GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: ELECTRICAL DRIVES
(COURSE CODE: 3360906)

Diploma Programme in which this course is offered	Semester in which offered
Electrical Engineering	Sixth

1. RATIONALE

Today's industrial and domestic loads demands precise and smooth variable speed control. The development of compact thyristor power converters has made this possible by smooth speed control of both AC and DC motors which are employed for several applications such as DC/AC drives, Vehicles and renewable energy. This course enables to develop the basics of electric drives and maintain different types of DC/AC drives in industries.

The competency in this area is highly required in diploma pass outs working in most of the industries since these industries employ large number of motors and drives and their smooth operation and maintenance requires lot of competent man power. Thus this course is must for students who want to work in industries.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Operate and maintain different types of DC/AC and special electrical machine drives in the industry.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Select a drive for a particular application based on power rating.
ii. Select a drive based on mechanical characteristics for a particular drive application.
iii. Operate and maintain solid state drives for speed control of DC machines.
iv. Operate and maintain solid state drives for speed control 3 phase induction motor.
v. Operate and maintain solid state drives for speed control of 3 phase Synchronous motor.
vi. Operate and maintain solid state drives for speed control of various special electrical machines.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**ESE**	**PA**	**ESE**	**PA**	
3	0	2	5	70	30	20	30	150

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

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I **Basics of Electrical Drives** .	1a. Explain the working of an electrical drive with the help of a neat block diagram. 1b. Justify the selection criteria for electrical drive(s) 1c. Select electric drives for a given application.	1.1 Electric drive, types, AC v/s DC drives, choice of electric drives 1.2 Parts of electrical drive-Source, power modulator, electric motor and control unit 1.3 Selection of electric drive for applications: agricultural pumps, steel mills, paper mills, rolling mills, spinning mills, cement industries, chemical industries, refineries, shipping, power stations and automobiles
	1d. Use heating and cooling curve for finding temperature rise in a drive. 1e. Determine power rating for different load curves by equivalent current, torque and power methods. 1f. Select a motor on the basis of duty cycles of motors.	1.4 Heating and cooling curve 1.5 Motor duty class, classification– continuous, short time, intermittent periodic a. Motor power rating for continuous, short time and intermittent duty, equivalent current, torque and power methods for fluctuating and intermittent loads.
Unit– II **Dynamics of Electrical Drives**	2a. Explain the nature of speed torque characteristic of various types of loads and drive motors with the help of neat sketch. 2b. Explain the multi quadrant operation of electrical drive. 2c. Describe different methods of braking used in any electric drive.	2.1 Steady state load Torque speed characteristics 2.2 Multi quadrant operation of drives 2.3 Types of Braking-(a) Plugging, (b) dynamic/rheostat braking and (c) regenerative braking. 2.4 Starters- Typical control circuits for shunt and series motors, Three phase squirrel cage and slip ring induction motors
	2d. Describe the basic concept of various control loops used in electrical drives.	2.5 Close loop control of drives i. Current limit control ii. Close loop torque control iii. Close loop speed control iv. Close loop speed control of multi motor drive
Unit– III **DC Drives** .	3a. Explain conventional speed control technique(s) of DC motors. 3b. Explain various solid state speed controls of single and three phase DC drives. 3c. Describe the speed control of	3.1 Speed control of DC series and shunt motors – armature and field control. 3.2 Solid state speed control of single phase and 3 phase DC drives with the following: i. Half wave converter ii. Semi converter

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	chopper controlled DC drives.	iii. Full converter iv. Dual converter 3.3 Solid state speed control of separately excited shunt and series motor drives 3.4 Chopper controlled drives
Unit– IV **AC Drives - Three Phase Induction Motor Drive**	4a. Explain speed control methods of a 3 phase induction motor. 4b. Explain the working of various 3 phase induction motor drives for precise variable speed control.	4.1 Basic principle of 3 phase induction motor drive. 4.2 Solid state control of 3 phase induction motor: i. Stator voltage control -3 phase AC voltage controller and soft start. ii. Stator variable frequency control-voltage source inverter- PWM drives and current source inverter drives, cycloconverter fed IM drive. iii. Stator voltage and frequency control - Basics of V/f drive, scalar and vector or field oriented control of drives, V/f sensor less flux control drive. iv. Static rotor resistance control v. Slip power control – Static Kramer and Static Scherbius drive.
Unit– V **AC Drives - Three Phase Synchronous Motor Drive**	5a. Explain the principle of two modes of variable frequency control in 3 phase synchronous motor. 5b. Explain the working of self-controlled synchronous motor drive employing load commutated thyristor inverter for high speed and high power applications. 5c. Describe the working of a cycloconverter fed Synchronous motor.	5.1 Control of synchronous motor - Synchronous mode and Self mode. 5.2 Self-controlled synchronous motor drive employing load commutated thyristor inverter, closed loop control 5.3 Self-controlled synchronous motor drive employing cycloconverter
Unit– VI **Drives for Advanced Electrical Machines**	6a. Describe the working of various advance electrical machines drives. 6b. Explain the working of solar powered pump drives. 6c. Explain the working of battery powered electrical vehicles.	6.1 Drive for brushless DC motor 6.2 Stepper motor drive 6.3 Drive for switched reluctance motor solar powered pump drive 6.4 DC drives with chopper control for electrical vehicle. 6.5 Induction motor drive with voltage source inverter control for electrical vehicle.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (Theory)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Electrical Drives	08	02	04	02	08
II	Dynamics of Electrical Drives	08	02	04	04	10
III	DC Drives	10	04	04	06	14
IV	AC Drives – 3 Phase Induction Motor Drives	10	04	06	08	18
V	AC drives – 3 Phase Synchronous Motor Drives	12	02	04	04	10
VI	Drives for Advance Electrical Machines	08	02	02	06	10
	Total	**56**	**16**	**24**	**30**	**70**

Legends: R = Remember; **U** = Understand; **A** = Apply and above levels (Bloom's revised taxonomy)
Note: This specification table shall be treated as a general guideline for students and teachers. The actual Distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED PRACTICALS/EXERCISES

The practical should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

***Note**: Here only outcomes in psychomotor domain are listed as practical. However, if these practical are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercises (Outcomes in Psychomotor Domain)	Approx. Hours Required
1	III	Test the performance of DC shunt motors.	2
2	III	Test the performance of DC series motors.	2
3	III	Control the speed of DC motor using single phase half wave Converter.	2
4	III	Control the speed of DC motor using single phase semi converter.	2
5	III	Control the speed of DC motor using single phase full converter.	2
6	III	Control the speed of DC motor using single phase dual converter.	2

S. No.	Unit No.	Practical/Exercises (Outcomes in Psychomotor Domain)	Approx. Hours Required
7	III	Control the speed of DC motor using three phase half wave converter.	2
8	III	Control the speed of DC motor using three phase semi converter.	2
9	III	Control the speed of DC motor using three phase full converter.	2
10	III	Control the speed of DC motor using three phase dual converter.	2
11	IV	Test the performance of closed loop speed control of 3 phase induction motor using stator voltage control.	2
12	IV	Test the performance of 3 phase induction motor V/f drive	2
13	IV	Test the performance of vector control drive	2
14	IV	Test the performance of field oriented control drive	2
15	IV	Test the performance of 3- Ø induction motor using VSI drive.	2
16	IV	Test the performance of cyclo converter fed induction Motor drive.	2
17	V	Test the performance of a self-controlled synchronous motor drive employing load commutated thyristor inverter	2
18	V	Test the performance of a self-controlled synchronous motor drive employing cycloconverter	2
19	VI	Test the performance of stepper motor drive	2
20	VI	Test the performance of BLDC motor drive	2
21	VI	Test the performance of switched reluctance motor drive	2
22	VI	Test the performance of solar powered pump drive	2
Total			**44**
Note: Perform any of the practical exercises from above list for a minimum of 28 hours depending upon the availability of resources so that skills matching with the most of the outcomes of every unit are included.			

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Prepare journals based on practical performed in laboratory.
ii. Assignments on solving numerical problems
iii. Visit websites of suppliers of electric drives and do a comparative study of different drives provided by different companies.
iv. List various motor controlling parameters and find how they affect the performance of motor and drives.
v. Find troubleshooting techniques and steps to troubleshoot DC drives.
vi. Simulate various DC motor drives.
vii. Analyze the specifications for various types of AC drives.
viii. Find practical applications of AC drives in home appliances and list various Parameters of those applications.
ix. Make comparative table for various drives based on its application and maximum power ratings.
x. Check the performance of at least two different types of drives using simulation software like MATLAB.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Show video/animation film to demonstrate the working principles, constructional features, testing and maintenance of different types of DC motor drives.
ii. Arrange expert lectures by engineers working in electric drive companies.
iii. Arrange a visit to nearby manufacturer of electrical drives.
iv. Use flash/animations to explain the working of different control devices.
v. Give mini projects to students.

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1.	Fundamentals of Electrical Drives	Dubey, Gopal K.	Narosa Publishing House, New Delhi ,2nd Edition
2.	Power Electronics	Bimbhra, P.S.	Khanna Publishers, New Delhi 5th Edition
3.	Power Electronics	Singh M.D., Khanchandani K.B.	Tata McGraw-Hill Education New Delhi
4.	Variable Speed Drives and Power Electronics	Barnes, Malcolm	Newnes, Elsevier ,2003
5.	Power Electronics: Circuits, Devices and Applications	Muhammad, Rashid H.	Pearson, New Delhi, 2003,3rd Edition or latest

B) Major Equipment/ Instrument with Broad Specifications

1. Digital Multimeter: 4 ½ digit hand held 9 V batteries operated, DC Voltage: 0 to 0.001 mV – 1000 V, AC Voltage: 0 to 0.01 mV – 1000 V, AC Current: 0 to 100 nA – 10 A, DC Current: 0 to 100 nA – 10 A,
2. Digital Tachometer: Hand held, battery operated, 5 digit display contact type, 60 to 50000 r.p.m.,
3. Four channel Digital Oscilloscope: Bandwidth :200MHz, Power supply:230V ± 10% tolerance,50 Hz AC supply
4. Various Trainer boards for DC and AC Drives:
   i. 3 phase induction motor for V/f control
   ii. Microcontroller based Slip ring induction motor speed control using Static Kramer Drive
   iii. DC shunt motor speed control using 3 phase fully controlled converter
5. Any one simulation software (Open source software preferred) : Scilab/Matlab and Simulink toolbox, CASPOC

C) Software/Learning Websites

i. http://nptel.iitm.ac.in/video.php?subjectId=108108077
ii. http://www.edumedia-sciences.com/en/a575-speed-controler-for-dc-motor

iii. http://www.engineeringtv.com/video/Texas-Instruments-Brushless-DChttp://www.scribd.com/doc/6883802/AdjustableSpeedDrivesTutorial
iv. SEQUEL (open source)
v. PSIM
vi. ORCAD

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. H I Joshi**, Lecturer in Electrical Engineering, Government Polytechnic, Ahmedabad
- **Prof. C T Patel**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad
- **Prof. R D Panchal**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. (Mrs.) C.S. Rajeshwari**, Professor and Head, Department of Electrical and Electronics Engineering,
- **Dr. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering,