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BASIC POWER ELECTRONICS **Course Code : 314363**

Programme Name/s	**: Digital Electronics/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electronics & Communication Engg./ Electronics Engineering/ Instrumentation & Control/ Industrial Electronics/ Instrumentation/**
Programme Code	**: DE/ EJ/ EK/ ET/ EX/ IC/ IE/ IS**
Semester	**: Fourth**
Course Title	**: BASIC POWER ELECTRONICS**
Course Code	**: 314363**

I. RATIONALE

Power electronics plays a important role in the efficient use of electrical energy and environmental control. The power electronic circuits are used in industrial automation and in manufacturing sector of control circuits. This course is developed to empower the students to apply their knowledge to solve broad power electronics based industrial application problems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help students to attain the following industry/employer expected outcome through various teaching learning experiences:

• Maintain electronic control systems comprising of power electronic components.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Identify power semiconductor devices used in Power Electronics circuit.
- CO2 - Maintain SCR Triggrering and Commutating Circuits.
- CO3 - Use phase controlled rectifiers in different applications.
- CO4 - Analyze power converter circuits.
- CO5 - Maintain power electronic circuits used in various domestic and industrial applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA			
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min		
314363	BASIC POWER ELECTRONICS	BPE	DSC	3	-	2	1	6	3	3	30	70	100	40	25	10	25@	10	25	10	175	

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Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Classify Thyristor family devices on the basis of applications and features. TLO 1.2 Explain the working of various power electronics devices with sketches. TLO 1.3 Interpret V-I characteristic of the given power electronic device. TLO 1.4 Calculate latching and holding current for given thyristor. TLO 1.5 Select proper triggering device for the given circuit and justify it. TLO 1.6 Identify various power electronic devices along with their specification for given application.	**Unit - I Power Semiconductor Devices** 1.1 Classification of Thyristor family devices 1.2 Construction ,working principle, V-I characteristics and applications of Power diode ,Power MOSFET and IGBT, Reverse recovery characteristics of power diode 1.3 SCR- Construction ,working principle, V-I characteristics and applications, Two transistor analogy, latching and holding current for SCR 1.4 LASCR, TRIAC, GTO,SCS - Construction ,working principle, V-I characteristics and applications 1.5 Triggering devices :UJT, PUT, SUS, SBS, DIAC - Construction, working principle, V-I characteristics and applications	Presentations Lecture Using Chalk-Board

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Describe the turn- ON mechanism of given SCR circuit. TLO 2.2 Explain with sketches the effect of the given firing angles on load voltages. TLO 2.3 Explain with sketches the triggering methods for the given SCR. TLO 2.4 Differentiate various types of commutation methods for SCR with sketches. TLO 2.5 Justify the need of protection circuit for SCR. TLO 2.6 Explain with sketches the working of protection circuits for the given SCR against over voltage and over current.	**Unit - II Triggering and Commutation methods of SCR** 2.1 Concept of turn ON mechanism for given SCR: High voltage, thermal triggering, dv/dt triggering, gate triggering 2.2 Gate trigger circuits: Types of gate signals: DC signal, AC signal and pulse signal 2.3 Thyristor Triggering Circuits: Resistance Triggering Circuit, Resistor-Capacitor (RC) Triggering Circuit, half wave and full wave triggering Circuit, UJT (Unijunction Transistor) Triggering Circuit, Pulse Transformer Triggering Circuit, UJT/ PUT-relaxation oscillator circuit 2.4 Turn OFF (commutation) methods: Natural and Forced Commutation, Types: Class A, Class B, Class C, Class D, Class E, Class F 2.5 SCR protection circuits: Need, Factors causing permanent damage to SCR, causes of over voltage and over current, Over voltage protection circuits using RC snubber circuit and non linear resistor, over current protection circuit using Fuse operation, Electronic crowbar protection circuit	Presentations Lecture Using Chalk-Board
3	TLO 3.1 Explain with sketches the effect of change in firing angle on output voltage of the given rectifier considering concept of phase control. TLO 3.2 Explain operation of Half wave and Full wave controlled rectifiers for given load. TLO 3.3 Explain operation of Semi-converters for given load. TLO 3.4 Calculate load voltage and load current of the given controlled rectifier. TLO 3.5 Describe working principle of multiphase rectifiers with circuit digram.	**Unit - III Phase controlled rectifiers** 3.1 Phase control parameters: Firing angle , and conduction angle 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, numerical 3.3 Single phase centre tapped full wave controlled rectifier and Bridge rectifier: circuit diagram, working and waveforms with R and RL load, effect of freewheeling diode with RL load, numerical 3.4 Semi- converters: circuit diagram, working and waveforms with R and RL load, effect of freewheeling diode with RL load 3.5 Three phase rectifier: need, circuit diagram, working and waveforms with R load	Lecture Using Chalk-Board Presentations Video Demonstrations

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Explain types of converters and classify. TLO 4.2 Explain the working of the given Choppers with sketches . TLO 4.3 Explain with sketches the working of the given type of inverter circuit. TLO 4.4 Describe performance parameters for inverters. TLO 4.5 Explain with sketches the working of the given type of Cycloconverter.	**Unit - IV Power Converters** 4.1 Chopper: Introduction, classification 4.2 Block diagram and working of step down chopper using IGBT, with R and RL load 4.3 Step up chopper using IGBT with R load 4.4 Inverter: Introduction, classification, Block diagram and working of Series inverter, Parallel inverter, Single phase Half bridge and Full bridge inverter 4.5 Performance parameters for the inverter: Harmonic factor of nth Harmonic, Total Harmonic Distortion, Distortion Factor, Lowest order Harmonic 4.6 Cyclo-converter: Introduction, Classification, Single phase Cyclo-converter: working principle of Midpoint configuration with R load	Lecture Using Chalk-Board Presentations Flipped Classroom
5	TLO 5.1 Describe the use of power electronic device in the given industrial circuit. TLO 5.2 Describe the performance of the given Industrial control circuit. TLO 5.3 Explain with sketches the working of the given type of UPS. TLO 5.4 Explain with sketches the working of the given type of SMPS.	**Unit - V Industrial applications of power electronic devices** 5.1 Proximity detector and Time delay circuit using SCR and PUT/UJT 5.2 Battery charger, Emergency light system and Flasher circuit using SCR 5.3 Static AC and DC circuit breaker and Zero Voltage Switch 5.4 Application of Choppers in Electric vehicles 5.5 Block diagram and concept of Online and Offline UPS 5.6 SMPS: concept, Block diagram and applications	Lecture Using Chalk-Board Presentations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Test the SCR in forward conduction state and measure holding current (IH) and latching current (IL).	1	*Performance of SCR using IC 2N4103 or any other equvalent IC	2	CO1
LLO 2.1 Test the forward and transfer characteristics of given IGBT.	2	*Performance of IGBT using IC BUP 402 or any other equivalent IC	2	CO1
LLO 3.1 Test the performance of DIAC and plot its V-I characterstics.	3	*Performance of DIAC using IC DB3/DB4 or any other equivalent IC through its V-I curve	2	CO1
LLO 4.1 Test the R and RC triggering circuits of SCR.	4	Masurement of output voltage by changing firing angle through variation in resistor, capacitor in R and RC triggering circuits of SCR.	2	CO2
LLO 5.1 Measure output voltage by changing firing angle in synchronized UJT triggering circuit.	5	*Synchronized UJT triggering circuit.	2	CO2
LLO 6.1 Observe and verify Input-Output waveforms of Class C-Complimentary type commutation circuit.	6	*Class C-Complimentary type commutation circuit	2	CO2

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 7.1 Observe and verify Input-Output waveforms of half wave controlled rectifier with R, RL load and measure load voltage.	7	* Half wave controlled rectifier	2	CO3
LLO 8.1 Observe and verify the Input-output waveforms of full wave controlled rectifier with R, RL load and measure load voltage.	8	Performance of full wave controlled rectifier with R, RL load and measure load voltage.	2	CO3
LLO 9.1 Calculate firing angle and observe input-output voltage waveforms of 3- phase half wave controlled rectifier using Delta-star transformer.	9	Performance of 3- phase half wave controlled rectifier	2	CO3
LLO 10.1 Measure output voltage of step-up chopper for different values of duty cycles.	10	Performance of step-up chopper for different values of duty cycles	2	CO4
LLO 11.1 Measure output voltage of step-down chopper for R load. LLO 11.2 Measure output voltage of step-down chopper for RL load.	11	*Step-down chopper for R and RL load	2	CO4
LLO 12.1 Measure frequency and output voltage of parallel inverter.	12	Performance of parallel inverter	2	CO4
LLO 13.1 Simulation of single phase midpoint Cyclo-converter with R load.	13	Single phase midpoint Cyclo-converter with R load.	2	CO4
LLO 14.1 Build / test Light dimmer circuit using DIAC-TRIAC.	14	*Light dimmer circuit using DIAC-TRIAC	2	CO5
LLO 15.1 Build / Test Emergency Light circuit using SCR.	15	Emergency Light circuit using SCR	2	CO5
LLO 16.1 Simulation of Temperature controller using SCR.	16	Temperature controller using SCR	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Build Battery charger circuit for charging a battery of 6V, 4AH.

Build fan speed regulator circuit using DIAC and TRIAC.
Build Speed control circuit for12V DC shunt motor using IGBT.
Build a circuit to control Intensity of light using phase control.
Build a circuit for Automatic street light using SCR.

Assignment

- Make Power point presentation on application of Chopper in Electric vehicle.

Make report on use of power electronics based systems in home/industrial applications.
Make a report on role of power electronic devices/system in application of EV Charging Station.

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Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Trainer kit for SCR: Trainer kit suitable to plot anode - cathode characteristics and gate characteristics of silicon controlled Rectifier (SCR). 0 - 10V and 0 - 150V DC power supply of required current rating & 4 no of digital voltmeter & current meter are inbuilt in the kit.	1
2	Function generator: 1 MHz , sine, square, triangular, ramp and pulse generator Freq range 0.01 Hz to 1 Mhz, Output amplitude 20V open circuited, Output impedance 50 ohms. Facility to indicate output frequency & amplitude on dispay.	10
3	MATLAB-SIMULINK / Scilab software, Proteus software, Multisim software	13,16
4	Trainer kit for IGBT:Trainer kit suitable to plot characteristics of IGBT. 2 no of variable DC Power supply of required current rating & 4 no of digital voltmeter & current meter are built in the kit.	2
5	Trainer kit for DIAC :Trainer kit suitable to plot forward and reverse characteristics of Diac. 0-50V DC power supply & required digital voltmeter & current meter is inbuilt in the kit.	3
6	Trainer kit for SCR triggering circuits :Trainer kit suitable to study the basic triggering methods of SCR like Resistance triggering circuit; R-C triggering circuit; UJT triggering circuit; IC 555 triggering circuit etc. Should be provided with SCR, Lamp load (15W) & isolation transformer. Required R & C components are provided in trainer which can be interconnected by patch cords to make the desired configuration. SCR should be operated on 230V, 50Hz AC supply.	4,5
7	Trainer kit for HWR , FWR without and with Capacitor and Inductor Filter: Trainer kit shall consists of Following parts provided on PCB with connecting terminals & test points. Mains transformer primary 230V A.C. Secondary centre tap 12-0-12VAC at 500 mA. 4 diodes which can be interconnected by patch cords to make HWR, FWR circuit, Filter Choke coil, filter Capacitors, Load Resistors. Required configuration of rectifier and filter can be assembled by patch cords. Waveforms can be observed on CRO & various measurements can be done. Line & load regulation can be found out.	7,8
8	LCR Q meter: Accurate 0.01% up to 5 MHz	8,10,11
9	Regulated power supply: 0- 30 Volt, 2 A with digital display, with S.C. protection	All
10	Digital multimeter: 3.5 digit with R , V, I measurements, diode and BJT testing	All
11	CRO : Dual Channel, 4 Trace CRT / TFT based Bandwidth 20 MHz/30 Mhz X10 magnification 20 nS max sweep rate, Alternate triggering ,Component tester and with optional features such as Digital Read out , USB interface	All
12	SCR(IC 2N4103),TRIAC(IC BT 139),MOSFET(IC 47N60C3),IGBT(BUP 402),DIAC (DB3/DB4 SSD3A)any other relevant IC can be used,	All

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Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
13	Analog multimeter: Suitable to measure AC/DC voltage , Current and Resistance, to test power devices DC voltage Range 400mV to 1000 V AC Voltage Range 4V to 750 V ,DC current 4 mA to 10A ,AC current 4 mA to 10 A Resistance 400 Ohm to 40 M ohm or any other better specifications and facilities	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Power Semiconductor Devices	CO1	12	4	8	4	16
2	II	Triggering and Commutation methods of SCR	CO2	8	4	4	6	14
3	III	Phase controlled rectifiers	CO3	10	4	4	8	16
4	IV	Power Converters	CO4	9	4	4	6	14
5	V	Industrial applications of power electronic devices	CO5	6	2	4	4	10
Grand Total				**45**	**18**	**24**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit tests of 30 marks and average of two unit test marks will be consider for out of 30 marks.

For formative assessment of laboratory learning 25 marks
Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment is of 70 marks.

End semester summative assessment of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	-	1	1	2	1	1			
CO2	3	-	1	1	2	1	1			
CO3	3	2	1	1	1	1	1			
CO4	2	2	2	1	2	1	1			

CO5	2	2	2	2	3	3	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	M.D. Singh, K. B .Khanchandani	Power Electronics	Tata Mc,Graw Hill ,ISBN-13: 9780070583894
2	P.S.Bimbhra	Power Electronics	Khanna Publisher, New Delhi, ISBN-10. 9788174092793
3	Rashid, Muhammad H.	Power Electronics Circuits Devices and Applications	Pearson Education India, New Delhi,ISBN-10. 9332584583
4	B.R.Gupta And V.Singhal	Power Electronics	S.K.Kataria and Sons, ISBN 10: 9350141078
5	Harish C Rai	Power electronics and Industrial application	CBS publishers ISBN-13: 9789386827869
6	Robert W.Erickson Dragan Maksimovic	Fundamental of Power Electronics	Springer,ISBN-13: 9783030438791

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://learnabout-electronics.org/Semiconductors/thyristors_63.php	Thyristor family, Thyristor protection
2	https://www.electronics-tutorials.ws/power/unijunction-transistor.html	Thyristor family devices, SMPS, Rectifiers.
3	https://www.electrical4u.com/chopper-dc-to-dc-converter/	Chopper operation
4	https://www.elprocus.com/cycloconverters-types-applications/	Cyclo-Converter
5	https://www.alldatasheet.com/	All Datasheets

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students