PRACTICAL WORK BOOK

For Academic Session 2013

Electrical Machines (EE-246)

For

SE (EL)

Name:

Roll Number:

Class:

Batch:

Department :

Department of Electrical Engineering

N.E.D. University of Engineering & Technology, Karachi

SAFETY RULES

1. Please don't touch any live parts.
2. Please don't work bare footed.
3. Never use an electrical tool near water.
4. Never use an electrical tool that has fallen into water.
5. Don't carry unnecessary item with you during performance (like water bottle, bags etc)
6. Before connecting any leads/wires make sure power is switch off.
7. In case of emergency, push the nearby red color emergency switch of any panel or immediately call the laboratory staff.
8. In case of electricity fire, never put water on it as it will further worse the condition; use the class C fire extinguisher.

Fire is a chemical reaction involving rapid oxidation (combustion) of fuel. Three basic conditions when met, fire takes place. These are fuel, oxygen & heat, absence of any one of the component will extinguish the fire.

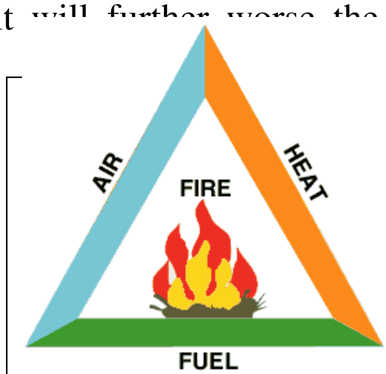


Figure: Fire Triangle

A(think ashes): paper, wood etc

B(think barrels): flammable liquids

C(think circuits): electrical fires

If there is a small electrical fire, be sure to use only a Class C or multipurpose (ABC) fire extinguisher, otherwise you might make the problem worsen.

The letters and symbols are explained in left figure. Easy to remember words are also shown.

***Don't** play with electricity, Treat electricity with respect, it deserves!*

CONTENTS

LAB SESSION 01

OBJECTIVE
To visualize the different Electrical Machines & identify their parts.

APPARATUS
- Transformers
- Fan Motor (Ceiling & Exhaust)
- Washing Machine Motor
- Pump Motor
- Juicer Motor
- Toys Motor

THEORY
Transformer

A transformer is a device that transfers electrical energy from one circuit to another by electromagnetic induction (transformer action). The electrical energy is always transferred without a change in frequency, but may involve changes in magnitudes of voltage and currents. The total VA at primary and secondary is always constant.

There are two types of transformers.
1. Core Type
2. Shell Type

Exercise:

Identify the following types of transformer & also label the parts.

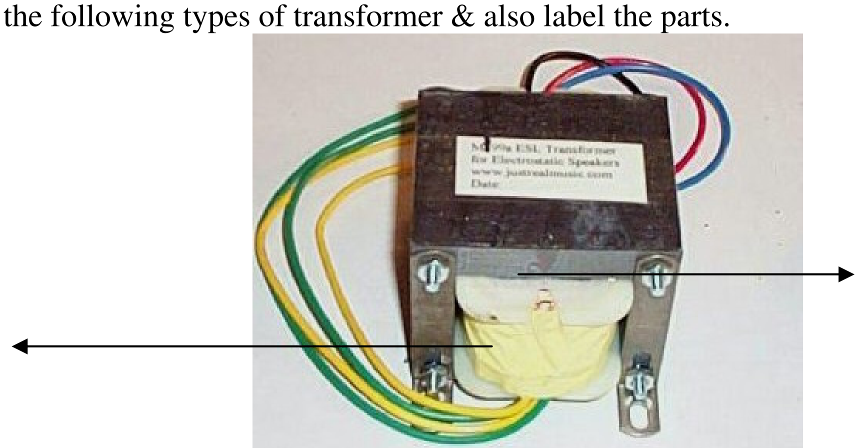


Figure: Type Transformer

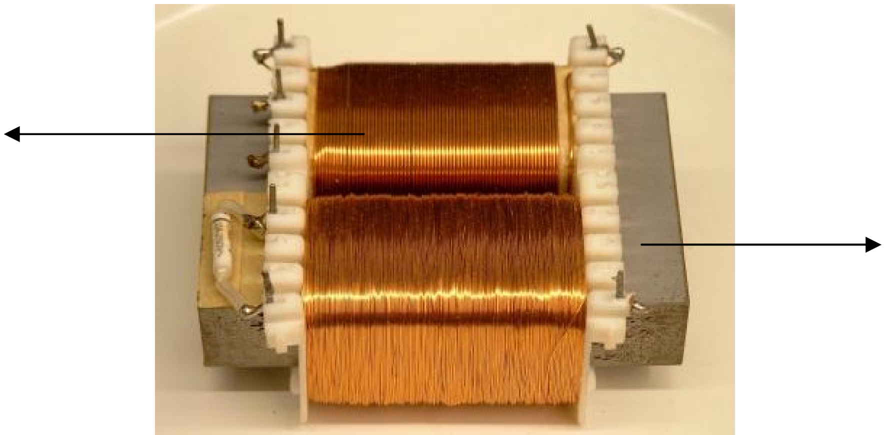


Figure: Type Transformer

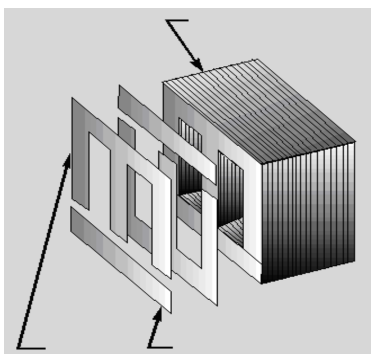


Figure: Type Core

Figure: Parts of Shell Type T/F Core

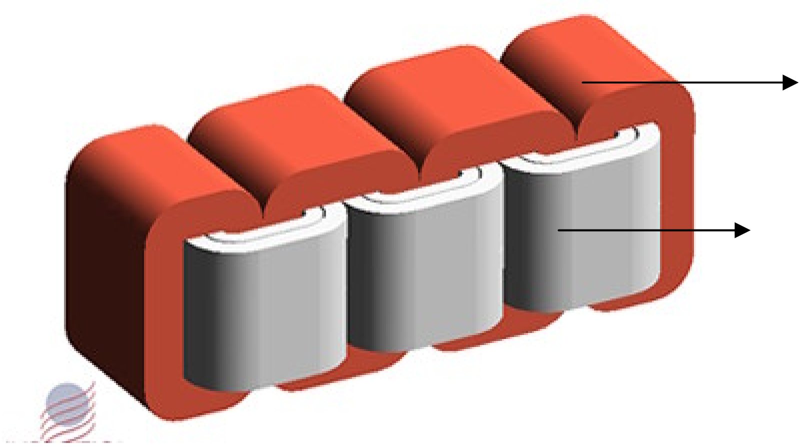


Figure: Type Transformer

Universal Motor

The universal motor is a rotating electrical machine similar to DC series motor, designed to operate either from AD or DC source. The stator & rotor windings of the motor are connected in series through the rotor commutator. The series motor is designed to move large loads with high torque in applications such as crane motor or lift hoist.

EXERCISE:

Label the parts.

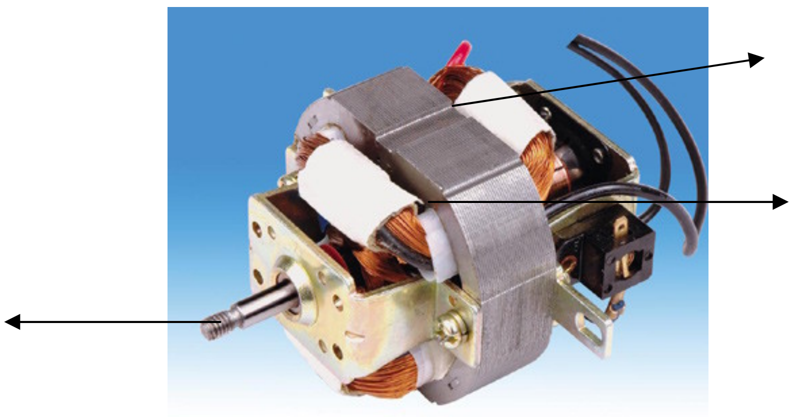


Figure: Universal Motor

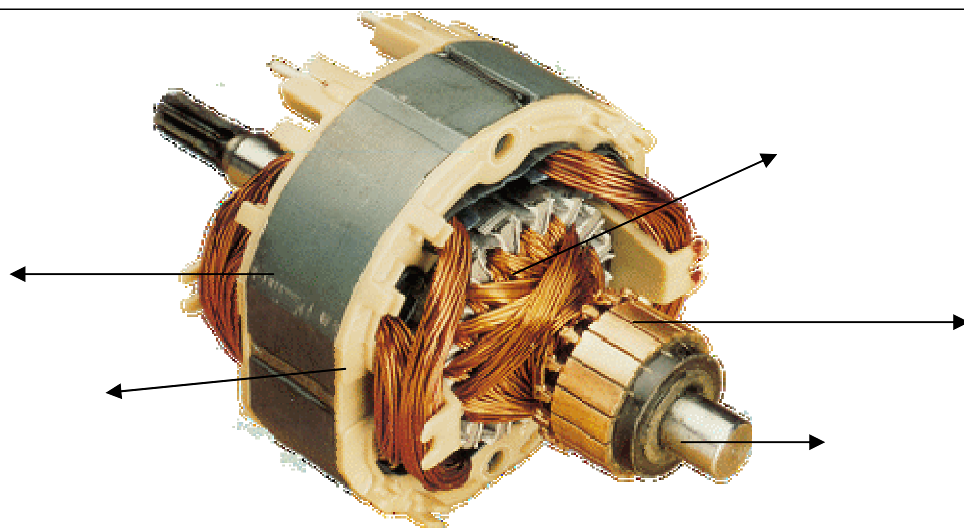


Figure: Universal Motor

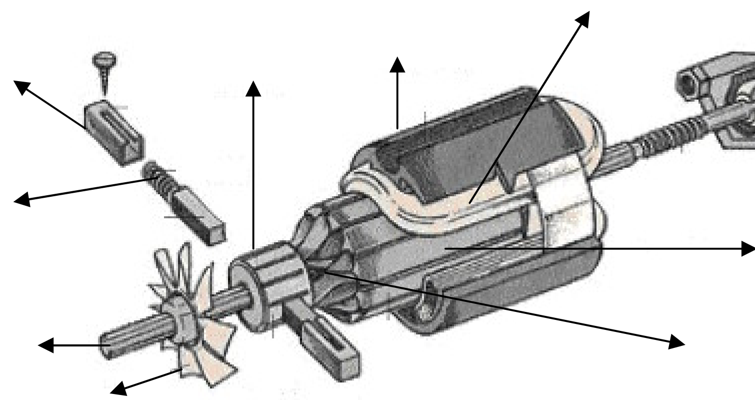


Figure: Assembly of Universal Motor

Induction Motor

An Induction motor is a motor without rotor windings, the rotor receives electric power by induction rather than by conduction, exactly the same way the secondary of a 2 windings transformer receive its power from the primary.

The single-phase induction motor has no intrinsic starting torque. Starting torque can be achieved by either one of the method.

1. Split phase windings
2. Capacitor type windings
3. Shaded pole stator

There are two types of rotor constructions.

1. Shaded cage rotor
2. Wound rotor

Figure: Induction Motor

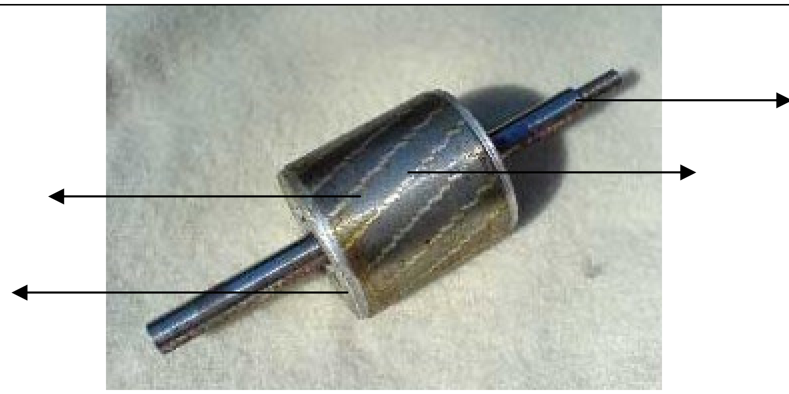


Figure:

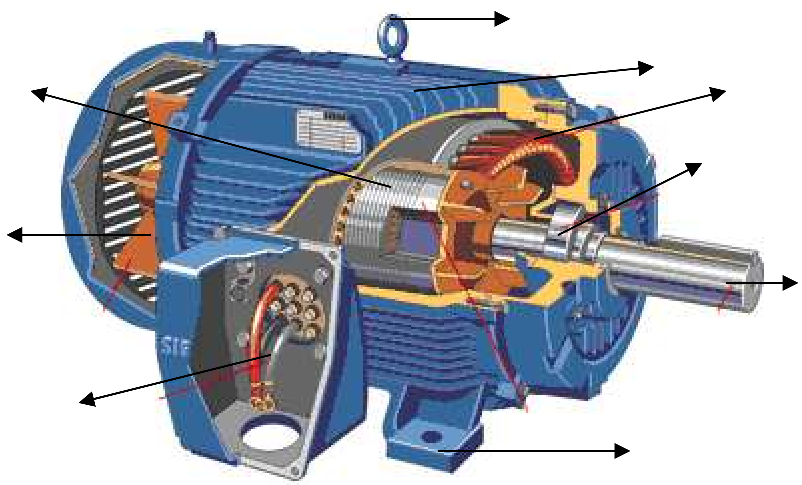


Figure:

PMDC motor

A permanent magnet DC motor is the simple motor that converts electrical energy into mechanical energy through the interactions of the two fields. One field is produced by a permanent magnet poles, the other field is produces by electrical current flowing in the armature windings. These two fields result in a torque which tends to rotate the rotor.

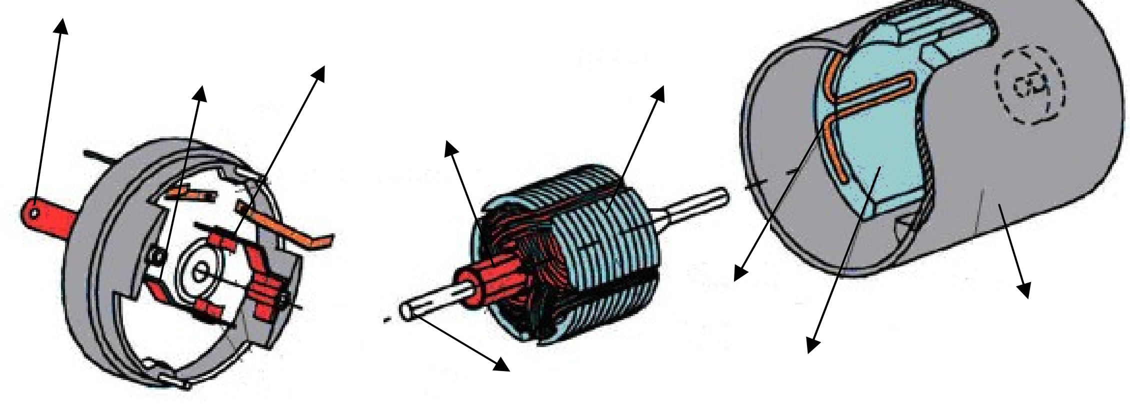


Figure: PMDC Motor's Assembly

PROCEDURE
Practical Demonstration.

RESULT
The basic parts of motors have visualized.

EXERCISE:
Answer the following questions:

Why do we use bearings in a machine?

___

___

___

___

Why do we use carbon brushes in a machine?

___

___

___

What are the basic differences in motors of ceiling fan and exhaust fan?

___

___

___

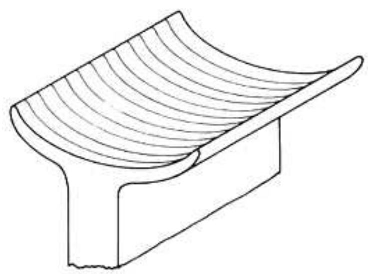
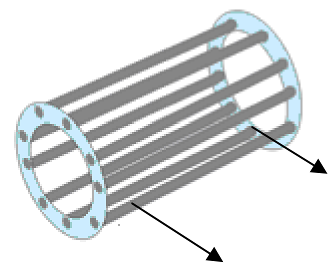
Why do we use split rings and slip rings in a machine?

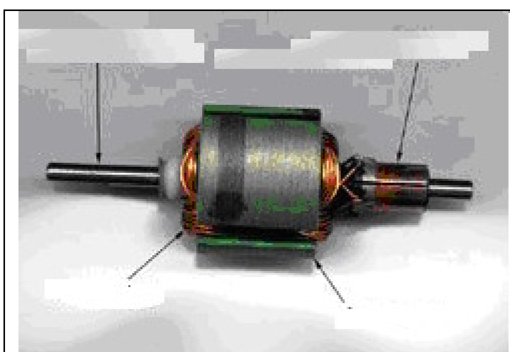
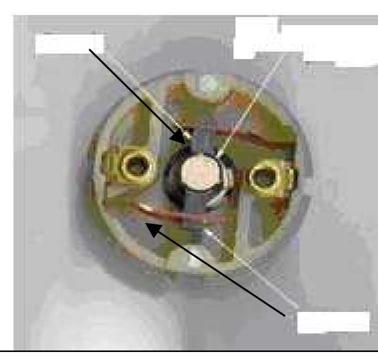
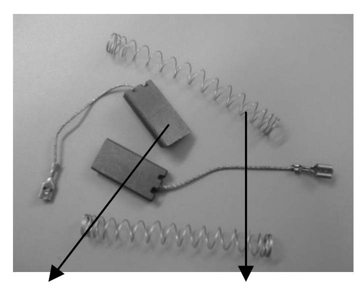
____
____
____
____

When do we use Split rings and slip rings?

____
____
____
____

Identify & label the following parts.

 Figure:	 Figure:	 Figure:

LAB SESSION 02

OBJECTIVE

To measure the Three Phase Power of Star connected load using Three Wattmeter methods.

APPARATUS

- ✓ Three Watt-meters
- ✓ Ammeter
- ✓ Voltmeter
- ✓ Star Connected Load

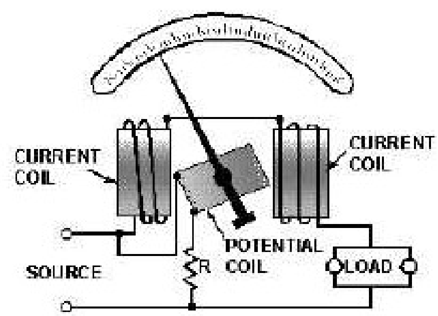
THEORY

Power can be measured with the help of

1. Ammeter and voltmeter (In DC circuits)
2. Wattmeter
3. Energy meter

By Ammeter and Voltmeter:
Power in DC circuits or pure resistive circuit can be measured by measuring the voltage & current, then applying the formula P=VI.

By Energy Meter:
Power can be measured wuth the help of energy meter by measuring the speed of the merter disc with a watch, with the help of following formula:



$$P = \frac{N \times 60}{K} \quad kW$$

Where
N= actual r.p.m of meter disc
K= meter constant which is equal to disc revolutions per kW hr

By Wattmeter: A wattmeter indicates the power in a circuit directly. Most commercial wattmeters are of the dynamometer type with the two coils, the current and the voltage coil called C.C & P.C.

Power in three phase circuit can be measured with the help of poly phase watt-meters which consist of one two or three single phase meters mounted on a common shaft.

<u>Single Phase Power Measurement:</u>
One wattmeter is used for single phase load or balanced three phase load, three and four wire system. In three-phase, four wire system, p.c. coil is connected between phase to ground, while in three wire system, artificial ground is created.

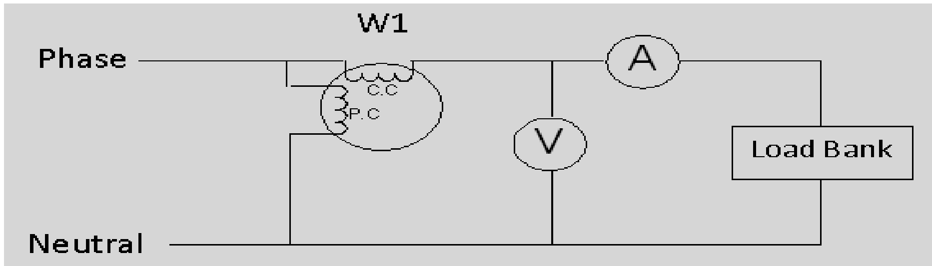


Figure: Single Wattmeter Method

PROCEDURE

Arrange the watt-meters as shown above.

OBSERVATION

Phase Voltage: _______

S. No.	Size of Load Bank (By Observation)	Measured Load (Using Wattmeter)	Current (A)	Voltage (V)
1	05x100W			
2	10x100W			

Three Phase Power Measurement Using Three Wattmeter Method:

Two watt-meters & three watt-meters are commonly used for three phase power measurement. In three watt-meter method, the potential coils are connected between phase and neutral.

For three wire system, three watt-meter method can be used, for this artificial neutral is created.

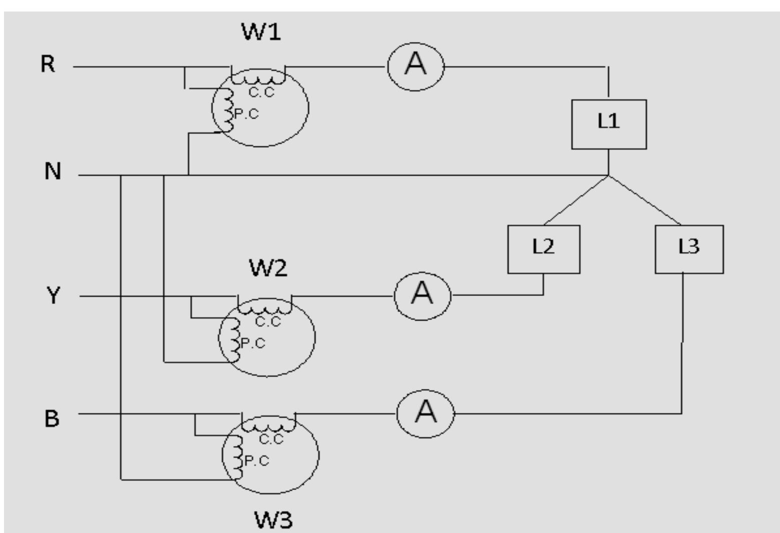


Figure: Three wattmeter method

PROCEDURE

Arrange the watt-meters as shown above.

OBSERVATION

Power of Star Connected Load: ________________________W
Line to Line Voltage: _____________ V
Line to Phase Voltage: _____________ V

Using Three Wattmeter Method

S. No	Wattmeter Reading (W1)	Wattmeter Reading (W2)	Wattmeter Reading (W3)	W1+W2+W3	Current (A)
1					

EXERCISE:

Here we are connecting phase with neutral without any load, doing this using a small wire in house could be very dangerous, then how it is possible here?

____
____
____
____

What do you understand by balance and unbalance load? In our case, is load balance or unbalance?

____
____
____
____

Suppose L1 is 70 W, ceiling fan, L2 is 100 W bulb, L3 is 350 W PC (Personal Computer), what amount of current will flow in the neutral?

____
____
____
____

LAB SESSION 03

OBJECTIVE

To measure the Three Phase Power of Delta connected load using Two Wattmeter methods.

APPARATUS

- ✓ Three Watt-meters
- ✓ Ammeter
- ✓ Voltmeter
- ✓ Star Connected Load

THEORY

Two Wattmeter Method:

In two watt-meter method, two wattmeters are used & their potential coils are connected between phase to phase and current coil in seies with the line. Two wattmeters can be used to measure power of star and delta connected load, but here we are performing experiment on delta connected load only, same method can be applied for star connected load. Following formulas are used for calculating P, Q and p.f.

TWO WATTMETER CALCULATIONS

1) Real power

$$P = W_1 + W_2$$

2) Reactive power

$$Q = \sqrt{3}\,(W_2 - W_1)$$

3) Power Factor

$$\cos\theta = \frac{P}{\sqrt{P^2+Q^2}}$$

$$\cos\theta = \sqrt{\frac{P^2}{P^2+Q^2}}$$

$$\cos\theta = \sqrt{\frac{(W_1+W_2)^2}{(W_1+W_2)^2+3\,(W_2-W_1)^2}}$$

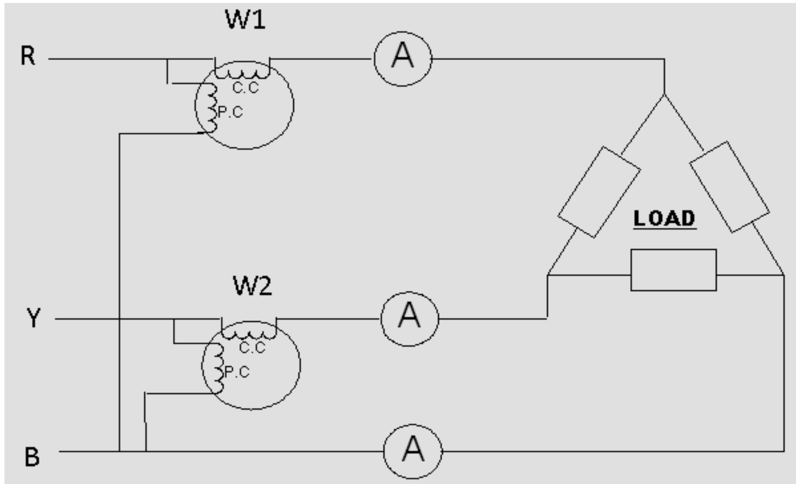


Figure: Two Wattmeter Method

PROCEDURE

Arrange the watt-meters according to the load (single phase or three-phase) and whether neutral available or not (as shown in the above figures).

OBSERVATION

Power of Delta Connected Load: 2 bulbs in series of ____________ W
Line to line Voltage: ______________ V

Using Two Wattmeter Method

S. No	Type of Load	Wattmeter Reading (W1)	Wattmeter Reading (W2)	W1+W2	p.f.	Current (I_L)
1	Three Phase Delta Connected Load					

RESULT:

The two wattmeter method of three phase power measurements have fully understood & performed.

EXERCISE:

Here for each delta connected load we are connecting two bulbs in series, why?

____
____
____
____

LAB SESSION 04

OBJECTIVE
To determine the turns ratio of a transformer, also determine the polarity of transformer windings for their parallel operation.

APPARATUS
- ✓ Two Single Phase Transformers (T1 & T2)
- ✓ Ammeter
- ✓ Voltmeter

THEORY
Turns Ratio:
Transformers provide a simple means of changing an alternating voltage from one value to another, keeping the apparent power S constant.

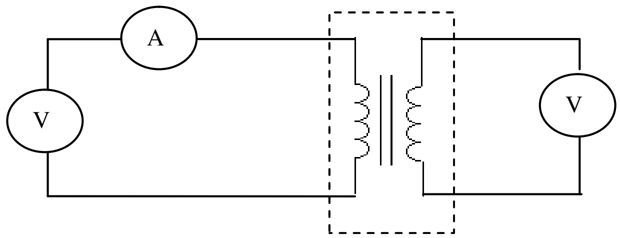


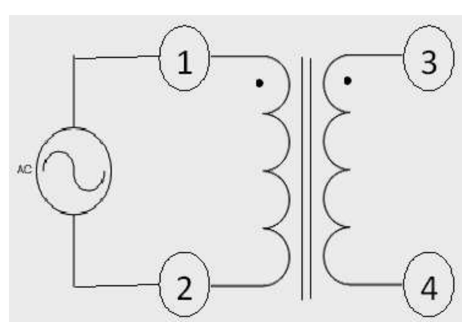
Figure 1. Finding the turns ratio

For a given transformer, the turns ratio can be find out using the relation.

$$\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P} = a$$

If a>1; The transformer is step down, otherwise step up.

Transformer Polarity:
When we speak "the polarity" of transformer windings, we are identifying all of the terminals that are the same polarity at any instant of time. "Polarity marks" are employed to identify these terminals. These marks may be black dots, crosses, numerals, letters, or any other convenient means of showing which terminal are of the same polarity. In our case, we use black dots. The black dots, as shown in the figure, indicate that for a given instant in time: ***when 1 is positive with respect to 2, then 3 is positive with respect to 4.***



The identification of polarity becomes essential when we operate the two transformers in parallel. Otherwise ***if terminals of unlike polarity connected to the same line, the two secondary windings would be short circuited on each other with a resulting excessive current flow.***

Suppose we have two transformers T1 & T2, having terminals H1, H2 (HV) & X1, X2(LV) as shown in figure 2. The transformers in fig 2 are so marked that if the H1's are connected to one primary line and the H2's to the other primary line then the X1's should be connected to the same secondary line and X2's to the remaining secondary line.

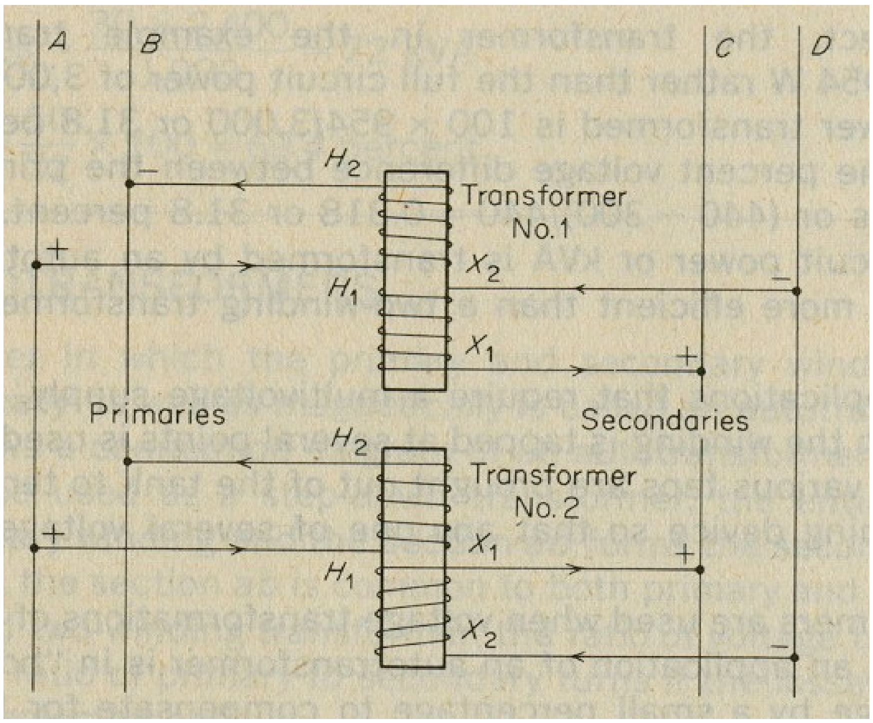


Figure 2: Two transformers connected for parallel operation

If the transformer terminals are arranged as shown in fig 3a, the transformer is said to have additive polarity and if arranged as shown in fig 3b, the transformer is said to have subtractive polarity.

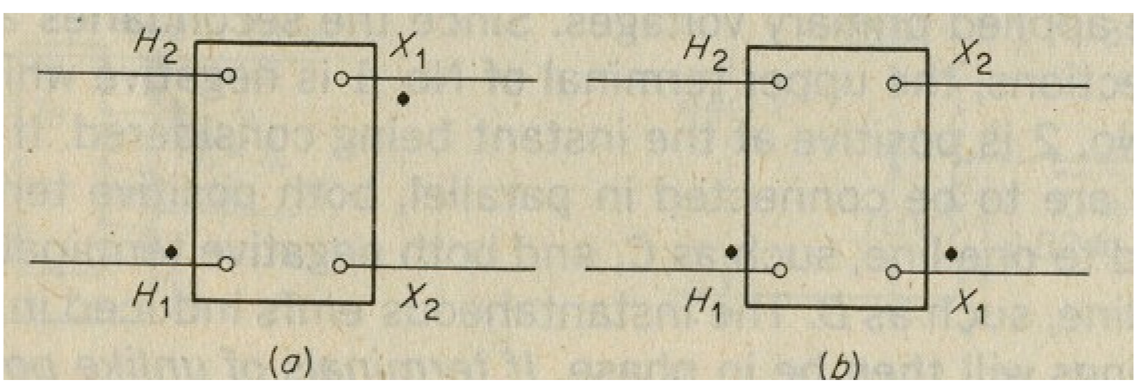


Figure 3: Standard polarity markings of transformers (a) additive polarity (b) subtractive polarity

If the polarity of the transformer is not known, it may be determined by the test connections shown in figure 4. Here low voltage side terminals may be temporary marked as X_A and X_B as shown in figure. Adjacent terminals are then connected and a voltmeter is connected across the other two terminals H_1 and X_B. Any convenient voltage is then applied to the high voltage winding of the transformer. If the voltmeter reads less than the value of the applied voltage, the polarity is subtractive and the terminals X_A & X_B may be marked as the X_2 and X_1 terminals, respectively.

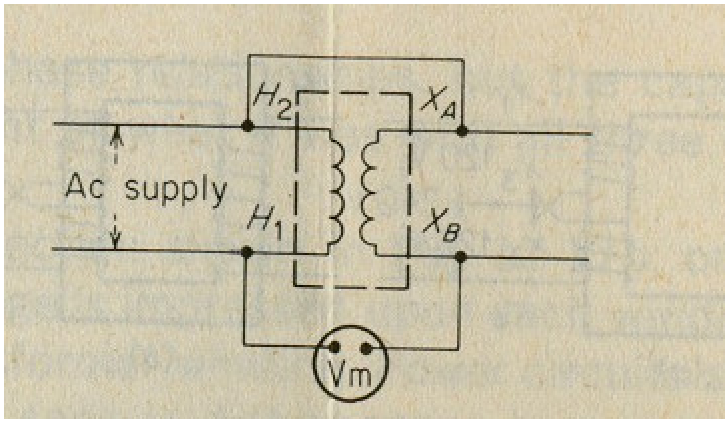


Figure 4: Connection for checking the polarity of a transformer

PROCEDURE

Finding out Turns Ratio:

1. Apply 220V AC to the primary of transformer T1 through autotransformer
2. Now measure Vs using voltmeter.
3. Now calculate turns ratio "a" and tabulate in observation column.
4. Repeat for transformer T2.

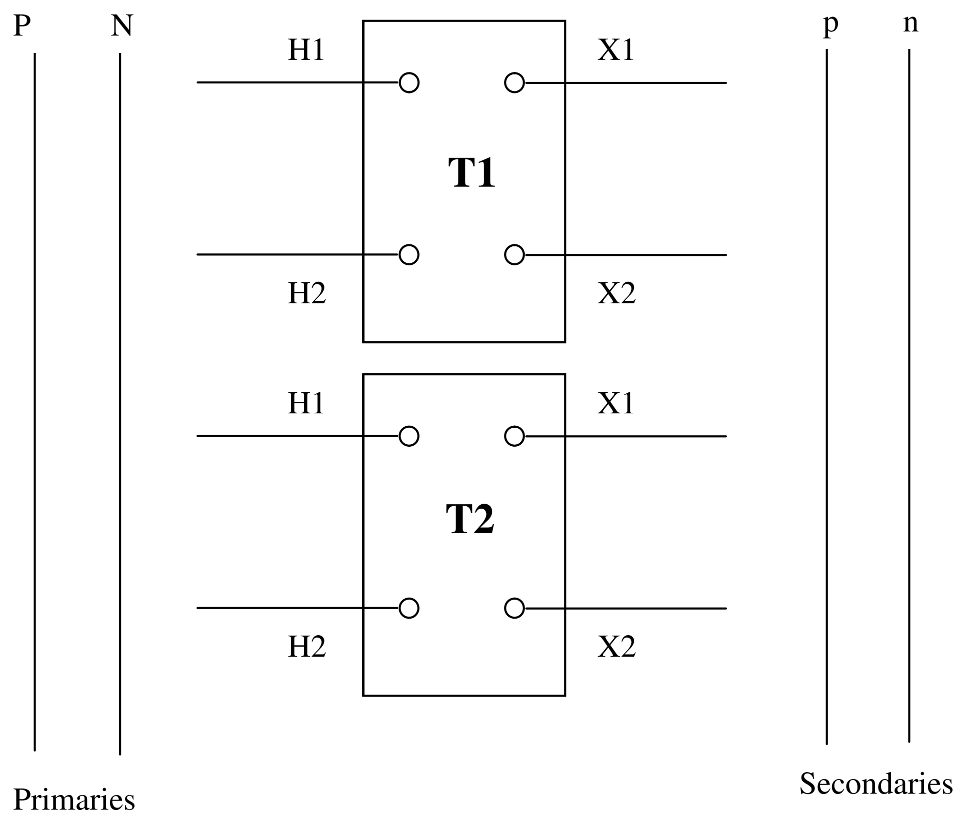
Finding out Turns Ratio:

1. Make connections according to the given circuit fig 4 for T1 and find out the polarity.
2. Make connections according to the given circuit fig 4 for T2 and find out the polarity.
3. Now connect the two transformers according to the figure 2.

OBSERVATION

The turns ratio for transformer T1 is found to be a= _____________
The turns ratio for transformer T2 is found to be a= _____________

Mark the dot (•) on the given two transformers, also connects the two with the buses using pencil.



RESULT:

The transformers ratio & polarity of the two transformers found out and parallel operation of single phase transformer fully understood.

EXERCISE:

Why must the transformer polarities be known when transformers are being connected for parallel operation?

____
____
____
____

In figure 1, there is no load connected except voltmeter, but some amount of current is flowing in the primary, why? What this current is called?

____
____
____
____

LAB SESSION 05

OBJECT

To find out the Cu losses and core losses of a single phase transformer by short circuit test.

APPARATUS

1. Voltmeter (0-15V)
2. Wattmeter (0-750)
3. Ammeter (0-15A)

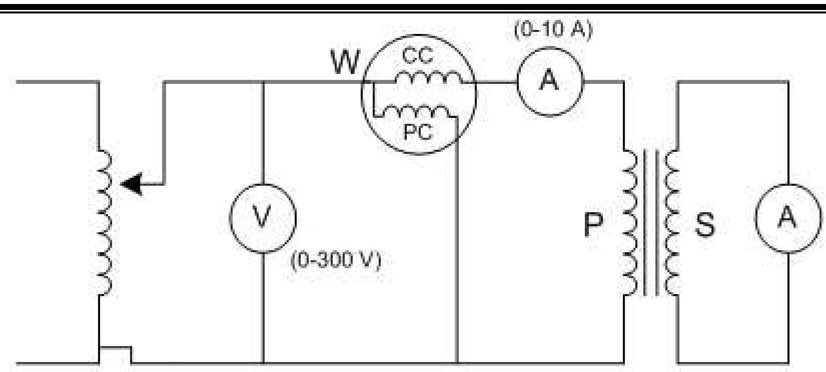


Figure: Transformer Short Circuit Test

THEORY

In this test one winding (usually low voltage winding) is short circuited by a thick conductor or by means of ammeter (Which may serve an additional purpose of indicating rated load). A low voltage (5-10% of the normal voltage) at normal frequency is applied to the primary and gradually increased, till full load current is flowing in both primary and secondary.

Since in this test the applied voltage is a small percentage of the normal voltage the mutual flux produced is also a small percentage of its normal value. Hence core losses are very small with the result that the wattmeter reading represents the full load copper loss.

PROCEDURE

1. Make connections according to the given circuit.
2. Connect primary of transformer with variable ac voltage supply.

3. Note down transformer rated current from name plate data and keep on increasing voltage until you get rated current read by Ammeter connected.
4. Once you get rated current at any specific voltage level, note down reading of instruments connected and calculate different parameters.

OBSERVATION

S.No	W (watts)	Vsc (Volts)	I_P (Ampere)	I_S (Ampere)

RESULT The copper losses of single phase transformer are__________ Watts

LAB SESSION 06

OBJECT

To find out the iron losses of single phase transformer (open circuit test).

APPRATUS

1. Voltmeter (0 – 300V)
2. Ammeter (0 – 2A)
3. Wattmeter (0 – 120 W)

CIRCUIT DIAGRAM

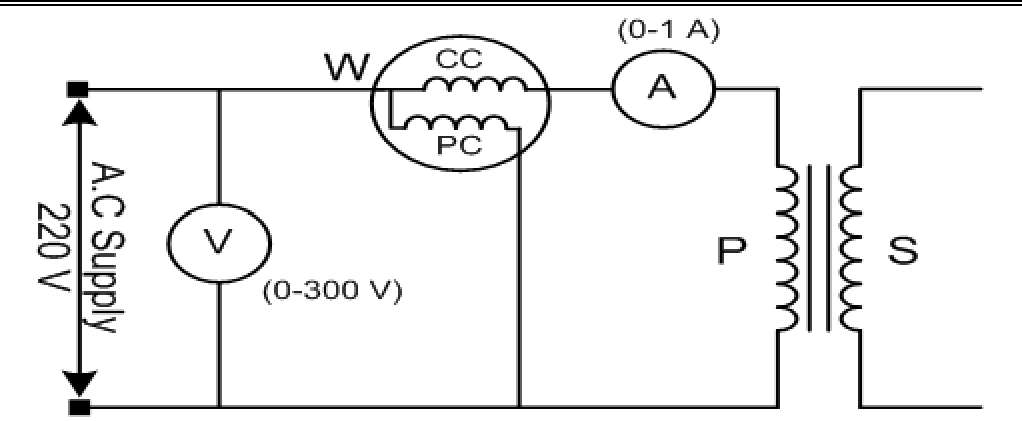


Figure: Transformer Open Circuit Test

THEORY

The purpose of this test is to determine no load loss or core loss and no load current Io which is helpful in finding Xo and Ro.

One winding of the transformer which ever is convenient but usually high voltage winding is left open and the other is connected to its supply of normal volt and frequency. A wattmeter, voltmeter and ammeter are connected in low voltage winding i.e. Primary winding in the present case. Normal voltage is applied to primary normal flux will be set up in the core hence normal iron loss will occur which are recorded by the wattmeter. As the primary no load I_o is small usually 2-10% of rated load current Cu losses is negligible small in primary I will in secondary b/c it is open. Therefore the wattmeter reading will show practically the core loss under no load condition.

OBSERVATIONS

S.No	W (watts)	V (Volts)	I_o (Ampere)

RESULT

The iron losses of single phase transformer are ___________ watt.

EXERCISE:
Answer the following questions:

Why do we perform short circuit & open circuit test on a transformer? What information we get?

____
____
____
____

Why do we apply rated voltage in open circuit test and below rated voltage in short circuit test?

____
____
____
____
____

Calculate the value of Xm, Rc, Req,p & Xeq,p from the observations table of Exp 5 & 6.
CALCULATIONS:

LAB SESSION 07

OBJECT

To find out the efficiency and voltage regulation of a single-phase step down transformer.

APPARATUS

1. Two Voltmeters (0 – 300V), (0 – 150V)
2. Two Ammeters (0 – 1A)
3. Step- down transformer
4. Variable load

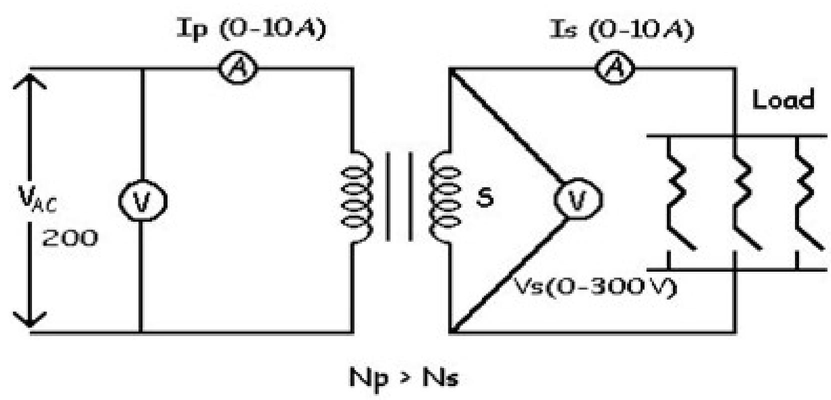


Figure: Transformer Voltage Regulation

THEORY

A step-down transformer transforms the high voltage at primary side to a lower voltage at the secondary side. It works on the principle of mutual induction i.e. the transformer secondary winding has an induced emf due to the change in voltage across the primary winding.

The efficiency of a transformer at a particular load and p.f is defined as the ratio between output power and input power.

$$\eta = (V_S I_S / V_P I_P) \times 100\ \%$$

When we increase load at the secondary terminals of a transformer, current drawn by transformer will increase. This increase in current will cause will increase in load dependant losses, Cu loss and leakage magnetic loss, hence causes decrease in output voltage. The change in secondary voltage from no load to full load with respect to no load voltage or with respect to full load voltage is called voltage regulation.

(Voltage Regulation) $\mathbf{VR = [(V_{SN} - V_{SL}) / V_{SN}] \times 100\ \%}$

PROCEDURE

1. Make the connections as shown in figure.
2. Switch on primary supply and read the no load secondary voltage.
3. Increase the load on the secondary side in steps
4. Following every step take reading.

OBSERVATION

No load secondary voltage V_{SN} = _______ Volts

S. No	V_P (Volts)	I_P (A)	V_S (Volts)	I_S (A)
1				
2				

CALCULATIONS

For First Load:

1. $\boldsymbol{\eta = (V_S I_S / V_P I_P) \times 100\%}$**=______________________________**

2. $\mathbf{VR = [(V_{SN} - V_{SL}) / V_{SN}] \times 100\%}$ **=_______________________________**

For Second Load:

1. $\boldsymbol{\eta = (V_S I_S / V_P I_P) \times 100\%}$**=______________________________**

2. $\mathbf{VR = [(V_{SN} - V_{SL}) / V_{SN}] \times 100\%}$ **=_______________________________**

RESULT

The efficiency and voltage regulation have been calculated and increase in both parameters is observed with increases in load.

LAB SESSION 08

OBJECT

Reading and explanation of the name plate data of DC & AC rotating machines.

APPARATUS

1. DC Motor
2. DC Generator
3. 3-Φ Induction Motor
4. 3-Φ Synchronous Motor
5. 3-Φ Synchronous Generator

THEORY

Name plate, is a sheet fixed on every electrical machine, shows the rated parameters. Rated parameters are the parameters on which machine perform at best efficiency. Therefore it is of immense importance to know about the rated parameters of any machines before putting it in operation. In addition to this, these parameters are also necessary for the further analysis like designing any controlling circuitry for that machine. Name plate data includes voltage, current, ambient temperature, number of poles, operating frequency, enclosure type, cooling employed, field current and voltage (in case of doubly excited machines/generator) etc.

PROCEDURE

- ✓ Check out name plate data of machines on different benches given below, installed at different benches.

1. NAME PLATE DATA OF DC MOTOR (Bench -):

1		**6**	
2		**7**	
3		**8**	
4		**9**	
5		**10**	

2. NAME PLATE DATA OF DC GENERATOR (Bench -):

1		**6**	
2		**7**	
3		**8**	
4		**9**	
5		**10**	

3. NAME PLATE DATA OF 3-Φ INDUCTION MOTOR (Bench -):

1		**6**	
2		**7**	
3		**8**	
4		**9**	
5		**10**	

4. NAME PLATE DATA OF 3-Φ SYNCHRONOUS MOTOR (Bench -):

1		**6**	
2		**7**	
3		**8**	
4		**9**	
5		**10**	

5. NAME PLATE DATA OF 3-Φ SYNCHRONOUS GENERATOR (Bench -):

1		**6**	
2		**7**	
3		**8**	
4		**9**	
5		**10**	

EXERCISE:

Suppose you are given the name plate of a typical induction motor.

1	**Frame**	**326T**	**7**	**Volts**	**460**
2	**Hp**	**50**	**8**	**Amps**	**61**
3	**Hertz**	**50**	**9**	**Phase**	**3**
4	**Insulation Class**	**F**	**10**	**Duty**	**Cont**
5	**Max Ambient**	**40 ° C**	**11**	**Temp Rise**	**70 ° C**
6	**RPM**	**1400**	**12**	**Nema Code**	**G (5.6-6.29)**

Answer the following questions:

What is the importance of mentioning frame size on name plate?

____

____

____

What do you understand by insulation class?

____

____

____

How many other insulation classes also exist? Give temperature ranges as well.

What do you understand by service factor?

____

____

____

From above name plate calculate the following data:

a) **The Three Phase Apparent Power** ____________________
b) **Torque Deliver (in N.m and lb.ft)** ____________________
c) **Starting KVA** ____________________
d) **Starting (Locked Rotor) Current** ____________________
e) **Maximum Allowable Continuous Load** ____________________
f) **Slip** ____________________

LAB SESSION 09

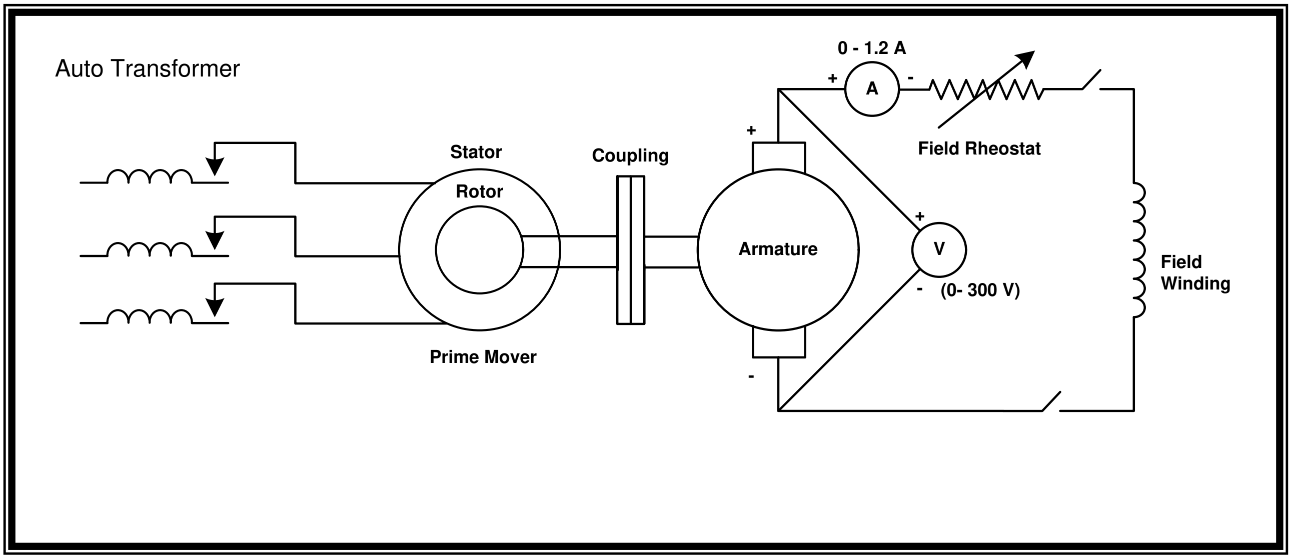
OBJECT

To draw the magnetization curve of self exited DC shunt generator (open circuit characteristics curve O.C.C).

APPARATUS

6. Bench 10-ES/EV or Bench 14-ES/EV
7. DC multi-range ammeter
8. DC multi-range voltmeter

CIRCUIT DIAGRAM



THEORY

The magnetization characteristics, also known as “No load” or “Open circuit” characteristics, is the relation between emf generated and field current at a given speed.

Due to residual magnetism in the poles, some emf is generated even when filed current is zero. Hence the curve starts a little way up. It is seen that the first part of the curve is practically straight. This is due the fact that at low flux densities reluctance of iron path is being negligible, total reluctance is given by air gap reluctance which is constant. Hence the flux and consequently the generated emf is directly proportional to exciting current. However at high flux densities iron path reluctance is being appreciable and straight relation between emf and field current no longer holds good. In other words saturation of poles starts.

PROCEDURE

1. Connect the shunt field to armature terminal through the ammeter, switch and rheostat.
2. Connect the multi-range voltmeter across the terminals of armature.
3. Press yellow switch "on" and increase AC voltage of induction motor (prime mover) by the help of 3-phase autotransformer until it reaches at normal speed.
4. Note the reading of voltmeter which indicates the voltage due to residual magnetism.
5. Close field switch and excite the field at low current.
6. Increase the field current in steps and note the voltage each time.
7. Take at least 11-12 readings.
8. Tabulate the reading and draw the curve between armature induced e.m.f and exciting current

OBSERVATIONS

S.No.	FIELD CURRENT 'I_F' (A)	TERMINAL VOLTAGE V_T (volts)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

RESULT

1. The curve starts somewhat above the origin. The voltage at zero excitation is due to residual magnetism of the field, which is necessary for building up the voltage of self-excitation generator.
2. The voltage increases rapidly at first and then changes a little in value at higher excitations indicating the effect of the poles saturation.

EXERCISE:
Answer the following questions:

What do you understand by "Self Excited"? If this is a self excited machine then why there is a need of supplying voltage to the auto transformer?

____

____

____

____

LAB SESSION 10

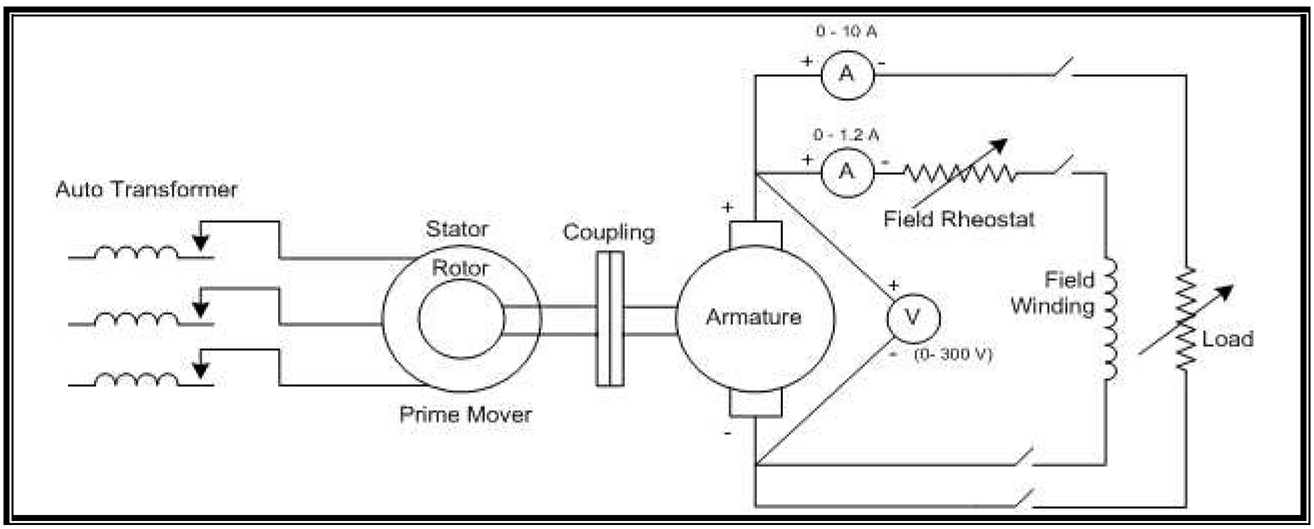
OBJECT

To draw the load characteristic curve of self excited D.C shunt generator.

APPARATUS

1. Bench 10-ES/EV or Bench 14-ES/EV
2. DC multi-range ammeter
3. DC multi-range voltmeter

CIRCUIT DIAGRAM



THEORY

Load characteristic curve is the graphical representation which shows change in terminal voltage with respect to change in load. After building up of voltage, if a shunt generator is loaded then terminal voltage drops with increase in load current. There are three main reasons for the drop of terminal voltage for a shunt generator under load.

i) Armature Reaction

Armature reaction is the effect of magnetic field set up by the armature current on the distribution of flux under main poles of a generator. Due to demagnetizing effect of armature reaction , pole flux is weakened and so induced e.m.f in the armature is decresed.

ii) Armature Resistance

As the load current increases, more voltage is consumed in ohmic resistance of armature circuit. Hence the terminal voltage (V_t=E–IaRa) is decreased where "E" is the e.m.f induced in armature under load condition.

iii) Drop In Terminal Voltage

The drop in terminal voltage (V_t) due to armature resistance and armature reaction results in decreased field current, which further reduces e.m.f induced.

For a shunt generator

$$Ia = I_L + I_f$$

$$E = V_t + IaRa$$

PROCEDURE

1. Make the connections as shown in circuit diagram.
2. Press yellow switch "on" and increase AC voltage of induction motor (prime mover) by the help of 3-phase autotransformer until it reaches at normal speed.
3. When motor reaches rated speed, close the shunt field switch.
4. Increase field current by changing the field resistance until the terminal voltage reaches to 220 volt.
5. Close the switch of load and vary the load current by means of load rheostat.
6. Note down the meter readings from all meters carefully.

OBSERVATIONS

S.No	I_f(A)	I_L(A)	V_T(V)	$I_a=I_f+I_L$	$V_d=I_aR_a$ Ra=0. 5 ohm
1					
2					
3					
4					
5					
6					
7					
8					

RESULT

The terminal voltage of a D.C. generator is maximum at no load, which decreases with increasing load.

LAB SESSION 11

OBJECT

To draw the external and internal characteristics of separately excited DC generator.

APPARATUS

1. Bench 10-ES/EV or Bench 14-ES/EV
2. DC multi-range ammeter
3. DC multi-range voltmeter

CIRCUIT DIAGRAM

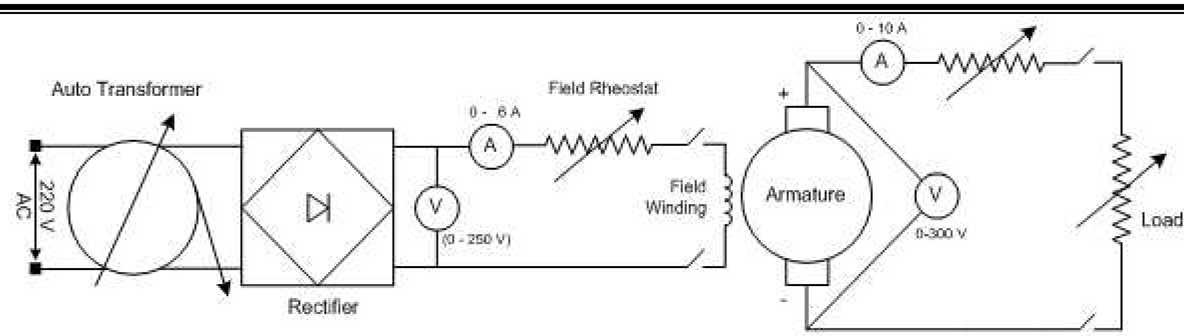


Figure: Separately Excited DC generator

THEORY

The load or external characteristic of a generator is the relation between the terminal voltage and load current. The characteristic expressed the manner in which the voltage across the load varies with I, the value of load current. The internal or total characteristic of a generator is the relation between the e.m.f actually induced in the generator E_a and the armature current I_a. The internal characteristic of the generator, which is separately excited, can be obtained as below:

Let:

V_t = Terminal voltage, I_a = Armature current, R_a = Armature resistance

Then,

$$E_a = V_t + I_aR_a$$
$$I_a = I_L$$

Therefore if we add drop of armature (I_aR_a) to terminal voltage V_t we get actually induced e.m.f (E_a).

PROCEDURE

1. Make the circuit as shown in circuit diagram.
2. Press yellow switch "on" and increase AC voltage of induction motor (prime mover) by the help of 3-phase autotransformer until it reaches at normal speed.
3. When motor reaches rated speed, close the shunt field switch.
4. Increase field current by changing the field resistance until the terminal voltage reaches to 220 volt.
5. Close the switch of load and vary the load current by means of load rheostat.
6. Note down the meter readings from all meters carefully.

OBSERVATIONS

S.No	I_L(A)	I_f(A)	V_T(V)	$E_a = V_t + I_aR_a$ (V)
1				
2				
3				
4				
5				
6				
7				
8				

RESULT

From the graph it is observed that the terminal voltage across generator decreases as the load increases.

LAB SESSION 12

OBJECT

Speed control of a DC shunt motor by flux variation method.

APPARATUS

1. Bench 13-ES/EV or Bench 15-ES/EV
2. DC multi-range ammeter
3. DC multi range voltmeters
4. Digital tachometer

CIRCUIT DIAGRAM

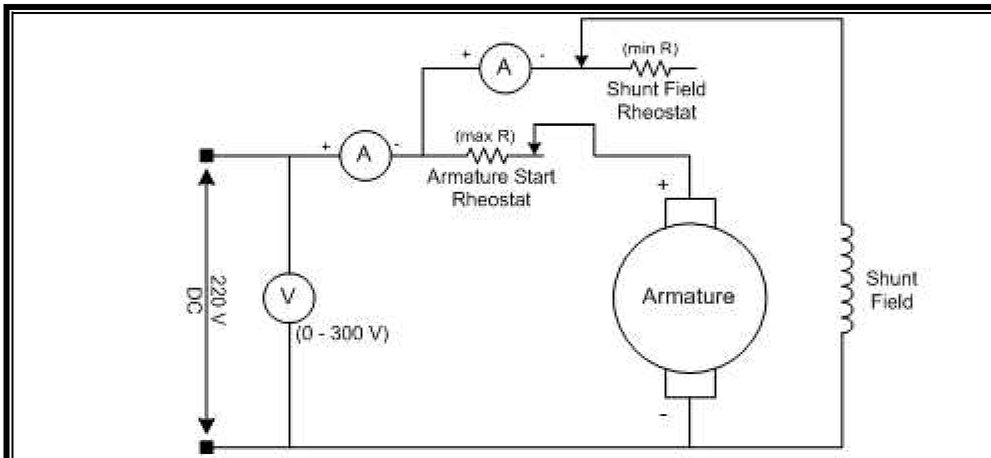


Fig: DC Shunt Motor

THEORY

This method is used to increase speed of DC motor above base speed.To understand what happens when the field resistance of dc motor is changed, assume that the field resistance is increased then the following sequence of cause and effect will take place

1. Increasing R_f causes I_f to decrease

2. Decreasing I_f Decreases φ

3. Decreasing φ lowers Ea

4. Decreasing Ea Increases Ia

5. Increasing Ia increases T_{ind}

6. Increasing T_{ind} makes $T_{ind} > T_{load}$, hence speed increases.

7. Increasing speed increases Ea

8. Increasing Ea decreases Ia

9. Decreasing Ia decrease T_{ind} until $T_{ind} = T_{load}$ at higher speed.

Naturally decreasing R_f would reverse the whole process and speed of motor will decrease. It is important to bear in mind, changing field resistance does not effect torque induced ,at the end its magnitude remains same but at higher or lower speed depending upon change in resistance.

PROCEDURE

1. Make connections as shown in the circuit.
2. Keep the motor starting rheostat at its maximum position and field rheostat at its minimum position while starting motor.
3. Start the motor by pressing yellow switch "ON" without load.
4. Adjust the motor start rheostat to its minimum value.
5. Decrease field current by the help of field rheostat step by step and take readings of field current and speed from digital tachometer at every step. Adjust the field rheostat to give maximum speed at which it is safe to operate the motor.

OBSERVATIONS

S. No	Field Current	Speed
	If(A)	N (RPM)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

RESULT

Speed increases as the field excitation decreases.

EXERCISE:

Answer the following questions:

Why do we set the armature rheostat at maximum and field rheostat at minimum?

____

____

____

____

____

____

After starting motor, why do we set the Ra to its minimum?

____

____

____

____

LAB SESSION 13

OBJECT
Speed control of a D.C. Shunt Motor by armature rheostatic control method.

APPARATUS

1. Bench 13-ES/EV or Bench 15-ES/EV
2. DC multi-range ammeter
3. Voltmeters
4. Digital tachometer

CIRCUIT DIAGRAM

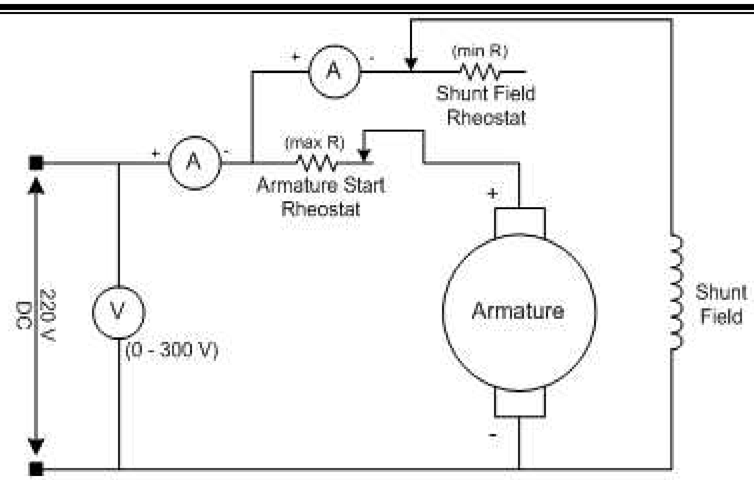


Fig: DC Shunt Motor

THEORY

This method is used to decrease speed of DC motor below base speed. To understand what happens when the armature resistance of DC motor is changed, assume that the armature resistance is increased then the following sequence of cause and effect will take place

1. Increasing R_a causes Ia to decrease
2. Decreasing Ia deccreases T_{ind}
3. Decreasing T_{ind} makes $T_{ind} < T_{load}$, hence speed decreases.

4. Decreasing speed decreases Ea
5. Decreasing Ea increases Ia again.
6. Increasing Ia increases T_{ind} until $T_{ind} = T_{load}$ at lower speed.

Naturally decreasing Ra would reverse the whole process and speed of motor will increase. It is important to bear in mind, changing armature resistance does not effect torque induced ,at the end its magnitude remains same but at higher or lower speed depending upon change in resistance.

PROCEDURE

1. Make connections as shown in the circuit.
2. Keep the motor starting rheostat at its maximum position and field rheostat at its minimum position while starting motor.
3. Start the motor by pressing yellow switch "ON" without load.
4. Adjust the motor start rheostat to its minimum value.
5. Increase the value of starting resistance by the help of motor start rheostat step by step and take readings of voltage across armature and speed from digital tachometer at every step.

OBSERVATIONS

S. No	Armature Voltage	Speed
	Va(V)	N (RPM)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

RESULT

Speed is very nearly proportional to the applied voltage in the case of armature control method.

LAB SESSION 14

OBJECT

To study the effect of field excitation on the generation of voltage by an alternator (open circuit magnetization curve)

APPARATUS

1. Bench 12 ES/EV or Bench 13-ES/EV
2. DC multi-range ammeter
3. AC Voltmeter
4. Frequency meter

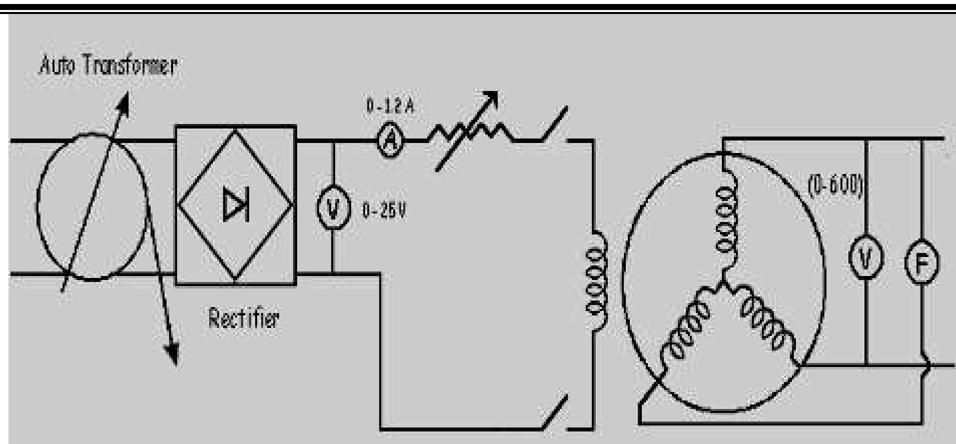


Figure: Alternator

THEORY

A.C generator (alternator), consists of two parts, namely the field system and an armature, but unlike a dc generator, alternator has rotating field system and an stationary armature, advantages of such system are given below. An excitation sysyem is attached to give dc supply to the field.

The advantages of rotating field and stationary armature are:

- Rotating field can run with high speed as output voltage is dependent on its rate.
- It is easy to insulate the stationary armature windings for high voltages.

- It is easy to collect the high voltage from a fixed terminal.
- Stator is outside of the rotor (fixed in yoke), so more space is available for 3-phase winding.

PROCEDURE

1. Make the connections as shown in figure
2. Excite the field with DC source
3. Adjust frequency of output to 50 Hz by adjusting speed of prime mover.
4. Nom increase the dc excitation current in steps.
5. Tabulate the readings after every step and draw the open circuit characteristics (O.C.C) or no load magnetization curve.

OBSERVATION

S. No	Rotor Field Excitation Current (I_f)	Terminal Voltage (V_t)
	Amperes	Volts
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

RESULT

Voltage increases directly for low exciting current and the curve then bends at higher excitation indicating the effect of saturation.

LAB SESSION 15

OBJECT

To observe the starting of three phase Synchronous and Induction motor

APPARATUS

1. 3-Φ Synchronous motor
2. 3-Φ Induction motor
3. Variable 3-Φ AC supply
4. DC Supply
5. Techometer

THEORY

To understand how the induction motor works, apply the three phase ac supply on stator of IM. The application of three-phase ac power causes a rotating magnetic field to be set up around the rotor. The voltages are induced on the rotor bars(short circuited at both ends), developing its own field. Both fields interact with each other causing the rotor to move at speed less than the synchronous speed. The reversal of any two applied phases causes the rotating magnetic field to rotate in opposite direction (w.r.t. to previous one). In this fashion an Induction motor works

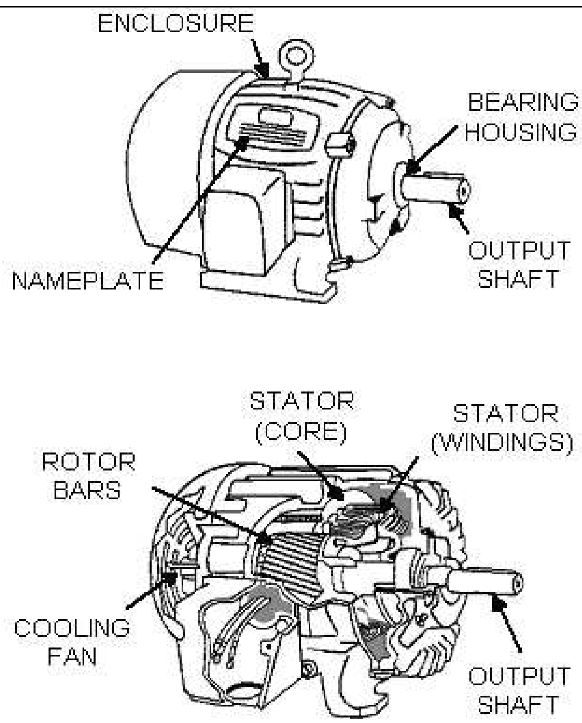


Figure: Induction Motor

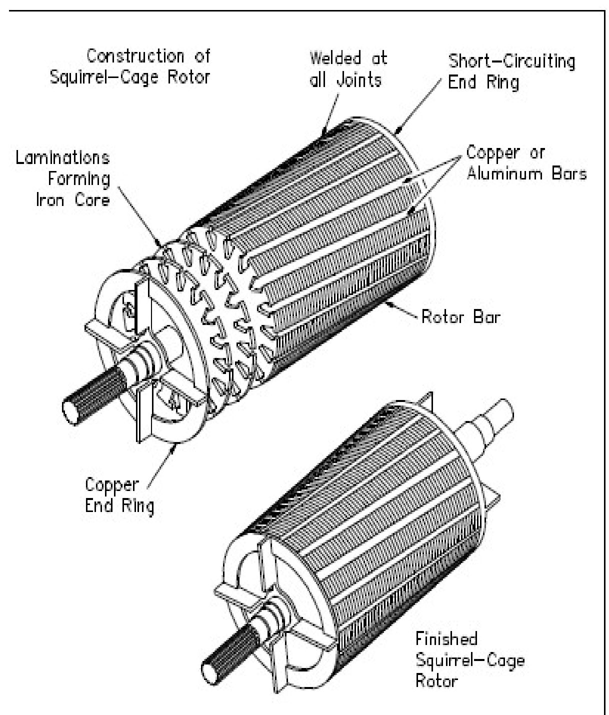


Figure: Induction Motor's Rotor

To understand how the synchronous motor works, assume that the application of three-phase ac power to the stator causes a rotating magnetic field to be set up around the rotor. The rotor is energized with dc (it acts like a bar magnet). The strong rotating magnetic field attracts the strong rotor field activated by the dc. This results in a strong turning force on the rotor shaft. The rotor is therefore able to turn a load as it rotates in step with the rotating magnetic field. It works this way once it's started.

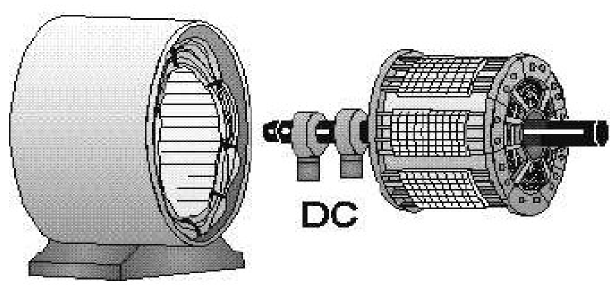


Figure: Synchronous Motor

However, one of the disadvantages of a synchronous motor is that it cannot be started from a standstill by applying three-phase ac power to the stator and dc to its rotor. When ac is applied to the stator, a high-speed rotating magnetic field appears immediately. This rotating field rushes past the rotor poles so quickly that the rotor does not have a chance to get started. In effect, the rotor is repelled first in one direction and then the other. A synchronous motor in its purest form has no starting torque. It has torque only when it is running at synchronous speed. A squirrel-cage type of winding is added to the rotor of a synchronous motor to cause it to start. The squirrel cage is shown as the outer part of the rotor in figure. It is so named because it is shaped and looks something like a turn able squirrel cage. Simply, the windings are heavy copper bars shorted.

Hence, three phase synchronous motor is not self started. At the starting time, it behaves as induction motor and gets accelerated. Once it approaches speed near to synchronous speed, its rotor winding is excited then synchronous motor start rotating at synchronous speed. If we have given rotor supply at start, motor will just produce humming sound.

PROCEDURE

For Induction Motor:

1. Make the circuit and switch on three phase ac supply and observe the performance.
2. Now reverse any of the two phases and verify double field revolving thery.

For Synchronous Motor:

1. Make the circuit and switch on both ac and dc supply and observe the performance.
2. Disconnect dc supply, switch on ac supply and observe the performance.
3. When motor run near to synchronous speed, which already calculated, switch on dc supply also and observe the behavior.

OBSERVATIONS:

Speed of Induction Motor:__________rpm

Calculate:

Slip speed =

Slip =

Speed of Synchronous Motor =___________rpm

EXERCISE:

Answer the following questions:

Why Induction motors have high starting current?

____
____
____
____

Write three differences between Induction & Synchronous motor.

____
____
____
____
____
____
____