



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Electrical Engineering

Subject Code: BE04009011

Subject Name: Electrical Machines-II

w. e. f. Academic Year:	2025-26
Semester:	2 nd Year/4 th Sem
Category of the Course:	PCC

Prerequisite:	Basics of Electrical Engineering, Electrical Machine I
Rationale:	The Electrical Machines II course provides in-depth knowledge of DC machines, synchronous machines, and special machines , essential for understanding their construction, operation, and performance characteristics. It equips students with analytical and practical skills for machine selection, performance evaluation, and industrial applications . The subject also integrates modern motor technologies like BLDC, PMSM, and SRM , preparing students for advancements in electric drives and automation.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Recall the fundamental concepts, construction, and operating principles of DC machines, synchronous machines, and special machines. <i>(Cognitive Level: Remember - R)</i>
02	Illustrate the working principles, characteristics, and applications of DC generators, DC motors, synchronous generators, and synchronous motors. <i>(Cognitive Level: Understand - U)</i>
03	Analyze the performance characteristics, armature reaction, voltage regulation, and power output of synchronous machines under different operating conditions. <i>(Cognitive Level: Analyze - N)</i>
04	Compare the construction, control methods, and applications of special electrical machines such as PMDC, BLDC, PMSM, Stepper, SRM, and Servo motors. <i>(Cognitive Level: Apply - A)</i>
05	Evaluate the efficiency, speed control methods, and suitability of different electrical machines for industrial applications. <i>(Cognitive Level: Evaluate - E)</i>

Teaching and Examination Scheme:

Teaching-Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	TH		Theory		Tutorial / Practical			
						ESE (E)	PA (M)	PA (I)	PBL (I)	ESE (V)	
45	0	30	45	120	4	70	30	20	30	50	200



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- Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	DC Machines: Construction and Working: Basic construction and operating principles. DC Generator: Induced EMF equation, field excitation types (separately excited, shunt, series), voltage build-up in a shunt generator, critical field resistance, and speed. DC Motor: Back EMF and torque equations, armature circuit equation, field excitation types, performance characteristics, and speed control methods. Losses and Efficiency: Overview of losses and efficiency considerations.	10	20
2.	Synchronous machines: Constructional Details, Working Principle, Types of rotor (cylindrical and salient pole), Rotating Magnetic Field, EMF equation, Armature winding (Effect of distribution factor, pitch factor). Armature Reaction, its effects and remedies.	05	15
3	Synchronous Generator (Alternator): Equivalent circuit & Phasor diagram of synchronous machine as generator in different load conditions (R, L, C), Armature reaction and its compensation, Power output equation. SCR and its effects, Voltage Regulation, Methods to find voltage regulation: Synchronous impedance method, MMF method, ZPF method, Operating characteristics of synchronous machines, Effects of harmonics on induced emf, Salient pole machine – two reaction theory, power angle characteristics, Sudden short circuit and unbalance conditions, Hunting, Losses and efficiency, Parallel Operation and Synchronization, Operation on load & infinite bus, Synchronous Generator capability characteristics	15	30
4.	Synchronous motors: Expression for torque, Phasor diagram of Synchronous motor, Starting methods of synchronous motor, Speed regulation, Effect of excitation, Losses and efficiency of motor, Application of synchronous motor as phase modifier and synchronous	06	15



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	condensers. V-curves of Synchronous motors, Power developed by Synchronous motor and stability, Power stages		
5.	Special machines: Permanent Magnet DC Motor (PMDC): Construction, working, and applications. Brushless DC Motor (BLDC): Construction, working principle, control techniques, and applications. Permanent Magnet Synchronous Machine (PMSM): Types (SPMSM, IPMSM), operation, and applications. Stepper Motor: Types (Variable reluctance, Permanent Magnet, Hybrid), working principle, and applications. Switched Reluctance Motor (SRM): Construction, working, and applications. Servo Motor: AC & DC servo motors, working, and industrial applications.	09	20
	Total	45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	20	20	20	20	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

- 1) E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
- 2) I J Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
- 3) J B Gupta, "Theory and Performance of Electrical Machines", Katson Publication, 2009.
- 4) B L Theraja, "Electrical Technology – Part II", S Chand Publications, 2011
- 5) M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
- 6) P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
- 7) G C Garg, "Electrical machines – II", Khanna Publishers,
- 8) S K Sen, "Principle of Electrical Machine Design with Computer Programs" Oxford & IBH
- 9) R. Krishnan, "Permanent Magnet Synchronous and Brushless DC Motor Drives" by CRC Press, Taylor & Fransis Grp

Suggested Course Practical List:

w.e.f. 2025-26

<https://syllabus.gtu.ac.in/>

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- 1) To obtain Magnetizing Characteristics, Internal & External Characteristic of Self Excited DC Shunt Generator. Also obtain the critical field resistance of the machine from magnetizing Characteristics.
- 2) Speed control of DC Shunt Motor using a) Armature control and b) field control methods.
- 3) To obtain Speed-Torque characteristics of DC Series Motor and DC Shunt Motor.
- 4) To determine the various losses in a D.C. machine and separation of its core losses.
- 5) To find out the voltage regulation of three phase alternator using direct load test.
- 6) To perform open circuit, short circuit and resistance measurement tests on alternator to find out its voltage regulation using synchronous impedance method and MMF method.
- 7) To perform open circuit, short circuit, zero power factor and resistance measurement tests on alternator to find out its voltage regulation using ZPF method.
- 8) To perform synchronization of two 3 phase Alternators.
- 9) To obtain direct axis and quadrature axis reactance of salient pole synchronous machine using slip test.
- 10) To plot V curves and inverted V curves of Synchronous Motor.
- 11) To perform Step Angle and Position Control of Stepper Motor and Switched Reluctance Motor (SRM)
- 12) Performance Analysis of Brushless DC Motor (BLDC) and Permanent Magnet Synchronous Machine (PMSM)

Open-Source Simulation Software

1. Scilab – MATLAB alternative for numerical computations and control simulations.
2. Octave – Open-source alternative to MATLAB, useful for control system analysis.
3. PSIM (Student Version) – Used for power electronics and motor drive simulations.
4. LTspice – Free circuit simulation tool useful for modeling electrical machines.
5. OpenModelica – Open-source simulation software for electrical and mechanical systems.

Websites for Self-Learning

1. NPTEL (<https://nptel.ac.in/>) – Free online courses on Electrical Machines by IIT professors.
2. MIT OpenCourseWare (<https://ocw.mit.edu/>) – Courses related to electrical machines and power electronics.
3. ALL ABOUT CIRCUITS (<https://www.allaboutcircuits.com/>) – Tutorials and interactive content on motors and power electronics.
4. Electrical4U (<https://www.electrical4u.com/>) – Conceptual explanations of electrical machines.
5. Texas Instruments (<https://www.ti.com/>) – Application notes on motor control techniques.
6. IEEE Xplore (<https://ieeexplore.ieee.org/>) – Research papers and white papers on machine advancements.

Interactive Learning Platforms

1. CircuitVerse (<https://circuitverse.org/>) – Online circuit simulation for basic DC motor concepts.
2. SimulIDE (<https://simulide.com/>) – Open-source electronics and motor simulation tool.
3. Khan Academy (<https://www.khanacademy.org/>) – Basic electrical engineering concepts.
4. edX & Coursera – Various free electrical engineering courses from top universities.



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List of Laboratory Resources Required:

1. DC Machines Laboratory Equipment

- ◆ DC Shunt Generator Setup (With excitation control & load bank)
- ◆ DC Shunt Motor with Speed Control Unit (Armature & field control)
- ◆ DC Series Motor with Load Setup (For torque-speed characteristics)
- ◆ DC Machine Loss Measurement Setup (For loss separation test)
- ◆ Rheostats (For field control and load variation)
- ◆ Tachometer (Digital/Analog) (For speed measurement)
- ◆ Load Banks (Resistive & Inductive loads for testing)
- ◆ Ammeter, Voltmeter, Wattmeter (Digital/Analog)

2. Synchronous Machines Laboratory Equipment

- ◆ Three-Phase Alternator Test Setup (With direct load and regulation test)
- ◆ Synchronizing Panel (For alternator synchronization)
- ◆ Slip Test Setup (For measuring X_d and X_q)
- ◆ Zero Power Factor (ZPF) Test Setup
- ◆ Synchronous Motor with V-Curve Measurement Unit
- ◆ Digital Power Analyzer (For efficiency and performance analysis)

3. Special Machines Laboratory Equipment

- ◆ Stepper Motor Trainer Kit (With Position & Step Angle Control)
- ◆ Switched Reluctance Motor (SRM) Trainer
- ◆ Brushless DC (BLDC) Motor Drive with Hall Sensor Feedback
- ◆ Permanent Magnet Synchronous Motor (PMSM) Test Setup
- ◆ Servo Motor Trainer Kit (Both AC & DC Servo Motor)
- ◆ Microcontroller/DSP-Based Motor Control Unit (For BLDC, PMSM, and SRM)

4. Measurement and Control Equipment

- ◆ Oscilloscope (DSO) (For waveform analysis in BLDC/PMSM control)
- ◆ Multimeters (Digital & Analog)
- ◆ Clamp Meter (For current measurement in motors)
- ◆ Power Quality Analyzer (For harmonic analysis)
- ◆ Torque Sensor & Dynamometer (For motor efficiency testing)

List of suggested activities for Problem Based Learning:

Sl.No.	Activity	Suggested Hours	Evaluation Criteria
1	Industry/Research Laboratory Visit (e.g., manufacturing plant for DC/Synchronous/Special Machines, or motor control R&D lab)	Visit = 5h, Report = 5h, Total = 10h	Report with observations, drawings, calculations based on actual data from visit



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2	Technical Video-based Learning (NPTEL, IEEE, All About Circuits – topics like Alternator testing, BLDC control)	Video = 5h, Report = 5h, Total = 10h	Summary/presentation of learning outcomes
3	Numerical Assignments (voltage regulation, torque-speed curves, slip test calculations)	5 × 2h = 10h	Accuracy and clarity of solved assignments
4	Simulation/Coding Tasks in MATLAB/Scilab/PSIM/Open Modelica (e.g., simulate alternator phasor diagram, BLDC control, PMSM torque profile)	5 × 2h = 10h	Simulation results, code documentation, correctness
5	Online Certification Course (minimum 10h) on Electrical Machines, Motor Control (Coursera, edX, NPTEL)	10h	Based on certificate and performance in course quiz
6	Complex Problem Solving (e.g., performance analysis of an alternator under varying loads, harmonics impact on PMSM)	2 × 5h = 10h	Depth of analysis, correctness of solution
7	Industrial Safety Video Learning (motor installation safety, alternator maintenance)	Video = 5h, Report = 5h, Total = 10h	Safety-focused quiz/report
8	Research Paper Discussion (recent IEEE papers on BLDC/PMSM/Synchronous motor applications)	5 papers × 4h = 20h	Summary and critical analysis
9	Poster/Chart/PPT on topics like 'Synchronization of Alternators' or 'BLDC Control Methods'	6h	Quality, technical content, presentation
10	Working/Non-working Model (Stepper Motor position control, SRM drive model)	Working = 12h, Non-working = 8h	Functionality/demo, innovation
11	Industrial Exposure (2–3 days) – Study & propose solutions for motor performance improvement or fault reduction	Visit = 15h, Problem-solving = 5h, Total = 20h	Evaluation of proposed solutions
12	Group Discussion on emerging trends (e.g., EV drives, high-efficiency motors)	1h each	Depth of knowledge, contribution
13	Case Study – Analysis of real-world motor failure or alternator synchronization issues	Data collection = 5h, Report = 5h, Total = 10h	Data quality, analysis depth
14	Application/Software Development (e.g., motor sizing calculator, alternator performance estimator)	10h	Complexity, accuracy, usability



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15	Technical Article/Blog Writing on Electrical Machines-II topics	Research = 6h, Writing = 4h, Total = 10h	Originality, clarity, references
16	Annotated Video Explanation of a machine concept (e.g., slip test procedure)	10h	Accuracy, clarity, presentation
17	Online Technical Quizzes/Simulations (GTU/NPTEL, industry quizzes)	10h	Quiz scores and reflection
18	Tech Blog/YouTube Channel Curation – Collect and review top resources on synchronous and special machines	10h	Summary report on curated content
19	Patent Search & Innovation Gap Analysis (e.g., BLDC drive control patents)	10h	Number of patents reviewed, novelty of identified gaps
20	Maintenance/Troubleshooting Logbook – Record & resolve lab equipment faults	10h	Completeness and quality of documentation

Note:

- All the suggested activities should be related to the subject.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
- Rubrics for the evaluation can be prepared by the faculty.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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