GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170921
Semester – VII
Subject Name: Power Quality and FACTS

Type of course: Professional Elective Course

Prerequisite: Power Electronics, Power systems

Rationale:

Electrical Power systems are heavily loaded because of the increase in the demand and restructured power system operation. The technical solution of utilizing available power system structure to deliver more power is using the power electronics devices in power systems for reactive power compensation and HVDC. The other uses of power electronics devices in the distribution and at consumer levels are also inevitable. The more and more use of power electronics devices in the power systems at every stage increases the problem of power quality. The course is aimed to provide exposure about power quality; the commonly used power electronics based compensating devices, its impact on Power Quality and various power quality mitigation techniques.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Power Quality** Introduction, Importance of Power Quality, Common Disturbances in Power Systems, Short-Duration Voltage Variation, Long-Duration Voltage Variations, Transients, Impulsive Transients, Oscillatory Transients, Voltage Imbalance, Harmonics, Interharmonics, DC Offset, Notching, Noise, Voltage Fluctuations, Power Frequency Variations, Solutions to Power Quality Problems, Ambiguous Terms CBEMA and ITI Curves, Features of Voltages in Power Systems, Grounding, Ground Electrodes, Ground Rods, Ground Rings, Plates Signal Reference Ground (SRG), Single-Point and Multipoint Grounding, Ground Loops, Isolated Ground, Electrochemical Reactions Due to Ground Grids, Reactive Power in Power Systems with Harmonic Distortion, Single-Phase Systems, Reliability, Power Quality Data Collection .	**06**
2	**Static Var Compensators** Introduction, Different Static Var Compensators, Increase in Transient Stability Margin, Damping of Power Oscillations, Voltage Support, Static Var Compensator Systems Versus Synchronous Condensers, Capacitors, and Reactors, Shunt and Series Compensation, Fundamentals of Load Compensation, Reactive Power Relationships Between Wye- and Delta-Connected Systems, Static Var Compensators for Transmission Systems, SVC Using a TCR and an FC, SVC Using a TCR and TSC, STATCOM (SVC Using Self-Commutated Inverters), SVC Using	**09**

	a Saturated Reactor (SR), Comparison of Static Var Systems, Specification of SVCs, FACTS Technology, Types of FACTS Controllers, Series Controllers, Shunt Controllers, Combined Series and Shunt Controllers, Case Study, Importance Three-Phase Power Flow Studies for PQ.	
3	**Control of Static Var Compensators** Introduction, Control Systems for SVCs in Transmission System Applications, Voltage Regulation, Gain Supervision, Reactive Power Control and Coordination, Control Signals for System Transient Stability, Power Oscillation Damping, and Subsynchronous Resonance Damping Enhancement, Control Systems for SVCs in Traction Applications, Load Compensation, Voltage Regulation and Balancing, Measurement of Sequence Components, Phase-Locked Oscillator Control System.	**06**
4	**Harmonics** Introduction, Converter Harmonics, Effect of Transformer Connections, Harmonics When There Is Overlap in the Commutation Process, Direct-Voltage Harmonics, Imperfect System Conditions, Single-Phase Power Supplies, DC Drives, AC Drives, Pulse-Width Modulation (PWM), Telecontrol Signals, Cycloconverters, Transformers, Harmonics in No-Load Exciting Current, Harmonics due to Inrush Current, DC Magnetization, Harmonics in Rotating Machines, Harmonics in Arc Furnace Loads, Harmonics in a Thyristor-Controlled Reactor, TheK-Factor.	**06**
5	**Utility Harmonics Regulations and Standards** Introduction, Undesirable Effects of the Harmonics, Specification of the Harmonic Limits, Philosophical Differences between IEEE 519-1992 and IEC 61000-Series Standards, IEEE 519-1992, IEC 61000-Series Standards, Assessment Procedure (Harmonic Limits), Summation Laws for Combining Harmonics, General Comments on the Standards, Allocation of Harmonic Voltage or Current or Both Limits to the Customers, Empirical Nature of the Standards, Legal Responsibility for Damages due to Harmonic Problems, Application of the Standards, Application of Standards—B.C. Hydro's Approach, Examples of the Harmonic Studies.	**06**
6	**Harmonic Filters** Introduction, Undesirable Effects of Harmonics, Harmonic Sources, Types of Filters, Types of Damped Filters, AC Network Impedance, Overhead Lines, Underground Cables, Transformers, Rotating Machines, Passive Loads, Electronic Loads, Norton Equivalents of Residential Loads, Design of Single-Tuned Filters, Filter Performance Evaluation, Design of Damped Filters, Comparison of Tuned and Damped Filters, Filter Component Ratings, Filter Capacitors, Tuning Reactors, Outline of Filter Design.	**06**
7	**Monitoring Power Quality** Introduction, Site Surveys, Spectrum Analyzers, Special-Purpose Power System Harmonic Analyzers, Transient-Disturbance Analyzers, Combination Disturbance and Harmonic Analyzers, Flicker Meters, Transducers, Measurement of the Frequency Response of Instrument Transformers, Description of the Instrument Transformers' Tests, Summary of the Conclusions from the Tests, Voltage Transformers, IEC-Recommended Measurement Techniques for Harmonics, Harmonics, RMS Value of a Harmonic Group, RMS Value of a Harmonic Subgroup, Total Harmonie Distortion (THD), Group Total Harmonic Distortion (THDG), Subgroup Total Harmonic Distortion (THDS), Partial Weighted Harmonic Distortion (PWHD), Interharmonics, RMS Value of an Interharmonic Component, RMS Value of an Interharmonic Group, RMS Value of an Interharmonic-Centered Subgroup, Relative and Absolute Harmonic Phase Angle Measurement, Necessity for the Measurement of Harmonic Voltages and Currents, Harmonic Monitoring System, Continuous Harmonic Analysis in Real Time, Presentation of Harmonic	**06**

	Measurements, Case Study, Flicker, IEC Flicker Meter, Short-Term Flicker Evaluation, Flicker Standards	

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**30**	**30**	**15**	**10**	**-**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. R. Sastry Vedam, Mulukulta S Sarma "Power Quality VAR Compensation in Power Systems" CRC Press Indian Edition Indian reprint 2013
2. C.Sankaran, "Power Quality", First Indian reprint, CRC press
3. T. K. Nagsarkar and M. S. Sukhija "Power System Analysis" Oxford University Press

Course Outcomes:

After completing the course, students will be able to;

Sr. No.	CO statement	Marks % weightage
CO-1	Explain Various Power Quality terms of Electrical Power System	25
CO-2	Analyze the application of Static Var Compensators for reactive power compensation in power systems.	25
CO-3	Analyze the causes of Harmonics, its effect on various equipment and its mitigation techniques.	25
CO-4	Evaluate performance of power systems (in regards to Power Quality Issues) under various power quality polluting devices using appropriate power quality monitoring tools.	25

List of Open Source Software/learning website:

https://nptel.ac.in/courses/108/106/108106025/