GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: Power Electronics and Electrical Drives (45)
SUBJECT NAME: PWM converter and Applications
SUBJECT CODE: 3714512
M.E. 1st SEMESTER

Type of course: Engineering Science (ELECTRICAL)

Prerequisite: Power Electronics

Rationale: Pulse Width Modulated Converter are being widely used in numerous applications due to its ability to synthesize the fundamental voltage and current with hard switching of the converter. Number of PWM methods have been developed over the years and each having its own significance for the application. The subject aims at developing a generalized analytic approach towards the PWM method. Based on this approach, some of the widely used applications of PWM converter are introduced.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs	% Weightage
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	6	15%
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	4	10%
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	6	15%
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.	8	20%
5	**Carrier Based Modulation of Multilevel Inverter:**	8	15%

	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		
6	**Application of PWM Converter:** Constant Volt Per hertz drives, Static VAR compensator, Renewable Energy Interface for Solar and Wind applications, Active Power Filter, PWM Rectifier, Bidirectional Converter for battery charging	10	25%

Reference Books:

1. Bin Wu, 'High Power Converters and AC drives', John Wiley & Sons., 2nd edition, 2005.
2. D. G. Holmes, T. A. Lipo, 'Pulse Width Modulation For Power Converters: Principles and Practice', John Wiley and Sons., 2003.
3. B. K. Bose, 'Modern Power Electronics and AC Drives', Prentice Hall PTR, 2002.
4. Ned Mohan, Tore M. Undeland, William P. Robbins, 'Power Electronics: Converters, Applications, and Design', 3rd Edition, John Wiley & Sons, 2002.
5. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad, 'Power Electronics For Renewable Energy Systems, Transportation And Industrial Applications', IEEE Press, 2014.

Course Outcome:

After learning the course, the students should be able to:

1. Develop Pulse Width Modulation method for power converter (Create)
2. Determine losses in converter operating with PWM. (Analyze)
3. Compare carrier-based modulation strategy and Space Vector Modulation (Analyze)
4. Evaluate harmonic spectrum of PWM method. (Evaluate)
5. Determine the PWM method for given application. (Apply)

List of Experiments:

1. Analyze the operation of Voltage Source Inverter in Square wave operation.
2. Develop unipolar and bipolar PWM scheme for single phase inverter.
3. Analyze the fundamental and sideband harmonics of output voltage with PWM with different carrier ratio.
4. Compare conventional sine PWM and third harmonic injected PWM.
5. Develop Space Vector PWM method for two-level inverter.
6. Evaluate the effect of zero placement on output of inverter.
7. Analyze operation of three level inverter operating with In Phase Disposition technique.
8. Analyze operation of three level inverter operating with Phase Shifted Carrier modulation technique.
9. Simulate Alternative Phase Opposite Disposition and Phase Opposite Disposition for five level Cascaded H Bridge Inverter.

Major Equipment:

1. Two Level Inverter Unit with Control Card
2. Digital Storage Oscilloscope
3. Current Clamp
4. Differential Voltage Probe

List of Open Source Software/learning website:

1. http://nptel.ac.in/courses/108108077/
2. https://www.semikron.com/service-support/semisel-simulation.html
3. http://www.digimat.in/nptel/courses/video/108108035/L01.html
4. https://www.plexim.com/
5. https://www.typhoon-hil.com/products/hil-software