NEHRU COLLEGE OF ENGINEERING AND RESEARCH CENTRE
(NAAC Accredited)
(Approved by AICTE, Affiliated to APJ Abdul Kalam Technological University, Kerala)

Moulding True Citizen
Since 1968

DEPARTMENT OF MECHATRONICS ENGINEERING

LAB MANUAL

MRL 201 ELECTRICAL TECHNOLOGY LAB

VISION OF THE INSTITUTION

To mould true citizens who are millennium leaders and catalysts of change through excellence in education.

MISSION OF THE INSTITUTION

NCERC is committed to transform itself into a center of excellence in Learning and Research in Engineering and Frontier Technology and to impart quality education to mould technically competent citizens with moral integrity, social commitment and ethical values.

We intend to facilitate our students to assimilate the latest technological know-how and to imbibe discipline, culture and spiritually, and to mould them in to technological giants, dedicated research scientists and intellectual leaders of the country who can spread the beams of light and happiness among the poor and the underprivileged.

ABOUT DEPARTMENT

- Established in: 2013
- Course offered: B.Tech Mechatronics Engineering
- Approved by AICTE New Delhi and Accredited by NAAC
- Affiliated to the University of A P J Abdul Kalam Technological University.

DEPARTMENT VISION

To develop professionally ethical and socially responsible Mechatronics engineers to serve the humanity through quality professional education.

DEPARTMENT MISSION

1) The department is committed to impart the right blend of knowledge and quality education to create professionally ethical and socially responsible graduates.

2) The department is committed to impart the awareness to meet the current challenges in technology.

3) Establish state-of-the-art laboratories to promote practical knowledge of mechatronics to meet the needs of the society

PROGRAMME EDUCATIONAL OBJECTIVES

I. Graduates shall have the ability to work in multidisciplinary environment with good professional and commitment.

II. Graduates shall have the ability to solve the complex engineering problems by applying electrical, mechanical, electronics and computer knowledge and engage in lifelong learning in their profession.

III. Graduates shall have the ability to lead and contribute in a team with entrepreneur skills, professional, social and ethical responsibilities.

IV. Graduates shall have ability to acquire scientific and engineering fundamentals necessary for higher studies and research.

PROGRAM OUTCOME (PO'S)

Engineering Graduates will be able to:

PO 1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2. 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.

PO 3. 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.

PO 4. 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.

PO 5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6. 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.

PO 7. 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.

PO 8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10. 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.

PO 11. 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.

PO 12. 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.

PROGRAM SPECIFIC OUTCOME(PSO'S)

PSO 1: Design and develop Mechatronics systems to solve the complex engineering problem by integrating electronics, mechanical and control systems.

PSO 2: Apply the engineering knowledge to conduct investigations of complex engineering problem related to instrumentation, control, automation, robotics and provide solutions.

PREPARATION FOR THE LABORATORY SESSION

GENERAL INSTRUCTIONS TO STUDENTS

1. Read carefully and understand the description of the experiment in the lab manual. You may go to the lab at an earlier date to look at the experimental facility and understand it better. Consult the appropriate references to be completely familiar with the concepts and hardware.

2. Make sure that your observation for previous week experiment is evaluated by the faculty member and your have transferred all the contents to your record before entering to the lab/workshop.

3. At the beginning of the class, if the faculty or the instructor finds that a student is not adequately prepared, they will be marked as absent and not be allowed to perform the experiment.

4. Bring necessary material needed (writing materials, graphs, calculators, etc.) to perform the required preliminary analysis. It is a good idea to do sample calculations and as much of the analysis as possible during the session. Faculty help will be available. Errors in the procedure may thus be easily detected and rectified.

5. Please actively participate in class and don't hesitate to ask questions. Please utilize the teaching assistants fully. To encourage you to be prepared and to read the lab manual before coming to the laboratory, unannounced questions may be asked at any time during the lab.

6. Carelessness in personal conduct or in handling equipment may result in serious injury to the individual or the equipment. Do not run near moving machinery/equipment. Always be on the alert for strange sounds. Guard against entangling clothes in moving parts of machinery.

7. Students must follow the proper dress code inside the laboratory. To protect clothing from dirt, wear a lab coat. Long hair should be tied back. Shoes covering the whole foot will have to be worn.

8. In performing the experiments, please proceed carefully to minimize any water spills, especially on the electric circuits and wire.

9. Maintain silence, order and discipline inside the lab. Don’t use cell phones inside the laboratory.

10. Any injury no matter how small must be reported to the instructor immediately.

11. Check with faculty members one week before the experiment to make sure that you have the handout for that experiment and all the apparatus.

AFTER THE LABORATORY SESSION

1. Clean up your work area.

2. Check with the technician before you leave.

3. Make sure you understand what kind of report is to be prepared and due submission of record is next lab class.

4. Do sample calculations and some preliminary work to verify that the experiment was successful

MAKE-UPS AND LATE WORK

Students must participate in all laboratory exercises as scheduled. They must obtain permissionfrom the faculty member for absence, which would be granted only under justifiablecircumstances. In such an event, a student must make arrangements for a make-up laboratory, which will be scheduled when the time is available after completing one cycle. Late submission will be awarded less mark for record and internals and zero in worst cases.

LABORATORY POLICIES

1. Food, beverages & mobile phones are not allowed in the laboratory at any time.

2. Do not sit or place anything on instrument benches.

3. Organizing laboratory experiments requires the help of laboratory technicians and staff. Be punctual.

SYLLABUS

LIST OF EXPERIMENTS

1. Brake test on DC series motor
2. Brake test on DC shunt motor.
3. Open circuit characteristics of dc shunt generator
4. Load test on dc shunt generator
5. Retardation test on a DC machine.
6. Load test on single phase transformer
7. OC and SC test on single phase transformer
8. Three phase power measurement using two wattmeter method
9. Load test on three phase squirrel cage induction motor
10. Load test on three phase slip ring induction motor
11. No load and block rotor test on three phase slip ring induction motor
12. Regulation of alternator by direct loading
13. Static characteristics of SCR.
14. Static characteristics of MOSFET.
15. Obtain output waveform of single phase bridge rectifier using SCR.

N.B Minimum of TEN experiments from the above list are to be done.

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VERIFICATION BY HOD

INTERNAL EXAMINER **EXTERNAL EXAMINER**

EXPERIMENT 1

BRAKE TEST ON DC SERIES MOTOR

AIM

To conduct Load test on DC series motor and plot the performance characteristics.

APPARATUS REQUIRED

Sl. No.	Name of the instrument	Specification	Quantity
1	Ammeter	(0-15)A, MC	1 No.
2	Voltmeter	(0-250)V, MC	1 No.
3	Tachometer		1 No.

PRINCIPLE

In a series motor, the field winding is connected in series with the armature winding. Thus the same current flows through the field and armature windings. Speed of a dc series motor.

$$N = \frac{V - I_a(R_a + R_{se})}{K_e \times \phi}$$

Where Ia is the armature current, Ra is the armature resistance, Rse is the series field resistance, ϕ is the flux per pole and N is the speed in rpm.

Electrical characteristics (T vs Ia):- It shows the variation of torque with the armature current.

We have

T α ϕIa where ϕ is the flux/pole

α IaIa (as ϕ α Ia up to the point of magnetic saturation)

Thus T α Ia2

However after magnetic saturation ϕ remains almost constant, Hence Tα Ia. Thus the curve is a parabola up to magnetic saturation and shows a linear variation after the point.

Mechanical Characteristics (N1 vs T): It shows the variation of speed with torque.

We have $N \propto \frac{Eb}{\emptyset} \propto \frac{1}{\emptyset}$ as Eb is almost constant where Eb is back emf.

In a series motor $\emptyset \alpha$ Ia. So $N \propto \frac{1}{Ia}$

That is, as Ia increases, Speed decreases. The same pattern is followed in the N-T characteristics. The curve traced is a rectangular hyperbola. A series motor should never be started at no load. At no load, Ia is very small, hence the speed of the motor becomes dangerously high as N α 1/Ia

The efficiency of a small motor can be measured directly by brake test. The motor is loaded directly by a belt placed on a pulley mounted on the shaft of the motor. The desired load is put by tightening belt. The tension applied on the belt is measured by using spring balance.

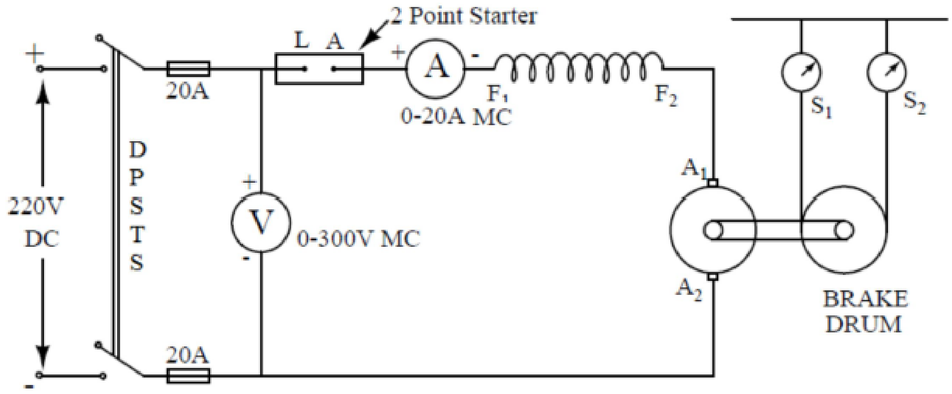
Output Torque = (S1-S2) x R x 9.81 Nm.

Where W1 is the tension on the tight side of brake in Kg. W2 is the tension on the slack side of the brake in Kg. R is the radius of the pulley in m. If N is the speed of the motor in rpm, then Power Output = ((S1-S2) x R x 9.81x 2πN)/60

PROCEDURE

1. Connections are made as per the circuit diagram.
2. Apply some load to the motor using spring and break drum.
3. Switch on the motor using the starter.
4. Note down the motor voltmeter reading and keep it at rated value.
5. Note down the current and spring balance readings.
6. The experiment is repeated for different loads till the rated current of the machine is reached.
7. During the experiment when the machine gets heated up, it is cooled by pouring water into the brake-drum.
8. The load is then reduced till the current reaches a small value and the supply is switched off.

CONNECTION DIAGRAM



OBSERVATIONS

Voltage (V)	Current (A)	Speed (RPM)	Weight		Torque (N-M)	Input Power W1(Watts)	Output power W2(Watts)	Efficiency (%)
			S1(kg)	S2(kg)				

SAMPLE CALCULATIONS

Sample Calculation (set no III)

Voltmeter reading (V) =

Current (I) =

Speed (N) =

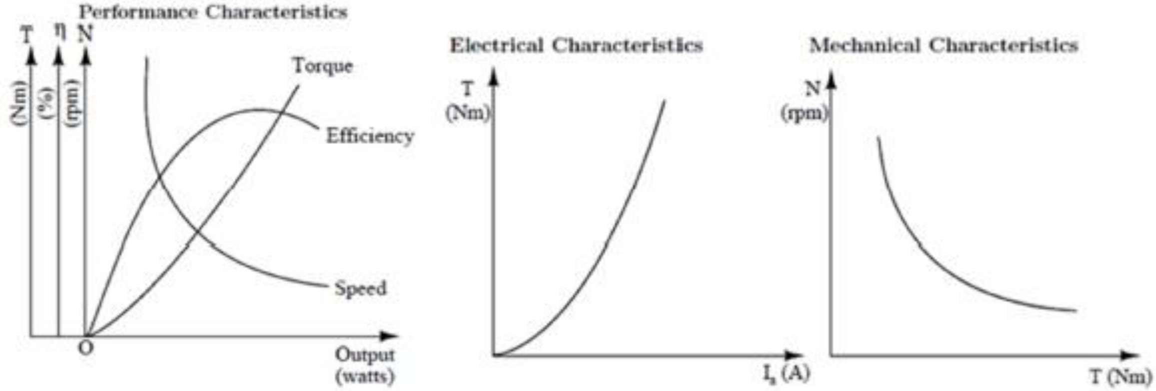
Torque (T) = 9.81 (S1 − S2) R =

Where R is the radius of brake drum.

Output power= (2πNT)/60=

Input power = V I =

Efficiency = Output power/ Input power =



RESULTS AND DISCUSSIONS:-

Torque =

Input power = V I =

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

Efficiency = Output power/ Input power =

CONCLUSION:

VIVA QUESTIONS

1. What is the precaution to be taken when working with a d-c series motor?
2. What is the need for starter with a d-c motor?
3. What is the condition for maximum efficiency in a d-c motor?
4. What are the different losses occurring in a d-c machine?
5. Give some applications of d-c series motor.

EXPERIMENT 2

BREAK TEST ON DC SHUNT MOTOR

AIM

To conduct Load test on DC shunt motor and plot its performance characteristics.

APPARATUS REQUIRED

Sl. No.	Name of the instrument	Specification	Quantity
1	Ammeter	(0-20)A, MC	1 No.
2	Voltmeter	(0-300)V, MC	1 No.
3	Rheostat	1300Ω; 1.5A	1 No.
4	Tachometer		1 No.

PRINCIPLE

A shunt DC motor connects the armature and field windings in parallel or shunt with a common D.C. power source. When electric voltage is supplied to the shunt DC motor, due to high resistance of the shunt winding, it draws very low current. The higher number of turns of the shunt winding helps in generating a strong magnetic field. The armature draws high current, thus also generating a high magnetic field. The motor starts rotating as the magnetic field of the armature and shunt winding interact. As the magnetic fields grow stronger, rotational torque will increase, thus resulting in an increase of rotational speed of the motor.

$$N = \frac{V - I_a R_a}{K_e \times \phi}$$

Where Ia is the armature current, Ra is the armature resistance, ϕ is the flux per pole and N is the speed in rpm.

Output Torque = (S1-S2) x R x 9.81 Nm

Where W1 is the tension on the tight side of brake in Kg. W2 is the tension on the slack side of the brake in Kg. R is the radius of the pulley in m. If N is the speed of the motor in rpm, then

Power Output = ((S1-S2) x R x 9.81x 2πN)/60

PRECAUTIONS:

1. DC shunt motor should be started and stopped under no load condition.
2. Field rheostat should be kept in the minimum position.
3. Brake drum should be cooled with water when it is under load.

PROCEDURE

1.Connections are made as per the circuit diagram.

2.After checking the no load condition, and minimum field rheostat position, DPST switch is closed and starter resistance is gradually removed.

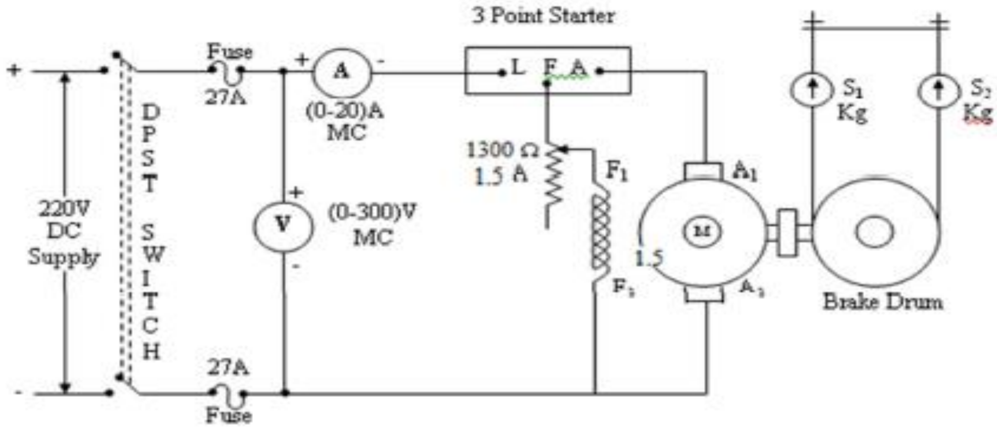
3.The motor is brought to its rated speed by adjusting the field rheostat.

4.Ammeter, Voltmeter readings, speed and spring balance readings are noted under no load condition.

5.The load is then added to the motor gradually and for each load, voltmeter, ammeter, spring balance readings and speed of the motor are noted.

6.The motor is then brought to no load condition and field rheostat to minimum position, then DPST switch is opened.

CONNECTION DIAGRAM



FUSE RATING:

125% of rated current

$\frac{125 \times \text{rated current}}{100} =$

NAME PLATE DETAILS:

Rated Voltage : 220V
Rated Current :
Rated Power :
Rated Speed :

OBSERVATIONS

SL NO	V (VOLT)	I (AMP)	S1 (KG)	S2 (KG)	SPEED (RPM)	TORQUE (NM)	OUTPUT (WATTS)	INPUT (WATTS)	EFFICIENCY %
1									
2									
3									
4									
5									
6									
7									

SAMPLE CALCULATIONS

Sample Calculation (set no.: 3)

Voltmeter reading (V) =

Current (I) =

Spring balance readings, S1 = & S2 =

Speed (N) =

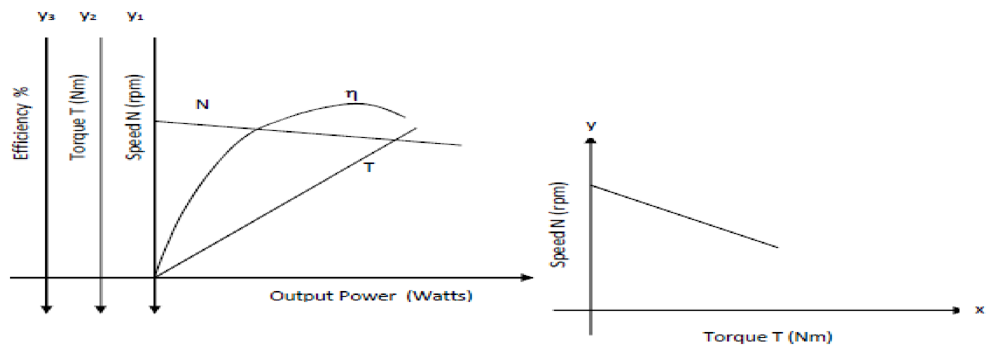
Torque (T) = 9.81 (S1 − S2) R = Where R is the radius of brake drum.

Output power = (2πNT)/60 =

Input power = V I =

Efficiency = Output power/ Input power =

MODEL GRAPHS:



RESULTS AND DISCUSSIONS

CONCLUSION

VIVA QUESTIONS

1. What is the significance of back emf in a d-c motor?
2. What is the difference between a three point starter and a four point starter?
3. What are the different methods to control speed of a d-c shunt motor?
4. What are the different factors which make effects on efficiency of a d-c machine?
5. Give some applications of d-c shunt motor.

EXPERIMENT 3

OCC OF DC SHUNT GENERATOR

AIM

To obtain the open circuit characteristics of the given DC shunt generator at its rated speed and determine the Critical resistance and Critical speed.

APPARATUS REQUIRED

Sl:no	Name of the instrument	Specification	Quantity
1	Ammeter	(0-20)A, MC	1 No
2	Voltmeter	(0-300)V, MC	1 No
3	DC Motor Generator Set		1 No
4	Rheostat	1300 ohm, 1.5 A	1 No
5	Tachometer		1 No

MACHINE DETAILS

Take down the name plate ratings of motor

SL:no	DC Motor	DC Generator

1	KW-3.7	KW-3
2	RPM-1500	RPM-1500
3	AMPS-16	AMPS-13
4	VOLTS-220	VOLTS-220

Apparatus: DC Motor Generator Set, Rheostat, Voltmeters, Ammeters, Tachometer, Required number of connecting wires

PRINCIPLE

The O.C.C is a curve showing the relationship between the no load emf generated and the shunt field current (Eo and If). Even when the field current is zero there is some residual magnetism present in the poles. Hence there is a small voltage generated even at zero field current, which is called the residual voltage. As the field current is increased, Eo also increases and the curve traced is almost a straight line. As If is further increased the poles start getting saturated, the straight line relation no longer holds good and the curve bends and becomes almost horizontal. In a D.C. generator, for any given speed, the induced emf in the armature is directly proportional to the flux per pole.

$E_g = (\Phi ZNP)/60A$

Volts Where Φ is the flux per pole in Weber's,

Z is the no. of conductors in the armature,

N is the speed of the shaft in rpm,

P is the no. of poles and

A is the no. of parallel paths.

A = 2 (wave)

A = P (lap)

Critical resistance:

It is that value of resistance in the field circuit at which the generator will just excite (or voltage build up begins). If the resistance is higher, the machine will fail to build up voltage. It is given by the slope of the tangent drawn to the linear portion of the magnetization curve from the origin.

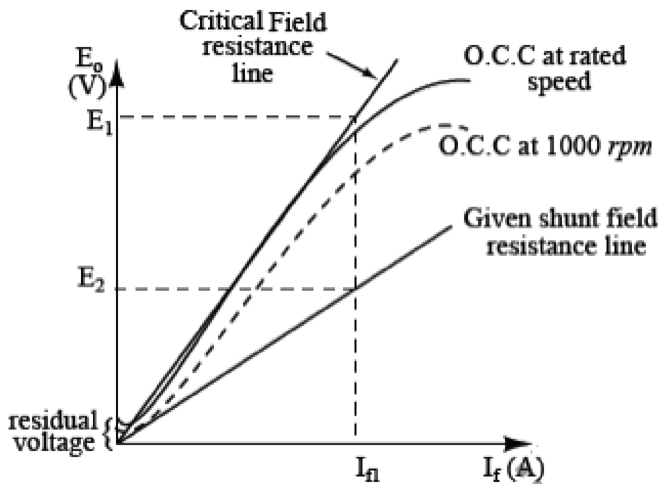
Conditions for voltage build up in a d.c shunt generator

1. There should be some residual magnetism in the poles.
2. For the given direction of rotation, the shunt field coils should be properly connected. That is, the coils should be so connected that the flux generated by the field current aids the residual flux.
3. When excited at no load, the shunt field circuit resistance should be less than the critical resistance

Critical speed:

It is that value of speed at which the given shunt field resistance represents the critical resistance. It is determined as follows. For the same value of If determine E1 and E2 from the field resistance lines. Then E1/E2 =N1/Nc ; Nc = (E2/E1)N1

Where, Nc is the Critical speed



Procedure:

1. Connections are made as per the circuit diagram.
2. Motor field rheostat is kept in minimum position.
3. Generator field rheostat is kept in maximum position.
4. D.C. Generator is driven at its rated speed with the help of prime mover (DC shunt motor).
5. Gradually the field rheostat of generator is varied in steps to get field current in steps and armature terminal voltage is measured in each step.
6. Step 5 is repeated till 120% of rated voltage is obtained.
7. Then, the field current of generator is decreased and the armature terminal voltage is noted in each step.
8. The O.C.C curve is plotted

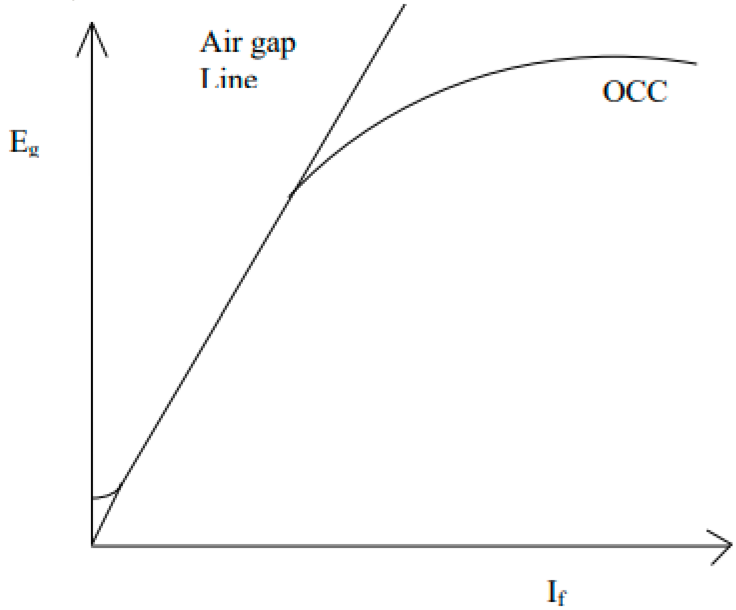
Observations:

SL:no	E1(V)	IE (A)
1		

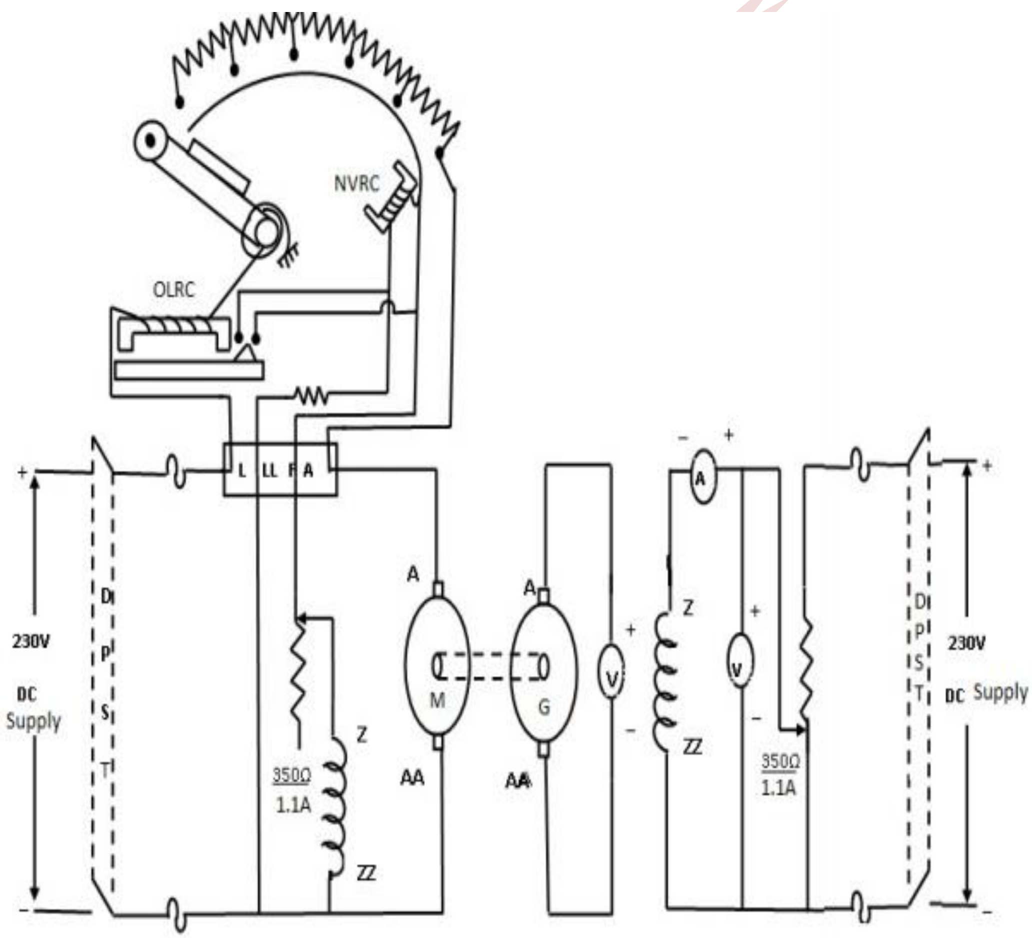
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		

SL-No	Voltage (V)	Current (A)	Rsh= V/I ohm
1			
2			
3			
4			
5			

GRAPHS:



Circuit Diagram:



Result:

Residual voltage=

Critical Resistance = Rc =

Critical Speed = Nc =

CONCLUSION:-

Viva Questions:

1. What is the need for starter in a d.c motor?
2. How does a 3-point starter function?
3. Why is Rheostat of dc motor kept in minimum position at starting?
4. Why is Rheostat of generator kept in maximum position at start up?
5. What is residual voltage? How is it measured?
6. What is critical resistance? How can it be determined?
7. What are the conditions necessary for voltage build up in a d.c shunt generator?
8. What is critical speed?
9. Explain the shape of OCC.

EXPERIMENT 4

LOAD TEST ON DC SHUNT GENERETOR

AIM

To determine the external and internal characteristic of a DC shunt generator.

APPARATUS REQUIRED

Sl:no	Name of the instrument	Specification	Quantity
1	Ammeter	(0-20)A, MC	1 No
2	Ammeter	(0-2)A, MC	1 No
3	Voltmeter	(0-300)V, MC	1 No
4	Rheostat	360 ohm, 1.4 A	2 No
5	Tachometer		1 No

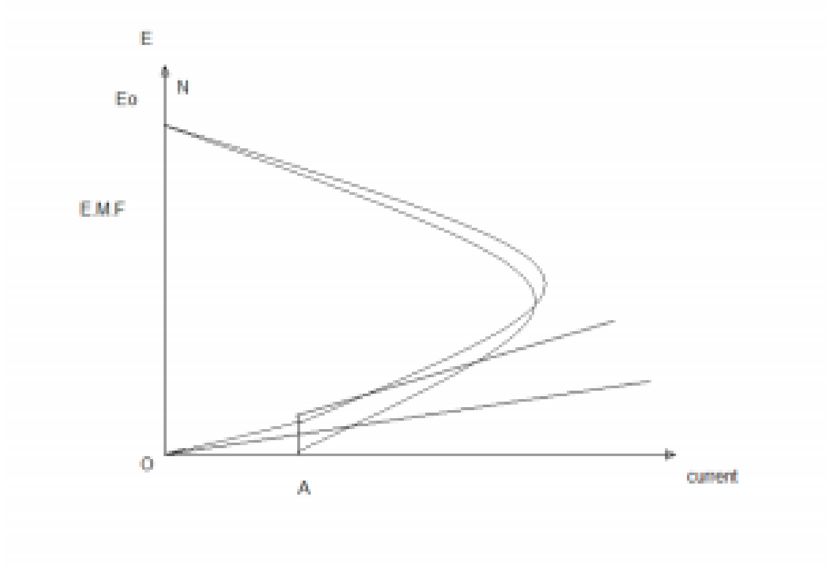
PRINCIPAL

In a DC shunt generator, on no-load the terminal pd. is equal to the no load induced e.m.f. E. When the armature delivers current, i.e. the generator is loaded:

a) The induced e.m.f. decreases because the armature reaction reduces the flux per pole.

b) V becomes less than E because of the voltage drop Ia Ra, where Ra is the total resistance of the armature circuit.

The graph of induced e.m.f. against armature current is the internal characteristic , and the graph of terminal voltage against load current is the external characteristic, or voltage characteristic .We see both the characteristic drop from no load point, N, the second more than the first, as shown. When the load current Il progressively increased (by reducing the load resistance), at first the tendency of decreased resistance to increase the current is greater than the tendency of the armature reaction and the voltage drop to reduced terminal potential Difference and therefore, the current. Eventually a point will be reached at which these two effects neutralize each other. Beyond that second tendency will be predominate and the characteristic will turn back as shown.



The point A at which the external characteristic cuts the current axis corresponds to short circuit- a gradual short circuit. The internal characteristic stops short at B directly above A, and the distance AB gives the internal e.m.f. required to produce the short circuit current, OA. If a tangent OP is drawn to the internal characteristic the resistance represented by its slope gives the minimum external resistance for which the generator will excite if it has to build up its field with the load circuit closed. If the external resistance is less than represented by the slope of OP, it will fail to excite. Thus the shunt generator has two critical resistances, one for the field circuit and other for the external circuit.

In a shunt generator, Ia=Il+If , where, Ia is armature current, Il is the load current and If shunt fiend current and E0=VT+ IaRa, E0=induced e.m.f. in armature, VT=Terminal voltage, Ra=armature winding resistance. Thus, once the external characteristic of the shunt generator is known, and after drawing the IaRa line , the internal characteristic can be determined. The value of Ra can be found out conventionally by the voltage drop method, as shown.

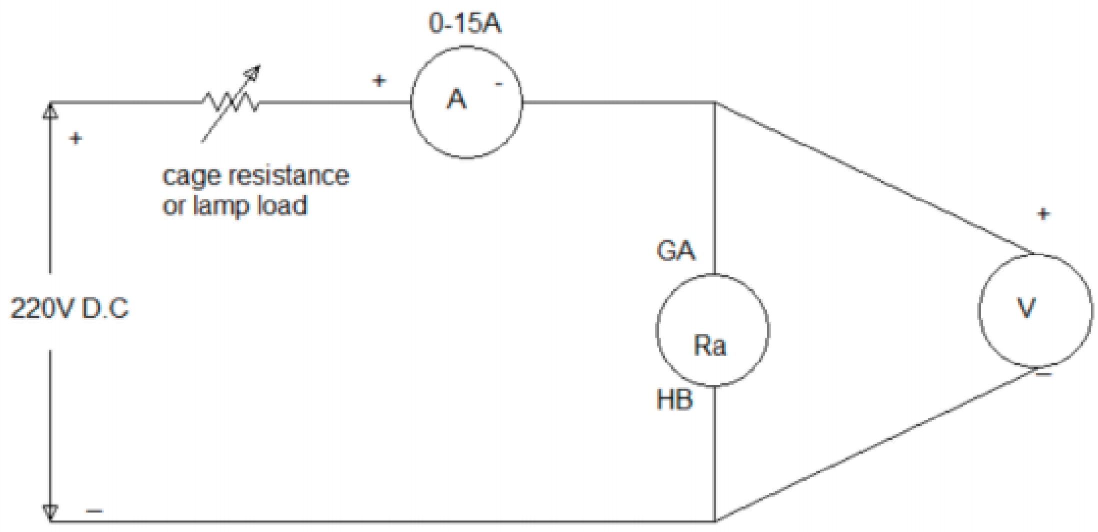
PROCEDURE:

1. Connect the circuit as shown in the diagram.
2. Start the motor with the help of the starter and obtain the rated speed.
3. In the experiment, it is necessary to obtain the no load e.m.f. of the shunt generator which will give the rated voltage at rated load (see the specification on the name plate of the generator). This is achieved by adjusting the field regulator so that the generator induced e.m.f. is well above the rated voltage and then actually loading is to its rated voltage at rated load current.
4. Once the step 3. Is obtained at rated speed of the generator, note down the meter readings and the speed of the generator

5. Reduce the load on the generator so as to obtain at least about 10 sets of readings

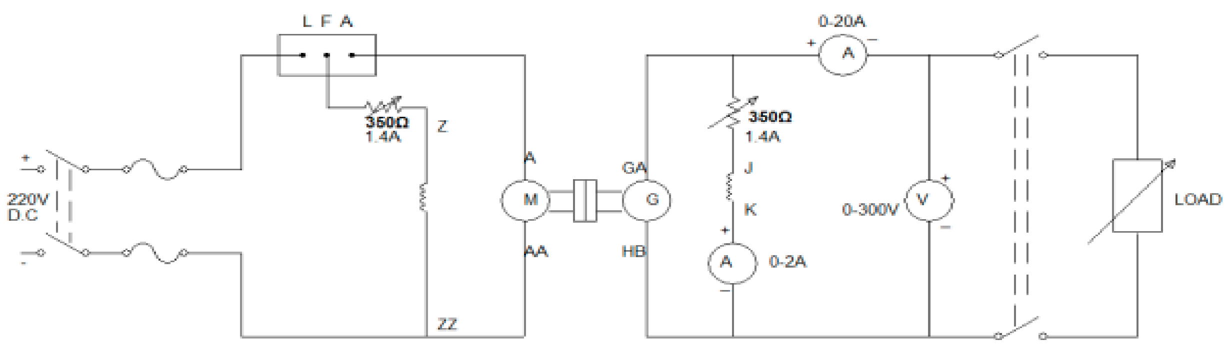
6. Switch off all the loads, reduce field current of the generator and then switch off the motor

7. Measure armature resistance Ra of the generator, or its value may be supplied.



Measurement of Ra

CIRCUIT DIAGRAM



Observation Table 1

Field Current I1(A)	Load Current I1(A)	Armature Current Ia=I1+If(A)	Terminal Voltage (V)	Armature Drop (v)	Generator Voltage (V)

Observation Table 2

Voltage (V)	Current (A)	Ra=V/I (ohm)

RESULT AND DISCUSSION:

CONCLUSION:

VIVA QUESTIONS

1. Specify the applications of DC shunt generators.
2. Differentiate between DC shunt Motor and DC shunt generator.
3. Which method is suitable for testing of high rating DC generator?
4. Why the terminal voltage decreases when load is increased on the generator?

EXPERIMENT 5

LOAD TEST ON DC SERIES MOTOR

AIM

To conduct load test on dc series motor and the plot the performance

APPARATUS REQUIRED

SL NO.	NAME OF THE INSTRUMENT	SPECIFICATIONS	QUANTITY
1	AMMETER	(0-15)A MC	1 NOS
2	VOLTMETER	(0-150)MC	1 NOS
3	TACHOMETER		

MACHINE DETAILS

Take down name plate details of motor

SL NO.	NAME PLATE DETAILS	
1	VOLTMETER	220 V
2	RATED CURRENT	16 A
3	SPEED(RPM)	1500 RPM

PRINCIPLE

In a series motor the field winding is in series with the armature winding. Thus the

Same current flows through the field and armature winding speed of a dc series motor.

$$N = \frac{V - I_a(R_a + R_{se})}{K_e * \phi}$$

Ra the armature coil resistence is the series field resistance, ϕ is the flux per pole

And N is the speed in RPM

Electrical characteristic (T vs la);- it shows the variation of torque with the armature current we have

T directly **proportional to** ϕI_a

T directly **proportional to** Ia I_a (as ϕ directly proportional to Ia up to the point of magnetic saturation).

Thus, T directly **proportional to** Ia^2

However, after magnetic saturation ϕ remains almost constant, Hence T directly **proportional to** Ia. Thus the curve is a parabola up to magnetic saturation and shows a linear variation after the point

Mechanical characteristics (N1 Vs T): It shows the variation of speed with torque.

We have N **directly proportional to** Eb/ϕ **directly proportional to** I/ ϕ as Eb is almost constant, where Eb is back EMF.

In a series motor ϕ **directly proportional to** Ia.

So N **directly proportional to** 1/Ia, i.e., as Ia increases, speed decreases. The same pattern is followed in the N-T characteristics. The cure traced is a rectangular hyperbola. A series motor should never be started at no load. At no load, Ia is very small, hence the speed of motor become dangerously high as N **directly proportional to** 1/Ia.

The efficiency of a small motor can be measured directly by brake test. The motor is loaded directly by a belt placed on a pulley mounted on the shaft of the motor. The desired load is put by tightening belt. The tension applied on the belt is measured by using spring balance.

Output torque=(s1-s2)xRx9.81 Nm

Where w1 is the tension on the tight side of the brake in kg.

W2 is the tension on the slack side of the brake in kg.

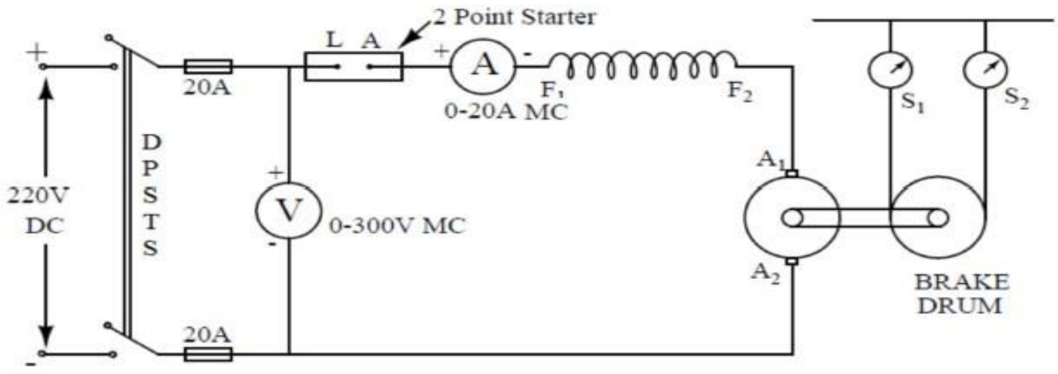
R is the radius of the pulley in m.

If N is the speed of the motor in rpm, then power output=(s1-s2)xRx9.81x2π/60 N

PROCEDURE

1. Connections are made as per the circuit diagram.
2. Apply some load to the motor using spring and brake drum.
3. Switch on the motor using the starter.
4. Note down the motor voltmeter reading and keep it at a rated value.
5. Note down the current and the spring balance readings.
6. The experiment is repeated for different loads till the rated current of the machine is reached
7. During the experiment, when the machine gets heated up, it is cooled by pouring water in the brake drum.
8. The load is then reduced till the current reaches a small value and the supply is switched off.

CIRCUIT DIAGRAM



OBSERVATION

SL No	V VOLTS	I Amp	S1 KG	S2 KG	SPEED RPM	TORQUE N.M	OUTPUT WATTS	INPUT WATTS	EFFICIENCY %
1									
2									
3									
4									
5									
6									

SAMPLE CALCULATION

Sample Calculation (set no.: 2)

Voltmeter reading (V) =

Current (I) =

Spring balance readings, S1 = S2 =

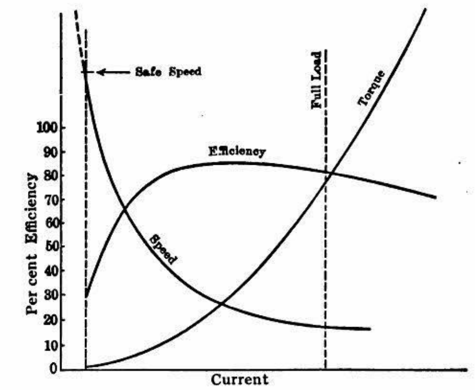
Speed (N) =

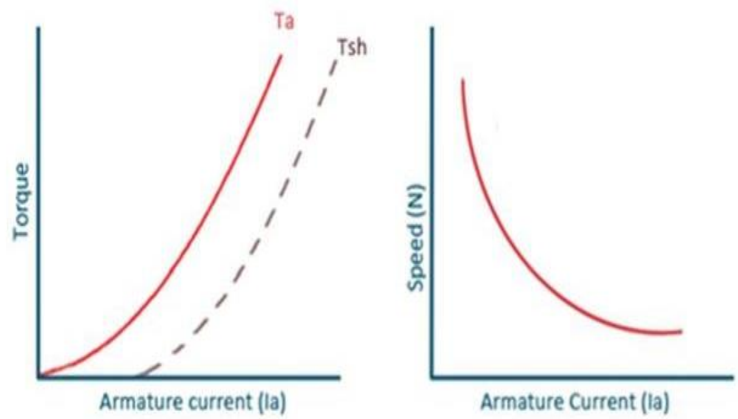
Torque (T) = 9.81 (S1 – S2) R= ; R is the radius of brake drum.

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

Input power = V I =

Efficiency=(output/input)*100=





RESULT AND DISCUSSION

CONCLUSION

EXPERIMENT 6

LOAD TEST ON SINGLE PHASE TRANSFORMER

AIM

To conduct load test on the given single phase transformer at unity power factor and determine the efficiency and regulation curve.

APPARATUS REQUIRED

Sl. No.	Name of the instrument	Specification	Quantity
1	Ammeter	(0-10)A,MI (0-5)A,MI	1 No. 1 No.
2	Voltmeter	(0-250)V, MI (0-150)V, MI	1 No. 1 No.
3	Wattmeter	150V,10A,UPF 300V, 5A, UPF	1 No. 1 No.
4	Autotransformer	230/(0-230)V	1 No.

PRINCIPLE

Regulation of a transformer is defined as the drop in terminal voltage of a transformer expressed as a percentage of the no-load terminal voltage.

$$\% \text{ Voltage Regulation} = \frac{V \text{ no load} - V \text{ on load}}{V \text{ no load}}$$

When a purely resistive load is connected across the secondary, the transformer will be working at unity power factor.

$$\text{Terminal voltage, } V = \text{Induced emf } [E_2] - I_2 r_2 - I_2 x_2$$

Where r2 and x2 are the secondary winding resistance and leakage reactance respectively and I2 is the secondary load current. The efficiency of transformer is defined as (output/input) x 100.

As the load current increases the power output increases.

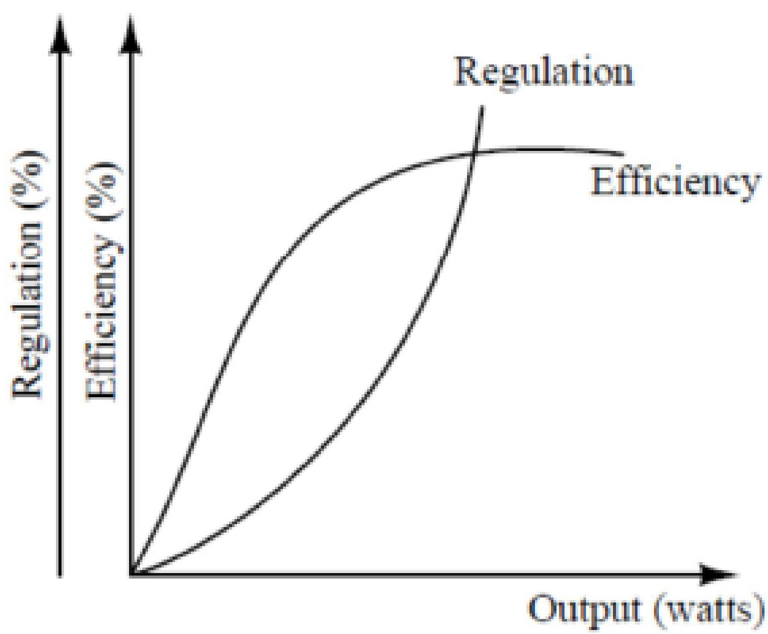
The iron loss remains constant from no load to full load. The copper loss increases as the square of the load current. Thus the efficiency curve starts from zero, increases to a maximum value

(When iron loss = Cu loss) and thereafter starts decreasing.

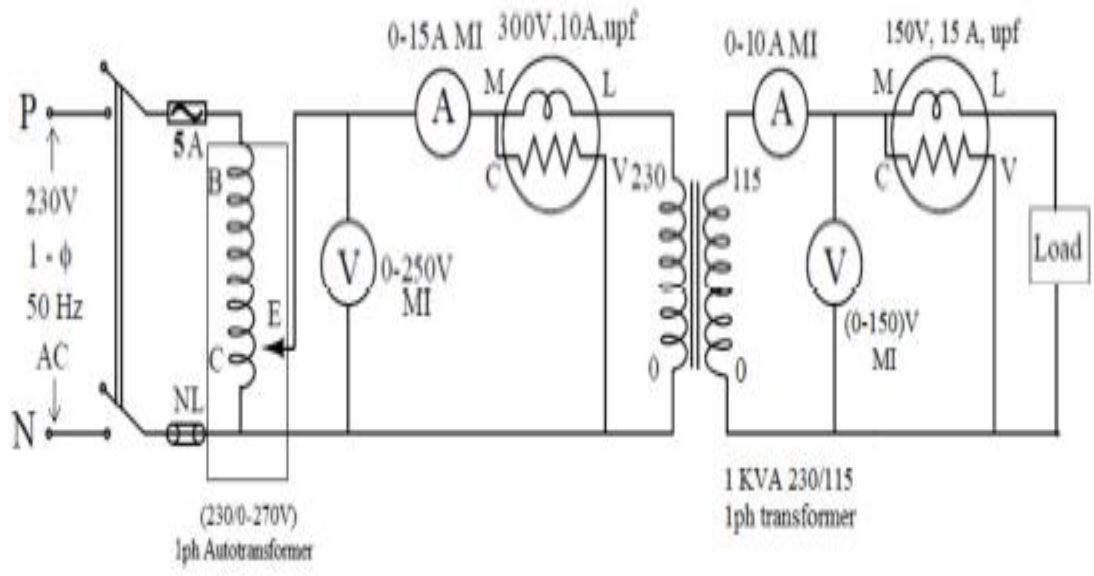
PROCEDURE

1. Connections are made as per the circuit diagram.
2. Auto transformer is kept at minimum position and supply was switched on.
3. Rated voltage is applied to the primary by varying the auto transformer.
4. The meter readings corresponding to no load was noted.
5. Load was applied gradually.
6. Each time the auto transformer is adjusted to maintain primary voltage.
7. The loading can be done up to 125% of the rated current of the load side.
8. The load is then reduced till the current reaches a small value and the supply is switched off.

REGULATION AND EFFICIENCY CURVES



CONNECTION DIAGRAM



OBSERVATIONS

SL NO	V1 (V)	I1 (A)	V2 (V)	I2 (A)	W1 (WATTS)	W2 (WATTS)	% REGULATION	% EFFICIENCY
1								
2								
3								
4								
5								
6								
7								
8								

SAMPLE CALCULATIONS

Sample Calculation (set no. . . .)

Primary Voltage (V1) =

Primary Current (I1) =

Wattmeter Reading (W1) =

Input power =

Secondary Voltage (V2) =

Secondary Current (I2) =

Wattmeter Reading (W2) =

Output power =

Efficiency = (Output power/Input power) ×100=

Regulation = (VNL – VL)/VNL ×100 =

VNL = V2NL

VL=V2FL

RESULT AND DISCUSSION

VIVA QUESTIONS

1. What do you understand by regulation of a transformer?
2. What are the other methods of testing transformers?
3. What is the disadvantage of testing a transformer using load test?
4. Is a high or low value of regulation preferred for a transformer? Give reasons.
5. What are the reasons for the drop in terminal voltage as the secondary current is increased?

EXPERIMENT 7

OC AND SC TEST ON SINGLE PHASE TRANSFORMER

AIM

To determine the efficiency and regulation of a given single phase transformer by conducting the OC and SC test and also to draw its equivalent circuit

APPARATUS REQUIRED

Sl:no	Name of the instrument	Specification	Quantity
1	Ammeter	(0-1)A, MI	1 No
2	Ammeter	(0-15)A, MI	1 No
3	Voltmeter	(0-300)V, MI	1 No
4	Voltmeter	(0-25) V,MI	I No
5	Watt Meter	0-150 V, 0-1 A	I No
6	Watt Meter	0-75V, 0_15 A	I No
7	Transformer	3 KVA,115/230V	I No
8	Auto transformer	230,0-270/15A	1 No

PRINCIPLE

1) Open Circuit test:

Consider a practical transformer on no load, i.e., secondary on open circuit. The primary will draw a small current I0 to supply the iron losses and a very small amount of copper loss in primary, hence the primary no load current I0 lags V1 by an angle Ø0 less than 900 and no load input power

$W_0 = V_1 I_0 \cos Ø_0$. The no load primary current I0 can be resolved into two components I_W & Iµ. I_W is in phase with V1 and known as working/active/Iron loss component.

$I_W = I_0 \cos Ø_0$

Iµ lags V1 by 900 and known as magnetizing component or lossless component.

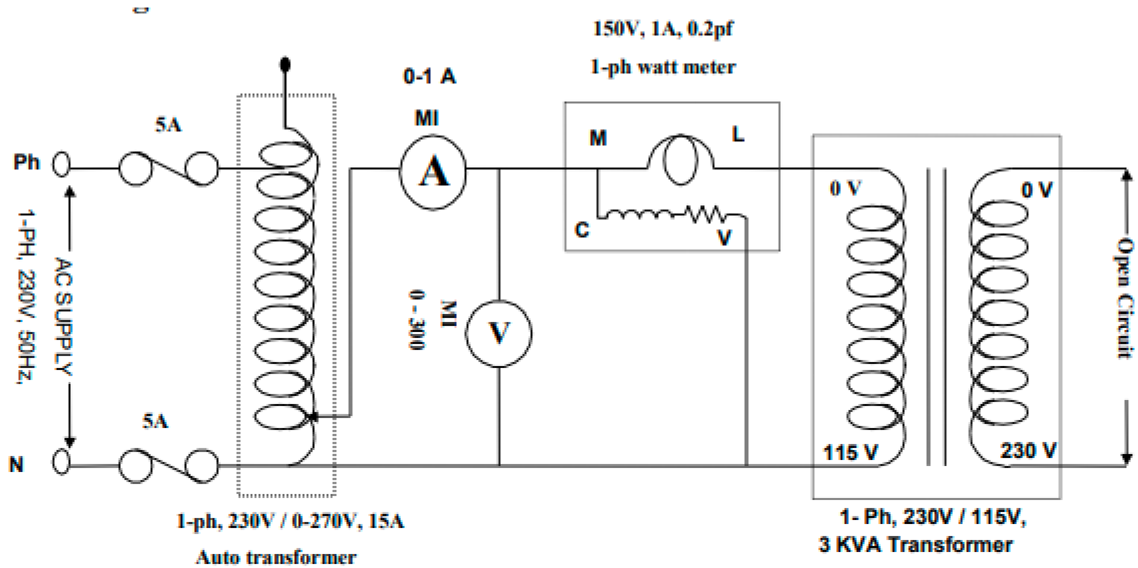
$I_\mu = I_0 \sin Ø_0$

2) Short Circuit test:

This test is conducted to determine R_{01} (or R_{02}), X_{01} (or X_{02}) and full load copper losses of the Transformer. In this test, the secondary (usually the LV winding) is short circuited by a thick wire and a variable voltage is applied to the primary and gradually raised till full load current I1 flows through the primary. Under this condition the copper loss in the winding is equal to that of full load copper losses (since the current in the secondary is equal to its rated value). Since there is no output in the transformer under the short circuit conditions, the input power is all equal the losses of the Transformer. The voltage VSC is very small in this condition, the core loss is negligibly small, and hence the total loss can be considered as full load copper losses of the Transformer winding

Circuit Diagram:

Open Circuit test:



Procedure:

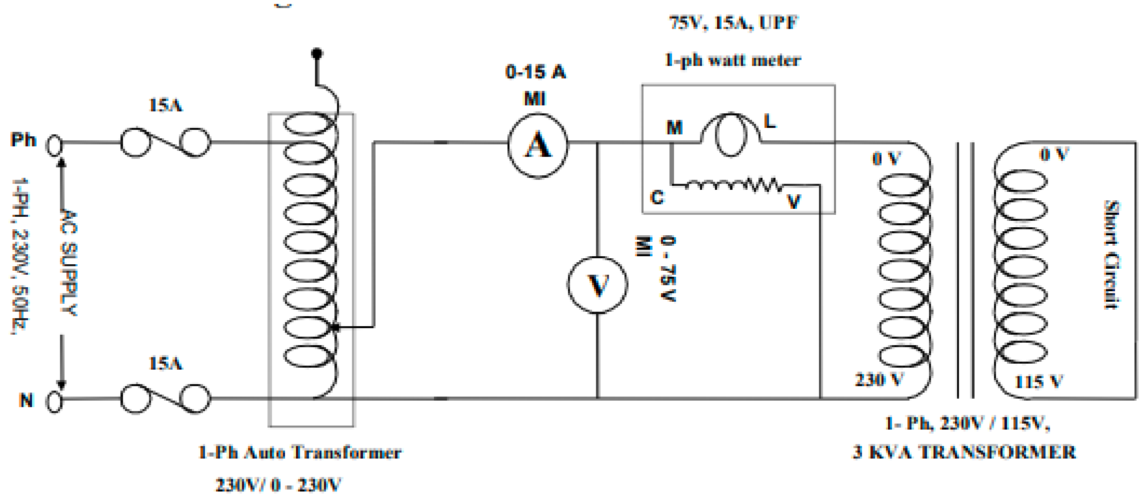
1) Connections are given as per circuit diagram
2) Switch on the power supply
3) With the help of Auto-Transformer, Apply voltage to HV side in steps (230V)
4) At each step note down Voltmeter, Ammeter and Wattmeter readings
5) After reaching maximum voltage of 230V on HV side, the supply is switched off.

Tabular Column

APPLIED VOLTAGE (V)	NO LOAD CURRENT Io (A)	POWER INPUT (Wo)	APPLIED VOLTAGE (V)	CURRENT Isc (A)	POWER INPUT Wsc (WATTS)

Short Circuit Test:

Circuit Diagram:



Procedure:

1) Connection are given as per the circuit diagram
2) The mains switch on HV side is closed.
3) With the help of Booster -Transformer Current is injected in to HV winding in steps.
4) The voltmeter, ammeter and Wattmeter reading are noted down for each step in HV side.
5) After reaching full load current on Secondary side the supply is switched off.

Tabular Column:

APPLIED VOLTAGE (V)	NO LOAD CURRENT Io (A)	POWER INPUT (Wo)	APPLIED VOLTAGE (V)	CURRENT Isc (A)	POWER INPUT Wsc (WATTS)

Calculations:

a) Open Circuit Test:

1) No load Power Factor $Cos\,\phi_0 = \frac{W_{SC}}{V_{SC} \times I_{SC}}$

Where $\mathbf{W_{OC}}$ is Open circuit power in watts
$\mathbf{V_{OC}}$ is Open circuit voltage in volts
$\mathbf{I_{OC}}$ is Open circuit current in amps
2) Resistance to account for core loss

$$R_C = \frac{V_{OC}}{I_{OC} Cos\phi_0} \Omega$$

3) Magnetizing Reactance

$$X_M = \frac{V_{OC}}{I_{OC} Sin\phi_0} \Omega$$

b) Short Circuit Test Observations:

4) a) Equivalent winding Resistance referred to **HV** side

$$R_{01} = \frac{W_{SC}}{I_{1_{SC}}^2} \Omega$$

Where Wsc is short circuit power in Watts

I_{SC} is Short circuit current in Amps

b) Equivalent winding Resistance referred to **LV** side

$$R_{02} = R_{01} K^2 \Omega$$

Where K (Transformation Ratio) = (V_2 / V_1)

5) a) Equivalent winding Impedance referred to **H V** side

$$Z_{01} = \frac{V_{SC}}{I_{1_{sc}}} \Omega$$

b) Equivalent winding Impedance referred to **LV** side

$$Z_{02} = Z_{01} K^2 \Omega$$

6) a) Equivalent winding Reactance referred to HV side

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

b) Equivalent winding Reactance referred to LV side

$$X_{02} = X_{01} K^2 \Omega$$

Where K (Transformation Ratio) = (V_2 / V_1)

c) To find Efficiency:

Core loss or Constant loss (**W_i**)

Rated short circuit current **I_2 sc**

KVA rating of transformer

Copper loss (**Wsc**) at full load Current

Output for other Pf = $V_2 I_2 Cos\phi$

Total power loss $W_T = W_i + W_{SC}$

7) Output = (X * KVA* COS Φ) in Watts

Where **'X'** is Fraction of load

KVA is Power rating of transformer

COS **Φ** is Power Factor

8) Copper Losses = (**X**) ^{2} **W$_{SC}$** in Watts

Where Wsc Is Copper loss in short circuit condition

Where **'X'** is Fraction of load

9) Total power loss = (Copper Loss + Iron Loss) In Watts

10) $\%Efficiency = \frac{Output}{Output + Total\ Losses} \times 100$ **(or)**

$$\%Efficiency = \frac{V\, I_L Cos\phi}{V\, I_L Cos\phi + W_T} \times 100$$

c) Tabular Column to find Efficiency:

Rated Secondary Voltage (V$_2$) = …………… Volts

Constant Losses (Iron Loss) W$_i$ = …………… Watts

GRAPHS

i. **Load Vs % Efficiency:**

ii. Power Factor Vs % Regulation:

RESULT AND DISCUSSION

EXPERIMENT 8

THREE PHASE POWER MEASUREMENT BY USING TWO WATTMETER

AIM

To measure the power and power factor of three phase balanced load by two wattmeter method.

APPARATUS REQUIRED

Sl. No.	Name of the instrument	Specification	Quantity
1	Ammeter	(0-10)A, MI	1 No.
2	Voltmeter	(0-500)V, MI	1 No.
3	Wattmeter	500V,10A,UPF	2 Nos.
4	Autotransformer	415/(0-415)V	1 No.

PRINCIPLE

In two wattmeter method the current coils of two watt meters are connected in two phases and the potential coils between the corresponding phase and the third phase. It can be proved that the sum of the wattmeter readings gives the total power.

From the phasor diagram

Reading of Wattmeter 1, W1 = VRY IR $\cos(30 + \phi)$

Reading of Wattmeter 2, W2 = VBY IB $\cos(30 - \phi)$

W1 +W2= VRY IR($\cos 30 \cos \phi - \sin 30 \sin \phi$) + VBY IB($\cos 30 \cos \phi + \sin 30 \sin \phi$)

= VRY IR ($\cos 30 \cos \phi$) + VBY IB($\cos 30 \cos \phi$)

Assuming balanced load

VRY = VBY = VBR = VL & IR = IB = IY = IL

Where VL and IL are the line values of voltage and current.

= VLIL $\cos 30 \cos \phi$ + VLIL $\cos 30 \cos \phi$

= 2VLIL $\sqrt{3}/2 \cos \phi$

$=\sqrt{3}V_L I_L \cos\phi$

$W2-W1 = V_L I_L(\cos(30 - \phi) - \cos(30 + \phi))$

$= V_L I_L \sin\phi$

$(W2-W1/ W1 +W2)=(1/\sqrt{3})\tan\phi$

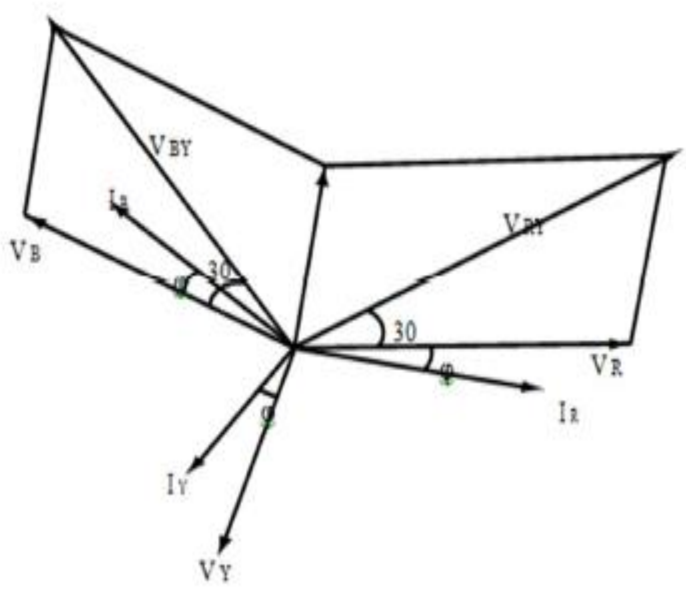
$\tan\phi=\sqrt{3}(W2-W1/ W1 +W2)$

$\phi=(\tan^{-1}(\sqrt{3}(W2-W1/ W1 +W2)))$

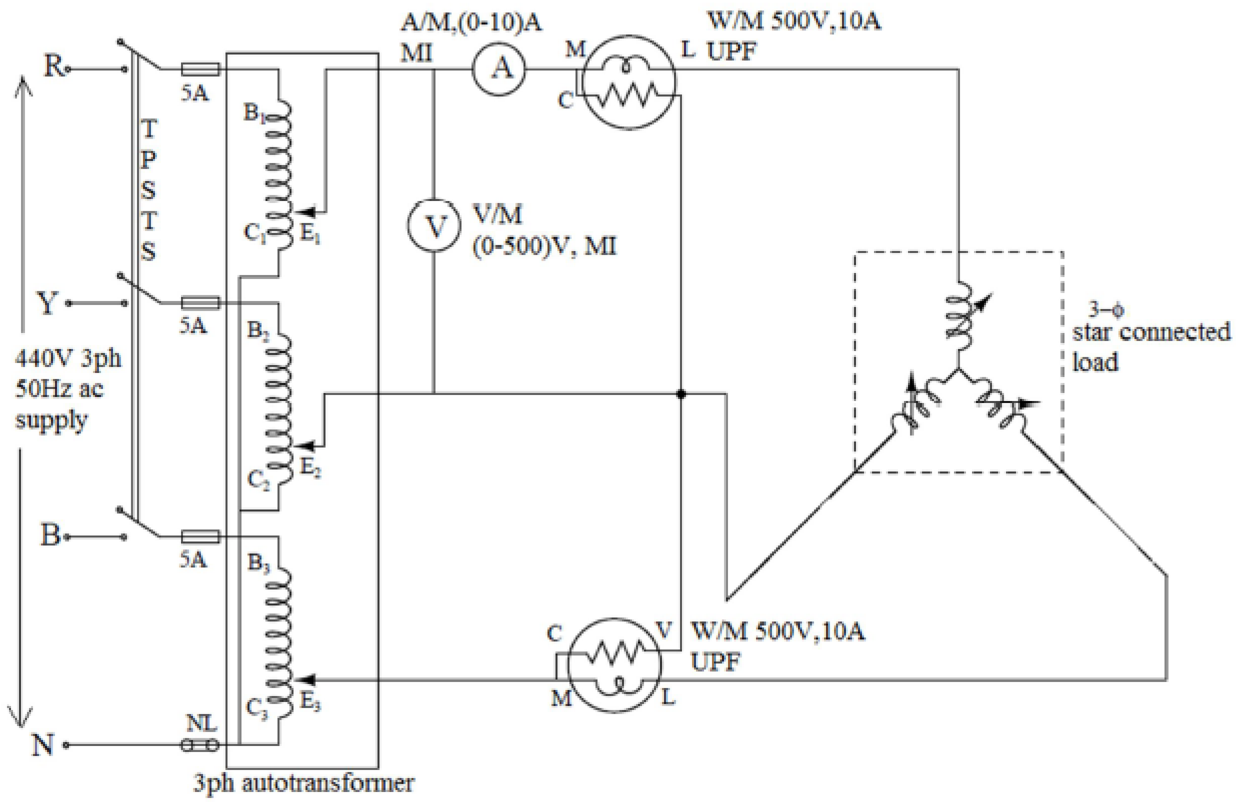
PROCEDURE

1. Connections are made as shown in figure.
2. Supply is switched on by keeping the autotransformer at minimum position.
3. Then the autotransformer is varied till the voltmeter shows rated voltage.
4. Note the ammeter and wattmeter readings.
5. Then the load is varied and the wattmeter, voltmeter and ammeter readings are noted.
6. The above procedure is repeated for different load conditions.

PHASOR DIAGRAM



CIRCUIT DIAGRAM



OBSERVATIONS

Sl no	V_{in} (v)	I_{in} (A)	Wattmeter reading		$P=(W_1+W_2)_{MF}$	$\emptyset = \tan^{-1}\frac{\sqrt{3}(w2-w1)}{(w1+w2)}$	Cos ∅
			W_1xmf	W_2xmf			

SAMPLE CALCULATION

Voltage V =

Current I =

Wattmeter reading W1 =

Wattmeter reading W2 =

Total power P = W1 +W2 =

Phase angle $\phi = \tan^{-1} \frac{\sqrt{3}(W_1 - W_2)}{(W_1 + W_2)} =$

Power factor = cos ϕ = ...

RESULT AND DISCUSSION

CONCLUSION

VIVA QUESTIONS

1. What is the expression for power in a 3ϕ circuit?
2. Derive the expression for power factor in terms of the wattmeter readings.
3. What are the other methods of measuring 3ϕ power?
4. What does a zero reading in one of the watt meters signify?

EXPERIMENT 9

LOAD TEST ON THREE PHASE INDUCTION MOTOR

AIM

To conduct load test on the given 3-ph squirrel cage induction motor and plot the performance characteristics.

APPARATUS REQUIRED

Sl. No.	Name of the instrument	Specification	Quantity
1	Ammeter	(0-15)A,MI	1 No.
2	Voltmeter	(0-500)V, MI	1 No.
3	Wattmeter	500V,15A,UPF	2 Nos.
4	Autotransformer	415/(0-415)V	1 No.
5	Tachometer		1 N0.

PRINCIPLE

A squirrel cage induction motor essentially consists of a stator and a rotor. The stator is a hollow cylindrical structure with slots on the inner periphery and carries a three phase winding. The winding can be connected in star or delta and is connected across a 3-ph supply. The rotor is also a cylindrical structure with slots on the outer periphery. The slots carry thick Al or Cu bars. These bars are short circuited at both ends by means of end rings. When a 3-ph supply is given to a 3-ph winding displaced by 120 degree in space, a magnetic field of constant magnitude but rotating at synchronous speed is produced. This flux links with the stationary rotor, thus inducing an emf in it. As the rotor circuit is closed, a current flows through it. The direction of the induced current is such as to oppose the cause producing it. The cause is the relative motion between the stator magnetic field and the rotor. So the rotor starts rotating in the same direction as the stator magnetic field and tries to catch up with it. But practically it is never able to do so. Because if it does so, there would be no relative motion, no emf and hence no torque.

Thus an induction motor always runs at a speed slightly less than the synchronous speed. The term slip is of importance in an induction motor and is defined as

$\%slip = ((N_s – N)/N_s) * 100$

Where, Ns - Synchronous speed =$120 \times fP$

N - rotor speed

f - frequency

P - No. of poles of the machine

An induction motor can never operate at s=0. It always operates between s=0 and s=1(starting).

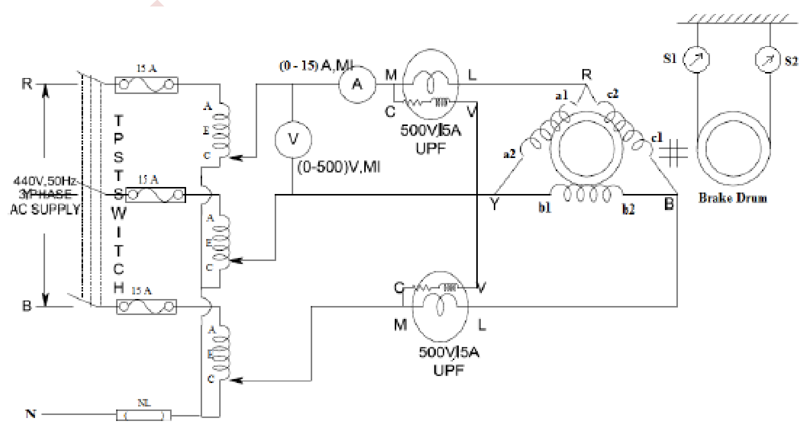
The performance characteristics are plots of efficiency, torque, speed, slip, pf and line current versus output. Current and torque increases with increase in output. The induction motor is essentially a constant speed motor. However speed reduces gradually with increase in output and slip increases gradually with increase in output. The pf is low at low

loads and increases with increase in output. The efficiency increases with increase in output, reaches a peak value and then gradually drops with further increase in output.

PROCEDURE

1. Connections are made as shown in figure.
2. Close the TPST switch.
3. Adjust the 3phase autotransformer till the voltmeter shows the rated line voltage of the induction motor.
4. Note down the line voltage, line current, power input and the speed indicated by the respective voltmeter, ammeter, wattmeter and tachometer under no load condition.
5. Load the machine by means of brake drum arrangement and note down the corresponding meter readings and speed.
6. Repeat the same procedure up to the rated current of the induction motor.

CONNECTION DIAGRAM

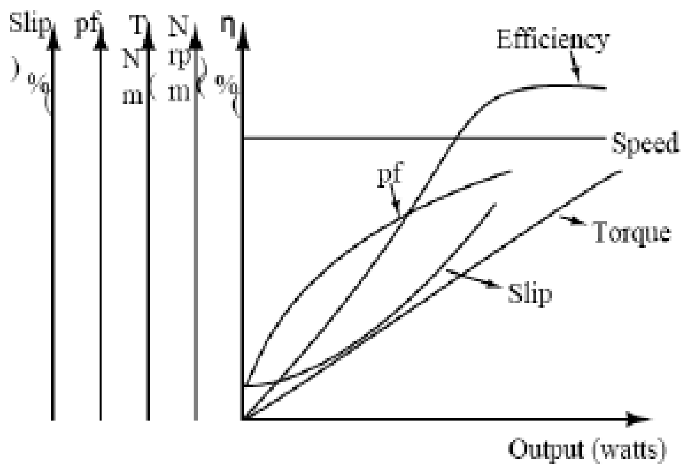


Voltage V	- 415 V
Current I	- 7.5A
Power	- 5HP
Connection	- Δ
Speed(*rpm*)	- 1440
Phase	- 3φ

OBSERVATIONS

SL NO.	V (volt)	()I (amp)	W1 (w)	W2 (w)	S1 (kg)	S2 (Kg)	N (rpm)	T (Nm)	O/P (w)	I/P (w)	SLIP %	PF	EFFICIENCY
1													
2													
3													
4													
5													
6													
7													

Model Graph



SAMPLE CALCULATIONS

Voltage V =

Current I =

Wattmeter reading W1 =

Wattmeter reading W2 =

Input power P = W1 +W2 =

Spring balance Readings S1 =   S2 =

Speed (N) =

Torque (T) = 9.8 (S1 − S2) R = Where R is the radius of brake drum.

Synchronous speed = 120 × fP

% slip = ((Ns – N)/Ns)∗100=

Power factor = cos ϕ = (w1+w2) / (√3*VI) =

Output power = (2ΠNT) / 60 =

% Efficiency = (output power) / (input power) ∗ 100 =

RESULT AND DISCUSSION

CONCLUSION

VIVA QUESTIONS

1. What is ‘slip’ in an induction motor?
2. What are the two types of 3-ph induction motors and what is the difference between the two.
3. What is the value of slip at starting?
4. What are the advantages and disadvantages of squirrel cage induction motor?
5. Give some applications of 3-ph squirrel cage induction motor?

EXPERIMENT10

STATIC CHARACTERISTICS OF SCR

AIM

1) To plot the static characteristics of the given SCR.

2) To find Latching and Holding current of the given SCR.

APPARATUS REQUIRED:

S.no	Apparatus	Range	Qty
1	SCR	TY604/612	1 No
2	Resistor	2.2KΩ	1 No
3	Resistor	560Ω	1 No
4	Ammeter (DC)	0-60mA	1 No
5	Ammeter (DC)	0-30mA	1 No
6	Voltmeter (DC)	0-60V	1 No
7	Regulated Power Supply	0-30V	3 Nos

THEORY

An SCR is a 4-layer, 3-junction, 3-terminal device. When anode is positive w.r.t cathode, the curve between VAK and IA is called the forward characteristics. During forward bias condition, the junction J_2 is reverse biased and when across J_2 above break over voltage (V_{BO}), J_2 breaks down and heavy current will flow in the device. Hence a load resistance is always connected in series with the SCR to limit the anode current to safe value. Latching current is the minimum anode current required to turn ON SCR without gate current. Holding current is the maximum anode current at which SCR turns OFF from ON condition, with gate open.

TABULAR COLUMN

V_{ak4}	I_A

PROCEDURE:

A) To Plot V.I Characteristics:

1. Make the connections as per the circuit diagram.
2. Switch ON the regulated power supply. Apply some constant voltage say 30V by varying VAK source.
3. Gradually increase the gate current by varying V_{GK} source till the SCR becomes ON. Note down the corresponding value of I_G from the milliammeter. Then decrease V_{AK} and V_{GK} to minimum.
4. Set gate current equal to noted value in step 3 by varying V_{GK} source.
5. Gradually increase V_{AK} in steps of 2V and for each step note down the value of V_{AK} and I_A , and then reduce V_{AK} to minimum.
6. Set gate current to some other value (preferably higher than that of the value set in step 3)
7. Repeat step 5.
8. Plot a graph of V_{AK} versus I_A for different values of I_G.

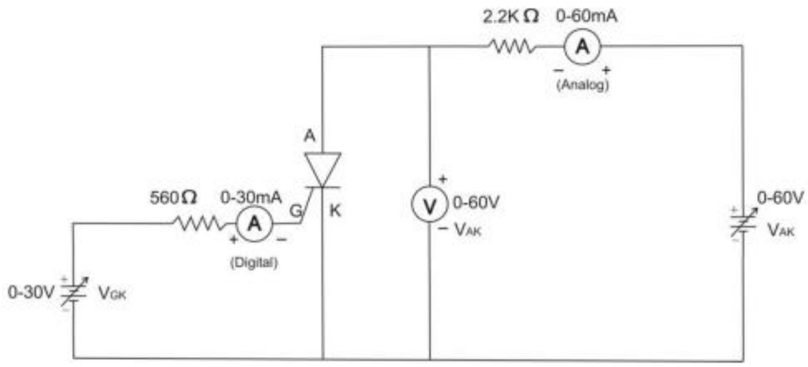
B) To find Latching current (IL):

1. Keep proper V_{AK} to trigger SCR by gate current. Then trigger SCR by applying gate current.
2. Gradually decrease V_{AK} in steps and at each step switch-off the gate supply (i.e. V_{GK} source) and observe that, whether device remains in the ON state or not.
3. Repeat step 2 (by trial and error method) till the SCR jumps to blocking state, and then note down the minimum value of I_A which keeps device in the on state as Latching current.

C) To Find Holding current (IH):

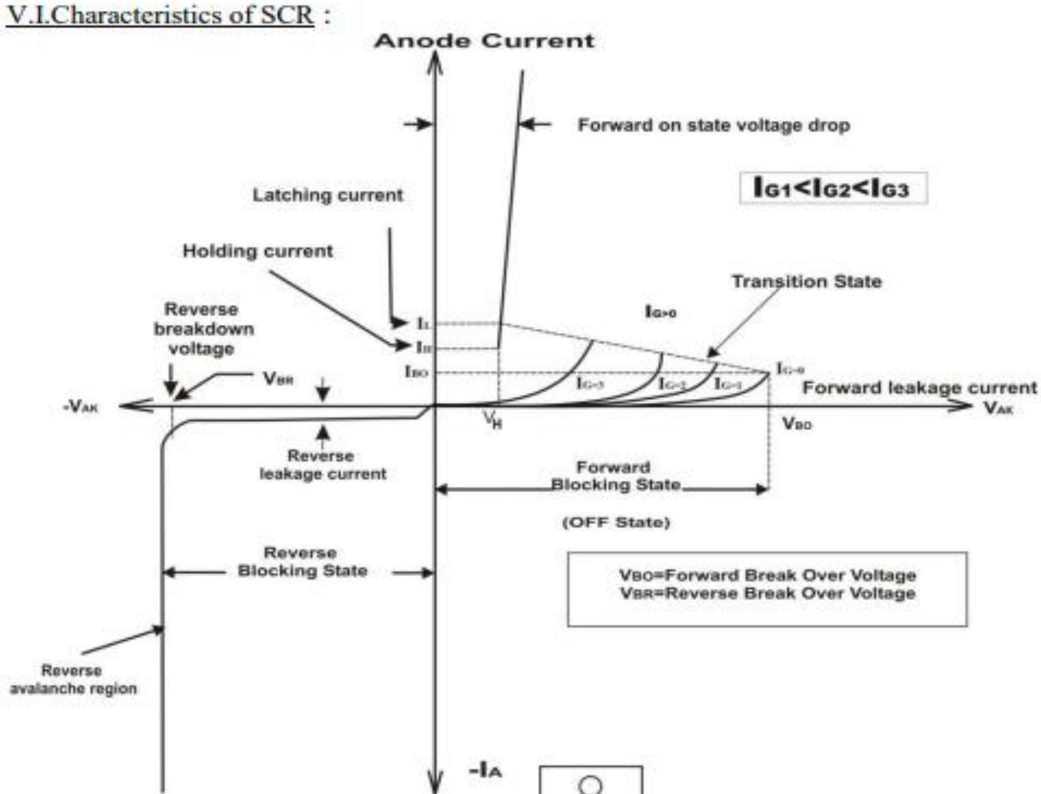
1. Keep proper V_{AK} to trigger SCR by gate current. Then trigger SCR by applying gate current.
2. Switch-Off V_{GK} source permanently. Now gradually decrease V_{AK} and note down the minimum value of I_A below which, the device suddenly falls from ON-state to OFF- state as Holding current.

CIRCUIT DIAGRAM OF SCR CHARACTERISTICS



NATURE OF GRAPH:

V.I.Characteristics of SCR :



Pin configuration of SCR:

RESULT AND DISCUSSION

CONCLUSION

VIVA QUESTIONS

1) What is hard switching of the thyristor?
2) What is holding current in SCR?
3) Name some of the voltage driven (Voltage controlled) devices?
4) What is latching current in SCR?
5) What a turn on methods of SCR?

EXPERIMENT 11

STATIC CHARACTERISTICS OF MOSFET

AIM

To plot the Transfer and Drain characteristics of MOSFET and determine Trans conductance and output Resistance

APPARATUS REQUIRED

S.no	Apparatus	Range	Qty
1	MOSFET	IRF 740	1 No
2	Resistor	560Ω	1 No
3	Ammeter (DC)	0-60mA	1 No
4	Voltmeter (DC)	0-60V	1 No
5	Voltmeter (DC)	0-30V	1 No
6	Multimeter	-	1 No
7	VRPS	0-30V	3 Nos
8	Connecting wires	-	Few

THEORY

A MOSFET (Metal oxide semiconductor field effect transistor) has three terminals called Drain, Source and Gate. MOSFET is a voltage controlled device. It has very high input impedance and works at high switching frequency. MOSFET's are of two types

1) Enhancement type

2) Depletion type.

TABULAR COLUMN:

1)Transfer characteristic

V_{DS}	I_O	V_{DS}	I_O

2)Drain Characteristic

V_{DS}	I_O	V_{DS}	I_O

CALCULATION:

Trans conductance:

$$g_m = \left| \frac{\Delta I_D}{\Delta V_{GS}} \right| = \_\_\_\_\_\_ \text{mho at constant } V_{DS}$$

Output Resistance:

$$R_0 = \left| \frac{\Delta V_{DS}}{\Delta I_D} \right| = \_\_\_\_\_\_\_\_\_ \Omega \text{ at constant } V_{GS}$$

PROCEDURE:

A) Transfer Characteristics:

1. Make the connections as per the circuit diagram.

2. Initially keep V_1 and V_2 at 0 V.

3. Switch ON the regulated power supplies. By varying V_1, set V_{DS} to some constant voltage say 5V.

4. Vary V_2 in steps of 0.5V, and at each step note down the corresponding values of V_{GS} and I_D. (Note: note down the value of V_{GS} at which I_D starts increasing as the threshold voltage).

5. Reduce V_1 and V_2 to zero.

6. By varying V_1, set V_{DS} to some other value say 10V.

7. Repeat step 4.

8. Plot a graph of V_{GS} versus I_D for different values of V_{DS}.

B) Drain or Output Characteristics:

1. Make the connections as per the circuit diagram.

2. Initially keep V_1 and V_2 at zero volts.

3. By varying V_2, set V_{GS} to some constant voltage (must be more than Threshold voltage).

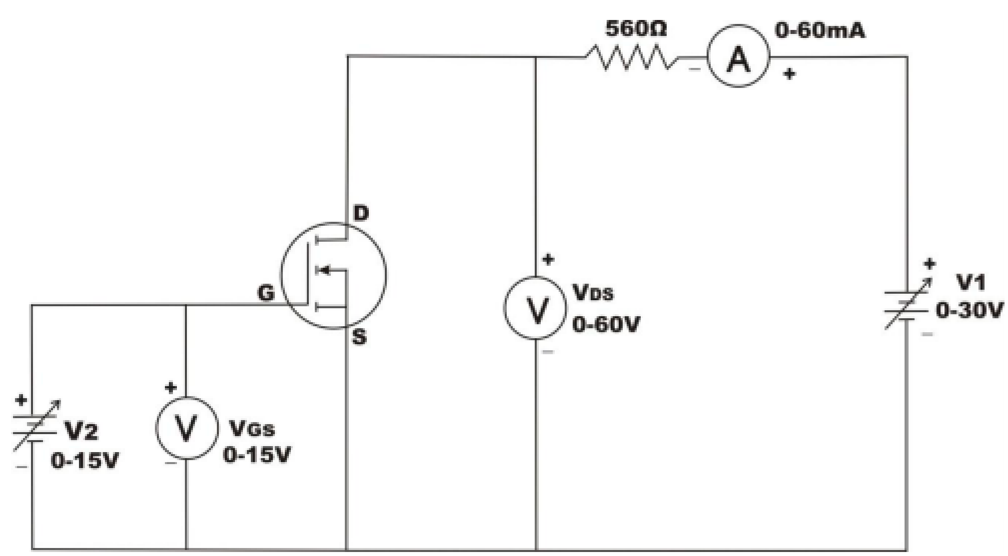
4. By gradually increasing $V_{1,}$ note down the corresponding value of V_{DS} and I_D. (Note: Till the MOSFET jumps to conducting state, the voltmeter which is connected across device as V_{DS} reads approximately zero voltage. Further increase in voltage by V^1 source cannot be read by V_{DS}, so connect multi-meter to measure the voltage and tabulate the readings in the tabular column).

5. Set V_{GS} to some other value (more than threshold voltage) and repeat step 4.

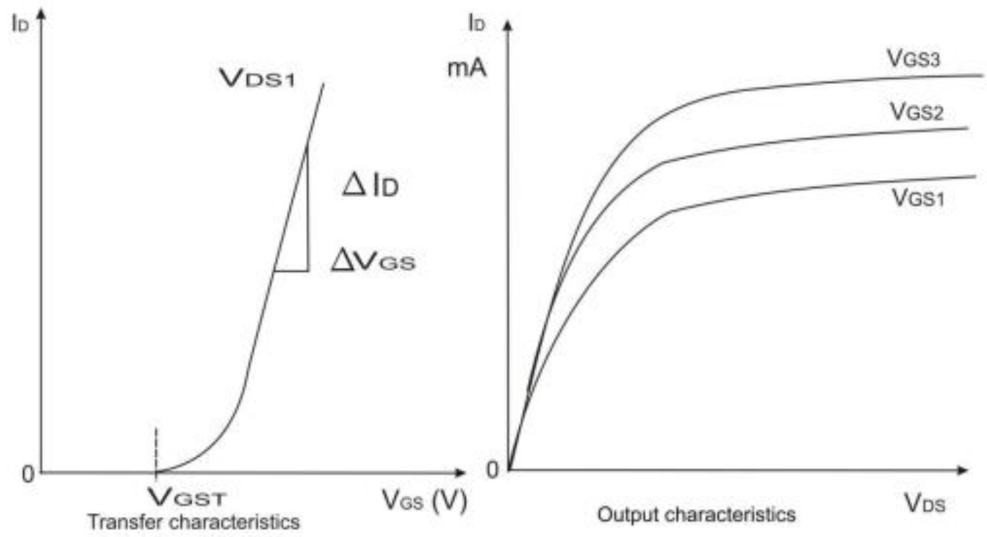
6. Plot a graph of V_{DS} versus I_D for different values of V_{GS}.

Note: If V_{DS} is lower than V_P (pinch-off voltage) the device works in the constant resistance region that is linear region. If V_{DS} is more than V_P, a constant I_D flows from the device and this operating region is called constant current region.

CIRCUIT DIAGRAM OF MOSFET CHARACTERISTICS:



Nature of Graph:



RESULT AND DISCUSSION

CONCLUSION

VIVA QUESTIONS

1. What is a MOSFET?
2. What are the types of MOSFET?
3. What are the differences between enhancement type and depletion type MOSFET?
4. What is pinch-off voltage of MOSFETs?
5. What is threshold voltage of MOSFET?

EXPERIMENT 12

OBTAIN OUTPUT WAVEFORM OF SINGLE PHASE BRIDGE RECTIFIER USING SCR

AIM

To Study SCR turn ON process using Digital Triggering for half wave rectifier.

APPARATUS REQUIRED

S.no	Apparatus	Range	Qty
1	Digital firing Module	-	1No
2	Rheostat	220Ω, 2.8Amps	1No
3	SCR Module	-	1No
4	Auto-Transformer	0-260V	1No
5	Isolation Transformer	230V	1No
6	CRO and probe	-	1Set
7	Multimeter	-	1 No
8	Connecting wires	-	Few

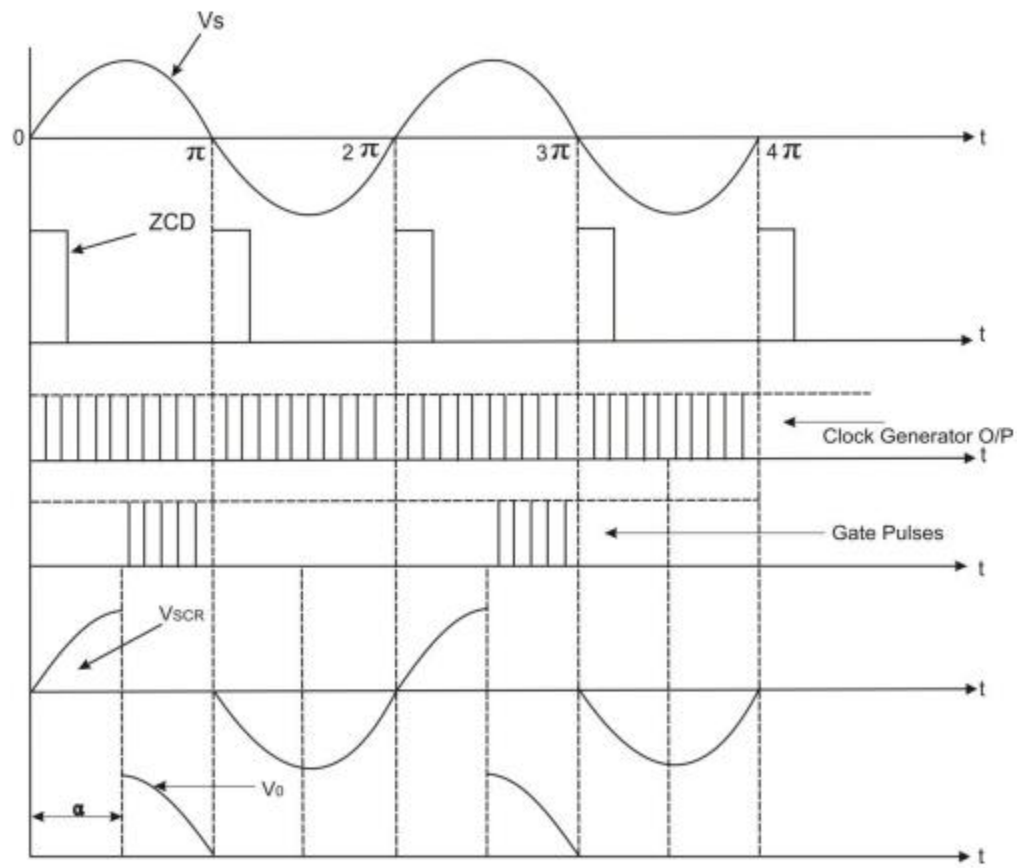
THEORY:

This firing circuit generates line synchronous pulse transformer isolated trigger output to trigger SCR's in
i) Single phase half wave converter.
ii) Single phase full wave converter.
iii) Triac firing.
iv) Chopper

The firing scheme is a based on zero Crossing Detector (ZCD) using digital IC's, mono pulse generator and high frequency carrier generator and pulse transformer isolation method. Zero crossing detector generates a narrow pulse whenever AC signal goes to its zero position.

This pulse is triggering pulse for mono-stable. A variable pulse width can be obtained by varying the potentiometer. Output of the mono#1 is connected to mono #2 to generate a narrow pulse at the trailing edge of the mono#1. Mono pulse generator together generates envelop for firing pulses. IC555 generates high frequency carrier pulses. These high frequency carrier pulses are amplified and isolated by pulse transformer isolation circuit. Finally isolated pulses can be connected to gate and cathode to trigger SCR/TRIAC.

NATURE OF GRAPH:



PROCEDURE:

1. Make the connections as per the circuit diagram.

2. Switch ON the power supply to Digital firing circuit.

3. Observe AC reference signal and compare it with ZCD output.

4. Connect one channel of the CRO to the AC reference terminal and other to the clock generator output terminal using CRO probes with respect to ground terminal of ZCD.

5. Adjust potentiometer ‘R’ such that, it generates 10 pulses in half cycle.

6. Set the thumbwheel switch to some number (as soon as synchronized signal crosses zero, counter starts counting clock pulses in down counting mode from the set value).

7. Observe train of pulses across TP and TN.

8. Connect T1 and T′ 1 of driver circuit to the gate and cathode of SCR module.

9. Switch ON power supply to SCR power circuit by keeping autotransformer knob at minimum position.

10. By varying auto transformer knob gradually, set voltage across SCR about 80V (measure set voltage using Multi-meter)

11. By setting different numbers in thumbwheel switch (each step corresponds to 18° firing angle delay), Observe load voltage and SCR voltage waveforms.

RESULT AND DISCUSSION

CONCLUSION

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VIVA QUESTIONS

1) What do you mean by commutation?
2) Distinguish between natural commutation and forced commutation.
3) How are the forced turn-off methods classified?
4) State the conditions under which a load carrying SCR can be successfully commutated
5) What are the purposes of commutation circuit?
6) What is forced commutation?
7) What are the different methods of commutation schemes?
8) What is DC chopper?

ADDITIONAL EXPERIMENT 1

LOADING OF THREE PHASE SLIP RING INDUCTION MOTORS

AIM

1. Connect a three phase asynchronous slip ring motor using various value of external rotor resistance

2. Measure the standstill current of the motor with various starter resistance in circuit

3. Select or change, the direction of rotation of the motor

APPARATUS REQUIRED

1 3-phase slip ring asynchronous motor

1 Magnetic powder brake

1 Control unit for brake

1 Rubber Coupling sleeve

1 Coupling guard

1 Shaft end guard

1 Rotation reversing switch

1 Start for slip ring motors

1 Cut out switch,

3 pole 1 Multimeter

1 Set of connection cables

CIRCUIT DIAGRAM

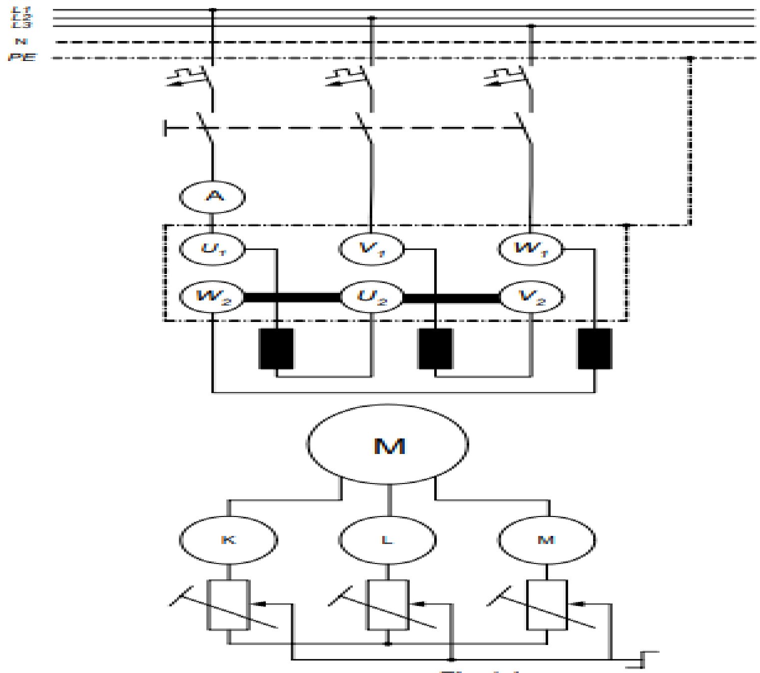


FIG 1

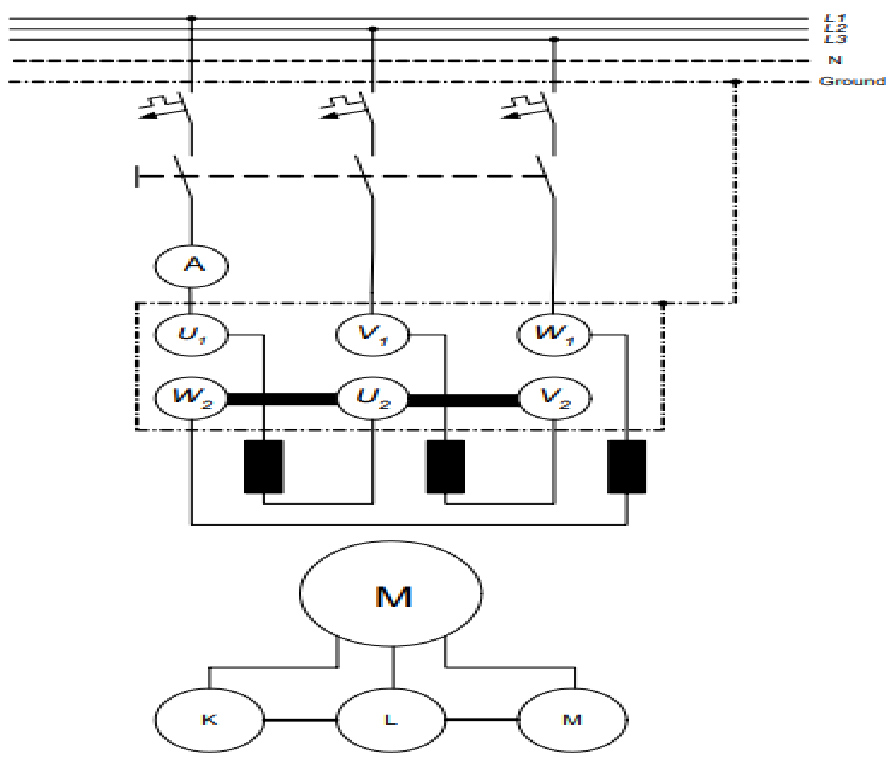


FIG 2

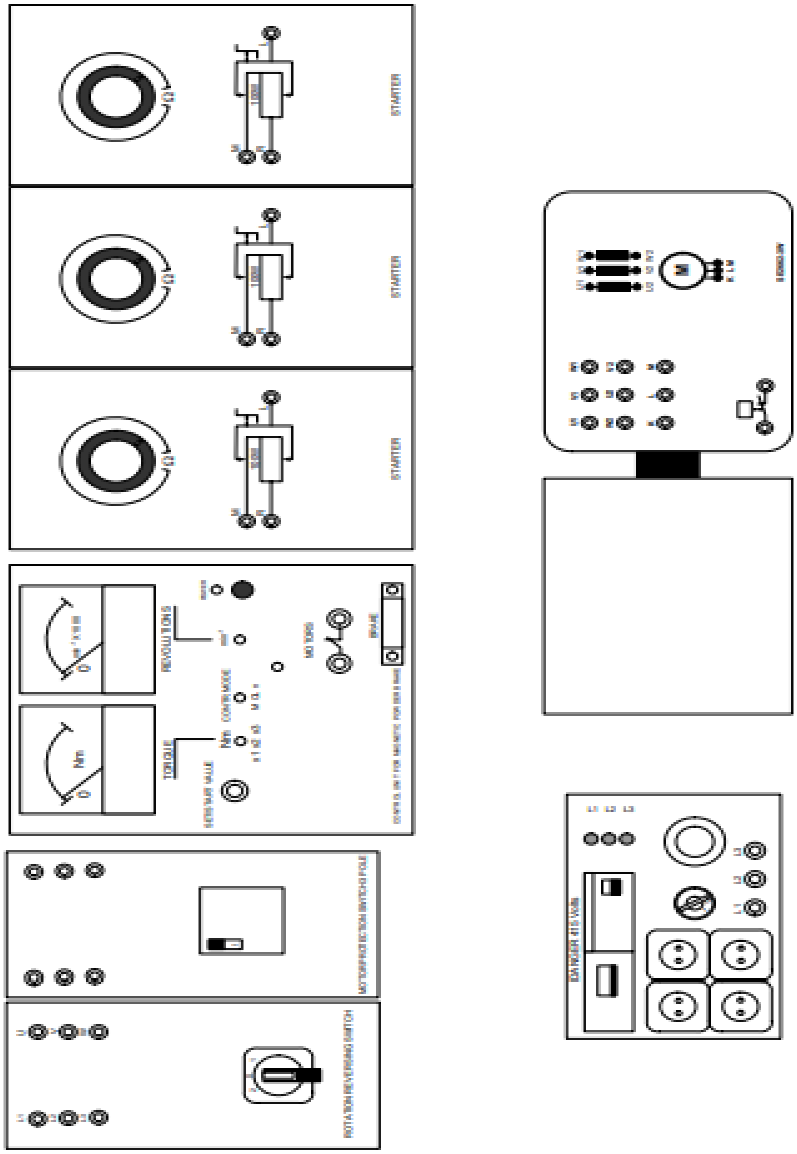


FIG 3

PROCEDURE

1. Construct the circuit as shown in the fig.1

2. Set the control unit as follows:

a) Speed n = 1500 rpm

b) Torque M = 5Nm

c) Operating Mode M = constant Range on multimeters Armature current IA = 3A

Adjust the starter to position 1

Adjust the start/set value, so that after switching on the motor under load, a start up is prevented.

3. Measure the standstill (when the rotor stops) at each starter position. Enter the value into the table .1

Starter	1	2	3	4	5	6
I (A)						

4. Now set the control unit as follows:

a) Speed n = 1500 rpm

b) Torque M = 2Nm

c) Operating Mode M = constant, a.c

Range on multimeter: Armature current IA = 3A

Operate the motor

5. Set the value on the control unit to 1.9 Nm Measure the motor current and speed, at each setting of the starter switch, commencing at position 1. Enter the values into table.2

Starter	1	2	3	4	5	6
N (rpm)						
I (A)						

6. Construct the circuit shown in Fig 3.

7. Set the control unit as in step 4 above. Turn the switch to position 1 and then 2. State the direction of rotation in each case

RESULT

ADDITIONAL EXPERIMENT 2

STARTING METHODS OF SQUIRELL CAGE INDUCTION MOTORS

AIM

To study the different starting methods of 3-phase squirrel cage induction motors& also study how to reverse the direction of rotation in a 3-phase induction motor.

THEORY

The most usual methods of starting 3-phase induction motors are:

1. For slip-ring motors - rotor resistance starting

2. For squirrel-cage motors - direct-on -line starting - star-delta starting - Autotransformer starting.

There are two important factors to be considered in starting of induction motors: ¨

the starting current drawn from the supply, and ¨

The starting torque.

The starting current should be kept low to avoid overheating of motor and excessive voltage drops in the supply network. The starting torque must be about 50 to 100% more than the expected load torque t ensure that the motor runs up in a reasonably short time.

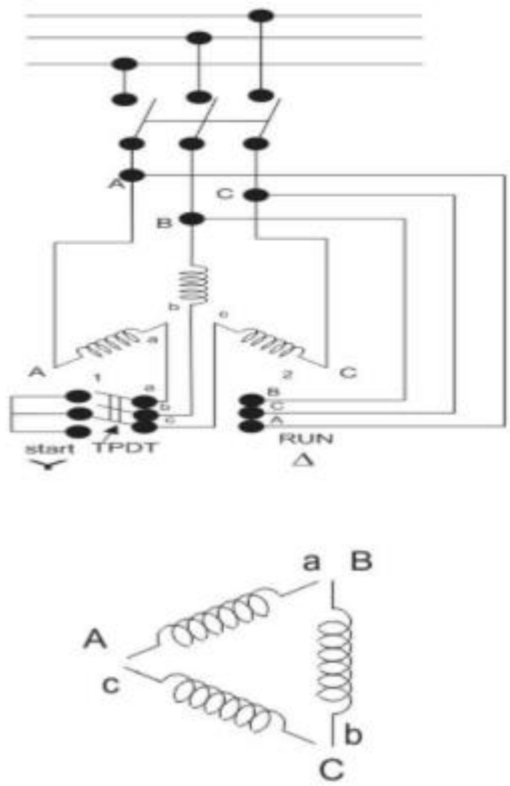
DIRECT-ON-LINE STARTING

This is the most simple and inexpensive method of starting a squirrel cage induction motor. The motor is switched on directly to full supply voltage. The initial starting current is large, normally about 5 to 7 times the rated current but the starting torque is likely to be 0.75 to 2 times the full load torque. To avoid excessive supply voltage drops because of large starting currents the method is restricted to small motors only. To decrease the starting current cage motors of medium and larger sizes are started at a reduced supply voltage. The reduced supply voltage starting is applied in the next two methods.

STAR-DELTA STARTING

This is applicable to motors designed for delta connection in normal running conditions. Both ends of each phase of the stator winding are brought out and connected to a 3-phase change -over switch. For starting, the stator windings are connected in star and when the machine is running the switch is thrown quickly to the running position, thus connecting the motor in delta for normal operation. The phase voltages & the phase currents of the motor in star connection are reduced to 1/Ö3 of the direct -on -line values in delta. The line current is 1/3 of the value in delta.

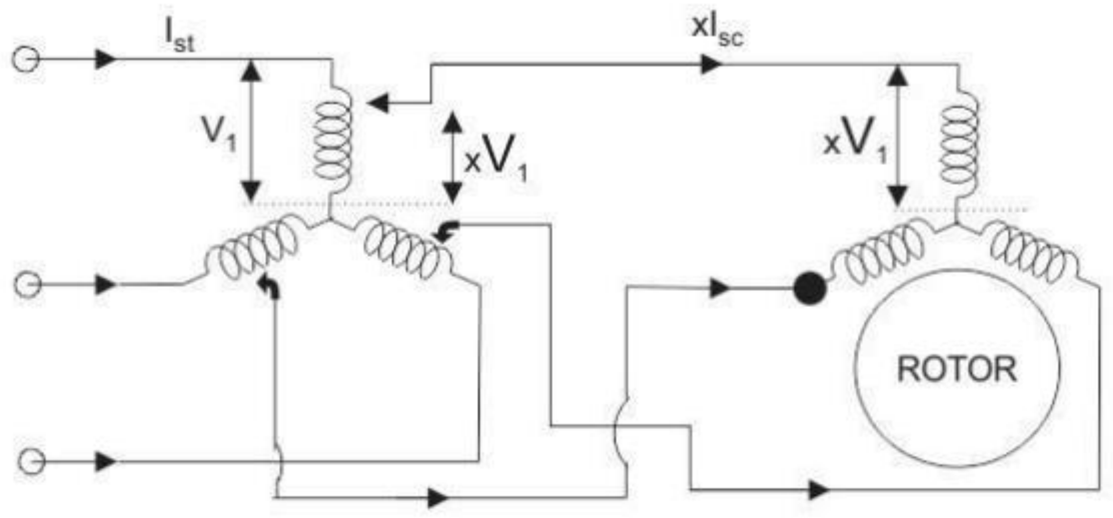
A disadvantage of this method is that the starting torque (which is proportional to the square of the applied voltage) is also reduced to 1/3 of its delta value.



Star Delta

AUTO-TRANSFORMER STARTING

This method also reduces the initial voltage applied to the motor and therefore the starting current and torque. The motor, which can be connected permanently in delta or in star, is switched first on reduced voltage from a 3-phase tapped auto -transformer and when it has accelerated sufficiently, it is switched to the running (full voltage) position. The principle is similar to star/delta starting and has similar limitations. The advantage of the method is that the current and torque can be adjusted to the required value, by taking the correct tapping on the autotransformer. This method is more expensive because of the additional autotransformer.



Pertaining to Auto-Transfer Starting

Reversing:

Reversing the connections to any two of the three motor terminals can reverse the direction of rotation of 3-phase induction motor

PROCEDURE

1. For direct-on -line starting , connect the cage motor as shown in FIG.2

2. For star-delta starting , connect the cage motor to the terminals of the stardeltaswitch (FIG.3)

3. For autotransformer starting, connect the cage motor as shown in FIG.4. Take care at starting that the "Run" switch is open and that it is not closed before the "Start" switch is opened.

4. In each case observe the starting currents by quickly reading the maximum indication of the ammeters in the stator circuit.

5. Reverse the direction of rotation of the motor by reversing of two phases at the terminal box. The reversal has to be made when the motor is stopped and the supply switched off.

RESULT:

ADDITIONAL EXPERIMENT 3

STARTING METHODS OF SLIP RING INDUCTION MOTORS

AIM

To study the different starting methods of 3-phase squirrel cage induction motors& also study how to reverse the direction of rotation in a 3-phase induction motor.

THEORY

The most usual methods of starting 3-phase induction motors are:

1. For slip-ring motors - rotor resistance starting

2. For squirrel-cage motors - direct-on -line starting - star-delta starting - Autotransformer starting.

There are two important factors to be considered in starting of induction motors: ¨

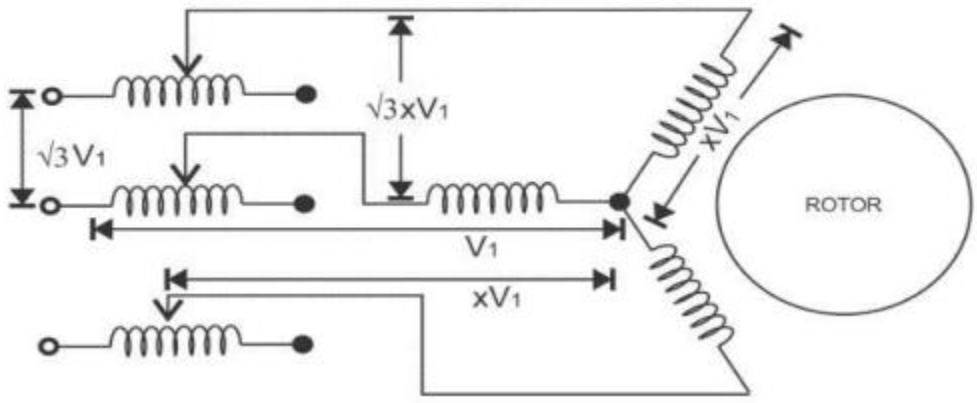
the starting current drawn from the supply, and ¨

The starting torque.

The starting current should be kept low to avoid overheating of motor and excessive voltage drops in the supply network. The starting torque must be about 50 to 100% more than the expected load torque t ensure that the motor runs up in a reasonably short time.

ROTOR RESISTANCE STARTING

By adding eternal resistance to the rotor circuit any starting torque up to the maximum torque can be achieved; and by gradually cutting out the resistance a high torque can be maintained throughout the starting period. The added resistance also reduces the starting current, so that a starting torque in the range of 2 to 2.5 times the full load torque can be obtained at a starting current of 1 to 1.5 times the full load current.



Reversing:

Reversing the connections to any two of the three motor terminals can reverse the direction of rotation of 3-phase induction motor

PROCEDURE

1. For rotor resistance starting, connect the slip-ring motor as shown in FIG.1. Start the motor with full starting resistance and then decrease the resistance in steps down to zero. Take observations of the stator & rotor currents

2. Reverse the direction of rotation of the motor by reversing of two phases at the terminal box. The reversal has to be made when the motor is stopped and the supply switched off.

RESULT: