



# GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Power Electronics

Subject Code: BE05024071

Subject Name: Power Quality

w.e.f.Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 2

<b>Prerequisite:</b>	<b>Basic concepts of Electrical Engineering, Power Systems and Power Electronics</b>
<b>Rationale:</b>	The increasing use of power-electronic converters, non-linear loads, and sensitive digital equipment has intensified Power Quality (PQ) issues in both utility and industrial systems. Voltage sags/swells, transients, and harmonics directly impact the performance of PE devices such as rectifiers, inverters, drives, and SMPS. Understanding PQ phenomena and mitigation techniques is essential for designing robust PE-based systems, ensuring compliance with standards, and improving reliability. This course builds foundational and medium-level skills for diagnosing, measuring, and mitigating PQ problems using both passive and active PE-based conditioners.

## Course Outcomes:

Sr.No.	CO statement	Marks% weightage
CO-1	Describe various power quality disturbances and associated terminology.	20
CO-2	Analyze voltage events, harmonics, transients, grounding issues, and their impact on PE systems.	25
CO-3	Measure PQ parameters using standard PQ instrumentation.	10
CO-4	Evaluate the performance of PE based mitigation devices (filters, compensators).	30
CO-5	Design basic PQ improvement solutions using passive/active methods in PE applications.	15

## Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/CA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

\* *Problem-Based Learning (PBL) aims to accommodate learning beyond the syllabus as per clause 9.4 of NBA manual.*

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End Semester Examination, PA = Progressive Assessment.



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## Content:

Sr. No.	Content	Total Hrs
1	<b>Introduction to Power Quality (6 hours)</b> Definition of power quality, terminology, susceptibility criteria, Linear vs non-linear loads, PE loads and their PQ impact, Common disturbances overview: sags, swells, flicker, interruptions, Responsibilities of utility and consumers, Overview of PQ standards (IEEE-519, IEC etc.)	6
2	<b>Power Frequency Disturbances &amp; Voltage Events</b> Voltage sags, swells, interruptions, under/over-voltage, Sources of disturbances (faults, PE drives, transformer energization), Mitigation using PE devices: DVR, UPS, AC voltage regulators, ITI/CBEMA curves and equipment sensitivity	7
3	<b>Electrical Transients</b> Transient system modelling, Impulsive & oscillatory transients, Capacitor switching, lightning, PE converter switching, Converter switching transients and their influence on DC-link & EMI	6
4	<b>Harmonics &amp; Harmonic Analysis</b> Harmonic sources: rectifiers, SMPS, inverters, EV chargers, Individual & total distortion (THD, TDD), Interharmonics, subharmonics, resonance Effects on motors, transformers, capacitors, PE devices, Passive filters (LC, trap filters), Active filters (shunt/series APF, hybrid filters) – basic operational concepts	10
5	<b>Grounding, Bonding &amp; EMI/EMC</b> Grounding systems, conductors, ground loops, Earthing in PE converters, UPS, inverters, EMI from switching devices, dv/dt and di/dt issues, Shielding, cable routing, common-mode filters	6
6	<b>Power Quality in Power Electronics Applications</b> PQ issues in converters, inverters, VFDs, welding sets, SMPS, Reactive power issues in harmonic-rich PE systems, Voltage support using STATCOM, SVC (conceptual overview), PQ impact of distributed generation (PV inverters, wind converters)	5
7	<b>Power Quality Measurement &amp; Monitoring</b> PQ meters, data loggers, oscilloscopes, Measurement setups, number of test points, duration, Practical interpretation of PQ waveforms, Introduction to PQ audit & reporting	5
<b>TOTAL</b>		<b>45</b>

## Suggested Specification table with Marks(Theory):(ForB.E.only)

Distribution of TheoryMarks					
RLevel	ULevel	ALevel	NLevel	ELevel	CLevel
30	25	20	15	10	==

**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 student sandteachers.Theactual distribution of marks in the question paper may vary slightly from the above table.

The course *Power Quality* is directly aligned with SDGs 7, 9, and 13 through its focus on



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maintaining stable, efficient, and distortion-free power using monitoring and mitigation techniques, essential for modern grids and renewable integration. It is indirectly aligned with SDGs 8, 11, and 12, as improved power quality enhances system reliability, reduces resource wastage, and supports sustainable industrial and urban development.

SDG 7	Affordable & Clean Energy — Direct Alignment Topics like harmonic analysis (THD), voltage disturbances, and mitigation using DVR, UPS, APF, STATCOM/SVC ensure efficient, stable, and high-quality power delivery in modern grids and renewable systems.
SDG 8	Decent Work and Economic Growth — Indirect Alignment Knowledge of PQ analysis, measurement tools, and mitigation techniques supports industries by reducing downtime, improving productivity, and enabling skilled employment.
SDG 9	Industry, Innovation & Infrastructure— Direct Alignment Study of power quality monitoring, EMI/EMC, grounding, and PQ issues in industrial loads (VFDs, SMPS, converters) supports a reliable and advanced electrical infrastructure.
SDG 11	Sustainable Cities & Communities— Indirect Alignment Ensuring a stable supply through voltage regulation, disturbance mitigation, and PQ monitoring enhances the reliability of urban systems like buildings, transport, and utilities.
SDG12	Responsible Consumption & Production— Indirect Alignment Concepts like harmonic reduction, efficient grounding, EMI control, and PQ audits minimize energy losses, improve equipment lifespan, and promote efficient resource utilization.
SDG 13	Climate Action— Direct Alignment Efficient mitigation of harmonics, reactive power issues, and transients improves energy efficiency and supports integration of renewable energy sources (PV, wind converters), reducing environmental impact.

## Reference Books:

1. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty, *Electrical Power Systems Quality*, Mc Graw Hill;
2. J. Arrillaga & N. Watson, *Harmonics and Power Systems*, Wiley
3. C. Sankaran, *Power Quality*, CRC Press
4. G.T. Heydt, *Electric Power Quality*, Stars in A Circle Publications
5. Ned Mohan, *Power Electronics Converters, Applications and Design*, John Wiley
6. Bimal K. Bose, *Power Electronics and AC Drives*, Prentice Hill
7. IEEE Std. 519 — Recommended Practice and Requirements for Harmonic Control

## List of Experiments: Suggested Experiment

1. Measurement of voltage sag, swell, interruption using PQ analyzer
2. Harmonic spectrum measurement of rectifier, inverter, SMPS load
3. Study of passive harmonic filter characteristics (LC/LCL)
4. Implementation of digital active power filter (simulation)
5. Observation of transients during capacitor switching
6. EMI/EMC measurement: impact of switching inverters



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7. Study of grounding systems and effect of ground loops
8. Flicker measurement under variable lighting loads
9. PQ impact analysis of solar PV inverter (simulation/hardware)
10. Mini-Project (Any one):

- Harmonic filter design
- DVR concept simulation
- Shunt active filter control (basic)
- PQ audit of a lab/small facility

### Major Equipment:

Power Quality Analyzer (Class A preferred; sag/swell logging), Programmable AC source / Variac (to create disturbances), Isolation transformer (safety + decoupling), Test load (resistive/inductive load bank), PC with analysis software (data logging, report export), PQ Analyzer, DSO (FFT capable), Rectifier + inverter trainer kit, LC components set, Capacitor bank, Basic grounding panel, MATLAB/Simulink license,

### List of Open-Source Software:

1. OpeModellica
2. GNU Octave
3. Scilab

### List of learning websites:

1. MIT OpenCourseWare (<https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/>)
2. NPTEL
3. Coursera
4. edX
5. Reputed Research Journal Website

### List of suggested activities for Problem-based Learning (PBL):

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry/Research laboratory Visit (Power company / Manufacturer of Active Power Filter / Power Quality related equipment)	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on the report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Video-Based Learning	Technical Video-based learning related to the subject (MOOC/NPTEL Video)	Duration of video = 5hrs Report preparation = 5hrs Total = 10hrs	Report /presentation based on the video learning outcomes.
		Self-learning online course	The minimum duration of the course should be 10	Examination-based assessment at the end of the course. Based on the certificate produced.



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Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
			hours.	
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on the accuracy of explanation, clarity, and presentation style.
3	Assignment/ Technical Writing / Research Writing	Assignment writing. Numerical-based assignment is preferable.	5 assignments of 2 hours each. Total = 10hrs	Based on the assignment submitted.
		Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solving targeting relevant SDGs. / Mini Project	Complex problem solving	Maximum 2 problems. Study of the problem and solution finding, Total = 15 hrs	Based on the depth of the solution submitted.
5	Research Paper Review / Analysis	Discussion on a research paper based on a relevant subject (SCOPUS Index/any reputed Journal)	5 research paper = 20 hrs	Summarize research paper and the evaluation of critical parameters
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
7	MicroProject	Working/non-working model on technical topics	Working = 10hrs non-working = 10hrs	Based on inter-department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on the subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth, knowledge etc.
		Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10 hours	Based on quiz scores and the reflection report after each quiz.
9	Case Study Analysis / Seminar	Real-world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on an in-depth study, technical depth, data collected, fact-finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on the number of relevant patents analyzed and the identification of innovation scope.

**Note:**

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject



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**Power Quality** incorporates study micro/ mini projects

These activities are incorporated as integral components of PBL. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total number of PBL hours and marks.

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