GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering
Level: PG
Branch: Electrical Engineering
Course / Subject Code: ME01000141

Course / Subject Name: Advance Power Electronics

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PCC

Prerequisite:	NA
Rationale:	Power Electronics has become an important area of electrical engineering where utilization and control of electrical energy, improvement of efficiency etc. is required. It is basic necessity for every application like Automation, Power Transmission and Control, Power Quality improvement, Advanced Transportation System etc. As per an estimation, 70% of energy today is processed through Power Electronics system and this will go on increasing. In this context, it is necessary for PG students in any branch related to electrical engineering to understand power electronics devices, converters and their applications. This subject deals with these requirements.

Course Outcome:

After Completion of the Course, the student will able to:

No	Course Outcomes
01	Select proper power electronic switches from various manufacturers for the given application.
02	Design magnetic components for given DC-DC power converter.
03	Select most appropriate gate driving circuit(s)/ IC(s).
04	Identify power converter topology for given application.

Teaching and Examination Scheme:

Teaching Scheme in Hours			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Review of Semiconductor Power Devices:** Review of Semiconductor devices like Power diode, Power BJT, SCR, MOSFET, IGBT,GTO,MCT; Static and dynamic characteristics of these devices; controlled and uncontrolled switches, Single quadrant, Two quadrant and bi-directional switches	6	10
2.	**Switching Voltage Regulators:** Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Half bridge, Full bridge configurations, Push-pull converter, C'uk converter, Sepic Converter; Design criteria for SMPS; Multi-output switch mode regulator.	8	15
3.	**Design of Magnetic Components:** Design of power transformer; high frequency transformers for flyback, forward, half-bridge–full bridge and push pull converters; Design of inductors for various converter topologies; Design of current transformers for high frequency current measurement; Different types of core materials.	8	15
4.	**DC-AC converters / Inverters:** Classification; Review of line commutated inverters; Bridge inverters with 120°,180°,and 150° modes of operation; Harmonic reduction techniques; Sine-triangular PWM; Space Vector Pulse Width Modulation; Current Source Inverters	6	15
5.	**Gate and Base drive circuits:** Preliminary design considerations; DC coupled drive circuits with unipolar and bipolar outputs; Importance of isolation in driver circuits; Electrically isolated drive circuits; Some commonly available driver chips (based on boot-strap capacitor); Cascade connected drive circuits; Thyristor drive circuits; Protection in driver circuits; Blanking circuits for bridge inverters.	7	20
6.	**DC-AC and AC-AC converters:** Review of On-off and phase control; Three phase half-wave and full wave controllers and their analysis with resistive loads; circulating current operation; non-circulating current operation; mean output voltage and harmonics in supply current waveform. Multilevel converters, topologies, working, control and applications. Matrix converters, topologies, working, control, and applications. Three phase Cyclo-converters their working, control and applications.	7	15

7	**Advancements:** Latest developments in Power Electronics field related to new materials, devices, power topologies, control strategies and ICs, applications etc.	3	5
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (%)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
30	20	20	20	10	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003- Mohan, Undeland and Robbins
2. "Power Electronics - circuits, devices and applications", Prentice Hall of India, 2nd ed., 2000- Muhammad H. Rashid
3. "Modern Power Electronics", S. Chand and Co. Ltd., New Delhi, 2000- P. C. Sen
4. "Design of magnetic components for switched mode power converters", Wiley Eastern Ltd., New Delhi, 1992- L. Umanand and S.R. Bhat
5. "Thyristorised power controllers", New Age International Publishers, 1986, (Reprint 2008)- G.K. Dubey, S.R. Doradia, A. Joshi, and R.M.K. Sinha,
6. "Fundamentals of Power Electronics", Springer International, 2nd ed., 2001- R.W. Erickson, D. Maksimovic
7. "Advanced Power Electronics Converters PWM Converters Processing Ac Voltages", Euzeli Cipriano Dos Santos Jr. and Edison Roberto Cabral Da Silva, IEEE Press Wiley, ISBN: 9781118880944

(b) Open source software and website:

1. https://nptel.ac.in/
2. https://americas.fujielectric.com/products/semiconductors/
3. https://www.yzpst.net/home
4. https://www.hitachi.us/psdd/
5. https://in.mitsubishielectric.com/en/feature/partneringindia/semi-conductor.html
6. https://toshiba.semicon-storage.com/ap-en/semiconductor.html
7. https://maxpowersemi.com/
8. https://www.infineon.com/cms/en/product/sensor/current-sensors/

Suggested Course Practical List:

Laboratory activities should be based on preparing working model / simulation of different power

converters like,

1. Design of an inductor for a given DC-DC converter configuration. The converter topology and the specifications for the inductor should be specified by the course instructor. Each student should be assigned a different design problem.
2. Design of a transformer for an isolated DC-DC converter configuration. The converter topology and the specifications for the inductor should be specified by the course instructor. Each student should be assigned a different design problem.
3. Design driver circuit for isolated / non isolated power switches connected in HB / FB configuration.
4. Write a code to determine the switching positions of the single phase bridge inverter so that the output voltage waveform is free from 3rd, 5th and 7^{th} harmonics.
5. Hardware or simulation or mathematical analysis related assignments based on other topics related to the course.

List of Laboratory/Learning Resources Required:

1. Simulation software like MATLAB, SCIAB, OCTAVE or similar.
2. 4 or more channel DSO/MSO with compatible high frequency high voltage differential voltage probe and current probe
3. Readily available hall effect current measurement sensor using ACS7xx /WCS17xx/ WCS16xx series or similar
4. Digital Multi Meter
5. PC with internet connectivity

Any Other:

1. https://www.infineon.com/cms/en/design-support/
2. https://www.onsemi.com/design/tools-software/elite-power-simulator-tool

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