

PPE331POWER SYSTEM HARMONICS AND FILTERS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To impart knowledge about harmonics, their sources, limits and their effect in power converter circuits and to learn about filters

HARMONIC ANALYSIS: Representation of harmonics, Fourier series and Coefficients, Measures of harmonic distortion namely voltage and current distortion factors, active and reactive power, apparent power, distortion power, power factor, displacement power factor, current and voltage crest factors, Harmonic Voltage Factor, Series and parallel resonance.

LIMITS OF HARMONIC DISTORTION: Voltage harmonic distortion limits: IEEE limits, IEC limits EN limits and NORSOK limit. Current harmonic distortion limits: IEEE limits IEC limits and NORSOK limits.

SOURCE OF HARMONICS: Introduction to harmonics, Types of Loads, Source of harmonics: Electromagnetic Interference, Stray Harmonic Torque and Pulsating Harmonic Torque in AC Drive, Power Quality Indices, Traditional and future sources of harmonics, Standardization of harmonics levels, Harmonic in transformers and inrush current, Harmonic in rotating Machines (mmf distribution of ac windings, slot harmonics, voltage harmonics produced by synchronous machines, rotor saliency effects, voltage harmonics produced by induction motors. Distortion caused by arcing devices: Electric arc furnaces and discharge type lighting. Distortion caused by dc power supplies.

EFFECTS OF HARMONICS: Effects on power system equipment, communication system, Solid state Devices etc. Thermal losses in harmonic environment, Harmonic amplification in capacitor banks, Effects of harmonics in transformers, Effects of harmonics in rotating machines, Harmonic interference with power system protection, harmonic problems during fault conditions, Effects of harmonics on consumer equipment, Interference with Communications.

HARMONICS ELIMINATION TECHNIQUE: Modulation based harmonics elimination technique, optimal PWM technique, Tuned and damped passive filters, Series and parallel connection of passive & active filters, Role of power converters, transformers, rotating machines and capacitor banks in reduction of harmonics, design of Series tuned filters and second order damped filters. Series Active Filtering in Harmonic Isolation Mode, Dynamic Voltage Restorer and its control, Power Quality Conditioner, Shunt Current Injection Type Filter and its Control. Three Phase three-wire and four-wire Shunt Active Filtering and their control using p-q theory and d-q modelling. Hybrid Filtering using Shunt Active Filters . Series Active Filtering in Harmonic Cancellation Mode .

HARMONIC MEASUREMENT AND ANALYSIS: THD and DIN, Methods of harmonics measurement & analysis in different PCC. Harmonic source representation, Harmonic Propagation facts, flux of harmonic currents, Interrelation between AC system and Load Parameters Analysis methods

Course Outcomes: After the completion of course the student may be able

- To conceptualize harmonics and their effect
- To measure harmonic components
- To analyse the harmonics in a circuit
- To develop the active filter circuit

Recommended Books:

1. Francisco C. De La Rosa, *Harmonics and Power systems*, Taylor & Francis group, CRC Press
2. J. Arrillaga, N.R. Watson, *Power System Harmonics, Second Edition*, John Wiley & Sons.
3. Deare A Paice, *Power Electronics Converter Harmonics*, IEEE Press.
4. Hirofumi Akagi, *Instantaneous Power Theory and Application to Power Conditioning* IEEE Press.
5. *Power Systems Harmonics*, George J. Wakileh, Springer

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25