GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-V

Course Title: AC Power Electronic Converters & Drives
(Course Code:4352401)

Diploma programmer in which this course is offered	Semester in which offered
Power Electronics	5th Semester

1. RATIONALE

Most of the modern AC motors are controlled by power electronic converters due to their versatility and efficiency. This course is mainly related with selection and speed control of AC motor drives used in industry. This course attempts to develop skills in operation and maintenance of inverter, regulator and cycloconverter based drives related to conversion of DC to AC and AC to AC power used for power control in industries.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Operate and Maintain AC Power Electronic Converters & Drives.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

CO 1) Select a proper speed control method of AC motor as per their characteristics.
CO 2) Maintain inverter fed AC motor Drives.
CO 3) Maintain regulator and cycloconverter fed AC motor Drives.
CO 4) Maintain Synchronous motor Drives.
CO 5) Operate AC Drives as per their industrial applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
4	-	2	5	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

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

5. SUGGESTED PRACTICAL EXERCISES

*Following practical outcomes (PrOs) that 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'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1.	Test the performance of induction motor with stator frequency control.	I	2
2.	To perform the Load Characteristics of 3-phase Induction Motor. (Electrical Load)	I	2*
3.	Test the performance of induction motor with stator voltage and frequency control (V/F).	I	2*
4.	Test the performance of induction motor with stator current control.	I	2*
5.	Test the performance of induction motor with rotor resistance control.	I	2*
6.	Test the performance of 1- Ø load using 1-phase full bridge inverter.	II	2*
7.	Test the performance of 3- Ø induction motor using SPWM inverter.	II	2*
8.	Test the performance of induction motor with stator voltage control	I	2*
9.	Test the performance of induction motor using CSI.	II	2
10.	Test the performance of static krammer drive.	II	2
11.	Test the performance of 1-phase full wave AC regulator for R load.	III	2*
12.	Test the performance of 1- Ø induction motor using AC voltage controller.	III	2
13.	Test the performance of 3- Ø induction motor using AC voltage controller.	III	2*
14.	Test the performance of 1-phase step down cycloconverter for different load.	III	2*
15.	Test the performance of 1-phase step up cycloconverter for different load.	III	2
16.	Test the performance of cycloconverter fed induction motor drive.	III	2*
17.	Test the performance of synchronous motor drive with VSI.	IV	2*
18.	Test the performance of synchronous motor drive with cycloconverter.	IV	2*
19.	Test the performance of AC drives for industrial applications.	V	4*
	Minimum 14 Practical Exercises		**28* Hrs.**

Note

*i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

*ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipments with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	3- Phase induction motor speed control trainer with measurement and drive panel, Table Top Machines / Accessories: Fractional HPAC/DC Motor 230VAC, 1/12 HP. Chassis mounted table top with brake pulley and spring balance loading arrangement.	1/2/3/4
2	Single Phase Bridge Inverter: On board firing circuit : Ramp Comparator method Interconnections : 2 mm sockets SCR : SCR 2P4M 400V/2A Mains Supply : 220V/110V, 50Hz / 60Hz	5
3	3Ø INDUCTION MOTOR SPEED CONTROL USING STATIC KRAMER DRIVE TRAINER with Starter panel, FWD-OFF-REV switch panel, DC voltmeter and DC ammeter panel, Variable AC / DC Supply Panel, 3 Ph. Bidirectional power cum Energy meter panel, 3 phase SCR Firing/Synchronizing Panel, 6 SCR/Diode Power Module.	9
4	3 Phase Slip Ring Motor Speed Control by rotor resistance control: AC Power Supply 0-415V AT 4A. Operated on Mains power 415V, 50Hz +10% Digital/Analog Meters: Voltmeter. Ammeter. RPM Meter With Proximity Sensor Components placed on the panel are:. Color Indication For Each Phase. DOL Starter. Rotor Resistance Starter	4
5	Speed Control of AC Motor Using TRIAC: On board firing circuits ,DIAC firing circuit Ramp & Pedestal firing circuit Pulse transformer : PT4502, 1:1 Mains Supply : 220V/110V, 50 Hz / 60 Hz	10

S. No.	Equipment Name with Broad Specifications	PrO. No.
	Universal motor specifications : Single Phase-1 / 8 Hp	
6	Three Phase Firing Circuit for 3 Phase AC Voltage Controller: Power Electronic Training Board has been designed specifically for the study of Three phase firing circuit for three phase ac voltage controller, The board consists of the following built-in parts: Three Phase line commuted Full wave bridge converter. Three pole Miniature Circuit Breaker (MCB). Three separate identical cards consisting of Zero Crossing Detector, Integrator, Comparator and Pulse Generator one for each phase, for controlling the triggering angles of the positive group of three thyristors. Angles of the negative group of three diodes. Firing angle control potentiometer. Three 415:50V at 0.2Amp transformer for rectifications & 6V AC supply for Triggering ± 12V at 100mA, IC regulated Power Supply for Triggering Circuits. Three nos. Driver Circuits with Pulse Transformers. High Frequency Gated Dual Gate Firing 3 nos. Three Phase Inbuilt Resistive Load. Two 3½ digital panel meter (DPM) for measurement of AC voltage 0 - 200V.	12
7	Single Phase Cycloconverter trainer: unit has to generate 8 line synchronized Isolated trigger pulses to trigger SCR's connected in center tap transformer and bridge type cycloconverter power circuit. This unit can also be used as 1-phase converter firing unit to conduct different single phase converter experiments. firing circuit will based on Ramp – Comparator and counter scheme using microcontroller 89C2051. Pulse Transformer Isolation is provided for trigger outputs.	13,14
8	PMSM Motor Control Trainer Kit with rectifier unit, inverter module, driver unit, protection unit, Development Board 3Phase IGBT POWER MODULE,PMSM Motor with Load Setup Patch Cords, Power cords, FRC Cable, 5VAC Adaptor,RS232 cable CCS Software Support, 230V/100V Step-down Transformer	15

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow error free measurement rules during measurement.
c) Practice environmentally friendly methods and processes.(Environment related)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit– I **AC Drive Fundamentals**	1a. Classify different types of AC Drives. 1b. Describe general AC Drive specifications. 1c. Explain performance characteristics of induction motor 1d. Explain various speed control methods of AC motors 1e. Compare merits and demerits of various speed control method.	1.1 AC drives classification, advantages & disadvantages. 1.2 Basic working principle of AC Drives, general equations of AC motors. 1.3 Typical torque speed characteristics and performance parameter. 1.4 Speed control methods of IM: speed torque characteristics of induction motor for Stator voltage control, Stator frequency control, Stator voltage and frequency control, stator current control, conventional and static rotor-resistance control and slip-energy recovery. 1.5 Merits and demerits of speed control methods.
Unit– II **Inverter fed AC drives.**	2a. Explain the working principle of 1-phase full bridge inverter for R and RL load with sketches. 2b. Explain SPWM drives with sketches. 2c. Explain CSI. 2d. Differentiate VSI and CSI circuits 2e. With a block diagram describe the closed loop speed control of motor using stator voltage control. 2f. Explain breaking and multi quadrant operation of voltage source inverter 2g. Explain static krammer and Scherbius drive.	2.1 1- Phase full bridge voltage source inverter: R, RL load. 2.2 Sinusoidal pulse width modulation PWM voltage source inverter fed induction motor drives. 2.3 Current source inverter. 2.4 Compare VSI and CSI. 2.5 Closed loop speed control using stator voltage control 2.6 VSI fed induction motor drive: braking and multi quadrant operation. 2.7 Static krammer drive, static Scherbius drive.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit – III AC regulator and cycloconverter fed AC Drives	3a. Explain the principle of AC voltage control for Integral cycle control and phase control.	3.1 Principle: Integral cycle control, phase controls.
	3b. Explain the working principle of 1- phase voltage controller using R and RL load with sketches.	3.2 1- Phase voltage controller: R and RL load.
	3c. Explain the principle of sequential control of AC voltage controller for two stage and multi stage configuration with sketch.	3.3 Sequential control of AC voltage controller: Two stage, Multi stage.
	3d. Explain stator voltage control using 3-phase AC voltage controller IM drive	3.4 Stator voltage control using 3-phase AC voltage controller for 3- Ø induction motor.
	3e. Explain the working principle of 1- phase midpoint and bridge Cycloconverter for step up and step down frequency with sketches.	3.5 1- Phase Cycloconverter: midpoint, bridge; step up, step down.
	3f. Explain the working of cycloconverter fed drive with the help of sketches	3.6 Cycloconverter fed induction motor drive
Unit– IV Synchronous motor drives	4a. List applications of synchronous motor drives.	4.1 Applications of synchronous motor drive.
	4b. Explain control of synchronous motor on variable frequency.	4.2 Control of Synchronous Motors on Variable Frequency Supply.
	4c. Explain VSI fed synchronous motor drive.	4.3 Self control of synchronous motor fed from VSI, Separately controlled synchronous motor fed from VSI.
	4d. Explain Control of thyristors either from rotor position sensor or voltages.	4.4 Control of thyristors either from rotor position sensor or voltages, Margin Angle Control.
	4e. Explain the working of cycloconverter fed synchronous motor drive using sketches.	4.5 Synchronous Motor Fed from a Cycloconverter.
Unit– V Industrial Applications of Electrical Drives.	5a. Explain industrial applications of electrical drives in various industries.	5.1 Applications of electrical drives in • Textile mill. • Paper mill. • Steel mill. • Electric traction. • Electric Vehicle.

***Note**: The UOs need to be formulated at an 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I.	**AC Drive Fundamentals**	12	6	3	4	13
II.	**Inverter fed AC drives.**	14	4	10	4	18
III.	**AC regulator and cycloconverter fed AC Drives**	14	6	9	3	18
IV.	**Synchronous motor drives**	8	3	7	0	10
V.	**Industrial Applications of Electrical Drives.**	8	0	4	7	11
Total		56	19	33	18	70

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

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 conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Make a chart of various characteristics of AC motors for all speed control method.
b) Make a chart of applications of Various AC motor Drives as per application.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.11***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students for reading a datasheet and selection of power electronic switches used for AC drives.

g) Guide students for selecting proper AC power electronic converters and methods for the speed control of AC motor.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro-project should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Make a Presentation for characteristics of various AC motors.
b) Make a presentation of classification of various AC Power electronic converters used in AC drives.
c) Design a basic 1-phase inverter/Regulator /cycloconverter Drive circuit.

13. SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Electric Drives concepts and applications.	Vedam Subrahmanyam	TMH ISBN: 9780070701991
2	A First Course on Electrical Drives	S.K.Pillai	NEW AGE ISBN:9788122433616
3	Power Electronics	P.S.Bimbhra	KHANNA ISBN: 9788174092793
4	Power Electronics	M Singh, K Khanchandani	TMH ISBN:9780070583894
5	Electric Drives	N.K.Dey P.K.Sen	PHI ISBN: 9788120314924

14. SOFTWARE/LEARNING WEBSITES

a) https://www.vlab.co.in
b) https://nptel.ac.in
c) https://swayam.gov.in/
d) https://shodhganga.inflibnet.ac.in/
e) https://onlinecourses.nptel.ac.in/

15. PO-COMPETENCY-CO MAPPING

Semester V	AC Power Electronic Converters & Drives						
	POs and PSOs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	**Operate and Maintain AC Power Electronic Converters & Drives.**						
CO 1) Select a proper speed control method of AC motor as per their characteristics.	2	1	2	1	2	1	2
CO 2) Maintain inverter fed AC motor Drives.	2	2	2	3	2	2	3
CO 3) Maintain regulator and cycloconverter fed AC motor Drives.	2	2	2	3	2	2	3
CO 4) Maintain Synchronous motor Drives.	2	2	2	2	2	2	3
CO 5) Operate AC Drives as per their industrial applications.	2	1	2	1	3	3	2

Legend: '**3**' for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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