**Program Name** : **Electrical Engineering Program Group**

**Program Code** : **EE/EP/EU**

**Semester** : **Sixth**

**Course Title** : **Industrial Drives and Control (Elective-II)**

**Course Code** : **22629**

## 1. RATIONALE

The electrical engineering applications in many industries use small and large AC and DC motors in some crucial application systems. Further electrical speed control in almost all industrial applications are incomplete without the use of the specific electric drive. This course will empower the students with the necessary skills to identify operate and maintain the AC and DC drives.

## 2. COMPETENCY

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

- **Maintain different types of electric drives.**

## 3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency:

a) Identify the relevant electric drive for the required speed torque characteristics.
b) Maintain the functioning of DC Drives using converters.
c) Maintain the functioning of DC Drives using choppers.
d) Maintain the functioning ofAC Drives.
e) Use microcontroller-based systems for motor control.

## 4. TEACHING AND EXAMINATION SCHEME

| Teaching Scheme | | | Credit (L+T+P) | Examination Scheme | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | | | | | | | Practical | | | | | |
| L | T | P | | Paper Hrs. | ESE | | PA | | Total | | ESE | | PA | | Total | |
| | | | | | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min |
| 3 | - | 2 | 5 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 25@ | 10 | 25 | 10 | 50 | 20 |

*(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment 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, **ESE** -End Semester Examination; **PA** - Progressive Assessment*

## 5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

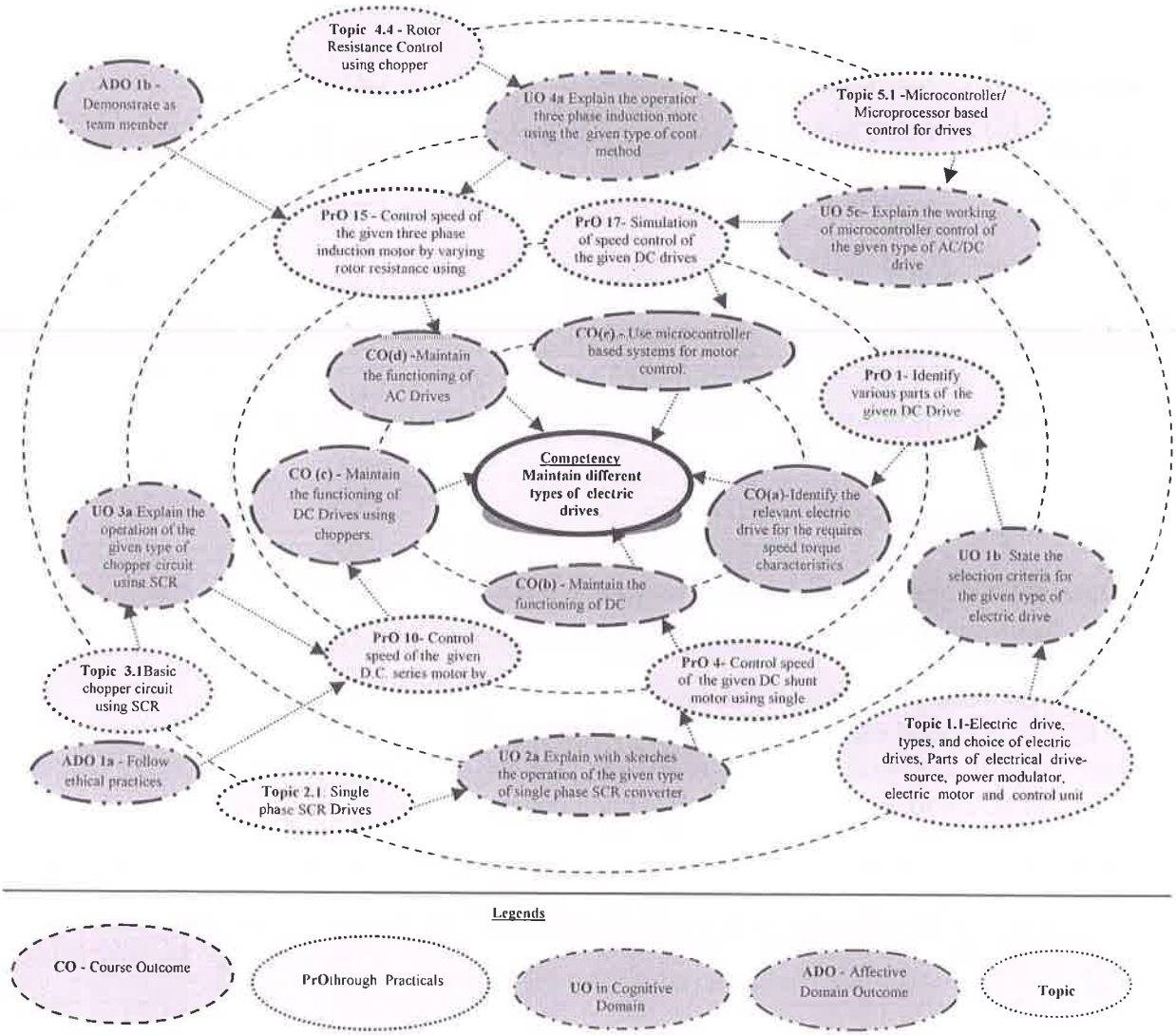


**Figure 1 - Course Map**

## 6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 1 | Identify various parts of the given DC Drive. | I | 02* |
| 2 | Identify various parts of the given AC Drive. | I | 02* |
| 3 | Test the given DC motor to interpret the speed torque characteristics | I | 02 |
| 4 | Control speed of the given DC shunt motor using single phase half wave converter | II | 02* |
| 5 | Control the speed of the given DC shunt motor using single phase full wave converter | II | 02* |
| 6 | Control the speed of the given separately excited DC motor by changing the firing angle of SCR using single phase semi converter. | II | 02 |
| 7 | Control speed of the given separately excited DC motor by changing the firing angle of SCR using single phase full converter. | II | 02 |

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 8 | Check high power SCR/power devices with heat sink arrangement. | II | 02* |
| 9 | Measure the output voltage of the given chopper for resistive load by varying the frequency and /or duty cycle of chopper. | III | 02* |
| 10 | Control speed of the given D.C. series motor by varying armature voltage using step down chopper. | III | 02* |
| 11 | Control the speed of the given D.C. separately excited motor by varying armature voltage using step down chopper. | III | 02 |
| 12 | Control the speed of the given three phase squirrel cage induction motor by varying stator voltage using thyristor circuit. | IV | 02 |
| 13 | Control the speed of the given three phase induction motor by using constant V/f method and plot the graph between speed and frequency. | IV | 02* |
| 14 | Control the speed of the given three phase induction motor by varying frequency and plot the graph between speed and frequency | IV | 02* |
| 15 | Control the speed of the given three phase induction motor by sensorless vector control. | IV | 02 |
| 16 | Control the speed of the given three phase induction motor by varying rotor resistance using chopper. | IV | 02* |
| 17 | Simulation of speed control of the given synchronous motor drives using microcontroller in SCILAB simulation software. | V | 02 |
| 18 | Simulation of speed control of the given DC drives using microcontroller in SCILAB simulation software. | V | 02* |
| | **Total** | | **36** |

***Note***

*i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory and any 04 from remaining so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

*ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

| S.No. | Performance Indicators | Weightage in % |
|---|---|---|
| 1 | Preparation of experimental set up | 20 |
| 2 | Setting and operation | 20 |
| 3 | Safety measures | 10 |
| 4 | Observations and Recording | 10 |
| 5 | Interpretation of result and conclusion | 20 |
| 6 | Answer to sample questions | 10 |
| 7 | Submission of report in time | 10 |
| | **Total** | **100** |

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.

d) Work as a leader/a team member.
e) Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year.

## 7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by administrators.

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 1 | Digital storage oscilloscope: Dual trace 50Mhz | 3 to 6, 8 to 14 |
| 2 | Ammeters DC, 0-5/10Amp,0-1.5 Amp,0-2.5Amp,0-0.5/1Amp | 3 to 6, 8 to 14 |
| 3 | Voltmeter DC, 0-150/300V, 0-250/500V,0-75/150V | 3 to 14 |
| 4 | Dimmer: 1-phase,1kVA,230V | 1 to 6, 8 to 10 |
| 5 | Dimmer: 3-phase, 5kVA,440V | 11 to 17 |
| 6 | Resistive load bank upto 10kW | 8 |
| 7 | Digital tachometer 4000 R.P.M.for speed measurement. | 3 to 6, 8 to 16 |
| 8 | DC Series motor 1 to 3 HP | 1,9,18 |
| 9 | DC Shunt motor 1 to 3 HP | 1,3,4,18 |
| 10 | Separately excited DC motor 1 to 3 HP | 5,6,10 |
| 11 | Three phase induction motor 1HPto 3 HP or Fractional horse power motor | 12,13,14,15,16 |
| 12 | Synchronous motor 1 to 3HP | 17 |
| 13 | Simulation soft ware such as SCILAB or similar | 17, 18 |

## 8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

| Unit | Unit Outcomes (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| **Unit – I Basics of Electric Drives** | 1a. Describe the block diagram of the given type of electric drive<br>1b. State the selection criteria for the given type of electric drive<br>1c. Determine the power rating for the given load curve by equivalent current, torque and power methods.<br>1d. Select the relevant motor on the basis of given duty cycles with justification.<br>1e. Describe with sketches the | 1.1 Electric drive, types and choice of electric drives, Parts of electrical drive-source, power modulator, electric motor and control unit<br>1.2 Motor duty class, classification– continuous, short time, intermittent period.<br>1.3 Motor power rating for continuous, short time and intermittent duty, equivalent torque current, and power methods for fluctuating |

| | | |
|---|---|---|
| | characteristics of the given type of motor(s).<br>1f. Describe the procedure to maintain the given type of electric motor. | and intermittent loads.(Simple numerical)<br>1.4 Speed-torque characteristics of DC motors<br>1.5 Speed-torque characteristics of three phase induction motor |
| **Unit – II DC Drive using converters** | 2a. Explain with sketches the operation of the given type of single phase SCR converter.<br>2b. Explain with sketches the operation of the given type of three phase SCR converter.<br>2c. Give the effect of power factor variation in the given type of SCR motor drive.<br>2d. Describe the procedure to maintain the given type of DC drive using converter | 2.1 Single phase SCR Drives<br>a) Half wave converter<br>b) Full wave converter<br>c) Semi converter<br>d) Dual converter<br>2.1 Three Phase SCR Drives<br>a) Half wave converter<br>b) Full wave converter<br>c) Semi converter<br>d) Dual converter<br>2.2 Power factor in SCR motor drives<br>2.3 Reversible SCR Drives. |
| **Unit- III DC Drive using choppers.** | 3a. Explain with sketches the operation of the given type of chopper circuit using SCR.<br>3b. Explain with sketches the operation of the given type of single quadrant chopper drive with quadrant diagram<br>3c. Explain with sketches the operation of the given type of two quadrant chopper drive with quadrant diagram<br>3d. Explain with sketches the operation of chopper controlled DC Drive in Solar and battery powered vehicles<br>3e. Describe the procedure to maintain the given type of DC drive using chopper | 3.1 Basic chopper circuit using SCR<br>3.2 Classification based on output voltage and quadrant of operation<br>3.3 Chopper Controlled DC Drives<br>a) Class A Chopper Drive<br>b) Class B Chopper Drive<br>c) Class C Chopper Drive<br>d) Class D Chopper Drive<br>e) Class E Chopper Drive<br>3.3 Application of chopper control drive in Solar and battery powered vehicles. |
| **Unit– IV AC Drives** | 4a. Explain with sketches the operation of three phase induction motor using the given type of control method<br>4b. Explain with sketches the operation of three phase induction motor using the given type ofslip power recovery system<br>4c. Describe with sketches the working of the given type of solar powered pump drives.<br>4d. Describe the procedure to maintain the giventype of AC | 4.1 Stator voltage control method using thyristor circuit.<br>4.2 Variable frequency control method using square wave inverter<br>4.3 Constant V/F control method<br>4.4 Rotor resistance control using chopper<br>4.5 Slip power recovery system<br>4.6 Solar powered pump drives<br>4.7 Drives required at each stage for following applications: Textile mills, Steel rolling mills, Paper mills, Sugar mills |

| | | |
|---|---|---|
| | drive. | |
| **Unit-V Advanced techniques of motor control** | 5a. Explain with sketches the working of PLL control for the given type of DC motor<br>5b. Explain with sketches the working of microprocessor control of the given type of AC/DC drive<br>5c. Explain with sketches the working of microcontroller control of the given type of electricdrive.<br>5d. Describe the procedure to maintain the given type of electric drive using microcontroller. | 5.1 Microcontroller/ Microprocessor based control for drives.<br>5.2 Phase locked loop control of DC motor.<br>5.3 AC/DC drive using microprocessor control<br>5.4 AC/DC drive using microcontroller control.<br>5.5 Synchronous motor drives.<br>5.6 Ratings and specifications of stepper motor.<br>5.7 Stepper motor drives employing microcontroller (No programming) |

*Note:To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.*

## 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 | Basics of Electric Drives | 4 | 2 | 4 | 4 | 10 |
| II | DC Drive using converters | 12 | 4 | 4 | 8 | 16 |
| III | DC Drive using choppers | 12 | 4 | 4 | 8 | 16 |
| IV | AC Drives | 12 | 4 | 4 | 8 | 16 |
| V | Advanced techniques of Motor Control | 8 | -- | 4 | 8 | 12 |
| **Total** | | **48** | **14** | **20** | **36** | **70** |

***Legends:*** *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note****: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary 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) Visit any one textile mill to know the types of drives used in each stage of operation.
b) Visit any one sugar mill to know the types of drives used in each stage of operation.
c) Visit any one paper mill to know the types of drives used in each stage of operation
d) Read the safety precautions of various electric motors used in different drives
e) Find troubleshooting techniques and steps to troubleshoot DC drives

f) Make comparative table for various drives based on its application and maximum power ratings.
g) Check the performance of at least two different types of drives using simulation software like Scilab.

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Use Flash/Animations to explain various theorems in circuit analysis
f) Guide student(s) in undertaking micro-projects.

## 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 are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed six.***

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 total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) **AC motor power rating for given application**: Determine the power rating of fractional h.p. ac motor requiredfor the given desert cooler to lift the water up to 1.5 meter. Assume efficiency between 50 to 75% of rated load.
b) **Brush less DC motor**: Design and assemble 24 Volt, 500 W BLDC motor for robotic applications.
c) **Reversible SCR drive** : Design reversible SCR drive using four quadrant chopper or using L293D and L298 dual H-bridge motor driver ICs for controlling the rotation of the motor in both clockwise and anticlockwise direction.
[Rcf.- http://playwithrobots.com/dc-motor-driver circuits/]
d) **PWM inverter**: Design PWM inverter using 8051 micro controller for speed control of the given AC motor.
e) **Battery operated vehicles**: Design a battery operated bicycle of rating 24V/36V/48V, 250W/500/W/1000W using brushless DC motor.A battery electric vehicle (BEV) is a type of electric vehicle (EV) that uses chemical energy stored in rechargeable battery packs. BEVs use electric motors and motor controllers instead of internal combustion engines (ICEs) for propulsion. They derive all power from battery packs

and thus have no internal combustion engine, fuel cell, or fuel tank. BEVs include motorcycles, bicycles, scooters, skateboards, rail cars, watercraft, forklifts, buses, trucks and cars.

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | Fundamentals of Electrical Engineering | Saxena, S.B lal; Dasgupta, K. | Cambridge university press pvt. Ltd., New Delhi, 2016, ISBN: 9781107464353 |
| 2 | A Text Book of Electrical Technology Vol-II | Theraja, B. L.; Theraja, A. K. | S. Chand and Co. Ramnagar, New Delhi, 2012; ISBN :9788121924405 |
| 3 | Basic Electrical Engineering | Mittle, V.N. ; Mittle, Arvind | McGraw Hill Education, Noida, 2005ISBN: 978-00-705-9357-2 |
| 4 | Power Electronics | P.C.Sen | Mcgraw-Hill Publishing CompanyLimited, New Delhi. |
| 5 | Fundamentals of Electrical Drives, | Dubey,Gopal K. | Narosa Publishing House,New Delhi, 2016, Second Edition |
| 6 | Electrical Drives Concepts and Applications | Subrahmanyam, Vedam | Mcgraw-Hill Publishing New Delhi, 2016 |
| 7 | Power Electronic Systems Theory and Design | Agrawal,Jai P. | Pearson Education ,Inc. New Delhi, 2016 |
| 8 | Electrical Machines | Deshpande,M.V. | PHI Learning, New Delhi, 2016 |
| 9 | A first course on Electrical Drives | Pillai,S.K. | Wiley Eastern Ltd. New Delhi, 2016 ISBN 81-224-0166-X |

## 14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) www.cesim.com/simulations
b) www.scilab.org/scilab
c) www.ni.com/multisim
d) www.youtube.com /electric circuits/AC-DC DRIVES
e) www.dreamtechpress.com /ebooks/AC-DC DRIVES
f) www.nptelvideos.in/electrical engineering/ AC-DC DRIVES
g) www.learnerstv.com/free-engineering/AC-DC DRIVES
h) www.orcad.com/resources/orcad-downloads
i) www.electricaltechnology.org
j) www.electrical4u.com