EXPERIMANT NO (1)

MEASURMENT OF THE RESISTANCE OF THE FOLLOWING CIRCUIT OF A D.C MACHINE

A) ARMATURE CIRCUIT.
B) FIELD CIRCUIT.

THEORY:-

D.C machine, in general, have two circuits:

A) ARMATURE CIRCUIT:
The armature core which is made up of sheet steel laminations, (0.4 to 0.5) mm. thick. The armature winding consists of large number of coils, each coil being made up of one or more turns. The conductors placed in armature slots are connected in suitable scheme to the segments of the commutator.

B) FIELD CIRCUIT:
The poles are excited by a current flows to the winding placed over the pole body, called field winding. The number of turns and cross-section of the field winding depend upon whether the machine is be operated as shunt, series, or compound machine.
Both armature and field circuit resistance are determined by drop of voltage.

PROCEDURE:-

A) ARMATURE CIRCUIT
1- Make the connection as shown in fig (1)
2- Record the voltage & current of each step by reducing the value of R, till the rated current.

B) FIELD CIRCUIT
1- Make the connections as shown in fig (2)
2- Cut off a part of the resistor (R) in suitable step.
3- Repeat (2) in suitable steps till full-rated value of "If" is reached.

REPORT:-

1- Plot curve between the current and voltage.
2- Calculate from the curves, the field and armature resistances [R_f & R_a].

QUESTIONS:-

1- Discuses the curves plotted in the report?
2- Why the voltmeter is connected to the armature directly?
3-Are there any other methods for measuring resistance, what are the differences? Which one is better?

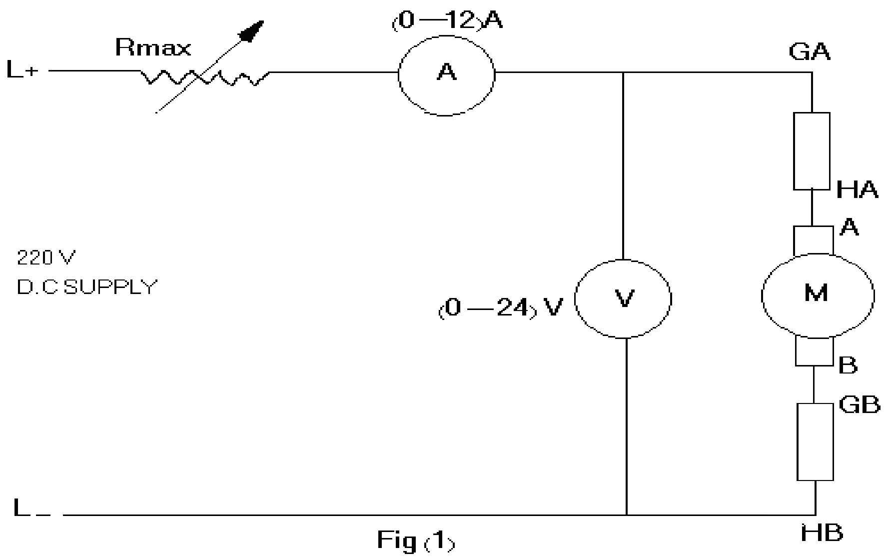


Fig (1)
ARMATURE CIRCUIT

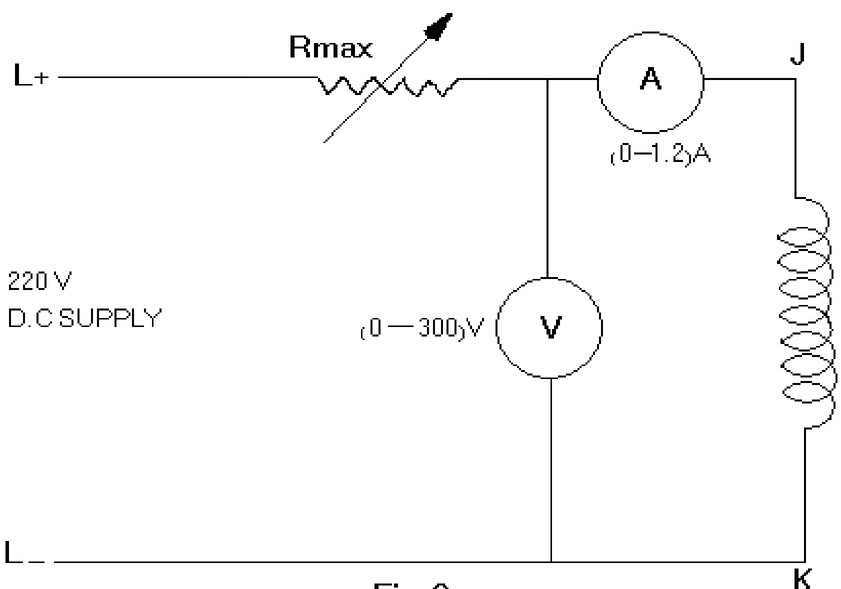


Fig (2)
FIELD CIRCUIT

EXPERIMENT NO. (2)

OPERATION OF D.C MOTORS, RUNING & REVERSING

THEORY:-

For the D.C motors the armature current (I_a) is:

$I_a = (V - E_b)/R_a$ ……………… (1)

& $E_b = KN\Phi$

Then:-

$N = (V - I_a R_a)/K\Phi$ ……………. (2)

Where:

$V =$ Voltage across the armature

$R_a =$ Armature resistance

$E_b =$ Back induced E.M.F

$N =$ Speed

$\Phi =$ Magnetic flux

$\mathrm{K} =$ Constant

Equation 2 shows that:
1- The speed of the motor is proportional to the voltage across the armature.
2- The speed of the motor inversely proportional with excitation current.

PROCEDURE:-

1- Connect the circuit as shown in fig (1).
2- Ensure that the resistance of the armature circuit is in its maximum value, and the field circuit resistance is in it's minimum value.
3- Switch on the motor and adjust the armature voltage to 180 V by increasing current of armature (decreasing armature resistance).
4- Now by changing the field current measures the speed of motor step by step and write the results.
5- Adjust the field current on 0.8A and by changing voltage across the armature measure the speed and write the results.
6- Stop the motor by switching off the mains.

Note: the direction of rotation for the above steps can be reversed by:-

A. changing the polarity of armature circuit only.
B. Changing the polarity of field circuit only.

Note:

If we change both field and armature polarity's the direction of rotation will not change

7- Stop the motor.

QUESTIONS:-

1- How the torque is developed by a D.C motor? On which factor dose it depend?
2- What is the backing E.M.F of a D.C motor? Is it more or less than the voltage applied to the armature?
3- How can the direction of rotation change? If the line terminals are reversed, will the direction of rotation change? Why?
4- What is the function of the field winding?
5- Plot the relation between:

A: speed and field current $(N \& I_f)$.

B: speed and armature voltage $(N \& V_a)$.

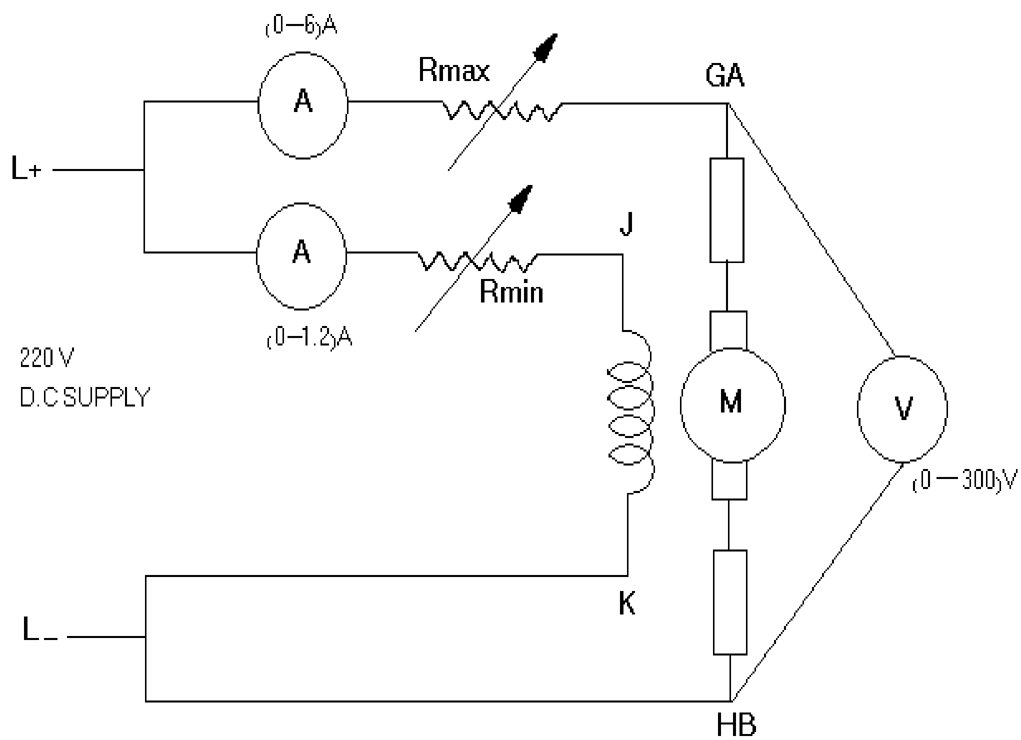


Fig (1)

EXPERIMENT NO. (3)

NO-LOAD TEST OF A SHUNT GENERATOR

A- SEPARATELY EXCITATION
B- SELF EXCITATION

THEORY:-

The voltage induced in the armature of a D.C machine is given by :
$E = (Z * P * N * \Phi)/(a * 60)$ …………….(1)

Where:-
$\Phi =$ Air gap flux per pole in webers / pole.
$N =$ Speed in (r.p.s).
$Z =$ Total number of armature conductors distributed in a parallel path.
$P =$ Number of pole.
$a =$ Number of path.

Since for a machine Z, a and P are fixed, then equation (1) my be written as:
$E = K * N * \Phi$ …………(2)
& $\Phi \alpha I_f$
Then:
$E = K * I_f * N$ …………(3)

Where I_f is the field current producing the flux, and K1 is a constant whose value depends upon the magnetic characteristic of the iron parts for the magnetic circuit of the generator.
Equation 3 shows that:

1- The relationship between the field current and the induced voltage givesthe magnetization characteristic.

The nature of this curve depends upon the magnetic permeability of the iron portion of the magnetic circuit.

2- The induced voltage is a function of two variables by keeping one quantity constant in turn two characteristic are obtained:-

a) E Vs If, speed is constant - no load magnetization.
b) E Vs N, field circuit undisturbed –voltage speed curve.

PROCEDURE:-

A- SEPARATELY EXCITATION

1- Make the connection as shown in fig (1) where the generator is separately excited.
2- Start the motor and bring it to the rated speed (1500 r.p.m).

Increase the value of field current (If) in suitable steps from zero to that value which induced the rated voltage across the generators terminal. Record all instrument readings in a table.

3- When the induce voltage reach its rate value, decrease the field current in suitable steps to zero. Record all readings in a table.

B- SELF EXCITATION

4- Make the connection as shown in fig (2) where the generator is self excited.
5- Repeat steps 2, 3 and 4 for the new case.

Note:-

If the generator fails to build up voltage, the polarity of the field winding must be reversed

REPORT:-

1- Plot terminal voltage E as a function of field current for both ascending and descending values of field current.
2- Find the critical resistance for the both case (self and separate excited generator).

QUESTIONS:-

1- At the starting point the magnetization curve shows some voltage although the field current is zero, why?
2- Explain why the initial portion of the magnetization curve is approximately a straight line?

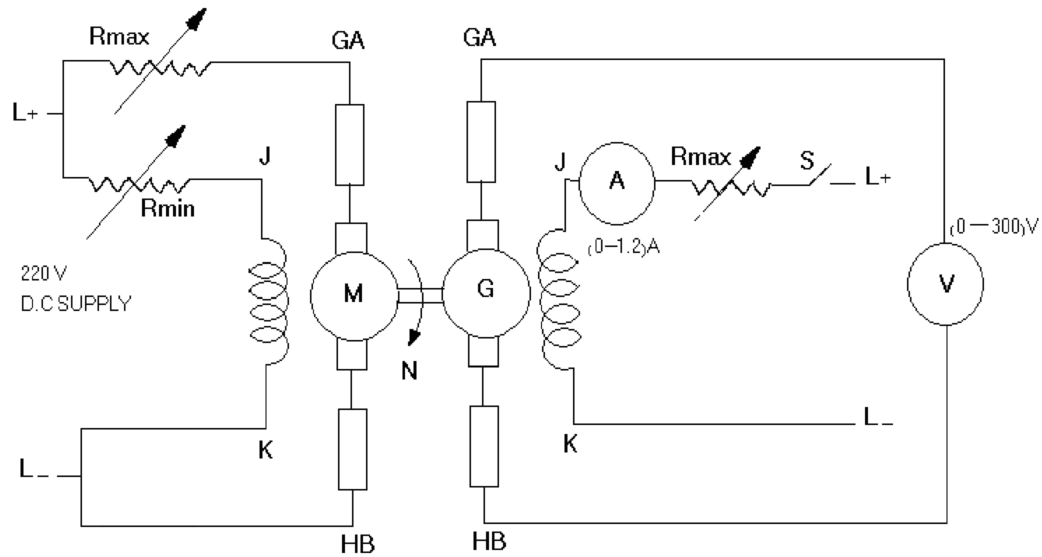


Fig (1)
Separately excitation

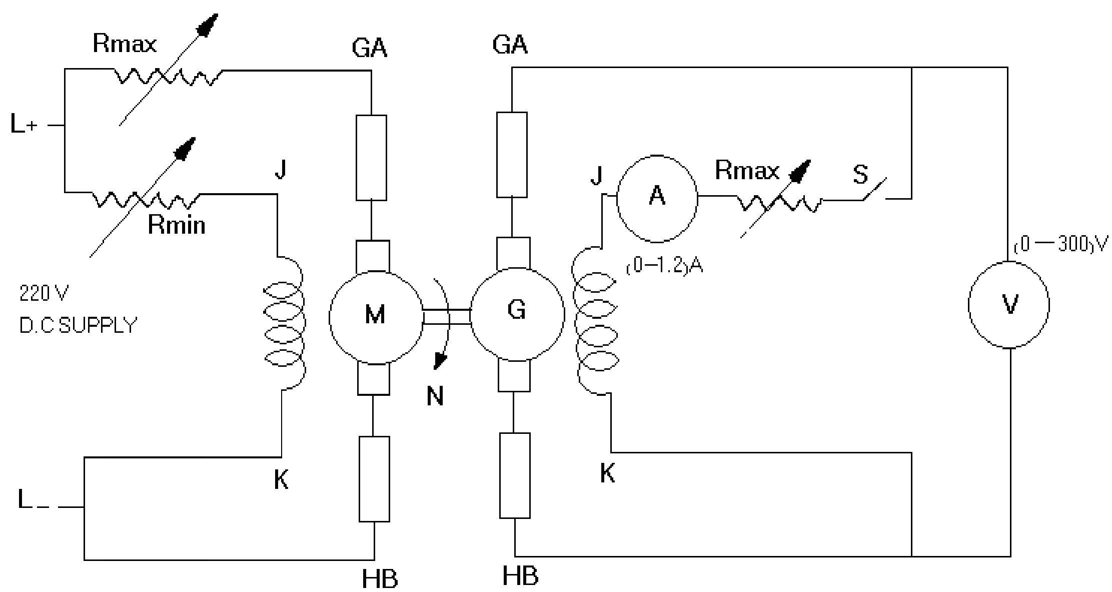


Fig (2)
Self excitation

EXPERIMENT NO (4)

LOAD TEST OF D.C SHUNT GENERATOR

A- SEPARATELY EXCITATION
B- SELF EXCITATION

THEORY:-

There are three important operating characteristic of the D.C generator.

1- External & Internal characteristic:-
The plot of the voltage across armature terminals as a function of the load current at constant speed is known as external characteristic
Speed constant, field adjustment unchanged, the point-to-point addition at armature drop to external characteristics is known as internal characteristic. The internally induce $e.m.f$ minus the armature reaction drop.

2- Load magnetization curve:-
The relationship between terminal voltage and field current with constant load current and speed.

3- Armature characteristic:-
The plot of the variation of field current with load current for a constant terminal voltage and speed.
The shape of these characteristics depends upon the nature of the magnetization characteristic of the machine and the load current.

PROCEDURE:-

A- SEPARATELY EXCITATION
Connect as shown in fig (1).
Run the motor, and bring it to the required speed by adjusting armature and field circuit rheostats (1500 $r.p.m$).
Adjust R_f so that the generator build up its rated voltage (E) 220 V at open circuit (switch s is open)
Close the switch S ; adjust the load resistance in suitable steps to the rated load current. Record $(I_f, I_a \& V_a)$.
Adjust load current to a specified value; increase the field current from zero to the value so that the generators build up its rated voltage in suitable steps record all reads of measuring instruments.

B- SELF EXCITATION

Connect as shown in fig (2).
Repeat the steps 2,3,4 and 5.
Obtain the rated voltage at suitable value of load current by simultaneous adjustment of load resistance and field current.
Record $(I_f, I_i \& V_i)$ for each step.

Note:-

Check the speed. If necessary adjust it to pre-set value (rated speed)

REPORT:-

Plot the external characteristic curve for both separately and self-excitation type in the same paper.
Plot the magnetization curve for separately and self excited in the same paper.
Plot armature characteristic for the shunt excited generator.
From the test result plot internal characteristic for both separately and shunt excited generator in the same paper.
Determine from internal characteristic the voltage drop due to armature reaction at maximum load current.

QUESTIONS:-

What are the causes for the fall in the terminal voltage of a D.C shunt generator on load?
In a D.C shunt generator why dose the total flux per pole decrease if the load on the machine increases even though the field current is constant?
Why is the voltage regulation of a separately excited generator better than that of a shunt-excited generator?

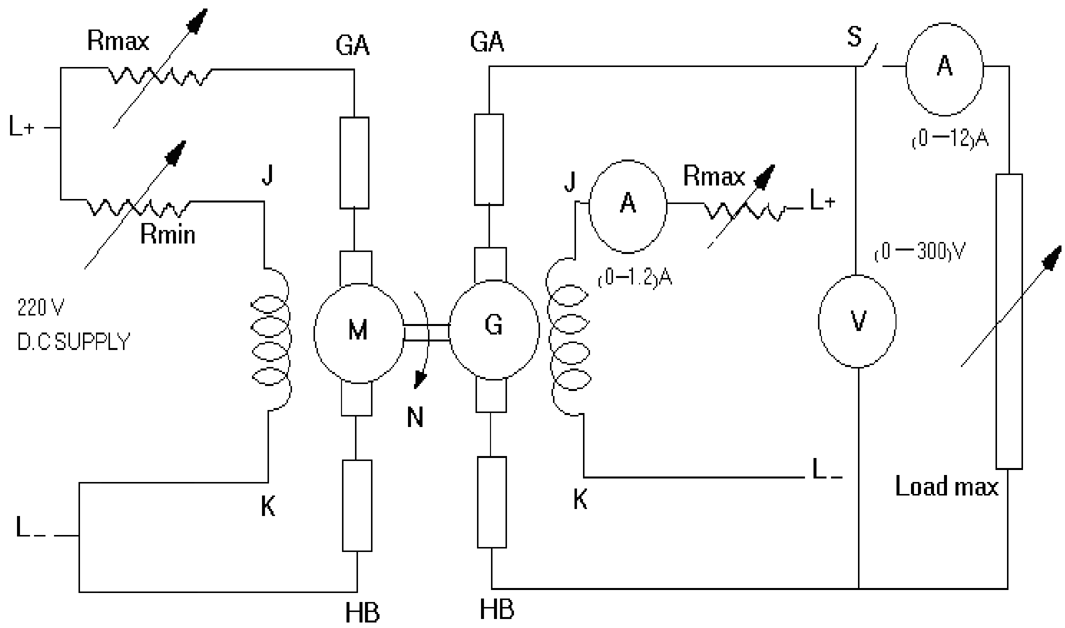


Fig (1)
Separately excitation

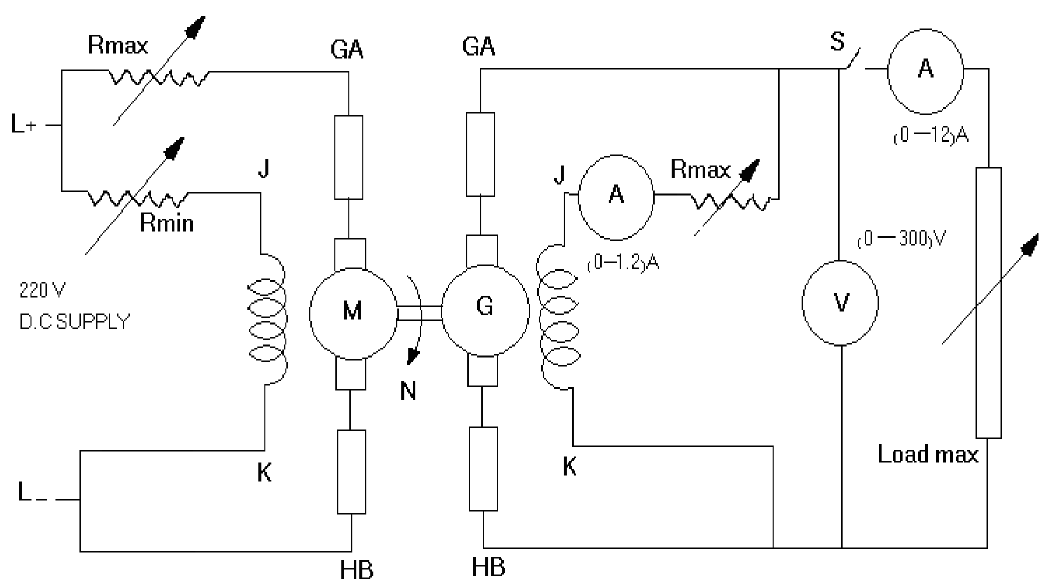


Fig (2)
Self excitation

EXPERIMENT NO (5)

TO DETERMINE THE EFFECINCY OF A D.C SHUNT MACHINE SWINBURNE'S METHOD

THEORY: -

In this method, the no-load losses of the machine are determined experimentally & additional losses on load are estimated from the known data of the machine (armature circuit resistance).
For a shunt motor, if:

I_a = armature current.
I_f = field current (shunt).
V = source voltage.

(A):- At no-load:

Power input to the armature = $V_0 * (I_0 - I_f)$

Power input to the shunt = $V_f * I_f$

No-load input = $V_0 * I_0$

Constant losses $W_c = (V_0 * I_0) - (I_a^2 * R_a)$
$= V_0 * (I_a + I_f) - I_a^2 * R_a$

(B):- At load:

I_L = Load current

$I_a = I_l - I_f$ If machine operates as motor

$I_a = I_L + I_f$ If machine operates as generator

Power input = $V_L * I_L$

Armature copper losses $P_{uc} = (I_L - I_f)^2 * R_a$

Total losses = $(I_L - I_f)^2 * R_a + W_c$

$$\eta_M = \frac{Inputpower - Totallosses}{Inputpower} * 100 = \frac{V_L * I_L - \left[(I_L - I_f)^2 * R_a + W_c\right]}{V_L * I_L} * 100$$

For generator: Total losses = $(I + I_f)^2 * R_a + W_c$

$$\eta_G = \frac{Outputpower}{Outputpower + Totallosses} * 100 = \frac{V_L * I_L}{V_L * I_L + (I_L + I_f)^2 * R_a + W_c} * 100$$

PROCEDURE:-

1- Determine armature circuit resistance.
2- Before starting the motor, ensure that the external resistance in the armature circuit is maximum value, & the resistance in the field circuit is zero.
3- Connect the circuit shown in fig (1). Run the motor.
4- Increase R_f to bring the motor to the rated speed.
5- Record I_a & I_f .

REPORT:-

1- Compute the efficiency, when the machine operates as a motor & generator.
2- Plot efficiency with respect to the line current.
3- Plot efficiency with respect to the output power of the motor.

QUESTIONS:-

1- How can the **SWINBURNE'S** test be adopted for series motor?
2- What are the advantages & disadvantages of **SWINBURNE'S** method?

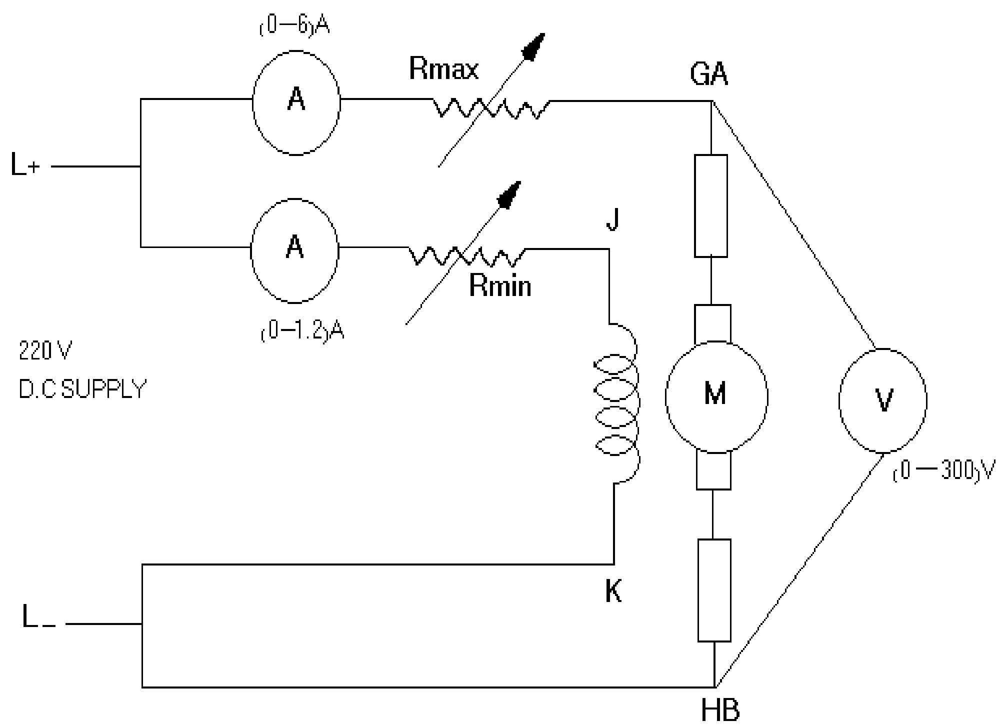


Fig (1)

EXPERIMENT NO. (6)

LOAD TEST OF D.C SHUNT MOTOR

THEORY:-

The torque developed by the shunt motor is given by

$T = K\Phi I_a$ (The flux assumed to be constant).
The speed equation is:

$$N = \frac{V_L - I_a R_a}{K\Phi}$$

The power input to the motor is given by the product of the voltage applied to the motor & the current drown by it:

$P_{in/p} = V_m I_m$ (Watts)

And the output power is given by
$P_{o/p} = 2\Pi NT/60$ (Watts)

PROCEDURE:-

1- Connect the circuit as shown in fig. (1).
2- Run the motor at rated speed.
3- Load the generator gradually. Record $(V_m, I_a, I_f, N, V_L, I_L)$, if & V_L most remain constant.
4- Complete table (1). By assuming $\eta_G = 0.85$

$V_m(V)$	$I_a(A)$	$I_f(A)$	$N(r.p.m)$	$V_L(V)$	$I_L(A)$

5- Switch off the supply after finishing the experiment.

REPORT:-

1- Plot N & T.
2- Plot I_L & T.
3- Plot I_L & N.

QUESTIONS:-

1- What would be the effect of inserting a resistance in the field circuit of a shunt motor on its speed & torque?
2- Why the D.C shunt motor is used for constant torque load?
3- In what way does a shunt motor differ from a shunt generator, in
a- Construction.
b- Working principle.
c- Function.

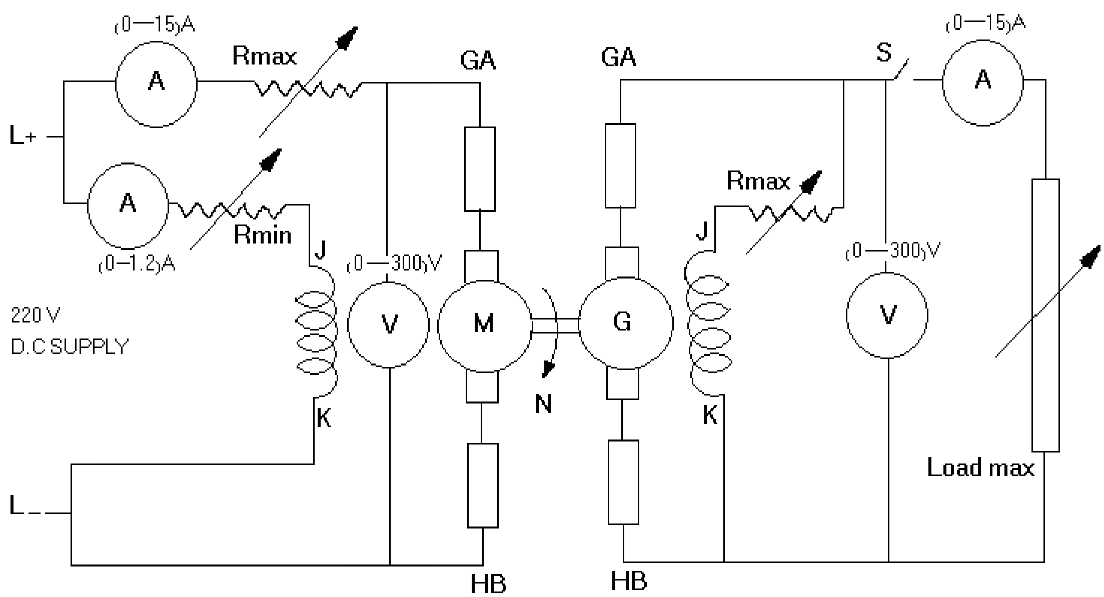


Fig (1)

EXPERIMENT NO. (7)

LOAD TEST OF D.C SERIES MOTOR

THEORY:-

The torque developed by the series motor is given by

$T = K\Phi I_a$ (The flux assumed to be constant).

$T = K I_a^2$ Because $\Phi \alpha I_a$

The speed equation is:

$$N = \frac{V_L - I_a R_a}{K\Phi}$$

The power input to the motor is given by the product of the voltage applied to the motor & the current drown by it:

$P_{inm} = V_m I_m$ (Watts)

And the output power is given by

$P_{om} = 2\Pi NT / 60$ (Watts)

PROCEDURE:-

5- Connect the circuit as shown in fig. (1).
6- Run the motor at rated speed.
7- Load the generator gradually. Record $(V_m, I_a, I_f, \mathrm{N}, V_L, I_L)$.
8- Complete table (1). By assuming $\eta_G = 0.85$

$V_m(V)$	$I_a(A)$	$I_f(A)$	$\mathrm{N}(r.p.m)$	$V_L(V)$	$I_L(A)$

5- Switch off the supply after finishing the experiment.

REPORT:-

1. Plot N & T.
2. Plot I_L & T.
3. Plot I_L & N.

QUESTIONS:-

1- Why the starting torque of D.C series motor is greater than D.C shunt motor?
2- Mention same applications of D.C series motor.
3- Why the D.C series motor is used for variable torque load?

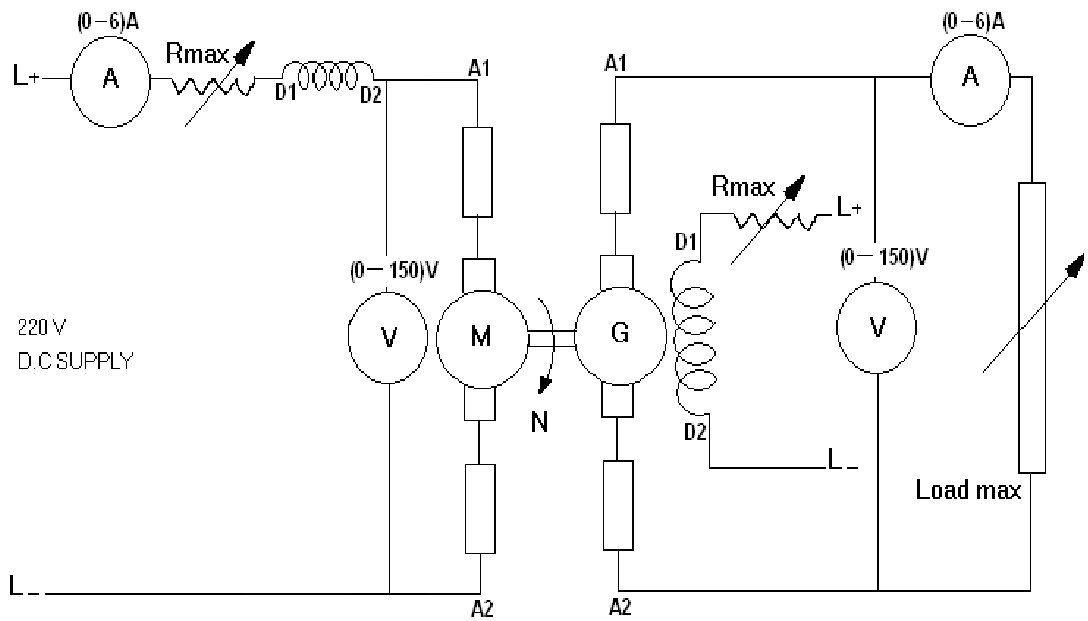


Fig (1)

EXPERIMENT NO. (8)

OPEN-CIRCUIT & SHORT-CIRCUIT

THEORY:-

The exact equivalent circuit of a transformer, referred to the primary side is shown in fig. (1) Where R_1 & X_1 = primary ending resistance & leakage reactance respectively.

R_2 & X_2 = Secondary winding resistance & secondary winding leakage reactance respectively, all referred to primary.

Where

G_o = A conductance representing equivalent power loss corresponding to the no-load iron loss.

B_o = An acceptance to take into account the magnetizing component of the no-load current.

V_1 = Primary applied voltage.

V_2 = Secondary terminal voltage V_2 referred to primary = $V_2(N_1/N_2)$.

I_o = No-load current.

$I_{s.c}$ = Short circuit current.

OPEN-CIRCUIT TEST (NO-LOAD TEST):

In this test, primary rated voltage is applied across the primary of the transformer with secondary winding open circuited.

The no-load power input to the transformer is generally taken copper losses are very small & are therefore neglected. The current taken by the transformer in this test is the vector sum of the magnetizing component $(I_m = I_0 Sin\Phi)$, where Φ is the phase angle at no-load. If P_0 is the power input in the .O.C test

$$G = \frac{I_o^2}{P_o} \quad , \quad \& \quad B_0 = Y_0^2 - G_0^2 \quad , \quad \text{where} \quad Y_0 = \frac{I_o}{V}$$

The equivalent circuit at no-load test is shown in fig (2) from the O.C test, the following information is obtained; core losses, G_o & B_0.

SHORT-CIRCUIT TEST:

In this test, the secondary of the transformer is short circuited & a sufficiently reduced V_1 voltage is applied across the primary winding normally, 6% to 8% of the voltage is sufficient to force the full-load current in the short-circuited secondary.
The equivalent circuit is shown in fig (3), where the equivalent resistance is

$$R_{eq} = R_1 + R_2' = \frac{P_{sc}}{I_{sc}^2}$$

Where
$P_{sc} =$ Power input in S.C test,

$$Z_{eq} = \frac{V_{sc}}{I_{sc}} \ \& \ X_{eq} = X_1 + X_2' = \sqrt{Z_{eq}^2 - R_{eq}^2}$$

V_{sc} Is the voltage across the primary winding at S.C test. The power input in this test is equal to the sum of the copper losses in the primary & secondary windings.

PROCEDURE:-

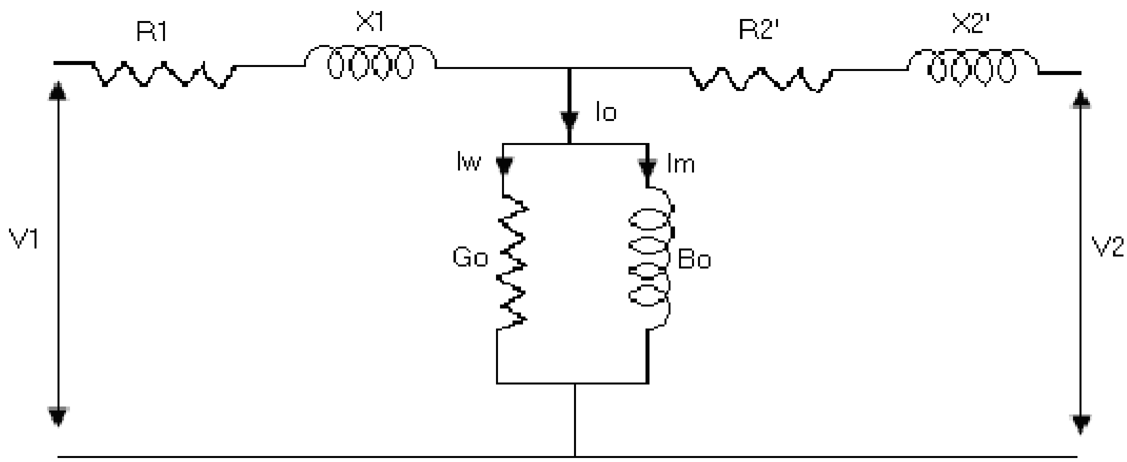
1- Connect as shown in fig (3).
2- Gradually increases the voltage applied from zero to 125% of the primary rated voltage. Record the reading of all measurement instruments, at each step.
3- Connect as shown in fig (4).
4- Gradually & slowly increases the voltage applied, to increase current in the (L.T) winding from zero to 100% of rated current. Record the reading of all measurement instruments, at each step.

REPORT:-

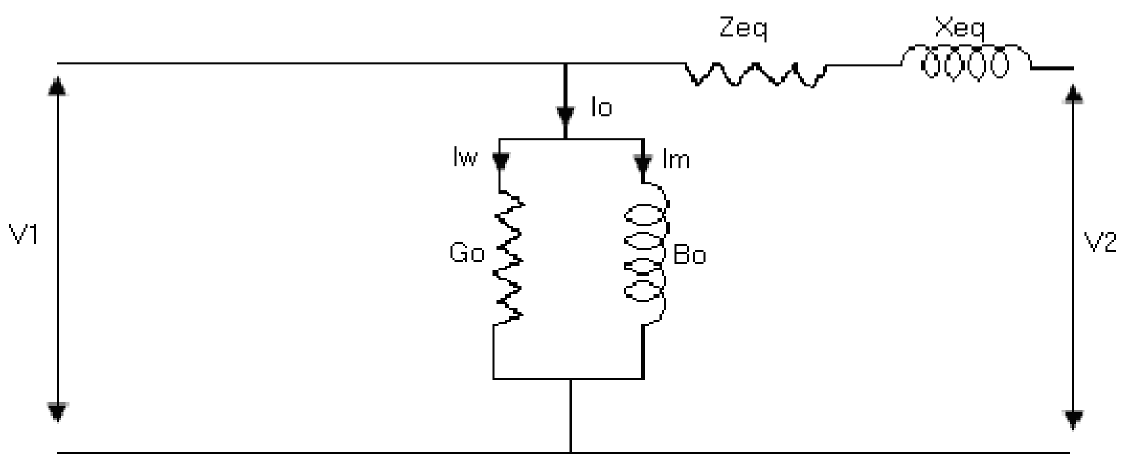
1- From the results of O.C test, plot I_0, I_m, I_w with respect to V_1.
2- Also, from O.C test results, plot P_0 versus V_1.
3- Compute G_0, B_0.
4- From the results of O.C test, compute the parameters of the equivalent circuit; plot the copper losses with respect to I_2.

QUESTIONS:-

1- What are the different losses in a transformer? which of these losses are taken care of this experiment?
2- In the equivalent circuit obtained in this experiment, what are the approximations involved & how far are these approximations involved & how far are these approximations valid?
3- Under what conditions of loading does the transformer have highest efficiency?



Equivalent circuit
Exactly
Fig (1)



Equivalent circuit
Approximate
Fig (2)

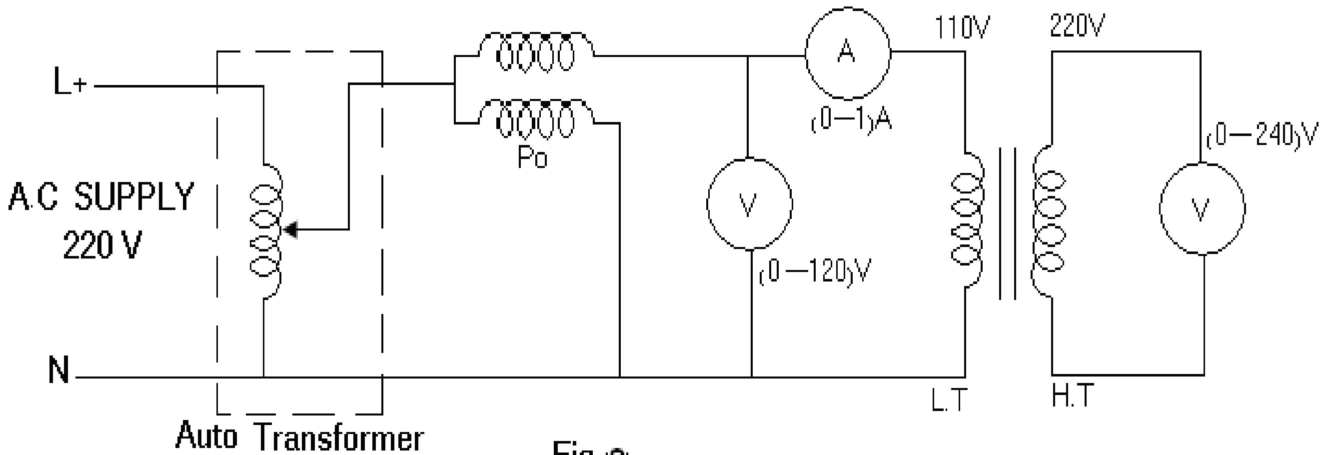


Fig (3)
Open Circuit

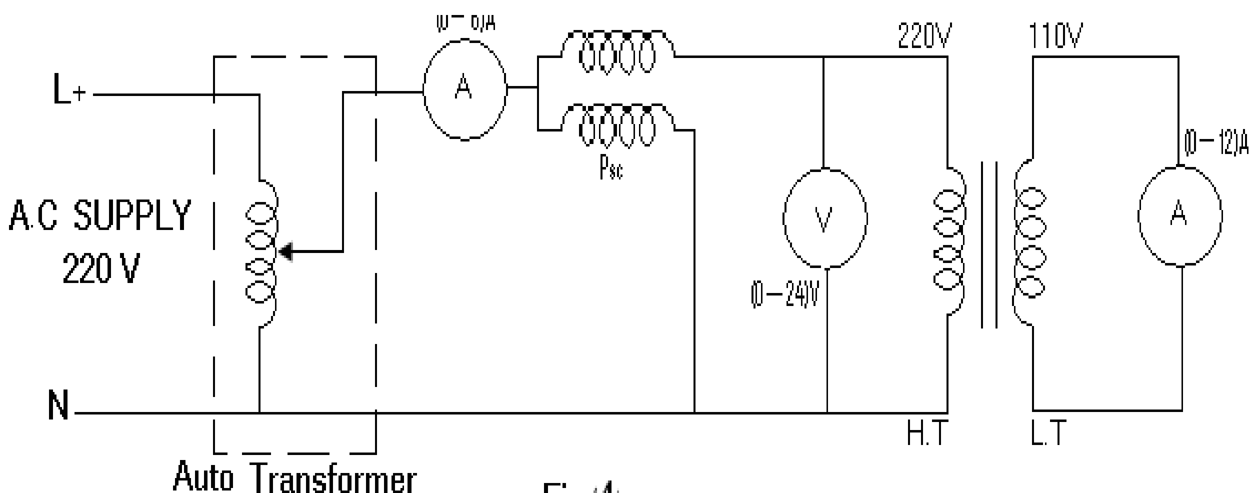


Fig (4)
Short Circuit

EXPERIMENT NO. (9)

SEPERATION OF TRANSFORMER CORE LOSSES

THEORY:-

There are two types of losses in single phase transformer, Iron losses & copper losses. The iron losses or core losses have two portions.

W_h Hysterises losses & W_e eddy current losses the equation of each one is given below where the Φ is the flux in the core & B_m is its maximum value the hysterics & eddy current loss components are

$$W_h = K_h * f * B_m^2$$

$$W_e = K_e * f^2 * B_m^2$$

Where K_h is constant depending upon the weight of core & units employed exponent depends upon the magnetic characteristics of the core material

f = Frequency of flux , $K_e =$ Constant

Depended upon the receptivity, thickness of lamination, volume of core materials.

Total core loss of iron loss=hysterics loss+ eddy current loss

$W_i = Kf + K_2 f^2$ when B_m is constant or $\frac{W_i}{F} = K_1 + K_2 f$

The graph between W_i & f would be a straight line. The interception Y-axis will give the constant K_1 & tangent of the gradient at X-axis gives constant K_2. Knowing K_1 & K_2 the hysterics & eddy current losses at any frequency can be determined separately for a particular maximum flux density.

PROCEDURE:-

1- Connect the circuit as shown in fig (1).
2- Run the D.C motor & adjust its speed such that the alternator voltage has a frequency equal to the rated frequency of transformer.
3- Adjust alternator excitation to such a value the terminal voltage is equal.
4- Close the switch, & record voltage, frequency or speed & the power input.
5- Reduce D.C motor speed by 10Hz & adjust alternator excitation to such a value that applied voltage/ frequency is the same as the rated voltage/rated frequency. Record applied voltage, frequency & power input transformer.
6- Repeat the same steps for a number of values of frequency both above & below the rated frequency keeping always V retie constant.
7- Switch off the transformer & stop motor generator set.

REPORT:-

1- Plot core loss/cycle as a function of frequency.
2- Evaluate K_1 & K_2 corresponding to voltage & frequency.
3- Calculate hysterics & eddy current losses at rated voltage & frequency.

QUESTIONS:-

1- Enlist the methods generally a depend to keep the hysteric's is loss & eddy current loss in transformer low?
2- If a transformer is operated at rated frequency but voltage higher then the rated value, how do you expect the following?

QUANTITES TO CHANGE:-

A) No-load current.
B) Hysterics loss.
C) Eddy current loss.

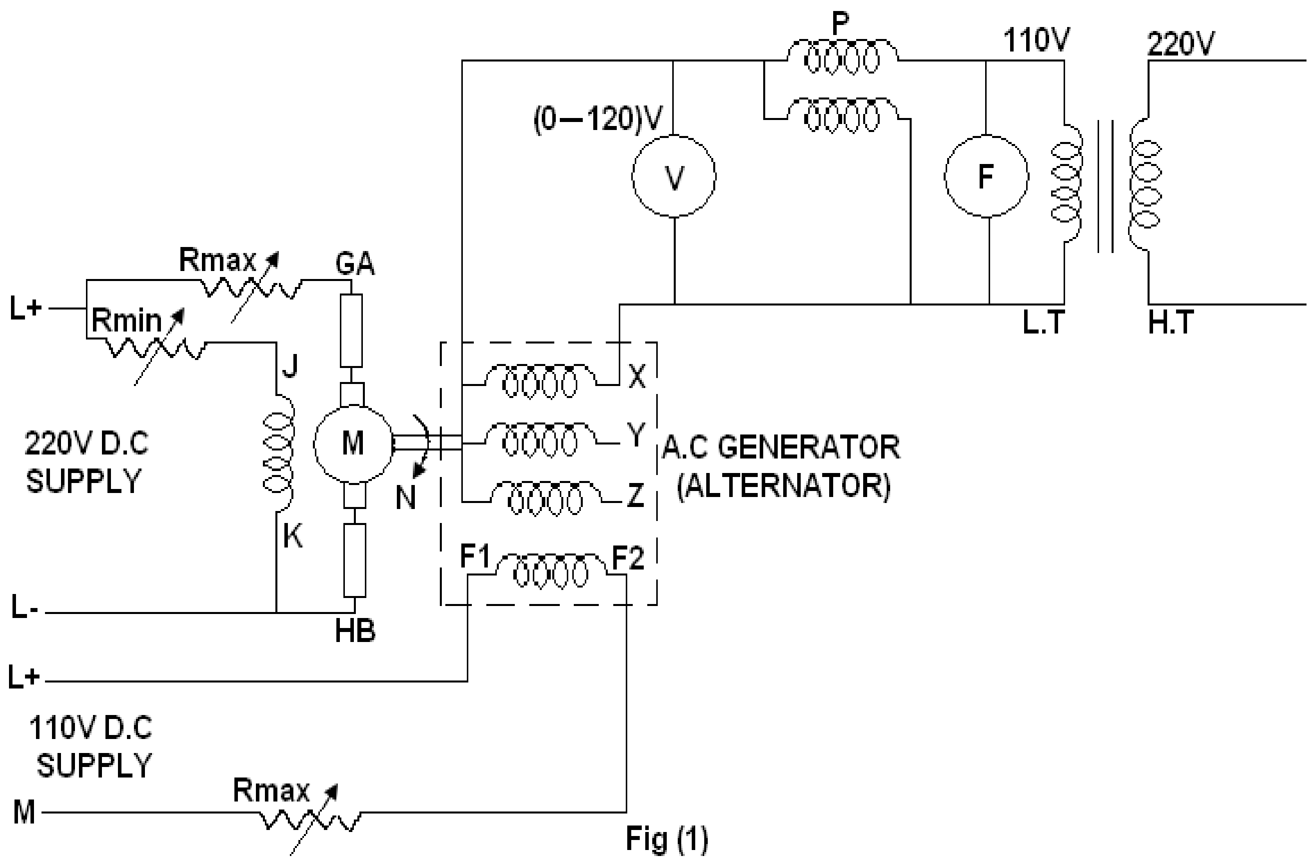


Fig (1)

EXPERIMENT NO. (10)

OPEARATION OF A SINGLE PHASE TRANSFORMER CONSTRUCTION & PERFOMANCE

THEORY:-

A transformer is a static piece of apparatus by means of which electric power one circuit is transformed into electric power of the same frequency in another circuit it can raise or lower the voltage in a circuit but with a corresponding decrease or increase current. In its simplest form a transformer consists of two inductive coils which are electrically separated but magnetically linked. The first coil, in which electric energy is fed from the A.C supply mains, is called primary winding & the other from which energy is drown out, is called secondary winding.
The r.m.s value of induced e.m.f in the primary winding is given by:

$E_1 = 4.44 * f * N_1 \Phi$ ……………. (1)

Similarly, r.m.s value of induce e.m.f in the secondary winding is

$E_2 = 4.44 * f * N_2 \Phi$ ……………… (2)

Where:
$E =$ r.m.s value of e.m.f (volt).
$\mathrm{N} =$ Number of turns.
$\Phi =$ Maximum flux in core (Weber).
$f =$ Frequency (Hz).
From equations (1) & (2)

$$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$

From:

If $N_2 > N_1$ the transformer is called step-up transformer
If $N_2 < N_1$ the transformer is called step-down

$$\frac{E_1}{E_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

Input VA=output VA

Hence $$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

PROCEDURE:-

1- Connect as shown in fig (1) & fig (2).
2- Decrease applied voltage from (220) v to (zero) in suitable steps, & record $I_1, V_1 \& V_2$
3-Adjust the applied voltage to (100) v. At secondary rated current. Record $I_1, I_2, V_1 \& V_2$.
4 – Decrease the load current in two steps, at each step record current & voltage. Measuring instrument.

REPORT:-

1- From the result, compute the transformation ratio $\left(\frac{N_1}{N_2}\right)$

QUESTION:-

1- What is the type of the transformer?
2- Show the effect of the load on the transformation ratio?
3- Can the D.C voltage be used for finding the transformation ratio? Why?

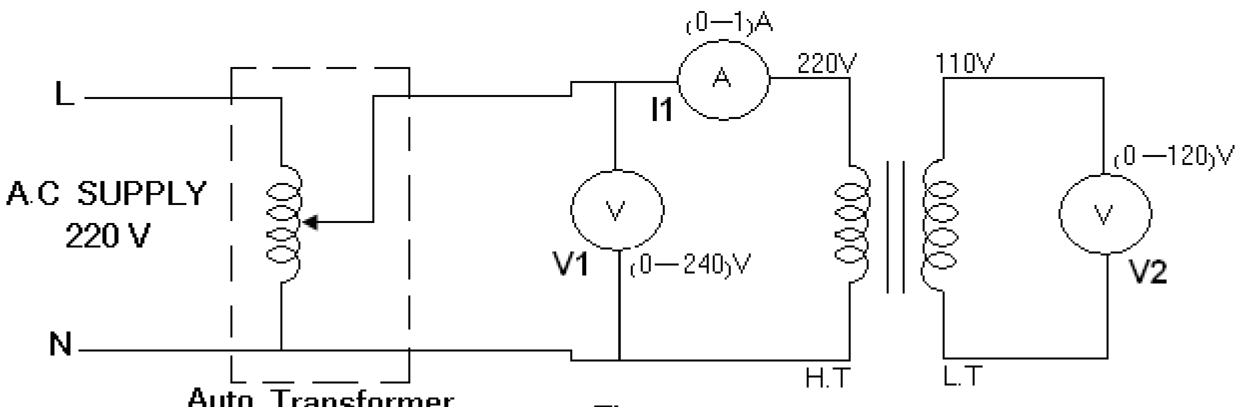


Fig (1)

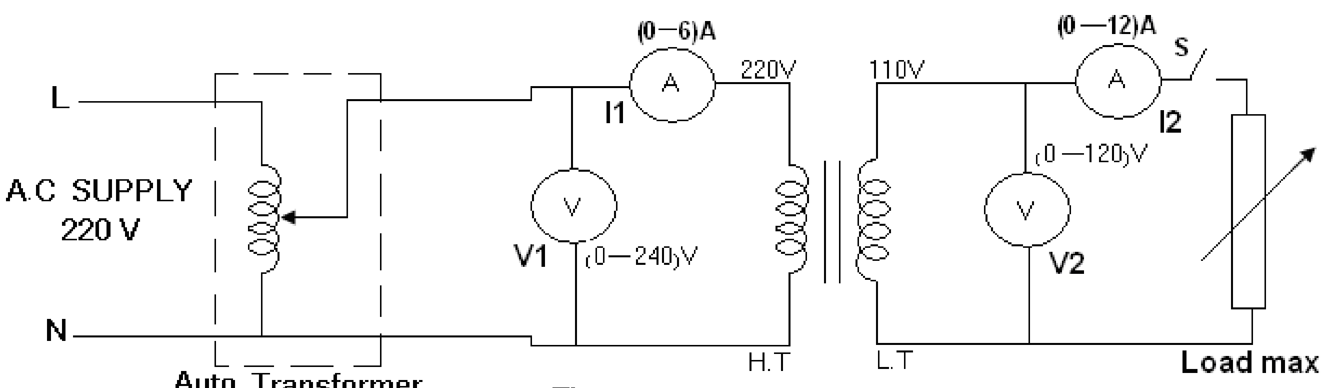


Fig (2)

EXPERIMENT NO. (11)

MEASURMENT OF THREE PHASE POWER BY TWO-WATTMETER METHOD

THEORY:-

This method is the commonest method of measuring three phase power it is particularly useful when the load is unbalanced. The connection for the measurement of power in the case of a star-connected three-phase load are shown in fig(1) the current coils of the wattmeter's are connected in line (R) & (T), & their voltage coils between line (R) & (S), and (S) & (T) respectively.

Fig(2) gives the vector diagram for the load circuit, assuming a balanced load currents & power factor factors are the some for all three phases.

$I_T = I_S = I_R = I_1 = I_{ph}$; (Line & phase current)

$V_T = V_S = V_R = V$; (Phase voltage)

$V_{Lts} = V_{Lrs} = V_{Lpt} = V_L$; (Line voltage)

$\Phi =$ Phase angle between phase voltage & current

$w_1 =$ The reading of wattmeter 1

$w_2 =$ The reading of wattmeter 2

From the vector diagram:

$w_1 = I_R V_L \cos\alpha$

$w_2 = I_T V_L \cos\beta$

Where

$\alpha =$ Phase angle between $I_R \& V_{LRS}$.

$\beta =$ Phase angle between $I_T \& V_{LTS}$.

Also, from the vector diagram:

$$\alpha = 30 + \Phi$$

$$\beta = 60 + \Phi$$

Let we assume:

$$w_t = w_1 + w_2$$

$\therefore w_t = I_R V_L \cos(30+\Phi) + I_T V_L \cos(30-\Phi)$

OR

$$w_{Ttt} = I_L V_L [\cos(30+\Phi) + \cos(30-\Phi)]$$

$$= I_L V_L [2\cos(30)\cos(\Phi)]$$

$$= I_L V_L (2 * 0.866 \cos\Phi) \quad \text{………… (1)}$$

$$= I_L V_L \cos\Phi \quad \text{…………… (2)}$$

Equation (1) & (2) represent, of course, the total power in the load. Hence, the total power in the circuit equal to the sum of the two wattmeter reading. It should be noted that if one of the voltages (such as V_{TS}) is more than 90 out of phase with current associated with this voltage in the wattmeter the voltage-coil connections must be reversed in order that the instrument may give a forward reading. Under these circumstances the watt meter readings are reckoned as negative & the algebraic sum of the reading of the two instruments gives the mean value of the total power.

Another important point is that, if the power factor of the load is 0.5 so that it large 60 behind V_T (cos60 being 0.5) then the phase angle between V_{LTS} & I_T is 90 & wattmeter w_1 should read zero.

For determining the power factor: If w_1 & w_2 are the two wattmeter readings.

$w_1 + w_2$ Gives the total power (as seen above).

$$w_1 - w_2 = I_L V_L [\cos(30+\Phi) - \cos(30-\Phi)]$$

& $$w_1 - w_2 = -I_L V_L \sin\Phi$$

$$\therefore \frac{w_1 - w_2}{w_2 + w_2} = \frac{-V_L I_L \sin\Phi}{\sqrt{3} V_L I_L \cos\Phi} = -\frac{1}{\sqrt{3}}\tan(\Phi)$$

$$\tan(\Phi)\frac{-\sqrt{3}(w_1 - w_2)}{w_1 + w_2}$$

$$\therefore \tan(\Phi) = \sqrt{3}\frac{(w_2 - w_1)}{(w_1 + w_2)}$$

From which & the power factor $\cos\Phi$ of the load may be found.

PROCEDURE:-

1- Connect the circuit as shown in fig (3) the load is pore resistance.
2- Choose the suitable ranges for the measuring instruments close the switch S.
3- Adjust the load in suitable steps, Record the readings of all measuring instruments & tabulate them in table (1)
4- Connect the circuit as shown in fig (4), the load is a three-phase motor driving a DC generator with variable load.
5- Repeat the steps (2) & (3), adjust the load by a changing the load on the DC generator.

REPORT:-

1- Calculate for the two cases, total active power phase angle & power factor for each step of wattmeter's readings.
2- Calculate the total active power, from the readings of ammeter & voltmeter, using the phase angle calculated in (1).

QUESTIONS:-

1- Dose there is any other methods for measuring power in the three-phase circuits?
State then & comment.

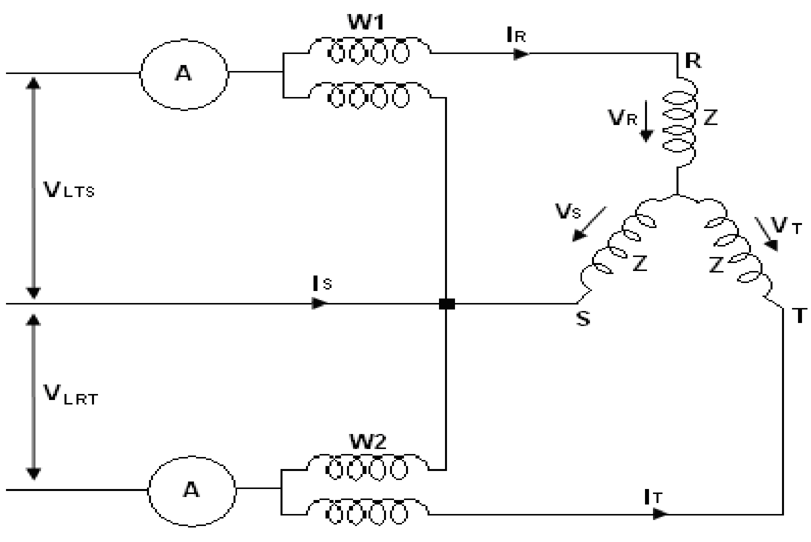


Fig (1)

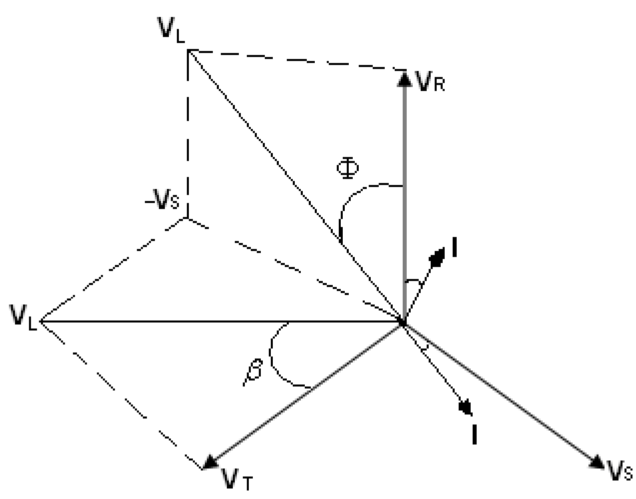


Fig (2)

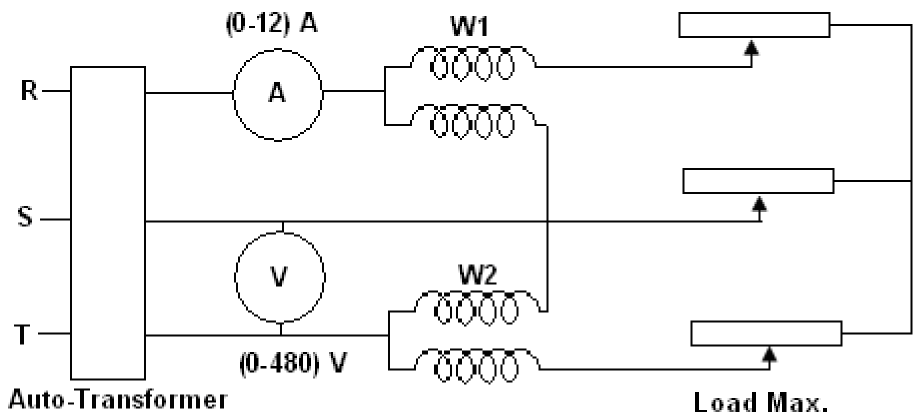

(0-12) A
W1
R
A
S
V
W2
T
(0-480) V
Auto-Transformer
Load Max.

Fig (3)

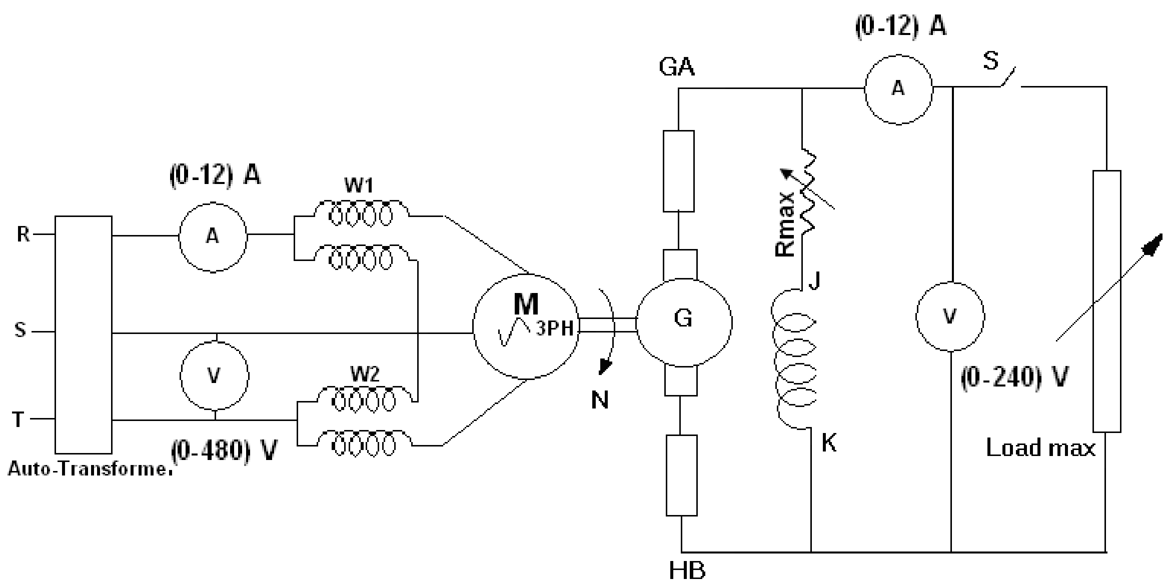

(0-12) A
GA
A
S
(0-12) A
W1
R
A
Rmax
J
M
3PH
S
G
V
V
W2
N
T
(0-240) V
K
(0-480) V
Auto-Transformer
Load max
HB

Fig (4)

EXPERIMENT NO. (12)

LOAD TEST OF A SIGLE-PHASE TRANSFORMER

THEORY:-

The direct method to determine the efficiency of a transformer is carried out by loading test on it. The efficiency of a transformer is given by:

$$\Upsilon = \frac{P_o}{P_i} = \frac{P_2}{P_2 + plosses} = \frac{V_2 I_2 \cos\Phi_2}{V_2 I_2 \cos\Phi_2 + P_i + P_c}$$

Where:-

$V_2 =$ Secondary terminal voltage.

$I_2 =$ Load current.

$\cos\Phi =$ Power factor of the load.

$P_i =$ Iron or core losses & it is equal to the no-load input power.

$P_c =$ Copper losses & to equivalent resistance, or

$P_c = I_2^2 * R_e = I_2^2 (R_1 + R_2)$

The transformer has a maximum efficiency where $P_c = P_i$, which is happened at 75% of rated load.
The voltage regulation is given by:

$$V.R\% = \frac{V_{noload} - V_{fullload}}{V_{noload}} * 100$$

Where:-

$V_{fullload} =$ Secondary terminal voltage at load.

$V_{noload} =$ No-load terminal voltage.

The regulation, also, may be given by:
Where

$$R\% = \frac{I_2 * R_e}{V_2} * 100 \quad , \quad X\% = \frac{I_2 * X_e}{V_2} * 100$$

R_e & X_e Are the total resistance & reactance of the transformer.

PROCEDURE:-

1- Make the connection according to circuit diagram fig (1).
2- Apply rated primary voltage to its primary windings.
3- Connect a pure resistance between the points A&B.

Adjust the resistance in suitable steps until the load current reaches 125% of its rated current and then record the readings of ammeter, voltmeter & wattmeter for each step.
4- Repeat (3), for power factors (0.8, 0.9) lagging.
5- Repeat (3), for power factors (0.8, 0.9) leading.

REPORT:-

1- Plot V_2 against I_2 for all types of loads.
2- Plot the efficiency as a function of I_2 for all loads.
3- Plot the relation between voltage regulation & power factor against the rated I_2.

QUESTIONS:-

1-Draw the vector diagram of the transformer, for power factor: Unity (0.8) lead, (0.8) lag.

Note:- If the current is larger than the full scale deflection of measuring instruments, use current transformer with measuring instrument.

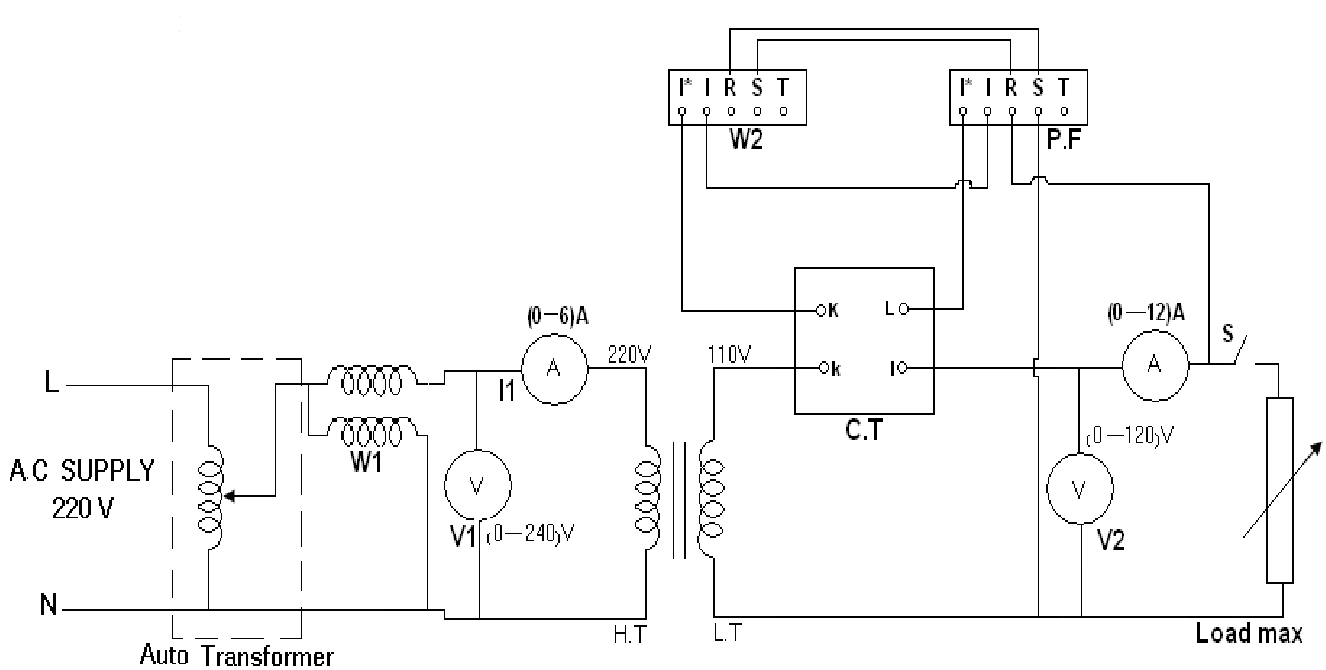


Fig (1)