JEPPIAAR ENGINEERING COLLEGE
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
EE8353-ELECTRICAL DRIVES AND CONTROLS

The Question bank contains the Following:

- Vision and mission of college and dept PEO,PSO,PO
- Blooms Taxonomy
- Syllabus
- Two marks and 16 Marks with page Nos
- Anna University Question Papers
- Gate Questions
- Notes
- Internal test- Question paper . Internal Test –Marks and sample papers.
- Tutorial – Problems – Question with Answer,
- Assignments, case, model
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- NPTEL – Record of usage
- Real world examples, collaborative learning,

VISION OF INSTITUTION

To build Jeppiaar Engineering College as an institution of academic excellence in technology and management education, leading to become a world class University.

MISSION OF INSTITUTION

- To excel in teaching and **learning, research and innovation** by promoting the principles of scientific analysis and creative thinking.
- To participate in the production, **development, dissemination of knowledge** and interact with **national and international communities.**
- To equip students with ethical **values, and life skills** that would enrich their lives and enable them to meaningfully contribute to the **progress of the society.**
- To prepare students for **higher studies and lifelong learning,** enrich them with the **practical and entrepreneurial skills** necessary to excel as future professionals and contribute to **Nation's economy.**

PROGRAM OUTCOMES (POs)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to

assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7 **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8 **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10 **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11 **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12 **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

VISION OF THE DEPARTMENT

The Department of Electrical and Electronics Engineering strives to be a Centre of Excellence in education and technical research, in the endeavour of which the Department will continually update the teaching methodologies, progress in the emerging technologies and continue to play a vital role in the development of the society.

MISSION OF THE DEPARTMENT

M1	To develop the ability to **learn** and work creatively that would enhance the ability of both students and faculty to do **innovative research**.
M2	To **create** and maintain state-of-the art **facilities** which provide **students** and faculty with opportunities to analyse, apply and **disseminate knowledge globally**.
M3	To impart the knowledge in essential interdisciplinary fields which will enhance the **interpersonal skills**, team work, professional **ethics** and make them work effectively for their own benefit and the **betterment of the society**.
M4	Prepare students for **lifelong learning** of theoretical and **practical concepts** to face intellectual, **economical** and career challenges.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 01	Strengthen the knowledge in Electrical and Electronics Engineering to enable them **work** for modern industries by promoting energy conservation and sustainability.
PEO 02	Enrich analytical, creative and critical **logical reasoning** skills to solve problems faced by emerging domains of electrical and electronics engineering industries worldwide.
PEO 03	Develop effective communication and inter-personal skills to work with enhanced team spirit in multidisciplinary projects with a broader **ethical**, professional, economical and **social** perspective.
PEO 04	Prepare the students either to establish **start ups** or to pursue **higher education** at reputed institutions.

PROGRAM SPECIFIC OUTCOME (PSOs)

PSO 1	**Professional Skills:** Apply the knowledge of Mathematics, Science and Engineering to solve real time problems in the field of **Power Electronics, Electrical Drives, Power Systems, Control Systems and Instrumentation**.
PSO 2	**Research and Innovation:** Analyze and synthesize circuits by solving complex engineering problems to obtain the **optimal solution** using effective software tools and hardware prototypes in the field of robotics and renewable energy systems.
PSO 3	**Product development:** Develop concepts and **products** by applying ideas of electrical domain into other diversified engineering domains.

BLOOM'S TAXONOMY

Definitions of the different levels of thinking skills in Bloom's taxonomy

1. **Remember –** recalling relevant terminology, specific facts, or different procedures related to information and/or course topics. At this level, a student can remember something, but may not really understand it.
2. **Understand** – the ability to grasp the meaning of information (facts, definitions, concepts,etc.) that has been presented.
3. **Apply –** being able to use previously learned information in different situations or in problem Solving.
4. **Analyze** – the ability to break information down into its component parts. Analysis also refers to the process of examining information in order to make conclusions regarding cause and effect, interpreting motives, making inferences, or finding evidence to support statements/arguments.
5. **Evaluate** – being able to judge the value of information and/or sources of information based on personal values or opinions.
6. Create – the ability to creatively or uniquely apply prior knowledge and/or skills to produce new and original thoughts, ideas, processes, etc. At this level, students are involved in creating their own thoughts idea

List of Action Words Related to Critical Thinking Skills

REMEMBER	UNDERSTAND	APPLY	ANALYZE	EVALUATE	CREATE
Count	Associate	Add	Analyze	Appraise	Categorize
Define	Compute	Apply	Arrange	Assess	Combine
Describe	Convert	Calculate	Breakdown	Compare	Compile
Draw	Defend	Change	Combine	Conclude	Compose
Identify	Discuss	Classify	Design	Contrast	Create
Label	Distinguish	Complete	Detect	Criticize	Drive
List	Estimate	Compute	Develop	Critique	Design
Match	Explain	Demonstrate	Diagram	Determine	Devise
Name	Extend	Discover	Differentiate	Grade	Explain
Outline	Extrapolate	Divide	Discriminate	Interpret	Generate
Point	Generalize	Examine	Illustrate	Judge	Group
Quote	Give	Graph	Infer	Justify	Integrate
Read	examples	Interpolate	Outline	Measure	Modify
Recall	Infer	Manipulate	Point out	Rank	Order
Recite	Paraphrase	Modify	Relate	Rate	Organize
Recognize	Predict	Operate	Select	Support	Plan
Record	Rewrite	Prepare	Separate	Test	Prescribe
Repeat	Summarize	Produce	Subdivide		Propose
Reproduce		Show	Utilize		Rearrange
Select		Solve			Reconstruct
State Write		Subtract			Related
		Translate			Reorganize
		Use			Revise
					Rewrite
					Summarize
					Transform
					Specify

Code& Name: **EE8353- Electrical Drives and Controls**
Degree/Programme: **B.E/EEE** Semester: **III** Section: **A, B,C**
Duration:**JUNE– DECEMBER 2018** Regulation: **2017/AUC**
Name of the Staff:

OBJECTIVES:
- To study the conventional and solid-state drives
- To study the different methods of starting D.C motors and induction motors.
- To understand the basic concepts of different types of electrical machines and their performance.

EE8353- Electrical Drives and Controls

UNIT -I INTRODUCTION

Basic Elements – Types of Electric Drives – factors influencing the choice of electrical drives – heating and cooling curves – Loading conditions and classes of duty – Selection of power rating for drive motors with regard to thermal overloading and Load variation factors

UNIT-II DRIVE MOTOR CHARACTERISTICS

Mechanical characteristics – Speed-Torque characteristics of various types of load and drive motors – Braking of Electrical motors – DC motors: Shunt, series and compound - single phase and three phase induction motors.

UNIT -III STARTING METHODS

Types of D.C Motor starters – Typical control circuits for shunt and series motors – Three phase squirrel cage and slip ring induction motors.

UNIT-IV CONVENTIONAL AND SOLID STATE SPEED CONTROL OF D.C DRIVES

Speed control of DC series and shunt motors – Armature and field control, Ward-Leonard control system - Using controlled rectifiers and DC choppers –applications.

UNIT-V CONVENTIONAL AND SOLID STATE SPEED CONTROL OF A.C. DRIVES

Speed control of three phase induction motor – Voltage control, voltage / frequency control, slip power recovery scheme – Using inverters and AC voltage regulators – applications.

EE8353 – ELECTRICAL DRIVES AND CONTROLS

LESSON PLAN

Topic No	Topic	Books for Reference	Page No.
UNIT I INTRODUCTION			
1.	Basic Elements	R1 T2	1.9 35
2.	Types of Electric Drives	R1 T2	1.32 64-65
3.	Factors influencing the choice of electrical drives	R1	1.33-1.71
4.	Heating and cooling curves	R1	2.1
5.	Loading conditions and classes of duty	R1 T2	2.7 86
6.	Selection of power rating for drive motors with regard to thermal overloading and Load variation factors	R1	2.19-2.30
UNIT II DRIVE MOTOR CHARACTERISTICS			
7.	Mechanical characteristics	R1	4.1-4.4
8.	Speed-Torque characteristics of various types of load and drive motors	R1	4.5-4.8
9.	Braking of Electrical motors	R1	4.8
10.	DC motors: Shunt, series and compound	R1	4.26
11.	Single phase induction motors**.**	R1	4.1-4.4
12.	Three phase induction motors**.**	R1	4.27-4.29
Topic No	**Topic**	**Books for Reference**	**Page No.**
UNIT III STARTING METHODS			
13.	Types of D.C Motor starters	R1 T2	5.13-5.22 221-223
14.	Typical control circuits for shunt and series motors	R1	5.22-5.23
15.	Three phase squirrel cage and slip ring induction motors	R1	5.23-5.24
UNIT IV CONVENTIONAL AND SOLID STATE SPEED CONTROL OF D.C. DRIVES			
16.	Speed control of DC series and shunt motors	R1	6.2
17.	Armature and field control	R1	6.17-6.22
18.	Ward-Leonard control system	R1	6.22-6.25
19.	Using controlled rectifiers and DC choppers	R1 R3	6.26-6.28 119-125
20.	Applications	R1 R3	6.29-6.37 172-179

UNIT V CONVENTIONAL AND SOLID STATE SPEED CONTROL OF A.C. DRIVES			
Topic No	**Topic**	**Books for Reference**	**Page No.**
21.	Speed control of three phase induction motor	R1	7.4
22.	Voltage control	R1	7.5-7.15
23.	voltage / frequency control	R1 R2	7.15-7.55
24.	Slip power recovery scheme	T2	225-228
25.	Using inverters and AC voltage regulators	T2	231-234
26.	Applications	R2	118-119

TEXT BOOKS:

T1. VedamSubrahmaniam, "Electric Drives (Concepts and Applications", Tata McGraw-Hill, 2001.

T2. Nagrath .I.J. & Kothari .D.P, "Electrical Machines", Tata McGraw-Hill, 1998

REFERENCES:

R1. Pillai.S.K "A First Course on Electric Drives", Wiley Eastern Limited, 1998

R2. Singh. M.D., K.B.Khanchandani, "Power Electronics", Tata McGraw-Hill, 1998

R3. Partab. H., "Art and Science and Utilisation of Electrical Energy", DhanpatRai and Sons, 1994.

Course outcomes:

C2 06.1	Derive the heating and cooling curve and study the various classes of duty and Selection of power rating
C2 06.2	Understand the working principle of DC &AC motors and their characteristics and its braking methods
C2 06.3	understand the Starting methods of DC &AC motors
C2 06.4	Understand the Concepts of speed control in DC motors
C2 06.5	Understand the Concepts of speed control in AC motors

QUESTION BANK

UNIT I
INTRODUCTION

1. Define Drive and Electric Drive. NOV/DEC 2013, NOV/DEC 2015, NOV/DEC 2016

Drive: A combination of prime mover, transmission equipment and mechanical working load is called a drive.

Electric drive: An Electric Drive can be defined as an electromechanical device for converting electrical energy to mechanical energy to impart motion to different machines and mechanisms for various kinds of process control.

2. List out some examples of prime movers.

I.C Engines, Steam engine, Turbine or electric motors

3. List out some advantages of electric drives.

i. Availability of electric drives over a wide range of power a few watts to mega watts.
ii. Ability to provide a wide range of torques over wide range of speeds.
iii Electric motors are available in a variety of design in order to make them compatible to any type of load.

4. Give some examples of Electric Drives.

i. Driving fans, ventilators, compressors and pumps.
ii. Lifting goods by hoists and cranes.
iii. Imparting motion to conveyors in factories, mines and Warehouses
iv. Running excavators & escalators, electric locomotives trains, Cars trolley buses, lifts & drum winders etc.

5. What are the types of electric drives? NOV/DEC 2009, NOV/DEC 2014

Group electric drives (Shaft drive),
Individual Drives,
Multi motor electric drives.

6. Classify electric drives based on the means of control.

Manual, Semi automatic, Automatic.

7. What is a Group Electric Drive (Shaft Drive)? APRIL/MAY 2010

- This drive consists of single motor, which drives one or more line shafts supported on bearings.
- The line shaft may be fitted with either pulleys & belts or gears, by means of which a group of machines or mechanisms may be operated.

8. What are the advantages and disadvantages of Group drive(Shaft drive)? NOV/DEC 2014

Advantages:

- A single large motor can be used instead of a number of small motors.
- The rating of the single motor may be appropriately reduced taking into account the diversity factor of loads.

Disadvantages:

- There is no flexibility, Addition of an extra machine to the main shaft is difficult.
- The efficiency of the drive is low, because of the losses occurring in several transmitting mechanisms.
- The complete drive system requires shutdown if the motor, requires servicing or repair.

- The system is not very safe to operate
- The noise level at the work spot is very high.

9. What is an individual electric drive? Give some examples.

In this drive, each individual machine is driven by a separate motor. This motor also imparts motion to various other parts of the machine. Single spindle drilling machine, Lathe machines etc.

10. What is a multi motor electric drive? Give some examples.

In this drive, there are several drives, each of which serves to activate on of the working parts of the driven mechanisms. Metal cutting machine tools, paper making machines, rolling mills, traction drive, Traveling cranes etc.,

11. What are the types Drive systems?

Electric Drives Mechanical Drives Electromechanical Drives Hydraulic drives.

12. Give an expression for the losses occurring in a machine.

The losses occurring in a machine is given by W = Wc + x2
Wv Where Wc = Constant losses
Wv = Variable losses at full load
X = load on the motor expressed as a function of rated load.

13. What are the assumptions made while performing heating & cooling calculation of an electric motor?

i. The machine is considered to be a homogeneous body having a uniform temperature gradient. All the points at which heat generated have the same temperature. All the points at which heat is dissipated are also at same temperature.

ii. Heat dissipation taking place is proportional to the difference of temperature of the body and surrounding medium. No heat is radiated.

iii. The rate of dissipation of heat is constant at all temperatures.

14. Indicate the importance of power rating & heating of electric drives. NOV/DEC 2016

Power rating: Correct selection of power rating of electric motor is of economic interest as it is associated with capital cost and running cost of drives.

Heating : For proper selection of power rating the most important consideration is the heating effect of load. In this connection various forms of loading or duty cycles have to be considered.

15. How heating occurs in motor drives?

The heating of motor due to losses occurring inside the motor while converting the electrical power into mechanical power and these losses occur in steel core, motor winding & bearing friction.

16. What are the classes of duties?

1. Continuous duty
2. Short time duty operation of motor Main classes of duties
3. Intermittent periodic duty
4. Intermittent periodic duty with starting
5. Intermittent periodic duty with starting & braking
6. Continuous duty with intermittent periodic loading
7. Continuous duty with starting & braking
8. Continuous duty with periodic load changes

20. How will you classify electric drives based on the method of speed control?

1. Reversible &non reversible in controlled constant speed
2. Reversible and non reversible step speed control
3. Reversible and non reversible smooth speed control
4. Constant predetermined position control

5. Variable position control
6. Composite control.

21. List out some applications for which continuous duty is required. NOV/DEC 2013

Centrifugal pumps, fans, conveyors & compressors

22. Why the losses at starting is not a factor of consideration in a continuous duty motor?

While selecting a motor for this type of duty it is not necessary to give importance to the heating caused by losses at starting even though they are more than the losses at rated load. This is because the motor does not require frequent starting it is started only once in its duty cycle and the losses during starting do not have much influence on heating.

23. What is meant by "short time rating of motor"?

Any electric motor that is rated for a power rating P for continuous operation can be loaded for a short time duty (Psh) that is much higher than P, if the temperature rise is the consideration.

24. What is meant by "load equalization"?

In the method of "load Equalization" intentionally the motor inertia is increased by adding a flywheel on the motor shaft, if the motor is not to be reversed. For effectiveness of the flywheel, the motor should have a prominent drooping characteristic so that on load there is a considerable speed drop.

25. How a motor rating is determined in a continuous duty and variable load ?

1. Method of Average losses
2. Method of equivalent power
3. Method of equivalent current
4. Method of equivalent Torque

26. Define heating time constant & cooling time constant?

The time required to heat the machine parts to 63.3% of its final temperature rise is called as heating time constant. The time required to cool the machine parts to 36.6% of its final temperature fall is called as cooling time constant. **NOV/DEC 2012**

27. What are the various function performed by an electric drive?

1. Driving fans, ventilators, compressors & pumps etc.,
2. Lifting goods by hoists & cranes
3. Imparting motion to conveyors in factories, mines & warehouses and
4. Running excavators & escalators, electric locomotives, trains, cars, trolley buses and lifts etc.

28. What is duty factor?

The ratio of ON time (Ton) of the drive to total time period(Ton +Toff) is called duty factor.

29. Mention the necessity of power rating? NOV/DEC 2009, NOV/DEC 2012

Power rating of electric drives for particular operation is important since, following reasons.

1. To get economy with reliability
2. To obtain the maximum efficiency on their full load without any damaging.

30. Define four – quadrant operation?

A motor operate in two modes and braking. In motoring, it converts electrical energy into mechanical energy, which support its motion. In braking it works as a generator converting mathematical energy into electrical energy and thus, opposes the motion. Motor can provide motoring and braking operations for both forward and reverse directions.

PART – B

1. Explain the factors governing the selection of motors. **NOV/DEC 2009, APRIL/MAY 2010, NOV/DEC 2016**
2. Discuss in detail the determination of power rating of motors. **NOV/DEC 2015**
3. Write a brief note on classes of duty for an electric motor. **APRIL/MAY 2010, NOV/DEC 2013, NOV/DEC 2015, NOV/DEC 2016**
4. Draw the typical temperature rise-time curve and derive the equation for temperature rise in an electric drive. **NOV/DEC 2013, NOV/DEC 2014**
5. Explain in detail about the various types of electric drives. **NOV/DEC 2009, NOV/DEC 2015**
6. Compare the D.C and A.C drives.
7. Explain the different types of loading of drives. **NOV/DEC 2012**
8. Explain the choice of selection of the motor for different loads.
9. Draw the block diagram and explain the basic elements of an electric drive system.
10. Explain the four quadrant operation of motor applicable for hoist.

UNIT – II
DRIVE MOTOR CHARACTERISTICS

1. Why a single phase induction motor does not self start?

When a single phase supply is fed to the single phase induction motor. Its stator winding produces a flux which only alternates along one space axis. It is not a synchronously revolving field, as in the case of a 2 or 3phase stator winding, fed from 2 or 3 phase supply.

2. What is meant by plugging?

The plugging operation can be achieved by changing the polarity of the motor there by reversing the direction of rotation of the motor. This can be achieved in ac motors by changing the phase sequence and in dc motors by changing the polarity.

3. Give some applications of DC motor.

Shunt : driving constant speed, lathes, centrifugal pumps, machine tools, blowers and fans, reciprocating pumps

Series : electric locomotives, rapid transit systems, trolley cars, cranes and hoists, conveyors **Compound :** elevators, air compressors, rolling mills, heavy planners.

4. What are the different types of electric braking? APRIL/MAY 2010, NOV/DEC 2013, NOV/DEC 2014, NOV/DEC 2015

Dynamic or Rheostatic braking, Counter current or plugging and Regenerative braking

5. What is the effect of variation of armature voltage on N-T curve and how it can be achieved?

The N-T curve moves towards the right when the voltage is increased. This can be achieved by means of additional resistance in the armature circuit or by using thyristor power converter.

6. Compare electrical and mechanical braking

Brakes require frequent maintenance very little maintenance not smooth can be applied to hold the system at any position cannot produce holding torque.

7. When does an induction motor behave to run off as a generator?

When the rotor of an induction motor runs faster than the stator field, the slip becomes negative. Regenerative braking occurs and the K.E. of the rotating parts is return back to the supply as electrical energy and thus the machine generates power.

8. Define slip.

S = Ns – Nr

Where, Ns = synchronous speed in rpm. Nr = rotor speed in rpm

S = Slip

9. Define synchronous speed.

It is given by Ns = 120f / p rpm. Where Ns = synchronous speed, p = no. of stator poles=supply frequency in Hz

10. Why a single phase induction motor does not self start?

When a single phase supply is fed to the single phase induction motor. Its stator winding produces a flux which only alternates along one space axis. It is not a synchronously revolving field, as in the case of a 2 or 3phase stator winding, fed from 2 or 3 phase supply.

11. What is meant by regenerative braking?

In the regenerative braking operation, the motor operates as a generator, while it is still connected to the supply here,the motor speed is grater that the synchronous speed. Mechanical energy is converter into electrical energy, part of which is returned to the supply and rest as heat in the winding and bearing.

12. Give some applications of DC motor.

Shunt: driving constant speed, lathes, centrifugal pumps, machine tools, blowers and fans, reciprocating pumps

Series: electric locomotives, rapid transit systems, trolley cars, cranes and hoists, conveyors
Compound: elevators, air compressors, rolling mills, heavy planners.

13. Compare electrical and mechanical braking.

Brakes require frequent maintenance very little maintenance not smooth can be applied to hold the system at any position cannot produce holding torque.

14. Differentiate cumulative and differential compound motors.

Cumulative

The orientation of the series flux **aids** the shunt flux

Differential

Series flux opposes shunt flux

15. What is meant by mechanical characteristics? NOV/DEC 2009, APRIL/MAY 2010, NOV/DEC 2013

A curve drawn between the parameters speed and torque.

16. What is meant by electrical characteristics?

A curve drawn between the armature current and armature torque.

17. What is meant by performance characteristics?

The graph drawn between the output power Vs speed, efficiency, current and torque.

18. What do you mean by Rheostatic braking? NOV/DEC 2016

In this braking armature is removed and connected across a variable rheostat.

19. Is Induction motor runs with synchronous speed or not.

Induction motor never runs with synchronous speed. It will stop if it tries to achieve synchronous speed.

20. Why the armature core in d.c machines is constructed with laminated steel sheets instead of solid steel sheets?

Lamination highly reduces the eddy current loss and steel sheets provide low reluctance path to magnetic field.

21. Why commutator is employed in d.c.machines?

Conduct electricity between rotating armature and fixed brushes, convert alternating emf into unidirectional emf (mechanical rectifier).

22. Distinguish between shunt and series field coil construction?

Shunt field coils are wound with wires of small section and have more no of turns. Series field coils are wound with wires of larger cross section and have less no of turns.

23. How will you change the direction of rotation of d.c. Motor?

Either the field direction or direction of current through armature conductor is reversed.

24. What is back emf in d.c. motor? NOV/DEC 2012

As the motor armature rotates, the system of conductor come across alternate north and South pole magnetic fields causing an emf induced in the conductors. The direction of the emf induced in the conductor is in opposite to current. As this emf always opposes the flow of current in motor operation it is called as back emf.

25. Compare Slip ring and squirrel cage motor

Slip Ring Rotor
Squirrel cage Rotor

26. Induction motor as a transformer?

Transformer is a device in which two windings are magnetically coupled and when one winding is excited by a.c. supply of certain frequency, the e.m.f gets induced in the second winding having same frequency as that of supply given given to the first winding. The winding of which supply is given is called primary winding while winding in which e.m.f gets induced is called secondary winding.

27. What are the types of Single phase induction motors? NOV/DEC 2012

Split phase induction motor
Capacitor start induction motor
Capacitor start capacitors run induction motor
Shaded pole induction motor

28. List the advantage of squirrel cage I.M?

Cheaper
Light in weight
Rugged in construction
More efficient
Require less maintenance
Can be operated in dirty and explosive environments

29. What is back e.m.f in a D.C. Motor? State its expression.

Armature starts rotating, the main flux gets cut by the armature winding and an e.m.f gets induced in the armature. This e.m.f opposes the applied d.c voltage and is called back e.m.f denoted as Eb.

30. Write the voltage equation of D.C. Motor.

$V=E_b+I_aR_a$. The back e.m.f is always less than supply voltage (Eb)

PART – B

1. Explain the Speed-Torque characteristics of three phase induction motor with neat diagrams. **NOV/DEC 2012, NOV/DEC 2014, NOV/DEC 2016**
2. Explain about the speed-torque characteristics of a DC Shunt Motor with Suitable graphs and diagrams. **APRIL/MAY 2010, NOV/DEC 2015**
3. Explain the various methods of braking of induction motors. **NOV/DEC 2009**
4. Draw and explain various load characteristics of DC Shunt Motor. **NOV/DEC 2013**
5. Explain various methods of braking of DC Shunt Motors with neat diagrams. **NOV/DEC 2012, NOV/DEC 2014, NOV/DEC 2015, NOV/DEC 2016**
6. Explain various methods of braking of DC Series Motors with neat diagrams.
7. Explain the Speed-Torque characteristics of Single phase induction motor with neat diagrams. **NOV/DEC 2009**
8. Single phase motor is not a self starting motor. Why? **APRIL/MAY 2010**

UNIT – III
STARTING METHODS

1. Mention the Starters used to start a DC motor.

Two point Starter
Three point Starter
Four point Starter

2. Mention the Starters used to start an Induction motor. NOV/DEC 2009

D.O.L Starter (Direct Online Starter)
Star-Delta Starter
Auto Transformer Starter
Reactance or Resistance starter
Stator Rotor Starter (Rotor Resistance Starter)

3. What are the protective devices in a DC/AC motor Starter? NOV/DEC 2016

Over load Release (O.L.R) or No volt coil
Hold on Coil
Thermal Relays
Fuses
(Starting /Running)
Over load relay

4. Is it possible to include/ Exclude external resistance in the rotor of a Squirrel cage induction motor?. Justify

No it is not possible to include/ Exclude external resistance in the rotor of a Squirrel cage induction motor because, the rotors bars are permanently short circuited by means of circuiting rings (end rings) at both the ends. i.e. no slip rings to do so.

5. Give the prime purpose of a starter for motors. NOV/DEC 2012, NOV/DEC 2015, NOV/DEC 2016

when induction motor is switched on to the supply, it takes about 5 to 8 times full load current at starting. This starting current may be of such a magnitude as to cause objectionable voltage drop in the lines. So Starters are necessary

6. Why motor take heavy current at starting?

When 3 phase supply is given to the stator of an induction motor, magnetic field rotating in space at synchronous speed is produced. This magnetic field is cut by the rotor conductors, which are short circuited. This gives to induced current in them. Since rotor of an induction motor behaves as a short circuited secondary of a transformer whose primary is stator winding, heavy rotor current will require corresponding heavy stator balancing currents. Thus motor draws heavy current at starting

7. What are the methods to reduce the magnitude of rotor current (rotor induced current) at starting?

By increasing the resistance in the rotor circuit by reducing the magnitude of rotating magnetic field i.e. by reducing the applied voltage to the stator windings

8. What is the objective of rotor resistance starter (stator rotor starter)?

To include resistance in the rotor circuit there by reducing the induced rotor current at starting. This can be implemented only on a slip ring induction motor.

9. Why squirrel cage induction motors are not used for loads requiring high starting torque?

Squirrel cage motors are started only by reduced voltage starting methods which lead to the development of low starting torque at starting. This is the reason why squirrel cage induction motors are not used for loads requiring high starting torque.

10. How reduced voltage starting of Induction motor is achieved? APRIL/MAY 2010

D.O.L Starter (Direct Online Starter)
Star-Delta Starter
Auto Transformer Starter
Reactance or Resistance starter

11. Give the relation between line voltage and phase voltage in a

(i) Delta connected network (ii) Star connected network

Delta connected network:

Vphase = Vline

Star connected network:

Vphase = Vline / _3

12. Give some advantages and disadvantages of D.O.L starter.

Advantages:

Highest starting torque
Low cost
Greatest simplicity

Disadvantages:

The inrush current of large motors may cause excessive voltage drop in the weak power system The torque may be limited to protect certain types of loads.

13. What is the function of no-voltage release coil in d.c. motor starter?

As long as the supply voltage is on healthy condition the current through the NVR coil produce enough magnetic force of attraction and retain the starter handle in ON position against spring force. When the supply voltage fails or becomes lower than a prescribed value then electromagnet may not have enough force to retain so handle will come back to OFF position due to spring force automatically.

14. Enumerate the factors on which speed of a d.c.motor depends?

$N= (V-I_aR_a)/\Phi$ so speed depends on air gap flux, resistance of armature, voltage applied to armature.

16. Define critical field resistance of dc shunt generator?

Critical field resistance is defined as the resistance of the field circuit which will cause the shunt generator just to build up its emf at a specified field.

17. Why is the emf not zero when the field current is reduced to zero in dc generator?

Even after the field current is reduced to zero, the machine is left out with some flux as residue so emf is available due to residual flux.

18. On what occasion dc generator may not have residual flux?

The generator may be put for its operation after its construction, in previous operation, the generator would have been fully demagnetized.

19. What are the conditions to be fulfilled by for a dc shunt generator to build back emf?

The generator should have residual flux, the field winding should be connected in such a manner that the flux setup by field in same direction as residual flux, the field resistance should be less than critical field resistance, load circuit resistance should be above critical resistance.

20. Name any two starters which can be used with only slip-ring induction motor

Rotor resistance starter

Solid state rotor resistance starter

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21. What is the Necessity of starter? NOV/DEC 2014

Both d.c motors as well as three phase induction motors are self starting but these motors show the tendency to draw very high current at the time of starting. Such a current is very high and can cause demage to the motor windings. Hence there is a need of a certain device which can limit such a high stating current. Such a device which limits the high starting current is called a starter.

22. What is meant by starting resistance?

To restrict this high starting armature current, a variable resistance is connected in series with the armature at start. This resistance is called starter or a starting resistance.

23. What are the main parts of three point starter?

L = line terminal to be connected to positive of supply

A = to be connected to the armature winding

F= to be connected to the field winding

24. What are the disadvantages of three point starter? NOV/DEC 2009, APRIL/MAY 2010, NOV/DEC 2015

Here NVC and the field winding are in series. so while controlling the speed of the motor above rated, field current is reduced by adding an extra resistance in series with the field winding. To avoid the dependency of NVC and the field winding, four point starter is used in which NVC and the field winding are connected in parallel.

25. What is automatic starter? NOV/DEC 2013, NOV/DEC 2014

Upon pressing ON-push button (start button), current limiting stating resistors get connected in series with armature circuit in DC motor. Then, some form of automatic control progressively disconnects these resistors until full-line voltage is available to the armature circuit. On pressing an OFF push button the system should get back to its original position.

26. Why starts are used for DC motors?

In DC motors starters are used to limit the starting current within about 2 to 3 times the rated current by adding resistance in series with the armature circuit. Other than this starting resistances starters are variable fitted with protective devices like no –voltage protection and over-load protection.

27. Why stator resistance rarely used?

Due to addition of resistance in the stator side cause the voltage available to the motor X times the normal voltage i.e. The starting current drawn by the motor as well as the current drawn from the supply get reduced by X times where as the starting torque developed gets reduced by X2 times.

28. What are the effects of increasing rotor resistance in the rotor circuit of a 3-phase induction motor as starting?

Due to addition of resistance in rotor circuit by the stator not only reduces the staring current, in addition to that the starting torque developed than those given by DOL starting.

29. What are the advantages of Electronic starter?

The moving parts and contacts get completely eliminated.

- The arcing problem gets eliminated.
- Minimum maintenance is required as there are no moving parts.
- The operation is reliable
- Starting time also gets reduced.

30. What is autotransformer starter?

A three phase star connected autotransformer can be used to reduce the voltage applied to the stator. Such a starter is called as autotransformer starter.

PART – B

1. Draw a neat schematic diagram of a three point starter and explain its working. **NOV/DEC 2012, NOV/DEC 2015, NOV/DEC 2016**

2.Draw a neat schematic diagram of a four point starter and explain its working. **APRIL/MAY 2010**

3. Explain with neat circuit diagram, the star-delta starter method of starting squirrel cage induction motor. **NOV/DEC 2012, NOV/DEC 2014, NOV/DEC 2016**
4. Explain the typical control circuits for DC Series and Shunt motors. **NOV/DEC 2009**
5. Explain with neat diagram the starting of three phase slip ring induction motor. **NOV/DEC 2009, NOV/DEC 2013, NOV/DEC 2014, NOV/DEC 2015**
6. Draw and explain the push-button operated direct-on line starter for three phase induction motor. **APRIL/MAY 2010**
7. Draw and explain the manual auto-transformer starter for three phase induction motor. **NOV/DEC 2016**

UNIT – IV
CONVENTIONAL AND SOLID STATE SPEED CONTROL OF D.C.DRIVES

1. Give the expression for speed for a DC motor.

Speed N = k (V-IaRa)j

Where V = Terminal Voltage in volts
Ia = Armature current in Amps
Ra = Armature resistance in ohms
j= flux per pole.

2. What are the ways of speed control in dc motors? NOV/DEC 2014, NOV/DEC 2016

Field control - by varying the flux per pole. -for above rated speed
Armature control- by varying the terminal voltage -for below rated speed

3. Give the Limitation of field control NOV/DEC 2012

a. Speed lower than the rated speed cannot be obtained.
b. It can cope with constant kW drives only.
c. This control is not suitable to application needing speed reversal.

4. What are the 3 ways of field control in DC series motor?

- Field diverter control
- Armature diverter control
- Motor diverter control
- Field coil taps control
- Series-parallel control

5. What are the main applications of Ward-Leonard system?

- It is used for colliery winders.
- Electric excavators
- In elevators
- Main drives in steel mills and blooming and paper mills.

6. What are the merits and demerits of Rheostatic control method?

- Impossible to keep the speed constant on rapidly changing loads.
- A large amount of power is wasted in the controller resistance.
- Loss of power is directly proportional to the reduction in speed. Hence efficiency is decreased.
- Maximum power developed is diminished in the same ratio as speed.
- It needs expensive arrangements for dissipation of heat produced in the controller resistance.
- It gives speed below normal, not above.

7. What are the advantages of field control method? NOV/DEC 2015

- More economical, more efficient and convenient.
- It can give speeds above normal speed.

8. Compare the values of speed and torque in case of motors when ii parallel and in series.

- The speed is one fourth the speed of the motor when in parallel.
- The torque is four times that produced by the motor when in parallel.

9. What is the effect of inserting resistance in the field circuit of a dc shunt motor on its speed and torque?

For a constant supply voltage, flux will decrease, speed will increase and torque will increase.

10. While controlling the speed of a dc shunt motor what should be done to achieve a constant torque drive?

Applied voltage should be maintained constant so as to maintain field strength

11. State the advantages of dc chopper drive. APRIL/MAY 2010, NOV/DEC 2015

- Dc chopper drive s has the advantages of
- High efficiency
- Flexibility in control
- Light weight
- Small size
- Quick response

12. Why chopper based DC drives give better performance than rectifier controlled drives.

- Less harmonic
- Low ripple content
- High efficiency

14.Name the solid state controllers used for the speed control of DC shunt motor and series motor,

- Phase controlled rectifier fed DC drives
- Chopper fed DC drives

15. Give application of Ward-Leonard system of speed control

It is used for elevators, hoist control and for main drive in steel mills where motor of ratings 750KW to 3750KW are required.

16. What is the principle of the field control method of speed control of DC shunt motors?

The speed of the DC motor can be controlled by varying the field flux. This method of speed control can be used for increasing the speed of motor above its rated speed, because the speed of the motor is inversely proportional to the field flux.

17. What is the effect of inserting resistance in the field circuit of of DC shunt motor on its speed and torque?

- Speed increases above base speed.
- Torque decreases.

18. What are the two main methods adopted for speed control of DC motors?

Armature resistance control
Flux control

19. What are the electrical parameters affecting the speed of the DC motors?

Armature voltage
Field current

20. State the types of controlled rectifier Dc drives NOV/DEC 2016

1. Single phase controlled rectifier DC drives
   (a)Half wave controlled rectifier Dc drives
   (b)Half controlled rectifier DC drives
   (c)Full controlled rectifier DC drives
2. Thee phase controlled rectifier fed DC drives

21. How can speed be controlled in a DC shunt motor? NOV/DEC 2013

- The DC shunt motor speed controlled by
  (a) Armature voltage control (below rated speed)
  (b)Flux control method (above rated speed)

22. List the advantages of DC six pulse converter compared with three pulse converter

- Current should be continuous •
Requires less filter circuits
- It gives two quadrant operation

23.What factors limit the maximum speed of field control Dc motor?

Field flux
Armature voltage

24. State control strategies of choppers NOV/DEC 2012

Time ratio control
Current limit control

25. What is meant by V/F control? NOV/DEC 2012, NOV/DEC 2013

When the frequency is reduced the input voltage must be reduced proportionally so as to maintain constant flux. Otherwise the core will get saturated resulting in excessive iron loss and magnetizing current. This type of induction motor behavior is similar to the working of dc series motors.

26. What is static Ward – Leonard drive? NOV/DEC 2009

Controlled rectifiers are used to get variable dc voltage from an ac source of fixed voltage. Controlled rectifiers fed dc drives are known as “static Ward – Leonard drive”.

27. What is meant by voltage control in induction motor? and where it is applicable?

In Induction motor speed can be controlled by varying the stator voltage. This can be done by using transformer. This method is called voltage control. This is suitable only for controlling the speed below rated value.

28. What is meant by armature control? NOV/DEC 2016

The armature having controller resistance in series during the speed control by varying the controller resistance R, the potential drop across the armature is varied. Hence the speed of the motor also varied. This method of speed control is applicable for speed less than no load speed.

29. What is meant by flux control (or) field control method?

By varying the field flux the speed can be controlled is called flux control. This method can be used for increasing the speed of the motor is inversely proportional to the field flux

30. In which type of control the field current and armature current control?

i).For armature control method (or) voltage control method the field current is kept constant

ii).For field control (or) flux control the armature current kept constant

31. What is Slip-Power recovery system? NOV/DEC 2009, APRIL/MAY 2010

The slip power can be recovered to the supply source can be used to supply an additional motor which is mechanically coupled to the main motor. This type of drive is known as slip-power recovery system

PART –B

1. Discuss the Ward-Leonard speed control system with a neat circuit diagram. Also mention its advantages and disadvantages. **NOV/DEC 2012, NOV/DEC 2014, NOV/DEC 2015, NOV/DEC 2016**
2. Explain how the speed of a DC Shunt Motor can be varied both above and below the rated speed at which it runs with full field current. **APRIL/MAY 2010**
3. Explain the speed control schemes of DC Series Motor. **NOV/DEC 2009, APRIL/MAY 2010**
4. Explain the single phase half wave converter drive speed control for DC drive with waveforms.
5. Explain with neat sketch the chopper control method of speed control of DC motors. **APRIL/MAY 2010, NOV/DEC 2012, NOV/DEC 2013, NOV/DEC 2015, NOV/DEC 2016**
6. Explain with neat sketches about the DC Shunt Motor speed control by using single phase fully controlled bridge converter **NOV/DEC 2009, NOV/DEC 2013, NOV/DEC 2014**

UNIT – V
CONVENTIONAL AND SOLID STATE SPEED CONTROL OF A.C. DRIVES

1. What is a controlled rectifier?

A controlled rectifier is a device which is used for converting controlled dc power from a control voltage ac supply.

2. What is firing angle?

The control of dc voltage is achieved by firing the thyristor at an adjustable angle with respect to the applied voltage. This angle is known as firing angle.

3. Give some applications of phase control converters.

Phase control converters are used in the speed control of fractional kW dc motors as well as in large motors employed in variable speed reversing drives for rolling mills. With motors ratings as large as several MW's.

4. What is the main purpose of free wheeling diode?

Free wheeling diode is connected across the motor terminal to allow for the dissipation of energy stored in motor inductance and to provide for continuity of motor current when the thyristors are blocked.

5. What is a full converter?

A full converter is a tow quadrant converter in which the voltage polarity of the output can reverse, but the current remains unidirectional because of unidirectional thyristors.

6. What is natural or line commutation?

The commutation which occurs without any action of external force is called natural or line commutation.

7. What is forced commutation?

The commutation process which takes place by the action of an external force is called forced commutation.

8. What is a chopper?

A chopper is essentially an electronic switch that turns on the fixed-voltage dc source for a short time interval and applies the source potential to motor terminals in series of pulses.

9. What are the two main difficulties of variable frequency system?

Control of Va requires variation of chopper frequency over a wide range. Filter design for variable frequency operation is difficult. At low voltage, a large value of t_{off} makes the motor current discontinuous.

11. What is voltage commutation?

A charged capacitor momentarily reverse-bias the conducting thyristor to turn it off. This is known as voltage commutation.

12. What is current commutation?

A current pulse is forced in the reverse direction through the conducting thyristor. As the net current becomes zero, the thyristor is turned OFF. This is known as current commutation.

13. What is load commutation?

The load current flowing through the thyristor either becomes zero (as in natural or line commutation employed in converters) or is transferred to another device from the conducting thyristor. This is known as load commutation.

14. What are the different means of controlling induction motor? NOV/DEC 2009, NOV/DEC 2013, NOV/DEC 2014, NOV/DEC 2015

- Stator voltage control.
- Frequency control
- Pole changing control.
- Slip power recovery control.

15. What are the two ways of controlling the RMS value of stator voltage?

- Phase control
- Integral cycle control

16. Mention the two slip-power recovery schemes. APRIL/MAY 2010, NOV/DEC 2012, NOV/DEC 2015

- Static Scherbius scheme
- Static Kramer drive scheme.

17. Give the basic difference between the two slip-power recovery schemes.

The slip is returned to the supply network in scherbius scheme and in Kramer scheme, it is used to drive an auxiliary motor which is mechanically coupled to the induction motor shaft.

18. Write short notes on inverter rectifier.

The dc source could be converted to ac form by an inverter, transformed to a suitable voltage and then rectified to dc form. Because of two stage of conversion, the setup is bulky, costly and less efficient.

19. Give the special features of static scherbius scheme.

- The scheme has applications in large power fan and pump drives which requires speed control in narrow range only.
- If max. Slip is denoted by S_{max}, then power rating of diode, inverter and transformer can be just S_{max} times motor power rating resulting in a low cost drive.
- This drive provides a constant torque control.

20. What are the advantages of static Kramer system,, over static scherbius system?

- Since a static Kramer system possesses no line commutated inverter, it causes bless reactive power and smaller harmonic contents of current than a static scherbius.
- What is electrical power supply system?
- The generation, transmission and distribution system of electrical power is called electrical power supply system.

21. What are the 4 main parts of distribution system?

- Feeders,
- Distributors and
- Service mains.

22. What are feeders?

Feeders are conductors which connect the stations (in some cases generating stations) to the areas to be fed by those stations.

23. What are the advantages of high voltage dc system over high voltage ac system?

- It requires only tow conductors for transmission and it is also possible to transmit the power through only one conductor by using earth as returning conductor, hence much copper is saved.
- No inductance, capacitance, phase displacement and surge problem.
- There is no skin effect in dc, cross section of line conductor is fully utilized.

24. What are the limitations of cyclo converter method of speed control?

1. It requires more semiconductor devices like thyristors, MOSFETs compared with inverters
2. Harmonic contents more with low power factor.

25. What are the classifications of PWM technique?

1. Single pulse width modulation
2. Multiple pulse PWM modulation
3. Sinusoidal Pulse PWM

26. Why do we go for PWM inverter control?

The output from inverter is square with some harmonic contents so we have to remove or reducing the harmonic contents by using some voltage control technique called PWM

27. Compare static Kramer and scherbius system. NOV/DEC 2016

Kramer: The system consists or SRIM,diode bridge rectifier and line commutated inverter The slip power can flow in one direction This is applicable for below synchronous speed operation

Scherbius: This system consists of SRIM,two SCR bridge (or) cyclo converter The slip power can flow in both direction Applicable for both below and above synchronous speed operation

28. What are the possible methods of speed control available by using inverters? NOV/DEC 2014

- Current controlled inverter.
- Pulse width modulated (PWM) inverter control
- Variable voltage output(VVO) inverter control
- Variable voltage input(VVI) inverter control

29. What is the function of freewheeling diode?

Free wheeling diodes are introduced to maintain the continuous current flow to the load when ever all thyistors are turned off condition.

30. What is meant by stator frequency control? NOV/DEC 2016

The three phase induction motor speed can be controlled by varying the stator frequency. The variable stator frequency can be obtained by inverters circuit.

31. What is meant by ac voltage controller?

AC voltage controller is nothing but, which is used to converters fixed ac voltage into variable ac voltage without changing supply frequency.

PART – B

1. Explain the V/f control method of AC drive with neat sketches.
2. Explain the speed control schemes of phase wound induction motors. **APRIL/MAY 2010, NOV/DEC 2012, NOV/DEC 2015**
3. Explain in detail about Slip power recovery scheme. **APRIL/MAY 2010, NOV/DEC 2015, NOV/DEC 2016**
4. Explain with neat diagram the method of speed control of dc drives using rectifiers. **NOV/DEC 2009**
5. Explain the different methods of speed control used in three phase induction motors. **NOV/DEC 2014**
6. Explain the Kramer system and Scherbius system. **NOV/DEC 2012**
7. Draw the power circuit arrangement of three phase variable frequency inverter for the speed control of three phase induction motor and explain its working. **NOV/DEC 2016**
8. Discuss the speed control of AC motors by using three phase AC Voltage regulators.
9. Explain the static Kramer method and static Scherbius method of speed control of three phase induction motor. **NOV/DEC 2013**

Explain in detail about the various methods of solid state speed control techniques by using inverters. **NOV/DEC 2013**

Reg. No. : [| | | | | | | | | |]

Question Paper Code : C 1248

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2010.

Third Semester

Mechanical Engineering

EE 1213 — ELECTRICAL DRIVES AND CONTROLS

(Common to B.Tech. Production Technology)

(Regulation 2004)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define Group drive system.

2. Give the formulae for computing power requirement for a linear movement.

3. Sketch the mechanical characteristics of DC shunt and Series motor in the same graph.

4. What is meant by dynamic braking?

5. State the difference between three point and four point starters.

6. Why is rotor resistance starter only suitable for slip ring induction motor?

7. How the speed of induction motor is more than its synchronous speed in static Kramer system?

8. How is the variable armature voltage obtained in Chopper based DC motor control? Sketch the speed torque characteristics of an induction motor for stator voltage control.

9. List out the advantages of slip power recovery scheme speed control of AC motor.

10. Draw the block diagram of soft starter.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Briefly explain the various factors that will influence the choice of an electrical drive. (8)

(ii) Explain the method of estimating equivalent continuous power rating of a motor for short time load applications. (8)

Or

(b) (i) Explain the different classes of Motor duty with the equations. (12)

(ii) The temperature rise of motor after operating for 30 minute on full load is 20°C and after another 30 minute it become 30°C on the same load. Find the final temperature rise and time constant. (4)

12. (a) (i) From electrical characteristics, derive the mechanical characteristic of DC series motor. (8)

(ii) Why is a 1-phase induction motor not self starting? Also describe any one method of starting a 1-phase induction motor. (8)

Or

(b) (i) Describe the operation of dynamic braking for 3-phase squirrel cage Induction motor. (8)

(ii) How are loads classified based on their speed – torque characteristic? Explain different characteristics. (8)

13. (a) With the neat diagram explain the operation of four point starter. Also mention the advantages of this over a three point starter. (16)

Or

(b) (i) Describe the operation of suitable starter for 3-phase slip ring Induction motor. (10)

(ii) Draw the control circuit for DOL starter. (6)

14. (a) (i) Explain the operation of armature control of a DC shunt motor. (8)

(ii) Draw and explain the speed control of DC motor using chopper drive. (8)

Or

(b) (i) With the block diagram explain the operation of armature and field control of DC motor drive using controlled rectifiers. (12)

(ii) Name the different flux control methods adopted for DC series motor. (4)

15. (a) Explain the operation of different speed control techniques employed for 3-phase squirrel cage induction motor. (16)

Or

(b) What is meant by slip power recovery scheme? Explain with the necessary diagram. (16)

K 4280

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2009.

Third Semester

Mechanical Engineering

EE 1213 — ELECTRICAL DRIVES AND CONTROLS

(Common to B.Tech. Production Technology)

(Regulation 2004)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Draw the block diagram of electric drive.

2. What is meant by intermittent duty?

3. Draw the speed torque characteristics of a DC series motor for different values of armature resistances.

4. When plugging is employed for stopping an induction motor, why is it necessary to disconnect it from supply when the speed reaches close to zero?

5. What do you understand by soft start?

6. What are the advantages of squirrel cage induction motor over dc motors?

7. Field control is employed For getting speeds higher than rated and armature voltage control is employed for getting speeds less than rated. Why?

8. What is time ratio control?

9. Mention the advantages of solid state control of ac drives?

10. Mention the usage of different types of motors with applications in a textile mill.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Explain the various factors influencing the choice of electrical drive. (10)

(ii) State and explain the disadvantages of using a motor of wrong rating with an illustration. (6)

Or

(b) (i) What are heating and cooling curves? Starting from the basic principles derive the expressions for heating and cooling curves for a electrical machine. Also mention the assumptions made. (10)

(ii) The 10 minutes rating of a motor used in domestic mixer is 200 watts. The heating time constant is 40 minutes and the maximum efficiency occurs at full load (continuous). Determine the continuous rating. (6)

12. (a) (i) Explain the speed torque characteristics of three phase induction motor with neat diagram. (8)

(ii) Explain why a dc series motor is more suited to deal with torque over load than other dc motors. (8)

Or

(b) (i) State and explain the important features of various braking methods of DC motors. (12)

(ii) Discuss how the dynamic braking can he made in a single phase induction motor. (4)

13. (a) (i) With a neat sketch, explain the operation of a three point starter used for starting a dc shunt motor. (10)

(ii) Explain the operation of a rotor resistance starter used in slip ring induction motor. (6)

Or

(b) Explain the different starting methods employed in a three phase squirrel cage induction motor. (16)

14. (a) (i) State and explain how armature current and speed of a dc separately excited motor will be affected when halving the armature voltage and field current with load torque remaining constant. (6)

(ii) Explain the operation of a conventional ward Leonard speed control system for a dc separately excited motor. (10)

Or

(b) (i) Draw and explain the operation of a speed control of a dc shunt motor by a single phase fully controlled converter for the continuous motor current. (10)

(ii) Describe the operation of a two quadrant type A chopper fed separately excited dc motor drive. (6)

15. (a) (i) Explain how the speed of a three phase induction can be controlled by varying its stator voltage. (8)

(ii) Write short notes on slip power recovery scheme. (8)

Or

(b) (i) With a simple block diagram explain the operation of a variable voltage variable frequency (VVVF) inverter fed three phase induction motor drive. (10)

(ii) Mention the advantages and disadvantages of ac voltage controller fed three phase induction motor drive when compared to inverter fed drives. (6)

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Question Paper Code : 57311

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2016

Third Semester

Mechanical Engineering

EE 6351 – ELECTRICAL DRIVES AND CONTROLS

(Common to Mechanical and Automation Engineering, Production Engineering, Manufacturing Engineering, Petrochemical Engineering, Chemical Engineering and Petrochemical Technology)

(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Answer ALL questions.

PART – A (10 × 2 = 20 Marks)

1. List the basic elements of electrical drives.
2. Define thermal overloading.
3. Draw speed-torque characteristics of a traction load.
4. What is meant by 'braking of electrical motor' ?
5. Why starter is necessary to start a electrical motor ?
6. State the difference between three phase squirrel cage and slip-ring induction motors.
7. List the advantages and disadvantages of D.C. Choppers.
8. Give the applications of controlled rectifier circuit.
9. List the types of speed control methods in three phase induction motor.
10. What is AC voltage Regulator ?

PART – B (5 × 16 = 80 Marks)

11. (a) Discuss the following :

(i) Heating and cooling curves (8)

(ii) Classes of duty (8)

OR

(b) (i) Discribe the factors influencing the choice of electrical drives. (8)

(ii) Discuss about selection of power rating for drive motors. (8)

12. (a) (i) Draw and explain the Speed-Torque Characteristics of DC shunt, series and compound motors with necessary equations. (10)

(ii) Draw and explain the Speed-Torque Characteristics of three phase induction motor. (6)

OR

(b) What are the different methods used for braking of electrical motors ? Explain all the methods with neat diagrams. Also explain which method is suitable for which electrical motor. (16)

13. (a) Explain typical control circuits in starter for shunt and series motors. (16)

OR

(b) Explain typical control circuits in starters for the three phase slip ring induction motors. (16)

14. (a) Explain armature and field control of D.C. motors using controlled rectifiers. (16)

OR

(b) Explain armature and field control of D.C. Motors using D.C. Choppers. (16)

15. (a) Explain speed control of three phase induction by combined voltage/frequency control. (16)

OR

(b) Explain slip power recovery scheme for the speed control of 3 phase induction motor. (16)

Reg. No. :

Question Paper Code : 51626

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2014.

Third Semester

Mechanical Engineering

ME 2205/ME 36/EE 1205 A/080120013/10122 ME 306 — ELECTRICAL DRIVES AND CONTROL

(Common to Production Engineering, Chemical Engineering, Petrochemical Engineering, Petrochemical Technology and Mechanical (sandwich) Engineering)

(Regulation 2008/2010)

(Also common to PTME 2205 Electrical Drives and Control for B.E. (Part-Time) Third Semester – Production Engineering – Regulation 2009)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the basic elements of electric drives?

2. What are the factors to be considered for the selection of electrical drives.

3. Draw speed-torque characteristic of constant torque type load.

4. Draw speed-armature current characteristic of DC series motor.

5. What are the types of DC motor starter?

6. What is the basic principle of primary resistance starter used in 3-phase induction motor?

7. Define armature control method of DC shunt motor.

8. Define duty cycle in DC chopper.

9. What are the conventional methods of speed control of three phase induction motor from stator side.

10. What is the basic principle in v/f control?

PART B — (5 × 16 = 80 marks)

11. (a) List and explain various classes of motor duty. (16)

Or

(b) Explain the selection of power rating for drive motor with regard to continuous duty load.

12. (a) With circuit diagram explain plugging method of braking of D.C. shunt motor and its torque speed characteristics. (16)

Or

(b) Describe speed-torque characteristics for DC dynamic braking of three-phase induction motor.

13. (a) Explain construction and operation of 4-point starter. (16)

Or

(b) Explain with diagram construction and working of rotor resistance starter.

14. (a) Describe with diagram Ward-Leonard speed control system for DC motor. (16)

Or

(b) With diagram describe working of single phase fully controlled rectifier drive.

15. (a) Explain various method of conventional speed control of three-phase induction motor from rotor-side. (16)

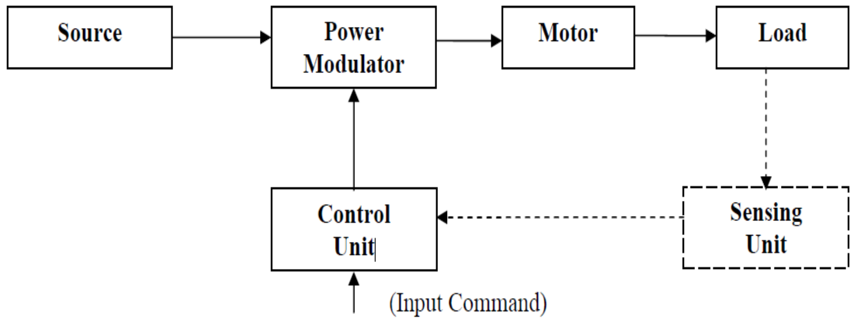
Or

(b) Explain working of conventional Kramer slip power recovery system.

UNIT I

INTRODUCTION TO ELECTRICAL DRIVES

Basic Elements:



A modern variable speed electrical drive system has the following components

- Electrical machines and loads
- Power Modulator
- Sources
- Control unit
- Sensing unit

Electrical Machines:

Most commonly used electrical machines for speed control applications are the following

DC Machines

- Shunt, series, compound, separately excited DC motors and switched reluctance machines.

AC Machines

- Induction, wound rotor, synchronous, PM synchronous and synchronous reluctance machines.

Special Machines

- Brush less DC motors, stepper motors, switched reluctance motors are used.

Power Modulators:

- Modulates flow of power from the source to the motor in such a manner that motor is imparted speed-torque characteristics required by the load
- During transient operation, such as starting, braking and speed reversal, it restricts source and motor currents with in permissible limits.
- It converts electrical energy of the source in the form of suitable to the motor
- Selects the mode of operation of the motor (i.e.) Motoring and Braking.

Types of Power Modulators

In the electric drive system, the power modulators can be any one of the following

- Controlled rectifiers (ac to dc converters)
- Inverters (dc to ac converters)
- AC voltage controllers (AC to AC converters)
- DC choppers (DC to DC converters)
- Cyclo converters (Frequency conversion)

Electrical Sources:

- Very low power drives are generally fed from single phase sources. Rest of the drives is powered from a 3 phase source. Low and medium power motors are fed from a 400v supply. For higher ratings, motors may be rated at 3.3KV, 6.6KV and 11 KV. Some drives are powered from battery.

Sensing Unit:

- Speed Sensing
- Torque Sensing
- Position Sensing
- Current sensing and Voltage Sensing from Lines or from motor terminals
- Torque sensing
- Temperature Sensing

Control Unit:

- Control unit for a power modulator are provided in the control unit. It matches the motor and power converter to meet the load requirements

TYPES OF ELECTRIC DRIVES:

According to Mode of Operation

- Continuous duty drives
- Short time duty drives
- Intermittent duty drives

According to Means of Control

- Manual
- Semi automatic
- Automatic

According to Number of machines

- Individual drive
- Group drive
- Multi-motor drive

According to Dynamics and Transients

- Uncontrolled transient period
- Controlled transient period

Another main classification:

- DC drive
- AC drive

DC DRIVES	AC DRIVES
The power circuit and control circuit is simple and inexpensive	The power circuit and control circuit are complex
It requires frequent maintenance	Less Maintenance
The commutator makes the motor bulky, costly and heavy	These problems are not there in these motors and are inexpensive, particularly squirrel cage induction motors
Fast response and wide speed range of control, can be achieved smoothly by conventional and solid state control	In solid state control the speed range is wide and conventional method is stepped and limited
Speed and design ratings are limited due to commutations	Speed and design ratings have upper limits

FACTORS INFLUENCING THE CHOICE OF ELECTRICAL DRIVES:

- **The limits of Speed range:** The range over which the speed control is necessary for the load.
- **The efficiency:** The motor efficiency varies as load varies so the efficiency consideration under variable speed operation affects the choice of the motor.
- **The braking:** The braking requirements from the load point of view. Easy and effective braking are the requirements of a good drive.
- **Starting requirements:** The starting torque necessary for the load, the corresponding starting current drawn by the motor also affects the selection of drive.
- **Power factor:** The running motor with low power factor value is not economical. The power factor of the motor affects the selection of drive.
- **Load factors:** There are varieties of types of load conditions possible like continuous, intermittent and impact. Such load variation factor and duty cycle of the motor influences the selection of drive.
- **Availability of supply:** The motors available are AC or DC. But the availability of supply decides the type of motor to be selected for the drive.
- **Effects of supply variations:** There is a possibility of frequent supply variations. The selected motor should be able to withstand such supply variations.
- **Economical aspects:** The size and rating of the motor decides its initial cost while the various losses and temperature rise decides its running cost. These economical aspects must be considered while selecting a drive.
- **Reliability of operation:** It is important to study the conditions of stable operation of an electric drive. This includes the investigation of reliability of operation of an electric drive.
- **Environmental effects:** Chemical gases, fumes, humidity etc. may affect the motor. It should be considered when we select a drive.

LOADING CONDITIONS:

- **Continuous or Constant loads:** In this type load occurs for a long time under the same conditions.

Eg. Fan, Paper making machine

- **Continuous variable loads:** The load is variable over a period of time but occurs repetitively for a long duration.

Eg. Metal cutting lathes, conveyors.

- **Pulsating loads:** The load is continuously variable.

Eg. Reciprocating pumps, compressors

- **Impact loads:** These are peak loads occur at regular intervals of time.

Eg. Rolling mils, Presses, Shearing machine, Forging hammers

- **Short time intermittent loads:** The load appears periodically identical duty cycles, each consisting of a period of applications of load.

Eg. Cranes, Hoists, Elevators

- **Short time loads:** A constant load appears on the drive and the system rests for the remaining period of cycle.

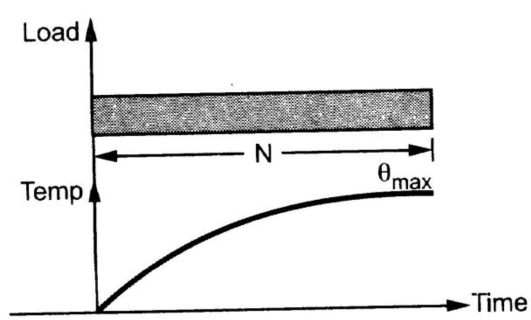
Eg. Motor – generator sets for charging batteries, house hold equipments.

CLASSES OF DUTY:

- Continuous duty
- Continuous duty, variable load
- Short time duty
- Intermittent periodic duty
- Intermittent periodic duty with starting
- Intermittent periodic duty with starting and braking

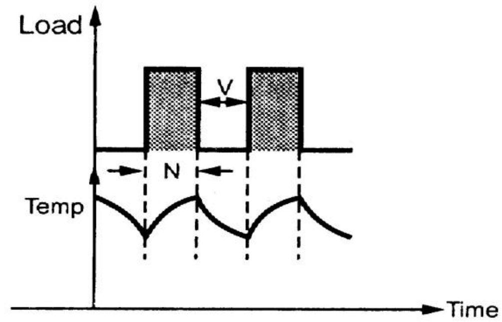
Continuous duty:

- Operation at constant load for a long duration of time
- ‘N’ indicates duration of operation.



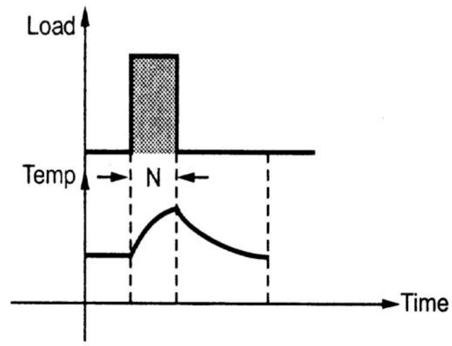
Continuous duty, variable load:

- It denotes a sequence of identical duty cycles each consisting of a period of operation at load and period of no load.



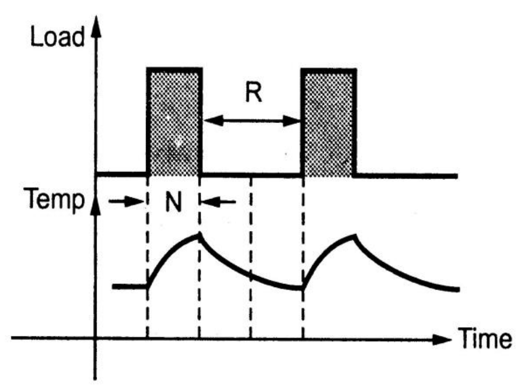
Short time duty:

It denotes operation at constant load during a given time, then followed by rest of sufficient duration



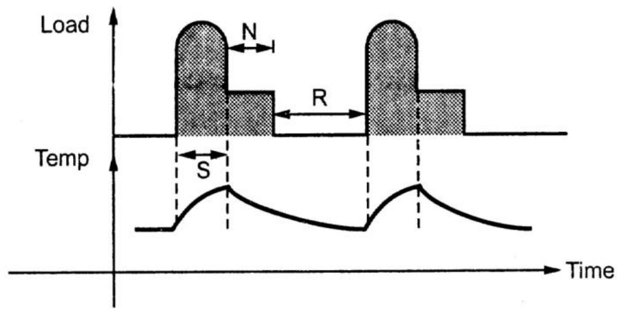
Intermittent periodic duty:

- Sequence of identical duty cycles each consisting of a period of operation at a constant load and then a period of rest.



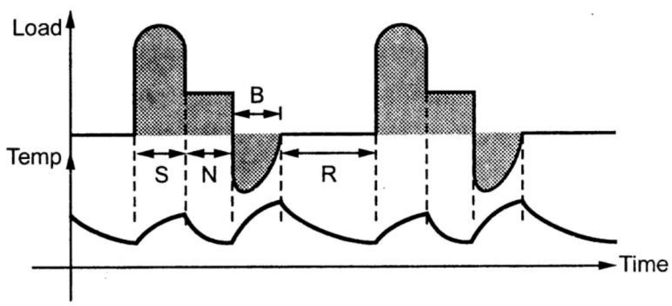
Intermittent periodic duty with starting:

- This consists of a load at start, then constant load and then a period of rest.



Intermittent periodic duty with starting and braking:

- This indicates a load as ‘Intermittent periodic duty with starting’ along with a period of braking and then a rest period.



Heating and Cooling Curves:

<u>Heating Curve:</u>

W – Loss taking place in a machine in watts
G – Mass of the machine in kg
S – Specific heat in watt-sec/kg degree Celsius
θ – Rise in temperature
θ_F – Final temperature rise
A – Area of cooling surface
λ – Rate of heat dissipation

Heat developed = Heat obserbed + Heat dissipated

Heat developed = Wdt
Heat Obserbed = $GSd\theta$
Heat dissipated = $A\lambda\theta dt$
$Wdt = GSd\theta + A\lambda\theta dt$
$Wdt - A\lambda\theta dt = GSd\theta$
$(W - A\lambda\theta)dt = GSd\theta$

$$\frac{dt}{GS} = \frac{d\theta}{W - A\lambda\lambda}$$

$$\frac{dt}{\left(\frac{GS}{A\lambda}\right)} = \frac{d\theta}{\left(\frac{W}{A\lambda} - \theta\right)}$$

When final temperature is reached, no heat obserbed
$Wdt = A\lambda\theta_F dt$
$W = A\lambda\theta_F$

$$\theta_F = \frac{W}{A\lambda}$$

$$\frac{dt}{\left(\frac{GS}{A\lambda}\right)} = \frac{d\theta}{(\theta_F - \theta)}$$

Integrating both sides of equation

$$\int \frac{dt}{\left(\frac{GS}{A\lambda}\right)} = \int \frac{d\theta}{(\theta_F - \theta)}$$

$$\frac{A\lambda}{GS} \times t = -\ln(\theta_F - \theta) + K$$

Where K is constant

To find out value of K, We can use initial condition

At t=0, $\theta = \theta_1$

$$0 = -\ln(\theta_F - \theta_1) + K$$

$$K = \ln(\theta_F - \theta_1)$$

Substitute K value

$$\frac{A\lambda}{GS} \times t = -\ln(\theta_F - \theta) + \ln(\theta_F - \theta_1)$$

$$\frac{A\lambda}{GS} \times t = \ln\left(\frac{\theta_F - \theta_1}{\theta_F - \theta}\right)$$

$$e^{\left(\frac{A\lambda}{GS} \times t\right)} = \frac{\theta_F - \theta_1}{\theta_F - \theta}$$

$$\theta_F - \theta = \left(\theta_F - \theta_1\right) e^{\left(-\frac{A\lambda}{GS} \times t\right)}$$

$\frac{GS}{A\lambda}$ is called heating time constant τ

$$\theta = \theta_F - \left(\theta_F - \theta_1\right) e^{\left(-t/\tau\right)}$$

If the machine is started from ambient temperature $\theta_1 = 0^0 C$

$$\theta = \theta_F (1 - e^{\left(-t/\tau\right)})$$

Let us consider the time period t = τ then

$$\theta = \theta_F(1 - e^{-1})$$

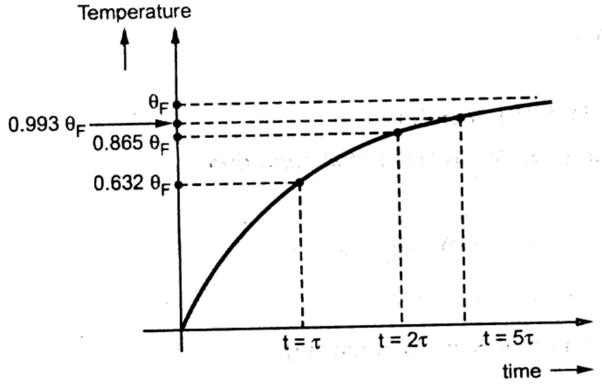
$\theta = 0.632\theta_F$

Similarly, at $t = 2\tau$, $\theta = 0.865\theta_F$

$t = 3\tau$, $\theta = 0.95\theta_F$

$t = 4\tau$, $\theta = 0.982\theta_F$

$t = 5\tau$, $\theta = 0.993\theta_F$



COOLING CURVE:

W – Loss taking place in a machine in watts

G – Mass of the machine in kg

S – Specific heat in watt-sec/kg degree Celsius

θ – Drop in temperature

θ_F' – Final temperature drop

A – Area of cooling surface

λ' – Rate of heat dissipation

Heat developed + Heat emitted = Heat dissipated

Heat developed = Wdt

Heat emitted = -GSdθ

Heat dissipated = A λ' θdt

Wdt - GSdθ = A λ' θdt

-GSdθ = A λ' θdt - Wdt

$$-GSd\theta = \left(A\lambda'\theta - W\right)dt$$

$$-\frac{GS}{A\lambda'}d\theta = \left(\theta - \frac{W}{A\lambda'}\right)dt$$

$$-\frac{d\theta}{\left(\theta - \frac{W}{A\lambda'}\right)} = \frac{dt}{\left(\frac{GS}{A\lambda'}\right)}$$

If θ'_F is final temperature drop, then heat generated is equal to heat dissipated

$$Wdt = A\lambda'\theta'_F dt$$

$$\theta'_F = \frac{W}{A\lambda'}$$

$$-\int \frac{d\theta}{\left(\theta - \frac{W}{A\lambda'}\right)} = \int \frac{dt}{\left(\frac{GS}{A\lambda'}\right)}$$

$$-\int \frac{d\theta}{\left(\theta - \theta'_F\right)} = \int \left(\frac{A\lambda'}{GS}\right) dt$$

$$-\left[\ln\left(\theta - \theta'_F\right)\right] = \frac{A\lambda'}{GS} \times t + K$$

$$\ln\left(\theta - \theta'_F\right) = -\frac{A\lambda'}{GS} \times t + K$$

Where K is constant of integration which can be found by using initial conditions

At t = 0, $\theta = \theta_0$

$$\ln\left(\theta_0 - \theta'_F\right) = K$$

$$\ln\left(\theta - \theta'_F\right) = -\frac{A\lambda'}{GS} \times t + \ln\left(\theta_0 - \theta'_F\right)$$

$$\ln\left(\theta - \theta'_F\right) - \ln\left(\theta_0 - \theta'_F\right) = -\frac{A\lambda'}{GS} \times t$$

$$\ln\left(\frac{\theta - \theta'_F}{\theta_0 - \theta'_F}\right) = -\frac{A\lambda'}{GS} \times t$$

$$\frac{\theta - \theta'_F}{\theta_0 - \theta'_F} = e^{-\frac{A\lambda'}{GS} \times t}$$

$$\theta - \theta'_F = \left(\theta_0 - \theta'_F\right) e^{-\frac{A\lambda'}{GS} \times t}$$

$$\theta = \theta'_F + \left(\theta_0 - \theta'_F\right) e^{-\frac{A\lambda'}{GS} \times t}$$

$$\frac{GS}{A\lambda'} = \tau'$$

$$\theta = \theta'_F + \left(\theta_0 - \theta'_F\right) e^{-t/\tau'}$$

The final temperature is ambient temperature ie, $\theta'_F = 0$

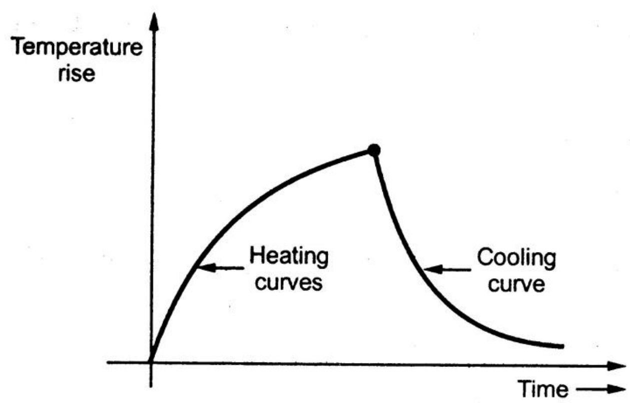
At t = τ', $\theta = 0.367\ \theta_0$

At t =2 τ', $\theta = 0.135\ \theta_0$

At t =3 τ', $\theta = 0.05\ \theta_0$

At t =4 τ', $\theta = 0.018\ \theta_0$

At t =5 τ', $\theta = 0.007\ \theta_0$



UNIT II
DRIVE MOTOR CHARACTERISTICS

Characteristics of DC motor

1. Torque Vs Armature Current Characteristics
2. Speed Vs Armature Current Characteristics
3. Speed Vs Torque Characteristics

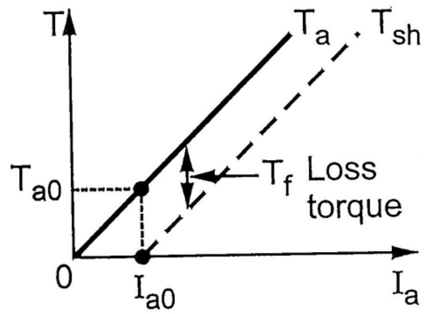
DC Shunt Motor

1. Torque Vs Armature Current Characteristics

$$T_a \propto \phi I_a$$

- For DC Shunt motor, φ is constant.
- Armature torque is directly proportional to Armature current.
- Torque increases linearly with armature current.
- Torque spent to rotate armature is loss.

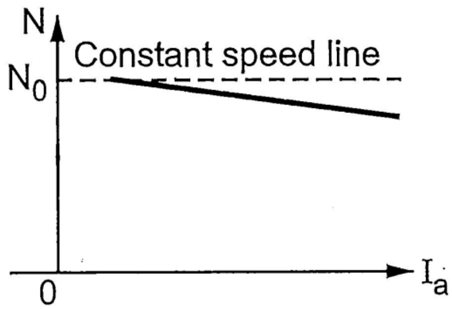
- The torque used to operate the load is called Shaft torque.



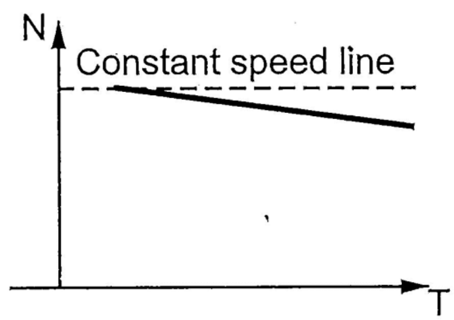
2. **Speed Vs Armature Current Characteristics**

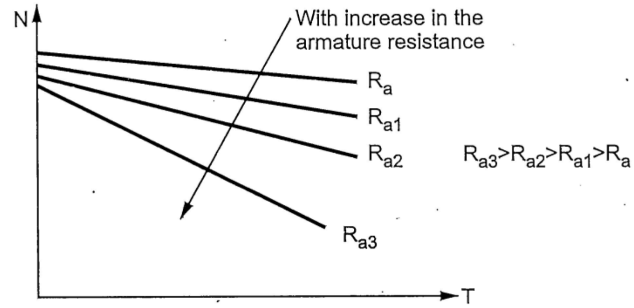
$$N \propto \frac{V - I_a R_a}{\Phi}$$

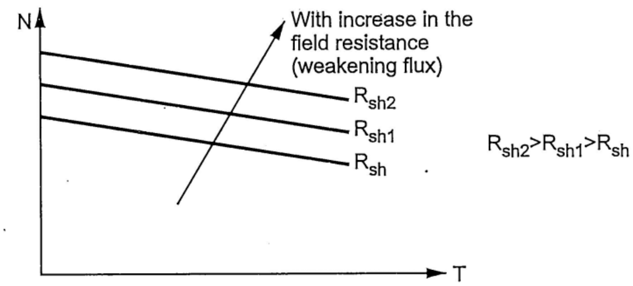
- When load increases, armature current increases.
- When armature current increases, drop increases.
- When drop increases, speed reduces.

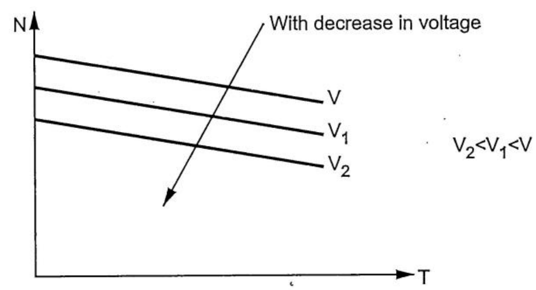


3. **Speed Vs Torque Characteristics**
   - This characteristic is similar to speed-armature current characteristics.
   - When torque increases, speed reduces.
   - The characteristic also varies with respect to armature current value, field resistance value and supply voltage.







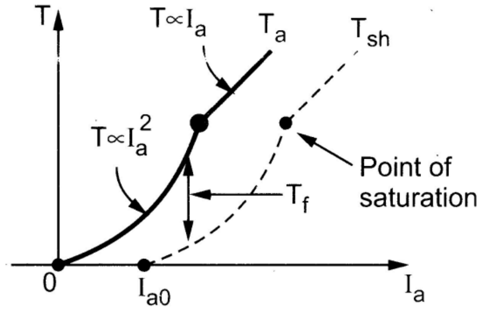


<u>DC Series Motor</u>

1. **Torque Vs Armature Current Characteristics**

$$T \propto I_a^2$$

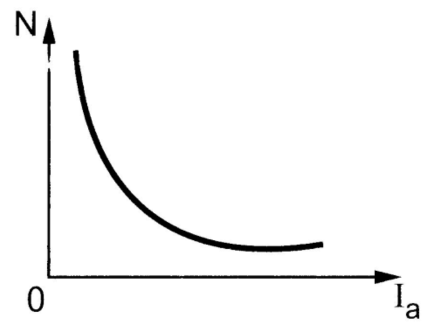
- Armature current and field current are same.
- At starting time, torque is proportional to square value of armature current and then torque is proportional to armature current.
- It can be used for high torque applications.



2. **Speed Vs Armature Current Characteristics**

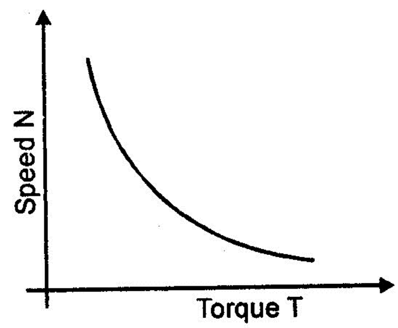
$$N \propto \frac{V - I_a R_a}{\Phi}$$

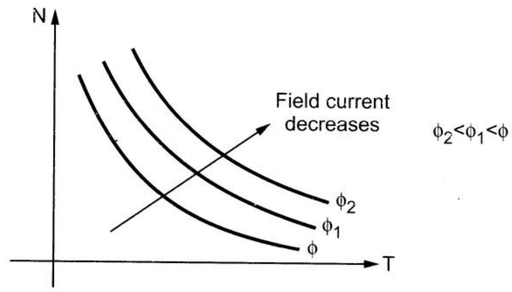
- For series motor, speed is inversely proportional to flux.
- Flux is directly proportional to armature current.
- When armature current increases, speed reduces.

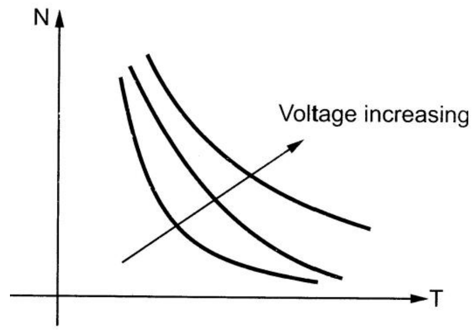


3. **Speed Vs Torque Characteristics**

- This characteristic is similar to speed-armature current characteristics.
- When torque increases, speed reduces.
- The characteristic also varies with respect to field current value and supply voltage.

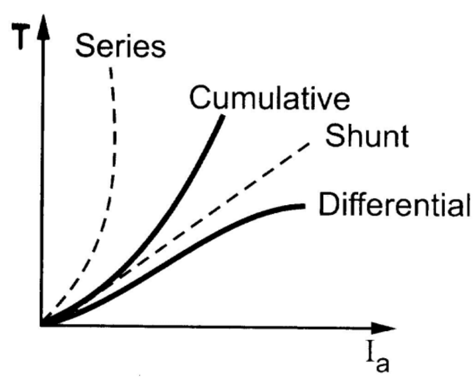


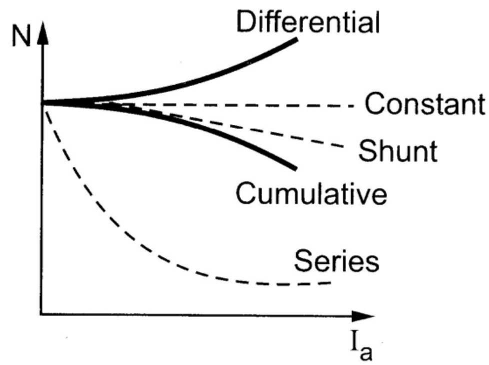


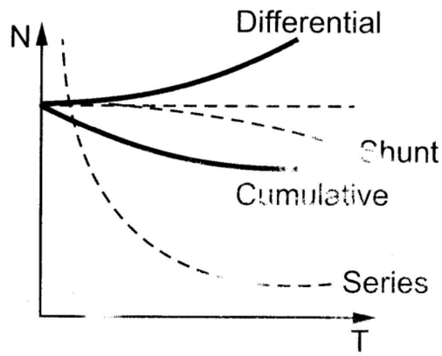


DC Compound Motor

- The characteristic of this motor is depending on flux produced by shunt winding and series winding.
- For cumulative compound motor, the total flux is the sum of shunt field coil flux and series field flux.
- For differential compound motor, the total flux is the difference of shunt field coil flux and series field flux.
- Cumulative compound motor has capability of developing large amount of torque compared to differential compound motor.







BRAKING OF ELECTRICAL MOTORS:

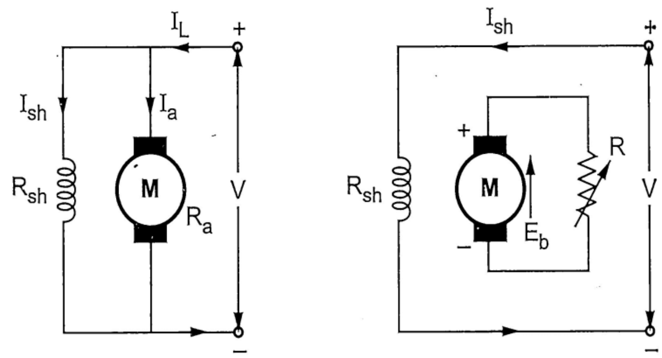
- The term braking comes from the term brake
- The process of reducing speed of any rotating machine

Types of Braking

- Rheostatic or Dynamic Braking
- Plugging or Counter Current Braking
- Regenerative Braking

DC Shunt Motor:

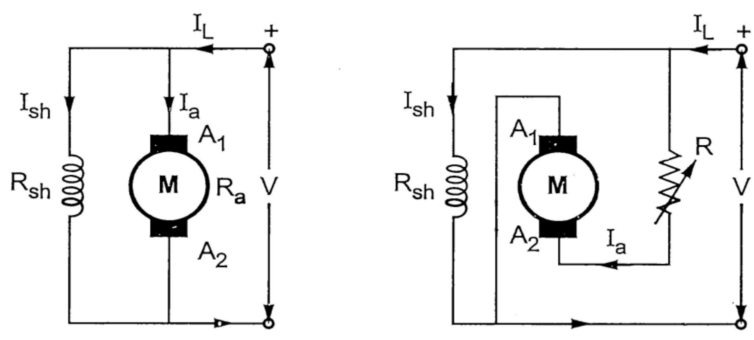
Rheostatic or Dynamic Braking:



(a) Running (b) Braking

- The method of reversing the direction of torque and braking the motor is **dynamic braking**
- In this method of braking the motor which is at a running condition is disconnected from the source and connected across a resistance
- When the motor is disconnected from the source, the rotor keeps rotating due to inertia and it works as a self –excited generator
- When the motor works as a generator the flow of the electric current and torque reverses
- During braking to maintain the steady torque sectional resistances are cut out one by one.

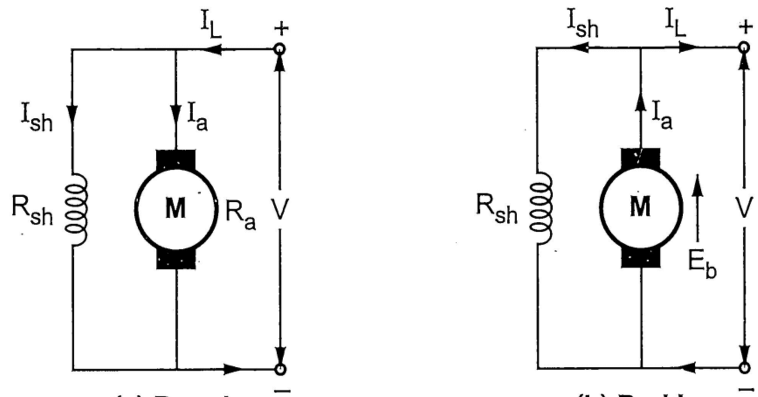
Plugging or Counter Current Braking:



(a) Running (b) Braking

- In this method the terminals of supply are reversed, as a result the generator torque also reverses which resists the normal rotation of the motor and as a result the speed decreases
- During plugging external resistance is also introduced into the circuit to limit the flowing current
- The main disadvantage of this method is that here power is wasted

Regenerative Braking:

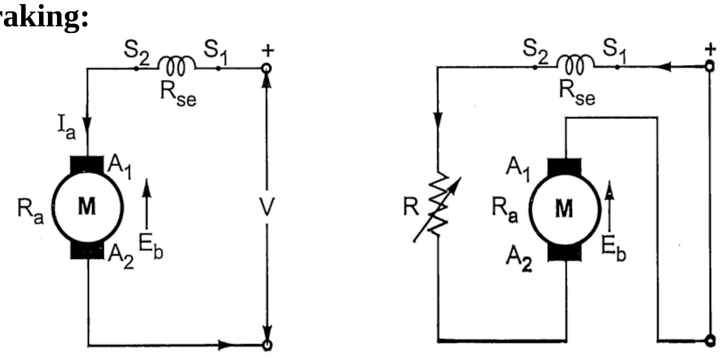


(a) Running (b) Braking

- **Regenerative braking** takes place whenever the speed of the motor exceeds the synchronous speed
- This baking method is called regenerative braking because here the motor works as generator and supply the voltage to main
- The main criteria for regenerative braking is that the rotor has to rotate at a speed higher than synchronous speed
- The motor will act as a generator and the direction of electric current flow through the circuit and direction of the torque reverses and braking takes place
- The only disadvantage of this type of braking is that the motor has to run at super synchronous speed which may damage the motor mechanically and electrically

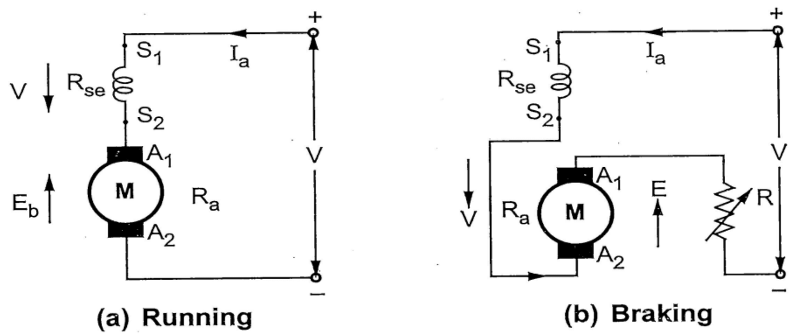
<u>DC SERIES MOTOR</u>:

Rheostatic or Dynamic Braking:



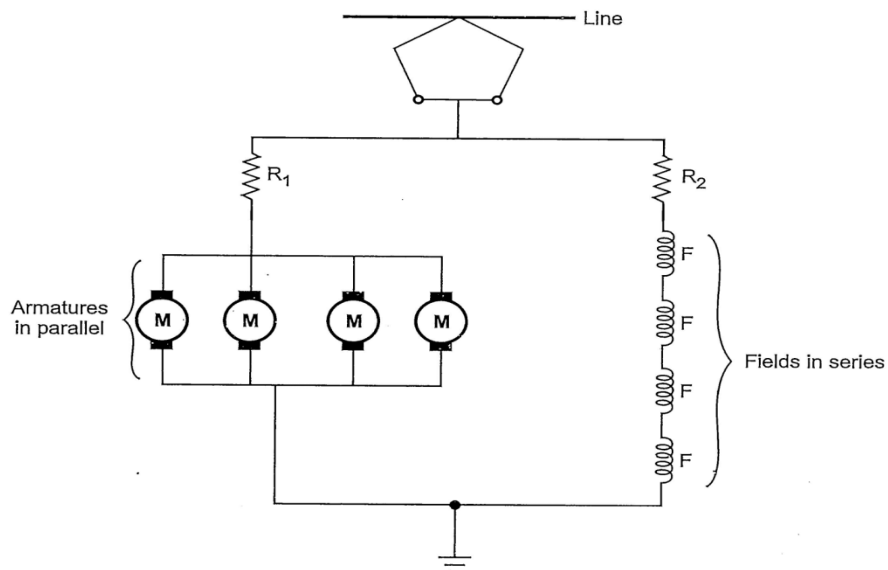
(Theory is same as DC shunt motor braking)

Plugging or Counter Current Braking:



(Theory is same as DC shunt motor braking)

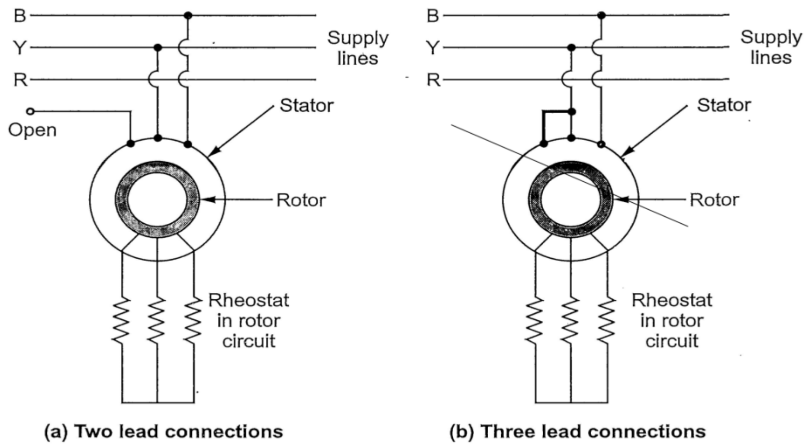
Regenerative Braking:



(Theory is same as DC shunt motor braking)

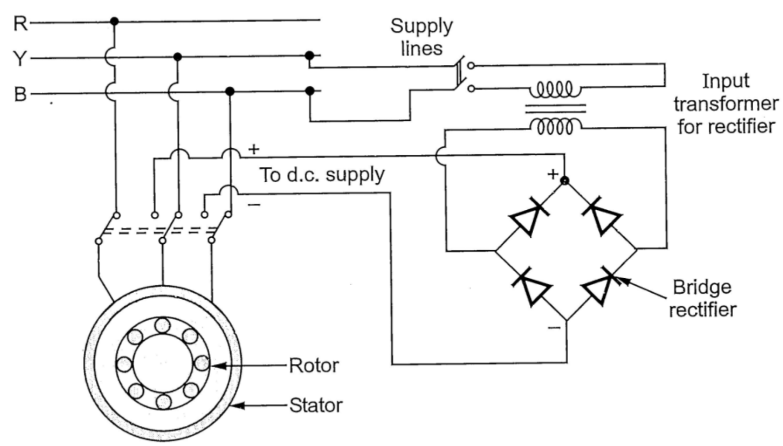
BRAKING OF INDUCTION MOTOR

Dynamic or Rheostatic Braking:



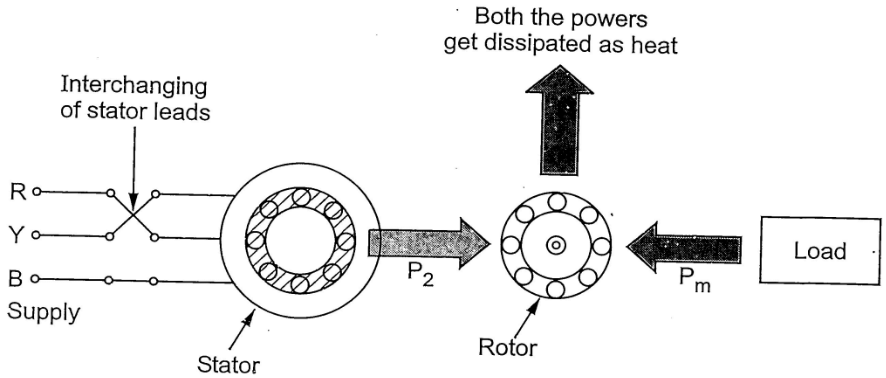
- This type of induction motor braking is obtained when the motor is made to run on a single phase supply by disconnecting any one of the three phase from the source
- The disconnected terminal is connected with another phase or the disconnected phase is left open
- When the disconnected phase is left open, it is called two lead connection
- When the disconnected phase is connected to another machine phase it is known as three lead connection
- The torque of three phase induction motor is reduced when motor runs with two phase supply
- Now the resistance value of rheostat can be adjusted to stop the motor

DC Dynamic Braking:



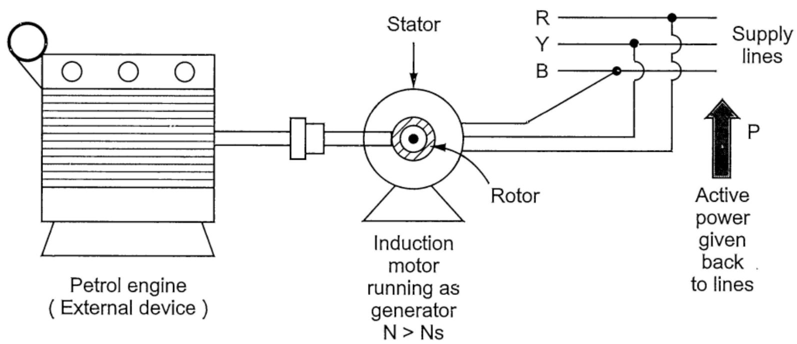
- To obtain this type of braking the stator of a running induction motor is connected to a dc supply
- The moment when AC supply is disconnected and DC supply is introduced across the terminals of the induction motor
- The stationery magnetic field is generated due to the DC electric current flow
- The machine works as a generator and the generated energy dissipates in the rotor circuit resistance and dynamic braking of induction motor occurs

Plugging or Counter Current Braking:



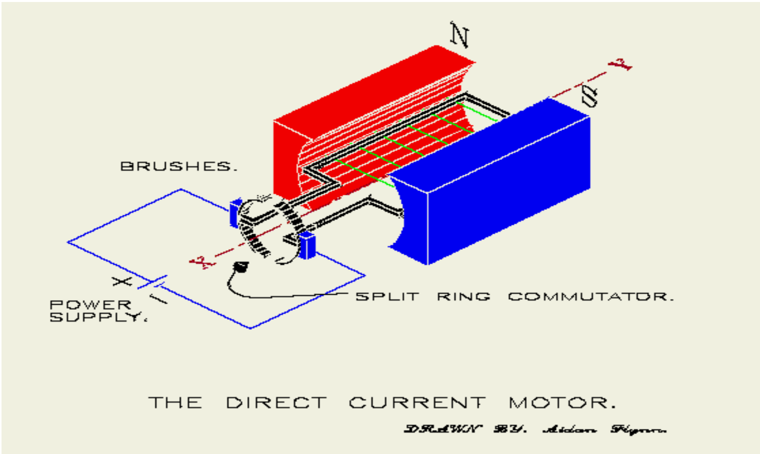
- Plugging **induction motor braking** is done by reversing the phase sequence of the motor
- The phase sequence of the motor can be changed by interchanging connections of any two phases of stator with respect of supply terminals
- When the phase sequence is changed, the direction of current flow is changed
- The counter current produces the opposite torque and then motor is stopped

Regenerative Braking:

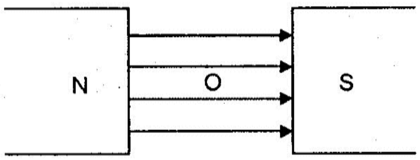


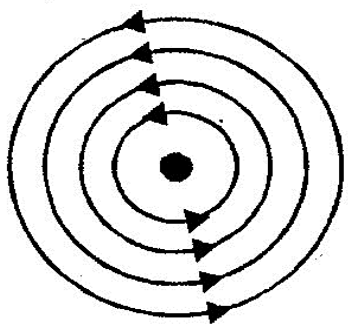
- The **regenerative braking of induction motor** can only take place if the speed of the motor is greater than synchronous speed
- The above synchronous speed is obtained by using Petrol engine
- This baking method is called regenerative braking because here the motor works as generator and supply the voltage to main
- The main criteria for regenerative braking is that the rotor has to rotate at a speed higher than synchronous speed
- The motor will act as a generator and the direction of electric current flow through the circuit and direction of the torque reverses and braking takes place

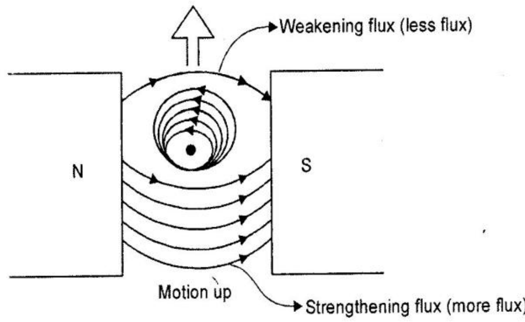
OPERATING PRINCIPLE OF DC MOTORS:

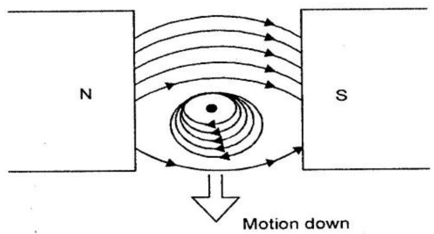


- This is a device that converts DC electrical energy to a mechanical energy
- Structurally and construction wise a direct electric current motor is exactly similar to a DC generator, but electrically it is just the opposite
- This DC or **direct electric current motor** works on the principal, when a current carrying conductor is placed in a magnetic field, it experiences a torque and has a tendency to move
- This is known as motoring action
- If the direction of electric current in the wire is reversed, the direction of rotation also reverses
- When magnetic field and electric field interact they produce a mechanical force, and based on that the working principle of **dc motor** established
- The direction of rotation of a this motor is given by Fleming's left hand rule
- **Fleming's left hand rule:** if the index finger, middle finger and thumb of your left hand are extended mutually perpendicular to each other and if the index finger represents the direction of magnetic field, middle finger indicates the direction of electric current, then the thumb represents the direction in which force is experienced by the shaft of the **dc motor**

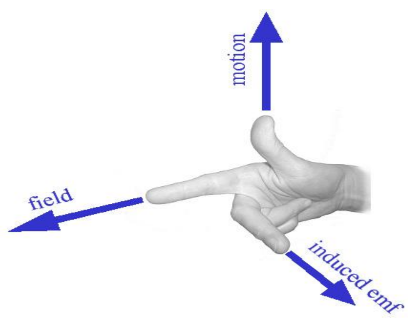


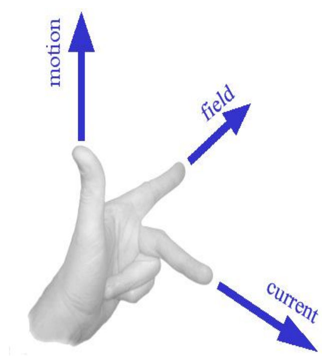




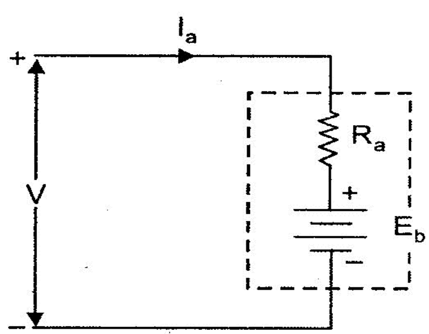


Fleming's Right & Left Hand Rule





Equivalent Circuit



TYPES OF DC MOTORS

- **Separately Excited DC motor.**
- **Self-excited DC motor.**

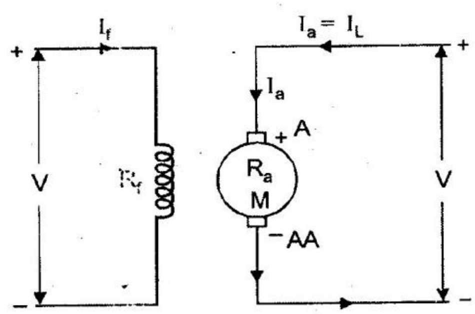
1. **Series motor.**
2. **Shunt motor.**
3. **Compound motor.**

a. **Cumulative compound** b. **Differential compound**

i. **Long Shunt compound motor.**
ii. **Short Shunt compound motor.**

<u>Separately Excited DC motor:</u>

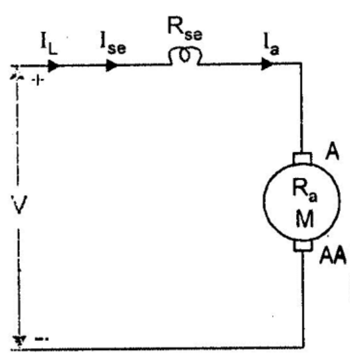
- The supply is given separately to the field and armature windings
- The main distinguishing fact in these types of dc motor is that, the armature electric current does not flow through the field windings, as the field winding is energized from a separate external source of dc electric current



<u>Self-excited DC motor</u>

Series motor:

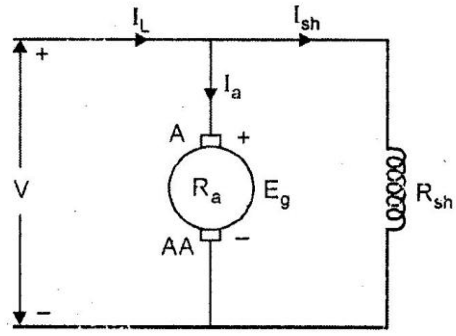
- The armature winding and field winding are connected in series
- The entire armature electric current flows through the field winding as its connected in series to the armature winding
- In a series wound dc motor, the speed varies with load



Shunt motor:

- The field winding is connected in parallel to the armature winding

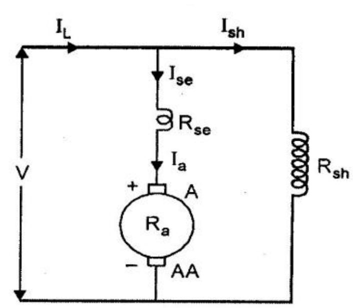
- The voltage is same across field winding and armature winding
- The line current is the sum of armature current and field current
- The shunt wound dc motor is a constant speed motor, as the speed does not vary here with the variation of mechanical load on the output.



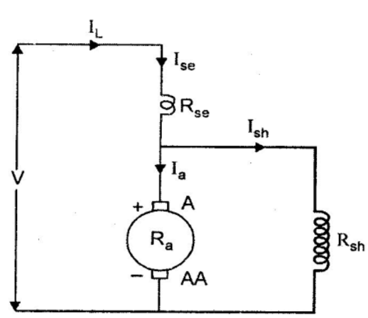
Compound Motor:

- The compound excitation characteristic in a dc motor can be obtained by combining the operational characteristic of both the shunt and series excited dc motor
- It contains the field winding connected both in series and in parallel to the armature winding
- If the shunt field winding is only parallel to the armature winding and not the series field winding then its known as short shunt dc motor
- If the shunt field winding is parallel to both the armature winding and the series field winding then it's known as long shunt type compounded wound dc motor
- When the shunt field flux assists the main field flux, produced by the main field connected in series to the armature winding then it's called cumulative compound dc motor
- In case of a differentially compounded self excited dc, the arrangement of shunt and series winding is such that the field flux produced by the shunt field winding diminishes the effect of flux by the main series field winding

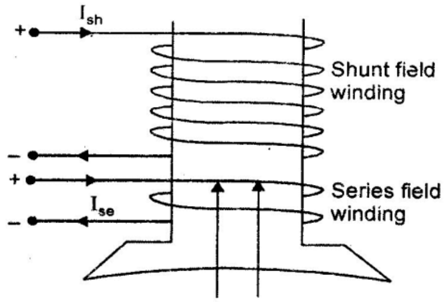
Long Shunt compound motor

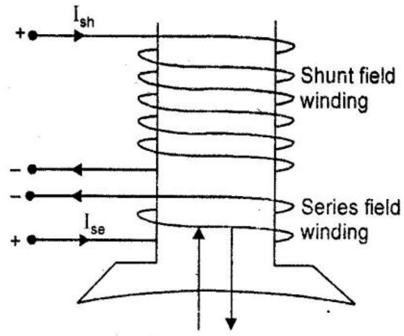


Short Shunt compound motor



Cumulative & Differential compound



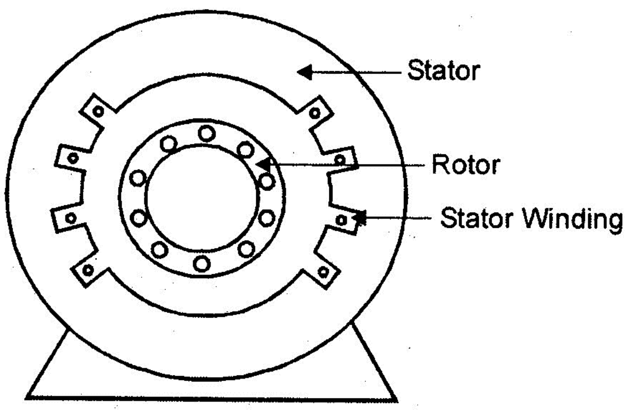


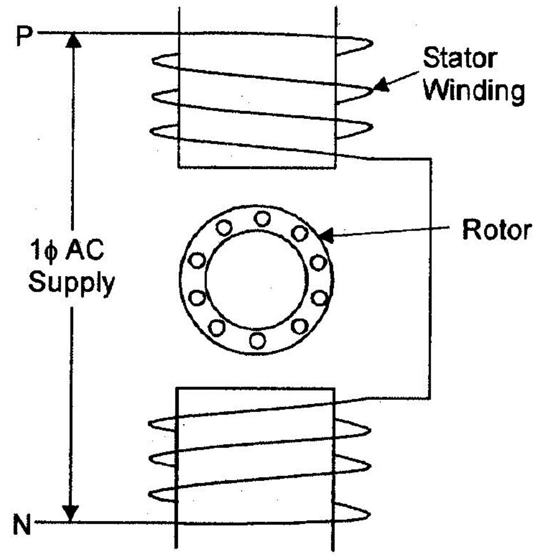
SINGLE PHASE INDUCTION MOTORS:

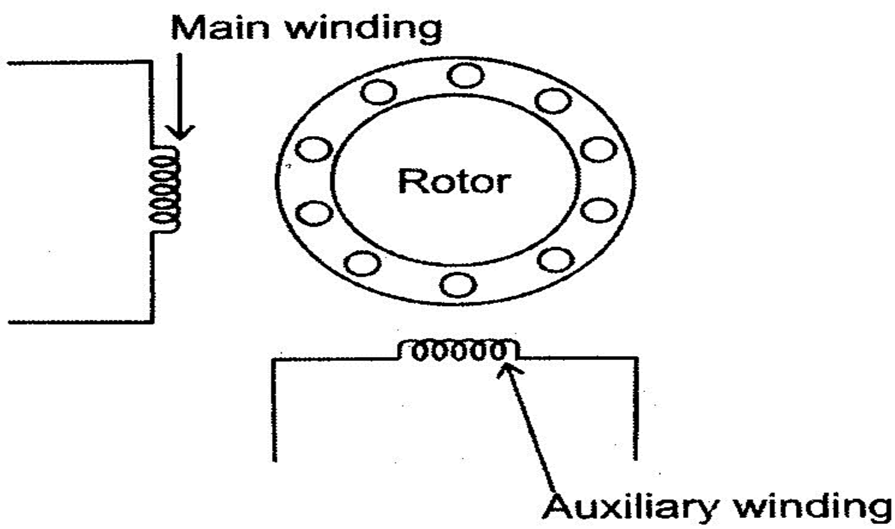
- Single phase motors are small motors.
- They have a power rating in fractional HP range.
- These motors are used in homes, offices, shops and factories.
- Disadvantages:

  1. Lack of starting torque.
  2. Reduced power factor.
  3. Low efficiency.

CONSTRUCTION:







- The construction of a single phase induction motor is similar to 3φ squirrel cage induction motor.
- Stator has a single phase distributed winding.
- Rotor → Squirrel cage rotor.
- It has no self starting torque.

PRINCIPLE OF OPERATION:

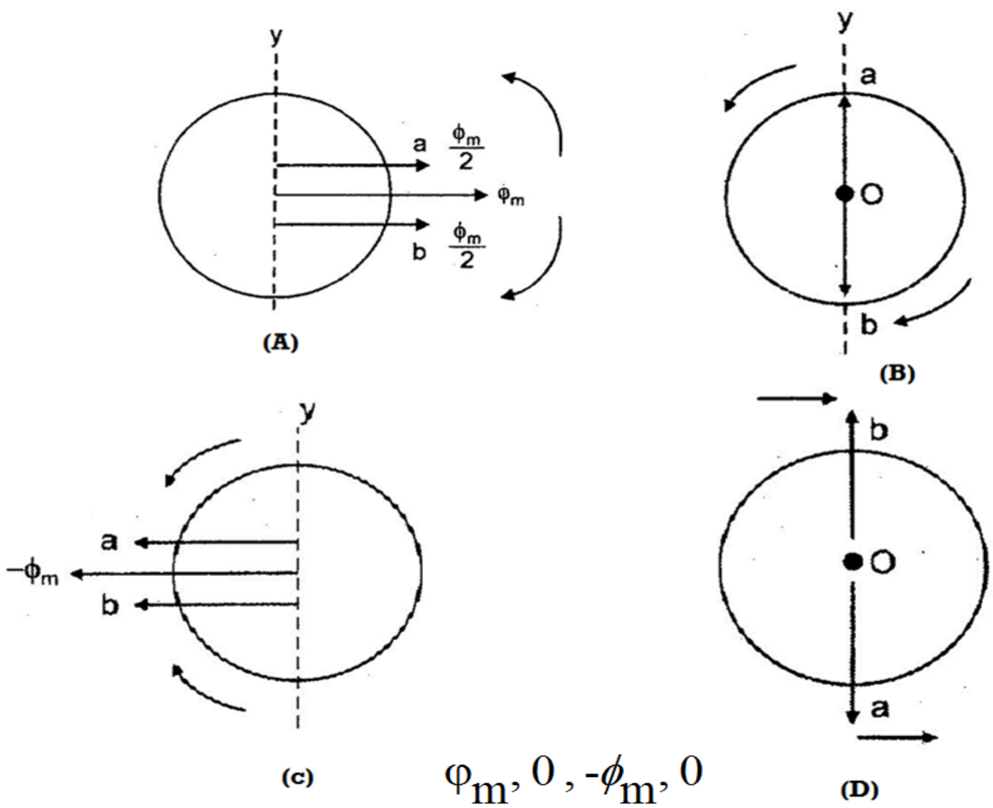
- The starting torque can be produced by using auxiliary winding.
- The angle between main winding and auxiliary winding should be 90 electrical degrees.

- The current passing through main winding and auxiliary winding should have some electrical angle to produce a rotating magnetic field.
- Rotating magnetic field produces high starting torque.
- The single-phase induction motor operation can be described by two methods:

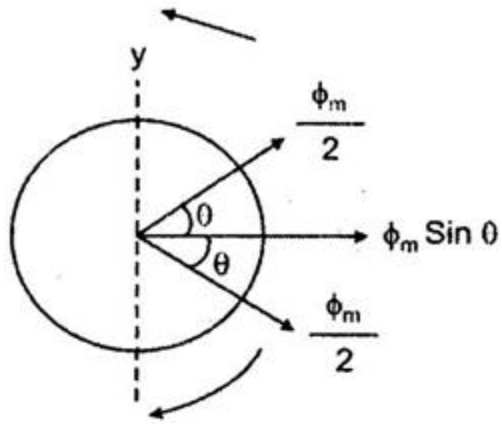
– Double revolving field theory; and
– Cross-field theory.

DOUBLE REVOLVING FIELD THEORY:

- A single-phase AC current supplies the main winding that produces a pulsating magnetic field.
- Mathematically, the pulsating field could be divided into two fields, which are rotating in opposite directions.
- The pulsating filed is divided a forward and reverse rotating field.
- The components ‘a’ and ‘b’ are forward and reverse rotating field respectively



Rotation of vector by an angle +φ and –φ



The flux variation with respect to φ:

The forward slip of the rotor is given by

$$s_f = \frac{N_S - N}{N_S}$$

$$s_f = 1 - \frac{N}{N_S}$$

$$\frac{N}{N_S} = 1 - s_f$$

The backward slip of the rotor is given by

$$s_b = \frac{N_S - (-N)}{N_S}$$

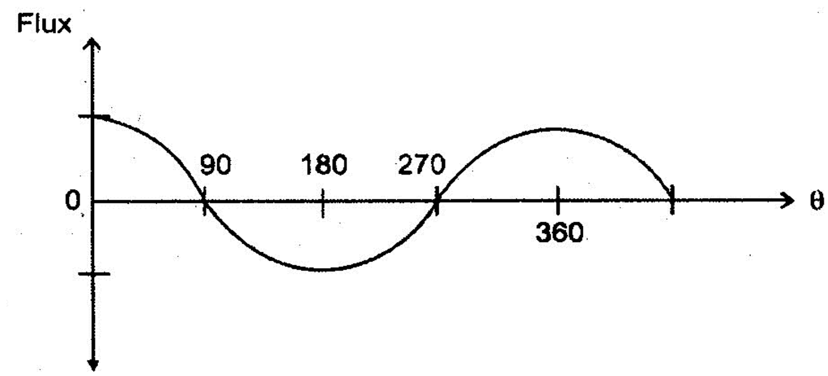
$$s_b = \frac{N_S + N}{N_S}$$

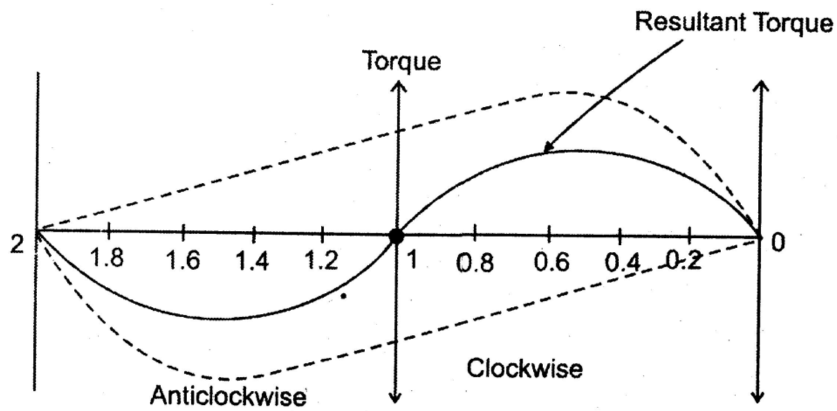
$$s_b = 1 + \frac{N}{N_S}$$

$$s_b = 1 + 1 - s_f$$

$$s_b = 2 - s_f$$

Flux versus time:



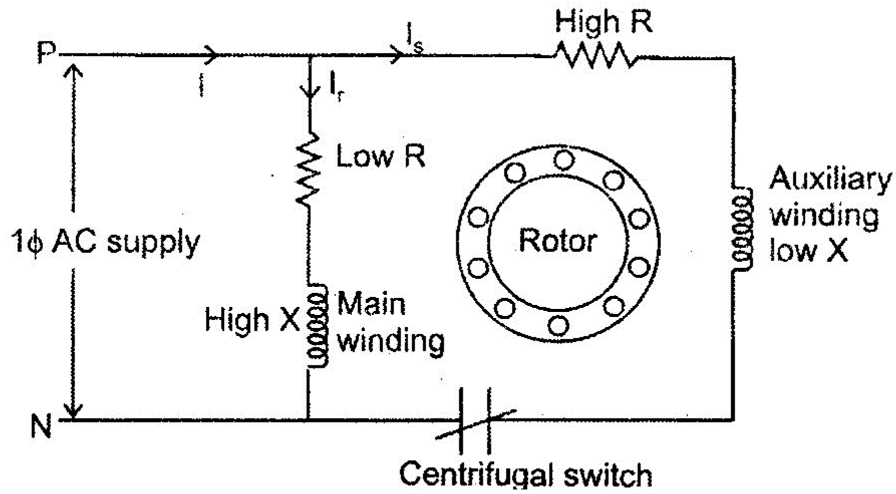


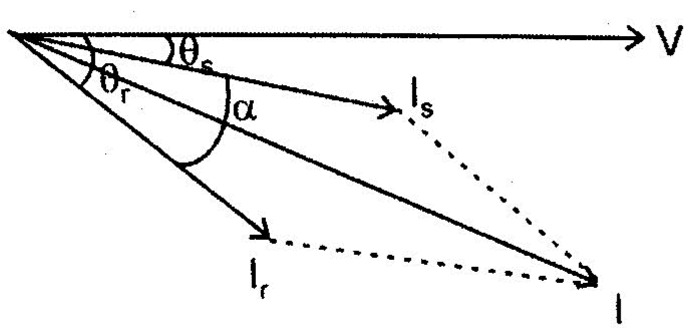
- At starting, the slip value of 1φ induction motor is '1'.
- When slip is 1, the components 'a' and 'b' are producing equal and opposite torque.
- The resulting torque is zero.
- This motor has no starting torque.

TYPES OF 1Φ IM (STARTING METHODS):

- Resistance – Start (Split phase) motor.
- Capacitor – Start induction motor.
- Capacitor – Run induction motor.
- Capacitor – Start and Capacitor – Run IM.
- Shaded – pole motor.

Resistance – Start (Split phase) motor:



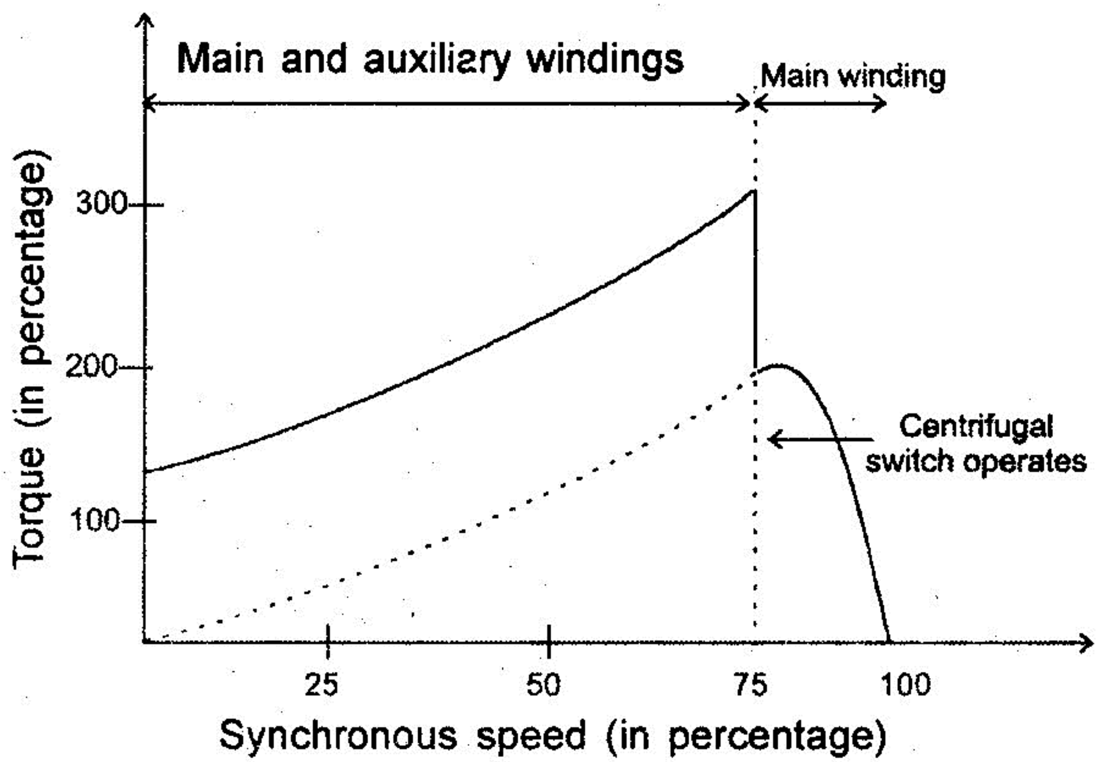


- It has two windings:

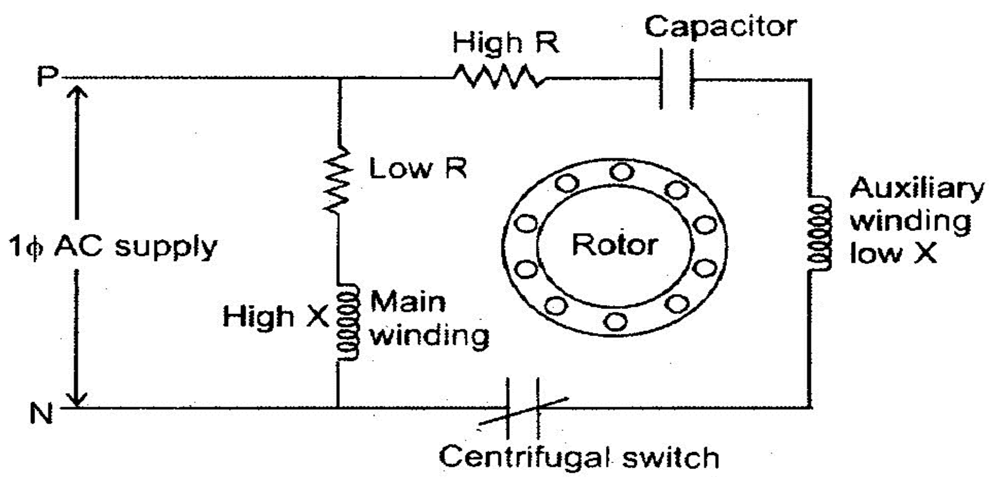
  1. Main winding or Running winding
  2. Auxiliary winding.
- These two winding axes are displaced by 90 electrical degrees.
- The main winding has high X (reactance) value and low R (resistance) value.
- The auxiliary winding has Low X value and High R value.
- This variation in the reactance makes two different phases.
- Two phase supply constructs rotating magnetic field.
- The rotating magnetic field produces high torque at the starting time.
- The centrifugal switch disconnects the auxiliary winding from the circuit after the motor reaches synchronous speed.
- **Applications:**

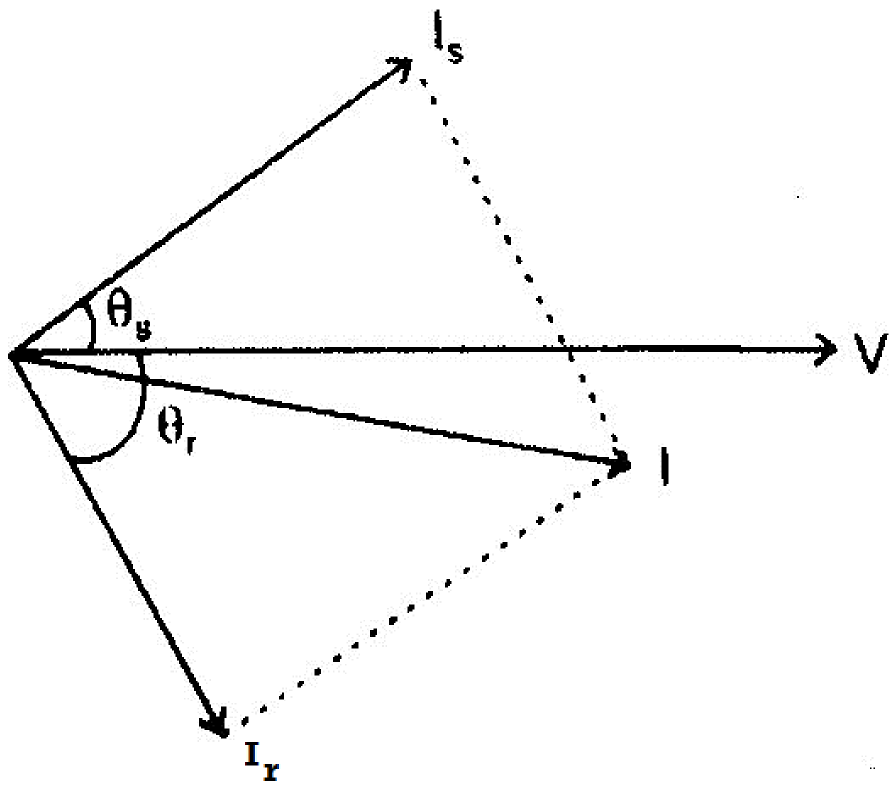
  Fans, Blowers, Centrifugal pumps, washing machines

Torque Vs Speed:



Capacitor – Start induction motor:

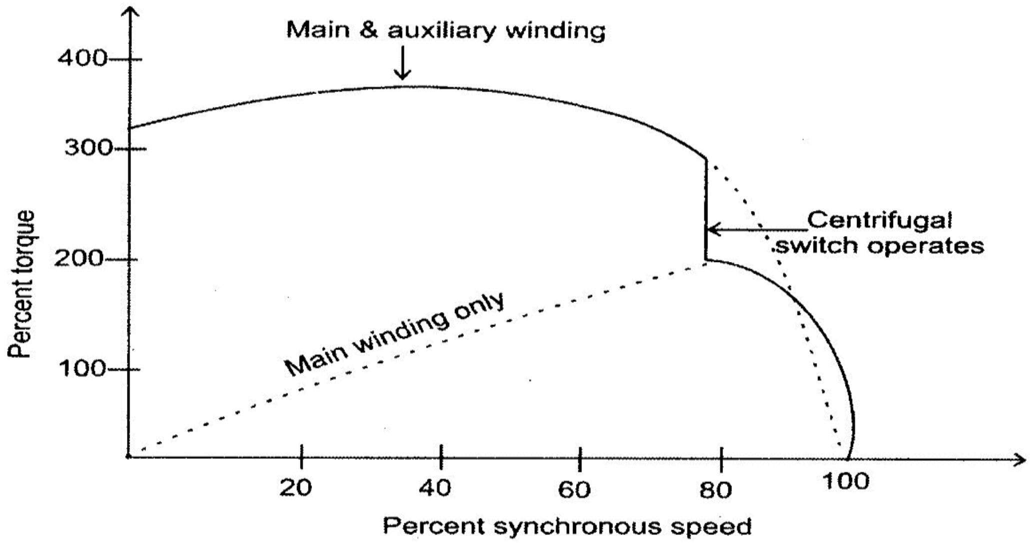




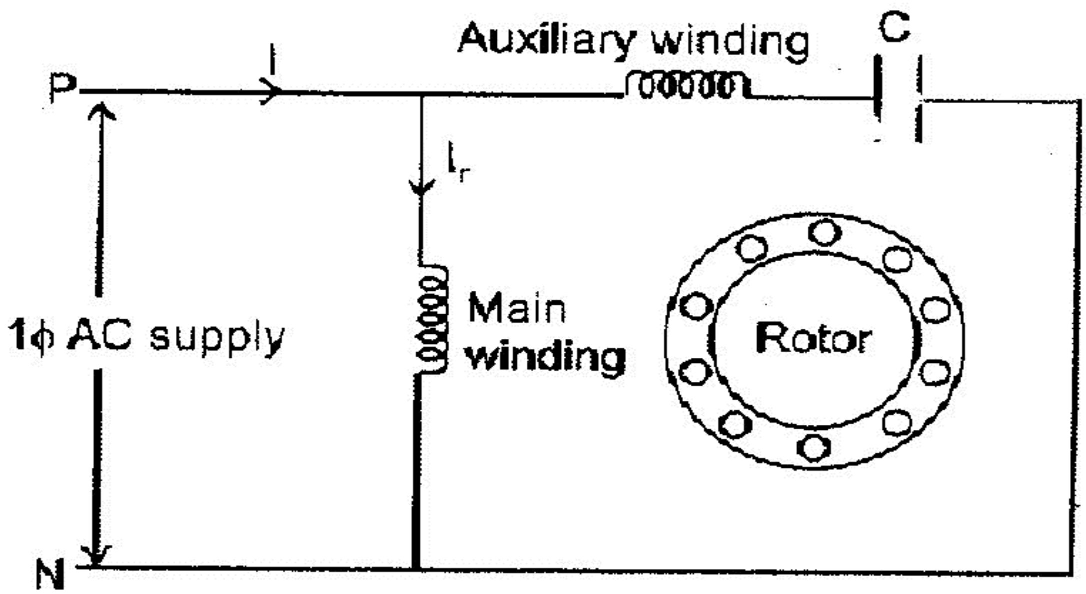
- A capacitor is connected in series with auxiliary winding to produce leading current in auxiliary winding.
- The high X value of main winding produces lagging current.
- Voltage across two windings produces two different phases.
- Two phase supply constructs rotating magnetic field.
- The rotating magnetic field produces high torque at the starting time.
- The centrifugal switch disconnects the auxiliary winding and capacitor from the circuit after the motor reaches 75% of synchronous speed.
- **Applications:**

Compressors, Pumps, Conveyors, Refrigerators, Air conditioning Equipments, Washing machines

Speed Vs Torque:



Capacitor – Run induction motor:

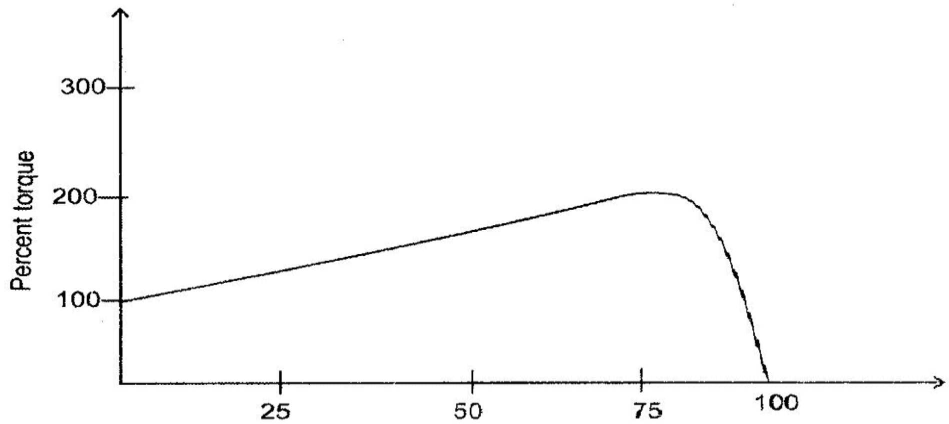


- A capacitor is connected in series with auxiliary winding to produce leading current in auxiliary winding.
- The high X value of main winding produces lagging current.
- Voltage across two windings produces two different phases.
- Two phase supply constructs rotating magnetic field.
- The rotating magnetic field produces high torque at the starting time.
- It does not use centrifugal switch.
- The capacitor is always connected with auxiliary winding so that the starting and running torque is high.

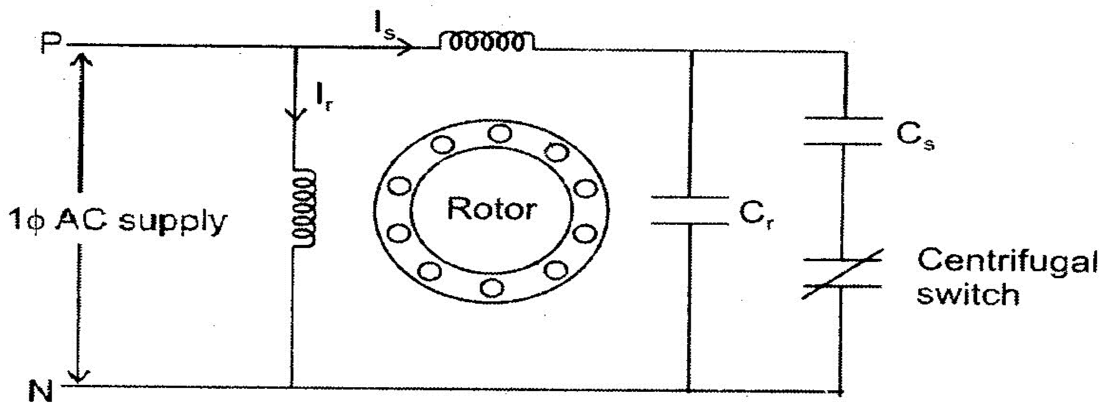
- **Applications:**

  Fans, Blowers, Centrifugal pumps

Speed Vs Torque:



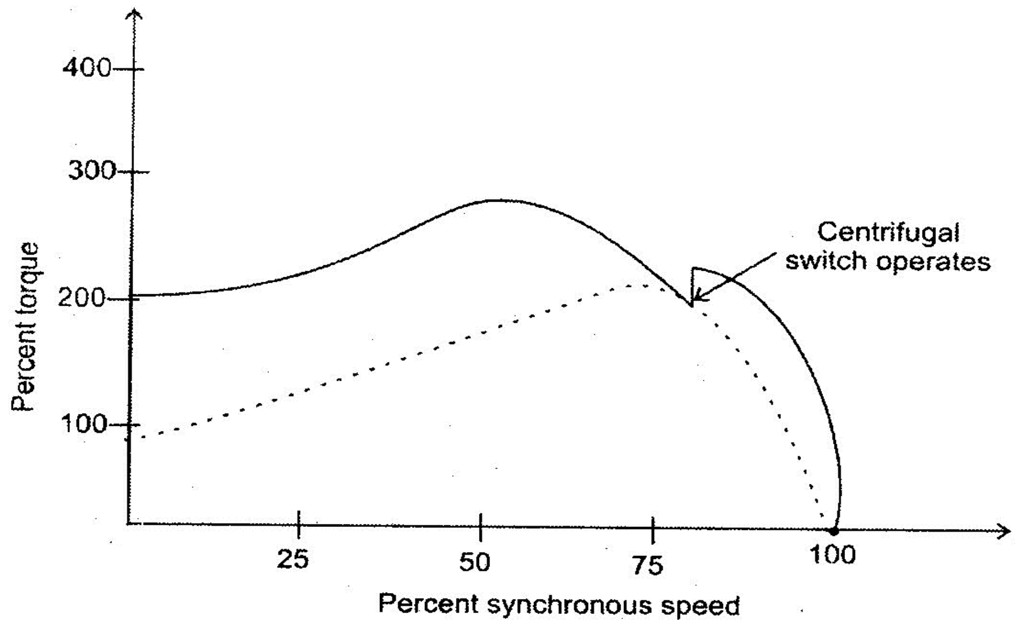
Capacitor – Start and Capacitor – Run IM:



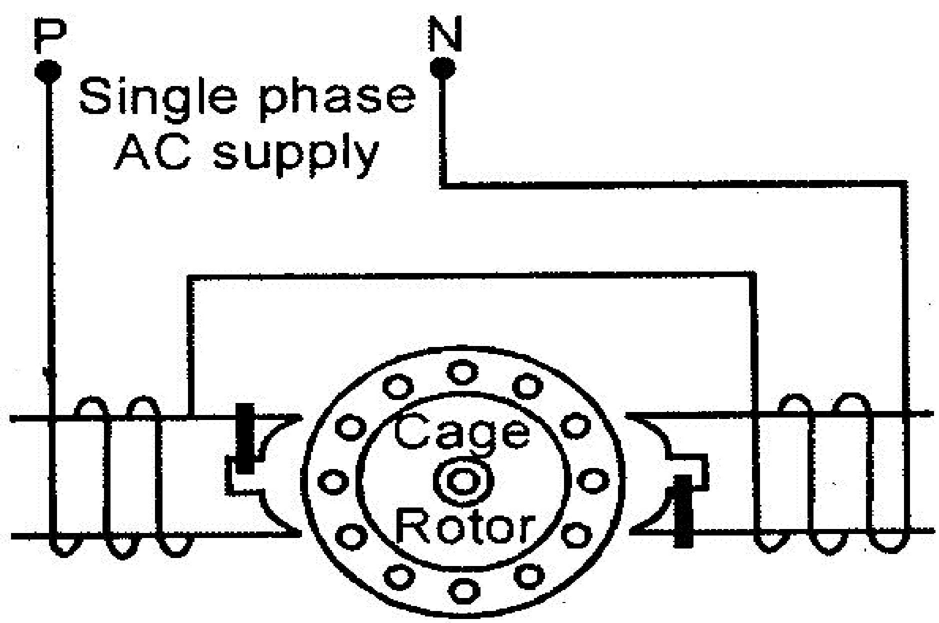
- It uses two capacitors, Running capacitor (Cr) and starting capacitor (Cs).
- Running capacitor always connected in series with auxiliary winding.
- Starting capacitor is disconnected from the circuit after the motor reaches 75% of synchronous speed by the help of Centrifugal switch.
- Starting torque and efficiency can be improved.
- **Applications:**

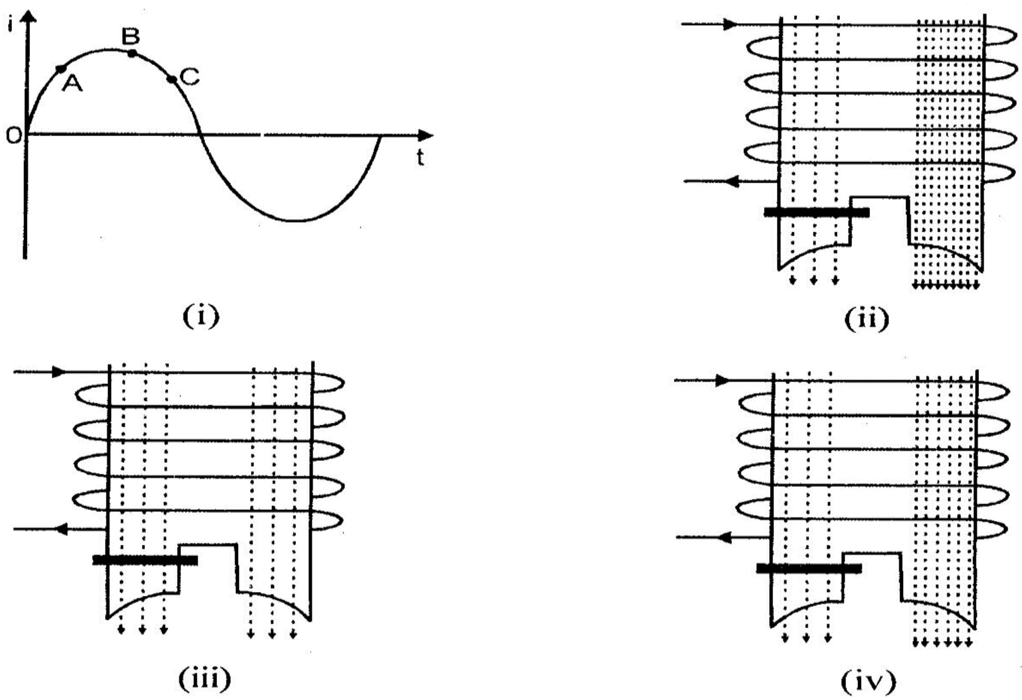
  Compressors, Pumps, Conveyors, Refrigerators

Speed Vs Torque:



Shaded – pole motor:





- During the portion OA of the alternating current cycle, the emf is induced in the shading coil. The induced emf produces magnetic flux in the shaded portion. This flux opposes the main field flux, so that the flux under shaded portion is weakened and flux under unshaded portion is strengthened .

- During the portion AB of the alternating current cycle, the flux under shaded portion and unshaded portion is uniform.

- During the portion BC of the alternative current cycle , the emf is induced in the shading coil. The induced emf produces magnetic flux in the shaded portion. This flux is added to the main field flux, so that the flux under shaded portion is strengthened and flux under unshaded portion is weakened.

- Alternatively it is producing strengthened and weakened magnetic flux under pole faces, so that it constructs rotating magnetic field.

- The rotating magnetic field produces high torque at the starting time.

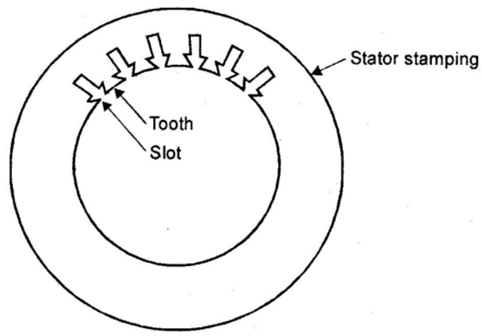
- Low efficiency, Low power factor and Very low starting torque.

- **Applications:**

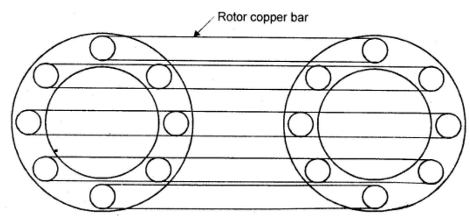
  Fans, Blowers, Turn tables, Hair driers, Motion picture projectors

PRINCIPLE OF OPERATION OF THREE-PHASE INDUCTION MOTORS:

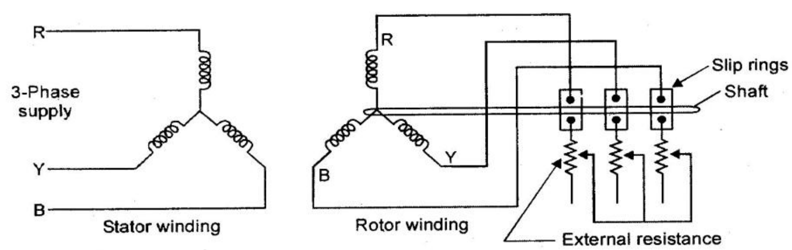
STATOR



Squirrel cage rotor



Slip ring or Wound Rotor



Principle of operation:

- Rotating magnetic field cuts the rotor windings and produces an induced voltage in the rotor windings.
- Due to the fact that the rotor windings are short circuited, for both squirrel cage and wound-rotor, and induced current flows in the rotor windings.
- The rotor current produces another magnetic field.
- A torque is produced as a result of the interaction of those two magnetic fields. This torque makes the rotation of the rotor.
- The IM will always run at a speed lower than the synchronous speed.
- The difference between the motor speed and the synchronous speed is called the Slip speed.

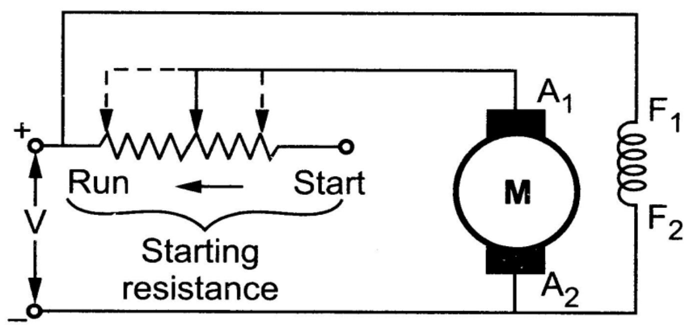
UNIT III

STARTING METHODS

STARTER:

- Starter is used to reduce starting current because armature consumes 15-20 times more than the full load current at starting time.
- High current blows out the fuses.
- It affects insulation of the coil.
- It also creates very high torque and very high torque causes mechanical damage to the motor.

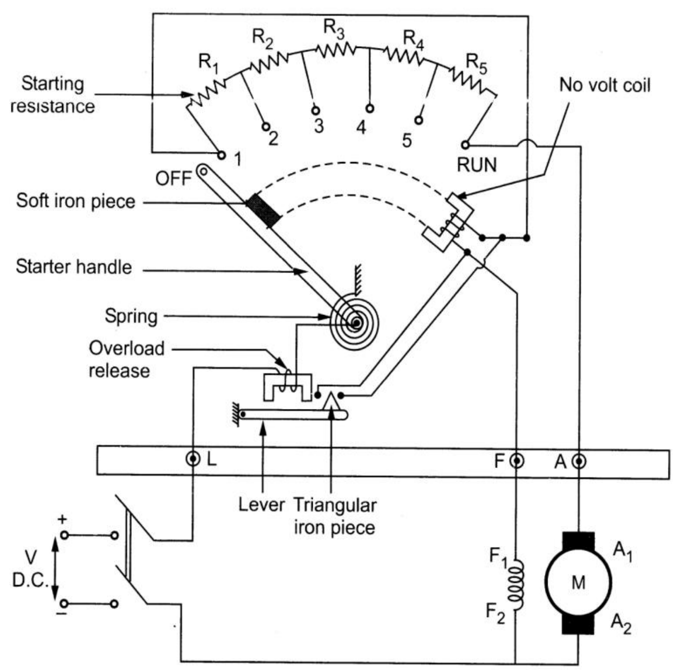
Basic Arrangement:



DC SHUNT MOTOR:

- Three Point Starter
- Four Point Starter

Three Point Starter:

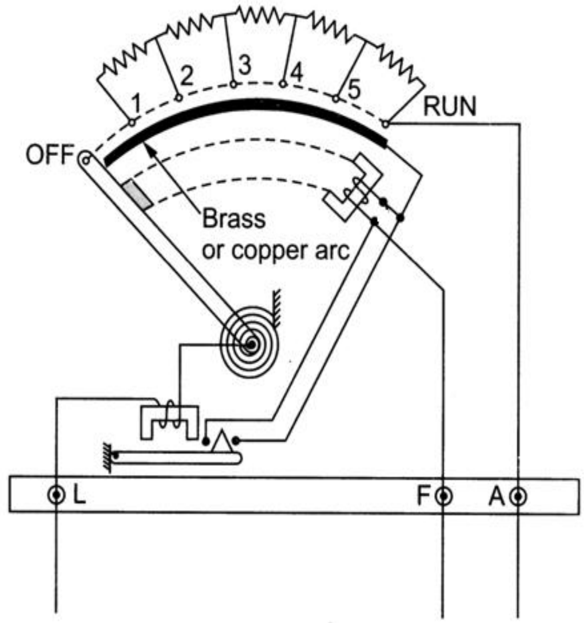


- The electric current will be dangerously high at starting (as armature resistance R_a is small) and hence its important that we make use of a device like the **3 point starter** to limit the starting electric current to an allowable lower value
- Construction wise a starter is a variable resistance, 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**
- There are 3 main points
  'L' Line terminal (Connected to positive of supply)
  'A' Armature terminal (Connected to the armature winding)
  'F' Field terminal (Connected to the field winding)
- The point 'L' is connected to an electromagnet called overload release (OLR)
- 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 the 3 point starter:

- 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 electric current thus gets limited as the electric 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
- when field electric 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 electric 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**
- when there is any kind of supply failure, the electric current flow through NVC is affected and it immediately loses 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
- Thus it also acts as a protective device safeguarding the motor from any kind of abnormality

3 Point Starter with brass Arc



FOUR POINT STARTER:

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

1. 'L' Line terminal. (Connected to positive of supply)

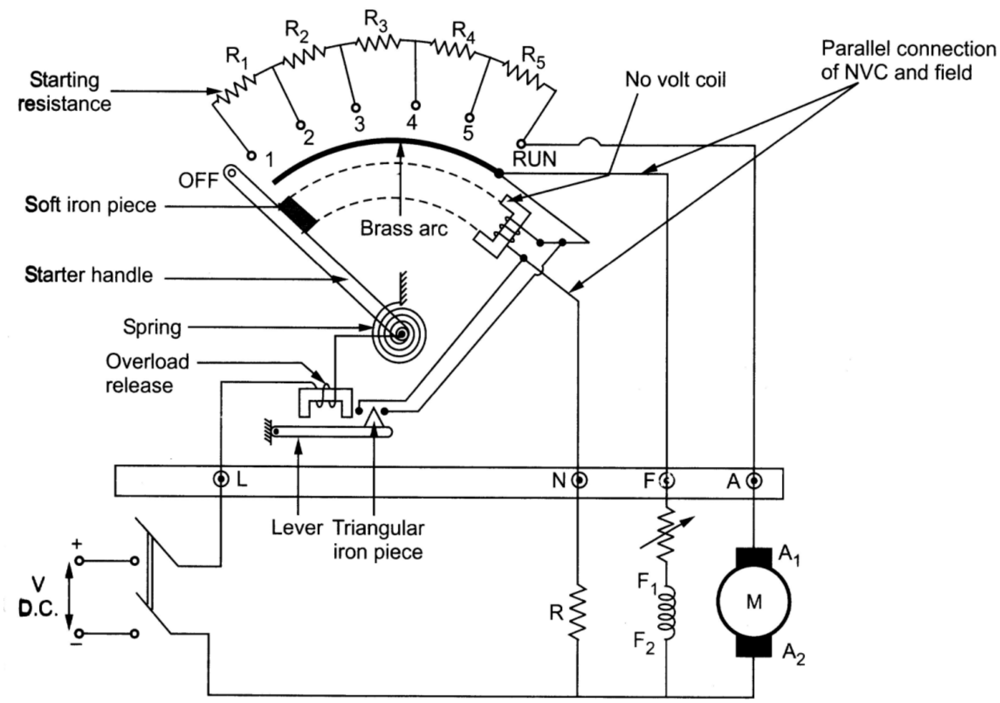
2. 'A' Armature terminal. (Connected to the armature winding)

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)

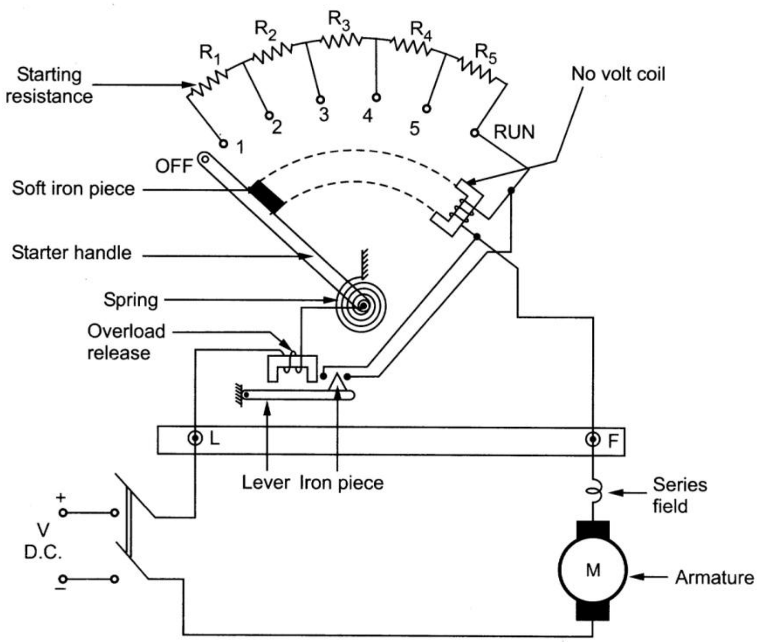
- The remarkable difference in case of a 4 point starter is that the No Voltage Coil is connected independently across the supply through the fourth terminal called 'N'
- The change in the field supply does affect the performance of the NVC
- Apart from this above mentioned fact, the 4 point and 3 point starters are similar in all other ways



<u>**DC Series Motor**</u>

TWO POINT STARTER:

- This starter is only for D.C. series motor only. The basic construction of two point starter is similar to that of three point starter except the fact that it has only two terminals namely line (L) and field (F)
- The F terminal is one end of the series combination of field and the armature winding. The action of the starter is similar to that of three phase starter.
- The main problem in case of D.C. series motor is it's over speeding action when the load is less
- This can be prevented using two point starters. The no-volt coil is connecting in series with the motor so both current are equal.
- At no load situation load current drawn by the motor decreases causes no-volt coil losses its required magnetism and releases the handle to OFF position.

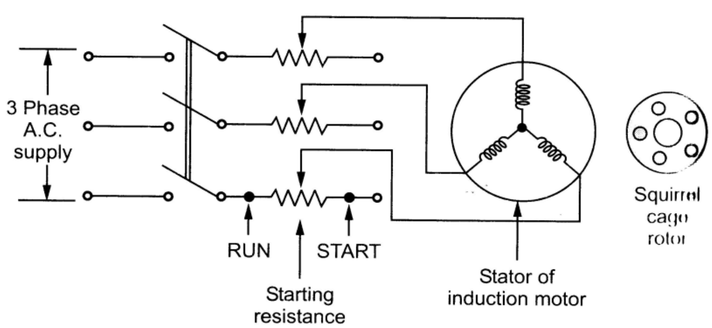


INDUCTION MOTOR STARTERS

- Stator Resistance Starter
- Autotransformer Starter
- Star – Delta Starter
- Rotor Resistance Starter
- Direct On Line Starter

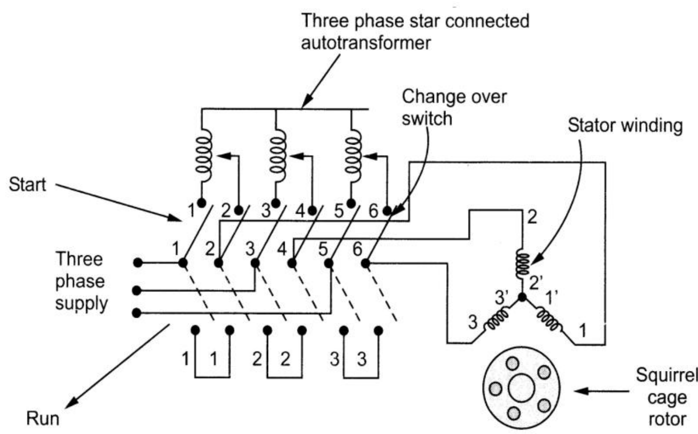
Stator Resistance Starter:

- The variable resistor connected in series with stator winding reduces the starting current
- The resistance value is varied from high to low by using sliding contacts of variable resistor
- Very simple speed control method
- Low maintenance
- Low cost



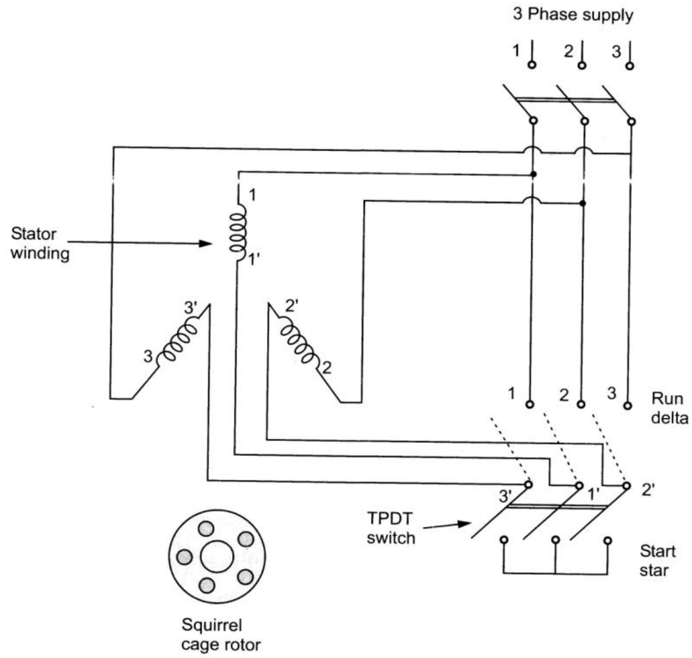
Autotransformer Starter:

- The operation principle of auto transformer method is similar to the star delta starter method
- The starting current is limited by (using a three phase auto transformer) reduce the initial stator applied voltage
- The auto transformer starter is more expensive, more complicated in operation and bulkier in construction when compared with the star – delta starter method
- The starting current and torque can be adjusted to a desired value by taking the correct tapping from the auto transformer



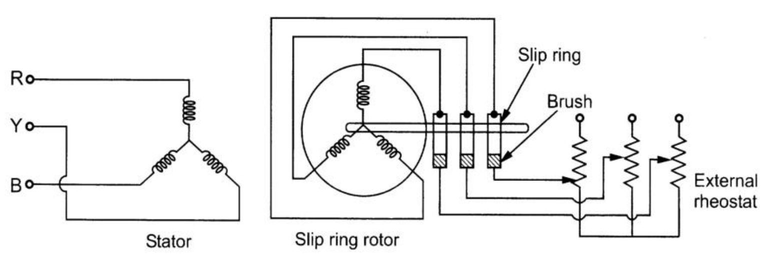
Star – Delta Starter:

- The star delta starting is a very common type of starter and extensively used, compared to the other types of the starters
- This method uses reduced supply voltage in starting
- Figure shows the connection of a 3phase induction motor with a star –delta starter
- The method achieved low starting current by first connecting the stator winding in star configuration
- After the motor reaches a certain speed, throw switch changes the winding arrangements from star to delta configuration
- At the time of starting when the stator windings are start connected, each stator phase gets voltage $\frac{V_L}{\sqrt{3}}$ where V_L is the line voltage
- As the voltage is reduced, the starting current also reduced
- Since the torque developed by an induction motor is proportional to the square of the applied voltage, star-delta starting reduced the starting torque to one – third that obtainable by direct delta starting



Rotor Resistance Starter:

- This method allows external resistance to be connected to the rotor through slip rings and brushes
- Initially, the rotor resistance is set to maximum and is then gradually decreased as the motor speed increases, until it becomes zero
- The rotor resistance starting mechanism is usually very bulky and expensive when compared with other methods
- It also has very high maintenance costs
- Also, a considerable amount of heat is generated through the resistors when current runs through them
- The starting frequency is also limited in this method
- However, the rotor resistance method allows the motor to be started while on load



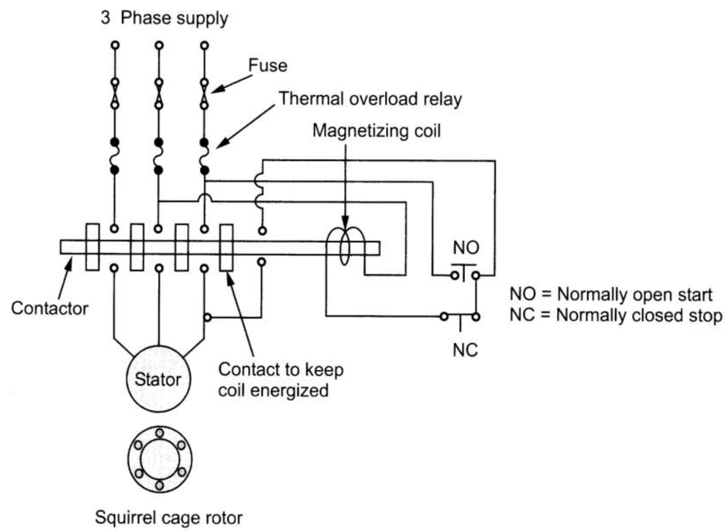
Direct On Line Starter:

- The Direct On-Line (DOL) starter is the simplest and the most inexpensive of all starting methods and is usually used for squirrel cage induction motors
- It directly connects the contacts of the motor to the full supply voltage
- The starting current is very large, normally 6 to 8 times the rated current

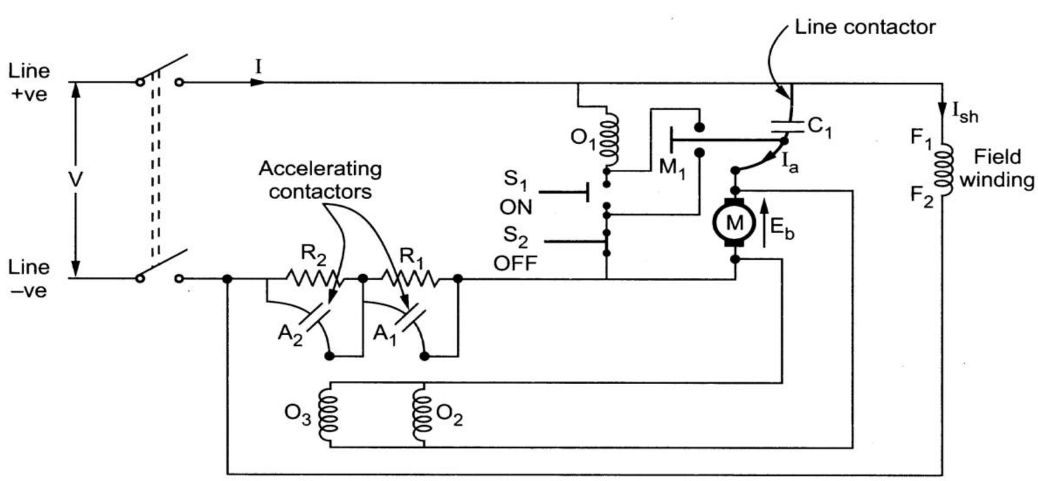
- The starting torque is likely to be 0.75 to 2 times the full load torque
- In order to avoid excessive voltage drops in the supply line due to high starting currents, the DOL starter is used only for motors with a rating of less than 5KW
- There are safety mechanisms inside the DOL starter which provides protection to the motor as well as the operator of the motor

Operation:

- The DOL starter consists of a coil operated contactors controlled by start and stop push buttons
- On pressing the start push button NO, the contactor coil is energized from line
- The three mains contacts and an auxiliary contact are closed
- The motor is thus connected to the supply
- When the stop push button NC is pressed, the supply through the contactor is Disconnected
- Since the coil is de-energized, the main contacts are opened. The supply to motor is disconnected and the motor stops



AUTOMATIC STARTER



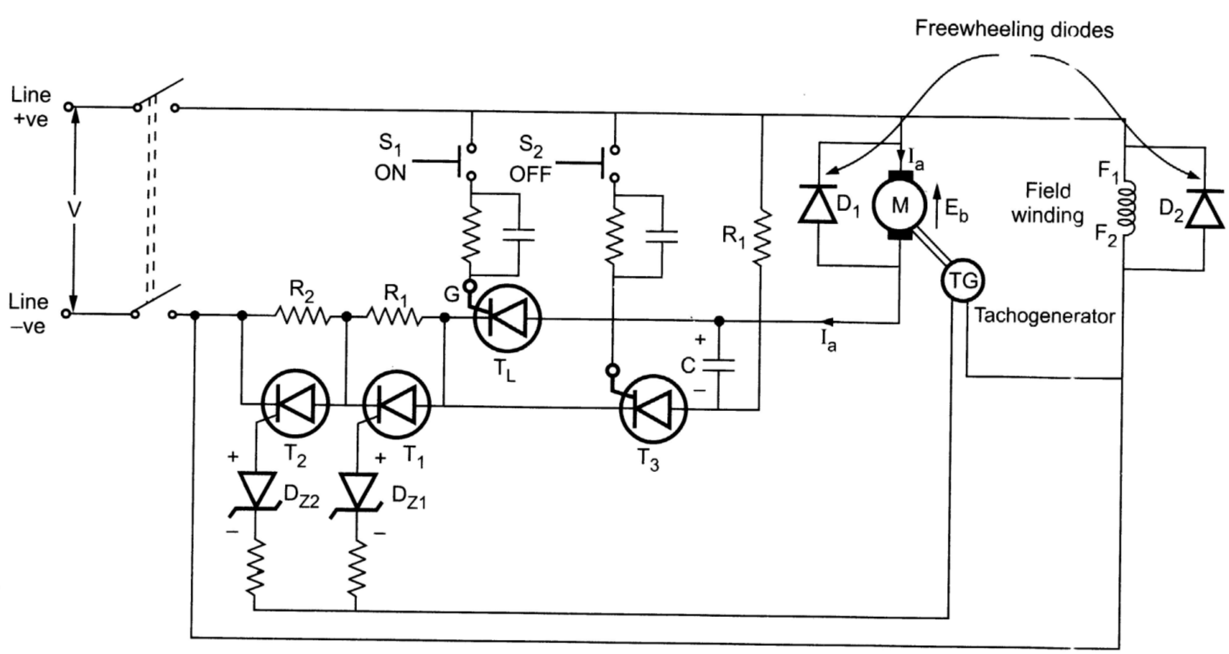
PARTS:

1. Magnetising coil O_1, O_2, O_3
2. Contacts M_1, C_1, A_1, A_2
3. ON switch, OFF switch
4. Resistors
5. DPST switch

WORKING:

- DPST switch is ON
- Press ON switch
- As soon as ON switch is pressed, Coil O_1 gets energised and Contacts M_1, $C_1$are closed
- When Contacts M_1, $C_1$are closed, the armature current flows through R_1 and R_2 and hence the starting current is reduced
- When the motor reaches above 60% speed, the coil O_2 gets energised and hence the contact A_1 is closed
- When the contact A_1 is closed, resistor R_1 is disconnected from armature circuit
- When the motor reaches above 80% speed, the coil O_2 and O_3 gets energised and hence the contact A_1 and A_2 are closed
- When the contacts A_1 and A_2 are closed, resistors R_1 and R_2 are disconnected from the armature circuit
- Finally, the motor rotates at normal speed
- To stop the motor, the OFF button should be pressed
- As soon as the OFF button is pressed, the coil gets reenergized and motor is stopped.

ELECTRONIC STARTER – SHUNT MOTOR



PARTS:

- Thyristor
- Freewheeling diodes

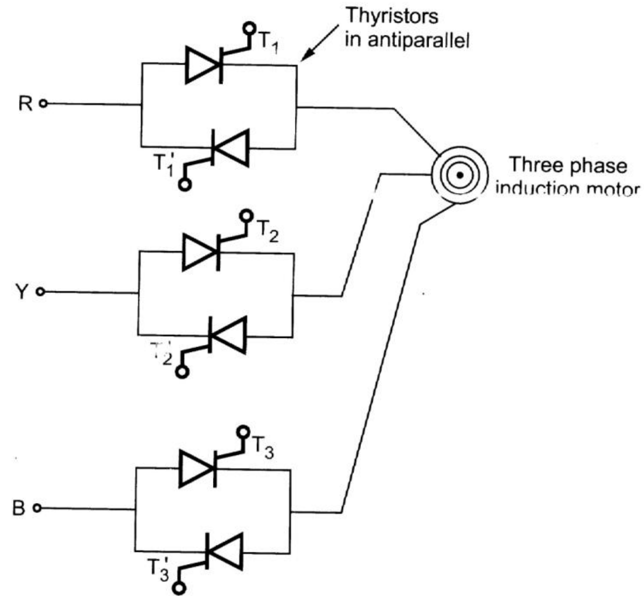
- Tachogenerator
- Zener diode
- Capacitor
- Resistors R_1 and R_2
- Switch S_1 and S_2

WORKING:

- The thyristor is an electronic switch
- It acts as a closed switch, when it conducts
- Resistors R_1 and R_2 are used to reduce starting current
- As soon as the ON button S_1 is pressed, thyristor T_L acts as closed switch, the supply is given to the armature of the motor
- Motor starts to rotate with low starting current because resistors R_1 and R_2 are connected in series with armature winding
- At the same time the capacitor C starts charging with the voltage polarities as shown in figure.
- To cut-off resistors R_1 and R_2, the tachogenerator is used
- When the motor reaches the speed above 60%, the zenerdiode D_{z1} starts conduction and hence the thyristor T_1 acts as a closed switch
- Resistor R_1 is disconnected from the armature circuit
- When the motor reaches the speed above 80%, the zenerdiode D_{z2} starts conduction and hence the thyristor T1andT2 act as a closed switch
- Resistors R_1 and R_2 are disconnected from the armature circuit and the motor runs with normal current
- To stop the motor, the OFF button S_2 should be pressed
- As soon as the OFF button S_2 is pressed, the thyristor T_L stops conduction because the capacitor starts discharging through the thyristor T_L by the aid of thyristor T_3

ELECTRONIC STARTER – IM (Soft Starter)

- The thyristor voltage control method is used in the soft starter
- Resistors are not used in soft starter to reduce the starting current
- The thyristors T_1, T_1', T_2, T_2' and T_3, T_3' are used in the soft starter
- Two thyristors are connected in antiparallel in each line
- Now the antiparallel connection acts as triac
- To control the voltage, the firing angle of triac is controlled
- The voltage and the current are directly proportional
- When the voltage reduces, the current reduces and vice versa
- The starting current is controlled by controlling the starting voltage



UNIT IV
SPEED CONTROL OF DC DRIVES

SPEED CONTROL OF DC MOTORS

- **Speed Control of Shunt Motor**

  * Flux Control
  * Armature Voltage Control (Rheostatic Control)
  * Applied Voltage Control
- **Speed Control of Series Motor**

  * Flux Control
  * Rheostatic Control
  * Applied Voltage Control
- **Ward- Leonard System of Speed Control**

1. **Speed Control of Dc Shunt Motor:**

Flux Control

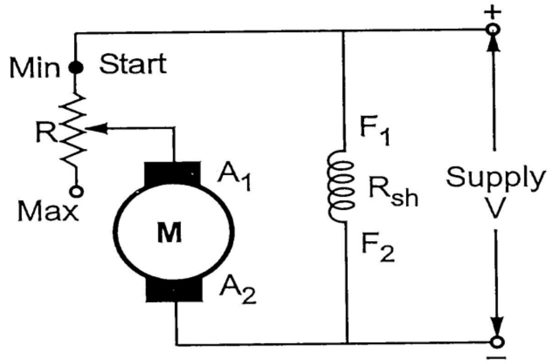
$$N \infty \frac{E_b}{\varphi}$$

$$N \infty \frac{V - I_a R_a}{\varphi}$$

- speed of the motor is inversely proportional to flux
- The speed can be controlled by varying flux
- To vary the flux, a rheostat is added in series with the field winding
- Adding more resistance in series with field winding will increase the speed, as it will decrease the flux

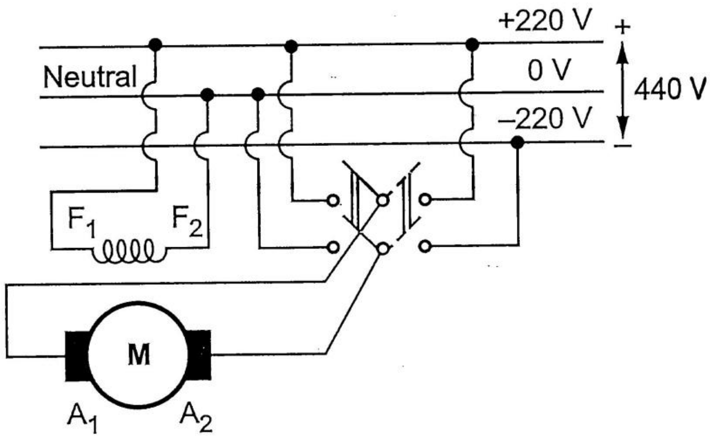
- Field current is relatively small and hence I^2R loss is small
- This method is quiet efficient
- The speed can be reduced by using this method.

Armature Voltage Control



- Speed of the motor is directly proportional to the armature voltage
- When armature voltage varies, the armature current varies
- Speed is directly proportional to armature current I_a
- If we add resistance in series with armature, I_a decreases and hence speed decreases.
- The speed can be reduced by using this method.

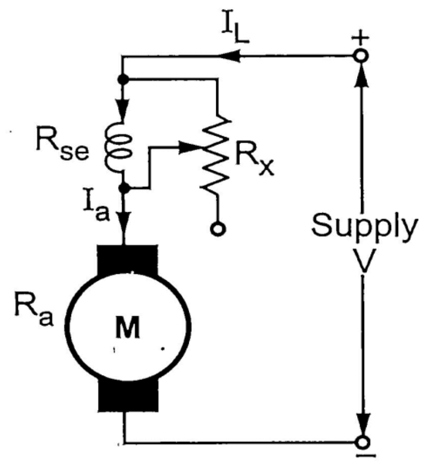
Applied Voltage Control:



- The speed is approximately proportional to the voltage across the armature.
- Voltage across armature is changed with the help of a suitable switchgear
- Armature is supplied with different voltages to get varies speed
- The shunt filed is connected to a fixed exciting voltage

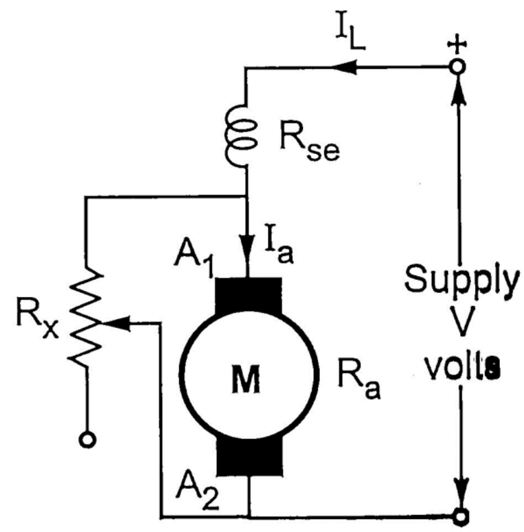
2. **<u>Speed Control of Series Motor:</u>**

Field Diverter Method:



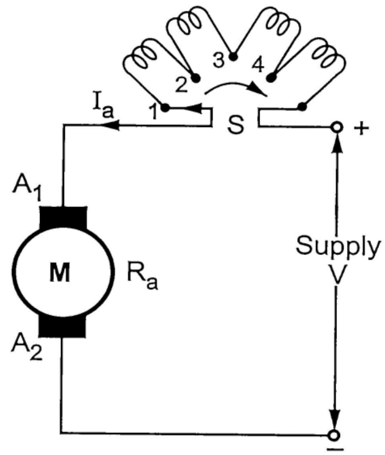
- A veritable resistance is connected parallel to the series field
- This variable resistor is called as diverter
- The desired amount of current can be diverted through this resistor and hence current through field coil can be decreased
- The flux can be decreased to desired amount and speed can be increased

Armature Diverter Method:



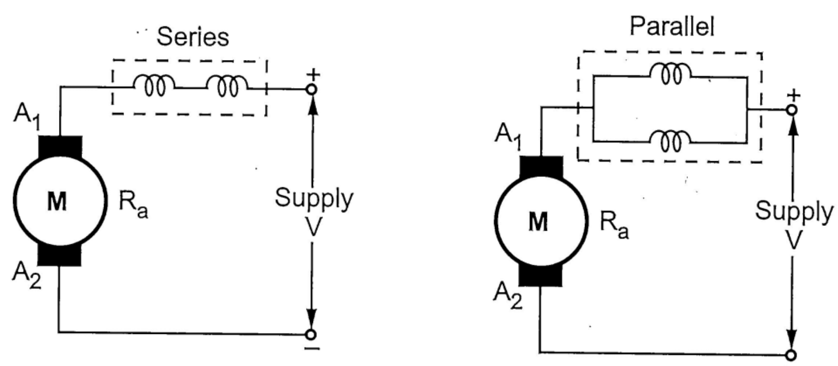
- The diverter is connected across the armature
- The desired amount of armature current can be diverted through this resistor and hence current through field coil and armature can be varied
- The flux is varied and speed can be increased

Tapped Field Method:



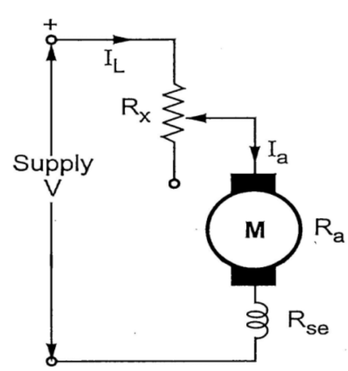
- The field coil is tapped
- The number of turns can be changed and hence the flux can be changed
- We can select different value of Ø by selecting different number of turns.
- The speed inversely proportional to flux Ø

Series – Parallel Connection of Field:



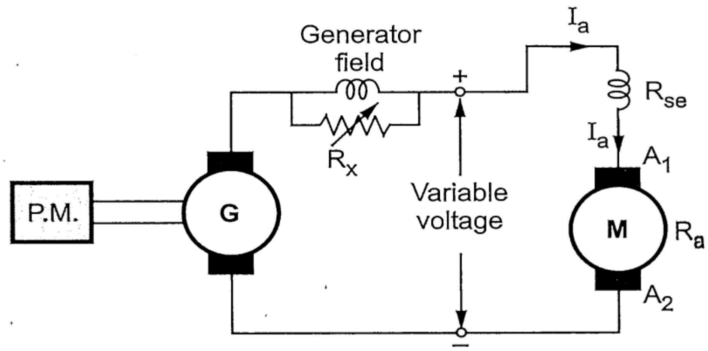
- This system is widely used in electric traction
- In this method, several speeds can be obtained by regrouping coils in parallel and series
- When the coils are in series, the same current passing through them and flux increases
- When the coils are in parallel, the current gets divided and flux reduces

3. Rheostatic Control



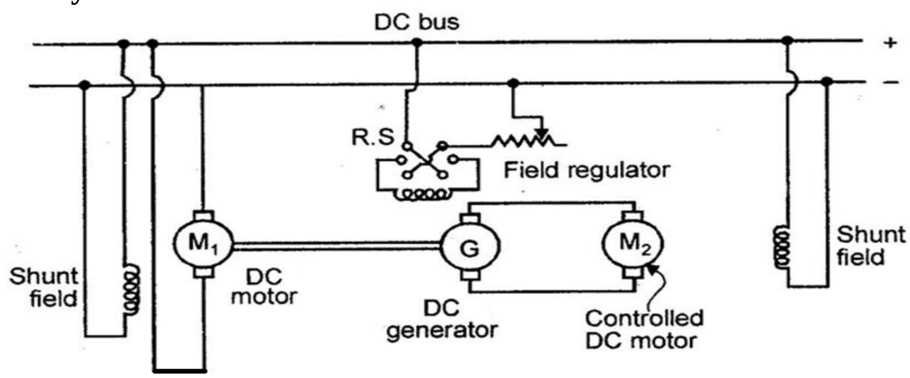
➢ By introducing resistance in series with armature, voltage across the armature can be reduced. And hence, speed reduces in proportion with it.

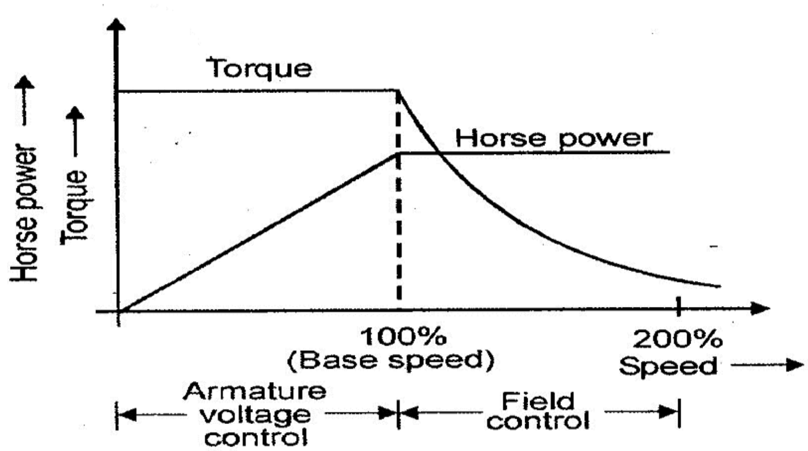
4. Applied Voltage Control



- ➢ The speed is approximately proportional to the voltage across the armature and field winding
- ➢ Voltage across the armature and field is changed with the help of a Dc motor generator set
- ➢ Armature and field is supplied with different voltages to get varies speed

Ward-Leonard control system





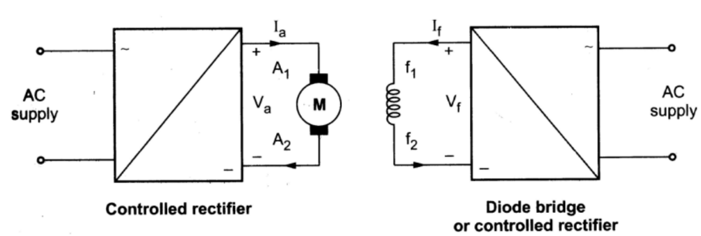
➢ This system is used where very sensitive speed control of motor is required (e.g electric excavators, elevators etc.)

➢ M_2 is the motor whose speed control is required

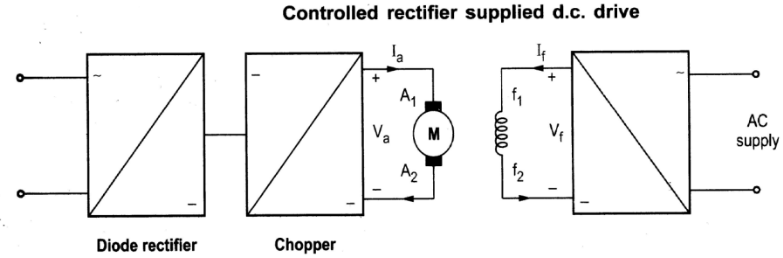
- M_1 may be any AC motor or DC motor with constant speed
- M_1 acts as prime mover to DC generator
- G is the generator directly coupled to M_1
- The output from the generator G is fed to the armature of the motor M_2 whose speed is to be controlled
- The output voltage of the generator G can be varied from zero to its maximum value, and hence the armature voltage of the motor M_2 is varied very smoothly
- Very smooth speed control of motor can be obtained by this method.

SPEED CONTROL DC MOTOR – USING CONVERTERS

- Direct current (dc) motors have variable characteristics and are used extensively in variable-speed drives.
- DC motors can provide a high starting torque and it is also possible to obtain speed control over a wide range.
- The methods of speed control are normally simpler and less expensive than those of AC drives.
- DC motors play a significant role in modern industrial drives.
- Both series and separately excited DC motors are normally used in variable-speed drives, but series motors are traditionally employed for traction applications.
- Due to commutator, DC motors are not suitable for very high speed applications and require more maintenance than do AC motors.
- With the recent advancements in power conversions, control techniques, and microcomputers, the ac motor drives are becoming increasingly competitive with DC motor drives.
- Although the future trend is toward AC drives, DC drives are currently used in many industries. It might be a few decades before the DC drives are completely replaced by AC drives.



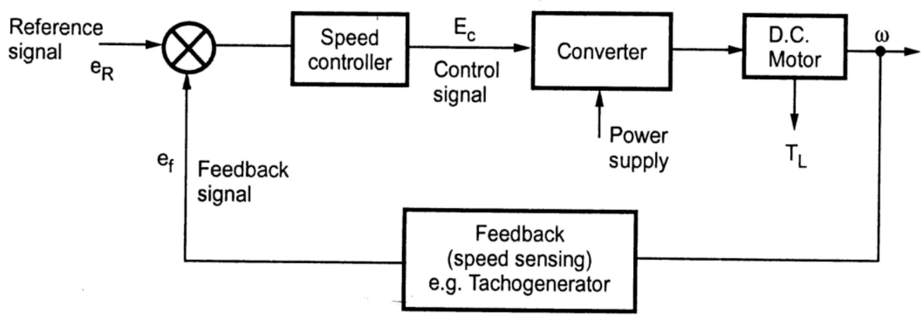
Controlled rectifier supplied d.c. drive



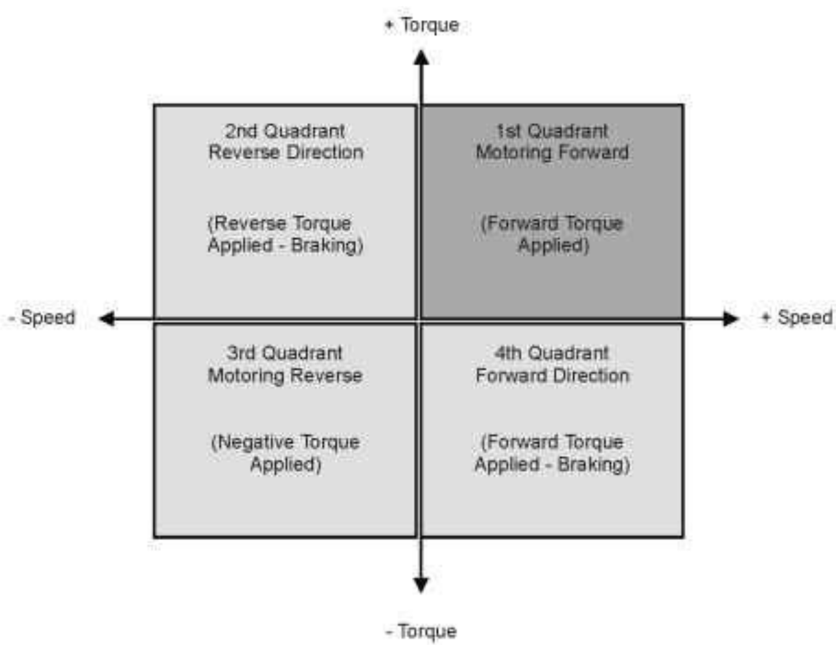
Chopper fed d.c. drive

CLOSED LOOP CONTROL OF DC DRIVES:

- The speed of dc motors changes with the load torque.
- To maintain a constant speed, the armature (and or field) voltage should be varied continuously by varying the delay angle of ac-dc converters or duty cycle of dc-dc converters.
- In practical drive systems it is required to operate the drive at a constant torque or constant power; in addition, controlled acceleration and deceleration are required.
- Most industrial drives operate as closed-loop feedback systems.
- A closed-loop control system has the advantages of improved accuracy, fast dynamic response, and reduced effects of load disturbances and system nonlinearities.
- The block diagram of a closed-loop converter-fed separately excited dc drive is shown in Figure
- If the speed of the motor decreases due to the application of additional load torque, the speed error V_e increases.
- The speed controller responses with an increased control signal V_c, change the delay angle or duty cycle of the converter, and increase the armature voltage of the motor.
- An increased armature voltage develops more torque to restore the motor speed to the original value.
- The drive normally passes through a transient period until the developed torque is equal to the load torque.



FOUR QUADRANT OPERATIONS



DRIVES CLASSIFICATION:

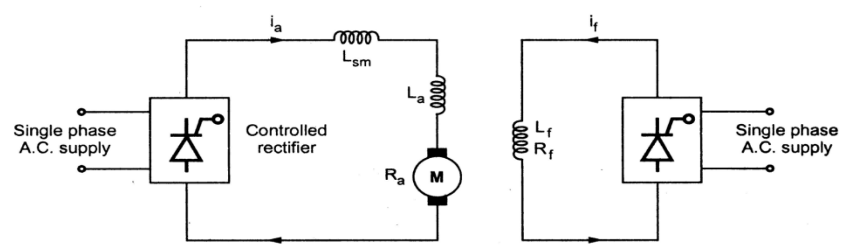
- Single phase drives
- Three phase drives
- Chopper drives

Single phase drives:

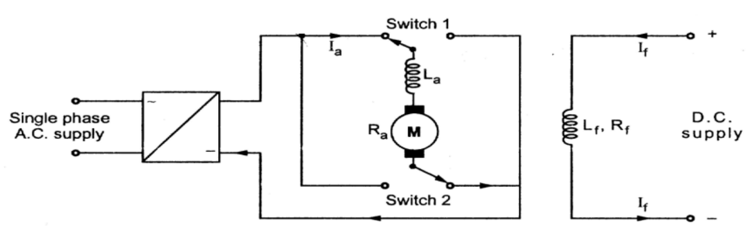
- The motor speed can be varied by
  - controlling the armature voltage V_a, known as voltage control;
  - controlling the field current I_f, known as field control; or
  - torque demand, which corresponds to an armature current I_a, for a fixed field current I_f.

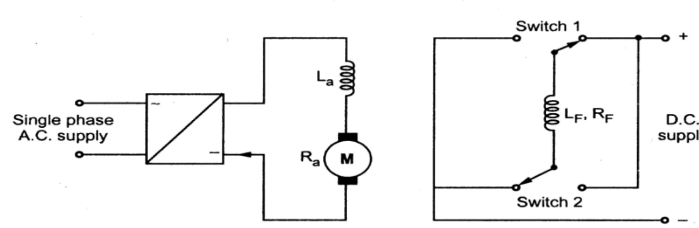
The speed, which corresponds to the rated armature voltage, rated field current and rated armature current, is known as the rated (or base) speed

- In practice, for a speed less than the base speed, the armature current and field currents are maintained constant to meet the torque demand, and the armature voltage V_a is varied to control the speed.
- For speed higher than the base speed, the armature voltage is maintained at the rated value and the field current is varied to control the speed.
- However, the power developed by the motor (= torque X speed) remains constant.
- Figure below shows the characteristics of torque, power, armature current, and field current against the speed.



Single phase drives with contactor:





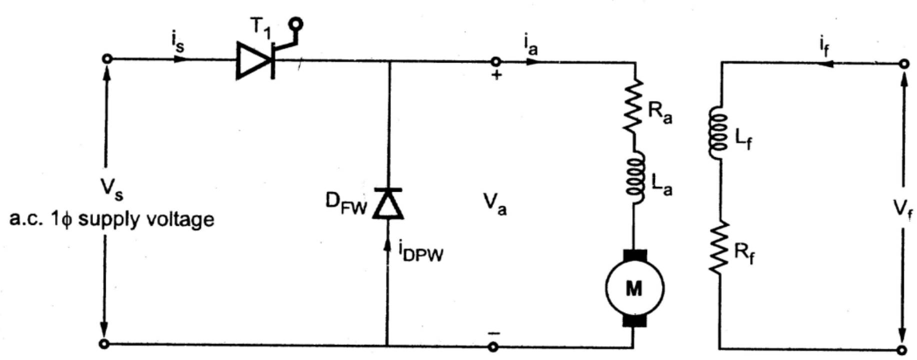
TYPES of Single Phase Drives:

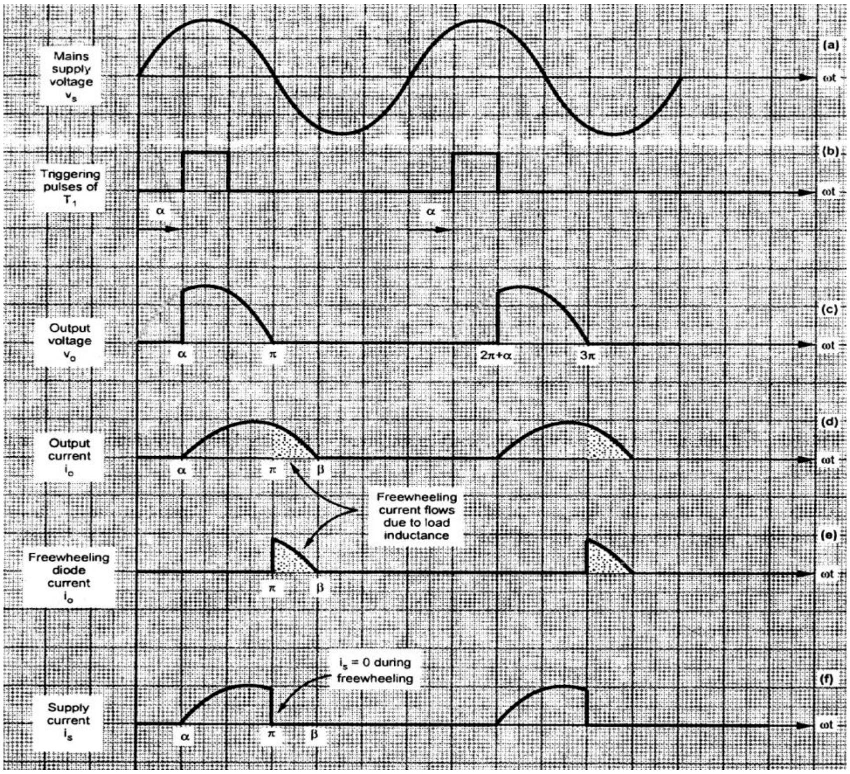
- Single phase half wave converter drive
- Single phase semi converter drive
- Single phase full converter drive
- Single phase dual converter drive

Single Phase Half Wave Converter Drive:

- A single-phase half-wave converter feeds a dc motor, as shown below.
- The armature current is normally discontinuous unless a very large inductor is connected in the armature circuit.
- A freewheeling diode is always required for a dc motor load and it is a one-quadrant drive.
- The applications of this drive are limited to the 0.5 kW power level.
- Figure shows the waveforms for a highly inductive load.
- A half-wave converter in the field circuit would increase the magnetic losses of the motor due to high ripple content on the field excitation current.
- The voltage across the armature $V_a = \frac{V_m}{2\Pi}(1+\cos\alpha)$ for $0 \leq \alpha \leq \Pi$

  V_a – Armature voltage
  V_m – Maximum voltage
  α - Firing angle

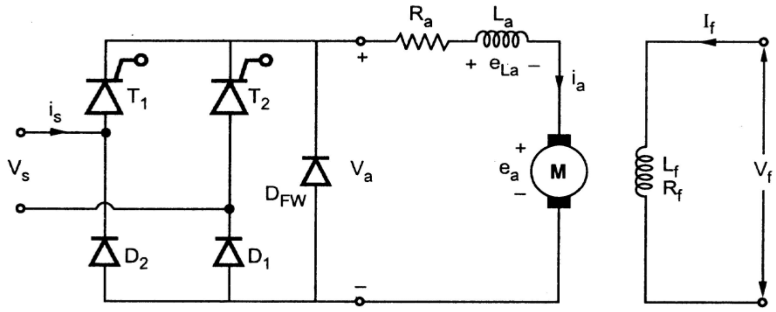


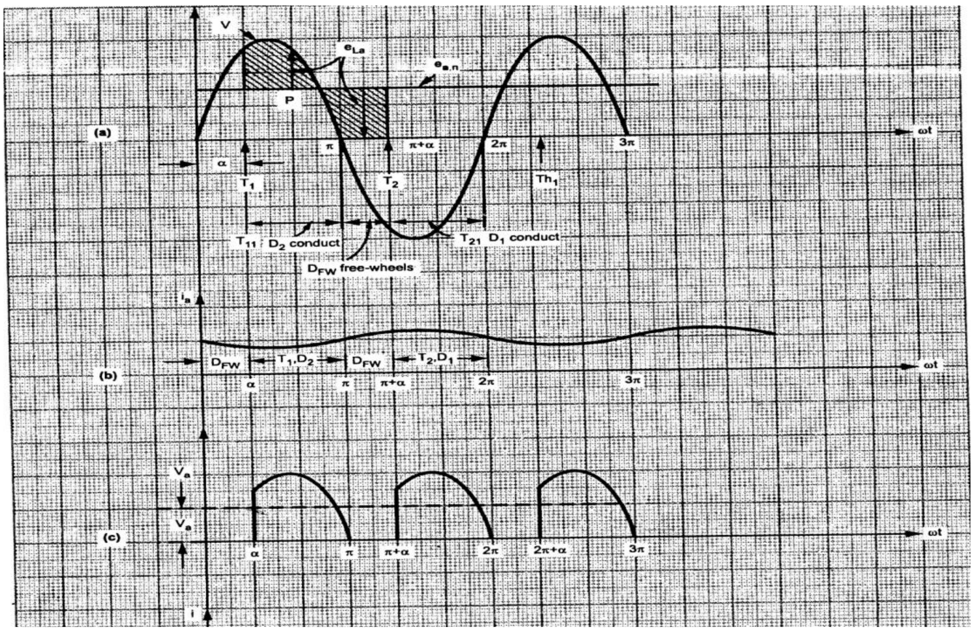


Single Phase Semi Converter Drive:

- It is one quadrant converter which gives current and voltage of one polarity
- Regenerative braking is not possible
- When T_1 and D_1 conducts, the positive cycle of input is transferred to armature of the motor
- When T_2 and D_2 conducts, the negative cycle of input is transferred to armature of the motor but the direction is the same
- Freewheeling diode is used to get continuous current flow through the armature winding.
- When thyristors off,   the stored energy in the coil is discharging through diode.
- The voltage across the armature $V_a = \frac{V_m}{\Pi}(1+\cos\alpha)$ for $0 \le \alpha \le \Pi$

  V_a – Armature voltage
  V_m – Maximum voltage
  α - Firing angle

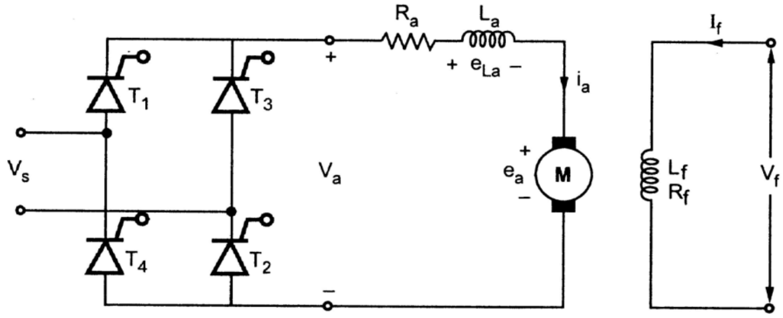


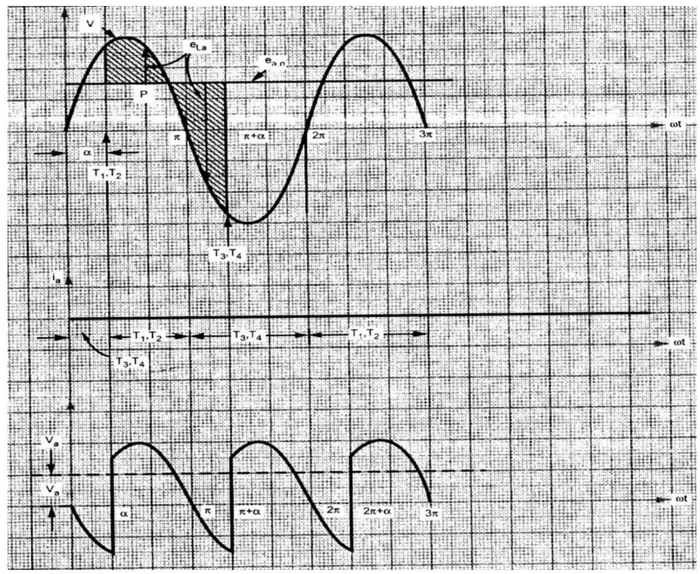


Single Phase Full Converter Drive:

- The armature voltage is varied by a single-phase full-wave converter, as shown in Figure
- It is a two-quadrant drive, as shown in Figure, and is limited to applications up to 15 kW.
- The armature converter gives + V_a or - V_a, and allows operation in the first and fourth quadrants.
- During regeneration for reversing the direction of power flow, the back emf of the motor can be reversed by reversing the field excitation.
- The converter in the field circuit could be a full, or even a dual converter.
- The reversal of the armature or field allows operation in the second and third quadrants.
- The current waveforms for a highly inductive load are shown in Figure for powering action.
- Freewheeling diode is not necessary
- The voltage across the armature $V_a = \frac{2V_m}{\Pi}\cos\alpha$ for $0 \le \alpha \le \Pi$

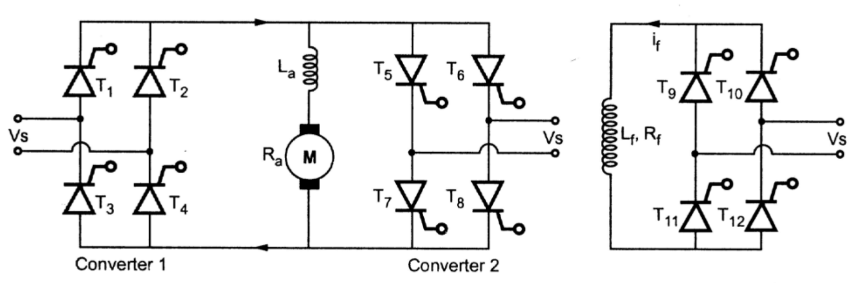
  V_a – Armature voltage
  V_m – Maximum voltage
  α - Firing angle





Single Phase Dual Converter Drive:

- Two single-phase full-wave converters are connected.
- Either converter 1 operates to supply a positive armature voltage, V_a, or converter 2 operates to supply a negative armature voltage, - V_a.
- Converter 1 provides operation in the first and fourth quadrants, and converter 2, in the second and third quadrants.
- It is a four-quadrant drive and permits four modes of operation: forward powering, forward braking (regeneration), reverse powering, and reverse braking (regeneration).
- It is limited to applications up to 15 kW. The field converter could be a full-wave or a dual converter.



THREE PHASE DRIVES

- The armature circuit is connected to the output of a three-phase controlled rectifier.
- Three-phase drives are used for high-power applications up to megawatt power levels.
- The ripple frequency of the armature voltage is higher than that of single-phase drives and it requires less inductance in the armature circuit to reduce the armature ripple current.
- The armature current is mostly continuous, and therefore the motor performance is better compared with that of single-phase drives.

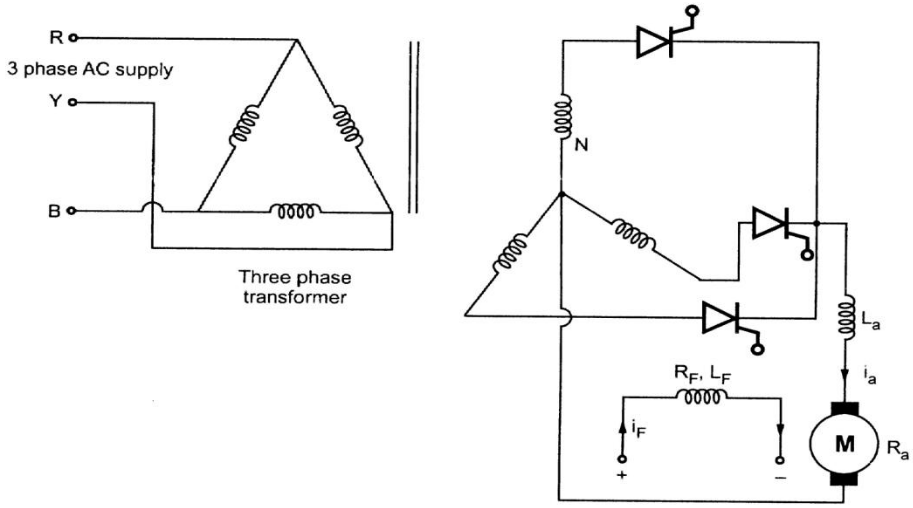
TYPES:

- Three phase Half converter drive
- Three Phase semi converter drive
- Three Phase full converter drive
- Three phase dual converter drive

Three Phase Half Converter Drive:

- Three **single phase half-wave converters** are connected together to form a **three phase half-wave converter**
- The thyristor T_1 in series with one of the supply phase windings *'a-n'* acts as one half wave controlled rectifier
- The second thyristor T_2 in series with the supply phase winding *'b-n'* acts as the second half wave controlled rectifier
- The third thyristor T_3 in series with the supply phase winding acts as the third half wave controlled rectifier
- The 3-phase input supply is applied through the star connected supply transformer as shown in the figure
- The common neutral point of the supply is connected to one end of the load while the other end of the load connected to the common cathode point.
- When the thyristor T_1 is triggered, the phase voltage V_{an} appears across the load when T_1 conducts
- The load current flows through the supply phase winding *'a-n'*and through thyristor T_1 as long as T_1 conducts
- When thyristor T_2 is triggered, T_1 becomes reverse biased and turns-off. The load current flows through the thyristor and through the supply phase winding *'b-n'* . When T_2conducts the phase voltage v_{bn} appears across the load until the thyristor T_3 is triggered
- When the thyristor T_3 is triggered, T_2 is reversed biased and hence T_2 turns-off. The phase voltage V*an* appears across the load when T_3 conducts
- The voltage across the armature $V_a = \frac{3\sqrt{3}V_m}{2\Pi}\cos\alpha$ for $0 \le \alpha \le \Pi$

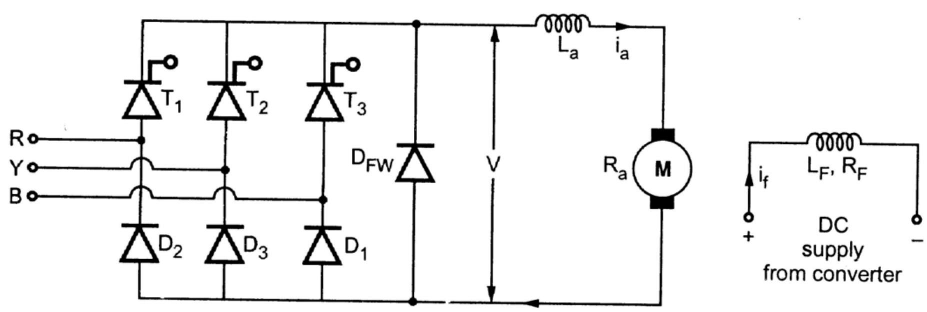
V_a – Armature voltage
V_m – Maximum voltage
α - Firing angle

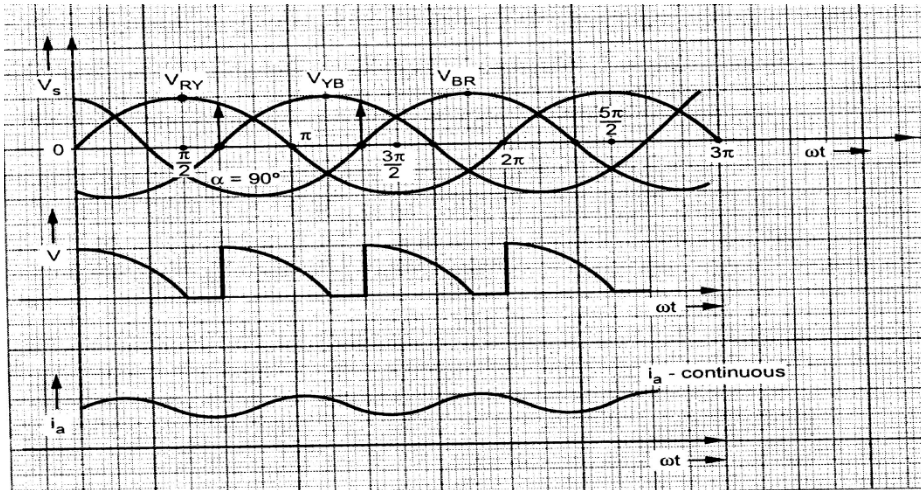


Three Phase Semi Converter Drive:

- 3-phase semi-converters are three phase half controlled bridge controlled rectifiers
- which employ three thyristors and three diodes connected in the form of a bridge configuration
- Three thyristors are controlled switches which are turned on at appropriate times by applying appropriate gating signals
- The three diodes conduct when they are forward biased by the corresponding phase supply voltages
- 3-phase semi-converters are used in industrial power applications up to about 120kW output power level
- The power factor of 3-phase semi-converter decreases as the trigger angle increases
- The power factor of a 3-phase semi-converter is better than three phase half wave converter
- The voltage across the armature $V_a = \frac{3\sqrt{3}V_m}{2\Pi}(1+\cos\alpha)$ for $0 \le \alpha \le \Pi$

  V_a – Armature voltage
  V_m – Maximum voltage
  α - Firing angle

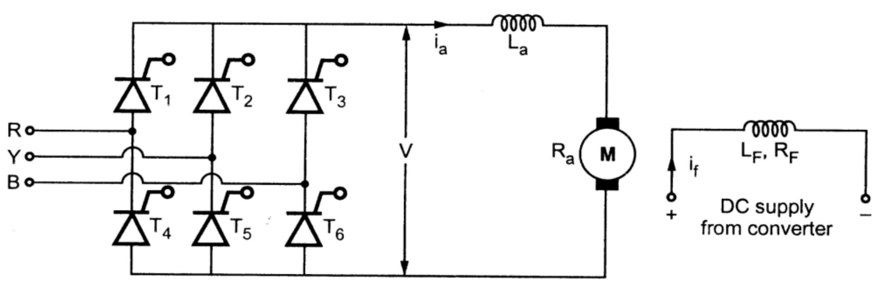


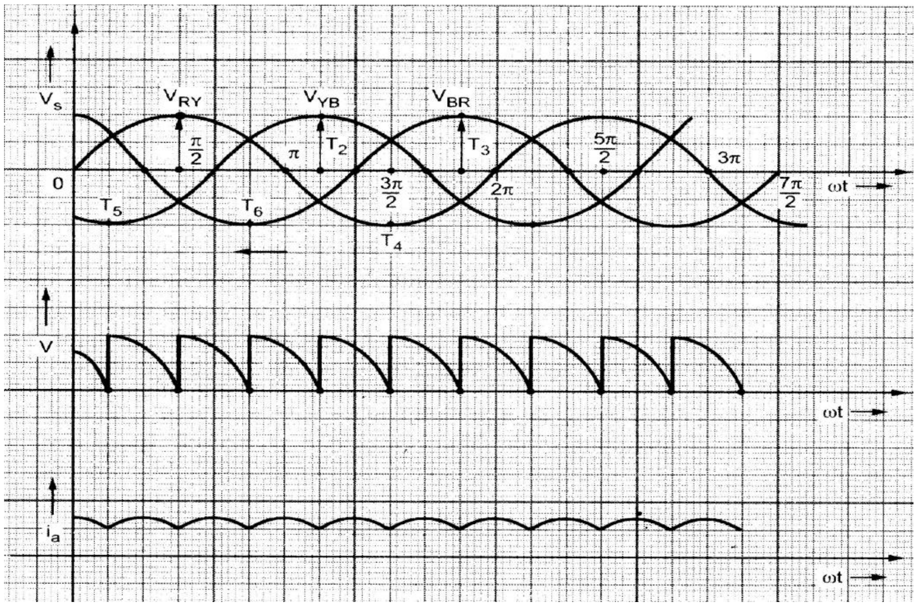


Three Phase Full Converter Drive:

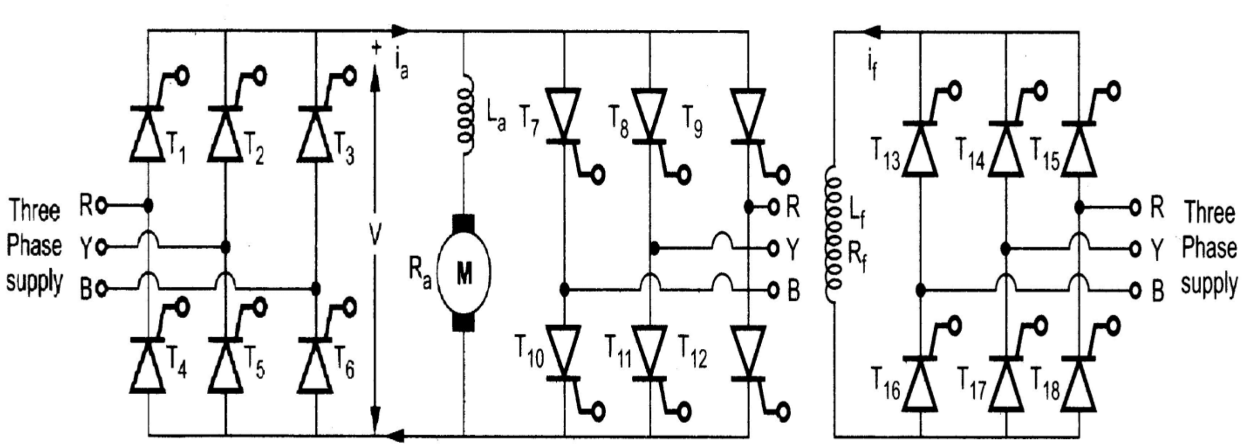
- A three-phase full-wave-converter drive is a two-quadrant drive without any field reversal, and is limited to applications up to 1500 kW.
- During regeneration for reversing the direction of power
- However, the back emf of the motor is reversed by reversing the field excitation.
- The converter in the field circuit should be a single- or three-phase full converter.
- Two three-phase full-wave converters are connected in an arrangement similar to Figure
- Either converter 1 operates to supply a positive armature voltage, V_a or converter 2 operates to supply a negative armature voltage, $-V_a$.
- It is a four-quadrant drive and is limited to applications up to 1500 kW.
- The field converter can be a full-wave converter.
- The voltage across the armature $V_a = \frac{3\sqrt{3}V_m}{\Pi}\cos\alpha$ for $0 \le \alpha \le \Pi$

V_a – Armature voltage
V_m – Maximum voltage
α - Firing angle





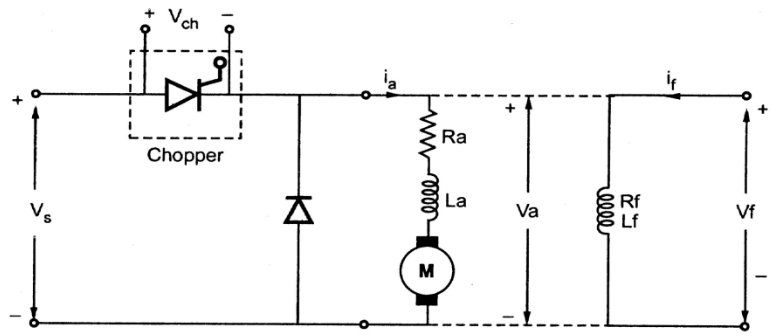
Three Phase Dual Converter Drive:

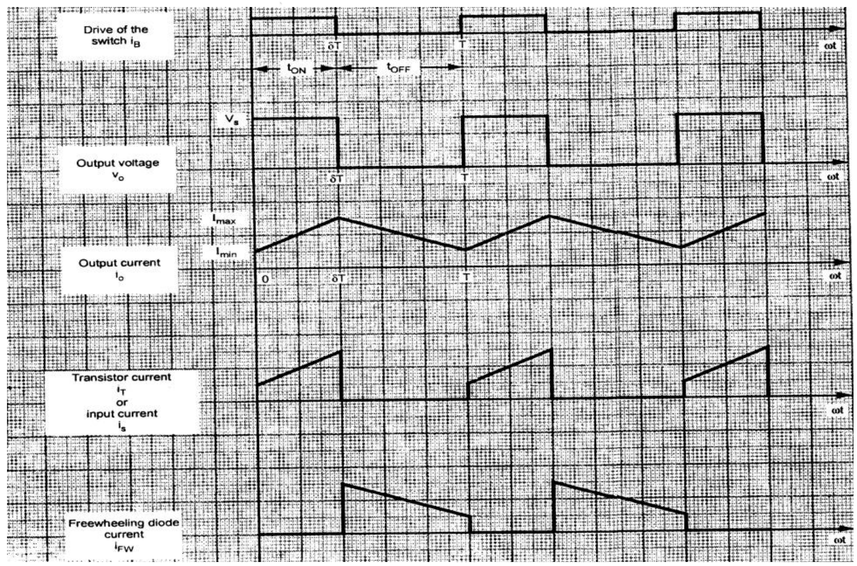


CHOPPER DC MOTOR CONTROL

- Chopper: The variable dc voltage is controlled by varying the on- and off-times of a converter
- Chopper: DC ⇒ DC (different voltage)
- Its frequency of operation is $f_c = \frac{1}{(t_{on} + t_{off})} = \frac{1}{T}$ and its duty cycle is defined as $d = \frac{t_{on}}{T}$
- Assuming that the switch is ideal, the average output is $V_{dc} = \frac{t_{on}}{T} V_s = dV_s$
- varying the duty cycle changes the output voltage
- The duty cycle d can be changed in two ways:
  (i) Varying the on-time (constant switching frequency).
  (ii) Varying the chopping frequency.

➢ Constant switching frequency has many advantages in practice





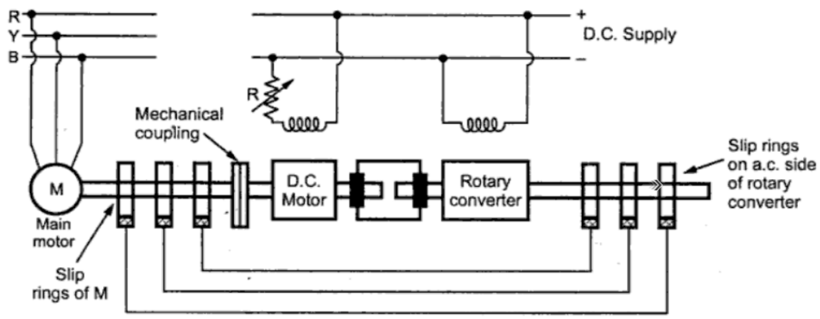
UNIT V

CONVENTIONAL AND SOLID STATE SPEED CONTROL OF A.C. DRIVES

Slip power recovery scheme:

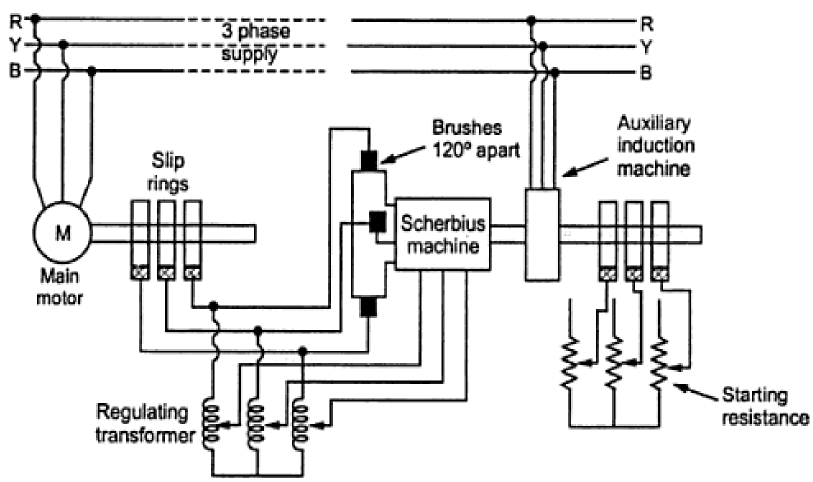
- The slip power recovery (SPR) drive is an external system connected to the rotor circuit in place of the external resistors.
- The SPR provides speed and torque control like the resistors but can also recover the power taken off the rotor and feed it back into the power system to avoid energy waste.
- The speed control of slip ring induction motor is achieved by Injecting E.M.F in Rotor Circuit
- The e.m.f injected in the rotor circuit must have the same frequency as the slip frequency
- When the injected voltage is in phase opposition with the induced rotor e.m.f, then the rotor resistance increases
- when the injected voltage is in phase with the induced rotor e.m.f, then the rotor resistance decreases
- By changing the direction of phase rotation, the resistance of the rotor circuit is varied and thus speed of the slip ring motor is controlled.

Conventional Kramer System:



- This system is basically used for the speed control of large motors of rating more than 4000Kw or above
- The main motor M has slip rings mounted on its shaft
- The induced e.m.f is supplied to the slip rings of a rotary converter by slip rings of main motor.
- The rotary converter converts the low-slip frequency a.c. power into d.c. power
- Which is used to drive a d.c. shunt motor
- The main motor "M" is directly coupled with the d.c. shunt motor .
- The d.c. output of the rotary converter is used to drive the d.c. shunt motor
- Both the rotary converter and the d.c. shunt motor are excited from a separate d.c exciter or d.c bus bar.
- The field regulator governs the back e.m.f Eb of the d.c. shunt motor
- The d.c. potential at the commutator of the rotary converter which controls the slip ring voltage and thus the speed of motor "M."

Conventional Scherbius System:

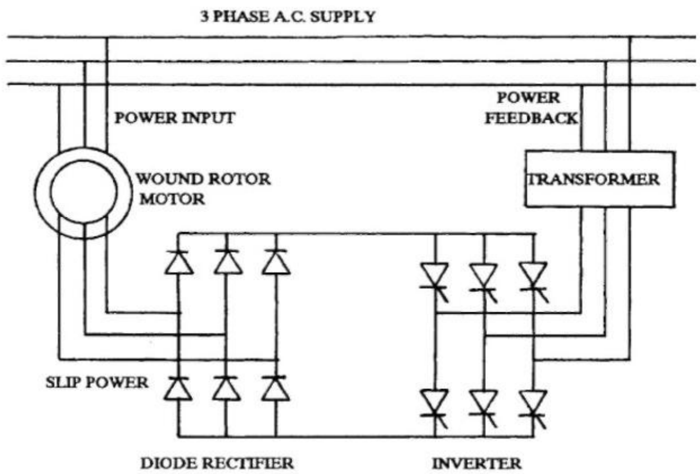


- In this system, the slip energy is not converted into d.c and then fed to a d.c. motor
- It is fed directly to a three phase or six phase a.c. commutator motor called as Scherbius machine.
- The low frequency output of the machine M is fed to the poly phase winding of the machine C through a regulating transformer RT.
- The commutator motor C is a variable speed machine and is controlled by the tapping on RT.

Advantages:

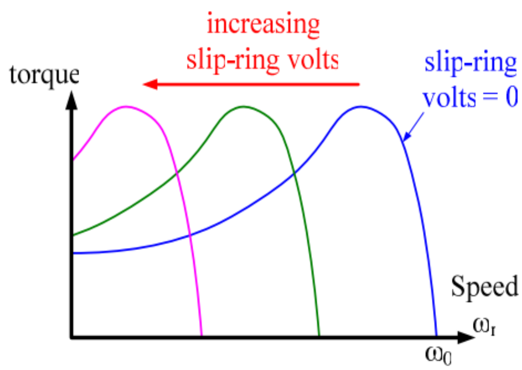
- Better efficiency than earlier methods
- Speed regulation is independent of load conditions
- It can be controlled manually by operator
- Disadvantages:
- Complex, Extra induction motor is needed
- Huge size, costly
- Require well-trained staff
- Can’t adjust speed at no-load condition.

Static Kramer System:



- The resistors are replaced by a rectifier-inverter system
- It takes the energy that previously was dissipated in the resistors and feeds it back into the mains supply
- It uses a step-up transformer to increase the voltage level.
- The frequency of the rotor current fr = sfs
- Rotor frequency set by speed of rotation
- Diode rectifier accepts any frequency
- The rotor current is rectified in a diode bridge, and then converted to 3-phase, 50 Hz by a line commutated inverter
- The magnitude of the voltage at the slip-rings is set by the rectifier-inverter link, and controlled by the delay angle α of the line-commutated inverter.

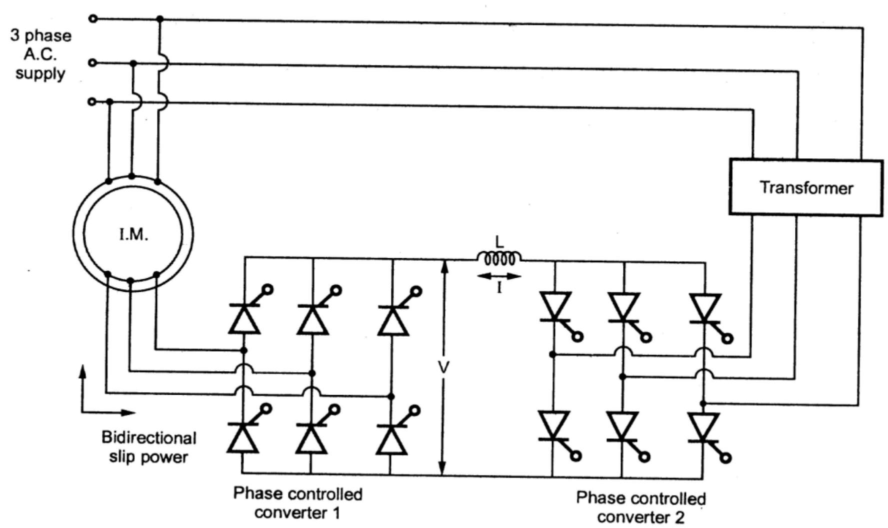
$$V_{dc} = \frac{3}{\pi}.\sqrt{2}.V_{rms}.\cos\alpha$$



Instead of wasting the slip power in the rotor circuit resistance, a better approach is to convert it to ac line power and return it back to the line. Two types of converter provide this approach:

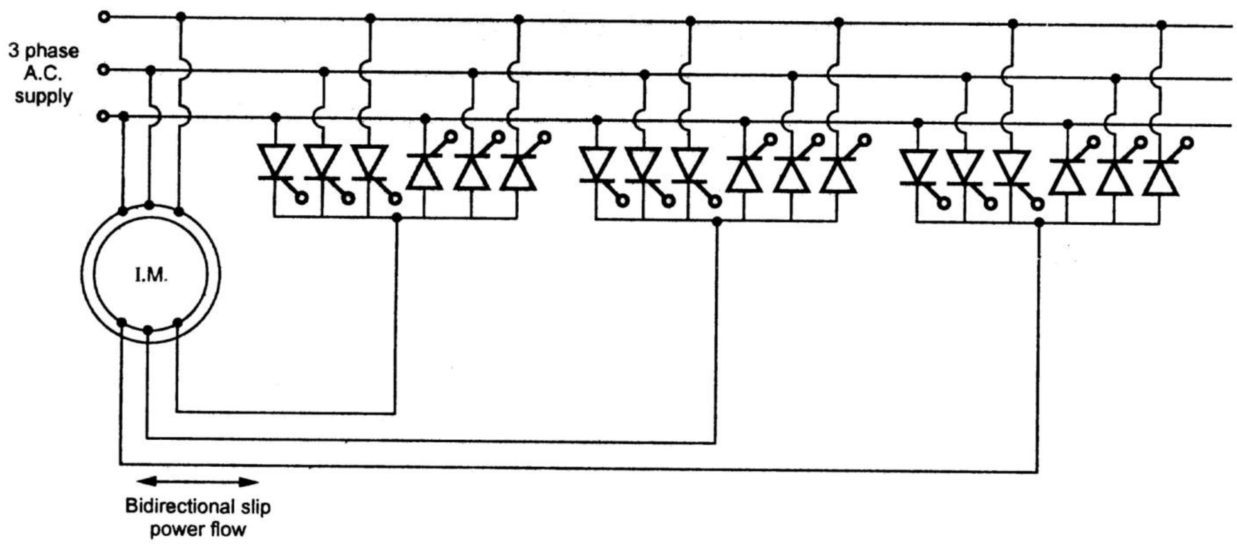
1) Static Kramer Drive - only allows operation at sub-synchronous speed.
2) Static Scherbius Drive – allows operation above and below synchronous speed.

Static Scherbius System:



- The static Scherbius drive overcomes the forward motoring only limitation of the static Kramer drive.
- Regenerative mode operation requires the slip power in the rotor to flow in the reverse direction.
- This can be achieved by replacing the diode bridge rectifier with a thyristor bridge.
- This is the basic topology change for the static Scherbius drive from the static Kramer drive.
- One of the limitations of the previous topology is that line commutation of the machine-side converter becomes difficult near synchronous speed because of excessive commutation angle overlap.
- A line commutated cycloconverter can overcome this limitation but adds substantial cost and complexity to the drive.
- At sub synchronous speeds, the slip power sP_m is supplied to the rotor by the exciter.
- At super synchronous speeds, the rotor output power flows in the opposite direction so that the total shaft power increases to $(1+s)P_m$.

Cycloconverter Scherbius System:



Cycloconverters: Converts single-phase or three-phase ac to variable magnitude and variable frequency, single-phase or three-phase ac

SPEED CONTROL OF THREE PHASE INDUCTION MOTOR

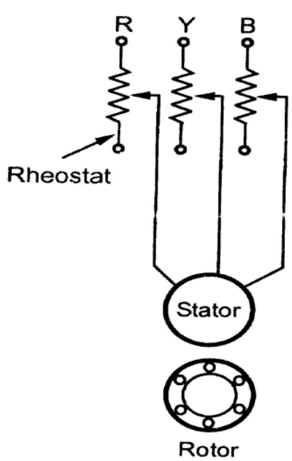
Speed Control from Stator Side:

1. By changing the applied voltage
2. By changing the applied frequency (or) V/f Control
3. Changing the number of stator poles

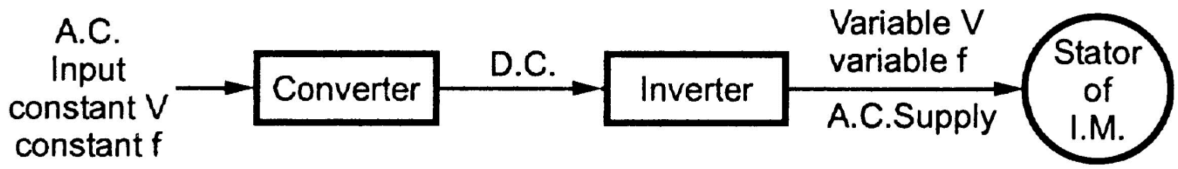
Speed Control from Rotor Side:

1. Rotor rheostat control
2. Cascade operation
3. By injecting EMF in rotor circuit

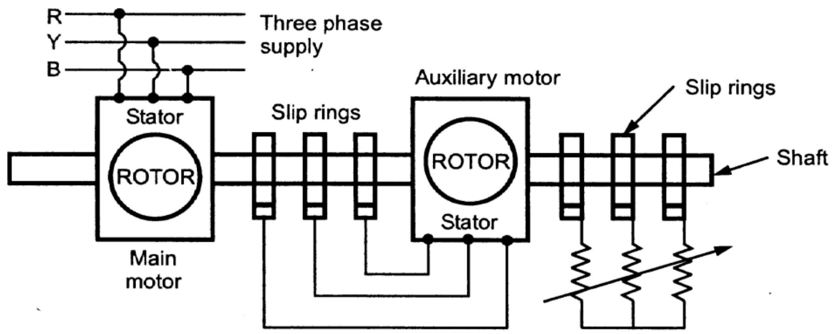
By Changing the Applied Voltage:



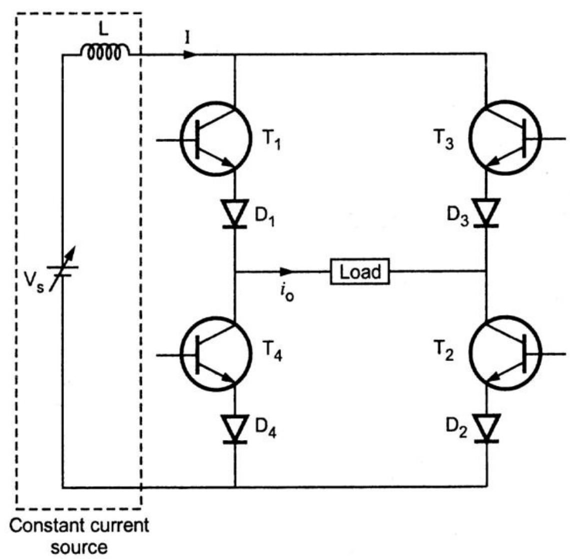
V/f Control:

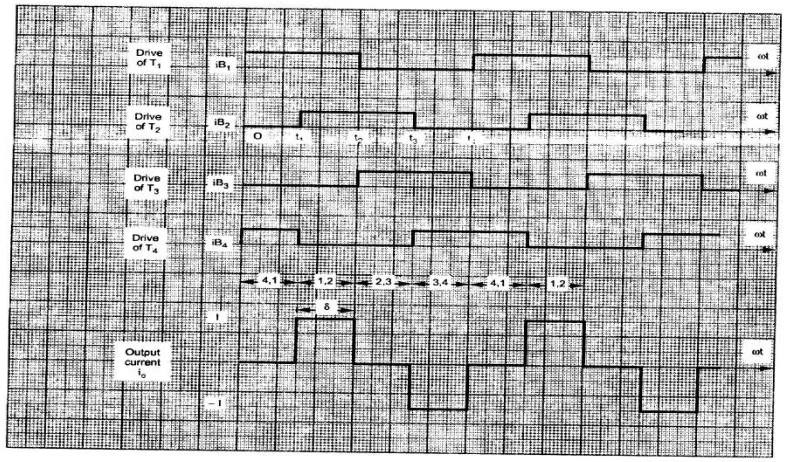


Cascade operation:

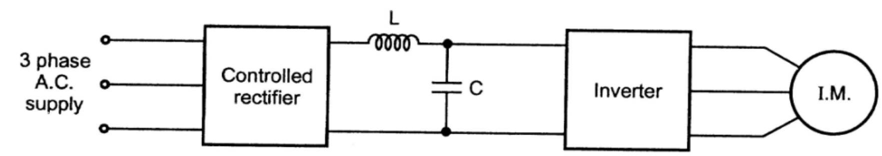


SPEED CONTROL – CURRENT SOURCE INVERTER

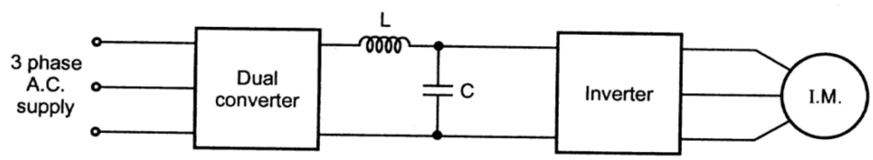




SPEED CONTROL – VOLTAGE SOURCE INVERTER



(a)



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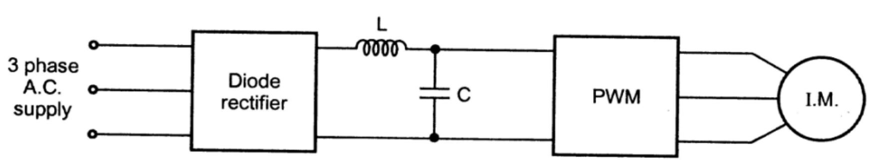

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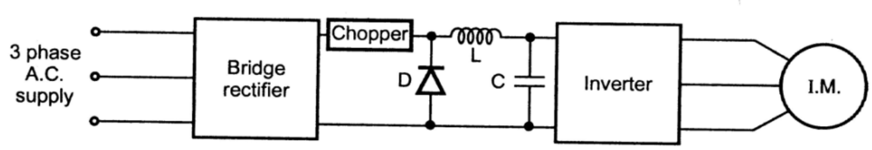

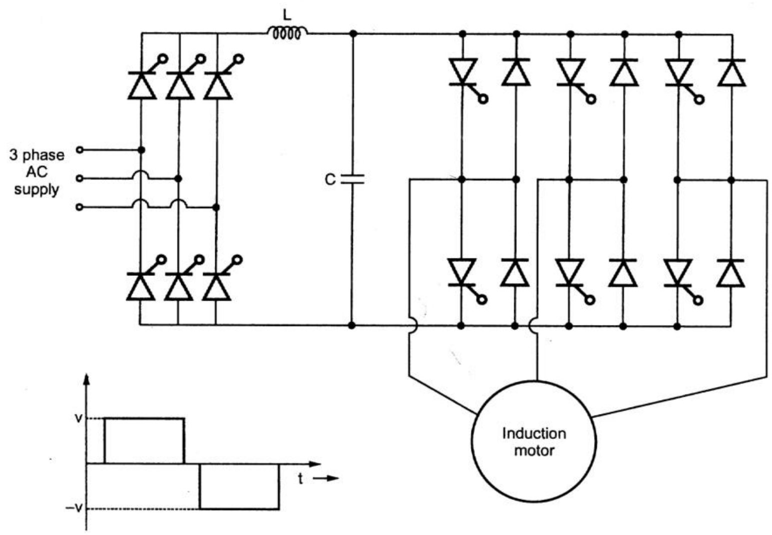

Square wave output

JEPPIAAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

UNIT TEST I

YEAR / SEM: II /III TIME: 2.00 hrs SUB:
EE6351 ELECTRIC DRIVES AND CONTROL TOTAL MARKS: 100

PART A (10*2=20)

1.What is dynamic braking?
2.Draw the slip – torque characteristics of a single phase induction motor.
3.Define plugging of 3 phase induction motor
4.Why DC series motors should never be started on no-load
5.Define torque.
6.List the types of rotors in induction motor.
7.Give the types of braking used for dc motor.
8.Draw the mechanical characteristics of DC series motor with different input voltage values.
9.How the starting torque of capacitor-start induction motor can be varied?
10. Single phase motor is not a self starting motor. Why?

PART B (4*20=80)

1.Draw and explain the characteristics of a DC shunt Motor with Suitable graphs and diagrams.
2.Explain the various methods of braking of induction motors.
3.Explain the construction and working principle of 3-phase induction motor with neat diagrams.
4.Explain the starting methods of single induction motors with neat diagrams.

JEPPIAAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

ASSESSMENT TEST II

YEAR / SEM: II /III TIME: 2.15 hrs
SUB: EE6351 ELECTRIC DRIVES AND CONTROL TOTAL MARKS: 60

PART A (3*2=6)

1.What are the protective devices in a DC/AC motor Starter?
2.Give some advantages and disadvantages of D.O.L
3.What is the Necessity of starter?

PART B (3*13=39)

5.Draw a neat schematic diagram of a three point starter and explain its working.
6.Explain with neat diagram the starting of three phase slip ring induction motor.
7.Draw and explain the push-button operated direct-on line starter for three phase induction motor.

PART C (1*15=15)

1 .Draw and explain the manual auto-transformer starter for three phase induction motor.

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DEPARTMENT OF MECHANICAL ENGINEERING

ASSESSMENT TEST III

EE6351 ELECTRICAL DRIVES AND CONTROL

YEAR / SEM: II /III TIME: 3.00 hrs

PART A (10*2=20)

1. Draw the block diagram of an electrical drive.
2. Give the examples where continuous duty at constant load is occurred.
3. Name the power modulators used for V/f control of 3 phase induction motor.
4. State the applications where stator voltage control is employed for three phase induction motors.
5. What are the factors to be considered for the selection of electrical drives?
6. What are the conventional methods of speed control of three phase induction motor from stator side?
7. What are the types of electrical drive?
8. Define cooling time constant of an electrical machine.
9. Define voltage source inverter and current source inverter.
10. Mention the advantages of slip power recovery system.

PART B (5*13=65)

11. (a) Explain the various factors that influence the choice of electric drives. (13)

(OR)

(b)List and explain various classes of motor duty. (13)

12. (a) Draw and explain the mechanical characteristic of DC drive. (13)

(OR)

(b) With neat diagram, explain braking methods of a DC Drive. (13)

13. (a) Explain the construction and operation of 3 point starter. (13)

(OR)

(b) With neat diagram, explain the construction and operation of an automatic starter. (13)

14. (a) Explain various methods of conventional speed control of a DC drive. (13)

(OR)

(b) Explain the working of ward-Leonard method of speed control.
(13)

15. (a) Explain working of conventional Kramer slip power recovery system. (13)

(OR)

(b) Explain with neat diagram the method of speed control of AC drives using current source inverter. (13)

PART C (1*15=15)

16. Explain the static Scherbius drive which provides speed below and above synchronous speed.

JEPPIAAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

MODEL EXAM

EE6351 ELECTRICAL DRIVES AND CONTROL

YEAR / SEM: II /III **TIME: 3.00 hrs**

PART A **(10*2=20)**

1. Draw the block diagram of an electrical drive.
2. Give the examples where continuous duty at constant load is occurred.
3. Define mechanical characteristics.
4. Write any five applications of single phase induction motor.
5. How the starting current of three phase IM can be reduced?
6. Differentiate three point starter and four point starter.
7. Differentiate uncontrolled and controlled rectifiers?
8. What is tapped control method?
9. Define voltage source inverter and current source inverter.
10. Mention the advantages of slip power recovery system.

PART B **(5*13=65)**

11. **(a)** Explain the different factors influencing the choice of electrical drives? (13)

(OR)

(b) Draw the typical temperature rise-time curve and derive the equation for temperature rise in an electric drive. (13)

12. (a) Draw and explain the characteristics of DC motor. (13)

(OR)

(b) Explain the various methods of braking of induction motors. (13)

13. (a) Draw a neat schematic diagram of a three point starter and explain its working. (13)

(OR)

(b) Draw the neat schematic diagram of Induction motor and explain its working. (13)

14. (a) Discuss the Ward-Leonard speed control system with a neat circuit diagram. Also mention its advantages and disadvantages. (13)

(OR)

(b) Explain with neat sketches about the DC Shunt Motor speed control by using single phase fully controlled bridge converter (13)

15. (a) Explain in detail about Slip power recovery scheme. (13)

(OR)

(b) Discuss the speed control of AC motors by using three phase AC Voltage regulators. (13)

PART C (1*15=15)

16. (a) List and explain various classes of motor duty.

(OR)

(b) Explain in detail the construction and operating principle of an automatic starter.

Solved Problems

As mentioned above, while guessing the value of I_{a2}, the proportion of armature-power should be 1.5.

$$\frac{E_{b2}\ I_{a2}}{E_{b1}\ I_{a1}} = \frac{206.56 \times 33.75}{211.2 \times 22} = 1.50$$

Thus, the results obtained are confirmed.

Example 30.17. *A 250 V, 25 kW d.c. shunt motor has an efficiency of 85% when running at 1000 r.p.m. on full load. The armature resistance is 0.1 ohm and field resistance is 125 ohms. Find the starting resistance required to limit the starting current to 150% of the rated current.*

(Amravati Univ., 1999)

Solution.

Output power = 25 kW, at full-load.

$$\text{Input power} = \frac{25{,}000}{0.85} = 29412 \text{ watts}$$

At Full load, Input Current = 29412/250 = 117.65 amp

Field Current = 250/125 = 2 amp

F.L. Armature Current = 117.65 – 2 = 115.65 amp

Limit of starting current = 1.50 × 115.65 = 173.5 amp

Total resistance in armature circuit at starting

$$= \frac{250}{173.5} = 1.441 \text{ ohms}$$

External resistance to be added to armature circuit

= 1.441 – 0.1 = 1.341 ohm.

ASSIGNMENT TOPICS:

1. Draw the typical temperature rise-time curve and derive the equation for temperature rise in an electric drive.
2. Explain various methods of braking of DC Shunt Motors with neat diagrams.
3. Explain with neat circuit diagram, the star-delta starter method of starting squirrel cage induction motor.
4. Explain with neat sketches about the DC Shunt Motor speed control by using single phase fully controlled bridge converter.

QUIZ QUESTIONS

1. The consideration involved in the selection of the type of electric drive for a particular application depends on

(A) Speed control range and its nature

(B) Starting torque

(C) Environmental conditions

(D) All of the above.

Answer: D

2. Which of the following is preferred for automatic drives ?

(A) Synchronous motors

(B) Squirrel cage induction motor

(C) Ward Leonard controlled dc motors

(D) Any of the above.

Answer: C

3. Which type of drive can be used for hoisting machinery

(A) AC slip ring motor

(B) Ward Leonard controlled DC shunt motor

(C) DC compound motor

(D) Any of the above.

Answer: D

4. The motor normally used for crane travel is

(A) AC slip ring motor

(B) Ward Leonard controlled DC shunt motor

(C) Synchronous motor

(D) DC differentially compound motor.

Answer: A

5. A wound rotor induction motor is preferred over squirrel cage induction motor when the major consideration involved is

(A) high starting torque

(B) low starting current

(C) speed control over limited range

(D) all of the above.

Answer:D

6. When smooth and precise speed control over a wide range is desired, the motor preferred is

(A) synchronous motor

(B) squirrel cage induction motor

(C) wound rotor induction motor

(D) dc motor.

Answer:D

7. When quick speed reversal is a consideration, the motor preferred is

(A) synchronous motor

(B) squirrel cage induction motor

(C) wound rotor induction motor

(D) dc motor.

Answer:D

8. Stator voltage control for speed control of induction motors is suitable for

(A) fan and pump drives

(B) drive of a crane

(C) running it as generator

(D) constant load drive.

Answer:A

9. The selection of control gear for a particular application is based on the consideration of

(A) duty

(B) starting torque

(C) limitations on starting current

(D) all of the above.

Answer:D

10. As compared to squirrel cage induction motor, a wound rotor induction motor is preferred when the major consideration is

(A) high starting torque

(B) low windage losses

(C) slow speed operation

(D) all of the above.

Answer:A

11. A synchronous motor is found to be more economical when the load is above

(A) 1 kW

(B) 10 kW

(C) 20 kW

(D)100kW.

Answer:D

12. The advantage of a synchronous motor in addition to its constant speed is

(A) high power factor

(B) better efficiency

(C) lower cost

(D) all of the above.

Answer:A

13. In motor circuit static frequency changers are used for

(A) power factor improvement

(B) improved cooling

(C) reversal of direction

(D) speed regulation.

Answer:D

14. In case of traveling cranes, the motor preferred for boom hoist is

(A) AC slip ring motor

(B) Ward Leonard controlled DC shunt motor

(C) Synchronous motor

(D) Single phase motor.

Answer:A

15. The characteristics of drive for. crane hoisting and lowering is

(A) smooth movement

(B) precise control

(C) fast speed control

(D) all of the above.

Answer:D

16. Belt conveyors offer

(A) zero starting torque

(B) low starting torque

(C) medium starting torque

(D) high starting torque.

Answer:D

17. In case belt conveyors

(A) squirrel cage motors with direct-on-line starters are used

(B) single phase induction motors are used

(C) dc shunt motors are used

(D) induction motors with star-delta starters are used.

Answer:A

18. Which of the following motor is preferred for blowers ?

(A) wound rotor induction motor

(B) squirrel cage induction motor

(C) dc shunt motor

(D) dc series motor.

Answer:B

19. Centrifugal pumps are usually driven by

(A) dc shunt motors

(B) dc series motors

(C) squirrel cage induction motors

(D) any of the above.

Answer:C

20. In a centrifugal pump if the liquid to be pumped has density twice that of water, then the horse power required (as compared to that while pumping water) will be

(A) half

(B) same

(C) double

(D) four times.

Answer:C

21. Wound rotor and squirrel-cage motors with high slip which develop maximum torque at stand still are used for

(A) machine tools

(B) presses and punches

(C) elevators

(D) all of the above.

Answer:B

22. Belted slip ring induction motor is almost invariably used for

(A) centrifugal blowers

(B) jaw crushers

(C) water pumps

(D) screw pumps.

Answer:B

23. In jaw crushers, a motor has to often start against

(A) low load

(B) medium load

(C) normal load

(D) heavy load.

Answer:D

24. Motor used for elevators is generally

(A) synchronous motor

(B) induction motor

(C) capacitor start single phase motor

(D) any of the above.

Answer:B

25. In synthetic fibre mills motor with

(A) constant speeds are preferred

(B) high starting torque are preferred

(C) variable speed are preferred

(D) low starting torque are preferred.

Answer:A

26. Which of the following motor is preferred for synthetic fibre mills ?

(A) series motor

(B) reluctance motor

(C) shunt motor

(D) synchronous motor.

Answer:B

27. Reluctance motor is a

(A) self-starting type synchronous motors

(B) low torque variable speed motor

(C) variable torque motor

(D) low noise, slow speed motor.

Answer:A

28. Power factor in case of reluctance motor is

(A) nearly unity

(B) always leading

(C) 0.8

(D) 0.3 to 0.4.

Answer:D

29. The efficiency of reluctance motor is around

(A) 95%

(B) 90%

(C) 75 to 85%

(D) 60 to 75%.

Answer:D

30. The size of a excavator is usually expressed in terms of

(A) cubic meters

(B) travel in meters

(C) angle of swing

(D) 'crowd' motion

Answer:A

31. Ward-Leonard controlled dc drives are generally used for

(A) light duty excavators

(B) medium duty excavators

(C) heavy duty excavators

(D) all of the above.

Answer:C

32. In case of contactors, the contacts are generally made of

(A) copper

(B) silver

(C) cadmium copper

(D) any of the above.

Answer:D

33. Which electromagnet is preferred for noiseless operation ?

(A) DC operated

(B) AC operated

(C) Any of the above.

Answer:A

34. For high frequency choppers the device that is preferred is

(A) Thyristor

(B) TRIAC

(C) Transistor

(D) GTO.

Answer:C

35. The number of operations per hour in case of class IV contactor will be around

(A) 100

(B) 600

(C) 900

(D) 1200.

Answer:D

36. In case of contactors, the duty in which the main contacts remain closed for a period bearing a definition relation to the no-load periods, is known as

(A) Standard duty

(B) Intermittent duty

(C) Temporary duty

(D) Un-interrupted duty.

Answer:B

37. n case of contactors the ratio of the in service period to the entire period, expressed as a percentage is known as

(A) duty

(B) load factor

(C) class of contact

(D) none of the above.

Answer:B

38. Heat control switches find applications on

(A) three phase induction motors

(B) single phase motors

(C) transformers

(D) cooling ranges.

Answer:D

39. A saturable core reactor is basically a

(A) variable resistor

(B) step down transformer

(C) thermal relay

(D) variable impedance.

Answer:D

40. The earth wire should not be thinner than a

(A) 20 SWG wire

(B) 16 SWG wire

(C) 10 SWG wire

(D) 8 SWG wire.

Answer:D

41. In automobiles the sound is produced by horn due to

(A) magnetostriction

(B) vibrating diaphragm

(C) moving coil

(D) oscillating coil.

Answer:B

42. The current drawn by a 6 V horn is roughly

(A) 0.1 A

(B)1A

(C) 2 A

(D) 20 A.

Answer:D

43. The hours are rated for

(A) continuous operation

(B) intermittent operation

(C) both (A) and (B) above

(D) none of the above.

Answer:B

44. Continuous operation of automobile horn will

(A) help in charging the battery

(B) improve mileage

(C) damage the operating coil

(D) change the tone.

Answer:C

45. In a constant power type load

(A) torque is proportional to speed

(B) torque is proportional to square of speed

(C) torque is inversely proportional to speed

(D) torque is independent of speed.

Answer:C

46. Which of the following pair is used for frequency converters ?

(A) Squirrel cage induction motor and synchronous motor

(B) Wound rotor induction motor and synchronous motor

(C) Wound rotor induction motor and squirrel cage induction motor

(D) Any of the above.

Answer:A

47. Belted wound rotor induction motors are preferred for

(A) machine tools

(B) gyratory crushers

(C) belt conveyor

(D) water pumps.

Answer:B

48. The cooling time constant is usually

(A) equal to the heating time constant

(B) more than heating time constant

(C) none of these.

Answer:B

49. A motor of less than full load power rating can be used if the load is

(A) continuous duty

(B) short time duty

(C) intermittent periodic duty

(D) none of these.

Answer:B

50. Pole changing method of speed control is used in

(A) slip ring induction motor

(B) dc shunt motor

(C) dc series motor

(D) squirrel cage induction motor.

Answer:D

NPTEL website:

**www.nptelvideos.in/2012/11/advanced-electric-drives.html

**www.eps-technology.blogspot.com/2011/02/online-video-courses-electric-drives.html

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Real world Examples

S.No	**Applications**	**Significance of the application Example**
1	Linear Time invariant systems	These are special case of proposed general design principle
2	Control of Robot Manipulators	Robust control of rigid-body robots under parameter uncertainties
3	Pulse width modulation for electric drives	Design philosophy of integral slidding mode can be directly applied to practical systems
4	Robust current control for permanent magnet synchronous motor	Utilisation of proposed perturbations estimator to achieve advanced performance.