Laboratory Manual

For

Electrical & Electronics Engineering's

(Part one)

Laboratory Staff

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Exp. Name: Introduction to Electrical lab, Motors types and Control panels

Objectives

1. Master correct use of digital multimeter as voltmeter and ammeter.
2. Reinforce understanding of series and parallel configurations.
3. Begin introduction to simple circuit diagrams.
4. Gain experience with wiring simple circuits.
5. Gain experience with supply and control panel (XPO-EMT)
6. Gain experience through Connecting all types of motors

Theory

Many common electrical measurement instruments are based on electrical current. This first lab exercise seeks to give you some rudimentary understanding of these instruments and to demonstrate their correct and intelligent use. The course lectures may not yet have presented fully the principles behind the operation of these instruments, but do not despair --- *most* of the circuitry inside modern instrumentation cannot be entirely explained during any introductory course! Athough you may not understand the details of what is inside the meter, you do need to learn how to connect and use the meter properly and comprehend the meaning of the readings.

A DC motor (direct current motor) has a lot of applications in today's field of engineering and technology. From electric shavers to automobiles – DC motors are everywhere. To cater to this wide range of applications – different types of DC motors are used depending on the applicaition.

The types of DC motor include:

1. Permanent Magnet DC Motor (PMDC Motor)
2. Separately Excited DC Motor
3. Self-Excited DC Motor

a. Shunt Wound DC Motor
b. Series Wound DC Motor
c. Compound Wound DC Motor

Circuit Diagrams and Connections

There are conventional symbols used for drawing diagrams of circuits, known as circuit schematics. It is best to learn and use the conventional symbols from the start, even with the relatively simple circuits examined in introductory physics. The schematic symbols for the circuit elements in this lab exercise (battery and resistor) are shown in Fig. 1. Conducting wires are used to connect the various circuit elements together and are represented by straight lines. Corners in schematics mean nothing; they are needed only to complete the circuit.

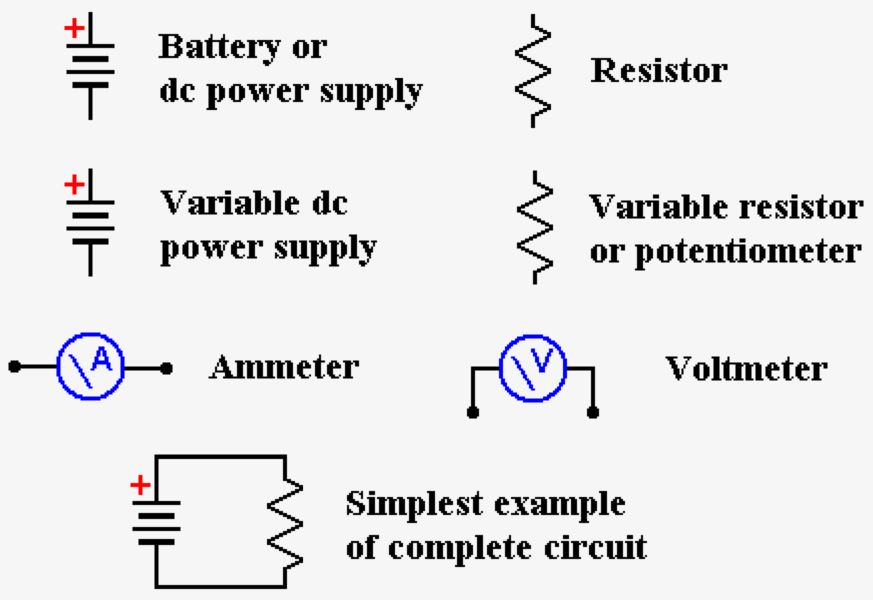


Figure 1. Schematic symbols for simple circuit elements.

Conducting wires (insulated in plastic to isolate the circuit) are often referred to as "leads." The ends of these leads often have convenient attachments. The three most commonly used ends, shown in Fig. 2, are:

1. banana plugs, so called because of their shape, which are easily pushed into the banana ``jacks'' to make the connection; many instruments in introductory laboratories have this kind of connection.
2. alligator clips, having jaws (thus the name) that clamp onto bare metal to make the connection.
3. BNS (Bayonet Neill-Concelman) connector, so named after its designers and twist-lock mechanism, is prevalent in scientific instrumentation.

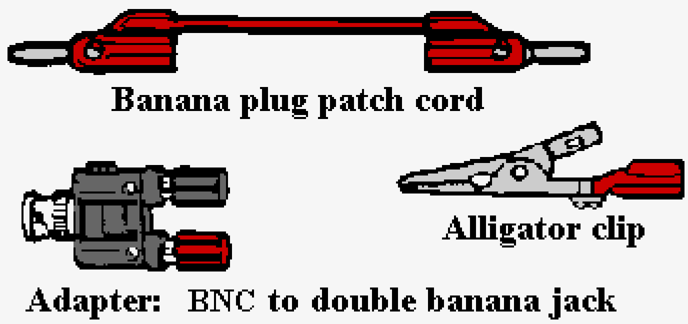


Figure 3. Typical connectors used in an introductory physics laboratory.

It is expected that you are already familiar with the difference between series and parallel connections of circuit elements from discussions in class. Carefully examine Fig. 3; if still unclear ask your laboratory or recitation instructor for further explanation.

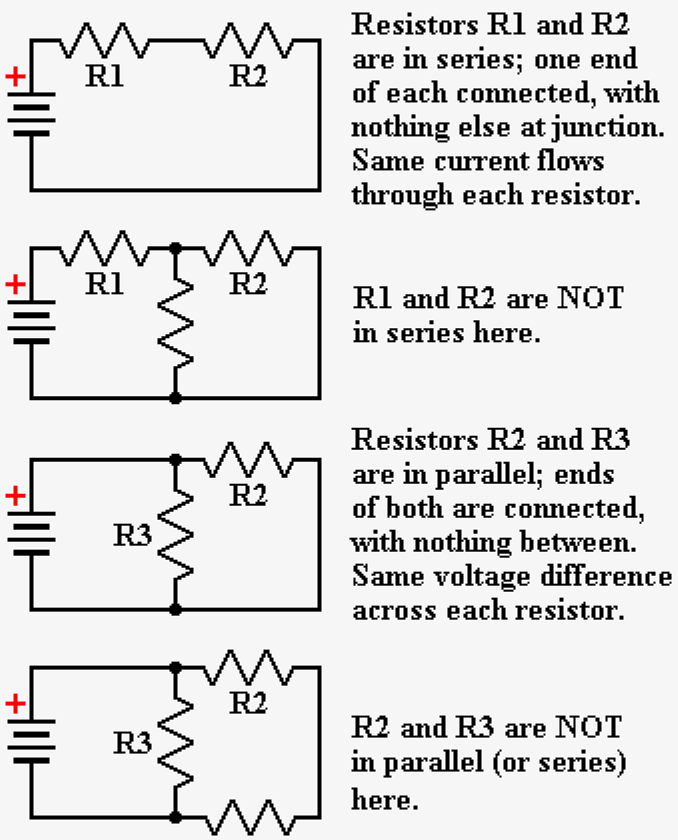
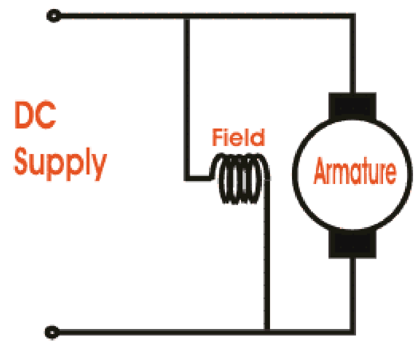
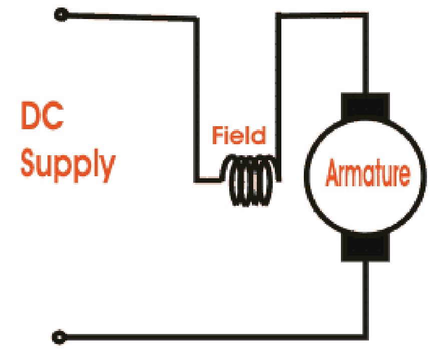
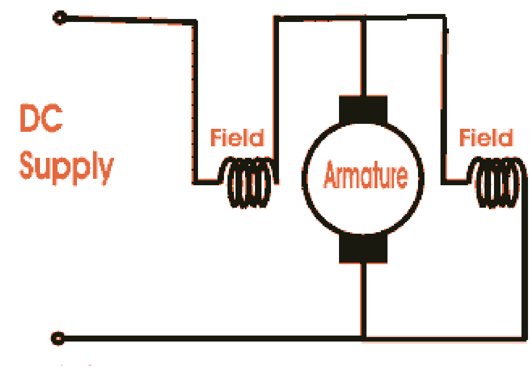
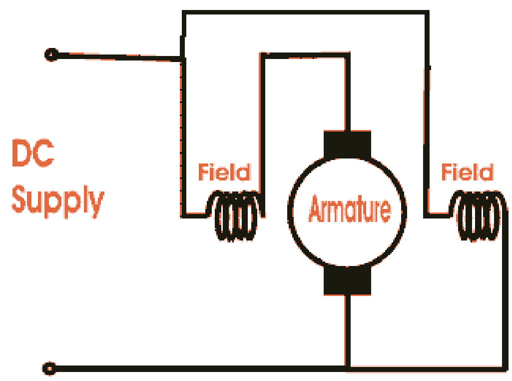


Figure 3. Series and parallel connections.

Self-Excited DC Motor types and connrctions

1. **Shunt wound DC motor**	2. **Series wound DC motor**
 Shunt Excited DC Motor	 Series Excited DC Motor
3. **Compound wound DC motor**	
 Short Shund DC Motor	 Long Shunt DC Motor

Supply and control board(XPO-EMT)

Discussion:

1. Discuss all types thoroughly. Specifically,
2. Compare and contrast the relationships among the voltages and/or currents for the series and parallel Motors combinations.

SPEED CONTROL OF D.C. SHUNT & SERIES MOTORS

AIM

To draw the speed characteristics of DC shunt & series motor by

(1) Armature control method

(2) Field control method

APPARATUS REQUIRED:-

Sl. No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0 -5) A	MC	1
2.	Ammeter	(0 - 2) A	MC	1
3.	Voltmeter	(0 - 300)V	MC	1
4.	Rheostat	400, 1.1 A	Wire wound	1
5.	Tachometer		Digital	1

PRECAUTION:

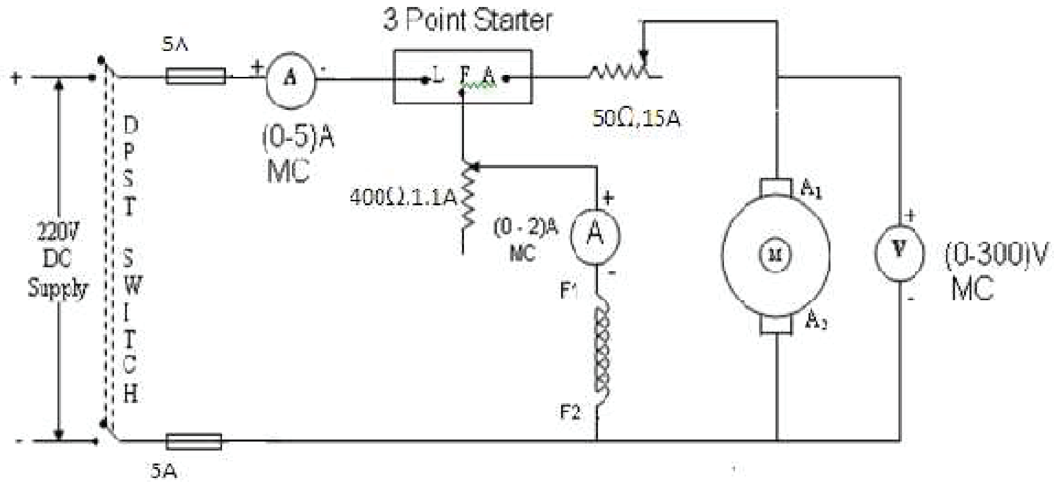
1. All the switches are kept open initially.
2. The field rheostat should be kept at minimum resistance position.
3. The armature rheostat should be kept at maximum resistance position.

PROCEDURE:

ARMATURE CONTROL METHOD:-

1. The connections are given as per the circuit diagram.
2. The DPST switch is closed.
3. The field current is varied in steps by varying the field rheostat.
4. In each step of field current the armature voltage is varied in steps by varying the armature rheostat.
5. In each step of armature rheostat variation the meter readings (Voltmeter & Tachometer) are noted.

CIRCUIT DIAGRAM:



FIELD CONTROL METHOD:-

1. The connections are given as per the circuit diagram.
2. The DPST switch is closed.
3. The armature voltage is varied in steps by varying the armature rheostat.
4. In each step of armature voltage the field current in steps by varying the field rheostat.
5. In each step of field rheostat the meter readings (Ammeter & tachometer) are noted.

TABULAR COLOUMN:

ARMATURE VOLTAGE CONTROL:

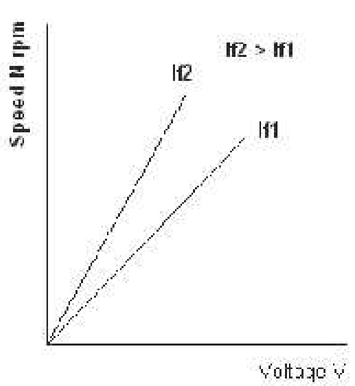
S.No	I_{F1} = A		I_{F2} = A	
	Voltage V	Speed N rpm	Voltage V	Speed N rpm

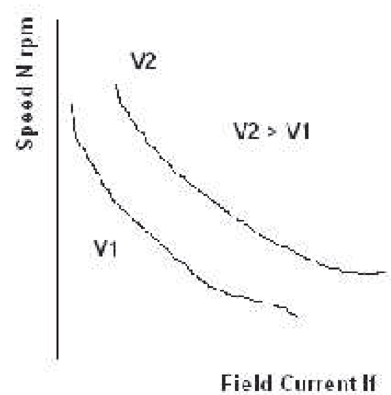
FIELD CONTROL:

S.No	Voltage V_1 = V		Voltage V_2 = V	
	Field current I_F A	Speed N rpm	Field current I_F A	Speed N rpm

MODEL GRAPH:

ARMATURE VOLTAGE CONTROL **FIELD CONTROL**





Discussion

1. draw the speed characteristics of DC shunt motor by armature voltage control method.
2. draw the speed characteristics of DC shunt motor by field control method.
3. is it possible to apply these control methods to DC series motor explain with the aid of drawings

LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

AIM:

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

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
2	Ammeter	MI	(0-10)A	1 no
	Tachometer	Digital	0-9999 RPM	1 no
4	Wattmeter	Dynamo-type	(0-150)V UPF (0-10)A	1 no
5	Connecting Wires	*****	(0-20)A	Required

NAME PLATE DETAILS:

1Φ Induction motor

Rated Voltage : ________________

Rated Current : ________________

Rated Speed : ________________

Rated Power : ________________

Rated Frequency: ________________

FORMULA USED:

Torque = 9.81 × (S_1-S_2) × R Nm, where R is the radius of the brake drum in meter.

Output power, P_o= 2πNT/60 Watts

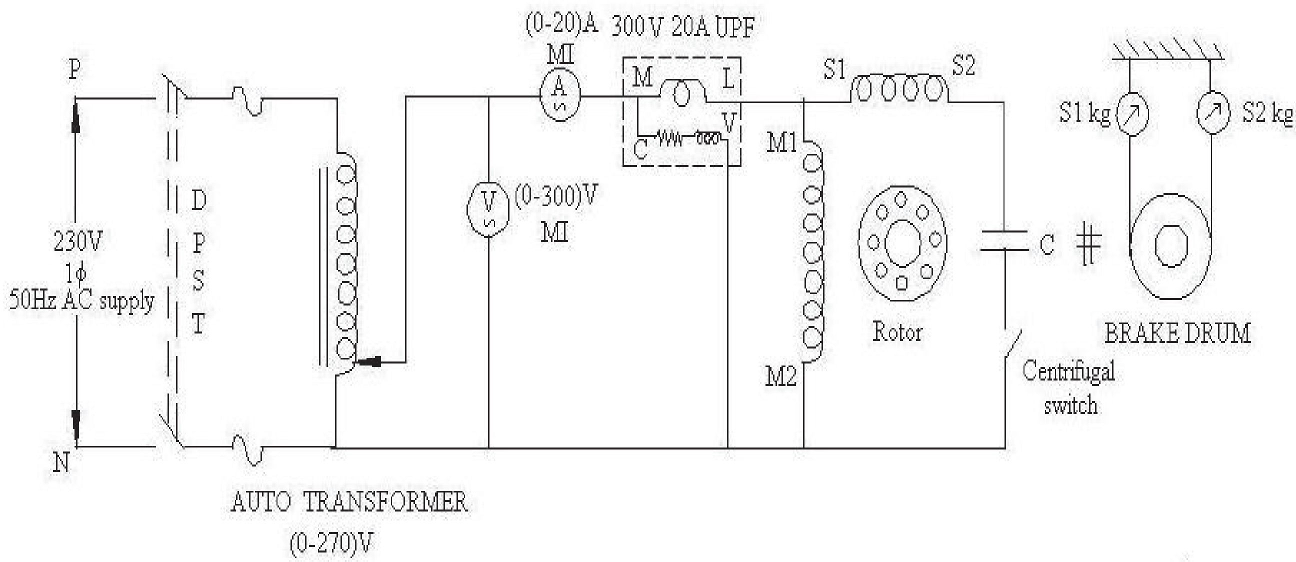
Input power, P_i = W_1+W_2 Watts

%Efficiency, %η = (output power/input power) ×100

% Slip = (Ns-N)/N ×100

Power factor = Cos φ=W/VI

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connections are given as per the circuit diagram.

2. Switch on the supply at no load condition.

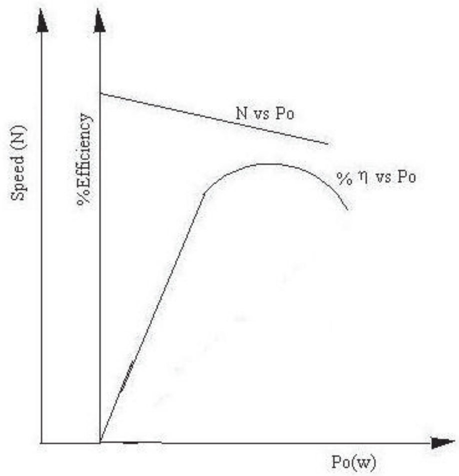
3. Apply the rotor voltage to the motor using the variac and note down the readings at ammeter And wattmeter.

4. Vary the load in suitable steps and note down all the meter readings till fill load condition.

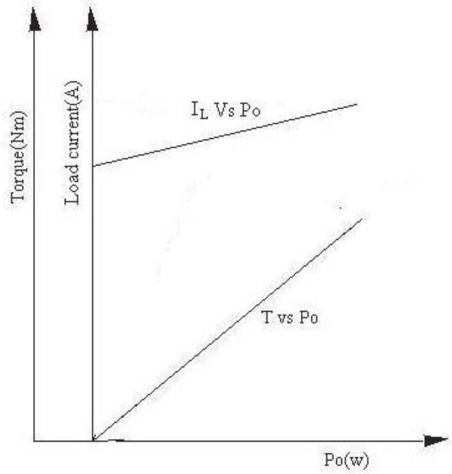
TABULAR COLUMN:

S. No	V_L Volts	I_L Amps	S_1 kg	S_2 kg	S kg	W watts	Speed rpm	Torque Nm	Po watts	%η
1	220									
2	220									
3	220									
4	220									
5	220									

MODEL GRAPH:

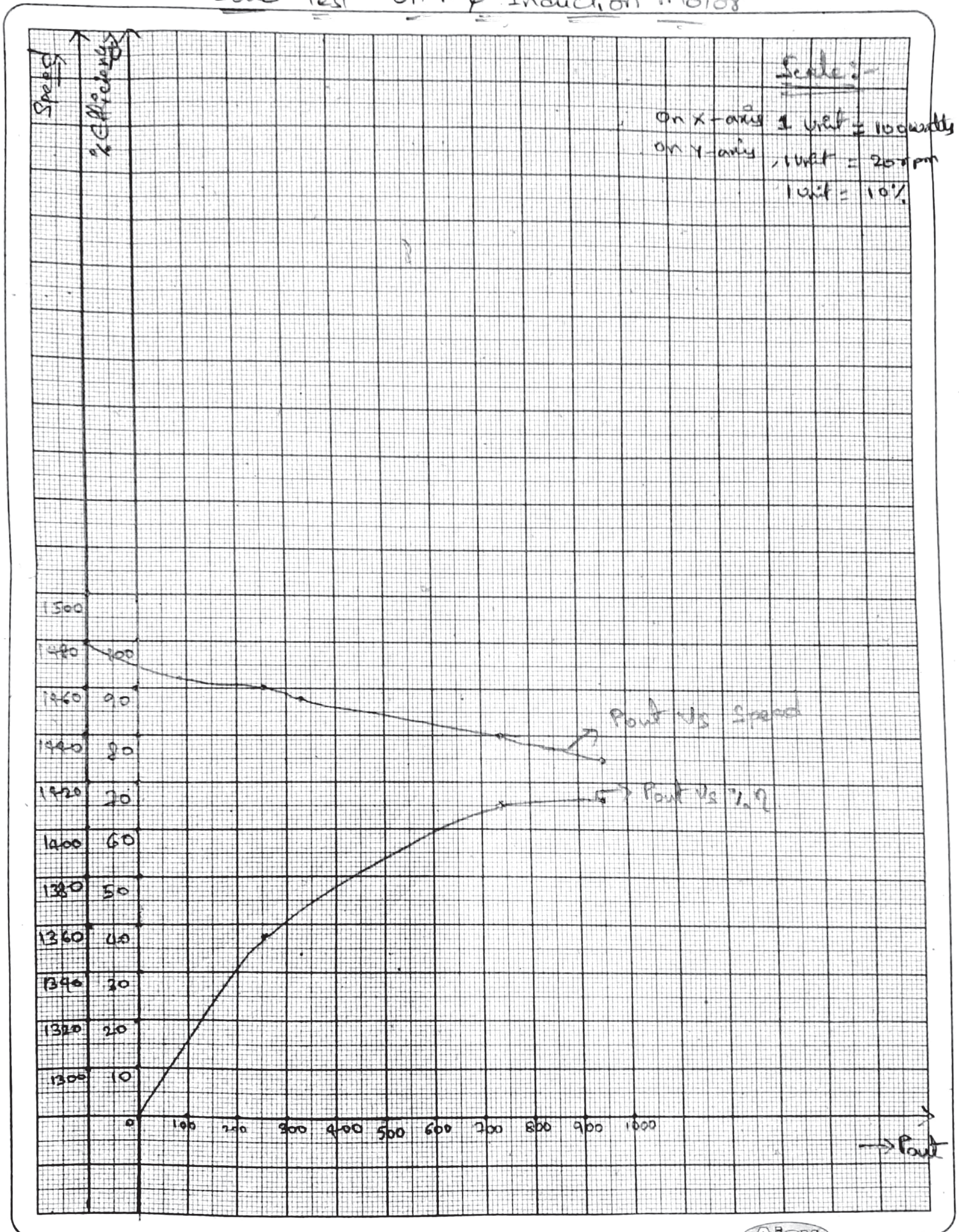


Speed (N)
%Efficiency
N vs Po
% η vs Po
Po(w)



Torque(Nm)
Load current(A)
IL Vs Po
T vs Po
Po(w)

Load Test on 1-ϕ Induction Motor



RESULT:

Thus load test on the single phase induction motor has been conducted and its performance characteristics determined.

VIVAQUESTIONS

1. What is the purpose of this experiment?

2. Whether single phase induction motor self starting motor?

3.What are the starting methods of single phase induction motor?

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EQUIVALENT CIRCUIT OF A SIGLE PHASE INDUCTION MOTOR

AIM:

To determine the equivalent circuit parameters of a single phase induction motor by performing the no- load and blocked rotor tests.

APPARATUS REQUIRED:

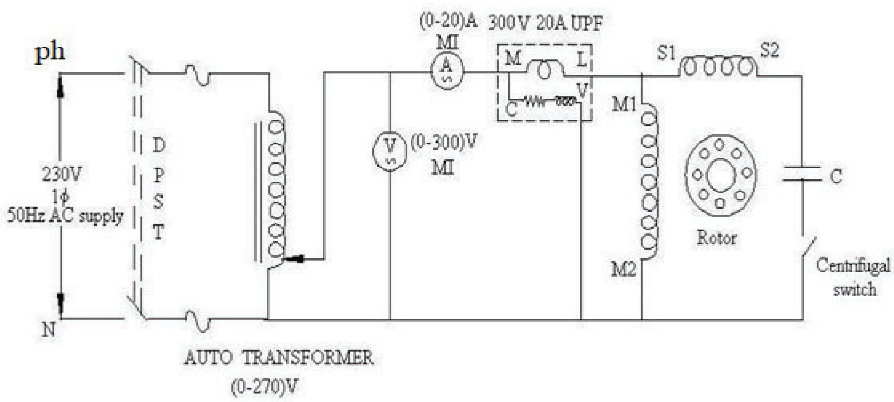
Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-300)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Wattmeter	Dynamo-type	(0-300)V LPF (0-10)A	1 no
4	Wattmeter	Dynamo-type	(0-150)V UPF (0-10)A	1 no
5	Connecting Wires	*****	(0-20)A	Required

1 - ϕ Induction motor specifications:

Name plate details:

Rated power	
Rated voltage	
Current	
Speed(RPM)	
Cos ϕ (pf)	
Frequency	
Rotor	

CIRCUIT DIAGRAM:



PROCEDURE:

No load Test:

1. The circuit connections are made as per the circuit diagram.
2. Be sure that variac (auto transformer) is set to zero output voltage position before starting the experiment.
3. Now switch ON the supply and close the DPST switch.
4. The variac is varied slowly, until rated voltage is applied to motor and rated speed is obtained.
5. Take the readings of Ammeter, Voltmeter and wattmeter in a tabular column.
6. The variac is brought to zero output voltage position after the experiment is done, and switch OFF the supply.

Blocked Rotor Test:

1. To conduct blocked rotor test, necessary meters are connected to suit the full load conditions of the motor.
2. Connections are made as per the circuit diagram.
3. Before starting the experiment variac (auto transformer) is set to zero output voltage position.
4. The rotor (shaft) of the motor is held tight with the rope around the brake drum.

5. Switch ON the supply, and variac is gradually varied till the rated current flows in the induction motor.
6. Readings of Voltmeter, Ammeter, and wattmeter are noted in a tabular column.
7. The variac is brought to zero output voltage position after the experiment is done, and switch OFF the supply.
8. Loosen the rope after the experiment is done.

Calculation for No-Load Test:

$$V_o I_o \cos \phi_o = W_o$$

$$\cos \phi_o = \frac{W_o}{V_o I_o}$$

$$Z_o = \frac{V_o}{I_o}$$

$$X_o = Z_o \sin \phi_o$$

$$X_o = X_1 + \frac{1}{2}(X_2 + X_m)$$

$$X_m = 2(X_o - X_1) - X_2$$

Calculation For Blocked Rotor Test:

$$Z_{sc} = \frac{V_{sc}}{I_{sc}}$$

$$R_{sc} = \frac{W_{sc}}{I_{sc}^2}$$

r_1 is the DC resistance of stator of motor

$$r_2 = R_{sc} - r_1$$

$$x_1 + x_2 = X_{sc}$$

since leakage reactance can't be seperated out , it is common practice to to assume $x_1 = x_2$

$$x_1 = x_2 = \frac{X_{sc}}{2} = X_{sc} = \frac{1}{2}\sqrt{Z_{sc}^2 - R_{sc}^2}$$

OBSERVATIONS:

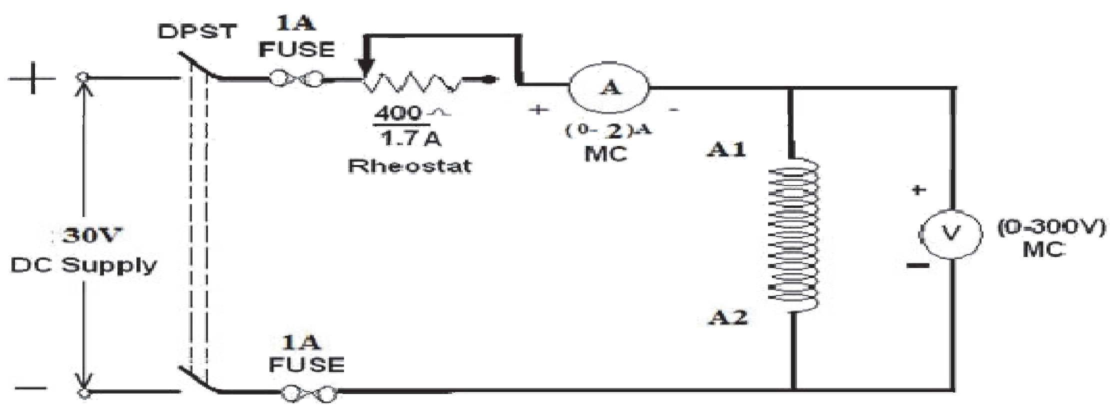
For No-Load Test:

Sl no.	Voltmeter reading V_o	Ammeter reading I_o	Wattmeter reading W_o	$\cos\Phi_0=W_0/V0I0$
1				

For Blocked Rotor Test:

Sl no.	Voltmeter reading Vsc	Ammeter reading Isc	Wattmeter reading Wsc	$\cos\Phi_{sc}$
1				

Circuit diagram for measurement of R_1 :



PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Initially rheostat is set at maximum resistance position.
3. Switch ON the supply, and vary the rheostat gradually and note down the readings of ammeter and voltmeter
4. For the corresponding values, average of r1 is take

To find stator Resistance:

S.NO.	V(volts)	I(Amps)	R=V/I Ω

Average Value: R_{dc} R_{ac} R_{dc} =1.1

Comments:

1. Since IM is not self starting Machine, it is started by placing an auxiliary winding in the circuit.

2. Here no-load test is similar to open circuiting the load terminals and blocking the rotor is similar to conducting short circuit on the IM.

VIVA Questions:

1. Why there is no starting torque in a single phase induction motor?
2. What are different starting methods employed in single phase induction motors?
3. Compare the performance of capacitor - start, capacitor – run, shaded pole single phase induction motors?
4. Mention a few applications of single phase induction motors?

PRECAUTIONS:

1. Connections must be made tight.

2. Before making or breaking the circuit, supply must be switched off

RESULT:

Equivalent circuit parameters of 1-Φ Induction motor are determined by using No-load and blocked rotor tests.

NO LOAD AND BLOCKED ROTOR TEST ON A 3- ϕ INDUCTION MOTOR

AIM:

To determine the equivalent circuit of a 3- ϕ induction motor and calculate various parameters of induction motor with the help of circle diagram.

APPARATUS REQUIRED:

Sl. No.	Equipment	Type	Range	Quantity
1	Voltmeter	MI	(0-600)V	1 no
2	Ammeter	MI	(0-10)A	1 no
3	Wattmeter	Electro dynamo meter type	10A/600V UPF 10A/600V LPF	1 no 1 no
4	Tachometer	Digital	(0-10000)RPM	1 no
5	Connecting Wires		(0-20)A	Required

NAME PLATE DETAILS:

Power rating	5Hp
Voltage	400V
Current	6.8A
Speed (RPM)	150
Frequency	50Hz
PF	Lagging

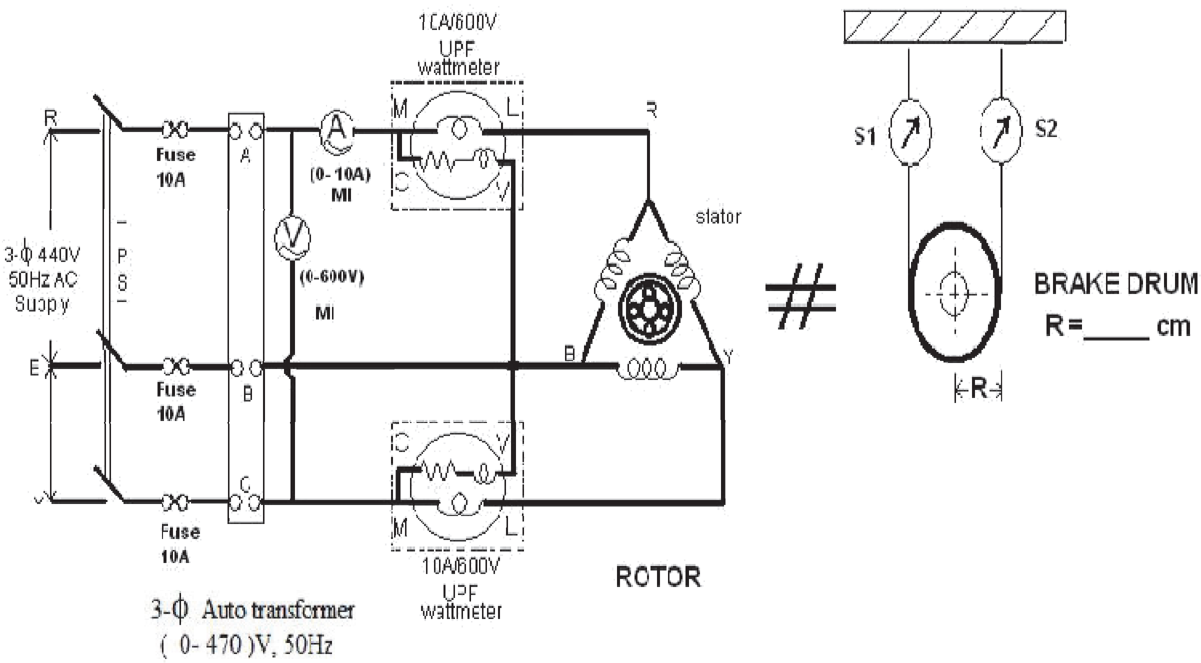
3- ϕ Auto transformer Details:

Input Voltage: _____415_____________ (Volt)

Output Voltage: ___(0-470)_______________ (Volt)

Current:_____________________ (Amp.)

CIRCUIT DIAGRAM:



PROCEDURE:

NO- LOAD TEST:

1. Connections are made as per the circuit diagram.
2. Ensure that the 3- ϕ variac is kept at minimum output voltage position and belt is freely suspended.
3. Switch ON the supply. Increase the variac output voltage gradually until rated voltage is observed in voltmeter. Note that the induction motor takes large current initially, so, keep an eye on the ammeter such that the starting current current should not exceed 7 Amp.
4. By the time speed gains rated value, note down the readings of voltmeter, ammeter, and wattmeter.

5. Bring back the variac to zero output voltage position and switch OFF the supply.

BLOCKED ROTOR TEST:

1. Connections are as per the circuit diagram.
2. The rotor is blocked by tightening the belt.
3. A small voltage is applied using 3- ϕ variac to the stator so that a rated current flows in the induction motor.
4. Note down the readings of Voltmeter, Ammeter and Wattmeter in a tabular column.
5. Bring back the Variac to zero output voltage position and switch OFF the supply.

OBSERVATIONS:

No Load Test:

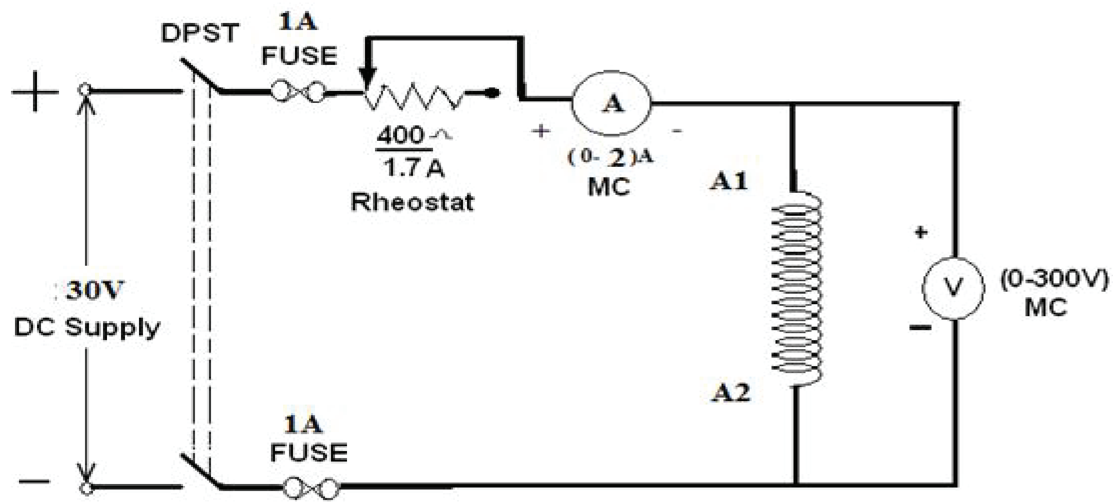
S No.	Voltmeter reading V_{nl} (V)	Ammeter reading I_{nl} (A)	Wattmeter reading		W_{nl} (P_{nl}) (W)
			W_1 (W)	W_2 (W)	W_1+W_2
1	420	1	60	98	158*2=316

Blocked Rotor Test

S No.	Voltmeter Reading V_{br}	Ammeter reading I_{br}	Wattmeter reading		W_{br} (P_{br}) W_1+W_2
			W_1 (W)	W_2 (W)	
1	38.5	8	56	64	120*2=240

Measurement of stator winding resistance (r_1):

CIRCUIT DIAGRAM:



TABULAR COLUMN:

S no.	Voltage (v)	Ammeter (I)	Resistance (R)

Procedure to find r $_1$:

1. Connections are made as per the circuit diagram
2. Switch ON the supply. By varying the rheostat, take different readings of ammeter and voltmeter in a tabular column.
3. From the above readings, average resistance r_1 of a stator is found

Measurement of Stator resistance

1. Connect the circuit as per the circuit diagram shown in fig (2).
2. Keeping rheostat in maximum resistance position switch on the 220 V Dc supply.
3. Using volt-ammeter method measure the resistance of the stator winding.
4. After finding the stator resistance, R_{dc} must be multiplied with 1.6 so as to account for skin effect i.e. $R_{ac} = 1.6\ R_{dc}$.

MODEL CALCULATIONS:

$G=W_0/3V_2$, $Y_0=I_0/V$, $B_0=Y_0^2-G_0^2$

$Z_{01}=V_{sc}/I_{sc}$, $R=W_{sc}/3xI_{sc}^2$, $X_{01}=\sqrt{Z_{01}^2-R_{01}^2}$

For circle diagrm:

$\cos\Phi_0=W_0/\sqrt{3}\ V_0I_0$, $\Phi_0=\cos^{-1}(W_0/\sqrt{3}\ V_0I_0)$

$\cos\Phi_{sc}=W_{sc}/\sqrt{3}\ V_{sc}I_{sc}$, $I_{sn}=I_{sc}(V/V_{sc})$;

PRECAUTIONS:

1. Connections must be made tight
2. Before making or breaking the circuit, supply must be switched off

RESULT:

No load and blocked rotor tests are performed on 3-Φ Induction motor.

VIVA Questions:

1. Explain why the locus of the induction motor current is a circle.
2. What is the difference between the transformer equivalent circuit and induction motor equivalent circuit
3. What are the reasons in conducting no-load test with rated voltage and blocked-rotor test with rated current?
4. Why do you choose LPF wattmeter in load test and hpf wattmeter in blocked rotor test?
5. How do you reverse the direction of rotation of induction motor?
6. What are the various applications of this motor?