Outline

Power Quality in Electrical Systems

by

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Authors

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- Marc Thompson, Ph.D, President, Thompson Consulting, Inc., Harvard MA and Adjunct Associate Professor of Electrical Engineering, Worcester Polytechnic Institute. Teaches graduate-level power electronics and analog circuit design; twenty years industrial experience in analog and power electronics design; author, co-author, 10 papers; 7 US Patents.
Overview

• Tremendous requirement for reliable, uninterruptible electric power service for all consumers, particularly manufacturing facilities, data-processing centers, and other locations with critical and sensitive loads.
• Power Quality is a measure of the reliability of electric power service.
• Multi-million dollar industry to provide engineering and equipment to resolve Power Quality problems.
• Book is based on a professional course sponsored by IEEE and taught by the authors.
• Book is directed toward real problems and solutions, rather than a total theoretical treatment.
• Book can be used as the text for a course and as a reference.
• Book will include treatment of switch-mode power supplies and other loads that produce conducted and radiated interference. Levels are regulated by FCC and other codes.
• Book will include description of standby power systems for emergency and independent operation to solve Power Quality problems.

Market

• Managers, concerned with reliable electric power service
  - Computers/Data Centers
  - Manufacturers
  - Manufacturing facilities
  - Office buildings
  - Electric utility companies
  - Government/Military agencies
  - Healthcare facilities

• Engineers concerned with standards compliance and reliable operation of equipment and systems
  - Electrical design
  - Electric and telecom utilities
- Transportation
- Computer/Telecom
- Unconventional power (e.g. wind)

- Students seeking knowledge and entrance to an active field
  - Fourth year and graduate engineer
  - Two-year associate engineer
  - Professional engineer

Focus
- Identification and correction of power quality problems.
- Listing of definitions and standards
- Case studies from authors’ experience and in references of power quality problems and solutions.
- References to significant articles in the professional and trade journals.

Organization of Book
- See Table of Contents
- Based on original six lectures expanded to 12 chapters.
- Figures suitable for PowerPoint presentation; can be emailed to students prior to each class.
- Preface of book will describe how the book can be used, for example, for a six- lecture professional course or for an 18-plus lecture academic course.
- Estimated length of book, 400 pages, including up to 100 figures (already done). See Attachment A for some representative figures.

Competitive Books
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  - Voltage sag, swell, transients, flicker
  - Harmonics
  - Frequency Deviations
  - Interference

- Examples of poor power quality
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  - Voltage distortion
  - Capacitor failures
  - Flicker
  - EMI, conducted and radiated

- Need for corrections
  - Customer needs
  - Standards and codes

- Scope
  - Events
  - Corrective measures

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- Factors causing poor power quality
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  - Inherent equipment design
  - Non linear loads, converters, arcing
  - Motor starts, utility switching
  - Standards non-compliance

- Relevant standards
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  - CBEMA curve
  - Engine-generator standards
  - UPS standards
- Utility, state and federal standards
- EMI standards
  o US: FCC Class A and B
  o International: CISPR 16-1, EN 61000

Chapter 3. Voltage Distortion

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  - Utility switching
- Causes, Internal to Facility
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  - Rotating

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  - Saturable Magnetic, SOLA

- Standby Power Systems

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  - Maintenance, 24/7 concept

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Attachment A
Representative Figures

Typical Lightning-Induced Transient

![Diagram of Typical Lightning-Induced Transient]

Figure 1—Lightning stroke current that can result in impulsive transients on the power system


UPS: Static Inverter

![Diagram of UPS: Static Inverter]

Phase Current and Voltage

Fig. 9. Measured current (solid) and voltage (dashed) at 5 m/s.

Table 1. Relative harmonic content of the voltages.

<table>
<thead>
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<th>order n</th>
<th>5</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>11</th>
<th>13</th>
<th>15</th>
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<td>frequency (Hz)</td>
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<td>350</td>
<td>400</td>
<td>450</td>
<td>550</td>
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<tr>
<td>$</td>
<td>U_{l(n)} (%)</td>
<td>1.1</td>
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<td>0.11</td>
<td>0.072</td>
<td>0.097</td>
<td>0.056</td>
</tr>
<tr>
<td>$</td>
<td>U_{l(n)} (%)</td>
<td>1.0</td>
<td>0.54</td>
<td>0.09</td>
<td>0.048</td>
<td>0.047</td>
<td>0.016</td>
</tr>
</tbody>
</table>


Resonance: Distribution Factor, with Reactor

$\rho_{fB} \rightarrow 1$ at $n = 5$

$\rho_{sB} \rightarrow 0$ at $n = 5$

In addition, power quality in electrical systems - Power Quality solutions, problems, tutorials, basics, issues, devices, software and standards a study of induction motor starting methods in - A Study of Induction Motor Starting Methods In Terms of Ewald F. Fuchs and Mohammad A.S. Masoum, Power Quality in Power Systems and Electrical Machines, power quality issues in power systems - - Common Power Quality Disturbances are. Reactive Power Demand; Harmonic Distortion; Voltage sags and swells; Under voltages and over voltages; Voltage Unbalance power quality: var compensation in power systems - Power Power Quality of power systems affects all connected electrical and electronic equipment. Power Quality is a measure of deviations in voltage and frequency of the particular supply system. In recent years, there has been a considerable increase in nonlinear loads; in particular distributed loads, such as computers, TV monitors and lighting. These draw harmonic currents which, when distorted, have detrimental effects including interference, loss of reliability, increased operating costs, equipment overheating, motor failures, capacitor failure and inaccurate power metering. This subject is pert