K.S.R.COLLEGE OF ENGINEERING (Autonomous)**,**
TIRUCHENGODE-637215 DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING COURSE / LESSION PLAN SCHEDULE

NAME: Dr.P.S.PERIASAMY **CLASS: II-ECE**

Subject Code - Name: 18EE331-Electrical Machines

TEXT BOOKS. 1. Nagarath I. J and Kothari D. P., Electric Machines, Tata McGraw Hill Publishing Company Ltd, Fourth Edition, Fifth Reprint 2012.

2. B.L.Theraja and A. K Theraja, "A Text Book of Electrical Technology", Volume–II, (AC & DC Machines), S. Chand & Company Ltd, New Delhi, 2015 (Reprint)

REFERENCE BOOKS. 1. A. E Fitzgerald, Charles Kingsely Jr. Stephen D. Umans, Electric Machinery, McGraw Hill Books Company Seventh Edition, 2013.

2. K.Murugeshkumar, Electric Machines, Vikas Publishing House Pvt. Ltd., First Edition 2003.

3. P.S Bhimbhra, Electrical Machinery, Khanna Publishers, Seventh Edition 2013.

4. SamarajitGhosh, Electrical Machines, Pearson Education, Second Edition, 2012.

5. NPTEL course link http: //nptel`ac`in/courses/108106071

B) LEGEND BB-BLACK BOARD L-LECTURE OHP-OVER HEAD PROJECTOR RX-REFERENCE BOOK

Sl. No	Lecture Hour	Topics to be covered	Teaching Aid Required	Book No	Page No
UNIT I - DC MACHINES					
1	L1	Laws of Electromagnetism	BB & OHP	TX_2	888
		Constructional of DC machines			888 - 895
2	L2	DC Generator: EMF Equation	BB	TX_2	914 - 915
		DC Generator : Methods of excitation - Types		TX_2	911 - 914
3	L3	DC Generator : Armature Reaction	BB	TX_2	938 - 943
4	L4	DC Generator : Characteristics	BB & PPT	TX_2	968 - 972
5	L5	Principle of operation of D.C. motor and Types	BB	TX_2	996 - 998
6	L6	Back EMF and Torque equation	BB	TX_2	998 & 1001 - 1002
7	L7	Characteristics of DC motor	BB	TX_2	1015 - 1020
8	L8	Starting of D.C. motors	BB	TX_2	1073 - 1078
9	L9	Speed control of D.C. series and shunt motors	BB	TX_2	1032, 1041 – 1042 1048 – 1049 1050- 1051
UNIT II TRANSFORMERS					
10	L10	Constructional details	BB & OHP	TX_2	1116 - 1121
11	L11	Principle of operation	BB	TX_2	1116
11112	L12	EMF equation – Transformation ratio	BB	TX_2	1122 - 1123
13	L13	Transformer on no load and load	BB	TX_2	1125 – 1125 1129 - 1130
14	L14, L15	Equivalent circuit	BB	TX_2	1142 - 1144
15	L16	Load test, open circuit and short circuit tests.	BB	TX_2	1146 - 1147 1150 – 1151
16	L17	Voltage Regulation	BB	TX_2	1156 - 1158
17	L18	Auto transformers	BB	TX_2	1186- 1188
UNIT III INDUCTION MOTORS					
(A): Three Phase Induction Motors					
18	L19, L20	Construction, Types	BB	TX_2	1244 - 1248
19	L21	Principle of operation	BB	TX_2	1244
20	L22	Torque Equation and Torque Slip Characteristics	BB	TX_2	1261 & 1264
21	L23, L24	Starting and speed control	BB	TX_2	1349 - 1351

(B): Single Phase Induction Motors					
22	L25	Principle of Single Phase Motors and Split phase motor	BB	TX_2	1368 - 1371
23	L26	Capacitor start capacitor run motor	BB	TX_2	1381 - 1383
24	L27	Shaded pole motor.	BB	TX_2	1383 - 1384
UNIT IV SYNCHRONOUS MACHINES					
25	L28	Construction	BB	TX_2	1402 - 1407
(A). Alternator					
26	L29	Working Principle	BB	TX_2	1402
27	L30	Types	BB	TX_2	1404 - 1405
28	L31	EMF Equation	BB	TX_2	1415
29	L32	OC and SC Characteristics	BB	TX_2	1439 - 1440
30	L33	Voltage regulation -EMF and MMF methods	BB	TX_2	1431 - 1432
31	L34	Brushless alternators	BB	TX_2	1439 - 1440
(B). Synchronous Motor					
32	L35	Principle and Starting Methods	BB	TX_2	1452
33	L36	Effect of Change of Excitation	BB	TX_2	1470 - 1471
UNIT V SPECIAL MACHINES					
34	L37	Introduction	BB	TX_2	1536
35	L38, L39	Stepper motor and its types	BB	TX_2	1536- 1538
36	L40	Hysteresis motor	BB	TX_2	Class notes
37	L41	Reluctance Motor	BB	TX_2	1538
38	L42	AC series motor	BB	TX_2	1540
39	L43	Universal motor	BB	TX_2	1541
40	L44	Linear induction motor	BB	TX_2	1542
41	L45	Brushless DC motor.	BB	TX_2	1544

UNIT I DC MACHINES

1. **State Faraday's laws of Electromagnetic Induction? (JAN 2016) (JAN 17) (Remembering) (CO 1)**
   First Law: Whenever flux linking in a conducting coil changes, an EMF is induced in the coil.
   Second Law: The magnitude of induced EMF is directly proportional to the rate of change of flux linkages
2. **List the important parts of a DC machine. (June 2016) (Remembering) (CO 1)**
   The main parts of a dc machine are stator and rotor
   Stator consists of Yoke, Field winding, inter pole Rotor consists of Armature, Commutator, Brushes and bearing.
3. **What are the functions of brushes and bearing in a DC machine? (Remembering) (CO 1)**
   The function of brushes is to collect the current from Commutator Ball bearings are frequently employed for quiet operation. But for heavy duty machine roller bearings are preferable.
4. **What is meant by excitation and mention the type of excitation in DC machine? (N/D 2012) (Remembering) (CO 1)**
   The process of giving DC voltage to the field winding of DC machine for producing necessary magnetic field is called excitation. Excitations are classified into two types (1) Self excited and (2) Separately excited.
5. **Write the expression for speed of a DC motor. (Remembering) (CO 1)**
   Speed N =k E_b/Φ where k=60A/PZ, E_b-back emf, Φ-flux/pole, P-No of poles
   Z- Total no armature conductors A-number of parallel paths in armature
6. **What is meant by back emf in a DC motor? (DEC 2009, 2012) (JAN 2016) (Remembering) (CO 1)**
   When the armature of a dc motor rotates in the magnetic field, the armature conductor cuts the magnetic flux. Hence emf will be induced in the armature conductor (according to faraday's law of

electromagnetic induction) this induced emf is always opposite direction to the applied voltage. This induced emf is referred as back emf or counter emf.

7. **What is the significance of back emf in a DC motor? (DEC 2009, 2012) (Remembering) (CO 1)**
   The back emf acts like a governor. It makes the DC motor self regulating machine it makes the motor to draw as much armature current is just sufficient to develop torque required by the load.
8. **What is the function of inter pole? (Apr 2010) (Remembering) (CO 1)**
   Inter poles or the commutating poles are fixed to the frame in between main poles. They are in small size compared with the main poles. The function of inter poles is two-fold
   1. The inter poles are used for sparkles commutation. (To improve commutation)
   2. The inter poles are to neutralize the cross-magnetizing effect of armature reaction.
9. **What are the three important characteristics of a DC generator? (Remembering) (CO 1)**
   The three important characteristics of a dc generator are:
   - Open circuit characteristics, internal characteristics, and External characteristics.
10. **What are the necessary conditions for the generator to be self excited? (Apr 2010) (Remembering) (CO 1)**
    - Some residual magnetism present in the field poles.
    - The residual flux and flux produced by the shunt field winding must aid each other.
11. **Compare Lap winding and Wave winding (Understanding)** (CO 1)

S.NO	Lap Winding	Wave Winding
1.	Number of Parallel paths (A)=Number of Poles(P)	Number of Parallel Paths (A)=2(Always)
2.	Number of Brush sets required is equal to number of Poles	Number of brush sets required is always equal to two.
3.	Preferable for high current, low voltage capacity generators.	Preferable for high voltage, low current capacity generators.
4.	Normally used for generators of capacity more than 500A	Preferred for generators of capacity less than 500A

12. **State the applications of various types of DC Generators. (Remembering) (CO 1)**

    DC Shunt Generator:

    1. Electroplating 2. Battery charging 3. Exciters for A.C generators.

    DC Series Generators:

    1. Series arc lighting. 2. Series incandescent lighting 3. Regenerative braking of DC locomotives.

    DC Compound Generators:

    1. It is possible to give constant voltage at the line end by proper compounding.
    2. Differentially compound generator may be used for welding purpose.
    3. To supply power to railway circuits, incandescent lamps, elevator motors etc
13. **Define pole pitch (DEC 2010) (Remembering) (CO 1)**
    Pole pitch can be defined in the following two ways
    a. The periphery of the armature divided by the number of poles of the dc machine. that is the distance between the two adjacent poles
    b. Pole pitch is equal to the number of armature conductors or armature slots per pole. If there are 48 conductors and 4 poles, the pole pitch is 48/4=12
14. **List out the different types of DC motors. (N/D 2010) (Remembering) (CO 1)**
    a. DC shunt motor b. DC series motor c. DC compound motor-differential
    d. DC compound motor cumulative.
15. **What are the various losses occurs in electrical machines? (N/D 2010)(June '16) (Remembering) (CO 1)**

A. Variable losses are Copper loss in armature and series field winding.
B. Constant losses are iron loss and shunt field copper losses.

16. **Why starter is necessary for a DC motor? (N/D 2010 M/J 2012 N/D 2010) (June 2015)** (CO 1)

When the motor is rest there is no back emf developed in the armature. If now full supply voltage is applied across the stationary armature, it will draw a very large current because armature resistance is very small. This excessive current will damage the Commutator and brushes. To reduce this high starting current starter is necessary.

17. **List the important parts of a DC starter. (Remembering) (CO 1)**

a. No volt release coil b.Over load release coil c. Handle d.Soft iron piece
e. Starting resistance f. Movable iron g. Electro magnet

18. **When a four point DC starter is required in DC motors? (Remembering) (CO 1)**

The four point starter is required in DC motor to have motor speed above the normal speed.

19. **What is the reason for drop in terminal voltage from no load to full load in a DC generator**? **(Remembering) (CO 1)**

Reason for drop on voltage

- Due to armature resistance and leakage reactance
- Due to armature reaction.

20. **State any two applications of DC motors. (Remembering) (CO 1)**

DC shunt motor: It is used for constant speed applications such as in lathe machine, blowers, fans, and centrifugal pumps.

DC series motor: It is used for variable speed applications such as traction work, electric locomotive, cranes, and hoists.

DC Compound Motor (Cumulative):1.Elevators 2.Shears 3.Rolling mills 4.Air compressors

21. **Mention the types of electric braking of dc motor? (Remembering) (CO 1)**

Electric braking, both for shunt and series motors, is the following three types

1. Rheostatic or dynamic braking 2. Plugging 3. Regenerative braking

22. **List different methods of speed control of DC shunt motor. (D 2009 D 2011) (Remembering) (CO1)**

- Flux control method and Armature resistance method. Voltage control method.

23. **What is the basic difference between DC generator and DC motor? (Remembering) (CO 1)**

An electrical machine which converts mechanical energy into an electrical energy is called a dc generator while an electrical machine which converts an electrical energy into the mechanical energy is called a dc motor.

24. **What is eddy current loss? (N/D 2010) (Remembering) (CO 1)**

When a magnetic core carries a time varying flux, voltages are induced in all possible path enclosing flux. Resulting is the production of circulating current in the core. These circulating current's do no useful work are known as eddy current's and causes Power loss in the core known as eddy current loss.

25. **Why DC series motor is stated with load? (DEC 2014) (Remembering) (CO 1)**

Starting torque is high therefore motor will start with enormously high speed. It is not desirable. So, DC series motors are always started with load

26. **Write down the mechanical characteristics of a dc motor. (June 2015) (Remembering) (CO 1)**

- Torque and armature current characteristics.
- Speed and armature current characteristics and
- Speed and torque characteristics.

27. **What is armature reaction? And state its effects in DC generator. D2009 (Remembering) (CO 1)**

The effect of Armature flux on main pole flux is called armature reaction

The armature magnetic field has two effects

(i).It demagnetizes or weakens the main flux-It leads to reduced generated voltage.

(ii).It cross magnetizes or distorts it.-It produces sparking at the brushes.

28. How will you find the direction of force produced using Fleming's left hand rule? D 2009 (Remembering) (CO 1)

The field magnet is excited and its armature conductors are supplied with current from the supply mains, they experience a force tending to rotate the armature. Armature conductors under N pole are assumed to carry current downwards and those under S poles, to carry current upwards. The magnitude is given by F=BIL Newton.

29. What is the function of no-voltage release coil in DC motor starter? D 2009 (Remembering) (CO 1)

This consists of an electromagnet. This is connected in series with the shunt field circuit .As soon as the field gets supply, this is energized. It holds the handle in the ON position when motor is in normal operation. But in the case of failure or disconnection of the supply, the hold on coil de energises and releases the handle. The handle will return to the OFF position by the tension of spring.

30. Define Speed Regulation. (Remembering) (CO 1)

The Speed regulation is defined as the change in speed when the load on the motor is reduced from rated value to zero, expressed as percent of the rated load speed.

$$\%\text{Speed regulation} = \frac{\text{No Load Speed} - \text{Full Load Speed}}{\text{Full Load Speed}} X100$$

31. Calculate the emf Induced in the armature of a 2 pole DC Generator whose armature has 280 Conductors and is revolving at 1000rpm .The flux per pole is 0.03Wb. (Analyze) (CO 1)

Solution: $\text{Induced emf} = \frac{P\Phi ZN}{60A}$ Volt $= \frac{0.03X280X1000X2}{60X2}$ E= 140Volt

32. A 4 Pole DC Motor has a wave wound armature with 556 conductors. Determine the torque Developed when armature current is 80A and the flux per pole is 0.037Wb. (Analyze) (CO 1)

Solution: $Torque\ Developed\ , T = 0.159X\Phi ZI_a\frac{P}{A}N-m$

$$T = 0.159X0.037X556X80X2 = 523.35\ N-m$$

33. A 230V DC shunt motor takes 12A at full load .The Resistance of the armature and shunt field winding are 0.5ohm and 230ohm respectively. Determine the back emf on full load. (Analyze) (CO 1)

Solution:

$I_{sh}=V/R_{sh}$ = 230/230= 1A; $I_a= I_L-I_{sh}$ = 12-1 = 11A, $E_b= V-I_aR_a$ = 230-(11X0.5)=224.5Volt.

34. State the EMF equation of DC Generator (D 2011) (June 2015) (Understanding) (CO 1)

Eg=Generated EMF/$\text{Induced emf} = \frac{P\Phi ZN}{60A}$ Volt

Where P=No.of Poles ϕ=Flux per pole in webers Z=Total no. of conductors in the armature N=Speed in RPM A= No. of Parallel Paths

35. What do you meant by commutation? Nov/Dec 2012. JAN 2017 (Remembering) (CO 1)

It is the process of converting bi directional current into unidirectional current.

36. What is meant by magnetization curve? Nov/Dec 2012. (Remembering) (CO1)

It is the curve drawn between excitation current (Field Current) versus Induced EMF

37. State the function yoke in a DC Machine. Nov/Dec 2009. (Understanding) (CO 1)

1. It acts as a protecting cover for the whole machine and provides mechanical support for the poles 2. It carries the magnetic flux produced by the poles.

38. What are the losses in DC machine (June 2016) (Understanding) (CO 1)

1. Copper loss-Armature Copper loss, Field Copper loss
2. Magnetic Losses – Hysteresis Loss, Eddy Current Loss
3. Mechanical Losses- Friction loss and wind age loss

16 MARK QUESTIONS

1. Describe with a neat diagram of the construction details of dc machines (DEC 2010)(JUN 2016, 2017) (Creating) (CO 1)
2. Explain in detail the construction and operating principle of DC generator. (Understanding) (CO 1)

3. List the methods off excitation of DC machines and discuss in brief(JUNE 2016, 2017) (Understanding) (CO 1)
4. Discuss how a DC generator builds up EMF. (MAY 2008) (Creating) (CO 1)
5. Derive the expression for EMF equation of a DC generator.(APRIL 2011) (JAN 2016, JUNE 2017) (Analyze) (CO 1)
6. Discuss about the characteristics of DC generators.(DEC 2007), (DEC 2010) (Creating) (CO 1)
7. How DC generators are classified.(APRIL 2011) (Understanding) (CO 1)
8. Draw and explain the load characteristics for shunt, series and over –compounded DC generator. (JUNE 2010) (Creating) (CO 1)
9. Explain in detail the construction and operating principle of D.C. motor.(DEC 2003) (JUNE 2016, 2017) (JAN 2016) (Understanding) (CO 1)
10. Discuss about the various types of D.C. motor.(DEC 2009) (Creating) (CO 1)
11. Explain the characteristics and various applications of D.C. series motor. (MAY 2004) (MAY 2008) (Understanding) (CO 1)
12. Explain the performance characteristics of D.C. shunt motor. list the various applications of this motor.(DEC 2004) (MAY 2008) (Understanding) (CO 1)
13. Explain the characteristics and various applications of D.C. compound motor. (Understanding) (CO 1)
14. What is meant by speed control of dc motor? Explain the various methods in detail.(JUNE 2010) (JAN 2016) (Understanding) (CO 1)
15. Explain the Swinburne's test to predetermine the efficiency of a D.C. machine.(DEC 2006) ()(Understanding) **(CO 1)**
16. Why starter is necessary to start a D.C. motor? Explain the working of any one type of starter. (Understanding) **(CO 1)**
17. Describe the brake test on dc motor to determine the efficiency and performance characteristics of D.C. motor. (Understanding) **(CO 1)**
18. A 4 pole, lap wound, 760 rpm, dc shunt generator has armature resistance of 0.4 ohm and field resistance of 200 ohm. The armature has 720 conductors and flux per pole is 30 mwb. If the load resistance is 15 ohm, find the terminal voltage.(JUNE 2010) (Evaluating) **(CO 1)**
19. A 400V DC shunt motor takes 5A at no load .Its armature resistance (including brushing) is 0.5Ω and shunt field resistance is 200Ω. Estimate the efficiency when the motor takes 50A on full load.(Evaluate) (**(CO 1)**)
20. Differentiate DC shunt and series motors (Nov / Dec 2011) (Evaluate) **(CO 1)**
21. Explain the working of DC series generator (Nov / Dec 2011)(Understanding) **(CO 1)**
22. Derive the torque equation of DC motor (Dec 2014) (Evaluate) **(CO 1)**
23. List the different types of starters and brief each of them (Nov / Dec 2011) (JU15)(Remember) **(CO1)**
24. A 220V DC shunt machine has an armature resistance of 0.5 ohm. If the full load armature current is 20A. Find the induced EMF when the machine acts as either motor as well as generator. (Nov / Dec 2011) (Evaluate) **(CO 1)**
25. A 4 pole, long shunt lap wound dc generator supplies 25kW at a terminal voltage of 500V.The armature resistance is 0.03 ohm, series field resistance is 0.04 ohm and shunt field resistance is 200 ohm. The brush drop may be taken as 1V.Determine the EMF generated. Calculate also number of conductors if the speed of the generator is 1200 rpm and flux per pole is 0.02 wb. Neglect the armature reaction. (CO1) (JAN 2016)
26. What is the procedure for starting a DC Motor? (JUNE 2016, 2017) (CO1)(Understanding)
27. Explain the importance of back EMF (JAN 207) (CO1)(Understanding)

UNIT II TRANSFORMERS

1. **Define a transformer.(DEC 2006) (Remembering) (CO2)**
   It is a static electromagnetic device that transforms electric power from one circuit to another circuit through magnetic induction and electrical isolation without change of supply frequency.
2. **What is meant by leakage flux? (Remembering) (CO2)**
   Magnetic flux cannot be confined to desired path. The greater portion of the flux (i,e. The mutual flux) remains confined to core and links both the windings, but a small portion called the leakage flux completes its path through the air surrounding the coils.
3. **What is an ideal transformer? (May 2011) (Remembering) (CO2)**
   An ideal transformer is one that has
   - No winding resistance and No leakage flux
   - No iron losses in the core and No copper loss in the winding.
4. **Name the different types of transformer. (May 2011) (Remembering) (CO2)**
   - Core type transformer and Shell type transformer
   - Step down transformer , Step up transformer and Auto transformer
   - Current transformer and Potential transformer
5. **What is meant by core type transformer.(May 2011) (Understanding) (CO2)**
   - The core of this transformer is in the form of a rectangular frame made from laminations .It provides single magnetic circuit.
   - The primary and secondary windings are uniformly distributed on two limbs of core.
   - Both the windings are of cylindrical shape and they are arranged in a concentric manner with low voltage winding placed near the core.
6. **What is the function of transformer oil in a transformer? (D 2009) (Remembering) (CO2)**
   Its mineral oil obtained by refines crude petroleum. It serves the following purpose.
   - Provides additional insulation.
   - Carries away the heat generated in the core & coils.
7. **Write down the EMF equation of a transformer. (DEC 2010) (Remembering) (CO2)**
   $E1=4.44f\Phi_m N_1$,
   Where Φ_m-Max flux in the core
   N_1-no of turns in primary winding and f-supply frequency
8. **A single phase transformer has 400Primary turns and 1000 secondary turns. The net cross sectional area of the core is 60cm^2,if the primary winding is connected to 50Hz supply at 500V. Calculate the value of maximum flux density in the core and the EMF induced in the secondary winding. (Evaluating) (CO2)**
   Solution: $E_2 = \frac{N_2 E_1}{N_1}$ = (1000X500)/400 =1250V; $E2=4.44\Phi_m f N_2$

   $\Phi = \frac{E_2}{4.44XfXN_2}$ $\Phi = \frac{1250}{4.44X50X100}$ Φ=0.0056Wb

   We know $\Phi=B_mA$, $\frac{Flux}{area} = B_m$ B_m= 0.0056 / (60X10^{-4}) = 0.933Wb/m^2

9. **What is transformation ratio of transformer?(DEC 2006)(N/D 2012)(Understanding) (CO2)**
   The transformation ratio is defined as the ratio of the EMF induced in the secondary winding to EMF induced in the primary winding. It is denoted by K, $K=E_2/E_1$
10. **How does change in frequency affect the operation of a given transformer? (Understanding) (CO2)**
    - Iron loss is classified in to two losses
      (i) Hysteresis loss which is proportional to frequency
      (ii). Eddy current loss which is proportional to square of the frequency

11. Distinguish between power transformers & distribution transformers? (Evaluating) (CO2)

Power transformers have very high rating in the order of MVA. They are used in generating and substations. Sophisticated controls are required. Voltage ranges will be very high. Distribution transformers are used in receiving side. Voltage levels will be medium. Power range will be medium in the order of several KVA. Complicated controls are not needed.

12. What are the advantages of auto-transformer over two winding transformer.(JUNE 2010) (Remembering) (CO2)

The following are advantages of auto-transformer over two winding transformer

- It uses less copper and hence is cheaper.
- It is used where transformer ratio differ little from unity.
- As compared to a 2 winding transformer of same output, an auto transformer has higher efficiency but smaller in size and Voltage regulation is also superior.

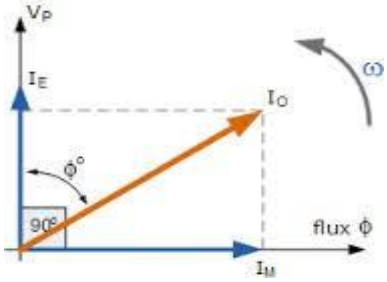
13. Define transformer on no load.(Remembering) (CO2)

If the primary winding is connected to ac supply and secondary winding is kept open then the transformer is said to be on transformer no load condition.

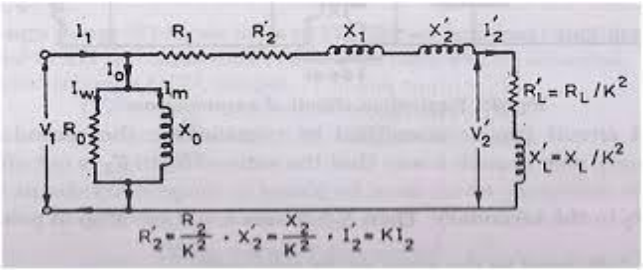
The primary input current under no load condition has to supply

1. Iron loss in the core 2.A very small amount of copper loss in primary

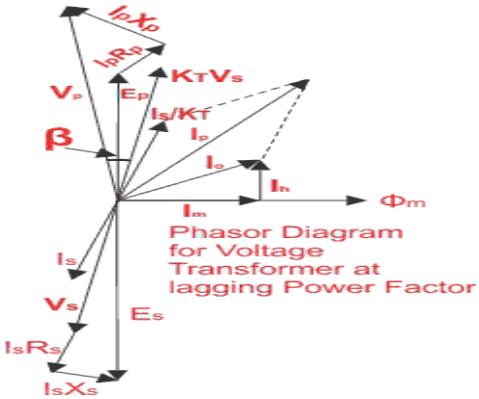
14. Draw the No load phasor diagram of a transformer. (Creating) (CO2)



15. Draw the approximate equivalent circuit of transformer (Analyzing) (CO2)



16. Draw the phasor diagram for a transformer with inductive load. (Analyzing) (CO2)



17. **What is step up and step down transformer? And state their applications.(JUNE 2008)(Dec 2009) (Understanding) (CO2)**

If the number of turns in secondary windings (N_2) is greater than the number of turns in primary winding (N_1).i.e., when the secondary voltage greater than the primary voltage the transformer is called step up transformer.

If the number of turns in secondary windings (N_2) is less than the number of turns in primary winding (N_1).i.e., when the secondary voltage less than the primary voltage the transformer is called step down transformer.

Applications: Step up : For transmission of AC voltage from generating station to substation

Step Down: For Distribution of voltages to the consumer

18. **State the different types of transformers based on input supply and cooling. (Analyzing) (CO2)**

Input supply: Single phase transformer and Three phase transformer

Cooling: Dry type transformer and Oil immersed transformer

19. **Define voltage regulation of a transformer. (JUNE 2010), (DEC 2010) (June 2015) (JUNE 2017), (Understanding) (CO2)**

The change in secondary terminal voltage from no load to full load is $=0V_2- V_2$. This change is divided by $0V_2$ is known as regulation down. If this change is divided by V_2 then it is called regulation up. % reg down= $(\frac{0V2-V2}{0V2})$ x 100, % reg up = $(\frac{0V2-V2}{V2})$x 100

20. **What is transformer all day efficiency?(JUNE 2006), (DEC 2010) (Remembering) (CO2)**

ALL DAY EFFIECIENCY=output power in KWh/input power in KWh

This efficiency is applied to distribution transformer

21. **What are the losses in a transformer? Why core is laminated?(DEC 2007), (JUNE 2010) (June 2016) (Analyzing) (CO2)**

There are two losses occur in transformer

1. Iron losses or core loss-it include eddy current and hysteresis loss 2.Copper losses
2. To reduce the eddy current losses core is laminated

22. **What are the two types of tests conducted in transformer for finding equivalent circuit parameter? (Understanding) (CO2)**

- Open circuit test and short circuit test

23. **Why are iron losses constant at all loads in a transformer? (DEC-2009) (Understanding) (CO2)**

It includes both hysteresis loss and eddy current loss. Because core flux remains constant for all loads, the core losses also remain constant.

24. **State the condition for maximum efficiency of a transformer.(JUNE 2010, DEC 2010) (Analyzing) (CO2)**

Copper loss = Iron loss is the condition for the maximum efficiency of transformer. i.e.,$W_c=W_i$

25. **Why transformer rating in KVA? (MAY 2011) (June 2015) (JAN 2016) (Analyzing) (CO2)**

Copper loss of a transformer depends on current and iron loss on voltage hence total transformer loss depends on volt ampere and not on the angle between voltage and current. That is why transformer rating is in KVA not in KW.

26. **2200/250V single phase transformer gives 0.6A and 60W as ammeter and wattmeter readings when supply is given to the low voltage winding and high voltage winding is kept open, find (i) Power factor of no-load current (ii) Magnetizing component(iii) Iron loss component. (Evaluating) Solution: (CO2)**

(i).Power factor of no load current

$P_O=V_1I_O\cos\Phi_O$

$\cos\Phi_O= \frac{P_O}{V_1 I_O}$

=60/(250X0.6)

Φ_O = 0.4(lagging)

(ii).Magnetizing component $I_\mu = I_O \sin\Phi_O = 0.6\sin(\cos^{-1} 0.4) = 0.549A$

(iii). Iron loss component, $I_W = I_O \cos\Phi_O = 0.6X0.4 = 0.24A$.

27. What are the various types of 3 phase transformer connections? (Remembering) (CO2)

- Star-star(Y-Y) and Star-delta(Y-Δ)
- Delta-delta (Δ-Δ)and Delta-star(Δ-Y)
- Open-delta and Scott connection

28. State different types of core construction of transformers (Nov /Dec 2011) (Understanding) (CO2)

1. Core type transformer 2. Shell type transformer 3. Berry type transformer

29. Give the difference in connection between OC and SC test of transformer. (Nov /Dec 2011) (Analyze) (CO2)

In Open circuit Test primary winding (usually high voltage winding) is left open and other winding is connected to the supply of normal voltage and frequency.

In short circuit test, the secondary winding (usually low voltage winding) is short circuited by a thick conductor and variable low voltage is applied to the primary winding till full load current flows in the winding.

30. Examine why stepped core are generally used in transformer? (CO2) (JUN 2016)

By the use of stepped core, coils can be wound in circular form. Therefore smooth flux distribution can be obtained.

31. An 1100/400V, 50 Hz single phase transformer has 100 turns on the secondary winding. Calculate number of turns on it primary (CO2) (JAN 2016)

275 Turns

16 MARK QUESTIONS

1. Explain in details the construction and operating principle of a transformer(DEC 2003, JUNE 2010) (JUNE 2016)((Understanding)(CO2)
2. Derive the EMF equation for a transformer (DEC 2003, JUNE 2010)(MAY 2011) (JUNE 2015) (JAN 2017)(Creating) (CO2)
3. Derive the equivalent circuit of transformer (DEC 2007), (DEC 2010) (JUNE 2015) (JUNE 2015) (Understanding) (CO4) (Analyzing) (CO2)
4. Explain with help of circuit diagrams how efficiency and regulation of single phase transformer are predetermined by conducting open and short circuit tests? (MAY 2011) JUNE 2016) (Understanding) (CO4) (Creating) (CO32)
5. Explain how the efficiency of a transformer may be found from the open circuit and short circuit tests (MAY 2008) (Evaluating) (CO2)
6. Describe the tests to determine core loss and full load copper loss of a transformer (or) Explain the OC and SC tests performed on a transformer (Nov/Dec 2011) (Analyzing) (CO2)
7. Explain the working of single phase transformer with neat sketch (Nov/Dec 2011) (Understanding) (CO2)
8. Define voltage regulation. Draw the phasor diagram of lagging power factor and determine voltage regulation (Creating) (CO2)
9. Write short notes on (DEC 2006) (Remembering) (CO2)
   a. Transformer on no- load b. Transformer on load
10. Discuss about power losses in a transformer (DEC 2009)(Understanding) (CO2)
11. Explain in detail about Voltage regulation of transformer. (Evaluating) (CO2)
12. A 10KVA, 200/400V, 50Hz single phase transformer gave the following test results.
    OC Test: 200V, 1.3A, 120W. ..... on L.V Side
    SC Test: 22V, 30A, 200W ..... on H.V side
    Calculate (i). The magnetizing current and the component corresponding to core loss at Normal frequency and voltage (ii) the magnetizing branch impedances and (iii) % voltage
13. Regulation when supplying full load at 0.8 pf leading. (DEC 2009) (Evaluating) (CO2)

12. A single phase 20KVA, 2200/220V, 50Hz transformer. The O.C/S.C test results are as follows. O.C test: 220V, 4.2A, 148W..... (L.V. Side) S.C test: 86V, 10.5A, 360W..... (H.V.Side) Determine (i).Regulation and efficiency at 0.8 p.f lagging at full load and (ii) Power factor on Short circuit (iii) obtain the approximate equivalent circuit referred to H.V.side. (Evaluating) **(CO2)**
13. A 600KVA single Φ transformer has an efficiency of 94% both at full load and half load at unity Power factor. Determine the efficiency at 75% of full load at 0.9 power factor. (JUNE 2015) (Understanding) (CO4) (Evaluating) **(CO2)**
14. The OC and SC tests on a 4KVA, 200/400V, and 50Hz single phase transformer gave the following Results: OC test on LV side: 200V, 1A, 100W. SC test with LV side shorted: 15V, 10A, 85W.Determine the parameters of the equivalent circuit and draw the equivalent circuit referred to LV side. (Analyze) (CO2)
15. The parameters of a 2300/230V, 50-Hz transformer is given below:
    R_1=0.286Ω R_2' =0.319Ω R_o=250Ω
    X_1=0.73Ω X_2'=0.73Ω X_0=1250Ω The secondary load impedance Z_L= 0.387+j0.29. Sketch the exact equivalent circuit with normal voltage across the primary. (Evaluate) (CO2)
14. 16. The number of turns on the primary and secondary windings of a single phase transformer is 350 and 35 respectively. If the primary is connected to a 2.2Kv 50Hz supply determine the secondary voltage. (May 2011) (Evaluate) (CO2)
15. 17. Explain the working of autotransformer with neat diagram. (JUNE 2015) (Understanding) (CO2)
16. Deduce the condition for maximum efficiency of transformer(JUNE 2015) (Understanding) (CO2)
17. Compare a normal step down transformer with an auto transformer JUNE 2016) (Understanding) (CO2)
18. Present the vector diagram for transformer on load and no load (JAN 2017)) (CO2)(Analyzing)
19. Write short note on auto transformer (CO2)(Analyzing)

UNIT III-INDUCTION MOTORS

1. **Why the slots on the induction motors are usually skewed?(JUNE 2006) (Understanding) (CO3)**
   The rotor bars are slightly inclined to the shaft axis due the skew provided while stacking the rotor stampings. The reason for this skewing is
   - To help the motor run quietly by reducing magnetic hum
   - To help reducing the locking tendency of the rotor teeth with stator teeth
2. **State the principle of 3 phase IM. (MAY 2011) (JUN 2016)(Remembering) (CO3)**
   While starting, rotor conductors are stationary and they cut the revolving magnetic Field produced by the 3 phase stator winding and so an emf is induced in them by electromagnetic induction. This induced emf produces a current if the circuit is closed. This current opposes the cause by Lenz's law hence the rotor starts revolving in the same direction as that of the rotating magnetic field.
3. **How can the reversal of rotation of poly-phase induction motor be attained? (Analyzing) (CO3)**
   In order to reverse the direction of rotation of a 3-phase induction motor, any 2 of the stator winding terminal must be interchanged thus causing the rotating field to rotate in opposite direction.
4. **What factors determine the direction of rotation of the motor? (Remembering) (CO3)**
   The phase sequence of the supply lines and the order in which these lines are connected to the stator winding
5. **Compare squirrel cage and wound rotor (JAN 2016) (JUNE 2017) (Analyze) (CO3)**

6.

Squirrel Cage Rotor	**Wound rotor or Slip Ring rotor**
As permanently shorted, external resistance cannot be added	Resistance can be added externally
Due to simple construction, the rotors are cheap	The rotors are very costly
Moderate starting torque which cannot be controlled	High starting torque can obtained
Used for lathes, drilling machine,fans,water pumps	Used for lifts, hoists, cranes, elevators, compressors

at is the function of slip ring in a 3 phase induction motor? (DEC 2010) (Remembering) (CO3)

- The rotor of a 3 phase slip ring induction motor is wound for as many poles as the number of stator poles
- The 3 phase are starred internally and the other three winding terminals are brought out and connected to the three insulated slip rings mounted on the shaft with brushes resting on them
- This arrangement helps to connect additional resistances in the rotor circuit during starting of induction motor for increasing the starting torque
- When the motor is running under normal conditions the slip rings are automatically short circuited by the means of a metal collar

7. **Define cogging of induction motor (DEC 2010) (Remembering) (CO3)**

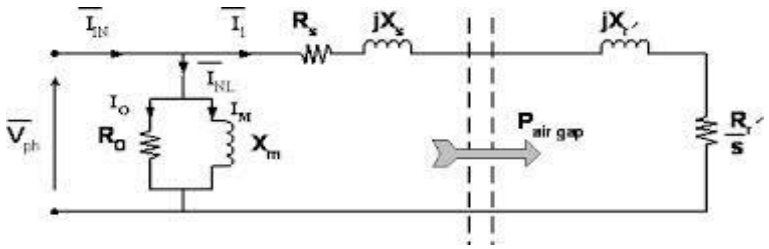
   The rotor of a squirrel cage induction motor sometimes refuses to start at all, particularly when the voltage is low. This happens when the number of stator teeth S1 is equal to the number of rotor teeth S2 and is due to the magnetic locking between stator and rotor teeth. This phenomenon is called cogging and sometimes referred as magnetic locking

8. **State the advantages of skewing.(Remembering) (CO3)**
   - It reduces humming and hence quite running of motor is achieved.
   - It reduces magnetic locking of the stator and rotor.

9. **What are the two fundamental characteristics of a rotating magnetic field in a 3 phase induction motor? (Understanding) (CO3)**

   Rotating magnetic field must be of 1. Constant magnitude 2. Constant speed

10. **Draw the equivalent circuit of 3 phase induction motor. (Understanding) (CO3)**



11. **What are the advantages of slip-ring I M over cage I M? Understanding)) (CO53)**

    (i) Rotor circuit is accessible for external connection.

    (ii) By adding external resistance to the rotor circuit the starting current is reduced with the added advantage of improving starting torque.

12. **What is locked rotor torque? (Understanding) (CO3)**

    The torque that a motor produces when full power is supplied to the motor and the rotor is not yet moving.

13. **Define slip.(MAY 2008) (Remembering) (CO3)**

    The difference between the synchronous speed Ns and actual speed N of the rotor divided by the synch speed Ns is known as slip. S=Ns-N/ Ns x100%

14. **Why starting torque of squirrel cage motor is low? (at synchronous speed)(M/J 2009)(Analyzing) (CO3)**

    The resistance is fixed and small as compared to its reactance. Hence the starting current of the rotor lags E2 by a very large angle, therefore the starting torque is very small and such motor are not useful where it has to start against heavy loads.

15. **A 6 pole, three phase induction motor runs at 800 rpm at load, determine the value of slip at this load condition (Evaluating) (CO3)**

    Ns=120f/P=120*50/6=1000 rpm, s=(Ns-N)/Ns=1000-800/1000=0.2

16. **A 6 pole, 50 Hz, 3Φ induction motor has a full load speed of 950 rpm.and has rotor copper loss of 5kw.calculte rotor input.(Evaluating) (CO3)**

Ns=120f/P=120*50/6=1000 RPM, s=(Ns-N)/Ns=1000-950/1000=0.05

rotor copper loss=s x rotor input, rotor input= rotor copper loss/s=5 x 10^3/0.05=100kw

17. **Define synchronous watt. (Remembering) (CO3)**

By defining a new unit of torque, we can say that the rotor torque equals rotor input. The new unit is synchronous watt. Synchronous wattage equals the power transferred across the air gap to the rotor.

18. **Explain the condition for maximum torque under running condition (Understanding) (CO3)**

Torque under running condition is maximum at that value of slip s which makes rotor reactance per phase equal to rotor resistance per phase.

$S=\frac{R_2}{X_2}$ $R_2=SX_2$

19. **The power input of a 3Φ phase induction motor is 60kw.the stator losses are 1 kw.Find mechanical power developed and rotor cu loss/phase, if the motor is running with slip of 3%.(Evaluating) (CO3)**

i) mechanical power developed $Pm=p_2(1-s)=60x10^3(1-0.03)=60000(0.07)=4.2kw$

ii) rotor cu loss/phase=$sp_2=0.03x60x10^3=1800w$

20. **What are the different types of starter to be used in three phase induction motor?(DEC 2006), (DEC 2010) (Understanding) (CO3)**

- Direct on-line starter and Primary resistance starter
- Auto transformer starter and Star delta starter

21. **Enumerate the possible reasons if a 3 phase motor fails to start. (Understanding) (CO3)**

- One or more fuses may be blown and Voltage may be too low
- The starting load may be too heavy

22. **Why starter is necessary for 3Φ induction motor.(Analyzing) (CO3)**

Induction motors, when direct switched, takes 5 to 7 times their full load current and developed only is to 2.5 times full load torque. The initial excess current is objectionable because it will produce large line voltage drop that, in turn will affect the operation of the other electrical equipment connected to the same lines. Hence it is advisable to use starters to start motors.

23. **Name the various speed control methods of cage induction motor(DEC 2003) (Remembering) (CO3)**

- By changing the applied voltage and By changing the supply frequency
- By changing the number of stator poles and Rotor rheostat control

24. **What are the disadvantages of speed control of Induction motor from stator side? (Remembering) (CO3)**

- A large change in voltage is required for relatively small change in speed
- A large change in voltage will result in a large change in the flux density
- The developed torque reduces greatly with reduction in supply voltage

25. **Name the two different theories with which principle of 1-phase induction motors are explained. (Remembering) (CO3)**

The two different theories are double revolving field theory and Cross field theory

26. **Name any four types of 1-phase induction motors. (MAY 2011) (Dec 2009) (Remembering) (CO3)**

Based on the method of starting, the 1-phase Induction motors are classified as follows

Split-phase motor and Capacitor start induction run motor.

Capacitor start and capacitor run motor and Shaded pole motor

27. **Why is single phase induction motor not self starting? (DEC 2010) (CO3)**

The stator winding when fed from a single phase supply; produce a field which is only alternating (i.e., one which alternates along one space axis only).now alternating /pulsating flux acting on a

stationary squirrel cage rotor cannot produce rotation (only a revolving flux Can).that's why a single phase motor is not self starting

28. **Differentiate between "capacitor start" & "Capacitor start capacitor run" single Phase induction motor? (CO3)**

Capacitor start – capacitor is connected series with starting winding, but it will be disconnected from supply when motor pick up its speed.

Capacitor start capacitor run motor- capacitor will not be disconnected from supply even though motor pick up its speed.

29. **State any 4 uses of single phase induction motor? (Remembering) (CO3)**

Fans, wet grinders, vacuum cleaner, small pumps, compressors, drills.

30. **What are the advantages and disadvantages of shaded pole motor? (Remembering) (CO3)**

Adv: Simple construction and Rugged, reliable, and cheap

Dis: Low starting torque

Very little overload capacity and Low efficiency

31. **Where the split phase induction motor is used? (DEC 2006) (Remembering) (CO3)**

- Fan, blowers and Centrifugal pumps
- Washing machines and Small machine tools and Domestic refrigerator

32. **What are the applications of shaded pole induction motor? (Remembering) (CO3)**

1. Small fans 2.Toys 3.Instruments 4.Hair dryers 5.Electric clocks 6.Circulators.

33. **What are the advantages of induction motor over other motors? (June 2015) (Remembering)** (CO3)

- It is cheap.
- It is simple and rugged in construction.
- It has high efficiency, as frictional losses are reduced due to absence of brushes.
- It works at a reasonable and good power factor and it requires less maintance.

34. **Can Induction Motor run at synchronous speed? True or False? Explain. (Remembering) (CO3)**

False, if the speed of induction motor is Ns then the relative speed between the rotating flux and rotor will be zero and so no torque is produced in the rotor.

35. **Why are centrifugal switches provided on many single phase induction motor**.(**MAY 2011) (JAN 2016) (Remembering) (CO3)**

A centrifugal switch is used in some types of motors in order to cut out a winding, used only for starting purpose.

36. **Name the tests to be conducted for predetermining the performance of 3 phase induction motor.** (**MAY 2011) (Remembering) (CO3)**

1. No load test 2. Blocked rotor test

37. **What type of single phase induction motor would you use for the following applications? (MAY 2011) (Remembering) (CO3)**

(i).Celling fan - Capacitor start and capacitor run induction motor. (ii).Wet grinder- Capacitor start induction run induction motor.

38. **Find the percentage slip of an induction motor Ns=2000 RPM and motor is running at 1850 RPM. (Nov/Dec 2011)(Evaluating) (CO3)**

% Slip= [(Ns-Nr)/Ns]*100 Given Data Ns=2000 RPM Nr=1850 RPM

% Slip= [(2000-1850)/2000]*100=7.5%

39. **Write the relation between speed and frequency or Define Synchronous Speed. (Nov/Dec 2012 Dec 2009) (Remembering) (CO3)**

N_s=120f/P where f: frequency P: Poles

40. **How the direction of rotation of 3 three phase induction motor can be reversed? (Understanding) (CO3)**

By inter changing phase sequence of supply frequency direction of rotation of 3 three phase induction motor can be reversed

41. Give the relation between torque and rotor power factor (Dec 2011) (Understanding) (CO3)

$T \propto \Phi I_{2r} \cos\Phi_{2r}$ $T = K\Phi I_{2r} \cos\Phi_{2r}$

Where Φ=Flux, $\cos\Phi_{2r}$ =Rotor PF I_{2r}=Rotor Current

16 MARK QUESTIONS

1. Explain the constructional features of squirrel cage rotor and slip ring rotor. (Understanding)(CO 3)
2. Compare between squirrel cage and slip ring induction motor.(Evaluating) (CO 3)
3. Explain how rotor rotates in 3phase induction motor. (Understanding) (CO 3)
4. Explain the principle of working of 3 phase induction motor. State how the direction of rotation of the motor can be reversed (DEC 2004), (DEC 2010) (JUNE 2015) (JAN 2017)(Understanding) (CO3) (Analyzing) (CO 5)
5. What is RMF? How RMF is produced in the stator of induction motor? (Nov/Dec 2012) (CO 3) (Understanding)
6. Develop the equivalent circuit of a three phase induction motor .(MAY 2011) (Creating) (CO 3)
7. Derive an expression for torque developed in a 3 phase induction motor and hence deduce the condition for maximum torque and also power and efficiency. (JUNE 2015) (Evaluating) (CO 3)
8. Draw the speed torque characteristics of induction motor and write the necessary relation between them. (Nov/Dec 2012) (JUNE 2015) (JUNE 2016) (Understanding) (CO4) (Evaluating) (CO 3)
9. How the performance calculation of induction motor is carried out? Explain. (Nov/Dec 2011) (Evaluating) (CO 3)
10. Discuss the different power stages of an induction motor with losses.(Understanding) (CO 3)
11. Explain various methods of starting of 3 phase induction motor. (JUNE 2006) (Understanding) (CO3)
12. Draw the diagram of an auto-transformer starter used for three phase induction motor and explain its operation. (Understanding) (CO 3)
13. Explain speed control methods of induction motor from stator and rotor side. (Understanding) (CO 5)
14. Write short notes on following (Understanding) (CO 3)
    a. Speed control schemes of 3 phase induction motor (DEC 2005)
    b. Types of single phase induction motor (DEC 2005)
15. Why starters are necessary for IM (N/D 2007) (Understanding) (CO 3)
16. Discuss various starters used for 3 phase induction motor (N/D 2009) (Understanding) (CO 3)
17. Explain the operation of star delta starter (N/D 2009) (Understanding)(CO 3)
18. Explain the operation of DOL starter (N/D 2009) (Understanding) (CO3)
19. Explain the operation of auto transformer starter (Understanding) (CO3)
20. Derive the equation of torque at starting and running conditions (N/D 2009) (Understanding) (CO3)
21. State and explain double revolving field theory of 1 phase induction motor. Hence deduce the equivalent circuit under normal condition (JUNE 2007) .(MAY 2011)(Creating)(CO 3)
22. The power input to a 500V, 50 Hz, 6 pole, 3 phase induction motor running at 975 rpm is 40 KW. The stator losses are 1 KW and friction and windage losses total 2 KW. calculate (i)slip (ii)rotor cu loss (iii)O/P power (iv)efficiency (JUNE 2010)(Evaluating) (CO3)
23. A 4 pole, 50Hz three phase induction motor has a rotor resistance of 0.024Ω/Phase and standstill reactance of 0.6Ω/phase. Determine the speed at which maximum torque is developed (Evaluating)(CO3)
24. A 220V,3 phase, 4 pole, 50Hz star connected induction motor is rated 3.73Kw. The equivalent circuit parameters are R_1=0.45Ω,X_1=0.8Ω,R_2'=0.4Ω,X_2'=0.8Ω,B_O=1/30 mho .The stator core loss is 50W and rotational loss is 150W. For a slip of 0.04, Find (a).Input current (b).pf (c).Air gap power (d).Mechanical power (e).Electromagnetic torque (f).output power (g).efficiency. (Evaluating)(CO3)
25. A 3300V 10 pole, 50Hz 3 phase Y connected induction motor has slip ring rotor resistance/phase =0.015Ω and standstill reactance/phase=0.25Ω. If the motor runs at a 2.5 percent slip on full load. Find the speed of the motor, speed at which the torque will be maximum and the ratio of maximum torque to full load torque. (Evaluating)(CO3)

26. The ratio of maximum torque to full load torque in a 3 phase squirrel cage induction motor is 22:1. Determine the ratio of actual starting torque to full load torque for direct starting, star delta starting and auto transformer starting with tapping of 70%. The rotor resistance and standstill reactance/phase are 0.5Ω and 5Ω respectively. (Evaluating)(CO3)
27. A 3 phase 50 Hz, 440V, 4 pole induction motor develops half the rated torque at 1490 RPM. With the applied voltage magnitude remaining at the rated value, what should be its frequency if the motor has to develop the same torque at 1600 RPM? Neglect stator and rotor winding resistances, leakage reactance and iron losses? (Evaluating)(CO3)
28. Explain the following motors with neat sketch (i).Split phase motor (ii). Shaded pole motor (iii).Capacitor start capacitor run motor(JUNE 2015) (JUNE 2016) (JAN 2017) (Understanding)(CO3)
29. Explain the typically torque slip curve of a three phase induction motor and deduce the condition for maximum torque.(JUNE 2016) (Understanding)(CO3)

UNIT IV-SYNCHRONOUS MACHINES

1. Compare synchronous generator and DC generator. (Analyzing) (CO4)

DC generator	Synchronous Generator
The induced emf in the armature conductors is of alternating type. By using Commutator and brush assembly it is converted to dc and made available to the external circuit	The induced emf in the armature conductors is of alternating type and is made available to the external circuit
The Commutator and brush assembly arrangement are used to tap the DC current	The slip ring and brush assembly arrangement are used to tape the AC current

2. Mention the two types of alternator (JAN 2016) (Remembering) (CO4)

Salient pole type and Smooth cylindrical type (or) Non salient pole.

3. Mention some of the special features of synchronous machine. (JUNE 2007) (Remembering)(CO4)

1. Constant speed machine 2. Capable of operating both as a motor and generator
3. Do not have Commutator and can be operated in wide range of power factor.

4. write down the EMF equation of an alternator (Remembering)(CO4)

Voltage /phase=4.44 $K_c K_d f T\phi$ volts Where, K_c-coil span factor K_d-distribution factor

f- Frequency of induced emf in Hz T- No. of coils per phase Φ-flux/pole in webers

5. State the characteristic features of synchronous motor. (CO4) (DEC 2010) (MAY 2011) (Remembering)

- The motor is not inherently self-starting.
- The speed of operation is always in synchronous with the supply frequency.
- Irrespective of load conditions the motor is capable of operating at any power factor.

6. What are the advantages of synchronous motor? (Remembering)(CO4)

1. The speed always synchronous irrespective of the load 2. It can be used as a synchronous Condenser for power factor improvement

7. Compare salient pole rotor and cylindrical pole rotor? (Analyzing)(CO4)

Salient pole type	Smooth cylindrical type
Diameter is high and axial length is small	Small diameter and large axial length
Poles are projecting out from the surface	Un slotted portion of the cylindrical acts as poles, hence poles are non-projecting
Air gap is non uniform	Air gap is uniform
Preferred for low speed alternators	Preferred for high speed alternators
Separate damper winding is proposed	Separate damper winding is not necessary

8. Define pitch factor and distribution factor as applied to an alternator (Understanding)(CO4)

Pitch factor: coil span factor K_p or K_c is defined as the ratio between vector sum of induced emf per coil to the arithmetic sum of the induced emf per coil $K_P = \cos \alpha/2$

Distribution factor: The distribution factor is defined as the ratio between emf with distributed winding to the emf with concentrated winding $\text{kd} = \frac{\sin m\beta/2}{m \sin \beta/2}$

9. **A 4 pole, 3 phase star connected alternator has 48 slots. The coil span is 150 electrical Degrees.detemine the coil span factor and distribution factor.(CO4)**
   Short pitched angle of α=180-150=30 Coil span factorK_P=cos 30/2=cos 15=0.966
   No .of slots/pole/phase,m=48/(4X3)=4 Pole pitch=48/4=12 Slot angle , β=180/2=15
   $$\text{kd} = \frac{\sin m\beta/2}{m \sin \beta/2} = \frac{\sin 4\ X15/2}{4 \sin 15/2} = 0.957$$
10. **In what way synchronous motor is different from other motors? (Understanding)(CO4)**
    All DC and AC motors work on the same principle. Synchronous motor operates due to magnetic locking taking place between stator and rotor magnetic fields.
11. **List the different types of torques associated with synchronous motor. (Understanding)(CO4)**
    Various torque associated with a synchronous motor are as follows
    1. Starting torque 2. Running torque 3.Pull in torque 4.Pull out torque
12. **Define pullout torque in synchronous motor (DEC 2010) (Understanding)(CO4)**
    The maximum torque which the synchronous motor can develop without pulling out of synchronism is called pull out torque.
13. **What are V and inverted V curves of synchronous motor? (Understanding)(CO4)**
    The variation of magnitude of line current with respect to the field current is called V curve.
    The variation of power factor with respect to the field current is called inverted V curve.
14. **What is the phasor relation between induced emf and terminal voltage of a 3 phase Synchronous motor? (Understanding)(CO4)**

The rotating magnetic field is initially established by the prime source of supply V. The main field then causes an emf to get induced in the 3phase winding. Hence when the machine operates as a synchronous motor the emf phasor always lags the terminal voltage phasor by the load torque.

15. **Why the synchronous motor is a constant speed motor? (Understanding)(CO4)**

Synchronous motor work on the principle of force developed due to the magnetic attraction established between the rotating magnetic field and the main pole field. Since the speed of rotating magnetic field is directly proportional to frequency of the motor operates at constant speed.

16. **Define the term voltage regulation. (MAY 2011) (JUN 2016) (JAN 2016) (Understanding)(CO4)**
    The voltage regulation of an alternator is defined as "the rise in voltage when full load is removed (field excitation and speed remaining the same) divided by the rated terminal voltage".
    % regulation "up"= (E_0-V/V)*100 Where E_0=No load induced emf, V=Rated terminal voltage.
17. **Name the methods to determine voltage regulation of alternators(Understanding)(CO4)**
    - Synchronous impedance or emf method and Ampere turn or MMF method
    - Zero power factor method and American standard association method
18. **Why MMF method of estimating voltage regulation is considered as optimistic Method? (JUN 2016) (JUNE 2017) (Understanding)(CO4)**
    This method gives the regulation of an alternator which is lower than that actually observed. Hence this MMF method is called optimistic method.
19. **What are the advantages and disadvantages of estimating the voltage regulation an alternator by EMF method? (MAY 2011)(Remembering)(CO4)**
    Adv: Easy to compute the regulation
    Dis Adv: 1.This method is not accurate.2.The value regulation obtained from this method more than that found from actual test.
20. **Why the Synchronous impedance method of estimating voltage regulation is considered as Pessimistic method? (Understanding)(CO4)**
    Compare to other methods, the value of voltage regulation obtained by this method is always higher than the actual value, so it is called as pessimistic method.

21. **What is synchronous impedance? (Understanding)(CO4)**
    It is the ratio between open circuit voltage to short circuit current which are obtained from the OCC and SCC test. Zs=E1 (Open circuit voltage)/I1(short circuit current)
22. **Name any two methods of starting a synchronous motor (Remembering)(CO4)**
    - By an extra 3 phase cage induction motor
    - By providing damper winding in pole phases
    - By operating the pilot exciter as a dc motor
23. **How a Synchronous motor can be made self-starting?(CO4)Nov/DEC 2011) (June 2015) (Creating)**
    The following techniques are employed to start a synchronous motor:
- A separate motor (called pony motor) is used to drive the rotor before it locks in into synchronization.
- The field winding is shunted or induction motor like arrangements are made so that the synchronous motor starts as an induction motor and locks in to synchronization once it reaches speeds near its synchronous speed.
- Reducing the input electrical frequency to get the motor starting slowly, variable-frequency drives can be used here which have rectifier-inverter circuits or cyclo converter circuits

24. **What do you meant by hunting? (May 2012) (Understanding)(CO4)**
    Due to fluctuation of power input to the prime mover if the driving torque applied to the alternator becomes pulsating. The rotor during rotation will oscillate from its normal speed, this oscillation is called hunting.
25. **Name two types of winding used in alternator (JAN 2017)(Understanding)**
    Damper winding for starting purpose and to avoid hunting also Armature winding.
26. **What are the applications of Synchronous motor (JAN 2017)(Understanding)**
    Power factor correction, Constant speed, constant load drives and Voltage regulation.

16 MARK QUESTIONS

1. Explain the construction of synchronous generator.(DEC 2003) (Dec 2010) (Understanding)(CO4)
2. Explain the Construction of a Salient pole Synchronous Machine. (JUNE 2016) (Understanding) (CO4) (Understanding) (CO4)
3. Discuss briefly the constructional features of cylindrical rotor alternator? Why do these alternators operate with high speed steam turbine? (Analyzing) (CO4)
4. Derive the induced emf equation of an alternator.(DEC 2009) (JUNE 2015) (JAN 2016) (JUN 2016) (JAN 2017)(Understanding) (CO4) (Analyzing) (CO4)
5. Explain the construction and operation of brushless alternator (Dec 2012) (Analyzing) (CO4)
6. Explain the construction and principles of operation of a synchronous motor(DEC 2010) (JAN 2016) (Understanding) (CO4)
7. Explain EMF method of predetermine the voltage regulation of an alternator. (JAN 2017)(Understanding) (CO4)
8. Explain in detail the MMF method of obtaining the voltage regulation of an alternator. (Analyzing) (CO4)
9. State the assumption made in the potier method and explain the effect of these assumptions on the accuracy of the voltage regulation.(JUNE 2010) (Analyzing)(CO4)
10. Discuss the synchronous motor starting and the effect of load on it in detail. (Nov/Dec 2011) (Creating) (CO4)
11. A 1200KVA, 3300V 50Hz 3 phase star connected alternator has armature resistance of 0.25 ohm/phase. A field current of 40 A produces a short circuit current of 200 A and an open circuit EMF of 1100v line to line .find the voltage regulation on a) full load 0.8 pf lag and b)full load 0.8 pf leading. (Evaluating) (CO4)
12. Calculate the % voltage regulation for a 3 phase Y connected 2500 KVA 6600 V alternator operating at full load and a) 0.8 pf lagging b) 0.8 pf leading. The per phase synchronous reactance is 10.4 ohm. Neglect armature resistance. (Evaluating) (CO4)

13. A 3 phase 12 pole syn.machine has a Y connected full pitch winding with 108 slots and 12 conductors/slot the flux/pole is 50 mwb and sine distributed .the speed of rotation is 500 rpm. Find the frequency, phase and line EMF. (Evaluating) (CO4)
14. With neat sketch explain the effect of change in excitation (JUNE 2015) (JUN 2016) JAN 2017) (Understanding) (CO4) (JAN 2016)
15. Explain why synchronous motor is not self-starting? (JAN 2016) (JUN 2016) (Understanding) (CO4)

UNIT V- SPECIAL MACHINES

1. What is stepper motor? (Understanding)(CO5)
A stepper motor is a digital actuator whose input is in the form of programmed energization of the stator windings and whose output is in the form of discrete angular rotation.
2. Define the term step angle. (Understanding) (CO5)
Step angle is defined as the angle through which the stepper motor shaft rotates for each command pulse. It is denoted as β.

Formula for step angle (β)

$$\beta = \frac{N_s \sim N_r}{N_s.N_r} \times 360$$

$$\beta = \frac{360}{m\,Nr}$$

where

N_s – No.of stator poles or stator teeth

N_r – No.of rotor poles or rotor teeth

m – No.of stator phases

3. Define slewing. (Understanding) (CO5)
The stepper motor may be operated at very high stepping rates i.e., 25000 steps per second. A stepper motor operates at high speeds is called slewing.
4. Write down the formula for motor speed of stepper motor. (Understanding) (CO5)

Motor speed

$$n = \frac{\beta \times f}{360^\circ} \text{ rps}$$

where

β – Step angle

f – Stepping frequency or pulse rate in pulses per second (pps)

5. Define resolution. (Understanding) (CO5)
It is defined as the number of steps needed to complete one revolution of the rotor shaft.
6. State some applications of stepper motor. (Remembering**)** (CO5)
1. Floppy disk drives 2. Quartz watches 3. Camera shutter operation 4.Dot matrix and line printers
5.Machine tool applications 6. Robotics

7. What are the advantages and disadvantages of stepper motor? (Remembering**)** (CO5)

Advantages

1. It can drive open loop without feedback.
2. Responds directly to digital control signals, so stepper motors are natural choice for digitalcomputer Controls.3. It is mechanically simple.4. It requires little or no maintenance.

Disadvantages

1. Low efficiency with ordinary controller.2. Fixed step angle.3. Limited ability to handle large inertia load
4. Limited power output and sizes available.

8. What are the different types of stepper motor? (June 2015) (Remembering**)** (CO5)

1. Variable reluctance stepper motor 2.Permanent magnet stepper motor 3.Hybrid stepper motor

9. What are the different modes of excitation in a stepper motor? (Remembering**)** (CO5)

1. 1 - Phase on or full - step operation 2. 2-phase on mode 3. Half- step operation (Alternate 1-phase on and 2-phase on mode) 4. Micro stepping operation

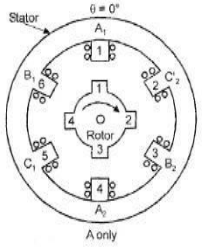
10. What is meant by full-step operation? (JUN 2016, JUNE 2017) (Remembering**)** (CO5)

It is the one-phase on mode operation. It means, at that time only one winding is energized. By energizing one stator winding, the rotor rotates some angle. It is the full-step operation.

11. What is meant by half- step operation? (Remembering**)** (CO5)

It is the alternate one-phase on and 2-phase on mode operation. Here, the rotor rotate an each step angle is half of the full-step angle.

12. Sketch the diagram of a VR stepper motor (Remembering**)** (CO5)



13. What is meant by micro stepping in stepper motor? (Remembering**)** (CO5)

Micro stepping means, the step angle of the VR stepper motor is very small. It is also called mini - stepping. It can be achieved by two phases simultaneously as in 2-phase on mode but with the two currents deliberately made unequal.

14. What is the main application of micro stepping VR stepper motor? (Remembering**)** (CO5)

Micro stepping is mainly used where very fine resolution is required. The applications are printing and photo type setting. AVR stepper motor with micro stepping provides very smooth low - speed operation and high resolution.

15. What is a multi - stack VR stepper motor? (Understanding) (CO5)

Micro stepping of VR stepper motor can be achieved by using multi stack VR stepper motion. It has three separate magnetically isolated sections or stacks. Here the rotor stator teeth are equal.

16. What are the advantages and disadvantages of VR stepper motor? (Remembering**)** (CO5)

Advantages

1. Low rotor inertia 2. High torque to inertia ratio 3. Lightweight
4. Capable of high stepping rate. 5. Ability to freewheel

Disadvantages

1. Normally available in 3.6° to 30 step angles.2. No detente torque available with windings de – energized

17. What are the advantages & disadvantages of permanent magnet stepper motor? (Remembering**)** (CO5)

A**dvantages**

1. Low power requirement2. High detente torque as compared to VR motor 3. Rotors do not require external exciting current4. It produces more torque per ampere stator current

Disadvantages

1. Motor has higher inertia2. Slower acceleration

18. What is hybrid stepper motor? (Remembering**)** (CO5)

A hybrid stepper motor combines the features of both PM and VR stepping motors.

19. What are the advantages and disadvantages of hybrid stepper motor? (Remembering**)** (CO5)

Advantages

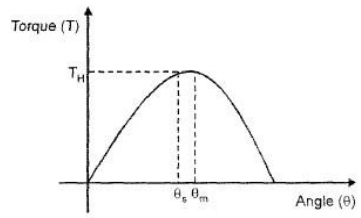
1. Less tendency to resonate 2. Provide detente torque with windings de-energized
3. Higher holding torque capability 4. High stepping rate capability

Disadvantages

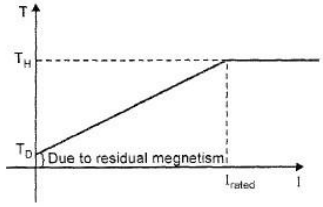
1. Higher inertia and weight due to presence of rotor magnet.2. Performance affected by change in magnetic strength.

20. Draw the typical static characteristics of a stepper motor. (Understanding) (CO5)

T-θ Characteristic



T-I Characteristic



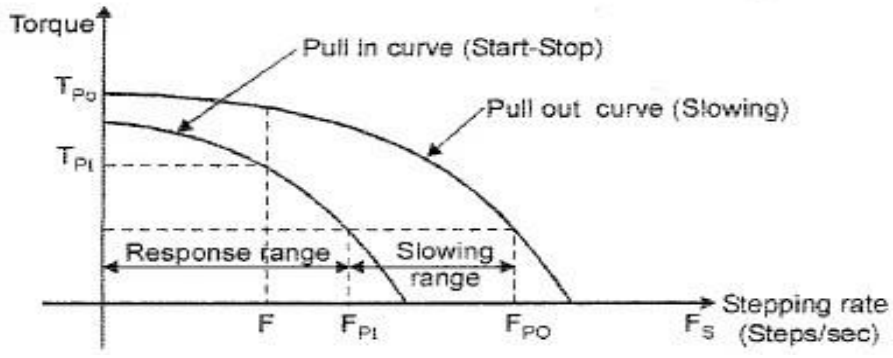
21. Differentiate between VR, PM and hybrid stepper motor. (Analyzing) (CO5)

Sl.No	VR Stepper Motor	PM Stepper Motor	HYBRID Stepper Motor
1	Low rotor inertia	high inertia	High inertia
2	Lessweight	More weight	Moreweight
3	No detente torque available windings de-energized	Provides détente torque	Provides détente torque with windings de-energized
4	Rotor is no permanent magnet	rotor is Permanent magnet	rotor is permanent magnet
5	Rotor is a salient pole type	rotor is a cylindrical type	rotor is a salient pole

22. Define holding torque. (Remembering)

Holding torque is the maximum load torque which the energized stepper motor can withstand without slipping from equilibrium position.

23. Draw the typical dynamic characteristics of a stepper motor. (CO5)



24. Define pull-in torque. (Remembering) (CO5)
It is the maximum torque the stepper motor can develop in start - stop mode at a given stepping rate F (steps/sec), without losing synchronism,
25. Define detente torque. (Remembering) (CO5)
Detente torque is the maximum load torque which is un energized stepper motor can withstand without slipping. It is also known as cogging torque.
26. Define torque constant. (Remembering) (CO5)
Torque constant of the stepper motor is defined as the initial slope of the torque current curveof the stepper motor. It is also called as torque sensitivity.
27. Define pull-out torque. (Remembering) (CO5)
It is the maximum torque the stepper motor can develop at a given stepping rate F (steps/sec), without losing synchronism.
28. Define pull-in rate. (Remembering) (CO5)
It is the maximum stepping rate at which the stepper motor will start or stop, without losing synchronism, against a given load torque.
29. Define pull-out rate. (Remembering) (CO5)
It is the maximum stepping rate at which the stepper motor will slow, without losing synchronism against a given load torque
30. What is a synchronous reluctance motor? (Remembering) (CO5)
A reluctance motor that utilizes an ac rotating field, which allows for the possibility of extremely smooth torque and good operation to low speeds.
31. What are the types of rotor in synchronous reluctance motor? (Understanding) (CO5)
1: Salient rotor 2. Radially laminated rotor 3. Axially laminated rotor
32. Mention some applications of synchronous reluctance motor. (Understanding) (CO5)
1. Fiber-spinning mills2. Industrial process equipment3. Metering pumps4. Wrapping and folding machines
33. What are the advantages of increasing LdILq ratio in synchronous reluctance motor? (CO5) (Understanding)
1. Motor power factor increases.2. 1^2R losses reduced.3. Reduced volt-ampere ratings of the inverter driving the machine.
34. Compare synchronous reluctance motor and induction motor. (Understanding) (CO5)

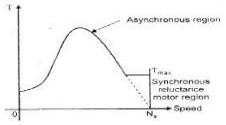
S.No	Induction motor	Synchronous reluctance motor
1	Efficiency is low compared with Synchronous reluctance motor	Better efficiency
2	Low Cost	High cost
3	High Power factor	Low power factor
4	Used for high power application	Used for high power application.

35. Write down the torque equation of synchronous reluctance motor. (Understanding) (CO5)

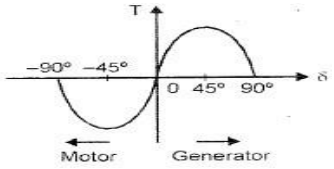
$$T = \frac{3}{\omega_s} V^2 \left(\frac{X_{sd} - X_{sq}}{2 X_{sd} X_{sq}} \right) \sin 2\delta$$

where, V = supply voltage, δ = load angle,
ω_s = synchronous speed, X_{sd}, X_{sq} = synchronous reactances of d and q axis

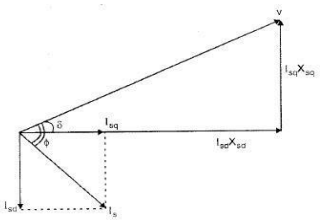
36. Draw the torque-angle characteristics of synchronous reluctance motor (Understanding) (CO5)



37. Draw the torque-angle characteristics of synchronous reluctance motor. (Understanding) (CO5)



38. Draw the steady-state phasor diagram of synchronous reluctance motor. (Understanding) (CO5)



39. Mention some advantages and disadvantages of synchronous reluctance motor. (Understanding) (CO5)

Advantages

1. There is no concern with demagnetization, hence synchronous reluctance.
2. There need be no excitation field at zero torque, thus eliminating electromagnetic spinning Losses.
3. Synchronous reluctance machine rotors can be constructed entirely from high strength, Low-cost materials.

Disadvantages

1. Compared to induction motor it is slightly heavier and has low power factor.
   But, increasing the saliency ratio L_{ds}/L_{qs}, the power factor can be improved.
2. High cost than induction motor.
3. Need speed synchronization to inverter output frequency by using rotor position sensor and sensor less control.

40. Write down any two properties of synchronous reluctance motor. (Understanding) (CO5)

1. High output power capability.2. Ability of the rotor to withstand high speeds.
3. Negligible zero-torque spinning losses.4. High reliability.

41. What is reluctance torque is synchronous reluctance motor? (Understanding) (CO5)

The torque exerted by the reluctance motor because of the tendency of the salient poles to align themselves in the minimum reluctance position. This torque is called reluctance torque.

42. What arc the design considerations in synchronous reluctance motor? (Understanding) (CO5)

1. Power factor 2. Copper loss and core loss 3. Cost 4. Efficiency

43. Why rotor position sensor is essential for the operation of switched reluctance motor? (Understanding) (CO5)

It is normally necessary to use a rotor position sensor for commutation and speed feedback. The turning ON and OFF operation of the various devices of power semiconductor switching circuit is influenced by signals obtained from rotor position sensor.

44. What are the applications of SRM? (Understanding)(CO5)

1. Washing machines 2.Vacuum cleaners 3. Fans
4. Future auto mobile applications 5.Robotics control applications

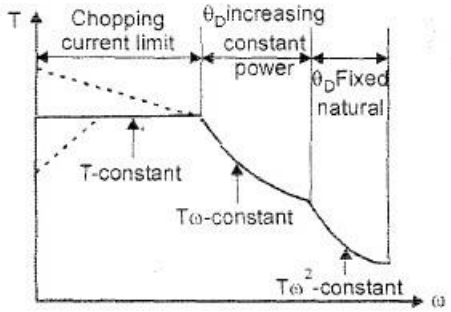
45. List the disadvantages of a switched reluctance motor? (Understanding) (CO5)

1. Stator phase winding should be capable of carrying magnetizing current.
2. For high speed operation developed torque has undesirable ripples, which develops Undesirable noises
3. For high speed current wave form has undesirable harmonics to suppress this effect large size capacitor is to be connected.
4. It requires position sensors.

46. What are the advantages of switched reluctance motor? (Understanding) (CO5)

1. Construction is simple and robust. 2, Rotor carries no windings, no slip rings, and no brushes, less maintenance.3. There is no permanent magnet.4. Ventilating system is simpler as losses takes place mostly in the stator.5. Power semiconductor switching circuitry is simpler 6. No shoot through fault likely to happen power short circuits, 7. Developed torque doesn't depend upon the polarity of current in the phase winding.8. The operation of the machine can be easily changed from motoring mode to generating mode by varying the region of conduction.9. It is possible to get very high speed.10. Depending upon the requirement T-ω characteristics can be achieved.11. It is the self-starting machine.12. Energy stored in the phase winding is fed back to the supply through the feedback diodes during off period.

47. Draw the general torque - speed characteristics of switched reluctance motor. (Understanding)(CO5)



48. What is Switched Reluctance Motor? (Understanding) (CO5)

The switched reluctance motor is a double salient, singly-excited motor. This means that it has salient pole on both the rotor and the stator, but only one member carries windings. The rotor has no windings, magnets (or) cage winding. It works on variable reluctance principle.

49.What are the two types of current control techniques? (Understanding) (CO5)

1. Hysteresis type control 2. PWM type control

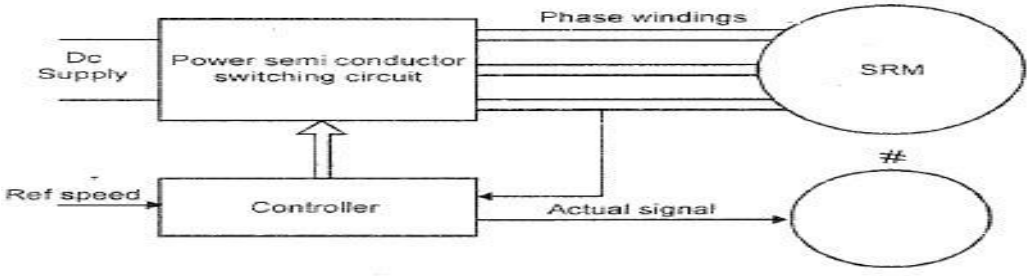
50. What is meant by energy ratio? (CO5)

$$\text{Energy ratio} = \frac{W_m}{W_m + R} \simeq 0.45$$

W_m = mechanical energy transformed.

This energy ratio cannot be called as efficiency. As the stored energy R is not wasted as a loss but it is feedback to the source through feedback diodes.

51. Draw the simple block diagram of SRM.(CO5)(Understanding)



52. What are phase windings? (Understanding) (CO5)

Stator poles carrying field coils. The field coils of opposite poles are connected in series such that mmf's are additive and they are called "Phase windings" of SRM.

53. What are the essential difference between SRM and Stepper Motor? (Analyse) (CO5)

S.No	SRM	Stepper Motor
1	SRM is designed for continuous rotation	Stepper motor is designed to rotate in step by step rotation
2	SRM requires a rotor-position sensor	It does not require rotor-position sensor

54. Write down the torque equation for a switched reluctance motor drive. (Analyse) (CO5)

$$T = \frac{1}{2} i^2 \frac{\partial L}{\partial \theta}$$

where

T = motor torque

i = current

$\frac{\partial L}{\partial \theta}$ = change of inductance with respect to rotor angle

55. What is hysteresis current control? (Analyse) (CO5)

This type of current controller maintains a more or less constant current throughout the conduction period in each phase. This controller is called hysteresis type controller.

56. Define Chopping and single pulse mode of operation of SRM. (Understanding) (CO5)

Chopping Mode

In this mode, also called low-speed mode, each phase winding gets excited for a Period which is sufficiently long.

Single-pulse mode

In single-pulse mode, also called high-speed mode, the current rise is within limits during the small time interval of each phase excitation.

57. What are the advantages of brushless dc motor drives? (JUN 2016, JAN 2017) (Understanding) (CO5)

1. Regenerative braking is possible. 2. Speed can be easily controllable.
3. It is possible to have very high speeds. 4. There is no field winding so that field copper loss is neglected.

58. What are the disadvantages of brushless dc motor drives? (Understanding) (CO5)

1. Motor field cannot be controlled. 2. It requires a rotor position sensor.
3. It requires a Power semiconductor switching circuit.
4. Power rating is restricted because of the maximum available size of Permanent magnets.

59. List the various PM materials. (CO5) (Understanding)

1. Alnico 2. Rare earth magnet 3. Ceramic magnet 4. NdFeB magnet.

60. Mention the some applications of PMBL DC motor. (Understanding) (CO5)

1. Power alternators. 2. Automotive applications.
3. Computer and robotics applications. 4. Textile and glass industries.

61. Why is the PMBL DC motor called electronically commutated motor? (Understanding) (CO5)

The phase windings of PMBL DC motor is energized by using power semiconductor switching circuits. Here, the power semiconductor switching circuits act as a commutator.

62. What are the classifications of BLPM dc motor? (Understanding) (CO5)

1. BLPM square wave motor 2. BLPM sine wave motor.

63. What are the two types of BLPM SQW DC motor? (Understanding) (CO5)

1. 1800 pole arc BLPM square wave motor.
2. 1200 pole arc BLPM square wave motor.

64. Name the position sensors that are used for PMBL DC motor. (Understanding) (CO5)

1. Optical position sensor.2. Hall Effect position sensor.

65. What are the materials used for making Hall IC pallet. (Understanding) (CO5)

1. Indium- antimony 2. Gallium- arsenide.

66. What are the relative merits of the brushless dc motor drives? (Understanding) (CO5)

1. Regenerative braking is possible.
2. Speed can be easily controllable.
3. It is possible to have very high speeds.
4. There is no field winding so that field copper loss is neglected.

67. Compare PMBLDC motor and SRM. (Understanding) (CO5)

S.No	PMBLDC motor	SRM
1	Rotor is a permanent magnet	No permanent magnet in the rotor
2	High cost	Cost is less compared with PMBLDC motor
3	More efficient	Less efficient

68. Name the two comparators used in the power controllers of PMBLDC motor? (Understanding) (CO5)

1. Speed Comparator.2. Current comparator.

69. What is permanent magnet DC commutator motor? (Understanding) (CO5)

A dc motor consists of permanent magnet in the stator and armature winding, commutator in the rotor. This motor is called permanent magnet DC commutator motor.

70. Write down the emf equation of P.M brush less D.C motor? (Remembering) (CO5)

E ph = 2 Bg r l Tph ωm volts. Where, Bg = The flux density in air gap (Wb/m2) r = Radius of the air gap (m) l = Length of the armature (m) ωm = Angular velocity in mech. rad / sec.
Tph = Number of turns per phase.

71. Write down the torque equation of P.M brush less D.C motor? (Remembering) (CO5)

T = 4 Bg r l Tph I N-m Where, Bg = The flux density in air gap (Wb/m2)
r = Radius of the air gap (m) l = Length of the armature (m)
ωm = Angular velocity in mech. rad / sec. I = The current flowing through the motor.

72. When does the demagnetization occur in BLPM DC motor? (Remembering) (CO5)

During the normal operation of motor, when the torque and back emf are constant, if the field flux level becomes low, then demagnetization occurs.

73. State the advantages of brushless configuration. (Remembering) (CO5)

1. Brush maintenance is no longer required. 2. Sparking associated with brushes are eliminated.
3. The absence of commutator and brush gear reduces the motor length.
4. The brushless permanent magnet motors will have better efficiency and greater output power.

74. State the principle of operation of PM brushless DC motor. (Remembering) (CO5)

When d.c supply is given to the motor, the armature winding draws a current. This current sets up an mmf which is perpendicular to the main mmf set up by the permanent magnet field. Hence a force is experienced by the armature conductors according to Fleming's left hand rule. As it is in the stator, a reactive force develops a torque in the rotor. If this developed torque is more than the load torque and frictional torque, the motor starts rotating.

75. Compare conventional dc motor and PMBLDC motor. (Remembering) (CO5)

S.No	PMBLDC motor	Conventional d.c motor
1	The Rotor has permanent magnets	Field magnets are located in the stator
2	Low maintenance	Maintenance requirement is high because of the Presence of commutator & brushes.
3	The motor can be designed for higher voltages subjected to the constraint caused by the power semiconductor switching circuits.	Standardized design procedures are available

76. Why is hysteresis motor free from mechanical and magnetic vibrations? (Remembering) (CO5)

The stator of hysteresis motor carries main and auxiliary windings to produce rotating magnetic field or of shaded pole type also. The rotor is smooth cylindrical type made up of hard magnetic material. The torque in this motor is constant at all speeds it runs at synchronous speed. There is not relative motion between stator and rotor field so the torque due to eddy current vanishes only hysteresis torque is present which keeps rotor running at synchronous speeds .the high retentively ensures continuous magnetic locking between stator and rotor. Hence it is free from magnetic vibrations

77. Discuss characteristics of single phase series motor (Remembering) (CO5)

1. To reduce the eddy current losses, yoke and pole core construction is laminated
2. The power factor can be improved by reducing the number of turns. But this reduces the field flux. But this reduction in flux increases the speed and reducing the torque.
3. To keep the torque same it is necessary to increase the armature turns proportionately. This increases the armature inductance.

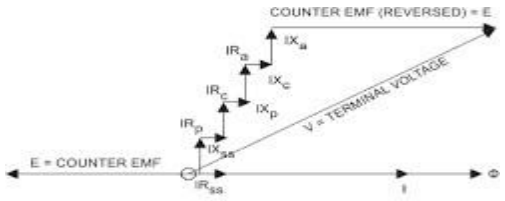
78. List four applications of reluctance motors? (Remembering) (CO5)

1. Signaling device 2. Control apparatus 3.Automatic regulators 4.Recording instruments
5. Clocks and all kinds of timing devices 6.Teleprompter Gramophones.

79. What is a universal motor? (JAN 2016) (JAN 2016) (Remembering) (CO5)

There are small capacity series motors which can be operated on DC supply or single phase AC supply of same voltage with similar characteristics called universal motors. The construction of this motor is similar to that of ac series motor

80. Draw the vector diagram of AC series motor (Understanding) (CO5)



Phaser Diagram for Single Series Motor

81. Write the advantages of reluctance machine. (Understanding) (CO5)

- As the slip rings and brushes are absent there is no sparking.
- No DC field excitation is required and hence field losses are reduced

82. What is sub synchronous reluctance motor? (Understanding) (CO5)

When the motor has a rotor that has an overall cylindrical outline and yet is toothed as a many Pole salient pole rotor then it is called sub synchronous motor.

83. What are the applications of universal motor?(JUNE 2010, 2017) (CO5)

Universal motors are used in vacuum cleaners where actual motor speed is the load speed. Other Applications where motor speed is reduced by a gear train are drink and food mixers, portable Drills and domestic sewing machine etc.

84. State the applications of hysteresis motor. (Remembering) (CO5)

- It has a very low noise level compared to single-phase induction motor because it operates at one speed(synchronous)and its rotor is smooth. With a permanent capacitor stator, hysteresis motor is the smoothest running, quietest single phase motor and is preferred for quality sound reproduction equipments like record players, tape recorders etc
- The most common application is for electric clocks and other timing devices
- Hysteresis motors are used for rotating gyroscope rotors in inertial navigation and control systems

85. Give some applications of Linear Induction motor (Remembering) (CO5)

- Automatic sliding doors in electric trains.
- Mechanical handling equipment, such as propulsion of a train of tubs along a certain route.
- Metallic conveyor belts.

16 MARKS QUESTION

1. Explain the principle of operation and constructional features of synchronous reluctance motor. (Understanding) (CO5)
2. Explain circle diagram and torque-speed characteristics of synchronous reluctance motor. (Understanding) (CO5)
3. Compare the constructional features of axial and radial gap synchronous reluctance motor. (Understanding) (CO5)
4. Describe the construction and principle of operation of synchronous reluctance motor with neat diagrams. (Understanding) (CO5)
5. Draw and explain the steady sate phasor diagram of synchronous reluctance motor. What changes will be made if a permanent magnet is placed on the rotor of same? (Analysing) (CO5)
6. Explain the different modes of excitation used in variable reluctance stepper motor? (JUN 2016) (CO5) (Understanding)
7. Describe the construction and working principle of hybrid stepping motor. (Remembering) (CO5)
8. Describe the working of a 3 stack stepper motor having 12 poles in stator and in rotor. (CO5) (Understanding)
9. Analyse the mechanism of torque production in VR stepper motors. (Analysing) (CO5)
10. State and explain static and dynamic characteristics of a stepper motor (Understanding) (CO5)
11. Explain the construction and working principle of SRM. (Understanding) (CO5)
12. Explain why rotor position sensor is essential for the operation of SRM. (Analysing) (CO5)
13. Sketch the general speed-torque curve of SR motor and discuss the type of control strategy used for different regions of the curve. Sketch the typical phase current waveforms of low speed operation. (Creating) (CO5)
14. Explain the various duty cycle schemes for a phase of three SR motor and its operation with phase current waveforms. (Understanding) (CO5)
15. Sketch the structure of controller for PMBLDC motor and explain the functions of various blocks. (Remembering) (CO5)
16. Derive the expressions for EMF and torque of a PM brushless dc motor. (JAN 2016) (Analysing) (CO5)
17. Compare PMBLDC motor with switched reluctance motor and bring out its features. (JUNE 2015) (Analysing) (CO5)
18. Explain the working of hysteresis motor with neat diagram. (JUNE 2016) (JUNE 2015) (Understanding) (CO5)
19. Explain the working of AC series motor with neat diagram. (Understanding) (CO5)
20. Explain the working of universal motor with neat diagram. (Understanding) (CO5)
21. State and explain the control methods used for universal motor (JUNE 2015) (Understanding) (CO5)
22. Explain the construction and operation of Reluctance Motor (JUNE 2015) (Understanding) (CO5)
23. Explain the construction and operation of Hysteresis Motor (JUN 2016) (Understanding) (CO5)
24. Explain the characteristics of (i). Stepper motor (ii) Hysteresis motor (iii). Reluctance Motor (iv).AC series motor (v). Universal motor (vi).Linear induction motor (vii). Brushless DC motor. (JUN 2016) (JAN 2017) (Understanding) (CO5)