



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Mechatronics Engineering

Subject Code: DI05020031

Subject Name: AC & DC Machines

W.e.f. Academic Year:	2026-27
Semester:	5 th
Category of the Course:	PEC - 04

Prerequisite	Students should have basic knowledge of Electrical circuits and machines, Fundamental concepts of electromagnetism, Basic electronics and microcontrollers
Rationale	Mechatronics is a field of engineering which mainly encompasses uses and control of electric motors for the applications of CNC machines, robotics, drones, and quad-copter and electric vehicles having sensors for smart technology. Electric motors have been used since the inception of their invention. However, the requirement of smart sensor-based technology entails precise and smooth control of electric motors using advance and fast microcontrollers. This severely imposes strict requirements on control of electric motor. This course will enable the students to develop skills to select, operate and smartly control electric motors using advance microcontroller and electronic circuitry. Practical features of the course will make the students capable of operating various electric motors. Consequently, the students will become familiar with working, specifications and applications of DC motor, BLDC motor, induction motor, servo motor and stepper motor.

Course Outcome:

The practical exercises, the underpinning knowledge, and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following Cos.

CO No.	Course Outcomes	RBT Level
01	Control speed of DC Motor by appropriate method.	A
02	Control BLDC motor using appropriate driver circuit and microcontroller.	A
03	Run three-phase induction motor using appropriate starter and control its speed.	A
04	Control stepper motor using appropriate driver circuit and microcontroller.	A
05	Control servo motor using appropriate driver circuit and microcontroller.	A

**Revised Bloom's Taxonomy (RBT)*



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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial/ Practical		
				ESE (E)	PA(M)	PA(I)	ESE(V)	
3	0	2	4	70	30	20	30	150

Legends: L-Lecture; T- Tutorial/Teacher Guided Theory Practice; PR-Practical; C – Credit, PA – progressive Assessment; ESE -End Semester Examination.

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
01: DC Motor	- Working principle of DC Motor. - Construction of DC Motor. - Types of DC Motors. - Torque-Armature current and Torque Speed Characteristics of DC Motors. - Speed Control of DC Motor. - Armature and field control. - Specifications and Applications of DC Motors. - Construction of Permanent Magnet DC (PMDC) Motor. - Applications of PMDC Motor.	08	19 %
02: Brushless DC Motor	- Construction and working of Brushless DC (BLDC) motor. - Types of Brushless DC (BLDC) Motors - Based on Design – In-runner Brushless DC Motor,	06	12 %



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	Out-runner Brushless DC Motor. • Based on Use of Sensor – Sensored BLDC Motor, Sensor less BLDC Motor. • Based on No of Poles – Single Pole BLDC Motor, Multi Pole BLDC Motor. • BLDC motor control using driver circuit and microcontroller. Advantages of BLDC motor over brushed DC motor for electric vehicle applications. • Specifications and applications of BLDC motor.		
03: Induction Motor	• Construction of polyphase Induction Motor (IM), its types - Squirrel Cage Induction Motor (SCIM) and Wound Rotor Induction Motor (WRIM) / Slip Ring Induction Motor. • Rotating magnetic field and working principle of polyphase IM. • Relation between synchronous speed and supply frequency, slip, torque-slip curve, starting torque, running torque and condition for maximum torque. • Necessity of starter in polyphase IM. Types of starters – Direct Online (DOL), star-delta, autotransformer type and rotor resistance starter. • Methods of speed control of SCIM (Squirrel Cage IM) and WRIM (Wound Rotor IM). • Applications and Specifications of polyphase induction motors. • Types of Single-Phase Induction Motor (SPIM). • Principle and working of	18	43 %



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	• Split Phase SPIM, • Resistance Start SPIM , • Capacitor Start SPIM, • Capacitor Start & Capacitor Run SPIM • Shaded Pole Induction Motor, • Fractional Horse Power (FHP) induction motor. • Applications and Specifications of single phase induction motors.		
04: Servo Motor	• Working principle and mechanism of servo motor. • Types of servo motor. • DC Servo motor – Series motor, Split Series Motor, Shunt control motor, Permanent magnet servo motor. • AC Servo Motor – Positional Servo Motor, Continuous rotation servo motor, Linear servo motor. • Servo motor control using driver circuit and microcontroller. • Advantages and disadvantages of servo motor. • Specifications and applications of servo motor.	06	12 %
05: Stepper Motor	• Construction and working of stepper motor. • Types of stepper motor • Permanent magnet stepper motor. • Hybrid Synchronous stepper motor. • Variable reluctance stepper motor.	07	14 %



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	- Torque equation and characteristics of stepper motor. - Stepper motor control using driver circuit and microcontroller. - Comparison of stepper motor and servo motor. - Specifications and application of stepper motors.		
	Total	45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
25%	35 %	40 %	-	-	-

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

References/Suggested Learning Resources:

(a) Books:

1.	Author: B. L. Theraja & A.K. Theraja, Title of Book: A textbook of Electrical Technology Volume-II., Publication : S. Chand and Co., New Delhi, 23rd or Latest edition (ISBN : 9788121924405)
2.	Author: Dr. P.S. Bimbhra, Title of Book: Electrical Machinery, Publication: Khanna Publication. New Delhi ISBN: 9788174091734
3.	Author: Padmaraja Yedamale, Microchip Technology Inc., Title of Book: Brushless DC (BLDC) Fundamentals (AN885), Publication : Available: https://www.microchip.com/en-us/application/notes/an885
4.	Author: V. V. Athani Title of Book Stepper Motors: Applications and Design., Publication New Age International Pvt. Ltd.



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(b) Learning Websites & Web-Portals:

Sr. No.	Web-Link of Websites/Web-Portal	Description
1.	https://onlinecourses.nptel.ac.in/noc22_me59/previous	Induction motor fundamentals and applications
2.	https://nptel.ac.in/courses/108102156	Electrical machines (DC & Induction motors theory)
3.	https://archive.nptel.ac.in/courses/108/105/108105155/	DC motor working and characteristics
4.	https://archive.nptel.ac.in/courses/108/105/108105131/	Induction motor operation and performance
5.	https://archive.nptel.ac.in/courses/108/105/108105062/	Three-phase induction motor concepts
6.	https://www.digimat.in/nptel/courses/video/112105211/L07.html	Detailed lecture on induction motor
7.	https://circuitdigest.com/microcontroller-projects/what-is-bldc-motor-and-arduino-bldc-motor-control	BLDC motor control using Arduino
8.	https://www.embitel.com/blog/embedded-blog/motor-control-system-for-bldc-motors-in-automotive-application	BLDC motor applications in electric vehicles
9.	https://robu.in/brushed-dc-motor-working-principle-construction-applications/	DC motor construction and applications
10.	https://components101.com/motors/servo-motor-basics-pinout-datasheet	Servo motor basics and specifications
11.	https://www.allaboutcircuits.com/projects/servo-motor-control-with-an-arduino/	Servo motor control using Arduino
12.	https://docs.arduino.cc/learn/electronics/stepper-motors	Stepper motor working and interfacing
13.	https://electricvehicles.in/types-of-motors-used-in-evs-and-why-bldc-motors-are-widely-used/	Motors used in EVs (focus on BLDC)



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Suggested Course Practical List:

The following Practical Outcomes (PrOs) are the sub-components of the Course Outcomes (COs). Some of the PrOs marked ‘*’ are compulsory, as they are crucial for that particular CO at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.

Sr. no.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
01	Demonstrate the construction and parts of DC motor.	1	2*
02	Perform the DC motor speed control using electronic devices.	1	2*
03	Control the speed of BLDC motor using appropriate driver circuit and Arduino microcontroller.	2	4*
04	Identify the various parts of the three-phase induction motor.	3	2*
05	Measure the slip of three-phase induction motor by using tachometer and by stroboscopic method.	3	2*
06	Make connections of DOL and star-delta starters for appropriate three-phase squirrel cage induction motor.	3	2*
07	Perform speed control of three-phase induction motor by 1. By changing the supply voltage 2. By changing the applied frequency	3	4*
08	Perform speed control of three-phase wound rotor/slip-ring induction motor by rotor rheostat control.	3	2
09	Test the circuit of capacitor start capacitor run single-phase induction motor used in a ceiling fan.	3	2*
10	Perform shaft position control of servo motor by interfacing it with Arduino microcontroller board.	3	4*
11	Perform control of stepper motor by interfacing it with driver circuit and Arduino microcontroller board.	4	4*
Total Hrs.		-	28

Note:

- I. Additional practical exercises may be designed and conducted by the respective course teacher to enhance **industry-relevant skills and learning outcomes** in alignment with the Course Outcomes (COs). The equipment and activities listed above are **indicative in nature** and not exhaustive.



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- II. While assigning and evaluating the **Second-Year Study Report**, due care must be taken to ensure proper academic rigor. The study report—including **data collection and analysis**—should be carried out in **groups**.

The course teacher must guide students by clearly explaining:

- **Type of data to be collected (what data)**
- **Purpose and relevance of data (why it is required)**

This guidance should be provided **before initiating the market survey or study activity**.

Further, the study report and practical exercises should focus on developing both:

- **Process-related skills**, and
- **Product-related skills**

These skills are embedded within the Course Outcomes (COs) and contribute toward achieving the **overall competency of the course**. Additional skills may be included or modified based on course requirements.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
Experimentation/performance type PrOs (PrOs Number: 2, 3, 4, 5, 6, 7, 8, 9, 10 & 11)		
1	Knowledge	30
2	Quality of Report	30
3	Participation	20
4	Punctuality	20
Total		100
For Demonstration type PrOs (PrOs Number: 1 & 12)		
1	Knowledge	20
2	Procedure follows	30
3	Observation Skill	20
4	Conclusion/ Summary	10
5	Quality of Report	10
6	Punctuality	10
Total		100



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Experimentation/performance type PrOs (PrOs number 2,3,4,5,6,7,8,9,10 & 11)					
Criteria	Weightage (%)	10 (Excellent)	9–8 (Good)	7–6 (Average)	5 (Poor)
Demonstration type PrOs (PrOs Number 1 &12)					
Criteria	Weightage (%)	10 (Excellent)	9–8 (Good)	7–6 (Average)	5 (Poor)
Knowledge	30%	Students give correct answers 90% or more	Students give correct answers between 70–89%	Students give correct answers between 50–69%	Students give correct answers less than 50%
Quality of Report	30%	Neat handwriting, proper figures and tables, complete labeling	Only formatting is not proper (location of figures/tables, use of pencil and scale)	Few required elements (labeling/notations) are missing	Several required elements (content, figures, tables) are missing
Participation	25%	Excellent focused attention in the exercise	Moderately focused attention in the exercise	Limited attention in the exercise	Minimum participation
Punctuality	15%	Timely submission	Submission late by one laboratory	Submission late by two laboratories	Submission late by more than two laboratories
Knowledge	20%	Students give correct answers 90% or more	Students give correct answers between 70–89%	Students give correct answers between 50–69%	Students give correct answers less than 50%
Procedure Follows	30%	Student follows all procedures with precautions in a logical order	Student follows all procedures with some precautions in a logical order	Student follows all procedures without precautions in a logical order	Student follows procedures without precautions in an illogical order
Observation Skill	20%	Excellent focused attention in the exercise	Moderately focused attention in the exercise	Limited attention in the exercise	Minimum participation
Conclusion / Summary	10%	Student concept is mostly clear	Student concept is partly clear	Student concept is somewhat clear	Student concept is not clear
Quality of Report	10%	Neat handwriting, proper figures and tables, complete	Only formatting is not proper (location of figures/tables, use	Few required elements (labeling/notations) are missing	Several required elements (content, labels, figures,



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Experimentation/performance type PrOs (PrOs number 2,3,4,5,6,7,8,9,10 & 11)					
		labeling	of pencil and scale)		tables) are missing
Punctuality	10%	Timely submission	Submission late by one laboratory	Submission late by two laboratories	Submission late by more than two laboratories

Major Equipment/ Instruments Required:

This major equipment with broad specifications for the PrO is a guide to procure them by the administrators to a user in uniformity of practice in all institutions across the state.

Sr. No.	Equipment Name	PrO No.
1	Cut section model of DC Motor	1
2	DC shunt motor – 230 V DC, 16 A, 1000 RPM, 5 HP	2
3	Three-phase out-runner type 1000 KV BLDC Motor driven by Li-Po 12 V Battery with 18–30 A Electronic Speed Controller (ESC) circuit and Arduino board	3
4	Cut section model of three-phase induction motor	4
5	Three-phase Squirrel Cage Induction Motor – 5 HP, 4 Pole, 415 V, 7.5 A, Class B Insulation, S1 Duty	5, 6, 7
6	Three-phase Wound Rotor / Slip-ring Induction Motor – 5 HP, 4 Pole, 415 V, 7.5 A, Class B Insulation, S1 Duty	5, 6, 7
7	5 V Servo motor (0° to 180° rotation, speed 0.1 s/60°) with driver IC and Arduino board (for applications like robotic arms, quadcopter, etc.)	8, 10
8	5 V DC Unipolar/Bipolar Stepper motor with driver circuit (Darlington array for unipolar, H-bridge for bipolar) and Arduino board	11

Affective Domain Outcomes:

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the Course Outcomes (COs) and Practical Outcomes (PrOs). Additional ADOs may be included to further support the development of course competency.

- Work as a leader or team member.
- Follow safety practices.
- Follow ethical practices.
- Maintain tools and equipment.
- Practice environment-friendly methods and processes (environment-related).



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These ADOs are best developed through laboratory and field-based exercises. The level of achievement of ADOs, according to Krathwohl's Affective Domain Taxonomy, should gradually increase as follows:

- **1st Year:** Valuing Level
- **2nd Year:** Organization Level
- **3rd Year:** Characterization Level

Suggested Specification Table For Question Paper Design:

Unit No.	Unit Title	Teaching Hours	R Level	U Level	A Level	Total Marks
I	DC Motor	08	05	05	04	14
II	Brushless DC Motor	06	03	03	02	08
III	Induction Motor	18	08	11	07	26
IV	Servo Motor	06	04	03	03	10
V	Stepper Motor	07	04	04	04	12
Total		45	24	26	20	70

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Suggested Student Activities

Sr. No.	Activity
1	Prepare chart of different parts of DC machine and label the material used for making each part
2	Prepare chart of different parts of three-phase induction motor and label the material used for making each part
3	Prepare PowerPoint presentation on different types of Brushless DC (BLDC) motors (with ratings) used in electric vehicles available in Indian market
4	Prepare chart showing construction of PMDC, Stepper and Servo Motor
5	Download and collect specifications of the BLDC motors used in drone applications
6	Download and collect specifications of the servo motor used for robotic and quad copter applications
7	Prepare chart showing difference between brushed DC motor and brushless DC motor



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Sr. No.	Activity
8	Prepare nameplate of three-phase induction motor
9	Verify and compare the performances (rotation speed, airflow, and starting time) of ceiling fan having single-phase induction motor and a ceiling fan having BLDC motor

Unit No.	Unit Name	Strategies
1	DC Motor	Demonstration by cut-section model of the motor, videos, charts, and animations
2	Brushless DC Motor	Massive Open Online Courses (MOOCs), demonstration by videos, charts, and animations; industrial visit to Electric Vehicle (EV) manufacturing industry; expert sessions on different types of motors used in EVs and their merits/demerits; student awareness workshop on electric vehicles and government subsidies/incentives
3	Induction Motor	Demonstration by cut-section model, animations, videos; industrial visit to process industry where electronic speed control of three-phase induction motor is used; field visit to small factory for rewinding of ceiling fans
4	Servo Motor	MOOCs, demonstration by videos and animations, hands-on laboratory practice
5	Stepper Motor	MOOCs, demonstration by videos and animations, hands-on laboratory practice

List of Projects:

Students are encouraged to undertake additional projects beyond the listed ones for improving their knowledge, practical skills, and understanding of the subject.

Sr. No.	Project Title
1	Prepare a chart showing different parts of a DC motor
2	Prepare a chart showing working principle and construction of a three-phase induction motor
3	Prepare a chart showing construction and working principle of BLDC motor
4	Collect specifications of BLDC motors for EV applications and prepare a survey report
5	Develop control circuit for BLDC motor using Arduino and write program using IDE



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Sr. No.	Project Title
6	Prepare a chart showing comparison between brushed DC motor and brushless DC motor
7	Prepare a chart showing working of three-phase motor starters
8	Develop working model of control wiring of star-delta starter using contactors
9	Prepare a chart showing construction of different types of single-phase induction motors
10	Collect specifications of single-phase induction motors and prepare a market survey report
11	Prepare a chart showing working and construction of different types of servo motors
12	Develop control circuit for servo motor using Arduino and write program for position control
13	Collect specifications of servo motors and prepare a market survey report
14	Prepare a chart showing working and construction of different types of stepper motors
15	Develop control circuit for stepper motor using Arduino and write program for speed control
16	Collect specifications of stepper motors and prepare a market survey report