GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Electrical Engineering / Renewable Energy

Subject Code: DI05000181

Subject Name: Advance Electrical Machines and Drives

w. e. f. Academic Year:	2026-27
Semester:	5th
Category of the Course:	Professional Electrical - III

Prerequisite:	**Students should have basic knowledge of electrical circuits, electrical machines (DC and induction motors), and fundamentals of power electronics.**
Rationale:	This subject provides essential knowledge of modern electrical drives and their control techniques, which are widely used in industrial and commercial applications. It enables students to understand the operation, control, and performance of various motor drives such as DC, induction, synchronous, and special machines like BLDC, stepper, and switched reluctance motors. The course focuses on speed control methods, braking techniques, multi-quadrant operation, and power electronic converters used in drive systems. This knowledge is crucial for selecting suitable drives, improving energy efficiency, and ensuring reliable operation in industries such as automation, electric vehicles, robotics, and manufacturing systems. The subject also prepares students for practical implementation and troubleshooting of drive systems in real-world applications.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Interpret multi-quadrant operation and different types of loads torque in drive systems.	R
02	Analyze Performance of DC motor drives.	A
03	Analyze Performance of three phase induction motor drives.	A
04	Evaluate operation and applications of BLDC motor drives.	A
05	Explain construction, operation, and characteristics of stepper motors and Switched Reluctance motors.	U

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

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

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Fundamentals of Electrical Drives** Contents: ➢ An Introduction & block diagram of Electrical Drives, Advantages of Electrical Drives ➢ Parts of Electrical Drives, Fundamental Torque Equations ➢ Concept of Multi-Quadrant Operation ➢ Classification of load torque ➢ Selection of Motor Power Rating ➢ Electrical Drive Systems: Components Used for Obtaining Signals, Interlocking and Sequencing Operations, Protections	05	12%
2.	**DC Motor Drives** Contents: ➢ DC Motors Speed – torque & Torque – Armature current characteristics of Separately Excited Motor, Series Motor & Compound Motor ➢ Maximum torque and power limitation of DC Drives ➢ DC Series motor speed control using transformer and controlled rectifier ➢ Controlled Rectifier Fed DC Drives: Concept of Single Phase Half Controlled & Fully Controlled Rectifier, Three Phase Half Controlled and Full Controlled Rectifier ➢ DC Separately Excited Motor Control by Single Phase Fully	10	22 %

	Controlled Rectifier & Three Phase Fully Controlled Rectifier ➢ Multi-Quadrant Operation of DC Separately Excited Motor Drives: Single Fully Controlled Rectifier with Reversing Switch ➢ Supply Harmonics, Power Factor and Ripple in Motor Current. ➢ Chopper Control of Separately Excited DC Motors ➢ Closed Loop Control of DC Drive Above & Below Speed ➢ PMDC Motor: Principal, Construction, Working & Speed Control. ➢ PMDC Motor and DC Motor control using Microcontroller		
3.	**Induction Motor Drives** ➢ Introduction, torque speed curve of three phase induction motor, torque speed curve at variable supply voltage and constant frequency, constant voltage and variable frequency operation, Variable voltage, variable frequency operation with constant V/F ➢ Speed Control of Three Phase Induction Motor: Stator Voltage Control by AC Voltage Controllers, Variable Frequency Control, Voltage Source Inverter (VSI) Control, Variable Stator Current Operation ➢ Maximum Torque and Power Limitation of AC Drives ➢ VSI Induction Motor Drives: Braking and Multi-Quadrant Operation ➢ Closed Loop Speed Control of VSI Induction Motor Drives ➢ Effect of harmonics, Energy saving with variable frequency drives.	8	18 %
4.	**Synchronous Motor and Brushless DC Motor Drives** Contents: ➢ Synchronous Motor: Speed – Torque Characteristics at Constant Frequency, Effect of Field Excitation on Power Factor ➢ Synchronous Motor Variable Speed Drives: Variable Frequency Control, Modes of Variable Frequency Control ➢ Self-Controlled Synchronous Motor Drive Employing Load	12	26 %

	Commutated Thyristor Inverter ➢ Construction & Working of Permanent Magnet Motor ➢ Permanent Magnet AC Motor Drives ➢ BLDC Motor: Types, Construction, Hall Sensors, Working, Commutation Sequence, Compare DC Motor & BLDC Motor ➢ Brushless DC Motor Drives, BLDC Motor Speed Control and Position Control Using Microcontroller		
5.	**Stepper Motor and Switched Reluctance Motor Drives** Contents: ➢ Stepper Motors: Important Terminologies, Variable Reluctance motor operation, Stepping Modes, Micro stepping, Permanent Magnet and Hybrid stepper motor operation and features, Important Features of Stepper Motors, Torque versus Stepping Rate Characteristics, Drive Circuits for Stepper Motors, Open loop and closed loop control of stepper motor ➢ Examples of step angle and resolution ➢ Stepper motor step controller using any microcontroller or U2004 Darlington Array ➢ Switched Reluctance Motors: construction, working, Effect of Rotor Position on Inductance, Voltage and Torque Equation, Control Requirements, Converter Circuits, Modes of Operation.	10	22 %
	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**
17 %	**33 %**	**50 %**	**-**	**-**	**-**

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. G.K. Dubey, "Power semiconductor-controlled Drives", Prentice Hall international, New Jersey, 1989.
2. B.K.Bose, “Modern Power Electronics and AC drives” Pearson Education Asia, 2003.
3. R.Krishnan, Electric Motor drives – Modelling, Analysis &Control: PHI India,Ltd.
4. Vedam Subramanyam, Thyristor Control of Electric Drives.
5. Pillai.S.K “A first course on Electric drives”, Wiley Eastern Limited, 1998
6. Nagarath.I.J& Kothari .D.P,”Electrical machines”, Tata McGraw-Hill.1998

(b) Open-source software and website:

- https://nptel.ac.in/courses/108104140
- https://electrical4u.in/electrical-motor-control/
- https://lectures.gtu.ac.in/
- https://circuitglobe.com/
- https://www.electricaltechnology.org/
- www.vlab.co.in
- www.khanacademy.org

Suggested Course Practical List:

Sr. No.	Practical Outcome/Title of Experiment	CO1	CO2	CO3	CO4	CO5
1	To Perform Closed loop speed control of DC motor using feedback.		√			
2	To Perform Speed control of DC motor using micro-controller. (Arduino / STM32)		√			
3	Build circuit on breadboard / PCB & perform speed control of DC Motor by using Microcontroller		√			
4	Build circuit on breadboard / PCB & perform speed control of PMDC Motor by using Microcontroller		√			
5	Control speed of dc motor using 3-phase full controlled bridge converter. Plot armature voltage versus speed characteristic.		√			
6	Control speed of a 3-phase induction motor in			√		

	variable stator voltage mode using 3 phase AC voltage regulator					
7	Perform speed control of three phase induction motor using V/f control (VFD drive).			√		
8	To Perform Speed control of BLDC motor using micro controller. (Arduino/STM32)				√	
9	Build circuit on breadboard / PCB & perform speed control of BLDC Motor by using Microcontroller				√	
10	To Perform Speed control of DC motor using chopper drive		√			
11	Interfacing and control of stepper motor using microcontroller (Arduino/STM32)					√
12	Build circuit on breadboard / PCB & perform step control of Stepper Motor					√

List of Laboratory/Learning Resources Required:

Sr. No.	Equipment Name with Broad Specifications
1	Single/Three-Phase Fully Controlled Rectifier DC Drive Trainer
2	DC Chopper Drive Trainer
3	Static Dual-Converter (Four-Quadrant) Drive Trainer
4	Variable Frequency Drive (VFD) Trainer Kit
5	AC Voltage Controller (Stator Voltage Control) Trainer
6	BLDC Motor Drive Trainer, Synchro and Resolver Trainer Kit
7	AC/DC Servo Motor Control Trainer
8	Micro-stepping Stepper Motor Trainer, Switched Reluctance Motor (SRM) Drive Trainer

When setting up the lab, prioritize getting at least one high-quality, multi-channel Digital Storage Oscilloscope (DSO) Without a DSO, students cannot visualize the chopping waveforms, SCR firing angles, or BLDC Hall sensor signals, which are the heart of this entire subject.

Suggested Project List:

1. Development of a chopper-fed DC motor drive with variable speed control.
2. Development of a V/f control scheme for three-phase induction motor drive.
3. Design and testing of a Voltage Source Inverter (VSI) for induction motor control.
4. Development of a BLDC motor drive with electronic commutation using Hall sensors.
5. Design and control of a stepper motor drive with micro-stepping technique.
6. Simulation of multi-quadrant operation of DC motor drive using dual converter.
7. Implementation of IoT-based monitoring system for motor drive parameters (speed, voltage, current).

Suggested Activities for Students:

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidence for their (student's) portfolio which may be useful for their placement interviews:

1. Perform **simulation of different motor drives** (DC, induction, BLDC) using software tools such as MATLAB/Simulink.
2. Prepare **charts/models showing torque-speed characteristics** of various motor drives.
3. Study and demonstrate **multi-quadrant operation of electrical drives** using simulation or lab setup.
4. Visit **industrial plants** to observe practical applications of electrical drives and automation systems.
5. Develop **mini projects on motor control using microcontrollers (Arduino/STM32)**.
6. Practice **troubleshooting of motor drive circuits** in laboratory conditions.

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