	-	-	-
11	Brake test on D.C. series motor.	-	✓	-	-	-
12	Reversal of rotation of D.C. compound motor.	-	✓	-	-	-
13	Demonstration of operating mechanism of three point starter of a D.C. Shunt Machine.	-	✓	-	-	-
14	Demonstration of operating mechanism of four point starter of a D.C. Compound Machine.	-	✓	-	-	-
15	Demonstration of operating mechanism of two point starter of a DC series Machine.	-	✓	-	-	-
16	Demonstration of a single phase & Three phase transformer construction.	-	-	✓	✓	-
17	Transformation ratio of single phase transformer	-	-	✓	-	-

18	Direct load test of single phase transformer.	-	-	✓	-	-
19	Open circuit and short circuit test on single phase transformer to determine equivalent circuit parameters.	-	-	✓	-	-
20	Open circuit and short circuit test on single phase transformer to determine voltage regulation and efficiency.	-	-	✓	-	-
21	Perform parallel operation of two single phase transformers to determine the load current sharing.	-	-	✓	-	-
22	Perform parallel operation of two single phase transformers to determine the apparent and real power load sharing.	-	-	✓	-	-
23	Perform polarity test on a single phase transformer whose polarity markings are masked.	-	-	✓	-	-
24	Scott-Connection of three phase transformer.	-	-	-	✓	-
25	Back to Back test on single phase transformer	-	-	✓	-	-
26	Connection of the auto-transformer.	-	-	-	-	✓
27	Functioning of the Current transformer (CT).	-	-	-	-	✓
28	Functioning of the Potential Transformer (PT).	-	-	-	-	✓
29	Functioning of the isolation transformer.	-	-	-	-	✓

Content Page

List of Practical’s and Progressive Assessment Sheet

16	Demonstration of a single phase & Three phase transformer construction.	117					
17	Transformation ratio of single phase transformer	123					
18	Direct load test of single phase transformer.	129					
19	Open circuit and short circuit test on single phase transformer to determine equivalent circuit parameters.	135					
20	Open circuit and short circuit test on single phase transformer to determine voltage regulation and efficiency.	143					
21	Perform parallel operation of two single phase transformers to determine the load current sharing.	151					
22	Perform parallel operation of two single phase transformers to determine the apparent and real power load sharing.	157					
23	Perform polarity test on a single phase transformer whose polarity markings are masked.	163					
24	Scott-Connection of three phase transformer.	169					
25	Back to Back test on single phase transformer	175					
26	Connection of the auto-transformer.	185					
27	Functioning of the Current transformer (CT).	192					
28	Functioning of the Potential Transformer (PT).	197					
29	Functioning of the isolation transformer.	202					
Total							

Note :
Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

Guidelines to Teachers

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain prior concepts to the students before starting of each experiment
3. Involve students in performance of each experiment.
4. Teacher should ensure that the respective skills and competencies are developed in. the students after the completion of the practical exercise.
5. Teachers should give opportunity to students for hands on experience after the demonstration.
6. Teacher is expected to share the skills and competencies to be developed in the students.
7. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected the students by the industry.
8. Finally give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions.

Instructions for Students

1. Listen carefully the lecture given by teacher about subject, curriculum, learning structure, skills to be developed.
2. Organize the work in the group and make record all programs.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and gain confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual
6. Student shall refer technical magazines.
7. Student should develop habit to submit the practical’s on date and time.
8. Student should well prepare while submitting write-up of exercise.
9. Attach/paste separate papers wherever necessary.

Practical No. 1: Dismantling of a D.C. machine

I Practical Significance

In Industry, it is required to dismantle machines for overhauling purpose and reassemble. Through this practical student identifies different parts and their functions.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related9 field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Generators.

IV Laboratory Learning Outcome(s)

Identify different parts of the D.C. machine.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

The DC machine used to convert electrical energy into mechanical energy, which is known as DC motor and the DC machine used to convert mechanical energy into electrical energy, which is known as DC generator**.** The same machine can be used either as a motor or generator. The construction is same for DC motor and DC generator. The DC machine consists of Yoke, Pole, and Pole shoe, Armature core, Field Winding, Armature Winding, Commutator, Brushes, shaft, and Bearings. Let"s explain each part in detail with applications.

VII Actual Circuit diagram used in laboratory with equipment Specifications

(Students are expected to **write the names** of different **parts in** the following **figure)**

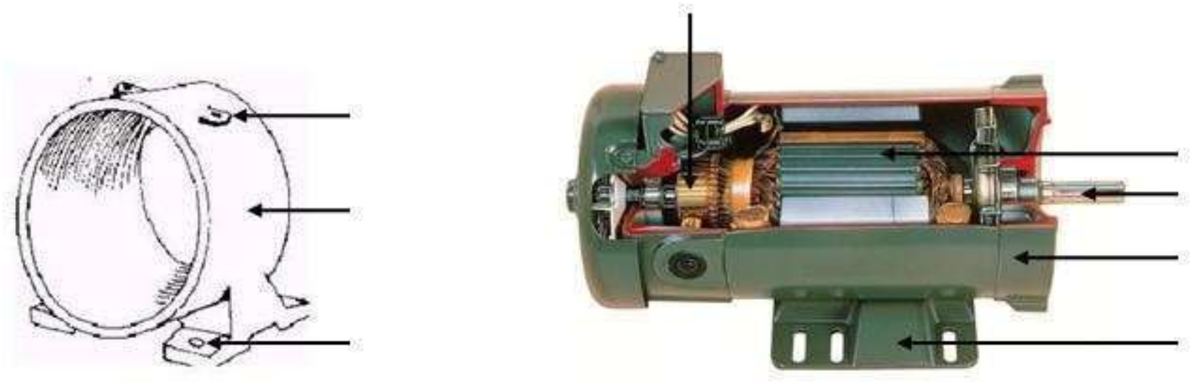


Fig 1.1 construction of DC machine

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC motor	2hp, 220V,DC motor	1 No.
2	Screw driver	Set	1 No.
3	Spanner	Set	1 No.
4	Wooden mallet		1 No.
5	Hammer		1 No.

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position and DC machine is disconnected from the supply.
2. The motor is mechanically disconnected from the load.

X Procedure

1. Remove the mechanical load/pulley of motor on the shaft.
2. View the external parts such as frame, eye bolt and foundation plate etc.
3. Remove the end covers.
4. Observe the various internal parts and their shapes and positions.
5. Note the material with which each part is made up of.
6. Write down in brief the function of each part after observation.
7. Reassemble the motor by putting back the end cover in original place

XI Observations and calculations

Sr. No.	Name of the part	Material used	Function
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Write the reasons for laminating the cores of armature and poles.
2. Write the function of air ducts provided in the armature core.
3. State the reason for larger area of cross section of pole shoe than the pole core.

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XVI References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2. Electrical Technology:Vol-2 B. L.Theraja S Chand Publications
3. www.E1ectrica14u.com
4. https://www.youtube.com/watch?v=oI-O9FCDqmg
5. https://www.youtube.com/watch?vmsWNGcZ-jds
6. https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	20%
2	Identification of components	30%
3	Working in teams	10%
Product Related: 10 Marks		**40%**
4	Interpretation of result	10%
5	Conclusions	10%
6	Practical related questions	15%
7	Submitting the journal in time	05%
Total		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 2: Measurement of D.C. Shunt Generator voltage by changing flux and speed.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to understand behaviour of DC machine. Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. This experiment is to equip students with fundamental knowledge, practical skills and a strong foundation in electrical power system and related fields.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Generators.

IV Laboratory Learning Outcome(s)

Verify generated output of the D.C. Shunt Generator.

V Relevant Affective Domain related outcome(s)

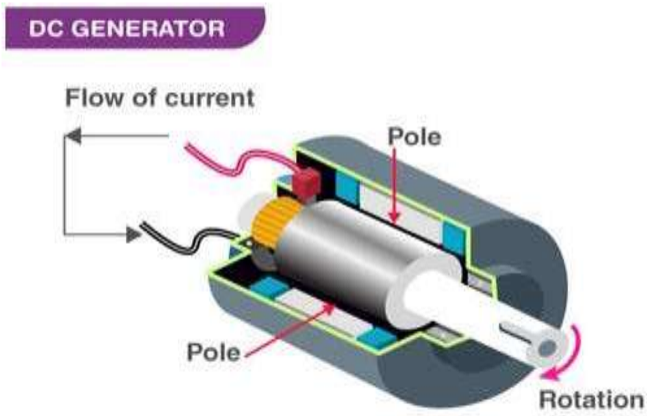
Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

A DC generator is an electrical machine whose main function is to convert mechanical energy into electricity. When the conductor slashes magnetic flux, an emf will be generated based on the electromagnetic induction principle of Faraday"s Laws. This electromotive force can cause a flow of current when the conductor circuit is closed.

Parts of a DC Generator



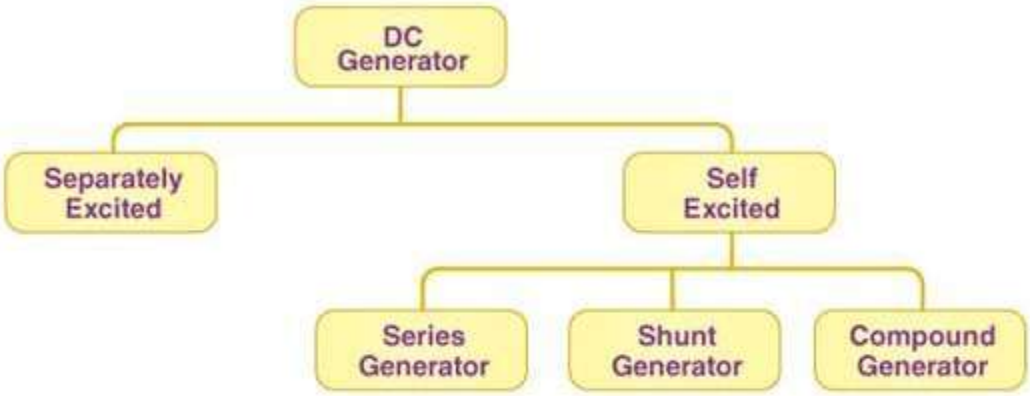
A DC generator can also be used as a DC motor without changing its construction. Therefore, a DC motor, otherwise a DC generator, can be generally called a DC machine. Below we have mentioned the essential parts of a DC Generator.

They are used for battery charging application.Shunt DC generators with field regulators are used for lighting and power supply purposes. Use for giving excitation to the alternators.

According to Faraday‟s law of electromagnetic induction, we know that when a current-carrying conductor is placed in a varying magnetic field, an emf is induced in the conductor. According to Fleming‟s right-hand rule, the direction of the induced current changes whenever the direction of motion of the conductor changes. Let us consider an armature rotating clockwise and a conductor at the left moving upwards. When the armature completes a half rotation, the direction of the motion of the conductor will be reversed downward. Hence, the direction of the current in every armature will be alternating. But with a split ring commutator, connections of the armature conductors get reversed when a current reversal occurs. Therefore, we get a unidirectional current at the terminals.

Types of DC generator

The DC generator can be classified into two main categories as separately excited and self-excited.

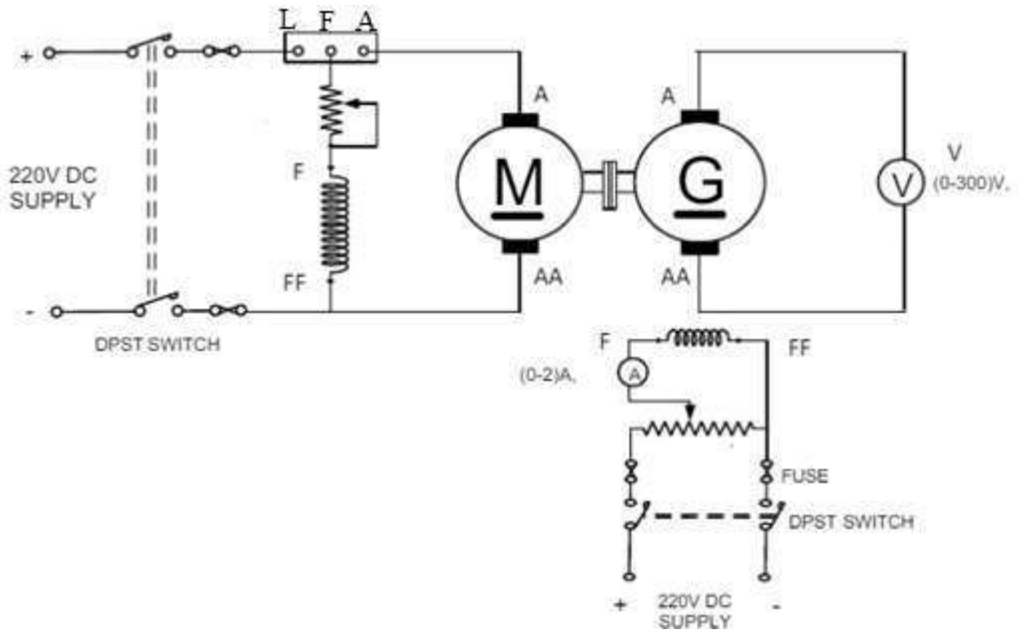


Applications of shunt generator:

1) Used for general lighting.
2) Used to charge the battery because they can be made to give constant output voltage.
3) Used for giving the excitation to the alternators.

4) In process of Electroplating.
5) Used for small power supply (such as a portable generator)

VII Actual Circuit diagram used in laboratory with equipment Specifications



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC Shunt Machine	Upto 230 V , 4 KW	1 No.
2	Rheostat	500 Ω , 1.2 Amp.	2 No.
3	Tachometer	Suitable range	1 No.
4	DC Ammeter	0-5/10 Amp	1 No.
5	DC Ammeter	0-150/300 V	1 No.

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position and DC machine is disconnected from the supply.

X Procedure

1. Connect meters as per circuit diagram.
2. Keep rheostat in the field circuit at the minimum position.
3. Increase the field current in steps by changing field rheostat of generator and note the reading of voltage across armature terminal of generator.
4. By changing the field rheostat of DC motor to run motor at different speed and note the reading of speed and voltage across armature terminal of generator.

XI Observations and calculations

1) D.C. Shunt Generator voltage by changing flux .

Sr. No.	Field Current (I_f) Amp.	Generated Armature Voltage (V) Volt
1		
2		
3		
4		
5		

2) D.C. Shunt Generator voltage by speed.

Sr. No.	DC Motor Speed (N) rpm	Generated Armature Voltage (V) Volt
1		
2		
3		
4		
5		

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Define DC generator. Write its working Principle.
2. List the types of DC Generator.
3. What is the effect of variation of speed on voltage build up ?
4. Write the parts and function of any four part of DC generator.
5. State the reason for larger area of cross section of pole shoe than the pole core.

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3) www.E1ectrica14u.com
4) https://www.youtube.com/watch?v=oI-O9FCDqmg
5) https://www.youtube.com/watch?vmsWNGcZ-jds
6) https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 3 : Load Test on D.C. Shunt Generator.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to understand behaviour of DC machine. Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. This experiment is to equip students with fundamental knowledge, practical skills and a strong foundation in electrical power system and related fields.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Generators.

IV Laboratory Learning Outcome(s)

Test the performance of D.C. Shunt generator.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

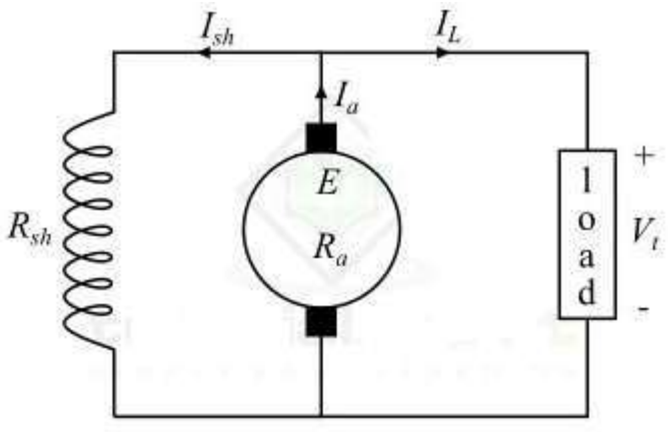
A DC generator is an electrical machine whose main function is to convert mechanical energy into electricity. When the conductor slashes magnetic flux, an emf will be generated based on the electromagnetic induction principle of Faraday"s Laws. This electromotive force can cause a flow of current when the conductor circuit is closed.

In a shunt generator field winding is connected in parallel to the armature. Compared to series field winding the shunt field winding is supposed to carry small current so that the generator is not unnecessarily loaded & the losses are not excessive. Due to this a shunt field winding is wound with thin wire & large no of turns.

As the shunt generator is started, a small amount of voltage is induced in the armature due to residual magnetic field. Since the field winding is connected across the armature a small current flows (Produced by residual magnetism) through it due to this small voltage. This field current produces same more flux which in turn increases the induced E.M.F. The increased induced E.M.F again increases the flux & this cumulative process continues till a steady value of e.m.f. Is decided by the field resistance & magnetization curve.

The current & flux depend upon the terminal voltage. As the load current increases, hence the terminal voltage decreases. Due to the reduction in the terminal voltage there is slight decreases in the field current, which in turn reduces the flux & hence the induced e.m.f. Also decreases due to the armature reaction.

A DC generator whose field winding is connected in parallel with the armature winding so that terminal voltage of the generator is applied across it, is known as a **shunt DC generator**. shows the connection diagram of a shunt DC generator.



Shunt DC Generator

In a shunt DC generator, the shunt field winding has a large number of turns of thin wire so it has high resistance, and therefore only a part of armature current flows through it and the rest flows through the load.

The following are important expressions of a shunt DC generator −

Armature current, Ia= IL + Ish

Terminal voltage, Vt = E−IaRa

E = V + Ia R a

The voltage regulation of a generator is defined as the change in the voltage drop from no load to full load to full load voltage. Ideally DC generators should have zero voltage regulation.

It is given by the formula:

$$\text{Voltage Regulation} = \frac{E_{\text{No Load}} - V_{\text{Full Load}}}{V_{\text{Full Load}}}$$

OR

$$VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%$$

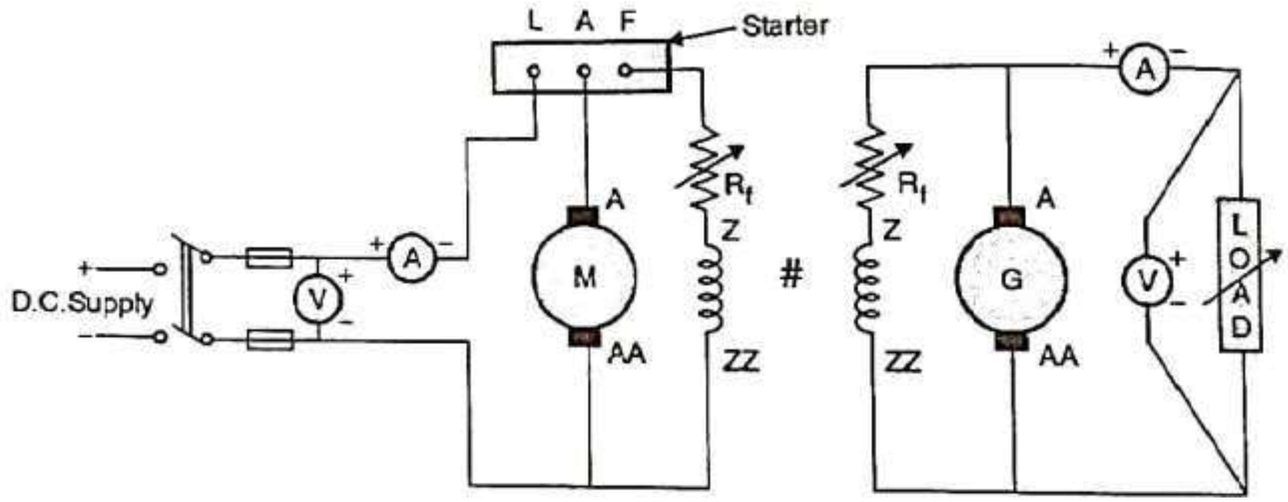
Where V_{NL} is the no-load voltage and V_{FL} is the full-load voltage.

Given, the full-load voltage regulation of a DC shunt generator at rated speed of 1000 rpm is 10%. This means that when the generator is operating at full load, the voltage drops by 10% from the no-load voltage. Now, if the generator is driven at 1250 rpm, we can assume that the armature current will increase due to the increase in speed. This will result in an increase in the armature reaction and a decrease in the field flux. As a result, the generated voltage will decrease. Therefore, the voltage regulation at full load would be more than 10%. This is because the voltage drop from no-load to full load will be higher due to the decrease in generated voltage.

Applications of shunt generator:

a. Used for general lighting.
b. Used to charge the battery because they can be made to give constant output voltage.
c. Used for giving the excitation to the alternators.
d. In process of Electroplating.
e. Used for small power supply (such as a portable generator)

VII Actual Circuit diagram used in laboratory with equipment Specifications



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC Shunt Machine	Upto 230 V , 4 KW	1 No.
2	Rheostat	500 Ω , 1.2 Amp.	2 No.
3	Tachometer	Suitable range	1 No.
4	DC Ammeter	0-5/10 Amp	1 No.
5	DC Voltmeter	0-150/300 V	1 No.

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position and DC machine is disconnected from the supply.

X Procedure

1. Set up the connections as per circuit diagram.
2. Start the generator at its normal speed with the help of prime mover. (d.c. Motor)
3. Adjust the terminal voltage to the rated value with the help of field rheostat.
4. Gradually increase load current of generator with the help of load bank.
5. At each time note down terminal voltage & load current of generator with help of voltmeter & ammeter respectively.

XI Observations and calculations

Sr. No.	Voltage (V) Volt	Load Current (I_L) Amp.	Voltage Regulation (V_{NL}-V_L)/V_L *100
1			
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Calculation –

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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Define DC generator. Write its working Principle.
2. List the types of DC Generator.
3. Define Voltage Regulation of DC generator?
4. What are different methods of calculating efficiency of dc shunt machine?
5. Draw DC shunt generator schematic diagram.

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XVI References/Suggestions for further reading

1) Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2) Electrical Technology:Vol-2 B. L.Theraja S Chand Publications
3) www.E1ectrica14u.com
4) https://www.youtube.com/watch?v=oI-O9FCDqmg
5) https://www.youtube.com/watch?vmsWNGcZ-jds
6) https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 4 : Load Test on D.C. Compound generator.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to understand behaviour of DC machine. Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. This experiment is to equip students with fundamental knowledge, practical skills and a strong foundation in electrical power system and related fields.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Generators.

IV Laboratory Learning Outcome(s)

Test the performance of D.C. Compund generator.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

In a **Compound Wound Generator,** there are two sets of the field winding on each pole. One of them is connected in series having few turns of thick wire, and the other is connected in parallel having many turns of fine wire with the armature windings. In other words, the generator which has both shunt and series fields is called the compound wound generators.

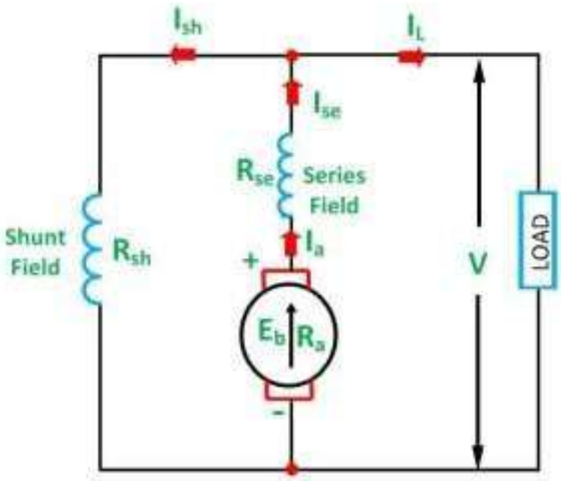
If the magnetic flux produced by the series winding assists the flux produced by the shunt winding, then the machine is said to be cumulative compounded. If the series field flux opposes the shunt field flux, then the machine is called the differentially compounded.

It is connected in two ways. One is a long shunt compound generator, and another is a short shunt compound generator.

If the shunt field is connected in parallel with the armature alone then the machine is called the short compound generator. In long shunt compound generator, the shunt field is connected in series with the armature. The two types of generators are discussed below in details.

Long Shunt Compound Wound Generator

In a **long shunt-wound generator,** the shunt field winding is parallel with both armature and series field winding. The connection diagram of the long shunt-wound generator is shown below:



The shunt field current is given as:

$$I_{sh} = \frac{V}{R_{sh}}$$

Series field current is given as:

$$I_{se} = I_a = I_L + I_{sh}$$

Terminal voltage is given as:

$$V = E_g - I_a R_a - I_{se} R_{se} = E_g - I_a (R_a + R_{se})$$

If the brush contact drop is included, the terminal voltage equation is written as:

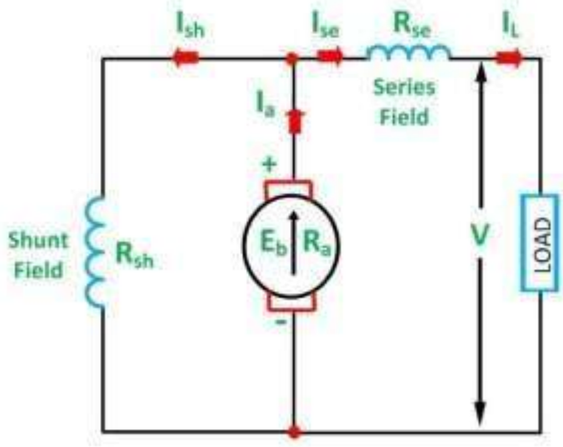
$$V = E_g - I_a (R_a + R_{se}) - 2V_b$$

$$\text{Power developed} = E_g I_a$$

$$\text{Power output} = V I_L$$

Short Shunt Compound Wound Generator

In **a Short Shunt Compound Wound** Generator, the shunt field winding is connected in parallel with the armature winding only. The connection diagram of a short shunt-wound generator is shown below.



Short Shunt Compound Wound Generator

Series field current is given as:

$$I_{se} = I_L$$

The shunt field current is given as:

$$I_{sh} = \frac{V + I_L R_{se}}{R_{sh}} = \frac{E_g - I_a R_a}{R_{sh}}$$

$$I_a = I_L + I_{sh}$$

Terminal voltage is given as:

$$V = E_g - I_a R_a - I_L R_{se}$$

If the brush contact drop is included, the terminal voltage equation is written as:

$$V = E_g - I_a R_a - I_L R_{se} - 2V_b$$

$$\text{Power developed} = E_g I_a$$

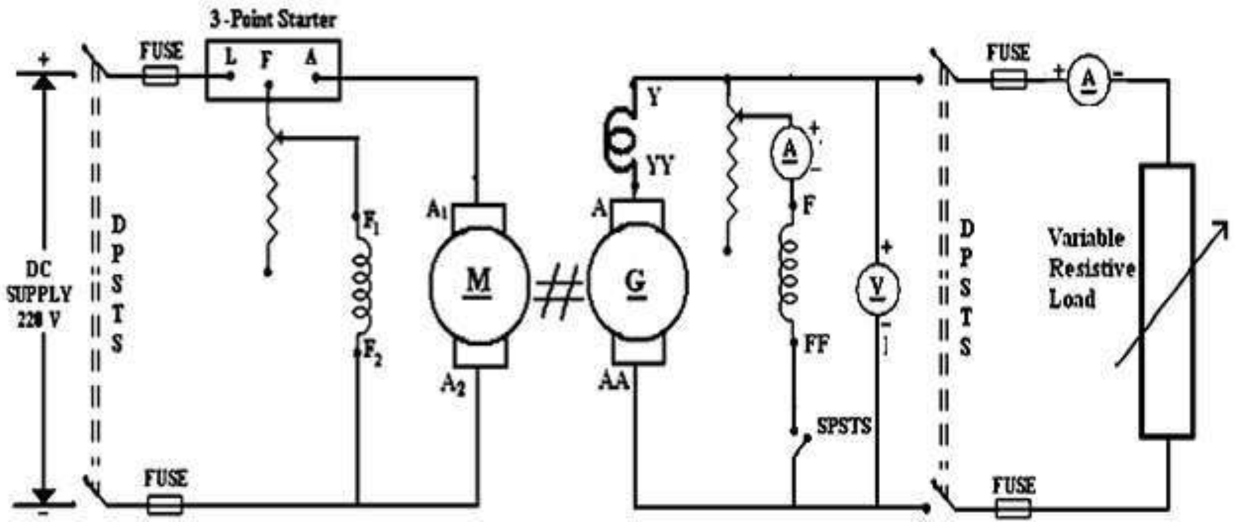
$$\text{Power output} = V I_L$$

In this type of DC generator, the field is produced by the shunt as well as series winding. The shunt field is stronger than the series field. If the magnetic flux produced by the series winding assists the flux produced by the shunt field winding, the generator is said to be **Cumulatively Compound Wound** generator.

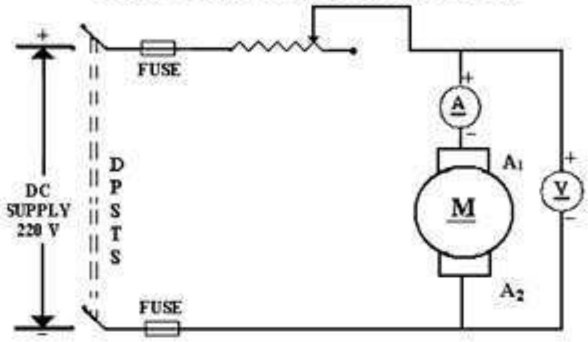
If the series field flux opposes the shunt field flux, the generator is said to be **Differentially Compounded.**

A shunt generator may be made to supply substantially constant voltage or even rise in voltage as the load increases, by adding to it a few turns joined in series with armature. These turns are so connected as to hide the shunt turns when the generator supplies the load. As the load current is increases, the current through the series winding also increases there by increasing the flux. Due to the increasing the flux, induced emf also increase. By adjusting the number of series turns, this increase emf can be load to be balance the combine voltage drop in the generator due to armature reaction and armature drop. Hence the voltage remains practically constant. The cumulatively – compound generators are used for motor driving which required DC supply constant voltage, for lamp loads and for heavy power service. The differential – compound generator is widely use in arc welding were larger voltage drop is desirable with increasing current.

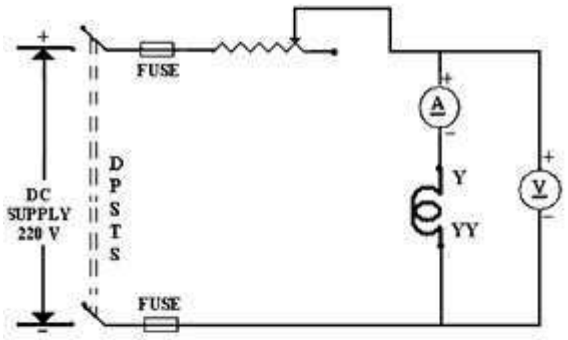
VII Actual Circuit diagram used in laboratory with equipment Specifications



CIRCUIT DIAGRAM TO MEASURE R_a



CIRCUIT DIAGRAM TO MEASURE R_{se}



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC Compound Machine	Upto 230 V , 4 KW	1 No.
2	Rheostat	500 Ω , 1.2 Amp.	2 No.
3	Tachometer	Suitable range	1 No.
4	DC Ammeter	0-5/10 Amp	2 No.
5	DC Voltmeter	0-150/300 V	1 No.
6	Lamp Load Bank	0-10/20 Amp.	1 No.

IX Precautions to be followed

1. All switches kept OFF initially.

2. The motor field rheostat, R1 is at minimum resistance initially and the generator field rheostat R2 is at maximum resistance position initially.

3. The speed of the machine is maintained constant for the whole experiment.

X Procedure

1. The DPST switch S1 is closed and the starter handle is moved from OFF position to ON position. Motor picks up speed. Adjust the motor field rheostat so that it runs at rated speed. Maintain the speed constant for the rest of the experiment.
2. Adjust the generator field rheostat so that the generator terminal voltage is the rated voltage. After this the generator field rheostat is not altered for the rest of the experiment.
3. The no load terminal voltage and field current is noted.
4. The DPST switch S2 is closed and the load is applied in steps from no load to full load. In each load the speed is maintained constant by adjusting motor field rheostat R1.
5. The terminal voltage V field current if and load current IL are noted for every load. The readings are tabulated.
6. After completion of the test, load is removed in steps, S2 is opened and motor supply is switch off by opening S1.
7. Induced EMF Eg is calculated, along with Ia, armature current. Here induced EMF Eg is the EMF after allowing for armature reaction.
8. Repeat procedure a to g for differentially compounded generator.

MEASUREMENT OF ARMATURE RESISTANCE AND SERIES COIL RESISTANCE:

1. The circuit is as shown in figure .
2. Keeping the rheostat at maximum resistance position, close S3 (or) S4.
3. Keep various voltmeter or ammeter readings by varying the rheostat. Meter readings are noted.
4. The ratio of voltage and current gives the required resistance.

XI Observations and calculations

S.No.	I_L Amp	I_F Amp	V_L Volt	Ia Amp	Ia(Ra+Rse) Amp	Eg=VL+Ia(Ra+Rse) Volt	Speed rpm

MEASUREMENT OF Ra:

S.No	Armature Voltage (Va) Volt	Armature Current (Ia) Amp	Armature Resistance (Ra) Ohm

MEASUREMENT OF Rse:

S.No	Voltage (Vse) Volt	Current (Ise) Amp	Resistance (Rse) Ohm

Calculation –

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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. List the types of DC Compound generator.
2. Draw schematic diagram of Short shunt and long shunt compound generator.
3. Write application of DC compound generator.

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XVI References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2. Electrical Technology:Vol-2 B. L.Theraja S Chand Publications
3. www.E1ectrica14u.com
4. https://www.youtube.com/watch?v=oI-O9FCDqmg
5. https://www.youtube.com/watch?vmsWNGcZ-jds
6. https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 5: Testing the performance of D.C. Shunt generator by Hopkison's Test.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to understand behaviour of DC machine. Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. This experiment is to equip students with fundamental knowledge, practical skills and a strong foundation in electrical power system and related fields.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Generators.

IV Laboratory Learning Outcome(s)

Test the performance of D.C. Shunt generator by Hopkison"s Test.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

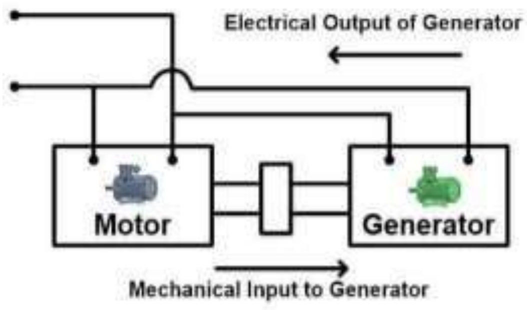
VI Relevant Theoretical Background (With diagrams if required)

A Hopkinson Test is used to identify the efficiency of two identical electrical machines (Such as Motor-Generator Set also known as coupling of DC Machines at full load operation. Both machines are connected mechanically coupled on the same shaft. Also, both machines are electrically coupled. One machine operates as a motor and the second machine operates as a generator.

The mechanical output of the first machine (motor) is fed to drive the second machine (generator). Hence, this test is known as a back-to-back test.

The electrical output of the second machine (generator) is used to supply the first machine (motor). Therefore, this test is known as the regenerative test.

Both machines are identical. It means ratings, armature resistance, filed winding resistance and losses are equal for both machines. If we consider an ideal machine (zero loss), the motor-generator pair continuously operate without any supply.



When an electrical input is given to the motor, it starts running. Both machines are connected with the same shaft. Hence, the motor drives the generator. And when the generator rotates on rated speed, it will generate rated electrical output. The electrical output generated by the generator is supplied with the electrical input.

When both machines are running at rated load, the electrical input supplied by the source is equal to the total losses of both machines. As both machines are identical, the losses of both machines are equal. So, the loss of one machine is half of the total loss.

For example, the power required to run this set is 100 W, and the losses of each machine are 15 W.

- Motor output = Motor Input – Motor losses
- Motor output = 100 – 15 = 85 W
- Motor output = Generator input = 85 W
- Generator output = Generator input – Generator losses
- Generator output = 85 – 15
- Generator output = 70 W

70 W output from the generator is supplied to the electrical input. Hence, 30 W is supplied by the input. And this 30 W is losses for both machines. In an actual case, we don‟t know the loss of the machine. And we conduct this test to find the losses.

Advantages & Disadvantages of Hopkinson's Test

Advantages

The advantages of the Hopkinson test are as listed below.

- The power required to perform this test is very small for large machines. Hence, it is an economical method of testing.
- This test is performed to find the efficiency of the DC machine. By this test, the efficiency of the machine can be found at various load conditions.
- In this test, both machines are operating at rated load conditions. Therefore, the stray load losses are taken into account.
- The temperature rise is also estimated during this test.

Disadvantages

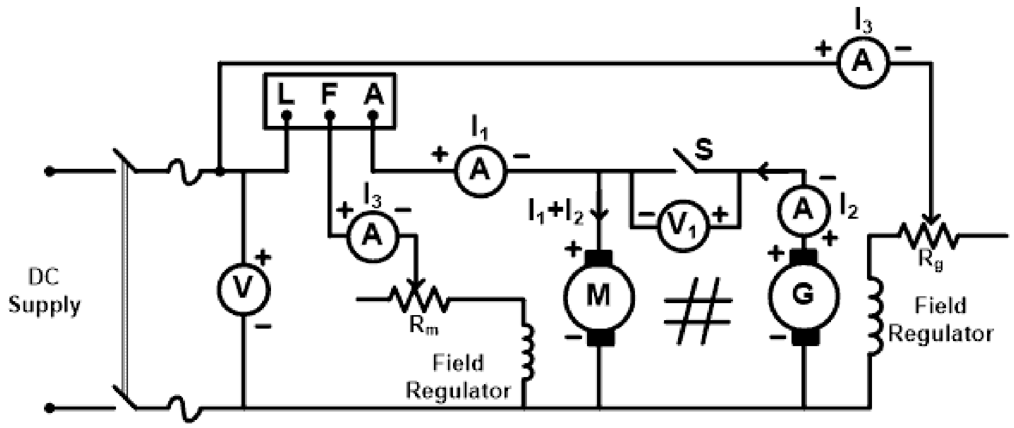
The disadvantages of the Hopkinson test are as listed below.

- In the Hopkinson test, two identical machines are required. And it is very difficult to find two identical machines.
- The excitation of both machines is different. Therefore, it is impossible to separate iron losses.
- Both machines cannot be loaded evenly.
- Because of the variation in field current, it is difficult to operate both machines at rated speed.

Applications of the Hopkinson Test.

As mentioned above, the main purpose of the Hopkinson test is to determine the efficiency of electrical machines especially in case of coupling of motors and generators (also known as Motor-Generator Set) based on the combined iron losses of both machines which can"t be separated.

VII Actual Circuit diagram used in laboratory with equipment Specifications



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC Shunt Machine	Upto 230 V , 4 KW	2 No.
2	Rheostat	500 Ω , 1.2 Amp.	2 No.
3	Tachometer	Suitable range	1 No.
4	DC Ammeter	0-5/10 Amp	3 No.
5	DC Voltmeter	0-150/300 V	1 No.

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position and DC machine is disconnected from the supply.

X Procedure

1. Make the connections as shown in figure
2. Ensure minimum resistance in motor field circuit and maximum resistance in generator field circuit, also ensure the switch is open condition, witch on the mains supply.
3. Pull the starter to ON-position and adjust the speed of the motor to its rated value.
4. Adjust the field of generator till rated or till voltage across switch is zero.
5. At this condition supply voltage opposes the generated voltage hence voltage across switch is zero.
6. Close the switch.
7. For generator voltage to supply motor, generator excitation to be increased in steps.
8. Note the readings of all meters at each step, till rated current of generator is reached.
9. Adjust the excitation for no load condition and switch off the main supply.
10. Measure the armature resistances and calculate the efficiencies and plot the same

XI Observations and calculations

Input voltage (V)	Current drawn from the supply (I_1)	Generator armature current (I_2)	Motor armature current (I_1+I_2)	Motor field current (I_3)	Generator field current (I_4)

Calculations :

Calculation of Hopkinson Test

- Input voltage = V
- Current drawn from the supply = I_1
- Generator armature current = I_2
- Motor armature current = $I_1 + I_2$
- Motor field current = I_3
- Generator field current = I_4
- Armature resistance for motor = R_m
- Armature resistance for generator = R_g

Now,

Power drawn from the supply = VI_1

The power drawn from the supply is equal to the losses of both machines. The losses of DC machines are; copper loss, iron loss, and mechanical loss.

Let"s assume the iron and mechanical loss for each machine is W_c.

Armature copper loss for motor;

$$P_{am} = (I_1 + I_2)^2 R_m$$

Armature copper loss for generator;

$$P_{ag} = I_2^2 R_g$$

Now, a sum of all losses is equal to the power drawn from the supply.

$$VI_1 = 2W_C + P_{am} + P_{ag}$$

$$VI_1 = 2W_C + (I_1 + I_2)^2 R_m + I_2^2 R_g$$

$$W_c = ½ (VI1 – (I_1 + I_2)^2 R_m – I_2^2 R_g$$

Efficiency of Motor

There are three types of losses in the motor;

- Armature copper loss (P_{am})
- Shunt field copper loss (P_{fm})
- Iron and mechanical loss (W_C)

The current that passes through the shunt field winding is I_3.

Hence, shunt field copper loss;

$$P_{fm} = VI_3$$

Total loss of motor;

$$P_{tm} = W_C + P_{am} + P_{fm}$$

$$P_{tm} = W_C + (I_1 + I_2)^2 R_m + VI_3$$

Total input power of motor;

$$Pi = V(I_1 + I_2) + VI_3$$

$$Pi = V(I_1 + I_2 + I_3)$$

Hence, the efficiency of a motor;

$$\%\,\eta = \frac{Input\ power - Total\ loss}{Input\ power} \times 100$$

$$\%\eta = \frac{P_i - P_{tm}}{P_i} \times 100$$

Efficiency of Generator

The current that passes through the field winding of the generator is I_4.

Hence, the shunt field copper loss;

$$P_{fg} = VI_4$$

Total loss for generator;

$$P_{tg} = W_C + P_{ag} + P_{fg}$$

$$P_{tg} = W_C + I_2^2 Rg + VI_4$$

The output of generator;

$$P_O = VI_2$$

Hence, the efficiency of a generator;

$$\%\eta = \frac{Output}{Output + Total\ losses} \times 100$$

$$\%\eta = \frac{P_O}{P_O + P_{tg}} \times 100$$

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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. What is meant by regenerative test?
2. What are the merits and demerits of Hopkinsons test
3. What is the condition to perform Hopkinsons test
4. Can we perform Regenerative test on DC series machines.

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XVI References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
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3. www.E1ectrica14u.com
4. https://www.youtube.com/watch?v=oI-O9FCDqmg
5. https://www.youtube.com/watch?vmsWNGcZ-jds
6. https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 6: Reversal of rotation of D.C. shunt motor.

I Practical Significance

In the industry it is often required to use the dc motor in both the directions in some applications without damaging or unnecessarily overloading it. This practical will enable the student to perform such operations.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related9 field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors.

IV Laboratory Learning Outcome(s)

Reverse the direction of rotation of the D.C. shunt motor

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

When a current carrying conductor is placed in a magnetic field, a mechanical force acts on it, which can be determined by Fleming‟s left hand rule. Due to this force the conductor starts rotating in the direction of the force.

If we stretch the first finger, second finger and thumb of our left hand to be perpendicular to each other, and first finger represents the direction of the magnetic field, the second finger represents the direction of the current, then the thumb represents the direction of the force experienced by the current carrying conductor.

VII Actual Circuit diagram used in laboratory with equipment Specifications

1. With Normal connection of armature and field winding

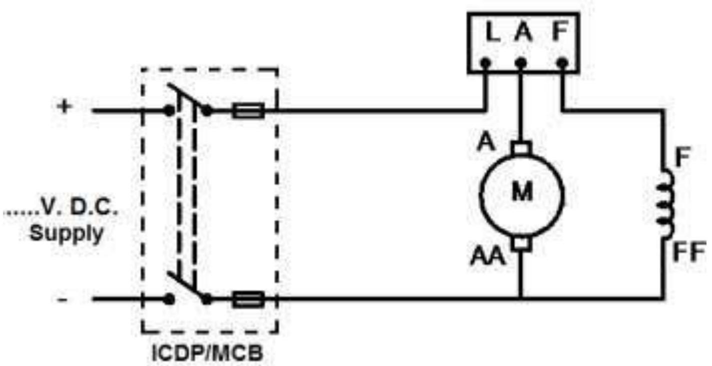

Fig. 6.1 (Forward/Normal rotation)

2. With Field connections reversed

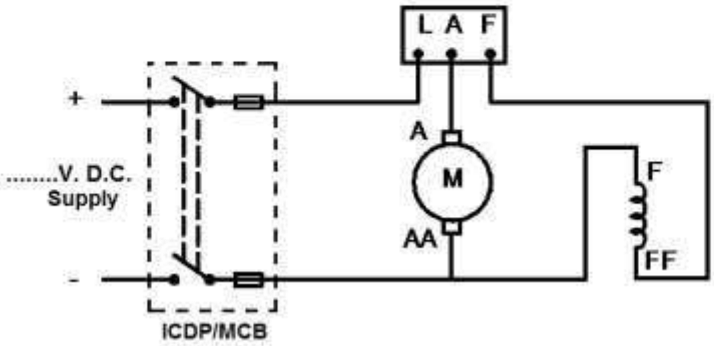

Fig. 6.2 (Reversed rotation by reversing filed current)

3. With armature winding connections reversed:

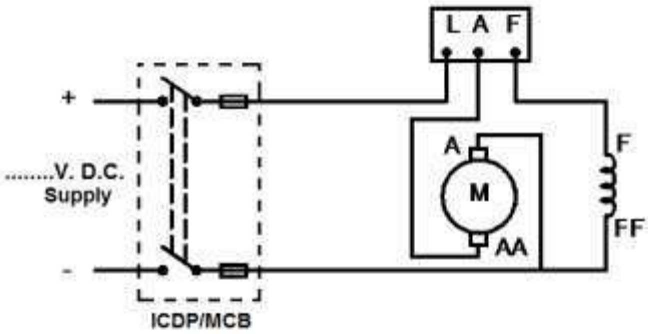

Fig. 6.3 (Reversed rotation by reversing armature current)

4. When both winding connections are reversed :
(student shall draw the circuit diagram)

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC motor with 3 point starter	1HP to 3HP, 230V, 1500RPM DC shunt motor	1 No.
2	Tachometer	0-5000 RPM	1 No.
3	Connecting wires	1.5Sqmm	As required

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position while making connections.
2. While using starter, make sure that the handle is in „OFF" position.
3. Wires used for circuit connection should have proper insulation cover.

X Procedure

1. Connect the circuit as per Fig. 6.1.
2. Switch „ON" the supply.
3. Using the starter, start the motor.
4. Observe the direction of rotation and record the same.
5. Switch OFF the supply and ensure that the starter handle comes back to OFF position.
6. Repeat the above procedure for connections in fig. 6.2, 6.3 and 6.4
7. Observe the effect of change in direction of rotation and record the same.
8. Switch „OFF" the supply.

XI Observations and calculations

Sr. No.	Connection	Direction of rotation	Remarks
1	As per fig 6.1		
2	As per fig 6.2		
3	As per fig 6.3		
4	As per fig 6.4		

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. State Fleming"s left hand rule.
2. Why does a motor rotate in reverse direction when the current through the field or armature circuit is reversed?
3. What will be the effect on the direction of rotation of a DC shunt motor if the supply terminals are reversed?
4. Which protective device is provided for protection of motor against low/no voltage condition?

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XVI References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2. Electrical Technology:Vol-2 B. L.Theraja S Chand Publications

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 7: Speed torque characteristics of D.C. shunt motor.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to understand behaviour of DC machine. Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. This experiment is to equip students with fundamental knowledge, practical skills and a strong foundation in electrical power system and related fields.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors.

IV Laboratory Learning Outcome(s)

Perform brake test on D.C. shunt motor.

V Relevant Affective Domain related outcome(s)

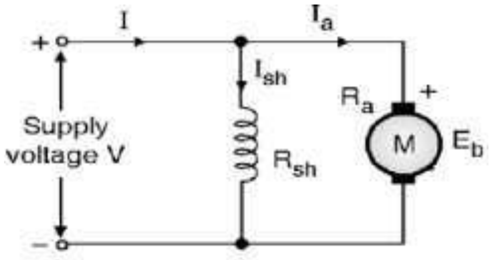
Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

The construction of a DC shunt motor is identical to that of any other DC motor. Basic components such as field windings (stator), a commutator, and an armature can be used to build this motor (rotor). The working principle of a DC Shunt Motor is that when the motor is turned on, DC passes between the stator and rotor. The pole as well as the armature will be generated by this current flow. There are two magnetic fields in the air gap between the armature and the field shoes, and they will react to each other to rotate the armature. At usual gaps, the commutator reverses the armature current flow direction. As a result, the armature field is always repelled by the pole field, which keeps the armature rotating in the same direction.

In the case of a shunt wound DC motor, the current supply will be split into two halves, Ia and Ish, with Ia supplying throughout the resistance armature winding. „Ish‟ will supply through the „Rsh‟ resistance field winding in the same way. As a result, we can write:



I_T=Ia+Ish

Ish=E/Rsh

Ia=I_T-Ish=E/Ra

When the DC motor is running and the power supply voltage is stable, the shunt field current is usually delivered as

Ish=E/Rsh

The armature current, however, is proportional to the field flux (Ish). As a result, the remains more otherwise less stable, and a shunt wound DC motor is referred to as a constant flux motor.

DC Shunt Motor Speed Control

When opposed to a series motor, a shunt motor has a different speed characteristic. When a DC Shunt motor reaches full speed, the armature current can be connected directly to the motor load. When the load on a shunt motor is very low, the armature current can likewise be very low. When the DC motor reaches its maximum speed, it becomes steady. The speed of the DC shunt motor can be easily regulated. Until the load changes, the speed can be kept constant. The armature tends to delay when the load changes, resulting in less back e.m.f. As a result, the DC motor will draw more current, resulting in increased torque to gain speed. As a result, whenever the load increases, the net effect of load on speed in a motor is nearly nil. Similarly, as the load falls, the armature accelerates and generates additional back e.m.f.

There are two techniques to control the speed of a DC shunt motor:
• Changing the total amount of current flowing through the shunt windings;
• Changing the total amount of current flowing through the armature.
DC motors are typically available with a specific rated voltage and speed in (revolutions per minute). The torque will be reduced once this motor is operating at its full voltage.

Brake Test on DC Shunt Motor

On the dc shunt motor, the brake test is one type of load test. This test can be performed on low-rated DC equipment in general. The major purpose of this test is to determine the efficiency, and it may also be used to compute and separate the output of mechanical power using electrical input. As a result, this test is used to calculate the efficiency of the DC motor. As a result, this type of test cannot be used on machines with higher ratings.

Brake test is generally done on low rated dc machines. The main Reason for conducting this test is to find the efficiency of the machine. From this test we calculate output mechanical power and divide it by electrical input and hence get the efficiency. It is a lossy method so can't be used on higher rating machines.

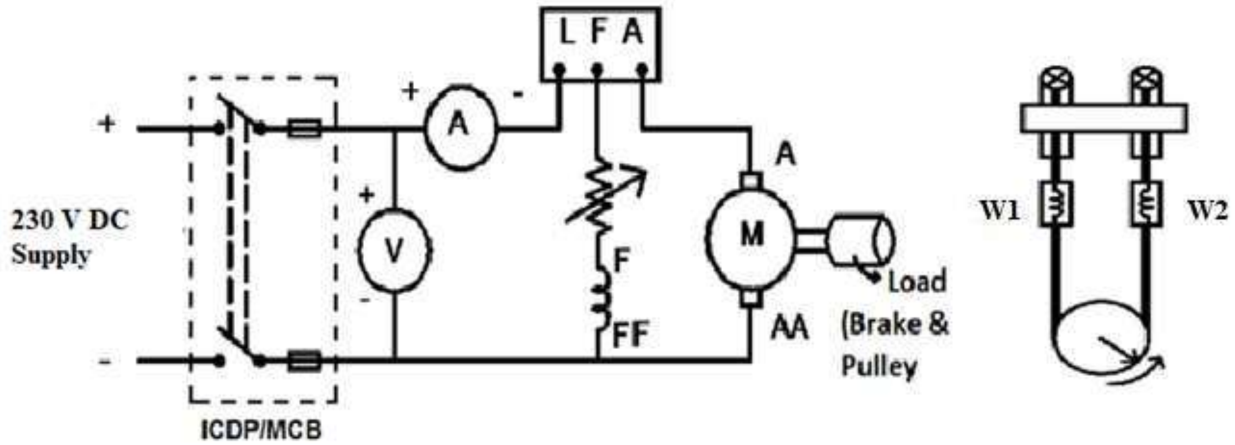
The disadvantages of brake test,

1) Due to friction, heat generated and hence there is large dissipation of energy.
2) Some type of cooling arrangement is necessary.
3) Convenient only for small machines due to limitations regarding heat dissipation arrangements.
4) The power developed gets wasted hence method is expensive.

Applications for DC Shunt Motors

Shunt DC motors are utilized in Centrifugal Pumps, Lifts, Weaving Machines, Lathe Machines, Blowers, Fans, Conveyors, Spinning Machines, and other applications where a consistent speed is required. As a result, this is all about a DC shunt motor overview. Finally, based on the aforementioned facts, we can infer that these motors are appropriate for applications requiring precise speed control due to their self-regulating speed capacity. This motor‟s primary uses include equipment like as grinders and locks, as well as industrial tools such as compressors and fans.Torque

VII Actual Circuit diagram used in laboratory with equipment Specifications



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC shunt motor with load and pulley arrangement	Upto 230 V , 4 KW	1 No.
2	Rheostat	500 Ω , 5 Amp.	1 No.
3	Tachometer	Suitable range	1 No.
4	DC Ammeter	0-5/10 Amp	1 No.
5	DC Voltmeter	0-150/300 V	1 No.

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position while making connections.
2. While using starter, make sure that the handle is in „OFF" position.
3. Wires used for circuit connection have proper size and insulation cover.
4. Belt/Rope used for pulley should be properly cooled at the regular interval in between the practical

X Procedure

1. Connect the circuit as per the circuit diagram.
2. Measure the radius of pulley (brake drum).
3. Keep the field circuit rheostat R to the minimum value.
4. Ensure that there is no load on the brake drum
5. Switch „ON" the supply and start the motor with the help of three point starter.
6. Adjust the field rheostat of motor to obtain rated speed of motor.
7. Note the speed using tachometer.
8. After setting the speed, rheostat position should not be altered.
9. Note down the input voltage, current using voltmeter, ammeter at no load.
10. Increase the load on the brake drum gradually up to full load in steps and record the corresponding readings of voltmeter, ammeter, tachometer and belt tensions.
11. Pulley must be water cooled at regular intervals.
12. Release the spring tension slowly and at no load switch „OFF" the supply.

XI Observations and calculations

Radius of the pully(r) in meter =…………

Sr. No.	Input Voltage (V) in Volts.	Armature Current (I) in Amps.	Speed (N) in RPM	W_1 in Kg	W_2 in Kg	W= (W_2-W_1) in Kg	Torque (T) in N-m	Output Power (P_o) in watts	Input Power (P_i) in watts	% Efficiency $(P_o/Pi)x100$
1										
2										
3										
4										
5										
6										

Calculation:

$W=(W2-W1)Kg$

$T=(W2-W1)\times r\times 9.81Nm$

$Pinput = 2\pi NT/60 watt$

$Poutput = V\times I$ watt.

$\%Efficiency = (Poutput / Pinput) \times 100$

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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Explain "Brake test is performed on small machines".
2. State various losses in d.c. machines.
3. State the effect of speed if the field rheostat is kept to its maximum at the time of starting the motor.
4. State the value of efficiency of motor under no load condition.
5. State the need for cooling the brake drum.
6. State any two industrial applications of d.c. shunt motor based on the above characteristics.

XVI References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2. Electrical Technology:Vol-2 B. L.Theraja S Chand Publications
3. www.E1ectrica14u.com
4. https://www.youtube.com/watch?v=oI-O9FCDqmg
5. https://www.youtube.com/watch?vmsWNGcZ-jds
6. https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8: Speed control of D.C. shunt motor using Armature control and flux control method.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to understand behaviour of DC motor. Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. Many a times it is required to change the speed of the motor as per application. This experiment is to equip students with fundamental knowledge of speed control of DC Motor, practical skills and a strong foundation in electrical power system and related fields.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors.

IV Laboratory Learning Outcome(s)

Control the speed of D.C. shunt motor by different methods.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Speed of a DC motor

Back emf E_b of a DC motor is nothing but the induced emf in armature conductors due to rotation of the armature in magnetic field. Thus, the magnitude of E_b can be given by EMF equation of a DC generator.

$$E_b = PØNZ/60A$$

(where, P = no. of poles, Ø = flux/pole, N = speed in rpm, Z = no. of armature conductors, A = parallel paths)

E_b can also be given as,

$E_b = V - I_aR_a$

thus, from the above equations

$$N = E_b\,60A/PØZ$$

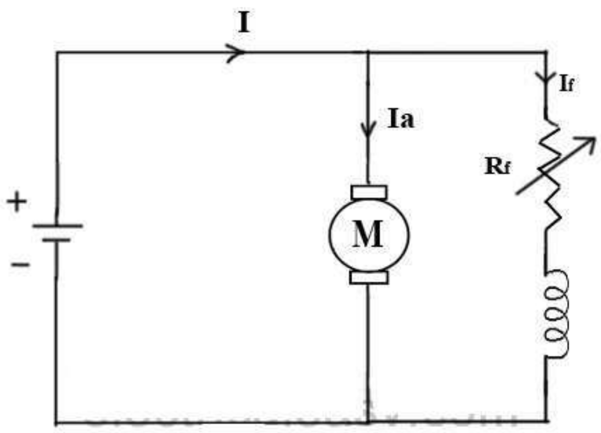
but, for a DC motor A, P and Z are constants

Therefore, $N \propto K\, E_b/\phi$ (where, K=constant)

This shows the **speed of a dc motor** is directly proportional to the back emf and inversely proportional to the flux per pole.

Speed control of Shunt motor

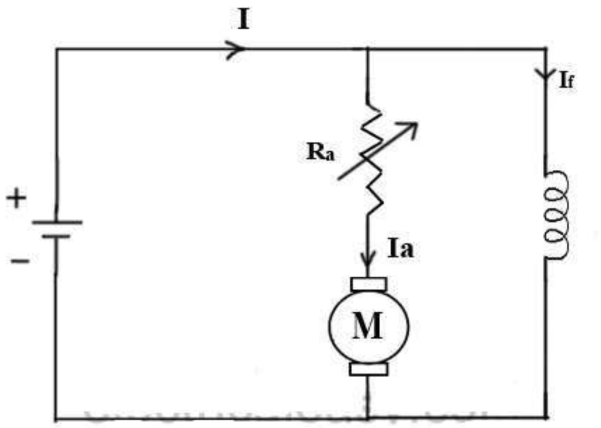
1. **Flux control method**



It is already explained above that the **speed of a dc motor** is inversely proportional to the flux per pole. Thus by decreasing the flux, speed can be increased and vice versa.

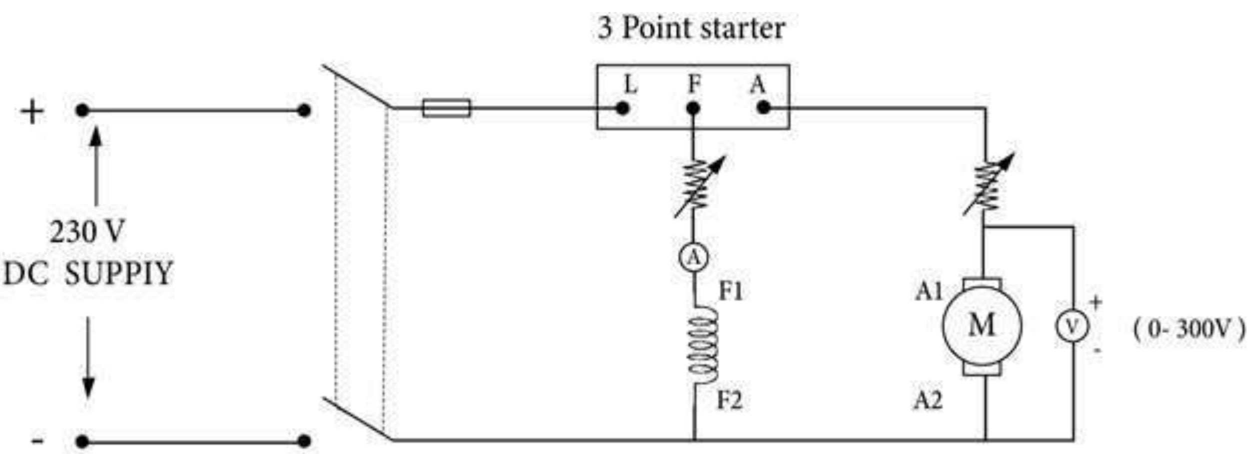
To control the flux, a rheostat is added in series with the field winding, as shown in the circuit diagram. Adding more resistance in series with the field winding will increase the speed as it decreases the flux. In shunt motors, as field current is relatively very small, I_{sh}^2R loss is small. Therefore, this method is quite efficient. Though speed can be increased above the rated value by reducing flux with this method, it puts a limit to maximum speed as weakening of field flux beyond a limit will adversely affect the commutation.

2. **Armature control method**



Speed of a dc motor is directly proportional to the back emf E_b and $E_b = V - I_aR_a$. That means, when supply voltage V and the armature resistance R_a are kept constant, then the speed is directly proportional to armature current I_a. Thus, if we add resistance in series with the armature, I_a decreases and, hence, the speed also decreases. Greater the resistance in series with the armature, greater the decrease in speed.

VII Actual Circuit diagram used in laboratory with equipment Specifications



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC shunt motor	Upto 230 V , 4 KW	1 No.
2	Rheostat	500 Ω , 5 Amp.	2 No.
3	Tachometer	Suitable range	1 No.
4	DC Ammeter	0-5/10 Amp	2No.
5	DC Voltmeter	0-150/300 V	1 No.

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position while making connection
2. Wires used for circuit connections are of proper size and insulation.
3. Ensure that the meters/components used in this practical have proper rating.
4. Motor field rheostat should be at minimum position at the time of starting.

X Procedure

Part A: Speed control of DC Shunt Motor by Armature Voltage control method.

1. Make the connections as per circuit diagram shown in the Figure.
2. Both motor field rheostat and armature rheostat should be kept at minimum position at the time of starting.
3. DPST switch is closed and motor is started using three point starter.
4. Bring the motor to the rated speed using rheostat connected in series with field circuit.
5. Maintain the field current at a constant value by adjusting the field rheostat and note down its value.
6. Note down the value of corresponding armature voltage(V_a)and speed(N)
7. Vary the armature rheostat to get different values of armature voltage (V_a) and note down the corresponding speed (N).
8. Bring the field and armature rheostats to the original position and switch "OFF" the supply.

Part B: Speed control of DC Shunt Motor by Field Current control method.

1. Make the connection as per circuit diagram shown in Fig.
2. Keep both field rheostat and armature rheostat at minimum position at the beginning of the practical.
3. Switch "ON" the supply. Start the motor with the help of starter.
4. Bring the motor to the rated speed using rheostat connected in series with field circuit.
5. Armature voltage is kept at a constant value by adjusting the armature rheostat.
6. Note down the corresponding values of field current (I_f)and speed (N).
7. Vary the field rheostat, take corresponding readings of field current and speed.
8. Bring the field and armature rheostats to the original position and switch "OFF" the supply

XI Observations and calculations

For part A:

Field current =. ....amp (To be kept constant)

Sr.No.	Armature Voltage (V») in volt	Speed in RPM

Note• A graph is plotted by taking Armature voltage along the X-axis and Speed along the Y- axis

For Part B:

Armature Voltage =......................volt (To be kept constant)

Sr.No.	Field Current in (I,)amp	Speed in RPM
1		
2		
3		
4		
5		
6		

Note: A graph is plotted by taking field current along the X-axis and Speed along the Y-axis.

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Write the advantages of d.c. shunt motor.
2. What are the methods of speed control in a D.C Shunt motor?
3. List the application of d.c. shunt motor.
4. State the type of starter used for a d.c. shunt motor.
5. Give the reason for high starting current of the d.c. shunt motor.
6. A dc shunt motor is constant speed motor. Explain.

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XVI References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
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5. https://www.youtube.com/watch?vmsWNGcZ-jds
6. https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 9: Reversal of rotation of D.C. series motor.

I Practical Significance

In the industry it is often required to use the dc motor in both the directions in some applications without damaging or unnecessarily overloading it. This practical will enable the student to perform such operations.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related9 field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors.

IV Laboratory Learning Outcome(s)

Reverse the direction of rotation of the D.C. series motor.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

When a current carrying conductor is placed in a magnetic field, a mechanical force acts on it, which can be determined by Fleming‟s left hand rule. Due to this force the conductor starts rotating in the direction of the force.

If we stretch the first finger, second finger and thumb of our left hand to be perpendicular to each other, and first finger represents the direction of the magnetic field, the second finger represents the direction of the current, then the thumb represents the direction of the force experienced by the current carrying conductor.

VII Actual Circuit diagram used in laboratory with equipment Specifications

With Normal connection of armature and field winding

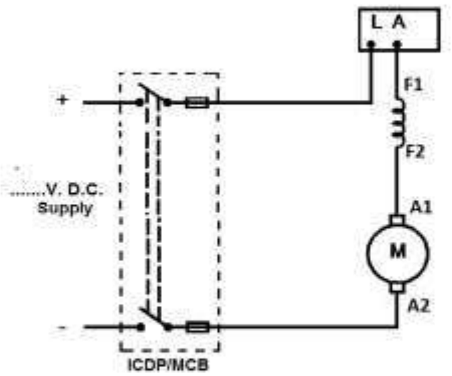

Fig. 9.1 (Forward/Normal rotation)

With Field connections reversed

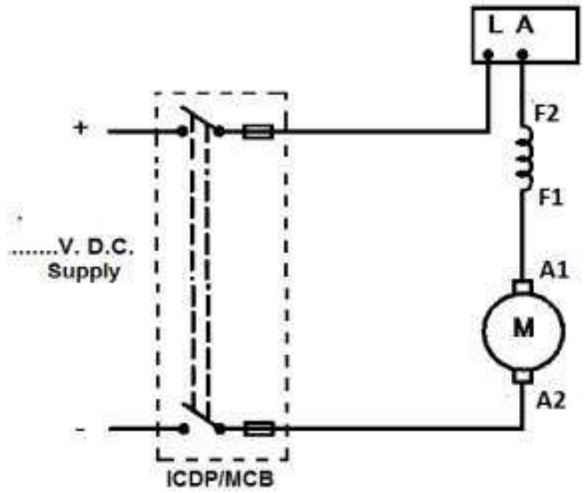

Fig. 9.2 (Reversed rotation by reversing filed current)

With armature winding connections reversed:

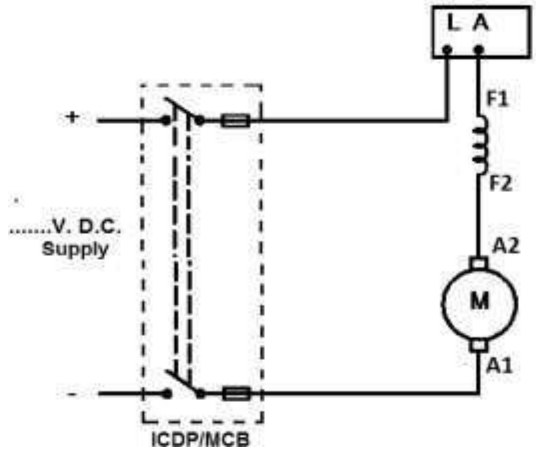

Fig. 9.3 (Reversed rotation by reversing armature current)

When both winding connections are reversed :

(student shall draw the circuit diagram)

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC series motor with 2 point starter	1HP to 3HP, 230V, 1500RPM DC series motor	1 No.
2	Tachometer	0-5000 RPM	1 No.
3	Connecting wires	1.5Sqmm	As required

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position while making connections.
2. While using starter, make sure that the handle is in „OFF" position.
3. Wires used for circuit connection should have proper insulation cover.
4. Make sure to apply mechanical load before starting the motor.

X Procedure

1. Connect the circuit as per Fig. 9.1.
2. Switch „ON" the supply.
3. Using the starter, start the motor.
4. Observe the direction of rotation and record the same.
5. Switch OFF the supply and ensure that the starter handle comes back to OFF position.
6. Repeat the above procedure for connections in fig. 9.2, 9.3 and 9.4
7. Observe the effect of change in direction of rotation and record the same.
8. Switch „OFF" the supply.

XI Observations and calculations

Sr. No.	Connection	Direction of rotation	Remarks
1	As per fig 9.1		
2	As per fig 9.2		
3	As per fig 9.3		
4	As per fig 9.4		

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. State Fleming"s left hand rule.
2. Why does a motor rotate in reverse direction when the current through the field or armature circuit is reversed?
3. What will be the effect on the direction of rotation of a DC series motor if the supply terminals are reversed?
4. State the reason for not starting the dc series motor on no load
5. List advantages and applications of dc series motor.
6. Give the reason for high starting torque of the dc series motor.
7. Explain why dc series motor is variable speed motor

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XVI References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2. Electrical Technology:Vol-2 B. L.Theraja S Chand Publications

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 10 : Speed control of D.C. series motor using Armature control and flux control method.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to understand behaviour of DC motor. Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. Many a times it is required to change the speed of the motor as per application. This experiment is to equip students with fundamental knowledge of speed control of DC Motor, practical skills and a strong foundation in electrical power system and related fields.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors.

IV Laboratory Learning Outcome(s)

Control the speed of D.C. series motor by different methods.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Speed Control of DC Series Motor

Speed control methods for a DC series motor can be classified as:

1. Armature Control Methods
2. Field Control Methods

Armature Controlled DC Series Motor

Speed adjustment of a DC series motor by **armature control** may be done by:

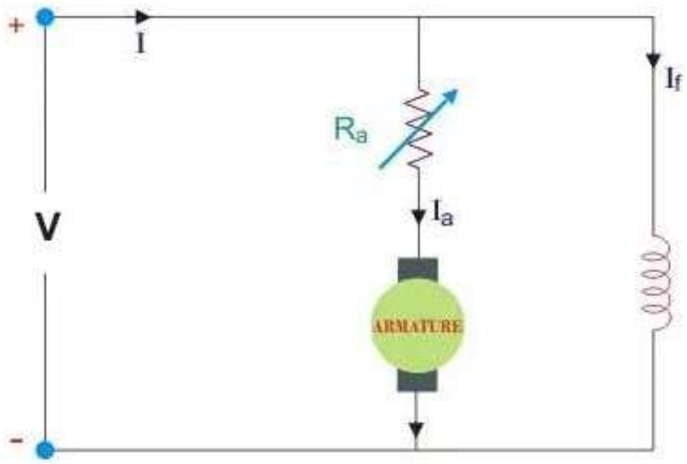
1. Armature Resistance Control Method
2. Shunted Armature Control Method
3. Armature Terminal Voltage Control

   The armature voltage control method involves controlling the voltage applied to the armature of the DC series motor. By manipulating the armature voltage, the motor's speed and torque can be regulated effectively. During motor starting, a reduced voltage is initially applied to the armature. This reduced voltage limits the armature current and prevents excessive starting current, which could damage the motor or associated electrical equipment.

As the motor gains speed, the full armature voltage is gradually applied, allowing the motor to reach its rated speed. For speed control, the armature voltage is varied by using a variable resistance in series with the armature. By increasing the resistance, the armature voltage decreases, reducing the motor's back EMF. As a result, the armature current increases, providing more torque and increasing the speed. Conversely, decreasing the resistance increases the armature voltage, leading to a decrease in speed. The armature voltage control method offers good speed control and provides high starting torque, making it suitable for applications requiring quick acceleration or heavy load starting. However, this method is less efficient than field flux control due to the energy dissipation across the variable resistance.

Armature Resistance Control Method

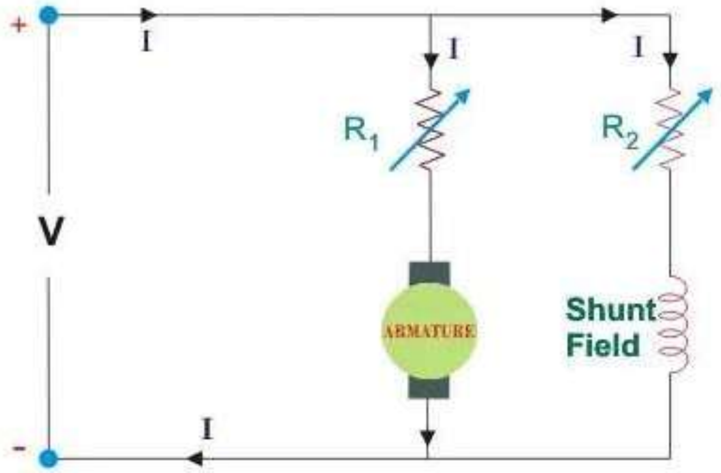
This common method involves connecting a controlling resistance directly in series with the motor‛‛s supply, as illustrated in the figure.



The power loss in the control resistance of DC series motor can be neglected because this control method is utilized for a large portion of time for reducing the speed under light load condition. This method of speed control is most economical for constant torque. This method of speed control is employed for DC series motor driving cranes, hoists, trains etc.

Shunted Armature Control

The combination of a rheostat shunting the armature and a rheostat in series with the armature is involved in this method of speed control. The voltage applied to the armature is varies by varying series rheostat R_1. The exciting current can be varied by varying the armature shunting resistance R_2. This method of speed control is not economical due to considerable power losses in speed controlling resistances. Here speed control is obtained over wide range but below normal speed.



Armature Terminal Voltage Control

Speed control of DC series motors can be achieved by using a separate variable voltage supply, although this method is costly and thus rarely used.

The field flux control method involves adjusting the field flux of the DC series motor to control its starting and speed. By controlling the field current, the magnetic field strength can be varied, which directly affects the motor's torque-speed characteristics. To start the motor using this method, the field current is gradually increased. As the field flux builds up, it induces a counter electromotive force (EMF) in the armature, limiting the armature current and preventing excessive starting current. Once the field flux reaches a sufficient level, the motor attains its rated speed. For speed control, the field flux control method relies on varying the field current. By decreasing the field current, the field flux reduces, leading to a decrease in the motor's back EMF. As a result, the armature current increases, providing more torque and consequently increasing the motor's speed. Similarly, increasing the field current reduces the armature current, leading to a decrease in speed. The field flux control method offers excellent speed control over a wide range but has limitations when it comes to achieving high starting torques. The motor may struggle to start under heavy load conditions due to limited torque during the starting phase.

In summary, both field flux control and armature voltage control methods offer ways to start and control the speed of a DC series motor. The field flux control method provides excellent speed control but may have limitations in starting under heavy load conditions. On the other hand, the armature voltage control method offers good starting torque but is less efficient due to energy dissipation. The choice between the two methods depends on the specific requirements of the application and the desired motor performance.

VII Actual Circuit diagram used in laboratory with equipment Specifications

Part A: For Armature Voltage control method (Fig.1)

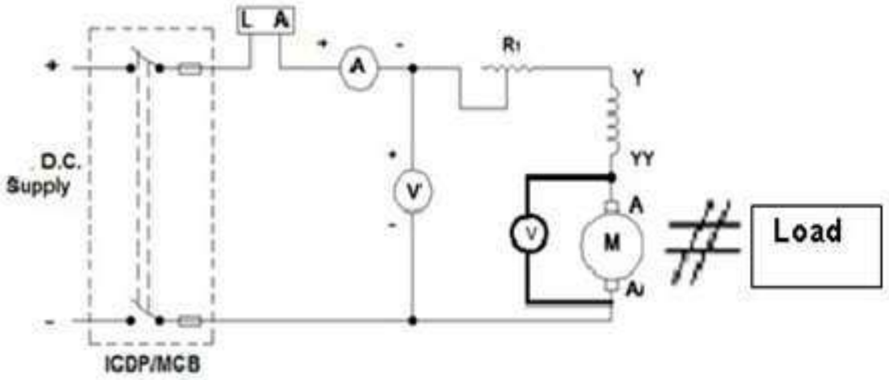
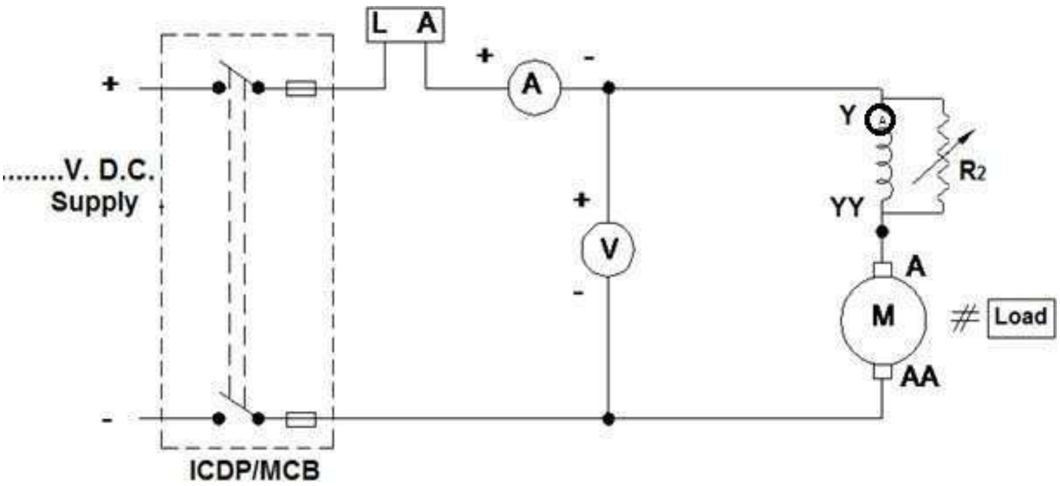


Fig. 1: Speed control of DC Series Motor by Armature Voltage Control Method

Part B: For Field or Flux Control Method (Fig. 2)



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC series motor with load ararangement	Upto 230 V , 4 KW	1 No.
2	Rheostat	500 Ω , 1.2 Amp.	2 No.
3	Tachometer	Suitable range	1 No.
4	DC Ammeter	0-5/10 Amp	2 No.
5	DC Voltmeter	0-150/300 V	1 No.

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position while making connections.
2. While using starter, make sure that the handle is in „OFF" position.
3. Belt / Rope used for pulley should be properly cooled at the regular interval of the practical.
4. Make sure to apply mechanical load before starting the motor.

X Procedure

1. <u>For Part A: Armature Voltage Control Method</u>

1. Calculate the full load torque using the formula, TFL
2. Calculate the torque to be set on belt(i.e, 2/3‟d of TFL)
3. Obtain the net tension, Fi-F2=(Required torque)/ (reX9.81), where reiS the effective radius of the pulley (Brake drum).
4. Apply the mechanical load as per the net tension obtained.
5. Make the connections as per circuit diagram shown in Fig.1
6. Switch "ON "the supply.
7. Start the motor with the help of starter.
8. Bring the motor to the rated speed by adjusting the rheostat connected in series with the field.

9. Note down speed (N), field current (I_f) and armature voltage (V_a)-
10. For various positions of increased armature resistance, take corresponding readings of armature voltage and speed.
11. Bring the variable rheostat to the minimum position
12. Switch "OFF" the supply.

For Part B: Flux or Field Current Control Method

1. Calculate the torque to be set on belt(i.e, 2/3rd of TFL)
2. Obtain the net tension , F1-F2=(Required torque)/(rex9.81)
3. Apply the mechanical load as per the net tension obtained.
4. Make the connection as per circuit diagram shown in Fig.2
5. Keep the field diverter to its maximum position.
6. Switch "ON" the supply. Start the motor with the help of starter.
7. Note down speed (N), field current (If) and armature voltage (Va).
8. For various positions of field diverter resistance take corresponding readings of field current and speed.
9. Bring the field diverter to the original position.
10. Switch "OFF" the supply.

XI Observations and calculations

Effective radius of the pulley, • • • • • • • • • • • • • •
Full load Torque = P_{out}'(2nN/60) N-m
Required Torque= (2/3) TFL

Net tension required, F1-F2' Required Torque/(9.8lr_e)

For part A: Armature Voltage Control Method

S.No	Armature Voltage (Va) Volt	Speed in RPM
1		
2		
3		
4		
5		
6		

Note: Plot the graph for speedlW-axis) V7s Armature voltage [X-axis) on a Graph paper.

For Part B: Flux or Field Current Control Method

S.No	Field Current in amp	Speed in RPM
1		
2		
3		
4		
5		
6		

Note• Plot the speed {W-axis) Vis Field current {X-axis) characteristics on a Graph paper.

Calculation –

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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. State the reason for not starting the dc series motor on no load?
2. State the advantages of d.c. series motor?
3. List the applications of d.c. series motor?
4. Give the reason for high starting torque of the d.c. series motor .
5. List the disadvantages of armature voltage control method of speed control of dc series motor.
6. A d.c. series motor is a variable speed motor. Explain.
7. Justify the armature voltage control method of speed control is only for small dc motors.

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XVI References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2. Electrical Technology:Vol-2 B. L.Theraja S Chand Publications
3. www.E1ectrica14u.com
4. https://www.youtube.com/watch?v=oI-O9FCDqmg
5. https://www.youtube.com/watch?vmsWNGcZ-jds
6. https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 11: Brake test on D.C. series motor.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. This experiment is to equip students with fundamental knowledge, practical skills and a strong foundation in electrical power system, in industries and related fields.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors.

IV Laboratory Learning Outcome(s)

Perform brake test on D.C. series motor.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

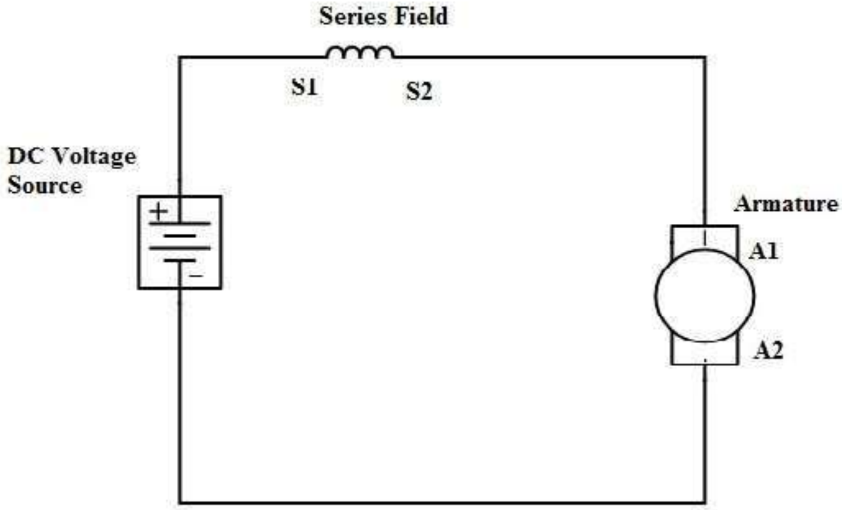
VI Relevant Theoretical Background (With diagrams if required)

There are two types of DC motors based on the construction such as self-excited, and separately excited. Similarly, self-excited motors classified into three types namely DC series motor, DC shunt motor, and DC compound motor. This article discusses an overview of the series motor, and the main function of this motor is to convert electrical energy to mechanical energy. The working principle of this motor mainly depends on electromagnetic law, which states that whenever a magnetic field is formed in the region of current carrying conductor & cooperates with an outside field, then the rotating motion can be generated. Once the series motor is started, then it will give utmost speed as well as torque slowly with high speed.

The DC Series Motor is similar to any other motor because the main function of this motor is to convert electrical energy to mechanical energy. The operation of this motor mainly depends on the electromagnetic principle. Whenever the magnetic field is formed approximately, a current carrying conductor cooperates with an exterior magnetic field, and then a rotating motion can be generated.

DC Series Motor Circuit Diagram

In this motor, field, as well as stator windings, are coupled in series by each other. Accordingly the armature and field current are equivalent. Huge current supply straightly from the supply toward the field windings. The huge current can be carried by field windings because these windings have few turns as well as very thick. Generally, copper bars form stator windings. These thick copper bars dissipate heat generated by the heavy flow of current very effectively. Note that the stator field windings S1-S2 are in series with the rotating armature A1-A2.



Speed Control of DC Series Motor

The **speed control of DC motors** can be attained by using the two following methods

- Flux control Method
- Armature-resistance Control Method.

The most frequently used method is armature-resistance control method. Because in this method, the flux generated by this motor can be changed. The difference of flux can be attained by using the three methods like field diverters, armature diverter, and tapped field control.

Armature-resistance Control

In the armature resistance control method, a changeable resistance can directly be connected in series through the supply. This can reduce the voltage which is accessible across the armature & the speed drop. By altering the variable resistance value, any speed under the regular speed can be attained. This is the most general method used to control the DC series motor speed.

Speed Torque Characteristics of DC Series Motor

In general, for this motor, there are 3-characteristic curves are considered significant like Torque Vs. armature current, Speed Vs. armature current, & Speed Vs. torque. These three characteristics are determined by using the following two relations.

$$T_a \propto \phi . I_a$$
$$N \propto E_b / \phi$$

The above two equations can be calculated at the equations of emf as well as torque. For this motor, the back emf‟s magnitude can be given with the similar DC generator e.m.f equation like Eb= Pϕ NZ / 60A. For a mechanism, A, P, and Z are stable, thus, N a Eb/ϕ.

The **DC series motor torque equation** is,

Torque= Flux* Armature current

$$T = I_f * I_a$$

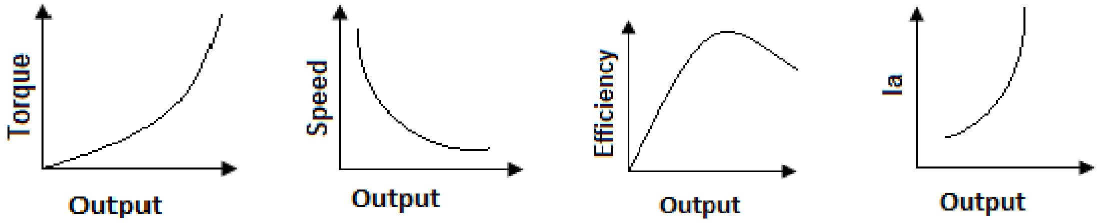
Here If= Ia, then the equation will become

$$T = I_a^2$$

The DC series motor torque (T) can be proportional to the I_a^2 (square of the armature current). In load test on dc series motor, the motor should be activated on load condition because if the motor can be activated on no load, then it will achieve an extremely high speed.

Brake test: It is a direct method of testing in which the motor is loaded by applying load on the mechanically coupled braking arrangement. It normally consists of mechanically coupled brake drum (i.e. pulley and belt arrangement) with spring balances at the two ends of the belt that goes halfway around the pulley. By adjusting belt tension, motor can be loaded from no load to full load

Expected nature of performance curves



What Are the Applications of SDC Motors?

Some of the important points we‟ve learned so far about series DC motors is that they produce high starting torque and operate properly under heavy load conditions. These features make SDC motors a good choice for industrial applications. These motors are used in airplanes as engine starters and the source to raise and lower the wings and cowl. They can also start an automobile‟s engine and are a good choice to be used in mobile electric equipment, tiny electrical appliances, winches, and hoists. SDC motors‟ changeable speed also makes them useful in tools like vacuum cleaners, sewing machines, elevators, and etc. In cases when stable speed is an important factor, however, series DC motors are not the best option. That is because their speed is dependent on the changes in the load. Moreover, changing their speed is not an easy task. So it is better to go for more suitable designs that are on the market.

Advantages and Disadvantages:

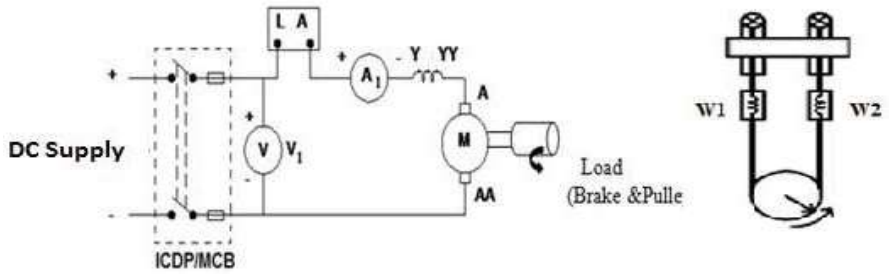
Series DC motors come with their own pros and cons that are listed below:

1) Producing a high starting torque
2) Being cost-effective
3) Easy assembly and design
4) Easy maintenance.

The disadvantages of DC series motor include the following:

1) Controlling their speed is challenging,
2) The increase in the speed comes with a sharp decrease in the torque, and
3) As the speed of the motor depends on the load, they cannot be used in many cases at which the load is removed.

VII Actual Circuit diagram used in laboratory with equipment Specifications



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC series motor with load and pulley arrangement	Upto 230 V , 4 KW	1 No.
2	Rheostat	500 Ω , 5 Amp.	1 No.
3	Tachometer	Suitable range	1 No.
4	DC Ammeter	0-5/10 Amp	1 No.
5	DC Voltmeter	0-150/300 V	1 No.

IX Precautions to be followed

1) Make sure that the main switch on the panel board is in „OFF" position while making connections.
2) While using starter, make sure that the handle is in „OFF" position.
3) Ensure that the belt is sufficiently tight before the motor is switched on to the supply as DC Series Motor shall not be started on no-load.
4) Wires used for circuit connection have proper size and insulation cover.
5) Belt/Rope used for pulley should be properly cooled at the regular interval in between the practical

X Procedure

1) Connect the circuit as per the circuit diagram.
2) Measure the radius of pulley (brake drum).
3) Keep the field circuit rheostat R to the minimum value.
4) Ensure that there is no load on the brake drum
5) Switch „ON" the supply and start the motor with the help of three point starter.
6) Adjust the field rheostat of motor to obtain rated speed of motor.
7) Note the speed using tachometer.
8) After setting the speed, rheostat position should not be altered.
9) Note down the input voltage, current using voltmeter, ammeter at no load.
10) Increase the load on the brake drum gradually up to full load in steps and record the corresponding readings of voltmeter, ammeter, tachometer and belt tensions.
11) Pulley must be water cooled at regular intervals.
12) Release the spring tension slowly and at no load switch „OFF" the supply.

XI Observations and calculations

Radius of the pully(r) in meter =…………

Sr. No.	Input Voltage (V) in Volts.	Armature Current (I) in Amps.	Speed (N) in RPM	W_1 in Kg	W_2 in Kg	W= (W_2-W_1) in Kg	Torque (T) in N-m	Output Power (P_o) in watts	Input Power (P_i) in watts	% Efficiency (P_o/Pi)x100
1										
2										
3										
4										
5										
6										

Calculation:

W=(W2−W1)Kg

T=(W2−W1)×r×9.81Nm

Pinput =2πNT/60watt

Poutput = V×I watt.

%Efficiency= (Poutput / Pinput) ×100

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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. State various losses in d.c. series machines.
2. State the value of efficiency of motor under no load condition.
3. State the need for cooling the brake drum.
4. State any two industrial applications of d.c. seies motor based on the above characteristics.

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XVI References/Suggestions for further reading

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2. Electrical Technology:Vol-2 B. L.Theraja S Chand Publications
3. www.E1ectrica14u.com
4. https://www.youtube.com/watch?v=oI-O9FCDqmg
5. https://www.youtube.com/watch?vmsWNGcZ-jds
6. https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 12: Reversal of rotation of D.C. compound motor.

I Practical Significance

In the industry it is often required to use the dc motor in both the directions in some applications without damaging or unnecessarily overloading it. This practical will enable the student to perform such operations.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related9 field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors.

IV Laboratory Learning Outcome(s)

Reverse the direction of rotation of the D.C. series motor.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

When a current carrying conductor is placed in a magnetic field, a mechanical force acts on it, which can be determined by Fleming‟s left hand rule. Due to this force the conductor starts rotating in the direction of the force.

If we stretch the first finger, second finger and thumb of our left hand to be perpendicular to each other, and first finger represents the direction of the magnetic field, the second finger represents the direction of the current, then the thumb represents the direction of the force experienced by the current carrying conductor.

VII Actual Circuit diagram used in laboratory with equipment Specifications

1. With Normal connection of armature and field winding

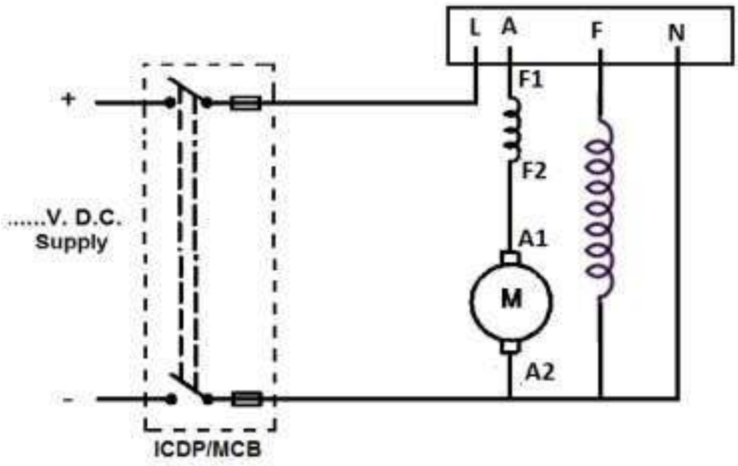

Fig. 10.1 (Forward/Normal rotation)

2. With armature winding connections reversed:
   (Students should draw the circuit diagram for reverse direction)

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC compound motor with 4 point starter	1HP to 3HP, 230V, 1500RPM DC compound motor	1 No.
2	Tachometer	0-5000 RPM	1 No.
3	Connecting wires	1.5Sqmm	As required

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF‟ position while making connections.
2. While using starter, make sure that the handle is in „OFF‟ position.
3. Wires used for circuit connection should have proper insulation cover.
4. Make sure to apply mechanical load before starting the motor.

X Procedure

1. Connect the circuit as per Fig. 9.1.
2. Switch „ON" the supply.
3. Using the starter, start the motor.
4. Observe the direction of rotation and record the same.
5. Switch OFF the supply and ensure that the starter handle comes back to OFF position.
6. Repeat the above procedure for connections in fig. 9.2, 9.3 and 9.4
7. Observe the effect of change in direction of rotation and record the same.
8. Switch „OFF" the supply.

XI Observations and calculations

Sr. No.	Connection	Direction of rotation	Remarks
1			
2			
3			
4			

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. State Fleming‟s left hand rule.
2. Why does a motor rotate in reverse direction when the current through the armature circuit is reversed?
3. List advantages and applications of dc compound motor.

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XVI References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2. Electrical Technology:Vol-2 B. L.Theraja S Chand Publications

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 13: Demonstration of operating mechanism of three point starter of a D.C. Shunt machine.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. DC shunt motor draws very high current during starting which may burn armature winding. Hence to protect DC shunt motor from damage due to heavy starting current, Three point starter is used to start DC shunt motor.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors

IV Laboratory Learning Outcome(s)

LLO 1. Identify different parts of a three point starter of a D.C. shunt motor.
LLO 2. Check the function of the various parts of three point starter.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

The starting of DC motor is somewhat difference from the starting of all other types of electrical motors. This difference is credited to the fact that a dc motor unlike other types of motor has a very high starting current that has the potential of damaging the internal circuit of the armature winding of dc motor if not restricted to some limited value. This limitation to the starting current of dc motor is brought about by means of the starter. Thus the distinguishing fact about the starting methods of dc motor is that it is facilitated by means of a starter. Or rather a device containing a variable resistance connected in series to the armature winding so as to limit the starting current of dc motor to a desired optimum value taking into consideration the safety aspect of the motor.

A three-point starter in simple words is a device that helps in the starting and running of a shunt wound DC motor. Now the question is why these type of DC motors require the assistance of the starter in the first case. The only explanation to that is given by the presence of back emf E_b, which plays a critical role in governing the operation of the motor. the back emf, develops as the motor armature starts to rotate in presence of the magnetic field, by generating action and counters the supply voltage. This also essentially means, that the back emf at the starting is zero and develops gradually as the motor gathers speed.

The general motor emf equation $E = E_b + I_aR_a$,

At starting is modified to $E = I_aR_a$ as the starting $E_b = 0$.

$I_a = E/R_a$

Thus we can well understand from the above equation that the current will be dangerously high at starting (as armature resistance R_a is small) and hence its important that we make use of a device like the three-point starter to limit the starting current to an allowable lower value.

What is a Three-Point Starter?

A three-point starter is an electrical device, used for starting as well as maintaining the DC shunt motor speed. The connection of resistance in this circuit is in series which decreases the initial high current and guards the equipment against any electrical failures. Here, the occurrence of back e.m.f plays an essential role in operating the motor. This emf extends when the armature of motor starts for rotating in the magnetic field by making the action as well as opposes the voltage supply.

Construction of 3 Point Starter

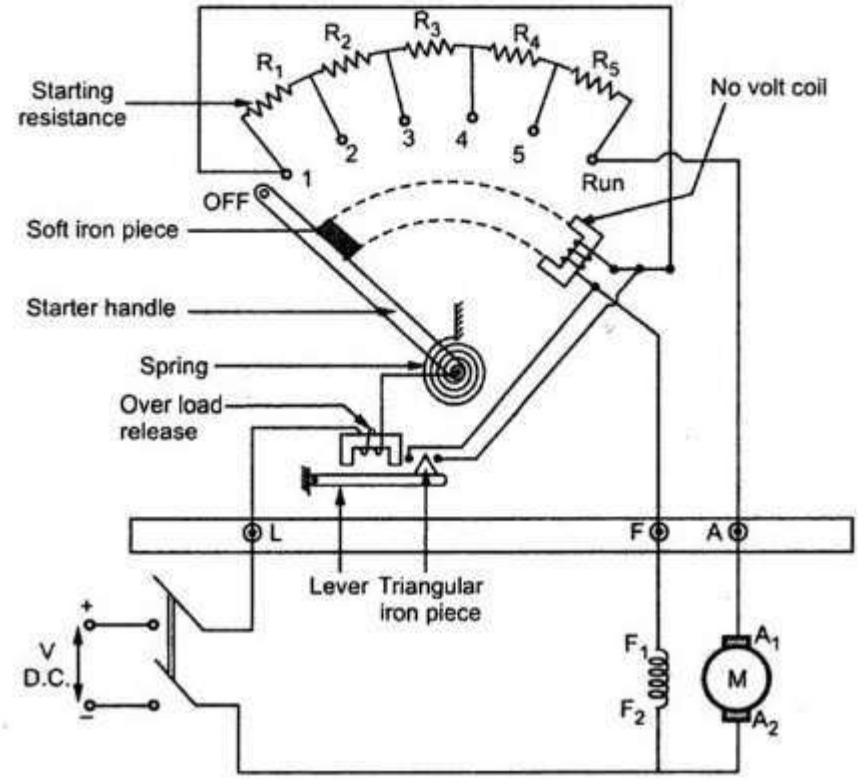
The DC motor based 3 point starter mainly includes three terminals namely L, A, and F. Here, L(line terminal) is connected to the positive supply, A (armature terminal) is connected to the windings of an armature terminal, and F (field terminal) is connected to the winding of field terminal.

The construction of 3 point starter includes a resistance „R‟‟ for controlling the initial current. The "H‟‟- handle in the circuit kept in the OFF condition with a spring „S‟‟. The H-handle can be operated manually for motor operation. At the beginning of the motor position, the motor field winding gets the total supply voltage, & the armature current is restricted to the particular secure value by the resistance R.

Working off a Three-Point Starter

The handle of the 3 point starter can be moved from one stud to another stud (contact positions), and this increases the speed of the motor till gets the RUN position. There are three main points are considered in this position which includes the following.

- The DC shunt motor gets the full speed
- The voltage supply in the circuit is straight across both the motor‟‟s windings.
- The R-resistance is totally cut-out.



The H-handle in the circuit is held in RUN condition with an electromagnet strengthened by an NVC (no volt trip coil). This NVC coil can be coupled in series with the motor field winding. In the incident turned OFF or dropped below a fixed value, then the NVC will get energized. By the act of S-spring, the handle-H is released as well as pulled back to the OFF condition.

At first when a DC supply is turned ON by H-handle in the OFF position, then the handle will move CLK wise direction to the stud1. The winding of the shunt field is directly associated across the voltage supply as the total resistance, in the beginning, is included in series with the armature circuit.

If the voltage supply is unexpectedly disrupted, then the no-volt discharge coil is demagnetized as well as the H-handle goes back to the OFF location in the pull of the spring. If no-volt coil were not utilized, then there will be a supply failure. The H-handle would stay on the last stud. If the voltage supply is returned, then the DC motor will be openly allied across the supply, resulting in an extreme armature current.

If the DC motor is overloaded, it will draw extreme current from the current supply, then it amplifies the ampere rotates off the excess release coil as well as pull the armature, therefore no-volt coil will be short-circuited. This coil is demagnetized as well as the H-handle is pulled near the OFF location by the S-spring. Hence the electric motor is automatically detached from the current supply

What is the Function of No-volt Release?

When the motor reaches the normal speed and the arm is reached the ON position, the entire starting resistance is cut off from the circuit. Now in running condition, if the supply is interrupted or disconnected, the starting arm remains at the ON position. And when the supply is restored, there is no back EMF in the circuit and armature winding is connected directly across the main supply.

Therefore, in this condition, an excessive amount of current starts flowing through the armature winding and it may damage. So, to avoid this situation no-volt release is used in a circuit to pull back the arm to the OFF position.

The no-release coil consists of an electromagnet that is connected in series with the shunt field winding. When the supply is ON, it attracts the soft iron keeper. But if the supply fails or interrupted, the electromagnet is demagnetized and releases a soft iron keeper. Due to the spiral force of the spring, the arm is pulled back to the OFF position and disconnects the main supply.

Also, another function of no-volt release is that it prevents open-circuit in shunt field winding. Because the no-volt release is connected in series with the shunt field winding. If the shunt filed winding is open-circuited, the current flowing through the no-volt release is zero. And it demagnetizes the coil and releases the arm to the OFF position.

What is the Function of Overload Release?

Another protective device overload release is connected in series with the motor to avoid the overload condition. As this device is connected in series with the motor, the current flows through the motor are the same current that flows through the overload release.

The overload release consists of a coil. In normal conditions, the current flows through this coil are not enough for the pull armature in an upward direction. But, in an overload condition, an excess amount of current will flow through the motor and coil of overload release. And this high amount of current is sufficient to pull the armature in an upward direction.

So, as the armature is pulled up, it short-circuited the no-volt release and resulted to demagnetize the no-volt release coil. So, the soft iron keeper detached from the no-volt release, and the arm is pulled back to the OFF position. Hence, in overload conditions, the motor will disconnect from the supply with the help of overload release.

VII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC Shunt Machine	Upto 230 V , 4 KW	1 No.
2	Three point starter	Suitable for DC shunt motor	1 No.

VIII Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position and DC machine is disconnected from the supply.
2. Connect the three point starter with DC shunt motor properly.

IX Procedure

1. Switch on DC supply.
2. Move the handle of 3 point starter from Start to Run position gradually.
3. Observe the starting of DC shunt motor.

X Observations

Identify Different parts and its function

Sr.No.	Name of Parts	Function
1		
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6		

XI Result(s)

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XII Interpretation of results

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XIII Conclusion and recommendation

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XIV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Why starter is necessary for DC Motor ?
2. What is Three point starter ?
3. What is function of No volt release coil ?
4. What is function of Overload release coil ?
5. What is drawback of three point starter ?

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XV References/Suggestions for further reading

1) Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2) Electrical Technology:Vol-2 B. L.Theraja S Chand Publications
3) www.E1ectrica14u.com
4) https://www.youtube.com/watch?v=oI-O9FCDqmg
5) https://www.youtube.com/watch?vmsWNGcZ-jds
6) https://www.youtube.com/watch?v=IC-PWxtcirI

XVI Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	20%
2	Identification of components	30%
3	Working in teams	10%
Product Related: 10 Marks		**40%**
4	Interpretation of result	10%
5	Conclusions	10%
6	Practical related questions	15%
7	Submitting the journal in time	05%
Total		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 14: Demonstration of operating mechanism of four point starter of a D.C. Compound machine.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. To protect DC compound machine from damage due to heavy starting current, four point starter is used to start DC compound machine.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors

IV Laboratory Learning Outcome(s)

LLO 1. Identify different parts of a four point starter of a D.C. shunt motor.
LLO 2. Check the function of the various parts of four point starter.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

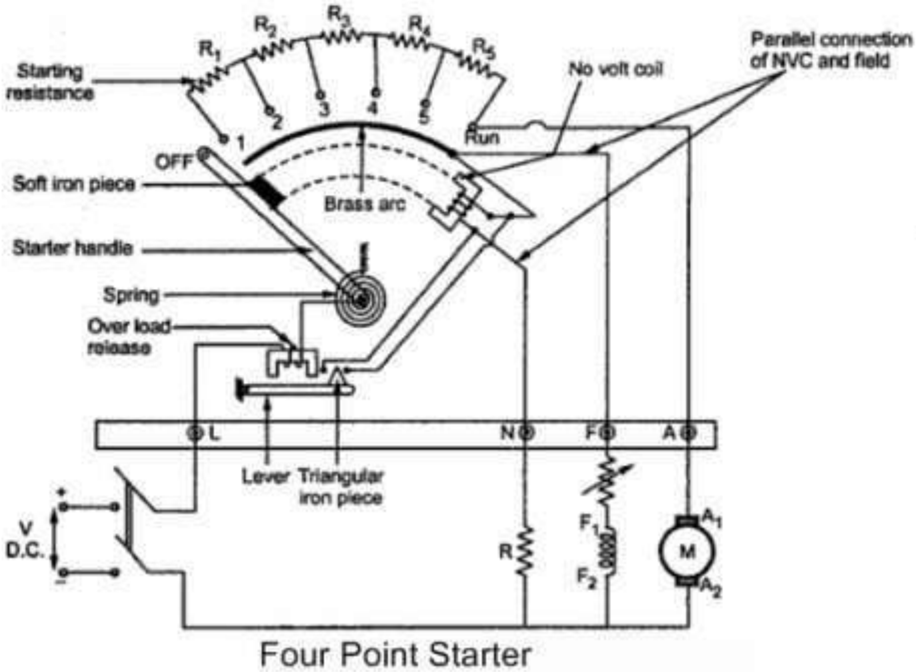
While starting a DC motor huge amount of current may be driven to the windings because of the absence of the back emf. This may rise about 4-6 times above the rated load current of the winding wire. So, during the starting of motor, due to heavy current the parts of motor may get damaged. Hence, to stop such high current rush, starters are utilized in DC motors. A starter consists of a variable resistance in series which is connected to the armature of the motor. It's utilized in order to cut back the starting voltage across the winding. When the motor hurries up the starter resistance decrease gradually. And it'll disconnect completely when the armature attains enough speed to come up with the back emf (that is that the normal speed). When the motor gains full speed, there is no effect on the armature circuit of the motor due to the starter. Then the contacts of the motor terminals are going to be directly connected.

The dc motor has no back emf. During the starting of the motor, the armature current is controlled by the resistance of the. The armature resistance Ra is very low(negligible), and when the full voltage is applied at the standstill condition of the motor, the armature current Ia becomes very high which may damage the parts of the motor. Due of the high armature current, the additional resistance is placed within the armature circuit at starting. The starting resistance of the machine is removed from the circuit when the machine speeds up. the armature resistance of a motor is extremely small, generally but one ohm, the starting armature current Ias becomes very large. Therefore, to limit this high starting current starter are used with the DC motor

WHAT IS 4-POINT STARTER? The functional characteristics of a 4-point starter are similar to a 3-point starter. 4-point starter works as a current controlling device in the deficiency of back EMF while starts running of the DC motor. A 4 -point starter alsoworks as a protecting device. The main difference between a 4-point starter compared to a 3-point starter is, the holding coil is detached from the shunt-field circuit. After this, it is connected in series with the current limiting resistance (R) across the line.

The four terminals of 4-point starter are

1. 'L' Line terminal. (Connected to positive of supply).
2. 'A' Armature terminal. (Connected to the armature winding).
3. 'F' „ Field terminal. (Connected to the field winding)
4. 'N' Connected to the No Voltage Coil.



Four Point Starter

Construction and operation of four-point starter:

The remarkable difference in case of a 4 point starter is that the No Voltage Coil is connected independently across the supply through the fourth terminal called “N” in addition to the „L‟, „F‟, and „A‟. As a direct consequence of that, any change in the field supply current does not brings about any difference in the performance of the NVC. Thus it must be ensured that no voltage coil always produce a force which is strong enough to hold the handle in its RUN position, against force of the spring, under all the operational conditions. Such a current is adjusted through No Voltage Coil with the help of fixed resistance R connected in series with the NVC using fourth point „N" as shown in figure.

Apart from this above mentioned fact, the 4 point and 3 point starters are similar in all other ways like possessing is a variable resistance, integrated into number of sections as shown in the figure above. The contact points of these sections are called studs and are shown separately as OFF, 1,2,3,4,5,RUN over which the handle is free to be moved manually to regulate the starting current with gathering speed.

Operation of Four-point starter:

Look into the above diagram of four-point starter, considering that supply is given and the handle is taken stud no. 1, then the circuit is complete and line current will be divided into 3 parts, flowing through 3 different points.

i). 1 part flows through the starting resistance ($R_1+R_2+R_3+\ldots$..) and then to the armature.

ii). a 2nd part flowing through the field winding F.

iii). A 3rd part flowing through the no voltage coil in series with the protective resistance R.

So the point to be noted here is that with this particular arrangement any change in the shunt field circuit not bring about any change in the no voltage coil as the two circuits are independent of each other. This essentially means that the electromagnet pull subjected upon the soft iron bar of the handle by the no voltage coil at all points of time should be high enough restoring the handle at its original OFF position, irrespective of how the field rheostat is adjusted.

Advantages of 4-point starter

1) The no volt coil is not affected by the change in field current. So, the user can increase or decrease
the field current to control the flux and thereby control the speed of the motor.

2) Protects the armature coil from burning up due to heavy armature current.

3) This starter reduces the starting current and protects the motor from unstable voltage/over voltage
and short circuit faults.

4) Protects the brushes and commutator from heavy sparking.

VII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC Compound Machine	Upto 230 V , 4 KW	1 No.
2	Four point starter	Suitable for DC shunt motor	1 No.

VIII Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position and DC machine is disconnected from the supply.
2. Connect the four point starter with DC compound motor properly.

IX Procedure

1. Switch on DC supply.
2. Move the handle of 4 point starter from Start to Run position gradually.
3. Observe the starting of DC compund motor.

X Observations

Identify Different parts and its function

Sr.No.	Name of Parts	Function
1		
2		
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XI Result(s)

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XII Interpretation of results

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XIII Conclusion and recommendation

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XIV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Why starter is necessary for DC compound machine ?
2. What is four point starter ?
3. Write four points in four point starter ?
4. What is advantages of four point starter ?

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XV References/Suggestions for further reading

1. Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2. Electrical Technology:Vol-2 B. L.Theraja S Chand Publications
3. www.E1ectrica14u.com
4. https://www.youtube.com/watch?v=oI-O9FCDqmg
5. https://www.youtube.com/watch?vmsWNGcZ-jds
6. https://www.youtube.com/watch?v=IC-PWxtcirI

XVI Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	20%
2	Identification of components	30%
3	Working in teams	10%
Product Related: 10 Marks		**40%**
4	Interpretation of result	10%
5	Conclusions	10%
6	Practical related questions	15%
7	Submitting the journal in time	05%
Total		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 15: Demonstration of operating mechanism of two point starter of a D.C. series machine

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. DC series motor draws very high current during starting which may burn winding. Hence to protect DC series motor from damage due to heavy starting current, Two point starter is used to start DC series motor.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of D.C. Motors

IV Laboratory Learning Outcome(s)

LLO 1. Identify different parts of a two point starter of a D.C. series motor.
LLO 2. Check the function of the various parts of two point starter.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

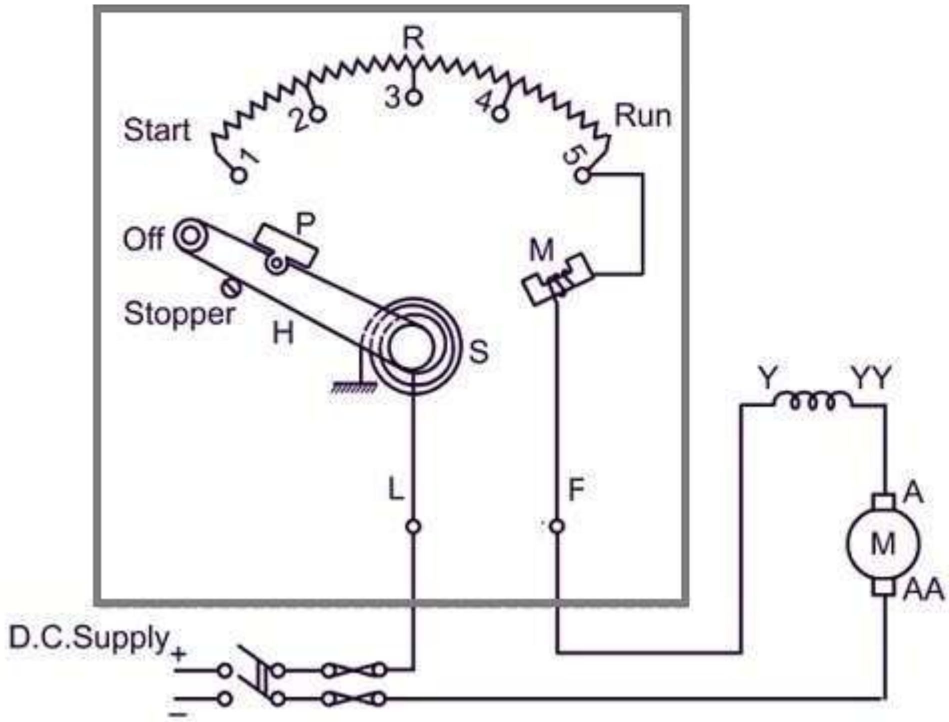
Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

A starter is a protection device used to protect the electric motor from overload & short circuits. There are different kinds of starters available for motor like; 2-point, 3-point & 4 point starters.. The main difference between these three starters is No Voltage Coil (NVC).

Two point starter

Definition of 2-point starter: a starter that is used to restrict the starting current of a DC series motor by starting and controlling its speed is known as a two-point starter. The main function of this starter is to defend the DC series motor from overvoltage and high starting current by restricting the high starting armature current to a secure value, by simply connecting a resistance within the series by the armature only at the starting time. This resistance can be decreased gradually whenever the motor gets speed.



Two Point starter working

A 2-point starter includes two main parts; a rheostat & a set of contacts. In this starter, the rheostat is mainly used for controlling the flow of current throughout the motor whereas the set of contacts is used for firstly start & after that control the speed of the motor. Whenever the contacts are closed, the motor is directly connected to the power supply to start. Once this motor gets speed, the set of contacts will be opened gradually by increasing the resistance within the circuit & decreasing the flow of current to the motor to control its speed. So, this kind of starter is used commonly in applications wherever exact speed control is required like in industrial equipment & machinery.

The circuit diagram of the 2-point starter is shown below. This circuit is similar to a three-point and four-point starter because it includes a starting resistance „R‟ which is subdivided in between the contact studs from 1 to 5. In this circuit, the „H‟ is a starting handle and is turned on a single side where the other side is easily moved from a strong „S‟ spring. So that it makes contact with every stud during the starting operation. The starter in the circuit is provided simply with a protective device with no load release.

A two-point starter works by starting the dc motor which has the over-speeding trouble because of load loss from its shaft. To start the DC motor, the control arm will be turned in a clockwise direction from its OFF to ON position against the spring tension. The L & F are two starter points that are simply connected through the motor terminals & supply.

The control arm will be held within the turn-ON position through an electromagnet. Here, the hold-on electromagnet is simply connected with the armature circuit in series. If the DC motor loses its load, then the flow of current reduces, thus the electromagnet strength also reduces. The control arm comes back to its OFF position because of its spring pressure and prevents the DC motor from overspending. Whenever the voltage supply reduces considerably, the starter arm can also return to its OFF position.

Advantages of a 2-point starter

1) This starter helps protect the motor from drawing maximum starting current.
2) These starters protect from short circuits and overload faults.
3) When the power supply is not there then it automatically turns OFF.

Disadvantages of a 2-point starter

1) It offers no adjustable starting characteristics and a soft stop is not possible at all
2) These are mechanically tough
3) This starter may decrease the lifespan of the motor.
4) This is not used for all types of motors.

Applications

1) 2 point starters are used with DC series motors.
2) These types of starters are used in cranes.
3) These are used in railways for starting and stopping the rail.
4) These starters help in starting the dc motor which has an over-speeding problem because of load loss from its shaft.
5) These are used normally in applications wherever the motor is anticipated to work above standard speed

VII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	DC Series Machine	Upto 230 V , 4 KW	1 No.
2	Two point starter	Suitable for DC shunt motor	1 No.

VIII Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position and DC machine is disconnected from the supply.
2. Connect the two point starter with DC series motor properly.

IX Procedure

1. Switch on DC supply.
2. Move the handle of 2 point starter from Start to Run position gradually.
3. Observe the starting of DC series motor.

X Observations

Identify Different parts and its function

Sr.No.	Name of Parts	Function
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XI Result(s)

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XII Interpretation of results

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XIII Conclusion and recommendation

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XIV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Why starter is necessary for DC Motor ?
2. What is Two point starter ?
3. What is difference between two point and three point starter ?
4. What is advantages and disadvantages of two point starter ?
5. What is application of 2 point starter ?

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XV References/Suggestions for further reading

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5. https://www.youtube.com/watch?vmsWNGcZ-jds
6. https://www.youtube.com/watch?v=IC-PWxtcirI

XVI Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	20%
2	Identification of components	30%
3	Working in teams	10%
Product Related: 10 Marks		**40%**
4	Interpretation of result	10%
5	Conclusions	10%
6	Practical related questions	15%
7	Submitting the journal in time	05%
Total		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 16: Demonstration of a single phase & Three phase transformer construction.

I Practical Significance

Transformer is a very essential and efficient device in A.C system. Power transformer plays a vital role in power system, generally used for stepping up and down the voltage level of power in transmission and distribution power system network. Knowledge of different parts of single and three phase transformer is very much essential.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

Identify the different parts of single phase & three phase transformer.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

- Basic principle: Electrical transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transforms electric power from one circuit to another without changing its frequency but with convenient change in voltage levels.

VII Actual Circuit diagram used in laboratory with equipment Specifications

Visit transformer manufacturing industry and observe the different parts of the single phase and three phase transformer

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity

IX Precautions to be followed

1. Follow Safety practices.

X Procedure

Visit transformer manufacturing industry and observe the different parts of the single phase and three phase transformer

XI Observations and Calculations

Sr. No.	Name of the part	Material used	Function of the part

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Define transformer.
2. State the working principle of transformer.
3. Give classification of transformer.
4. State the applications of single phase and three phase transformer.

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XVI References/Suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1	Electrical Machines	Kothari D. P. and Nagrath I. J.	McGraw Hill Education, New Delhi ISBN: 9780070699670
2	Principals of Electrical Machines	Rohit Mehta and V. K. Mehta	S Chand
3	Electrical Technology- Vol-2	B. L. Theraja	S Chand

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	20%
2	Identification of components	30%
3	Working in teams	10%
	Product Related: 10 Marks	**40%**
4	Interpretation of result	10%
5	Conclusions	10%
6	Practical related questions	15%
7	Submitting the journal in time	05%
	Total	**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 17: Transformation ratio of single phase transformer.

I Practical Significance

Transformer is a very essential and efficient device in A.C system. Power transformer plays a vital role in power system, generally used for stepping up and down the voltage level of power in transmission and distribution power system network. For various operations of transformer determination transformation ratio plays very important role.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

Find the transformation ratio of single phase transformer.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

- Basic principle: Electrical transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transforms electric power from one circuit to another without changing its frequency but with convenient change in voltage levels.
- Transformation ratio: It is the ratio of secondary voltage to primary voltage. It is denoted by "k" and is given by relation

$$Transformation\ ratio\ (k) = \frac{secondary\ voltage\ V2}{primary\ voltage\ V1}$$

$$Transformation\ ratio\ (k) = \frac{V2}{V1} = \frac{N2}{N1} = \frac{E2}{E1} = \frac{I1}{I2}$$

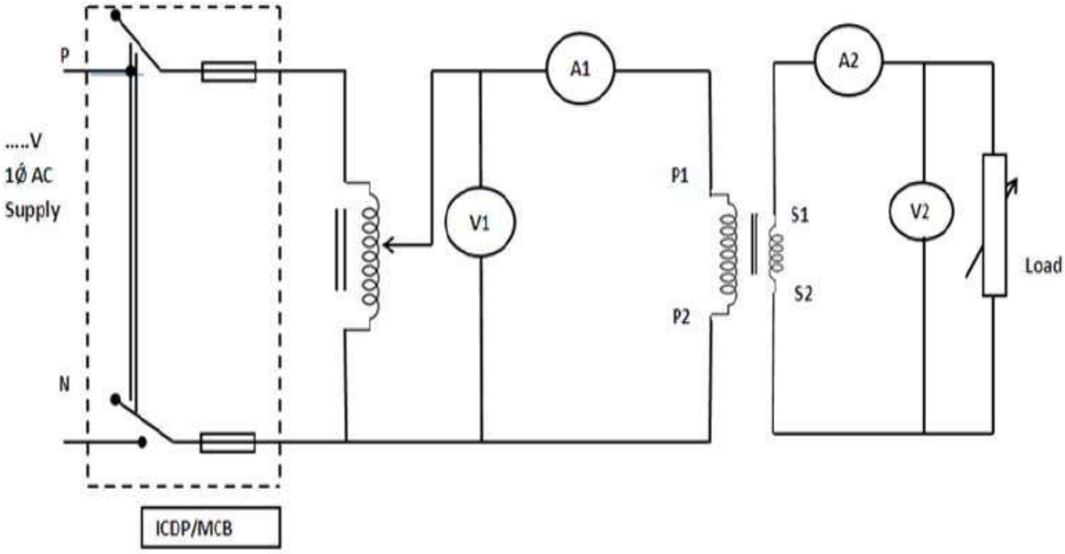
- Step up transformer: In a step up transformer, the number of turns of the secondary winding(N2) is more than the number turns of the primary winding(N1) or the emf induced in secondary winding(E2) is more than the emf induced in the primary winding (E1).

$$N_2 > N_1 \quad \text{or} \quad E_2 > E_1 \qquad \text{i.e. } k > 1$$

- Step down transformer: In a step down transformer, the number of turns of the secondary winding (N2) is less than the number turns of the primary winding(N1) or the emf induced in the secondary winding (E_2) is less than the emf induced in the primary winding (E1)

$$N_2 < N_1 \text{ or } E_2 < E_1 \qquad \text{i.e. } k < 1$$

VII Actual Circuit diagram used in laboratory with equipment Specifications



17.1 circuit diagram for step down mode

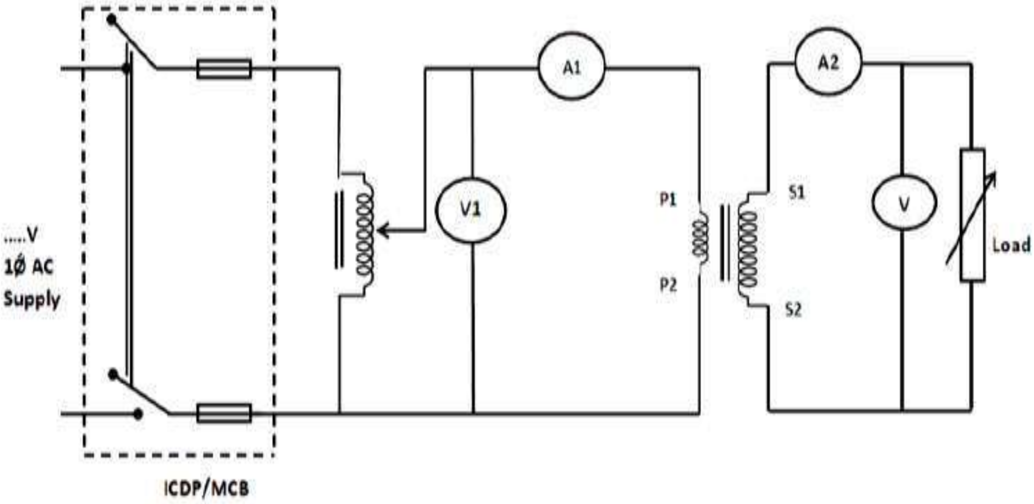


Fig. 17.2 circuit diagram for step down mode

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Single phase transformer	1 kVA, 230/115V	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	AC Voltmeter	(0-150-300)V	2 No.
4	AC Ammeter	(0-5-10)A	2 No.
5	Lamp load	230V, 10A	1 No.

IX Precautions to be followed

1) Follow Safety practices.
2) DO NOT make any connections with the power supply ON. Get in the habit of turning OFF the power supply after the practical.
3) Keep the auto transformer output position to zero at start before switching on.

X Procedure

Step-down Mode:

1. Calculate the full load currents of primary and secondary and select the meters accordingly.
2. Make the connections as per circuit diagram shown in Fig.1
3. Set the autotransformer to its minimum output position and keep the load switches OFF. Turn “ON” the supply.
4. Increase the output voltage of autotransformer gradually till the rated voltage of primary winding is reached.
5. Switch on the load in steps and record voltmeter and ammeter reading on both primary and secondary side at 1/3 of full load, half of full load and full load.
6. Switch “OFF” the load and bring the autotransformer to minimum position and switch “OFF” the supply.

Step up Mode:

1) Make the connections as per circuit diagram as shown in Fig. 2

2) Follow the same steps mentioned in the procedure for step-down mode.

XI Observations and Calculations

Step down mode:

Sr. No.	Primary voltage V_1 volt	Secondary voltage V_2 volt	Primary current I_1 amp	Secondary current I_2 amp	Voltage ratio $\frac{V,}{V,}$	Current ratio $\frac{I,}{I,}$	Transformation ratio $\frac{V,}{V,}$	Input power V,×I,	Output power V,×V,

Step up mode:

Sr. No.	Primary voltage V_1 volt	Secondary voltage V_2 volt	Primary current I_1 amp	Secondary current I_2 amp	Voltage ratio $\frac{V,}{V,}$	Current ratio $\frac{I,}{I,}$	Transformation ratio $\frac{V,}{V,}$	Input power V,×I,	Output power V,×V,

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1) Define transformation ratio, voltage ratio, turns ratio and current ratio.
2) Define step up transformer and step down transformer
3) State the significance of transformation ratio

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XVI References/Suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1	A text book of Laboratory Course in Electrical Engineering	Tarnekar S. G. and Karbanda P. K.	S Chand and Co. Ltd. New Delhi Edition 2013 ISBN: 9788121901048
2	Electrical Machines	Kothari D. P. and Nagrath I. J.	McGraw Hill Education, New Delhi ISBN: 9780070699670
3	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 18: Direct load test of single phase transformer.

I Practical Significance

Computation of Regulation and efficiency of transformers with utmost accuracy and precision is prime requirement of the power system and industry. These two important parameters decide the acceptance of transformer. Direct loading test is a direct method to determine the efficiency & regulation of transformer.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

Test the performance of single phase transformer.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Voltage Regulation of a transformer:

It is defined as the change in secondary terminal voltage from no load to full load, expressed as fraction of no load secondary voltage, keeping the primary voltage constant. It is usually expressed as a percentage of full load secondary voltage value.

$$\%\,Voltage\ Regulation = \frac{No\ load\ secondary\ voltage - Full\ load\ seondary\ voltage}{No\ load\ secondary\ voltage} \times 100$$

Efficiency of Transformer:

Efficiency of transformer defined as the ratio of output power to input power. It is usually expressed in percentage.

$$\%\,Efficiency = \frac{Output\ Power}{Input\ Power} \times 100$$

VII Actual Circuit diagram used in laboratory with equipment Specifications

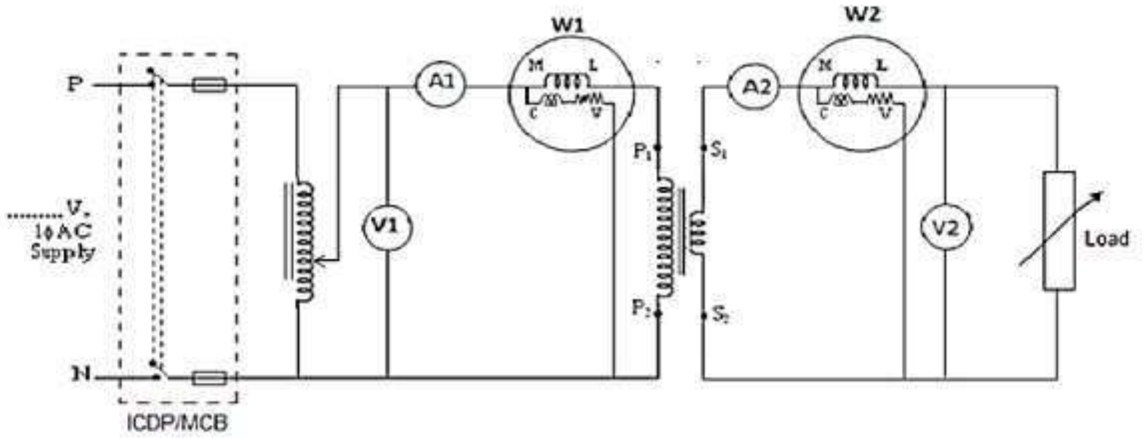

Fig. 18.1 circuit diagram for direct loading test

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	**Single phase transformer**	**1 kVA, 230/115V**	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	AC Voltmeter	(0-150-300)V	3 No.
4	AC Ammeter	(0-5-10)A	2 No.
5	Lamp load	230V, 10A	1 No.
6	wattmeter	(0-150-300V, 5/10A)	1 No.

IX Precautions to be followed

1) Follow Safety practices.
2) DO NOT make any connections with the power supply ON. Get in the habit of turning OFF the power supply after the practical.
3) Keep the auto transformer output position to zero at start before switching on.

X Procedure

1. Set the autotransformer to its minimum output and keep the load switches "OFF".
2. Switch "ON" the supply.
3. Vary the auto transformer output to increase the primary voltage to its rated value and note down the meter reading at no load.
4. By varying the lamp load in steps, corresponding ammeter, voltmeter and wattmeter readings are noted down.
5. The same procedure is repeated up to the rated current.
6. Switch "OFF" the load, bring the autotransformer to minimum position and Switch "OFF" the supply.

XI Observations and calculations

Primary Voltage V_1 = ...volts (constant)

No load secondary terminal voltage V_{20} = ... volt

Sr. No.	Secondary current I_2 amp	Secondary voltage V_2 volt	Primary current I_1amp	Input power W_1 watt	Output power W_2 watt	% Efficiency $= \frac{W_2}{W_1} \times 100$	% regulation $= \frac{V_{20} - V_2}{V_{20}} \times 100$

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1) For no output power, there is still some input power. Write the reason.
2) State the effect of load on efficiency and regulation of the transformer referring the observation.
3) What changes are to be made, if the primary and secondary winding of the given transformer are interchanged. Draw corresponding circuit diagram.

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XVI References/Suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1	A text book of Laboratory Course in Electrical Engineering	Tarnekar S. G. and Karbanda P. K.	S Chand and Co. Ltd. New Delhi Edition 2013 ISBN: 9788121901048
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3	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 19: Open circuit and short circuit test on single phase transformer to determine equivalent circuit parameters.

I Practical Significance

Determination of equivalent circuit parameters of a transformer is utmost important in electrical power system and industry. Percentage impedance is very essential parameter of transformer during installing and parallel operation .Open circuit test and short circuit test are very economical and convenient method to determine equivalent circuit parameters to analyze the performance of transformer for various industrial applications.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

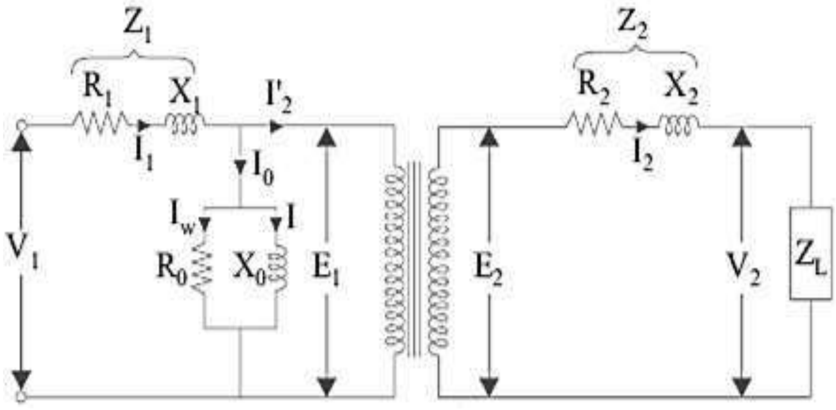
Test the performance of single phase transformer.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Equivalent circuit is a very useful way of understanding or predicting the operation and behavior of a transformer. In a transformer equivalent circuit we can account for winding losses and flux leakage with a series resistance and reactance on the primary side. Core losses can be modeled similarly with a parallel resistance and reactance on the primary side.



Open Circuit test (O.C. Test)

It is used to estimate iron losses, transformation ratio and parameters of magnetizing branch of equivalent circuit. It is determined by applying rated voltage to the low voltage winding and keeping the high voltage winding open.

Short Circuit test (S.C. Test)

It is to estimate copper losses and parameters of impedance branch by applying low voltage sufficient to circulate rated full load current in the high voltage winding, keeping the low voltage winding short circuited.

VII Actual Circuit diagram used in laboratory with equipment Specifications

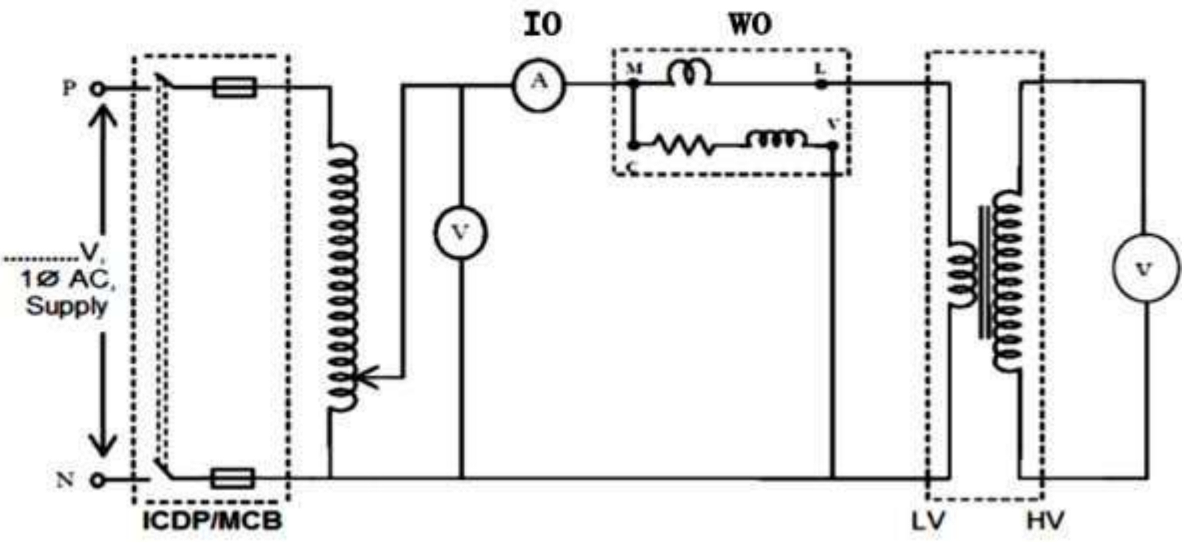


Fig. 19.1 circuit diagram for Open circuit test

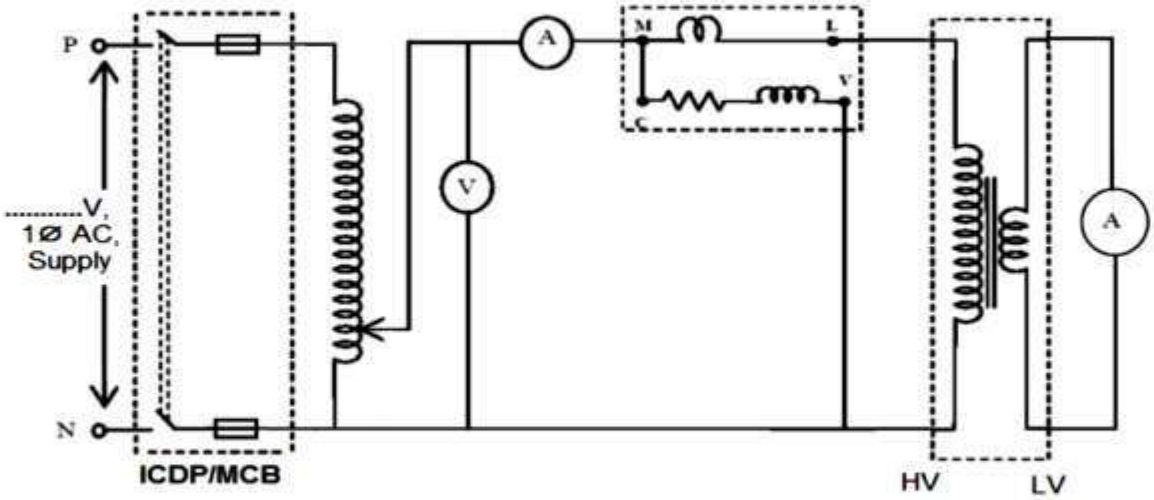


Fig. 19.2 circuit diagram for Short circuit test

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	**Single phase transformer**	**1 kVA, 230/115V**	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	AC Voltmeter	(0-300)V	2 No.
4	AC Ammeter	(0-5-10) A	2 No.
5	LPF Wattmeter	0-150-300V, 1/2A	1 No.
6	Wattmeter	0-150-300V, 5/10A	1 No.

IX Precautions to be followed

1. DO NOT make any connections with the power supply "ON". Get in the habit of turning "OFF" the power supply after experiment.
2. Due care must be taken while taking reading in O.C. test to avoid any accident as open terminals of H.V winding are at higher voltage. (for higher voltage rated transformers the HV terminals are at fatally high voltages and hence due precautions must be taken to avoid contact and the specified procedure to be followed then).
3. It is extremely important to note that a low voltage is to be applied to the high- voltage winding during S.C test, just sufficient to circulate full-load current through it.

X Procedure

<u>Open circuit test:</u>

1. Make the connections as per the circuit diagram shown in Fig.1
2. Note the rated voltage to determine the range of instruments required
3. Set the auto transformer output to zero and switch "ON" supply.
4. Increase the auto transformer output voltage gradually till rated voltage of low-voltage winding is reached.
5. Note down the readings of voltmeter, ammeter and wattmeter.
6. Bring the autotransformer to minimum position and switch "OFF" the supply

<u>Short circuit test:</u>

1. Make the connections as per the circuit diagram shown in Fig.2
2. Note down the name plate ratings and determine the rated currents for both the windings.
3. Set the auto transformer output to zero and switch "ON" supply.
4. Increase the auto transformer output voltage very slowly & carefully till rated

current flows through the winding.

5. Note the readings of voltmeter, ammeters and wattmeter.
6. Bring the autotransformer to minimum position and switch "OFF" the supply.

XI Observations and calculations

Open circuit test:

Sr. No.	Applied voltage Vo Volt (V,)	No load current Io amp	No load power Wo watt	Secondary voltage V, volt	Transformation ratio K= V,/V,

Short circuit test:

Sr. No.	Voltage applied Vsc volt	Current circulated Isc amp	Short circuit power Wsc watt

Calculations:

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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. Draw equivalent circuit of transformer referred to primary side. (with above calculated values inserted in proper position)
2. Explain the need for low power factor (LPF) wattmeter for the O.C test.
3. Open circuit and short circuit tests on a transformer are carried out first at 50 Hz and then the same tests are repeated at 60 Hz. Will the parameters obtained from the test in two cases be different? Justify your answer

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XVI References/Suggestions for further reading

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3	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 20: Open circuit and short circuit test on single phase transformer to determine voltage regulation and efficiency

I Practical Significance

Pre-determining the regulation and efficiency of a transformer at any load condition (at any power factor) is of utmost importance in electrical power system or the relevant industry. Open circuit test and short circuit test are very economical and convenient methods to predetermine the regulation and efficiency of high capacity transformer as they are performed without actually loading of the transformer.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

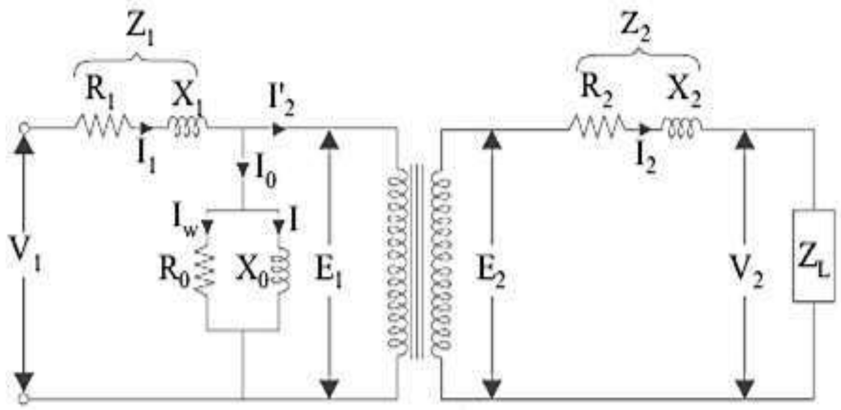
Test the performance of single phase transformer.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Equivalent circuit is a very useful way of understanding or predicting the operation and behavior of a transformer. In a transformer equivalent circuit we can account for winding losses and flux leakage with a series resistance and reactance on the primary side. Core losses can be modeled similarly with a parallel resistance and reactance on the primary side.



Open Circuit test (O.C. Test)

It is used to estimate iron losses, transformation ratio and parameters of magnetizing branch of equivalent circuit. It is determined by applying rated voltage to the low voltage winding and keeping the high voltage winding open.

Short Circuit test (S.C. Test)

It is used to estimate copper losses and parameters of impedance branch by applying low voltage sufficient to circulate rated full load current in the high voltage winding, keeping the low voltage winding short circuited.

Expressions for percentage regulation and efficiency

a) % Regulation at full load= $\frac{(I, \text{o}, cos\emptyset \pm I, \text{Ko}, sin\emptyset)}{V,}\times 100$

Or

$$\frac{(I, \text{o}, cos\emptyset \pm I, \text{Ko}, sin\emptyset)}{V,}\times 100$$

% regulation at any load= $\frac{(xI, \text{o}, cos\emptyset \pm xI, \text{Ko}, sin\emptyset)}{V,}\times 100$

b) % efficiency at any load= $\frac{(VA\ rating)\times cos\emptyset}{(VA\ rating)\times cos\emptyset + \text{Wo} + x^2 \text{W}sc}\times 100$

VII Actual Circuit diagram used in laboratory with equipment Specifications

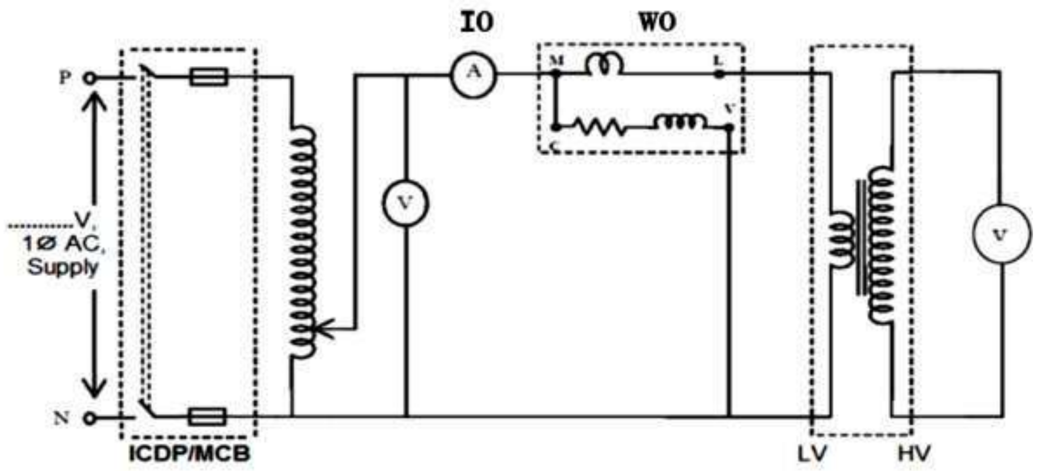


Fig. 19.1 circuit diagram for Open circuit test

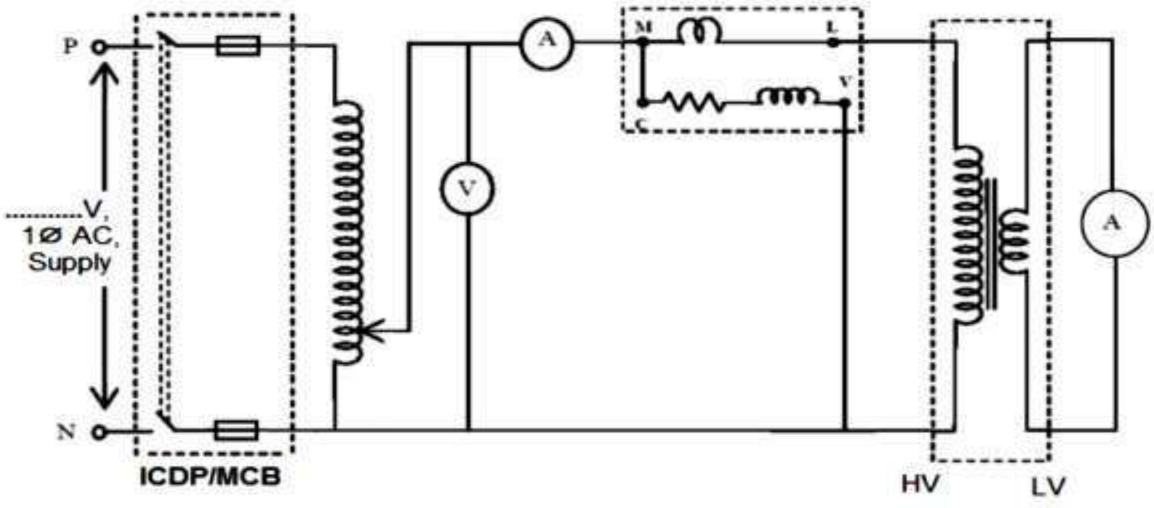


Fig. 19.2 circuit diagram for Short circuit test

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	**Single phase transformer**	**1 kVA, 230/115V**	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	AC Voltmeter	(0-300)V	2 No.
4	AC Ammeter	(0-5-10) A	2 No.
5	LPF Wattmeter	0-150-300V, 1/2A	1 No.
6	Wattmeter	0-150-300V, 5/10A	1 No.

IX Precautions to be followed

1) DO NOT make any connections with the power supply "ON". Get in the habit of turning "OFF" the power supply after experiment.
2) Due care must be taken while taking reading in O.C. test to avoid any accident as open terminals of H.V winding are at higher voltage. (for higher voltage rated transformers the HV terminals are at fatally high voltages and hence due precautions must be taken to avoid contact and the specified procedure to be followed then).
3) It is extremely important to note that a low voltage is to be applied to the high-voltage winding during S.C test, just sufficient to circulate full-load current through it.

X Procedure

Open circuit test:

1. Make the connections as per the circuit diagram shown in Fig.1
2. Note the rated voltage to determine the range of instruments required
3. Set the auto transformer output to zero and switch “ON” supply.
4. Increase the auto transformer output voltage gradually till rated voltage of low-voltage winding is reached.
5. Note down the readings of voltmeter, ammeter and wattmeter.
6. Bring the autotransformer to minimum position and switch “OFF” the supply

Short circuit test:

1. Make the connections as per the circuit diagram shown in Fig.2
2. Note down the name plate ratings and determine the rated currents for both the windings.
3. Set the auto transformer output to zero and switch “ON” supply.
4. Increase the auto transformer output voltage very slowly & carefully till rated current flows through the winding.
5. Note the readings of voltmeter, ammeters and wattmeter.
6. Bring the autotransformer to minimum position and switch “OFF” the supply.

XI Observations and calculations

Open circuit test:

Sr. No.	Applied voltage Vo Volt (V,)	No load current Io amp	No load power Wo watt	Secondary voltage V, volt	Transformation ratio K= V,/V,
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Short circuit test:

Sr. No.	Voltage applied Vsc volt	Current circulated Isc amp	Short circuit power Wsc watt
1		Half F.L.=	
2		Rated or F.L.	

Calculations:

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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1) Draw equivalent circuit of transformer referred to primary side. (with above calculated values inserted in proper position)
2) Explain the need for low power factor (LPF) wattmeter for the O.C test.
3) Open circuit and short circuit tests on a transformer are carried out first at 50 Hz and then the same tests are repeated at 60 Hz. Will the parameters obtained from the test in two cases be different? Justify your answer

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XVI References/Suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1	A text book of Laboratory Course in Electrical Engineering	Tarnekar S. G. and Karbanda P. K.	S Chand and Co. Ltd. New Delhi Edition 2013 ISBN: 9788121901048
2	Electrical Machines	Kothari D. P. and Nagrath I. J.	McGraw Hill Education, New Delhi ISBN: 9780070699670
3	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 21: Perform parallel operation of two single phase transformers to determine the load current sharing.

I Practical Significance

A power transformer is one of the most vital and an expensive component in the power system. For supplying a load in excess of the rating of an existing transformer, two or more transformers may be connected in parallel with the existing transformer. The transformers are connected in parallel when load on one of the transformers is more than its capacity. The reliability is increased with parallel operation than that having single larger unit. The cost associated with maintaining the spares is less when two transformers are connected in parallel.

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II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

Perform parallel operation of two single phase transformers.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Parallel Operation:

Two transformers are connected in parallel means that the two primary windings are connected in parallel to supply bus and the two secondary windings are connected in parallel to load bus-bar.

Two or more transformers may be connected in parallel with the existing transformer to supply a load in excess of the ratings of an existing transformer. Parallel operation of transformers provides more reliability i.e. even in the failure or out off service of one transformer, critical load can be driven using single transformer in emergency cases.

Conditions for Parallel operation of Transformers

1. The line voltage ratio of two transformers must be equal.
2. The per unit impedance of each transformer should be equal for load sharing in proportion to their kVA ratings.
3. They should have same ratio of equivalent leakage reactance to the equivalent resistance(X/R) for sharing at identical power factors.

4. Identical polarity terminals on the respective sides of the transformers are to be connected to each other.

Formula for load current sharing

If I_L is the load current, then the load current shared by the transformers can be found out by

$$I_1 = I_L \times \frac{Z_2}{Z_1+Z_2} \qquad I_2 = I_L \times \frac{Z_1}{Z_1+Z_2}$$

VII Actual Circuit diagram used in laboratory with equipment Specifications

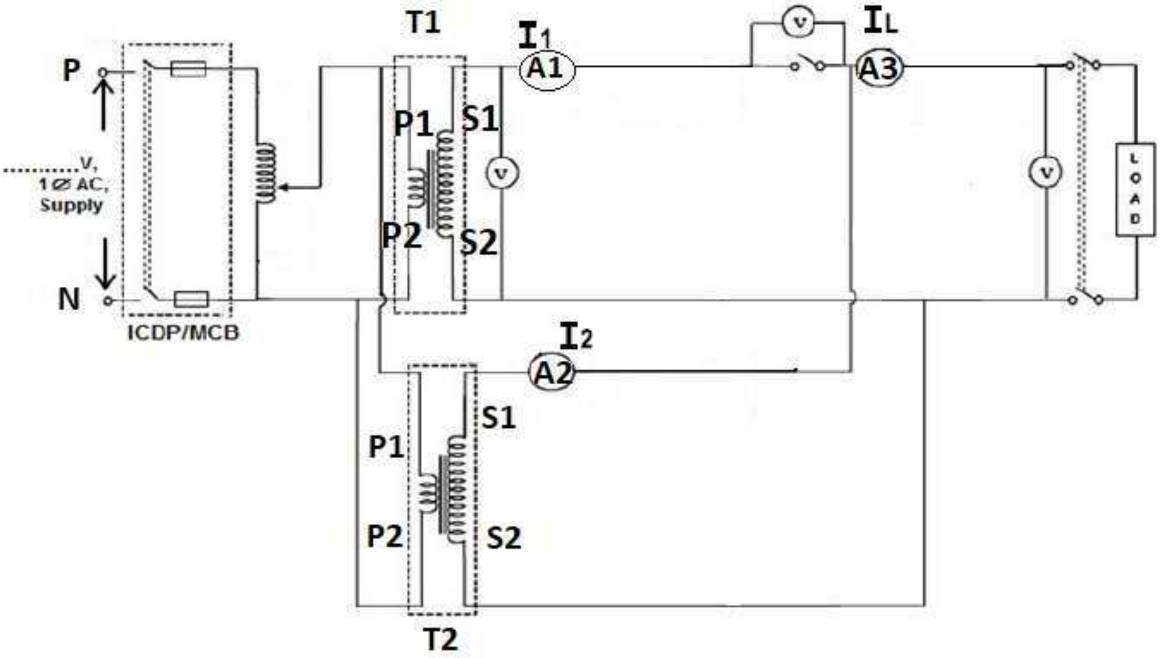

Fig. 21.1 circuit diagram for parallel operation

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Single phase transformer	1 kVA, 230/115V	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	AC Voltmeter	(0-150-300)V	3 No.
4	AC Ammeter	(0-5-10)A	3 No
5	Lamp load	230V,20A	1 No.

IX Precautions to be followed

1. DO NOT make any connections with the power supply ON. Get in the habit of turning OFF the power supply after measurement.
2. The load should be in the off position while starting of the practical.
3. The two units must have identical voltage ratings and the same transformation ratio.
4. Transformers should be connected in such a way that the terminals of similar polarity are connected together

X Procedure

1. Connect the circuit as per the circuit diagram.
2. Set the autotransformer to its minimum output position and keep the load switches OFF.
3. Slowly increase the autotransformer output voltage to the rated value of transformer primary voltage.
4. Verify the voltage across the switch in the secondary circuit by observing the volt meter reading. If it is zero, then close the switch, otherwise switch off the supply and change the transformer secondary connections for correct polarity and repeat the above steps
5. After closing the switch, gradually increase the load and note the values of all meters at half full load and full load.
6. Decrease the load and switch off the mains supply.
7. Switch off the load and bring the autotransformer to minimum position and switch OFF the supply
8. Calculate load current shared by each transformer using relevant formula.

XI Observations and calculations

Sr. No.	I, amp	I, amp	Measured load current IL amp	Calculated load current IL amp

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. What is the use of voltmeter connected across the switch connected in the secondary circuit?
2. What will happen if two transformers are connected in parallel with unequal impedances?
3. Write the equation for circulating current, if the transformers with unequal voltage ratios.(Consider E1>E2).

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XVI References/Suggestions for further reading

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3	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 22: Perform parallel operation of two single phase transformers to determine the apparent and real power load sharing.

I Practical Significance

A power transformer is one of the most vital and an equally expensive component in a power system. Due to load growth an existing transformer may not be able to withstand the demand during peak-hours without exceeding its long-term MVA rating. In most cases, instead of commissioning an entirely new higher capacity unit, a more viable alternative exists in connecting a new smaller unit 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.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

Perform parallel operation of two single phase transformers.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Parallel Operation:

Two transformers are connected in parallel means that the two primary windings are connected in parallel to supply bus and the two secondary windings are connected in parallel to load bus-bar.

Two or more transformers may be connected in parallel with the existing transformer to supply a load in excess of the ratings of an existing transformer. Parallel operation of transformers provides more reliability i.e. even in the failure or out off service of one transformer, critical load can be driven using single transformer in emergency cases.

Conditions for Parallel operation of Transformers

1) The line voltage ratio of two transformers must be equal.
2) The per unit impedance of each transformer should be equal for load sharing in proportion to their kVA ratings.
3) They should have same ratio of equivalent leakage reactance to the equivalent resistance(X/R) for sharing at identical power factors.
4) Identical polarity terminals on the respective sides of the transformers are to be

connected to each other.

Formula for load current sharing

If S is the load power in KVA, then the KVA shared by the transformers can be found out by

$S_1 = S \times \frac{Z2}{Z_1+Z_2}$ $S_2 = S \times \frac{Z1}{Z_1+Z_2}$

VII Actual Circuit diagram used in laboratory with equipment Specifications

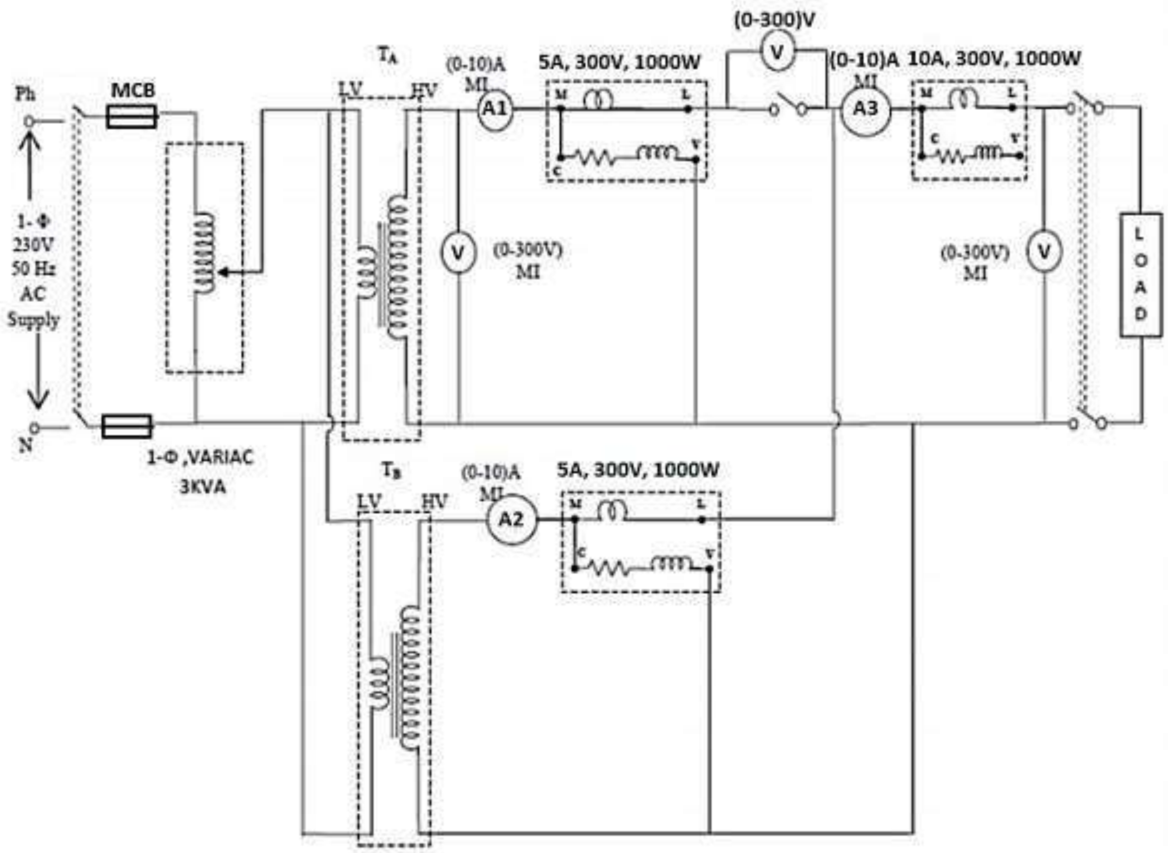

Fig. 22.1 circuit diagram for parallel operation

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Single phase transformer	1 kVA, 230/115V	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	AC Voltmeter	(0-150-300)V	3 No.
4	AC Ammeter	(0-5-10)A	3 No
5	Lamp load	230V,20A	1 No.
6	Wattmeter	(300V, 10A)	3 No

IX Precautions to be followed

1. DO NOT make any connections with the power supply ON. Get in the habit of turning OFF the power supply after measurement.
2. The load should be in the off position while starting of the practical.
3. The two units must have identical voltage ratings and the same transformation ratio.
4. Transformers should be connected in such a way that the terminals of similar polarity are connected together

X Procedure

1. Connect the circuit as per the circuit diagram.
2. Set the autotransformer to its minimum output position and keep the load switches OFF.
3. Slowly increase the autotransformer output voltage to the rated value of transformer primary voltage.
4. Verify the voltage across the switch in the secondary circuit by observing the volt meter reading. If it is zero, then close the switch, otherwise switch off the supply and change the transformer secondary connections for correct polarity and repeat the above steps
5. After closing the switch, gradually increase the load and note the values of all meters at half full load and full load.
6. Decrease the load and switch off the mains supply.
7. Switch off the load and bring the autotransformer to minimum position and switch OFF the supply
8. Calculate load current shared by each transformer using relevant formula.

XI Observations and calculations

Sr. No.	I, amp	Real power W1 watts	I, amp	Real power W2 watts	Real load power WL= (W1+W2) watts	Apparent power S1(VA)	Apparent power S2(VA)	Total Apparent power S(VA)

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. State the purpose of voltmeter connected across the switch for parallel operation. What does it indicate if voltmeter reading is zero?
2. What will happen if two transformers are connected in parallel with wrong polarity?

3. Compare the experimental and analytical results.
4. When is the circulating current present in the winding circuit of the two transformers connected in parallel?

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XVI References/Suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1	A text book of Laboratory Course in Electrical Engineering	Tarnekar S. G. and Karbanda P. K.	S Chand and Co. Ltd. New Delhi Edition 2013 ISBN: 9788121901048
2	Electrical Machines	Kothari D. P. and Nagrath I. J.	McGraw Hill Education, New Delhi ISBN: 9780070699670
3	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 23: Perform polarity test on a single phase transformer whose polarity markings are masked.

I Practical Significance

Polarity test is must for transformers when parallel operation is done. Because while doing parallel operation, if you connect terminals of opposite polarity, it will result in a dead short - circuit. So, to connect the same polarity windings together both in primary and secondary, polarity test is done.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

Perform polarity test on a single phase transformer.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

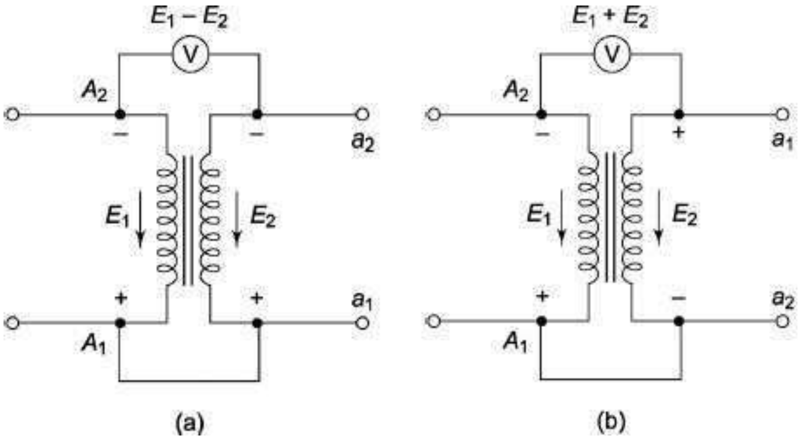
VI Relevant Theoretical Background (With diagrams if required)

Polarity test is conducted to identify the terminals of identical polarity of the primary and secondary winding of each phase of transformer. There are two types of polarity one is Additive, and another is Subtractive.

It is essential to know the relative polarities at any instant of the primary and the secondary terminals for making the correct connections if the transformers are to be connected in parallel or they are used in a three-phase circuit.

Additive Polarity: In additive polarity, the voltage between the secondary side and the primary side will be the sum of both the low voltage and high voltage.

Subtractive Polarity: In subtractive polarity, the voltage between the secondary side and the primary side will be the difference of both the low voltage and high voltage.



VII **Actual Circuit diagram used in laboratory with equipment Specifications**

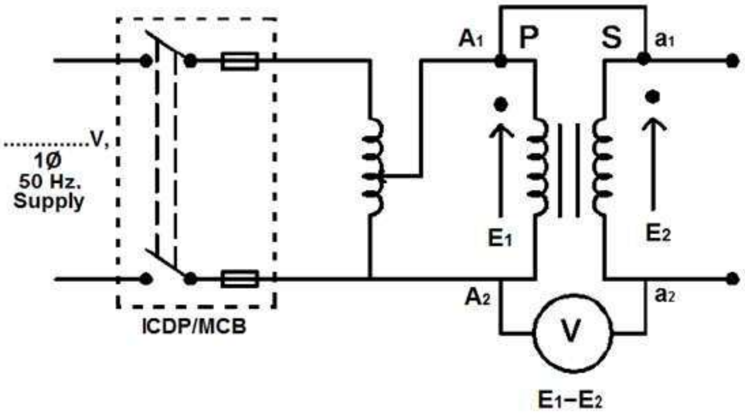


Fig. 23.1 circuit diagram for subtractive polarity

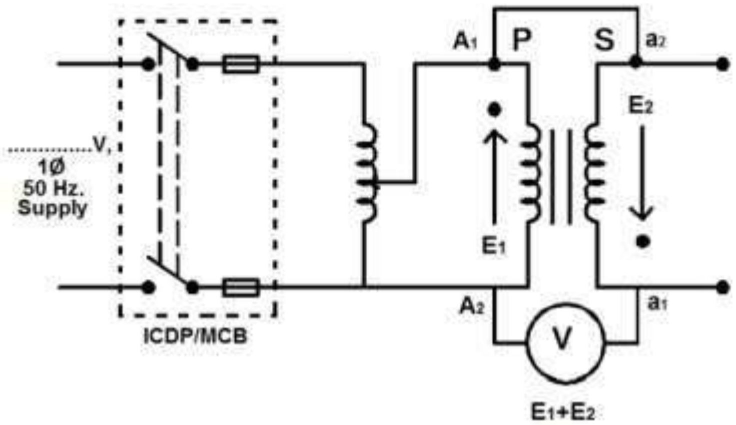


Fig. 23.2 circuit diagram for additive polarity

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	**Single phase transformer**	**1 kVA, 230/115V**	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	AC Voltmeter	(0-150-300)V	3 No.

IX Precautions to be followed

1) Follow Safety practices.
2) DO NOT make any connections with the power supply ON. Get in the habit of turning OFF the power supply after the practical.
3) Keep the auto transformer output position to zero at start before switching on.

X Procedure

1. Make the connections as per circuit diagram shown in fig. 23.1
2. Primary terminals are marked A1 and A2.
3. Short A1 and a1 by low resistance wire.
4. Apply suitable voltage through auto transformer across primary.
5. Measure primary voltage E1, secondary voltage E2and voltmeter reading
6. If voltmeter reading is equal to difference of primary voltage E1 and secondary voltage E2 then the connected terminals are of same polarity.
7. Make the connections as per circuit diagram shown in fig 23.2
8. Short A1 and a2 by low resistance wire.
9. Apply voltage through auto transformer across primary and measure voltage across the remaining terminals of the interconnected windings.
10. If voltmeter reading is equal to sum of primary voltage E1 and secondary voltage E2 then the connected terminals are of opposite polarity.
11. Bring the autotransformer to minimum position and switch OFF the supply

XI Observations and calculations

Sr. No.	Figure No.	E1 volt	E2 volt	Measured Voltage (V)	Calculated voltage V=(E1-E2) or V=(E1+E2)	Type of polarity

Voltmeter reading

V=E1-E2 indicates subtractive polarity connection

V=E1+E2 indicates additive polarity connection

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1) Why is subtractive polarity preferred?

2) What will be the effect on parallel operation of transformer if polarity is not proper?

XVI References/Suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1	A text book of Laboratory Course in Electrical Engineering	Tarnekar S. G. and Karbanda P. K.	S Chand and Co. Ltd. New Delhi Edition 2013 ISBN: 9788121901048
2	Electrical Machines	Kothari D. P. and Nagrath I. J.	McGraw Hill Education, New Delhi ISBN: 9780070699670
3	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.24 : Scott-Connection of three phase transformer.

I Practical Significance

In same case we may require two phase power instead of three phase or one phase -power that it is necessary to convert three- phase to two phase transformation is accomplished with the help of two identical 1-ϕ transformer having the same current rating.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

Convert three phase to two phase conversion by Scott-Connection.

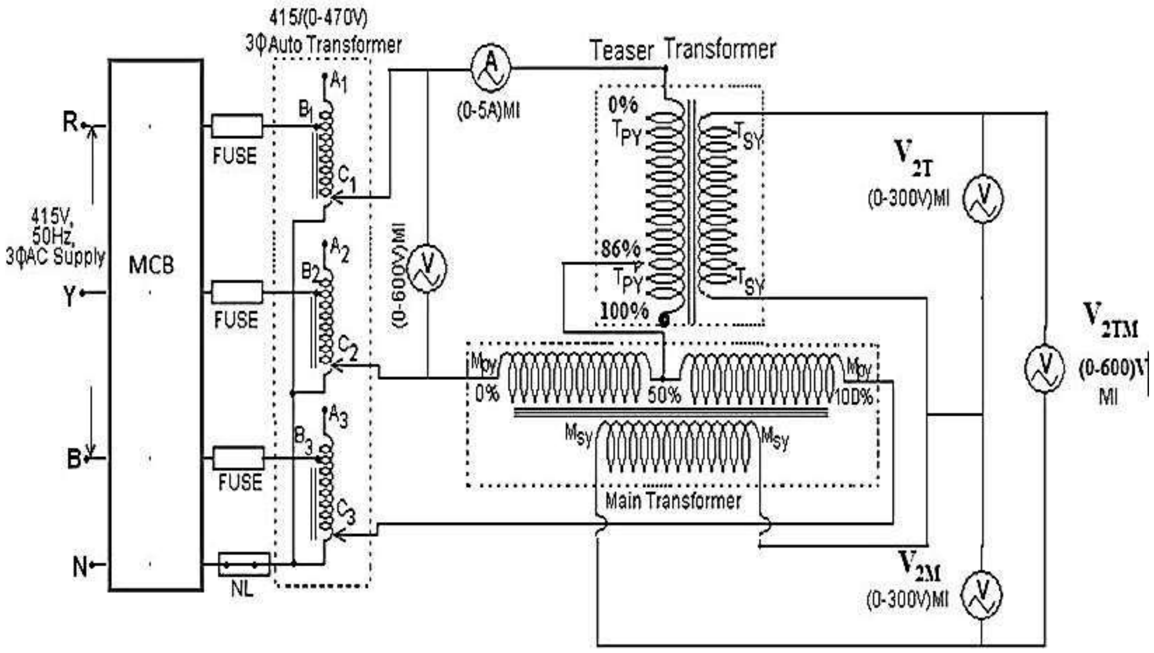
V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

The Scott connection is the most common method of connecting two single phase transformers to perform the 3 phase to 2 phase conversion and vice-versa. The two transformers are connected electrically but not magnetically, one transformer is called main transformer and other is auxiliary or teaser transformer. The main transformer is having 50% tapping and auxiliary transformer is having 86.6% tapping. One end of primary winding of the auxiliary transformer is connected to the centre tapping provided on the primary winding of the main transformer with equal number of turns on. The voltage per turn is same in primary of both main & teaser transformer with equal number of turn on secondary on both the transformer. The secondary voltage will be equal in magnitude which results in symmetrical & phase system.

VII Actual Circuit diagram used in laboratory with equipment Specifications



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Three phase auto transformer of suitable size	(1 kVA to 3 kVA)	1 No.
2	Single phase transformer	1kVA	2 No.
3	Teaser transformer	1kVA 100%,86.6%,50%, 0% Tappings	1 No.
4	AC Voltmeter	(0-150-300)V	2 No.
5	AC Ammeter	(0-5-10)A	2 No.
6	Lamp load	230V, 10A	1 No.

IX Precautions to be followed

1) Follow Safety practices.

2) DO NOT make any connections with the power supply ON. Get in the habit of turning OFF the power supply after the practical.
3) Keep the auto transformer output position to zero at start before switching on.

X Procedure

1. Connections are made as per the circuit diagram
2. Ensure that output voltage of the variac is set in zero position before starting the experiment.
3. Switch ON the supply.
4. The output voltage of the variac is gradually increased in steps upto rated voltage of single phase MAIN transformer and readings are correspondingly taken in steps.
5. After observations, the variac is brought to zero position and switch OFF the supply

XI Observations and Calculations

Sr. No.	Voltmeter reading (V_1)	Ammeter reading (V_1)	Voltmeter reading (V_{2T})	Voltmeter reading (V_{2M})	Voltmeter reading (V_{2TM})	Calculated $V2TM = \sqrt{V^2 2T + V^2 2M}$

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1) State advantages of Scott connection.
2) State applications of Scott connection.
3) What is teaser transformer?

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XVI References/Suggestions for further reading

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3	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 25 : Back to Back test on single phase transformer.

I Practical Significance

In the industry environment Electrical Engineering diploma graduate are expected to Despite advancements in electrical technology, single phase transformer still find applications in various industries, power sector and commercial sectors. Further the Transformers are essential components of power systems. This practical is to equip students with fundamental knowledge, practical skills and a strong foundation in electrical power system and related fields.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Test the performance of single phase transformers.

IV Laboratory Learning Outcome(s)

Perform Back to Back test on single phase transformer.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

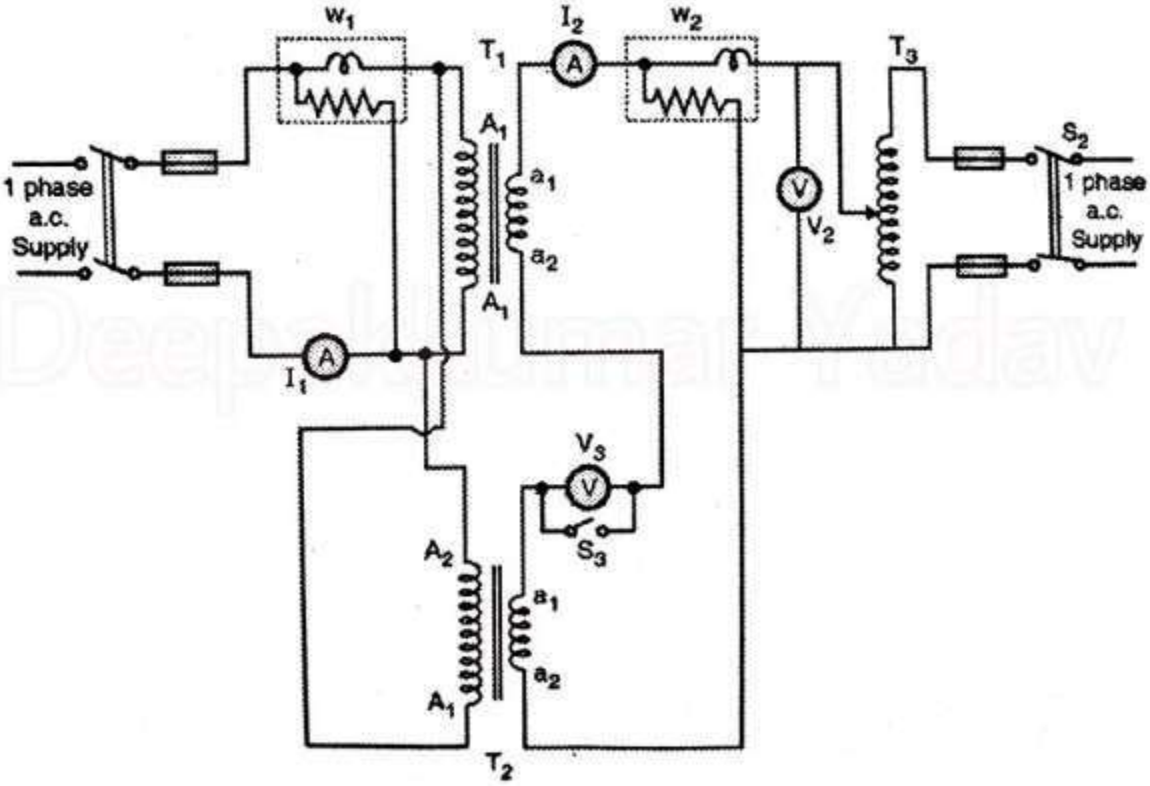
If large transformer are to be tested for determining their efficiency, temperature rise and regulation then a load of high capacity, may not be available and if available, the energy consumed in testing will be wasted. To overcome this difficulty back to back test is adopted.

The open-circuit test and short circuit test are performed to determine the equivalent circuit parameter. With the help of these tests, we cannot find the temperature rise in a transformer. Because the open-circuit test is examined only core loss and short-circuit test is examined only copper loss. However, the transformer is not subjected concurrently to both losses. Hence, the alternative is Sumpner"s test. The solution to this problem is the Sumpner"s test. The Sumpner"s test is performed to determine the transformer efficiency, voltage regulation, and heating effect of the transformer under loading conditions. The **Sumpner’s test** is also known as the **back-to-back test** as this test consists of two identical transformers connected back-to-back.

In Sumpner"s test, actual loading conditions are simulated without connecting actual load. For a small transformer, it is convenient to connect full-load. But it is difficult to connect full-load in the case of large transformers. Therefore, this test helps to find the important parameters of the transformer. And the Sumpner"s test gives more accurate results compared to open-circuit and short-circuit tests.

Sumpner's Test – (Back-to-Back Test)

To perform the Sumpner‟s test, two single-phase transformers with identical ratings are required. The experimental circuit diagram of the Sumpner‟s test is shown in the figure below.



It is a regenerative test and hence economical and very useful. T_1 and T_2 are two identical transformers T_3, autotransformer S_1 ,S_2 andS_3, switches A-ammeters, V-voltmeters, W-wattmeters.

- Two similar transformers are required to carryout this test. As shown in Figure the primaries of two transformers (T_1 and T_2) are connected in parallel across the supply at rated voltage of primary.
- Their secondary's are connected in phase opposition or back to back fashion.
- When primaries of two transformers are energized by switching on switch S_1, the emfs induced in secondary windings come in phase opposition. Since the two transformers are identical, there is no circulating current in the local circuit formed by secondary's even, if primaries energized.
- To ensure that the secondary's are connected in phase opposition, a voltmeter (V_3) and a switch is connected in parallel as shown. V_3 should be of the double range of that of secondary voltage.

- This is because, if the polarities are not connected in phase opposition the voltmeter may receive twice the voltage of secondary i.e. secondary voltage of first pulse secondary voltage second transformer.
- If voltmeter indicates zero it ensure that secondary's are Le. connected in phase opposition, then switch V_3 is closed. If voltmeter does indicate more voltage then secondary connections are interchanged.
- To circulate the necessary current one auto transformer (T_3) is used in the secondary circuit as shown.
- Voltage is injected by switching on S_2 and by varying the voltage with the help of T_3 full load current is circulated in the secondary's.
- The current corresponding to this circulating current also flows in the closed circuit formed in the primaries, however it does not appear in the ammeter and wattmeter W, connected in primary side. So the current taken from supply side is only the total no load current of two transformers.
- The wattmeter reading (W_1) connected in the primary side indicates total no load loss or iron loss of two transformers.
- The wattmeter connected in secondary side (W_2) indicates total copper loss or load loss of two transformers caused by the circulating current. Since both the losses are known efficiency of the transformer can be easily determined.

The reading of measuring devices connected in the circuit of Sumpner"s test is as follows;

- Ammeter A_1 = No-load current = $2I_0$
- Voltmeter V_1 = Applied rated input voltage (Primary voltage)
- Wattmeter W_1 = Core losses (iron losses) of both transformers = $2P_i$
- Ammeter A_2 = Full load secondary current of both transformers = $2I_2$
- Voltmeter V_2 = Total voltage across series connection of both secondary windings
- Wattmeter W_2 = Full load copper loss of both transformers = $2P_{cu}$

Here, we have connected two identical transformers. Therefore, the losses that occurred in both transformers are the same. The wattmeter (W_1 and W_2) connected in the circuit measures the iron loss and copper loss for both transformers. So, if you need to find the losses for each transformer, you need to do half the reading.

$$Iron\ loss\ in\ each\ transformer = \frac{W_1}{2}$$

$$Copper\ loss\ in\ each\ transformer = \frac{W_2}{2}$$

Calculation of Efficiency

Therefore, the efficiency of a transformer is calculated by;

$$\% \, Efficiency \, of \, each \, transformer = \frac{Full \, load \, output}{Full \, load \, input + \frac{W_1}{2} + \frac{W_2}{2}} \times 100$$

<u>Calculation of Voltage Regulation</u>

The injected voltage (V_2) supplied to secondary side circulates the full load current in the secondary's of both transformers. The current corresponding to this circulating current also flows in the primaries (in the local circuit formed). Thus this injected voltage (V_2) supplies the voltage drops (IZ drop) of both transformers. Hence voltage drop of one transformer will be $V_2 / 2$

i.e. injected voltage / 2

Advantages of Back to back test

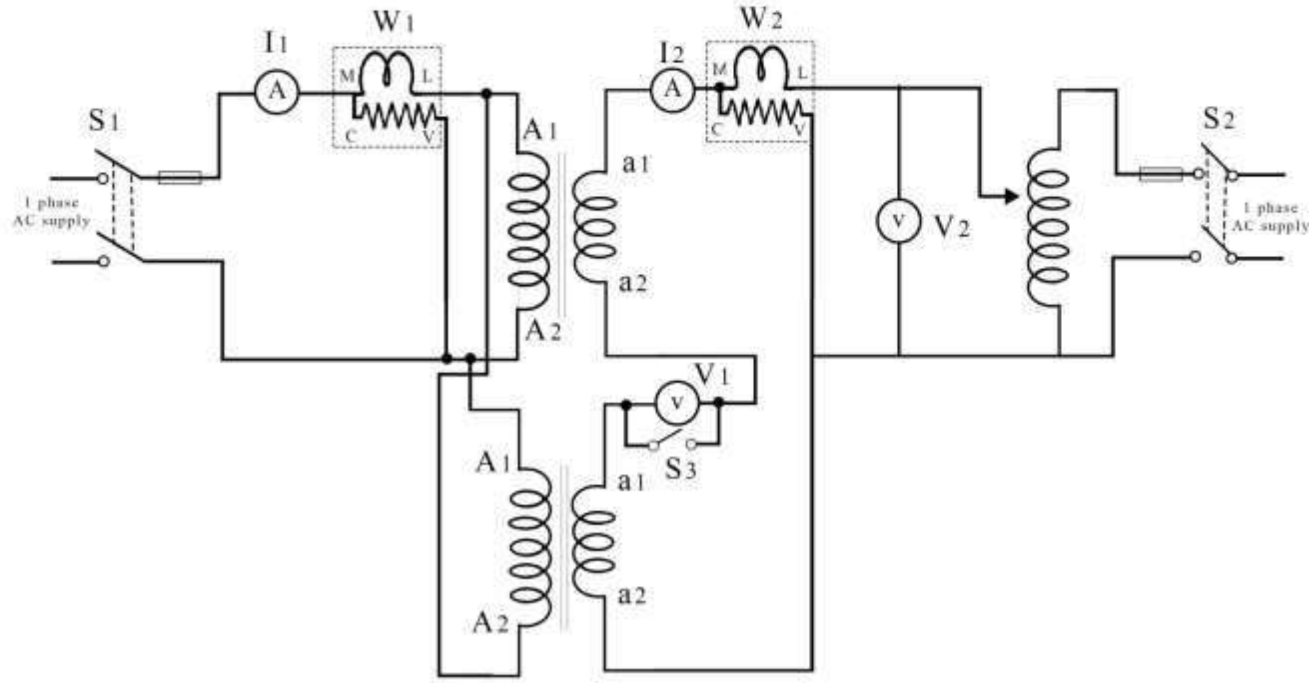
The advantages of the Sumpner"s test of a transformer are listed below.

- The big capacity of a transformer can be tested without connecting actual load.
- The power required to perform this test is very little. It is equal to the loss of both transformers.
- With the help of the Sumpner"s test, we can find the copper loss, iron loss, temperature rise, equivalent circuit parameters, and efficiency of the transformer.

Disadvantage of Back to back test

The only disadvantage of the Sumpner"s test is that two identical transformers are required to perform this test.

VII Actual Circuit diagram used in laboratory with equipment Specifications



VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Single Phase Transformer	1 KVA	2 No.
2	Wattmeter	0-300V, 5/10A	2 No.
3	Single Phase Autotransformer	0-270 V , 15 A	2 No.
4	AC Ammeter	0-5/10 Amp , 0-1/2 Amp	1 No. Each
5	AC Voltmeter	0-150/300 V	2 No.

IX Precautions to be followed

1. All electrical connections should be neat and tight.
2. Make sure that main switch is off position while making connections.
3. The auto transformer should be kept at zero output position initially.
4. Check the correctness of polarities of the two transformers by measuring voltage across switch.

X Procedure

1. Make the connections as shown in circuit diagram.
2. Initially keep switch„s‟ in open condition.
3. Switch ON the supply and check the correctness of polarities of the two transformers by measuring voltage across switch , if voltage gets zero then close switch „s‟.
4. Note the reading of V1, I1 and W1.
5. Now increase voltage of auxiliary transformer gradually so that full load current flows through secondary windings.
6. Note down V2, I2and W2. While doing so, the values shown by V1, I1 and W1 should not deviate from their earlier readings.

XI Observations and calculations

Sr.No.	**Primary Side**			**Primary Side**		
	Primary Voltage (V1)	**Primary Current (I1)**	**Primary Power (W1)**	**Secondary Voltage (V2)**	**Secondary Current (I2)**	**Secondary Power (W2)**

Calculation

Secondary no load voltage ....Volt

Iron loss per transformer Wi = W1/2 =................... Watts

Copper loss per transformer Wcu = W2/2 =...................Watts

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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1) The magnitude of the regulation of transformer should be high or low. Justify

2) List out various tests to be conducted on transformer for finding out efficiency and regulation.

3) State condition to be satisfied for back to back connection?

4) State advantages and limitations of Back to Back test

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XVI References/Suggestions for further reading

1) Principals of Electrical Machines Rohit Mehta and V. K. Mehta S Chand Publications
2) Electrical Technology:Vol-2 B. L.Theraja S Chand Publications
3) www.E1ectrica14u.com
4) https://www.youtube.com/watch?v=oI-O9FCDqmg
5) https://www.youtube.com/watch?vmsWNGcZ-jds
6) https://www.youtube.com/watch?v=IC-PWxtcirI

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 26: Connection of the Autotransformer.

I Practical Significance

In Industry it is quite often required for diploma Electrical Engineer to use the autotransformer for testing electrical equipment at the limits of specified voltage ranges. This practical gives confidence to use the auto transformers to obtain output voltages above or below the input value.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

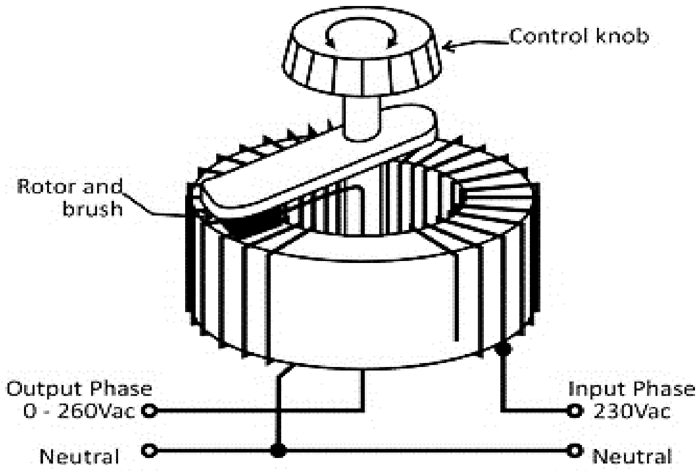
Connect the auto-transformer in step-up and step-down modes, measure input and output voltage.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Autotransformer is a transformer with one winding only, part of this being common to both primary and secondary. Autotransformer consists of only one winding wound on a laminated core with a rotary movable contact. Auto transformer can operate as step-up or step-down transformer. As only one winding is used less copper is used hence cost is less.



VII Actual Circuit diagram used in laboratory with equipment Specifications

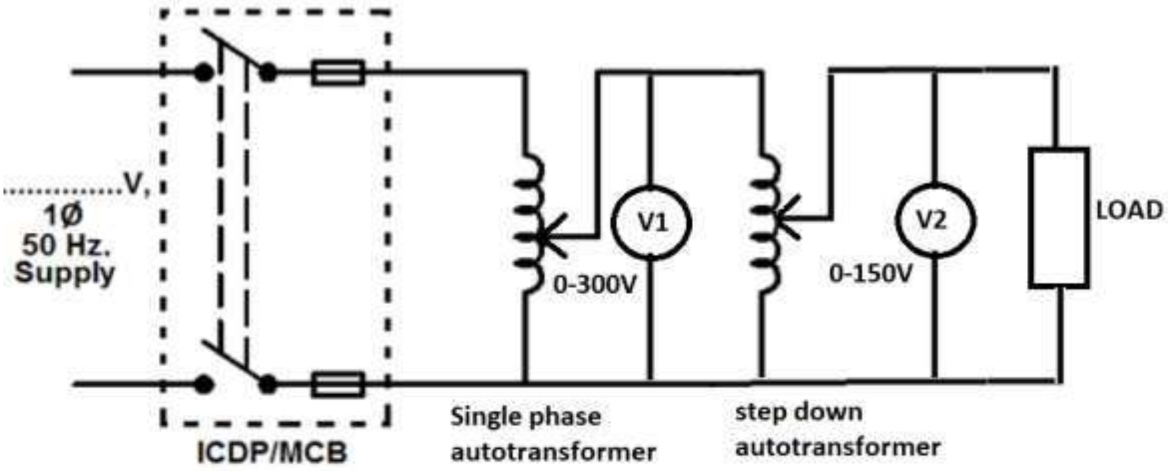


Fig. 26.1 circuit diagram for autotransformer in stepdown mode

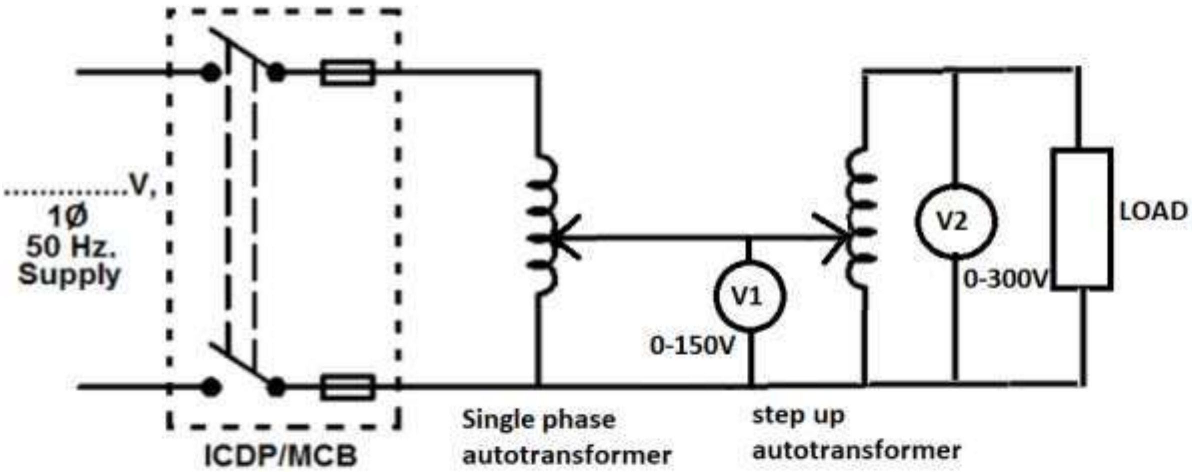


Fig. 26.2 circuit diagram for autotransformer in stepup mode

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Single phase autotransformer	0-270V, 10A	2 No.
2	Voltmeter	(0-300)V	1 No.

3	Voltmeter	(0-150)V	1 No.
4	Lamp load	Single phase 230V, 10A	1 No.

IX Precautions to be followed

1. Make sure that the main switch is in „OFF" position while making connections.
2. Make sure variable knob of the autotransformer to be stepped down/up is at zero position at the beginning of the practical for part A and at maximum position at the beginning of practical for part B.
3. Make sure load is switched off at the beginning of the practical.

X Procedure

Part A:

1. Make the connections as per the circuit diagram shown in Fig.1
2. Keep the knob of autotransformer to be stepped down at minimum position.
3. Switch on the single phase AC supply.
4. Increase the input voltage so that the voltmeter Vereads some voltage, say 100 volts using variac. Note down this voltmeter reading as input voltage Var
5. Turn the knob of step-down auto transformer clock wise, so as to apply some voltage across the load.
6. Turn on some load.
7. Observe the reading in voltmeter V2.and note down this as output voltage V2
8. Repeat the steps 4 to 7for different readings of Ve(say 150V, 200V) and note down input voltage Veand corresponding output voltage V2
9. Switch off the load.
10. Bring back the knob of the step-down autotransformer to the zero position.
11. Bring the variac output voltage to the minimum.
12. Switch off the supply.

Part B:

1. Make the connections as per the circuit diagram shown in Fig.2
2. Keep the variac at minimum position.
3. Keep the knob of step up autotransformer at the maximum position.
4. Switch on the AC supply.
5. Increase the variac output voltage so that to voltmeter V reads some voltage, say 20 volts. Note down this voltmeter reading as input voltage Vt.
6. Turn the knob of the step-up autotransformer (antic1ockwise),so asto apply voltage higher than the input voltage to the load.
7. Turn on some load.
8. Observe the reading in voltmeter V2and note down this as output voltage V2.

9. Repeat the steps 4 to 8 for different readings of Vt (say 25V, 30V) and note down input voltages Veand corresponding output voltages V2
10. Switch off the load.
11. Bring back the knob of the step-up autotransformer to the maximum position.
12. Bring back the variac output voltage to minimum.
13. Switch off the supply.

XI Observations and calculations

Part A: Autotransformer in step up mode

Sr. No.	Input Voltage V1 volt	Output voltage V2 volt	Transformation ration (V2/V1)
1			
2			
3			
4			

Part B: Autotransformer in step down mode

Sr. No.	Input Voltage V1 volt	Output voltage V2 volt	Transformation ration (V2/V1)
1			
2			
3			
4			

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. List the differences between two winding transformer and autotransformer.
2. Give the applications of autotransformer.
3. Give the reason for not using the autotransformers as distribution transformers.
4. List the advantages of autotransformers.
5. List the disadvantages of autotransformers.

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XVI References/Suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1	A text book of Laboratory Course in Electrical Engineering	Tarnekar S. G. and Karbanda P. K.	S Chand and Co. Ltd. New Delhi Edition 2013 ISBN: 9788121901048
2	Electrical Machines	Kothari D. P. and Nagrath I. J.	McGraw Hill Education, New Delhi ISBN: 9780070699670
3	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

XVII Suggested Assessment Scheme

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 27: Functioning of the Current Transformer (CT).

I Practical Significance

Current transformers are used at generating stations, electrical substations and in industrial and commercial electric power distribution systems**.** Current transformers are used with low-range ammeters to measure high current in high-voltage AC circuits where it is not practicable to connect instruments and meters directly to the lines.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

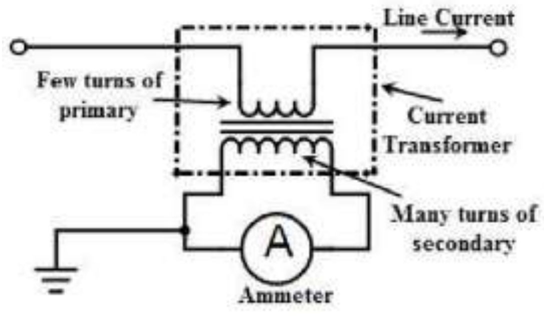
Verify the Current Transformer (CT) ratio.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Current transformer is used along with a low range AC ammeter to measure high value of AC Current of an AC circuit which cannot be measured by the normal ammeter having low range. CT has two winding primary winding and secondary. CT has two winding primary winding and secondary. CT has few turns on primary winding and it has large cross-sectional area. Primary winding is connected in series with the load. It carries load current. Secondary of CT has more no. of turns having small cross-sectional area. Low range ammeter is connected in series with secondary winding to measure current through the load



High value of current to be measured is equal to the reading of low range AC ammeter multiplied by current ratio of the CT

Where current ratio = primary current / secondary current

VII Actual Circuit diagram used in laboratory with equipment Specifications

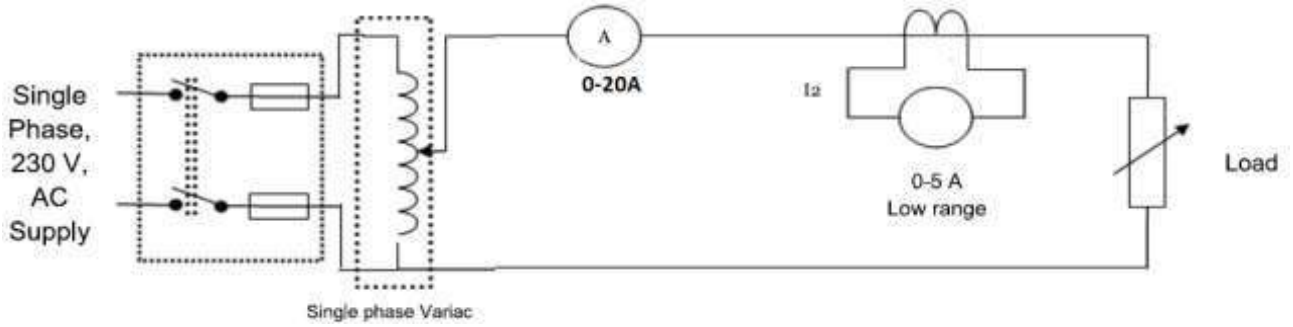


Fig 27.1 circuit diagram

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Current Transformer	Suitable rating	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	Ammeter	(0-20)A	1 No.
4	Ammeter	(0-5)A	1 No.
5	Lamp load	Single phase 230V, 10A	1 No.

IX Precautions to be followed

1. Identify primary and secondary windings properly.
2. Do not leave the secondary of CT open circuited.

X Procedure

1. Make the connections as per the circuit diagram.
2. Keep the auto transformer at minimum output position.
3. Switch „ON" the supply.
4. Increase the supply voltage to its rated value.
5. Switch „ON" some load.
6. Observe primary current I1 and the corresponding secondary current I2 and note down the reading respectively.
7. Repeat the steps 4 to 6 and observe the readings of ammeters A_1 and A_2 for different loads.
8. At the end, switch off the entire load.

9. Bring the autotransformer knob to the minimum position.
10. Switch „OFF" the supply

XI Observations and calculations

Sr. No.	Reading of Ammeter A1	Reading of Ammeter A2	CT ratio I1/I2	Actual current= I2*CT ratio
1				
2				
3				
4				

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. State the differences between CT and PT.
2. List the applications of CT and PT.

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XVI References/Suggestions for further reading

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1	A text book of Laboratory Course in Electrical Engineering	Tarnekar S. G. and Karbanda P. K.	S Chand and Co. Ltd. New Delhi Edition 2013 ISBN: 9788121901048
2	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 28: Functioning of the Potential Transformer (PT).

I Practical Significance

Potential transformer or voltage **transformer** is used in electrical power system for stepping down the system **voltage** to a safe value which can be fed to low rating meters and relays. Commercially available relays and meters used for protection and metering, are designed for low voltage.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

Verify the Potential Transformer (PT) ratio.

V Relevant Affective Domain related outcome(s)

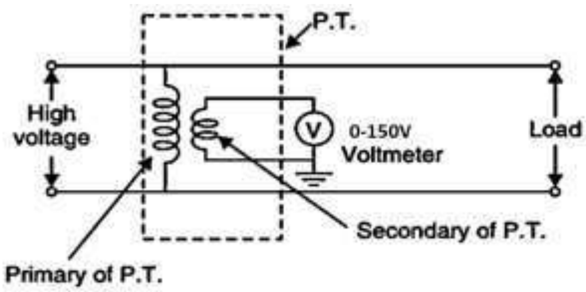
Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Potential transformer is used along with a low range AC voltmeter to measure high value of AC voltage of an AC circuit which cannot be measured by the normal voltmeter having low range. PT has two winding primary winding and secondary. PT has more turns on primary winding and it is connected to high voltage AC supply. Secondary of PT has less no. of turns and Low range voltmeter is connected across secondary winding to measure voltage. PT is basically a step-down transformer which is used to measure high value of voltage.

High value of voltage to be measured is equal to the reading of low range AC voltage multiplied by voltage ratio of the PT

Where voltage ratio = rated primary voltage / rated secondary voltage



VII Actual Circuit diagram used in laboratory with equipment Specifications

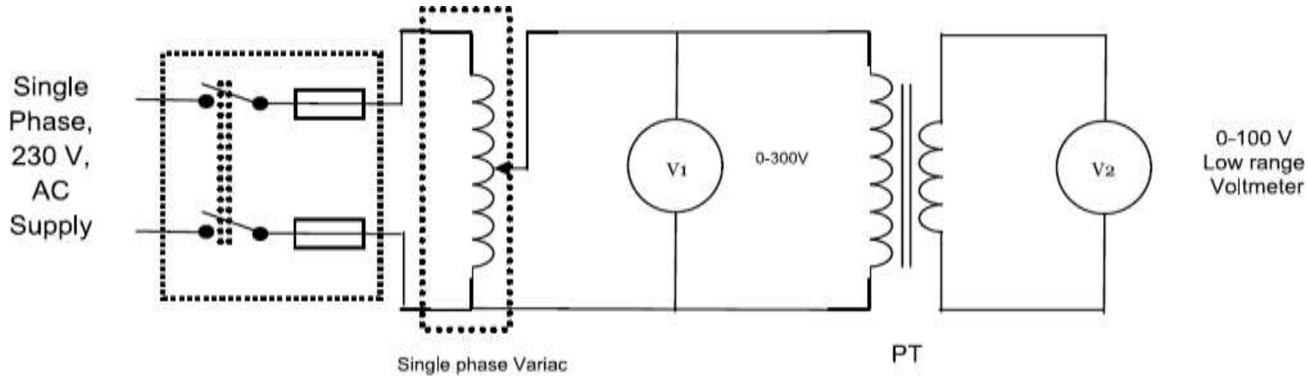


Fig 28.1 circuit diagram

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Potential Transformer	Suitable rating	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	Voltmeter	(0-300)V	1 No.
4	Voltmeter	(0-150)V	1 No.

IX Precautions to be followed

1. Make sure that the main switch on the panel board is in „OFF" position while making connections.
2. Never short-circuit the secondary terminals of a potential transformer even when it is not in use. The short-circuited secondary will cause the PT to overheat and fail in a very short period of time.

X Procedure

1. Connect the circuit as per the circuit diagram.
2. Switch „ON" the supply.
3. Apply some voltage to the primary of the Potential Transformer through variable power supply.
4. Note down the primary voltage V1 and the corresponding secondary voltage V2
5. Repeat the steps 3 to 4 for different sets of primary voltage V1
6. Bring the variable power supply to the minimum value.
7. Switch „OFF" the supply.

XI Observations and calculations

Sr. No.	Reading of Voltmeter V1	Reading of Voltmeter V2	PT ratio V1/V2	Actual voltage= V2*PT ratio
1				
2				
3				
4				

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1) State the differences between CT and PT.
2) List the applications of CT and PT.

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XVI References/Suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1	A text book of Laboratory Course in Electrical Engineering	Tarnekar S. G. and Karbanda P. K.	S Chand and Co. Ltd. New Delhi Edition 2013 ISBN: 9788121901048
2	Laboratory Manual for Electrical Machines	Kothari D. P. and B. S. Umre	I. K. International Publishing House Pvt. Ltd. ISBN: 9789385909757

XVII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 29 : Functioning of the isolation transformer.

I Practical Significance

In Industry an isolation transformer is used to transfer electrical power from a source of alternating current (AC) to some equipment or device while **isolating** the powered device from the power source, usually for safety reasons. Through this practical the student will be able to use Isolation transformer.

II Industry/Employer Expected Outcome(s)

Maintain D.C. Machines and Transformers used in Industry and related field.

III Course Level Learning Outcome(s)

Use relevant special purpose transformers for different applications.

IV Laboratory Learning Outcome(s)

Verify turns ratio of the isolation transformer.

V Relevant Affective Domain related outcome(s)

Select, test, operate, and maintain various types of DC machines and transformers.

VI Relevant Theoretical Background (With diagrams if required)

Isolation transformer are specially designed transformer used to provide electrical isolation between primary and secondary circuits without change in voltage and current.

- Isolation transformer is similar in construction as two winding transformer
- It has primary and secondary winding having equal no. of turns placed o the common core limbs
- As no. of primary and secondary turns are equal, primary voltage is equal to secondary voltage
- Special insulation is used between primary and secondary

VII Actual Circuit diagram used in laboratory with equipment Specifications

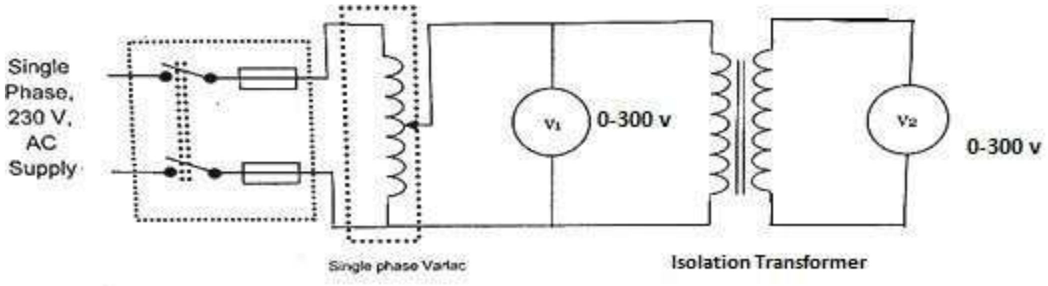

Fig. 29.1 circuit diagram for subtractive polarity

VIII Required Resources/apparatus/equipment with specification

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Isolation transformer	Suitable rating	1 No.
2	Single phase autotransformer	0-270V, 10A	1 No.
3	AC Voltmeter	(0-150-300)V	3 No.

IX Precautions to be followed

1) Follow Safety practices.
2) DO NOT make any connections with the power supply ON. Get in the habit of turning OFF the power supply after the practical.
3) Keep the auto transformer output position to zero at start before switching on.

X Procedure

1. Connect the circuit as per the circuit diagram.
2. Keep the output of variable ac power supply at minimum.
3. Switch ON the supply.
4. Increase the variable supply output of autotransformer to give some input voltage to the primary of isolation transformer.
5. Note down the Input voltage $V_e$and corresponding Output voltage $V_2$of the Isolation Transformer.
6. Repeat the steps 4 to 5 for different sets of readings Vt.

XI Observations and calculations

Sr. No.	Primary voltage (V1) volt	Primary voltage (V2) volt	Voltage ratio (V2/V1)

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

(Teacher should provide various questions related to practical- sample given)

1. List the applications of Isolation Transformer.
2. State the difference between an Isolation transformer and an autotransformer.
3. State the difference between isolated and non-isolated power supply.

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2	Electrical Machines	Kothari D. P. and Nagrath I. J.	McGraw Hill Education, New Delhi ISBN: 9780070699670

XVII Suggested Assessment Scheme

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7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	