NIRMA UNIVERSITY

Institute:	**Institute of Technology, School of Engineering**
Name of Programme:	**B. Tech. in Electrical Engineering**
Semester:	**VII**
Course Code:	4EE301ME25
Course Title:	**Multi-level Converters**
Course Type:	**Department Elective-III**
Year of Introduction:	**2025 –26**

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Course Learning Outcomes (CLOs):

At the end of the course, the students will be able to -

1. select different multi-level converter topologies and use them based on application need (BL5)
2. make use of the various PWM techniques and their comparative analysis for multi-level converters (BL3)
3. analyse issues related to multi-level converters (BL4)
4. apply various techniques to eliminate the issues related to multi-level converters (BL3)

Unit	Contents	Teaching hours (Total 45)
Unit-I	**Concept of Multi-Level Inverters** Introduction to multi-level inverters, equivalent circuits of five-level, and general n-level inverter, comparison of multi-level inverter with their two-level counterpart (two-level inverter), advantages and disadvantages of multi-level inverter, scope and applications of multi-level inverters for high power induction motor drives	06
Unit-II	**Multi-Level Converter Topologies** Neutral point clamped (NPC) / diode clamped, capacitor clamped (flying capacitor), cascaded multi-cell (cascaded h-bridge), hybrid h-bridge, asymmetric dc-link inverters, cascaded inverters, other advanced multi-level inverter topologies	08
Unit-III	**Voltage Space Vector (Phasor) Structure of Multi-Level converter** Introduction to Space Vector (Phasor) representation, voltage space phasor structure of two-level inverter, redundancy of switching states, significance of switching state redundancy in PWM and reduction of switching losses	08
Unit-IV	**PWM Techniques for Multi-Level Converters** Voltage-controlled pulse width modulation (VC-PWM), sine-triangle PWM (SPWM), carrier-based SPWM: level shifted and	12

	phase shifted, types of level shifted carrier based SPWM techniques, comparison between level shifted and phase shifted carrier based SPWM techniques, comparison of SPWM and SVPME, switching time determination for voltage vectors in SVPWM for two-level inverter, current controlled pulse width modulation (CC-PWM) techniques, Current error space phasor based hysteresis controller for three-level inverter	
Unit-V	**Generation and Mitigation of Alternating Common-Mode Voltage** PWM inverter-induction motor (drive) model, generation of shaft voltage, flow of bearing currents in the drive system, conventional mitigation techniques, mitigation of common-mode voltage by PWM	05
Unit-VI	**Applications of Multi-level Converters** Variable frequency drives, Power quality improvement devices, Electric vehicle charging infrastructure development, HVDC transmission	06

Self-Study:

Topologies and control strategies for the active-clamped multi-level inverter circuits. Back-to-back connected multi-level converter and inverter configurations and their applications.

Tutorial Work:

This shall consist of at least 6 tutorials based on the above syllabus.

Suggested Reading:

1. Ned Mohan, Tore M. Undeland and William P. Robbins, *Power Electronics: Converters, Applications and Design*, John Wiley & Sons.
2. B. K. Bose – *Power Electronics & AC Drives*, Prentice-Hall
3. M. H. Rashid – *Power Electronics*, Prentice Hall of India
4. Bin Wu, *High-Power Converters and AC Drives*, IEEE Press, Wiley-Interscience
5. J. Rodriguez, Samir Kouro, Ramon C. Portilloand, and Marcelo A. Perez, *Multi-level converters: an enabling technology for high power applications*, IEEE Proceedings, vol. 97, no. 11, November 2009, pp. 1786-1817.
6. J. S. Lai, and F. Z. Peng, *Multilevel converters - a new breed of power converters*, IEEE Trans. Ind. Applications., vol. 32, no. 3, May/June 1996, pp. 509-517.
7. J. Rodriguez, J. S. Lai, and F. Z. Peng, *Multi-level inverters: a survey of topologies, controls, and applications*, IEEE Trans. Ind. Electron., vol. 49, no. 4, August 2002, pp. 724-738.
8. M. D. Manjrekar, P. K. Steimer, and T. A. Lipo, *Hybrid multilevel power conversion system: a competitive solution for high-power applications*, IEEE Trans. Ind. Applicat., vol. 36, no. 3, May/June 2000, pp. 834-841.
9. Recent papers of IEEE Transactions