Utilization of Web-based Power Quality Monitoring to Assess Customer Power System Performance

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Abstract: Power quality monitoring is an essential service many utilities perform for their industrial and larger commercial customers. Because of the technology and software now available, this monitoring is a highly effective tool. Not only can a system provide information about the quality of the power and the causes of power system disturbances, but it can also identify problem conditions throughout the system before they cause widespread customer concerns, equipment malfunctions, and even equipment failures. Power quality problems are not necessarily limited to the power supply system. Many surveys have shown that the majority of problems are localized within customer facilities. Given this fact, monitoring is a service opportunity that can be applied to the entire utility customer base.

Essential requirements for a successful monitoring system include extensive data gathering (monitoring), processing capabilities, easily understood reports, and universal sharing of information both within the utility and with the customer's facilities personnel.

Utilizing state-of-the-art monitoring technology and software, many utilities are able to offer their customers the benefits of power monitoring through a low-cost monitoring service. Using recently developed software for the World Wide Web, utilities are able to give customers access to power quality monitoring data via the Internet. In fact, several utilities offer this service to their largest customers as a value-added service. Using the Internet based software to display monitoring data allows utility engineers and customers to gain access to data with a minimal amount of system configuration, engineering, or training on specialized software packages. Any Internet browser can be employed to view the monitoring data on a password-protected site. The monitors are remotely downloaded via central servers maintained by the utility or third party consulting firms, with the data and analysis made available over the Internet. Alarming features are available that allow almost instantaneous notification of power quality disturbances via alphanumeric pages, faxes, or e-mails.

This paper describes the deployment of this monitoring service in a utility customer's location, and how usage of the system is benefiting both the utility and the customer.

Introduction

Initially, the primary method of monitoring steady state voltage regulation in the Consolidated Edison Company of New York, Inc. (Con Edison) secondary distribution networks was via recording devices placed at the electrical load center, or master point. These devices were strip chart electro-mechanical voltage recorders with approximately a 1/3 second response time to RMS voltage variations. They are mounted at one or two "master point" locations within the network. Because of the slow response time, these devices could only be utilized to trend the steady state voltage in the network. This could be utilized to track correct operation of the area substation load tap changers, and validate each area substation's respective load/voltage schedule. Each device is capable of recording one phase of the three phase secondary system, and requires collection and replacement of the strip chart at this field location every two weeks. In addition, a significant amount of time is required in the office to review each paper strip chart for anomalies and average regulation levels.

The necessity for evaluating new technologies to replace these existing devices was based on the following:

1. A desire to utilize field and technical forces in a more efficient and productive manner.
2. The need to enhance the quality and levels of information supplied by the device.
3. The need for data that could be accessed in a timely manner and made available to both utility and customer personnel. The need for this was driven by customers, who require detailed information on power quality levels on the distribution network that supplies their power.

In June 1992, Con Edison initiated an R&D project to evaluate the Dranetz-BMI 8010 PQNode as a suitable enhanced recording device to replace the existing master point devices. The project was run as a pilot in eight networks in the Manhattan Customer Service areas. Following the success of this pilot, Con Edison installed PQNodes in all the distribution networks in Manhattan. The project has been expanded to several of the surrounding boroughs and an adjoining county with great success.

Along with this expanding power quality monitoring program, Con Edison has established a power quality service center in their Manhattan service territory. Although this service center is located in Manhattan, it serves as a resource for the entire company. For this reason, it became necessary to develop and implement a system that would allow engineers from all operating districts and boroughs to query measurement data and case study information.

The Monitoring System - Hardware

The monitoring system consists of Dranetz-BMI 8010 PQNodes and 3100 PQPagers. Sixty of the PQNodes were deployed in the first phase of the system and the PQPagers were added as they became available. Ultimately, Con Edison plans to have a total of 120 monitors installed at the end of Phase 2. Both the PQNode and the PQPager are configurable via modem, and the data can be collected via telephone line and modem as well.

Figure 1. Typical PQNode installation.

The Monitoring System - Software

The heart of any monitoring system is the software that drives the system. Without the proper software, gathering, analyzing, and reporting the monitoring data would be a tedious task. The following sections describe the software used to communicate with the monitoring instruments, analyze the monitoring data, and report the data to the user via the Internet. Figure 2 illustrates the basic monitoring system.

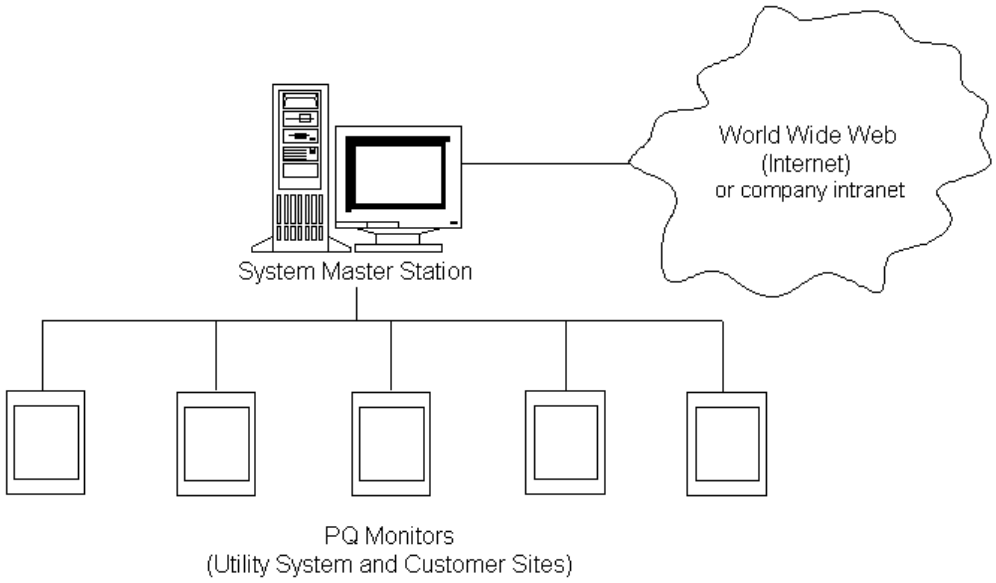

Figure 2. Utility master station and power quality monitors on utility system and customer sites.

The system consists of four basic components

- Monitoring instruments
- Downloading computers
- Master station
- Internet or company intranet

The monitoring instruments are used to gather the required measurements. Thresholds are selected by engineers to allow the instruments to capture power quality phenomena without capturing unwanted data. This process normally takes one to two weeks to fully evaluate how the power system operates and to fine-tune the measurement parameters of the instruments.

Every two hours, the download computers “call” and download the monitoring instruments. A monitoring system may have as many as five download computers. It is normally recommended that each download computer be responsible for up to 20 monitoring instruments.

The master station is used to communicate with the download computers and store the monitoring data. This computer is generally a dual processor Microsoft Windows NT based system. A multi-gigabyte drive is used to store the power quality data. With this drive, Con Edison has the capability of storing approximately two years worth of data on-line.

The Internet is used to disseminate the power quality data to the appropriate engineers and technicians. Using custom software, it is possible for many engineers, technicians, and customers to view the power quality data. This is accomplished with minimal training and software. For a person to view the data, three things are required.

- A computer with an Internet connection and a Web browser supporting Java Script
- The URL for the power quality data site
- Appropriate user ID and password to access the data.

No special hardware, software, or training is required for the users.

WebPASS

WebPASS was developed for use on the Con Edison intranet to enable engineers and technicians throughout the company to view and analyze power quality data. The Con Edison power quality group was concerned about the security of the data files and decided to seek a way to give users read-only access to the databases. In addition, Con Edison was concerned about the extensive training requirements for the PQNode Application System Software (PASS) used to setup and communicate with the monitoring instruments.

By relying on Internet browsers and hyperlinks, WebPASS allows users to have read-only access to the power quality data and requires no extensive training. In addition, its extensive online help makes the software easier to use.

WebPASS allows the user to plot trends of the RMS voltages and currents. These trends can be selected for one day, one week, one month, one year, or any arbitrary period of time. The trend data displays the minimum, maximum, and average RMS values of all cycles. It is a convenient method to summarize the power quality of a site over a given period of time. This plot is also useful to show voltage regulation and load change patterns.

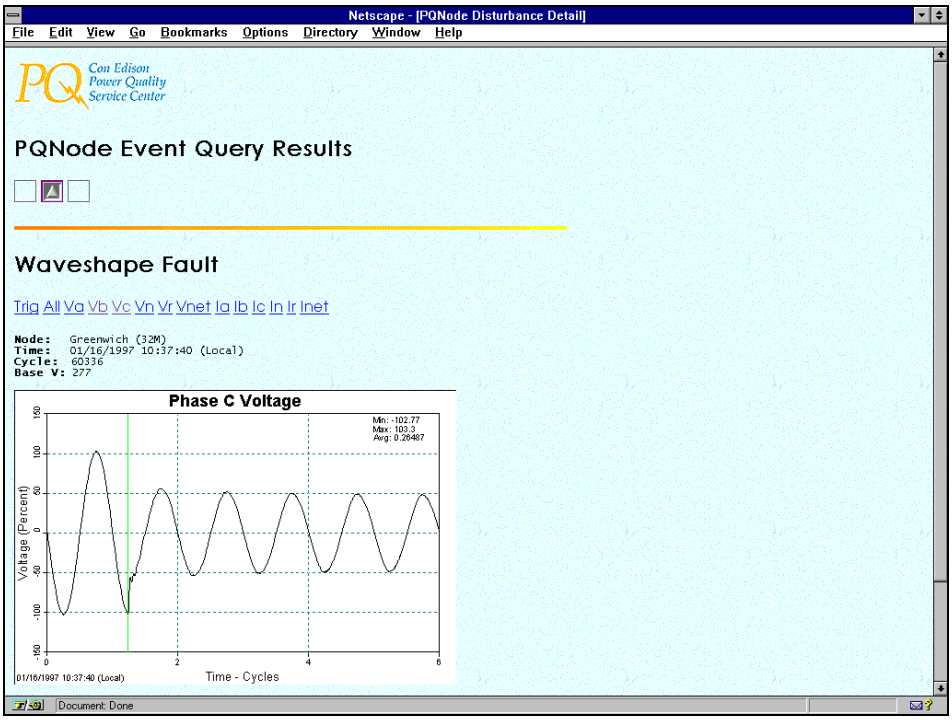

Figure 3. Actual event data from the Con Edison PQ Intranet site.

Steady-state snapshot results can also be displayed in WebPASS. These events reveal loading conditions prior to an event and allow the user to monitor normal conditions.

All of this allows the users to view power quality data without having to install a large amount of software on their computers. All of the work is done on the Web server, so the user only needs a standard Web browser to view the data.

PQWeb

With the tremendous volume of power quality data available at most utilities, a need existed to allow engineers in other customer service areas to view the information. This was accomplished with the development and release of the Electric Power Research Institute (EPRI) PQ Database. However, several utilities also needed to respond to both customer and company inquiries into power quality measurements. In the past, one central location in the utility was used to monitor power quality data from around the utility operating area. This information was then stored on a computer and analyzed by power quality engineers. If a customer or utility engineer needed this information, a request was submitted to the power quality group in the utility. The request was then processed and a report was generated and delivered to the party requesting the information. It was Con Edison's and EPRI's goal to make this information more readily available to key customers and Con Edison personnel in other Customer Service Areas.

In response to this need, PQWeb was developed by Electrotek Concepts. PQWeb is an Intra- and Internet application based on the EPRI/Electrotek PQView software developed to analyze power quality data and integrated into the Measurement Module of the EPRI Power Quality Diagnostic System. PQWeb allows users to view data over the web from a power quality measurement database characterized and managed by PQView. While the data gathering and characterization is conducted at a central location, the information is available to any user with a Web browser. Security protocols and passwords were built in to keep unauthorized personnel from viewing highly confidential and often proprietary data.

How it Works

PQWeb uses a Web or intranet server to make power quality information and data available to engineers, customers, and representatives who need quick access to that data. In order to access the data, the user needs to know the address (URL) of the power quality data site(s), have a Web browser such as Netscape Navigator or Microsoft Internet Explorer, and have the required passwords to enter the system. PQWeb processes the request from the user and sends an HTML file back to the user, which is viewed with a Web browser. The main screen for PQWeb is illustrated in Figure 4.

The user may view a RMS report, which may contain an event list, histogram table, CBEMA curve, and/or 3D Histogram. A time range filter is applied to the request, and the report is sent back to the user. Figure 4 illustrates the screen used to submit a query to the back-end server.

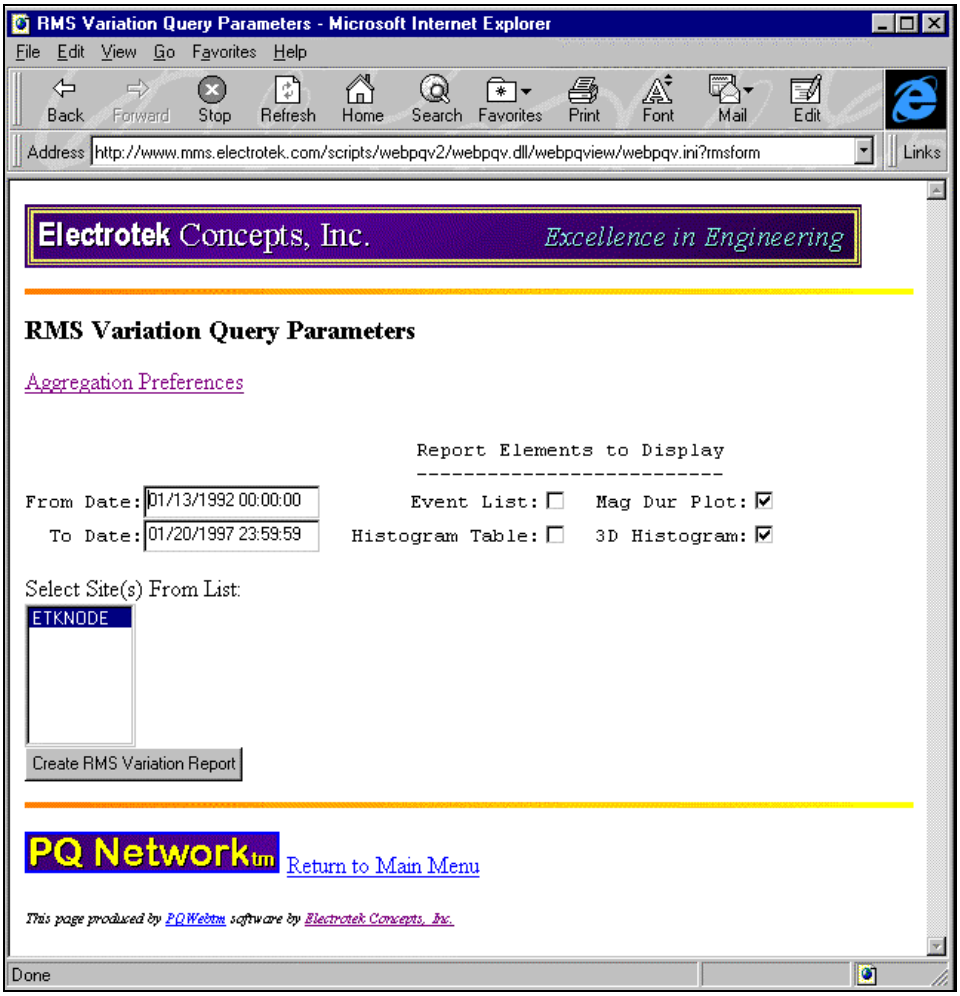

Figure 4. Query select form for PQWeb.

The date and time ranges are entered, the monitoring site(s) is selected, and the desired power quality information is selected. The request is sent to the back-end server, and the results are displayed as shown in Figures 5 through 7.

What Can be Viewed?

The PQWeb software allows viewing of all data that has been previously downloaded from the monitoring instruments using the monitor's proprietary software and stored on the network server. For example, if an engineer is looking for events that occurred during the previous week, a password is entered, sites of interest are selected, and the date and time of interest are entered. An event list is returned, and the user may view each event in more detail. The events are viewed individually by phase as shown in Figure 8.

The disturbance detail feature allows the user to view all aspects of an event. Cycle-by-cycle RMS summaries and waveform captures can be used for event analysis and troubleshooting. Voltages and or currents can be displayed. Data such as this is now immediately available to such groups as control room operators, system protection engineers, customer service representatives, and any other employee connected to the Con Edison network. Access is available across a range of operating systems, including Windows 95/98/NT, OS2 and UNIX.

Event List

Type	Event Description	Mag (Per Unit)	Duration
RMS Variation	ETKNODE - Phase A Voltage Inst. Nominal 10/29/93 09:04:21 PM	0.89	2 Cyc
RMS Variation	ETKNODE - Phase C Voltage Inst. Sag 10/29/93 08:55:08 PM	0.88	3 Cyc
RMS Variation	ETKNODE - Phase C Voltage Inst. Nominal 10/29/93 02:50:56 PM	0.86	3 Cyc
RMS Variation	ETKNODE - Phase B Voltage Inst. Nominal 10/25/93 01:30:39 PM	0.77	5 Cyc
RMS Variation	ETKNODE - Phase C Voltage Inst. Sag 10/25/93 12:49:59 AM	0.86	3 Cyc
RMS Variation	ETKNODE - Phase B Voltage Inst. Nominal 10/12/93 01:42:18 PM	0.88	4 Cyc
RMS Variation	ETKNODE - Phase A Voltage Inst. Nominal 10/12/93 12:11:16 PM	0.85	5 Cyc
RMS Variation	ETKNODE - Phase C Voltage Inst. Nominal 10/08/93 02:59:55 PM	0.25	3 Cyc
RMS Variation	ETKNODE - Phase B Voltage Outage 10/02/93 10:11:13 PM	0.00	00:36:45
RMS Variation	ETKNODE - Phase C Voltage Inst. Nominal 10/01/93 01:04:37 PM	0.77	2 Cyc

Figure 5. Event list returned via Internet and HTML document to user after submitting request.

The event list displays information about power quality measurements that match the given criteria submitted to the back-end server. This information includes the following:

- Event type
- Event description
- Event magnitude
- Event duration

From the event list the user may select to view the detail of the disturbance.

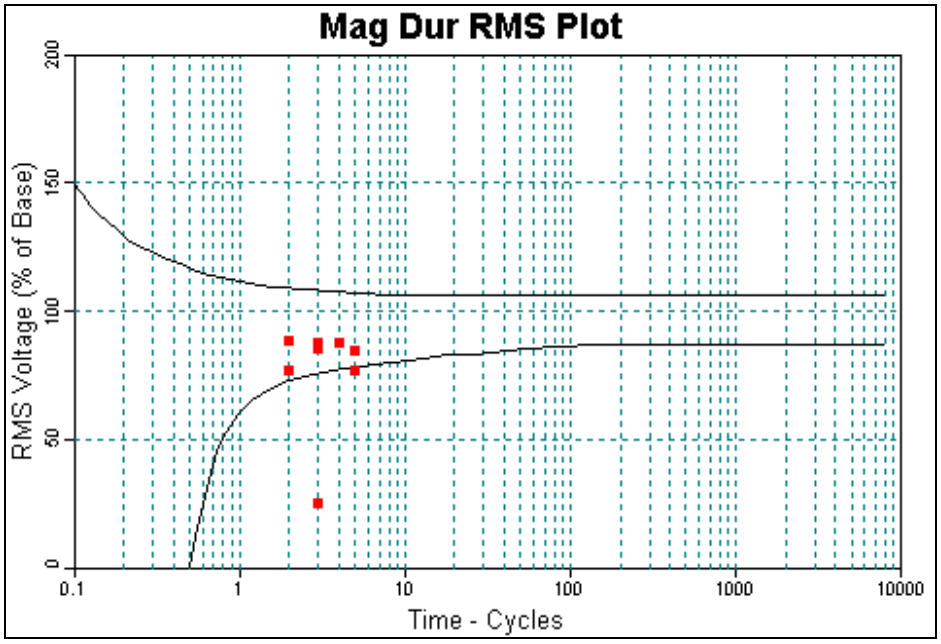

Figure 6. Example magnitude duration plot with CBEMA curve overlay.

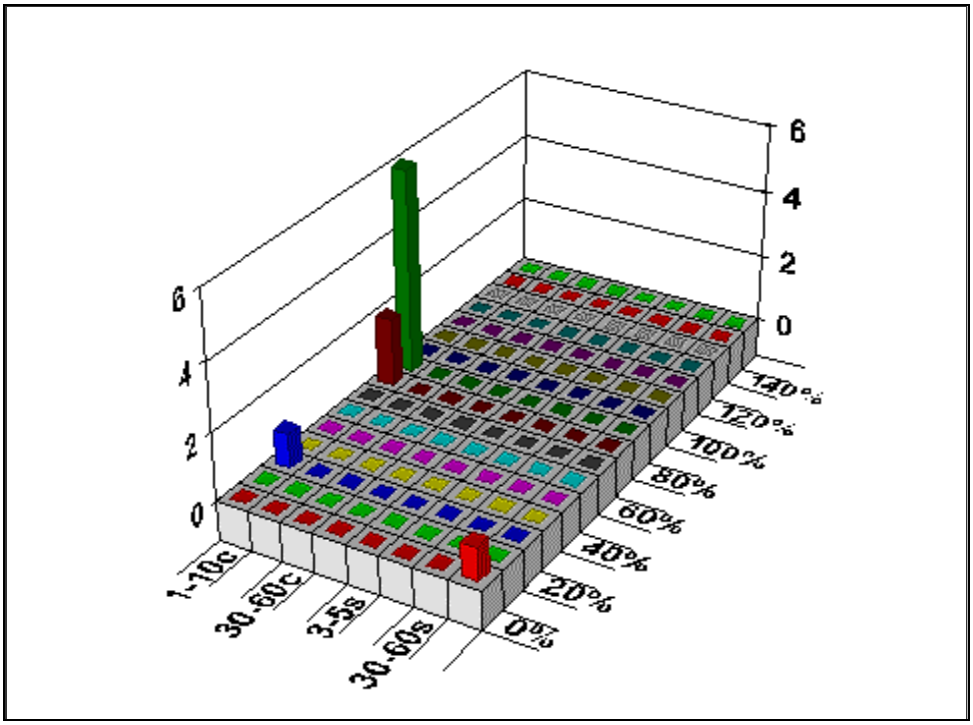

Figure 7. Example 3-D histogram bar chart illustrating RMS variations for given time range.

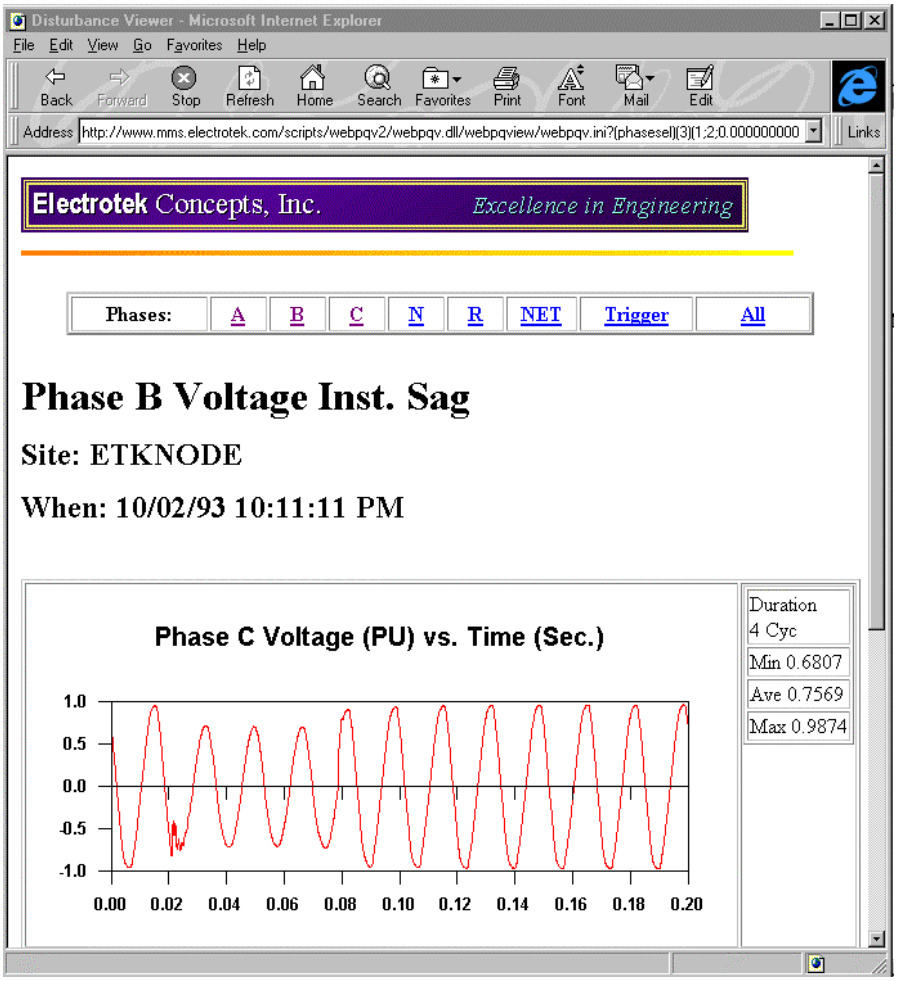

Figure 8. PQWeb single event viewer.

Power Quality Monitoring: Preparing for the Future Marketplace

With the utility industry entering a period of increased competition, more and more attention will be paid to the quality of the power delivered to customers. Power quality has become increasingly important due to the expanded usage of sophisticated motors and process control equipment in manufacturing. Increased utilization of computer and telecommunications equipment has also compelled more utilities and customers to focus on the reliability and performance of their power systems. Power quality monitoring has become increasingly critical to utilities in assessing the performance of their systems and reducing customer problems. Con Edison has recognized this reality, and implemented technology and programs to make the results of their monitoring program available both to their customers and their own personnel. This will undoubtedly not only improve Con Edison's operations as a whole, but also help position them to compete in the new utility marketplace

Related Reading

[1] EPRI Innovator IN-107153, December 1996.

[2] Power Quality Database: Users Guide, EPRI Final Report AP-106028, December 1995.

[3] Dabbs, William, et al, "Probing Power Quality Data", IEEE Computer Applications in Power, Volume 7 Number 2, April 1994.

[4] Melhorn, Christopher J., Aubrey Barz, Peter Hofmann, Ralph Mauro, "An Evaluation of Energy Storage Techniques for Improving Ride-Through Capability of Sensitive Customers on Underground Networks," IEEE Transactions on Industry Applications, Volume 33 Number 4, July/August 1997.

Acknowledgements

PQWeb is a module of the EPRI PQView software and is part of the EPRI Power Quality Diagnostic System.