

**COURSE NAME** : Electrical Power System  
**COURSE CODE** : EP  
**SEMESTER/YEAR** : Sixth  
**SUBJECT TITLE** : Power Quality (Elective-II)  
**SUBJECT CODE** :

**Teaching and Examination Scheme:**

Teaching Scheme			Examination Scheme					
TH	TU	PR	PAPER HRS.	TH	PR	OR	TW	TOTAL
04	--	02	03	100	--	--	25@	125

# - External

@ - Internal

\* On Line Examination

**NOTE:**

- Two tests each of 25 marks to be conducted as per the schedule given by MSBTE.
- Total of tests marks for all theory subjects are to be converted out of 100 and to be entered in mark sheet under the head Sessional Work. (SW)

**Rationale:**

Modern power system has become a large size, complex, advanced integrated network. It is facing many field and on line challenges. The huge increase in sensitive loads, electronic controls, shunt capacitors for power factor correction, adjustable speed drives have raised the visibility of power quality problems. The common thread running through all these problems for increased concern about quality of electric power is continued push for increasing productivity for all utility customers. The equipment installed suffers the most common power disturbances and is sometimes a source of additional power quality problems.

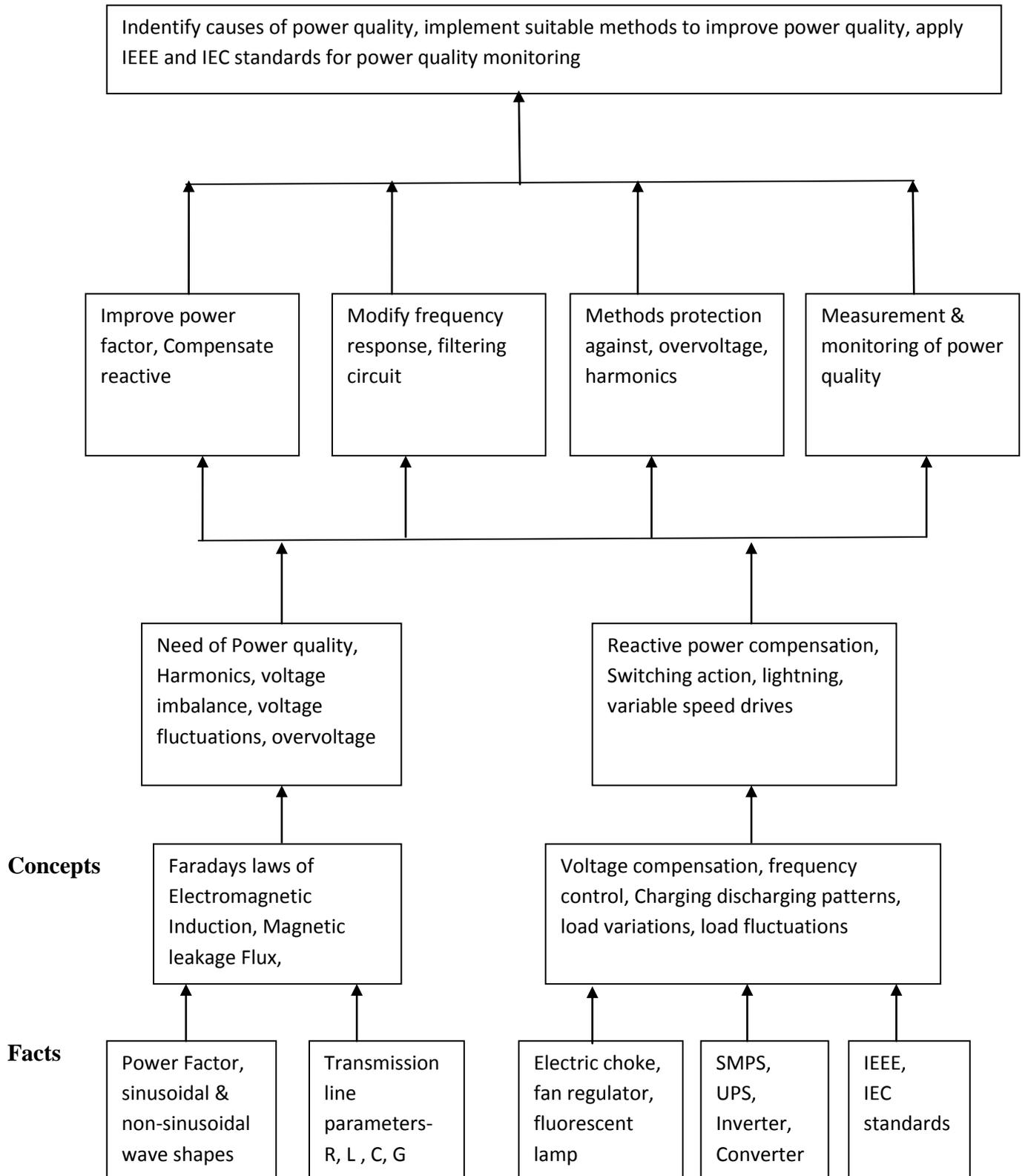
The subject deals with power quality issues between the utility and the end user. The content like the impact of transients, sags, swells, voltage imbalance, fluctuations, over voltages, capacitor switching, and harmonics are included in the curriculum. The contents on monitoring and mitigation techniques such as filters, compensators, power quality analyzers, flicker, meters, digital cameras useful to control quality power supply are also included.

**General Objectives:**

Students will be able to:

1. Understand the concepts of power quality problems.
2. Know the impacts of power quality problems on utility and end user.
3. Know the mitigation techniques for the various power quality problems.
4. Know the various IEEE and IEC standards related to power quality issues.
5. Understand the power quality monitoring and assessment tools.

**Learning Structure:**



**Theory:**

Topic and Contents	Hours	Marks
<p><b>Topic 1: Power Quality Problems</b></p> <p>Specific Objectives:</p> <ul style="list-style-type: none"> <li>➤ Understand concept of power quality</li> <li>➤ Know the importance of power quality</li> <li>➤ Analyze the power quality problems</li> </ul> <p>Conents:</p> <p>1.1 Concept and importance of Power quality <b>04 marks</b></p> <p>1.2 Concept of transients</p> <ul style="list-style-type: none"> <li>• Impulsive transients- definition, characteristics</li> <li>• Oscillatory transients- definition, characteristics</li> </ul> <p>1.3 Long duration voltage variations <b>08 marks</b></p> <ul style="list-style-type: none"> <li>• Overvoltages- definition, impacts</li> <li>• Undervoltages- definition, impacts</li> <li>• Sustained Interruptions- definition, impacts</li> </ul> <p>1.4 Short Duration voltage variations</p> <ul style="list-style-type: none"> <li>• Interruption- definition, impacts</li> <li>• Sags and Swells- definition, impacts</li> </ul> <p><b>1.5 Waveform Distortion 06 marks</b></p> <ul style="list-style-type: none"> <li>• DC offset- concepts, causes, impacts</li> <li>• Harmonics and Inter harmonics- concepts, causes, impacts</li> <li>• Notching- concepts, causes, impacts</li> </ul> <p>1.6 Voltage imbalance, voltage fluctuations, power frequency variations- concept, impacts</p>	10	18
<p><b>Topic 2: Sags and Interruptions</b></p> <p><b>Specific Objectives</b></p> <ul style="list-style-type: none"> <li>➤ Identify causes of sags and interruptions</li> <li>➤ Select method of improving voltage sag</li> </ul> <p>2.1 Sources of voltage sag and interruptions <b>08 marks</b></p> <p>2.2 Equipment sensitivity to voltage sag- concept, classification</p> <p>2.3 Methods of improving voltage sag performance <b>12 marks</b></p> <ul style="list-style-type: none"> <li>• Ferro-resonant transformer- working principle, operation</li> <li>• Magnetic Synthesizers- operation</li> <li>• Active series compensators- operation, special features</li> </ul>	12	20

<ul style="list-style-type: none"> <li>• Online UPS, Standby UPS, Hybrid UPS- block diagram, operation</li> <li>• Motor Generator switches- diagram, operation</li> </ul>		
<p><b>Topic 3: Transient Overvoltage</b></p> <p><b>Specific Objectives</b></p> <ul style="list-style-type: none"> <li>➤ Identify causes of transients</li> <li>➤ Know the methods of overvoltage protection</li> </ul> <p>3.1 Sources of transients</p> <ul style="list-style-type: none"> <li>• Capacitor switching, magnification of capacitor switching transients</li> <li>• Lighting and Ferro-resonance- characteristics, impacts</li> </ul> <p>3.2 Methods of overvoltage protection</p> <ul style="list-style-type: none"> <li>• Surge arrestors, utility surge arrestors, surge suppressors, isolation transformers- operation</li> <li>• Low pass filters, low impedance power conditioners- diagram, operation</li> </ul>	12	16
<p><b>Topic 4: Harmonics</b></p> <p><b>Specific Objectives:</b></p> <ul style="list-style-type: none"> <li>➤ Understand concept of harmonics</li> <li>➤ Identify causes and impacts of harmonics</li> <li>➤ Select methods of controlling harmonics</li> </ul> <p>4.1 Concept of total harmonic distortion, harmonic phase sequences, inter harmonics      <b>04 marks</b></p> <p><b>4.2 to 4.4 ----- 10 marks</b></p> <p>4.2 Commercial sources of harmonics</p> <ul style="list-style-type: none"> <li>• 1- phase power supplies- characteristics, impacts</li> <li>• Fluorescent lighting- characteristics, impacts</li> <li>• Adjustable speed drives for HVAC and elevators- characteristics, impacts</li> </ul> <p>4.3 Industrial sources of harmonics</p> <ul style="list-style-type: none"> <li>• 3-phase converters- characteristics, impacts</li> <li>• Arcing and saturable devices- characteristics, impacts</li> <li>• DC and AC drives- characteristics, impacts</li> </ul> <p>4.4 Effects of harmonic distortion on capacitors, transformers, motors, energy and demand metering</p> <p>4.5 and 4.6 ----- <b>12 marks</b></p> <p>4.5 Methods of controlling harmonics</p> <ul style="list-style-type: none"> <li>• Reducing harmonic currents in loads-Concept, features</li> <li>• Filtering- Concept, features</li> <li>• Modifying the system frequency response- Concept, features</li> </ul>	16	26

4.6 Methods of Controlling harmonic distortion <ul style="list-style-type: none"> <li>• Inline reactors-Concept, operation</li> <li>• Zigzag transformers-Concept, operation</li> <li>• Active and Passive filters (series and shunt)- Concept, operation</li> </ul>		
<b>Topic 5: Power Quality Monitoring</b> <b>Specific Objectives</b> <ul style="list-style-type: none"> <li>➤ Understand the necessity of PQ monitoring</li> <li>➤ Select instruments for PQ measurement</li> <li>➤ Know the PQ monitoring standards</li> </ul> 5.1 to 5.3 ----- <b>10 marks</b> 5.1 Objectives of PQ monitoring 5.2 Procedure of PQ monitoring 5.3 PQ measuring instruments <ul style="list-style-type: none"> <li>• Multimeters, Oscilloscopes- operation, characteristics</li> <li>• Digital cameras- operation, characteristics, special features</li> <li>• Spectrum and Harmonic Analysers- operation, characteristics, special features</li> <li>• Smart PQ monitors- operation, special features</li> </ul> 5.4 PQ monitoring standards <b>10 marks</b> <ul style="list-style-type: none"> <li>• IEC 61000-4-30- details of testing PQ measurement methods</li> <li>• IEEE 1159- details, guidelines of PQ monitoring</li> <li>• IEEE 519-1992 Details, guidelines of harmonics</li> <li>• IEC 61000-2-2, IEC 61000-3-2, IEC 61000-3-4</li> </ul>	<b>14</b>	<b>20</b>
<b>Total</b>	<b>64</b>	<b>100</b>

**Practical:**

**Skills to be developed:**

**Intellectual Skills:**

1. Understand the problems of power quality
2. Identify causes and sources
3. Suggest the method of improvement

**Motor Skills:**

1. Collect information from various resources
2. Measure parameters and record
3. Observe and interpret the waveforms

**List of Practicals:**

1. Identify the causes of voltage fluctuations and frequency fluctuations on different electrical gazettes

2. Select one method of improving sags. Write procedure and precautions while applying it.
3. Collect the information of transient over voltages and latest methods of overvoltage protection from internet and write a report on it.
4. Collect the details of harmonic distortion controlling devices from various manufacturers and write a report on it.
5. Search case studies on impact of harmonics caused by electrical furnaces, transformers, motors and nonlinear loads and write report on it. Also write the latest methods of controlling these impacts
6. Prepare a PQ monitoring survey report of a area and indentify the locations of PQ monitoring.
7. Collect information on harmonic analysers and write a report on basis of specifications and special features.
8. Collect the details of IEEE 1159 standards for PQ monitoring and write a report mentioning procedure and special features.
9. Collect the details of IEC 61000-4-30 regarding testing and measurement of power quality problems
10. Search for details of latest methods of power quality measuring equipments from different manufactures and write a report on it.
11. Collect standards for harmonics and write a report on procedure and special features.

### Learning Resources:

#### 1. Books:

Sr. No.	Author	Title	Publisher
01	Heydt	Power quality	
02	IEEE Standard 512	Recommended practices for power quality	
03	Dugan	Power quality	

#### Websites:

<http://powerstandards.com/tutor.htm>

<http://www.powerqualityinternational.com/pqi-case-studies.asp>

<http://www.powerqualityinternational.com/pqi-papers-articles.asp>

<http://www.powerqualityinc.com>

<http://www.ornl.gov/sci/ees/etsd/pes/pubs/ORNLTM200491FINAL.pdf>

<http://powerstandards.com/IEC.htm>

<http://powerstandards.com/IEEE.htm>

- ❖ Strategy for implementation -