



# GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Subject Code: ME02000761

Subject Name: Modelling and Analysis of Power Converters

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	PCC

<b>Prerequisite:</b>	Power Electronics Fundamentals, Control Systems, Mathematics
<b>Rationale:</b>	The topic "Modeling and Analysis of Power Converters" is crucial for grasping and advancing modern power electronics, which are fundamental to our technology-driven society. Power converters play a vital role in various applications, including renewable energy systems, electric vehicles, industrial automation, and consumer electronics. This course aims to equip students with a thorough understanding of power converters, covering both theoretical concepts and practical applications.

## Course Outcomes:

After completing the course, students will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Comprehend and Classify Power Electronic Converters	20
CO-2	Analyze and Model Steady State and Dynamic Characteristics	20
CO-3	Design and Implement Pulse Width Modulation (PWM) Control Techniques	20
CO-4	Develop and Apply Feedback Control Systems	20
CO-5	Integrate Advanced Analysis Techniques and Practical Hardware Skills	20

## Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150



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## Contents:

Sr. No.	Content	Total Hrs	% Weightage
1	<b>Introduction to Power Electronic Converters:</b> Overview of basic and advanced power electronic converters, Applications and basics of utility power conversion, Isolated and non-isolated converter circuits, Types of power converter models	6	10
2	<b>Steady State Converter Analysis:</b> Steady state modeling of power converters, DC transformer model and loss modeling	7	20
3	<b>Dynamic Modeling of Power Converters:</b> AC modeling of converters, State-space averaging, Transfer functions and frequency domain analysis, Extra Element Theorem	7	20
4	<b>Pulse Width Modulation (PWM) Control:</b> PWM control of power converters, Voltage source and current source inverters	6	15
5	<b>Feedback Control Design:</b> Voltage mode and current mode control, Control of inverters and rectifiers	5	10
6	<b>Advanced Analysis and Control Techniques:</b> Analog and digital implementation of controllers, Advanced analysis and control techniques applied to power electronics converters	6	10
7	<b>Power Electronic circuit Design:</b> Power semiconductor devices, Gate drivers, Snubber design, Thermal design, Magnetics design, Electromagnetic interference in power electronic converters, Familiarity and design on power electronic hardware	8	15
<b>TOTAL</b>		<b>45</b>	<b>100</b>

## References:

1. Ned Mohan, Tore M. Undel and, William P. Robbins, Power Electronics: Converters, Applications, and Design, 3rd Ed. Wiley, 2007.
2. Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, 4th Ed. Pearson Education, 2017.



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3. L. Umanand, Power Electronics: Essentials and Applications, John Wiley India, 2009, 1 st Edition.
4. B. Jayant Baliga, Fundamentals of Power Semiconductor Devices, Springer, 2018, 2nd Edition.
5. Bin Wu, High Power Converters and AC Drives, Wiley-Inter science, 2017, 2nd Edition.
6. Derek A Paice, Power Electronic Converter Harmonics Multi pulse Method for Clean Power, IEEE Press, 1995
7. Course Material on Switched Mode Power Conversion by V. Ramanarayanan, Indian Institute of Science

[https://ee.iisc.ac.in/wp-content/uploads/2023/01/SMPC\\_VRamnarayanan.pdf](https://ee.iisc.ac.in/wp-content/uploads/2023/01/SMPC_VRamnarayanan.pdf)

## **Suggested List of practical:**

1. Simulate and analyze the performance of buck, boost, and buck-boost converters using simulation software like MATLAB/Simulink.
2. Perform steady state analysis of a buck converter and verify results using simulation tools.
3. Develop and simulate the dynamic model of a boost converter, including the derivation of transfer functions.
4. Simulate and analyze the AC response of a power converter using state-space averaging and frequency domain techniques.
5. Implement and simulate PWM control techniques for a power converter, analyzing the effects of different duty cycles.
6. Simulate the voltage mode control strategy for a buck converter, including designing the feedback loop.
7. Develop and simulate a current mode control strategy for a boost converter, including the design of the current sensing and feedback loop.
8. Perform loss modeling and simulation for different power converter topologies, including conduction and switching losses.
9. Simulate and analyze the electromagnetic interference in power electronic converters, exploring different mitigation techniques.
10. Design and simulate a voltage source inverter (VSI) for DC-AC conversion, including harmonic analysis.
11. Design, build, and test a hardware buck converter circuit. Measure and analyze the steady state and transient responses.



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12. Design and implement gate driver circuits for power semiconductor devices. Test the performance and analyze the switching characteristics.

### **Suggested MOOC courses for further study:**

1. High Power Multilevel Converters - Analysis, Design, and Operational Issues
  - o [https://onlinecourses.nptel.ac.in/noc22\\_ee16/preview](https://onlinecourses.nptel.ac.in/noc22_ee16/preview)
2. Power Electronics
  - o <https://archive.nptel.ac.in/courses/108/102/108102145>
3. Design and Simulation of Power Conversion Using Open Source Tools
  - o [https://onlinecourses.nptel.ac.in/noc20\\_ee12/preview](https://onlinecourses.nptel.ac.in/noc20_ee12/preview)
4. Fundamentals of Power Electronics
  - o [https://onlinecourses.nptel.ac.in/noc22\\_ee03/preview](https://onlinecourses.nptel.ac.in/noc22_ee03/preview)
5. Design of Power Electronic Converters - Course by Shabari Nath, IIT Guwahati
  - o [https://onlinecourses.nptel.ac.in/noc24\\_ee39/preview](https://onlinecourses.nptel.ac.in/noc24_ee39/preview)

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