DHANALAKSHMI COLLEGE OF ENGINEERING

MANIMANGALAM. TAMBARAM, CHENNAI

B.E. – ELECTRICAL AND ELECTRONICS ENGINEERING

IV SEMESTER

LAB MANUAL

EE6461 ELECTRICAL ENGINEERING AND CONTROL SYSTEMS LABORATORY

EXPT.NO: 1(a) OPEN CIRCUIT CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR

DATE:

AIM:

To obtain the O.C.C of the given self excited DC shunt generator and hence to determine

i) Critical field resistance

ii) Critical speed

iii) O.C.C at the specified speed

NAME PLATE DETAILS:

D.C. GENERATOR:

- Rated Voltage :
- Rated Current :
- Rated Speed :
- Power Rating :

D.C. MOTOR :

Rated Voltage :

Rated Current :

Rated Speed :

Power rating :

APPARATUS REQUIRED:

S.no.	Apparatus	Range	Type	Quantity

THEORY:

A D.C. generator requires an excitation circuit to generate an induced voltage. Depending on whether the excitation circuit consumes power from the armature of the machine or from separately required power supply, the generators may be classified as self excited or separately excited generators respectively

The induced EMF in a DC generator is given by the equation $E_g = PZ\phi N/ 60A$ volts. Since P,Z and A are constants the above equation can be rewritten as $E_g = K\phi N$. If the speed of the generator is also maintained constant then $E_g = K_1\phi$, but the flux is directly proportional to the field current, hence $E_g = K_2 I_f$. From the above equation it is clear that the induced EMF is directly proportional to the field current when speed is maintained constant. The plot between the induced EMF and the field current is known as open circuit characteristics of the DC generator. The typical shape of this characteristic is shown in figure.

The induced EMF when the field current is zero is known as residual voltage. This EMF is due to the presence of a small amount of flux retained in the field poles of the generator called residual flux. Once the O.C.C is obtained the parameters such as critical field resistance, critical speed and the maximum voltage to which the machine can build up can be determined. If required the O.C.C at a different speeds can also be obtained. Critical speed is minimum speed below which the generator shunt fails to excite.

PRECAUTIONS: (Not to be included in the Record)

1. Remove the fuse carriers before wiring and start wiring as per the circuit diagram.
2. Keep the motor field rheostat at minimum resistance position and generator field rheostat at maximum resistance position.
3. The SPST switch is kept open at the time of starting the experiment.
4. Fuse calculations. As the test is a no-load test the required fuse ratings are 20% of motor rated current.
5. Replace the fuse carriers with appropriate fuse wires after the circuit connections are checked by the staff-in-charge.

PROCEDURE:

1. The circuit connections are made as per the circuit diagram in the shown figure.
2. Keeping the motor field rheostat in its minimum position, generator field rheostat in maximum position; and the starter in its OFF position, the main supply is switched ON to the circuit.
3. The motor is started using the 3-point starter by slowly and carefully moving the starter handle from its OFF to ON position,
4. The motor is brought to its rated speed by adjusting its rheostat and checked with the help of a tachometer.
5. With the SPST switch open, the residual voltage is noted.
6. Now the SPST switch is closed and the Potential divider is varied in steps and at each step the field current (I_f) and the corresponding induced EMF (E_g) are recorded in the tabular column. This procedure is continued until the generator voltage reaches 120% of its rated value the speed of the machine is maintained constant.
7. After the experiment is completed the various rheostats are brought back to their original position in sequence and then main supply is switched OFF.

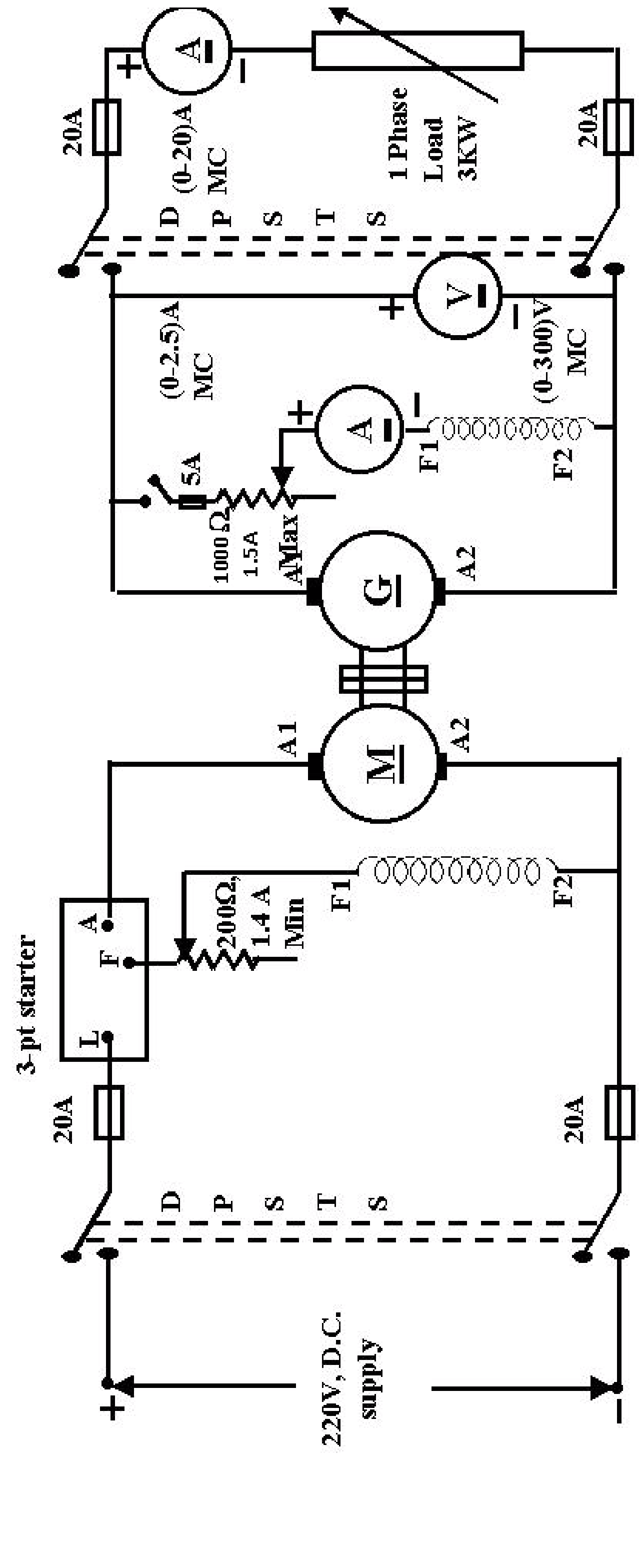
Table for OCC

S. No.	**Field current I_f (amps)**	**Generator voltage E_g (volts)**

Table for Measuring R_f

V_f (volts)	**I_f (amps)**	**R_f (ohms)**

CIRCUIT DIAGRAM FOR OCC AND LOAD TEST ON SELF EXCITED D.C.SHUNT GENERATOR



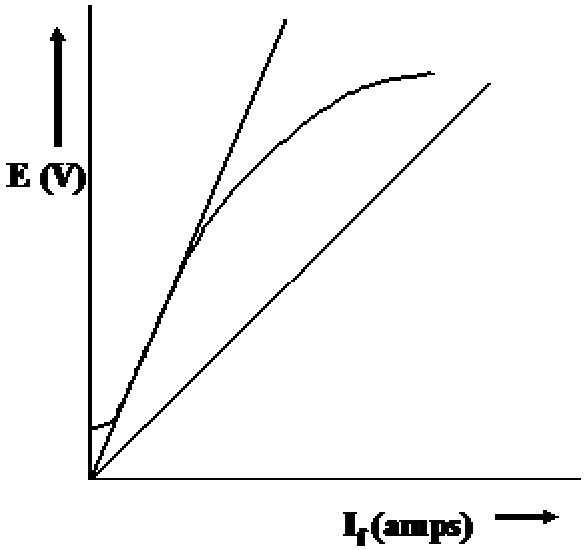
OCC AND LOAD TEST ON SELF EXCITED D. C. SHUNT GENERATOR

MODEL CALCULATION:

To calculate critical resistance R_c and Critical speed N_C

$N_{Critical} / N_{Rated} = E_{critical} / E_{Rated}$

MODEL GRAPH:



RESULT:

The magnetization characteristics curve is drawn and the value of build up voltage is obtained from graph. Critical Resistance and Critical speed are determined from the graph.

REVIEW QUESTIONS:

1.What is critical resistance and critical speed?

2.What is the working principle of dc generator?

3.What are the applications of dc shunt denerator?

4.What are the conditions for building up of an EMF?

EXPT.NO: 1(b) LOAD CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR

DATE:

AIM:

To conduct the direct load test on the given separately excited DC shunt generator to plot

1) External Characteristics (or Load Characteristics)
2) Internal Characteristics (or Total Characteristics)

NAME PLATE DETAILS:

D.C GENERATOR:

- Rated Voltage :
- Rated Current :
- Rated Speed
- Power Rating :

D.C. MOTOR:

Rated voltage :
Rated Current :
Rated Speed :
Power Rating :

EXCITATION

- Voltage :
- Current :

EXCITATION

Voltage :
Current :

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity

THEORY:

A D.C. Generator works on the principle of Faraday's law of electro magnetic induction which says that, "whenever a conductor is moved in magnetic field, an emf is generated in it". "The magnitude of induced emf is directly proportional to the rate of change of flux". The voltage equation for a DC shunt generator is given; by $V_L = E_g - I_aR_a$, Under no load condition; since I_a is negligibly small, from the above equation, the terminal voltage (V_L) is the no; load induced EMF (E_g), As the load on the generator increases, the load current and hence the armature current increases due to armature reaction the induced emf in the armature decreases. Also increased armature current causes increase in l_aR_a drop. Hence the terminal voltage decreases with increasing load. The plot between the terminal voltage (V_L) and load current (I_L) is known as the external or load characteristics. The plot between the induced EMF (E_g) and the armature current (I_a) is known as the internal or total characteristics. The typical graph of internal and external characteristics is shown in model graph.

PRECAUTIONS: (Not to be included in the Record)

1. Remove the fuse carriers before wiring and start wiring as per the circuit diagram.
2. Check the position of the various rheostats as specified below:
   - Motor field rheostat is kept at minimum resistance position.
   - Generator field rheostat is kept at maximum resistance position.
3. The DPST switch on the load side is kept open at the time of starting the experiment.
4. Fuse calculations. As this is a load test, the required fuse ratings are
   - 120% of the motor rated current for supply side DPST.
   - 120% of the generator rated current for load side DPST.
5. Replace the fuse carriers with appropriate fuse wires after the circuit connections are checked by the staff-in-charge.

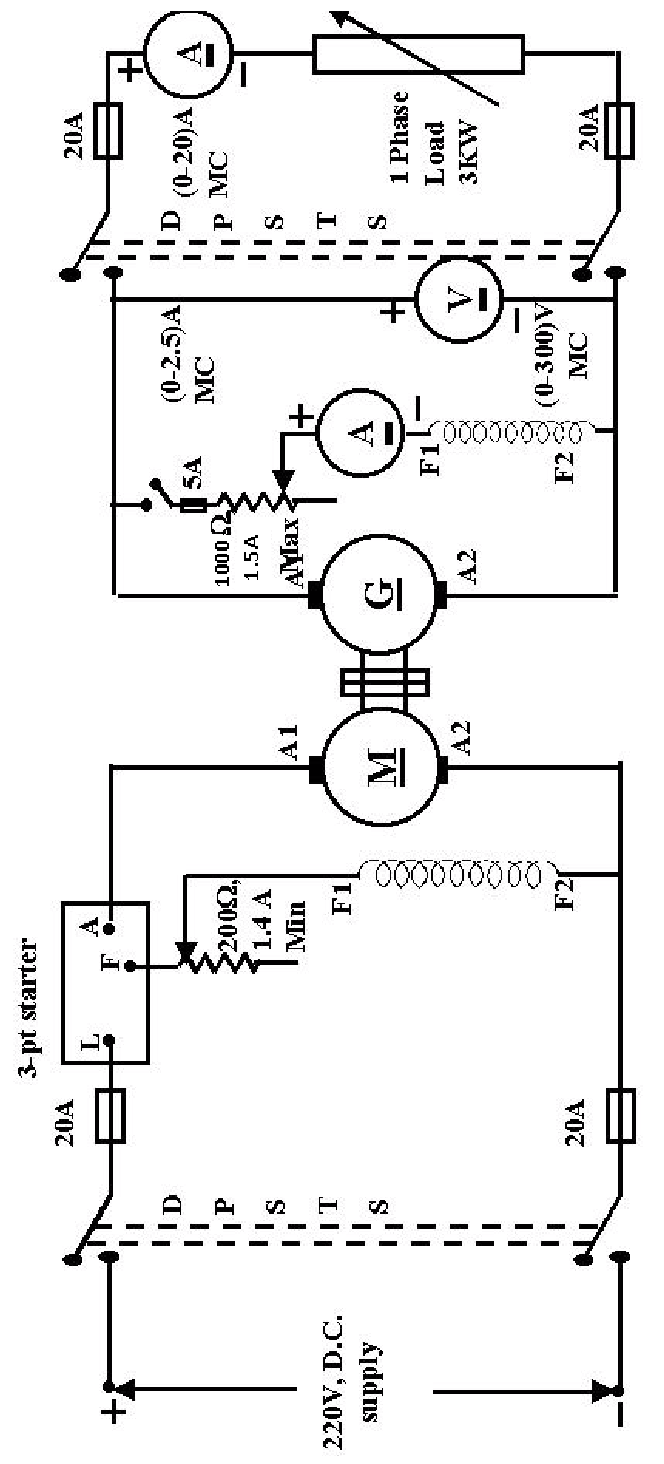
PROCEDURE:

1. The circuit connections are made as per the circuit diagram.
2. Keeping the motor field rheostat in its minimum position, generator field rheostat in maximum position and the starter in its OFF position, the main supply is switched ON to the circuit.
3. The motor is started using the 3-point starter by slowly and carefully moving the starter handle from its OFF to ON position.
4. The motor is brought to its rated speed by adjusting its field rheostat and checked with the help of the tachometer.
5. With the DPST switch open, the potential divider is slowly varied until the generator voltage is equal to its rated value (220V). The terminal voltage and the field current are noted in the tabular column.
6. The DPST switch on the load side is now closed and the load on the generator is gradually increased in steps. At each step the speed of the generator is checked and maintained constant at its rated value by adjusting the field rheostat of the motor. After satisfying this condition at each step of loading, the terminal voltage (V_L), field current (I_f) and the load current (I_L) are noted down in the tabular column.
7. This procedure is continued until the generator is loaded to 120% of its rated value.
8. Once the experiment is completed the load on the generator is gradually decreased, the various rheostats are brought back to their original position in sequence and the main supply is switched OFF.

Table for Load Test

S.NO.	V_L (V)	I_L (A)	I_f(A)	I_a(A)	I_aR_a (V)	$E_g=V_L+ I_a R_a$ (V)

CIRCUIT DIAGRAM FOR LOAD TEST ON SELF EXCITED D.C.SHUNT GENERATOR



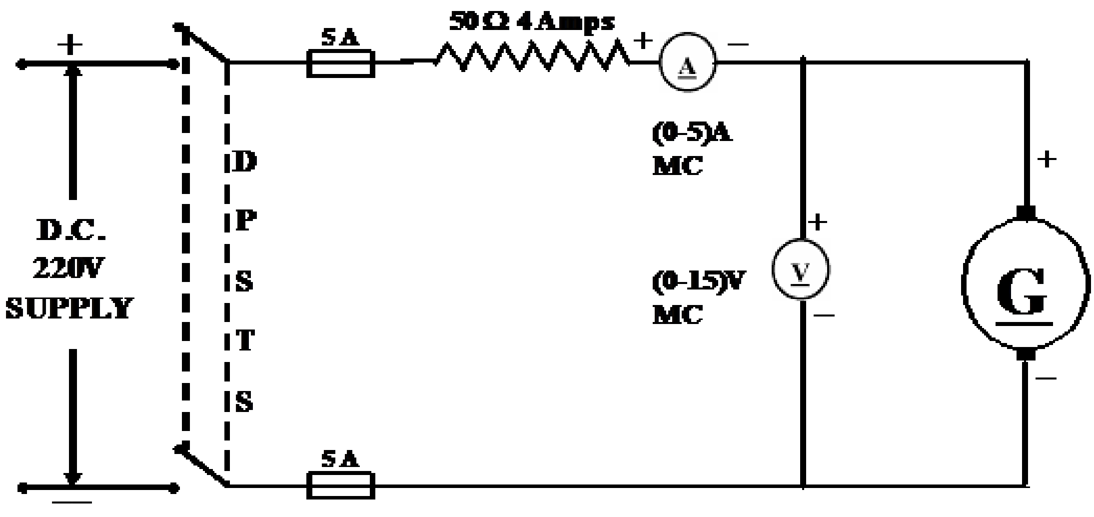
OCC AND LOAD TEST ON SELF EXCITED D. C. SHUNT GENERATOR

PROCEDURE FOR MEASUREMENT OF ARMATURE RESISTANCE

1. The circuit connections are made as per the circuit diagram.
2. Keeping the lamp load at the OFF position the main supply is switched ON.
3. The load is increased such that the current in the circuit is approximately adjusted to 25%, 50% and 75% of rated current of the generator and at these load conditions the armature voltage (V) and current (I) are noted in the tabular column.

Table for Measuring R_a

V_a (v)	I_a (A)	R_a (OHMS)



ARMATURE RESISTANCE MEASUREMENT

CALCULATION:

1. Determination of armature resistance (R_a):

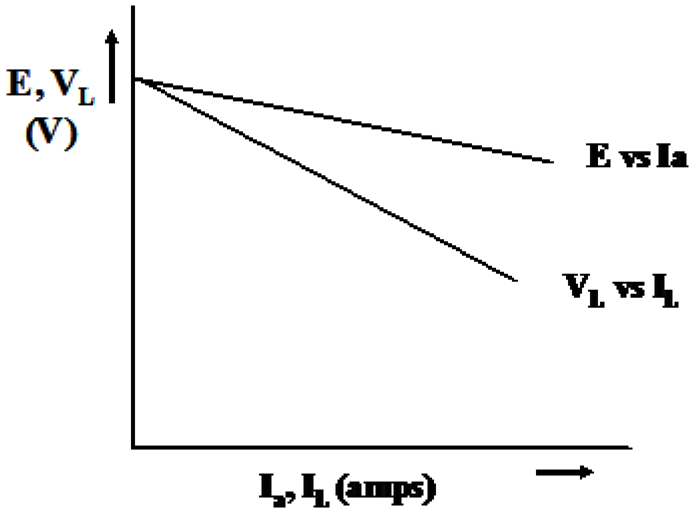
The armature winding resistance is calculated using ohms law R_a = V/I for each set of readings and the average of them is calculated. The effective resistance of the armature winding after taking into account the effect of temperature rise and skin effect is 1.2 times the average resistance R_a i.e. R_a (effective) = 1.2 R_a (average).

2. To plot the internal characteristics, the armature current and the induced EMF are calculated using the expressions,

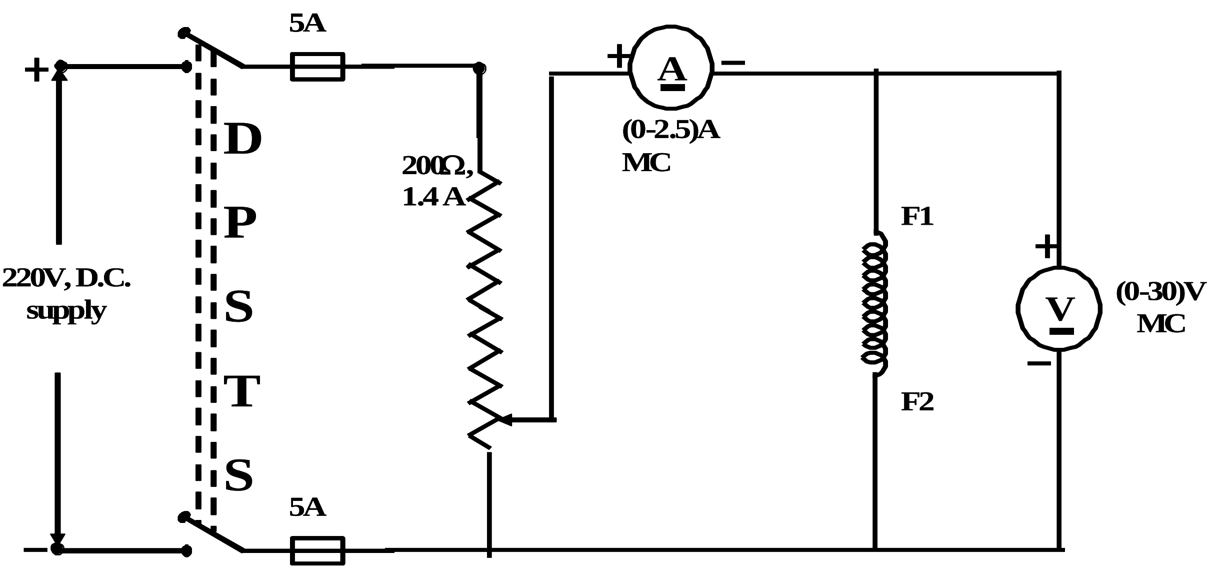
$I_a = I_L + I_f$ and $E_g = V_L + I_aR_a$ (eff)

3. The plots of V_L Vs I_L and E_g Vs I_a are drawn to scale in the same graph sheet.

Model Graph



Circuit diagram



Measurement of Field Resistance

RESULT:

The direct load test on the given self excited DC shunt generator has been conducted and the internal and external characteristics are plotted.

REVIEW QUESTIONS:

1 What is the difference between cumulatively compounded and differentially compounded dc generators?

2 What are the applications of dc compound generators?

3.What are the special characters of dc compound generators

EXPT.NO: 2(a) OPEN CIRCUIT CHARACTERISTICS OF SEPARATELY EXCITED DC SHUNT GENERATOR

DATE:

AIM:

To obtain the O.C.C of the given separately excited DC shunt generator and hence to determine

iv) Critical field resistance

v) Critical speed

vi) O.C.C at the specified speed

NAME PLATE DETAILS:

D.C. GENERATOR:		D.C. MOTOR	:
• Rated Voltage	:	Rated Voltage	:
• Rated Current	:	Rated Current	:
• Rated Speed	:	Rated Speed	:
• Power Rating	:	Power rating	:

APPARATUS REQUIRED:

S.no.	Apparatus	Range	Type	Quantity

THEORY:

A D.C. generator requires an excitation circuit to generate an induced voltage. Depending on whether the excitation circuit consumes power from the armature of the machine or from separately required power supply, the generators may be classified as self excited or separately excited generators respectively

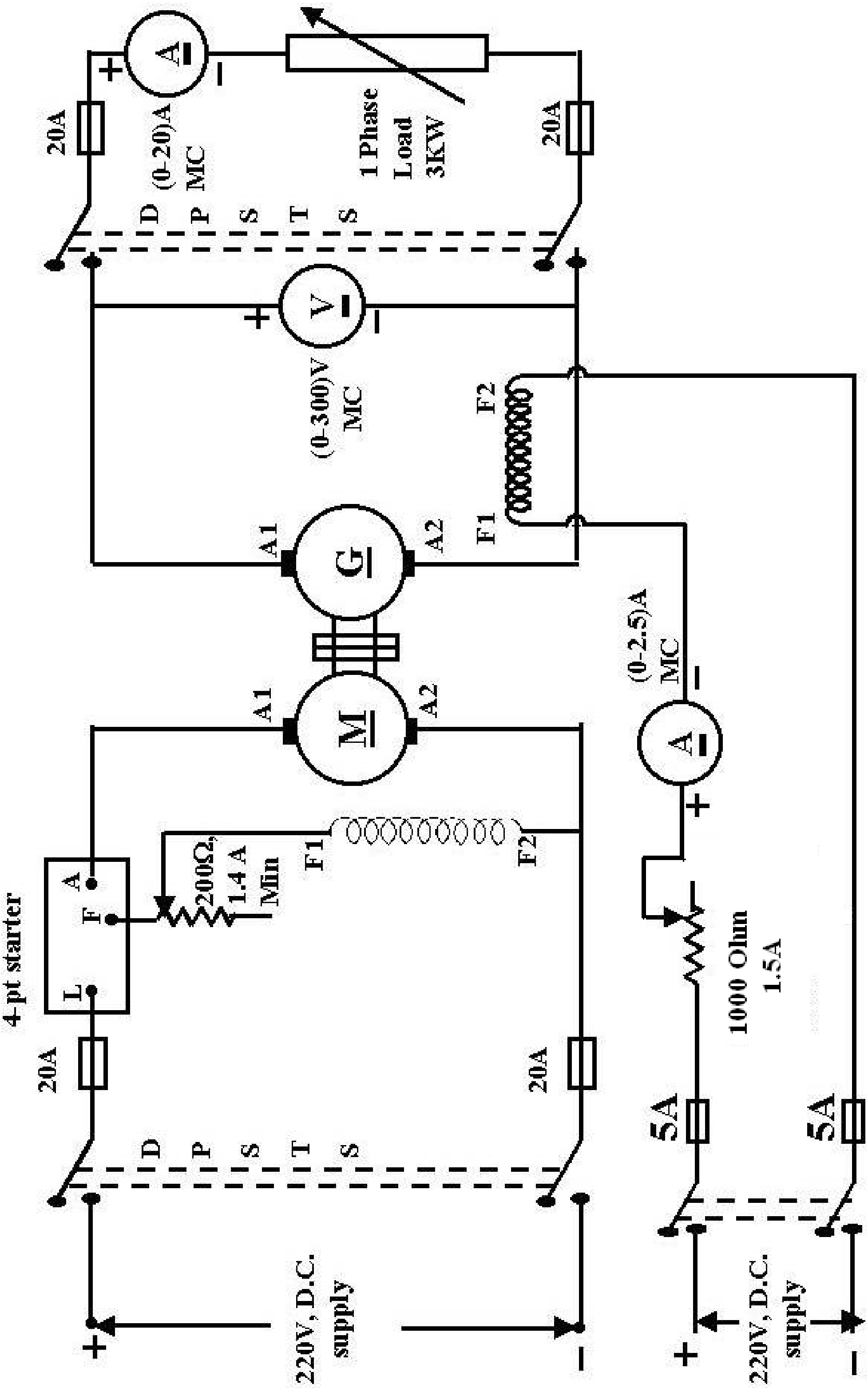
The induced EMF in a DC generator is given by the equation $E_g = PZ\phi N/ 60A$ volts. Since P,Z and A are constants the above equation can be rewritten as $E_g = K\phi N$. If the speed of the generator is also maintained constant then $E_g = K_1\phi$, but the flux is directly proportional to the field current, hence $E_g = K_2 I_f$. From the above equation it is clear that the induced EMF is directly proportional to the field current when speed is maintained constant. The plot between the induced EMF and the field current is known as open circuit characteristics of the DC generator. The typical shape of this characteristic is shown in figure.

The induced EMF when the field current is zero is known as residual voltage. This EMF is due to the presence of a small amount of flux retained in the field poles of the generator called residual flux. Once the O.C.C is obtained the parameters such as critical field resistance, critical speed and the maximum voltage to which the machine can build up can be determined. If required the O.C.C at a different speeds can also be obtained. Critical speed is minimum speed below which the generator shunt fails to excite.

PRECAUTIONS: (Not to be included in the Record)

1. Remove the fuse carriers before wiring and start wiring as per the circuit diagram.
2. Keep the motor field rheostat at minimum resistance position and generator field rheostat at maximum resistance position.
3. The SPST switch is kept open at the time of starting the experiment.
4. Fuse calculations. As the test is a no-load test the required fuse ratings are 20% of motor rated current.

5. Replace the fuse carriers with appropriate fuse wires after the circuit connections are checked by the staff-in-charge**.**



OCC & LOAD TEST ON SEPERATELY EXCITED D.C. SHUNT GENERATOR

PROCEDURE:

1. The circuit connections are made as per the circuit diagram in the shown figure.
2. Keeping the motor field rheostat in its minimum position, generator field rheostat in maximum position; and the starter in its OFF position, the main supply is switched ON to the circuit.
3. The motor is started using the 3-point starter by slowly and carefully moving the starter handle from its OFF to ON position,
4. The motor is brought to its rated speed by adjusting its rheostat and checked with the help of a tachometer.
5. With the SPST switch open, the residual voltage is noted.
6. Now the SPST switch is closed and the Potential divider is varied in steps and at each step the field current (I_f) and the corresponding induced EMF (E_g) are recorded in the tabular column. This procedure is continued until the generator voltage reaches 120% of its rated value the speed of the machine is maintained constant.
7. After the experiment is completed the various rheostats are brought back to their original position in sequence and then main supply is switched OFF.

Table for OCC

S. No.	**Field current I_f (amps)**	**Generator voltage E_g (volts)**

Table for Measuring R_f

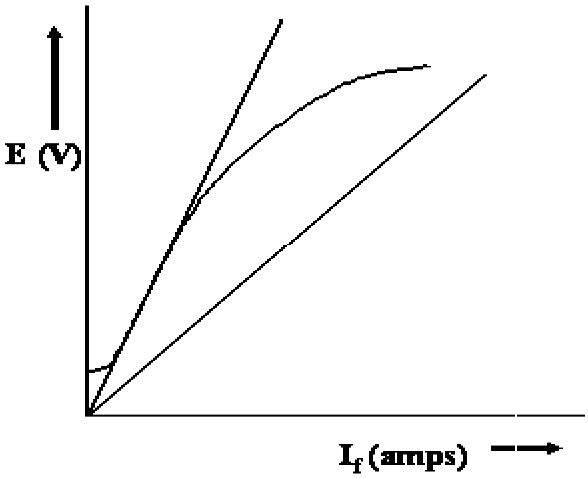
V_f (volts)	I_f (amps)	R_f (ohms)

MODEL CALCULATION:

To calculate critical resistance R_c and Critical speed N_C

$N_{Critical} / N_{Rated} = E_{critical} / E_{Rated}$

MODEL GRAPH:



RESULT:

The magnetization characteristics curve is drawn and the value of build up voltage is obtained from graph. Critical Resistance and Critical speed are determined from the graph.

REVIEW QUESTIONS:

1.What is critical resistance ?

2.what is critical speed ?

3.What are the applications of separately excited dc shunt generator?

4.What are the conditions for building up of an EMF?

EXPT.NO: 2(b) LOAD CHARACTERISTICS ON SEPARATELY EXCITED DC SHUNT GENERATOR

DATE:

AIM: To conduct the direct load test on the given separately excited DC shunt generator to plot

1) External Characteristics (or Load Characteristics)

2) Internal Characteristics (or Total Characteristics)

NAME PLATE DETAILS:

D.C GENERATOR:

- Rated Voltage :
- Rated Current :
- Rated Speed :
- Power Rating :

D.C. MOTOR:

Rated voltage :
Rated Current :
Rated Speed :
Power Rating :

EXCITATION

- Voltage :
- Current :

EXCITATION

Voltage :
Current :

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity

THEORY:

A D.C. Generator works on the principle of Faraday's law of electro magnetic induction which says that, "whenever a conductor is moved in magnetic field, an emf is generated in it". "The magnitude of induced emf is directly proportional to the rate of change of flux". The voltage equation for a DC shunt generator is given; by $V_L = E_g - I_aR_a$, Under no load condition; since I_a is negligibly small, from the above equation, the terminal voltage (V_L) is the no; load induced EMF (E_g), As the load on the generator increases, the load current and hence the armature current increases due to armature reaction the induced emf in the armature decreases. Also increased armature current causes increase in l_aR_a drop. Hence the terminal voltage decreases with increasing load. The plot between the terminal voltage (V_L) and load current (I_L) is known as the external or load characteristics. The plot between the induced EMF (E_g) and the armature current (I_a) is known as the internal or total characteristics. The typical graph of internal and external characteristics is shown in model graph.

PRECAUTIONS: (Not to be included in the Record)

1. Remove the fuse carriers before wiring and start wiring as per the circuit diagram.
2. Check the position of the various rheostats as specified below:
    a. Motor field rheostat is kept at minimum resistance position.
    b. Generator field rheostat is kept at maximum resistance position.
3. The DPST switch on the load side is kept open at the time of starting the experiment.
4. Fuse calculations. As this is a load test, the required fuse ratings are
    a. 120% of the motor rated current for supply side DPST.
    b. 120% of the generator rated current for load side DPST.
5. Replace the fuse carriers with appropriate fuse wires after the circuit connections are checked by the staff-in-charge.

PROCEDURE:

1. The circuit connections are made as per the circuit diagram.
2. Keeping the motor field rheostat in its minimum position, generator field rheostat in maximum position and the starter in its OFF position, the main supply is switched ON to the circuit.

3. The motor is started using the 3-point starter by slowly and carefully moving the starter handle from its OFF to ON position.
4. The motor is brought to its rated speed by adjusting its field rheostat and checked with the help of the tachometer.
5. With the DPST switch open, the generator field rheostat is slowly decreased until the generator voltage is equal to its rated value (220V). The terminal voltage and the field current are noted in the tabular column.
6. The DPST switch on the load side is now closed and the load on the generator is gradually increased in steps by switching on the lamps one by one. At each step the speed of the generator is checked and maintained constant at its rated value by adjusting the field rheostat of the motor. After satisfying this condition at each step of loading, the terminal voltage (V_L), field current (I_f) and the load current (I_L) are noted down in the tabular column.
7. This procedure is continued until the generator is loaded to 120% of its rated value.
8. Once the experiment is completed the load on the generator is gradually decreased, the various rheostats are brought back to their original position in sequence and the main supply is switched OFF.

TABULAR COLUMN:

S.NO.	**V_L (V)**	**I_L (A)**	**I_f(A)**	**I_a(A)**	**I_aR_a (V)**	**$E_g=V_L+ I_a R_a$ (V)**

PROCEDURE FOR MEASUREMENT OF ARMATURE RESISTANCE

1. The circuit connections are made as per the circuit diagram.
2. Keeping the lamp load at the OFF position the main supply is switched ON.
3. The load is increased such that the current in the circuit is approximately adjusted to 25%, 50% and 75% of rated current of the generator and at these load conditions the armature voltage (V) and current (I) are noted in the tabular column.

V_a (v)	I_a (A)	R_a (OHMS)

CALCULATION:

1. Determination of armature resistance (R_a):

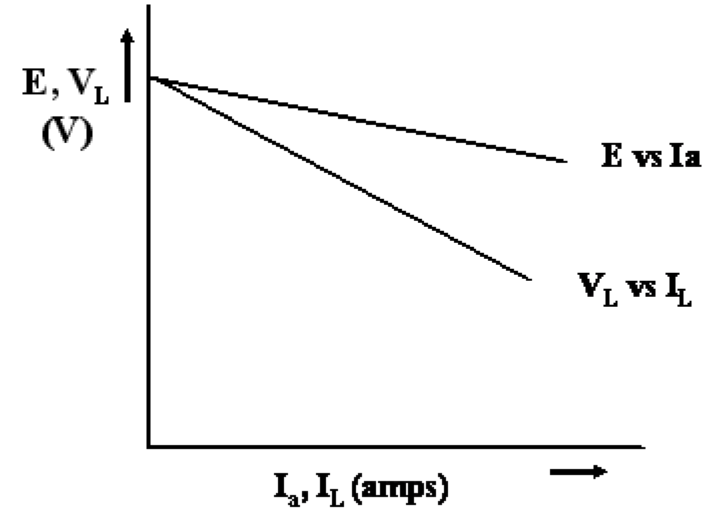
The armature winding resistance is calculated using ohms law $R_a = V/I$ for each set of readings and the average of them is calculated. The effective resistance of the armature winding after taking into account the effect of temperature rise and skin effect is 1.2 times the average resistance R_a i.e. R_a (effective) = 1.2 R_a (average).

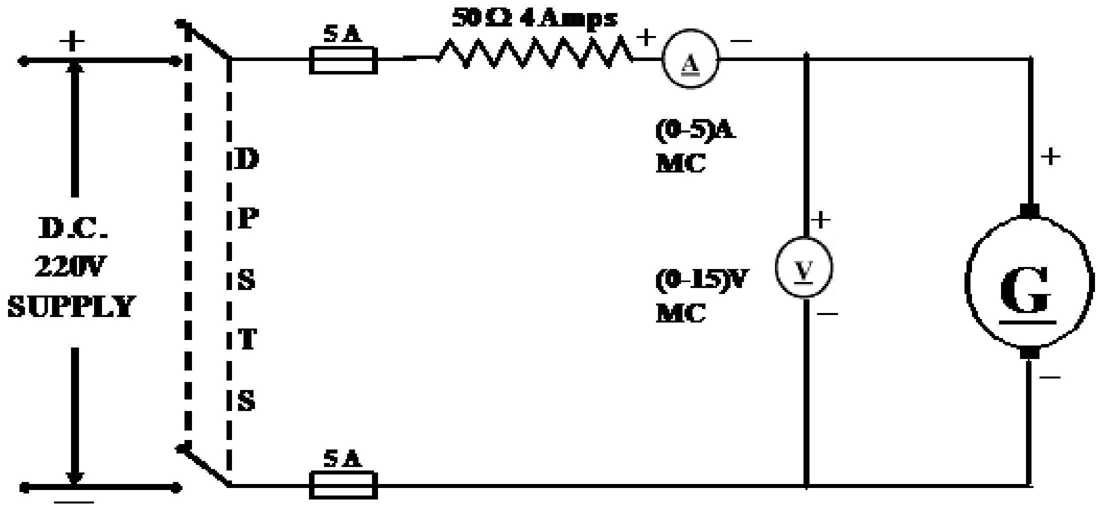
2. To plot the internal characteristics, the armature current and the induced EMF are calculated using the expressions,

$I_a = I_L + I_f$ and $E_g = V_L + I_aR_a$ (eff)

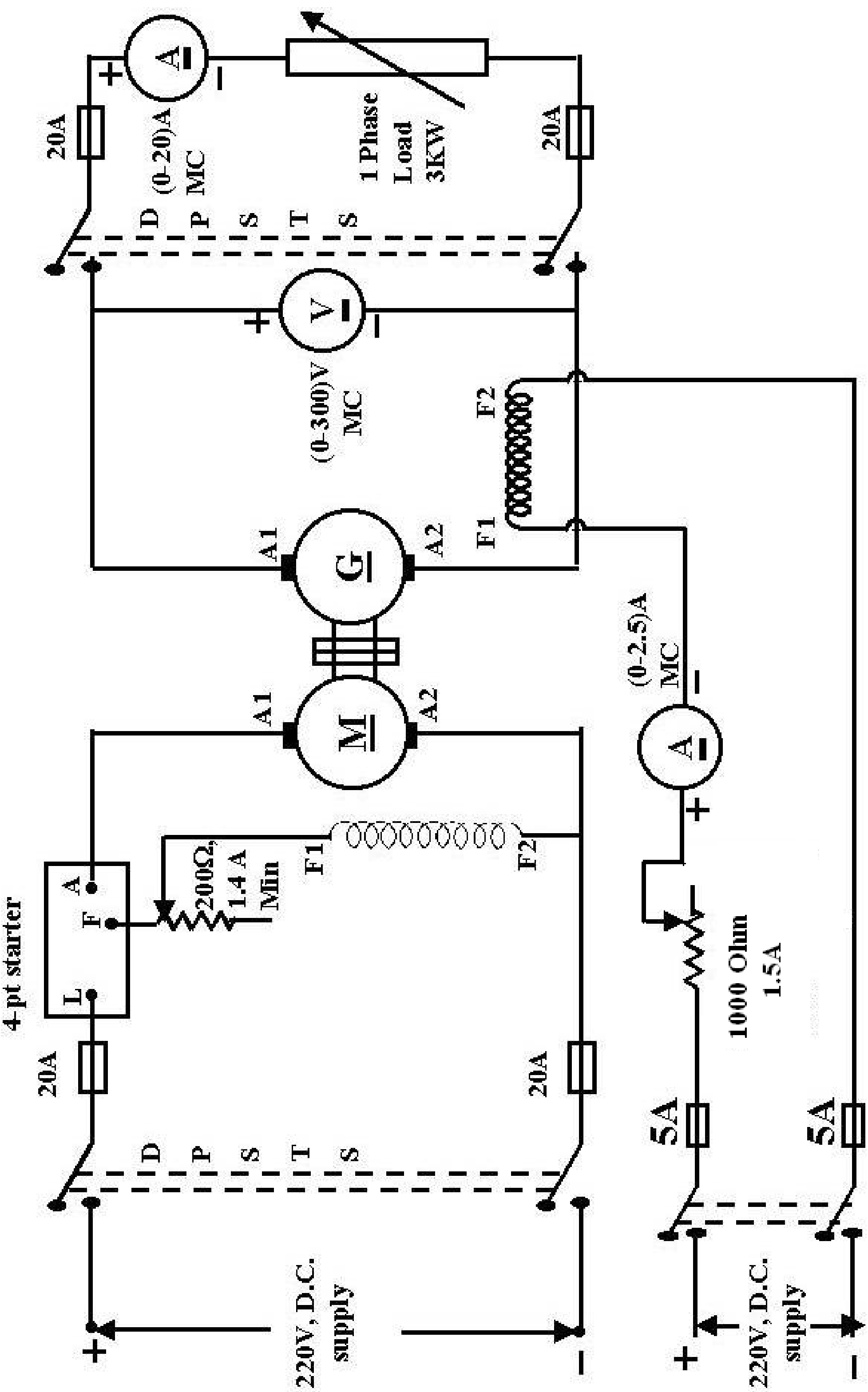
4. The plots of V_L Vs I_L and E_g Vs I_a are drawn to scale in the same graph sheet.

Model Graph:

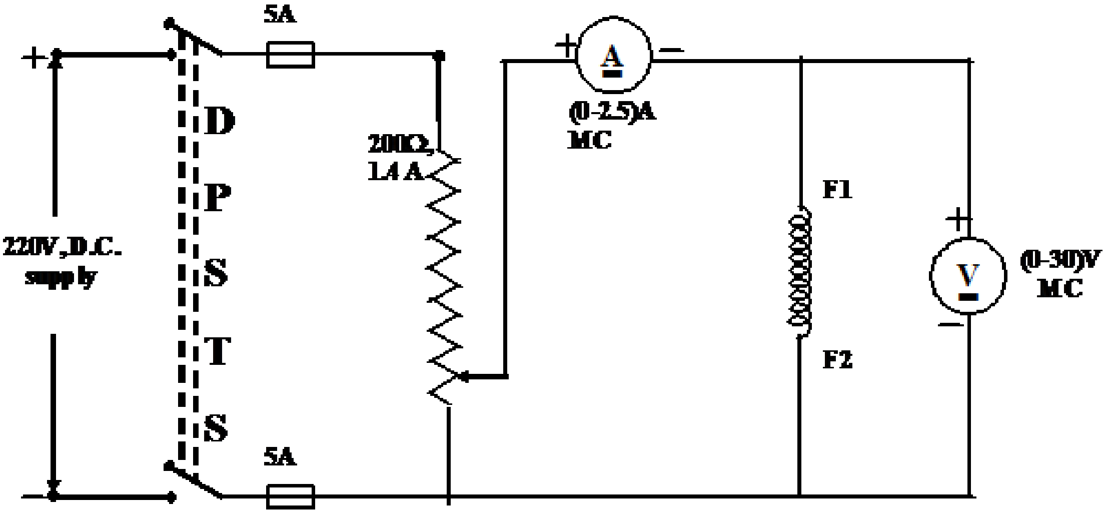




ARMATURE RESISTANCE MEASUREMENT



OCC & LOAD TEST ON SEPERATELY EXCITED D.C. SHUNT GENERATOR



Measurement of Field Resistance

RESULT :

The direct load test on the given DC shunt generator has been conducted and the internal and external characteristics are plotted.

REVIEW QUESTIONS:

1.Which type generator Equalizer bus is necessary for parallel operation?

2.What is mean by commutation?

3.What is armature reaction?

4.State the effects of armature reaction?

5.What is use of compensating windings?

EXPT.NO: 3 LOAD TEST ON DC SHUNT MOTOR

DATE:

AIM:

To conduct a direct load test on the given dc shunt motor to plot the following performance characteristics.

1) Efficiency Vs Output
2) Torque Vs output
3) Speed Vs Output
4. Torque Vs Speed
5. Torque Vs Armature Current
6. Speed Vs Armature Current

NAME PLATE DETAILS:

Rated Voltage =

Power rating =

Rated Speed =

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity

THEORY:

Load test on motor are performed to know about the efficiency, torque and speed characteristics, which enable us to select an appropriate motor for on application.

The torque equation of a DC Motor is given by

$$T_a = 0.159\ (\phi PZ / A) * I_a \text{ N-m}$$

P,Z,A being constant the equation reduces to $T_a = K\phi\ I_a$

In a DC Shunt motor flux is constant, then the torque is directly proportional to the armature current. The speed of a DC motor is given by $N = K (V - I_a R_a) / \phi$

Since ϕ is constant, the speed is directly proportional to (V I a R a) As the load on motor increases, the drop $I_a R_a$ through increases is negligible as R_a is very small and the speed is nearly constant . hence a DC shunt motor is considered as a constant speed motor. If a DC shunt motor is started on load, it draws a heavy armature current, which in turn will damage the machine itself. Hence DC shunt motors are always started on no-load.

PRECAUTIONS: (NOT TO BE INCLUDED IN THE RECORD)

1. Remove the fuse carriers before wiring and start wiring as per the circuit diagram.
2. Check the position of the rheostat as specified.
3. The load on motor must be released initially.
4. Fuse calculations: As this is al load a test the required fuse ratings are 120% of the rated current of the motor.
5. Replace the fuse carriers with appropriate fuse wires after the circuit connections are checked by the staff-in-charge.

PROCEDURE:

1. The circuit connections are made as per the circuit diagram .
2. Keeping the motor field rheostat in its minimum position and the starter in its OFF position the main supply is switched ON to the circuit.
3. The motor is started using the three point starter by slowly and carefully moving the starter handle from its OFF to ON position.

4. The motor is brought to its rated speed by gradually adjusting the field rheostat and checked with the help of a tachometer.

5. Under this no load condition one set of readings namely, applied voltage (V_L), line current (I_L), the two spring balance readings (F_1 and F_2) and motor speed (N) are noted down in the tabular columns.

6. The load on the motor is increased in steps gradually and at each step, all the meter readings and the motor speed are recorded in the tabular column. The above procedure is repeated until the motor is loaded to 120% of its rated current.

7. After the experiment is completed, the load on motor is gradually decreased to minimum and the rheostat is brought back to its original position and then the main supply is switched OFF.

TABULAR COLUMN:

Sl No:	**VL (v)**	**IL (A)**	**If (A)**	**S1 (Kg)**	**S2 (Kg)**	**S1-S2 (Kg)**	**T (N)**	**N (rpm)**	**Ia (A)**	**I/p (w)**	**O/p (w)**	**η (%)**

CALCULATIONS:

1. The circumference of the brake drum is measured and the radius of the drum is calculated using the expression $r=c/2\pi$, $R=r + t/2$, R=_______meters. t – thickness of the belt.

2. The armature current is calculated as $Ia = I_L - I_F$

3. The input to the motor is VL * IL Watts.

4. The torque developed by the motor is given by T= (F1-F2) * r*9.81N-m.

5. The output of the motor in watts 2πNT/60

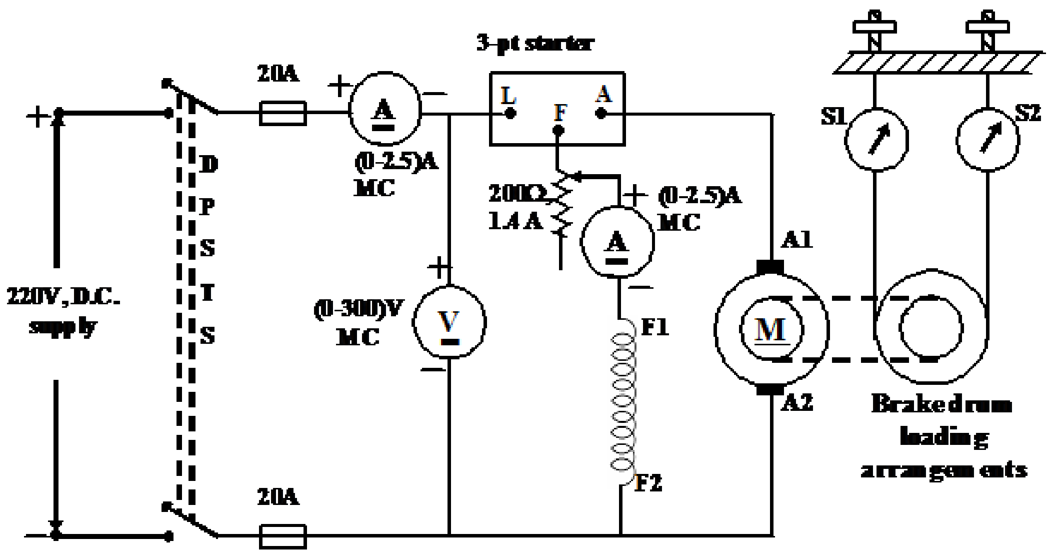
6. The efficiency of the motor =(O/P/I/P) * 100%

7. The plots of efficiency Vs Output, Torque Speed Vs Output are plotted in the same graph sheet.

8. The plot of Torque Vs Armature Current and Speed Vs Armature Current are drawn in another graph sheet.

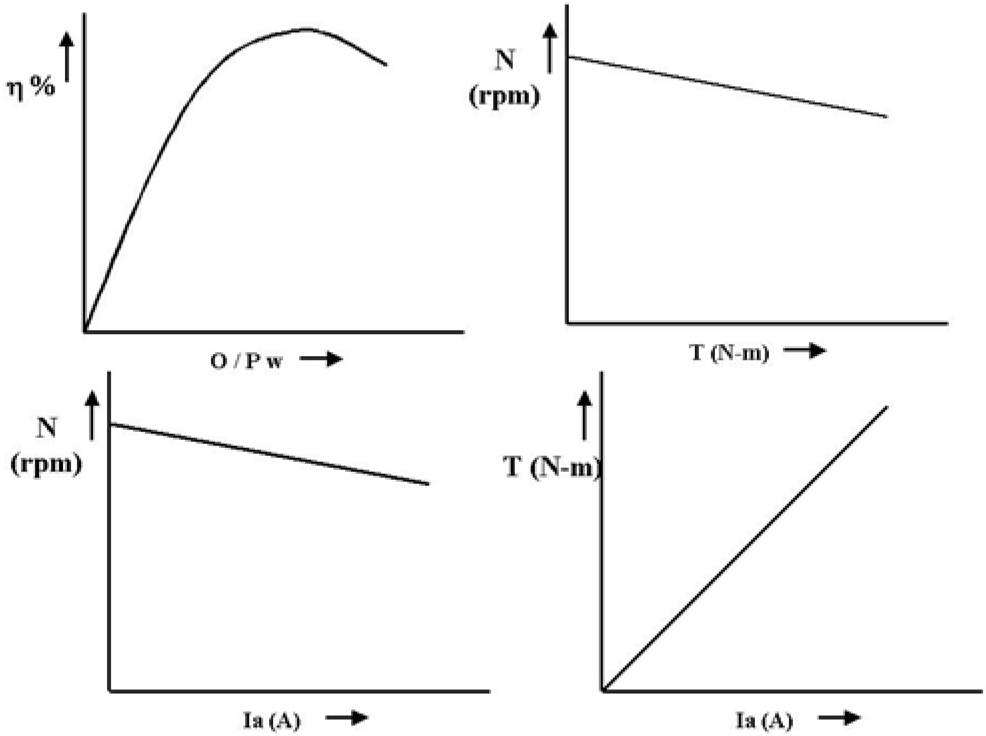
9. The plot of speed Vs Torque is also plotted in separated in separate graph sheet.

CIRCUIT DIAGRAM:



Load Test On D.C. Shunt Motor

MODEL GRAPH :



RESULT:

Thus the direct load test on DC shunt motor has been conducted and the various performance characteristics are plotted.

REVIEW QUESTIONS:

1. Which method is chosen to control the speed above rated speed?
2. Which method is chosen to control the speed below rated speed?
3.Can u apply this methods for dc series motor?
4.What are other methods are there for speed control of dc shunt motor?
5.What are disadvantages of voltage control method of speed control?

EXPT.NO: 4 SPEED CONTROL OF DC SHUNT MOTOR

DATE:

AIM:

To determine the variation of speed with (i) armature voltage (Rheostatic control method) and (ii) Field excitation (Flux control method).

NAME PLATE DETAILS

Hp :

Armature voltage :

Current :

Speed :

Excitation :

APPARATUS REQUIRED:

SNO	APPARATUS	RANGE	TYPE	QTY

THEORY:

A dc motor is an electrical machine that takes electrical energy and converts it into mechanical energy.

The speed of the dc motor is given by the relation

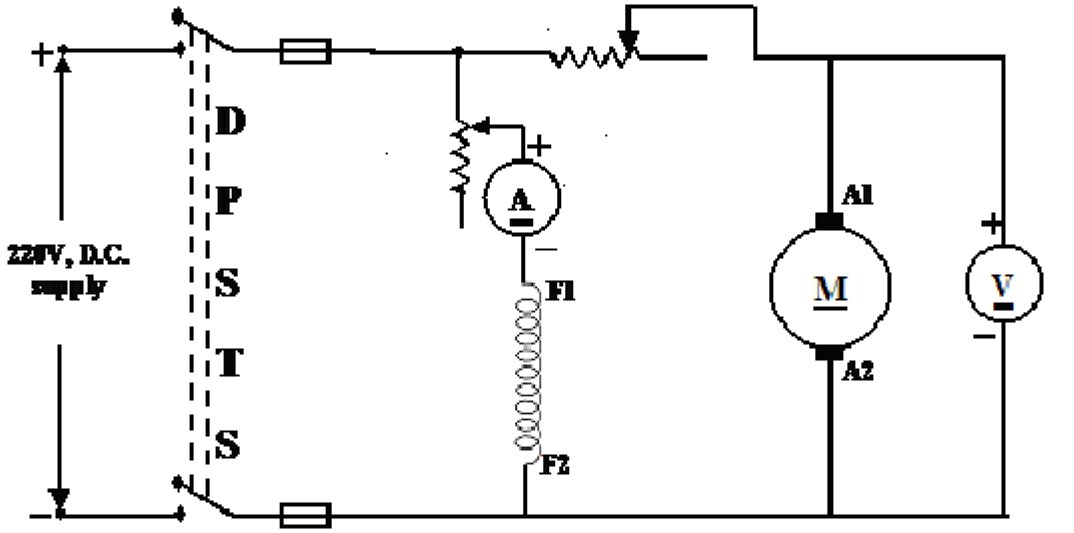
$$N = \frac{V - I_a R_a}{K \phi} \text{ rpm.}$$

From the above relation, the speed of the dc shunt motor can be varied by varying,

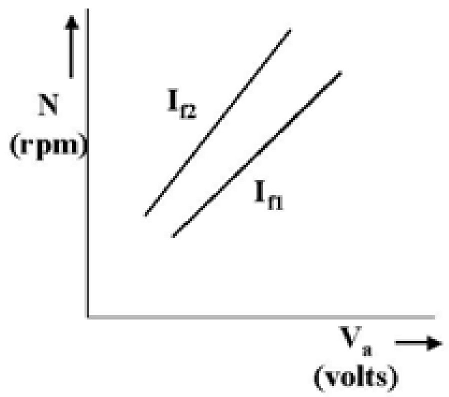
1. The voltage V applied to armature.
2. The armature circuit resistance Ra and
3. The flux ϕ

The speed is nearly proportional to armature voltage if the armature drop is small, while it is inversely proportional to the flux ϕ .

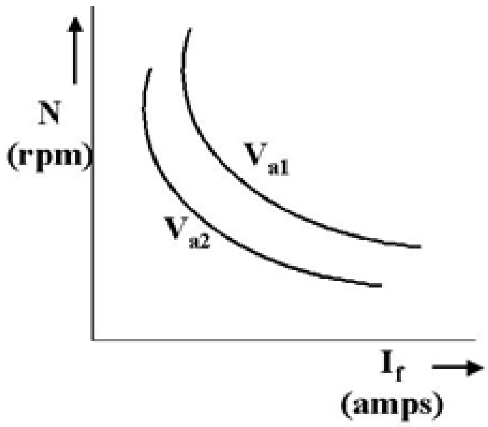
CIRCUIT DIAGRAM FOR SPEED CONTROL OF DC SHUNT MOTOR



MODEL GRAPHS



Armature Control Method



Flux Control Method

PRECAUTIONS :

1. While starting and stopping the machine the armature circuit rheostat is kept at maximum resistance position and the field circuit rheostat is kept at minimum resistance position.
2. DPST switch is kept open initially.

PROCEDURE

1. The no load current is approximately 15 % of full load current. So the fuse rating should be 15% of full load current.
2. The type and range of all meters are selected according to the ratings of the motor.
3. The connections are made as per circuit diagram.
4. The armature rheostat is kept at maximum resistance position and the field rheostat is kept at minimum resistance position initially.
5. The speed of the dc shunt motor is directly proportional to armature voltage and inversely proportional to flux.
6. In the armature voltage control method the flux or field excitation is kept constant and armature voltage is varied to obtain different speeds.
7. In the field control method the armature voltage is kept constant and flux is varied by varying the field current to obtain different speeds

A. ARMATURE VOLTAGE CONTORL METHOD :

1. The motor is started by closing DPST switch, the motor starts running slowly.
2. As the armature rheostat resistance is reduced gradually the motor picks up speed.
3. The field current is kept at one constant value by adjusting the filed rheostat.
4. The armature voltage is a varied in steps by varying the armature rheostat and corresponding speed is noted down in each step. The readings are taken for speeds below the rated value.
5. The experiment is repeated for different constant values of field current.
6. A set of graphs between armature voltage and speed are drawn for different constant values of field current.

NOTE : The readings should be taken for speed below the rated value.

B. FLUX CONTROL METHOD :

1. In flux control method the armature voltage is kept at one constant value by adjusting the armature rheostat.
2. The field current is varied in steps by varying the field circuit rheostat and the corresponding speed is noted down in each case. The readings are tabulated.
3. A set of graphs between field current and speed are drawn for different values of armature voltage.

NOTE : The readings should be taken for speed above the rated value.

TABLE FOR ARMATURE VOLTAGE CONTROL

I_f (A)	Va (V)	N (rpm)

I_f (A)	Va (V)	N (rpm)

TABLE FOR FLUX CONTROL

Va (V)	I_f (A)	N (rpm)

Va (V)	I_f (A)	N (rpm)

RESULT :

Thus the speed control of dc shunt motor was conducted by (i) Armature voltage control method and (ii) Field control method.

REVIEW QUESTIONS:

1. Which method is chosen to control the speed above rated speed?
2. Which method is chosen to control the speed below rated speed?
3. Can u apply these methods for dc series motor?
4. What are other methods are there for speed control of dc shunt motor?
5. What are disadvantages of voltage control method of speed control?

EXPT.NO: 5 LOAD TEST ON A SINGLE PHASE TRANSFORMER

DATE:

AIM:

To conduct a direct load test on the given single phase transformer to determine the efficiency and regulation at different load conditions.

NAME PLATE DETAILS:

- KVA Rating
- Rated H.V side Voltage
- Rated L.V side Voltage

APPARATUS REQUIRED:-

S.No.	Apparatus	Type	Range	Quantity

THEORY:

Direct load test is conducted to determine the efficiency characteristics and regulation characteristics of the given transformer. An ideal transformer ;is supposed to give constant secondary voltage irrespective of the load current . But practically the secondary voltage decreases as the transformer is loaded due to primary and secondary impedance drops. Since these drops are dependent on load current this variation in terminal voltage is founded using direct loading,

PRECAUTIONS:

Remove the fuse carriers before wiring and start wiring as per the circuit diagram.
Fuse Calculations: This being a load test the required fuse ratings are 120 % of rated current on L.V side

PROCEDURE:

1. The circuit connections are made as per the circuit diagram as shown in figure.
2. Keeping the autotransformer in its; minimum position and the DPST switch in open position, the main supply is switched ON.
3. By slowly and carefully operating the Auto transformer the rated voltage (115V) is applied to the L.V side of the transformer.
4. Under this no-load condition one set of readings namely VH.V, IH.V,, W.V,, Vi. .V,, Wi . .V, are recorded in the tabular column.
5. The DPST switch on the load side is now closed and the load is increased in gradual steps and at each step all meter readings are noted down in the tabular column.
6. The procedure is continued is completed, the load is decreased to its minimum the auto transformer is brought, back to its original position and then the main supply is switched OFF.

TABULAR COLUMN:

% Load	Vp	Ip	Wp	Vs	Is	Ws	%η	% Reg

CALCULATIONS:

1.EFFICIENCY CALCULATION:

The efficiency of the transformer for each set of reading is calculated and tabulated using the expression,

$$\eta \% = OUTPUT * 100 / INPUT$$

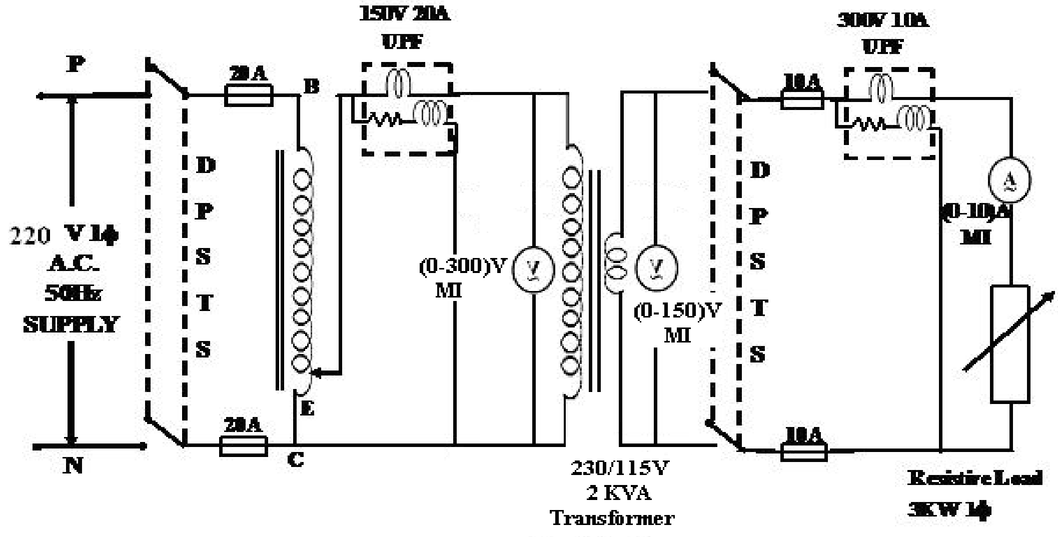
Where, the output of the transformer = VH.V * I H.V on the H.V side & the input of the transformer = W L.V = Wattmeter reading on the I.V side. A Graph is plotted between the percentage efficiency and the output taking % efficiency on Y – axis and the output on X-axis, as shown in figure.

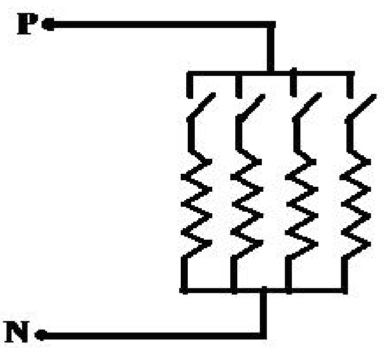
2. REGULATION CALCULATIONS:

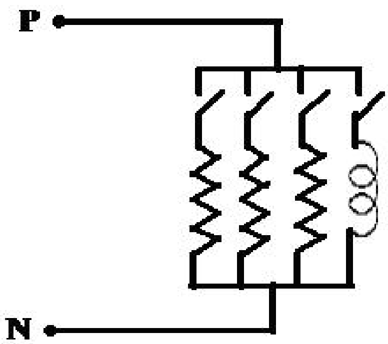
The regulation is calculated and tabulated for each set of readings using the expression % Regulation = $V_{H.V}$ (No-load) –$V_{H.V}$ (load) * 100 / $V_{H.V}$ (No–load) $V_{H.V}$ (No-load) is the no-load voltage on the H.V side, $V_{H.V}$ (Load) – is the actual voltage on the H.V side under load condition. A Graph is plotted between the percentage regulation and the output taking % regulation on Y-axis and the output on X-axis

MODEL CALCULATION:

CIRCUIT DIAGRAM:







RESULT:

Thus the direct load test has been conducted on the given 1-phase transformer and the percentage efficiency and regulation are determined at different load condition and hence the efficiency and regulation graphs are drawn.

REVIEW QUESTIONS:

1. What is the working principle of transformer?
2. What are the types are there according to construction?
3. Why the efficiency of the transformer is always more
4. What is use of breather?
5. State the methods of cooling of transformers?

EX.NO: 6 O.C. AND S.C. TESTS ON A SINGLE PHASE TRANSFORMER

DATE:

AIM:

To conduct the open circuit test and short circuit test on a single-phase transformer and hence to predetermine the efficiency and regulation and also to draw the equivalent circuit as referred to H.V side.

NAME PLATE DETAILS :

KVA rating =

Rated H.V side Voltage =

Rated L.V side Voltage =

APPARATUS REQUIRED:-

S.No.	Apparatus	Type	Range	Quantity

THEORY:

The actual performance characteristics of transformers can be obtained by conducting a direct load test on them. When this has to be performed on large rating transformers, the loads of the required size may not be available, and the power consumed during this test will be very large as the transformers are loaded up to 120% of their capacity. The time required to perform such a test is also more. The same performance characteristics can be obtained by comparatively easier methods, which are known as indirect methods or predetermination techniques.

To predetermine the efficiency and regulation of transformers, the open circuit test {(to determine the core loss (iron loss or constant loss)} and short circuit test [to determine the full load copper loss (variable loss)] are carried out. Assuming the output and load power factor, the efficiency at different loads are computed. The regulating on full load for different assumed load power factors can also be computed. The data obtained from these tests are also useful to find the equivalent circuit parameters. The results obtained from these tests are almost closer to the actual values obtained by direct load test.

PRECAUTIONS: (Not to be included in the Record)

1. Remove the fuse carriers and start wiring as per the circuit diagram.
2. Keep the autotransformer in its minimum position at the time of starting.
3. Fuse calculations:
   a. For O.C. test – fuse rating – 20% or rated current of L.V. side.
   b. For S.C. test - fuse ratings – 120% of rated current of H.V. side.
4. Replace the fuse carrier with appropriate fuse wires after the circuit connections at checked by the staff-in-charge.

PROCEDURE:

I) O.C. TEST:

1. The circuit connections are made as per the circuit diagram.
2. Keeping the H.V. winding open and the autotransformer in its minimum position the main supply is switched ON.
3. By slowly and carefully adjusting the autotransformer, the rated voltage (115V) is applied to L.V. winding of the transformer.
4. Under this condition the ammeter (Io), Voltmeter (Vo) and Wattmeter (Wo) readings a noted down.
5. After the experiment is completed, the autotransformer is slowly brought back to minimum position and then the main supply is switched OFF.

II) S.C. TEST:

1. The circuit connections are made as per the circuit diagram.
2. Short circuiting the LV winding and keeping the autotransformer in its minimum position, the main supply is switched ON.
3. By slowly and carefully adjusting the autotransformer the rated current (which is calculated as IH.V.= KVA Rating *1000 / V H.V. is circulated through the H.V. winding.
4. Under this condition, the ammeter (ISC), the voltmeter (VSC) and the Wattmeter (WSC) readings are noted down.
5. After the experiment is completed, the autotransformer is brought back to its minimum position and main supply is switched OFF.

TABULATION :

TEST	VOLTAGE(V)	CURRENT(A)	POWER(W)
O.C TEST (On L.Vside)	Vo =	Io =	Wo =
S.C. TEST (On H.V side)	Vsc =	Isc =	Wsc=

CALCULATIONS :

1. To obtain the equivatent circuit parameters w.r.t. H.V side

i). From the O.C test the; constant loss Iron loss is noted $W_c = W_o =$ _________watts.

ii). From the S.C test full load copper loss is noted $W_{cu} = W_{sc} =$ __________watts.

For a transformer, the equivalent circuit parameters can be determined ether w.r.t H.V side or L.V side. If the parameters are estimated on the H.V side ;the resulting equivalent circuit is called H.V side equivalent circuit of the transformer.

From the O.C test Ro and Xo are calculated using the following expressions,

R_o (L.V) $=V_o / I_w$ Ohms ; X_o (L,V) $=V_o / I_m$ Ohms. Where $I_m = I_o$ $\cos\theta$, $I_m = I_o \sin\theta$ and $\theta = \cos^{-1}$[Wo/VoIo]

Since these values are calculated w.r.t L. V side (because O.C test is conducted on the I.V side), the equivalent values of 'R_o' and 'X_o' as referred to H.V side are determined as Ro(H.V) = Ro (L.V) / K^2 & Xo(H.V) = Xo (L.V) / K^2

Where K= (secondary voltage) / (primary voltage)

= 115/230 for a step down operation.

= 230/115 for a step up operation.

Since we are assuming a step down operation k = 115 / 230 = 0.5.

R_T (H.V) = W_{sc}/ I_{sc}^2 Z_T (H.V) = V_{sc} / I_{sc}

X_T (H.V) = $[Z_T^{\ 2}$ (H.V) – $R_T^{\ 2}$ (H.V)$]^{1/2}$

R_T (H.V) and X_T (H.V) are the total equivalent resistance and reactance of the transformer as referred to the H.V side whose values are calculated from the S.C test.Now the H.V side equivalent circuit is drawn

2. To Predetermine The Efficiency:

The percentage efficiency is then predetermined for different load conditions for a specified load power factor using the expression,

$$\% \text{ Efficiency} = \frac{X*KVA * \cos\phi * 1000}{(x* KVA * \cos\phi * 1000) + Wo+x^2 WF.L}$$

When x is the fraction ;of the full load which is 0.25 for 25% load, o.5 for 50% load, 0.75 for 75% load, 1.0 for full load and 1.25 for 125% load and Cosϕ is the load p.f (usually assumed as 0.8 lag) The efficiency valued so calculated are entered in the tabular column as shown. A graph is plotted between percentage efficiency and the output as shown in model graph

TABULATION:

% Of load X	Output power Watts X*kva*cosϕ*100		Copper loss Watts $X^2 w_{sc}(f.l)$	Total loss watts W_c+copper loss	Input power Watts O/p power + losses		Eeficiency% [(o/p)/(i/p)] x 100	
	0.8	1.0			0.8	1.0	0.8	1.0
0.2								
0.3								
0.4								
0.5								
0.6								
0.7								
0.8								
0.9								
1.0								
1.1								
1.2								

3.To Predetermine The Percentage Regulation :

The regulation on full load for different leading and lagging power factors are predetermined by formula,

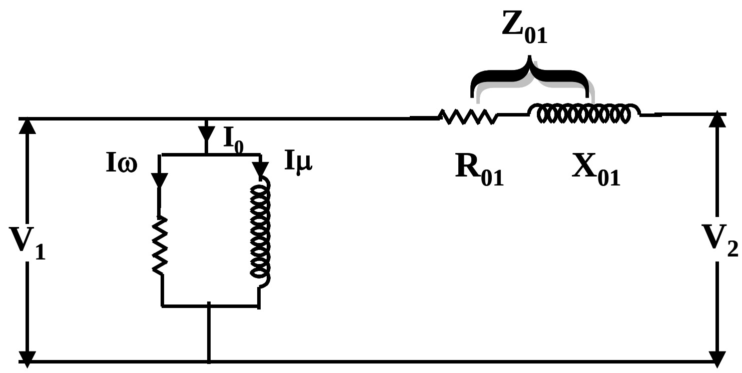
% Regulation = IH.V (RT(H.V) Cosϕ + XT (H.V) Sinϕ * 100 / VH.V Where + for lagging power factor, - for leading power factor.

LH.V = Rated current on H.V side, VH.V = Rated voltage on H.V side. By assuring different leading and lagging power factor such as 0.2,,0.4,0.6,0.8 and 1.0 the regulation of the transformer for full load are determined and tabulated as shown below.

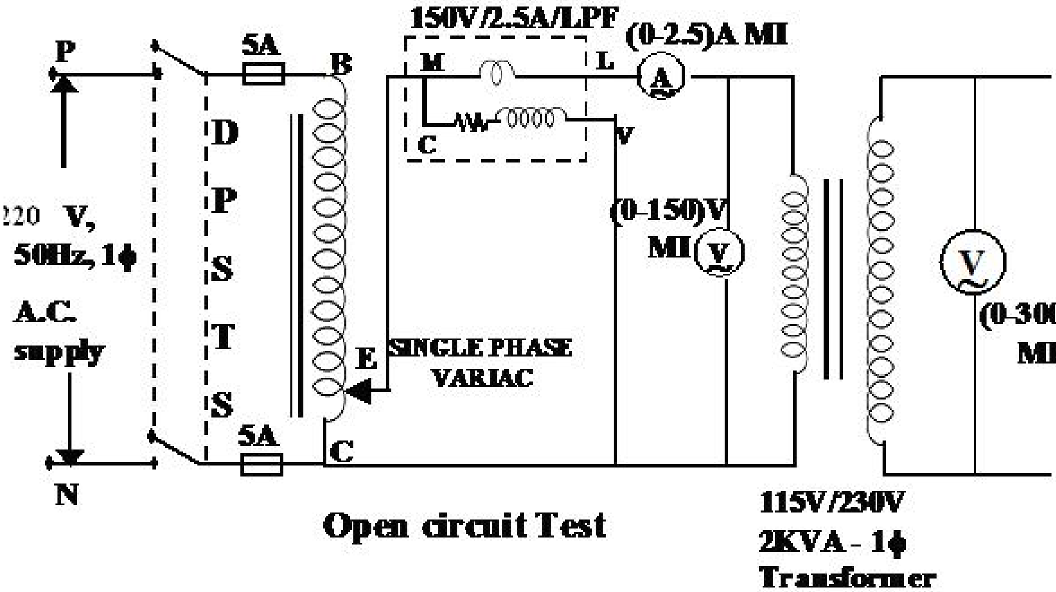
TABULATION:

POWER FACTOR	% Reg for lagging P.F	% Reg for leading P.F
0.2		
0.4		
0.6		
0.8		
1.0		

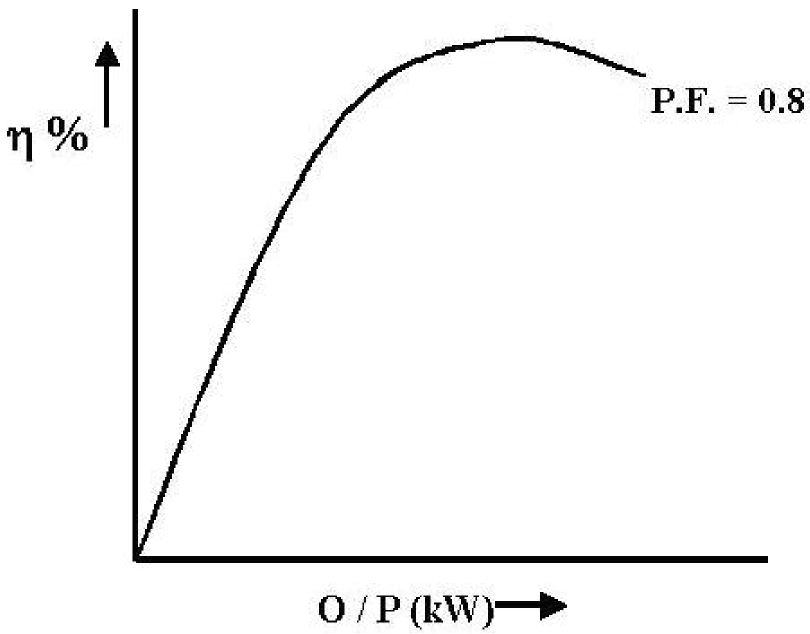
Now a graph is plotted between the percentage regulation and P.F as shown in figure which is known as the regulation graph.



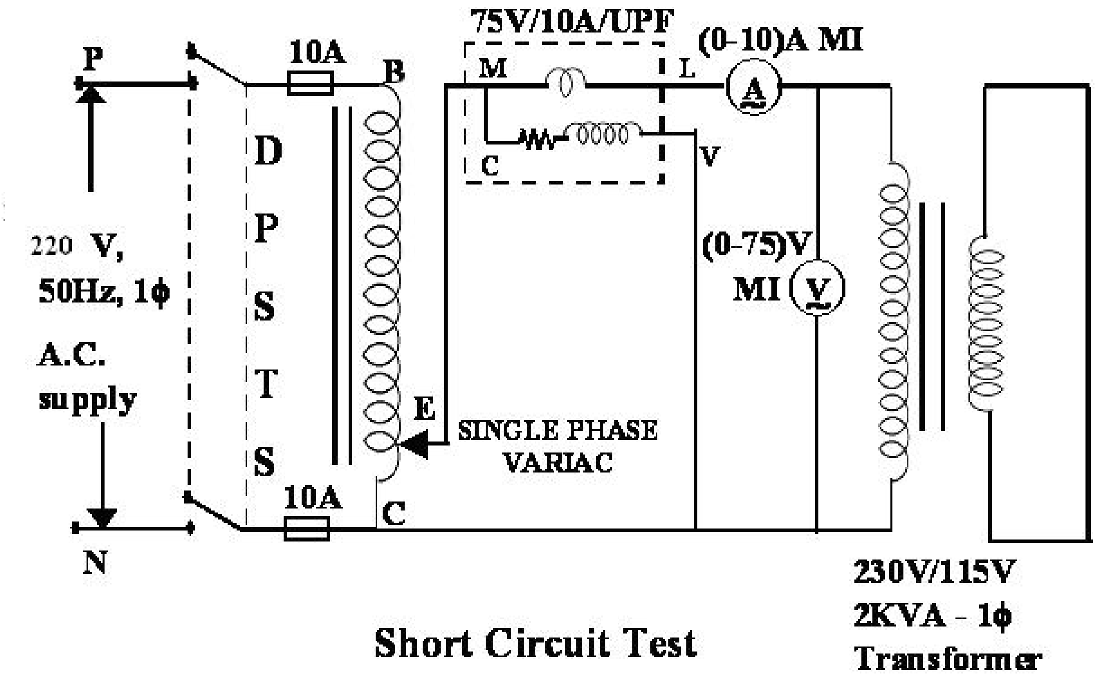
Circuit Diagram



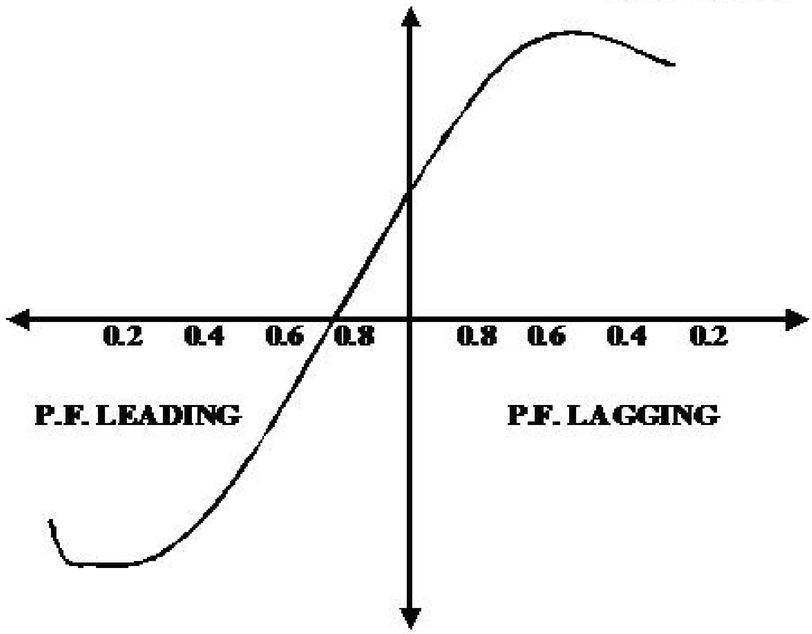
Open circuit Test



Circuit Diagram



Short Circuit Test



REGULATION CURVE

RESULT:

Thus the O.C and S.C tests are conducted on the single phase transformer and the efficieny and regulation graphs and also the equivalent circuit as referred to H.V side are drawn.

REVIEW QUESTIONS

1.What is the working principle of transformer?

2.What are the types are there according to construction?

3.Why the efficiency of the transformer is always more

4.What is use of breather?

EX NO: 7 TRANSFER FUNCTION OF SEPARATELY EXCITED DC GENERATOR

DATE:

AIM

To find the transfer function of separately excited dc generator.

APPARATUS REQUIRED

S.NO	APPARATUS	RANGE	TYPE	QTY

DERIVATION

$E_g(t) = K_g * I_f(t)$ -----------(1)

$E_f(t) = R_f * I_f(t) + L_f\, d(I_f(t))/dt$ -------------(2)

Taking Laplace Transform:

From eqn.(2)

$E_f(s) =(R_f + L_f *s)I_f(s)$

$I_f(s)/E_f(s) = 1/(R_f + L_f *s)$

$I_f(s) = [1/(R_f + L_f *s)]\, E_f(s)$ -------------(3)

From eqn.(1)

$E_g(s) = K_g * I_f(s)$

Subs $I_f(s)$ value $E_g(s) = K_g *[E_f(s) /(R_f + L_f *s)]$

$E_g(s)/ E_f(s) = K_g /(R_f + L_f *s)$ for no load

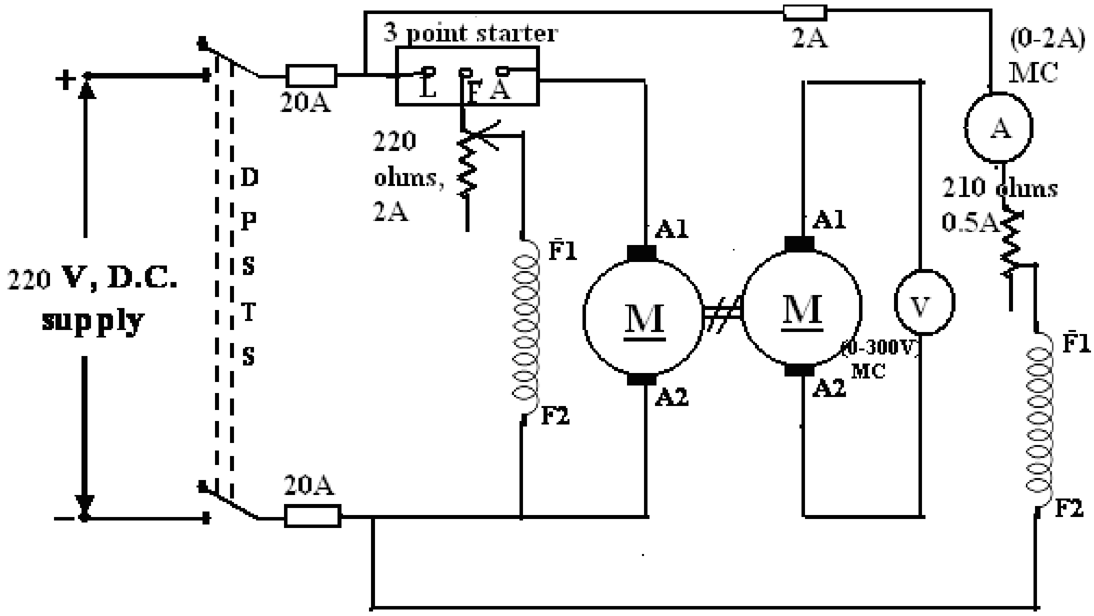
Apply the final value theorem

$$\lim_{S\to 0} E_g(s) = \lim_{S\to 0} K_g *S* E_f(s) /(R_f + L_f *s)$$

THEORY

A DC Generator is commonly used in control systems for power applications. The field of Dc generator is separately excited by a constant voltage source & generator is run by a constant speed prime mover. Let the inductance & resistance of the field winding be L_f & R_f respectively and that of the armature be L_a & R_a. The generator supplies a load Z_L under no load condition I_a =0 and the generator induced voltage E_g is equal to the terminal voltage V_T & under conditions. The transfer function is E_g / E_f . For the field circuit loop equation is written & the transfer functions as derived above.

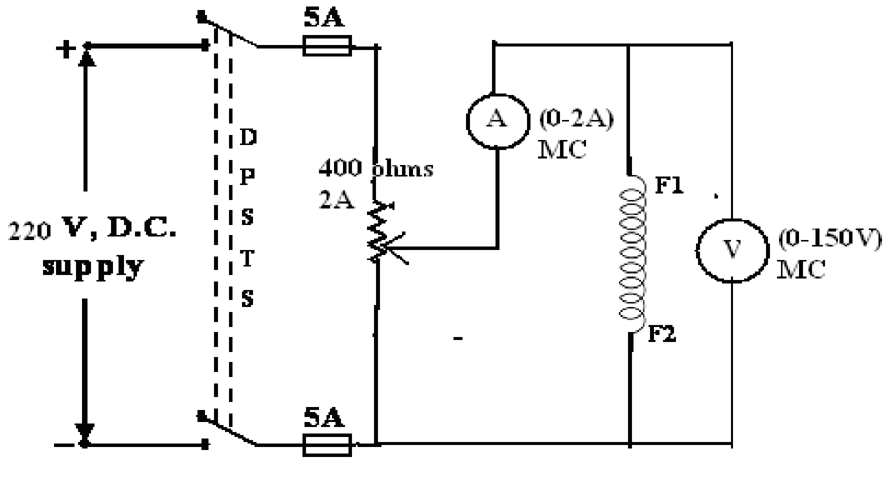
Circuit Diagram for Kg



TABULATION:

S.No	Eg	I_f

Circuit Diagram for R_E

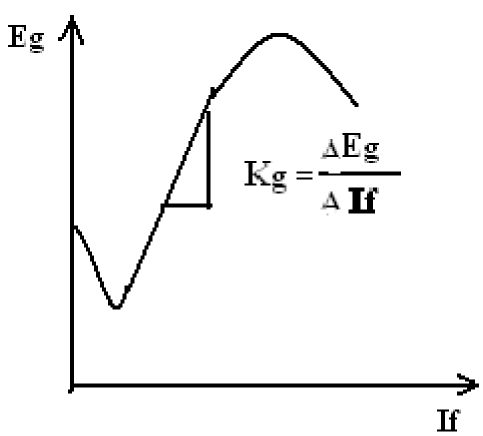


Circuit Diagram for Re

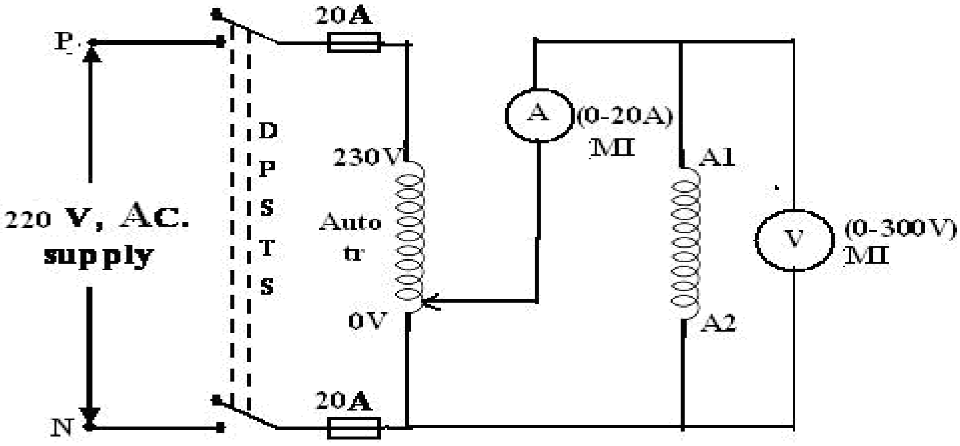
TABULATION FOR R_F

S.No	V_f	I_f	$R_f = V_f / I_f$

Model Graph



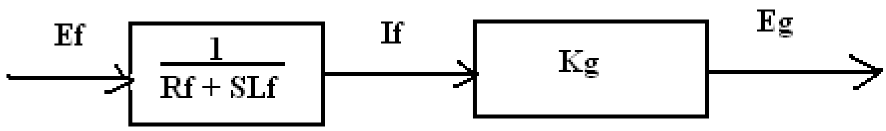
Circuit Diagram for Z_f



Circuit Diagram for La

S.No	V_f	I_f	$Z_f = V_f / I_f$

Block Diagram



PROCEDURE

1) The connections are given as per circuit diagram.

2). The rated speed is setup by adjusting the field rheostat.

3)The field current is varied by adjusting the field rheostat & note the E_f & E_g. for different field current upto rated voltage.

1) To plot the O.C.C curve for E_g Vs I_f & Find out the K_g by taking the slope.

MODEL CALCULATION

RESULT

Thus the transfer function of separately excited DC generator was found as

$E_g(s)/ E_f(s) = K_g /(R_f + L_f *s)$

REVIEW QUESTIONS:

1.Which type of starter is used to start dc compound generator?

2.What is the difference between cumulatively compounded and differentially compounded dc generators?

3.What are the applications of dc compound generators?

4.What are the special characters of dc compound generators**?**

EXP NO: 8 REGULATION OF ALTERNATOR BY EMF AND MMF METHODS

DATE:

AIM:

To conduct OC and SC tests on a given 3-phase alternator and hence to predetermine the regulation by (i) EMF and (ii) MMF method.

NAME PLATE DETAILS:

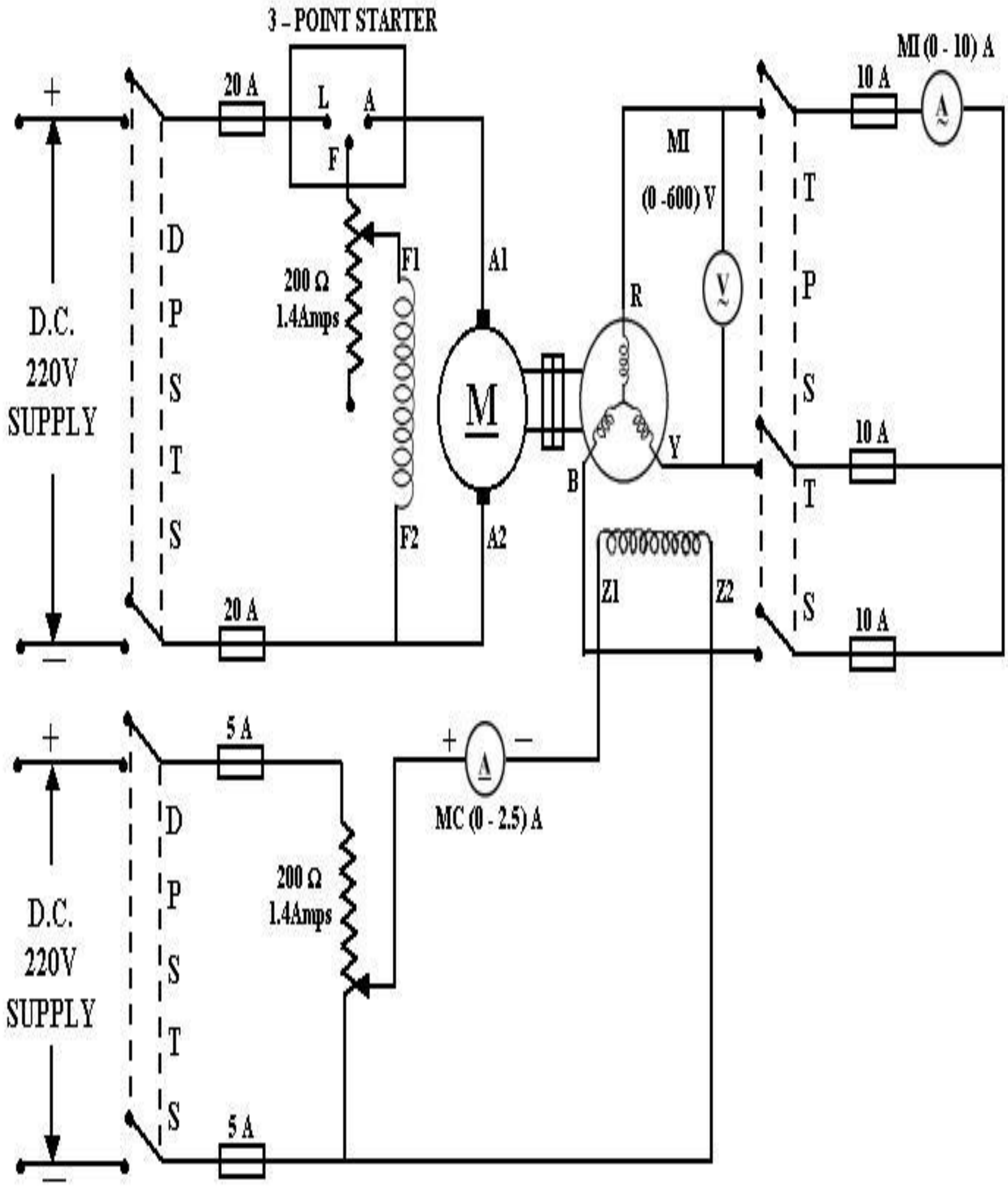
- Rated Voltage = Rated Output=
- Rated Current= Rated Speed=

APPARATUS REQUIRED :

S.NO	APPARATUS	RANGE	TYPE	QTY

Regulation of Alternator by EMF and MMF Method

CIRCUIT DIAGRAM



OBSERVATION:

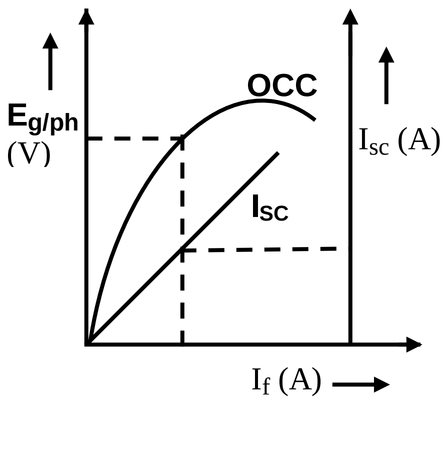
O.C. Test:

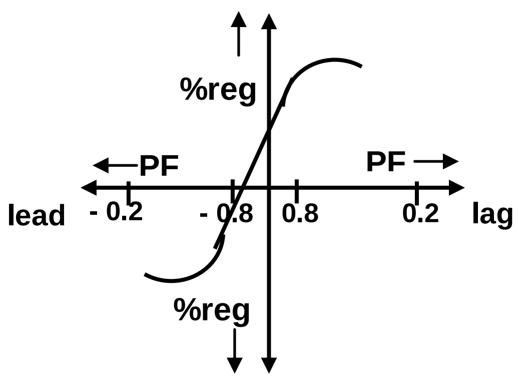
If (Amps)	Vg (l-l) (Volts)	Vg (ph) (Volts)

S.C. Test:

If (Amps)	I SC (Amps)

MODEL GRAPH:





THEORY:

Loading an alternator cause its terminal voltage to drop or rise depending upon (i) magnitude of load (ii) nature of load. For a pure resistive load it drops by 8-12%

below no-load value while for a lagging power factor load the drop is 25-50%elow no-load value

and it is 20-30 % higher for leading power factor loads. The reasons are 1) Armature resistance 2) Armature winding leakage reactance and 3) Armature reaction.

Emf and Mmf methods are used to predetermine the regulation of non-salient pole alternators. In emf method, the effect of armature reaction is represented as a fictitious reactance Xar for each phase of the alternator. In mmf method effect of armature leakage reactance is replaced by additional armature reaction.MMF method is more accurate.

Direct load test is not preferred due to the absence of large sized loads and the enormous power wastage involved in testing. Volyage regulation is defined as a percentage of rated votage when load current is reduced to zero suddenly by throwing off the load keeping If and speed constant.

PROCEDURE:

1. The circuit connections are made as per the circuit diagram.
2. Keeping the rheostat in the minimum position and with the TPST open the motor supply is switched on.
3. Motor is started using the 3-pt starter by moving the handle from its OFF position to ON position and the motor is brought to its rated speed by adjusting the rheostat in the motor field circuit.
4. 220 V dc supply is switched on to the field winding of the alternator by closing the corresponding DPST.

O.C. TEST:

1. Using the 220 ohm potential divider, current in field circuit is increased in steps of 0.1A and at each step the alternator induced voltage indicated by voltmeter and the corresponding field current (If) are noted down.
2. This procedure is continued until the alternator voltage is 150% of its rated voltage.

S.C.TEST:

1. After completing OC test, (I_f) is brought to its minimum using 200 ohm potential divider and then the TPST is closed.
2. The rated current is made to flow through the armature of the stator windings by carefully adjusting 200 ohm potential divider. At this moment the value of If required to pass the rated current through stator winding is noted down.
3. After completing the SC test the TPST switch is opened. The rheostats are brought to their original positions in sequence and then the main supplies are switched off.

Calculation:

Synchronous Impedance (ph) : $Zs = \frac{\text{Open circuit voltage/phase}}{\text{Short circuit current /phase}}$

Synchronous Reactance (ph) : Xs = {(Zs)2 – (Rs)2} 1/2

EMF METHOD:

E0 = {(V_{ph} cos ϕ + IscRs)2 + (V_{ph} sin ϕ + IscXs)2 } 1/2

V = Rated Voltage per phase, R_S — Measured in multimeter in DC
where '+' for lagging power factor load, '-' for leading power factor load

% Reg = ((E0 - V)*100)/ V

TABULATION

S.No	P.F. (lag)	E0 (volts)	% Reg	P.F. (lead)	E0 (volts)	% Reg
1.	**0.2**			**0.2**		
2.	**0.4**			**0.4**		
3.	**0.6**			**0.6**		
4.	**0.8**			**0.8**		
5.	**1.0**			**1.0**		

MMF METHOD:

From the O.C.C. graph, find the (i)If1 – field current required to produce rated voltage per phase (ii)If2 – field current required to produce rated current per phase during S.C. test.

I_{fr} = { I_{f1}^2 + I_{f2}^2 + 2* I_{f1}* I_{f2} cos(180 – 90 +ϕ)^ 1/2

Where '+' for lagging power factor load, '-' for leading power factor load.I_{F1} & I_{F2} are from graph.

Now determine E0 corresponding to Ifr from the graph.

% Reg = ((E0 - V_{ph})*100)/ V_{ph}

TABULATION:

S.No	P.F. (lag)	E_O	Ifr (amps)	% Reg	P.F. (lead)	E_O	Ifr (amps)	% Reg
1.	**0.2**				**0.2**			
2.	**0.4**				**0.4**			
3.	**0.6**				**0.6**			
4.	**0.8**				**0.8**			
5.	**1.0**				**1.0**			

MODEL CALCULATION:

RESULT:

Thus the open and short circuit tests were conducted on the given 3- phase alternator and the regulation of the alternator was predetermined by EMF and MMF method.

REVIEW QUESTIONS

1.Which type generator Equalizer bus is necessary for parallel operation?

2.What is mean by commutation?

3.What is armature reaction?

4.State the effects of armature reaction?

Ex.No: 9a) LOAD TEST ON 1Φ INDUCTION MOTOR

(CAPACITOR START / INDUCTION RUN)

Date:

AIM: To conduct the load test on 1Φ Induction Motor (Capacitor Start / Induction Run) & also to plot the performance Characteristics curves.

APPARATUS REQUIRED:

S.No	Description	Range	Quantity

THEORY:

The motor which operates on single phase input supply is called as single phase induction motor. Constructionally this motor is similar to a three phase induction motor except that

1) It stator is provided with a single phase winding
2) An auxiliary winding is provided for starting purpose

This single phase Induction motor is fed from single phase supply. Its stator winding produces a flux which is only alternating. It is not a revolving (or) rotating flux. As in the case of three phase motor, stator winding fed from three phase supply. An alternating flux acting on a stationary squirrel cage rotor can not produce rotation in a single phase induction motor. Thus a single phase induction motor is not self starting.

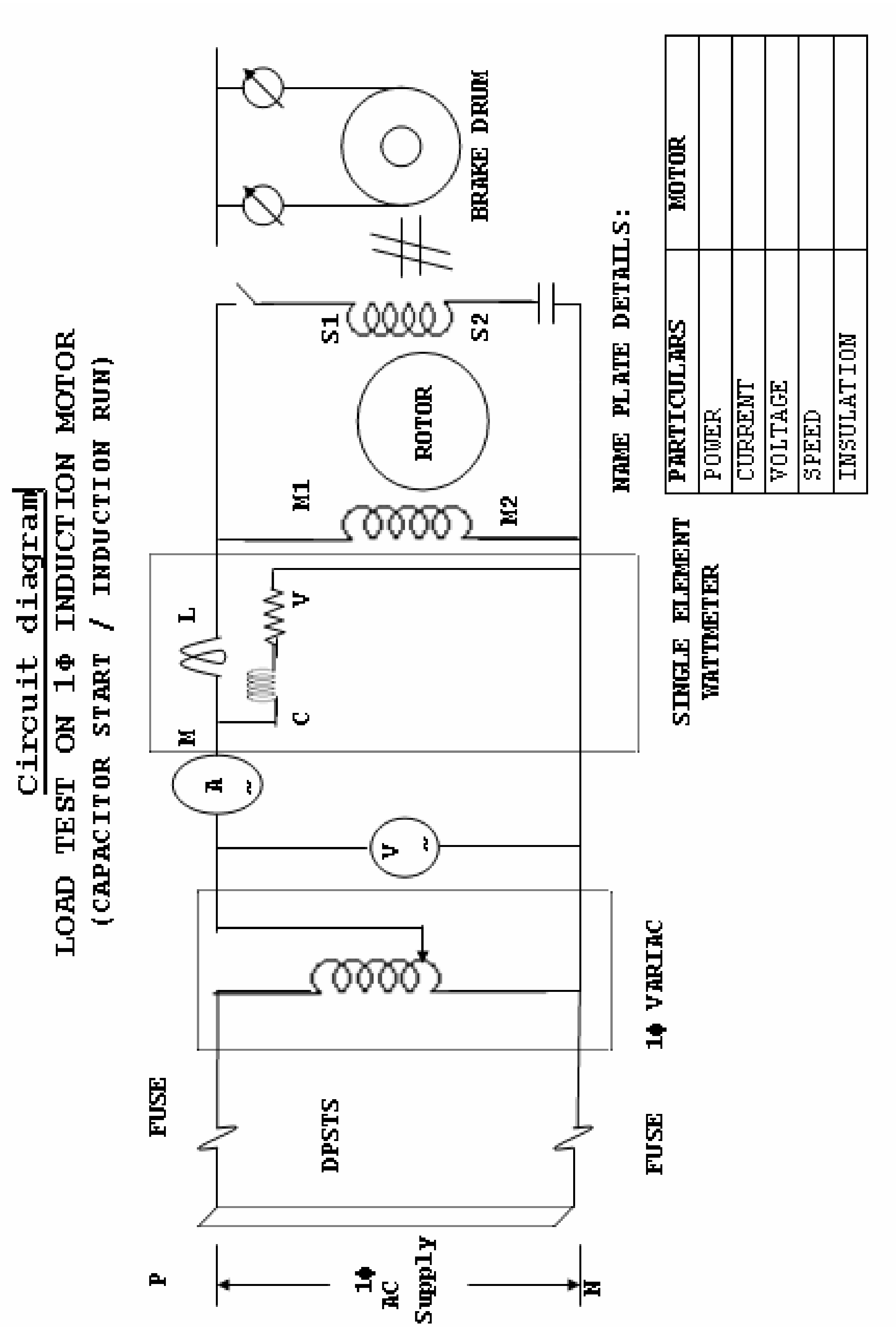
To overcome this drawback and make the motor self starting, It is temporarily converted into a two phase motor during the starting period. For this purpose, the stator of single phase motor is provided with an extra wining known as starting (or) auxiliary winding in addition to the main (or) running winding. The two windings are spaced 90^o electrically apart and are connected in parallel across the single phase supply. It is so arranged that the phase difference between the currents in the tow stator windings is very large. Hence the motor behaves like a two phase motor. These two currents produce a revolving flux and hence make the motor self starting.

Capacitor Start/ Induction Run Motors:

In these motors the necessary phase difference between the starting and main winding is produced by connecting a capacitor in series with the starting winding.

As shown in the figure, the current I_m drawn by the main winding lags the supply voltage by large angle where as I_s leads voltage by a certain angle. The two current are out of phase which produces the revolving flux, which makes the motor self starting. When the motor reaches 75% of its speed, the centrifugal switch S open and cuts out both starting winding and the capacitor from the supply, thus leaving only the running winding across the supply.

CIRCUIT DIAGRAM:

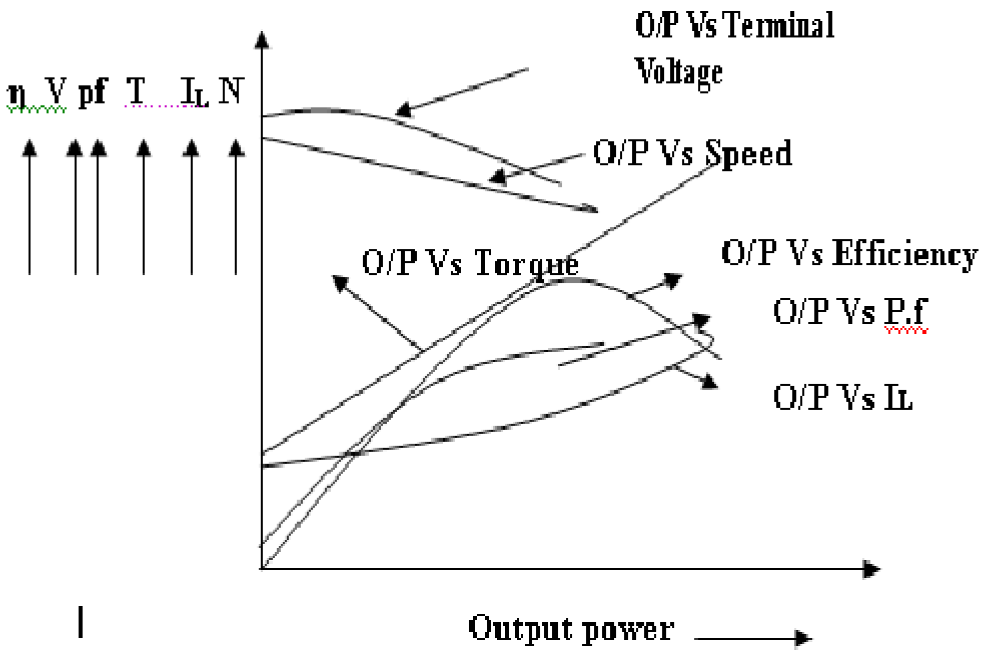


PARTICULARS	MOTOR
POWER	
CURRENT	
VOLTAGE	
SPEED	
INSULATION	

PROCEDURE:

1. Circuit connections are made as per the circuit diagram.
2. 3Φ supply is applied to the circuit.
3. Start the motor by using D.O.L starter.
4. At the No load condition, note down the all meter readings & also speed.
5. Load is gradually applied. For various values of load currents, note down the all meter readings & also speed.
6. Stop the motor.
7. Plot the performance characteristics curves.

MODEL GRAPH:



OBSERVATION:

Sl. no	Line Voltage (V) in Volt	Line Current (A) in Amp	Input power (W) in Watt	Speed (N) in r.p.m	Spring Balance	
					W1	W2

CALCULATION:

Sl. no	LineCurrent(A)	Input power(W)	Speed (RPM)	Torque (NM)	Output power(W)	η %	% Slip	Power factor

FORMULA:

$$T = (W_1 \sim W_2) * R * 9.81 \text{ N-m}$$

$$P_{out} = (2*\prod * N * T) / 60 \text{ watt}$$

$$\% \text{ slip} = [(N_s - N) / N] * 100$$

$$\text{Power factor} = P_{in} / (V_L * I_L)$$

$$\eta = (Pout / Pin) * 100$$

Model Calculation:

RESULT: Thus the load test on 1Φ Induction Motor (Capacitor Start / Induction Run) was Conducted & the performance Characteristics curves were drawn.

REVIEW QUESTIONS:

1. Why single phase induction motor is not self starting?
2. Classify single-phase motors based on their construction and method of
3. Starting?
4. What happens when the starting winding is not disconnected from the supply
5. after it has started?
6. What are the two theories which explains the behavior of single phase
7. Induction motor?

EXP NO : 9b) LOAD TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR

DATE :

AIM:

To conduct the direct load test on the given three phase induction motor and to determine and plot its performance characteristics.

NAME PLATE DETAILS:

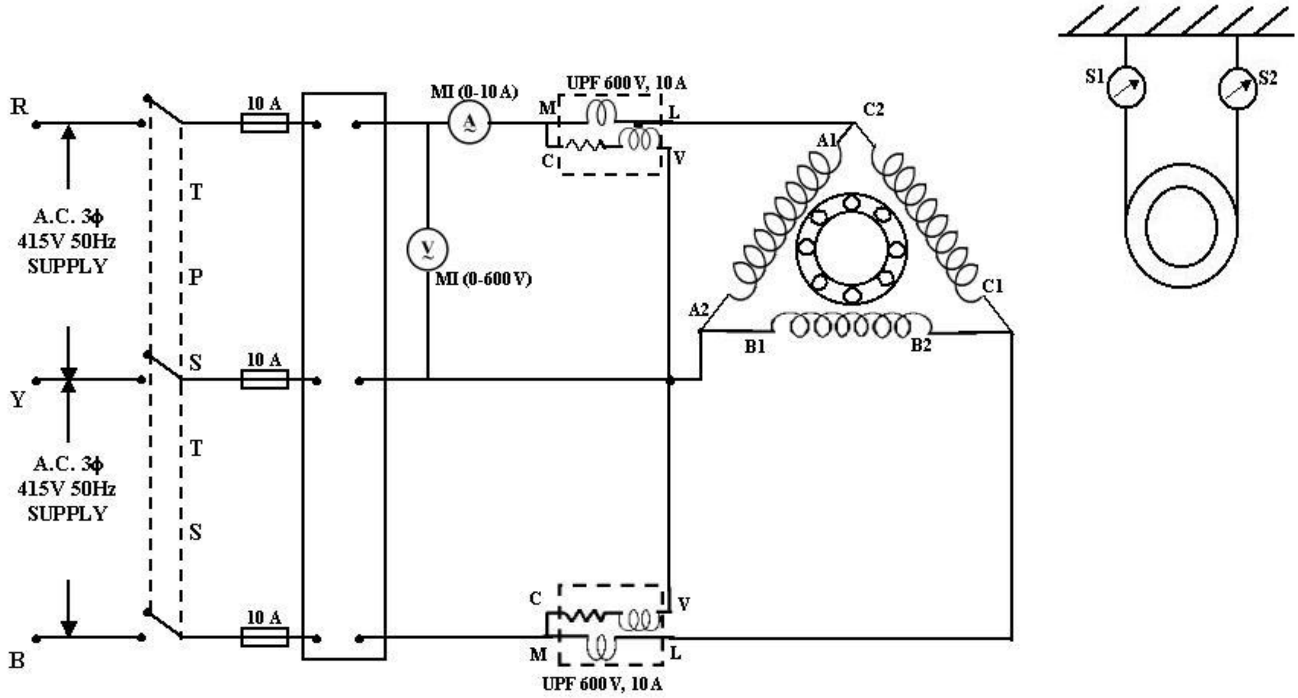
- Rated Voltage
- Rated Current
- Rated Output
- Rated speed
- Frequency

APPARATUS REQUIRED :

S.No.	APPARATUS	TYPE	RANGE	QUANTITY

LOAD TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR

CIRCUIT DIAGRAM:



TABULAR COLUMN:

V_L (V)	I_L (A)	I/P (W)	I/P (W)	N rpm	F_1 (Kg)	F_2 (Kg)	F = $F_1 - F_2$ (Kg)	T N-m	I/P (W)	O/P (W)	% η	P.F.	*Slip* %

MODEL CALCULATION:

1. Torque (T) = F*9.81*r N-m

r – radius of the brake drum (m) & F1,F2 – spring balance readings (Kg)

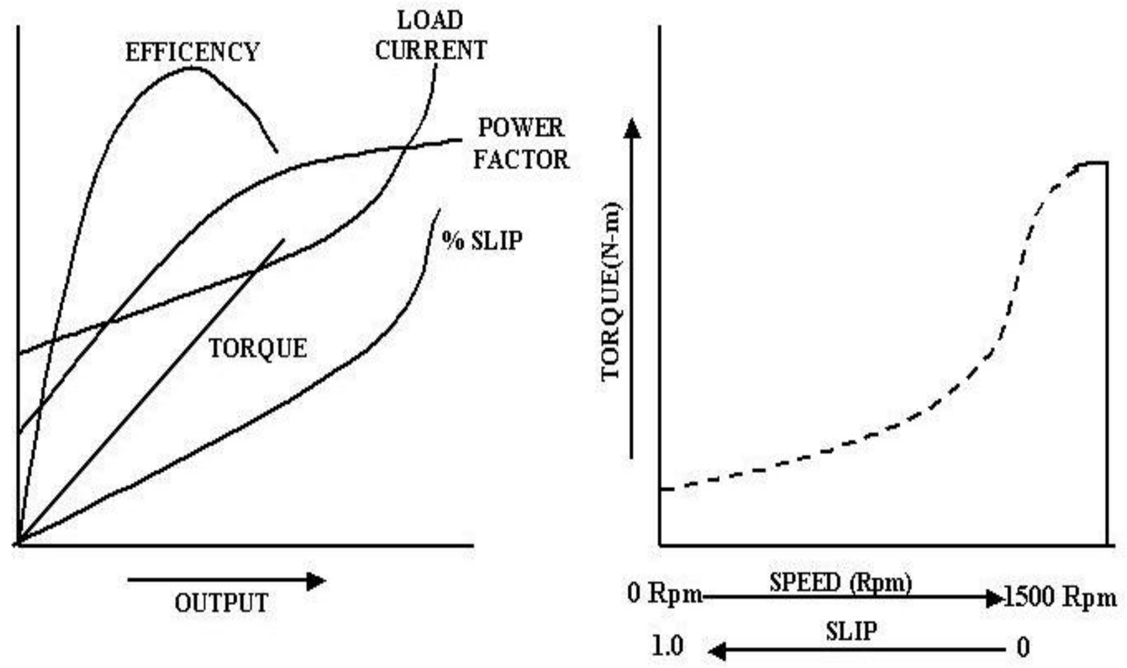
2. Input Power = W (wattmeter reading) watts
3. Output Power = 2πNT / 60 watts
4. Power Factor = W/ ($\sqrt{3}\ V_L I_L$)
5. %η = (output / input)*100
6. % Slip = (Ns – N)/ Ns

THEORY:

Slip ring induction motor is also called as wound rotor motor. The rotor has a proper 3-phase winding with three leads brought out through slips rings and brushes. These leads are normally short circuited when the motor is running. Resistances are introduced in the rotor circuit via the slip rings at the time of starting to improve the starting torque.

The rotating field created by the stator winding moves past the shorted rotor conductors inducing currents in the latter. These induced currents produce their own field which rotates at the same speed (synchronous) with respect to the stator as the stator – produced field. Torque is developed by the interaction of these two relatively stationary fields. The rotor runs at a speed close to synchronous but always slightly lower than it. At the synchronous speed no torque can be developed as zero relative speed between the stator field and the rotor implies no induced rotor currents and therefore no torque.

MODEL GRAPHS:



PROCEDURE:

1. The connections are made as per the circuit diagram.
2. The three phase AC supply is switched on to the motor using the starter.
3. Under this load condition one set of readings of the ammeter, voltmeter, wattmeter, spring balance and the speed of the motor are noted down.
4. Now the mechanical load on the motor is increased in regular steps in such a way that the current drawn by the motor increases in steps of 1A.
5. At each step of loading the entire meter readings are noted down in the tabular column.
6. This procedure is continued until the current drawn by the motor equals 120% of its rated value.

RESULT:

Thus the direct load test on the given three phase induction motor was conducted and its performance characteristics are determined and plotted.

REVIEW QUESTIONS

1.What is critical resistance and critical speed?

2.What is the working principle of dc generator?

3.What are the applications of dc shunt denerator?

4.What are the conditions for building up of an EMF?

EXP NO : 10 MEASUREMENT OF PASSIVE ELEMENTS USING BRIDGE NETWORKS

10 a) Measurement of medium Resistance using WHEATSTONE BRIDGE

DATE:

AIM:

To measure the given medium resistance using Wheatstone bridge.

APPARATUS REQUIRED:

S.No	Name of the Trainer Kit/ Components	Quantity
1.	Wheatstone bridge trainer	1
2.	Unknown Resistors specimen	5 different values
3.	Connecting wires	Few
4.	DMM	1
5.	CRO	1

THEORY:

Wheatstone bridge trainer consists of basic bridge circuit as screen printed on front panel with a built in 1 kHz oscillator and an isolation transformer. The arm AC and AD consists of a 1KΩ resistor. Arms BD consists of variable resistor. The unknown resistor (R_x) whose value is to be determined is connected across the terminal BC .The resistor R_2 is varied suitably to obtain the bridge balance condition. The DMM is used to determine the balanced output voltage of the bridge circuit.
For bridge balance,

I1R1=I2R2

For the galvanometer current to be zero the following conditions also exists

$$I_1 = I_x = \frac{E}{R_1 + R_x}$$

and I2=I3=ER2+R3
E = EMF of the supply, combining the above equations we obtain

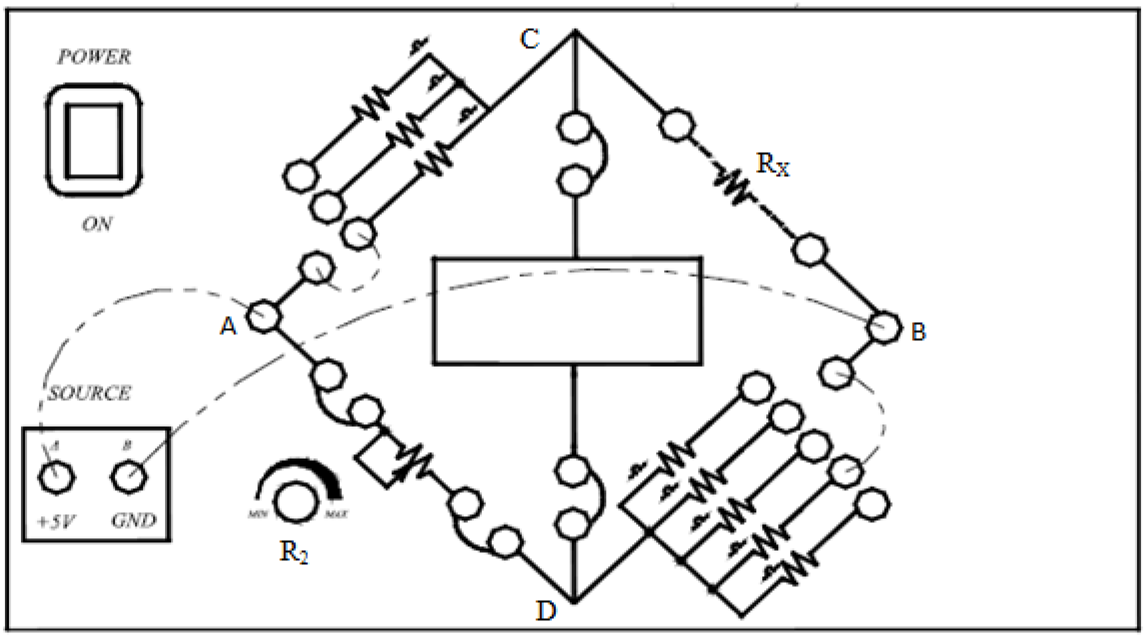
ER1+RxR1=ER2+R3R2

The unknown resistance.Rx=R1R3R2 If three of the resistances are known, the fourth may be determined.

PROCEDURE:

1. Connect the unknown resistor in the arm marked R_x.
2. Connect the DMM across the terminal CD and switch on the trainer kit.
3. Vary R_2 to obtain the bridge balance condition.
4. Find the value of the unknown resistance R_x using DMM after removing wires.
5. Compare the practical value with the theoretical value of unknown resistance R_x calculated using the formula.

PANEL DIAGRAM



TABULATION:

Sl.No	R_1 (Ω)	R_2 (Ω)	R_3 (Ω)	Rx(Ω) (Actual)	Rx(Ω) (Observed)	Percentage Error
1						
2						
3						
4						
5						

MODEL CALCULATION:

RESULT:

Thus the medium resistance was measured using Wheatstone's Bridge.

REVIEW QUESTIONS

1. What are the applications of Wheatstone bridge?
2. What are standard arm and ratio arm in Wheatstone bridge?
3. What are the detectors used for DC Bridge?
4. What do you meant by sensitivity?
5. Why Wheatstone bridge cannot be used to measure low resistances?

EXP NO: 10 b) Measurement of low Resistance using KELVIN'S DOUBLE BRIDGE

DATE:

AIM:

To measure the given low resistance using Kelvin's Double bridge.

APPARATUS REQUIRED :

S.No	Name of the Trainer Kit/ Components	Quantity
1.	Kelvin's Double bridge trainer kit	1
2.	Unknown Resistors specimen	5
3.	Connecting wires	Few
4.	Galvanometer	1

THEORY:

Kelvin's double bridge is a modification of Wheatstone's bridge and provides more accuracy in measurement of low resistances It incorporates two sets of ratio arms and the use of four terminal resistors for the low resistance arms, as shown in figure. Rx is the resistance under test and S is the resistor of the same higher current rating than one under test. Two resistances Rx and S are connected in series with a short link of as low value of resistance r as possible. P, Q, p, q are four known non inductive resistances, one pair of each (P and p, Q and q) are variable. A sensitive galvanometer G is connected across dividing points PQ and pq. . The ratio P/Q is kept the same as p/q, these ratios have been varied until the galvanometer reads zero.

Balance Equation:

For zero balance condition,

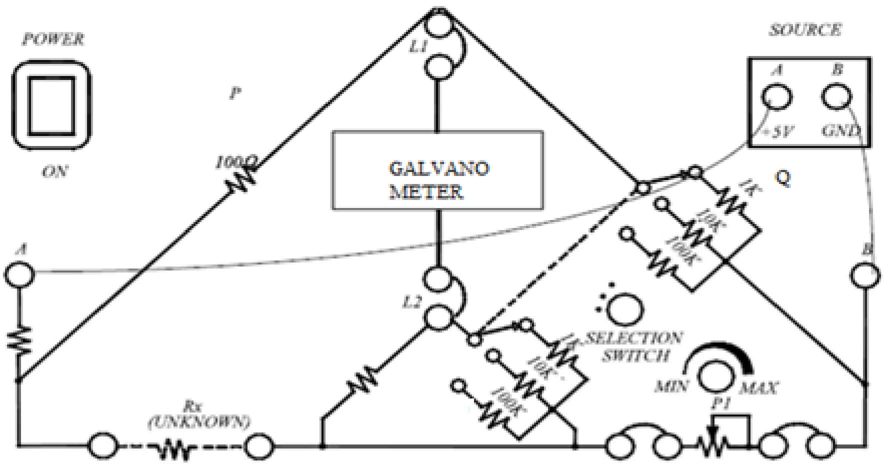
$$\frac{P}{P+Q} I\left[R+S+\frac{(p+q)r}{p+q+r}\right] = I\left[R+\frac{p}{p+q}\left(\frac{(p+q)r}{p+q+r}\right)\right]$$

If $\frac{P}{Q}=\frac{p}{q}$ Then unknown resistance Rx=(P/Q)P1

PROCEDURE:

1. Connect the unknown resistance Rx as marked on the trainer
2. Connect a galvanometer G externally as indicated on the trainer
3. Energize the trainer and check the power to be +5 V.
4. Select the values of P and Q such that P/Q = p/q = 500/50000 = 0.01
5. Adjust P_1 for proper balance and then at balance, measure the value of P_1.

PANEL DIAGRAM



TABULATION:

Sl.No	P (Ω)	Q (Ω)	P_1(Ω)	R_x(Ω) (Observed)

RESULT:

Thus the low resistance was measured using Kelvin's Double Bridge.

REVIEW QUESTIONS

1. Name the bridge used for measuring very low resistance.
2. Classify the resistances according to the values.
3. Write the methods of measurements of low resistance
4. What is the use of lead resistor in kelvin's Double bridge?
5. Why Kelvin's double bridge is having two sets of ratio arms?

EXP NO: 10 c) Measurement of unknown inductance using MAXWELL'S BRIDGE

DATE:

AIM:

To measure the unknown inductance and Q factor of a given coil.

APPARATUS REQUIRED :

S.No	Name of the Trainer Kit/ Components	Quantity
1.	Maxwell's inductance- capacitance bridge trainer kit	1
2.	Unknown inductance specimen	3 different values
3.	Connecting wires	Few
4.	Head phone/ CRO	1

THEORY:

In this bridge, an inductance is measured by comparison with a standard variable capacitance. The connection at the balanced condition is given in the circuit diagram.

Let L_1 = Unknown Inductance.
R_1 = effective resistance of Inductor L1.
R_2, R_3 and R_4 = Known non-inductive resistances.
C_4 = Variable standard Capacitor.

writing the equation for balance condition,

$$\left(R_1 + j\omega L_1\right)\left(\frac{R_4}{1 + j\omega C_4 R_4}\right) = R_2 R_3$$

separating the real and imaginary terms, we have

R1=R2R3R4 L1=R2R3C4

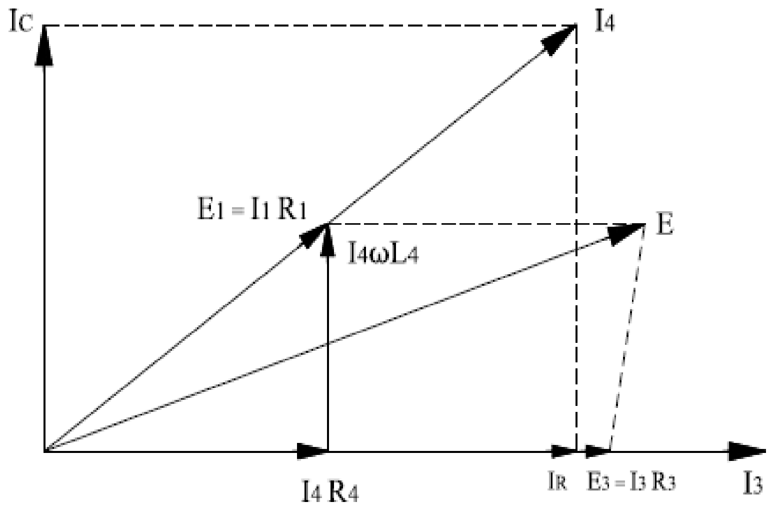
Thus we have two variables R_4 and C_4 which appear in one of the two balance equations and hence the two equations are independent. The expression for Q factor is given by

$$Q = \frac{\omega L_1}{R_1} = \omega C_4 R_4$$

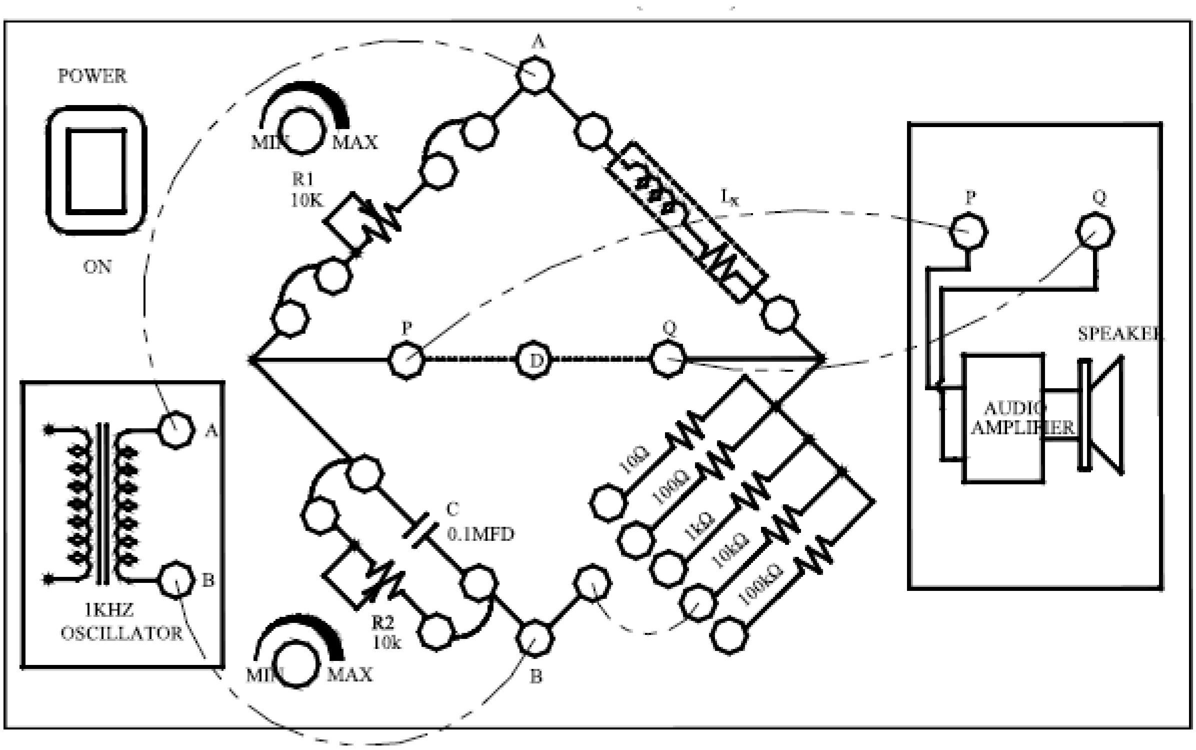
Formula used:

Lx=R1R3C Q=ωLxRx Rx=R1R3R2

Phasor Diagram



PANEL DIAGRAM



PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Connect the unknown inductance in the arm marked L_1 .
3. Switch on the trainer kit.
4. Observe the sine wave at secondary of isolation transformer on CRO.
5. Vary R_4 and C_4 from minimum position in the clockwise direction to obtain the bridge balance condition.
6. Connect the CRO between ground and the output point to check the bridge balance.

TABULATION:

Sl. No.	R_1 (Ω)	R_3 (Ω)	C (μF)	L_1 (mH) Actual	L_1 (mH) Observed	Quality factor Q
1						
2						
3						

MODEL CALCULATION

RESULT:

Thus the unknown inductance was measured using Maxwell’s Bridge.

REVIEW QUESTIONS

1. What are the sources of errors in AC bridges?
2. List the various detectors used for AC Bridges.
3. Define Q factor of an inductor. Write the equations for inductor Q factor with RL series and parallel equivalent circuits.
4. Why Maxwell's inductance bridge is suitable for medium Q coils?
5. State merits and limitations of Maxwell's bridge when used for measurement of unknown inductance.

EXP NO: 10 c) Measurement of unknown capacitance using SCHERING'S BRIDGE

DATE:

AIM:

To measure the value of unknown capacitance using Schering's bridge & dissipation factor.

APPARATUS REQUIRED:

S. No.	Components / Equipments	Quantity
1.	Schering's bridge trainer kit	1
2.	Decade Conductance Box	1
3.	Digital Multimeter	1
4.	CRO	1
5.	Connecting wires	Few

THEORY:

In this bridge the arm BC consists of a parallel combination of resistor & a Capacitor and the arm AC contains capacitor. The arm BD consists of a set of resistors varying from 1Ω to 1 MΩ. In the arm AD the unknown capacitance is connected. The bridge consists of a built in power supply, 1 kHz oscillator and a detector.

BALANCE EQUATIONS:

Let C_1=Capacitor whose capacitance is to be measured.

R_1= a series resistance representing the loss in the capacitor C_1.

C_2= a standard capacitor.

R_3= a non-inductive resistance.

C_4= a variable capacitor.

R_4= a variable non-inductive resistance in parallel with variable capacitor C_4.

At balance,

$$Z_1Z_4=Z_2Z_3$$

Substituting the values of z_1, z_2, z_3 and z_4 in the above equation, we get

$$\left(r_1 + \frac{1}{j\omega c_1}\right)\left(\frac{r_4}{1 + j\omega c_4 r_4}\right) = \frac{r_3}{j\omega c_2}$$

$$\left(r_1 + \frac{1}{j\omega c_1}\right) r_4 = \frac{r_3}{j\omega c_2}(1 + j\omega c_4 r_4)$$

$$r_1 r_4 - \frac{j r_4}{\omega c_1} = -\frac{j r_3}{\omega c_2} + \frac{r_3 r_4 c_4}{c_2}$$

Equating the real and imaginary parts and the separating we get,

$$r_1 = \frac{r_3 c_4}{c_2}$$

$$c_1 = c_2 \frac{r_4}{r_3}$$

Equating the real and imaginary terms, we obtain

r1 = R3C4C2 and C1=C2R4R3

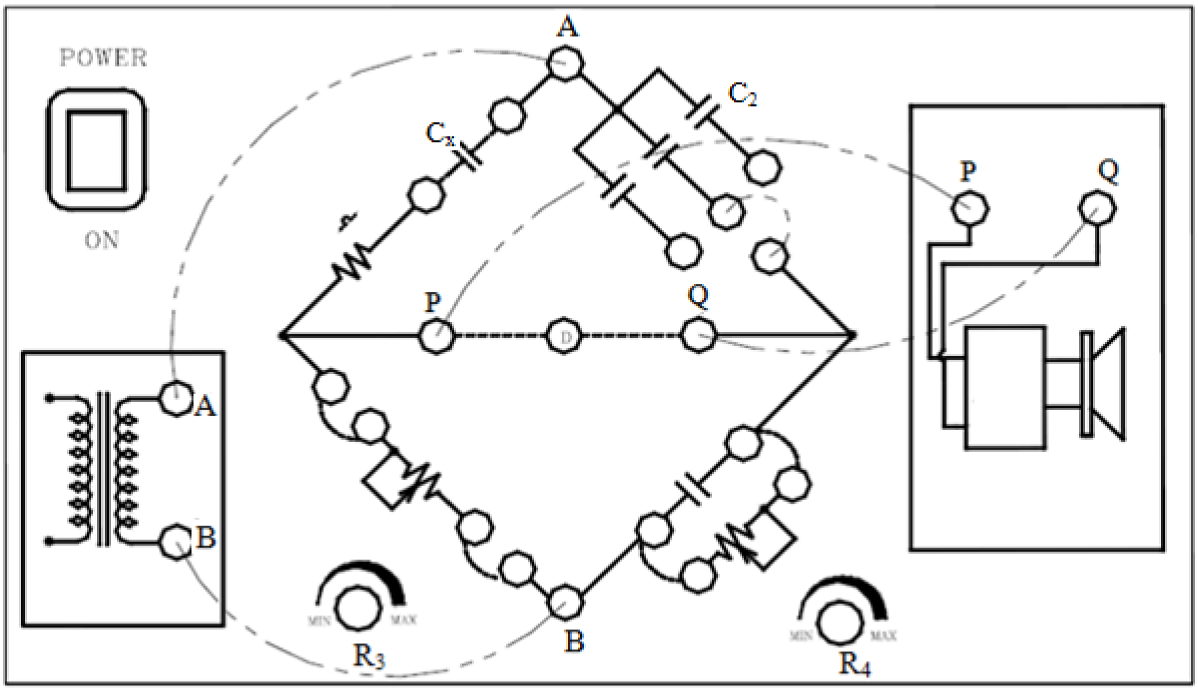
Two independent balance equations are obtained if C_4 and R_4 are chosen as the variable elements.

Dissipation Factor:

The dissipation factor of a series RC circuit is defined as a co-tangent of the phase angle and therefore by definition the dissipation factor is

$$tan\delta = \omega c_1 r_1 = \omega \frac{c_2 r_4}{r3} \times \frac{r_3 c_4}{c_2} = \omega c_4 r_4$$

PANEL DIAGRAM:



FORMULAE USED:

$$C_x = \frac{R_4}{R_3} C_2 \qquad D_1 = \omega C_4 R_4 \quad \text{where } C_4 = C_x \ \& \ R_4 = R_x$$

PROCEDURE:

1. Switch on the trainer board and connect the unknown in the arm marked Cx.
2. Observe the sine wave at the output of oscillator and patch the ckt by using the wiring diagram.
3. Observe the sine wave at secondary of isolation transformer on CRO. Select some value of R_3.
4. Connect the CRO between ground and the output point of imbalance amplifier.
5. Vary R_4 (500 Ω potentiometer) from minimum position in the clockwise direction.
6. If the selection of R_3 is correct, the balance point (DC line) can be observed on CRO. (That is at balance the output waveform comes to a minimum voltage for a particular value of R_4 and then increases by varying R_3 in the same clockwise direction). If that is not the case, select another value of R_4.
7. Capacitor C_2 is also varied for fine balance adjustment. The balance of the bridge can be observed by using loud speaker.
8. Tabulate the readings and calculate the unknown capacitance and dissipation factor.

TABULAR COLUMN:

S.No.	**C2 (µF)**	**R_3(Ω)**	**R_4(Ω)**	**Cx(µF)**		**Dissipation factor (D_1)**
				True value	**Measured Value**	

MODEL CALCULATION:

RESULT:

Thus the unknown capacitance was measured using Schering's Bridge.

REVIEW QUESTIONS:

1. State the two conditions for balancing an AC bridge?
2. State the uses of Schering's Bridge?
3. What do you mean by dissipation factor?
4. Give the relationship between Q and D.
5. Derive the balance equations.

EXP NO: 11 a) STUDY OF DISPLACEMENT TRANSDUCER

DATE:

AIM :

To study the displacement transducer using LVDT

APPARATUS REQUIRED :

S.No	Name of the Trainer Kit/ Copmponents	Quantity
1.	LVDT trainer kit containing the signal conditioning unit	1
2.	LVDT calibration jig	1
3.	Multi meter	1
4.	Patch cards	Few

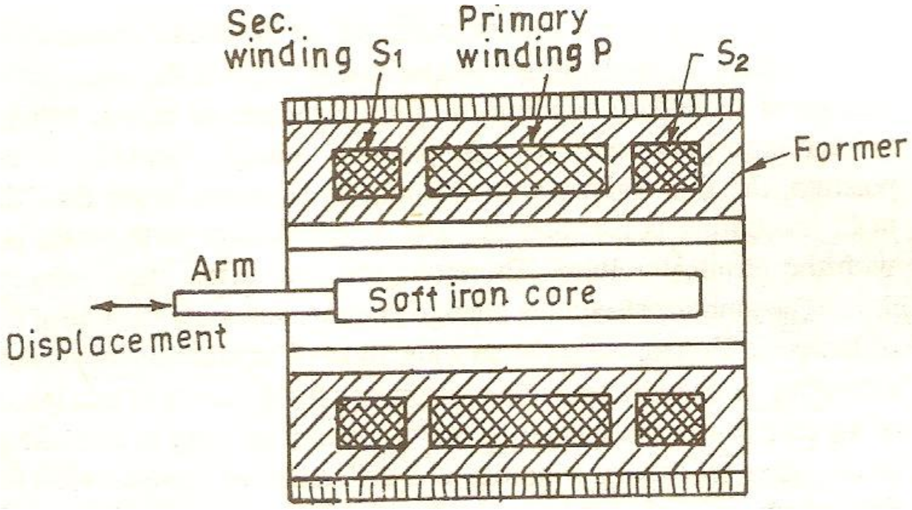
THEORY:

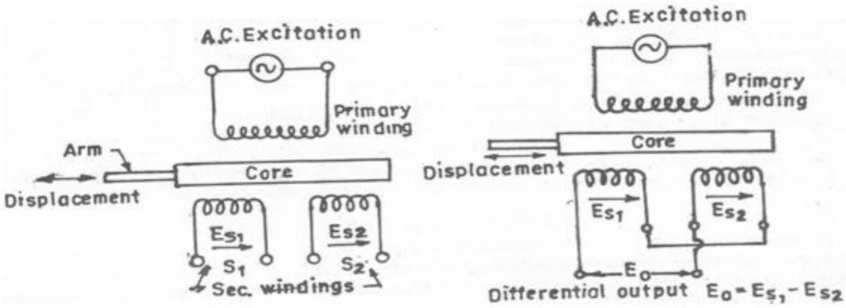
LVDT is the most commonly and extensively used transducer, for linear displacement measurement. The LVDT consists of three symmetrical spaced coils wound onto an insulated bobbin. A magnetic core, which moves through the bobbin without contact, provides a path for the magnetic flux linkage between the coils. The position of the magnetic core controls the mutual inductance between the primary coil and with the two outside or secondary coils. When an AC excitation is applied to the primary coil, the voltage is induced in secondary coils that are wired in a series opposing circuit. When the core is centered between two secondary coils, the voltage induced in the secondary coils are equal, but out of phase by 180°. The voltage in the two coils cancels and the output voltage will be zero.

CIRCUIT OPERATION:

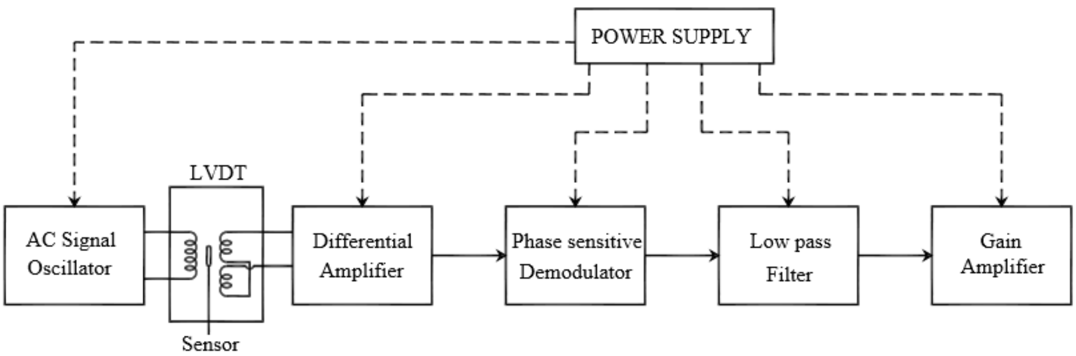
The primary is supplied with an alternating voltage of amplitude between 5V to 25V with a frequency of 50 cycles per sec to 20 K cycles per sec. The two secondary coils are identical & for a centrally placed core the induced voltage in the secondaries Es_1&Es_2 are equal. The secondaries are connected in phase opposition. Initially the net o/p is zero. When the displacement is zero the core is centrally located. The output is linear with displacement over a wide range but undergoes a phase shift of 180°. It occurs when the core passes through the zero displacement position.

GENERALIZED DIAGRAM:





BLOCK DIAGRAM:



RESULT:

Thus the displacement transducer characteristics was studied using LVDT.

REVIEW QUESTIONS

1. What is LVDT?
2. .What is null position in LVDT?
3. What is the normal linear range of a LVDT?
4. List the advantage of LVDT.
5. List the applications of LVDT.

EXP NO: 11 b) STUDY OF PRESSURE TRANSDUCER BOURDON TUBE

AIM :

To study the pressure transducer using Bourdon tube and to obtain its characteristics.

APPARATUS REQUIRED :

S.No	Name of the Trainer Kit/ Components	Quantity
1.	Bourdon pressure transducer trainer	1
2.	Foot Pump	1
3.	Multi meter	1
4.	Patch cards	Few

THEORY:

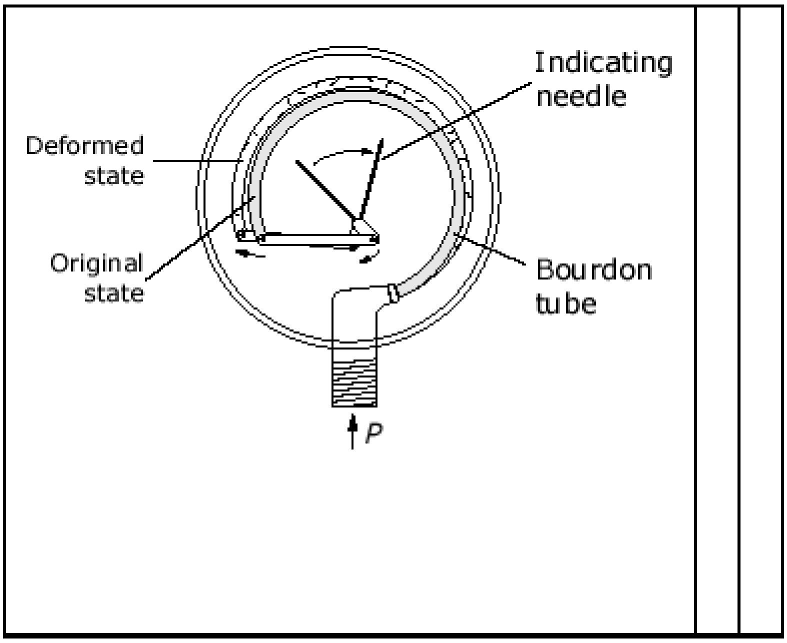
Pressure measurement is important not only in fluid mechanics but virtually in every branch of Engineering. The bourdon pressure transducer trainer is intended to study the characteristics of a pressure(P) to current (I) converter. This trainer basically consists of

1. Bourdon transmitter.
2. Pressure chamber with adjustable slow release valve.
3. Bourdon pressure gauge (mechanical)
4. (4- 20) mA Ammeters, both analog and digital.

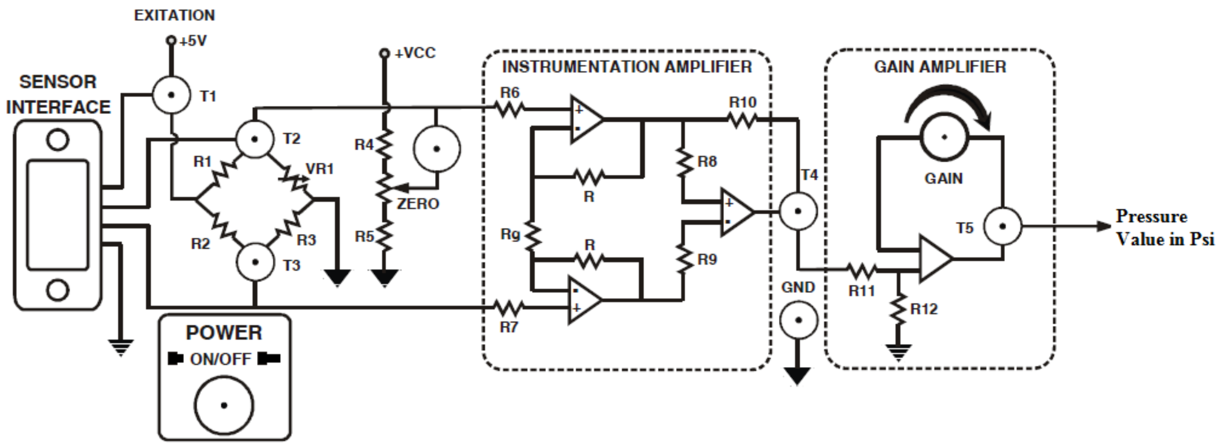
The bourdon transmitter consists of a pressure gauge with an outside diameter of 160 mm including a built-in remote transmission system. Pressure chamber consists or a pressure tank with a provision to connect manual pressure foot pump, slow release valve for discharging the air from this pressure tank, connections to mechanical bourdon pressure gauge, and the connections for bourdon pressure transmitter. Bourdon pressure gauge is connected to pressure chamber. This gauge helps to identify to what extent this chamber is pressurized.

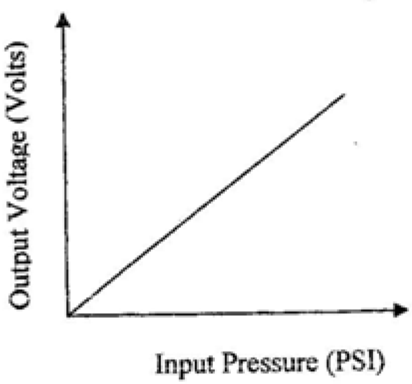
There are two numbers of 20 mA Ammeters. A digital meter is connected in parallel with analog meter terminals and the inputs for these are terminated at two terminals (+ ve and – ve). So positive terminal and negative terminal of bourdon tube is connected to, positive and negative terminals of the Ammeters.

DIAGRAM:



MEASUREMENT SETUP:





MODEL GRAPH

RESULT:

Thus the pressure transducer was studied using Bourdon tube.

REVIEW QUESTIONS

1. Define Transducer. What are active and passive transducers?
2. List any four pressure measuring transducers?
3. What is the advantage of pinion in bourdon tube?
4. Write the operational principle of bourdon tube.
5. State the advantages of bourdon tube over bellows & diaphragms.

EXPT.NO: 12(a) STUDY OF D.C MOTOR STARTERS

DATE:

AIM: To study the different kinds of D.C motor starters

APPARATUS REQUIRED:

S. No.	Name of the apparatus	Quantity
1	**Two Point starter**	**1**
2	**Three Point starter**	**1**
3	**Four Point starter**	**1**

THEORY: The value of the armature current in a D.C shunt motor is given by

$$I_a = (V - E_b) / R_a$$

Where V = applied voltage.

R_a= armature resistance.

E_b = Back .e.m.f.

In practice the value of the armature resistance for 2 to 3 h.p. motor is the order of 1 ohms and at the instant of starting the value of the back e.m.f. is zero volts. There fore under starting conditions the value of the armature current is very high. This high inrush current at the time of starting may damage the motor. To protect the motor from such dangerous current the D.C motors are always started using starters.

The types of D.C motor starters are

i. Two point starters
ii. Three Point Starters
iii. Four Point starters

The functions of the starters are

i. It protects the from dangerous high spee

ii. It protects the motor from overloads.

i) **TWO POINT STARTERS :-** It is used for starting a d.c. series motors which has the problem of over speeding due to the loss of load from its shaft. Here for starting the motor the control arm is moved in clock – wise direction from its OFF position to the ON position against the spring tension. The control arm is held in the ON position by the electromagnet E. The exciting coil o the hold-on electromagnet E is connected in series with the armature circuit. If the motor loses its load, current decreases and hence the strength of the electromagnet also decreases. The control arm returns to the OFF position due to the spring tension, Thus preventing the motor from over speeding. The starter also returns to the OFF position when the supply voltage decreases appreciably. L and F are the two points of the starter which are connected with the motor terminals.

ii) **THREE POINT STARTER :-** It is used for starting the shunt or compound motor. The coil on the hold on electromagnet E is connected in series with the shunt field coil. In the case of disconnection in the field circuit the control arm will return to its OFF position due to spring tension. This is necessary because the shunt motor will over speed if it loses excitation. The starter also returns to the OFF position in case of low voltage supply or complete failure of the supply. The protection is therefore is called No Volt Release (NVR).

Over load protection :- when the motor is over loaded it draws a heavy current. This heavy current also flows through the exciting coil of the over load electromagnet (OLR). The electromagnet then pulls an iron piece upwards which short circuits the coils of the NVR coil. The hold on ;magnet gets de-energized and therefore the starter arm returns to the OFF position, thus protecting the motor against overload. L, A and F are the three terminals of the three point starter.

iii) **FOUR POINT STARTER :-** The connection diagram of the four point starter is shown in fig 3. In a four point starter arm touches the starting resistance, the current from the supply is divided into three paths. One through the starting resistance and the armature, one through the field circuit, and one through the NVR coil. A protective resistance is connected in series with the NVR coil. Since in a four point starter the NVR coil is independent of the of the field ckt connection, the dc motor may over speed if there is a break in the field circuit. A D.C motor can be stopped by opening the main switch. The steps of the starting resistance are so designed that the armature current will remain within the current limits and will not change the torque developed by the motor to a great extent.

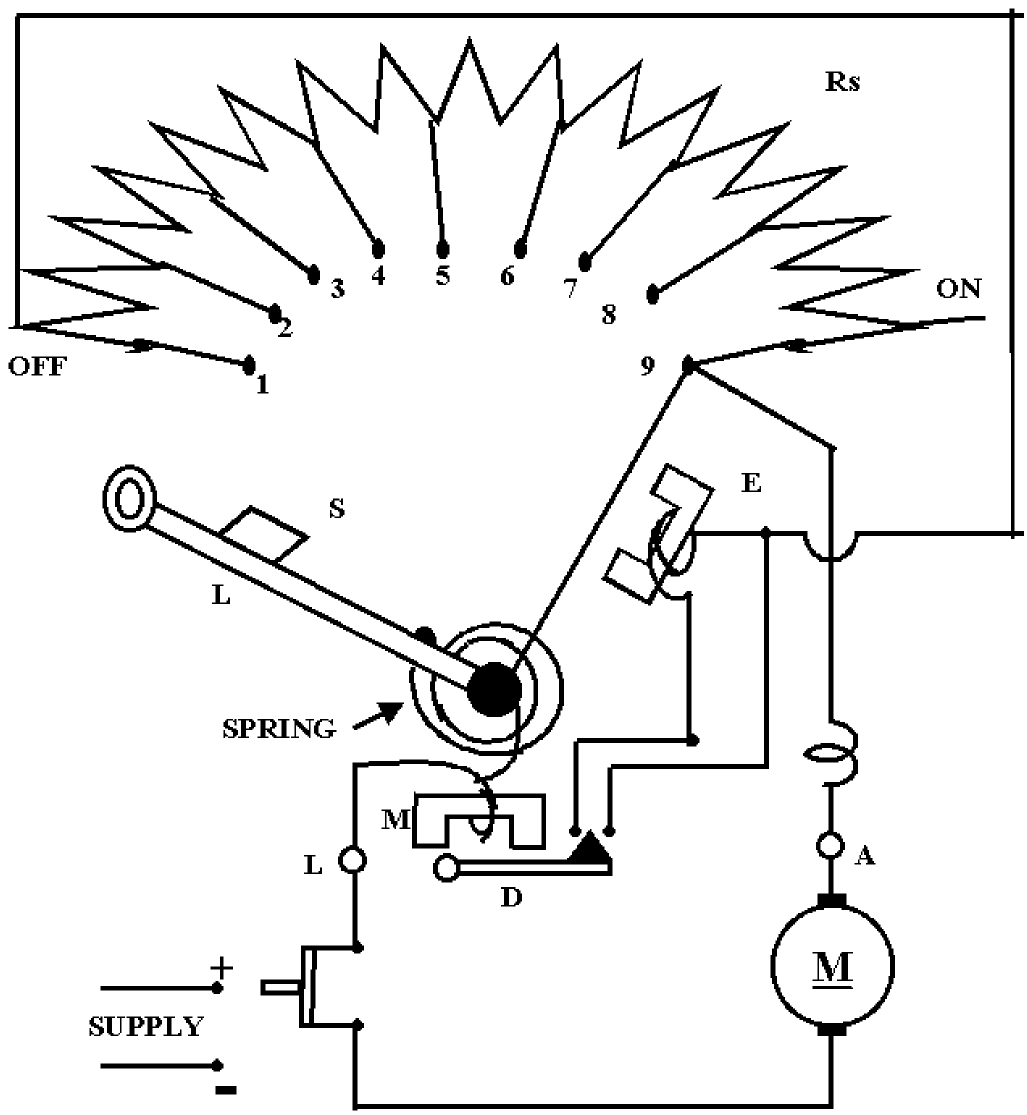


Fig : Two point starter

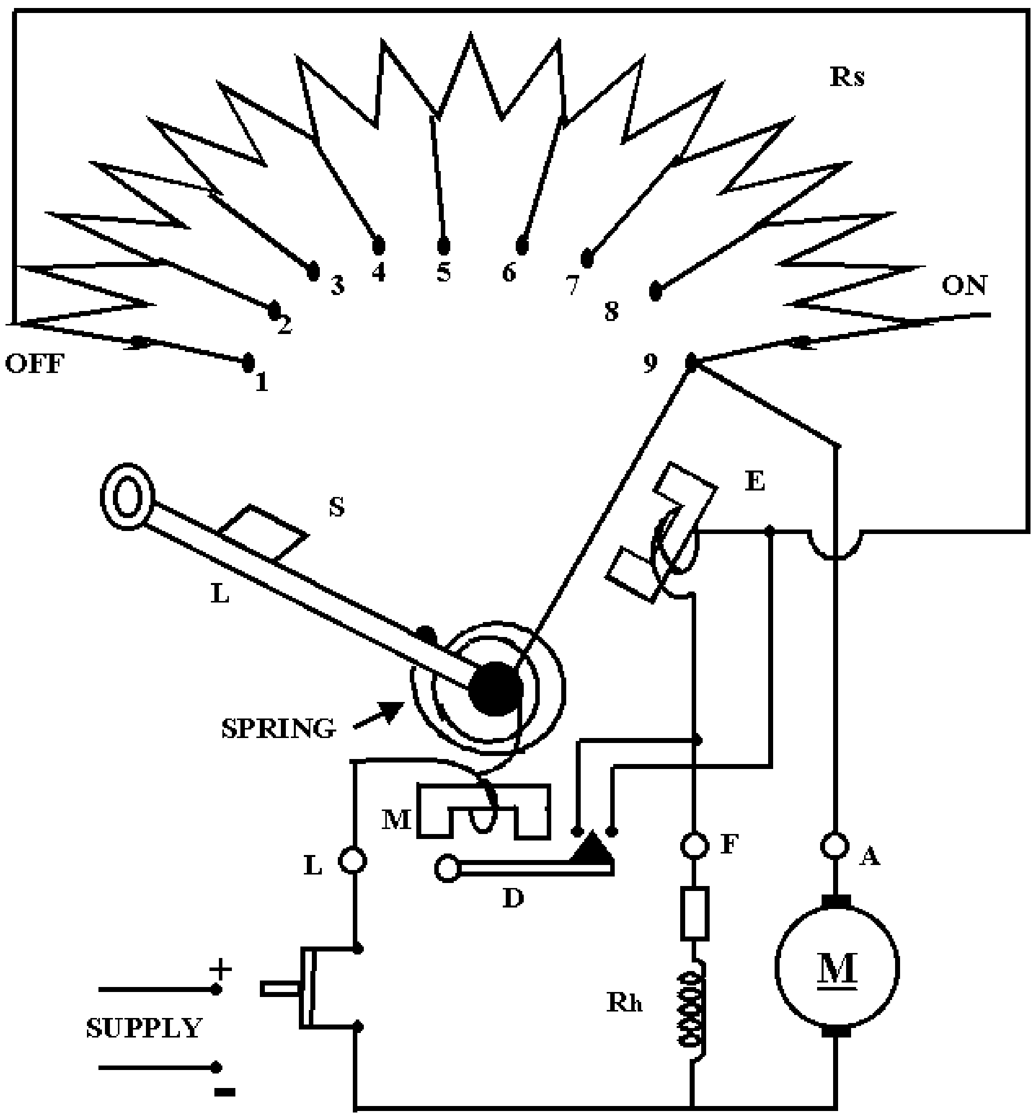


Fig : Three point starter

RESULT:

Thus the starters used for DC motors are studied.

EXP NO : 12(b) STUDY OF INDUCTION MOTOR STARTERS

DATE:

AIM:

To study the different types of AC motors starters used.

THEORY:

AUTO TRANSFORMER STARTING:

An autotransformer starter consists of an auto transformer and a switch as shown in the fig. When the switch S is put on START position, a reduced voltage is applied across the motor terminals. When the motor picks up speed say to 80 percent of its normal speed, the switch is put to RUN position. Then the auto-transformer is cut out of the circuit and full rated voltage gets applied across the motor terminals.

The circuit diagram in the fig is for the manual auto-transformer starter. This can be made push button operated automatic controlled starter so that the contacts switch over from start to run position and the motor speed picks up to 80% of its speed. Over-load protection relay has not been shown in the figure. The switch S is air-break type for small motors and oil break type for large motors. Autotransformer may have more than one tapping to enable the user select any suitable stating voltage depending upon the conditions.

Series resistors or reactors can be used to cause voltage drop in them and thereby allowing the voltage to be applied across the motor terminals at starting. These are cut out of the circuit after the motor picks up speed.

STAR-DELTA METHOD OF STARTING:

The starter phase windings are first connected in star and full voltage is connected across the terminals. As the motor picks up speed, the windings are disconnected through a switch and are reconnected in delta across the supply terminals. The current drawn by the motor from the lines is reduced to as compared to the current it would have drawn if connected in delta. The motor windings, first in star and then in delta the line current drawn by the motor at starting is reduced to one third as compared to starting current with the winding delta connected. In making connections for star delta starting, care should be taken such that sequence of supply connection to the winding terminals doesn't change while changing from star connection to delta connection. Otherwise the motor will start rotating in the opposite direction, when connections are changed from star to delta. Star – Delta starters are available for manual operation using push button control. An automatic star-delta starter used time delay relays (TDR) through star to delta connections take place automatically with some pr-fixed time delay. The delay time of the TDR is fixed keeping in view the starting time of the motor.

FULL VOLTAGE OR DIRECT - ON – LINE STARTING:

When full voltage is connected across the terminals of the stator of an induction motor large current is drawn by the windings. This is because at starting the induction motor behaves as a short-circuited transformer with its secondary shorted, i.e. the rotor separated from the primary and the stator by a small air – gap.

At starting when the rotor is at standstill, emf is induced in the rotor circuit cause harm to the motor since the constructions of induction motors are rugged. Otherwise, equipment connected to the supply lines will receive reduced voltage. In industrial applications however, if a number of large motors are started by this method, the voltage drop will go high and may be objectionable for the other types of loads connected to the system. The amount of voltage will not only be depend on the size of the motor, but also on them capacity of the power supply system, the size and length of the line leading to the motor. Indian Electricity rule restricts direct online starting of 3 phase induction motors above 5 Hp.

RESULT:

Thus, the starters used for three phase induction motor are studied.

REVIEW QUESTIONS

1. What is the necessity of starter?

2. Why three point starters cannot be used for dc series motors?

3. What is the main drawback of three point starter?

4. What are the advantages of four point starter?

EX NO:13 STABILITY ANALYSIS OF LINEAR SYSTEMS

DATE:

AIM

To Write a program to (or using SIMULINK) to analyse the stability of linear system using Bode plot, Root locus and Nyquist plot.

APPARATUS REQUIRED

A PC with MATLAB package

THEORY

A linear time inconvenient systems is stable if the following two notations of system stability are satisfied.

- When the system is excited by bounded input, the output is also a bounded output.
- In the absence of the input, the output tends towards zero, irrespective of the initial conditions.

The following are the general considerations regarding system stability and are

- If all the roots of the characteristics equation have negative real parts, then the impulse response is bounded and eventually decreases to zero, then the system is stable.
- If any root of the characteristics equation has a positive real part, then system is unstable.
- If the characteristics equation has repeated roots on the jω- axis, then system is unstable.
- If one are more non-repeated roots of the characteristics equation on the jω-axis, then system is unstable.

PROCEDURE

1. **BODE PLOT**

   Consider a single-Input system with transfer function

$C(S) / R(S) = (b_0 s^m + b_1 s^{m-1} + …….. +b_m) / (a_0 s^n + a_1 s^{n-1} + ……+ a_n)$

1. Write a program to (or using SIMULINK) obtain the Bode plot for the given system.
2. Access the stability of the given system using the plots obtained.
3. Compare the usage of various plots in assessing stability.

TRANSFER FUNCTION

$G(S) = 25 / (S^2 + 4S + 25)$

Source Code

```
% Bode Plot
% Enter the Numerator and Denominator
num = [0   25]
den = [1   4   25]
ω = logspace(-2,3,100)
sys = tf(num,den)
[mag,phase,ω] = bode(sys, ω)
bode(sys, ω)
margin(mag,phase,ω)
xlabel('frequency')
ylabel('phase(deg);magnitude(db)')
title('bode plot')
```

2. ROOT LOCUS

1. Write a program to (or using SIMULINK) obtain the Root locus for the given system.
2. Access the stability of the given system using the plots obtained.
3. Compare the usage of various plots in assessing stability.

TRANSFER FUNCTION

$G(S) H(S) = k(S + 1) / S(S + 2)(S + 3)$

This transfer function can be rewritten as

$G(S) H(S) = kS + k / (S^3 + 5S^2 + 6S + 10)$

Assuming k = 1

Source Code

```
% Root locus
num = [0   0    1    1]
den  = [1   5    6   0]
subplot(2,1,1)
title('Root locus')
rlocus(num,den)
xlabel('Real axis')
ylabel('Imaginary axis')
subplot(2,1,2)
title('Root locus')
r = rlocus(num,den)
plot(r,'o')
v = [-6   6   -6   6]
axis (v)
xlabel('Real axis')
ylabel('Imaginary axis')
```

3. NYQUIST PLOT

1. Write a program to (or using SIMULINK) obtain the Nyquist plot for the given system.
2. Access the stability of the given system using the plots obtained.
3. Compare the usage of various plots in assessing stability.

TRANSFER FUNCTION

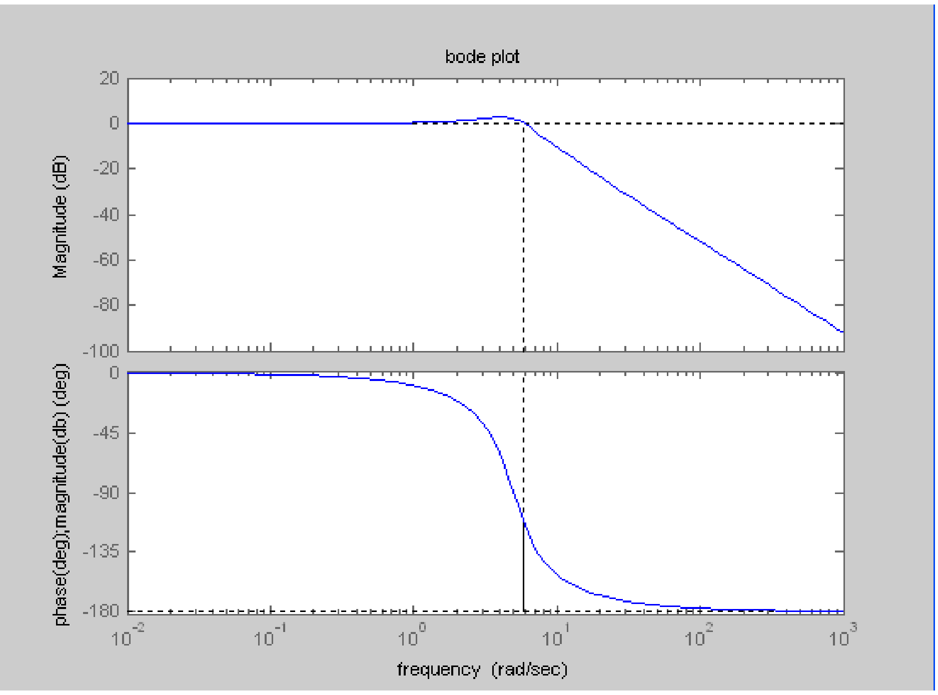
$G(S) = 25 / (S^2 + 4S + 25)$

Source Code

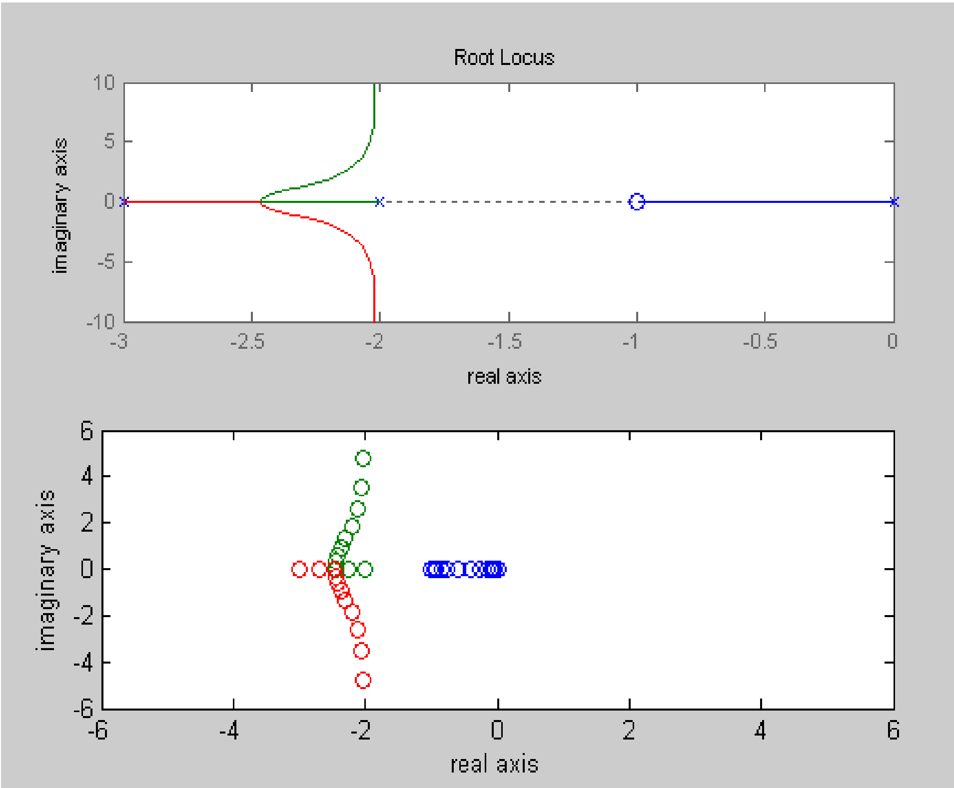
```
% Nyquist plot
% Enter the transfer function
num = [0   0   25]
den = [1   4    25]
sys= tf(num,den)
nyquist(sys)
```

SIMULATION OF LINEAR SYSTEM

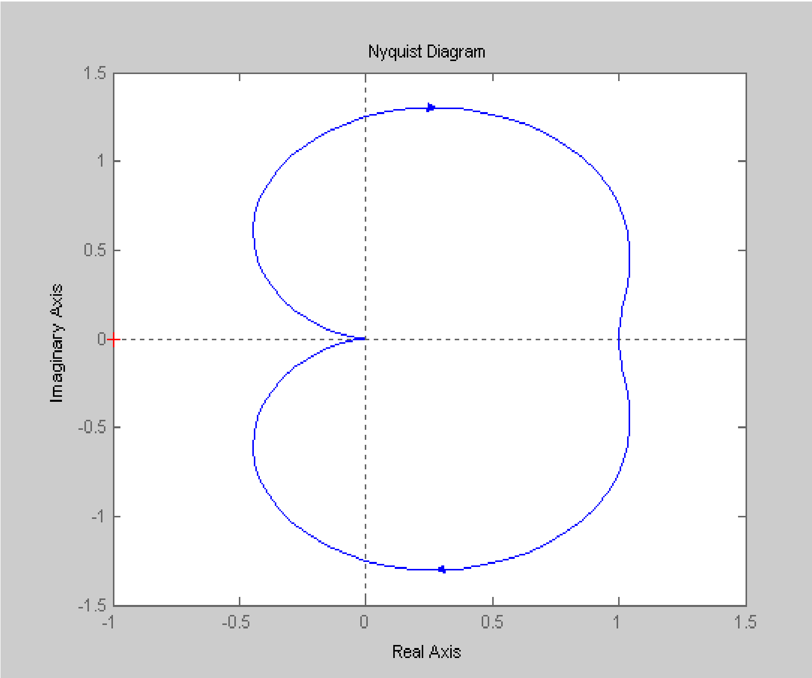
BODE PLOT



ROOT LOCUS



NYQUIST PLOT



RESULT

Thus the stability of linear systems using bode plot, root locus and nyquist plot were analysed.

REVIEW QUESTIONS

1. What is control system?
2. What is feedback? What type of feedback is employed in control system?
3. Define transfer function.
4. State whether transfer function technique is applicable to non-linear system and whether the transfer function is independent of the input of a system

EXP NO:14 DESIGN OF LEAD AND LAG COMPENSATOR

DATE:

AIM:

To plot phase angle Vs frequency and gain Vs Frequency for lag, lead and lag – lead networks

APPARATUS REQUIRED:

A PC with MATLAB package

THEORY:

The nature of compensation depends upon the given plant, the compensator may be an electrical, mechanical, hydraulic, pneumatic or other type of devices are network usually an electric network serves as compensator in many control systems. The compensator transfer function may be placed in cascade with the plant transfer function (cascade or series compensation) or in the feed back path (feed back or parallel compensation).

The compensators are of three types

a) Lead compensator

The compensator having transfer function of the form given below is known as lead compensator.

G_C (s)= (s+z_c)/(s+p_c) = (s+ 1/τ)/(s+1/$\alpha\tau$); α= z_c/p_c<1, τ >0

α< 1 ensures that the pole is located to the left of the zero.

Lead compensator speeds up the transient response and increases the margin of stability of a system. It also helps to increase the system error constant though to limited extent.

b) Lag Compensator

The Compensator having transfer function of the form given below is known as lag compensator.

G_C (s)= (s+z_c)/(s+p_c) = (s+ 1/τ)/(s+1/$\beta\tau$); β = z_c/p_c>1, α>0

β>1 ensures that pole is to the right of Zero, that is nearer the origin than Zero.

Lag compensator improves the steady state behaving a system, while nearly preserving its transient response.

c) <u>Lag – Lead Compensator</u>

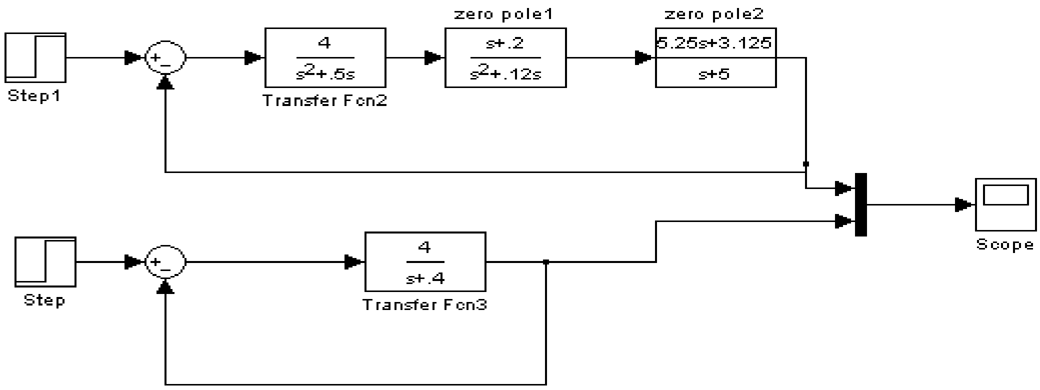
When both the transient and steady state response require improvement a Lag –Lead compensator is required. This is basically a Lag and Lead compensator connected in series.

PROCEDURE:

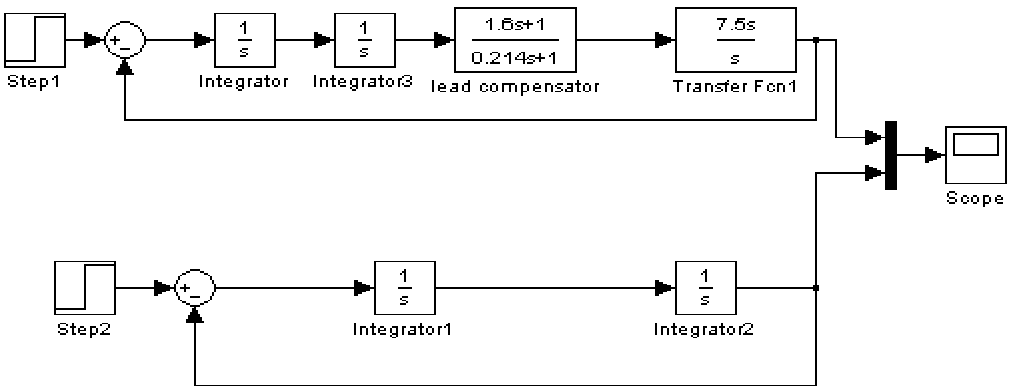
1. Open the MATLAB software and create a blank Model file.
2. Develop the block diagrams for lag, lead and lead-lag compensator using the simulink function
3. Simulate the MATLAB model and obtain the phase angle Vs frequency and gain Vs Frequency for lag, lead and lag – lead networks

.

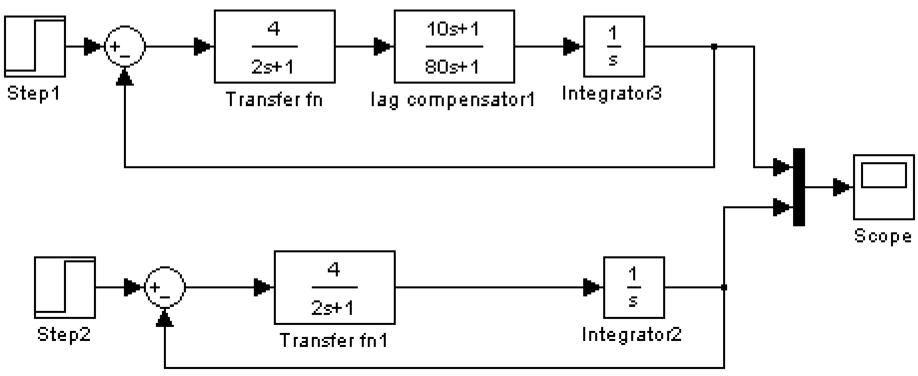
<u>Lead compensator</u>



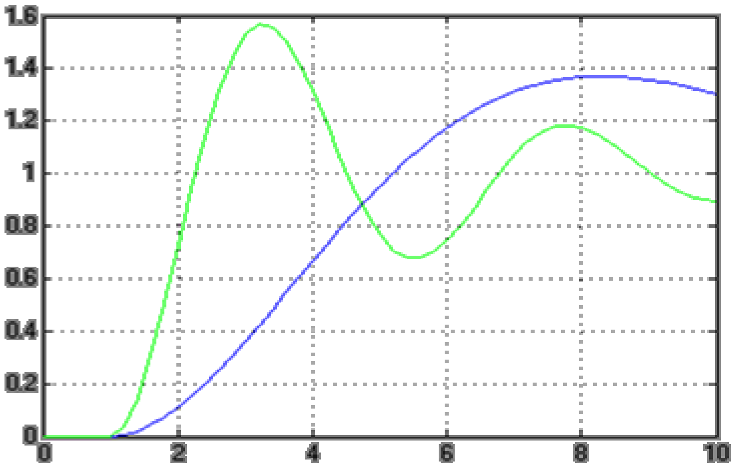
<u>Lag Compensator</u>



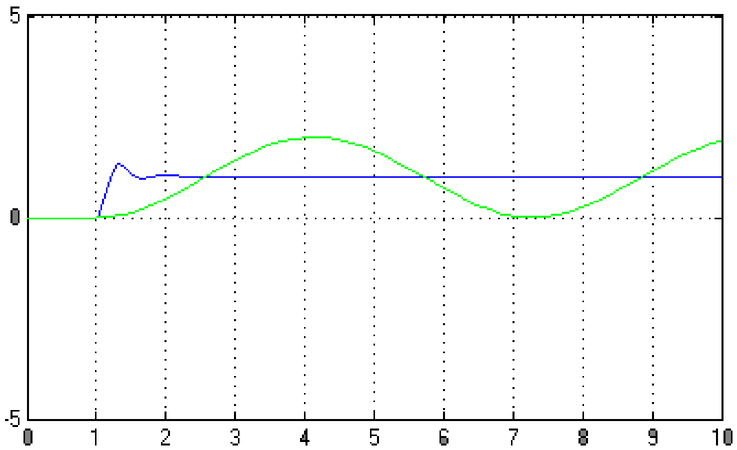
Lag – Lead Compensator



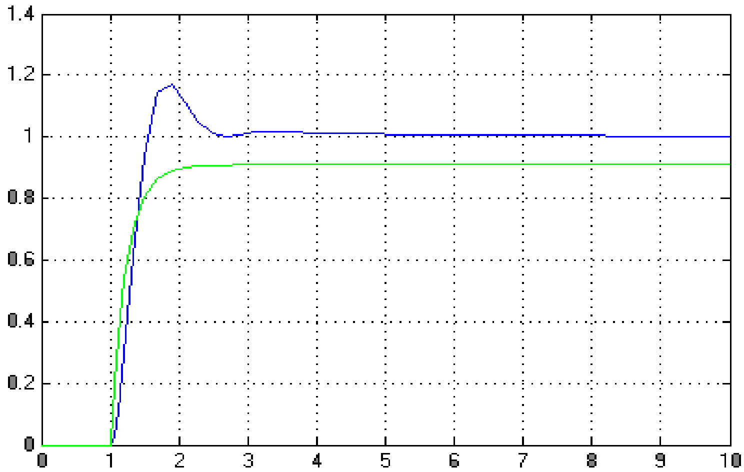
MODEL GRAPH:



Lead compensator



Lag compensator



Lag-Lead compensator

RESULT:

Thus the phase angle Vs frequency and gain Vs Frequency for the given lag, lead and lag – lead networks was plotted.

REVIEW QUESTIONS

1. Why derivative controller is not used in control systems?
2. Draw the initial slope of first order system.
3. What are the standard test signals employed for time domain studies?
4. Define peak time of II order system?

EXPT NO: 15 STUDY THE EFFECT OF P, PI, PID CONTROLLERS USING MAT LAB.

AIM:

To study the effect of Proportional, Proportional –Integral, Proportional –Integral-Derivative controller using MATLAB

APPARATUS REQUIRED:

A PC with MATLAB software

PROCEDURE:

4. Open the MATLAB software and create a blank M- file
5. Write the Program for P,PI,PID Controller in MATLAB
6. Simulate the MATLAB program and obtain the response of the transfer function of higher order system.

SYNTAX

C = pidstd(Kp,Ti,Td,N)
C = pidstd(Kp,Ti,Td,N,Ts)
C = pidstd(sys)
C = pidstd(Kp)
C = pidstd(Kp,Ti)
C = pidstd(Kp,Ti,Td)
C = pidstd(...,Name,Value)
C = pidstd

DESCRIPTION

C = pidstd(Kp,Ti,Td,N) creates a continuous-time PIDF (PID with first-order derivative filter) controller object in standard form. The controller has proportional gain Kp, integral and derivative times Ti and Td, and first-order derivative filter divisor N:

$$C = K_p\left(1+\frac{1}{T_i}\frac{1}{s}+\frac{T_d s}{\frac{T_d}{N}s+1}\right).$$

C = pidstd(Kp,Ti,Td,N,Ts) creates a discrete-time controller with sampling time Ts. The discrete-time controller is:

$$C = K_p \left(1 + \frac{1}{T_i} IF(z) + \frac{T_d}{\frac{T_d}{N} + DF(z)} \right).$$

$IF(z)$ and $DF(z)$ are the *discrete integrator formulas* for the integrator and derivative filter. By default, $IF(z) = DF(z) = T_s z/(z - 1)$. To choose different discrete integrator formulas, use the IFormula and DFormula inputs. See Input Arguments for more information.

C = pidstd(sys) converts the dynamic system sys to a standard form pidstd controller object.

C = pidstd(Kp) creates a continuous-time proportional (P) controller with Ti = Inf, Td = 0, and N = Inf.

C = pidstd(Kp,Ti) creates a proportional and integral (PI) controller with Td = 0 and N = Inf.

C = pidstd(Kp,Ti,Td) creates a proportional, integral, and derivative (PID) controller with N = Inf.

C = pidstd(...,Name,Value) creates a controller or converts a dynamic system to a pidstd controller object with additional options specified by one or more Name,Value pair arguments.

C = pidstd creates a P controller with Kp = 1.

Source coding of P controller

```
kp=300;
num=[kp];
den=[1 10 20+kp];
t=0:0.01:2;
step(num,den,t);
```

Source coding of Pi controller

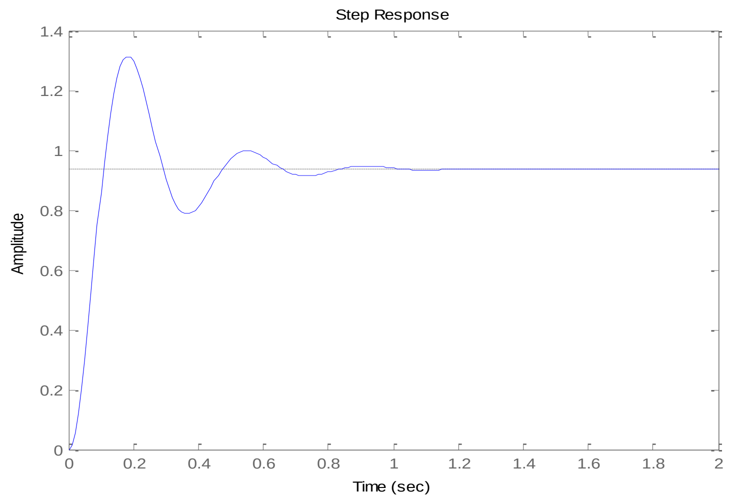
```
kp=300;
ki=10
num=[ki kp];
den=[1 10+ki 20+kp];
```

```
t=0:0.01:2;
step(num,den,t);
```

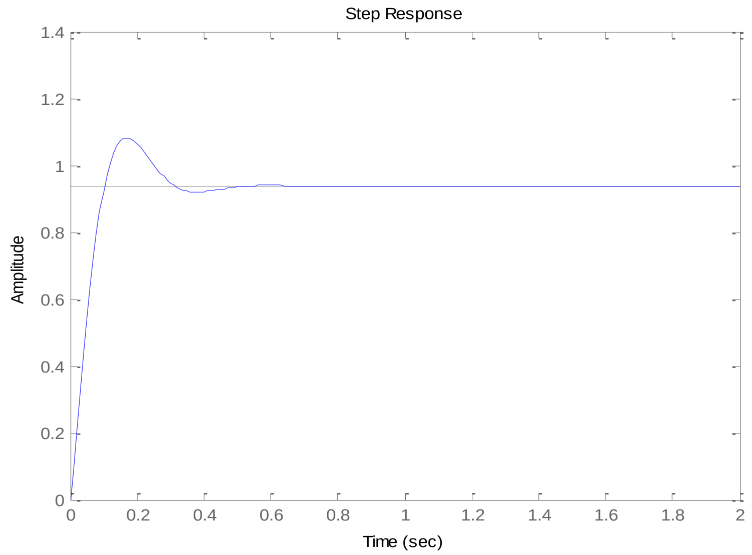
Source coding of Pid controller

```
kp=350;
ki=300
kd=50;
num=[kd kp ki];
den=[1 10+kd 20+kp ki];
t=0:0.01:2;
step(num,den,t);
```

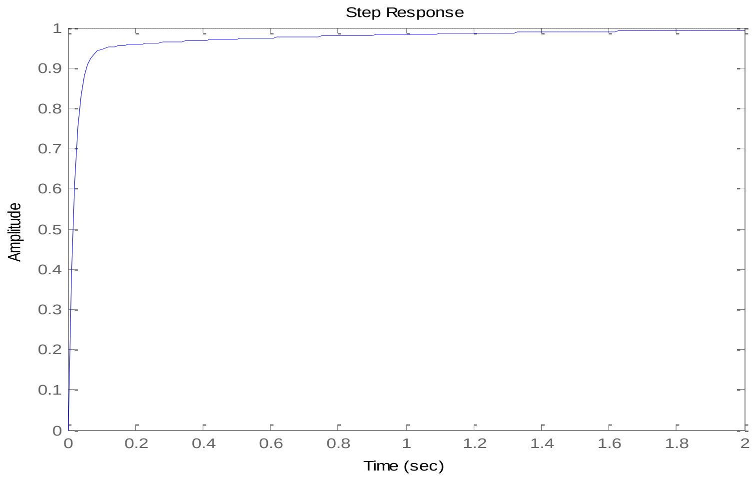
MODEL GRAPH:



P Controller



Pi controller



Pid Controller

RESULT:

Thus the response of P, PI, PID controller were studied and verified using MATLAB

REVIEW QUESTIONS

1.What is the effect of PD controller on the system performance?

2.Why derivative controller is not used in control systems?

3. Draw the initial slope of first order system.

4. What are the standard test signals employed for time domain studies?

5. Define peak time of II order system?

EXPT NO: 16 DIGITAL SIMULATION OF LINEAR SYSTEM

DATE:

AIM:

1. To digitally simulate in time response characteristics of higher order multi input , multi output , linear system using stable variable information .
2. To WAP or to build block diagram model using MATLAB
3. To obtain the impulse, step response characteristics

APPARATUS REQUIRED:

A PC with MATLAB software

PROCEDURE:

1. Open the MATLAB software and create a blank model in the stimulant.
2. Simulate the step response for the block diagram model of an armature controlled DC motor
3. Obtain the step response for the block diagram model and impulse response by writing the code in M-file for an armature controlled DC motor
4. Obtain the step and impulse response for a first order and a second order linear system

Source coding for Step Response of a first order system:

```
num=[1];
den=[1 0.1];
t=tf(num,den);
step(t);
```

Source coding for Impulse Response of a first order system:

```
num=[1];
den=[1 0.1];
t=tf(num,den);
impulse(t);
```

Source coding for Step Response of a second order system:

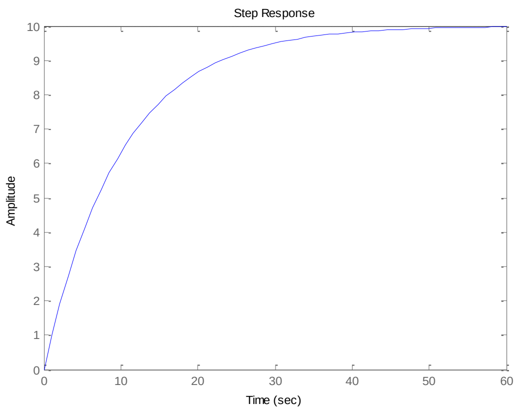
```
num1=[0.1];
den1=[1 0.1];
t1=tf(num1,den1);
num2=[0.2];
den2=[1 0.2];
t2=tf(num2,den2);
step(t1,t2);
```

Source coding for Impulse Response of a Second order system:

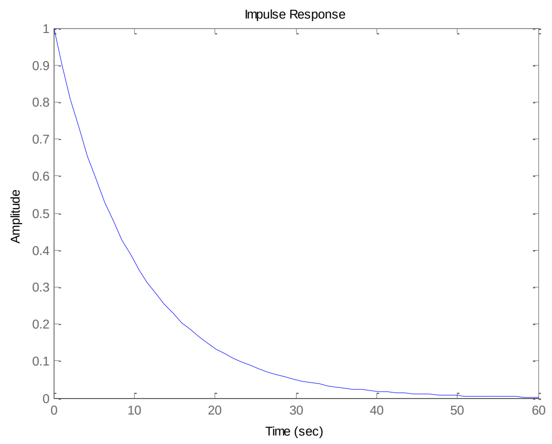
```
num1=[0.1];
den1=[1 0.1];
t1=tf(num1,den1);
num2=[0.2];
den2=[1 0.2];
t2=tf(num2,den2);
impulse(t1,t2);
```

MODEL GRAPH:

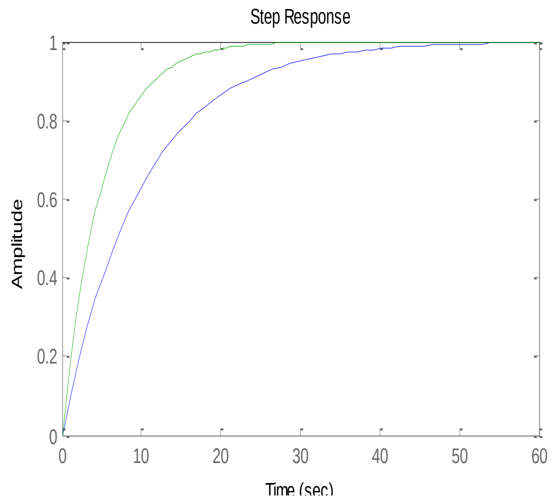
Step Response of a first order system



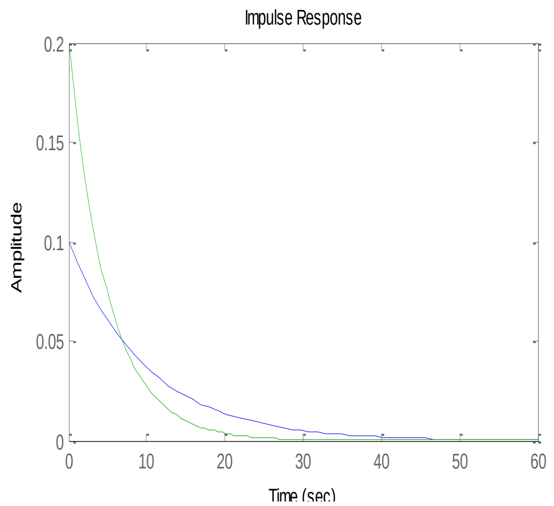
Impulse Response of a first order system

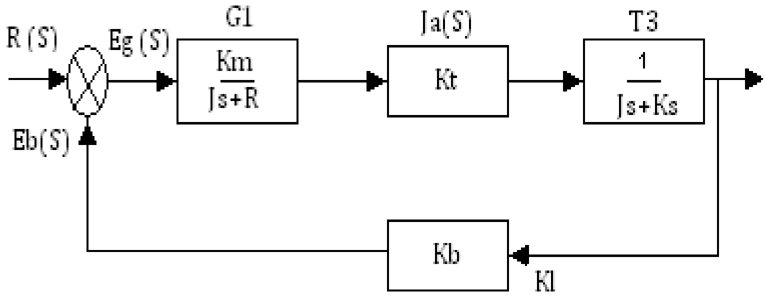


Step Response of a second order system



Impulse Response of a Second order system





RESULT:

Thus the block diagram is build using MATLAB and Step response and impulse response characteristics are obtained.

REVIEW QUESTIONS

1. Define transfer function.
2. State whether transfer function technique is applicable to non-linear system and whether the transfer function is independent of the input of a system.
3. What is time response?
4. What is transient and steady state response?
5. Name the test signals used in control system?
6. What is the order of a system?

****