LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY(A)
(Approved by A.I.C.T.E & Permanently Affiliated to JNTUGV, Vizianagaram)
Accredited by NBA & NAAC with 'A' Grade
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Department of Electrical and Electronics Engineering

LAB MANUAL

Name of the laboratory: Electrical Engineering Virtual Lab

Regulation: R20

Subject Code: C329

Branch: Electrical and Electronics Engineering

Year & Semester: III B. Tech- II Semester

INSTITUTE VISION, MISSION
DEPARTMENT VISION, MISSION
PEO & PO/PSO

INSTITUTE

VISION

Produce globally competent and quality technocrats with human values for the holistic needs of industry and society.

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behaviour of students towards employment and higher studies.
- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.
- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value based education.

Department of Electrical and Electronics Engineering

VISION

To be a hub for imparting knowledge, skills, and behaviour for exemplary contributions in the field of Electrical and Electronics Engineering.

MISSION

- To impart Technical Education through the state-of-the-art infrastructure facilities, laboratories and instruction.
- To inculcate industry-oriented learning through industrial visits, internships, projects at Industries, MOUs, to make students' technically skills oriented.
- Creating conducive environment for higher education, employment and entrepreneurship through quality education, professional skills and research.
- To promote societal commitment among students by inculcating moral and ethical values.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates shall have strong foundation in core and allied Electrical and Electronics Engineering, in sciences and mathematics, to become globally competent in designing, modelling and critical problem solving.
PEO2: Graduates shall involve in research activities in the field of electrical and electronics engineering through lifelong learning and provide solutions to engineering problems for sustainable development of society.
PEO3: Graduates shall have good communication skills and socio-ethical values for getting employment or higher studies by excelling in competitive examinations and be able to work in supportive and leadership roles.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Capable of design, develop, test, verify and implement electrical and electronics engineering systems and products.
PSO2: Succeed in national and international competitive examinations for successful higher studies and employment.

PROGRAM OUTCOMES (POs)

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-Long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE OUTCOMES (COs)

CO1: Analyze Basic Network Theorems.

CO2: Analyze the performance and characteristics of DC Machine & Transformer

CO3: Determine the Equivalent circuit parameters of Induction Motor

CO4: Apply Speed control techniques of Induction Motor

CO5: Apply the Knowledge of Synchronization to ensure safe integration of synchronous machines and optimize the performance by adjusting excitation to achieve the desired power factor

COURSE INFORMATION SHEET

AY-2023-24

PROGRAM: **Electrical and Electronics Engineering**	DEGREE: **B.TECH**
COURSE: **Electrical Engineering Virtual Lab**	SEMESTER: **III-II** CREDITS: **2**
COURSE CODE: **C329** REGULATION:**R20**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **Electrical Circuits & Electrical Machines**	CONTACT HOURS: **3 Hours/Week.**
CORRESPONDING LAB COURSE CODE (IF ANY):-	LAB COURSE NAME (IF ANY):

SYLLABUS:

UNIT	DETAILS	HOURS
I	Verification of Superposition Theorem.	3
II	Verification of Thevenin's Theorem.	3
III	Verification and Norton's Theorem.	3
IV	Magnetization characteristics of DC Shunt Generator. Determination of Critical FieldResistance and Critical Speed.	3
V	Load test on DC Shunt Generator.	3
VI	Speed control of DC Shunt motor by Field and Armature Control.	3
VII	Equivalent circuit of Three Phase Induction Motor.	3
VIII	Speed control of Slip ring Induction Motor.	3
IX	OC & SC Test on Single Phase Transformer.	3
X	V and Inverted V curves of a Three Phase Synchronous Motor.	3
	Additional Experiments	
XI	Verification Of Maximum Power Transfer Theorem	3
XII	Synchronization of Alternator With Infinite busbar	3
TOTAL HOURS		36

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T	A. Chakrabarti, Circuit Theory (Analysis and Synthesis). Fifth Edition : 2006, Dhanpat Rai and Co.
R	Parker Smith, Problems in Electrical Engineering. Ninth Edition :2003 , M/s Constable and Company, London.
R	D.P. Kothari, I.J. Nagrath, Electrical Machines, Tata McGraw-Hill, 2004
R	N. Mohan, Electric Machines and Drives: A First Course, Wiley, 2012.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
C115	Electrical Circuits	Electrical circuit theorems	II-I
C203 & C212	Electrical Machines-I & Electrical Machines-II	Speed control methods, Characteristics of Generator and Induction motor, O.C & S.C tests of Transformers.	II-I & II-II

COURSE OBJECTIVES:

1	To verify the Network Theorems.
2	To Control the Speed of the DC Motors & Induction Motor.
3	To Evaluate the Performance of DC Machines & Transformer.
4	To Obtain Equivalent circuit parameters of Induction Motor
5	To Assess the V & Inverted V Curves of Three Phase Synchronous Motor.

COURSE OUTCOMES:

CO.NO	DESCRIPTION	PO(1..12) MAPPING	PSO(1,2) MAPPING
C329.1	Analyze Basic Network Theorems.	PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.	PSO1,PSO2
C329.2	Analyze the performance and characteristics of DC Machines & Transformer.	PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.	PSO1,PSO2
C329.3	Determine the Equivalent circuit parameters of Induction Motor.	PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.	PSO1,PSO2
C329.4	Apply Speed control techniques of Induction Motor.	PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.	PSO1,PSO2
C329.5	Apply the Knowledge of Synchronization to ensure safe integration of synchronous	PO1,PO2,PO3,PO5,PO8,PO9,	PSO1,PSO2

	machines and optimize the performance by adjusting excitation to achieve the desired power factor	PO10,PO11,PO12.	
COURSE OVERALL PO/PSO MAPPING: PO1,PO2,PO3,PO5,PO8,PO9,PO10,PO11,PO12, PSO1,PSO2			

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

CO.NO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C329.1	3	2	3	-	3	-	-	2	3	2	1	2	3	2
C329.2	3	2	3	-	3	-	-	2	3	2	1	2	3	2
C329.3	3	2	3	-	3	-	-	2	3	2	1	2	3	2
C329.4	3	2	3	-	3	-	-	2	3	1	1	2	3	2
C329.5	3	2	3	-	3	-	-	2	3	2	1	2	2	2
C329*	3	2	3	-	3	-	-	2	3	2	1	2	3	2

** For Entire Course, PO & PSO Mapping*

POs & PSO REFERENCE:

PO1	Engineering Knowledge	PO7	Environment & Sustainability	PSO1	Capable of design, develop, test, verify and implement Electrical and Electronics Engineering systems and products.
PO2	Problem Analysis	PO8	Ethics	PSO2	Succeed in national and international competitive examinations for successful higher studies and employment.
PO3	Design & Development	PO9	Individual & Team Work		
PO4	Investigations	PO10	Communication Skills		
PO5	Modern Tools	PO11	Project Mgt. & Finance		
PO6	Engineer & Society	PO12	Life Long Learning		

COs VS POs MAPPING JUSTIFICATION:

SNO	PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
C329.1	PO1	3	Understanding the Network theorems strongly required to enhance engineering knowledge by enabling efficient circuit design.
	PO2	2	Incorporating theorems into problem analysis involves identifying circuit elements and reducing them to their equivalent forms moderately.
	PO3	3	Analyzing basic network theorems is crucial in design and development because they simplify complex circuits,

			enabling efficient design, validation, and optimization of electrical systems highly.
	PO5	3	Implementation of Network theorems with modern tools is highly required for precise simulations and visualizations of circuit behaviour.
	PO6	2	The use of network theorems supports moderate learning for practical application.
	PO9	3	Analyzing basic network theorems is highly required for both individuals and teams work together better. It gives everyone a clear way to solve problems and communicate designs.
	PO10	2	Analyzing basic network theorems slightly strengthens communication skills by enabling engineers to clearly explain complex circuit concepts.
	PO11	1	Slightly impacts lifelong learning as it introduces engineering concepts to continue developing.
	PO12	2	Analysis of network theorems are somewhat required for Life long learning.
	PSO1	3	Implementation of network theorems equips engineers with essential skills to design, develop, test, verify in electrical and electronics systems.
	PSO2	2	Moderate importance for problem-solving and optimization in electrical systems.
C329.2	PO1	3	analyzing the performance and characteristics of DC Machine & Transformer is strongly required to engineering knowledge
	PO2	2	Understanding key parameters like efficiency, torque, and voltage regulation, engineers can identify issues, optimize performance, and ensure reliability moderately in electrical systems.
	PO3	3	Evaluating the performance and characteristics of DC machines and transformers is Substantially required for design and development in engineering.
	PO5	3	Analyzing the performance and characteristics of DC machines and transformers using modern tools is Substantially required for accurate simulations and data visualization.
	PO6	2	Moderate requirement for practical application of performance analysis.
	PO9	3	Evaluating the performance and characteristics of DC machines and transformers are Substantially required to both

			individual and team work by encouraging collaboration in testing.
	PO10	2	Analyzing performance and characteristics of DC machines and transformers moderately strengthens communication skills by enabling engineers to clearly explain complex circuit concepts.
	PO11	1	Minimal impact on lifelong learning, though technical understanding contributes to broader skills.
	PO12	2	Analysis of performance and characteristics of DC machines and transformers are somewhat required for Life long learning.
	PSO1	3	Implementation of performance and characteristics of DC machines and transformers equips engineers with essential skills to design, develop, test, verify in electrical and electronics systems.
	PSO2	2	Moderate role in addressing real-world problems in electrical and electronics systems.
C329.3	PO1	3	Obtaining the equivalent circuit parameters of an induction motor is Substantially required for applying engineering knowledge effectively. It allows engineers to analyze motor performance, design control systems, and optimize efficiency.
	PO2	2	Understanding the equivalent circuit parameters is moderately required for engineers can accurately diagnose performance issues, optimize operation, and develop solutions for enhancing efficiency and reliability in motor applications.
	PO3	3	Acquiring the equivalent circuit parameters of an induction motor is Substantially required for design and development.
	PO5	3	Using modern tools to obtain the equivalent circuit parameters of an induction motor enhances accuracy and efficiency.
	PO6	2	Moderate requirement for applying the knowledge in practical scenarios for real-world solutions.
	PO9	3	Function effectively as an individual and as member in a team for obtaining the equivalent circuit parameters of an induction motor.
	PO10	2	Equivalent circuit parameters of an induction motor improves communication skills slightly by necessitating clear explanations of technical details and results.

	PO11	1	Minimal contribution to lifelong learning but supports continued development in engineering practice.
	PO12	2	Equivalent circuit parameters of an induction motor are somewhat required for lifelong learning.
	PSO1	3	Obtaining circuit parameters of an induction motor is essential for engineers to design, develop, test, verify, and implement electrical and electronics systems effectively
	PSO2	2	Moderate requirement for ensuring operational efficiency in electrical systems.
C329.4	PO1	3	The Engineering knowledge is Substantially required for analysing the speed control techniques of motors.
	PO2	2	analysing the speed control of motors is moderately Problem analysis is required
	PO3	3	Speed control techniques for different motors are Substantially required for develop and design.
	PO5	3	speed control techniques enhances accuracy and efficiency Using modern tools is Substantially required
	PO6	2	Moderate requirement for practical knowledge application in motor control.
	PO9	3	Analysing the speed control techniques of motors Function effectively as an individual and as member in a team.
	PO10	1	Analyzing the speed control of motors is slightly strengthens communication skills by enabling engineers to clearly explain complex circuit concepts.
	PO11	1	understanding supports professional growth is slightly impact on lifelong learning, but the
	PO12	2	Analyzing of speed control methods of motor are somewhat required for lifelong learning.
	PSO1	3	Speed control of Motor is Substantially for engineers to design, develop, test, verify, and implement in electrical and electronics systems effectively
	PSO2	2	Supports optimization and efficiency in motor systems for electrical systems.
C329.5	PO1	3	Creating the V and inverted V curves of a three-phase synchronous motor is supported by engineering knowledge, as it requires analyzing how the motor performs under different loads and excitation levels.
	PO2	2	Develop the V & Inverted V Curves of Three Phase Synchronous Motor Problem analysis is moderately required

	PO3	3	Development of V & Inverted V Curves of Three Phase Synchronous Motor are highly required for develop and design.
	PO5	3	Using modern tools is Highly required to develop the V & Inverted V Curves of Three Phase Synchronous Motor enhances accuracy and efficiency.
	PO6	2	Moderate requirement for practical understanding and application in engineering.
	PO9	3	Function effectively as an individual and as member in a team in the development of V & Inverted V Curves of Three Phase Synchronous Motor .
	PO10	2	Analyzing the V & Inverted V Curves of Three Phase Synchronous Motor slightly strengthens communication skills by enabling engineers to clearly explain complex circuit concepts.
	PO11	1	Slightly contributes to lifelong learning by extending knowledge of motor characteristics.
	PO12	2	Analysis of V & Inverted V Curves of Three Phase Synchronous Motor are somewhat required for lifelong learning.
	PSO1	2	V & Inverted V Curves of Three Phase Synchronous Motor is moderately required for engineers to design, develop, test, verify, and implement in electrical and electronics systems effectively
	PSO2	2	Supports real-world engineering problem-solving related to synchronous motor performance.

WEB SOURCE REFERENCES:

1	https://www.vlab.co.in/broad-area-electrical-engineering
2	https://ems-iitr.vlabs.ac.in/

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑CHALK & TALK	☐ICT TOOLS	☐WEB REFERENCES	☐STUDENT SEMINARS
☐INDUSTRIAL VISITS	☐INTERNSHIPS	☑EXPERIMENTAL LEARNING	☐MODEL-BASED LEARNING
☐GUEST LECTURES	☑COLLABORATIVE LEARNING	☐MINI/MAJOR PROJECTS	☐CASE STUDIES/REAL LIFE EXAMPLES

ASSESSMENT METHODOLOGIES-DIRECT

☐ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ END SEM EXAM
☑STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☐ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by

Approved by
PAC Member

Signature of HOD, EEE

Course Code	Course Title	Hrs./Week L: T: P	Credits
R20EEE-PC3205	Electrical Engineering Virtual Lab	0:0:3	1.5

Course objectives:

- To verify the Network Theorems.
- To Control the Speed of the DC Motors & Induction Motor.
- To Evaluate the Performance of DC Machines & Transformer.
- To Obtain Equivalent circuit parameters of Induction Motor
- To Assess the V & Inverted V Curves of Three Phase Synchronous Motor.

Course outcomes: At the end of this course, the students will be able to

1. Analyze Basic Network Theorems. (L4)
2. Analyze the performance and characteristics of DC Machines & Transformer. (L4)
3. Determine the Equivalent circuit parameters of Induction Motor. (L4)
4. Apply Speed control techniques of Induction Motor. (L3)
5. Apply the Knowledge of Synchronization to ensure safe integration of synchronous machines and optimize the performance by adjusting excitation to achieve the desired power factor (L3)

All the Following Experiments are to be conducted:

1. Verification of Superposition Theorem.
2. Verification of Thevenin‘s Theorem.
3. Verification and Norton‘s Theorem.
4. Magnetization characteristics of DC Shunt Generator. Determination of Critical Field. Resistance and Critical Speed.
5. Load test on DC Shunt Generator.
6. Speed control of DC Shunt motor by Field and Armature Control.
7. Equivalent circuit of Three Phase Induction Motor.
8. Speed control of Slip ring Induction Motor.
9. OC & SC Test on Single Phase Transformer.
10. V and Inverted V curves of a Three Phase Synchronous Motor.

LIST OF EXPERIMENTS (Performed in the Laboratory)

1. Verification of Superposition Theorem
2. Verification of Thevenin‘s Theorem.
3. Verification and Norton‘s Theorem.
4. Magnetization characteristics of DC Shunt Generator. Determination of Critical Field Resistance and Critical Speed.
5. Load test on DC Shunt Generator.
6. Speed control of DC Shunt motor by Field and Armature Control.
7. Equivalent circuit of Three Phase Induction Motor.
8. Speed control of Slip ring Induction Motor.
9. OC & SC Test on Single Phase Transformer.
10. V and Inverted V curves of a Three Phase Synchronous Motor.

ADDITIONAL EXPERIMENTS

11. Verification of Maximum Power Transfer Theorem
12. Synchronization of Alternator With Infinite busbar

INDEX

1. VERIFICATION OF SUPERPOSITION THEOREM

AIM:-

To Verify Superposition Theorem.

THEORY:-

If a number of voltage or current source are acting simultaneously in a linear network, the Resultant current in any branch is the algebraic sum of the currents that would be produced in it, when each source acts alone replacing all other independent sources by their internal resistances.

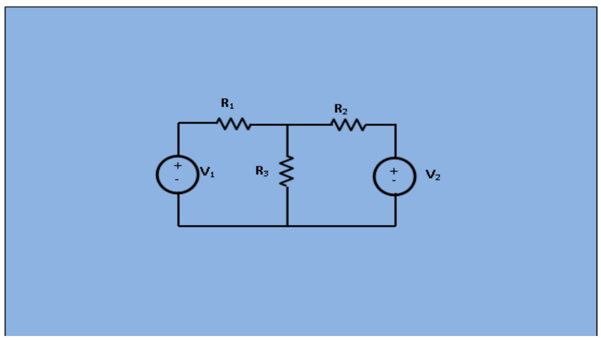


Fig.1 : Circuit for analysis of Superposition theorem

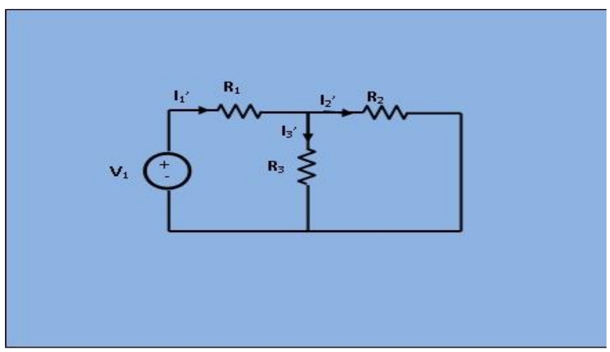


Fig.2 : Circuit with only V_2 short circuited

In given figure 1 apply superposition theorem , let us first take the sources V_1 alone at first replacing V_2 by short circuit as shown in figure 2.Here,

$$I_{1'} = \frac{V_1}{\frac{R_2 * R_3}{R_2 + R_3} + R_1}$$

$$I_{2'} = I_{1'} * \frac{R_3}{R_2 + R_3}$$

$$I_{3'} = I_{1'} - I_{2'}$$

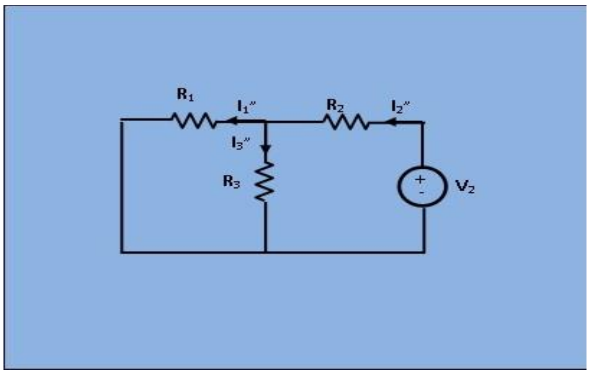


Fig.3 : Circuit with only V_1 short circuited

Next, removing V_1 by short circuit, let the circuit be energized by V_2 only as shown in figure 3. Then,

$$I_{2''} = \frac{V_2}{\frac{R_2 * R_3}{R_2 + R_3} + R_2}$$

$$I_{1''} = I_{2''} * \frac{R_3}{R_1 + R_3}$$

$$I_{3''} = I_{2''} - I_{1''}$$

As per superposition theorem,

$$I_3 = I_{3'} + I_{3''}$$

$$I_2 = I_{2'} - I_{2''}$$

$$I_1 = I_{1'} - I_{1''}$$

CIRCUIT DIAGRAM:-

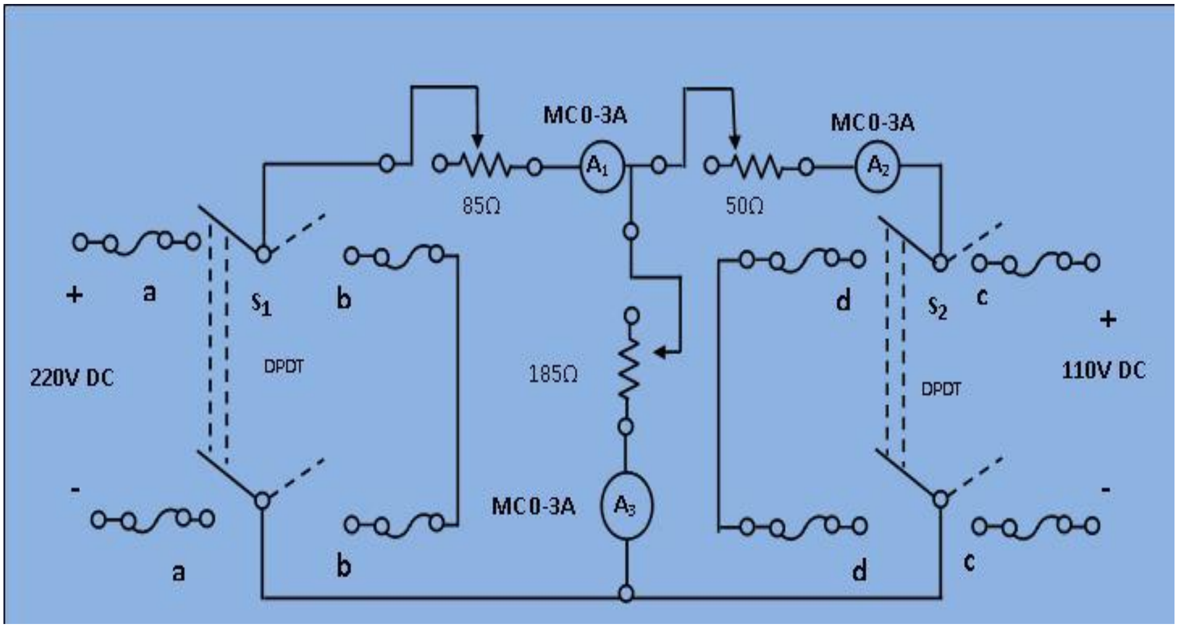


Fig.1 : Circuit diagram of experimental set-up for verification of Superposition theorem

PROCEDURE:-

1. Connect the circuit as shown in the diagram, keeping the switches open and resistance at their maximum positions.
2. Set S_1 to position "aa" and S_2 to position "cc" respectively which means both the sources are energized. Note down the current I_1, I_2 and I_3 from ammeter A_1, A_2 and A_3.
3. Set S_1 to positions "aa" and S_2 to position "dd" respectively which means the, only 220V source is energized and the terminals of S_2 are shorted. Note down current $I_{1'}$, $I_{2'}$ and $I_{3'}$from the ammeter A_1, A_2 and A_3.
4. Set S_1 to position "bb" and S_2 to position to "cc" respectively. Which means the, only 110V source is energized and the terminals of S_1 are shorted. Note down current $I_{1''}$, $I_{2''}$ and $I_{3''}$ from the ammeter A1, A2 and A3.
5. Compare I_1, I_2 and I_3 with $I_{1'}$+$I_{1''}$, $I_{2'}$+$I_{2''}$ and $I_{3'}$+$I_{3''}$ taking care of signs properly of verify the theorem.

6. Repeat the step (2) to (6) for five different values of resistance for each three rheostats.

OBSERVATION TABLE:-

Serial no. of Observation	In presence of both V_1 and V_2			In presence of V_1 only			In presence of V_2 only		
	Brach current I_1 (in amps)	Brach current I_2 (in amps)	Brach current I_3 (in amps)	Brach current I_1 (in amps)	Brach current I_2 (in amps)	Brach current I_3 (in amps)	Brach current I_1 (in amps)	Brach current I_2 (in amps)	Brach current I_3 (in amps)
1st	0.42308	-0.084615	0.33846	0.59231	-0.33846	0.25385	-0.16923	0.25385	0.084615
2nd	0.57037	-0.12222	0.44815	0.81481	-0.48889	0.32593	-0.24444	0.36667	0.12222
3rd	0.47143	-0.15714	0.31429	0.78571	-0.62857	0.15714	-0.31429	0.47143	0.15714
4th	0.82500	-0.13750	0.68750	1.1000	-0.55000	0.55000	-0.27500	0.41250	0.13750
5th	1.1000	0.0000	1.1000	1.3200	-0.44000	0.88000	-0.22000	0.44000	0.22000

RESULT:- Hence Verified the Superposition Theorem and Note down the observation values Virtually

OUTCOME: By doing this Experiment CO1 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained

2. VERIFICATION OF THEVENIN'S THEOREM

AIM :-

To Verify Thevenin's Theorem.

THEORY:-

Its provides a mathematical technique for replacing a given network, as viewed from two terminals, by a single voltage source with a series resistance. It makes the solution of complicated networks quite quick and easy. The application of this extremly useful theorem will be explained with the help of following simple example.

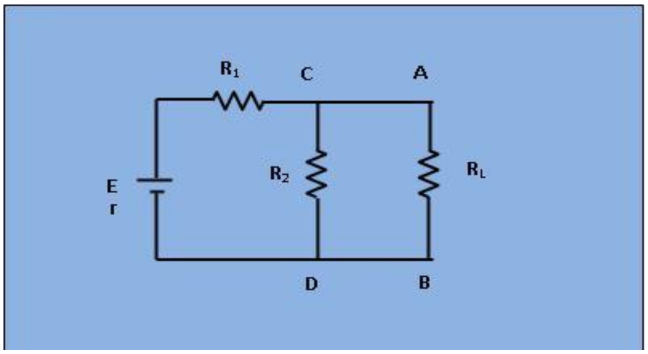


Fig.1 : Circuit with source E and Load R_L

Suppose, it is required to find current flowing through load resistance R_L, as shown in figure 1.

This expression proceed as under:

1) Remove R_L from the circuit terminals A and B and redraw the circuit as shown in figure

2. Obviously, the terminal have become open circuited.

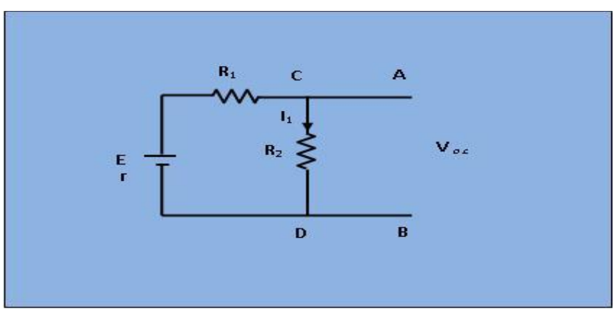


Fig.2 : Circuit with R_L removed

2) Calculate the open circuit Voltages $V_{O.C.}$ which appears across terminals A and B when they are open .ie. when R_L is removed.

As seen, $V_{.O.C.}$= drop across R_2= IR_2 where I is the circuit current when A and B is open.

$$I = \frac{E}{r + R_1 + R_2}$$

$$V_{o.c.} = I * R_1$$

$$V_{o.c.} = \frac{E * R_2}{r + R_1 + R_2}$$

It is also called Thevenin voltage(V_{th}).

3) Now, imagine the battery to be removed from the circuit, leaving its internal resistance r behind and redraw the circuit as shown in figure 3.

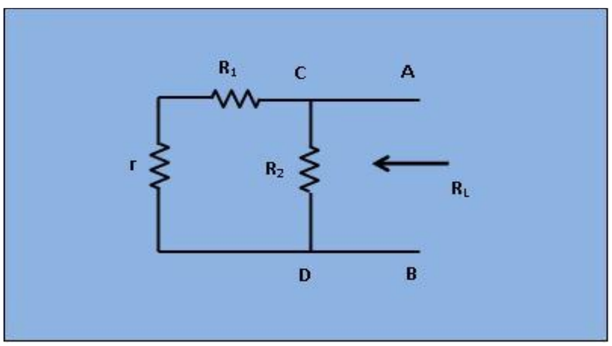


Fig.3 : Circuit with R_L and E removed

When viewed inwards from the terminals A and B, the circuit consists of two parallel paths: one containing R_2 and another containing (R_1+r). Theequivalent resistance of the network as viewed from these terminals is given as,

$$R_{th} = \frac{(R_1 + r) * R_2}{R_1 + r + R_2}$$

The resistance "R_{th}" is also called Thevenin equivalent resistance.

Consequently , as viewed from terminals A and B, the whole network (excluding R_1) can be reduced to single source (called thevenin's source) whose e.m.f equal to $V_{O.C.}$ and whose internal reistance equal to R_{th} as shown in figure 4.

4) R_L is now connected back across terminals A and B from where it was temporaily removed earlier. Current flowing through R_L is given by,

$$\boldsymbol{I_1 = \frac{V_{th}}{R_{th} + R_L}}$$

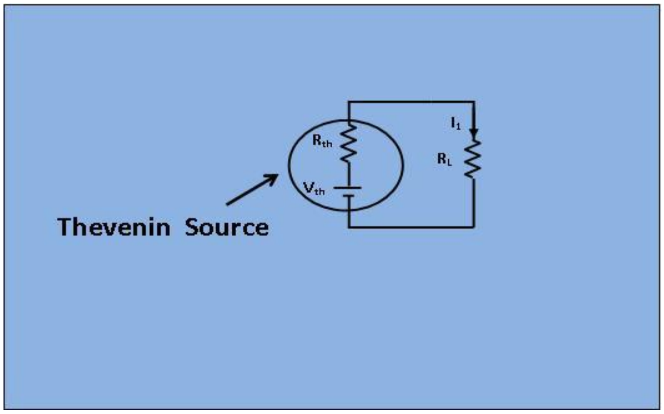
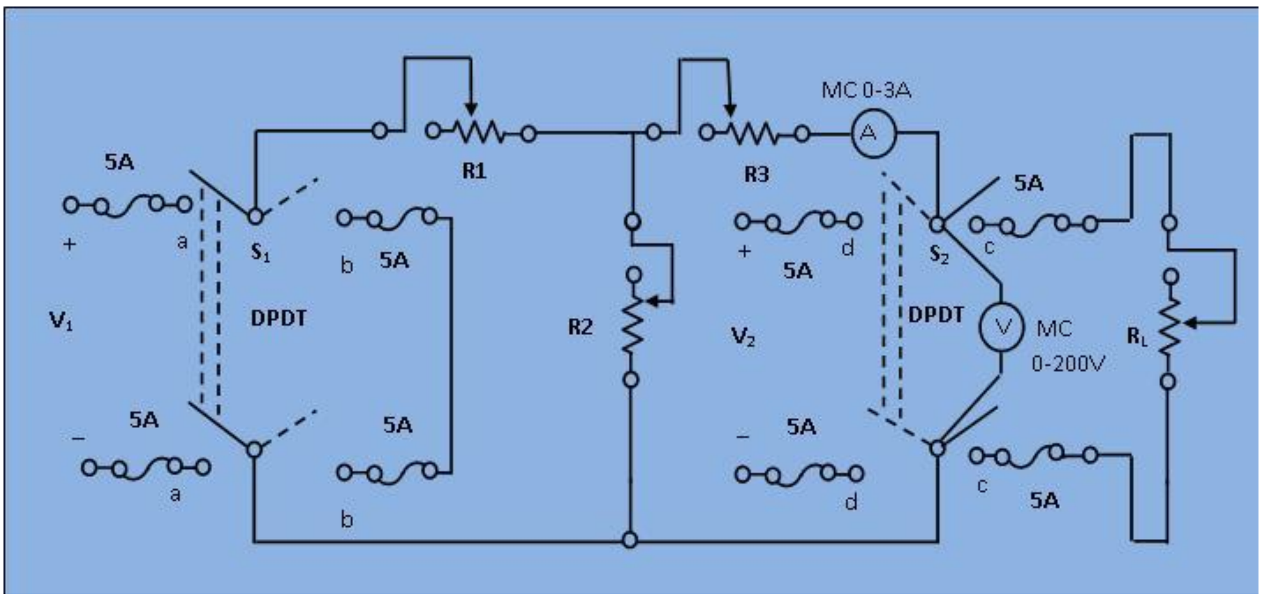


Fig.4 : Thevenin's equivalent circuit

PROCEDURE:-



[Fig 1: Circuit diagram for Experimental set-up for verification of Thevenin's theorem]

1) Keep all the resistance close to their maximum respective values.

2) Close the switch S_1 to "aa" and S_2 to "cc" positions. Observe the load current (I_L) and voltage (V_L) readings. The load resistance

$$\boldsymbol{R_L = \frac{V_L}{I_L}}$$

3) Remove the load by opening the switch S_2 and read the open circuit voltage (or Thevenin equivalent voltage) V_{th}.

4) Next, compute the resistance (R_{TH}) of the network as seen from the load terminals,

a) Replace the 220 V source by a short by closing S_1 to "bb".

b) Apply 110 V at the output terminals by closing S_2 to "dd". Read the voltmeter (V) and ammeter (I) and get

$$\boldsymbol{R_{th} = \frac{V}{I}}$$

5) Now compute the load current. Applying Thevenin theorem

$$\boldsymbol{I_L = \frac{V_{th}}{R_{th} + R_L}}$$

6) Compare the above computed load current with its observed value in step (2) and verify the theorem.

OBSERVATION TABLE:-

Serial no. of Observation	Load Current(I_L) from case 1	Load Voltage(V_L)	Load Resistance (R_L)=V_L/I_L	Thevenin Voltage(V_{th}) from case 2(a)	2nd Voltage source(v) for case 2(b)	Ammeter Reading(I) from case 2(b)	Thevenin Resistance R_{th}=V/I	Load current (I_L)=V_{th}/(R_{th}+R_L)
1st	0.12941	38.823	300	73.333	220	0.82500	266.67	0.12941
2nd	0.12941	25.88199999	200	73.333	220	0.60000	366.67	0.12941
3rd	0.078571	15.7142	200	88.000	110	0.30556	359.99	0.15715
4th	0.31429	62.8580000	200	110.00	110	0.73333	150.00	0.31429
5th	0.15714	31.428	200	55.000	220	1.4667	150.00	0.15714

RESULT:- Hence Verified The Thevenin's Theorem And Note down The Observation Values Virtually

OUTCOME:- By doing this Experiment CO1 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained

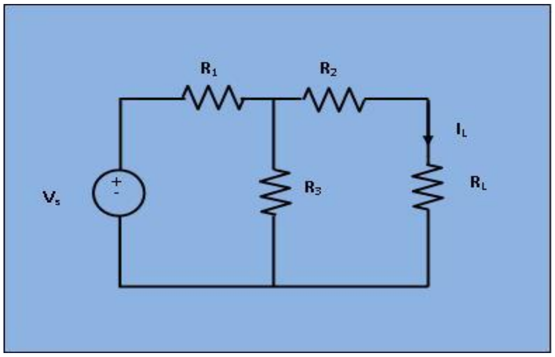
3. VERIFICATION OF NORTON'S THEOREM

AIM :-

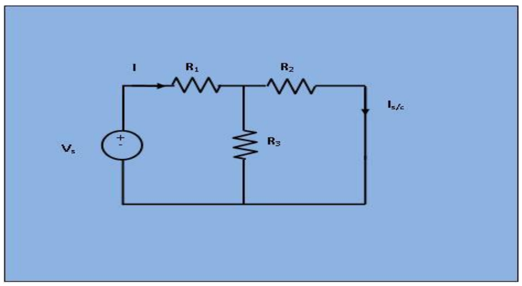
To Verify Norton Theorem.

THEORY:-

A linear active network consisting of independent and(or) dependent voltage and current sources and linear bilateral network elements can be replaced by an equivalent circuit consisting of current sources in parallel with the resistance, the current source being the short circuited current across the load terminal and resistance being the internal resistance of the source network looking through the open circuited load terminals. In order to find the current throughR_L, the load resistance of the figure 1 by Norton's theorem, let,replace R_L by short circuit as shown in figure 2.



[Fig 1: Circuit with source V_S and Load R_L]



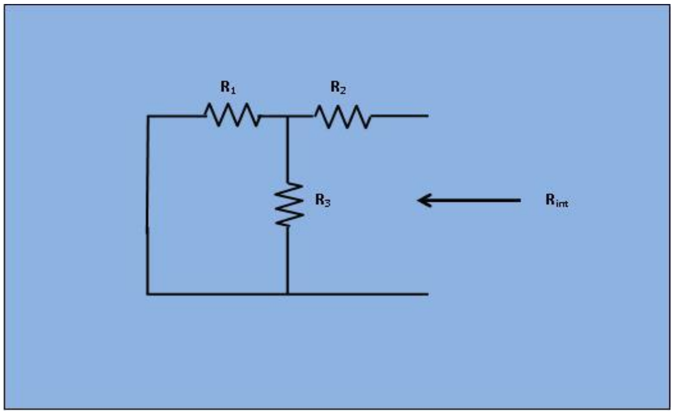
[Fig 2: Circuit with R_L shorted]

Obviously, in Fig 2;

$$I = \frac{V_s}{R_1 + \frac{R_2 * R_3}{R_2 + R_3}}$$

$$I_{s/c} = I \frac{R_3}{R_3 + R_2}$$

Next, the short circuit is removed and the independent source is deactivated as shown in figure 3.

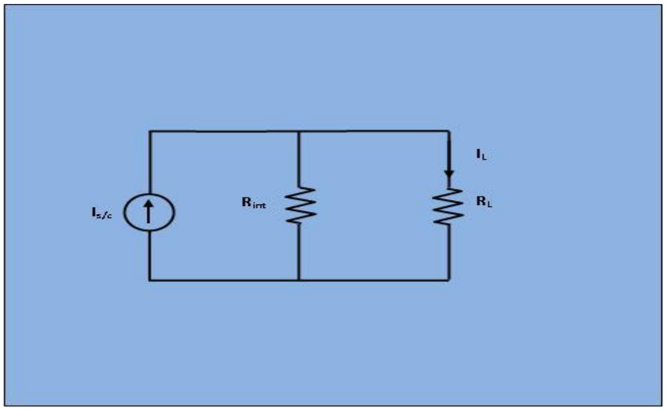


[Fig 3: Circuit with source V_s deactivated and Load R_L open]

From Fig 3;

$$R_{int} = R_2 + \frac{R_1 * R_3}{R_1 + R_3}$$

As per Norton's theorem , the equivalent circuit as shown in figure 4, would contain a current source in parallel to the internal resistance, the current source being the short circuited current across the shorted terminals of the load resistor.

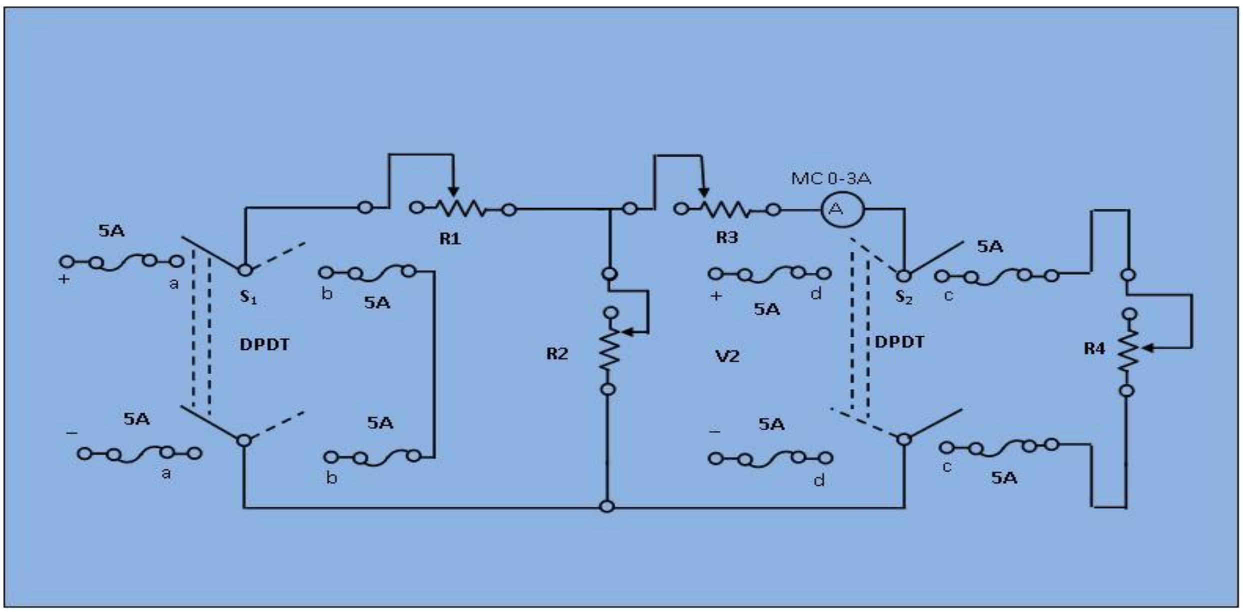


[Fig 4: Norton equivalent circuit]

Obviously, from Fig 4;

$$I_L = I_{s/c} \frac{R_{int}}{R_{int} + R_L}$$

<u>PROCEDURE :-</u>



[Fig 1: Circuit diagram for Experimental set up]

1. Keep all the resistance close to their maximum respective values.
2. Close the switch$s_1$to “aa” and$s_2$to “cc” positions .Observes the load current $I_L$and voltage $V_L$readings. The load resistance ,$R_L = V_L / I_L$
3. Short the load terminals and find the short circuited current I_{sc}.
4. Next, compute the resistance R_{int} of the network as seen from the load terminals,
    - Replace the 220 V source by a short by closing s_1 to "bb".
    - Apply V=110 V at the output terminals by closing s_2 to "dd". Read the current from ammeter (I) and get $R_{int} = V/I$
5. Now compute the load current I_L applying Norton theorem.

$$\boldsymbol{I_L = I_{sc}\frac{R_{int}}{(R_{int} + R_L)}}$$

6. Compare the above computed load current with its observed value in step (2) and verify the theorem.

OBSERVATION TABLE:-

Serial no. of Observation	Load Current(I_L) from case 1	Load Voltage(V_L)	Load Resistance (R_L)=V_L/I_L	Norton current(I_{sc}) from case 2(a)	2nd Voltage source(v) from case 2(b)	Ammeter Reading(I) from case 2(b)	Norton Resistance R_n=V/I	Load current (I_L)=I_{sc}*R_n/(R_n+R_L)
1st	0.28387	85.161	300	0.67692	110	0.50769	216.67	0.28387
2nd	0.25882	77.646	300	0.67692	110	0.59231	185.71	0.25882
3rd	0.15714	47.142	300	0.44000	220	1.3200	166.67	0.15714
4th	0.20000	40.000	200	0.44000	220	1.3200	166.67	0.20000
5th	0.22000	22.000	100	0.36667	220	1.4667	150.00	0.22000

RESULT:- Hence Verified The Norton’s Theorem And Note down The Observation Values Virtually

OUTCOME:- By doing this Experiment CO1 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained.

4. MAGNETIZATION CHARACTERISTICS OF DC SHUNT GENERATOR. DETERMINATION OF CRITICAL FIELD RESISTANCE AND CRITICAL SPEED

AIM:-To study the magnetisation characteristics of DC Shunt Generator. Draw the graph between the armature voltage and field current.

THEORY:-

A DC generator, whose schematic equivalent circuit is shown in figure 1, is an electrical machine that converts the mechanical energy of a prime mover (e.g. DC motor, AC induction motor or a turbine) into direct electrical energy. The generator shown in figure 1 is self-exciting. It uses the voltage Ea generated by the machine to establish the field current I_f, which in turn gives rise to the magnetic-field flux Φ. When the armature winding rotates in this magnetic field to cut the flux, the voltage Ea is induced in the armature. This voltage is commonly referred to as the armature electromotive force or EMF. The induced EMF is proportional to the rate of cutting the flux and is given by emf formula.

$$\boldsymbol{E = \frac{P\emptyset NZ}{60A}}$$

where,

Φ = flux in webers

N = armature speed in rpm

Z = total number of armature conductors

P = number of poles

A = number of parallel paths

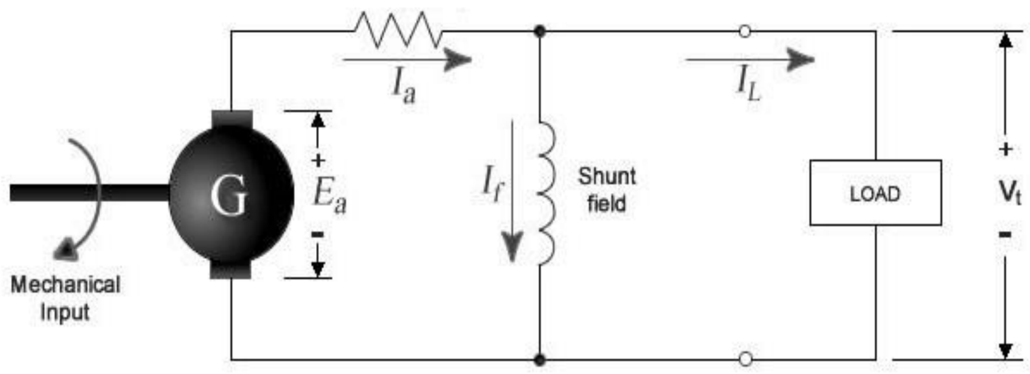


Fig. 1

Equivalent circuit of DC Shunt Generator

The magnetic field necessary for generator action may be provided by

(a)permanent magnets,

(b)(b) electromagnets receiving their exciting current from an external source, and

(c)electromagnets being excited from the current obtained from the generator itself.

The use of permanent magnets is confined to very small generators. The electromagnetic excitations listed in (b) and (c) above give rise to generators having somewhat different types of characteristics.

In the case of a compound generator, the series and shunt fields may be connected so as to aid each other, i.e., the fluxes set up by each will add up.

An increase in the total flux will generate a greater EMF. Such a connection is known as cumulative. If, however, the shunt and series windings are so connected that the flux set up by one opposes the other, then the induced EMF will be smaller. This type of connection is called differential.

Critical Field Resistance:

It is that value of the field resistance at which the D.C. Shunt Generator will fail to excite. It is that speed for which the given shunt field resistance becomes the critical field resistance. Critical field resistance is obtained by plotting the OCC as in fig.2 and determining the slope of the tangent to the linear position of the curve from the origin. While drawing the tangent, the initial position of the O.C.C is neglected.

Due to residual magnetism in the poles, a small amount of EMF is generated even when $I_f = 0$. Hence, the curve starts a little way up. The slight curvature at the lower end is due to magnetic inertia. It has seen that the first part of the curve is practically straight. Hence the flux and consequently generated EMF is directly proportional to the exciting current. However at the higher flux densities where it is small iron path reluctance becomes appreciable and straight. Field windings are connected parallel to the armature, so it is called DC Shunt Generator. Due to residual magnetism some initial emf and hence some current will be generated. This current while passing into the field coils will strengthen the magnetism of poles. This will increase pole flux which will further increase the generated emf. Increased emf and flux proceeds till equilibrium reached. This reinforcement of emf and flux proceeds till equilibrium reached at some point in the graph between I_f and E_g*

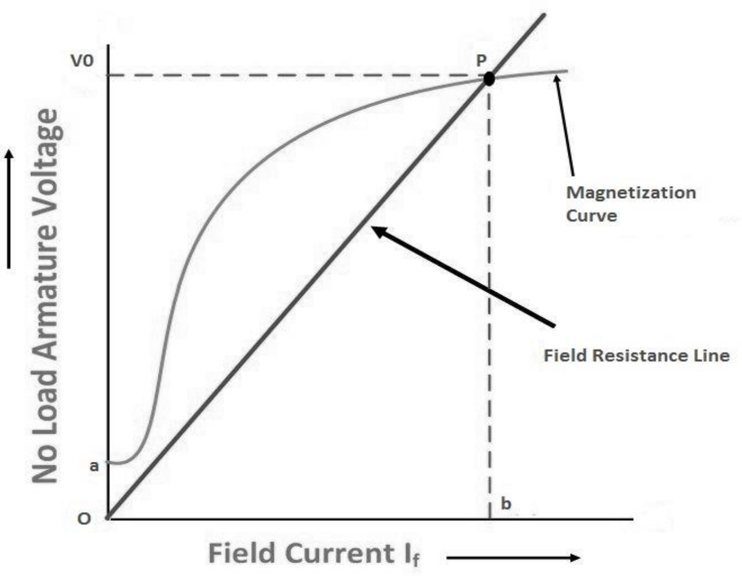
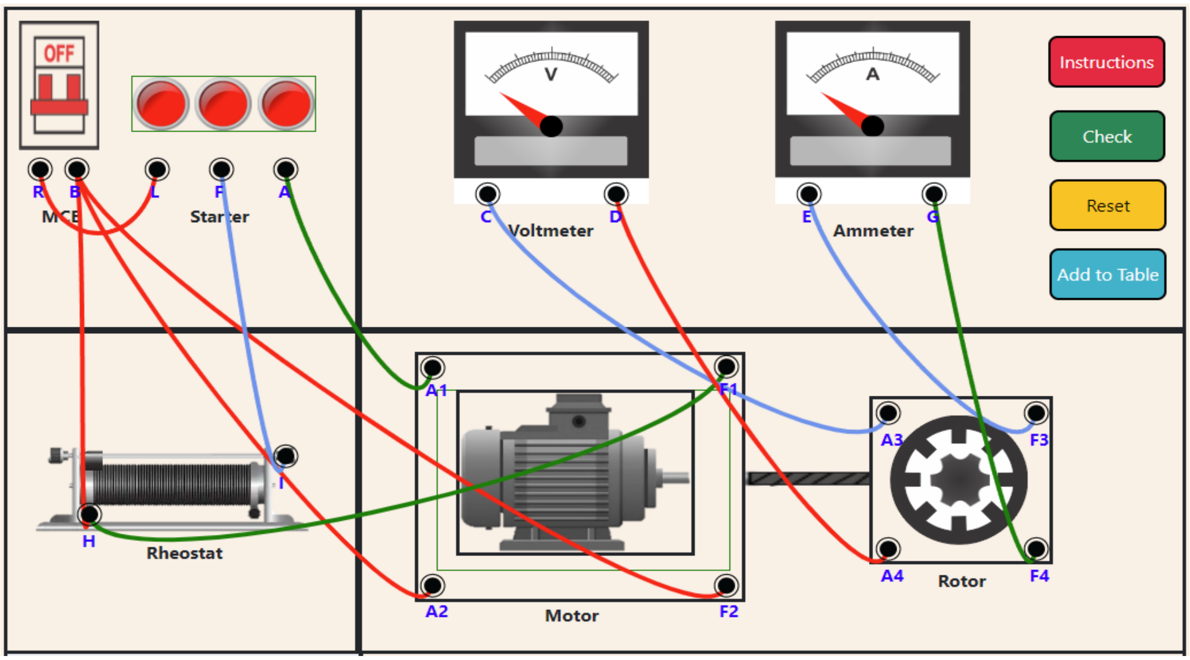


Fig. 2 Magnetisation characteristics of DC Shunt Generator

CIRCUIT DIAGRAM:-

STEP 1: Make connections as per the instructions given below:

From	R	B	B	B	F	A	H	C	D	E	G
To	L	H	A2	F2	I	A1	F1	A3	A4	F3	F4



PROCEDURE:-

NOTE: If wire is wrongly connected, Click on node number to detach the wire.

STEP 2: Click on Check button for checking the connections.

STEP 3: Click on MCB to turn on the supply.

STEP 4: Now, move the slider on the rheostat to take observations from Voltmeter and Ammeter.

STEP 5: Click on Add to Table button to add values to the observation table.

STEP 6: Repeat steps 4 to 5 to add more values in the table.

STEP 7: Click on Graph button to make a respective graph regarding the values in the table.

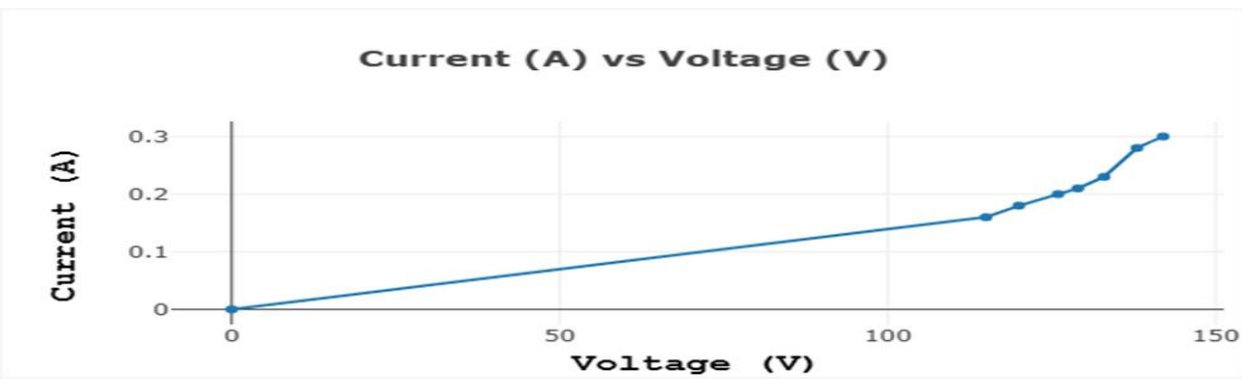
STEP 8: Click on Print button to print the webpage.

STEP 9: Click on Reset button to reset the webpage.

OBSERVATION TABLE:

S.No.	Voltage (V)	Current (A)
1	0	0
2	115	0.16
3	120	0.18
4	126	0.20
5	129	0.21
6	133	0.23
7	138	0.28
8	142	0.30

GRAPH:-



RESULT:- Hence studied the Magnitization Characteristics of DC Shunt Generator & Draw the graph between the Armature voltage and Field current Virtually

OUTCOME:- By doing this Experiment CO2 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained

5. LOAD TEST ON DC SHUNT GENERATOR

AIM:- To study the load characterstics of DC Shunt Generator. Draw the internal characteristics and external characteristics under different loading condition.

THEORY:-

In a shunt generator, the field winding is connected in parallel with the armature winding so that terminal voltage of the generator is applied across it. The shunt field winding has many turns of fine wire having high resistance. Therefore, only a part of armature current flows through shunt field winding and the rest flows through the load. Figure shows the connections of a shunt wound generator. The armature current I_a splits up into two parts- a small fraction I_{sh} flowing through shunt field winding while the major part I_L goes to the external load.

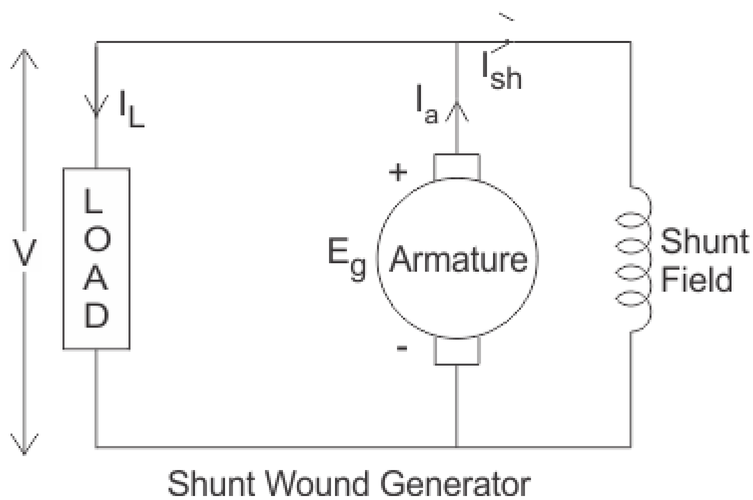


Fig. 1 Equivalent circuit of DC shunt generator for load characteristics

Internal characteristic

The internal characteristic curve represents the relation between the generated voltage E_g and the load current I_L. When the generator is loaded then the generated voltage is decreased due to armature reaction. So, generated voltage will be lower than the emf generated at no load. Here in the figure below AD curve is showing the no load voltage curve and AB is the internal characteristic curve.

External or Load characteristic

AC curve is showing the external characteristic of the shunt wound DC generators. It is showing the variation of terminal voltage with the load current. Ohmic drop due to armature resistance gives lesser terminal voltage the generated voltage. That is why the curve lies below the internal characteristic curve.

$$\mathbf{V = (E_g - I_a R_a) = E_g - (I_L + I_{sh})R_a}$$

The terminal voltage can always be maintained constant by adjusting the load terminal. External characteristics of shunt dc generator When the load resistance of a shunt-wound DC generator is decreased, then load current of the generator increased as shown in above figure. But the load current can be increased to a certain limit with (up to point C) the decrease of load resistance. Beyond this point, it shows a reversal in the characteristic. Any decrease of load resistance results in current reduction and consequently, the external characteristic curve turns back as shown in the dotted line, and ultimately the terminal voltage becomes zero. Though there is some voltage due to residual magnetism. We know, Terminal voltage Now, when IL increased, then terminal voltage decreased. After a certain limit, due to heavy load current and increased ohmic drop, the terminal voltage is reduced drastically. This drastic reduction of terminal voltage across the load results the drop in the load current although at that time load is high or load resistance is low. That is why the load resistance of the machine must be maintained properly. The point in which the machine gives maximum current output is called breakdown point (point C in the figure).

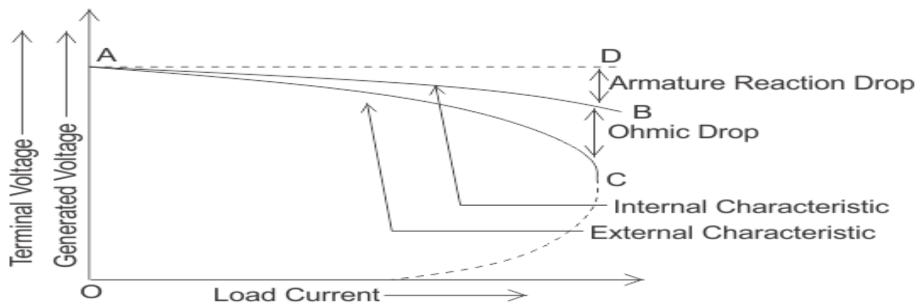
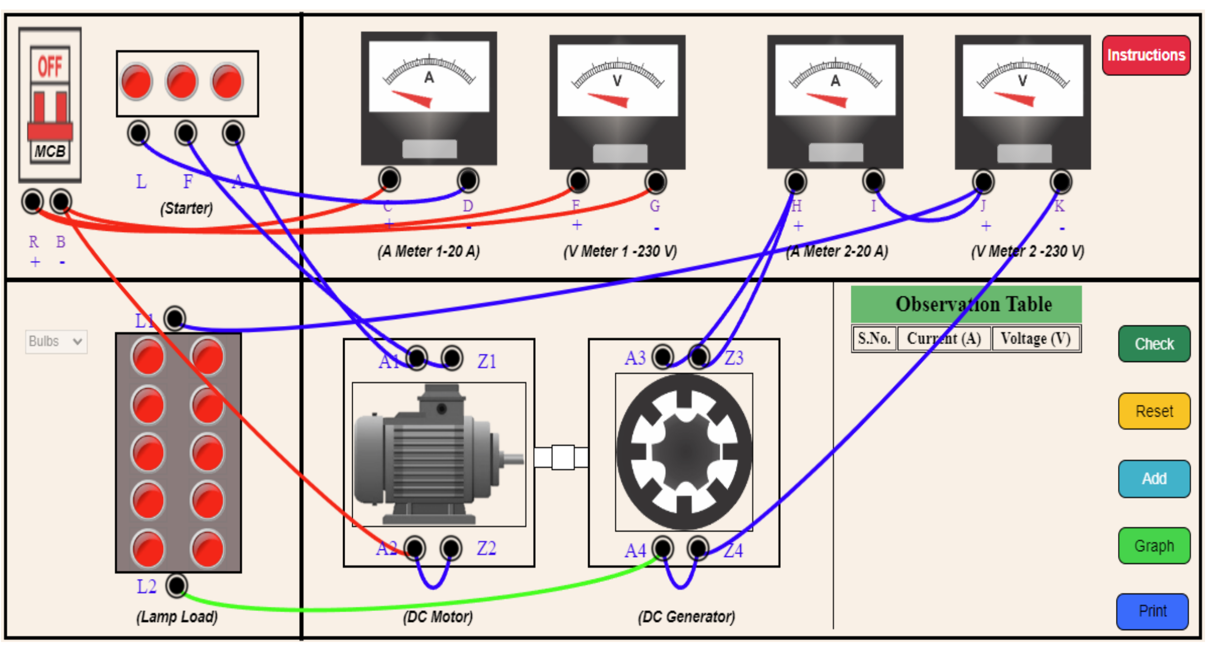


Fig. 2 Load characteristics of DC shunt generator

Note - It may be seen from the external characteristic that change in terminal voltage from no-load to full load is small. The terminal voltage can always be maintained constant by adjusting the field rheostat R automatically.

CIRCUIT DIAGRAM:-

From	R	R	B	B	A2	L	F	A	L2	A4	Z4	I	J	H	H
To	C	E	G	A2	Z2	D	Z1	A1	A4	Z4	K	J	L1	A3	Z3



PROCEDURE:-

STEP 1: Make Connections as per the instructions

STEP 2: Click on **"Check"** Button for checking the connections.

STEP 3: If connections is correct, MCB will be turned ON.

STEP 4: Select the No. of Bulbs from the Lamp load.

STEP 5: Click on **"Add"** Button to add the values to the Observation Table.

STEP 6: Add different values to the Table by increasing the lamp load.

STEP 7: Click on **"Graph"** Button to Create Graph.

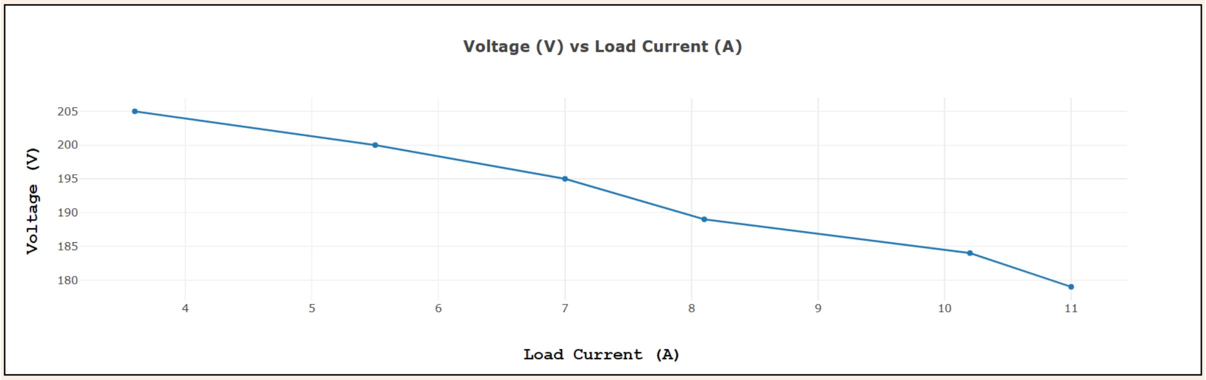
STEP 8: Click on **"Print"** Button to print the webpage.

STEP 9: Click on **"Reset"** Button to reset the webpage.

OBSERVATION TABLE:-

S.No.	**Current (A)**	**Voltage (V)**
1	3.6	205
2	5.5	200
3	7	195
4	8.1	189
5	10.2	184
6	11	179

Graph:-



RESULT:- Hence Studied the Load characteristics of DC shunt generator & Draw the internal & External characteristics under different load conditions virtually.

OUTCOME:- By doing this Experiment CO2 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained

6. SPEED CONTROL OF DC SHUNT MOTOR BY FIELD AND ARMATURE CONTROL

(A).Speed Control of DC motor by Armature Resistance Control

AIM:- *To study the speed control of D.C. Shunt motor by armature control method. Draw the graph between armature voltage and motor speed by varying the armature voltage.*

THEORY:-

We know that the speed of DC motor is given by:

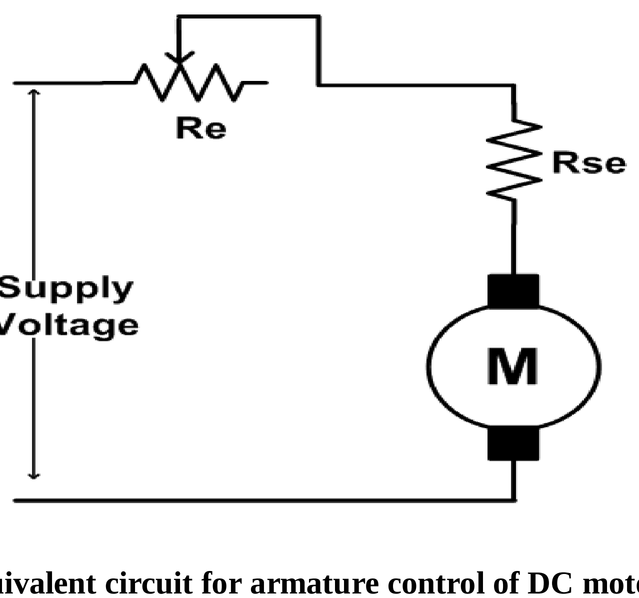
$$N = \frac{V-I_aR_a}{k\Phi}$$

The above equation shows that the speed depends upon the supply voltage V, the armature circuit resistance Ra, and the field flux Φ, which is produced by the field current. In practice, the variation of these three factors is used for speed control. Thus, there are three general methods of speed control of D.C. Motors.

1. Resistance variation in the armature circuit. This method is called armature resistance control or Rheostat control.

2. Variation of field flux Φ. This method is called field flux control.

3. Variation of the applied voltage. This method is also called armature voltage control.



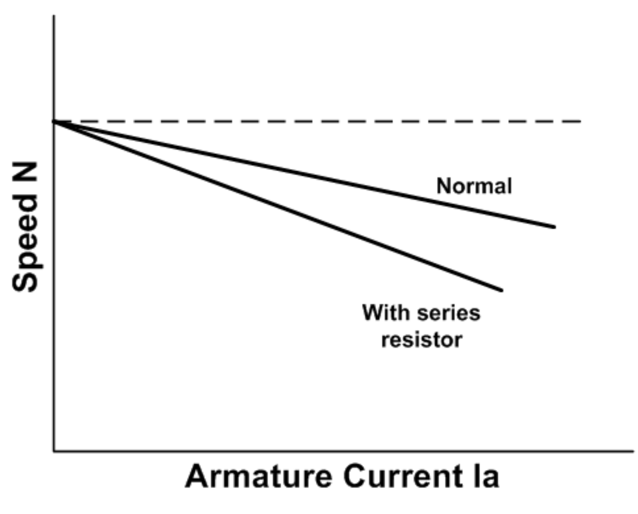
Equivalent circuit for armature control of DC motor

Speed control by varying armature resistance:

In this method a variable series resistor R_{ext} is put in the armature circuit. In this case the field is directly connected across the supply and therefore the flux ϕ is not affected by variation of R_{ext}. in this case the current and hence the flux are affected by the variation of the armature circuit resistance. The voltage drop in R_{ext} reduces the voltage applied to the armature and therefore the speed is reducing.

The slope of the n vs. I_a or n vs. Te characteristic can be modified by deliberately connecting external resistance rext in the armature circuit. One can get a family of speed vs. armature curves for various values of r_{ext}. From these characteristics it can be explained how speed control is achieved. Let us assume that the load torque T_L is constant and field current is also kept constant.

Therefore, since steady state operation demands $T_e = T_L$, $T_e = k_\varphi$ too will remain constant; which means I_a will not change. Suppose $r_{ext} = 0$, then at rated load torque, operating point will be at C and motor speed will be n. If additional resistance r_{ext1} is introduced in the armature circuit, new steady state operating speed will be n1 corresponding to the operating point D. In this way one can get a speed of n2 corresponding to the operating point E, when r_{ext2} is introduced in the armature circuit. This same load torque is supplied at various speed. Variation of the speed is smooth and speed will decrease smoothly if rext is increased. Obviously, this method is suitable for controlling speed below the base speed and for supplying constant rated load torque which ensures rated armature current always. Although, this method provides smooth wide range speed control (from base speed down to zero speed), has a serious draw back since energy loss takes place in the external resistance rext reducing the efficiency of the motor.

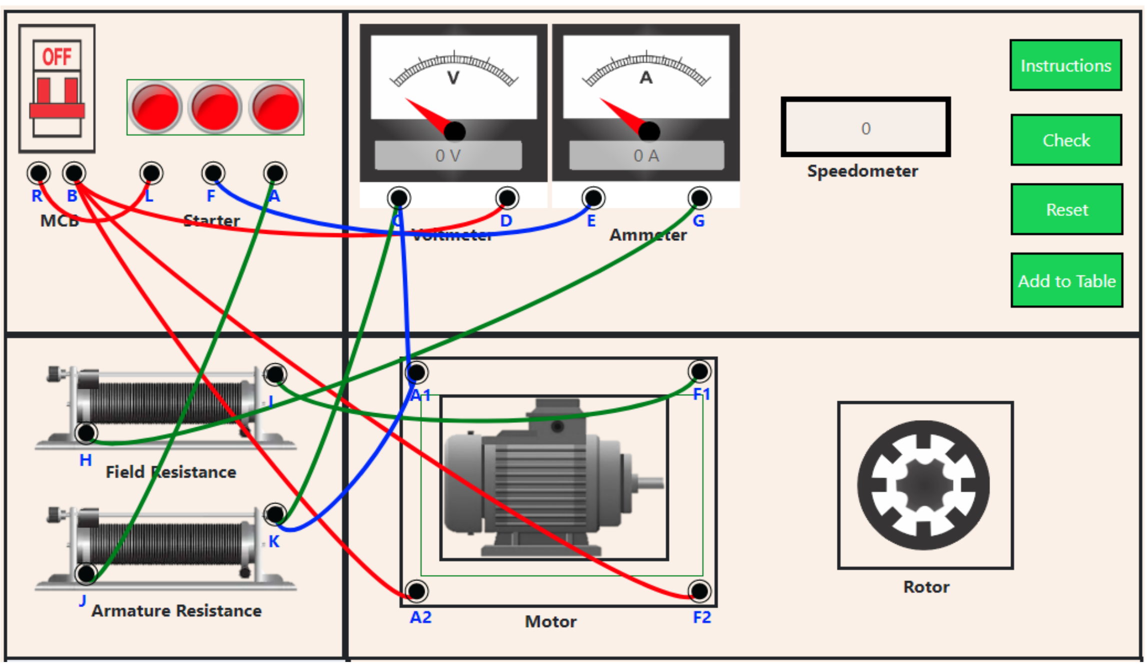


Armature current speed characteristics of DC motors

PROCEDURE:-

STEP 1: Make connections as per the instructions given below:

From	R	B	B	B	F	A	G	I	C	A1	K
To	L	D	A2	F2	E	J	H	F1	A1	K	C



NOTE: If wire is wrongly connected, Click on node number to detach the wire.

STEP 2: Click on Check button for checking the connections.

STEP 3: Click on MCB to turn on the supply.

STEP 4: Now, move the second slider to get corresponding values of Voltmeter and Speedometer.

STEP 5: Click on Add to Table button to add values to the observation table.

STEP 6: Repeat steps 4 to 5 to add more values in table.

STEP 7: Click on Graph button to make a respective graph regarding the values in table.

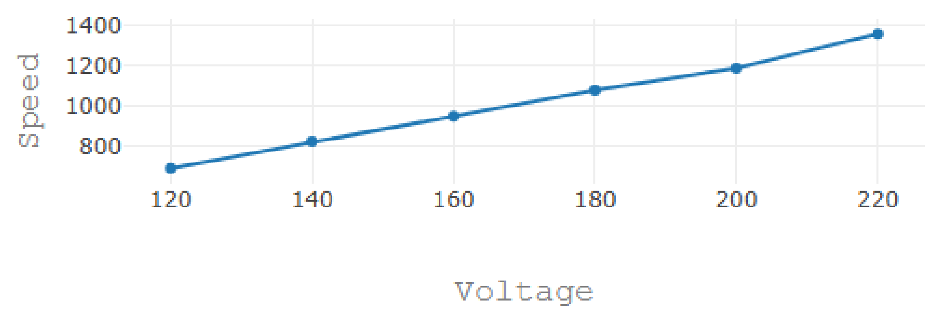
STEP 8: Click on Print button to print the webpage.

STEP 9: Click on Reset button to reset the webpage.

OBSERVATION TABLE:-

S.No.	Voltage (V)	Speed (RPM)
1	220	1360
2	200	1190
3	180	1080
4	160	950
5	140	825
6	120	690

GRAPH:-



RESULT:- Hence the speed control of DC Shunt motor by Armature control method Verified.

and Draws the graph between Voltage and motor speed by varying the Armature voltage

OUTCOME:- By doing this Experiment CO2 and PO1,PO2,PO3,PO5,PO8,PO9,

PO10,PO11,PO12.PSO1,PSO2 are Attained

6(B). Speed Control of DC motor by field resistance control

AIM: *To study the speed control of DC Motor by field resistance Control. Draw the graph between the armature current and motor speed by varying the field resistance.*

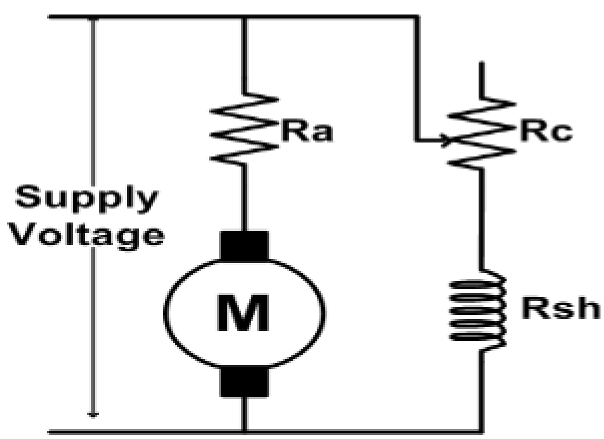
THEORY:- We know that the speed of shunt motor is given by:

$$N = (V_a - I_a R_a)/k\Phi$$

Where, V_a is the voltage applied across the armature and φ is the flux per pole and is proportional to the field current I_f. As explained earlier, armature current I_a is decided by the mechanical load present on the shaft. Therefore, by varying V_a and If we can vary n. For fixed supply voltage and the motor connected as shunt we can vary V_a by controlling an external resistance connected in series with the armature. I_f of course can be varied by controlling external field resistance R_f connected with the field circuit.

Thus for shunt motor we have essentially two methods for controlling speed, namely by:

1. Varying armature resistance.
2. Varying field resistance.



Speed control by varying field current:

In this method field circuit resistance is varied to control the speed of a d.c shunt motor. Let us rewrite the basic equation to understand the method.

$$N = (V_a - I_a R_a)/k\Phi$$

If we vary I_f, flux φ will change, hence speed will vary. To change I_f an external resistance is connected in series with the field windings. The resistance is called the shunt field regulator the field coil produces rated flux when no external resistance is connected and rated voltage is applied across field coil. It should be understood that we can only decrease flux from its rated value by adding external resistance. Thus the speed of the motor will rise as we decrease the field current and speed control above the base speed will be achieved. Speed versus armature current characteristic is shown below.

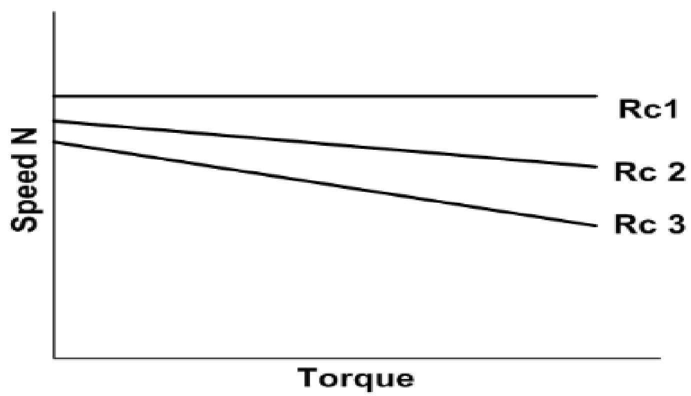
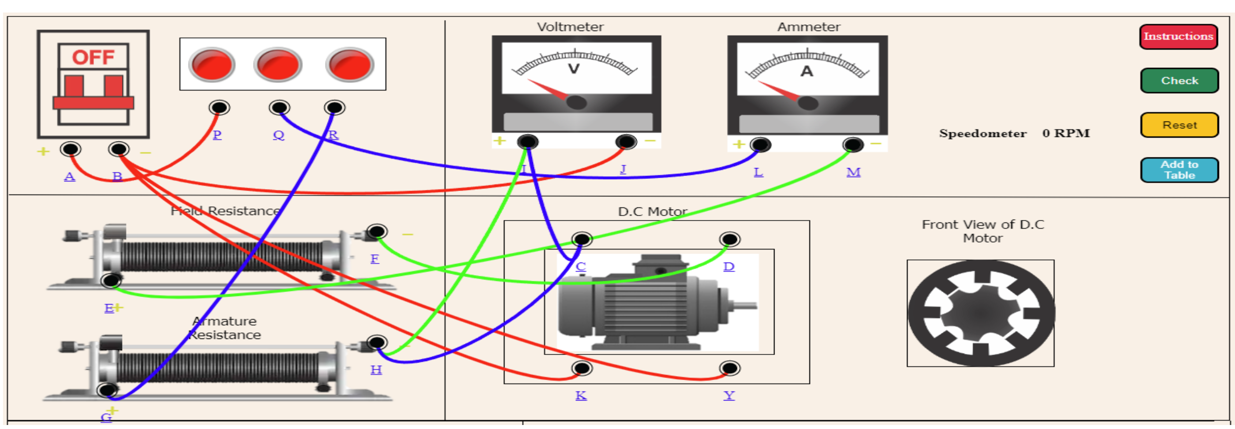


Fig. 2 Torque speed characteristics of DC motors

Procedure:

STEP 1: Make connections as per the instructions given below:

From	A	B	B	B	Q	G	E	F	H	I	C
To	P	K	Y	J	L	R	M	D	I	C	H



STEP 2: Then Check the connections by clicking on **"Check"** Button.

STEP 3: If it shows alert **"Incorrect Corrections"** then click on node number to detach the wire or press reset button and make connection again.

STEP 4: If it shows alert **"Correct Connections"** then Turn On the MCB.

STEP 5: Then set the Voltmeter first with the help of the second slider.

STEP 6: Now, move the first slider to get corresponding values of Ammeter andSpeedometer.

STEP 7: Press the **"Add to table"** button to insert the values in the table.

STEP 8: After inserting values on table click on **"Plot graph"** to get your required graph.

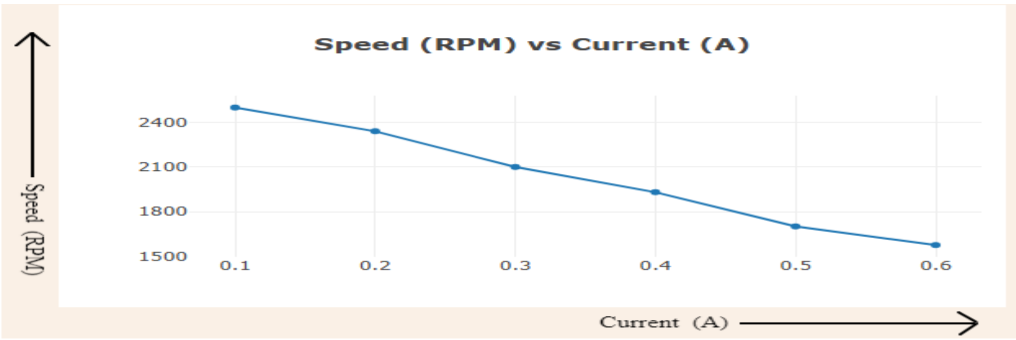
STEP 9: Click on **"Print"** button to print the webpage.

STEP 10: Click on **"Reset"** button to reset the webpage.

OBSERVATION TABLE:-

S.No.	Current (A)	Speed (RPM)
1	0.1	2500
2	0.2	2340
3	0.3	2100
4	0.4	1930
5	0.5	1700
6	0.6	1575

GRAPH:-



RESULT:- Hence the speed control of DC Motor by Field control method Verified. And draws field resistance and Armature current virtually.

OUTCOME:- By doing this Experiment CO2 and PO1,PO2,PO3,PO5,PO8,PO9,

PO10,PO11,PO12.PSO1,PSO2 are Attained

7. EQUIVALENT CIRCUIT OF THREE PHASE INDUCTION MOTOR.

7(A).No load test on three phase induction motor

Aim: To Study No Load Test on Three Phase Induction Motor

Theory:

A large percentage of the electrical power generated in the world is consumed by induction motors, as these are the main drive motors used in the industries. Practicing engineers should be conversant with the performance characteristics. Equivalent circuit parameters of the machine should be known for predicting the performance. While motor designer calculates the parameters using design details, measured values are preferable for prediction.

The steady-state performance of a poly-phase induction motor can be obtained using per phase equivalent circuit**.**

The symbols are,

- V1 = input voltage per Phase
- R1,X1 = resistance and leakage reactance of the stator per phase
- R2,X2 = resistance and leakage reactance of the rotor per phase
- Xm= magnetizing reactance
- Rc= core loss resistance
- I1, I2 = stator and rotor currents (referred to stator) per phase.

The developed torque is given as, T=3(I2)2R2/(sωs) N-m

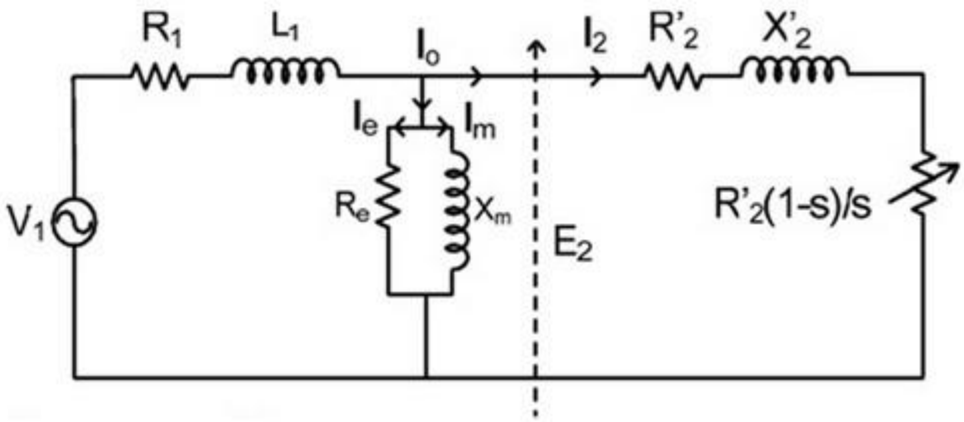
Where,

- ωs = synchronous speed in radians/sec
- ωr = rotor speed in radians/sec
- s = slip.

The parameters could be determined by 'no-load' and 'blocked-rotor' tests, the former determines Rc and Xm while the latter yields R1, R2, X1, X2. Following equations could be used

- X1 = R1+jX1
- X2 = R2/S+jX2
- S = ωs-ωr/ω

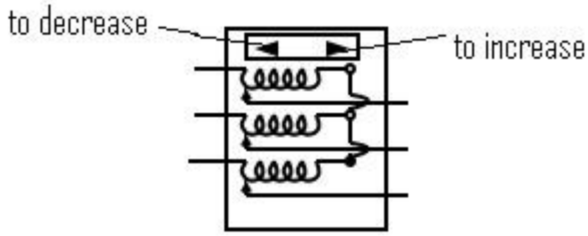
- The Torque T = 3(I2)2R2/s
- Input power = 3V1*I1*pf
- Output power = (1-S) ωs



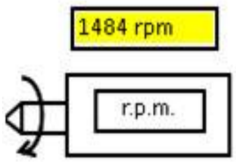
Per phase equivalent circuit of a poly phase induction motor
Start the motor by applying the normal frequency reduced voltage to the stator and gradually increases the voltage to its rated value under no load condition. In case of slip-ring motor short circuit the slip rings before starting. Note down the readings of voltmeter, ammeter, wattmeters and tachometer at different voltages.

PROCEDURE:-

1. NO load is connected to Induction motor so as to carry out NO load test on induction motor.
2. Close the TPST (Triple Pole Single Throw) switch connecting three phase mains supply to induction motor.
3. Start the motor by applying reduced voltage to the stator.
4. Gradually increases the voltage to its rated value.
5. Now increase the voltage by clicking the arrows on three phase variac

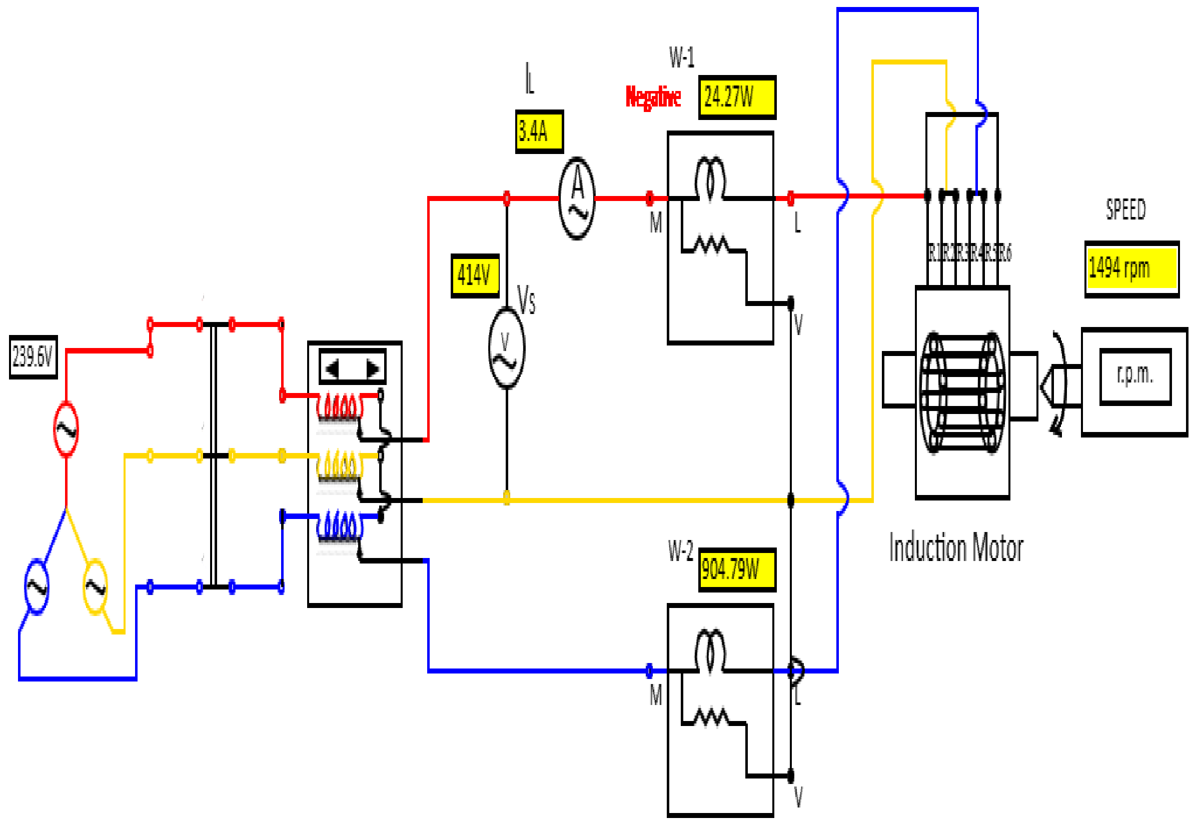


6. As we go on increasing the supply voltage we can observe the change in speed of motor in digital tachometer.



7. Observe the readings of voltmeter, ammeter, wattmeters and tachometer at various stator input voltages.
8. Store the data by clicking "Start Storing Data" at various i/p voltages
9. Go on repeating this procedure till sufficient readings are stored.
10. Now display the data by clicking "Show data". It will display data as shown.
11. Now select one of the graph from available graphs and use "Generate graph" to plot the graph .For Ex.

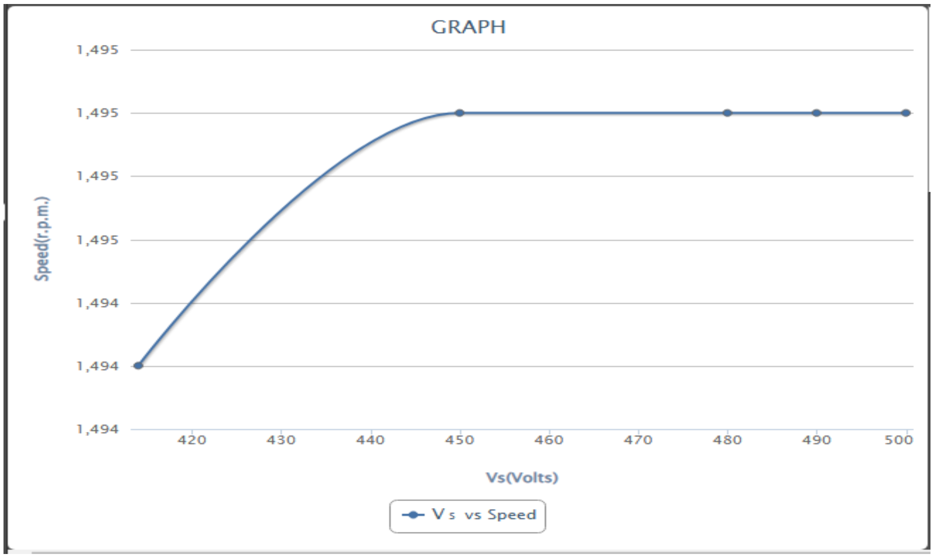
12. While switching off, gradually decrease the voltage applied to motor and make it zero.
13. Open the TPST switch.



OBSERVATION TABLE:-

V_S (Volt)	I_L (Amp)	W-1 (Watt)	W-2 (Watt)	Speed (r.p.m)	Total copper loss	Rotor angle	i/p Power
414.00	3.40	-24.27	904.79	1494.00	125.30	79.8	431.74
450.00	3.72	-580.77	1076.03	1495.00	376.36	80.3	488.53
480.00	4.00	-31.54	1234.15	1495.00	173.22	80.3	560.32
490.00	4.05	-688.49	1275.61	1495.00	446.20	80.3	579.14
500.00	4.13	-716.42	1327.36	1495.00	464.35	80.3	602.63

GRAPH:-



RESULT:- Hence The test verifies that the motor is functioning correctly under no load conditions Virtually

OUTCOME:- By doing this Experiment CO3 and PO1,PO2,PO3,PO5,PO8,PO9,

PO10,PO11,PO12.PSO1,PSO2 are Attained

7(B).Blocked Rotor test on three phase induction motor

AIM:- Study blocked rotor test on induction motor

THEORY:-

A large percentage of the electrical power generated in the world is consumed by induction motors, as these are the main drive motors used in the industries. Practicing engineers should be conversant with the performance characteristics. Equivalent circuit parameters of the machine should be known for predicting the performance. While motor designer calculates the parameters using design details, measured values are preferable for prediction.

The steady-state performance of a poly-phase induction motor can be obtained using per phase equivalent circuit. The symbols are,

- V1 = input voltage per Phase
- R1,X1 = resistance and leakage reactance of the stator per phase
- R2,X2 = resistance and leakage reactance of the rotor per phase
- Xm = magnetizing reactance
- Rc = core loss resistance
- I1, I2 = stator and rotor currents (referred to stator) per phase.

The developed torque is given as,

T = 3(I2)2R2/(sωs) N-m

Where,

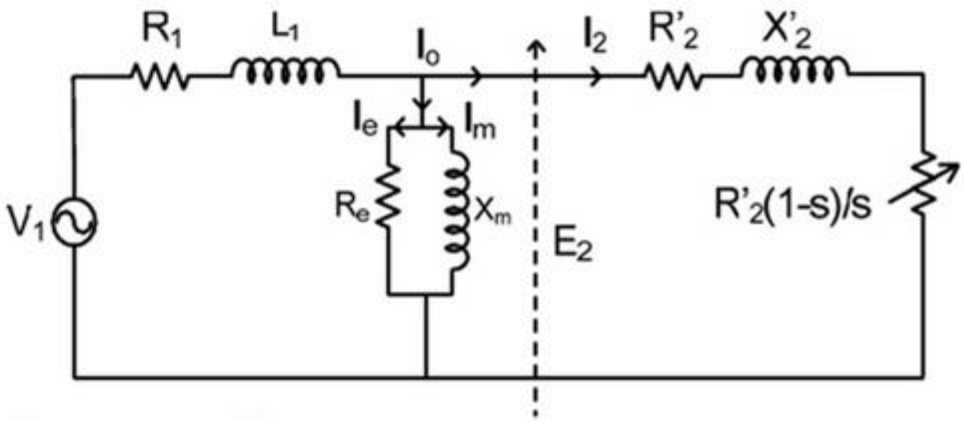
- ωs = synchronous speed in radians/sec
- ωr = rotor speed in radians/sec
- s = slip.

The parameters could be determined by 'no-load' and 'blocked-rotor' tests, the former determines Rc and Xm while the latter yields R1, R2, X1, X2.

Following equations could be used

- X1 = R1+jX1
- X2 = R2/S+jX2
- S = ωs-ωr/ω
- The Torque T = 3(I2)2R2/s
- Input power = 3V1*I1*pf

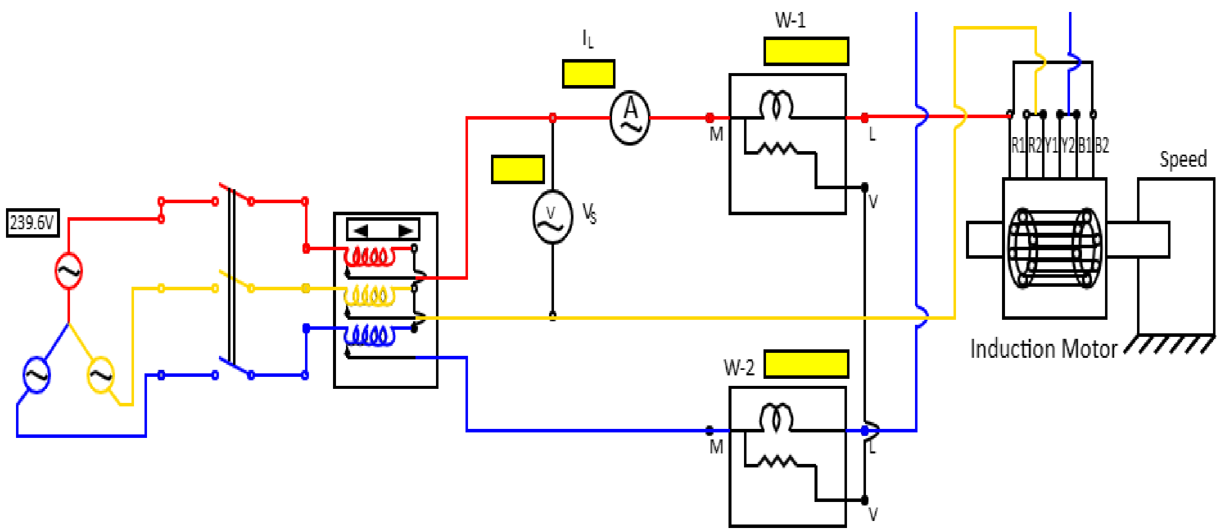
- Output power =(1-S) ωs



Per phase equivalent circuit of a poly phase induction motor

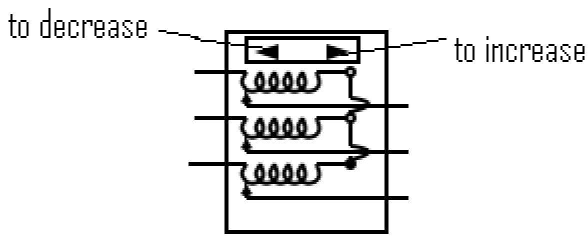
In blocked rotor test, rotor is not allowed to rotate so the speed of the rotor is zero r.p.m, slip corresponding to zero speed is unity. Now, increase the stator voltage till motor current reaches to its rated value. Note down the readings of voltmeter, ammeter, wattmeters and tachometer at different stator voltages.

CIRCUIT DIAGRAM:-



PROCEDURE:-

1. Rotor of induction motor is blocked in order to perform block rotor test.
2. Close the TPST (Triple Pole Single Throw) switch connecting three phase mains supply to induction motor.
3. Vary input current from zero to rated value (415V).
4. Observe the readings of voltmeter, ammeter, watt meters and tachometer at different i/p voltages.
5. Now increase the voltage by clicking the arrows on three phase variac



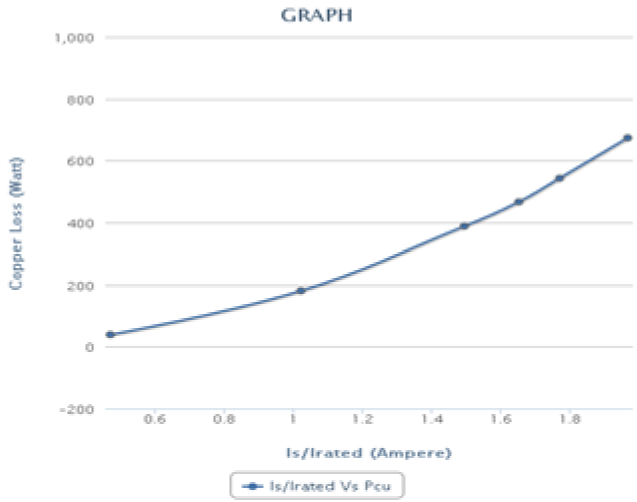
6. Store this data by clicking "Start Storing Data"
7. Go on repeating this procedure till sufficient readings are stored.
8. Now display the data by clicking "Show data".It will display data as shown

9. Now select one of the graph from available graphs and use "Generate graph" to plot the graph. For Ex.

OBSERVATION TABLE:-

Current	Total Copper Loss	Rotor Angle	Supply Voltage
0.47	39.06	29.31	15
1.02	180.94	29.31	35
1.50	388.12	29.31	50
1.65	466.81	29.31	55
1.77	542.97	29.31	60
1.97	673.42	29.31	65

GRAPH:-



RESULT:- Hence The test verifies that the motor is functioning correctly under Blocked rotor load conditions Virtually

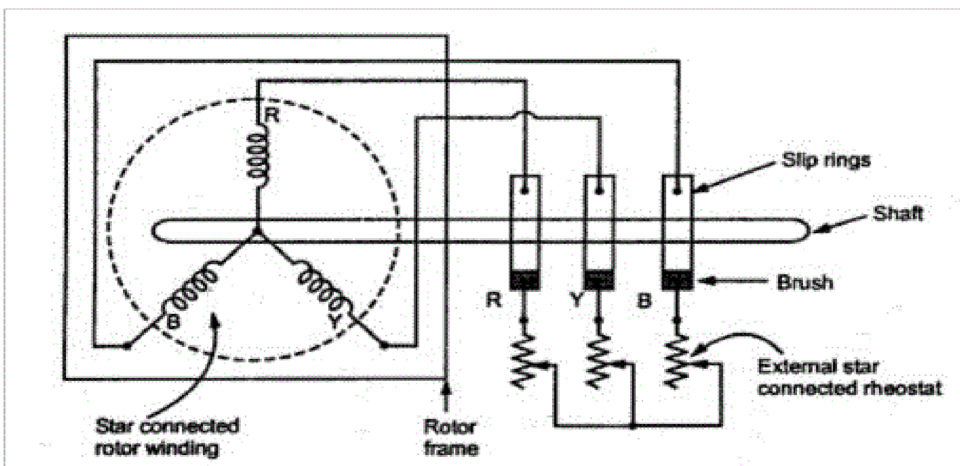
OUTCOME:- By doing this Experiment CO3 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained

8. SPEED CONTROL OF SLIPRING INDUCTION MOTOR

AIM:- To perform the speed control test on slip ring induction motor by rotor resistance control method. Plot the motor speed characteristics at different values of applied resistance in slip ring of induction motor.

THEORY:-

A wound rotor induction motor or slip ring induction motor has a stator like the squirrel cage induction motor, but a rotor with insulated windings brought out via slip rings and brushes. However, no power is applied to the slip rings. Their sole purpose is to allow resistance to be placed in series with the rotor windings while starting.



SLIP RING CHARACTERISTCS

A slip ring motor or a phase wound motor is an induction motor which can be started with full line voltage, applied across its stator terminals. The rotor winding terminals of a wound rotor motor are connected to three slip-rings mounted on but insulated from the shaft. The leads, from the three brushes pressing on these slip-rings are taken to external resistances. At the time of start, the value of starting current is adjusted by adding up external resistance to its rotor circuit. As the rotor speeds up, the external resistance is decreased in steps so that motor torque tends to remain maximum during the accelerating period. Finally, under normal operation, the external resistance is fully cut off and the slip-rings are short-circuited so that motor now develop full load torque at low value of slip-rings. The point to be noted is the “slip necessary to generate maximum torque is directly proportional to the rotor resistance.” So it is evident that the slip increases with increase in external resistance.

With the above statements, let us discuss the different methods of speed control of slip ring induction motors:

1. Rotor Rheostat Control
2. Cascade Control

SPEED CONTROL BY ROTOR RHEOSTAT CONTROL

The external rheostat which is used for the starting purpose of these slip ring motors can be used for its speed control too. But the point to look into is the starting rheostat must be rated for “continuous” operation. With the same rheostat added to the rotor circuit, it is possible to regulate the speed of slip ring motors. The resistance is engaged maximum during starting and slowly cut-off to increase the speed of the motor. When running at full speed, if the need arises to reduce the speed, the resistance is slowly added up and thus speed reduces. To understand the speed control, let us look into the torque-slip relation given below.

Torque T = S/R

Where,

S is the slip of the motor,

R is the Rotor resistance.

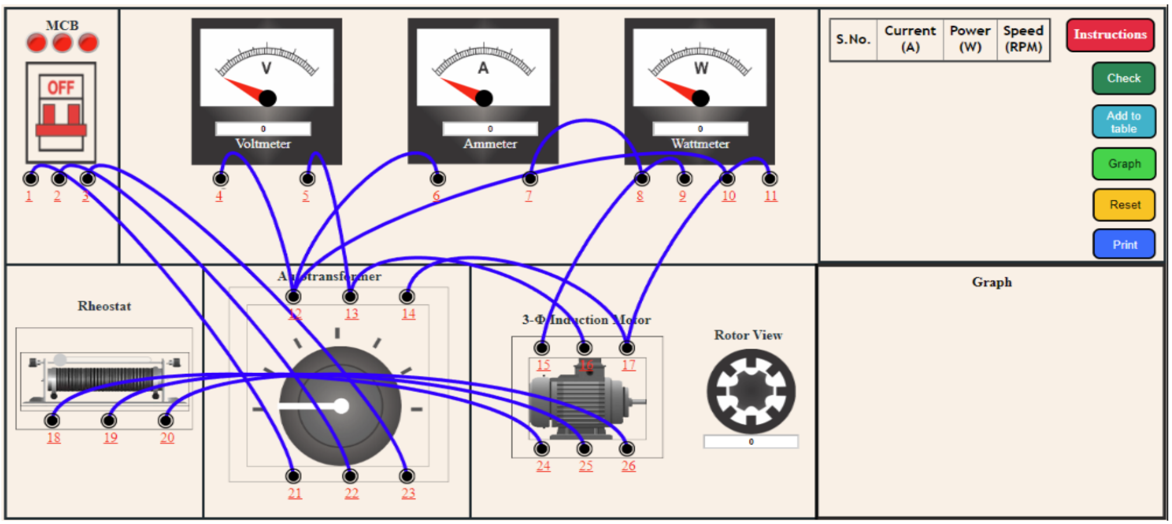
It is evident from the above relation that as the rotor resistance increases, the torque decreases. But for a given load demand, the motor and thus the rotor has to supply the same torque without any decrease. So in order to maintain the torque constant, as the rotor resistance increases the slip also increases. This increase in slip is nothing but decrease in motor speed.

DISADVANTAGES:

But there are some disadvantages in this method of speed control. As the rotor resistance is increased, the “I^2R” losses also increases which in turn decreases the operating efficiency of the motor. It can be interpreted as the loss is directly proportional to reduction in speed. Since the losses are more, this method of speed reduction is used only for short period only.

CIRCUIT DIAGRAM:-

From	1	2	3	4	5	6	7	9	10	11	16	17	18	19	20
To	21	22	23	12	13	12	8	15	12	17	13	14	24	25	26



PROCEDURE:-

STEP 1: Make connections as per the instructions. If the wire is wrongly connected, Click on node number to detach the wire. detach the wire.

STEP 2: Click on **"Check"** button for checking the connections.

- If connection is correct, an alert appears. Click ok. Now, go to step 4.
- If connection is wrong, an alert appears. Click ok. Now, go to step 3.

STEP 3: Check the connection and either detach the incorrect wire connection or Click on Reset button and start from step 1.

STEP 4: Switch on the MCB

STEP 5: Click on the autotransformer knob.

STEP 6: Slide the knob of the Rheostat to change the resistance.

STEP 7: Click on **"Add to table"** button to insert the readings in the table.

STEP 8: Follow the procedure from step 6 to step 7, till you have the 6 readings in the table.

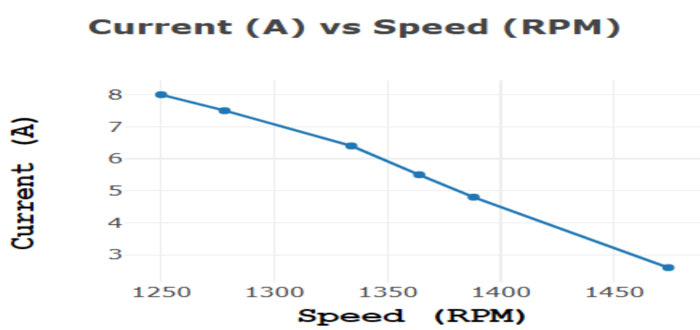
STEP 9: After taking minimum 6 readings, Click on the **"Graph"** button.

STEP 10: Click on **"Print"** button to print the full connections with graph and table.

OBSERVATION TABLE:-

S.No.	Current (A)	Power (W)	Speed (RPM)
1	2.6	40	1474
2	4.8	680	1388
3	5.5	820	1363
4	6.4	1040	1334
5	7.5	1160	1278
6	8	1200	1250

GRAPH:-



RESULT:- Hence performed the speed control test on Slip ring Induction motor by Rotor resistance control method virtually

OUTCOME:- By doing this Experiment CO4 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained

9. OC & SC TEST ON SINGLE PHASE TRANSFORMER

AIM:- Open Circuit and Short Circuit Test On ingle Phase Transformer.

THEORY:-

The open circuit and short circuit tests are performed for determining the parameter of the transformer like their efficiency, voltage regulation, circuit constant etc. These tests are performed without the actual loading and because of this reason very less power is required for the test. The open circuit and the short circuit test gives a very accurate result as compared to the full load test.

OPEN CIRCUIT TEST

The purpose of the open-circuit test is to determine the no-load current and losses of the transformer because of which their no-load parameter is determined. This test is performed on the primary winding of the transformer. The wattmeter, ammeter, and the voltage are connected to their primary winding. The nominal rated voltage is supplied to their primary winding with the help of the ac source.
The secondary winding of the transformer is kept open and the voltmeter is connected to their terminal. This voltmeter measures the secondary induced voltage. As the secondary of the transformer is open, no-load current flows through the primary winding. The value of no-load current is very small as compared to the full rated current. The copper loss occurs only on the primary winding of the transformer because the secondary winding is open. The reading of the wattmeter only represents the core and iron losses. The core loss of the transformer is same for all types of loads.

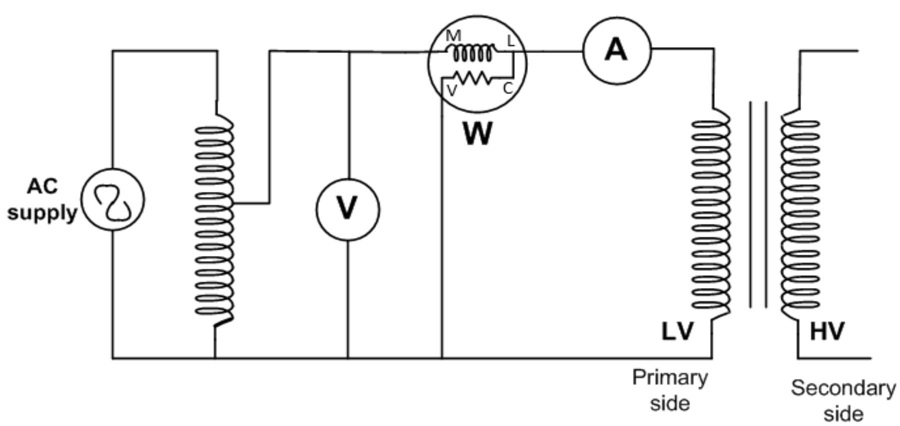


Fig. 1 Equivalent circuit diagram for open circuit test on transformer

CALCULATION OF OPEN CIRCUIT TEST:-

Let,

W_0 – wattmeter reading
V_1 – voltmeter reading
I_0 – ammeter reading
Then the iron loss of the transformer $P_i = W_0$ and

$W_0 = V_1 I_0 \cos\Phi$ ....(1)

The no-load power factor is

$\cos\Phi = W_0/(V_1 I_0)$

Working component I_w is

$I_w = W_0/V_0$ .... (2)

Putting the value of W_0 from the equation (1) in equation (2) you will get the value of working component as

$I_w = I_0 \cos\Phi$

Magnetizing component is

$I_m = (I_0^2 - I_w^2)^{1/2}$

No load parameters are given below:

Equivalent exciting resistance is

$R_0 = V_1/I_1$

Equivalent exciting reactance is

$X_0 = V_1/I_m$

SHORT CIRCUIT TEST:

The short circuit test is performed for determining the below mention parameter of the transformer.

1. It determines the copper loss occurs on the full load. The copper loss is used for finding the efficiency of the transformer.

2. The equivalent resistance, impedance, and leakage reactance are known by the short circuit test.

The short circuit test is performed on the secondary or high voltage winding of the transformer. The measuring instrument like wattmeter, voltmeter, and ammeter are connected to the high voltage winding of the transformer. Their primary winding is short circuited by the help of thick strip or ammeter which is connected to their terminal. The low voltage source is connected across the secondary winding because of which the full load current flows from both the secondary and the primary winding of the transformer. The full load current is measured by the ammeter connected across their secondary winding.

The low voltage source is applied across the secondary winding which is approximately 5 to 10% of the normal rated voltage. The flux is set up in the core of the transformer. The magnitude of the flux is small as compared to the normal flux. The iron loss of the transformer depends on the flux. It is less occur in the short circuit test because of the low value of flux. The reading of the wattmeter only determines the copper loss occur on their windings. The voltmeter measures the voltage applied to their high voltage winding. The secondary current induces in the transformer because of the applied voltage.

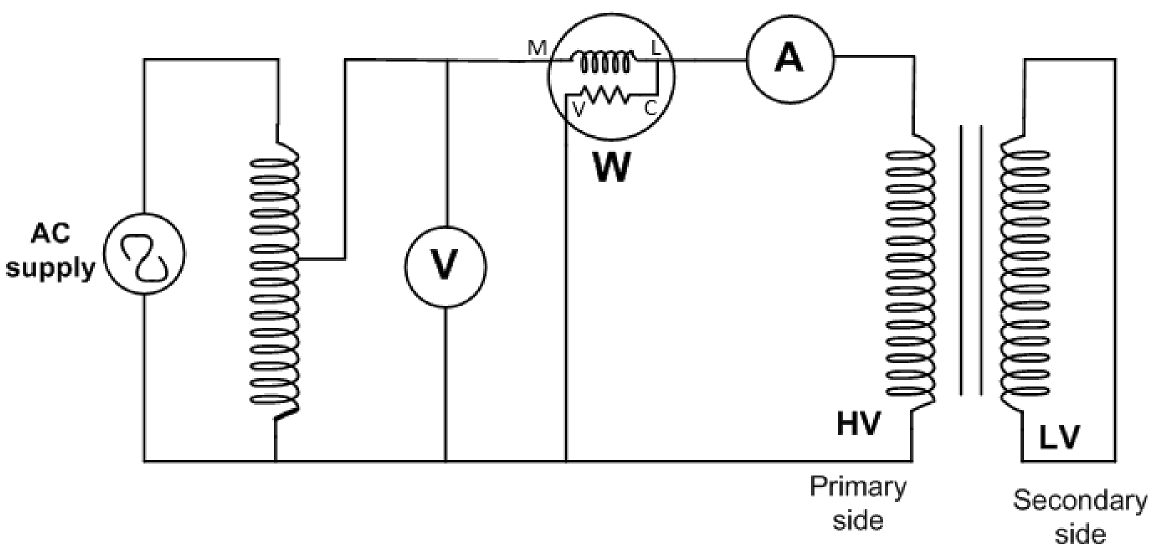


Fig. 2 Equivalent circuit diagram for short circuit test on transformer

CALCULATION OF SHORT CIRCUIT TEST:-

Let,

W_c – Wattmeter reading
V_{sc} – Voltmeter reading
I_{sc} – Ammeter reading

Then the full load copper loss of the transformer is given by

$P_c = [I_{fl}/I_{sc}]^2.W_c$

$I_{sc}^2.R_s = W_c$

Equivalent resistance referred to secondary side is

$R_s = W_c.I_{sc}^2$

Equivalent impedance referred to the secondary side is given by

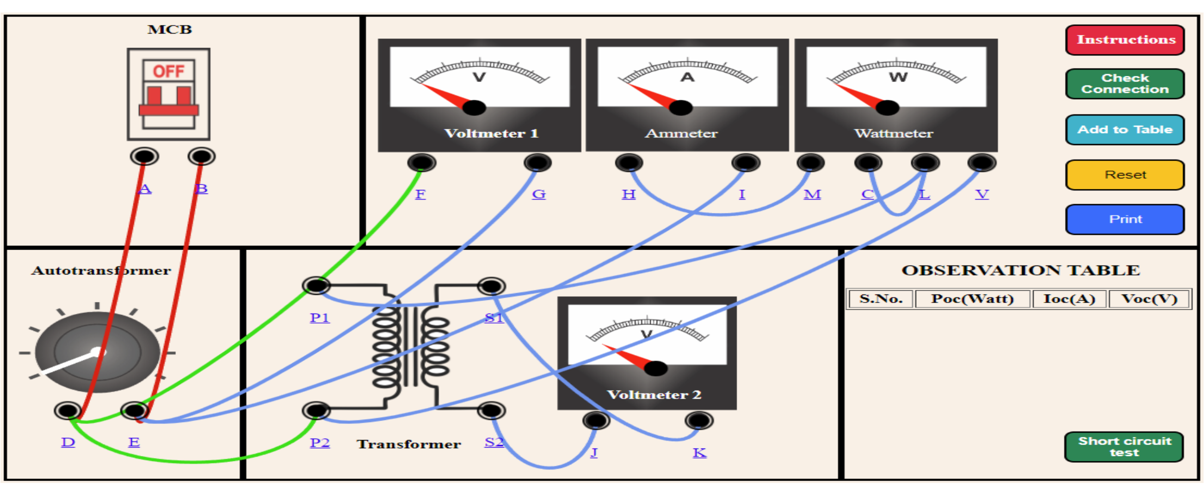
$Z_s = V_{sc}/I_{sc}$

The Equivalent reactance referred to the secondary side is given by

$X_s = [Z_s^2 - R_s^2]^{1/2}$

CIRCUIT DIAGRAM:-

From	A	B	D	E	E	D	H	C	L	V	S1	S2
To	D	E	F	G	I	P2	M	L	P1	P2	K	J



PROCEDURE:-

STEP 1: Make the proper connection by clicking the node as instructed below. If the wire is wrongly connected, Click on the node number to detach the wire.

STEP 2: Click on **"Check Connection"** button for checking the connections.

- If connection is correct, an alert appears. Click ok.
  Now, go to step 4.
- If connection is wrong, an alert appears. Click ok.
  Now, go to step 3.

STEP 3: Check the connection and either detach the incorrect wire connection or Click on **"Reset"** button and start from step 1.

STEP 4: Switch on the MCB.

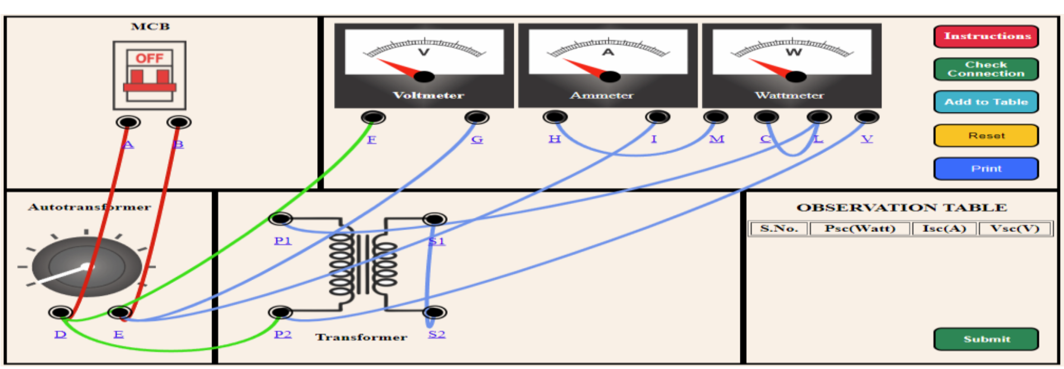
STEP 5: Click on the Autotransformer knob.

STEP 6: Click on **"Add to Table"** button to add the readings to the observation table.

STEP 7: Click on **"Short Circuit Test"** button to perform the SC Test.

STEP 8: Make the proper connection by clicking the node as instructed below. If the wire is wrongly connected, Click on the node number to detach the wire.

From	A	B	D	E	E	D	H	C	L	V	S1
To	D	E	F	G	I	P2	M	L	P1	P2	S2



STEP 9: Repeat steps 2 to 6.

STEP 10: Click on **"Submit"** button to get an equivalent circuit diagram of transformer.

STEP 11: Click on **"Print"** button to print the webpage.

OC TEST:

OBSERVATION TABLE

S.No.	Poc(Watt)	Ioc(A)	Voc(V)
1	50	0.9	230

SC TEST:

OBSERVATION TABLE

S.No.	Psc(Watt)	Isc(A)	Vsc(V)
1	37.5	4.5	11

RESULT: Hence Determined the Transformer Equivalent Circuit from open circuit and Short circuit

OUTCOME: By doing this Experiment CO2 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained

10. V AND INVERTED V CURVES OF THREE PHASE SYNCHRONOUS MOTOR

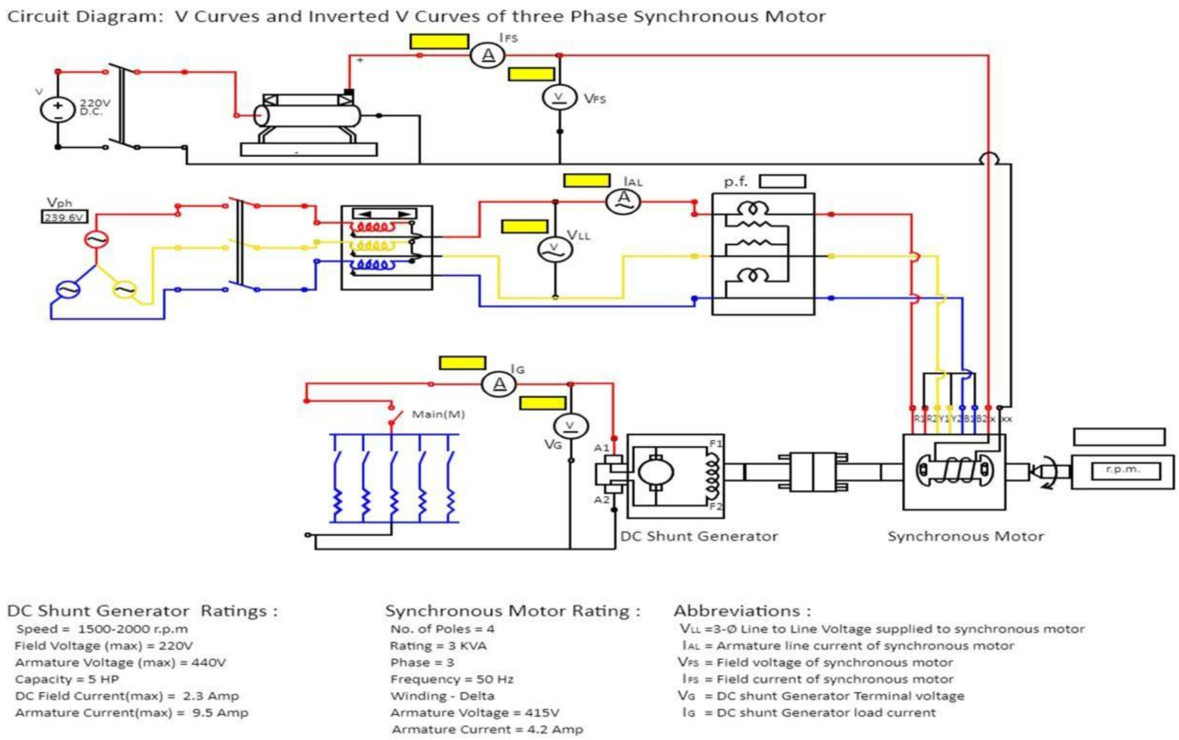
AIM:- V Curves and Inverted V curves of Three Phase Synchronous Motor.

THEORY:-

Electromagnetic devices draw a magnetizing current from the a.c source, in order to establish the working flux. This magnetizing current lags the applied voltage by almost 900.

A synchronous motor is a double-excited machine, its armature winding is energised from an a.c source and its field winding from d.c source. When synchronous motor is working at constant applied voltage, the resultant air gap flux demanded by applied voltage remains constant. This resultant air gap flux is established by both a.c in armature winding and d.c in the field winding. If the field current is sufficient enough to set up the air-gap flux, as demanded by constant applied voltage then magnetizing current or lagging reactive VA requied from the a.c source is zero and therefore motor operates at unity power factor. This field current, which causes unity power factor operation of the synchronous motor, is called normal excitation or normal field current. If the current less than the normal excitation, i.e the motor is under excited, then the deficiency in flux must be made up by the armature winding m.m.f. In order to do the needful, the armature winding draws a magnetizing current or lagging reactive VA from the a.c source and as a result of it, the motor operates at a lagging power factor. In case the field current is made more than its normal excitation, i.e the motor is over-excited, operates at leading power factor. Fig(1) shows the variation of armature current and power factor with field current at no load, half load and full load conditions.

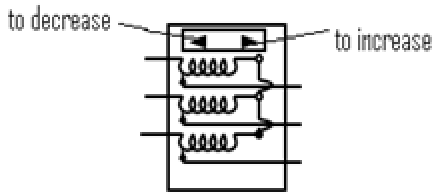
CIRCUIT DIAGRAM:-



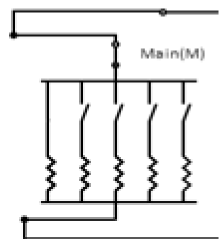
PROCEDURE:-

1. The machine under consideration salient pole synchronous motor. The short circuited aluminium damper bars are put in the rotor to make it self-starting. When 3 phase supply is applied to the stator of motor, motor will act like induction machine and it will attain speed slightly less than synchronous speed. This is achieved by switching on the 3 phase supply with TPST (triple pole single throw) for synchronous motor.

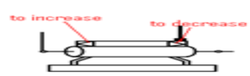
2. With the help of 3 phase auto-transformer the voltage to be applied to the stator of synchronous motor is varied smoothly. When motor attends speed near to synchronous speed (generally at rated voltage), turn field supply on of motor with help of DPST (double pole single throw) switch and apply rated voltage in steps. Here onwards the speed of synchronous machine will be constant as synchronous speed.



3.Output of motor will drive DC generator which in turn will drive electrical load (resistive load bank).



4.Now depending on excitation for synchronous machine (which can be varied by altering rheostat arrangement in expt.) given to the synchronous motor, the power factor of motor will operate on the (over-excitation) leading, (critical) unity or (under-excited) lagging power factor.



To keep air gap flux constant in synchronous motor reactive power is needed. It is met by AC supply of synchronous motor depending on its field excitation. Plot the variations of stator current drawn by the synchronous motor with its field current.

5. Its graph follows shape of V, hence the name V curves. This characteristic of synchronous machine. Variation of power factor with field current of motor in exactly reverse fashion, which is called as inverted V curves. The point of least armature current drawn from stator of Synchronous motor will correspond to unity power factor and both graphs will have same field current reading.
6. Store this data by clicking "Start Storing Data"
7. Go on repeating this procedure till all load are connected and data is stored.
8. Now display the data by clicking "Show data". For Ex.

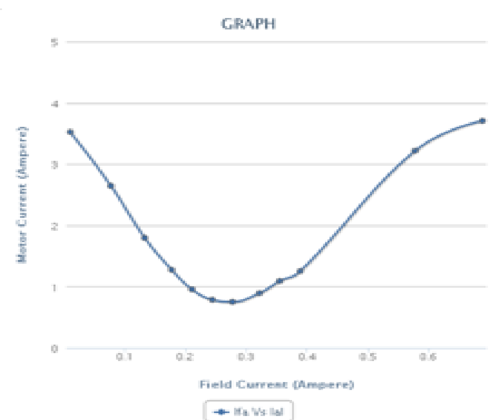
OBSERVATION TABLE:-

Vfa	Ifa	Vs	Ial	Vt	Il	speed	Power Factor
2	0.01	300	3.52	429	1.26	1500	0.09
14	0.08	300	2.65	429	1.26	1500	0.20
24	0.13	300	1.80	429	1.26	1500	0.33
32	0.18	300	1.27	429	1.26	1500	0.53
38	0.21	300	0.96	429	1.26	1500	0.72
44	0.24	300	0.79	429	1.26	1500	0.93
50	0.28	300	0.75	429	1.26	1500	1.00
58	0.32	300	0.89	429	1.26	1500	0.87
64	0.36	300	1.10	429	1.26	1500	0.77
70	0.39	300	1.25	429	1.26	1500	0.65
104	0.58	215	3.22	420	1.23	1467	0.42
124	0.69	215	3.71	420	1.23	1467	0.37

- Vfa=field voltage of alternator
- Ifa=field current of alternator
- Vt=terminal voltage
- Vs=supply voltage
- Ial=alternator current

10. These V curves can be performed on various loads and no load conditions on the synchronous motors.

11.While switching motor off, in stepwise manner reduce the stator supply to zero, and switch off TPST (triple pole single throw) switch. Then in steps cut down field supply for synchronous motor.



11. Now select one of the graph from available graphs and use "Generate graph" to plot the graph.

RESULT:- Hence Verified the V curves and Inverted V curves of 3 Phase synchronous Motor Virtually.

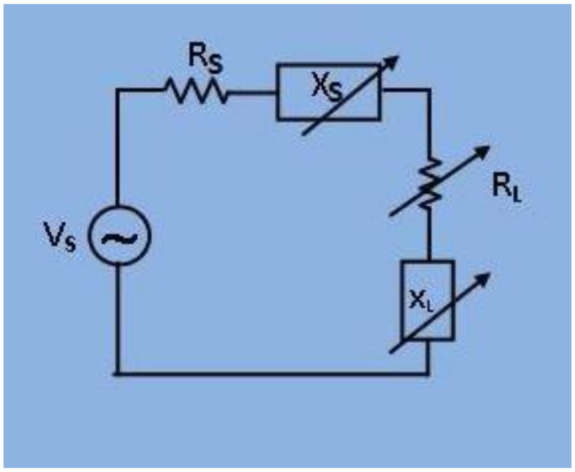
OUTCOME:- By doing this Experiment CO5 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained

11.VERIFICATION OF MAXIMUM POWER TRANSFER THEOREM

AIM:- Verification of Maximum Power Transfer Theorem

THEORY:

Maximum power is transferred from a source of given voltage and an internal impedance to the load impedance Z_L in the following circuit shown in figure 1, under three conditions



[Fig 1: Circuit diagram with source and load impedance(i.e. Z_S and Z_L)]

1. When only X_L is adjustable:

Under this condition the power consumed by the load ($I^2 * R_L$) is maximum, when I is maximum, since R_L is constant.

$$I = \frac{V_s}{R_s + jX_s + R_L + jX_L} \ldots (1)$$

$$|I|_{max} = \frac{V_s}{R_s + R_L} \ldots\ldots\ldots\ldots (2)$$

when

$$X_L = -X_s$$

This means that if the load reactance(X_L) is made equal magnitude and opposite in sign to theinternal reactance(X_s), the power transferred is maximum.

When only R_L is adjustable:

From equation (1) in section (1), one may write

$$P = |I^2| * R_L = \frac{V_s^2 * R_L}{(R_s + R_L)^2 + (X_s + X_L)^2} \dots (3)$$

Differentiating the equation (3) w.r.t R_L and equating to zero, one obtains.

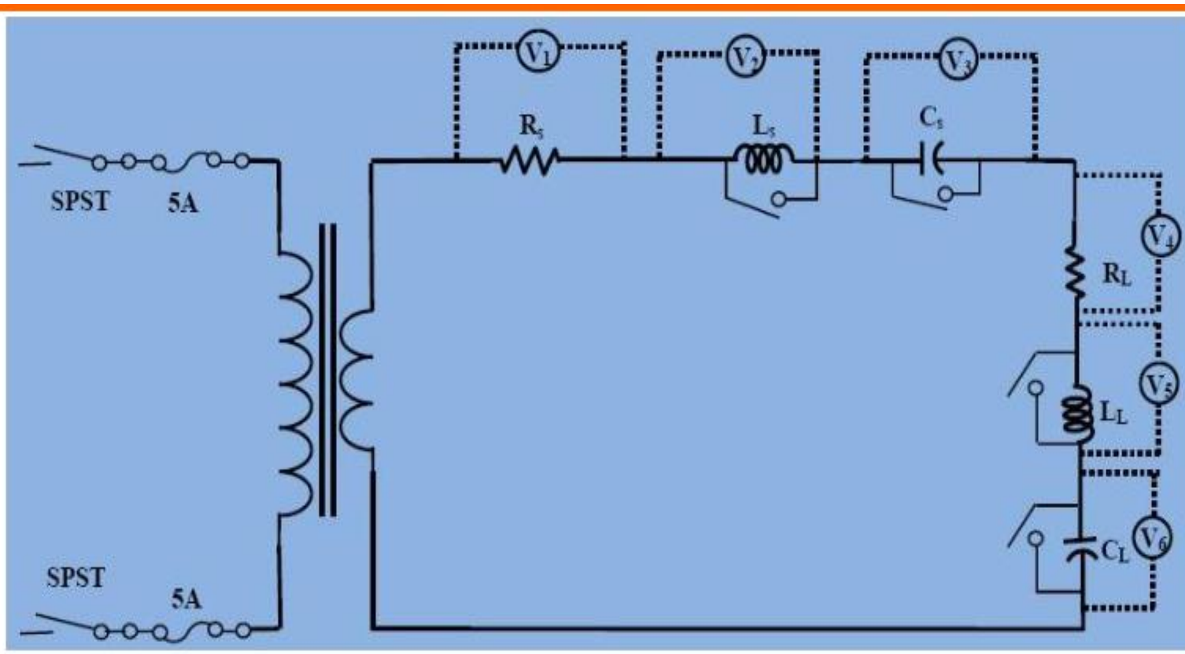
$$R_L = \sqrt{R_s^2 + (X_s + X_L)^2} \dots\dots\dots\dots\dots\dots (4)$$

3. When both R_L and X_L are adjustable:

Under this condition both equation (2) and (4) are valid simultaneously and one obtains.

RL=Rs

PROCEDURE:-



1. When only XL is adjustable:-

1. Take a suitable set of values of V_s, X_S, X_L as shown in the figure. You can choose X_S to be inductive (L_s) and capacitive (C_s). X_L can choose as inductive(L_L) and capacitive (C_L) to the load.
2. Next choose a suitable load resistance (R_L).
3. For the maximum power theorem, the condition would be $R_L=R_S$, X_S(i.e. X_1)=-X_L.(i.e. X_2)

   Where,

$$x_1 = \sqrt{(wL_s - \frac{1}{wC_s})^2}$$

$$x_2 = \sqrt{(wL_L - \frac{1}{wC_L})^2}$$

$$w * L_S = \frac{1}{W * C_L}$$

$$C_L = \frac{1}{w^2 * L_s}$$

$$= \frac{1}{4 * \pi^2 * f^2 * L_s}$$

Take an example, put L_s=1mH, C_s=10.1µF.

Now for different value of C_s, note down V_1 and V_4.

Load power (P_L) = I^2*R_L = $I*I*R_L$ = $(V_1/100)*V_4$
= $K*V_1*V_4$
where K=1/100 = 1/R_s

Enter the value of the voltage for different values of C_s and obtain the set corresponding to the maximum value of (V_1*V_4). Verify that for this set $V_2=V_6$.

2. When only RL is adjustable:

Repeat the procedure of part (1), with C_s fixed and R_L varied. At the point of maximum power check

$$R_L = \sqrt{(R_s^2 + (X_1 + X_2)^2)}$$

3. When both RL and XL are adjustable:

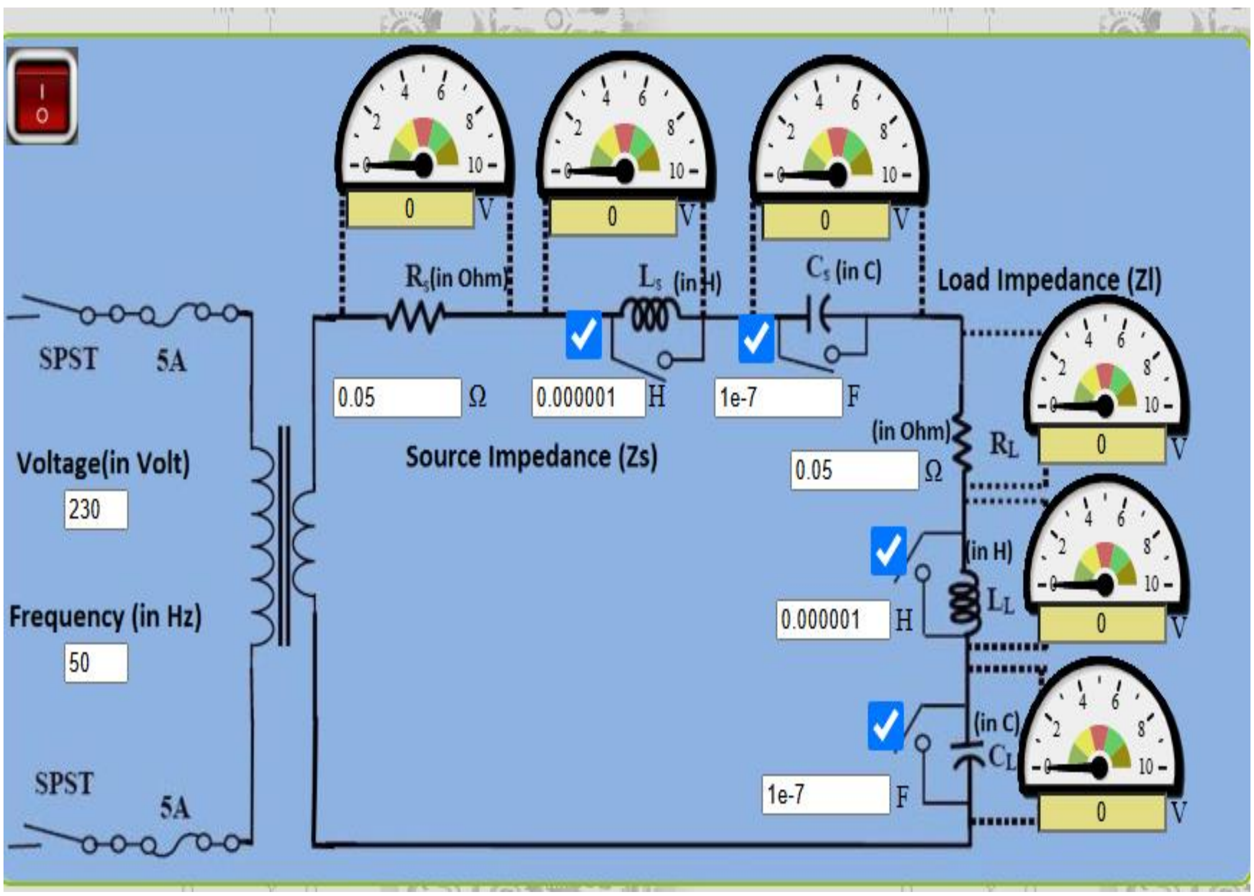
Repeat the procedure of part (2), varying C_s and obtain the maximum power condition.

Check under this condition,

$V_{RL} - V_{RS}$ i.e. $V_1 - V_4$:

$V_{LS} - V_{CL}$ i.e. $V_2 - V_6$:

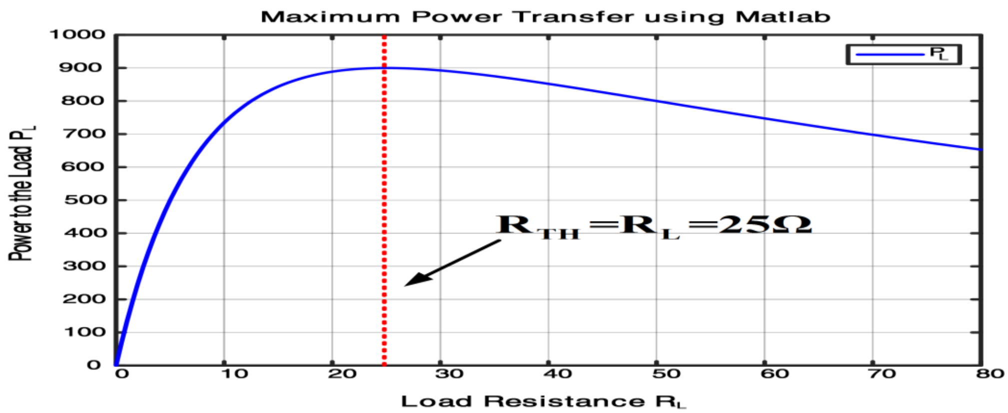
CIRCUIT DIAGRAM:-



OBSERVATION TABLE:-

Load Resistance (Rl)	Power(p)
10	700
20	900
30	900
40	850
50	800
60	750
70	700
80	650

GRAPH:-



RESULT:- Hence Verified the Maximum power Theorem and Note down the observation values Virtually

OUTCOME: By doing this Experiment CO1 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained

12. SYNCHRONIZATION OF ALTERNATOR WITH INFINITE BUS BAR

Aim:

To study the Synchronization of the alternator with infinite bus bar.

EQUIPMENTS REQUIRED:

1. DC Motor - Alternator Set
2. Voltmeter-1
3. Rheostats-2
4. Tachometer- 1

THEORY:

Before synchronization, following conditions must be satisfied:

(1) EQUALITY OF VOLTAGE

The terminal voltage of both the systems i.e. the incoming alternator and the bus bar voltage or other alternator must be same.

(2) PHASE SEQUENCE

The phase sequence of both the systems must be same.

(3) EQUALITY OF FREQUENCY

The frequency of both the systems must be same. The condition (1) can be checked with the help of voltmeter and the condition (2) and (3) by any synchronizing method. There are two synchronizing methods

a. Using incandescent lamp
b. Using synchroscope.

Now we discuss in detail about these methods.

(a) Using Incandescent lamp:

Let machine G2 be synchronized with machine G1 which is already connected with the bus bar, using three lamps (L1, L2 and L3) method. These lamps are known as synchronizing lamps connected as shown in Fig.1

If the speed of machine 2 is not brought upto that of machine 1 then its frequency will also be different, hence there will be a phase difference between their voltages as shown in Fig.2. Due to difference in frequencies the resultant voltage will under go changes similar to the frequency changes of beats produced when two sound sources of nearly equal frequencies are sounded together.

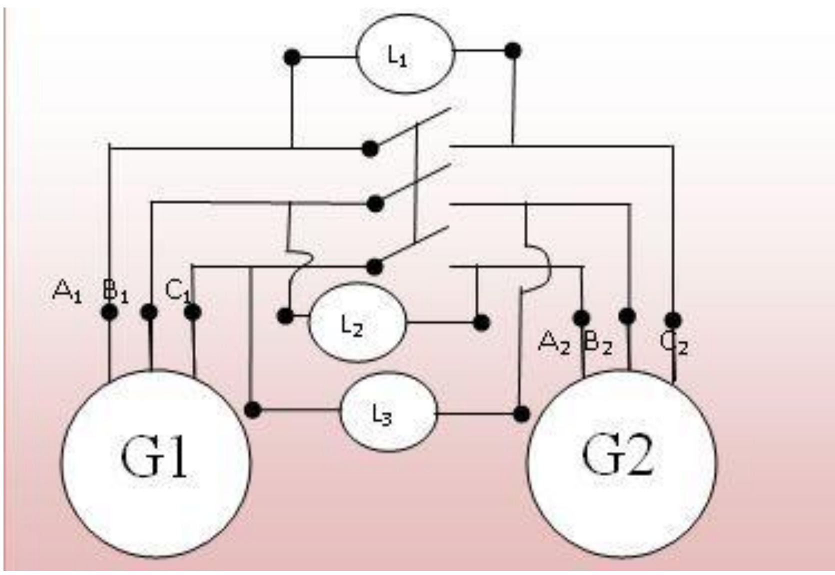


Fig. 1 Synchronization using three lamp method

The resultant voltage is sometimes maximum and sometimes minimum. Hence, the lamps will flicker, sometimes dark and sometimes bright. Synchronization is done at the middle of the dark period. This method of synchronizing is known as dark lamp method.

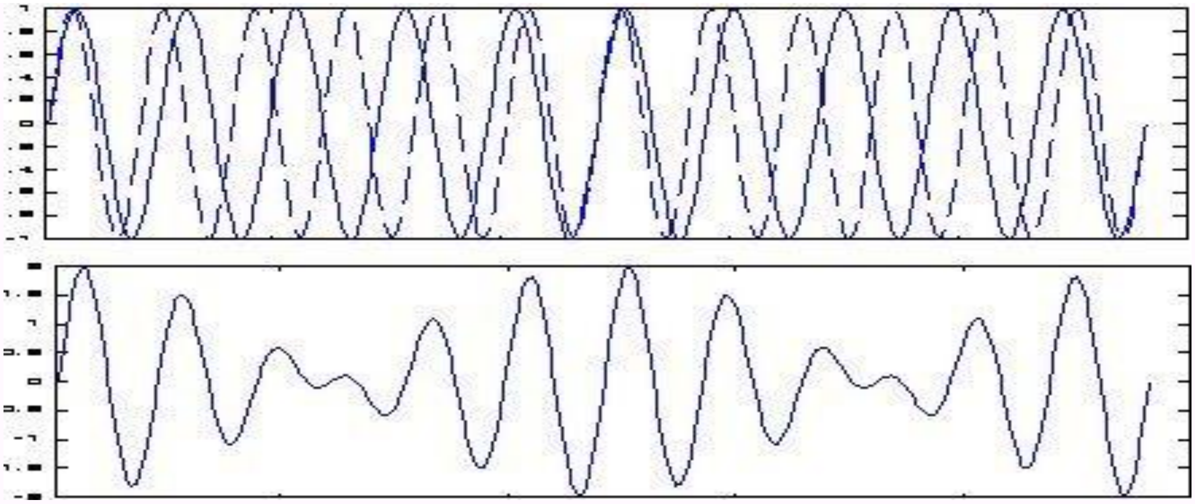


Fig. 2 Waveforms when two systems operating at different frequencies

Lamp L1 is connected between A1 and A2, L2 between B1 and C2 and L3 between C1 and B2. These three lamps slowly brighten and darken in cyclic successor in a direction depending upon whether incoming machine 2 is fast or slow. The synchronizing switch will be closed at the moment when lamp L1 will be completely dark. This transposition of two lamps suggested by Siemens and Aalske helps to indicate

Whether the incoming machine 2 is running too slow or too fast. If lamps were connected symmetrically, they would dark out or glow up simultaneously (if phase rotation is same.).

This method has following drawbacks:

The lamps become dark at about one third of the rated voltage. Hence, faulty synchronizing may be done in dark period.

1. Using this method it is not possible to find out that how much the� machine is slow or fast.
2. This method is not applicable for high voltage alternators, because lamp ratings are normally low. For such situations we need an extra transformer to step down the voltage.

(b) SYNCHRONIZING BY SYNCHROSCOPE:

Synchroscope is a device that shows the correct instant of closing the synchronizing switch with the help of a pointer which will rotate on the dial. The rotation of pointer also indicates whether the incoming machine is running too slow or too fast. If incoming machine is slow then pointer rotates in anticlockwise direction and if machine is fast then pointer rotates in clockwise direction.

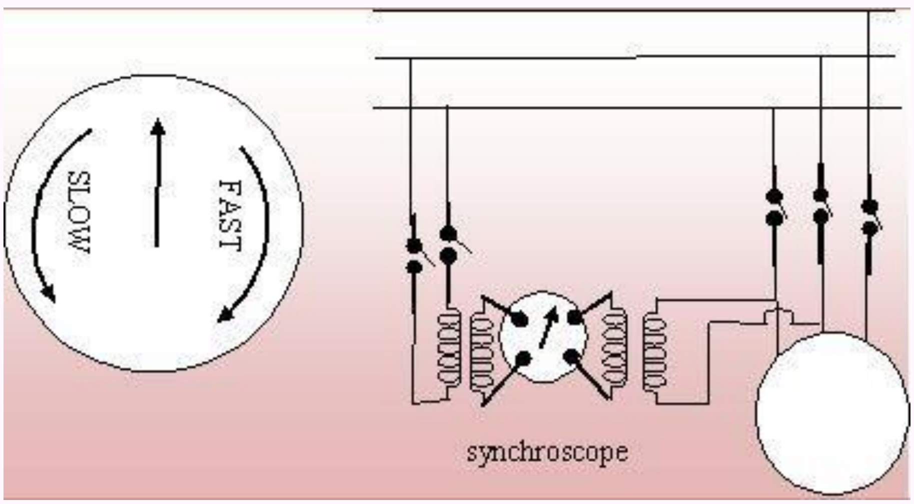
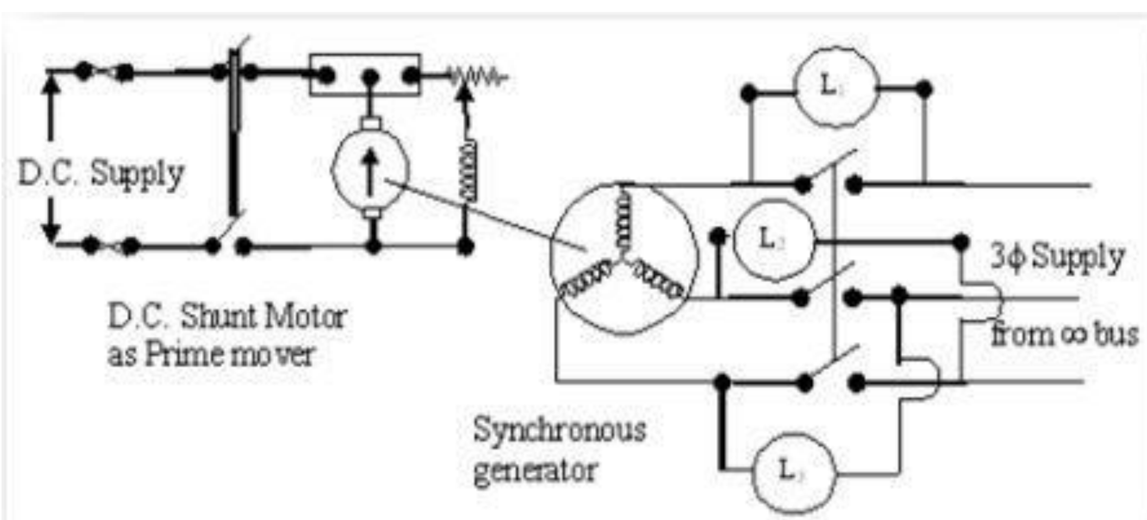


Fig. 3 Synchronizing by Synchroscope

CIRCUIT DIAGRAM:

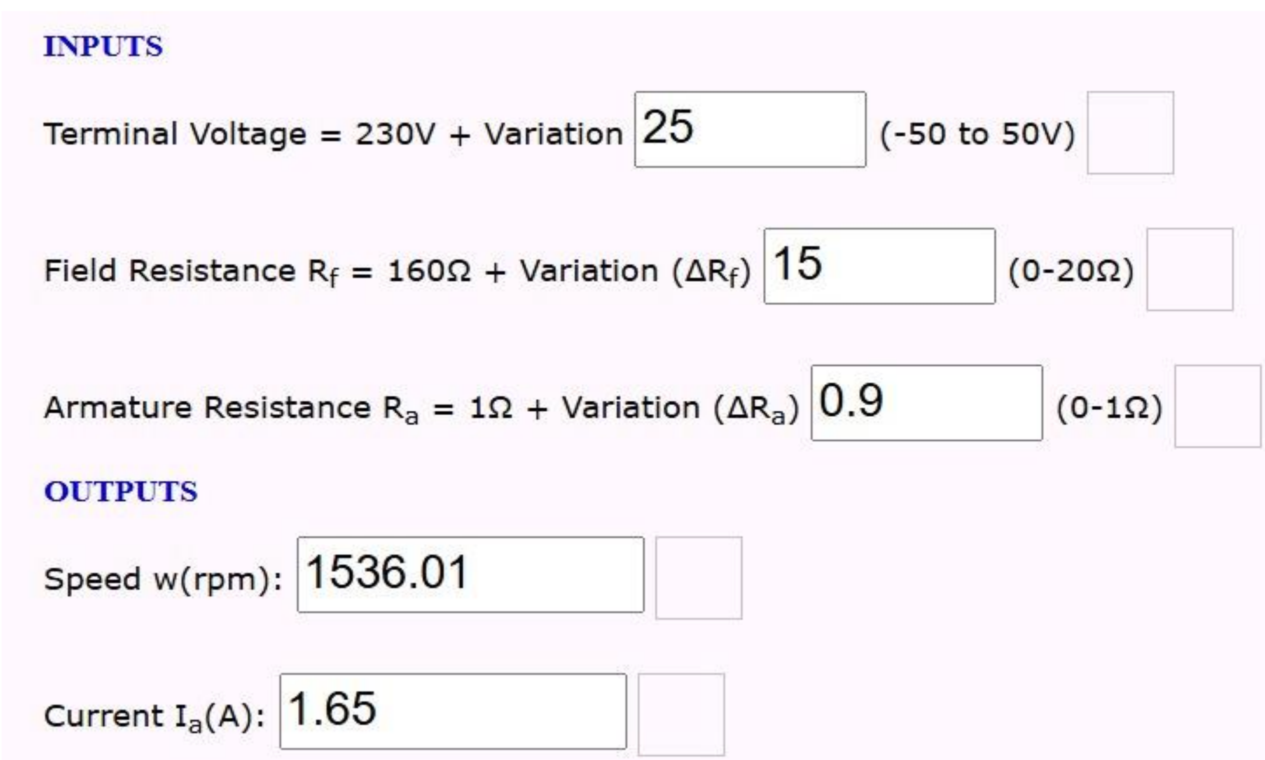


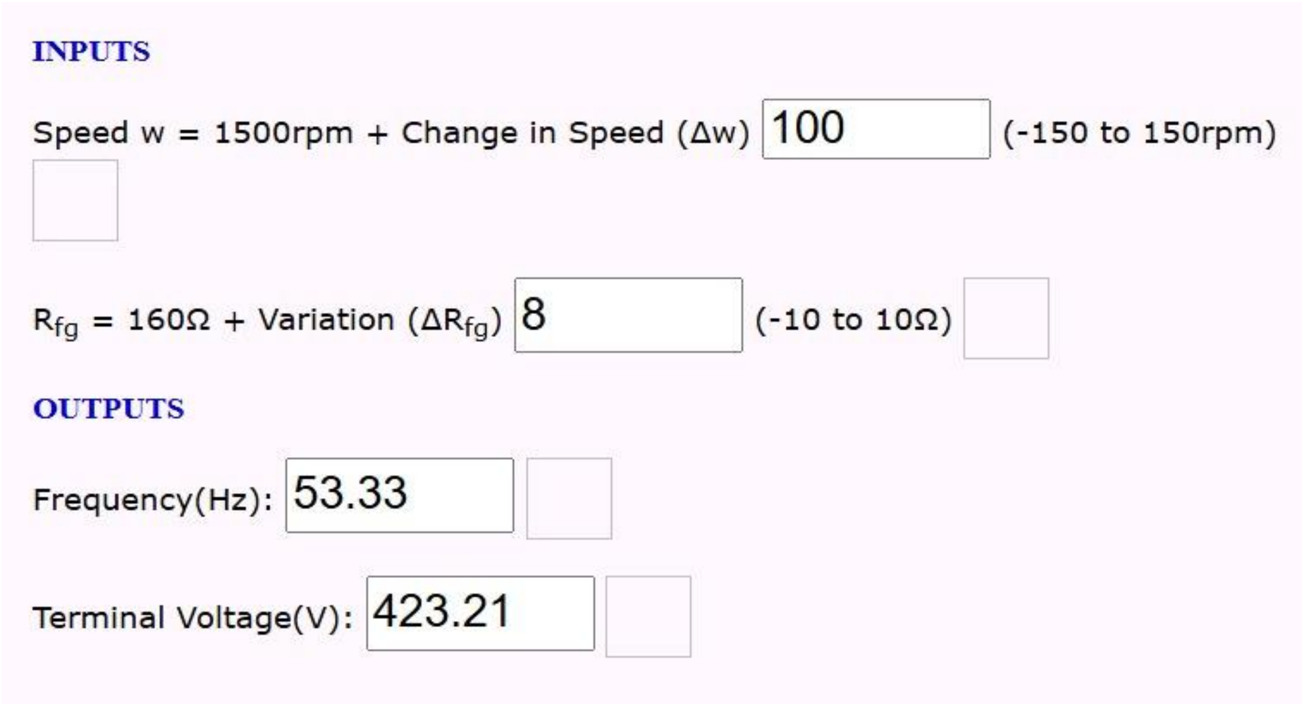
PROCEDURE:-

1. Make the connections.
2. Run one of the alternators and adjust its voltage at rated value and close the switch to connect with the bus bar.
3. Start the second set (incoming machine 2), bring it upto proper speed equal to that of the running machine (bus bar voltage).
4. Synchronize the incoming machine by any one synchronization method.

OBSERVATION:-

1. Measure and adjust voltage of incoming machine (Vg) and bus bar (Vs) till Vg=Vs.
2. Measure and adjust the speed of incoming machine, till synchroscope needle creeps.
3. Close synchronizing switch





RESULT:- Hence The alternator was successfully synchronized with the infinite bus bar at 53.33Hz frequency and 25v voltage

OUTCOME:- By doing this Experiment CO5 and PO1,PO2,PO3,PO5,PO8,PO9, PO10,PO11,PO12.PSO1,PSO2 are Attained