INSTITUTE	**FACULTY OF TECHNOLOGY**
PROGRAM	**MASTER OF TECHNOLOGY in ELECTRICAL ENGINEERING**
SEMESTER	**1**
COURSE TITLE	**PULSE WIDTH MODULATION OF POWER ELECTRONIC CONVERTER**
COURSE CODE	**01PE1104**
COURSE CREDITS	**4**

Objective:

1 Student will develop skill to evaluate different Pulse Width Modulation techniques of Voltage Source Inverter and apply these techniques to various applications.

Course Outcomes: After completion of this course, student will be able to:

1 Differentiate among different carrier based and zero space vector Pulse Width Modulation schemes (Evaluate).

2 Calculate losses in VSI converter operating with PWM(Apply).

3 Evaluate harmonic spectrum of PWM method (Evaluate).

4 Decide the most appropriate PWM method for specific industrial applications (Analyze).

Pre-requisite of course: Power Electronics

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	**Overview of PWM converter** Single Phase Inverter, Voltage Source Inverter – Voltage and Current in Square wave mode, switching function representation of Three Phase Converter, Concept of Space Vector, Multilevel Inverter Topologies – Cascaded H Bridge, Flying Capacitors and Neutral Point Clamped Inverter Topologies	8
2	**Carrier Based Modulation of Single-Phase Inverter** Two level modulation, Three level modulation, Analytic Calculation of Harmonic Losses, Sideband Modulation, Switched Pulse Position, Switched Pulse Sequence	6

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Contents : Unit	Topics	Contact Hours
3	**Carrier Based Modulation of Three Phase Inverter** Three-Phase Modulation with Sinusoidal References, Third-Harmonic Reference Injection - Optimum Injection Level, Solution for Third-Harmonic Injection, Calculation of Harmonic Losses, Discontinuous Modulation Strategies, Carrier Ratios and Subharmonics	8
4	**Zero Space Vector Placement Modulation Strategies** Principle of Space Vector Modulation, Comparison of Natural Sampled PWM and SVM, Phase Leg References for Space Vector Modulation, Analytical Solution for SVM, Harmonic Losses for SVM, Placement of the Zero Space Vector, Discontinuous Modulation, Analysis of Discontinuous PWM	12
5	**Carrier Based Modulation of Multilevel Inverter** Phase-Shifted Multicarrier Modulation, Level-Shifted Multicarrier Modulation – In Phase Disposition, Phase Opposite Disposition, Alternative Phase Opposite Disposition, Comparison Between Phase- and Level-Shifted PWM Schemes, Space Vector Modulation of Multilevel Inverter, Neutral Point Voltage control in Diode Clamped Multilevel Inverter	8
Total Hours		**42**

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	**Experiment No. 01** Obtain the Frequency Domain Analysis of Voltage Source Inverter in Square wave operation.	2
2	**Experiment No. 02** Develop unipolar PWM scheme for single phase inverter. Perform analysis and simulation of the unipolar PWM.	2
3	**Experiment No. 03** Obtain the Frequency Domain Analysis of output voltage for sine PWM with different carrier ratio with IM load.	2
4	**Experiment No. 04** Compare spectrum of conventional sine PWM and zero space vector PWM applied to Induction Motor.	2
5	**Experiment No. 05** Develop Space Vector PWM method for two-level inverter.	2
6	**Experiment No. 06** Evaluate the effect of zero placement on output of inverter with RL load.	2
7	**Experiment No. 07** Analyze operation of three level inverter operating with In Phase Disposition technique.	2

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Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
8	**Experiment No. 08** Analyze operation of three level inverter operating with Phase Shifted Carrier modulation technique.	2
9	**Experiment No. 09** Simulate Alternative Phase Opposite Disposition and Phase Opposite Disposition for five level Cascaded H Bridge Inverter with IM load.	2
10	**Experiment No. 10** Develop three level space vector modulation technique for Cascaded H Bridge Inverter.	2
Total Hours		**20**

Textbook :

1 Pulse Width Modulation For Power Converters: Principles and Practice, D. G. Holmes, T. A. Lipo, John Wiley and Sons., 2003

2 High Power Converters and AC drives, Bin Wu, John Wiley & Sons., 2nd edition, 2005

References:

1 Modern Power Electronics and AC Drives, Modern Power Electronics and AC Drives, B. K. Bose, Prentice Hall PTR, 2002

2 Power Electronics: Converters, Applications, and Design - 3rd Edition, Power Electronics: Converters, Applications, and Design - 3rd Edition, Ned Mohan, Tore M. Undeland, William P. Robbins, John Wiley & Sons, 2002

3 Power Electronics For Renewable Energy Systems, Transportation And Industrial Applications', Power Electronics For Renewable Energy Systems, Transportation And Industrial Applications', Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad, IEEE News, 2014

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking / Creative**
5.00	10.00	15.00	30.00	20.00	30.00

Instructional Method:

1 The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

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Instructional Method:

2 The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and classroom

3 Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

4 Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory.

Supplementary Resources:

1 https://archive.nptel.ac.in/courses/108/108/108108035/