Darbhanga College of Engineering

Darbhanga

Course File

Of

Electrical Machine-II

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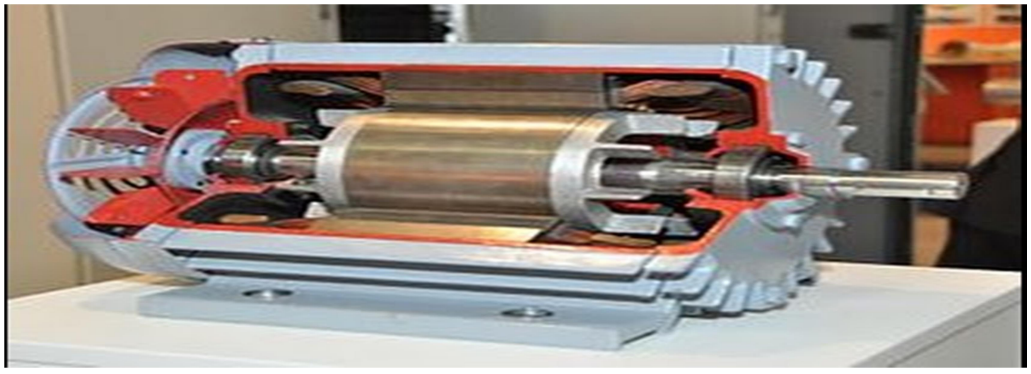


Course Co-ordinator
Prabhat Kumar
Asst. Prof.
EEE Dept., DCE Darbhanga

Vision of EEE: - To bring forth engineers with an emphasis on higher studies and a fervour to serve national and multinational organisations and, the society.

Mission of EEE: -

M1: - To provide domain knowledge with advanced pedagogical tools and applications.

M2: - To acquaint graduates to the latest technology and research through collaboration with industry and research institutes.

M3: - To instil skills related to professional growth and development.

M4: - To inculcate ethical valued in graduates through various social-cultural activities.

PEO of EEE

PEO 01 – The graduate will be able to apply the Electrical and Electrical Engineering concepts to excel in higher education and research and development.

PEO 02 – The graduate will be able to demonstrate the knowledge and skills to solve real life engineering problems and design electrical systems that are technically sound, economical and socially acceptable.

PEO 03 – The graduates will be able to showcase professional skills encapsulating team spirit, societal and ethical values.

PSO of EEE

PSO 01 Students will be able to identify, formulate and solve problems using various software and other tools in the areas of Automation, Control Systems, Power Engineering and PCB designing.

PSO 02 Students will be able to provide sustainable solutions to growing energy demands.

Course Outcomes

1. Understand the working principle construction and operation of synchronous machine, induction machine.
2. Explain different methods for calculation of voltage regulation of synchronous generator and torque speed characteristics of induction machines.
3. Select the speed control and starting method of induction motor.
4. Analyse phasor diagram at different power factor and various performance characteristics of synchronous machine.
5. Acquire knowledge about testing, performance parameter and application of synchronous machine and induction machines.

Institute/College Name:	Darbhanga College of Engineering
Program Name:	B.Tech (EEE, 4th semester)
Course Code:	PCC-EEE08
Course Name:	Electrical Machines-II
Lecture/Tutorial(per week):	3/0
Course Credits:	3
Course Co-coordinator Name:	Mr. Prabhat Kumar

1. Scope and Objective of Course

This course is designed to introduce the concepts and phenomenon of synchronous machine which explain different types and methods of excitation. Testing, armature reaction and voltage regulation gives information about practical way to understand machine efficiency. Students will also be familiarized with the parallel operation, curve and starting methods. It also imparts knowledge of single phase induction machine and its applications. It will give clear understanding of special motors to the student.

2. Textbooks

TB1: Electrical Machines by Fitzgerald A.E. & Kingsley: TMH
TB2: Electrical machines by Nagrath I.J. and Kothari D.P. TMH
TB3: Electrical Machines by P.S. Bimbra, Khanna Publication.

3. Reference Books

1. Electrical machines by Samarjit Ghosh, Pearson Education Pvt. Ltd.

Other readings and relevant websites

S. No.	Link of journals, Magazines, websites and Research papers
1.	https://www.youtube.com/watch?v=Qy6mA4TEpyI
2.	http://nptel.ac.in/courses/108105017/
3.	https://www.youtube.com/watch?v=b24jORRoxEc&t=2061s
4.	http://nptel.ac.in/courses/108106072/10
5	http://ieeexplore.ieee.org/document/8281954/
6	http://ieeexplore.ieee.org/search/searchresult.jsp?queryText=synchronous%20motor&searchWithin=induction%20motor

Course plan

Lecture No.	Date of Lecture	Topics	Web Links for Videos Lecture	Text Books/Reference books/Reading Materials	Page No. of Text Books
1-3		Synchronous Generator-Part-I Principle, construction and types of synchronous machines.	http://nptel.ac.in/courses/108106072/10	TB1	176-184
		Tutorial-1			
4-6		Synchronous Generator-Part-II Methods of excitation, Armature windings, EMF equation of Alternator.	http://nptel.ac.in/courses/108106072/11	TB1	200-212
		Tutorial-2			
7-9		Synchronous Generator-Part-III Testing(OC and SC test) Voltage regulation, Phasor diagram.	http://nptel.ac.in/courses/108106072/12	TB1	256-265
		Tutorial-3			
10-13		Two reaction Part-I Theory Modified Phasor diagram, Power angle characteristics Parallel operation	http://nptel.ac.in/courses/108106072/13	TB1	266-292
		Tutorial-4,			
14-18		Two reaction Part-II Effect of change of fuel supply and excitation on alternator connected to infinite bus, Cooling of synchronous Generator.	http://nptel.ac.in/courses/108106072/14	TB3	690-693
		Tutorial-5			
19-22		Synchronous Motor- Part I Principle of operation, equivalent circuit, effect of	http://nptel.ac.in/courses/108106072/15	TB3	559-661

		varying field current.			
		Tutorial-6			
		Synchronous Motor- Part II			
23-26		V-curves, Inverted V-curves, Phasor diagram, starting of synchronous motors, hunting application.	https://www.youtube.com/watch?v=b24jORRoxEc&t=2061s	TB3	633-637
		Tutorial-8			
		Single phase induction motors - Part I			
27-30		Introduction, Working principle, double revolving field theory, Equivalent circuit.	http://nptel.ac.in/courses/108106072/3	TB3	730-736
		Tutorial-7			
		Single phase induction motors- Part II			
31-34		Starting method and Types of single phase Induction motors, Applications.	http://nptel.ac.in/courses/108106072/8	TB1	189-223
		Tutorial-9			
35-37		Special motors- Part-I Single phase synchronous motors, Two phase AC Servo Motor	https://www.youtube.com/watch?v=Qy6mA4TEpyI	TB1	437-463
		Tutorial-10			
38-42		Special motors - Part-II Single phase series (universal) motor, stepper motor, Permanent magnet DC motor, etc, Applications.	https://www.youtube.com/watch?v=dZyO5gcWP-o	TB1	385-397
		Tutorial-11			

Syllabus

Topics	No. of Lectures	Weightages

Synchronous Generator: Principle, construction and types of synchronous machines, Methods of excitation, Armature windings, EMF equation of Alternator, Armature reaction, testing (OC and SC test) Voltage regulation, Phasor diagram.	9	21.5%
Two reaction: Theory Modified Phasor diagram, Power angle characteristics, Parallel operation. Effect of change of fuel supply and excitation on alternator connected to infinite bus, Cooling of synchronous Generator.	9	21.5%
Synchronous Motor: Principle of operation, equivalent circuit, effect of varying field current. V-curves, Inverted V-curves, Phasor diagram, starting of synchronous motors, hunting application.	8	19%
Single phase induction motors: Introduction, Working principle, double revolving field theory , Equivalent circuit, Starting method and Types of single phase Induction motors, Applications.	8	19%
Special motors: Single phase synchronous motors, Two phase AC Servo Motor, single phase series (universal) motor, stepper motor, Permanent magnet DC motor, etc, Applications.	8	19%

This document is approved by

Designation	Name	Signature
Course Coordinator	Mr. Prabhat Kumar	
H.O.D	Mr. Prabhat Kumar	
Principal	Prof. (Dr.) Achintya	
Date		

Evaluation and Examination Blue Prints:

Internal assessment is done through quiz tests, presentations, assignments and projects work. Two sets of question paper are asked from each faculty and out of these two, without the knowledge of faculty, one question paper is choose for the concerned examination. Examination rules and regulations are uploaded on the student's portals. Evaluation is a very transparent process and the answer sheets of sessional tests, internal assessment assignments are returned back to the students.

The components of evaluation along with their weightage followed by the university are given below:

Component-1	Sessional test-1	20%
Component-2	Assignments, Quiz's, Test, Seminars	10%

Component-3	End Term Examination	70%
Total		100%

Electrical machine-II
Assignment I

1. A synchronous motor is connected to an infinite bus at 1.0 pu voltage and draws 0.6 pu current at unity power factor. Its synchronous reactance is 1.0 pu resistance is negligible.The excitation voltage (E) and load angle (δ) will respectively be _____
2. Explain principle of synchronous machine.
3. Explain double revolving field theory of induction machine.
4. A three-phase, three-stack, variable reluctance step motor has 20 poles on each rotor and stator stack. The step angle of this step motor is ____.
5. A three phase squirrel cage induction motor has a starting current of seven times the full load current and full load slip of 5% If a star-delta starter is used to start this induction motor, the per unit starting torque will be ____
6. Explain principle of operation of induction machine.
7. Explain starting method of induction machine.

Electrical machine-II
Assignment II

1) Differentiate V curve and inverted V curve.
2) Describe briefly about application single phase of induction machine.
3) Explain power angle characteristics and parallel operation of synchronous machine
4) Define universal motor, stepper motor and permanent magnet dc motor with diagram.
5) Derive equation of EMF of three phase synchronous machine.
6) A synchronous motor is connected to an infinite bus at 1.0pu voltage and draws 0.6pu current at unity power factor. Its synchronous reactance is 1.0pu resistance is negligible. Keeping the excitation voltage same, the load on the motor is increased such that the motor current increases by 20%. What is the operating power factor?
7) A 100 kVA, 415V (line), star-connected synchronous machine generates rated open circuit voltage of 415 V at a field current of 15 A. The short circuit armature

current at a field current of 10 A is equal to the rated armature current. What is per unit saturated synchronous reactance.

Electrical machine-II
Assignment III

1. A 3 phase alternator wound with a 60 degree phase spread armature windings and develops 300 KVA. If the armature windings is reconnected utilizing all coils for single phase operation with a phase spread of 180 degree. What is the new rating of the machine?

2. A three-phase, 50 Hz salient-pole synchronous motor has a per-phase direct-axis reactance (X_d) of 0.8 pu and a per-phase quadrature-axis reactance (X_q) of 0.6 pu. Resistance of the machine is negligible. It is drawing full-load current at 0.8 pf (leading). When the terminal voltage is 1 pu,per-phase induced voltage, in pu, is _____.

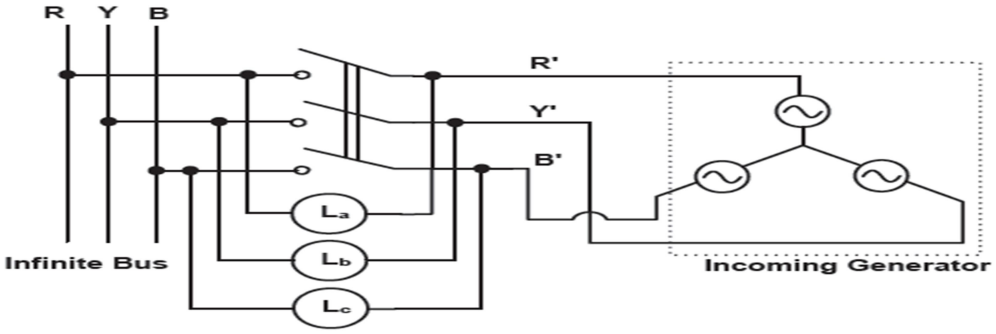
3. A 3-phase 50 Hz square wave (6-step) VSI feeds a 3-phase, 4 pole induction motor. The VSI line voltage has a dominant 5^{th} harmonic component. If the operating slip of the motor with respect to fundamental component voltage is 0.04, the slip of the motor with respect to 5^{th} harmonic component of voltage is _____..

4. A star connected 400 V, 50 Hz, 4 pole synchronous machine gave the following open circuit and short circuit test results:
Open circuit test: V_{oc} = 400 V (rms, line-to-line) at field current, I_f = 2.3 A
Short circuit test: I_{sc} = 10 A (rms, phase) at field current, I_f = 1.5 A The value of per phase synchronous impedance in Ω at rated voltage is _____.

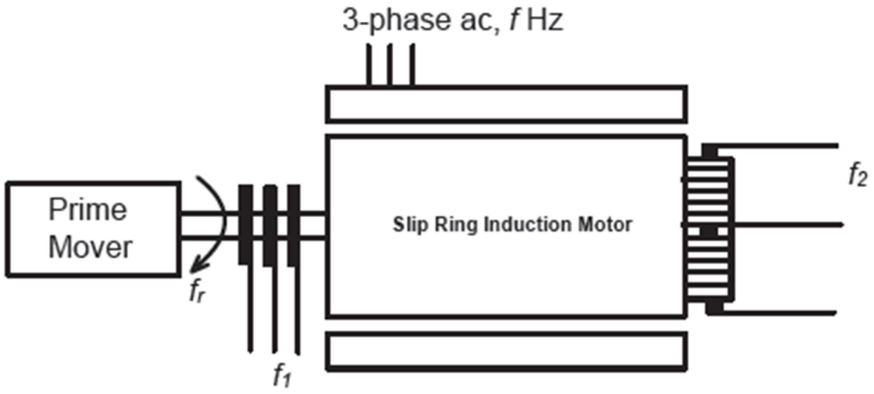
5. A 3 phase, 50 Hz, six pole induction motor has a rotor resistance of 0.1 Ω and reactance of 0.92 Ω. Neglect the voltage drop in stator and assume that the rotor resistance is constant. Given that the full load slip is 3%, what is the ratio of maximum torque to full load torque?

6. A three phase synchronous generator is to be connected to the infinite bus. The lamps are connected as shown in the figure for the synchronization. The phase sequence of bus voltage is R-Y-B and that of incoming generator voltage is R'-Y'-B'.

7. It was found that the lamps are becoming dark in the sequence L_a-L_b-L_c. What is the phase sequence of incoming generator?



8. A three-phase slip-ring induction motor, provided with a commutator winding, is shown in the figure. The motor rotates in clockwise direction when the rotor windings are closed.



If the rotor winding is open circuited and the system is made to run at rotational speed f_r with the help of prime-mover in anti-clockwise direction, then the frequency of voltage across slip rings is f_1 and frequency of voltage across commutator brushes is f_2. The values of f_1 and f_2 respectively are _____.

Electrical machine-II
Tutorial-1

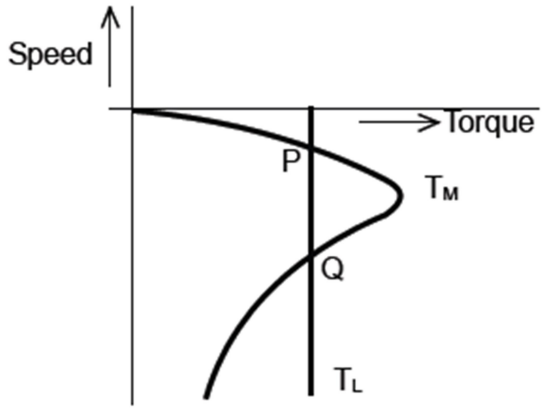
1. A 20-pole alternator is having 180 identical stator slots with 6 conductors in each slot. All the coils of a phase are in series. If the coils are connected to realize single-phase winding, the generated voltage is V_1. If the coils are reconnected to realize three-phase star-connected winding, the generated phase voltage is V_2. Assuming full pitch, single-layer winding, the ratio V_1/V_2 is _____.

2. A synchronous generator is connected to an infinite bus with excitation voltage E_f = 1.3 pu. The generator has a synchronous reactance of 1.1 pu and is delivering real power (P) of 0.6 pu to the bus. Assume the infinite bus voltage to be 1.0 pu. Neglect

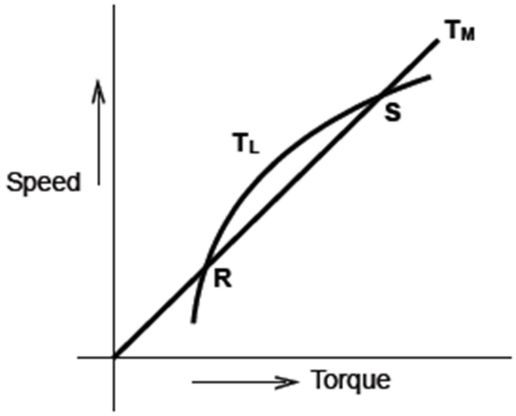
stator resistance. The reactive power (Q) in pu supplied by the generator to the bus under this condition is _____.

Tutorial-2

3. The torque-speed characteristics of motor (T_M) and load (T_L) for two cases are shown in the figures (a) and (b). The load torque is equal to motor torque at points P, Q, R and S



(a)



(b)

4.

5. The stable operating points are_____.

6. A non-salient pole synchronous generator having synchronous reactance of 0.8 pu is supplying 1 pu power to a unity power factor load at a terminal voltage of 1.1 pu. Neglecting the armature resistance, the angle of the voltage behind the synchronous reactance with respect to the angle of the terminal voltage in degrees is _____.

7. A 4-pole induction motor, supplied by a slightly unbalanced three-phase 50 Hz source, is rotating at 1440 rpm. The electrical frequency in Hz of the induced negative sequence currents in the rotor are _____.

Electrical machine-II

Tutorial-3

1. The slip of an induction motor normally does not depend on_____.

2. The locked rotor current in a 3-phase, star connected 15 kW, 4-pole, 230 V, 50 Hz induction motor at rated conditions is 50 A. Neglecting losses and magnetizing current, the approximate locked rotor line current drawn when the motor is connected to a 236 V, 57 Hz supply is_____.

3. A three phase, salient pole synchronous motor is connected to an infinite bus. It is

operated at no load a normal excitation. The field excitation of the motor is first reduced to zero and then increased in reverse direction gradually. Then the armature current is _____.

Tutorial-4

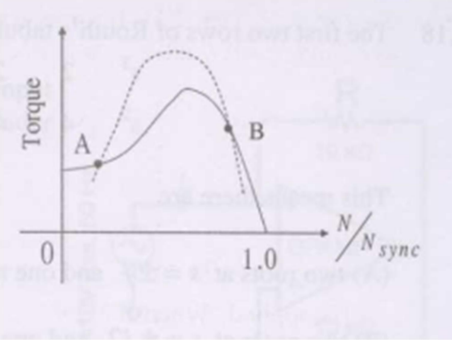
4. A three-phase 440 V, 6 poles, 50 Hz, squirrel cage induction motor is running at a slip of 5%. The speed of stator magnetic field to rotor magnetic field and speed of rotor with respect of stator magnetic field are _____.

5. The direct axis and quadrature axis reactance of a salient pole alternator are 1.2p.u and 1.0 p.u respectively. The armature resistance is negligible. If this alternator are delivering rated kVA at upf and at rated voltage then its power angle are _____.

6. A field excitation of 20 A in a certain alternator results in an armature current of 400A in short circuit and a terminal voltage of 2000V on open circuit. The magnitude of the internal voltage drop within the machine at a load current of 200A is _____.

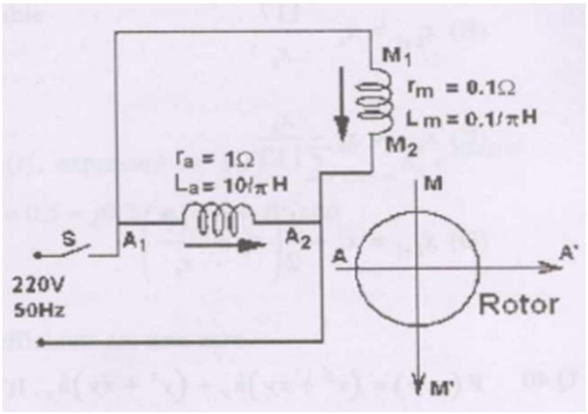
Tutorial-5

7. A 3-phase squirrel cage induction motor supplied from a balanced 3-phase source drives a mechanical load. The torque-speed characteristics of the motor (solid curve) and of the load (dotted curve) are shown. Of the two equilibrium points A and B, which of the following options correctly describes the stability of A and B?



Tutorial-6

8. A 220V, 50Hz, single-phase induction motor has the following connection diagram and winding orientations shown. *MM′* is the axis of the main stator winding (M_1M_2) and *AA′* is that of the auxiliary winding (A_1A_2). Directions of the winding axes indicate direction of flux when currents in the windings are in the directions shown. Parameters of each winding are indicated. When switch *S* are closed, the motor _____.



9. In a stepper motor, the detent torque means _____.

10. A 230 V, 50 Hz, 4-pole, single-phase induction motor is rotating in the clockwise (forward) direction at a speed of 1425 rpm. If the rotor resistance at standstill is 7.8 Ω, then the effective rotor resistance in the backward branch of the equivalent circuit will be