CHAPTER

1

# Introduction to Power Quality

Notes

## 1.1 Scope of this Program

Power quality is increasingly important to facility owners and/or managers, electrical equipment manufacturers, and end-users of electrical products.

Good power quality lowers electricity costs, minimizes maintenance problems with electrical installations in buildings and similar structures, and lets electrical utilization equipment operate properly and efficiently.

Poor power quality increases electricity costs, causes serious maintenance problems with electrical installations, leads to utilization equipment failures and operational problems, and can even create serious safety problems such as fires of electrical origin.

There are many factors that degrade power quality; but one of the most serious is harmonics, caused by what the *National Electrical Code* and other industry standards refer to as nonlinear loads.

Harmonics in electrical distribution systems, caused by nonlinear loads, affect everyone: people operating computers, electricians troubleshooting system problems, electrical contractors absorbing the cost of replacing damaged equipment, inspectors investigating the causes of electrical fires, and facilities management staff who are interested in effective and efficient equipment operation and reduced downtime.

The causes, effects, and prevention of harmonics are a complex subject, and few people in the electrical trade have a good working knowledge of the problem. This textbook provides the foundation necessary to understand the power quality and reliability issues and solutions, causes of harmonic problems, which solution(s) to apply, and when to call an expert.

## 1.2 Changing Electrical Environment

Much of today's electronic technology requires power that is sufficiently free of voltage and current disturbance so as not to cause undue energy waste or heating of supplied equipment. In decades past, this was not the case.

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Several decades ago, most electrical equipment operated on ideal voltage and current waveforms and was not sensitive to power distortions. However, in the past 25 years (particularly since the late 1980s) there has been an explosion in the use of solid-state electronic technology. This highly efficient technology provides for improved product quality with increased productivity by the use of smaller and lighter electrical components. Today, we are able to manufacture products at costs substantially lower than in years past. However, this new technology requires clean electric power and is highly sensitive to power distortions such as high-voltage spikes and brownouts (undervoltage).

> **Author's Comment:** "Clean electric power" can be thought of as power that is sufficiently free of waveform distortion, voltage imbalance, induced noise, or other anomalies such that the combined anomalies do not cause undue energy waste or heating of supplied equipment. A "power distortion" is an undesirable change in the current or voltage waveform. Examples include phase shift and peak clipping. The most common example may be harmonic multiples riding on the fundamental waveform. The acceptable amount of power distortion varies with the application, but the mere presence of power distortion does not normally indicate a problem that needs to be solved.

New electronic devices contain rectifiers and capacitors that convert 60 Hz alternating current (ac) to direct current (dc) by the use of switching power supplies. In addition to converting alternating current to direct current, the current is sometimes converted back to alternating current, but at a different frequency. The conversion of alternating current to direct current by the use of rectifiers is the main cause of high harmonic currents in electrical distribution systems.

## 1.3 Poor Power Quality

Poor power quality increases operating costs, equipment malfunction and failure, and operational problems, among others. But most importantly, poor power quality can lead to serious safety issues.

Electronic equipment (switching power supplies) draws current differently than non-electronic equipment. Instead of a load having a constant impedance and drawing current in proportion to the sinusoidal voltage, electronic power supplies change their impedance by switching on and off near the peak of the voltage waveform. This switching on and off results in short, abrupt, nonsinusoidal current pulses during a controlled portion of the incoming peak voltage waveform.

These abrupt, pulsating currents introduce unanticipated reflective currents (harmonics) back into the power distribution system. These currents operate at frequencies other than the fundamental 60 Hz. Harmonic currents can be thought of as the vibration of water in a water line when a valve is rapidly opened and closed.

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## 1.4 Why Power Quality is Important

Distribution systems which are properly designed and installed should provide safe clean power, which reduces operating costs, minimizes maintenance issues, and improves employee productivity. Basically, this improves the bottom line for a business. How much downtime is acceptable? For reliability, it is important that there is dependable power available at all times. **Figure 1–1**

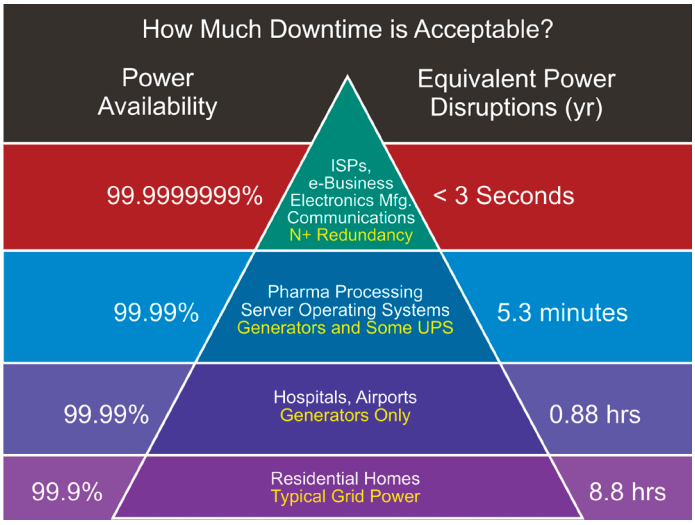


**Figure 1–1**

## 1.5 What's the Problem?

There are many factors that degrade power quality. The most significant include:

- Voltage, and current disturbances,
- Poor system design,
- Field wiring errors, and
- Improper grounding.