# SNS COLLEGE OF ENGINEERING

**COIMBATORE - 641107**

**DEPARTMENT OF EEE**

**Academic year 2022-2023 (Even Semester)**

**Regulation 2019**

**19EE407 - ELECTRICAL MACHINES AND DRIVES LABORATORY**

Name :

Register Number :

Degree / Branch : B.E. / MECH

Year / Semester : II / 04

# DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Name : ......................................................................

Register Number : ......................................................................

Degree & Branch : ......................................................................

Year / Semester : ......................................................................

*Certified that this is the bonafide record of work done by Mr. / Ms.............................................................................................. in the* **19EE407 ELECTRICAL MACHINES AND DRIVES LABORATORY** *during the academic year 2022- 2023.*

Signature of Faculty In-Charge with date

Signature of Head of the Department with date

Submitted for the University Practical Examination held on .................................

**Internal Examiner**

**External Examiner**

## GENERAL INSTRUCTIONS FOR LABORATORY CLASSES

- Students must wear lab uniform for all laboratory sessions.
- Closed foot wear must be worn inside the laboratory.
- Avoid wearing fashion accessories like chains, rings, etc inside the laboratory.
- Long hair must be properly secured and not let loose while working near the rotating machineries.
- Students must not operate any other machines or equipments other than the prescribed ones.
- Avoid leaning or going too close to the rotating components in the laboratory.
- Instruments / meters/ tools/ gauge sets, etc., must be duly returned to the lab technician before leaving the laboratory.
- Prepare for the viva-voce before coming to the lab.
- Diagram, tabulations, model calculations, model graphs, etc, should be neatly tabulated in the left side of the record.
- Graphs and figures drawn in a separate sheet in special cases must be neatly and firmly pasted on to the record.
- Completed records must be submitted in the next laboratory session.
- Experiment number with date must be written in the top left corner.

# 19EE309 – ELECTRICAL MACHINES AND POWER SYSTEM

**OBJECTIVES**:

- To provide hands on experience with motors.
- To Understand the working of DC/AC motors
- To learn the use of transformer
- To understand how the starters are working.

**LIST OF EXPERIMENTS:**

1. Load test on DC Shunt motor.
2. Load test on three phase Induction Motor.
3. Speed control of DC shunt motor.
4. Study of DC and AC Starters.
5. Speed Control of DC Motor using Solid State Controlled Rectifier Drive.
6. Speed Control of Three Phase Induction Motor using Solid State Controlled Inverter Drive.

**OUTCOMES:**

**At the end of the course, the student will be able to:**

- Demonstrate the working principle of DC motors with speed control.
- Identify the parts of transformers
- Demonstrate the induction motor on various loads with speed control
- Perform experiments to study the load characteristics of DC motors / Induction motors.

# INDEX

| EX. NO. | DATE | NAME OF EXPERIMENT | PAGE NO. | MARKS | SIGNATURE |
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## CIRCUIT DIAGRAM OF LOAD CHARACTERISTICS OF DC SHUNT MOTOR

| Ex. No: | LOAD CHARACTERISTICS OF D.C. SHUNT MOTOR |
|---|---|
| DATE: | |

**AIM:**

To conduct the load test on a given DC shunt motor and to draw its performance curves.

**FUSE RATING:**

125 % of rated current

**APPARATUS REQUIRED:**

| S.NO. | NAME OF THE APPARATUS | TYPE | RANGE | QUANTITY |
|---|---|---|---|---|
| 1 | Ammeter | MC | 0-30A | 1 |
| 2 | Voltmeter | MC | 0-300V | 1 |
| 3 | Rheostat | Wire wound | 360Ω,1.2A | 1 |
| 4 | Tachometer | Digital | - | 1 |

**FORMULAE:**

1. Torque $T= (S_1 \sim S_2) * (R + t/2) * 9.81$ N-m

Where R= Radius of the brake drum in m

t= Thickness of the belt in m

$S_1$, $S_2$ = spring balance reading in Kg

2. Input power = $V_L * I_L$ in Watts

Where $V_L$ = Line Voltage in Volts $I_L$ = Line current in amps

3. Output power = $(2\pi NT) / 60$ in watts

Where N= speed of the armature in rpm

T= Torque in N-m

4. Percentage of Efficiency = (output power/ input power) x 100 in %

**PRECAUTIONS:**

1. The motor field rheostat should be kept at minimum resistance position at the time of starting the motor
2. At the time of starting, the motor should be in no load condition

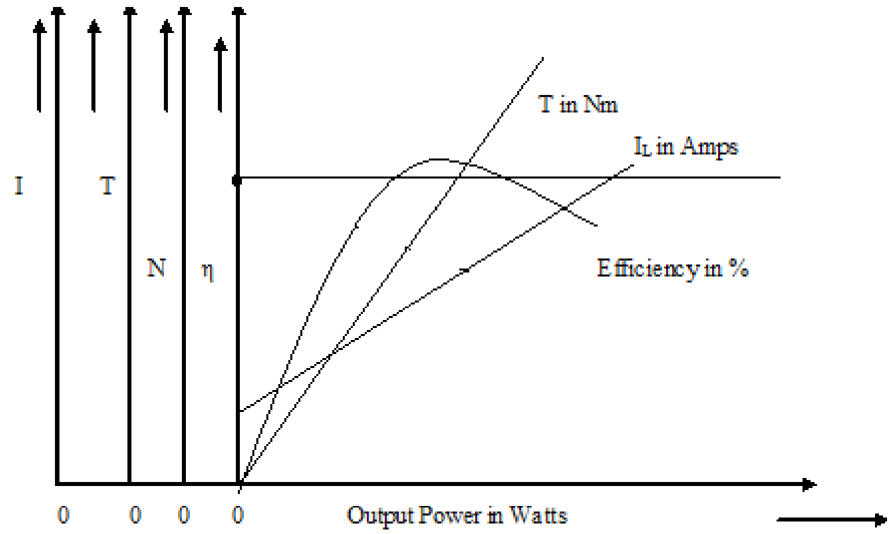
# TABULATION OF LOAD CHARACTERISTICS OF D.C. SHUNT MOTOR

Radius of the drum = .............m Thickness of the belt =………… m

| S. No. | Line current ($I_L$) In mps | Line voltage ($V_L$) In volts | Speed (N) In RPM | Spring balance | | | Torque (T) In Nm | Output power (Po) In watts | Input power (Pi) In watts | Efficiency (η) In % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $S_1$ | $S_2$ | $S_1 \sim S_2$ | | | | |
| | | | | | | | | | | |

## MODEL GRAPH

## ELECTRICAL CHARACTERSTICS



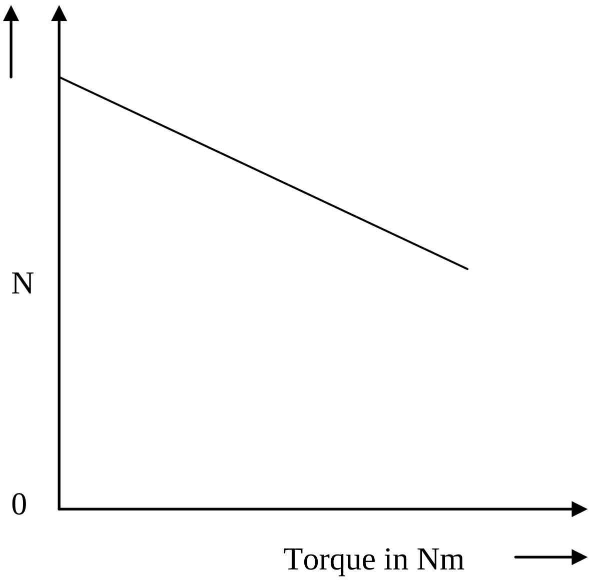
**PROCEDURE:**

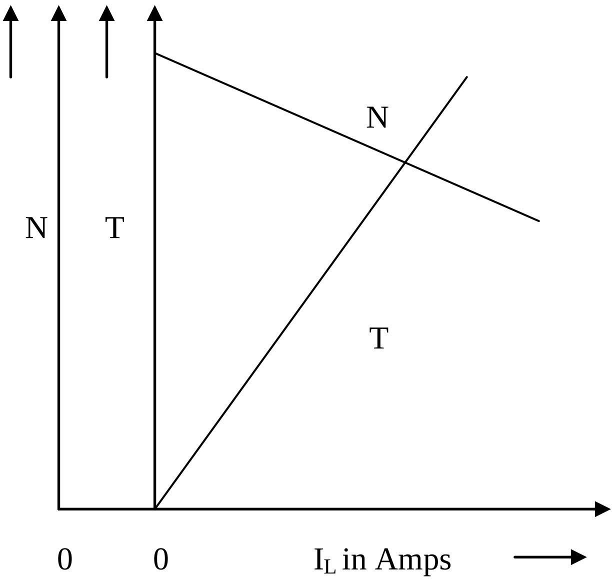
1. Connections are given as per the circuit diagram
2. Using the three point starter the motor is started to run at the rated speed by adjusting the field rheostat if necessary
3. The meter readings are noted at no load condition
4. By using the brake drum with spring balance arrangement the motor is loaded and the corresponding readings are noted up to the rated current
5. After the observation of all the readings the load is released gradually
6. The motor is switched off by using the DPST switch.

**VIVA QUESTIONS:**

1. Why a DC shunt motor is called a constant Speed motor?
2. What is the role of commutator in a DC motor?
3. What is the effect of armature reaction on the performance of DC motor?
4. What happen when the field circuit gets opened when a DC shunt motor is running?
5. How to reverse the direction of rotation of DC motor?
6. What is the working principle of DC Motor?
7. What is DC Shunt Motor?
8. List the important parts of a DC machine.
9. For DC Shunt motor, Which Starters to be used?

**MECHANICAL CHARACTERSTICS**




**MODEL CALCULATION:**

10. Where we can use the DC shunt motor?

11. Why we have to use DC shunt motor for some specified application?

12. Why the Motor Field Reheostat shoud be kept in Minimum position?

**RESULT:**

Thus the load test on a given DC shunt motor was conducted and its performance characteristics were drawn.

## CIRCUIT DIAGRAM OF SPEED CONTROL OF DC SHUNT MOTOR

| Ex. No: | SPEED CONTROL OF DC SHUNT MOTOR |
|---|---|
| DATE: | |

**AIM:**

To conduct an experiment to control the speed of the given DC shunts motor by field and armature control method and to draw its characteristic curves.

**FUSE RATING:**

**No load**: 10 % of the rated current **Load**: 125% of rated current

**APPARATUS REQUIRED:**

| S.NO | Name of the apparatus | Type | Range | Quantity |
|---|---|---|---|---|
| 1 | Ammeter | MC | 0-2A | 1 |
| 2 | Voltmeter | MC | 0-300V | 1 |
| 3 | Rheostat | Wire wound | 360Ω,1.2A | 1 |
| 4 | Rheostat | Wire wound | 40Ω,5A | 1 |
| 5 | Tachometer | Digital | - | 1 |

**PRECAUTIONS:**

1. The motor field rheostat should be kept at minimum resistance position
2. The motor armature rheostat should be kept at maximum resistance position.
3. The motor should be in no load condition throughout the experiment

**PROCEDURE:**

**FIELD CONTROL METHOD (FLUX CONTROL METHOD)**

1. Connections are given as per the circuit diagram
2. The armature rheostat is adjusted to run the motor at rated speed by means of applying the rated voltage.
3. The field rheostat is varied gradually and the corresponding field current and speed are noted up to 120% of the rated speed by keeping the armature voltage constant.
4. The motor is switched off using the DPST switch after bringing all rheostats to their initial position.

**TABULATION OF FIELD CONTROL METHOD**

| S.NO | Armature voltage = ..............v | | Armature voltage = ..............v | |
|---|---|---|---|---|
| | Field current in amps | Speed in rpm | Field current in amps | Speed in rpm |
| | | | | |

**TABULATION OF ARMATURE CONTROL METHOD**

| S.NO | Field current =..............A | | Field current =..............A | |
|---|---|---|---|---|
| | Armature voltage in volts | Speed in rpm | Armature voltage in volts | Speed in rpm |
| | | | | |

**ARMATURE CONTROL METHOD (VOLTAGE CONTROL METHOD)**

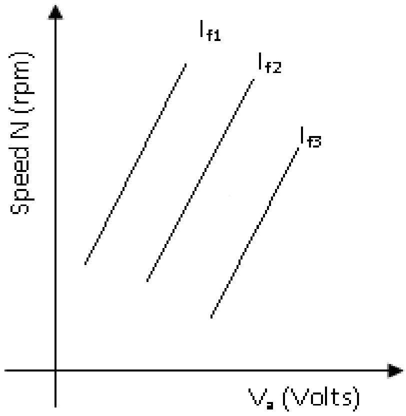
1. Connections are given as per the circuit diagram.
2. The armature rheostat is adjusted to run the motor at rated speed by means of applying the rated voltage
3. The armature rheostat is varied gradually and the corresponding armature voltage and speed are noted up to the rated voltage.
4. The motor is switched off using the DPST switch after bringing all the rheostats to their initial position

**VIVA QUESTIONS:**

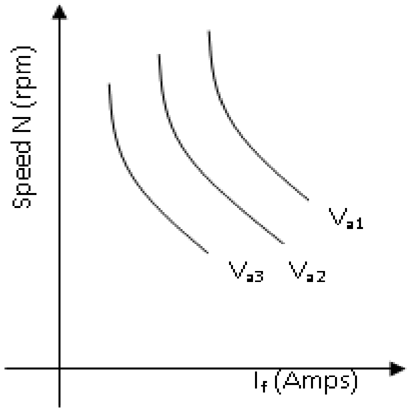
1. Which method of speed control is used for controlling the speed of the motor above its rated speed? Give reason.
2. Which method of speed control is used for controlling the speed of the motor below its rated speed? Give reason.
3. Write the expression for speed of a DC motor.
4. What are the functions of brushes and bearing in a DC machine?
5. Explain the reasons for the shape of the graphs obtained.
6. State any method to control the speed of a D.C series motor?
7. Why the Motor Armature Reheostat shoud be kept in Maximum position?
8. Why the speed control is important in a DC Motors?

## MODEL GRAPH

**ARMATURE CONTROL**




**FIELD CONTROL**



**RESULT:**

Thus the speed control of the given DC shunt motor by field and armature control method was conducted and also its characteristic curves were drawn.

**CIRCUIT DIAGRAM OF LOAD TEST ON THREE PHASE INDUCTION MOTOR**

| Ex. No: | LOAD TEST ON THREE PHASE INDUCTION MOTOR |
|---|---|
| DATE: | |

**AIM:**

To conduct the load test on the given 3 phase induction motor and draw its performance characteristics.

**APPARATUS REQUIRED:**

| S.NO | APPRATUS | RANGE | TYPE | QUANTITY |
|---|---|---|---|---|
| 1 | Voltmeter | (0-600)v | MI | 1 |
| 2 | Ammeter | (0-10)A | MI | 1 |
| 3 | Watt meter | 600V,10A | UPF | 2 |
| 4 | Tachometer | - | Digital | 1 |

**PRECAUTIONS:**

Before switching on the supply

1. The induction motor should not be on no load on side.

**FORMULA USED:**

(i)Torque T= (S1~S2) x rx9.81 in Nm

r- Radius of the brake drum

(ii)Output power ($P_o$)=2ΠNT/60 in watts

(iii)Input power ($P_i$)=W1+W2 in watts

(iv)Efficiency (η)=Po/Pi*100 in %

(v)slip=(Ns-N/Ns)*100 in %

(vi)Power factor (cosφ)=Pi/√3$V_L I_L$

**PROCEDURE:**

1. Circuit connections are given as per the diagram.
2. After closing the TPST switch motor is started by using star-delta starter.
3. Note down the no load reading of $V_1$, I1, W1, W2, S1, S2 and N.
4. By applying load take different readings till the current reaches 120% of the rated current.
5. Using the formula ,efficiency ,torque, power factor and slips are calculated and curves are plotted,

## TABULATION OF LOAD TEST ON THREE PHASE INDUCTION MOTOR

| S. No | $V_L$ (V) | $I_L$ (A) | Spring readings | | | N (rpm) | watt meter (w) | | Input power (pi) | T Nm | output power (po) | PF | S (%) | Efficiency (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | S1 (Kg) | S2 (Kg) | S1~S2 (Kg) | | W1 | W2 | | | | | | |
| | | | | | | | | | | | | | | |

**MODEL GRAPH:**

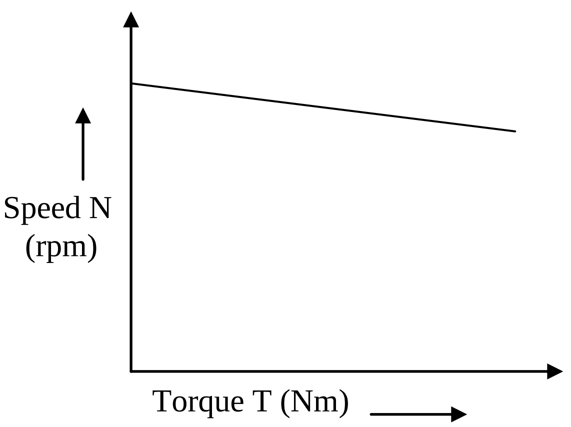



**Fig.2: Mechanical Characteristics**

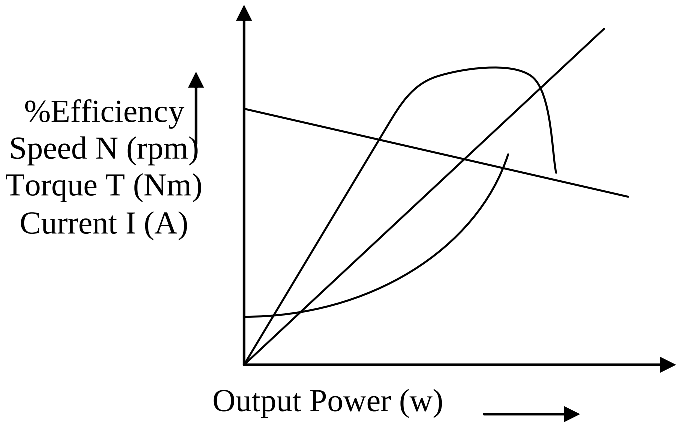



**Fig.3: Performance Characteristics**

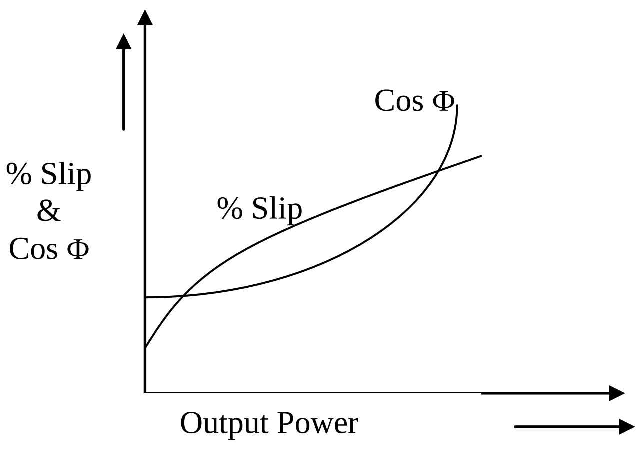



**Fig.4: Power factor and Slip Characteristics**

**VIVA QUESTIONS**

1. What is squirrel cage induction motor?
2. What is the normal range of no load current of an induction motor?
3. Distinguish between rotating transformer and static transformer?
4. Define slip.
5. Draw the torque- slip Characteristics of an Induction motor.
6. What are the different types of starter to be used in three phase induction motors?

**MODEL CALCULATION:**

**RESULT:**

Thus the load test on three phase induction motor was performed and performance curve were drawn.

| Ex. No: | STUDY OF AC and DC STARTERS |
|---|---|
| DATE: | |

**AIM:**

To study about the various AC and DC Starters.

**INTRODUCTION:**

1. The three phase induction motors are self starting. It Works on the principle of transforming works similar to a three phase transformer. The rotor current under running condition is $I_{2r} = SE_2 / (R^2 + (SX_2)^2)^{1/2}$
2. The $I_{2r}$ directly depends on the slip of the motor. The slip at starting condition is equal to unity. Also as rotor conductors are started. High current flows at rotor side which is 5 to 8 times of rated current. This is similar to a transformer short circuited at the secondary side.
3. As the secondary current increase the stator current also increase so high current flow through the whole motor circuit. This may damage the motor. To avoid the above condition to reduce the starting torque current various types of startes are used

    i. Stator resistance starter
    ii. Rotor resistance starter
    iii. Auto transformer starter
    iv. Star-delta starter
    v. Direct online starter

## STATOR RESISTANCE STARTER:

**Operation:**

1. The resistance of the starter is gradually reduced as a result of the current is slowly increased so the motor starts running.
2. When motor runs at the high speed the resistance are in zero ON position

**Advantages:**

a) Simple connection

b) Cheap in costive

c) It can be used for both star and delta connected starter

**Disadvantage:**

a) Starting torque reduced

b) High power loss

c) More heat produced

d) Size of rheostat is very big

## ROTOR RESISTANCE STARTER:

**Operation:**

Initially the resistance rotor is kept at maximum position. When the motor gathers speed is gradually cutoff. This process may be automatic (or) manual.

**Advantages:**

a) Starting torque is increased as rotor resistance is directly proportional to starting torque.

b) Starting current of rotor is much reduced.

**Disadvantages:**

a) It cannot be used in squirrel cage rotor type.

## AUTO TRANSFORMER STARTERS:

**Operation**:

This starter has a three phase auto transformer so it is called as autotransformer starter. The applied voltage is reduced autotransformer and it is gradually increased. When the motor gathers 80% of normal speed the switched is on to run position from initial start position.

This change can be done automatically and by manual control.

**Advantages:**

a. Power loss is much lesser.

b. It can be used for both star or delta connected load.

**Disadvantages:**

a. It is costlier than starter resistance

## STAR DELTA STARTERS:

**Operation:**

When the switch is in star position, the windings are star connected so 1/3 times of full voltage.

**Advantages:**

a. Cheap

b. No maintenance required.

## DIRECT ONLINE STARTERS:

**Operation:**

This types of starters are used for the power rating less than 5 HP motors. Which can withstand high starting current without starter. When the switch is pushed form NC to NO it will get energized hence supply is connected to the stator winding. When NC is processed the will deenergized hence motor stopped.

**Advantages:**

a. Provide protection from various source abnormal conditions like over loading low voltage single phasing etc.

b. Cheap when compared to other starters

**Disadvantages:**

**a.** Not applicable for high power motors.

## INTRODUCTION TO DC MOTOR STARTERS

The starting of DC motor is somewhat different from the starting of all other types of electrical motors. This difference is credited to the fact that a dc motor unlike other types of motor has a very high starting current that has the potential of damaging the internal circuit of the armature winding of dc motor if not restricted to some limited value. This limitation to the starting current of dc motor is brought about by means of the starter. Thus the distinguishing fact about the starting methods of dc motor is that it is facilitated by means of a starter. Or rather a device containing a variable resistance connected in series to the armature winding so as to limit the starting current of dc motor to a desired optimum value taking into consideration the safety aspect of the motor.

**THREE POINT STARTER:**

A 3 point starter in simple words is a device that helps in the starting and running of a shunt wound DC motor or compound wound DC motor. Now the question is why these types of DC motors require the assistance of the starter in the first case. The only explanation to that is given by the presence of back emf $E_b$, which plays a critical role in governing the operation of the motor. The back emf, develops as the motor armature starts to rotate in presence of the magnetic field, by generating action and counters the supply voltage. This also essentially means, that the back emf at the starting is zero, and develops gradually as the motor gathers speed.

The general motor emf equation $E = E_b + I_a.R_a$,

at starting is modified to $E = I_a.R_a$ as at starting $E_b = 0$.

$$\therefore\ I_a = \frac{E}{R_a}$$

Thus we can well understand from the above equation that the current will be dangerously high at starting (as armature resistance $R_a$ is small) and hence its important that we make use of a device like the 3 point starter to limit the starting current to an allowable lower value.

Let us now look into the construction and working of three point starter to understand how the starting current is restricted to the desired value. For that let’s consider the diagram given below showing all essential parts of the three point starter.

**Construction Of 3 Point Starter**

Construction wise a starter is a variable resistance, integrated into number of sections as shown in the figure beside. The contact points of these sections are called studs and are shown separately as OFF, 1, 2,3,4,5, RUN. Other than that there are 3 main points, referred to as

1. 'L' Line terminal. (Connected to positive of supply.)
2. 'A' Armature terminal. (Connected to the armature winding.)
3. 'F' Field terminal. (Connected to the field winding.)

And from there it gets the name 3 point starter.

Now studying the construction of 3 point starter in further details reveals that, the point 'L' is connected to an electromagnet called overload release (OLR) as shown in the figure. The other end of 'OLR' is connected to the lower end of conducting lever of starter handle where a spring is also attached with it and the starter handle contains also a soft iron piece housed on it. This handle is free to move to the other side RUN against the force of the spring. This spring brings back the handle to its original OFF position under the influence of its own force. Another parallel path is derived from the stud '1', given to the another electromagnet called No Volt Coil (NVC) which is further connected to terminal 'F'. The starting resistance at starting is entirely in series with the armature. The OLR and NVC acts as the two protecting devices of the starter.

**Working of Three Point Starter**

Having studied its construction, let us now go into the working of the 3 point starter. To start with the handle is in the OFF position when the supply to the DC motor is switched on. Then handle is slowly moved against the spring force to make a contact with stud No. 1. At this point, field winding of the shunt or the compound motor gets supply through the parallel path provided to starting resistance, through No Voltage Coil. While entire starting resistance comes in series with the armature. The high starting armature current thus gets limited as the current equation at this stage becomes $I_a = E/(R_a+R_{st})$. As the handle is moved further, it goes on making contact with studs 2, 3, 4 etc., thus gradually cutting off the series resistance from the armature circuit as the motor gathers speed. Finally when the starter handle is in 'RUN' position, the entire starting resistance is eliminated and the motor runs with normal speed.

This is because back emf is developed consequently with speed to counter the supply voltage and reduce the armature current. So the external electrical resistance is not required anymore, and is removed for optimum operation. The handle is moved manually from OFF to the RUN position with development of speed. Now the obvious question is once the handle is taken to

the RUN position how is it supposed to stay there, as long as motor is running ? To find the answer to this question let us look into the working of No Voltage Coil.

**Working of No Voltage Coil of 3 Point Starter**

The supply to the field winding is derived through no voltage coil. So when field current flows, the NVC is magnetized. Now when the handle is in the 'RUN' position, soft iron piece connected to the handle and gets attracted by the magnetic force produced by NVC, because of flow of current through it. The NVC is designed in such a way that it holds the handle in 'RUN' position against the force of the spring as long as supply is given to the motor. Thus NVC holds the handle in the 'RUN' position and hence also called hold on coil.

Now when there is any kind of supply failure, the current flow through NVC is affected and it immediately looses its magnetic property and is unable to keep the soft iron piece on the handle, attracted. At this point under the action of the spring force, the handle comes back to OFF position, opening the circuit and thus switching off the motor. So due to the combination of NVC and the spring, the starter handle always comes back to OFF position whenever there is any supply problems. Thus it also acts as a protective device safeguarding the motor from any kind of abnormality.

**FOUR POINT STARTER:**

**Working Principle of Four Point Starter**

The 4 point starter like in the case of a 3 point starter also acts as a protective device that helps in safeguarding the armature of the shunt or compound excited dc motor against the high starting current produced in the absence of back emf at starting.

The 4 point starter has a lot of constructional and functional similarity to a three point starter, but this special device has an additional point and a coil in its construction, which naturally brings about some difference in its functionality, though the basic operational characteristic remains the same.

**Construction and Operation of Four Point Starter**

A 4 point starter as the name suggests has 4 main operational points, namely

1. 'L' Line terminal. (Connected to positive of supply.)
2. 'A' Armature terminal. (Connected to the armature winding.)
3. 'F' Field terminal. (Connected to the field winding.)

Like in the case of the 3 point starter, and in addition to it there is,

4. A 4th point N. (Connected to the No Voltage Coil)

The remarkable difference in case of a 4 point starter is that the No Voltage Coil is connected independently across the supply through the fourth terminal called 'N' in addition to the 'L', 'F' and 'A'. As a direct consequence of that, any change in the field supply current does not bring about any difference in the performance of the NVC. Thus it must be ensured that no voltage coil always produce a force which is strong enough to hold the handle in its 'RUN' position, against force of the spring, under all the operational conditions. Such a current is adjusted through No Voltage Coil with the help of fixed resistance R connected in series with the NVC using fourth point 'N' as shown in the figure above.

Apart from this above mentioned fact, the 4 point and 3 point starters are similar in all other ways like possessing is a variable resistance, integrated into number of sections as shown in the figure above. The contact points of these sections are called studs and are shown separately as OFF, 1, 2, 3, 4, 5, RUN, over which the handle is free to be maneuvered manually to regulate the starting current with gathering speed.

Now to understand its way of operating lets have a closer look at the diagram given above. Considering that supply is given and the handle is taken stud No.1, then the circuit is complete and line current that starts flowing through the starter. In this situation we can see that the current will be divided into 3 parts, flowing through 3 different points.

i) 1 part flows through the starting resistance ($R_1$+ $R_2$+ $R_3$…..) and then to the armature.

ii) A 2$^{nd}$ part flowing through the field winding F.

iii) a 3$^{rd}$ part flowing through the no voltage coil in series with the protective resistance R.

So the point to be noted here is that with this particular arrangement any change in the shunt field circuit does not bring about any change in the no voltage coil as the two circuits are independent of each other. This essentially means that the electromagnet pull subjected upon the soft iron bar of the handle by the no voltage coil at all points of time should be high enough to keep the handle at its RUN position, or rather prevent the spring force from restoring the handle at its original OFF position, irrespective of how the field rheostat is adjusted.

This marks the operational difference between a 4 point starter and a 3 point starter. As otherwise both are almost similar and are used for limiting the starting current to a shunt wound DC motor or compound wound DC motor, and thus act as a protective device.

**TWO POINT STARTER / DC SERIES MOTOR STARTER:**

Construction of DC series motor starters is very basic as shown in the figure. A start arm is simply moved towards right to start the motor. Thus at first maximum resistance is connected in series with the armature and then gradually decreased as the start arm moves towards right. The no load release coil holds the start arm to the run position and leaves it at no load.

**VIVA QUESTIONS**

1. Differentiate two point and three point starter.
2. What is the need for starter in electrical technology?
3. Differentiate four point and three point starter
4. What are the types of starter?
5. What are the protective devices used in starters?
6. What is the function of no-voltage release coil in DC motor starter?
7. What is the function of over-load release coil in DC motor starter?
8. Differentiate star – delta and auto transformer starter
9. Differentiate auto transformer and DOL starter

**RESULT:**

Thus various types of starter's characteristics are studied.

## GATE QUESTIONS

1. For a specified input voltage and frequency, if the equivalent radius of the core of a transformer is reduced by half, the factor by which the number of turns in the primary should change to maintain the same no load current is
   (A) 1g (B) In (C) 2 (D) 4

2. A star connected 400V, 50Hz, 4 pole synchronous machine gave the following open circuit and short circuit test results: Open circuit test: V oc = 400V (rms, line-to-line) at field current, If = 2.3A Short circuit test: I'" =lOA(rms, phase) at field current, If =1.5A The value of per phase synchronous impedance in n at rated voltage is ________________

3. A 15kW, 230V de shunt motor has armature circuit resistance of 0.4Q and field circuit resistance of 230!2.. At no load and rated voltage, the motor runs at 1400 rpm and the line current drawn by the motor is 5 A. At full load, the motor draws a line current of 70A. Neglect armature reaction. The full load speed of the motor in rpm is _________________

4. A 3 phase, 50 Hz, six pole induction motor has a rotor resistance of 0.1.Q and reactance of 0.92 Q. Neglect the voltage drop in stator and assume that the rotor resistance is constant. Given that the full load slip is 3%, the ratio of maximum torque to full load torque is
   (A) 1.567 (B) 1.712 (C) 1.948 (D) 2.134

5. A single-phase transformer has no-load loss of 64 W, as obtained from an open-circuit test. When a short-circuit test is performed on it with 90% of the rated currents flowing in its both LV and HV windings, the measured loss is 81 W. The transformer has maximum efficiency when operated at
   (A) 50.0% of the rated current. (B) 64.0% of the rated current.
   (C) 80.0% of the rated current. (D) 88.8% of the rated current.

6. Leakage flux in an induction motor is
   (A) flux that leaks through the machine
   (B) flux that links both stator and rotor windings
   (C) flux that links none of the windings
   (D) flux that links the stator winding or the rotor winding but not both

7. The slip of an induction motor normally does not depend on
   (A) Rotor speed (B) Synchronous speed
   (C) Shaft torque (D) Core-loss component

8. A 220 V1 1S kW1 1000 rpm shunt motor with armature resistance of 0.2S.Q r has a rated line current of 68 A and a rated field current of 2.2 A. The change in field flux required to obtain a speed of 1600 rpm while drawing a line current of S2.8 A and a field current of 1.8 A is
   (A) 18.18% increase (B) 18.18% decrease (C) 36.36% increase (D) 36.36% decrease

9. A single phase 10 kVA1 50 Hz transformer with 1kV primary winding draws 0.5 A and 55 W, at rated voltage and frequency, on no load. A second transformer has a core with all its linear dimensions ../2 times the corresponding dimensions of the first transformer. The core material and lamination thickness are the same in both transformers. The primary windings of both the transformers have the same number of turns. If a rated voltage of 2 kV at 50 Hz Is applied to the primary of the second transformer, then the no load current and power, respectively, are
   (A) 0.7 A, 77.8 W (B) 0.7 A, 155.6 W (C) 1 A, 110 W (D) 1 A, 220 W

10. The locked rotor current in a 3-phase, star connected 15 kW, 4-pole, 230 Vr 50 Hz induction motor at rated conditions is 50 A. Neglecting losses and magnetizing current, the approximate locked rotor line current drawn when the motor is connected to a 236 Vr 57 Hz supply is
    (A) 58.5 A (B) 45.0 A (C) 45.7 A (D) 55.6 A

11. An analog voltmeter uses external multiplier settings. With a multiplier setting of 20 k.n, It reads 440 V and-with a multiplier setting of 80 k.n It reads 352 V. For a m ultlpller setting of 40 k.n , the voltmeter reads
    (A) 371 V (B) 383 V (C) 394 V (D) 406 V

12. If the de bus voltage Vd = 300 V, the power consumed by 3-phase load is
    (A) 1. 5 kW (B) 2.0 kW (C) 2. 5 kW (D) 3.0 kW

13. A 4 - point starter is used to start and control the speed of a
    (A) de shunt motor with armature resistance control
    (B) de shunt motor with field weakening control
    (C) de series motor
    (D) de compound motor

14. A three-phase, salient pole synchronous motor is connected to an infinite bus. Ig is operated at no load a normal excitation. The field excitation of the motor is first reduced to zero and then increased in reverse direction gradually. Then the armature current
    (A) Increases continuously (B) First increases and then decreases steeply
    (C) First decreases and then increases steeply (D) Remains constant

15. A 220 V1 DC shunt motor is operating at a speed of 1440 rpm. The armature resistance is 1.0 n and armature current is lOA. of the excitation of the machine is reduced by 10%1 the extra resistance to be put in the armature circuit to maintain the same speed and torque will be
    (A) 1.79 n (B) 2.1 n (C) 18.9 n (D) 3.1 n

16. The pressure coil of a dynamometer type wattmeter is
    (A) high I y inductive (B) highly resistive
    (C) purely resistive (D) pu rei y inductive

17. How many 20 ow /220 v i ncan descent I amps connected in series would consume the same total power as a single 100W/220V incandescent lamp?
    (A) not possible (B) 4 (C) 3 D)2

18. 50 kW dc shunt motor is loaded to draw rated armature current at any given speed. When driven (i) at half the rated speed by armature voltage control and (ii) at 1.5 times the rated speed by field control, the respective output powers delivered by the motor are approximately
    (a) 25 kW in (i) and 75 kW in (ii) (b) 25 kW in (i) and 50 kW in (ii)
    (c) 50 kW in (i) and 75 kW in (ii) (d) 50 kW in (i) and 50 kW in (ii)

19. Relation to the synchronous machines, which one of the following statements is false?
    (a) In salient pole machines, the direct-axis synchronous reactance is greater than the quadrature-axis synchronous reactance
    (b) The damper bars help the synchronous motor self-start
    (c) Short circuit ratio is the ratio of the field current required to produce the rated voltage on open circuit to the rated armature current
    (d) The V-curve of a synchronous motor represents the variation in the armature current with field excitation, at a given output power.

20. Under no load condition, if the applied voltage to an induction motor is reduced from the rated voltage to half the rated value,
    (a) the speed decreases and the stator current increases
    (b) both the speed and the stator current decrease
    (c) the speed and the stator current remain practically constant
    (d) there is negligible change in the speed but the stator current decreases

21. A three-phase cage induction motor is started by direct-on-line (DOL) switching at the rated voltage. If the starting current drawn is 6 times the full load current, and the full load slip is 4%, the ratio of the starting developed torque to the full load torque is approximately equal to
    (a) 0.24 (b) 1.44 (c) 2.40 (d) 6.00

22. In a single phase induction motor driving a fan load, the reason for having a high resistance rotor is to achieve
    (a) low starting torque (b) quick acceleration
    (c) high efficiency (d) reduced size

## INTRODUCTION TO EXPERIMENTS

### LOAD TEST ON DC SHUNT MOTOR

D.C motor converts electrical energy into mechanical energy (rotational) with the help of the excitation.

In this experiment the effect of mechanical loading on torque, speed, Output power, line current and efficiency can be understood.

**SPEED CONTROL OF DC SHUNT MOTOR**

This experiment helps in understanding

1. the effect of back e.m.f on speed, at constant excitation(Armature control method)
2. the effect of field current( before saturation) on speed, at consant armature voltage(Field control method)

**LOAD TEST ON SQUIRREL CAGE INDUCTION MOTOR**

Induction motor converts electrical energy into mechanical energy(rotational) (supply provided to the stator winding itself acts as excitation /aiding mechanism, as per Lenz law and Faraday's laws of electromagnetic induction)

In this experiment the effect of mechanical loading on torque, speed, output power, power factor, line current and efficiency can be understood.

**STUDY OF D.C MOTOR STARTERS**

This study is helpful in understanding the performance of starter and its salient features like no voltage/over load protection circuitry.

**STUDY OF INDUCTION MOTOR STARTERS**

This study is helpful in understanding the performance of starter and its salient features like no voltage/over load protection circuitry, thermal over load protection etc. in addition to starting torque developments and starting current limitations.