① 5 ✱

DATE:

EXPERIMENT NO:

TITLE OF THE EXPERIMENT: CALIBRATION OF DC AMMETER AND DC VOLTMETER

OBJECTIVES:

- To compare the readings of a given ammeter and voltmeter with the corresponding calculated value of current and voltage from the observations of a dc potentiometer
- To calculate the percentage error for different observed values of current and voltage

THEORY:

Instrument calibration is one of the primary processes used to maintain instrument accuracy. Calibration is the process of configuring an instrument to provide a result for a sample within an acceptable range. Eliminating or minimizing factors that cause inaccurate measurements is a fundamental aspect of instrumentation design.

The instruments must be calibrated periodically to ascertain their claimed accuracy. The best method of calibration is to measure the true value of current or voltage in the circuit and compare it with the value measured by the given ammeter or voltmeter. The true value of current or voltage in the circuit can be measured up to a fair grade of accuracy by using a potentiometer. The percentage error of the instrument can be calculated as follows:

$$Percentage\ of\ error = \frac{measuredvalue - truevalue}{truevalue} \times 100$$

A potentiometer is an instrument for measuring an unknown emf or potential difference by balancing it, wholly or in part, by a known potential difference. Potentiometers are, therefore, used for measuring emfs. Generally, the maximum voltage that can be measured by a potentiometer is 0-1.8V. If a higher voltage range is to be measured, then a volt-ratio box is used. A volt-ratio box is actually a potential divider. For instance, a dc voltage connected at the high end terminal of the volt-ratio box is 300V gives an output of 1.8V at the low end terminal.

For calibration of voltmeter a dc source is required. A potential divider is connected to the supply. Output of the potential divider is connected between the common terminal and the high voltage post of the volt-ratio box. A voltmeter is also connected at this point. Output of the volt ratio box is connected with the potentiometer. If the reading of the potentiometer is 0.975V, then the value of the unknown voltage is 0.975x300/1.8=162.5V.

For calibration of ammeter, a standard resistor of suitable value and sufficient current carrying capacity is placed in series with the ammeter. The voltage across the standard resistor is measured with the help of potentiometer and the current through the standard resistor can be computed as

$$I = \frac{V_s}{S}$$

Where, V_S=voltage across the standard resistor as indicated by the potentiometer, S=resistance of the standard resistor.

CIRCUIT DIAGRAMS:

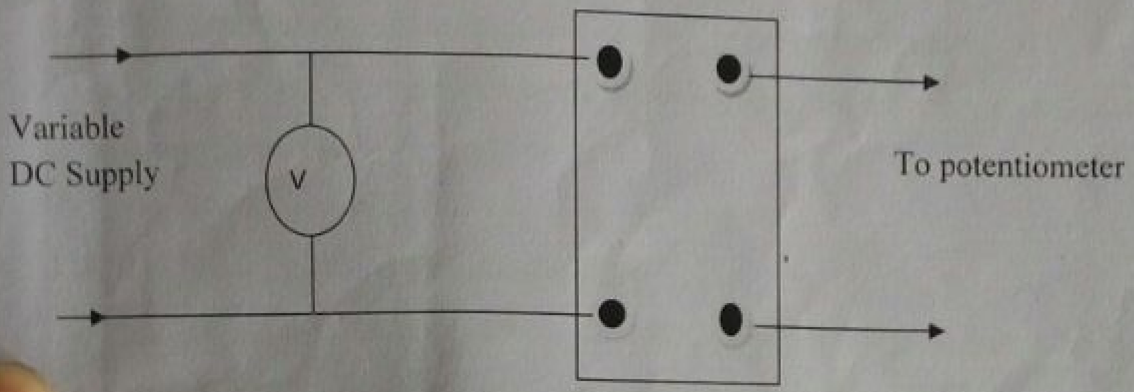

Fig. 1 Calibration of Voltmeter with potentiometer and volt-ratio box

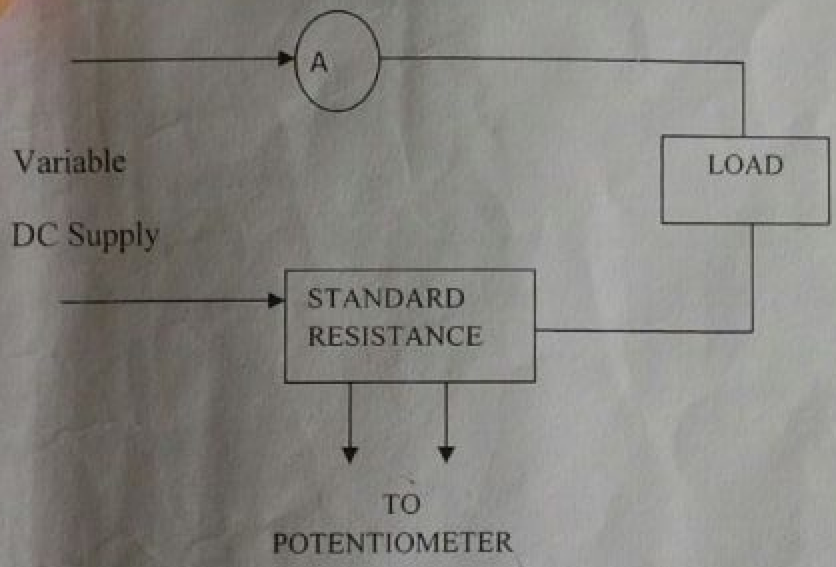

Fig. 2 Calibration of Ammeter with potentiometer and standard resistance

APPARATUS USED:

Sl. No.	Name of the apparatus used	Quantity	Maker's Name	Range / rating of the apparatus

PROCEDURE:

Calibration of Voltmeter

- The connections are made as shown in the figure 1.
- The potentiometer is first standardized.
- The variable dc supply source is adjusted at any voltage value so that the pointer coincides exactly with a major division of the voltmeter.
- The corresponding dc voltage is measured by the potentiometer.
- The actual voltage measured by the potentiometer and the error are calculated.

Calibration of Ammeter

- The connections are made as shown in the figure 1.
- The potentiometer is first standardized.
- The variable dc supply source is adjusted at any current value so that the pointer coincides exactly with a major division of the ammeter.
- The voltage drop across the standard resistance is measured by a potentiometer.
- The actual current measured by the potentiometer and the error are calculated.

EXPERIMENTAL DATA TABLE:

Calibration of Voltmeter:

Sl. No.	Voltmeter Reading (V_x)Volts	Voltage Measured by the Potentiometer (V_p) Volts	Ratio of Volt-Ratio Box (K)=Input/Output	Actual Voltage Calculated (V_p x K) Volts	Percentage of error

Calibration of Ammeter:

Sl. No.	Ammeter Reading (A_x) Amp	Voltage Measured by the Potentiometer (V_s) Volts	Value of the Standard Resistance (S) ohm	Actual Current Calculated (V_s/ S) Amp	Percentage of error

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CONCLUSION:

QUESTIONAIRE:

- Why is it necessary to calibrate an ammeter and a voltmeter?
- Explain why is it necessary to standardize the potentiometer before making any measurement.

THE END

① #

DATE:

EXPERIMENT NO:

TITLE OF THE EXPERIMENT: DETERMINATION OF THE MAGNETIZATION CHARACTERISTICS (O.C.C.) OF A D.C. SHUNT GENERATOR

OBJECTIVES:

- To perform no load test on a dc shunt generator.
- To obtain the magnetization characteristics at rated speed under separate excitation.
- To obtain the Critical Field Resistance.

THEORY:

A dc shunt generator is a machine which converts mechanical energy to electrical energy. This conversion of energy is based on the principle of the production of a dynamically induced emf. In a D.C. shunt generator, the field is on the stator and the armature is on the rotor. The field is excited by a dc supply. With the help of a prime mover, the rotor is rotated thereby cutting the flux produced by the field coils. This rate of change of flux-linkage with the conductor induces an alternating voltage, which is rectified through a commutator converting it into a d.c. output which is given by

$$E_g = \frac{\varphi ZN}{60} X \frac{P}{A}$$

where, φ =Flux per pole,

Z= Total number of conductors,

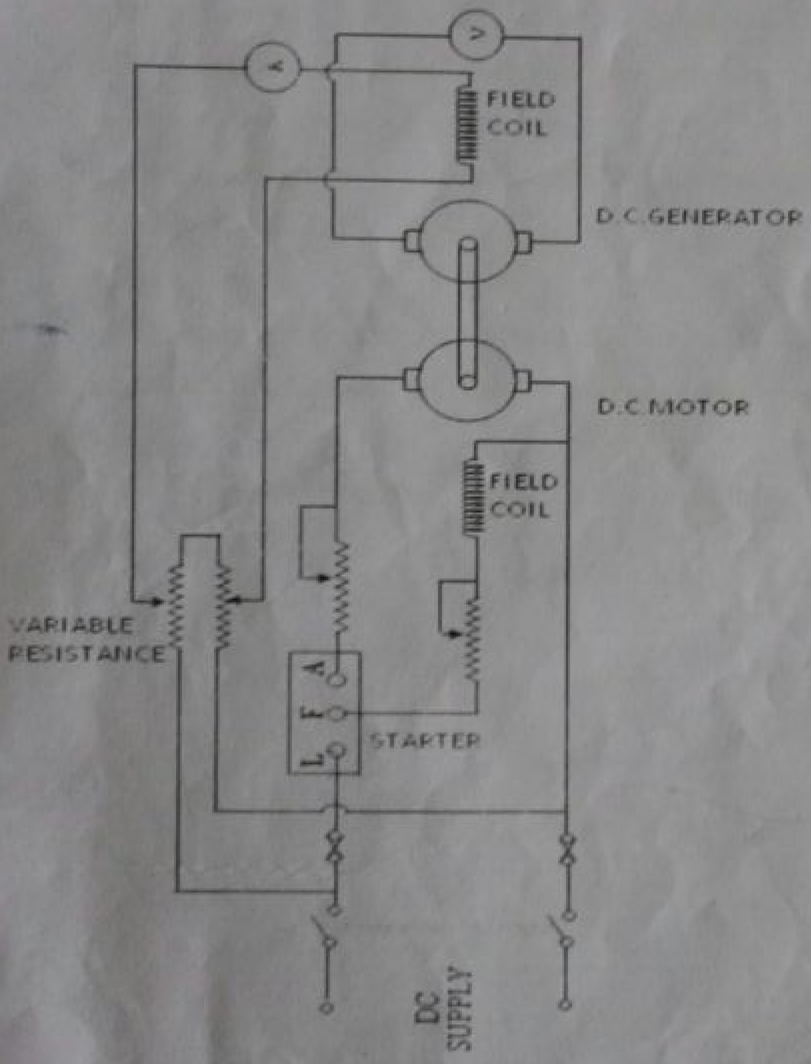
P= Number of poles,

A= Number of parallel paths,

N=Speed in rpm.

The magnetic circuit in a dc machine contains ferromagnetic material viz, iron having silicon content sheet. Hence, except at low values of field current, Φ shows a nonlinear relation with the field current, but it gets saturated as field current rises further. Again, the magnetic material has some retentivity i.e., residual magnetism. So there may be some armature voltage even at no field current. All these can be reflected by a plot at a fixed speed called the no load magnetization characteristic. The voltage due to residual magnetism is used to circulate current through shunt field winding in a direction (so connected across d.c. m/c armature) to aid further magnetization or flux and hence more built up voltage. This is known as self-building up process. However, because of B-H characteristic or magnetic saturation, this self-building up again depends on the total maximum field circuit resistance (known as critical field resistance) at certain specified speed and also on speed (known as critical speed) at certain field circuit resistance.

CIRCUIT DIAGRAM:



APPARATUS USED:

Sl. No.	Name of the apparatus used	Quantity	Maker's Name	Range / rating of the apparatus

PROCEDURE:

- The connections are made as shown in the circuit diagram.
- The d.c. shunt motor is started with maximum armature resistance and minimum field circuit resistance through a 3 point starter.
- The speed is set to rated value by adjusting the motor armature rheostat.
- The generated voltage and motor speed at zero field current of the generator field winding are noted.
- The field current of the generator is gradually increased in steps keeping the speed at its rated value. The corresponding values of armature voltage and field current are also noted down.
- The field current of the generator is reduced to zero and the motor generator set is switched off.

EXPERIMENTAL DATA TABLE:

Obs. No.	D.C.Generator.		
	Field Current (I_f) A	Generated Voltage (E_g) V	Speed(N) rpm

(SIGNATURE OF THE FACULTY / TECHNICAL STAFF)

(4) #

PHYSICAL CHARACTERISTICS:

- Plot Generator voltage (E_g) Vs. Field current (I_f) at N= rated
- Draw the critical field circuit resistance line which is a straight line passing through the origin and touching the maximum portion of the straight (approximate) part of the plot and get its slope in ohm. This is the value of the critical field resistance.

CONCLUSION:

QUESTIONAIRE:

- What are the conditions for voltage build up in a self-excited dc shunt generator?
- Why is the generated emf not equal to zero when there is no field excitation?
- What is the importance of critical field resistance?
- What is the importance of critical speed?

DATE:

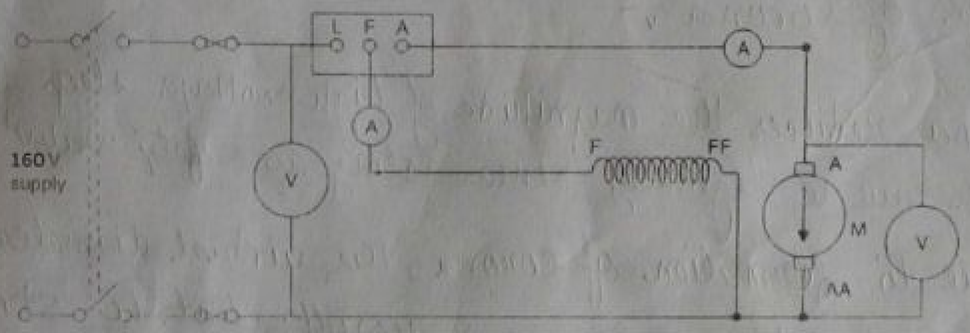
EXPERIMENT NO:

TITLE OF THE EXPERIMENT: Starting and Reversing speed of a DC shunt motor.

OBJECTIVES:

- To become familiar with the starting and reversing the speed of a D.C. shunt motor.
- To become familiar with the starting of a D.C. shunt motor using 3-point starter.

CIRCUIT DIAGRAM:



THEORY:

When a D.C. motor is connected to its rated supply it draws high current which is more than rated armature current. This current may cause damage to the armature winding. The motor voltage equation is given by-

$$V=E_b+I_aR_a$$

Where, E_b- Back e.m.f= $\frac{P\text{Ø}ZN}{60A}$, I_a= Armature Current, R_a= Armature Resistance

$I_a=(V-E_b)/R_a$

$$\text{So, } E_b = K\text{Ø}N$$

As, $E_b \propto N$, and at starting N=0, So $E_b = 0$,

At starting the armature current equation becomes

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

Generally the value of the armature resistance is very low for that huge current will flow through armature winding. To reduce the heavy inrush of such current a suitable rheostat is to be

2

connected in series with the armature winding. Resistance needs to be gradually decreased with the increase of speed.

Torque equation is given by,

$T = K I_a \varnothing$ [Where, $\varnothing$ = Flux per pole, I_a = Armature Current, K= Constant]

Torque is related to I_a and $\varnothing$.. So, by changing the polarity of either I_a or $\varnothing$ the direction of torque can be changed.

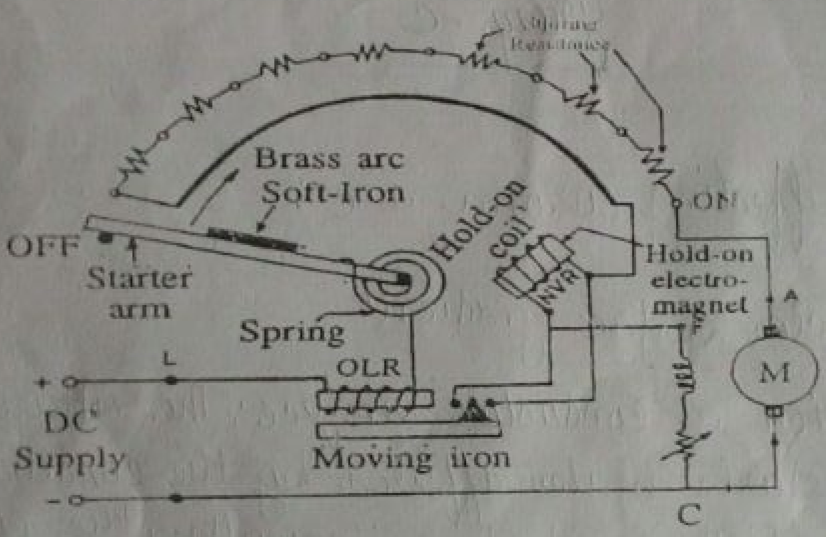


Fig. 1- Three Point Starter

EQUIPMENTS/INSTRUMENTS REQUIRED:

Name of apparatus	Quantity	Type	Range	Maker's Name
Voltmeter				
Ammeter				
Resistors				
Techo Meter				
3-point starter				

DEVICE UNDER TEST:

1. DC motor

9805298870

PROCEDURE:

- The circuit is connected as shown in the circuit diagram.
- The DC supply is switched on with minimum resistance in the field circuit and the starting handle is moved to first position slowly.
- As soon as the arm makes contact with first stud of the 3 point starter, the motor stars running.
- The armature current increases rapidly and settles to a steady value.
- The armature current, armature voltage and field current at the instant of starting are noted.
- Gradually all resistances are cut by further moving the arm to the right slowly.
- When the arm reaches the run position, all the resistances are bypassed and starting arm would be attached with electromagnet.
- The armature current, armature voltage and field current and speed are noted when values settle to a steady value.
- The direction of rotation of motor is observed at different connection mentioned in table-2.
- The supply is switched off and starting arm comes to off position automatically.

EXPERIMENTAL DATA:

TABLE-1

Obs. No.	Operation mode	Field Current (I_f) A	Armature Current (I_a) A	Speed (N) rpm
1.	At the start			
2.	Final			

TABLE-2

Particulars of observation	Speed (N), rpm	Direction of rotation
Connection as in circuit diagram		
Reverse field winding only		
Reverse armature winding only		
Reverse both armature and field winding		

PRECAUTION:

- Voltage across armature should not be applied without applying voltage to the field winding of a D.C.motor.
- All connections are to be tightly connected.

CONCLUSION:

QUESTION:

1. If a three point starter is not available, how can a DC motor be started?

2. What is the function of no volt release in 3 point starter?

3. What is the function of overload release?

4. Write the appropriate range of meters used in the circuit diagram.

DATE:

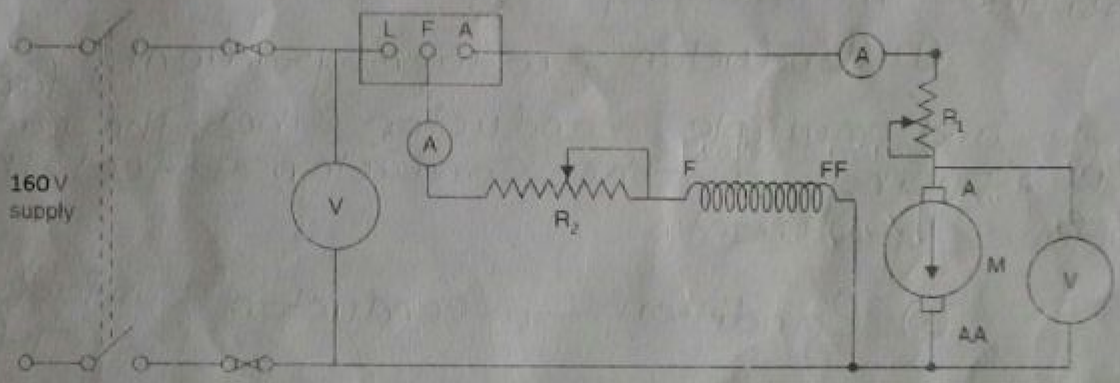
EXPERIMENT NO:

TITLE OF THE EXPERIMENT: Speed control of DC Shunt Motor.

OBJECTIVES: To study the speed control of a DC shunt motor by the following methods:

- Armature voltage control: Variations of speed with armature voltage control at constant field current.
- Field Control: Variation of speed with variation of field current at constant voltage.

CIRCUIT DIAGRAM:



THEORY:

Fundamental Relationship:

DC motor voltage equation is given by-

$$V=I_aR_a+E_b \quad \text{.....................(1)}$$

Where V= supply DC voltage in volt, I_a = Armature current in amp, R_a =Armature resistance in ohm and E_b is the back e.m.f or counter e.m.f. in volt.

$$\text{Now, } E_b = K\O_f N \quad \text{................. (2)}$$

where $\O_f$ is the field flux/pole in wb and K=PZ/60A is constant depends on construction of the motor.

The field flux $\O_f$ is proportional to the field current if the magnetic parh is not saturate as is represented as,

$$\O_f \propto I_f \qquad [I_f = \text{Field Current}] \text{ .... (3)}$$

combining equation (1), (2) and (3) we get

$$V \;\alpha\; I_aR_a + KI_fN$$

$$N \;\alpha\; \frac{V - I_aR_a}{I_f} \quad \text{............ (4)}$$

From the equation (4), it is seen that the rotor speed depends on V, I_a, R_a and I_f. If the supply is constant the the motor speed can be controlled by controlling I_a, R_a or I_f.

[A] Field Control:

In field control, the applied armature voltage is maintained constant. Then the speed is represented by

$$N \;\alpha\; \frac{1}{I_f} \quad \text{...................... (5)}$$

It is evident from the above equation that motor speed is inversely proportional to the field current. Now, I_f is given by

$$I_f = \frac{V}{R_f} \quad \text{where } R_f = \text{field resistance............. (6)}$$

In this type of control an external variable resistance(R_{ex}) is connected with the field circuit to vary the field current

$$I_f = \frac{V}{R_f + R_{ex}} \quad \text{..................(7)}$$

By increasing the field resistance the I_f can be decreased which in turns increases the speed according to the equation (5). The upper speed is limited by the commutator and brushes structure. The speed control below the rated speed control is not possible using this type of control. Armature voltage control is used to control the motor speed below the rated speed.

[B] Armature Resistance Control:

In this method a external variable resistance (R_x) is connected in series with the armature. The supply voltage is kept constant to maintain the I_f or field flux constant. So the equation (4) can be written as

$$N \;\alpha\; V - I_a(R_a + R_x) \quad \text{.................(4)}$$

It can be seen from the above equation that the motor speed will be decreased from the value rated to zero value by varying the R_x from zero to infinity. This type of control can only be used for speed control below the rated speed.

EQUIPMENTS/INSTRUMENTS REQUIRED:

Name of apparatus	Quantity	Type	Range	Maker's Name
Voltmeter				
Ammeter				
Resistors				
Techo Meter				
3-point starter				

DEVICE UNDER TEST:

1. DC motor

PROCEDURE:

- The circuit is connected as shown in the circuit diagram.
- The DC supply is switched on with minimum resistance in the field circuit and maximum value of R_1 in the armature circuit.
- The field current is adjusted to normal value corresponding to the normal speed.
- Keeping field current constant, the voltage across the armature is changed by changing R_1 in 5 steps. The armature voltage, speed and field currents are noted in Table-1 for each step.
- The voltage across the armature is kept at rated value.
- Keeping armature voltage constant, the field current of the motor is decreased in 5 steps with the help of rheostat R_2. The armature voltage, speed and field currents are noted in Table-II for each step.

EXPERIMENTAL DATA:

TABLE-I

No. of Observation	Armature Voltage (Volts)	Speed (N) rpm	Field current (I_f) A (Constant)	Armature Current (I_a) A
1				
2				
3				
4				
5				
6				

TABLE-II

No. of Observation	Field current (I_f) A	Speed (N) rpm	Armature Voltage (constant)	Armature Current (I_a) A
1				
2				
3				
4				
5				
6				

PRECAUTION:

- The current, voltage and speed are noted when values settle to a steady value.
- Voltage across armature should not be applied without applying voltage to the field winding of a D.C. motor.
- All connections are tightly connected.
- The speed of the machine should not exceed 125% of the rated value.
- The supply is switched off after experiment is over.

REPORT:

- The graph of Speed vs. Armature voltage with field current constant is plotted on a graph paper.
- The graph of Speed vs. Field current with armature voltage constant is plotted on a graph paper.
- The graph of Speed vs. Armature current with armature voltage constant is plotted on a graph paper.

CONCLUSION:

QUESTION:

1. What will happen if the field circuit is opened during experiment?
2. In this experiment, does the saturation in the machine play any role? Explain.
3. Why N vs. V_a curve is linear and N vs. I_f is nonlinear?
4. Can you get speeds above rated speed by armature resistance control method?
5. Can you get speeds below rated by field control method?
6. In the above experiment, does the saturation in the machine play any role? Explain.
7. Write the appropriate range of meters used in the circuit diagram.

DATE:

EXPERIMENT NO:

TITLE OF THE EXPERIMENT: Open Circuit and Short Circuit Test of a Single Phase Transformer.

OBJECTIVES:

To find the equivalent circuit parameters and different losses of a single phase transformer.

CIRCUIT DIAGRAM:

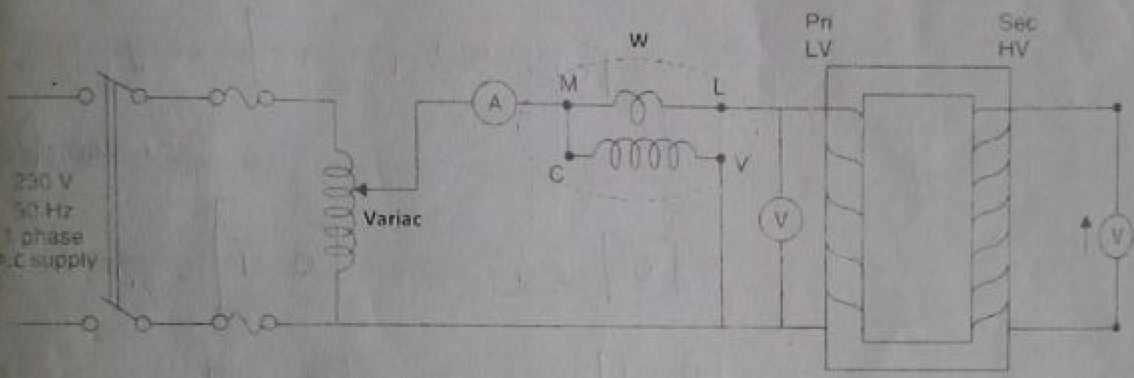


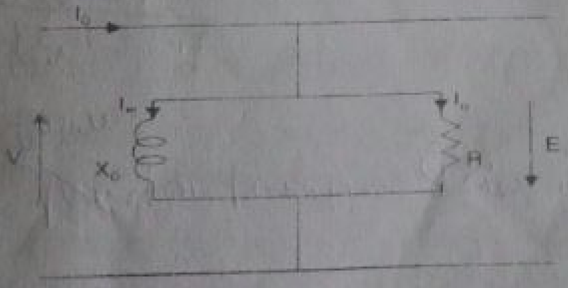
Figure: 1

THEORY OF OPEN CIRCUIT TEST OR NO LOAD TEST:

This test is used to determine the core (or iron or excitation) loss, P_i, and no-load current I_0 and the shunt branch parameters R_0 and X_0 of the equivalent circuit.

In this test the high voltage winding is kept open and the rated voltage at rated frequency is applied to the other winding as shown in fig.1. The wattmeter connected in the primary (LV) will then read the total hysteresis and eddy current loss (W_0) in the single phase transformer. Since the primary no load current is small, the copper losses due to it can be neglected. No copper loss will occur at secondary because the secondary current is zero. If the supply voltage is V volts,

$$V_1 I_0 \cos\emptyset_0 = W_0$$



The open circuit test gives enough data to compute the equivalent circuit constants R_0, X_0, no load power factor $\cos\O_0$, no load current I_0, and the iron losses of a transformer.

Iron loss, P_i = Input power on no load= W_0 (watt)

No load current = I_0 amperes

Applied voltage to primary = V_1 volts.

Angle of lag $\O_0 = \cos^{-1}\frac{P_0}{V_1 I_0}$

No load working component of current, $I_c = I_0 \cos\O_0 = \frac{W_0}{V_1}$

No load magnetizing component of current, $I_m = \sqrt{I_0^2 - I_c^2}$

Equivalent circuit parameter, $R_0 = \frac{V_1}{I_c} = \frac{V_1^2}{W_0}$

Equivalent circuit parameter, $X_0 = \frac{V_1}{I_m} = \frac{V_1}{\sqrt{I_0^2 - I_c^2}}$

CIRCUIT DIAGRAM:

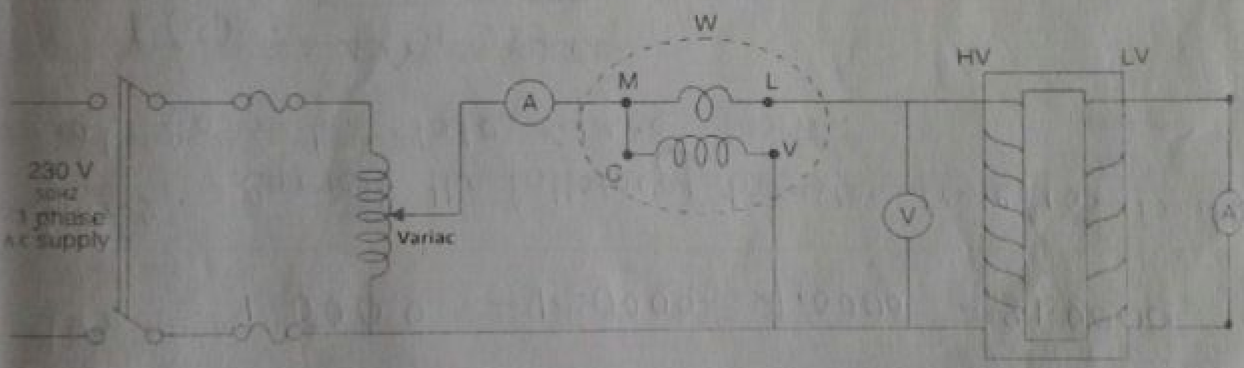


Figure: 2

THEORY OF SHORT CIRCUIT TEST OR IMPEDENCE TEST:

The purpose of this test is to determine full load copper loss and the equivalent resistance and reactance referred to metering side.

In this test, the terminals of secondary winding (Low voltage side) are short circuited through an ammeter and a variable low voltage is applied to the primary side through a variac, as shown in fig-2. The transformer now becomes equivalent to a coil having an impedance equal to impedance of both the windings.

The applied voltage, V_1 to the primary is gradually increased till the ammeter A indicates the full load (rated) current of the metering side. Since applied voltage is very low (5-8% of the rated voltage) so the flux linking with the core is very small and therefore, iron losses are so small that these can be neglected. Thus, the power input gives total copper loss at rated load, the output being nil. Let the readings of voltmeter, ammeter and wattmeter be V_1, I_1 and W_1 respectively.

Full load copper loss, $P_c = I_1^2 R_{eq} = W_1$

Equivalent resistance, $R_{eq} = \frac{W_1}{I_1^2}$

Equivalent impedance, $Z_{eq} = \frac{V_1}{I_1}$

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

DEVICES UNDER TEST:

Name of device	Quantity	Type	Rating	Maker's Name
Transformer				

EQUIPMENTS/ INSTRUMENTS REQUIRED:

Name of apparatus	Quantity	Type	Range	Maker's Name
Voltmeter				
Ammeter				
Wattmeter				
Variac				

PROCEDURES:

(Open circuit test):

- The circuit is connected as shown in the circuit diagram.
- Maintaining the supply frequency constant, the applied voltage is varied to the rated normal value by means of a Variac and the reading of primary current, input power, voltage impressed and secondary voltage are noted.

(Short Circuit Test):

- The circuit is connected as shown in the circuit diagram. Here the LV winding is short circuited by a connection having negligible resistance and good contacts, preferably by an ammeter.
- Maintaining the supply frequency constant, the applied voltage is varied so that full load rated current flows and the readings of current, power, voltages are noted.

EXPERIMENTAL DATA:

TABLE-I (Open Circuit Test)

Sl. No.	Primary Voltage (V_1) V	Ammeter Reading (I_0) A	Wattmeter Reading (W_0) W	Secondary Voltage (V_2) V	Active Current $I_c = \frac{W_0}{V_1}$	Magnetizing Current $I_m = \sqrt{I_0^2 - I_c^2}$	Equivalent Circuit Parameter	
							$R_0 = \frac{V_1}{I_c} = \frac{V_1^2}{W_0}$	$X_0 = \frac{V_1}{I_m} = \frac{V_1}{\sqrt{I_0^2 - I_c^2}}$

TABLE-II (Short Circuit Test)

Sl. No.	Applied Voltage V_1 (V)	Ammeter Reading I_1 (A)	Secondary Current I_2(A)	Wattmeter Reading (W_1)	Equivalent resistance $R_{eq} = \frac{W_1}{I_1^2}$	Equivalent impedance $Z_{eq} = \frac{V_1}{I_1}$	Equivalent reactance $X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2}$

PRECAUTIONS:

- The open circuit test is performed at rated voltage and frequency.
- For measuring power at no load, a wattmeter of low power factor should be used.
- During short circuit test, the supply voltage should be applied through a variac and voltage is increased very slowly from its low value, so that rated current flows through the secondary. The current should not exceed the rated value otherwise it would damage windings.
- All connection must be clean and tight.

...ed at this point. Output of the volt... and the high
...er. If the reading of the potentiometer is 0.975V, then
...voltage is 0.975x300/1.8=162.5V.

...meter, a standard resistor of suitable value and sufficient current carrying
...series with the ammeter. The voltage across the standard resistor is
...of potentiometer and the current through the standard resistor can be

CONCLUSION:

QUESTION:

1. Why is the OC test usually carried out on the LV side, keeping HV side open?
2. Why is the SC test usually carried out on the HV side, keeping LV side shorted?
3. State the losses occurring in a transformer at no load and on what factors do these depend?
4. Why iron losses are not considered in short circuit test calculation?
5. Why rated voltage is to be applied to primary for OC test?
6. Why rated current should flow in the secondary for SC test?

DATE: EXPERIMENT NO:

TITLE OF THE EXPERIMENT: THREE PHASE POWER MEASUREMENT USING TWO WATTMETERS

OBJECTIVES:

- To measure the total power consumed in a balanced three phase star / delta connected load by using two wattmeters.
- To calculate the power factor of the load connected to the three phase system.

THEORY:

A wattmeter consists of two coils: a low resistance current coil which is connected in series with the line carrying the current, and a high resistance potential coil which is connected across the two points whose potential difference is to be measured. Thus, a wattmeter shows a reading which is propoprtional to the product of the current through its current coil, the potential drop across its voltage coil and the cosine of the angle between this voltage and the current.

In order to measure the power consumed in a three phase ac circuit (**whether wye or delta**) by two wattmeters, the current coils of the wattmeters are inserted in series in any of the two lines and the potential coils are shorted and connected to the third line.

(i) Wye or Star connection

Let the phase voltages be $V_1=V_2=V_3=V_P$, the line-to-line voltage be V_L, phase currents be I_P and line currents be I_L. For a star connection, the phase and line voltages are realated as

$$V_L = \sqrt{3}V_P \qquad (1)$$

and the phase and line currents are related as

$$I_L = I_P \qquad (2)$$

If the power factor of the load is cos θ, then, the power measured by wattmeter W_1 is $I_L V_L \cos(30^\circ-\theta)$. Similarly, the power measured by wattmeter W_2 is $I_L V_L \cos(30^\circ+\theta)$. Adding the two readings,

$$W_1 + W_2 = \sqrt{3}V_L I_L \cos\theta \qquad (3)$$

Similarly,

$$W_1 - W_2 = V_L I_L \sin\theta \qquad (4)$$

Therefore,

$$\tan\theta = \sqrt{3}\frac{(W_1 - W_2)}{W_1 + W_2} \qquad (5)$$

or, $$\cos\theta = \cos\left(\tan^{-1}\sqrt{3}\frac{W_1 - W_2}{W_1 + W_2}\right) \quad (6)$$

(ii) Delta Connection

Let the phase voltages be $V_1=V_2=V_3=V_P$, the line-to-line voltage be V_L, phase currents be I_P and line currents be I_L. For a delta connection, the phase and line voltages are realated as

$$V_L = V_P \quad (7)$$

and the phase and line currents are related as

$$I_L = \sqrt{3} I_P \quad (8)$$

If the power factor of the load is cos θ, then, the power measured by wattmeter W_1 is $I_L V_L \cos(30^o-\theta)$. Similarly, the power measured by wattmeter W_2 is $I_L V_L \cos(30^o+\theta)$. Adding the two readings,

$$W_1 + W_2 = \sqrt{3} V_L I_L \cos\theta \quad (9)$$

Similarly,

$$W_1 - W_2 = V_L I_L \sin\theta \quad (10)$$

Therefore, $$\tan\theta = \sqrt{3}\frac{(W_1 - W_2)}{W_1 + W_2} \quad (11)$$

or, $$\cos\theta = \cos\left(\tan^{-1}\sqrt{3}\frac{W_1 - W_2}{W_1 + W_2}\right) \quad (12)$$

CIRCUIT DIAGRAMS:

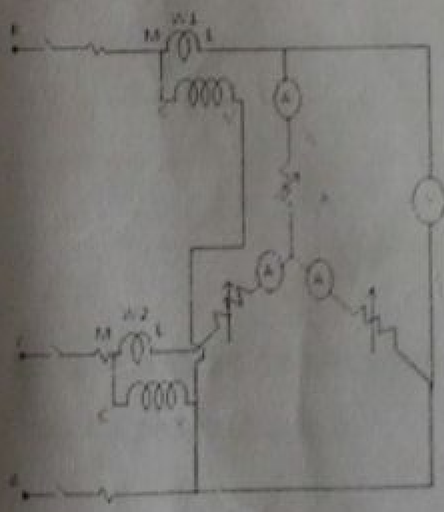


Fig. 1 Power Measurement using 2 Wattmeters in a star connected load

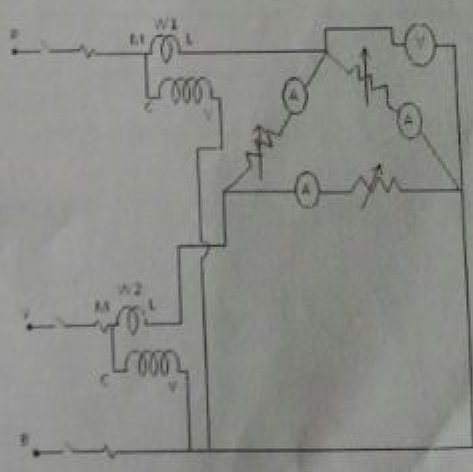


Fig. 2 Power Measurement using 2 Wattmeters in a delta connected load

APPARATUS USED:

Sl. No.	Name of the apparatus used	Quantity	Maker's Name	Range / rating of the apparatus

PROCEDURE:

- The connections are made as shown in the circuit diagram (1 or 2).
- The supply is switched on and the variac is gradually increased to a fixed value.
- The three phase load is adjusted till all the ammeters show the same readings approximately.
- The voltmeter and wattmeter readings are noted down.
- The above steps are again repeated with different values of variac voltage or different values of load current.
- Finally the variac is brought to zero and the supply is switched off.

EXPERIMENTAL DATA TABLE:

Sl. No.	V_{RY} (V)	V_{YB} (V)	V_{BR} (V)	I_R (A)	I_Y (A)	I_B (A)	P_1 (W)	P_2 (W)	Total Power P_1+P_2 (W)	Total Power $(\sum V_{ph} \times I_{ph})$ (W)	Power Factor ($\cos\theta$)

(SIGNATURE OF THE FACULTY / TECHNICAL STAFF)

PHYSICAL CHARACTERISTICS:

- Plot the phasor diagram

CONCLUSION:

QUESTIONAIRE:

- While measuring power in a three phase circuit by two wattmeter method, one of the wattmeters indicates a negative reading. What should be done to read the wattmeter correctly?
- Comment on the wattmeter readings when power factor is unity.