



# GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch: Power Electronics

Course / Subject Code: ME01000261

**Course / Subject Name: Switched Mode and Resonant Converters**

w. e. f. Academic	2024-25
Semester:	1 <sup>st</sup> Semester
Category of the	PEC

Prerequisite	NA
Rationale:	This subject is an elective subject dealing with various power converters for controlled DC output. With rapid growth in use of electronics products, demand for high efficiency and performance power supply for these products is increasing. Every domestic, industrial, military, space application with electronics circuits requires some kind of conversion of electrical energy from raw form to desired form. This makes this subject an important subject for the students of Power Electronics Engineering.

### Course Outcome:

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

No	Course Outcomes
01	Illustrate principles of operation of Non-isolated and Isolated hard-switched DC-DC converters through simulation.
02	Choose appropriate switching frequency considering losses in various components.
03	Design magnetic components used in various converters.
04	Make use of control ICs available in the market from various manufacturers.

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 Hrs	% of Weightage



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1	<b>Non-Isolated Converters:</b> Non-Isolated switching regulator topologies like Buck, Boost and Buck-Boost. Components, circuits, operating principle, losses and efficiency, voltage and current waveforms at various points, output voltage polarity for these regulators, output filter circuit, operating mode, Optimum switching frequency, design examples.	06	15
2	<b>Isolated Converters1:</b> The Push-Pull Topology – Schematic, Operation (With Master/Slave Outputs), Waveforms, Slave Line-Load Regulation, Slave Output Voltage Tolerance, Master Output Inductor Minimum Current Limitations. Various problems of Push Pull converters, Power Transformer Design, peak and RMS voltage and current, leakage inductance, losses, output power, limitations, output filter design. The Forward Topology – Schematic, Operation, Design Relations: Output/Input Voltage, “On” Time, Transformer, Turns Ratios, Slave Output Voltages, Secondary Load, Free-Wheeling Diode, and Inductor Currents, Relations Between Primary Current, Output Power, and Input Voltage, Maximum Off-Voltage Stress in Power Transistor, Practical Input Voltage / Output Power Limits, Forward Converter With Unequal Power and Reset Winding Turns, Power Transformer, Output Filter Design. Double-Ended and Interleaved Forward Converter Topology: Basic Operation, Merits, Drawbacks, and Output Power Limits Flyback Converters: Schematic, Basic Operation and Waveforms, Operating Modes, Discontinuous-Mode Operation, Design Relations and Sequential Design Steps, Design Example for a Discontinuous-Mode Flyback Converter, Design Relations—Continuous-Mode Flybacks, Interleaved Flybacks, Double-Ended (Two Transistor) Discontinuous-Mode Flyback	12	30



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<b>3</b>	<b>Isolated Converters2:</b> Half and Full Bridge Converters: Half-Bridge Converter Topology, Basic Operation, Half-Bridge Magnetics, Output Filter Calculations, Blocking Capacitor to Avoid Flux Imbalance, Half-Bridge Leakage Inductance Problems, Double-Ended Forward Converter vs. Half Bridge, Practical Output Power Limits in Half Bridge Full-Bridge Converter Topology, Basic Operation, Magnetics, Output Filter Calculations, Transformer Primary Blocking Capacitor	07	15
<b>4</b>	<b>Resonant Converters:</b> Soft Switching: Need for and importance of switching circuits. Resonant Converters, The Resonant Forward Converter, Resonant Converter Operating Modes, Resonant Half Bridge in Continuous-Conduction Mode	05	10
<b>5</b>	<b>Current-Mode and Current-Fed Topologies:</b> Introduction, Current-Mode Control, Current-Mode vs. Voltage-Mode Control Circuits, Current-Mode Advantages, Current-Mode Deficiencies and Limitations Study of a typical Current Mode PWM Control IC UC3842, Study of PWM Control ICs like SG3524, SG3525, TL494, MC34060	06	10
<b>6</b>	<b>High Frequency Magnetics:</b> High Frequency Magnetics Design fundamentals: Area Product Method, Optimum Flux Density, Optimum Wire Size for Transformer Transformer Design for Half-Bridge, Full-Bridge, Forward, Flyback and Push-Pull Converters, Transformer Design for Driver Circuits Inductor Design for Power Converters, EMI Generation and Filtering in SMPS, EMI Filtering at Input and Output, Effect of EMI Filter On SMPS Control, Design of Snubber Circuits in SMPS, Analysis of Turn “On” and Turn “Off” Switching Losses, Design of Load-Line Shaping Snubber Circuits	09	20
<b>Total</b>		<b>45</b>	<b>100</b>

**Suggested Specification Table with Marks (Theory):**

Distribution of Theory Marks (%)					
R Level	U Level	A Level	N Level	E Level	C Level
20	15	20	20	10	15



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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. Abraham I. Pressman, Keith Billings, Taylor Morey, "Switching Power Supply Design", Third Edition, McGraw Hill Publishing Company, 2001.
2. L. Umanand and S. R. Bhat, "Design of Magnetic Components for Switched Mode Power Converters", New Age International Publishers
3. Daniel M Mitchell, "DC-DC Switching Regulator Analysis," McGraw Hill Publishing Company, 1988.
4. Sanjaya Maniktala, "Switching Power Supplies A to Z", Newnes
5. M. K. Kazimierczuk, 'Pulse-width Modulated DC-DC Power Converters', John Wiley and Sons, 2008.
6. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India Private Limited, 2009
7. Robert W. Erickson & Dragon Maksimovic "Fundamentals of Power Electronics" Second Edition, 2001 Springer.
8. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics: Converters, Applications, and Design", 3<sup>rd</sup> Edition, John Wiley & Sons, 2002

### **(b) Open-source software and website:**

1. <https://www.nptel.ac.in>
2. <https://www.mathworks.com/>
3. <https://powersimtech.com>
4. <https://www.scilab.org/>

### **Suggested Course Practical List:**

1. Study of basic topologies of DC-DC Converters
2. To design transformer for forward converter/fly-back converter/ push-pull converter/ half bridge converter/ full bridge converter
3. To design inductor for Buck/Boost/Buck-Boost Regulators
4. Output filter design and study of its frequency response
5. Study of resonant converters
6. Study and design of Forward/Flyback/Push-Pull/Half-Bridge/Full-Bridge Regulators
7. Develop closed loop control of buck/boost converter in voltage/current mode control.

### **List of Laboratory / Learning Resources Required:**



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Laptop/PC with simulation software,

**Suggested Activities for Students: If any**

Small practical projects/ case study based on theory with presentation and report for the same can be given to students.

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