7. SUBJECT DETAILS

7.5 ELECTRICAL MACHINES-III

7.5.1 Objective and Relevance

7.5.2 Scope

7.5.3 Prerequisites

7.5.4 Syllabus

i. JNTU

ii. GATE

iii. IES

7.5.5 Suggested Books

7.5.6 Websites

7.5.7 Experts' Details

7.5.8 Journals

7.5.9 Findings and Developments

7.5.10 i. Session Plan

ii. Tutoiral Plan

7.5.11 Student Seminar Topics

7.5.12 Question Bank

i. JNTU

ii. GATE

iii. IES

7.5 ELECTRICAL MACHINES-III

7.5.1 OBJECTIVE AND RELEVANCE

The objective and relevance of this subject is to provide the student a comprehensive treatment of synchronous machines viz. synchronous generator which is universally employed for the generation of 3-phase power at all generation stations, synchronous motors and single-phase induction motors which are used in daily life like washing machines, fans, etc. The philosophy of the subject is to emphasize the physical understanding of basic principles underlying the operation of electrical machines. The physical concepts regarding the internal behaviour of electrical machines are important because these concepts only lead to creative engineering and motivation.

This subject is an extension of previous machines courses. It deals with the detailed analysis of Synchronous generators and motors which are the prime source of electrical power generation and its utilities. Also concerns about the different types of single phase motors which are having significant applications in house hold appliances and control systems.

7.5.2 SCOPE

Most of the advances in the applications and control of electric machines have taken place owing to the break thourghs in power electronics and microprocessor based control systems. As a result, a much broader spectrum of electric machine types are now available. Particularly permanent magnet and variable reluctance machines are now finding many applications that are bound to increase in future. AC drives are becoming more and more attractive in many applications, such as those requiring variable speed and flexible control while earlier DC machines were the only choise.

7.5.3 PREREQUISITES

The knowledge of various networks theorems, theory and operation of DC and AC electrical machines are required. Some of the basic principles from electromagnetic field and its applications are also essential to study this subject. The subjects to be referred are network theory, electro mechanics-I and electro mechanics-II.

7.5.4.1 JNTU SYLLABUS

UNIT-I

OBJECTIVE

The objective of this unit is to give detailed concepts on the working principle of various types of synchronous generators with their constructional details.

SYLLABUS

SYNCHRONOUS MACHINES AND CHARACTERESTICS: Constructional features of round rotor and salient pole machines, armature windings, integral slot and fractional slot windings, distributed and concentrated windings, distribution pitch and winding factors, e.m.f. equation

Harmonics in generated e.m.f., suppression of harmonics, armature reaction-leakage reactance, synchronous reactance and impedance, experimental determination, phasor diagram, load characteristics.

SYLLABUS

UNIT II

OBJECTIVE

The objective of this unit is to deal with the rigorious details of most useful methods to find the regulation of cylindrical and salient pole alternators with phasor diagrams.

SYLLABUS

REGULATION OF SYNCHRONOUS GENERATOR: Regulation by synchronous impedance method, M.M.F. method, Z.P.F. method and A.S.A. methods, salient pole alternators, two reaction analysis, experimental determinations of X_d and X_q (Slip test), phasor diagrams, regulation of salient pole alternators.

UNIT-III

OBJECTIVE

The objective of this unit is to acquire the detail knowledge on parallel operation and load sharing of synchronous generators and the effect of change of excitation and mechanical power input in synchronous generators.

SYLLABUS

PARALLEL OPERATION OF SYNCHRONOUS GENERATOR: Synchronizing alternators with infinite bus bars, synchronizing power torque, parallel operation and load sharing, effect of change of excitation and mechanical power input, analysis of short circuit current wave form, determination of sub-transient, transient and steady state reactances.

UNIT-IV

OBJECTIVE

The objective of this unit is to give knowledge on the basic principle of operation of synchronous motor and the effect of excitation on armature current and power factor.

The objective of this unit is to describe the various methods of starting of synchronous motors, hunting and its suppression in synchronous motors. This unit also gives knowledge on principle of operation of induction generator.

SYLLABUS

SYNCHRONOUS MOTORS: Theory of operation, phasor diagram, variation of current and power factor with excitation, synchronous condenser, and mathematical analysis for power developed

POWER CIRCLES: Excitation and power circles, hunting and its suppression, methods of starting, synchronous induction motor.

UNIT-V

OBJECTIVE

The objective of this unit is to give fair knowledge on single phase induction motors with construction details and analysis which are extensively used in general appliances in and around us.

The objective of this unit is to give fair knowledge on A.C series motor, basic principles on permanent magnet and reluctance motors and their applications.

SINGLE PHASE MOTORS & SPECIAL MOTORS: Single phase Motors: Single phase induction motor, constructional features, double revolving field theory, equivalent circuit, split-phase motors, capacitor start capacitor run motors.

Principle of A.C. Series motor, universal motor, stepper motor shaded pole motor. (Qualitative Treatment Only).

7.5.4.2 GATE SYLLABUS

UNIT–I
Synchronous generator construction features and EMF equation.

UNIT–II
Regulation of an alternator.

UNIT–III
Parallel operation of synchrnous generator.

UNIT–IV
Principle and operation of synchrnous motor, synchrnous condensers. Starting methods of synchrnous motor.

UNIT–V
Single phase induction motor, shadded pole motor. Stepper motor.

7.5.4.3 IES SYLLABUS

UNIT–I
Synchronous generator construction features and EMF equation.

UNIT–II
Regulation of an alternator.

UNIT–III
Parallel operation of synchrnous generator.

UNIT–IV
Principle and operation of synchrnous motor, synchrnous condensers. Starting methods of synchrnous motor.

UNIT–V
Single phase induction motor, shadded pole motor. Stepper motor.

7.5.5 SUGGESTED BOOKS

TEXT BOOKS

T1 Electric Machines, I.J. Nagrath and D.P. Kothari, 7th Edn.,Tata Mc Graw-Hill Publishshers, 2005.
T2 Electrical Machines, P.S. Bimbra, Khanna Publishers.

REFERENCE BOOKS

R1 The Performance and Design of A.C.Machines, M.G. Say, ELBS and Pitman Sons.
R2 Electric Machinery, A.E.Fitzgerald, C.Kingsley and S.Umans, 5th Edn., Mc Graw-Hill Companies, 1990.
R3 Theory of Alternating Current Machinery, Langsdorf, 2nd Edn., Tata Mc Graw-Hill.

R4 Electromachines-III (Synchronous and single-phase machines), S.Kamakashiah, Right Publishers.
R5 Electrical Machines, Mukerjee and Chjakravarthy, Khanna Publishers.
R6 Electrical Machines, S.K. Battacharya, Tata Mc Graw-Hill Publishers.
R7 Alternating Current Machines, E.R. RK Rajput, Laxmi Publications.

7.5.6 WEBSITES

1. www.mit.edu (massachusetts institute of technology)
2. www.soe.stanford.edu (stanford university)
3. www.grad.gatech.edu (georgia institute of technology)
4. www.gsas.harward.edu (harward university)
5. www.eng.ufl.edu (university of florida)
6. www.iitk.ac.in
7. www.iitd.ernet.in
8. www.iitb.ac.in
9. www.iitm.ac.in
10. www.iitr.ac.in
11. www.iitg.ernet.in
12. www.bits-pilani.ac.in
13. www.bitmesra.ac.in
14. www.psgtech.edu
15. www.iisc.ernet.in
16. www.ieee.org
17. www.school - for - champions.com / science / actransformers.html
18. www.onesmartclick.com / engineering / electrical - machines.html

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To be prepared is half the victory.

- Miguel De Cervantes

7.5.7 EXPERTS' DETAILS

INTERNATIONAL

1. Dr. Sui - Lau Ho,
   B.Sc., Ph.D., C. Engg., MIEE,
   e-mail : eslho@poly.edu.hk.

2. Dr. Edward Wai-chau Lo, M.Phil.,
   Honorary Associate Professor,
   University of Hongkong,
   e-mail : eewclo@poly.edu.hk.

NATIONAL

1. Dr. D.P. Kothari,
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2. Dr. Sivaji Chakravorti,
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   Jadavpur University,
   Kolkatta - 700032, India,
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REGIONAL

1. Dr. Dhanvanthri,
   Head of EEE Department,
   Bharat Engg. College,
   Hyderabad,
   Cell : 9849052608.

2. Dr. A.D. Rajkumar,
   Electrical Engineering Department,
   University College of Engineering,
   Osmania University - 500007.

7.5.8 JOURNALS

INTERNATIONAL

1. IEEE Transactions on energy conversion
2. IEEE Computer applications in power
3. IEE Proceedings : Part-C [Generation, Transmission and Distribution]
4. IEEE Transactions on Power Systems
5. IEEE Electrical Insulation magazine
6. Power Engineering Journal, IEE

NATIONAL

1. Electrical India
2. Journal of Institution of Engineers India)
3. Electrical Engineering Update

7.5.10 i. SESSION PLAN

7.5.9 FINDINGS AND DEVELOPMENTS

1. Field computation for an axial flux permanent magnet synchronous generator, T.F. Chan, L.Z. Lai & S. Xie, IEEE Transactions on Energy Conversion, Vol. 24, No. 1, March 2009.

2. Analysis and real time testing of a controlled single phase wavelet-modulated inverter for capacitor-run induction motors, S.A. Saleh & M.A. Rahman, IEEE Transactions on Energy Conversion, Vol. 24, No. 1, March 2009.

3. Development of a switched-reluctance motor drive with PFC front end, J.Y. Chai & C.Y. Liaw, IEEE Transactions on Energy Conversion, Vol. 24, No. 1, March 2009.

4. Sensorless slowdown detection method for single-phase induction motors, F. Ferreyre, R. Goyet & T. Bousccasse, IEEE Transactions on Energy Conversion, Vol. 24, No. 1, March 2009.

5. Decentralized non-linear control of wind turbine with doubly fed induction generator, F. Wu, X.P. Zhang and P. Ju, IEEE Transactions on Power Systems, Vol. 23, No. 2, May 2008.

6. Permanent Magnet Synchronous Machine Model for Real- Time Simulation, A.B. Dehkordi, Student Member, IEEE, A. M. Gole, Senior Member, IEEE, T. L. Maguire, Senior Member, IEEE International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005 Paper No. IPST05 - 159.

7. Synchro nous moto r pr otection system, Starting p rotection, synchr onization and control for synchronous motors. www.GEDigitalEnergy.com

8. High Torque Density AC Synchronous Servo Motor, Modelling and simulation of synchronous machine transient analysis using SIMULINK, A.Demiroren and H. L. Zeynelgil..
Web: http://www.kinavo.com

9. A Novel Protective Scheme to Protect Small-Scale Synchronous Generators Against Transient Instability Industrial Electronics, IEEE Transactions on (Volume:60 , Issue: 4)Date of Publication: April 2013)

10. Pattern Classification based Intelligent Numerical Protection of Salient-pole Synchronous Generator using Neural Networks J. Electrical Systems 9-1 (2013): 125-136 © JES 2013 on-line : journal/esrgroups.org/je

11. A Novel Adaptive Loss of Excitation Protection Criterion Based on Steady-State Stability Limit Ya-dong Liu Zeng-ping Wang Tao Zheng National Key Laboratory of New Energy Power System, North China r University National Basic Research Program of China (2012CB215200), State Grid Cooperation chnology Program support. 978-1-4799-2522-3/13/$31.00 ©2013 IEEE

7.5.10 i. SESSION PLAN

Sl. No.	Topics in JNTU Syllabus	Modules and Sub Modules	Lecture No.	Suggested Books	Remarks
UNIT-I					
1	Harmonics in generated EMF Suppression of harmonics	Problems on EMF equation	L9	T1-Ch5,T2-Ch3 R1-Ch17,R5-Ch12 R4-Ch6,R6-Ch5 R7-Ch5	GATE IES
		Problems on EMF equation	L10	T1-Ch5,T2-Ch3 R1-Ch17,R5-Ch12 R4-Ch6,R6-Ch5 R7-Ch5	GATE IES
2	Armature reaction Leakage reactance Synchronous reactance and impedance	Nature of armature reaction	L11	T1-Ch8,R1-Ch17 R4-Ch6,R7-Ch5	GATE IES
3	Experimental determination	OCC, SCC and short circuit ratio	L12	T1-Ch8,R1-Ch17 R2-Ch5,R5-Ch12 R4-Ch6,R7-Ch5	GATE IES
		Problems on short circuit ratio, X_S and Z_S	L13	T1-Ch8,R4-Ch6 R7-Ch5	GATE IES
4	Phasor diagrams Load characteristics	UPF, lagging and leading power factors	L14	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch12 R4-Ch6,R6-Ch5 R7-Ch5	GATE IES
UNIT-II					
5	Regulation by synchronous impedance method	Voltage regulation Vector diagrams Problems	L15	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch13 R3-Ch10,R4-Ch6 R6-Ch5,R7-Ch5	GATE IES
		Problems on regulation by synchronous impedance method	L16	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch13 R3-Ch10,R4-Ch6 R6-Ch5,R7-Ch5	GA TE IES

The closest to perfection a person ever comes is when he fills out a job application form.

- Stanely J. Randall

Sl. No.	Topics in JNTU Syllabus	Modules and Sub Modules	Lecture No.	Suggested Books	Remarks
6	Regulation by MMF method	Relevant vector diagrams Problems	L17	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch13 R3-Ch10,R4-Ch6 R7-Ch5	GATE IES
		Problems on MMF method	L18	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch13 R3-Ch10,R4-Ch6 R7-Ch5	GATE IES
7	Regulation by ZPF method	Relevant vector diagrams Problems	L19	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch13 R3-Ch10,R4-Ch6 R7-Ch5	GATE IES
		Problems on ZPF method	L20	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch13 R3-Ch10,R4-Ch6 R7-Ch5	GATE IES
8	Regulation by ASA method	Relevant vector diagrams Comparison between various methods	L21	T1-Ch8,T2-Ch5 R1-Ch17,R2-Ch5 R5-Ch13,R3-Ch10 R4-Ch6,R7-Ch5	GATE IES
		Problems on various methods	L22	T1-Ch8,T2-Ch5 R1-Ch17,R2-Ch5 R5-Ch13,R3-Ch10 R4-Ch6,R7-Ch5	GATE IES
9	Salient pole alternators Two reaction analysis	EMF equation	L23	T1-Ch8,T2-Ch5 R1-Ch17,R3-Ch10 R4-Ch6	GATE IES
		Analysis of phasor diagram Problems	L24	T1-Ch8,T2-Ch5 R1-Ch17,R2-Ch5 R3-Ch10,R4-Ch6	GATE IES
		Power angle characteristics Introduction Power angle characteristics of cylindrical machines with and without resistance	L25	T1-Ch8,T2-Ch5 R1-Ch17,R2-Ch5 R5-Ch14,R4-Ch6	GATE IES
		Power angle characteristics of salient pole machines	L26	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch14 R4-Ch6	GATE IES

		Problems	L27	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch14 R4-Ch6	GATE IES
10	Experimental determination of X_d and X_q (Slip test)	Phasor diagrams	L28	T1-Ch8,T2-Ch5 R5-Ch13,R3-Ch10	GATE IES

Striving to better, oft we mar what's well.

- William Shakespeare

Sl. No.	Topics in JNTU Syllabus	Modules and Sub Modules	Lecture No.	Suggested Books	Remarks
11	Regulation of Salient pole alternator	Regulation of salient pole alternator	L29	T2-Ch5,R4-Ch6	GATE IES
		UNIT-III			
12	Synchronizing alternators with infinite bus bars Synchronizing power and torque	Synchronizing alternators with infinite bus bars Synchronizing power and torque	L30	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch15 R4-Ch6,R7-Ch5	GATE IES
		Problems on synchronizing power and torque	L31	T2-Ch5,R1-Ch17 R4-Ch6,R7-Ch5	GATE IES
13	Parallel operation and load sharing	Parallel operation requirements Synchronizing procedure Synchronoscope	L32	T1-Ch8,T2 -Ch5 R1-Ch17,R2-Ch5 R5-Ch15,R3-Ch12 R4-Ch6,R6-Ch5 R7-Ch5	GATE IES
		Load sharing and problems on parallel operation	L33	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch15 R4-Ch6,R6-Ch5	GATE IES
		Problems on parallel operation	L34	T1-Ch8,T2-Ch5 R5-Ch13,R4-Ch6 R7-Ch5	GATE IES
14	Effect of change of excitation	Operation at constant load with variable excitation Minimum excitation Effect of unequal excitations on	L35	T1-Ch8,T2-Ch5 R1-Ch17,R4-Ch6 R6-Ch5,R7-Ch5	GATE IES
15	Mechanical power input	Power flow equations Derivation	L36	T1-Ch8,T2-Ch5 R1-Ch17,R5-Ch14 R4-Ch6	GATE IES
16	Analysis of short-circuit current waveform Determination of sub-transient, transient and steady state reactance's	Analysis of short-circuit current waveform, determination of sub-transient, transient and steady state reactance's	L37	T1-Ch8,T2-Ch5 R2-Ch6,R5-Ch13 R3-Ch10,R4-Ch6	GATE IES
		Short circuit transient in synchronous machine	L38	T1-Ch8,T2-Ch5 R2-Ch6,R5-Ch13	GA TE IES

Sl. No.	Topics in JNTU Syllabus	Modules and Sub Modules	Lecture No.	Suggested Books	Remarks
UNIT-IV					
UNIT-V					
	Synchronous motor theory of operation Phasor diagram	Characteristics Applications	L39	T1-Ch8,T2-Ch5 R5-Ch13,R3-Ch11 R4-Ch7,R7-Ch6	GATE IES
	Variation of power factor and current with excitation Synchronous Condenser	V curves and Λ curves As a capacitor As a inductor	L40	T1-Ch8,T2– Ch5 R1-Ch17,R3-Ch11 R4-Ch7,R6-Ch5 R7-Ch6	GATE IES
		Problems on synchronous motor	L41	T1-Ch8,T2– Ch5 R5-Ch14,R4-Ch7 R7-Ch6	GATE IES
25	Mathematical Analysis for power developed	Maximum power developed	L42	T1-Ch8,R5-Ch14 R3-Ch11, R4-Ch7	GATE IES
		Problems on power developed	L43	T1-Ch8,R5-Ch14 R3-Ch11, R4-Ch7	GATE IES

Sl. No.	Topics in JNTU Syllabus	Modules and Sub Modules	Lecture No.	Suggested Books	Remarks
		UNIT-VI			
26	Excitation and Power circles	Excitation and Power circles	L44	T2-Ch5,R4-Ch7	
		Maximum power condition Problems	L45	T2-Ch5,R4-Ch7	
27	Hunting and suppression Methods of starting	Auxiliary motor starting Induction motor starting	L46	T1-Ch 8,T2-Ch 5 R5-Ch15,R3-Ch11 R4-Ch7,R6-Ch5 R7-Ch 6	GATE IES
28	Synchronous induction motor	Determination of equivalent secondary current Current diagram	L47	T2-Ch5,R4-Ch7 R7-Ch6	GATE IES
		Problems on synchronous motors	L48	T1-Ch8,T2-Ch5 R5-Ch14,R4-Ch7 R7-Ch6	GATE IES
		UNIT-VII			
29	Single phase induction motor Constructional features	Introduction to single phase induction motors Types	L49	T1-Ch10,R5-Ch20 R4-Ch8,R6-Ch6 R7-Ch4	GATE IES
30	Double revolving field theory	Double revolving field theory	L50	T1-Ch10,R5-Ch20 R3-Ch9,R4-Ch8 R6-Ch6,R7-Ch4	GATE IES
		Torque speed characteristics (qualitative treatment and semi quantitative treatment)	L51	T1-Ch10,R5-Ch20 R3-Ch9,R4-Ch8 R6-Ch6,R7-Ch4	GATE IES
		Problems on Equivalent Circuit	L52	T1-Ch10,R5-Ch20 R3-Ch9,R4-Ch8 R6-Ch6,R7-Ch4	GATE IES
31	Elementary idea of cross field theory	Elementary idea of cross field theory	L53	R5-Ch20,R3-Ch9 R4-Ch8,R6-Ch6 R7-Ch4	GATE IES
32	Split phase motors	Starting torque Resistance split phase motor Capacitance split phase motors Problems on split phase motors	L54	T1-Ch10,R2-Ch11 R5-Ch20,R4-Ch8 R6-Ch6,R7-Ch4	GATE IES
		Problems on single phase motors	L55	T1-Ch10,R2-Ch11 R5-Ch20,R4-Ch8 R6-Ch6,R7-Ch4	GATE IES

Sl. No.	Topics in JNTU Syllabus	Modules and Sub Modules	Lecture No.	Suggested Books	Remarks
		UNIT-VIII			
33	Principle and performance of AC series motor Universal motor	Circuit model Phasor diagram Torque developed Performance characteristics	L56	T1-Ch10,R2-Ch11 R5-Ch20,R4-Ch8 R6-Ch6,R7-Ch4	GATE IES
34	Stepper motor	Principle of working of stepper motor	L57	T1-Ch10,R2-Ch11 R5-Ch20,R4-Ch8 R6-Ch6,R7-Ch4	GATE IES
35	Shaded pole motor	Problems on single phase motors	L58	T1-Ch10,R2-Ch11 R5-Ch20,R4-Ch8 R6-Ch6,R7-Ch4	GATE IES

ii. TUTORIAL PLAN

Sl. No.	Topics Scheduled	Salient topics to be discussed
1	Synchronous Generator Constructional features of round rotor and salient pole machines Armature windings Integral slot windings, fractional slot windings	Discussion on construction details of synchronous generator
2	Distributed windings and concentrated windings Pitch factor, distribution factor, winding factor EMF Equation	Problems on EMF equation
3	Harmonics in generated EMF, suppression of harmonics Armature reaction, leakage reactance, synchronous reactance and impedance Experimental determination	Problems on EMF equation
4	Phasor diagrams Load characteristics Regulation by synchronous impedance method	Problems on EMF method
5	Regulation by MMF method Regulation by ZPF method	Problems on MMF and ZPF method
6	Regulation by ASA method Salient pole alternators Two reaction analysis	Discussion on salient pole alternators and two reaction analysis
7	Experimental determination of X_d and X_q (Slip test) Regulation of salient pole alternator	Problems on regulation of salient pole alternators
8	Synchronizing alternators with infinite bus bars Synchronizing power and torque Parallel operation and load sharing	Problems on parallel operation

Sl. No.	Topics Scheduled	Salient topics to be discussed
9	Effect of change of excitation Mechanical power input	Discussion on change of effect of change of excitation and mechanical power input with phasor diagrams
10	Analysis of short-circuit current waveform, determination of sub-transient, transient and steady state reactances Synchronous motor theory of operation, phasor diagram Variation of power factor and current with excitation Synchronous Condenser	Discussion on short circuit transients in synchronous machine Review on synchronous motor basic operation with phasor diagrams
11	Mathematical Analysis for power developed Excitation and Power circles	Problems on mechanical power developed in synchronous motor, excitation and power circles
12	Hunting and suppression Methods of starting Synchronous induction motor	Discussion on starting methods of synchronous motor
13	Single phase induction motor Constructional features Double revolving field theory	Problems on equivalent circuit of single phase induction motor
14	Elementary idea of cross field theory Split phase motors Shaded pole motor	Problems on split phase motors
15	Principle and performance of AC series motor, Universal motor Principle of permanent magnet motor and reluctance motors	Discussion on universal motor and stepper motors

7.5.11 STUDENT SEMINAR TOPICS

1. Industrial applications for induction motors C. Thangaraj, Dr. S.P. Srivastava and Dr. Promod Agarwal, Eletrical India, Vol. 48, No. 3, Mar. 08.

2. Energy efficient motors for smart choice, Millind Raje, Eletrical India, Vol. 48, No. 3, Mar. 08.

3. Motor design and manufacturing aspects, JDK Patel, Eletrical India, Vol. 48, No. 3, Mar. 08.

4. Ventilation Systems of Fanless HV Motors, J.K. Patel, M.B. Kanitkar, H.V. K.Shetty,Eletrical India, Vol 47, No.1, January 2007.

5. Electric Motor : Major Causes of Failure and Detection,Prof. V.N. Ghate and Dr. S.V. Dudul, Electrical India, Vol 47, No. 2, Feb 07.

6. A Review of Development of Hybrid Excitation Synchronous Machine, IEEE ISIE 2005, June 20-23, 2005,

7. New Drive System with Synchronous Motor: "SANMOTION"G SANYO DENKI Technical Report No18 Nov. 2004.

8. Study and Development of Anti-Islanding Control for Synchronous Machine-Based Distributed Generators, Z. Ye GE Global Research Center Niskayuna, New York, November 2001 - March 2004.

7.5.12

QUESTION BANK UNIT-I

1. Derive an expression for power developed in a non salient pole alternator. **(May 11)**

2. A 3 phase, 10 pole star connected alternator runs at 600 rpm. It has 120 slots with 8 conductors per slot and conductors of each phase are connected in series. Determine the phase and line electromotive forces if the flux per pole is 56 mWb.What harmonics due to slots might occure in the phase and line voltages. **(May 11)**

3. A 6.6 KV, 1 MVA, 3 phase alternator delivering full load at 0.8 p.f. lagging. Its reactance is 20% and resistance negligible. By changing the excitation, the EMF is increased by 25% at this load. Calculate the new current and power factor. The machine is connected to infinite bus bars. **(May 11)**

4. The phase emf of a 3 phase, 50 Hz alternator consists of a fundamental, a 20% 3rd harmonic and a 10% 5th harmonic. The amplitude of the fundamental voltage is 1000V. Calculate the rms line voltage when the alternators windings are in star and delta. If the reactance per phase at 50 Hz is 12Ω calculate the circulating current when the machine is delta connected. **(May 11)**

5. i. Why is a rotating field system used in preference to a stationary field? A 6-pole alternator rotates at 1000 rpm. What is the frequency of the generated voltage?
   ii. List difference between salient type and non salient type of rotor construction. **(Nov 10)**

6. A star connected 3 phase, 4 pole, 50 Hz alternator has a single layer winding in 24 stator slots. There are 50 turns in each coil and the flux per pole is 0.05 Wb. Find the open circuit voltage? **(Nov 10)**

7. What is armature reaction? Explain the effect of armature reaction on the terminal voltage of an alternator at
   i. u.p.f. load
   ii. zero leading power factor load. Draw the relevant phasor diagrams. **(Nov 10)**

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8. Enumerate various methods used for minimizing harmonics in turbo alternators? **(June 10)**

9. i. Derive the commonly used expression for power developed by synchronous motor.
   ii. The input to a 11000 volts three phase star connected synchronous motor is 60 amperes. The effective resistance and synchronous reactance per phase are 1 ohm and 30 ohms respectively. Find the power supplied to the motor. **(June 10)**

10. A 11 KV, 3 phase cylindrical rotor type alternator has the following O.C.C. at rated speed

Line Voltage(V)	7300	10300	12400	14000
Field Current(A)	40	60	80	100

The excitation to produce full load current on S.C. is 34 A and when the machine supplies full load output at 11 KV and zero p.f., the excitation is 106 A. Determine:
   i. % synchronous reactance drop
   ii. % leakage reactance drop
   iii. The armature reaction in equivalent field amperes at full load. Neglect the armature resistance. **(Nov 09)**

11. Explain the effect of armature reaction on the performance of an alternator. How it depends on the load p.f.? Explain with suitable diagrams. **(Nov 09)**

12. Derive an expression for the induced emf in an alternator in terms of terminal voltage, p.f and armature parameters from the phasor diagram. **(Nov 09)**

13. Draw and explain the phasor diagram of a salient pole synchronous generator supplying a lagging p.f. load? **(Nov 09)**

14. i. Explain the leakage reactance and armature reactance of an alternator.
 ii. A 3 -ϕ, star connected alternator is rated 1600KVA, 13500V. The effective armature resistance and reactance are 1.5 Ω/ph and 30 Ù/ph respectively. Calculate the percentage regulation for a load of 1280KW at a power factor of a. 0.8 leading b. 0.8 lagging. **(Nov 09)**

15. Explain the effect of armature reaction on the EMF induced. Is it possible to obtain load voltage more than EMF inducted? If yes, how? **(Nov 09, 07)**

16. Find the rms value of fundamental and third harmonic EMF per phase for an alternator having the following data. 50Hz, 3ϕ, 20poles, 4 slot / pole / phase, double layer winding with 6 conductors / slot, coil span of 150^0 electrical, the fundamental flux per pole is 0.1wb and third harmonic is 17% of fundamental. All coils of a phase are connected in series. **(Nov 09, 08)**

17. i. What are harmonics? Explain the sources of harmonics. What are the various effects of harmonics on generated emf in an alternator?
 ii. In a 50KVA, star connected, 440v, 3-ϕ, 50Hz alternator, the effective armature resistance is 0.25Ω/ph, the leakage reactance is 0.5Ω/ph. Determine the following at rated load and power factor
 a. Internal emf
 b. No load.s emf
 c. Value of synchronous reactance which replaces armature reaction. **(Nov 09)**

18. i. What is armature reaction? Explain how it affects the performance of an alternator for different power factors of load.
 ii. The OC and SC test data for a 500KVA, 1100V, 50Hz, star connected synchronous generator are 1280v between lines on open circuit with a field current of 8A and 380A on short circuit with same field current. When a DC voltage of 5v was applied to two of its terminals, a current of 25A was measured. Find the value of synchronous impedance and synchronous reactance. **(Nov 09)**

19. i. Explain de-magnetising, cross magnetising & magnetising nature of armature reaction.
 ii. Calculate the RMS value of the induced EMF per phase of a 4 pole, 3-ϕ, 50 Hz, alternator with 3 slots per pole per phase and 6 conductors per slot in two layers. The coil span is 150^0. The flux per pole has a fundamental component of 0.2 wb & a 16 % third harmonic component. **(May 09)**

20. i. Explain with neat diagram, the various tests to be conducted on an alternator to obtain its synchronous reactance.
 ii. Find the synchronous impedance and reactance in an alternator in which a given field current produces an armature current of 250 A on short circuit nad generates an open circuit voltage of 1500 volts. The effective armature resistance is 0.5 Ω/ph. Hence calculate the terminal PD when a load of 250 A 6600 V at a power factor of 0.8 lagging is switched off potential difference. **(May 09)**

21. i. Explain the operation and effect of load power factor on the performance of alternator.
 ii. The effective resistance of a 2200 V, 50 Hz, 440 kVA, single phase alternator is 0.5 Ω. On short circuit, a field current of 4 A gives the full load current. The EMF on open circuit for the same field current is 1160 V. Find Synchronous impedance, Synchronous reactance and % regulation of 0.6p.f lagging. **(May 09)**

22. Explain the sources of harmonics. What are the various effects of harmonics on generated emf in an alternator? **(Nov 08)**

23. i. Explain the effects of harmonics on electrical power system & utility.
    ii. Calculate the RMS value of EMF induced per phase of a 10 pole, 3-phase, 50 Hz, alternator with 2 slots per pole per phase and 4 conductors per slot in two layers. The coil span is 150^0 electrical. The flux per pole has a fundamental component of 0.12 wb & a 20% of third harmonic component. **(Nov 08)**

24. i. Explain the causes of harmonics? Explain the concept of fictitious poles.
    ii. A 10 pole, 3-phase, 50 Hz, alternator has 8 slots per pole & 6 conductors per slot. The winding is 7/8 pitch. There are 0.03 wb entering the armature from each north pole & this flux is sinusoidaly distributed along the air gap. The star armature coils are connected in series. Determine the open circuit EMF of the alternator. Find the breadth factor for 3rd & 5th harmonics. **(Nov 08)**

25. i. What is armature reaction? Explain armature reaction for different power factors of load?
    ii. Data from tests performed to determine the parameters of a 200 kVA, 480 V, 60 Hz, 3-phase, stat connected alternator are V_{OC}=480 V, I_{SC}=209.9A for constant I_f & for DC test V_{DC} = 91.9 V, I_{DC}=72.8 A (stator). Determine synchronous impedance & the SCR of the alternator. **(Nov, Feb 08)**

26. i. Explain the effects of harmonics present in generated emf of alternator.
    ii. The flux distribution curve of a smooth core 50 Hz generator is $B = \sin\theta + 0.2\sin 3\theta + 0.2\sin 5\theta + 0.2\sin 7\theta$ wb/m^2 where θ is the angle measured from neutral axis. The pole pitch is 35 cm the core length is 32 cm and stator coil span is four-fifth pole pitch. Find equation for EMF induced in one turn its RMS value. **(Feb 08)**

27. i. Explain the factors affecting synchronous reactance of alternator.
    ii. The SC, OC & DC test data for a star connected 25 kVA, 240 V, 60 Hz, alternator are (between two terminals):
    V_{OC} = 240 V, I_{SC} = 60.2 A - - - - For same field current
    V_{DC} = 120.6 V, I_{DC} = 50.4 Determine: Synchronous reactance.
    (Feb 08)

28. i. Explain the characteristics and nature of harmonics present in generated emf of alternator?
    ii. The flux density distribution in the air gap of an alternator is $B = B_1 \sin\theta + B_3 \sin 3\theta + B_5 \sin 5\theta$ wb/m^2, where $B_3 = 0.3B_1$ & $B_5 = 0.2B_1$. The total flux per pole is 0.08 wb. The coil span is 80% of pole pitch. Find the RMS value of EMF induced in single turn machine. **(Feb 08)**

29. i. Explain the load characteristics of an alternator.
    ii. The phase EMF of a 3-phase alternator consist of fundamental, 20 % 3rd harmonic & 10 % fifth harmonic. The amplitude of fundamental is 1000 V. Calculate the RMS value of line & phase voltage, when the alternator is connected in
    a. Star b. Delta **(Nov 07)**

30. Justify the statement 'The terminal voltage of an alternator is not only depends on the load current, but also on the nature of load'. **(Nov 07)**

31. A 200 kVA, 480 V, 50 Hz, star connected synchronous generator with a rated field current of 5A was tested and the following data were obtained:
    OC test: 540 V between lines on open circuit.
    SC test: 300 A.
    When a DC voltage of 10 V was applied to two of its terminals, a current of 25 A was measured, find the value of synchronous impedance, synchronous reactance voltage regulation of 0.6 p.f leading. **(Nov 07)**

32. i. A 16 pole, 3-phase star connected alternator has 144 slots. The coils are short pitched by one slot. The flux per pole is phase = 100 sin θ + 30 sin 3θ + 20 sin 5θ. Find the harmonics as percentage of phase voltage & line voltage.
    ii. Define
    a. synchronous reactance b. synchronous impedance and c. leakage reactance in an alternator.

33. What is armature reaction? How it is accounted as a reactance drop? **(Feb 07)**

34. What is armature reaction? Explain the effect of armature reaction on the terminal voltage of an alternator at
    i. Unity power factor load
    ii. Zero lagging power factor load
    iii. Zero leading power factor load. Draw the relevant phasor diagram. **(Feb 07, May 05, Nov 03)**

35. What is synchronous reactance? How do you calculate synchronous impedance experimentally? **(Feb07, Nov 03)**

36. Draw and explain the phasor diagram of an alternator at lagging power factor **(Nov 06)**

37. A 3-phase, 50 hz cylindrical rotor synchronous machine has the following parameters.
    Self inductance per phase = 3.15 mH
    Armature leakage inductance = 0.35 mH for this machine, calculate the mutual inductance between armature phases and its synchronous reactance. **(Nov 06, May 04)**

38. With neat circuit diagrams, explain the various tests conducted on an alternator to determine its synchronous reactance. **(Mar 06)**

39. Describe armature reaction and explain its effect on terminal voltage. **(Nov 05)**

40. What are slot harmonics and how they are suppressed. **(Nov 05, 04)**

41. Discuss how synchrnous impedance of alternator can be determined. **(Nov 05)**

42. Explain the effect of harmonics on pitch and distribution factors. **(May 05)**

As the old proverb says "Like readily consorts with like."
- Cicero

43. What are the causes of harmonics in the voltage and current waveforms of electrical machinery and what means are taken in design to reduce them? **(May 05)**

44. An alternator has 18 slots/pole and the first coil lies in slots 1 and 16. Calculate the pitch factor for
    i. Fundamental
    ii. 3rd harmonics
    iii. 5th harmonics and
    iv. 7th harmonics. **(May 05)**

45. Calculate the speed and open –circuit line and phase voltages of a 4-pole, 3-phase, 50HZ, star-connected alternator with 36 slots and 30 conductors per slot. The flux per pole is 0.0496 Wb and is sinusoidally distributed. **(Nov 04)**

46. Determine their values for a 3-phase winding with 4 slots per pole per phase, the coil span being 10 slot pitches. Calculate the percentage increase in R.M.S. Value of the phase voltage due to a 25% third harmonic. **(Nov 04)**

47. i. Discuss the effect of armature reaction in an alternator.
    ii. A 3.3 KV, 3-phase, star connected alternator has full-load current of 100A. Under short circuit condition it takes 5A filed current to produce full-load short circuit current. The emf on open circuit for the same excitation is 900V (line to line). The armature resistance is 0.9 Ohm per phase. Determine synchronous reactance per phase. **(Nov 04)**

48. i. Describe the method of finding synchronous impedance of a given alternator.
    ii. The following data is obtained for 100KVA, 1100V, 3-phase alternator
    D.C. resistance test between lines = 10V
    Current in line = 10 A.
    Line circuit test; field current I_f = 12 A.
    Line voltage = 420V;
    Short circuit test; I_f = 12 A.
    Line current L_{sc} = rated value
    Calculate synchronous impedance **(Nov 04)**

49. Explain about harmonics generated in e.m.f. of a synchronous machine. How do you suppress them? What are the problems due to harmonics. **(Nov 04)**

50. Explain the effect of armature reaction on terminal voltage of an alternator at i. u.p.f. ii. zero p.f. load. Draw the relevant phasor diagrams. What is leakage reactance? **(Nov 04, 03)**

51. i. Explain how open circuit and short circuit tests are conducted on a synchronous machine.
    ii. What is an air-gap line? In an alternator, explain why short circuit characteristic is a straight line where as open circuit characteristic is a curve. **(May 04)**

52. A 3-Phase star connected, 4-pole, 50 Hz., alternator develops an open circuit voltage of 12.5 KV for an applied field voltage of 400 V. For a field circuit resistance of 10 Ohms, Calculate the amplitude of armature to field mutal inductance. **(May 04)**

53. Draw and explain the phasor diagram of alternator under loaded conditions. **(Nov 03)**

54. Discuss open circuit and short circuit characteristics of a synchronous generator.
    Draw the phasor diagram under short circuit condition. What do you understand by the term "short circuit ration"? Discuss how short circuit ratio can be calculated from the two characteristic curves? **(Nov 02, IES 00)**

Get not your friends by bare compliments, but by giving them sensible tokens of your love.
- Socrates

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55. A synchronous generator is feeding a zero power factor (lagging) load at rated current. The armature reaction is
i. magnetizing
ii. demagnetizing
iii. cross-magnetizing
iv. ineffective **(GATE 06)**

56. The resultant flux density in the air gap of a synchronous generator is the lowest during. i. open circuit
ii. solid short circuit iii. full load
iv. half load **(IES 06)**

57. Sketch and explain the open circuit and short circuit characteristics of a synchronous machine **(IES 97)**

58a) Discuss briefly the load characteristics of alternator for different power factors.
b) The effective resistance of a 2200 V, 50 Hz, 440 KVA, 1-phase alternator is 0.5Ω On short circuit, a field current of 40 A gives the full-load current of 220 A. The voltage on open-circuit with same filed excitation is 1160 V, Calculate
i) Synchronous impedance ii) Synchronous reactance.]

2.a) What is the effect of harmonics and how do you supress
How do you determine synchronous reactance and impedance experimentally? Dr characteristics of an alternator. [8+8]

UNIT-II

1. From the following test results, determine the voltage regulation of a 2000V, single phase alternator delivering a current of 100A at:
i. unity p.f.
ii. 0.8 leading
p. iii. 0.71 lagging
p.f. Test results:
Full load current of 100A is produced on short circuit by a field excitation of 2.5A, an emf of 500V is produced on open circuit by the same excitation. The armature resistance is 0.8 ohms. **(May 11)**

2. The effective resistance of a 1200 KVA, 3.3KV, 50Hz, 3 phase star connected alternator is 0.25Ω/ phase. A field current of 35A produces a current of 200A on short circuit and 1.1KV (line to line) on open circuit. Calculate the power angle and p.u. change in magnitude of the terminal voltage when the full load of 1200KVA at 0.8 p.f. (lag) is thrown off. Draw the corresponding phasor diagram. **(May 11)**

3. A 3 phase, 4 pole, star connected turbo alternator has a cylindrical rotor. The reactance per phase of winding is 2.5Ω and resistance per phase is 0.15Ω. The alternator has a terminal potential di”erence of 6600 V when delivering a current of 250A. Calculate
i. The generated emf at 0.6 p.f lagging
ii. The regulation at 0.8 p.f lagging. **(May 11, Nov 09)**

4. The following test results are obtained from a 3 phase, 6000 KVA, 6600V, star connected, 2 pole, 50 Hz turbo alternator: With a field current of 125A, the open circuit voltage is 8000V at the rated speed; with the same field current and rated speed the short circuit current is 800A. At the rated full load, the resistance drop is 3%. Find the regulation of alternator on full load and at a p.f. of 0.8 lagging. **(May 11)**

5. A 1000KVA, 6.6KV, 3 phase star connected synchronous generator has a synchronous reactance of 25Ω per phase with negligible resistance. It supplies full load current at 0.8 p.f. lagging and at rated terminal voltage. Compute the terminal voltage for the same excitation when the generator supplies full load current at 0.8 p.f. leading. **(Nov 10)**

6. Sketch and explain the O.C. and S.C. characteristics of a synchronous machine. How voltage regulation can be calculated by the use of their results? **(Nov 10)**

7. A 1200 KVA, 6600V, 3 phase star connected alternator has its armature resistance as 0.25Ω per phase and its synchronous reactance as 5Ω per phase. Calculate its regulation if it delivers a full load at 0.8 lagging and 0.8 leading p.f. **(Nov 10)**

8. A 11KV, 3 phase, star connected synchronous generator delivers 4000 KVA at unity power factor when running on constant voltage constant frequency bus bars. If the excitation raised by 20%, determine the KVA and power factor at which the machine now works. The steam supply is constant and the synchronous reactance is 30! per phase. Neglect the power losses and assume the magnetic circuit to be un saturated? **(Nov 10)**

9. A straight line connects terminal voltage and load of a 3 phase star connected alternator delivering current at 0.8 p.f. lagging. At no load the terminal voltage is 3500V and at full load of 2280KW, it is 3300V. Calculate the terminal voltage when delivering current to a 3 phase star connected load having a resistance of 8Ω and a reactance of 6Ω per phase. Assume constant speed and field excitation. **(Nov 10)**

10. The O.C.C. of a 10 MVA, 6.6KV, 3 phase star connected alternator is given by the following data:

Exiciting Curent (A)	0	35.5	60	80	100	118	142
Line Volage(KV)	0	3	4.8	6.0	6.8	7.2	7.8

And the full load z.p.f. characteristic is given by:

Exciting Current(A)	40	92	128	156	170
Line Voltage(KV)	0	3	4.8	6.0	6.6

Assuming the leakage reactance to be 15% and ignoring resistance, determine the excitation required for full load, normal voltage at a p.f. of 0.8 lagging. **(Nov 10)**

11. i. Compare the results obtained for voltage regulation by emf, mmf, zpf, ASA and saturated synchronous method.
    ii. A 3 phase 17.32KVA, 400V, star connected alternator is delivering rated load at 400V and at p.f. 0.8lag. Its synchronous impedance is 0.2 + j2Ω per phase. Find the load angle at which it is operating. **(June 10)**

12. Explain the synchronous impedance method of determining the voltage regulation of an alternator? Comment on the merits and limitations of this method. Why is this method considered as pessimistic method? **(June 10)**

13. Describe the slip test method for the measurement of Xd and Xq of synchronous machine? **(June 10)**

14. A 400V, 50kVA, 50Hz, star connected alternator has the armature effective resistance of 0.1 ohm per phase. An excitation of 2.5A produces on open circuit emf of 130V (line). The same excitation produces a current of 90A on short circuit.
    Calculate:
    i. The synchronous impedance and reactance;
    ii. The full load regulation of alternator for:
    a. 0.866 lagging p.f b. unity p.f. **(Nov 09)**

15. A 30kVA, 440V, 50 Hz, star connected synchronous generator gave the following test data:

Field Current (A)	2	4	6	7	8	10	12	14
Terminal Volts	155	287	395	440	475	530	570	592
S.C. Current	11	22	34	40	46	57	69	80

Resistance between any two terminals is 0.3Ω Find regulation at full load 0.8 p.f. lagging by Rothert's ampere turn method. Taking Zs corresponding to S.C. current of 80A. **(Nov 09)**

16. A 3 phase star connected alternator is rated at 1500kVA, 12000V. The armature effective resistance and synchronous reactance are 2Ω and 35Ω respectively per phase. Calculate the % regulation for a load of 1200KW at p.f. of 0.8 lagging. **(Nov 09)**

17. i. Explain the two axis theory of a salient pole alternator.
ii. Explain the various tests conducted on an alternator to find the voltage regulation of an alternator by potier triangle method. **(Nov 09)**

18. The following table gives the OCC & SCC data of a 2-pole, 11KV, 50Hz, 3ϕ star connected alternator.
I_f(A) 16 20 25 32 45
E_{OL}(KV) 4.4 5.5 6.6 7.7 8.8
When E_{OL} is line voltage at no load, the stator resistance between two terminals is 0.2Ω. Calculate the regulation at full load current of 125A at 0.8 pf lagging by synchronous impedance method.
(Nov 09, 08, Feb 08)

19. Explain the synchronous impedance method for finding the voltage regulation of an alternator. Mention its limitations. **(Nov 09)**

20. The no-load excitation of an alternator required to give rated voltage is 160A. In a short circuit test with full current flowing in the armature, the field excitation is135A. Determine the approximate excitation that will be required to give full load current at 0.8 pf lagging at the rated terminal voltage. **(Nov 09, 07)**

21. i. Explain the potier triangle method of finding the voltage regulation of an alternator.
ii. A 1 MVA, 11KV, 3-ϕ, star connected synchronous machine has the following OCC test data
I_f(A) 50 110 140 180
E_{OL}(KV) 7 12.5 13.75 15
Where E_{OL} is line to line voltage at no load. The short circuit test yielded full load current at a field current of 65A, the armature resistance is negligible calculate the voltage regulation at full load 0.866 pf lagging by MMF method. **(Nov 09)**

22. i. Explain the Roher's AT method of finding voltage regulation.
    ii. A 1 MVA, 6.6 kV, 3-phase star connected synchronous generator has a synchronous reactance of 25 ohms per phase. It supplies full load current at 0.8 lagging pf and a rated terminal voltage. Compute the terminal voltage for the same excitation when the generator supplies full load current at 0.8 leading pf.

(May 09, Nov, Feb 08)

23. A 3-ϕ, 200 kVA, 1.1 kV, 50 Hz star connected alternator having an effective per phase resistance of 0.62Ω gave the following results:

Field Current (A)	20	35	50	80	100	120
OC Voltage VL	692.8	1120	1450	1750	1953	2180
SC Current (A)	0	22	44	66	88	110

Using MMF method, find the voltage regulation at 100 A
    i. 0.8 pf lagging
    ii. 0.8 pf leading. **(May 09, Nov 07)**

24. i. Explain the various tests to be conducted on an alternator to find the voltage regulation of an alternator.
    ii. Explain the effect of 'Saturation' on the performance of an alternator. How the effect of saturation can be overcome in calculation. **(May 09)**

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25. i. Explain the various tests conducted on an alternator to find the voltage regulation of an alternator by Potier triangle method.
    ii. The no load excitation of an alternator required to give rated voltage is 1 pu. In a short circuit test with full current flowing in the armature, the field excitation was 0.85 pu. Determine the approximate excitation that will be required to give full load current at 0.78 PF leading at the rated terminal voltage. **(Nov 08)**

26. What is the synchronous impedance method? Why the method is called so? What are the limitations of this theory? **(Nov, Feb 08)**

27. i. Explain the 'Zero power factor' method of finding voltage regulation of an alternator.
    ii. The no load excitation of an alternator required to give rated voltage is 1 pu. In a short circuit test with full current flowing in the armature, the field excitation was 0.75 pu. Determine the approximate excitation that will be required to give full load current at 0.866 PF lagging at the rated terminal voltage. **(Nov 08)**

28. i. How the MMF method is different from EMF method in finding voltage regulation of an alternator? Explain the drawbacks of each method.
    ii. A 1 MVA, 11 kV, 3-phase, star connected synchronous machine has following OCC test data:

I_f	50	110	140	180
E_{OL}-kV	7	12.5	13.75	15

(where EOL is the line voltage at no load)
The short circuit test yielded full load current at a field current of 60 A. The ZPF yielded a full load current at terminal voltage for a field current of 150 A. The armature resistance is negligible. Calculate the voltage regulation at full load 0.866 pf lagging by Potier triangle method. **(Feb 08)**

29. A 3-phase, 440 V, 50 Hz, delta connected alternator has direct axis & quadrature axis reactance of 0.12 ohms and 0.09 ohms respectively. If the alternator supplies 900 A at 0.8pf lagging, calculate the following:
    i. the excitation EMF, neglecting saliency (Xd = Xq)
    ii. the excitation EMF, taking into account the saliency.

Neglect armature resistance. **(Feb 08)**

30\. i. Explain the voltage regulation method of an alternator by which the armature reaction & leakage reactance can be separated.

ii. A 3-phase, star connected salient pole synchronous generator is driven at a speed near synchronous with the field circuit open and the stator is supplied from a balanced 3-phase supply. Voltmeter connected across the line gave minimum and maximum readings of 1196 V & 1217 Volts. The line current fluctuated between 120 & 225 Amp. Find the direct and quadrature axis reactances per phase. Neglect armature resistances. **(Nov 07)**

31\. With proper explanation & diagram, Justify the statement 'MMF method for finding voltage regulation is optimistic and EMF method for finding voltage regulation is pessimistic'. **(Nov 07)**

32\. i. Derive an expression for finding regulation of salient - pole alternator using two reaction theory . Draw its Phasor diagram. **(Feb 07, Nov 06)**

ii. A generator rated at 25 MVA, 0.8 pf lag, 13.8 kV, 3- phase is operating at normal terminal voltage and rated load . The direct axis synchronous reactance is 7.62, Quadrature axis synchronous reactance is 4.57 and the armature resistance is 0.15/ph. Determine the direct axis and quadrature axis components of armature current and internal induced voltage. Also find the regulation. **(Feb 07)**

33. i. Explain why synchronous-impedance method of computing the voltage regulation leads to a pessimistic value at lagging power factor loads.

ii. The open and short - circuit test readings for

Field Amps:	10	20	25	30	40	50
O.C.Terminal V	800	1500	1760	2000	2350	2600
S.C.armature current in A:	-	200	250	300	-	-

The armature effective resistance is 0.2 per phase. Draw the characteristic curves and estimate the full-load percentage regulation at

a. 0.8 p.f.lagging b. 0.8 p.f. leading. **(Feb 07, Nov 06)**

34. i. Explain the two reaction theory applicable to salient pole synchronous Machine.

ii. A 4500 KVA,50 Hz,3-phase,synchronous generator having a synchronous reactance of 0.3 p.u. is running at 1500 r.p.m and is excited to give 11000 V.If the rotor deviates slightly from its equilibrium position, what is the synchronizing torque in N-m per degree mechanical displacement. **(Feb 07)**

35. i. Explain the terms direct axis synchrnous reactance and quadrature axis synchronous reactance of a salient pole alternator. On what factors do these values depend?

ii. A 3 MVA, 6 ple alternator runs at 1000 rpm in parallel with other machines on 3.3 KV bus bars. The synchrnous reactance is 20%. Calculate the synchronizing power per one mechanical degree of displacement and the corresponding synchrnonizing torque when the alternator as supplying full load at 0.8 lag p.f. **(Feb 07, Mar 06, 05)**

36. i. What is voltage regulation? Discuss the synchronous impedance method of calculating voltage regulation.

ii. A 500V, 50KVA, 1-phase alternator has an effective resistance of 0.2Ω, field current of 10A produces an armature current of 200A on short circuit and an emf of 450V on open circuit. Calculate

a. Synchronous impedance and reactance b. Full-load regulation with 0.8p.f. lagging.

(Feb 07, Nov 06, 05, May 05)

37. i. Explain the potier - triangle method of determining the voltage regulation of an alternator.

ii. A 3-phase star-connected alternator is rated at 1600KVA and 13,5000V. The armature effect resistance and synchronous reactance per phase are 1.5Ω and 30Ω respectively. Calculate the percentage regulation for a load of 1280KW at p.f of

a. 0.8 lagging b. unity c. 0.8 lead **(Feb, Nov 07, Nov 05)**

38. i. What happens to the value of synchronous reactance if air gap is increased.

ii. A 30KVA, 440V, 50Hz, 3-Phase, Star-connected alternator gave the following test data:

Field Current (A)	2	4	6	7	8	10	12	14
Terminal Voltage (V)	155	287	395	440	475	530	570	592
S.C. Current (A)	11	22	34	40	46	57	69	80

Resistance between any two terminals is 0.3 Ohms. Find the regulation at full load, 0.8 p.f. lagging, by MMF method **(Feb 07, Nov 03)**

39. Explain how the Potier triangle can be drawn with the help of O.C.C and any two points on the Z.P.f curve and also explain the Potier reactance method of determining regulation of an alternator. **(Nov 06)**

40. A 2000 KVA, 11KV, 3-phase, star connected alternator has a resistance of 0.3 ohm and reactance of 5 ohm per phase It delivers full-load current at 0.8 lagging p.f at rated voltage. Compute the terminal voltage for the same excitation and load current at 0.8 p.f leading. **(Nov 06)**

41. i. What is an infinite bus? State the characteristics of an infinite bus. What are the operating characteristics of an alternator connected to an infinite bus?

    ii. A 3 MVA,6-pole alternator runs at 1000 r.p.m in parallel with other machines on 3.3 KV bus-bars. The synchronous reactance is 20%.Calculate the synchronizing power per one mechanical degree of displacement and the corresponding synchronizing torque . **(Nov 06)**

42. i. Decribe the slip test method for the measurement of X_d to X_q of synchronous machines.

    ii. A 3.5 MVA, slow-speed, 3-phase synchrnous generator rated at 6.6 KV has 32 poles its direct and quadrature axis synchronous reactances as measured by the slip test atre 9.6 ohm and 6 ohm respectively. Neglecting armature, determine the regulation and the excitation emf needed to maintain 6.6 KV at the terminals when supplying a load of 2.5 MW at 0.8 pf lagging. What maximum power can the generator supply at the rated terminal voltage, if the field becomes open-circuited? **(Nov, Mar 06, May, Nov 05)**

43. i. Develop the expression for finding regulation of salient pole alternator using two-reaction theory. Draw its phasor diagram.

    ii. A 3-phase, star-connected, 50 Hz synchronous generator has direct-axis synchronous reactance of 0.6 pu. and quadrature axis synchronous reactance of 0.45 p.u. The generation delivers rated KVA at rated voltage. Drw the phasor diagram at full-load 0.8 p.f. Lagging and hence calculate the open circuit volage and voltage regulation. Resistive drop at full-load is 0.015 p.u. **(Nov, Mar 06)**

44. Explain the factors responsible for making terminal voltage of an alternator less than the induced voltage. **(Mar 06)**

45. i. Explain the MMF method of determining the voltage regulation of alternator.

    ii. A 1000KVA, 11000V 3-phase, 50 Hz, star-connected turbo-generator has an effective resistance of 2ohm/ phase. The O.C.C. and zero p.f. full load data is as follows:

O.C. Voltage (V)	5805	7000	12550	13755	15000
Field current (A)	40	50	110	140	180
T V at F.L. Zero p.f	0	1500	8500	10500	12400

Estimate the % regulation for F.L. at 0.8 p.f lagging. **(Mar 06)**

46. Sketch and explain the open-circuit and short circuit characteristics of a synchronous machine. How voltage regulation can be calculated by the use of their results. **(Mar 06, Nov 04, 02)**

47. A 3-phase star connected alternator is rated at 1600KVA, 13,500 V. The armature effective resistance and synchronous reactance are 1.5 ohm and 30 ohm respectively per phase. Calculate the percentage regulation for a load of 1280 KW at power factors of
    a. 0.8 leading and
    b. 0.8 lagging. **(Mar 06)**

48. Draw the phasor diagram of an alternator corresponding to zero full load regulation. **(Mar 06, Nov 03)**

49. i. Explain how regulation is determined from slip test.

    ii. A 3-phase salient pole synchronous generator has X_d=0.8 p.u; X_q = 0.5 p.u and R_a=0 generator supplies full-load at 0.8 p.f. Lagging at rated terminal voltage. Computer
    a. Power angle and
    b. No-load voltage if excitation remains constant. **(Nov 05)**

50. i. Discuss about two reaction theory with relevant phasor diagram.

ii. A 4 pole, 50 Hz, 22 KV, 500 MVa synchronous generator having a synchronous reactance of 1.57 pu is feeding into a power system, which can be represented by a 22 KV infinite bus in series with a reactance of 0.4Ω. The generator excitation is continually adjusted (by means of an automatic voltage regulator) so as to maintain a terminal voltage of 22 KV independent of the load on the generator.

a. Draw the phasor diagram, when the generator is feeding 250 MVA into the power system. Calculate the generator current, its power factor and real power fed by it. What is the excitation emf of the generator. **(Nov 05)**

51. Define and explain the terms synchronous impedance and voltage regulation of an alternator. State the assumptions made in the synchronous impedance method. **(Nov 05)**

52. A 3-phase, 50 Hz, star-connected, 2000KVA, 23000V alternator gives a short circuit current of 600A for a certain field excitation. With the same excitation, the O.C. Voltage was 900 V. The resistance between a pair of terminal was 0.12Ω. Find full-load regulation at

a. u.p.f

b. 0.8 p.f lagging

c. 0.8 p.f leading. **(Nov 05, Nov 04, 02)**

53. i. Develop the expression for finding voltage regulation of salient-pole alternator.

ii. The no-load and full-load zero power factor characteristics for a 23.5MVA, 13.8 KV, 3-phase, star-connected turbo-generator are given below in per unit values: No-load characterstics

No-load characterstics

I_f	0.10	0.20	0.40	0.60	0.80	1.0	1.2	1.4	1.6	2.0	2.5
V	0.13	0.23	0.45	0.69	0.87	1.0	1.09	1.15	1.21	1.28	1.36

Zero power factor characterstics

I_f	1.2	1.3	1.4	1.6	1.8	2.0	2.2	2.4	2.6
V	0.015	0.13	0.25	0.49	0.69	0.83	0.92	0.99	1.04

Determine the regulation at full-load, 0.8 p.f lag by the zero p.f method. Neglect armature resistance. **(Nov 05)**

54. i. Define voltage regulation of an alternator. Explain the various factors, which may affect the regulation of an alternator.

ii. A 100-KVA, 3000V, 50Hz, 3-phase, star –connected alternator has effective armature resistance of 0.2Ω. The field current of 40A produces short-circuit current of 200A and an open-circuit emf of 1040V(line value). Calculate the full-load voltage regulation at 0.8 p.f.lagging and 0.8 p.f.leading. Draw phasor diagrams. **(Nov 04, 03, 02)**

55. i. Explain the method of determining the voltage regulation of an alternator by ASA method.

ii. An alternator has a synchronous reactance of 20% and negligible resistance calculate its voltage regulation when working at full load.

a. 0.8 P.f Lag b. Unity P.f and c. 0.8 P.f. Lead **(Nov 04, 03)**

56. i. Explain the two reaction theory applicable to salient pole synchronous Machine.

ii. A 6.6 kV, 1MVA, 3ø alternator is delivering full load at 0.8 p.f. lagging. Its reactance is 20% and resistance is negligible. By changing the excitation, the e.m.f. is increased by 25% at this load. Calculate the new current and the power factor. The machine is connected to infinite bus-bars. **(Nov 04)**

57. i. Describe synchronous impedance method to determine regulation of an alternator for Lagging power factor.

ii. A 600V, 60KVA, Single-phase alternator has an effective resistance of 0.2 Ohms. A field current of 10A produces an armature current of 210A on short circuit and an e.m.f. of 480V on open circuit calcute.

a. Synchronous impedance and reactance.

b. Regulation with 0.8 P.f Lagging and unity P.f. leading **(Nov 04, 03, 02)**

58. What are the precautions to be taken while conducting Slip test? Draw the Phasor diagram when the load connected is of Leading p.f. **(May 04)**

59. The following data was obtained for the OCC of a 10MVA, 13KV, 3 Phase, 50 hz, Star connected synchronous generator.

I_F(A)	50	75	100	125	10	162.5	200	250	300
V_{OC}(Line)(KV)	6.2	8.7	10.5	11.8	12.8	13.2	14.2	15.2	15.9

An excitation of 100A causes the full load current to flow during the short circuit test. The excitation required giving the rated current at zero p.f. and rated voltage is 290A.

i. Calculate the synchronous reactance of the machine.
ii. Calculate the leakage reactance of the machine assuming the resistance to be negligible.
iii. Determine the excitation required when the machine supplies full load at 0.8 P.f Lagging by using the leakage reactance and drawing the MMF Phasor diagram. What is the voltage regulation of the machine? **(Nov 03)**

60. A 1000 KVA, 11000V, 3 Phase star connected alternator has an effective resistance of 2 Ohms/Phase. The characteristics on Open – circuits and with full load current at zero P.f. and the open circuit core losses are:

Field Current (A)	40	50	110	140	180
OC teminal Voltage (V)	—	7000	12500	13750	15000
Core loss (KW)	—	7.5	16.6	22.4	33.5
Saturation curve zero P.f (V)	0	—	8500	10500	12400

Deduce by the Z.P.f method.

i. The percentage regulation for full load at a Lagging 0.8 P.f. Find also.
ii. The efficiency at this load, given that the field current has resistance of 0.5 Ohms and that the mechanical and additional losses amount to 10 KW. **(Nov 03, 02)**

61. A 600KVA, 3300V, 8 pole, 3 Phase, 50 Hz alternator has the following characteristics.

Amp-turns/pole	4000	5000	7000	10000
Terminal EMF	2850	3400	3850	4000

There are 200 conductors in series per phase. Find the SC characteristics, the field ampere-turns for full load 0.8 P.f (lagging) and the voltage regulation, having given that the inductive drop at full load is 7% and that the equivalent armature reaction in amp-turns per pole= 1.06 X ampere conductor per phase per pole. **(Nov 03)**

62. Explain the Phasor diagram of salient pole synchronous machine

i. At Lagging P.f.
ii. At Leading P.f. **(Nov 03)**

63. i. Explain the A.S.A. method of predetermining the regulation of an alternator.
Note: You need not explain how to conduct the tests necessary for this method but take the test results.

ii. The open and short circuit test date on a 3 phase, 1 MVA, 3.6 KV, star connected synchronous generator is given below:

Field Current (Amps)	60	70	80	90	100	110
Voc (line) volts	2560	3000	3360	3600	3800	3960
S.C. Test (Amp.)	180	-	-	-	-	-

Find the unsaturated synchronous reactance, the adjusted synchronous reactance and the short circuit ratio. **(Nov 03)**

64. Explain Potier triangle method of finding regulation of an alternator. **(Nov 02)**

65. Develop phasor diagram for a salient pole alternator supplying a leading pf load and explain 2 reaction theory. **(Nov 02)**

66. A 10 KVA, 380 V, 4 pole, 50 HZ star connected salient pole alternator has direct axis and quadrature axis reactances of 12W and 8W respectively. The armature has a resistance of 1W per phase. The generator delivers rated load at 0.8 Pf lagging with terminated voltage being maintained at rated value. If the load angle is 16.15 degrees determine
   i. Direct and quadrature axis components of armature current
   ii. Excitation voltage of generator. **(GATE 93)**

67. A 10 KVA, 380 V, 4 pole, 50 HZ star connected cylindrical rotor alternator has a stator resistance and synchronous reactance of 1W and 15W respectively. It supplies a load of 8 KW at rated voltage and 0.8 power factor lagging.
   i. Draw a Phasor diagram
   ii. Express resistance and synchronous reactance in per unit values with the machine rating as base.
   iii. Calculate percentage regulation
   iv. What is terminal voltage if the load is suddenly removed. **(GATE 91)**

68. In which one of the following is reluctance power developed ?
   i. Salient pole alternator
   ii. Non-salient pole alternator
   iii. Squirrel cage induction motor
   iv. Transformer **(IES 06)**

69. Find the synchronous impedance and reactance of a single phase alternator in which a given field current produces an armature current of 250A, on short circuit and a generated emf of 1500V on open circuit. The armature resistance is 2 ohms. Calculate potential difference when the load of 250A at 6.6 Kv at a lagging p.f of 0.8 is switched off. **(IES 03)**

70. A 2000 KVA, 11 KV, 3 phase, Y connected alternator has a resistance of 0.3 Ω and reactance of 5 Ω per phase. It delivers full load current at a p.f of 0.8 lagging and normal rated voltage. Compute the terminal voltage for the same excitation and load current at a 0.8 pf leading. **(IES 00)**

71. i. A 10KVA, 440 V, 50 Hz three phase alternator has the following occ: **(IES 99)**

Field current	Terminal voltage
1	100
3	300
5	440
8	550
11	600
15	635

With full load zero power factor load applied an excitation of 14A produced a critical voltage of 500V. On short circuit, 4 A excitation was required to circulate the full load current. Using MMF method determine the full load percentage regulation for p.f. lagging and 0.6 pf leading

   ii. Explain how to determine the direct and quadrature axis reactances of a salient pole synchronous machine

72. A 3.5 MVA, slow speed, 3 phase synchronous generator rated at 6.6 KV has 32 poles. Its direct and quadrature axis synchronous reactances as measured by the slip test are 9.6 and 6.2 respectively. Neglecting regulation and the excitation emf needed to maintain power. Can the generator supply at the rated terminal voltage, if the field becomes open-circuited **(IES 94)**

73. i. A 10 KVA, 440 V, 50 Hz, 3 phase alternator has the following O.C.C

Field current (amp)	1.5	3.0	5.0	8.0	11.0	15.0
Terminal voltage (volts)	150	300	440	550	600	635

With full load zero p.f load applied; an excitation of 14A produced a terminal voltage of 500V on the short circuit, 4A excitation was required to circulate full load current. Using MMF method determine the full load percentage regulation for 0.8 pf lagging and 0.8 pf leading

ii. When three phase supply is given to a three phase winding, a rotating magnetic field of constant amplitude will be produced. Justify the above statement. **(IES 93)**

74. A 3 ph star connected synchronous generator is rated at 1.5 MVA, 11 KV. The armature effective resistance and synchronous reactance are 1.2Ω and 25Ω respectively per phase. Calculate the percentage voltage regulation for a load of 1.4375 MVA.

i. 0.8 pf lagging
ii. 0.8 pf leading.

Also find out the pf at which the regulation becomes zero **(IES 92)**

75. In an alternator, a lagging current weakens the main field but in a synchronous motor it strengthens the main field. Explain why?

(IES 92)

76.a) Discuss the Potier method of predetermining the regulation of an alternator.

b) 3 phase star connected alternator is rated at 1800 KVA, 11 KV. The armature effective resistance and synchronous reactance are 1.4 Ω and 28 Ω respectively per phase. Calculate the percentage regulation for a load of 1250 KW at p.f. 0.8 lag. [8+8]

77.a) Explain the Z.P.F method for finding the regulation of an alternator.

b) In a single phase alternator, a voltage of 50 V is generated in O.C test and current of 200A is flowing in S.C test at same field current and the armature resistance is 0.1 ohm. Calculate the synchronous reactance and impedance, generated voltage and voltage regulation when it supplies a current of 100 A at 200 V, 0.8 p.f. lagging. [8+8]

UNIT-III

1. What are the effects of hunting on the performance of synchronous motor and explain the method of suppressing the hunting. **(May 11)**

2. i. State the conditions necessary for paralleling alternators?

ii. A 500 MVA, 3 phase, 6 pole, and 11 KV star connected alternator is running in parallel with other synchronous machine on 11000 V bus. The synchronous reactance of the machine is 5 Ω per phase. Calculate the synchronizing power per mechanical degree at full load and 0.8 p.f. lagging. **(May 11)**

3. What do you mean by synchronizing alternators? Describe any one method of synchronizing? **(May 11, 10)**

4. i. Derive an expression for the reactive power output from the terminals of a cylindrical rotor alternator.

ii. A 3 phase, 20MVA, 11KV, star connected alternator has Zs = 1 + j8 Ω per phase. Determine the max. reactive power that can be delivered by this alternator for an excitation voltage of 14KV. **(Nov 10)**

5. Describe a method of synchronizing 3 phase synchronous machine to the infinite bus bars using two bright one dark lamp method with relevant circuit diagram. **(Nov 10)**

6. Two exactly similar 3000 KVA synchronous generators operate in parallel. The governor of the first machine is such that the frequency drops uniformly from 50 Hz on load to 48 Hz on full load. The corresponding uniform speed drop of second machine is from 50 Hz to 47.5 Hz.

i. How will the two machines share a load of 5000 KW?

ii. What is the max. load at u.p.f. that can be delivered without overloading either machine? **(Nov 10)**

7. Explain why prime movers driving alternators operating in parallel should have drooping speed load characteristics? **(June 10)**

8. Describe briefly the effect of varying excitation upon armature current and power factor of synchronous motor when input power to the motor is maintained constant. **(June 10)**

9. A synchronous generator is connected to an infinite bus. Discuss with the help of phasor diagrams

i. Effect of changing excitation at constant mechanical input

ii. Effect of changing the input at constant excitation. **(June 10)**

10. Describe the method of synchronizing the 3 phase alternator to the infinite bus giving the relevant circuit diagram. **(June 10)**

11. Explain the following:

i. Why bright lamp of synchronizing is preferred over dark lamp method.

ii. How do synchronizing lamps indicate the phase variation of the incoming machine and running machine. **(Nov 09)**

12. Two exactly similar 3000 KVA synchronous generators operate in parallel. The governor of the first machine is such that the frequency drops uniformly from 50 Hz on load to 48 Hz on full load. The corresponding uniform speed drop of second machine is from 50 Hz to 47.5 Hz.

i. How will the two machines share a load of 5000 KW?

ii. What is the max. load at u.p.f. that can be delivered without overloading either machine? **(Nov 09)**

13. Two 15 KVA, 400V, 3 phase alternators in parallel supply a total load of 25KVA at 0.8 p.f. lagging. If one alternator shares half the power at u.p.f. determine the p.f. and KVA shared by the other alternator. **(Nov 09, 05, 04)**

14. Show that an alternator running in parallel on constant voltage and frequency bus bars has a natural time period of oscillation. Deduce a formula for the time of one complete oscillation and calculate its value for a 5000 KVA, 3 phase, and 10000V machine running at 1500 rpm on constant 50 Hz bus bars. The moment of inertia if the whole moving system is 14,112 Kg-m^2 and the steady S.C. current is five times the normal full load value. **(Nov 09, May 04)**

15. i. Explain the operation of an alternator on infinite busbars with varying steam supply?

ii. Two alternators are working in parallel supplying a lighting load of 300KW and a motor load of 5MW at 0.866 pf lagging. One machine is loaded up to 5MW, at 0.9 pf lagging. What is the load and power factor of other machine? **(Nov 09)**

16. i. Why parallel operation of alternators is necessary? What are the advantages of connecting alternators in parallel? Mention all necessary conditions for successful parallel operation of alternators.

ii. A 25MVA, 6.6KV, 50Hz, 4 pole alternator has pu, armature resistance of 0.004 and synchronous reactance of 0.67pu, when the machine is supplying rated current at rated voltage, the induced EMF is 1.5pu. Find the torque angle and load power factor. **(Nov 09)**

17. Explain, how alternators working in parallel share a load if their electrical speeds are not same. **(Nov 09)**

18. A 5MVA, 10KV, 1500rpm,3-ϕ, 50Hz alternator is operating on infinite bus bar. Find synchronizing power per mechanical degree of angular displacement at

i. No-load

ii. Full-load at rated voltage and 0.8pf lagging. **(Nov 09, Feb 08)**

19. Explain the effect of change in excitation on the parallel operation of two alternators. **(Nov 09, 08)**

20. Two identical 3MVA alternators are running in parallel. The frequency drops from no load to full load for the two alternators are 50Hz to 47 Hz and 50Hz to 48Hz respectively.
   i. How will they share a load of 4000KW?
   ii. What is maximum load they can share at unity power factor without overloading any alternator?

(Nov 09)

Aptitude found in the understanding and is often inherited. Genius coming from reason and imagination, rarely.

- Samuel Taylor Coleridge

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21. i. A 2 MVA, 8 pole, 3-ϕ, alternator is connected to 6000 V, 50 Hz bus bars & has a synchronous reactance of 4 Ω/ph. Calculate the synchronizing power & synchronizing torque per mechanical degree of rotor displacement at no load. Assume normal excitation.
    ii. Explain the effect of damper winding & field winding on the transient behavior of an alternator. How the effect of these two can be minimised? **(May 09)**

22. i. Explain the various methods of synchronization of alternators.
    ii. Two similar 4 MVA alternators operate in parallel. The governor of first machine is such that frequency drops from 50 Hz at no load to 47.5 Hz at full load. The corresponding drop for second machine is 50 Hz to 48 Hz.
    a. How will they share a load of 6 MW?
    b. What is the maximum load they can share at UPF without over loading any generator?**(May 09, Nov 08)**

23. i. Why parallel operation of alternators is necessary? What are the advantages of connecting alternators in parallel?
    ii. A 5 MVA, 10kV, 1500 RPM, 3-ϕ, 50 Hz alternator is opening on infinite bus bar. Find synchronizing power per mechanical degree of angular displacement at:
    a. No load
    b. Full load at rated voltage & 0.8 power factor lagging. Also find synchronizing torque for a 0.5^0 mechanical displacement in each case. x_s=20%. **(May 09)**

24. i. Explain all the necessary conditions for successful parallel operation of alternators.
    ii. A 2 MVA, 3-ϕ, star connected, 4 pole, 750 RPM alternator is operating on 6000 V bus bars, Xs is 6Ω/ph. Find synchronizing power and torque for full load 0.8 power factor lagging. **(May 09, Nov 07)**

25. i. Explain the operational differences in parallel operation of two alternators & synchroning an alternator to infinite bus bars.
    ii. Two star connected alternators supply a load of 3 MW at 0.8 pf lagging and share the load equally. The excitation of second machine is adjusted so that it is supplying 150 A at a lagging pf. The synchronous impedances are 0.4 + j12 Ω/ph& 0.5 + j10 Ω/ph. Find current, power factor, induced EMF and load angle of each machine. Terminal voltage is 6.6 kV. **(Nov 08)**

26. i. Explain the term synchronization, and hence explain, synchronizing power.
    ii. Two identical 3 MVA alternators are running in parallel. The frequency drops from no load to full load for the two alternators are 50 Hz to 47 Hz and 50 Hz to 48 Hz respectively.
    a. How they will share a load of 4000 kW?
    b. What is maximum unity factor load which they can supply jointly supply without any one of them over loaded? **(Nov 08)**

27. Two similar stat connected alternators 3-phase alternators share a load of 7500 kW equally at 6000 V and 0.8 pf lagging. The synchronous impedance of 2.5 + j50 Ω/ph. The excitation of second machine is changed, so that it delivers 40 A at a lagging pf. Find:
    i. Armature current of first machine
    ii. EMF of each machine
    iii. Power factor of each machine. **(Nov 08)**

28. A 2 pole, 50 Hz, 3-phase turbo alternator is excited to generate a bus-bar voltage of 11 kV on no load. The machine is star connected and the short circuit current for this excitation is 1000 A. Calculate the synchronizing power per degree of mechanical displacement of the rotor and the corresponding synchronizing torque. **(Nov 08)**

29. i. Explain the 'two bright one dark' & 'all dark' method of synchronization of alternators.
    ii. The EMFs of two alternators are $3000 \angle 20^0$ & $2900 \angle 0^0$ V. Their synchronous impedances are 2 + j20 Ω/ph & 2.5 + j30 Ω/ph. The load impedance is 10 +j4 Ω/ph. Find the circulating current. **(Feb 08, Nov 07)**

30. i. Explain, why synchronous motor is not self starting?
    ii. A 3-ϕ, 600 V, star connected SM has effective per phase armature resistance & synchronous reactance of 0.4 Ω & 3.6 Ω respectively. Calculate the induced EMF per phase if the motor works on full load delivering 326 kW. The full load efficiency is 87 % having power factor of 0.8 leading. Also calculate the load angle. **(Feb 08, Nov 07)**

31. i. State and explain the different conditions for operating alternators in parallel.
    ii. Two three - phase alternators operate in parallel. The rating of one machine is 200 MW and that of the other is 400 MW.The droop characteristics of their governors are 4% and 5% respectively from no - load to full load of 600 MW be shared between them? What will be the system frequency at this load ? Repeat the problem if both governors have a drop of 4%. **(Feb 07)**

32. i. Explain the necessity of parallel operation of alternators.
    ii. Two 50MVA, 3-phase alternators operate in parallel. The settings of the governors are such that the rise in speed from full-load to no-load in 2% in one machine and 3% in the other, the characteristics being straight lines in both cases. If each machine is fully loaded when the total load is 100MW,what will be the load on each machine when the total load reduced 60MW? **(Feb 07, Mar 06, May 05, Nov 05)**

33. A 3 MVA , 6- Pole alternator runs at 1000 rpm in parallel with other machines on 3.3KV bus bars .The synchronous reactance is 20%. Calculate the synchronizing power per one mechanical degree of displacement and the corresponding synchronizing torque when the alternator as supplying full load at 0.8 lag p.f. **(Feb 07, Nov 06, 05, 04, May 05)**

34. i. Discuss load sharing between two alternators.
    ii. Two 750 KW alternators operate in parallel. The speed regulation of one set is 100% to 102% from full load to no load and that of the other is 100% to 104%. How will the two alternators share a load of `1000KW and at what load will one machine cease to supply any portion of the load. **(Feb 07, Nov 04)**

35. A 6000 KVA, 5000V, 50 Hz, 3 phase alternator with 4 poles and a synchronous reactance of 25% operates an constant voltage and constant frequency bus bars. The moment of inertia of the whole rotating system is 16800 kg-m^2. Calculate the time of one complete oscillation for full load and unity power **(Feb 07, May 04)**

36. What conditions must be fulfilled before an alternator can be connected to an infinite bus? **(Nov 06)**

37. i. Explain the procedure how to bring the incoming machine to operate in parallel with running machines.
    ii. Two alternators working in parallel supply a lighting load of 300kW and a motor load aggregating to 5000kW at a p.f. of 0.71. One machine is loaded to 5000kw at 0.8 p.f. Lagging. What is the load and power factor of the other machine. **(Nov 06)**

38. Describe the effect of sudden short circuit on the performance of synchronous generator. **(Nov 06)**

39. i. Prove that sharing of common load by the alternators in parallel depends upon input to the prime movers.
    ii. Two identical 2000 KVA alternators operate in parallel. The governor of first machine is such that the frequency drops uniformly from 50 HZ on no load to 48 Hz on full load. The ocrresponding unfirom speed drop of the second machine is 50 Hz to 47.5 Hz.
    a. how will the two machines share a load of 3000 kW?
    b. What is the maximum load at unity power factor that can be delivered without over loading either machine? **(Nov 06, Mar 06, May 05)**

Man cannot live by incompetence alone.

- Laurence J. Peter

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40. Show that in order to obtain a constant - voltage constant frequency of practical bus bar systems the number of alternators connected in parallel should be as large as possible. **(Nov 06)**

41. What is an infinite bus? State the characteristics of an infinite bus. What are the operating characteristics of an alternator connected to an infinite bus? **(Nov 06, 05, 04)**

42. Derive the expression for load sharing between the dissimilar alternators. **(Nov 06, May 05)**

43. i. Derive the expressions for load sharing between the dissimilar alternators.
ii. Calculate the synchronizing torque for unit mechanical angle of phase displacement for a 5000KVA, 3-phase alternator running at 1500 rpm when connected to 6600 volt. 50 Hz , bus-bars. The armature has a short circuit reactance of 15%. **(Nov 06, 05)**

44. Two similar 6000V, 3-ϕ generators are running in parallel at constant voltage and frequency bus bars. Each has an equivalent resistance and reactance of 0.05Ω and 0.5Ω respectively and supplies one half of a total load of 10000KW at a lagging power factor of 0.8, the two machines being similarly excited, If the excitation of one machine is adjusted until the armature current is 438 A and the steam supply to the turbine remains unchanged, find the armature current, the emf and the power factor of the other alternator. **(Nov 06, May 04)**

45. Two single phase alternators are connected in parallel and the excitation of each machine is such as to generate an open circuit emf of 3500V. The stator winding of each machine has a synchronous reactance of 30 Ohms and negligible resistance. If there is a phase displacement of 40 electrical degrees between the emf's. Calculate.
i. The current circulating between the two machines.
ii. The terminal voltage and
iii. The power supplied from one machine to the other. **(Nov 06, 03)**

46. i. Decribe any two methods for synchronizing alternators?
ii. A 3-hase, Y-Connected synchrnous generator supplies current of 10A having phase angle of 20^0 lagging at 400V. Find the load angle and the components of armature current I_d and I_q if X_d=10 ohm and X_q=6.5 ohm. Assume armature resistance to be negligible. **(Mar 06)**

47. i. Explain the procedure to determine the following
a. Sub transient reactance b. Transient reactance c. Steady state reactance
ii. The speed regulation of two 500 KW alternators A and B running in parallel are 100% to 104% and 100% to 105% from full load to no load respectively. How will the two alternators share a load of 800KW and also find the load at which one machine ceases to supply any portion of the load? **(Mar 06, May, Nov 05)**

48. Show that for alternators running in parallel, the division of load between them is governed mainly by the speed load characteristics of their prime movers. **(Nov 05, 04)**

49. i. Derive the expression for load sharing between the dissimilar alternators.
ii. Two similar 13,000 V, 3-phase alternators are operated in parallel on infinite bus-bars. Each machine has an effective resistance and reactance of 0.05 ohm and 0.5 ohm respectively. When equally excited, they share equally a total load of 18 MW at 0.8 power factor lagging. If the excitation of one generator is adjusted until the armature current is 400A. And the steam supply to its turbine remains unaltered, find the armature current, the emf and the power factor of the other generator. **(May 05)**

50. A 5000kVA, 10 KV, 1500 rpm, 50 Hz alternator runs in parallel with other machines. Its synchronous reactance is 20%. Find the synchronizing power per unit mechanical angle of the phase displacement for
a. No load and b. Full load at 0.8 p.f (lag)
Also calculate the synchronizing orque if the mechanical displacement is 0.5^0. **(May 05, Nov 04, 03)**

The boy was as useless as rubber lips on a woodpecker.
- Earl Pitts

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51. i. Show that the behavior of a synchronous machine of infinite bus is quite different from its isolated operation.
    ii. Two single phase alternators operate in parallel and supply a load impedance of (3+j4)Ω. If the impedance of the machine is (0.2+j2)Ω and emfs are (220+j0) and (220+j0) volts respectively, determine for each machine. a.Terminal voltage b. power factor and c. output. **(Nov 04)**

52. A 3-phase, star –connected,50-Hz synchronous generator has direct-axis synchronous reactance of 0.6 p.u. and quadrature-axis synchronous reactance of 0.45 p.u. The generator delivers rated KVA at rated voltage. Draw the phasor diagram at full –load 0.8 p.f. Lagging and hence calculate the open –circuit voltage and voltage regulation. Resistive drop at full-load is 0.015 p.u. **(Nov 04)**

53. Two exactly similar turbo – alternators are rated 20 MW each. They are running in parallel. The speed – load characteristics of the driving turbines are such that the frequency of alternator 1 drop uniformly from 50 Hz on no-load to 48 Hz on full – load, and that of alternator 2 from 50 Hz to 48.5Hz. How will the two machines share a load of 30MW? **(Nov 04)**

54. Explain different synchronization methods used for synchronizing alternators. **(Nov 04)**

55. Define the significance of transient and sub transient reactances in an alternator. **(Nov 04)**

56. How do you calculate the time constant in case of an alternator. **(May 04)**

57. Two identical 2 MVA alternators operate in Parallel. The governor of the first machine is such that frequency drops uniformly from 50 Hz on no load to 48 Hz on full load. The corresponding uniform speed drop of the second machine is 50 Hz to 47.5 Hz.
    i. How will the two machines share a load ot 3 MW
    ii. What is the maximum load at UPF that can be delivered without overloading either machine. **(Nov 03)**

58. In brief explain the operation of a 3 phase cylindrical rotor alternator under constant load with variable excitation. Draw the phastor diagram. **(Nov 02)**

59. i. What are the conditions for parallel operation of alternators?
    ii. A 3 MVA 6 pole alternator runs at 1000 rpm in parallel with other machines on 3300V bus bars. The synchronous reactance is 25%. Calculate the synchronizing power per one mechanical degree displacement and the corresponding synchronous torque. **(Nov 02)**

60. Derive the power angle characteristic of synchronous generator when it is connected to infinite bus bars. **(Nov 02)**

61. Define synchronizing power coefficient and synchronizing power. When does it come into action? How is it related to the stability limit of a synchronous machine? **(Nov 02)**

62. i. From the equivalent circuit of an alternator determine the expression for input power and output power.
    ii. A 3 phase Y connected alternator is operated at a constant voltage of 6.63 KV and its excitation voltage is adjusted to 6.4 KV. Find the maximum output power and pf at this power assuming Z_s = 1 + 10j ohm per phase. **(Nov 02)**

63. A star connected alternator is synchronized with an infinite bus of 11 KV, its steam input is then increased till its output power is 15 MW. Now when its excitation emf is increased to 130%. The synchronous machine starts operating at a pf of 0.8 lagging. Compute synchronous reactance of the machine. Neglect armature resistance. Determine the power factor, load angle and armature current of the machine before the excitation emf increased. **(Nov 02)**

64. Explain how an alternator is synchronized to the bus bars. **(Nov 02)**

65. Two identical synchronous generators, each of 100 MVA, are working in parallel supplying 100 MVA at 0.8 p.f at rated voltage. Initially the machines are sharing load equally. If the field current of first generator is reduced by 5% and of the second generator increased by 5%, find the sharing of load (MW and MVAR) between the generators. Assume $X_d=X_q=0.8$ p.u., no field saturation and rated voltage across load. Reasonable approximations may be made. **(GATE 01, 00)**

66. A 5 MVA, 11 kV, 3-phase star connected alternator is synchrnonized to the bus bars and is operating with an nduced EMF of 125% of the rated voltage. If the load current is 500 A, what is the power factor of operation? The machine has a synchronous reactance of 5Ω and negligible resistance per pahse. **(GATE 99)**

67. A 10,000 kVA, 3 phase, star connected 11,000 V, 2 pole turbo-generator has a synchrnous impedance of (0.0145+j0.5) ohms per phase, the various losses in this generator are as follows:
Open circuit core loss at 11000 V is 90 kW
Windage and friction loss is 50 kW
Short circuit load loss at 525 A is 220 kW
Field windings resistance is 3 ohms, Field current is 175 amps
Ignoring the change in field current, compute the efficiency at
   i. rated load 0.8 power factor leading.
   ii. half rated load, 0.9 power factor lagging. **(GATE 96)**

68. A 10 kVA, 380V, 4-pole, 50 Hz, star connected cylindrical rotor alternator has a stator resistance and synchronous reactance of 1 ohm and 15 ohms respectively. It supplies a load of 8 kW at rated voltage and 0.8 power factor lagging.
   i. Draw a phasor diagram of operation
   ii. Express the resistance and synchrnous reactance in per unit values with the machine rating as the base.
   iii. Calculate the percentage regulation. **(GATE 91)**

69. What is the value of the load angle when the power output of a salient oike synchronous generator is maximum?
i. 0^0 ii. 45^0 iii. 90^0 iv. None of the above **(IES 06)**

70. A star-connected 3-phase alternator delivers a 3-phase star-connected load at power factor of 0.8 lagging. A wire connects the load and the alternator. The terminal voltage at no-load is 2500 V and at full-load of 1460 kW it is 2200 V. Determine the terminal voltage when it delivers a 3 phase star-connected load having a resistance of 6 ohms and reactance 8 ohms per phase respectively. Assume constant current and field excitation. **(IES 06)**

71. Two identical 60 MVA alternators operate in parallel. The governor of the first m/c is such that the rise in speed from full load to no load is 3% and second is 4% in the other. The characteristics being straight lines in both cases. If each machine is fully loaded when the total load is 160 MW, what will be the load on each machine when total load is reduced to 100 MW. **(IES 03)**

72. i. A cylindrical rotor hydro generator is feeding an active power of 0.25 pu into a large network bus which is held at 1.0 pu voltage. The generator is overexcited with an induced voltage of 1.5 p.u. The synchronous impedance of the generator and connecting link are j0.725 pu/ phase and j0.11 p.u/ phase respectively. Calculate the percentage in the reactive power output measured at the network bus in each of the following cases
   a. If the turbine torque is increased by 100% keeping the excitation of generator constant
   b. If the turbine torque is held constant at initial value, but the excitation is increased by 20%.
   ii. Using double revolving field theory explain the working of a single phase induction motor **(IES 02)**

73. Two alternators working in parallel supply a lighting load of 300 kW and motor load aggregating to 5000 kW at a pf of 0.71 one machine is loaded upto 5000 kW at 0.8 pf lagging. What is the load and power factor of the other machine. **(IES 02)**

74. A 5 MVA, 10 KV, 1500 rpm, 50 Hz alternator runs in parallel with other machines. The synchrnous reactance is 90% find for i. no load, ii. full load power factor 0.8 lagging, synchronizing power per unit mechanial angle of phase displacement, and calculate the synchronizing torque if the mechanical displacement is 0.5. **(IES 01)**

75. Using synchronous-impedance method, determine the voltage regulation of a 2000 volt single-phase alternator supplying a load current of 100A at rated voltage and a power factor of
i. unity ii. 0.8 leading, and iii. 0.707 lagging.
The test results available are as follows: The full load current of 1000A is produced on short-circuit by a field excitation of 2.5 A, an emf of 500 V is produced on open circuit by the same excitation, and the armature resistance is 0.8 ohm. **(IES 98)**

76. What is meant by infinite bus bars? State
i. The conditions required to be satisfied for connecting a synchronous generator to a infinite bus bar. Explain how the instant for synchronizing can be determined.
ii. A generator has synchronous reactance of 1.7241 p.u and is connected to a very large system. The terminal voltage of the generator is 1.0 p.u. and generator is supplying to the system a current of 0.8 p.u at 0.9 pf lagging. Neglecting resistance calculate
a. Internal voltage.
b. Active and reactive power output of the generator
c. The power angle and reactive power output of the generator if the excitation of the generator is increased by 20% keeping active power constant. **(IES 98)**

77.a) A 3000 KVA, 6 pole alternator runs at 1000 rpm in parallel with other machines on 3300 V bus – bars. The synchronous reactance is 20 %. Calculate the synchronizing Power for one mechanical degree of displacement and the corresponding torque.
b) Define the infinite bus – bar? What are the characteristics of an infinite bus – bar?
November/December-2013

78.a) Discuss the analysis of parallel operation of alternators and obtain the expression for synchronizing power and torque under different conditions.
b) A 3 phase, 8pole, 50Hz, 2 MVA alternator is operating on 6000V bus bars. The synchronous reactance X_S = 6 ohms. Calculate synchronizing power and torque per one mech degree displacement operating on full load 0.8 PF.
November/December-2013

UNIT-IV

1. i. Derive necessary equations for power developed in a synchronous motor.
   ii. A 2300 volts three phase star connected synchronous motor has synchronous impedance of (0.2+j 2.2) ohms per phase. The motor is operating at 0.7 power factor leading with line current of 200 amperes. Determine back emf per phase. **(May 11, Nov 10)**

2. Explain two important functions served by damper windings in a synchronous motor. State application of a synchronous motor.
   (May 11)

3. i. Explain different torques of a synchronous motor.
   ii. The input to a 11000 volts three phase star connected synchronous motor is 60 amperes. The effective resistance and synchronous reactance per phase are 1 ohm and 30 ohms respectively. Find the induced emf for a power factor of 0.8 leading. **(May 11)**

4. i. Derive the commonly used expression for power developed by synchronous motor.
   ii. The input to a 11000 volts three phase star connected synchronous motor is 60 amperes. The effective resistance and synchronous reactance per phase are 1 ohm and 30 ohms respectively. Find the power supplied to the motor. **(May 11)**

5. Assume two axis model and draw the phasor diagram of a synchronous motor drawing leading current.
   (Nov 10)

6. Explain the construction and principle of operation of synchronous motor. **(Nov 10)**

7. Explain different methods of starting of a synchronous motor. **(Nov 10)**

8. What are the effects of hunting on the performance of synchronous motor and explain the method of suppressing the hunting. **(June 10)**

9. Describe with neat sketches the principle of operations of a three phase synchronous motor.
   (June 10)

10. Explain why the speed of a three phase synchronous motor remains constant at various loads when fed from a constant frequency. **(June 10)**

11. i. Explain the action of synchronous motor under loaded conditions.
    ii. Three phase star connected synchronous motor rated 200KVA, 2000V, has an effective resistance of 1.5ohms, and synchronous reactance of 20ohms per phase. Determine the internal power developed by the motor when it operating the rated current operated at 0.8 power factor leading. **(Nov 09)**

12. i. Describe why synchronous motor will not run other than synchronous speed.
    ii. A 50Kw, 400V, three phase synchronous motor is operating at full load with an efficiency of 90% if the field current is adjusted to make its power factor 0.8 leading estimate the armature current. **(Nov 09)**

13. Draw and explain the phasor diagrams of synchronous motor when over and under excited conditions.
    (Nov 09)

14. What is the relation between the speed and frequency and number of poles of a synchronous motor also gives the principle of operation of synchronous motor. **(Nov 09)**

15. i. Explain the 'V-curves' and 'inverted v-curves' of synchronous motor.
    ii. A 3-ϕ star connected 440v; the synchronous motor takes a power input of 5472W at rated voltage. Its synchronous reactance is 10Ω/ph and resistance is negligible. If its excitation voltage is adjusted equal to rated voltage of 400V, compute the load angle, power factor and armature current. **(Nov 09)**

16. Explain the construction and working principle of synchronous motor. **(Nov 09)**

17. A 3-ϕ, 600v, star connected synchronous motor has effective per phase armature resistance and synchronous reactance of 0.4Ω & 3.6Ω respectively. Calculate the induced emf per phase if the motor works on full load delivering 326KW. The full load efficiency is 87% having power factor of 0.8 leading. Also, calculate the load angle. **(Nov, May 09)**

18. With neat diagram explain the 'constant excitation with variable load' operation of synchronous motor. **(Nov 09)**

19. An industrial load of 4MW is supplied at 11KV, the power factor being 0.8 lagging. A synchronous motor is required to meet an additional load of 1103.25 KW and at the same time to raise the resultant power factor to 0.95 lagging. Determine the KVA capacity of the motor and the power factor at which it must operate. The efficiency of motor is 80%. **(Nov 09, 08, Feb 08)**

20. Explain the various power stages of synchronous motor. What are the various losses taking place in synchronous motor. **(Nov 09, 08, Feb 08)**

21. With the help of vector diagram explain the operation of synchronous motor as synchronous condenser. **(Nov 09)**

22. Explain, why synchronous motor is not self starting? **(May 09)**

23. A 500 V, 3-ϕ, star connected synchronous motor has resistance & Synchronous reactance of 0.4 Ω/ph & 3.6 Ω/ph respectively. The OC voltage is 600 V. If friction and core losses are 1 kW, calculate the line current & power factor when the motor output is 62 kW. **(May 09)**

24. A 3-ϕ, 400 V, 40 kVA, star connected synchronous motor is supplying 15 kW load with 0.8 pf lagging. The windage & friction losses are 1.5 kW & core losses are 1.0 kW. Calculate the following:
    i. Armature current & Excitation voltage
    ii. Armature current & power factor if the excitation is increased by 40% and power supplied to the load remains constant **(May 09)**

25. A 3-ϕ, 30 kW, 400 V, star connected synchronous motor operates on full load at 0.8 pf lagging. The machine has synchronous reactance of 4 Ω & negligible armature resistance. Calculate the new value of current & power factor if the excitation is increased by 50%. **(May 09)**

26. i. A substation operating at full load of 1200KVA supplies a load at 0.7 pf lagging. Calculate the permissible additional load at this power factor and the rating of synchronous condenser to the raise of the substation power factor to 0.9 pf lagging.
    ii. Derive the expression for the maximum power developed by a synchronous motor. **(Nov 08, 07, 04)**

27. i. An industrial plant has a load of 800 kW at power factor of 0.8 lagging. It is desired to purchase a synchronous motor of sufficient capacity to deliver a load of 200 kW and also serve to correct the over all plant power factor to 0.92. Assuming that the synchronous motor has an efficiency of 92%, determine its kVA input rating and power factor at which it will operate.
    ii. Explain the load angle characteristics of a synchronous motor. **(Nov 08)**

28. i. A 3-phase, synchronous motor observing 60 kW is connected in parallel with a factory load of 240 kW having lagging pf of 0.8. If the combined load has a pf of 0.9 lagging, what is the value of leading kVAR supplied by the motor & at what power factor it is working?
    ii. Explain the 'power factor v/s field current' & 'armature current v/s field current' characteristics of synchronous motor. **(Nov 08)**

29. A 3-ϕ, 6600 V, star connected synchronous motor has effective per phase synchronous reactance / phase of 15 Ω & negligible armature resistance. For a certain load, the input is 900 kW at normal voltage and the induced line EMF is 8900 V. Determine
    a. Line current b. Power factor. **(Feb 08)**

30. i. Compare (all 3-ϕ) synchronous motor, Induction motor & transformer.
    ii. A synchronous motor absorbing 50 kW is connected in parallel with a factory load of 200 kW at 0.8 lagging pf. If the resultant power factor after connecting SM is 0.9 lagging, how much leading kVAR are supplied by synchronous motor. At what power factor is it working? **(Feb 08)**

31. i. Explain the construction & working principle of synchronous motor.
    ii. A 3-ϕ, 400 V star connected SM has effective per phase armature resistance & synchronous reactance of 0.2Ω & 2 Ω respectively. It takes 20 A to deliver a certain load. Calculate the excitation EMF induced in the motor if it works with
    a. 0.8 pf lagging b. 0.8 pf leading **(Nov 07)**

Genius without education is like silver in the mine.
- Sir Winston Churchill

32. A 20 pole, 30 kW, 660 V, 50 Hz, star connected synchronous motor is operating with it's per phase generated voltage exactly equal to the phase voltage applied to armature. At loaded condition the motor is retarded by 5o mechanical from its synchronous position. Per phase synchronous reactance & the effective armature resistance are 10 Ω & 1 Ωrespectively. Calculate:
   i. Armature current
   ii. The total power drawn by the motor from bus.
   iii. The developed power. **(Nov 07)**

33. i. What happens when the excitation of the D.C machine is changed? Is the effect is same in a synchronous motor?
   ii. A 220V, 3-phase, star connected synchronous motor has a resistance of 0.22 per phase and a synchronous reactance of 2.4 per phase. The motor is operating at 0.6 power factor leading with a line current of 180A. Determine the value of generated emf. **(Feb 07)**

34. A synchronous motor has an equivalent armature reactance of 3.3 The exciting current is adjusted to such a value that the open circuit emf is 950V. Find the pf at which the motor would operate when it takes 80kW from 800V supply line. **(Feb 07)**

35. i. What is the effect on synchronous motor when the excitation is varied.
   ii. A 3000KVA, 15KV, 1500 rpm, 50HZ alternator runs in parallel with other machines. Its synchronous reactance is 30%. Find the synchronizing power per unit mechanical angle of the phase displacement for
   a. No load and b. Full load at 0.7pf (lag)
   Also calculate the synchronizing torque if the mechanical displacement is 0.6^0. **(Feb 07)**

36. i. What are the advantages of synchronous motor over induction motors?
   ii. Why at any load, the power factor decreases and the armature current increases if the field current is varied above and below the normal excitation. **(Feb 07, Nov 06, 03)**

37. i. Explain about different torques of a synchronous motor?
   ii. A 400V, 3-phase synchronous motor takes 52.5A at a power factor of 0.8 leading. Calculate the power supplied and induced emf. The motor impedance per phase is (0.25+j3.2) ohm. **(Feb 07, Nov 06,05)**

38. Why it is necessary to increase the excitation to obtain minimum current with the application of load. **(Feb 07, Mar 06, Nov, May 05)**

39. The synchronous reactance per phase of a 3-phase star connected 6600V synchronous motor is 10. For a certain load, the input is 900kW and the induced line emf is 8900V(line value). Evaluate the line current. Neglect resistance. **(Feb 07, Nov 06, 05, May 05)**

40. i. Describe briefly the effect of varying excitation upon the armature current and p.f. of a synchronous motor when input power to a motor is maintained constant.
   ii. A 400V, 50Hz, 3-Ø, 37.3KW, star connected synchronous motor has a full load efficiency of 88%. The synchronous impedance of the motor is (0.2 + j1.6) Ohms/Phase. If the excitation of the motor is adjusted to give a leading p.f. of 0.9, calculate for full-load
   a. the induce emf b. the total mechanical power developed. **(Feb 07, Nov 05)**

41. i. What are the causes of faulty starting of synchronous motor?
   ii. The input to a 11kV, 3-phase star connected synchronous motor is 60A. The eective resistance and synchronous reactance per phase are 1 and 30. Find the power supplied to the motor and the induced emf for power factor of 0.8 leading. **(Nov 06)**

42. i. What are the advantages and disadvantages of the synchronous motor?
    ii. A Synchronous motor takes 25kWfrom 400V supply mains. The synchronous reactance of the motor is 4. Find the power factor at which the motor would operate when the exciting current is so adjusted that the generated emf is 500V. **(Nov 06, 05, Mar 06, May 05)**

43. A synchronous motor has an equivalent armature reactance of 3.3 Ohms The exciting current in adjusted to such a value that the open circuit emf is 950V. Find the pf at which the motor operate when it takes 80kW from 800V supply line. **(Nov 06, 03)**

44. i. Write short notes on the power factor improvement with synchronous motor?
    ii. A 2300V, 3-phase, star connected synchronous motor has a resistance of 0.2 per phase and a synchronous reactance of 2.2 per phase. The motor is operating at 0.6 power factor leading with a line current of 200A. Determine the value of generated emf per phase. **(Nov 06)**

45. Write short notes on the following.
    i. V and inverted V curves of synchronous motor.
    ii. Synchronous condensor for power factor improvement. **(Mar 06)**

46. i. Explain why a synchronous motor will only develop a continuous torque at synchronous speed. How does it reach synchronous speed?
    ii. A three phase synchronous motor has 12 poles and operates ffrom 440V, 50 Hz supply calculate its speed. If it takes a line current of 100A at 0.8 pf leading what torque will be the machine developing. Neglect the losses. **(Mar 06)**

47. i. What is the effect of load on a synchronous motor?
    ii. A 400V, 8KW, 3-phase synchronous motor has a negligible resistance and a synchronous reactance of 8 ohm per phase. Determine the minimum current and the corresponding induced emf for full load condition. Assume an efficiency of 88%? **(Nov 05)**

48. i. What is the effect on synchronous motor when the load is changed.
    ii. A 3300V, star connected synchronous motor is operating at constant terminal voltage and constant excitation. Its synchronous impedance is (0.8+j5) ohm. It operates at a p.f of 0.8 leading when drawing 800KW from the mains. Find its power factor when the input is increased to 1200kW, excitation remaining constant. **(Nov 05)**

49. i. Explain synchronous motor ratings?
    ii. A 3-phase, star connected synchronous motor has a synchronous reactance of 4 ohm per phase and is working on 1100V. Calculate the power factor of the machine when taking 90kW from the mains. The excitation being adjusted to a value corresponding to an induced emf of 1200V. Neglect armature resistance? **(May 05)**

50. A 400V, 3 phase, Y connected synchronous motor takes 3.73kW at normal voltage and has an impedance of (1+j8) per phase. Calculate the current and pf if the induced emf is 460V. **(May 05)**

51. i. What is synchronous condenser? What is the use of synchronous condenser?
    ii. A 500V, 50 Hz, 3- circuit takes 20A at a lagging power factor of 0.8 A synchronous motor is used to raise the power factor to unity. Calculate the kVA input to the motor and its power factor when driving a mechanical load of 7.5 KW. The motor has an efficiency of 85% **(Nov 04)**

History will be kind to me for I intend to write it.

- Sir Winston Churchill

52. A synchronous motor runs at a load angle of 20° at rated voltage and at rated frequency. Armature circuit resistance is neglected. For constant field current, compute the value of load angle with the following changes in its operating conditions:
   i. Frequency increased by 10%, load power and applied voltage constant.
   ii. Frequency reduced by 10%, load torque and applied voltage constant.
   iii. Both applied voltage and frequency reduced by 10%, load power constant.
   iv. Both applied voltage and frequency reduced by 10%, load torque constant. **(Nov 04)**

53. i. Define back – emf. Draw the equivalent circuit diagram of synchronous motor. Also deduce the expression for a. excitation voltage, b. Synchronous impedance and c. armature current.
   ii. A 3-ϕ, Y-connected Synchronous motor take 48KW at 693V (line), the p.f. being 0.8 lag. The induced emf is now increased by 30%, the power input being the same. Find the new current and power factor. Synchronous impedance equals to (0+2j) Ohms/Phase. **(Nov 04)**

54. i. Explain the characteristics features of a synchronous motor
   ii. The excitation of a 400V, 3-phase mesh connected synchronous motor is such that the induced emf is 510V. The impedance per phase is (0.6+j4.5) . If the friction and iron losses are constant at 800W, Calculate power output, line current and power factor. **(Nov 04)**

55. A salient pole synchronous motor with $r_a = 0$, $X_d = 0.5$ p.u. is operated on infinite bus-bar of 1.0 p.u. voltage. Show that for 1.00 synchronous power, the excitation voltage is $E_r = \text{Cosec}\theta - \text{Cos}\theta$. Also derive the condition for load angle when synchronous power is maximum. **(Nov 04)**

56. i. Draw the phasor diagram of a salient pole synchronous motor working at leading p.f. and obtain there from an expression for power in terms of load angle d Neglect armature resistance.
   ii. A salient pole synchronous motor has the following per unit constants:
   $X_d = 1.25$; $X_q = 1.00$ Find the excitation voltage when the motor takes rated current (leading) at rated voltage, delivering 0.5 p.u. mechanical power. Ignore all losses. **(Nov, May 04)**

57. The input to a 1100V, 3-phase, star connected synchronous motor is 60A. The effective resistance and synchronous reactance are 1 ohm and 30 ohm respectively. Find the power supplied to the motor and the induced emf for power factor 0.8 leading. **(Nov 04)**

58. i. Explain the principle of operation of a synchronous motor.
   ii. A 3-ϕ, star connected synchronous motor has a synchronous reactance of 4 Ω/phase and is working on 1,100V bus-bar. Calculate the power factor of this machine when taking 90KW from the mains, the excitation being adjusted to a value corresponding to an induced emf of 1,200 V. Neglect armature resistance. **(Nov 04)**

59. i. What are the salient features of a synchronous motor.
   ii. The input to a 11 KV, 3-ϕ, Y connected synchronous motor is 60 A. The effective resistance and synchronous reactance per phase are 1Ω and 30Ω respectively. Find i. Power supplied to the motor and ii. the induced emf for a power factor of 0.8 leading. **(Nov 04)**

60. i. Explain the construction and principle of operation of synchronous motor?
   ii. Explain the characteristics features of a synchronous motor **(Nov 04, 03)**

61. i. For a salient pole synchronous motor, working at lagging p.f., Show that $\tan\delta = \dfrac{I_a\,(X_q\,Cos\theta - r_a\,Sin\theta)}{V_t - I_a(X_q Sin\theta + r_a Cos\theta)}$
   ii. Find an expression for power in terms of load angle θ, for a salient pole synchronous motor working at a lagging p.f. Armature resistance may be neglected. **(Nov 03)**

Mart, be intelligent and be informed.

- Tony Alesandra

62. A 750 kW, 11KV, 2 Phase star connected synchronous motor has a synchronous reactance of 35 Ohms / Phase and negligible resistance. Determine the excitation emf per phase when the motor is operating on full load at 0.8 pf leading. Its efficiency under this condition is 93% **(Nov 03)**

63. A 500V, 3-ϕ, mesh connected motor has an excitation emf of 600V. The motor synchronous impedance is (0.4 + j5) Ohms while the windage, friction and iron losses are 1200 W. What maximum power output can it deliver? What is the corresponding line current, pf and motor efficiency. **(Nov 03)**

64. Why it is necessary to increase the excitation to obtain minimum current with application of load? **(Nov 03)**

65. A 3 Phase synchronous motor is designed for a terminal voltage of 3300V and its synchronous impedance is 0.25 + j2.00 Ohms/Phase. The excitation is adjustable to a value which corresponds to an open circuit terminal voltage of 3500 V Determine the current and p.f. from an output of 750 kW. **(Nov 03)**

66. Explain V curves and inverted V curves. **(Nov 03)**

67. i. Mention the essential parts of a synchronous motor. Explain neatly with diagrams each one of them.
ii. A 3-phase, 220V, 50Hz, 1500 rpm, mesh connected synchronous motor has a synchronous impedance of 4 Ohms/Phase. It receives an input line current of 30 Amps. at a leading p.f. of 0.8 Find the line value of the induced emf and the load angle in mechanical degrees. If the mechanical of current under the new conditions. Neglect losses. **(Nov 03)**

68. i. Explain the operation of a synchronous motor with variable load at constant excitation.
ii. Derive the torque developed in a synchronous motor. **(Nov 03)**

69. A 1000 kVA, 11 KV, 3-phase star connected synchronous motor has an armature resistance and reactance are perphase are 3.5 ohm and 40 ohm respectively. Determine the induced emf and angular retardation of the rotor when fully loaded at unity power factor **(Nov 02)**

70. A-3 phase, 400 V, 5 kW, star connected synchronous motor having an internal reactance of 10 ohms is operating at 50% load, unity pf. Now, the excitation is increased by 1%. What will be the new load in percent, if the power factor is to be kept same ? Neglect all losses and consider linear magnetic circuit.
i. 67.9% ii. 56.9% iii. 51% iv. 50% **(GATE 06)**

71. A 415V, 2 pole, 3 phase, 50 Hz, star connected, non-salient pole synchronous motor has synchronous reactance of 2 Ω per phase and negligible stator resistance. At a particular field excitation, it draws 20 A at unity power factor from a 415V, 3 phase, 50 Hz supply. The mechanical load on the motor is now increased till the stator current is equal to 50A. The field excitation remains unchanged. Determine:
i. The per phase open circuit voltage E_0.
ii. The developed power for new operating condition and corresponding power factor. **(GATE 02)**

72. A 415V, 2 pole, 50Hz supply, the mechanical load on motor is now increased till the stator current is equal to 50A. The field excitation remains unchanged. Determine per phase open circuit voltage E_o developed power for the new operating condition and corresponding power factor. **(GATE 02)**

73. Driving it by another motor tests a 50 kW synchronous motor. When the excitation is not switched on, the driving motor takes 800W. When the armature is short circuited and rated armature current of 10A is passed through it, the driving motor requires 2500W on open circuiting the armature with rated excitation, the driving motor takes 1800W. Calculate the efficiency of synchronous motor at 50% load. Neglect looses in driving motor. **(GATE 01)**

Give advice by the bucket, but take it by the grain.
- William R. Alger

74. Two alternators working in parallel supply a lighting load of 3000 kW and a motor load aggregating to 5000 kW at a.p.f. of 0.72. One machine is loaded upto 5000 kW at 0.8 p.f. lagging. What is the load and power factor of the other machine ? **(IES 06)**

75. Why synchronous motors have no starting torque of their own? **(IES 03)**

76. A 500V, 50 Hz, 3-phase circuit takes 20A at a lagging power factor of 0.8 A synchronous motor is used to raise the power factor to unity. Calculate the KVA input to the motor, and its power factor when driving a mechanical load of 7.5KW. The motor has an efficiency of 85% **(IES 98)**

77.a) What is synchronous condenser? Explain with help of phasor diagram its operation.

b) A 2300 V, 3- phase star connected synchronous motor has a synchronous reactance of 10 ohm per phase. When the motor delivers 255 hp (metric) the efficiency is 90% (exclusive of field loss). The power angle is 20^0. Calculate

a) E per phase, b) I, c) Power factor. Neglect resistance.

November/December-2013

78.a) Discuss the variation of current and power factor with excitation in a synchronous motor. Draw the relevant curves and explain.

b) The excitation of a 415 V, 3 phase, mesh connected synchronous motor is such that the induced emf is 520V. The impedance per phase is (0.5 + j4.0) ohm. If the friction and iron losses are constant at 1000W, calculate the power output, line current, power factor and efficiency for maximum power output.

November/December-2013

1. Explain the effects of varying excitation on armature current and power factor in a synchronous motor. Draw "V" curves. **(May 11)**

2. Draw the excitation circle for a synchronous motor. How is it derived? **(May 11, Nov 10, 09)**

3. Show the locus of stator current for a constant output of 3phase a synchronous motor connected to a constant voltage, constant frequency bus- bars is circle. **(Nov, June 10, Nov 09)**

4. i. Draw the phasor diagram of synchronous motor. Explain the effect of change in excitation if load is constant.

   ii. A 60Kw, 400V, three phase synchronous motor is operating at full load with an efficiency of 92% if the field current is adjusted to make its power factor 0.8 leading estimate the armature current. **(Nov 10)**

5. What is meant by constant power circle for a synchronous motor . How is it derived.

(June 10, Nov 09)

6. Discuss with circuit diagram any one of method of starting. **(Nov 09)**

7. i. Explain the various starting methods of synchronous motor?
   ii. Write short notes on synchronous induction motor. **(Nov 09)**

8. i. Explain the construction of "excitation circle" of a synchronous motor.
   ii. Why synchronous motor is not self starting? Explain the various starting methods of synchronous motor. **(Nov 09)**

9. i. Explain the effect of damper winding on the performance of a synchronous machine.
   ii. Show that the locus of power of a synchronous machine is circle? Give the co-ordinates of the power circle. **(Nov 09)**

10. i. What is hunting in a synchronous motor? Explain how it can be suppressed.
    ii. A 440V, 50Hz, 3-ϕ circuit takes 18A at a lagging power factor of 0.8. A synchronous motor is used to raise the power factor to unity. Calculate the KVA input to motor and its power factor, when delivering a mechanical load of 6KW. The motor has an efficiency of 88%. **(Nov 09)**

11. Explain the procedure to plot 'V curves' & 'inverted V' curves for a given synchronous machine with help of its circles diagrams. **(May 09, Nov 08)**

12. A 2 pole, 50 Hz, 3-ϕ turbo alternator is excited to generate a bus-bar voltage of 11 kV on no load. The machine is star connected and the short circuit current for this excitation is 1000 A. Calculate the synchronizing power per degree of mechanical displacement of the rotor and the corresponding synchronizing torque. **(May 09)**

13. i. What is hunting? Why it is essential to suppress the hunting?
    ii. Explain the various staring methods of synchronous motor. **(May 09)**

14. i. Explain the 'powercircle' for a given synchronous motor.
    ii. A 4.5 MVA, 50 Hz, 3-ϕ, synchronous generator having a synchronous reactance of 0.3 pu is running at 1500 RPM and excited to give 11 kV. If the rotor deviates slightly from its equilibrium position, what is the synchronizing torque in Nm per degree mechanical displacement? **(May 09)**

15. The data for no load saturation curve of a 6.6 kV, 1.8 MVA. 3-ϕ, 50 Hz, star connected synchronous motor is given below:

K(kV)	3.6	5.9	7.4	7.9	8.4
I_f Amp	45	91	130	160	210

The effective resistance & synchronous reactance per phase of the motor are 0.35Ω & 7Ω respectively. Plot the V curves for this machine when the input is maintained constant at 450 kW **(May 09)**

16. i. What are the different methods of starting a synchronous motor? **(IES 06)**
    ii. What are the uses of damper winding in a synchronous motor? **(Nov 08, 07, 03, Feb 08)**

17. A 1000 HP, 6.0 kV, 3-phase, star connected synchronous motor has a synchronous impedance of 1.5 +j16 Ω/ph. It is excited to develop an open circuit EMF of 5 kV. Draw the locus diagram of current for loads up to 1250 HP, with constant excitation. Determine the maximum value of power factor. **(Nov 08)**

18. The effective resistance & synchronous reactance per phase of a 50 Hz, 6.6 kV, 1MVA, 3-phase, star connected synchronous motor are 0.5 Ω & 12 Ω respectively. Plot the V curves for this machine when the input is maintained constant at 250 kW. No load saturation curve:

I_f	50	100	150	175	200
V	3400	5700	7200	7900	8400

(Nov 08)

19. Explain the characteristics of synchronous induction motor. **(Nov 07)**

20. i. Explain the procedure for starting of synchronous motor.
    ii. A 500V, 3-phase mesh connected motor has an excitation emf of 600V. The motor synchronous impedance is (0.4+j5) while the windage, friction and iron losses are 1200W. What maximum power output can it deliver? **(Feb 07)**

21. What are the uses of damper windings in a synchronous motor? **(Feb 07, Mar 06, Nov 05, May 05)**

22. What could be the reasons if a synchronous motor fails to start? **(Feb 07, Nov 06, 05, May 05)**

23. What is meant by hunting in a synchronous motor? **(Nov 06, 03)**

24. Show that the current locus of a synchronous motor developing constant power is a circle. Determine its center and radius. **(Mar 06, Nov 04)**

25. Explain the excitation circles of synchronous motor. **(May 05)**

26. Explain the power circle diagrams of the synchronous motor. **(May 05, Nov 03, 02)**

27. Show that the current locus of a synchronous motor developing constant power is a circle. Determine its radius and centre. **(Nov 04)**

We always love those who admire us; we do not always love those whom we admire.

- Francois De La Rochefoucauld

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28. Describe the methods of starting of synchronous motor. **(Nov 02)**

29. A single phase induction motor is running at N r.p.m. Its synchronous speed is Ns. If its slip with respect to forward field is s, what is the slip with respect to the backward field ?
i. s ii. – s iii. (1 – s) iv. (2 – s) **(IES 06)**

30. In relation to the synchronous machines, which one of the following ststatements is false ?
   i. In salient pole machines, the direct-axic synchronous reactance is greater than the quadrature-axis synchronous reactance.
   ii. The damper bars help the synchronous motor self start
   iii. Short circuit ratio is the ratio of the field current required to produce the rated voltage on open circuit to the rated armature current.
   iv. The V-curve of a synchronous motor represents the variation in the armature current with field excitation, at a given output power. **(IES 06, GATE 05)**

31. Which one of the following is the type of single phase induction motor having the highest power factor at full load ? **(IES 06)**
   i. Shaded pole type
   ii. Split-phase type
   iii. Capacitor-start type
   iv. Capacitor-run type

32. Briefly explain the phenomenon of 'hunting' of a synchronous machine. How is it remedied. **(IES 96)**

33. Show that as the power developed goes on increasing, the radius of power circle goes on decreasing. **(T2-Ch5)**

34. Derive the condition for maximum power with respect to radius using power.circle diagram. **(T2-Ch5)**

35. Briefly explain the bad effects of hunting. **(T2-Ch5)**

36. Why hunting is called as phase swinging, explain ? **(T2-Ch5)**

37. Explain about the incomplete type and complete type damper windings. **(T2-Ch5)**

38. A 1100-V, 50 Hz, 3-phase star-connected cylindrical-rotor synchronous motor has its synchronous impedance of 0.7 + j3.2 ohm per phase. It is working at rated voltage, rated frequency with an input of 350 kW. The field current is adjusted to give and electromative force of 1650 V. Calculate the armature current, power factor and load angle. **(T2-Ch5)**

39. Develop the excitation circles for a cylindrical rotor synchronous motor. How are these circles helpful in studying the steady state behaviour of synchronous motors? **(T2-Ch5)**

40. Explain the development of power circles for a cylindrical rotor synchronous motor.
Show that :
   i. Zero-power circle passes through origin.
   ii. $P_{max} = \frac{V_t^2}{4r_a}$ and
   iii. Efficiency at maximum power output = 50% **(T2-Ch5)**

I have always been an admirer. I regard the gift of admiration as indispensable if one is to amount to something; I don't know where I would be without it. - Thomas Mann

41. Explain how the excitation and power circles can be superimposed to obtain V-curves of a cylindrical rotor synchronous motor.
Hence show that :
i. Minimum and maximum currents for any power occur at u.p.f.
ii. Minimum p.f. for any load power occurs when the current line is tangent to the power circle for that load.

42.a) Explain the sequence of events which take place when the load on a synchronous a motor is changed? What is hunting? How can it be prevented?
b) Why synchronous motor is not self starting? Explain the methods of starting of synchronous motor. [8+8]

43.a) Explain the methods of starting of synchronous motor.
b) How do you determine the performance of synchronous motor with power circles?

UNIT-V

1. Explain the operation of a single phase induction motor using split phase technique. **(May 11, Nov 10, 09)**

2. Show that the self starting torque of a single phase induction motor is zero. **(May 11)**

3. Explain two field revolving theory for single phase induction motor and give its Torque slip characteristic. **(May 11, 10)**

4. Using double field revolving field theory explain the torque slip characteristic of of a single phase induction motor and prove that it can not produce starting torque. **(May 11, Nov 09)**

5. Prove that a single phase induction motor winding when excited by a single phase supply Produces two equal and opposite revolving fields. **(Nov 10)**

6. Sketch and explain the torque slip characteristic of a single phase induction motor based on two field revolving field theory. **(Nov 10, 09)**

7. Draw the connection diagram of a capacitor start capacitor run single phase induction motor and explain its principle of operation. **(Nov 10)**

8. Explain the constructional features and principles of operation of single phase induction motor. **(June 10)**

9. Explain with appropriate theoretical concept why single phase induction motor is not having self starting torque. **(Nov 09)**

10. i. Explain why single phase induction motors are not self starting. How can they be started?
ii. Draw and explain the torque – slip characteristics of
a. Shaded pole motor
b. Capacitor start – induction run motor, mention their applications. **(Nov 09)**

11. Explain various types of single phase induction motors. **(Nov 09, 08, May 09)**

12. Derive equation for forward slip and backward slip of a single phase induction motor. **(Nov 09)**

13. Explain the working principle of a shaded pole motor. **(Nov 09)**

14. Explain the 'doubly revolving field theory' related to single phase Induction motor. **(Nov 09, 08, Feb 08)**

15. i. Explain the torque-slip characteristics of a single phase, single winding induction motor.
    ii. Explain the operation of "capacitor start and run" and "capacitor start – induction run" single phase induction motors. **(Nov 09)**

16. Explain the equivalent circuit of single phase Induction motor & give all necessary equations. **(May 09, Feb 08)**

17. What is splitting of phases? Why splitting of phase is necessary in single phase Induction motor. **(May 09)**

18. i. The following data pertains to a single phase Induction motor:
    No. of poles = 4, Supply voltage = 110, Rated output = 125 W, Slip = 6%, total full load copper losses = 25 W, Rotational losses = 25W. Calculate the full load efficiency & the rotor copper loss caused by the backward field. Neglect stator resistance.
    ii. Give the comparison between 'capacitor start-capacitor run' single phase Induction motor & 'capacitor start-run motor' single phase Induction motor. **(May 09)**

19. Explain, the speed of single phase Induction motor can be controlled by supply voltage where as them is not possible with 3-ϕ IM, why?
    The name plate of single phase IM, 4 pole Induction motor gives the following data:
    Output = 410 W, Supply voltage = 230 V, Frequency = 50 Hz, Input current = 3.2 A, Power factor = 0.7, speed = 1410 RPM. Calculate:
    i. The efficiency of the motor
    ii. The slip of the motor when delivering rated output. **(May 09, Nov 07)**

20. Explain the construction & give the applications of single phase Induction motor. **(Nov, Feb 08)**

21. i. Why single phase motors are not self starting?
    ii. Explain the necessary arrangements made to make single phase Induction motor self starting & with neat diagram explain the operations of same. **(Nov 08, 07)**

22. Explain the construction & operation of 'capacitor start and run' single phase Induction motor. **(Nov 08)**

23. The following test results were obtained in case of a 220 V single phase induction motor:
    Free running test: 220V, 5.8 A, 310 W
    Blocked rotor test: 120 V, 13.8 A, 530 W
    Stator winding resistance = 1.4Ω
    Determine the approximate equivalent circuit of motor. **(Feb 08)**

"The greater danger for most of us lies not in setting our aim too high and falling short; but in setting our aim too low, and achieving our mark." - Michelangelo Buonarroti

24. The constants of a quarter HP, 230 V, 50 Hz, 4 pole single phase IM are as follows: Stator resistance = 10.0 Ω; Stator reactance = 12.8Ω, Magnetising reactance = 258Ω, Rotor resistance referred to stator =11.65Ω, Rotor reactance referred to stator =12.8Ω The total load is such that the machine runs at 3% slip, when the voltage is at 210 V. The iron losses are 35.5 W at 210 V. If mechanical losses are 7 W; Calculate:
    i. Input current
    ii. Power developed
    iii. Shaft power
    iv. Efficiency. **(Feb 08)**

25. Explain how the direction of a single phase Induction motor cab be reversed. **(Nov 07)**

26. i. Using double revolving field theory explain the torque-slip characteristic of a single phase induction motor and prove that it cannot produce starting torque.
    ii. Explain the constructional details and principle of operation of a split phase induction motor. List out its industrial applications. **(Nov 07, May 04)**

27. "A single phase motor is not a self starting motor" justify the statement. **(Nov 07, Jun 03)**

28. Explain what is meant by the split-phase method of motor starting **(Feb 07, Nov 06, Mar 06, Nov 04)**

29. i. Explain the cross field theory of a single phase induction motor.
    ii. A 230V, 6 pole, 50Hz, single phase induction motor has the following impedance at standstill.
    Auxiliary winding ra= 5 xa= 5
    Main winding rm=1.5 xm= 4.0.
    The resistance of the rotor winding when referred to the main stator winding is 0.5. Assuming the number of turns of the main winding and Auxiliary winding are equal, estimate the resistance to be added to the auxiliary winding to obtain maximum starting torque and also estimate the value of the maximum starting torque. **(Feb 07)**

30. The full load slip of a single phase induction motor is higher than of corresponding 3phase induction motor. Why? **(Feb 07)**

31. A 220V, 500W, 50Hz series motor has a total resistance of 2 ohm and total reactance of 20 ohm. The full load stray losses and speed are 40W and 500rpm. Determine the current taken by the motor and power factor at rated load. **(Feb 07, May 05)**

32. Draw the slip-torque characteristics of all types of single phase induction motors and compare their merits and demerits. **(Feb 07, Nov 04)**

33. Why cannot a shaded pole motor be made to rotate in the reverse direction? **(Feb 07, Nov 03)**

34. i. Explain capacitor split phase motor.
    ii. A 220V, 4 pole, 50Hz, capacitor split phase motor has the following impedance at standstill.
    Auxiliary winding ra= 3, xa= 6
    Main winding rm = 2, xm = 5.
    The resistance of the rotor winding when referred to the main stator winding is 0.5. Assuming the number of turns of the main winding and Auxiliary winding are equal, estimate the starting torque, maximum starting torque and the capacitance to be inserted to get maximum starting torque. **(Nov 06)**

35. Write short notes on following:
   i. Double revolving field theory.
   ii. Capacitor Start single phase induction motor. **(Nov 06)**

36. i. Compare the performance characteristics of a.c. series motor when it is connected across
   a. A.C. supply and
   b. D.C. supply.
   ii. Describe the construction and principle of operation of a single phase shaded pole motor with a neat diagram. Give its industrial applications. **(Nov 06)**

37. Compare operating characteristics of a resistance-start induction –run-motor with those of a capacitor start induction–run motor. **(Nov 06, 04)**

38. i. Draw the equivalent circuit of a single phase induction motor and discuss the experimental procedure to determine the parameters.
   ii. Find the mechanical power out put of a 185Watts, 4 pole 110 volts, 50 Hz single phase induction motor whose constants are given below at a slip of 0.05
   R_1 = 1.86 Ohms X_1 = 2.56 Ohms
   X_m = 53.5 Ohms R_2 = 3.56 Ohms
   X_2 = 2.56 Ohms Core loss = 4.0 Watts
   Friction and windage losses = 13.0 Watts. **(Nov 06, May 04)**

39. Explain double field revolving theory. **(Nov 06, 02)**

40. A 110V, 6 pole, 50Hz, single winding single phase induction motor has the following equivalent circuit parameters as referred to the stator r1= 1.5W x1= 2.5W r2=0.75W x2= 1.0W.
   Neglecting the magnetizing current, estimate the following when the motor is running at a slip of 3%.
   i. the ratio (E_{sf}/E_{sb}) ii. the ratio ($V_{f/}V_b$)
   iii. the ratio (T_f/T_b) and iv. the gross total torque. **(Nov 05)**

41. A laboratory test on a single-phase induction motor has given the following data with rotational losses being equal to 17W.
   Block rotor test: Vsc= 110V, Isc=14.8A and Psc=1130W
   No load test: Vo=110V, Io= 2.8A and Po=60W
   Determine the parameters of the equivalent circuit and the core loss. **(May 05)**

42. Describe the construction and operation of a shaded pole motor. **(Nov 04)**

43. Show that in a shaded pole motor, the flux in the shaded part of pole segment lags behind the flux of the shaded pole segment both in space and time, resulting a rotational torque in the motor. **(Nov 04)**

44. i. Explain how the performance of a single phase induction motor is estimated from the equivalent circuit?
   ii. A 2 pole, 50Hz single phase induction motor has an effective rotor resistance and stand still leakage reactance of 0.5 ohm and 5.0 ohms respectively. If the motor is running at 2600 rpm, determine the frequencies of the motor current components and the relative magnitude of the forward and backward fluxes. Neglect magnetization and stator impedance drop. **(Nov 04)**

45. i. Compare various types of single phase induction motors in terms of construction and performance.
   ii. The resistance and inductive reactance of each winding of a 50 Hz single phase capacitor induction motor are 80 Ohms and 237.5 Ohms respectively. Additional resistance "R" and a capacitor "C" are in series with one winding inorder to achieve a phase difference of 90 degrees while both winding carry equal current. Calculate the values of R C **(May 04)**

It is all one to me if a man comes from Sing Sing Prison or Harvard. We hire a man, not his history.

- Henry Ford

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46. i. A capacitor connected in series with the starting winding of a resistance start split phase induction motor. Explain the changes in the performance characteristics.
   ii. A 220V, 50 Hz 4 pole single phase induction motor has the following equivalent circuit parameters
   R_{1m} = 3.6 Ohms
   (X_{1m} + X2) = 15.6 Ohms
   R_2 = 6.8 Ohms
   X = 96 Ohms
   The rotational losses of the motor are estimated to be 80 watts. Calculate the current, power factor and efficiency when the motor is running 1410 rpm. **(May 04)**

47. i. Prove that a single phase motor winding when excited by a single phase supply produces two equal and opposite revolving fields.
   ii. "The centrifugal switch of a single phase motor failed to open". Explain the factory effects in the performance. **(Nov 03)**

48. i. Explain the constructional features and principle of operation of a capacitor start induction run motor. Draw the slip-torque characteristic and list out its merits over split phase motor.
   ii. In a direct load test on a single phase motor the following readings were obtained
   Supply voltage : 230V
   Line Current : 12.0 A Watt meter reading 1.96KW
   Speed : 1410 rpm
   Torque : 1.01 kg-m, Determine a. Slip b. efficiency c. Power factor **(Nov 03)**

49. i. Describe cross field theory as applied to single phase induction motor.
   ii. The following data pertains to a 50Hz single phase motor.
   Supply Voltage : 110V
   Rated Output : 125W
   Rated speed : 1410 rpm
   Total copper loss at full load : 25 w
   Rotational losses : 25W
   Calculate the full load efficiency and the rotor copper loss caused by the backward field. Neglect stator losses. **(Nov 03)**

50. In a direct load test on a single phase motor the following readings were obtained supply voltage is 230V, line current 12.0A. Wattmeter reading 1.96KW, speed 1410 rpm, torque 1.01 Kg-m. Determine i. slip ii. efficiency iii. power factor. **(Nov 03)**

51. The following test results were obtained in case of a 230V single phase induction motor no load test – 230V, 4.8A, 350W; Locked rotor test – 125V, 15.6 A, 550W; Stator winding resistance = 1.8 Ohms. Determine the approximate equivalent circuit of motor. **(Nov 03)**

52. A capacitor connected in series with the starting winding of a resistance start split phase induction motor. Explain the changes in the performance characteristics. **(Nov 03, 02)**

53. Classify single phase induction motor and explain? **(Nov 03)**

54. "The centrifugal switch of a single phase motor failed to open" explain the after effects in the performance. **(Jun 03)**

55. Describe the construction and principle of operation of a single phase shaded pole motor with a neat diagram. Give its industrial applications. **(Jun 03)**

56. i. Discuss the different between capacitor start induction run motor and capacitor start and run induction motor. Draw the performance characteristics.
   ii. The following tests results were obtained in respect of 230 Volts single phase induction motor.
   No load tests 230V, 6.25A 360 Watts
   Locked rotor test 126v, 15.0A, 577
   Watts Stator winding resistance = 1.5
   Ohms
   Draw the equivalent circuit diagram with parameters **(Jun 03)**

57. Explain the constructional details and principle of operation of split phase induction motor. List out its industrial applications. **(Jun 03)**

58. Explain single phase induction motors fail to start but continues to run once started by double revolving field theory. **(Nov 02)**

59.a) Explain the working principle and applications of Single phase Induction Motor.

In a 6 – pole,50 Hz, single - phase induction motor the gross power absorbed by the forward and backward fields are 160 W and 20 W, respectively, at a motor speed of 950 rpm. If the no – load frictional losses are 75 W, find the shaft torque.

60.a) Briefly explain the working principle of single phase induction motor.

Explain the working principle of shaded pole motor. Give its applications.

1. Explain the principle of operation of a universal motor along with neat Diagram. **(May 11, Nov 10, 09)**
2. Explain the construction and principle of operation of universal motor and mention its applications. **(May 11, 10)**
3. i. Compare the results obtained for voltage regulation by emf, mmf, zpf, ASA and saturated synchronous method.
   ii. A 3 phase 17.32KVA, 400V, star connected alternator is delivering rated load at 400V and at p.f. 0.8lag. Its synchronous impedance is 0.2 + j2 Ω per phase. Find the load angle at which it is operating. **(Nov 10)**
4. Explain the principle of operation of a A.C. series motor with neat sketch. **(Nov, June 10, Nov 09)**
5. Describe constructional features and operating characteristics of a shaded pole single phase induction motor and mention its uses. **(June 10)**
6. Draw the diagram of a shaded pole single phase induction motorand explain its principle of operation. **(June 10)**
7. Describe the construction and working and uses of a reluctance motor. **(Nov 09)**
8. i. Compare AC series motor and DC series motor. What are the operational difficulties of each?
   ii. Explain, how a stepper motor works with variable reluctance principle. **(Nov 09)**
9. Write short notes on the following.
   i. Shaded pole motor
   ii. AC series motor
   iii. Universal motor
   iv. Stepper motor **(Nov 09)**
10. i. Explain the variable reluctance motor principle.
    ii. Compare AC series motor and Universal motor, Mention their operational difficulties. **(Nov 09)**
11. Write short notes on following:

i. AC series motor
ii. Universal motor
iii. Variable reluctance stepper motor
iv. Permanent magnet stepper motor. **(May 09, Nov 08)**

12. i. Explain the construction of variable reluctance stepper motor.
    ii. Explain the torque-speed characteristics of AC series motor. **(May 09, Feb 08)**

13. i. Explain the working principle of reluctance motor.
    ii. Compare working of AC series motor & Universal motor. **(Nov, Feb 08)**

14. With neat diagram explain the construction & working of variable reluctance step-per motor. Also explain its static & dynamic characteristics. **(Nov 08)**

15. With neat diagram explain the construction & working Universal motor. Explain its operation with the help of vector diagram. **(Feb 08)**

16. i. Neatly draw & explain the vector diagram of Universal motor. Give your observations.
    ii. How step angle for a given stepper motor is decided? Obtain the relation between step angle & rotor teeth. **(Feb 08)**

17. i. Compare AC series motor & Universal motor.
    ii. Compare variable reluctance stepper motor & permanent magnet stepper motor. **(Nov 07)**

18. i. Give the applications of various types of permanent magnet motors.
    ii. Explain the working principle of permanent magnet motors. **(Nov 07)**

19. i. Explain the static characteristics of stepper motor.
    ii. Explain the role of compound winding in the operation of AC series motor. **(Nov 07)**

20. Why are small fractional horse power ac series motors called universal motors? **(Feb 07, Nov 06, Mar 06, Nov 04)**

21. Explain the operating characteristics of AC series motor. **(Feb 07, May 05)**

22. Compare the constructional features of AC series motor with DC series motor. **(Nov, Feb 07, Nov 03)**

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23. What are the differences between AC and DC series motors? **(Nov 04)**

24. Explain the construction and operation of Universal motor. List out its merits and demerits. **(Nov 04, May 04)**

25. Explain the function of compensation winding in a.c. series motors. **(May 04)**

26. The resistance and total inductance of a single phase a.c. series motor are 36 ohms and 0.58H respectively. It draws 0.92 A current and runs at 2000 rpm when connected across 230 Volts D.C. supply. Calculate the speed and power factor when connected to 230V, 50 Hz a.c. supply, drawing the same current. **(May 04)**

27. What is the difference between conductively compensated series motor and an inductively compensated series motor. **(Jun 03)**

28. Compare the performance characteristics of AC series motor when it is connected across
    a. AC supply and b. DC Supply. **(Jun 03)**

29. Explain the design modifications necessary for satisfactory operation of a DC series motor from and AC supply. **(Nov 02)**

30. Write short notes on repulsion motor. **(Nov 02)**

31. Draw and explain vector diagram of a compensated single phase series motor. **(Nov 02)**

32. A 250V, 50 C/s universal motor has a total resistance of 30 ohms and total reactance of 160 ohms. Estimate the power factor when running at a speed of 1500 rpm and taking a current of 0.8 A. Find the speed when motor is connected to a 250V D.C. supply and loaded to a current of 0.8 A. **(Nov 02)**

33. Why are the compensating winding and interpole used in universal motor for a.c operation. Draw schematic connection diagram of all the stator windings and the armature for an a.c operated series motor. **(IES 96)**

34. Which one among the following the highest numerical value in a stepper motor ?
a. Detent torque b. Holding torque c. Dynamic torque d. Ripple torque **(IES 06)**

35. Describe a series (universal) motor. Give its cross-sectional view when connected to AC supply. Describe its performance characteristics? **(IES 95)**

36. A universal motor (ac operated) has a two pole armature with 960 conductors. At a certain load the motor speed is 5000rpm and the armature current is 4.6A. The armature terminal voltage and input are respectively 100V and 300 W. Compute the following, assuming an armature resistance of 3.5 ohms.
   i. Effective armature resistance
   ii. Maximum value of useful flux / pole. **(T1-Ch10)**

37. Obtain the circuit model and draw the phasor diagram for a.c. series motor. **(T1-Ch10)**

38. What are the different types of emfs induced in a.c. series motors ? Derive the necessary equations. **(T1-Ch10)**

39. Explain the torque-speed characteristics of reluctance motor. **(T1-Ch10)**

40. The resistance and total inductance of a single phase fractional horse power series motor are 30 ohms and 0.5 H respectively. It draws 0.8A current and runs at 2000 rpm, when connected to 250V D.C. supply. Calculate the speed and power factor when connected to 250V, 50Hz supply and loaded to take the same current. **(R7-Ch4)**

41.a) What is the reluctance torque? Draw the torque – speed curve of a reluctance motor.
List the some of the advantages of an ac series motor.
8. Explain the working principles and constructional details of the following motors:
a) Reluctance motor
b) b) Universal motor. [16]

Assignment Qestions.

UNIT-1

1. Whystationaryarmatureispreferredoverrotatingarmature?Givetheclassificationofalternatorsbased onrotorused.

2. A3-,4□pole,starconnectedalternatorhas72slotswithtwoconductorsperslot.Thepitchofthecoilhas 4slotslessthanthepolepitch.Thefluxperpoleis0.163wb.Calculatetheno-loadterminalvoltage,ifthe speedofthealternatoris1500rpm.

3. Explaintheconstructionofstatorofa3□-alternator?

4. A16pole3-□,alternatorhasastarconnectedwindingwith144slots&10conductorsperslot.Thefluxper poleis0.03wbdistributedsinusoidalyandthespeedis375RPM.Findthelinevoltage.

5. Explainthevariouswindingfactors?Explaintheeffectsofeachofthem. Determinetheslotdistribution andthepole phasegroupsequencefora45 slot, 6 pole,3-□winding.

UNIT-II

1. Explaintheoperationandeffectofloadpowerfactorontheperformanceofalternator. Theeffectiveresistanceofa2200V,50Hz,440kVA,singlephasealternatoris0.5Ω.Onshortcircuit,afield currentof4Agivesthefullloadcurrent.TheEMFonopencircuitforthesamefieldcurrentis1160V.Find Synchronousimpedance,Synchronousreactanceand% regulationof0.6p.flagging

2. Explainthesourcesofharmonics.Whatarethevariouseffectsofharmonicsongeneratedemfinan alternator?
3. CalculatetheRMSvalueofEMFinducedperphaseofa10pole,3-phase,50Hz,alternatorwith2slotsper poleperphaseand4conductorsperslotintwolayers.Thecoilspanis150^{0}electrical.Thefluxperpole hasafundamentalcomponentof0.12wb&a20%ofthirdharmoniccomponent.

4 .Explainthecausesofharmonics?Explaintheconceptoffictitiouspoles.

5. A10pole,3-phase,50Hz,alternatorhas8slotsperpole&6conductorsperslot.Thewindingis7/8pitch. Thereare0.03wbenteringthearmaturefromeachnorthpole&thisfluxissinusoidalydistributedalong theairgap.Thestararmaturecoils areconnected inseries.Determine theopencircuitEMFofthe alternator.Findthebreadthfactorfor3rd&5thharmonics.

UNIT –III

1. i. Whatisvoltageregulation?Discussthesynchronous impedancemethodofcalculatingvoltageregula- tion.
   ii. A500V,50KVA,1-phasealternatorhasaneffectiveresistanceof0.2Ω,fieldcurrentof10Aproducesan armaturecurrentof200Aonshortcircuitandanemfof450Vonopencircuit.Calculate
   a.Synchronousimpedanceandreactance b.Full-loadregulationwith0.8p.f.lagging.

2. i. Explainthepotier-trianglemethodofdeterminingthevoltageregulationofanalternator.
   ii A3-phasestar-connectedalternatorisratedat1600KVAand13,5000V.Thearmatureeffectresistanceand synchronousreactanceperphaseare1.5Ωand30Ωrespectively.Calculatethepercentageregulationfor aloadof1280KWatp.fof
   a.0.8lagging b.unity c.0.8lead

3 .i. Whathappens tothevalueofsynchronousreactance ifairgapisincreased.
   ii. A30KVA,440V,50Hz,3-Phase,Star-connectedalternatorgavethefollowingtestdata:

FieldCurrent(A)	2	4	6	7	8	10	12	14

TerminalVoltage(V)	155	287	395	440	475	530	570	592
S.C.Current(A)	11	22	34	40	46	57	69	80

Resistancebetweenanytwoterminalsis0.3Ohms.Findtheregulationatfullload,0.8p.f.lagging, by MMFmethod

4. ExplainhowthePotiertrianglecanbedrawnwiththehelpofO.C.CandanytwopointsontheZ.P.fcurve andalsoexplainthePotierreactancemethodofdeterminingregulationofanalternator.

5. A2000KVA,11KV,3-phase,starconnectedalternatorhasaresistanceof0.3ohmandreactanceof5ohm perphaseItdeliversfull-loadcurrentat0.8laggingp.fatratedvoltage.Computetheterminalvoltagefor thesameexcitationandloadcurrentat0.8p.fleading.

UNIT-IV

1. Whatisaninfinitebus?Statethecharacteristicsofaninfinitebus.Whataretheoperatingcharacteristics ofanalternatorconnectedtoaninfinitebus?

2. Derivetheexpressionforloadsharingbetweenthedissimilaralternators.

3. i. Derivetheexpressionsforloadsharingbetweenthedissimilaralternators.
   ii. Calculatethesynchronizingtorqueforunitmechanicalangleofphasedisplacementfora5000KVA, 3-phasealternatorrunningat1500rpmwhenconnectedto6600volt.50Hz,bus-bars.Thearmaturehasa shortcircuitreactanceof15%.

4. Twosimilar6000V,3-ϕgeneratorsarerunninginparallelatconstantvoltageandfrequencybusbars.Each hasanequivalentresistanceandreactanceof0.05Ωand0.5Ω respectivelyandsuppliesonehalfofatotal loadof10000KWatalaggingpowerfactorof0.8,thetwomachinesbeingsimilarlyexcited,Iftheexcitation ofonemachineisadjusteduntilthearmaturecurrentis438Aandthesteamsupplytotheturbineremains unchanged,findthearmaturecurrent,theemfandthepowerfactoroftheotheralternator.

5 Twosinglephasealternatorsareconnectedinparallelandtheexcitationofeachmachineissuchasto generateanopencircuitemfof3500V.Thestatorwindingofeachmachinehasasynchronousreactance of30Ohmsandnegligibleresistance.Ifthereisaphasedisplacementof40electricaldegreesbetweenthe emf's.Calculate.
   i. The currentcirculatingbetweenthetwomachines.
   ii. Theterminalvoltageand
   iii. Thepowersuppliedfromonemachineto theother.

UNIT- V

1 Theinputtoa11kV,3-phasestarconnectedsynchronousmotoris60A.Theeectiveresistanceand synchronousreactanceperphaseare1and30.Findthepowersuppliedtothemotorandtheinducedemfforpower factorof0.8leading

2 i. Whataretheadvantagesanddisadvantagesofthesynchronousmotor?
   ii. ASynchronousmotortakes25kWfrom400Vsupplymains.Thesynchronousreactanceofthemotoris4. Find the powerfactoratwhichthemotorwouldoperatewhentheexcitingcurrentissoadjustedthat the generatedemfis500V.

3. Asynchronousmotorhasanequivalentarmaturereactanceof3.3OhmsTheexcitingcurrentinadjusted tosuchavaluethattheopencircuitemfis950V.Findthepfatwhichthemotoroperatewhenittakes80kW from800Vsupplyline.

4 .i. Writeshortnotesonthepowerfactorimprovement with synchronous motor?
   Ii A2300V,3-phase,starconnectedsynchronousmotorhasaresistanceof0.2perphaseandasynchronous

reactanceof2.2perphase.Themotorisoperatingat0.6powerfactorleadingwithalinecurrentof200A. Determinethe valueofgeneratedemfperphase.

5. Writeshortnoteson thefollowing.
   i. VandinvertedV curvesofsynchronousmotor.
   ii. Synchronouscondensorforpowerfactorimprovement.

UNIT VI

1. Whataretheusesofdamperwindingsinasynchronousmotor?

2. Whatcouldbethereasonsifasynchronous motorfailstostart?

3. Whatismeantbyhuntinginasynchronousmotor?

4. Showthat thecurrentlocusofasynchronousmotor developingconstantpowerisacircle.Determineits centerandradius

5. Explaintheexcitationcirclesofsynchronousmotor

UNIT VII

1 A220V,500W,50Hzseriesmotorhasatotalresistanceof2ohmandtotalreactanceof20ohm.Thefullload straylossesandspeedare40Wand500rpm.Determinethecurrenttakenbythemotorandpowerfactorat ratedload.

2. Drawtheslip-torquecharacteristicsofalltypesofsinglephaseinductionmotorsandcomparetheirmerits anddemerits

3. Whycannot a shaded polemotor bemadetorotate inthereversedirection?

4. i. Explaincapacitorsplitphasemotor.
   ii. A220V,4pole,50Hz,capacitorsplitphasemotorhasthefollowingimpedanceatstandstill.
   Auxiliarywindingra=3,xa=6
   Mainwindingrm=2,xm=5.
   Theresistanceoftherotorwindingwhenreferredtothemainstatorwindingis0.5.Assumingthenumber ofturnsofthemainwindingand Auxiliary windingareequal,estimatethestartingtorque,maximum startingtorqueandthecapacitancetobeinsertedtogetmaximumstartingtorque.

UNIT -VIII

1. ExplaintheprincipleofoperationofaA.C.seriesmotorwithneat sketch.

2. Describeconstructionalfeaturesandoperatingcharacteristicsofashadedpolesinglephaseinduction motorandmentionitsuses

3. Drawthediagramofashadedpolesinglephaseinductionmotorandexplainitsprincipleofoperation.

4. Describetheconstructionandworkingandusesofareluctancemotor.

5.i. CompareACseriesmotorandDCseriesmotor.Whataretheoperationaldifficultiesofeach?
   ii. Explain,howasteppermotorworkswithvariablereluctanceprinciple