CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET436	POWER QUALITY	PEC	2	1	0	3

Preamble: The objective of this course is to introduce the fundamental concepts of power quality. This course covers different power quality issues and its mitigation methods.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify the sources and effects of power quality problems.
CO 2	Apply Fourier concepts for harmonic analysis.
CO 3	Explain the important aspects of power quality monitoring.
CO 4	Examine power quality mitigation techniques.
CO 5	Discuss power quality issues in grid connected renewable energy systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	2	-	1	-	-	-	2
CO 2	3	3	-	-	-	-	-	-	-	-	-	2
CO 3	3	3	-	-	3	-	-	-	-	-	-	2
CO 4	3	3	2	-	-	-	-	1	-	-	-	2
CO 5	3	2	-	-	-	-	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	40
Understand	20	20	40
Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is meant by Power Quality? (K2, PO1, PO2, PO8)
2. Explain the sources and effects of different power quality problems. (K1, PO1, PO2, PO6, PO12)
3. Discuss the different types of power quality disturbances. (K1, PO1, PO2, PO12)

Course Outcome 2 (CO2)

1. Discuss the important sources of harmonics in the power network. (K1, PO1,PO2, PO12)
2. What are the effects of harmonics in the power system and other networks? (K2, PO1, PO2, PO12)
3. Conduct harmonic analysis using suitable methods. (K3, PO1, PO2)

Course Outcome 3(CO3):

1. Explain the important indices used to quantify harmonics in a power network? (K2, PO1, PO2)
2. Describe the key aspects of different power quality standards. (K2, PO1, PO2, PO12)
3. Discuss the objectives, features and measurement issues of different monitoring instruments. (K2, PO1, PO2, PO5, PO12)

Course Outcome 4 (CO4):

1. Design passive filters for mitigating harmonic distortion. (K3, PO1, PO2, PO3, PO8, PO12)

2. Discuss the important active filters used for harmonic suppression and sag/swell correction. (K2, PO1, PO2, PO12)
3. Explain the operation of a single phase active power factor converter. (K2, PO1, PO2)

Course Outcome 5 (CO5):

1. Discuss the configuration and working of shunt and series-shunt power quality conditioners. (K2, PO1, PO2)
2. Identify the important power quality issues associated with grid connected renewable energy systems. (K2, PO1, PO2, PO12)
3. Explain the operating conflicts in connection with grid connected renewable energy system. (K2, PO1, PO2, PO12)
4. Discuss the problems and its solutions associated with wiring and grounding. (K2, PO1, PO2, PO12)

Model Question Paper

QP CODE:

PAGES:2

Reg.No:_____
Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH& YEAR
Course Code: EET436
Course Name: POWER QUALITY

Max. Marks: 100 **Duration: 3 Hrs**

PART A

Answer all questions. Each Question Carries 3 marks

1. 'Power Quality is voltage quality'. Comment.
2. Differentiate between impulsive and oscillatory transients.
3. What do you mean by triplen harmonics and what are its effects in the power system?
4. Explain the generation of harmonics in the presence of non-linear loads.
5. Write short note on IEEE 519 standard.
6. Discuss the objectives of power quality monitoring.
7. List the merits and demerits of passive filters to reduce harmonic distortion.
8. Define Telephone Interference Factor.
9. What is meant by islanding? List the problems caused by it.
10. Describe the term Ground Loops. List solutions for mitigating this problem.

PART B

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. a) Explain the sources of voltage sag in a power network. (6)

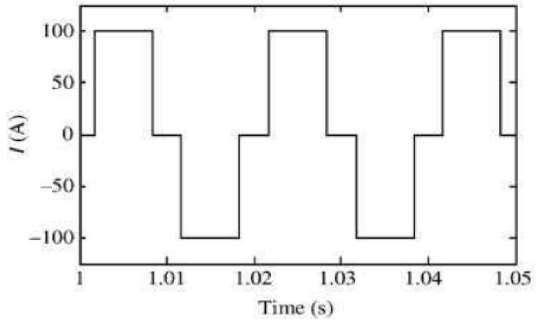
b) Discuss any four effects of power quality problems. (8)

12. What is meant by waveform distortions? Using neat diagrams, explain the five primary types of waveform distortion. (14)

Module 2

13. Explain the effects of power system harmonics on different components of power systems. (14)

14. For a quasi-square wave of (120° pulse width) of current with an amplitude I of 100A (shown in Fig), calculate (a) crest factor (CF), (b) distortion factor (DF), and (c) total harmonic distortion. (14)



Module 3

15. a) Define total harmonic distortion, distortion factor, total demand distortion and telephone influence factor. (8)

b) Derive the relationship between total power factor, distortion factor and displacement factor. (6)

16. a) How is RMS value computed by a power quality monitoring instrument? (7)

b) Describe the functionalities offered by a power quality analyzer. (7)

Module 4

17. a) Explain the working principle of DVR for sag and swell correction. (6)

b) A single-phase fully controlled bridge converter is fed from a supply of 230V at 50 Hz at a thyristor firing angle of 60°. Consider continuous load current of 200 A. Design a shunt passive filter with third, fifth, seventh and a ninth passive tuned filters. (8)

18. Draw the configuration of a unified power quality conditioner and show that it offers a single solution for mitigating multiple power quality problems. (14)

Module 5

19. Explain the operation of a PWM power factor correction circuit. Using a block diagram, explain the control logic of the same. (14)

20. Discuss the important solutions to wiring and grounding problems. (14)

Syllabus

Module 1 **(6 hours)**

Power quality phenomenon - Sources and effects of power quality problems, Need for concern of Power quality, types of power quality disturbances –Transients – classification and origin, Short duration voltage variation – interruption, sag, swell, Long duration voltage variation, voltage unbalance, waveform distortion - notching, harmonics and voltage flicker

Module 2 **(8 hours)**

Harmonics - mechanism of harmonic generation, Triplen harmonics, Harmonic sources – switching devices, arcing devices and saturable devices, Effects of harmonics on power system equipment and loads – transformers, capacitor banks, motors and telecommunication systems, Effect of triplen harmonics on neutral current, line and phase voltages.

Harmonic analysis using Fourier series and Fourier transforms – simple numerical problems

Module 3 **(6 hours)**

Harmonic indices (CF, DF, THD, TDD, TIF, DIN, C – message weights), Displacement and total power factor

Overview of power quality standards: IEEE 519, IEEE 1433 and IEC 61000

Power quality Monitoring: Objectives and measurement issues, different monitoring instruments – Power quality analyzer, harmonic spectrum analyzer, flicker meters

Module 4 **(6 hours)**

Mitigation of Power quality problems - Harmonic elimination - Design simple problems and analysis of passive filters to reduce harmonic distortion – demerits of passive filters – description of active filters - shunt, series, hybrid filters, sag and swell correction using DVR

Power quality conditioners - DSTATCOM and UPQC - Configuration and working

Module 5 **(6 hours)**

Power factor correction – Single phase active power factor converter – circuit schematic and control block diagram

Power Quality issues of Grid connected Renewable Energy Systems – operating conflicts

Grounding and wiring– reasons for grounding – wiring and grounding problems - solutions to these problems

Note: It is encouraged to conduct assignments involving case studies to get hands-on experience of use of power quality instruments for power quality monitoring.

Text/Reference Books

1.R. C. Dugan, M. F. Me Granaghen, H. W. Beaty, *'Electrical Power System Quality',* McGraw-Hill, 2012
2. Angelo Baggini (Ed.) *Handbook of Power Quality,* Wiley, 2008
3. C. Sankaran, *'Power Quality',* CRC Press, 2002
4. G. T. Heydt, *'Power Quality',* Stars in circle publication, Indiana, 1991
5. Jose Arillaga, Neville R. Watson, *'Power System Harmonics',* Wiley, 1997
6. Math H. Bollen, 'Understanding Power Quality Problems' Wiley-IEEE Press, 1999
7. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, "Power Quality problems and mitigation techniques", John Wiley and Sons Ltd, 2015.
8. Surajit Chattopadhyay, 'Electric power quality' – Springer, 2011

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (32 Hours)
1	**Power quality phenomenon**	**6**
1.1	Sources and effects of power quality problems	1
1.2	Need for concern of Power quality	1
1.3	Types of power quality disturbances – Transients – classification and origin	1
1.4	Short duration voltage variation – interruption, sag, swell	1
1.5	Long duration voltage variation, voltage unbalance	1
1.6	Waveform distortion - notching, harmonics and voltage flicker	1
2	**Harmonics**	**8**
2.1	Mechanism of harmonic generation	1
2.2	Harmonic sources – switching devices, arcing devices and saturable devices	1
2.3	Effects of harmonics on power system equipment and loads –	2

	transformers, capacitor banks, motors and telecommunication systems	
2.4	Effect of triplen harmonics on neutral current, line and phase voltages.	1
2.5	Harmonic analysis using Fourier series and Fourier transforms simple numerical problems	3
3	**Harmonic indices, PQ standard and monitoring**	**6**
3.1	Harmonic indices - CF, DF, THD, TDD, TIF	1
3.2	Harmonic indices - DIN, C – message weights, Displacement and total power factor	1
3.3	Overview of power quality standards: IEEE 519, IEEE 1433 and IEC 61000	2
3.4	Power quality Monitoring: Objectives and measurement issues	1
3.5	Different monitoring instruments – Power quality analyzer, harmonic spectrum analyzer, flicker meters	1
4	**Mitigation of Power quality problems and Power factor correction**	**6**
4.1	Harmonic elimination – Design of passive filters simple problems	1
4.2	Analysis of passive filters	1
4.3	Demerits of passive filters –description of active filters - shunt, series, hybrid filters	1
4.4	Sag and swell correction using DVR	1
4.5	DSTATCOM and UPQC - Configuration and working	2
5	**Power quality conditioners, PQ in Grid connected RE systems, Grounding & Wiring**	**6**
5.1	Power factor correction – Single phase active power factor converter – circuit schematic and control block diagram	1
5.2	Power Quality issues of Grid connected Renewable Energy Systems	1
5.3	Operating conflicts	1
5.4	Grounding and wiring– reasons for grounding	1
5.5	Wiring and grounding problems - solutions to these problems	2