Program Name : **Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ/IE/IS/IC**

Semester : **Fourth**

Course Title : **Basic Power Electronics**

Course Code : **22427**

1. RATIONALE

Electronic control circuits play major role in industries. In this era of automation in industry and manufacturing sector, the mechanical controls are largely replaced by power electronic devices. In this context this course aims at acquainting the pass outs with the basic principles and applications of basic power electronics devices, so that they can maintain the control circuits used in the field. Hence this course has been designed to achieve this aim.

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 power electronic devices in electronic circuits.**

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 power electronic devices in circuits.
b. Maintain triggering and commutation circuits.
c. Use phase controlled rectifiers in different applications.
d. Use choppers and inverters in different applications.
e. Maintain control circuits consisting of power electronic devices.

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.

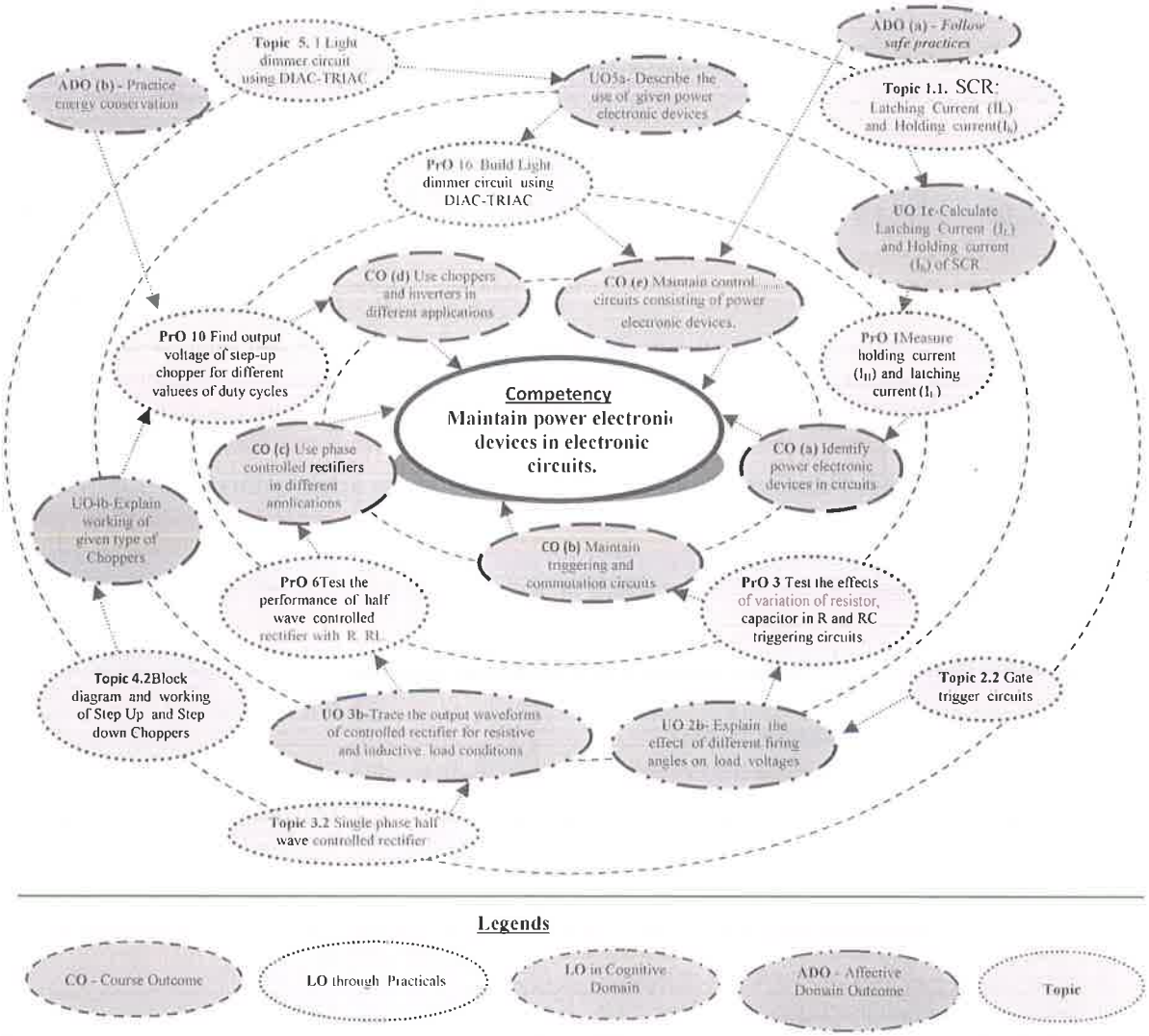

Figure 1 - Course Map

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 Exercises(PrOs)	Unit No.	Approx. Hrs. Required
1	Measure holding current (I_H) and latching current (I_L) of a given SCR from its V-I characteristic curve.	I	2*
2	Test the performance of given IGBT.	I	2*
3	Determine break over voltage of given DIAC from its V-I curve.	II	2
4	Test the effect of variation of resistor, capacitor in R and RC triggering circuits of firing angle of SCR.	II	2
5	Test the effects of variation of R on firing angle in synchronized UJT triggering circuit.	II	2
6	Test the performance of Class C-Complimentary type commutation circuit.	III	2*
7	Test the performance of half wave controlled rectifier with R, RL	III	2*

S. No.	Practical Exercises(PrOs)	Unit No.	Approx. Hrs. Required
	load and measure load voltage.		
8	Determine firing angle and output voltage of 3- phase half wave controlled rectifier using Delta-star transformer.	III	2*
9	Test the performance of full wave controlled rectifier with R, RL load and measure load voltage.	IV	2
10	Find output voltage of step-up chopper for different values of duty cycles.	IV	2
11	Test parallel inverter to the measure frequency and output voltages.	IV	2
12	Measure output voltages of step-down chopper for different values of duty cycles. Part I	IV	2*
13	Measure output voltages of step-down chopper for different values of duty cycles. Part II	IV	2*
14	Build/test SMPS for mobile phone charging. Part I	IV	2
15	Build/test SMPS for mobile phone charging. Part II	V	2
16	Build Light dimmer circuit using TRIAC test the effect of resistance variation on intensity of lamp.	V	2*
	Total		**32**

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, 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 %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	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. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
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
- 'Organizing Level' in 2nd year
- 'Characterizing 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 authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Power scope: dual channel, dual trace,5Mhz,max .voltage 1000vp-p	4,6,8,9, 11-16
2	TONG Tester for ac line current measurement up to 100A	7
3	CRO:20 MHz with color display , dual channel, ac voltage 750v max	6-8
4	Digital Tachometer- non – contact type up to 2000rpm	Micro project
5	LCR Q meter Accurate 0.01% - up to 5 MHz	3,5,1
6	Multiple output DC regulated power supply: 0-30V,0-100V,0-300V up to 2A	1,2,10
7	Function generator: DC to 10 MHz , max output 0-30Vp-p, sine, triangle, square wave function within build counter.	10
8	Single phase DIMMERSTAT :0-300Vac,5A	6-8
9	Digital meter for DC voltage measurement up to 700V, DC current measurement up to 10A	1,2
10	Desktop PC, 32GHz with multimedia features, LED monitor	Micro project

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught 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 (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Thyristor Family Devices	1a. Explain with sketches the working of the given type of thyristor device. 1b. Interpret V-I characteristics of the given power electronic device. 1c. Calculate latching current (I_L) and holding current (I_h) for the given type of SCR. 1d. Select relevant triggering device for the given circuit with justification. 1e. Identify various power electronic	1.1 SCR: Construction, operating Principle with Two transistor analogy, V-I characteristics, latching current (IL) and holding current(I_h), applications of SCR 1.2 Thyristor family devices: LASCR, SCS, GTO and TRIAC, power MOSFET, IGBT : Construction, operating principle, V-I characteristics and applications 1.3 Triggering devices- UJT, PUT,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	devices along with their specifications. 1f. Describe with sketches the procedure to troubleshoot the simple given type of thyristor circuit	SUS, SBS and DIAC: Construction, operating Principle, V-I characteristics and applications
Unit– II Turn ON and Turn OFF methods of SCR	2a. Describe the turn-ON mechanism of the given SCR circuit. 2b. Explain with sketches the effect of the given firing angles on load voltages. 2c. Explain with sketches the methods of triggering for the given SCR. 2d. Explain with sketches the turn OFF method of the given SCR. 2e. Explain with sketches the working of protection circuits for the given SCR against over voltage, over current. 2f. Describe with sketches the procedure to troubleshoot the simple given type of thyristor turn-ON/OFF circuit.	2.1 Concept of turn ON mechanism of SCR: High voltage thermal triggering, illumination triggering, dv/dt triggering, gate triggering of SCR. 2.2 Gate trigger circuits : resistance triggering circuit, resistance, capacitance triggering circuit 2.3 SCR triggering Method: UJT/ PUT-relaxation oscillator circuit , synchronized UJT triggering circuit, pulse transformer and optocoupler (MCT2E) 2.4 Turn OFF methods : Class A-series resonant commutation circuit, class B-Shunt resonant commutation circuit, class C-Complimentary Symmetry commutation circuit 2.5 Protection circuits of SCR: over voltage, over current, snubber circuit and crowbar
Unit– III Phase controlled Rectifiers	3a. Explain with sketches the effect of change in firing angle on output current of the given rectifier considering concept of phase control. 3b. Interpret the output waveforms of the given phase controlled rectifier for given load condition. 3c. Calculate load voltage and load current of the given controlled rectifier. 3d. Explain effect of the given load on the output of the given controlled rectifier. 3e. Describe with sketches the procedure to troubleshoot the simple given type of phase controlled rectifier	3.1 Phase control parameters: Firing angle (**α**) and conduction angle (**Ø**) 3.2 Single phase half wave controlled rectifier: circuit diagram , working and waveforms with R and RL load, effect of freewheeling diode with RL load 3.3 Single phase centre tapped full wave controlled rectifier : circuit diagram , working and waveforms with R and RL load, effect of freewheeling diode with RL load 3.4 Basic three phase half wave controlled rectifier

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-IV Choppers and Inverters	4a. Explain the working of the given Choppers with sketches and formulae. 4b. Explain with sketches the working of the given type of inverter circuit. 4c. Select the chopper and inverter for the given application. 4d. Describe with sketches the procedure to troubleshoot the simple given type of Chopper/Inverter	4.1 Convertors and its types 4.2 Block diagram and working of step up and step down choppers using power MOSFET 4.3 Inverters: circuit diagram, working of series inverter, parallel inverter
Unit –V Industrial applications of power electronic devices	5a. Describe the use of power electronic device in the given industrial circuit. 5b. Identify industrial control circuit in the given PCB. 5c. Describe the performance of the given Industrial control circuit. 5d. Explain with sketches the working of the given type of UPS 5e. Describe with sketches the procedure to troubleshoot the given power electronic application such as the UPS/SMPS and others.	5.1 Light dimmer circuit using DIAC-TRIAC 5.2 Battery charger using SCR 5.3 Emergency lighting system 5.4 Temperature controller using SCR 5.5 Block diagram and concept of UPS (on line and off line) 5.6 Block diagram and concept of SMPS

***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 QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Thyristor Family Devices	12	4	6	8	18
II	Turn ON and Turn OFF methods of SCR	10	4	4	6	14
III	Phase controlled Rectifiers	10	2	4	8	14
IV	Choppers and Inverters	10	2	4	8	14
V	Industrial Applications of power electronic devices	06	2	2	6	10
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. Library survey regarding different data sheets and manuals.
b. To collect the literature related to specification of available power devices in the market.
c. Refer technical magazine to collect information of current devices used in power electronics industry.
d. Prepare power point presentation for controlled rectifiers.
f. Visit to nearby industry related to power electronics.

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. ***'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. Guide student(s) in undertaking micro-projects.
f. Use PPTs to explain the construction and working of various power electronic devices.
g. Use PPTs to explain the construction and working of controlled rectifiers.
h. Guide students to use data manuals.
i. Deliver seminar on related topic.
j. Prepare industrial visit report with reference to specification, uses of power electronics application.

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 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 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. **Controlled Rectifier**: Build a circuit of the Battery charger for charging a battery of 6V, 4AH.
b. **Controlled Rectifier:** Build fan speed regulator circuit using DIAC, TRIAC on zero PCB.
c. **Phase controlled Rectifiers:** Build the circuit for Speed control of 12V DC shunt motor using IGBT on zero PCB.
d. **Phase controlled Rectifiers:** Build AC power flasher using two SCRs on zero PCB.
e. **Industrial Applications of power devices:** Build DC time delay relay using PUT on zero PCB.
f. **Turn ON and Turn OFF methods of SCR:** Build Ramp and pedestal synchronized triggering circuit using UJT and pulse transformer on zero PCB.
g. **Industrial Applications of power devices:** Build temperature controller using PT-100 thermistor and thyristor on zero PCB.
h. **Industrial Applications of power devices:** Build Emergency light system. For 6V battery on zero PCB.
i. **Choppers and Inverters:** Build Step down chopper using MOSFET/IGBT on zero PCB.
j. **Industrial Applications of power devices:** Build low power SMPS of 0 to
k. 12V DC using suitable power electronic device on zero PCB.
l. **Industrial Applications of power devices:** Simulate control of intensity of light using phase control.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Power Electronics	Moorthi, V.R.	Oxford University Press , New Delhi 110001, 2013, ISBN 0-19-567092-2
2	Fundamentals of Power Electronics	Bhattacharya, S. K.	ISTE Learning materials centre,2006 , ISBN 9788125918530
3	Power Electronics Essentials and Applications	Umanand, L	Wiley India Pvt. Ltd, New Delhi, 2011, ISBN :9788126519453
4	Power Electronics Circuits Devices and Applications	Rashid, Muhammad H.	Pearson Education India, New Delhi, 2012,ISBN: 9780133125100
5	SCR Manual Including TRIACS and other thyristors (6th Edition)	General Electric(Author)	General Electric Co,2007, ISBN:9780137967636

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.nptel.ac.in/courses /108101038
b. PSIM software for power electronics
c. www.en.wikibooks.org/wiki/Power_Electronics
d. www.books.google.co.in/books/about/Power_Electronics