GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: ELECTRICAL ENGINEERING
SUBJECT NAME: POWER QUALITY
SUBJECT CODE: 3710716
M.E. 1st SEMESTER

Type of course: Program Elective I

Prerequisite: Power Electronics, Power Systems, Measurement and Instrumentation, Electrical Machines

Rationale: Quality of power can have direct impact on many industrial consumers. There has recently been a great emphasis on revitalizing industry with more automation and more modern equipment. Changing power system regulations and increased use of nonlinear devices have made power quality (PQ) a highly important issue. The short duration transient disturbances, along with the stationary harmonics have become very common due to the increased use of power electronic switches. The proliferated use of such devices worsen the quality of power further. Both utility and consumers are equally responsible for poor power quality and hence power quality parameter need to be monitored, assessed and mitigated based on data acquired. This course would make the students aware about the various issues affecting the power quality as well as techniques available to improve the quality of power.

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	**Introduction to Power Quality** • Introduction-power quality-voltage quality-overview of power Quality phenomena classification of power quality issues. • Power quality measures and standards-THD-TIF-DIN-C-message weights. • Responsibility of supplier and users of elect power Quality • Susceptibility Criteria • Flicker factor transient phenomena-occurrence of power quality problems • Power Quality Standards and recommended practices such as; IEEE 519, IEEE 1159-2009, IEC 61000-4-30 etc.	**7**	15
2	**Transient Disturbances** • Modelling of networks and components under non-sinusoidal conditions • Transmission and distribution systems • Transient system model • Examples of models & response • Types and causes of transients • Examples of transient wave forms	**6**	15
3	**Harmonics**	**5**	15

	• Harmonics-individual and total harmonic distortion, Triplen harmonics, effect of harmonic distortion • Causes and Effects of harmonics • Important harmonic introducing devices; SMPS, three phase power converters, arcing devices, saturable devices, other nonlinear loads • Guide lines for harmonic voltage & current limitation, Harmonic current mitigation • Harmonic Signatures of Non-linear Loads; fluorescent lamps, LED lamps, controlled & uncontrolled rectifiers, etc.		
4	**Harmonic Mitigation** • Harmonic Filters • Devices for Controlling Harmonic Distortion • Standards of Harmonics • Active Harmonic Filters • Passive Harmonic Filters • Types, Ac network impedance, Design of filters – single tuned, double tuned & damped filter, filter component ratings • Dynamic Voltage Restorers for sag, swell and flicker problems	**6**	18
5	**Power Factor Improvement** • Effects of poor Power Factor • Power factor penalty, voltage rise due to capacitance • Power factor improvement- Passive Compensation • Passive Filtering, Harmonic Resonance, Impedance Scan Analysis • Active Power Factor Corrected Single Phase Front End • Control Methods for Single Phase APFC • Three Phase APFC and Control Techniques • PFC based on Bilateral Single Phase and Three Phase Converter.	**6**	12
6	**Power Quality measurement and monitoring** • Power quality monitoring • Methods for Power quality Classification • Power Quality Indices • Introduction to Intelligent methods as applied to Power quality Monitoring and Assessment • Power quality measurement devices • Number of test locations and Test duration • Power Quality Instrument set-up and Instrument set up guidelines	**7**	15
7	**Grounding & Bonding** • Grounding and wiring introduction • NEC grounding requirements-reasons for grounding • Typical grounding and wiring problems solutions to grounding and wiring problems • Ground electrodes, Earth resistance tests, Earth ground grid system • Power Ground system, Signal reference ground and methods, Single and multi-point grounding, Ground loops	**5**	10

Reference Books:

1. G.T. Heydt, "Electric power quality", McGraw-Hill Professional, 2007
2. Math H. Bollen, "Understanding Power Quality Problems", IEEE Press, 2000
3. J. Arrillaga, "Power System Quality Assessment", John wiley, 2000
4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,"Power system Harmonic Analysis", Wiley, 1997

5. C. Sankaran, “Power quality” , CRC Press, 2002

Course Outcome:

Students will be able to:

1. Acquire knowledge about the harmonics, harmonic introducing devices and effect of Harmonics on system equipment and loads
2. develop analytical modeling skills needed for modeling and analysis of harmonics in networks and components
3. To introduce the student to active power factor correction based on static VAR compensators And its control techniques
4. To introduce the student to series and shunt active power filtering techniques for harmonics.

List of Experiments:

Practicals based on above topics. Some experiments are suggested here for reference.

- Evaluate the impact of various non-linear loads on utility by using simulation software.
- Analysis of input current in rectifier with and without capacitor at output of rectifier.
- Harmonics analysis of input current in induction motor with and without load.
- Power Factor improvement by using passive filter.
- Determine input displacement and true power factor in non-linear load.
- Comparison of input power factor in case of AC- DC converter
- Transient Response Analysis of RLC circuits.
- Simulate phenomena of flickering in house hold applications
- Simulate the phenomena of voltage sag due to sudden starting of large induction motor.

Major Equipment:

1. Power Quality Analyzer
2. True RMS Meter
3. Digital Storage Oscilloscope
4. Clamp-on Power meter

List of Open Source Software/learning website:

- E-materials available at the website of NPTEL- http://nptel.ac.in/
- Power Standard Lab – teaching tool
- https://pqs.schaffner.com/
- MATLAB (Trial version): Software is useful for simulation and analysis of electrical systems