PQNews

EPRI ELECTRIC POWER RESEARCH INSTITUTE

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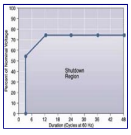
EPRI PQ Knowledge Development and Transfer 2020 Year-End Update

The EPRI Power Quality Knowledge Development and Transfer supplemental project provides a wealth of high-impact resources in a well-designed, readable, and accessible format. Paramount among these are numerous and highly readable documents covering a wide range of PQ topics, written not only for use by busy PQ professionals, but also to expedite problem solving and education of important end-use customers and internal utility management.

The EPRI PQ Knowledge Development and Transfer supplemental project (PQK) is pleased to announce the completion of over two dozen new documents, online resources, and PQ Hotline Calls of the Month for the 2020 deliverable year.

Please note that the links to documents included on this Web page require a valid EPRI login for access to full documents.



PQ TechWatches

The *PQ TechWatch* gives in-depth coverage of a power quality topic, including practical advice for diagnosing, preventing, and resolving common problems. Reports feature easy navigation, illustrative case studies, and quality graphics.

Five new TechWatch documents are now complete and posted for the 2020 deliverable year:

Guiding End-Use Customers on Mitigation of PQ Phenomena (3002019387)

Despite the availability of solutions, problems around power quality (PQ) that have accompanied the increased use of power electronics have persisted, indicating that end-use customers are in need of some guidance to find those solutions. Given that these customers may have a general lack of awareness regarding the causes of PQ issues, possible mitigation methods, and the possibility of incorporating more robust control designs at reasonable cost, the purpose of this PQ TechWatch is to provide useful information about these topics.

PQ Issues for Electric and Plug-in Hybrid Electric Vehicles (3002019374)

Sales of electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) have increased in recent years, and the charging of the batteries in those vehicles has brought a new load to the residential electrical grid. Although presently the numbers of EVs and PHEVs compared to conventional gasoline-powered vehicles remains relatively small in the United States as a whole, individual states and large municipalities may have greater numbers, and the magnitude of effects on the distribution system may depend on the numbers of vehicles connecting to each distribution circuit. As these numbers rise, so also may the PQ effects. EPRI has not only conducted an in-depth study on the impact of this increased load on the distribution grid, but also taken a look at the PQ effects of the electrical supply on these vehicle chargers and their charging behavior and at the effects of the charging systems on the existing electrical supply. Higher-voltage, fast-charging systems are of particular interest and concern. This PQ TechWatch gives an overview of testing that has been done on electric vehicle supply equipment and the effects of electric vehicles and chargers on modeled systems. Indications of voltage effects and current harmonics are discussed. In addition, the various industry standards and codes that apply to these new loads are explored.

Review of Existing Software Resources for PQ Monitoring and Data Analysis (3002019386)

Utilities are in need of software to assist with their various levels of power quality (PQ) monitoring, which can range from single-site investigations to grid-wide fleets of more than a thousand meters. During the past five years, significant growth in PQ monitoring has taken place not only at the industrial and commercial level, but also at the distribution and transmission levels as new viable grid applications such as fault location, grid health, asset health, lightning correlation, and incipient fault detection have been discovered. In this PQ TechWatch, existing PQ monitoring software resources are researched and assessed. While PQView and the open-source Open PQ Dashboard have been innovative and helpful for gathering data from many formats into a usable database, utilities are widening their software searches, looking for more capabilities, better ease of use, or new turnkey solutions. Before reviewing these resources, the report covers what is required from PQ monitoring. PQ

monitoring can be broken up into three areas—gathering, processing, and reporting. Software could provide a complete enterprise solution, covering all of these areas, or it could support an individual area. Our assessments include both varieties of products.

Understanding the Economic Value of Good Power Quality — Harmonics (3002019375)

The impacts of harmonics can be difficult for utilities to quantify. Because of this, harmonics and power quality in general are not treated the same way as power factor, for example, with the utility response to harmonics more “reactionary” than “precautionary.” However, as utilities integrate distributed energy resources (DERs) and end-use loads employing power electronic circuits into their power grids, harmonics are once again receiving attention. Although efforts have been made by some organizations to develop frameworks for assessing the economic impact of harmonics, these efforts have largely remained confined to literature, and utilities are still some ways off from understanding the economic impact that harmonics-producing loads in general, and DERs and power electronics devices in particular, have on their systems. This PQ TechWatch is part of an attempt to bridge this gap in knowledge. A new framework is proposed here that couples the Harmonic Losses Calculator, which quantifies the losses to a utility caused by the flow of harmonic currents on a distribution circuit and assigns a dollar value to them, with the preexisting Harmonics Evaluation Module to accurately determine the economic impact of nonlinear load or DER penetration. The objective is to evaluate the adverse impacts of harmonic load or savings due to DER penetration at the planning stage. In addition to understanding the economic value, good power quality can be used as another yardstick while planning for expansion on an existing feeder, or for a new feeder altogether. The impact of penetration of harmonic load and DER on two known distribution circuits in the OpenDSS simulation framework is shown, and is followed by a discussion of the increase (or decrease) in operating costs of the feeder due to such load or generation. The document closes with a discussion of anticipated future research and expected capabilities to be added to this framework.

Needs and Gaps in PQ Monitoring and Data Standards (3002019377)

Distributed energy resources (DERs) and microgrids promise to revolutionize the traditional power-system paradigm, providing a more environment-friendly means of energy generation, increased reliability of supply, and more choice and flexibility for the end user. However, along with these positive changes come challenges, especially in the power quality (PQ) domain. For example, DERs tend to be mostly inverter-interfaced, and this coupled with more power electronics in end-use load may lead to a rise in PQ events in the future. To cope with this change in production and consumption, PQ engineers must reanalyze and reassess the framework in which the grid operates. Standards and regulations should be revisited, keeping in mind that these standards now apply to sources of generation as well as load. For example, integration of inverter-interfaced resources has forced a reevaluation of the voltage and current harmonic limits, but a framework to assess the potential impact of such changes is missing. Similarly, the change from centralized to decentralized power generation has shown the need to rethink the traditional definition of the power factor metric and how PQ engineers view it. This PQ TechWatch discusses some of the gaps and needs in PQ standards today (e.g., the lack of a common format to exchange PQ data and differences in the way the duration of events such as sags are calculated). Considering the dynamic nature of the grid and the pace at which changes happen, these gaps in standards and regulations need to be closed, and PQ monitoring and enforcement of PQ regulations need to be more proactive. Finally, the document takes a look at the unique problem of supraharmonics, which requires significant research and the likely creation of a new standard of measurement. The attempt here is to give the reader the most up-to-date information possible and to clarify why some gaps exist and the background behind them. Where possible, examples from real-life situations have been provided to put these discussions into a utility perspective.

PQ Two-Pagers

The *PQ Two-Pager* is a short-format treatment of a single, important PQ topic in a concise, readable format. They are intended to help utilities to educate end-use customers on complex subjects, but in a non-intimidating way.

Three new Two-Pager documents are now complete and posted for the 2020 deliverable year:

Facility Design for PQ: Power Conditioning (3002019380)

Power-conditioning equipment changes or controls the electrical environment to make it acceptable for electrical end-use equipment. In the real world of electrical aberrations, the designers of electronic equipment cannot economically produce competitive designs that take care of all possible electrical anomalies. When a compatibility issue exists between the electrical system and end use sensitive electrical or electronic equipment, power conditioners may be useful when properly applied. However, misapplying power-conditioning equipment is a commonplace occurrence. A good understanding of power-line disturbances, how end-use electrical equipment operates, and how power-conditioning devices can help (or hurt) is essential to the proper resolution of a PQ-related problem using power conditioners.

Power Quality and Energy Efficiency (3002019381)

The energy efficiency of a particular process is the measure of the power consumed by that process as work compared to the power supplied to the process. In mechanical processes, much of the energy lost may result from friction and other heat losses. In electrical processes, heat may be generated and lost due to the resistance in wiring and other factors. Before energy can be saved, the ways it is lost or wasted must first be identified. For example, power quality variations such as harmonic distortion may cause energy losses in the form of heat released to the environment. After these losses are understood, then methods for saving the lost energy can be identified. The topics that follow concern approaches to power quality and energy efficiency and how they may or may not be related.

Understanding Power Factor (3002019382)

The study of any subject requires an understanding of terminology, and an understanding of power factor involves several concepts.

Training Videos

Three training videos are now complete and posted for the 2020 deliverable year:

Understanding and Applying PQ Standards (3002019391)

The subject of this Power Quality (PQ) Training Module video is Understanding and Applying PQ Standards. This product is part of EPRI's PQ Training, a series of modules providing information and expertise from EPRI to those interested in learning about power quality phenomena and methods of addressing the effects of these phenomena.

Understanding Power Factor (3002019392)

The subject of this Power Quality (PQ) Training Module video is Understanding Power Factor. This product is part of EPRI's PQ Training, a series of modules providing information and expertise from EPRI to those interested in learning about power quality phenomena and methods of addressing the effects of these phenomena.

Facility Design for PQ — Power Conditioning (3002019393)

The subject of this Power Quality (PQ) Training Module video is Facility Design for PQ — Power Conditioning. This product is part of EPRI's Power Quality Training, a series of modules providing information and expertise from EPRI to those interested in learning about power quality phenomena and methods of addressing the effects of these phenomena.

EPRI PQ Color Book

In 2017, the EPRI PQ program produced its first comprehensive PQ Color Book, comprising the 24 chapters of the *PQ Encyclopedia* in one continuous, integrated volume. The current edition contains over 600 pages, including the following chapters:

- What Is Power Quality?
- The Economics of Power Quality
- Understanding Voltage Sags
- Mitigation Techniques for Power Quality
- Understanding Voltage Flicker
- Understanding Harmonics
- PQ Standards for System Compatibility
- Adjustable-Speed Drive Technology and Power Quality Considerations
- Power Quality Monitoring: Concepts, Equipment, and Applications
- Understanding Power Factor
- Understanding Voltage Unbalance
- Transient and Temporary Overvoltage Protection
- Grounding: A Broad-Spectrum Requirement for Power Quality
- Facility Design for PQ: Introduction and Equipment Needs
- Facility Design for PQ: Voltage Quality and Regulation
- Facility Design for PQ: Power Conditioning and Mitigation
- Conducting a Power Quality Audit
- Electromagnetic Compatibility for Power Quality Engineering
- Electromagnetic Shielding: A Power Quality Engineering Perspective
- Electromagnetic Interference of Power Lineswith Co-Located Telephony and Communications Cables
- Understanding Stray and Contact Voltage
- Application of Small Uninterruptible Power Supply (UPS) Systems
- Power Quality and Energy Efficiency
- Distribution Harmonics: Impacts, Management, and Practical Considerations

In 2020, EPRI updated three chapters:

- Chapter 4: Mitigation Techniques for Power Quality
- Chapter 9: Power Quality Monitoring: Concepts, Equipment, and Applications

- Chapter 12: Transient and Temporary Overvoltage Protection

Download the EPRI PQ Color Book (3002019378)

PQ Hotline

Every year, dozens of inquiries from participating PQ Knowledge utilities pour into the EPRI Power Quality Hotline, comprising all manner of PQ issues, including measurement concerns, equipment performance and compatibility, electrical system configurations, management issues, and more. Experience timely responses to your individual concerns and access to over 60 PQ experts at EPRI.

Access to the PQ Hotline is an exclusive benefit of PQ Knowledge participation and is available 24/7. Most questions are addressed within a single business day.

Submit your question to the PQ Hotline:

Email: **PQHotline@epri.com**
Online: **mypq.epri.com**

PQ Hotline Calls of the Month

Each month, one call received by the Power Quality Hotline is explored in detail by the EPRI staff and shared with PQ Knowledge members via email in the very popular PQ Hotline Call of the Month.

Below are the twelve PQ Calls of the Month provided in 2020:

- January: **Mitigating Voltage Surges on a Distribution Circuit**
- February: **Residential HVAC Unit Draws Distorted Current Even When the Compressor Is Off**
- March: **The Relationship Between Measured DC Offset and Measured Even Harmonics**
- April: **The Manual for a Motor Drive Provides Solutions for Drive Malfunctions**
- May: **Economic Application of a Dynamic Sag Corrector**
- June: **Flicker Caused by the Normal Operation of an Arc Furnace**
- July: **PQ Conditions Cause Computer Tripping and Failure**
- August: **VArs and the Generation of Electricity**
- September: **Installing a Three-Conductor Outlet with USB Ports in a Two-Conductor System**
- October: **Catastrophic Failure of a Capacitor Bank at an Industrial Facility**
- November: **Perplexing Graph of Three-Phase Voltage Measurements Could Be Caused by Faulty Meter**
- December: **Determining the Effectiveness of the Bonding Infrastructure of an In-Ground Swimming Pool**

For the complete archive of Hotline Calls of the Month, visit **mypq.epri.com**.

The 2020 PQ Hotline Call of the Month Compendium is available at the EPRI Member Center (**3002016842**).

Online Catalog of EPRI PQ Reports

Find the research you need—the first detailed catalog of previously created EPRI reports is available to PQ Knowledge funders. This catalog of over 600 documents available from EPRI offers intuitive search tools and user-driven results. For the complete archive, visit **mypq.epri.com**.

MyPQ Power Quality Online Resource Center

The PQ Knowledge subscriber website—MyPQ.epri.com—is rich with content and functions. It features access to over 1,500 authoritative EPRI-authored PQ resources (documents, videos, and other items). The upgrade of MyPQ to Version 4.0 began in 2018 and was completed in 2020. New features include:

- Database of grid-side solutions.
- Free training videos.
- Improved Hotline database searching.
- Addition of PQ Two-Pagers.

Below is a snapshot of that content and functions available to PQ Knowledge funders in 2020 (in addition to those already discussed).

Serial Publications

PQ TechWatches
The *PQ TechWatch* series builds on EPRI's broad expertise and power quality testing and evaluation work to provide a vital flow of information, including important

information on emerging trends powering ebusinesses and developments in next-generation power quality mitigation and energy-storage technologies.

PQ Two-Pagers
The *PQ Two-Pager* is a short-format treatment of a single, important PQ topic in a concise, readable format. They are intended to help utilities to educate end-use customers on complex subjects, but in a non-intimidating way.

PQ Encyclopedia
The *EPRI PQ Color Book* provides a definitive desk reference for power quality phenomena, and their effects on utility and end-user processes and mitigation technologies. This document serves as the ultimate guide for training, client education, and general support of all aspects of power quality management and problem solving.

PQ Technical Library

The PQ Technical Library comprises a number of expert EPRI technical resources.

Applications are packed with valuable "how to" information composed for utility customers, who can use them to solve or prevent power quality problems. The level of technical detail in PQTN Applications varies depending upon the audience so that end users can understand and, more importantly, use the information.

Briefs report the results of equipment-characterization tests and discuss the significance of the results to the discipline of power quality research. Each *Brief* includes a historical or technical overview of the problem or opportunity that engendered the need for testing, an objective of the conducted tests, detailed test results, and a discussion of the test results. The content is moderately to highly technical.

The subject of ***Commentaries*** varies widely. Some are detailed explanations of current or emerging technologies, the benefits of their applications, and trends in their development. Some Commentaries also discuss power quality theory so that utility engineers can better understand real and perceived threats to a healthy power system, such as harmonic currents. Other *Commentaries* offer a detailed explanation of a particular power quality technique, such as wiring and grounding. Of the documents in the PQ Technical Library, *Commentaries* are by far the most technical.

Solutions describe power quality problems encountered by utility engineers and the solutions to those problems. The anecdotal information in *Solutions* can be extrapolated to other power quality problems, but perhaps the most useful feature of a *Solution* is the detailed analysis of problem-solving procedures. The content is moderately technical.

Case Studies
Case Studies are similar to *Solutions* but focus more on measurements, monitoring equipment, and system compatibility issues than troubleshooting procedures. The content is moderately technical.

PQ News
View the latest news in EPRI power quality, as well as the archive of past news items.

Continuing in 2021, the Expanded *EPRI PQ Online Newsletter Article Library (News Builder)*

The *EPRI PQ Online Newsletter Library (News Builder)* was launched as a new PQ Knowledge feature in 2010, resulting from goals set in the EPRI PQ Strategic Plan and strong feedback from funders. In 2013, EPRI expanded this new resource, consisting of a growing library of 500- to 1,000-word articles that are provided to PQ Knowledge funders in both RTF and HTML formats for distribution either as standalone articles or for inclusion in website or newsletter formats. The library currently contains dozens of articles with many more planned for 2020 and beyond, drawing upon our over 500 detailed articles in the EPRI PQ Online Resource Center.

Hotline Calls and Hotline Calls of the Month

The site has an abundant log of Power Quality Hotline calls from funders, real-life problem-solving in a convenient access point.

Hotline Database

This database has hundreds of records and comments based on Hotline Calls that Program 1 receives every year.

Case Study Database

This database currently has around 300 case studies. Each case study has been tagged with keyword by our experts.

Power Quality in Transmission and Distribution

The PQTD section of MyPQ was created to provide tools and resources to improve customer reliability and power quality. PQTD contains article downloads and links to other resources and concentrates on practices and equipment that can be used to minimize the effect of faults on customers.

Standards and Guidance Documents

MyPQ contains four categories of standards and guidance documents: IEEE, Power Quality, Power Quality Standards, and Power Systems.

Global Document Search

Documents accessible from MyPQ can be searched by document type, title keyword, and published year.

Video Center

This feature provides technical content via video clips, such as training videos and webcasts.

EPRI Industrial PQ Training Videos

This feature provides complementary training videos to help solidify the concepts for both the utility members and their customers.

Services

The Services menu contains two services associated with the EPRI Power Quality Program: SEMI F47 Testing and Industrial Assessments.

Online Tools

The EPRI PQ Knowledge Program offers a variety of online tools for busy power quality professionals, including:

Conductor Derating Calculator
This tool evaluates conductor rating in nonsinusoidal environments. This methodology was developed from *Adjustable-Speed Drives and Power Rectifier Harmonics—Their Effect on Power System Components,* written by David Rice of GE. Just enter the conductor type and size of the conductor, fundamental current, and system frequency, and the calculator returns total harmonic distortion, harmonic load factor, RMS current, conductor ampacity, derated conductor ampacity, and conductor derating value.

Power Factor Correction
Enter the transformer size, transformer impedance, size of the load being served (in kW), and current and desired power factor. The kVAr required to correct the power factor to the desired level will be calculated. Other values such as the voltage rise on the bus will be calculated as well.

Voltage Drop Calculator
Conveniently calculate the voltage drop in single-phase or polyphase systems for a wide variety of voltages, conductor sizes, and amperages.

Visit **mypq.epri.com** to see all the features, documents, and tools available to PQ Knowledge subscribers.

Conferences and Events

As part of EPRI's effort to prevent the spread of the COVID-19 virus, EPRI postponed many of it's scheduled 2020 events, including the 2020 *EPRI Grid Analytics and Power Quality Conference and Exhibition* and *PQ Week.*

The EPRI PQ Knowledge Project in 2021

In 2021, the EPRI PQ Knowledge Development and Transfer supplemental project will continue to provide vital support for the base-funded EPRI Program 1, Power Quality.

PQ Knowledge in 2021 will continue to offer a wealth of new and insightful documents, online resources, access to the EPRI PQ Hotline and Call-of-the-Month articles, events, and other resources essential for busy PQ professionals. PQ Knowledge is one of the most highly leveraged offerings in the EPRI portfolio because of the large number of utility and government funders. We look forward to working with you in 2021.

For more information about PQ Knowledge for 2021, please **download the brochure.** For more information about the EPRI PQ Portfolio in general, please visit **epri.com** to see the new 2021 EPRI PQ Research Portfolio, or contact:

Bill Howe, PE, at email: **bhowe@epri.com**, or tel: 720-565-6888.

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