AMIRAJ

COLLEGE OF ENGINEERING & TECHNOLOGY

LABORATORY MANUAL

ELECTRICAL MACHINE-I

SUBJECT CODE: 3140913

DEPARTMENT OF ELECTRICAL ENGINEERING

B.E. 4TH SEMESTER

NAME:________________________________

ENROLLMENT NO: ________________________________

BATCH NO: ________________________________

YEAR: ________________________________

Amiraj College of Engineering and Technology,

Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

COLLEGE OF ENGINEERING & TECHNOLOGY

Amiraj College of Engineering and Technology,

Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

CERTIFICATE

This is to certify that Mr. / Ms. ____ Of class____________________ Enrolment No ___________________________has Satisfactorily completed the course in ____________________________________as by the Gujarat Technological University for ____ Year (B.E.) semester___ of Mechanical Engineering in the Academic year_______.

Date of Submission:-

Faculty Name and Signature

(Subject Teacher)

Head of Department

(ELECTRICAL)

COLLEGE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

B.E. 4TH SEMESTER

SUBJECT: ELECTRICAL MACHINE-I

SUBJECT CODE: 3140913

LIST OF EXPERIMENTS

Sr. No.	Title	Date of Performance	Date of submission	Sign	Remark
1.	To study the d.c.shunt motor starter.				
2.	Study of D.C.machine components				
3.	To find the efficiency and regulation of a single phase transformer by direct loading method.				
4.	To find efficiency and regulation of a single phase transformer by indirect loading method (o.c & s.c test)				
5.	To determine external and internal characteristics of a d.c.shunt generator				
6.	To determine external and internal characteristics of a d.c. series generator				
7.	Determine external and internal characteristics of a d.c. compound generator.				
8.	To study the performance of single-phase transformers connected in parallel.				
9.	Speed control of a D.C.shunt motor by Armature voltage control (Rheostatic control) and Field control.				
10.	To determine the parameters of an equivalent circuit of a single-phase transformer.				

EXPERIMENT NO: - 1 **DATE:-_________**

AIM: - To study the d.c.shunt motor starter.

NECESSITY OF STARTER:

The current drawn by the motor is given by

$$I_a = \frac{V - E_b}{R_a}$$

Where V = supply voltage

Eb = back e.m.f.

Ra = armature resistance

Back e.m.f. is directly proportional to the speed of rotation. At zero speed when motor is just connected to d.c. supply, back e.m.f. is zero. Hence supply voltage directly appears across the armature winding causing extremely large current through the armature winding. This excessive current may damage the motor. This current can be limited to a safe value by adding external resistance in the armature circuit. The starting resistance is gradually cut out as the motor gains speed and develops the back e.m.f. which then regulates its speed.

THREE POINT STARTER:-Figure shows a three point starter for a d.c. shunt motor. To start the motor the main switch is first closed and then the starting arm is slowly moved to the right. As soon as the arm makes contact with stud no.1, the field circuit is directly connected across the line and at the same time full starting resistance Rs is placed in series with the armature.

The starting current drawn by the armature = V/(Ra + Rs).

As the arm is further moved, the starting resistance is gradually cut out till when the arm reaches the running position, the resistance is all cut out. The arm moves over the various studs against a strong spring. There is a soft iron S attached to the arm, which in the running position (ON position) is attracted and held by an electromagnet Energized by the field current. It is known as *HOLD-ON* coil or *NO-VOLT* release. When the arm is in on position the starting resistance Rs will be in the field circuit. This results in slight decrease of shunt current. This defect can be overcome by using a brass arc. The arm makes contact with the stud no.1 and the arc simultaneously. The field circuit is completed through this arc.

D.C. starters are provided with two protective devices:-

1. No Volt release
2. Overload release

NO VOLT RELEASE: -The no volt release consists of an electromagnet with proper winding on it. The winding of the electromagnet is connected in series with the field winding. The normal function of it is to hold on the arm in the running position. In case of failure of the supply or break in the field circuit, the electromagnet gets demagnetized and releases the starter arm to the "OFF" position by the action of the spiral spring. Hence the no volt release safeguards the motor from the above two types of dangers in addition to holding the starter arm in the running position of the motor.

OVER LOAD RELEASE:-It consists of an electromagnet with a proper winding over it. It is connected in series with the armature circuit so that the current flowing in the electromagnet winding is equal to the armature current. If motor becomes overloaded drawing an over current from the lines, the electromagnet of the overload release gets more magnetized and as a result attracts the iron part G, thus short circuiting the hold on coil (No Volt release coil) which gets demagnetized and releases the starter arm to return to its "OFF" position. When motor is to be stopped, switch off the main switch only. It will cause the current in the holding coil to die down and electromagnet of the no volt release would release the starter arm to return to its "OFF" position. The three-point starter has a serious drawback in case of motors with large variation of speed by adjustment of field rheostat. In such cases, field current may become very low (because $N \propto 1/\Phi \propto 1/If$) because of the insertion of high resistance to get a high speed. A very low field current will make the electromagnet (E) too week to overcome the force exerted by starter arm even during the normal operation of the motor which is not desirable. This difficulty can be overcome by using a four-point starter. The basic difference in the circuit of four-point starter as compared to three-point starter is that the holding coil has been removed from the shunt field circuit and has been connected directly across the mains with a current limiting resistance in series.

EXPERIMENT NO: - 2 **DATE:__________**

AIM: - Study of D.C. machine components.

D.C. machine consists of the following essential parts.

1. Magnetic frame or yoke.
2. Pole cores and pole shoes.
3. Field coils or pole coils.
4. Armature core.
5. Armature winding or conductors.
6. Commutator.
7. Brushes and bearings.

(1) YOKE:-

It provides mechanical support to the poles and acts as a protecting cover for the whole machine. It also carries the flux produced by the poles. It is made up of cast iron for small machines while for large machines cast steel or rolled steel is employed.

(2) POLE CORES AND POLE SHOES:-

The field magnets consist of pole cores and pole shoes. The pole shoes spread out the flux in the air gap and support the exciting coil. The retentivity of the material used for pole cores should be higher in case of generator action. Both pole cores and pole shoes are laminated and riveted together under hydraulic pressure. The thickness of the laminations varies from 1 mm to 0.25 mm.

(3) FIELD COILS:-

The field coils or pole coils, which consist of copper wire or strip, are former wound for the correct dimension. The wound coil is put into place over the core as shown in the figure. When current passes through the coil, the coil magnetizes the poles which produce the necessary flux that is cut by revolving armature conductors.

(4) ARMATURE CORE :-

It houses the armature conductors or coils and causes them to rotate and hence cut the magnetic flux of the field magnets. It also provides a path to the flux at very low reluctance from N-pole to S-pole. It is cylindrical or drum-shaped, laminated from the circular sheet steel. The slots are punched on the outer periphery of the stampings. For large machines where cooling is essential, axial ventilating ducts shown in the figure are provided.

(5) ARMATURE WINDINGS: -

Armature windings are first wound in the form of rectangular coils and are then pulled into their proper shape in a coil puller. Various conductors of the coils are insulated from each other. The conductors are placed in the armature slots, which are lined with tough insulating material. It is secured in place by special hard wooden or fiber wedges.

(6) COMMUTATOR :-

The function of the commutator is to facilitate collection of current from the armature conductors. It converts the alternating current induced in the armature conductors into unidirectional current in the external load circuit in case of generator. It is of cylindrical structure and built up of wedge shaped segments shown in the figure insulated from each other by thin layers of mica. The number of segments is equal to the number of armature coils. Each commutator segment is connected to the armature conductor by means of a copper lug or riser(strip).

(7) BRUSHES:-

The function of brushes is to collect current from commutator or to draw current to commutator. They are usually made of carbon and are in the shape of rectangular block. These brushes are housed in brush holders usually of the box type variety shown in figure. The brushes are made to bear down on the commutator by a spring whose tension can be adjusted by changing the position of lever in the notches. A flexible copper pig tail mounted at the top of the brush conveys current from the brushes to the holder.

(8) BEARINGS:-

Ball bearings are frequently employed due to their reliability, though for heavy duties, roller bearings are preferable. The ball and roller are generally packed in hard oil for quieter operation and for reduced bearing wear, sleeve bearings are used.

EXPERIMENT NO:- 3 **DATE:-_______**

AIM:- To find the efficiency and regulation of a single phase transformer by direct test.

MACHINE SPECIFICATION:-

1-phase, 1.5KVA, 230/115 Volts, 50 Hz transformer

APPARATUS: -

(1) Voltmeter (MI)	300V		1
(2) Voltmeter (MI)	150V		1
(3) Ammeter (MI)	10A		1
(4) Ammeter (MI)	20A		1
(5) Wattmeter	300 V,5A 1500 W		1
(6) Wattmeter	150 V,10A 1500 W,		1
(7) Single phase variac, 230v, 10A, 50Hz			1

THEORY:- Efficiency of an apparatus is defined as the ability of a device to convert energy from one form to other. In other words it is the ratio of the useful power output to the input power. While converting energy, some losses take place in the device. Losses are more in case of rotating machines due to friction and windage. The transformer is a static device so its efficiency is in the range of 96 to 99%. In transformer there are mainly two types of losses (1) constant loss (iron loss) (2) variable loss (copper loss). Constant losses are constant for a given frequency and voltage. Variable loss depends on the square of the load current. In large transformers iron losses are in between 0.5 to 1.0% and Cu losses between 0.5 to 1.5% of its capacity. To find efficiency at any load, we require evaluating output and hence inputting. This can be done by actually loading the transformer, known as load test. In this case keeping power factor constant, load impedance is varied and for different values of load output in KVA. Corresponding input is measured. Thus in this case, there is no necessity of calculating the losses separately. Voltage regulation is defined as the change in magnitude of the secondary (terminal) voltage form no-load to full-load.

i.e. voltage regulation (%) = $\frac{V_{2o} - V_{2.fl}}{V_{2.o}} \times 100$

Where V_{2o} = secondary voltage when load is thrown off.

$V_{2.fl}$ = rated secondary voltage at full load and specified p.f.

PROCEDURE:-

1. Connect the transformer to supply system through single phase variac by including appropriate meters as shown in circuit diagram.
2. Connect lamp banks on secondary side of the transformer. Very load to give load current equal to 20 %, 40 % 60 % 80 % and 100 % of the full load current in steps. For each step, measure input power and output power. At each load condition see that the input voltage to primary of the transformer remains normal. For this purpose make use of variac.
3. To determine regulation, set rated conditions and disconnect the load. Measure secondary no load voltage (V2o) with primary voltage held constant.
4. Draw the graph of efficiency v/s load current (I2) or output (W2) and comment.

OBSERVATION TABLE:-

SR NO	INPUT			OUTPUT			EFFICIENCY	REGULATION
	V_1 VOLTS	I_1 AMPS.	W_1 WATTS	V_2 VOLTS	I_2 AMPS.	W_2 WATTS	$\eta = \frac{W2}{W_1} \times 100$	$= \frac{V_{20} - V_{2\,fl}}{V_{2\,fl}}$
1								
2								
3								
4								
5								
6								

CALCULATION:-

Reading no: ___

(1) $\eta(\%) = W_1 \ / W_2 \ \times 100$ = ________ %

(2) Percentage Regulation $= \frac{V_{20} - V_{2\,fl}}{V_{2\,fl}} * 100$

GRAPH:- plot the graph of efficiency v/s load.

CONCLUSION:-

1. Comment on the nature of graph.
2. Discuss about the value of regulation obtained.

RELEVANT IS:-

1. IS 13956: 1994 testing of transformers
2. IS 10028
   Part I: 1985 code of practice for selection of transformer
   Part II: 1985 code for installation of transformer
   Part III: 1981 code for maintenance of transformer

EXPERIMENT.NO:- 4 **DATE:-_________**

AIM:-To find efficiency and regulation of a single phase transformer by indirect loading method (o.c & s.c test)

MACHINE SPECIFICATION:-

1-phase, 1.5 KVA, 230/115 Volts, 50 Hz. transformer.

APPARATUS:-

(1) Voltmeter (MI) 300V 1
(2) Voltmeter (MI) 30V 1
(3) Ammeter (MI) 10A 1
(4) Ammeter (MI) 5A 1
(5) Wattmeter 1-2A
150-300V 1
200 W,0.2p.f.
(6) Wattmeter 5-10A 1
30-60V
200 W
(7) Single phase variac 1

THEORY:- Efficiency of a single phase transformer at a particular load and power factor is defined as the output divided by input both being measured in the same unit. In indirect method, losses are predicted at different loads and power factors without actually loading the transformer in order to evaluate the efficiency and regulation. Open circuit test (O.C) and short circuit test (S.C) are performed to predict the losses.

OPEN CIRCUIT TEST :- In this test one of the winding is connected to supply at rated voltage while the other winding is kept open circuited. From the point of view of convenience and availability of supply, the test is usually performed from the L.V side while the H.V side is kept open circuited as shown in fig.1 As the no load current is hardly 3 to 5 percent of the full load current, the copper losses under this test will be negligible. Hence the wattmeter reading represents practically the core loss(iron loss) under no load condition. This loss is same for all loads. So iron losses are also known as constant losses. This test also serves the purpose of determining the shunt branch parameters.

SHORT CIRCUIT TEST:- For convenience of supply arrangement and current to be handled, the test is usually performed from the H.V side while the L.V side is short circuited as shown in fig.2 Since the transformer resistance and leakage reactance are very small the voltage (Vsc) required to circulate the full load current under short circuit is approximately 5 to 8 percent of the rated voltage. As Vsc is very low , iron losses are negligible and hence wattmeter reading represents full load copper losses of the transformer. This test also serves the purpose of determining the series parameters of the transformer. From the knowledge of losses, efficiency can be evaluated and regulation can be obtained from the knowledge of series parameters.

PROCEDURE:-

(1) Connect the transformer to supply system through single phase variac by including appropriate meters as shown in fig.1
(2) Keep the secondary (H.V) open circuited and adjust input voltage to a rated value and note down the various readings of the meters
(3) Connect the circuit as shown in fig.2 for short circuit test. Adjust the input voltage (Vsc) such that rated full load current flows in the windings. Note down the various readings of the meters.

OBSERVATION TABLE:-

Table:1 Open circuit test.

Vo(Volts)	Io(Amps)	Wo(Watts)

Table:2 Short circuit test.

Vsc(Volts)	Isc(Amps)	Wsc(Watts)

CALCULATIONS:-

(1) $W_i = W_o$ = __________ watts

(2) $W_{cu\text{-}fl} = W_{sc}$ = __________ watts

(3) $\eta = \dfrac{m \times \text{rated output} \times \cos\Phi}{(m \times \text{rated output} \times \cos\Phi) + W_i + (m^2 \times W_{cu\text{-}fl})}$

where m= Fraction of the full load

= ________________________

(4) $Zo_2 = Z_{sc} = V_{sc} / I_{sc}$ = ________ ohm
$Zo_1 = Zo_2 / K^2$ = ________ohm

(5) $Ro_2 = R_{sc} = W_{sc} / I_{sc}^2$ = ________ ohm
$Ro_1 = Ro_2 / K^2$ =________ohm

(6) $Xo_2 = X_{sc} = \sqrt{Z_{sc}^2 - R_{sc}^2}$ = _______ohm
$Xo_1 = Xo_2 / K^2$ =_______ohm

(7) $I_1 = \dfrac{KVA \times 100}{V_1}$

(8) $I_1 Ro_1$ = __________ volts

(9) $I_1 Xo_1$ = __________ volts

(10)Percentage regulation = $\dfrac{I_1 \sqrt{}\ Ro_1 \times \cos\Phi \pm I_1 Xo_1 \times \sin\Phi}{V_1}$ *100 %

RESULT TABLE:-

SR. NO	FRACTION OF LOAD	LOAD POWER FACTOR	Wi WATTS	Wcu WATTS	OUTPUT WATTS	INPUT WATTS	EFFICIENCY	REGULATION
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								

GRAPH:- plot the graph of efficiency v/s load.

CONCLUSION:-

1. Compare the efficiencies obtained by o.c test, s.c test and direct loading test.
2. Discuss the effect of load and pf on regulation.

RELEVANT IS:-

1.IS 13956: 1994 testing of transformers
2.IS 10028:
Part I: 1985 code of practice for selection of transformer
Part II: 1985 code for installation of transformer
Part III: 1981 code for maintenance of transformer

EXPERIMENT NO:- 5 **DATE:- _________**

AIM:- To determine external and internal characteristics of a d.c. shunt Generator.

MACHINE SPECIFICATION:-

3 HP, 1500 RPM , 230 V D.C. SHUNT MOTOR. COUPLED WITH 2.2 KW, 230 V, D.C. SHUNT GENERATOR.

APPARATUS:-

1. Voltmeter (MC) 300V 1
2. Voltmeter (MC) 30V 1
3. Ammeter (MC) 10A 1
4. Ammeter (MC) 1A 1
5. Rheostat 366 ohms,1.2 A 1
6. Tachometer 1

THEORY:- The external characteristic of a d.c. generator expresses the relationship between the terminal voltage and the load current at a constant speed. The external characteristics clearly indicate the terminal voltage maintained by the generator at a particular load. The shape of the characteristics depend on (i)armature reaction (ii)voltage drop in the armature winding, series ,interpole and compensating winding and (iii) voltage drop at the brush contact. In shunt wound generator the field winding is connected across the armature winding. The voltage across the shunt field winding is equal to the terminal voltage of the generator. The terminal voltage of the generator falls down due to armature reaction and ohmic drop in the armature winding as the load on the generator increases. As a result voltage across the field winding also decreases with increase in the load which causes a decrease in the exciting current. The terminal voltage further falls. Hence the total decrease in the voltage in case of shunt generator is much greater than that in the separately excited generators. The internal characteristic express the relationship between the e.m.f (Ea) actually induced in the armature(after allowing for the demagnetizing effect of armature reaction) and the armature current.

PROCEDURE:-

1. Connect the circuit as shown in circuit diagram of fig.1
2. Switch on the supply and adjust the excitation such that generator develops rated voltage at rated speed on no load condition. Note down the readings as per table.1.
3. Increase the load gradually and at suitable intervals note down the various readings at constant speed.
4. Reduce the load to zero and switch off the supply.
5. Connect the circuit as shown in fig.2. Switch on the supply and take various readings by changing the load. Note down the readings in table.2.

OBSERVATION TABLE:-

TABLE 1

SR. NO.	TERMINAL VOLTAGE Vt(Volts)	LOAD CURRENT I_L(Amps)	FIELD CURRENT Ish(Amps)	ARMATURE CURRENT $Ia = I_L + Ish$	INDUCED E.M.F. $Ea = Vt + Ia.Ra.$
1					
2					
3					
4					
5					

TABLE - 2

SR. NO.	VOLTAGE - Va Volts	CURRENT - Ia Amps	Ra = Va / Ia Ohms	AVERAGE Ra Ohms

CALCULATION:-

For reading no :______

(1) $Ia = I_L + Ish$ = ________ = __________

(2) $Ea = Vt + IaRa$ = ________ = __________

Plot the graph of Vt v/s I_L and Ea v/s Ia

CONCLUSION:-

Mention both the characteristics and discuss the nature of the graph and also mention about the drops occurring.

RELEVENT IS:

IS 489:1968

Mehtod of determination of efficiency of rotating electrical machine.

EXPERIMENT NO:- 6 DATE:-___________

AIM:-To determine external and internal characteristics of a d.c. series generator.

MACHINE SPECIFICATION:-

3 HP, 1500 RPM , 230 V D.C. SHUNT MOTOR. COUPLED WITH 2.2 KW, 230 V, D.C. SERIES GENERATOR.

APPARATUS:-

(1)Voltmeter	0-300 V(MC)	1
(2)Voltmeter	0-30 V(MC)	1
(3)Ammeter	0-10 A(MC)	1
(4)Lamp bank		1
(5)D.P.S.T. Switch		1

THEORY:- The external characteristic of a d.c. generator expresses the reletionship between the terminal voltage and the load current at a constant speed. The external characteristic clearly indicate the terminal voltage maintained by the generator at a particular load. The internal characteristic expresses the relationship between the e.m.f.(Ea) actually induced in the armature(after allowing for the demagnetising effect of the armature reaction.

In d.c. series generator, the field winding is connected in series with the armature so that the armature current, field current and load current are the same. When the generator is run at its rated speed on no load, no current passes through the field and hence the induced emf is due to residual magnetism. When the generator is loaded the current passes through the field. If the series field is properly connected so as to aid the residual flux, the terminal voltage increases with load current. This increase in the terminal voltage continues to increase up to the certain value of the load current. Any further increase in the load current reduces the terminal voltage. Induced voltage is also reduced due to the armature reaction at large value of the load current.

The series generators are not used in applications where constant voltage is required because of their rising external characteristic but these generators are generally used as boosters to compensate for the resistive voltage drop in the feeders of the d.c. distribution systems such generators are also used in arc welding.

PROCEDURE:-

1. Connect the circuit as shown in circuit diagram of fig. 1
2. Switch on the supply and adjust the speed of the motor to the rated speed of the set. Initially the generator will have small voltage due to residual magnetism. Note down the readings and record them in the table.1.
3. Load the generator in steps preferably for loads 10%, 25%, 50%, 75%, 100% and 110% approximately by adjusting the resistance of the load. Speed must be maintained constant at its rated value during the test. Observe the various readings and record them in table.1.
4. Reduce the load gradually to zero and switch off the supply.
5. Connect the circuit as shown in connection diagram of fig.2.
6. Take various readings by changing the resistance of the lamp bank and record them in table 2.

OBSERVATION TABLES:-

TABLE-1

SR. NO.	TERMINAL VOLTAGE Vt(Volts)	LOAD CURRENT IL(Amps)	VOLTAGE ACROSS SERIES FIELD Vse(Volts)	ARMATURE DROP Va = Ia.Ra	INDUCED E.M.F. Ea = Vt + Vse + Va
1					
2					
3					
4					
5					
6					

TABLE - 2

SR. NO.	VOLTAGE - Va Volts	CURRENT - Ia Amps	Ra = Va / Ia Ohms	AVERAGE Ra Ohms

CALCULATIONS:-

Reading No:______

1. Ra = Va / Ia (From table no.2)
2. Armature drop Va = Ia.Ra
3. Induced e.m.f. (Ea) = Vt + Vse + Va

GRAPH :-

1. Terminal voltage (Vt) v/s load current (I_L)
2. Induced e.m.f. (Ea) v/s armature current(Ia)

CONCLUSION:-

RELEVENT IS:

IS 4889:B9168

Method of determination of efficiency of rotating electrical machine.

EXPERIMENT NO:- 7 **DATE:-___________**

AIM:-To determine external and internal characteristics of a d.c. compound generator.

MACHINE SPECIFICATION:-

3 HP, 1500 RPM , 230 V D.C. SHUNT MOTOR. COUPLED WITH 2.2 KW, 230 V, D.C. COMPOUND GENERATOR.

APPARATUS:-

(1)Voltmeter	0-300 V(MC)	1
(2)Voltmeter	0-30 V(MC)	1
(3)Ammeter	0-10 A(MC)	1
(4)Ammeter	0-1 A(MC)	1
(5)Lamp bank		1
(6)Tachmeter		1
(6)D.P.S.T. Switch		1

THEORY:- The external characteristic of a d.c. generator expresses the reletionship between the terminal voltage and the load current at a constant speed. The external characteristic clearly indicate the terminal voltage maintained by the generator at a particular load. The internal characteristic expresses the relationship between the e.m.f.(Ea) actually induced in the armature(after allowing for the demagnetising effect of the armature reaction) and the armature current.

Compound generator is provided with two field windings, shunt and series. The shunt winding consists of a large number of turns of thin wire. It has a high resistance and is connected in parallel with the armature terminals. The series field winding consists of few turns of thick wire. It has a low resistance and connected in series with the armature.

Depending upon the method of connection of the field windings, compound generators are classified as (i) long shunt type and (ii) short shunt type.

In short-shunt type compound generator, the shunt winding is connected directly across the armature alone. The current through the series winding is the load current (I_L) which is equal to armature current(Ia) minus shunt field current (Ish) . In long shunt compound generator, the series field is directly in series with the armature and carries the armature current. The shunt field winding is connected across the series combination of armature and series field.

The shunt and series field windings are on the same pole. If the flux due to series field winding (Φs) aids the flux due to shunt field winding(Φsh) connection is said to be a cumulative connection. If the flux due to series field winding(Φs) opposes the flux due to shunt field winding(Φsh), it is said to be a differential connection.

Based on the combination of the connections and the directions of currents through the field windings, compound generators are further classified as:-

1. Long shunt cumulative compound generator
2. Long shunt differential compound generator
3. Short shunt cumulative compound generator
4. Short shunt differential compound generator

In d.c. compound generator, the series field winding is generally arranged to assist the shunt field winding. The manner in which the terminal voltage varies with the load current depends upon the relative strengths of the two windings as well as on the initial no-load voltage.

By suitably selecting the number of turns on the series winding, the terminal voltage can be made practically constant when the load varies from no-load to full load, the generator is said to be flat(level) compound generator. The characteristic is shown by curve A in fig.1.

By using relatively strong series field winding it is possible to off-set the voltage drop in the armature and the series field windings. The terminal voltage then rises with an increase in the load current as shown by curve B in fig.1, and the generator is said to be over compounded. If a series field is not strong, the terminal voltage decreases with the load current as shown by curve C in fig.1 and the generator is said to be under compound.

PROCEDURE:-

1. Connect the circuit as shown in circuit diagram of fig.2.
2. Switch on the supply and start the motor. Adjust the speed of the motor to the rated speed of the set.
3. Excite the shunt field till the e.m.f. on open circuit or on no load is the rated voltage. Note down the various readings and record them in the table.1.
4. Load the generator in steps preferably 10%, 25%, 50%, 75%, 100% and 110% load approximately by adjusting the resistance of the lamp bank. Observe the various readings during each step of load and record them. The speed of the set must be maintained at its rated value during the test.
5. Decrease the load gradually to zero and switch off the supply.
6. Connect the circuit as shown in connection diagram of fig.3.
7. Take various readings by changing the resistance of the lamp bank and record them in table 2.

OBSERVATION TABLES:-

TABLE.1

SR.NO	TERMINAL VOLTAGE Vt(Volts)	LOAD CURRENT IL(Amps)	SHUNT FIELD CURRENT Ish(Amps)	ARMATURE CURRENT Ia = IL + Ish	VOLTAGE ACROSS SERIES FIELD Vse(Volts)	ARMATURE DROP Va = Ia.Ra	INDUCED EMF E = Vt + Vse + Va
1							
2							
3							
4							
5							
6							

TABLE - 2

SR. NO.	VOLTAGE - Va Volts	CURRENT - Ia Amps	Ra = Va / Ia Ohms	AVERAGE Ra Ohms

CALCULATIONS:-

Reading No:___

1. Ra = Va/Ia (From table no 2.)
2. Ia = I_L + Ish
3. Va = Ia.Ra
4. E = Vt + Vsc + Va

CONCLUSION:-

Discuss about the machine used, also discuss the characteristics and nautre of the graph.

RELEVENT IS:-

IS 4889:1968

Mehtod of determination of efficiency of rotating electrical machines

IS 9320:1979

Guide for testing of direct current.

EXPERIMENT NO: 8 **DATE:_________**

AIM:-To study the performance of single phase transformers connected in parallel.

MACHINE SPECIFICATION:-

Two transformers:- 1-phase, 1.5 KVA, 230/115 Volts, 50 Hz.

APPARATUS:-

(1) Voltmeter	(MI)	300V	1
(2) Ammeter	(MI)	20A	1
(3) Ammeter	(MI)	10A	2
(4) Lampbank			1
(5) SPST switch			1

THEORY:-

For supplying a load in excess of the rating of an existing transformer,a second transformer may be connected in parallel. For this, primary windings are connected to the same supply busbars and secondary windings are connected to the load busbars. It is essential that terminals of similar polarities are joined to the same busbars. If this is not done, the two emfs induced in the secondaries will act together in the local secondary circuit resulting in a dead short-circuit, even on no load condition. There are certain definite conditions which must be satisfied in order to avoid local circulating current and to ensure that the transformers share the common load in proportion to their KVA ratings.

The conditions are as under:-

1. Primary windings of the transformers should be suitable for supply system voltage and frequency.
2. The transformers should be properly connected with regard to polarity.
3. The transformers should have the same transformation ratio.
4. The percentage impedances should be equal in magnitude and have the same X/R ratio in order to avoid circulating currents and operation at different power factors.
5. The equivalent impedance should be inversely proportional to the individual KVA rating in order to avoid circulating current in case of transformers having different KVA ratings.

From the above conditions, condition 1 and 2 are absolutely essential. If condition 3 is not satisfied, it results in some circulating current. When secondaries are loaded, circulating current will tend to produce unequal loading condition. So full KVA output can not be taken from the parallel connected group. If condition 4 is not satisfied powerfacter at which the transformers operate will be different.So the transformers will not share the load in proportion to their KVA ratings so for satisfactory operation, the above conditions should be satisfied.

PROCEDURE:-

1. Connect the circuit as shown in figure.
2. Keep the switch "S" open. Switch on the supply. If voltmeter connected across the switch "S" indicates twice the secondary side voltage, interchange one of the transformer connections. If voltmeter indicates zero close the switch "S".
3. Increase the load gradually and at suitable intervals of the load, note down the various readings.
4. Make the load zero and switch off the supply.

OBSERVATION TABLE :-

SR. NO.	LOAD CURRENT FROM TRANSFORMER-1 I_1 (Amps)	LOAD CURRENT FROM TRANSFORMER-2 I_2 (Amps)	TOTAL LOAD CURRENT I(Amps)
1			
2			
3			
4			
5			
6			
7			

GRAPH: - (1) I_1 v/s I and (2) I_2 v/s I (on the same graph.)

CONCLUSION: -

Comment on the nature of the graph and load sharing by each transformer.

RELEVANT IS:-

1. IS 13956: 1994 testing of transformers
2. IS 10028:

Part I: 1985 code of practice for selection of transformer
Part II: 1985 code for installation of transformer
Part III: 1981 code for maintenance of transformer

EXPERIMENT NO:- 9 **DATE:-________**

AIM:- To control Speed of a D.C.shunt motor by
(i) armature voltage control (rheostatic control) and
(ii) field control.

MACHINE SPECIFICATION:-

3 HP, 1500 RPM , 230 V D.C. SHUNT MOTOR.

APPARATUS:-

(1) Voltmeter (MC) 300V	1
(2) Ammeter (MC) 3A	1
(3) Rheostat 366 ohm, 1.2A	1
(4) Rheostat 100 ohm, 5A	1
(5) Tachometer	1

THEORY:- The speed of a D.C.motor is given by

$$N = \frac{(V - IaRa)(A)\ (60)}{Z.\ \Phi\ \ (P)} = K\ \frac{(V - IaRa)}{\Phi} = K\ \frac{Eb}{\Phi} \qquad (1)$$

Where V = applied voltage (V),
Ia = armature current (A)
Φ = flux per pole (Wb) ,
Ra = resistance of armature circuit (ohms)

It is obvious that the speed can be controlled by varying

(i) resistance of armature circuit (Ra)-rheostatic control
(ii) flux per pole (Φ) -flux control
(iii) applied voltage (V) - voltage control

- **FLUX CONTROL METHOD :-**

From equation (1)

$$N = K/\Phi \text{ (assuming other parameters constant)}$$

The equation indicates that the speed of the motor is inversely proportional to the flux per pole . Flux is proportional to the field current (up to saturation). So the speed is inversely proportional to the field current. Thus the speed can be increased by decreasing the flux or shunt field current which can be achieved by inserting a rheostat in the field circuit of the motor. Field current is 4 to 10 percent of full load current so losses are minimum. Normally speed higher than rated values are obtained by using this method of control. For specially designed motors this method can give a large variation of speed even of the order of 2:1 .

- **RHEOSTATIC CONTROL (ARMATURE VOLTAGE CONTROL):-**

speed of the motor is given by

$$N = K \frac{V - I_a(R_a + R)}{\Phi} \text{ r.p.m.}$$

(where R = external resistance)

The above equation clearly indicates that the voltage drop in the armature circuit increases even for a particular value of the load current resulting in a reduced voltage available across the armature terminals of the motor. As a result , the speed of the motor decreases with an increase in the value of external resistance R. Thus this method of speed control can only lower the speed of the motor below the rated speed. Speeds above the no load speed can not be obtained by this method. The speed regulation is very poor. A further disadvantage is the excessive wastage of power in the external resistance, which lowers the efficiency of the motor considerably. This method is used where frequent speed control is not needed and reduction in speed is of the order of 30 to 50 percents.

PROCEDURE:-

1. Connect the circuit as shown in the circuit diagram
2. For rheostatic control first adjust the normal speed of the motor without extra resistance in the armature circuit. Note down the reading.
3. Vary the external resistance(R) connected in armature circuit. Note down the various readings for each variation.
4. For field control, first adjust the normal speed of the motor without extra resistance in the field circuit. Note down the various readings
5. Vary the field current by external resistance connected in the field circuit. and note down the various readings for each variation.
6. Draw the graph of N v/s Va and N v/s If.

OBSERVATION TABLE:-

RHEOSTATIC CONTROL

SR. NO.	ARMATURE APPLIED VOLTAGE Va(volts)	SPEED IN R.P.M.	FIELD CURRENT If (Amps)
1			
2			
3			
4			
5			

FIELD CONTROL

SR. NO.	FIELD CURRENT If (Amps)	SPEED IN R.P.M.	ARMATURE APPLIED VOLTAGE Va(volts)
1			
2			
3			
4			
5			

GRAPH:- (1) N Vs If (2) N Vs Va

CONCLUSION:-

Mention in brief both the methods of speed control and also discuss the nature of the graph.

EXPERIMENT NO :- 10 **DATE:- ________**

AIM:-To determine the parameters of an equivalent circuit of a single phase transformer.

MACHINE SPECIFICATION:-

1-phase, 1.5 KVA, 230/115 V, 50 Hz TRANSFORMER.

APPARATUS:-

1. Voltmeter 0-300 V (MI) 1
2. Voltmeter 0-60 V (MI) 1
3. Ammeter 0-10 Amp(MI) 1
4. Ammeter 0-1 Amp(MI) 1
5. Wattmeter 0-300-600 V, 0-1.5-3Amp, 0-200W 0.2 p.f 1
6. Wattmeter 0-150-300 V, 0-10-20 Amp, 0-200 Watt 1
7. Single phase variac 1

THEORY:- It is useful to describe the behavior of an electrical equipment in terms of its equivalent circuit. The equivalent circuit is quite helpful in predetermining the behavior under various conditions of operation from the known parameters of the equivalent circuit. The transformer can be assumed to be an ideal alongwith the additional impedances inserted between the supply and the primary winding and between the secondary winding and load as shown in fig.1. R1 and R2 represent the resistances of the primary and secondary windings respectively of the actual transformer. Similarly X1 and X2 represent the actual values of the leakage reactances. The no-load current Io which is equal to the phasor sum of the magnetizing component Im and active component Iw is equivalent to that drawn by a resistance Ro and reactance Xm connected in parallel as shown in fig.1. The value of Ro is such that it takes the current Iw so that Iw^2 Ro is equal to the core loss of the actual transformer. Similarly the value of Xm is such that it takes a current equal to the magnetising current of the actual transformer. It is more convenient to solve the circuit by taking the values of resistance and leakage reactance referred to one side either primary or secondary than considering them in a mixed manner. This reduces the equivalent circuit in simple form. Let R2' be the resistance added in the primary circuit to cause the same copper loss as caused by the resistance R2 in the secondary circuit. Since the current I2 when transferred to primary appear as I2', this additional resistance causes a copper loss $(I2')^2.R2'$

Therefore $(I2')^2.R2' = I2^2.R2$

$R2' = (I2/I2')^2.R2$ But $I2/I2' = N1/N2$

$\therefore$ $R2' = R2.(N1/N2)^2$

R2’ is called the resistance of secondary referred to the primary.
and, $X2' = X2(N1/N2)^2$
X2' is called the leakage reactance of secondary referred to the primary.
Similarly load impedance (Zl) can also be transferred to the primary side. Fig.2 shows the exact equivalent circuit with all parameters transferred to the primary side. Similarly parameters of the primary side can be transferred on the secondary side.
The parameters when transferred to secondary side are given as

$R1' = R1(N2/N1)^2$ and

$X1' = X1(N2/N1)^2$

APPROXIMATE EQUIVALENT CIRCUIT:- As the no-load current Io is hardly 3 to 5 percent of the full load current, parallel branch consisting of Ro and Xm can be shown across the supply as shown in fig.3. The circuit of fig.3 can be further reduced as shown in fig.4. In fig.4,

$$R01 = R1 + R2' = R1 + R2(N1/N2)^2$$
$$X01 = X1 + X2' = X1 + X2(N1/N2)^2$$

R01 = equivalent resistance referred to primary
X01 = equivalent reactance referred to primary

The above parameters can be obtained from O.C. and S.C. test. Ro and Xm can be obtained from the o.c. test while R01 and X01 can be obtained from s.c. test.

O.C.TEST:-Usually low voltage side is exited. The core loss is the same measured on either side provided the rated voltage of that winding is applied. Nevertheless if the measurements were made on the high voltage side, the required voltage would be rather high and the current Io would be inconveniently small. It is pertient to add that the power factor under no-load condition is very low(around 0.3 or so). Therefore it is advisable to use a low power factor wattmeter to ensure accurate value of the no-load loss.
Let Vo, Io and Wo be the readings of no-load voltage,current and power.

Then $$\cos \Phi o = \frac{Wo}{Vo.Io} \quad ----(1)$$

Core loss component (active component of no-load current)

$$Iw = Io.\cos \Phi o \quad ----(2)$$ and

magnetising current(reactive component of no-load current)

$$Im = Io.\sin \Phi o \quad ----(3)$$

$$Ro = Vo/Iw \text{ and } Xm = Vo/Im \quad ----(4)$$

S.C.TEST:-This test is conducted to find out the equivalent resistance and leakage reactance of the windings. In this test, normally low voltage(LV) side is shorted and the high voltage(HV) side is excited by a suitable voltage so that rated full-load current may flow in the windings. Only a few percent of the rated voltage need be applied. Core losses are negligible. Therefore the wattmeter reading is equal to the full-load copper losses of both the windings provided full-load current is flowing.

Let Vsc, Isc and Wsc be the readings of voltmeter, ammeter and wattmeter then

$$Zo1 = Vsc/Isc \qquad \text{------}(1)$$

$$Ro1 = Wsc/Isc^2 \qquad \text{------}(2)$$

$$Xo1 = \sqrt{Zo1^2 - Ro1^2} \quad \text{---}(3)$$

Where Zo1, Ro1 and Xo1 denote the equivalent impedance, resistance and leakage reactance respectively referred to the primary side.

PROCEDURE:-

1. Connect the circuit as shown in fig.5 for o.c. test.
2. Apply rated voltage to the low voltage side keeping high voltage side open. Note down the various readings and record them in the observation table.
3. Connect the circuit as shown in fig.6 for s.c. test.
4. Apply suitable voltage such that full load current flows in the windings. Note down the various readings and record them.

OBSERVATION TABLE:-

O.C.TEST:-

Vo(Volts)	Io(Amps)	Wo(Watts)

S.C.TEST:-

Vsc(Volts)	Isc(Amps)	Wsc(Watts)

CALCULATIONS:-

Reading No:__

O.C.TEST:-

N1/N2 = V1/V2 = ____________

No load current referred to the primary(H.V.) side

Io' = Io(N2/N1) = Io(V2/V1)

Cos Φo = Wo/V1.I1' (V1 = primary rated voltage)

Iw = Io'Cos Oo

Im = Io'Sin Oo

Ro = V1/Iw

Xm = V1/Im

S.C.TEST:-

$Zo1 = Vsc/Isc$

$Ro1 = Wsc/Isc^2$

$$Xo1 = \sqrt{Zo1^2 - Ro1^2}$$

CONCLUSION:-

The parameters of the equivalent circuit are as under

Ro = __________ ohm
Xm = __________ ohm
Ro1 = __________ ohm
Xo1 = __________ ohm
Zo1 = __________ ohm

RELEVENT IS:

IS 13956:1994
Testing of transformer