Power Quality The Invisible Thief

Terry Chandler, Director of Engineering, Power Quality Inc

Abstract: **Unacceptable power quality is the invisible thief that steals corporate profits. This paper introduces the business, the engineering and the technologies of stopping the invisible thief. It provides background for all aspects of the power quality business and explores the new entries in the market. This paper discusses examples of the various power quality situations and their economic impact.**

In 1999, the industry estimates were $150 billion for losses due to unacceptable power quality. In that year, businesses spent more than $12 billion for power quality products and services. In 2002, it is estimated the market will be greater than $20 billion for PQ goods and services. The power quality situations responsible for these losses range from voltage sags to harmonics and ground loops. This paper will discuss the business of providing the $20 Billion of goods and services.

The power quality market includes end users, electric utilities, equipment and PQ mitigation equipment suppliers, , power quality measurement instruments, suppliers, consultants and regulatory bodies. This paper will discuss the roles and position of each in the market. This paper will also review a brief history of the power quality market and its projected short term and long-term growth both in the Southeast Asia and Worldwide.

I. History of Power Quality in Asia

The history of power quality in Asia traces back to early electrification of the region. The early issues were reliability and voltage variations. As manufacturing plants automated and sensitive electronic controls were introduced, the power quality issues changed to voltage sags, high speed transients and grounding problems. The well-documented case of power quality disturbances was recorded in Penang, Malaysia in 1989. It was widely referred to as the Penang micro outage. The incident is actually a misnomer because as it was actually a voltage sag caused by a fault on the utility grid. At about the same time in Thailand a manufacturer of disc drive parts complained to Provential Electrical Authority of voltage distortion causing problems. The result of both of these incidents was the utilities investing in instruments and training to document the power quality. During the 1990's, the utilities in Malaysia and Thailand began monitoring programs and engineering studies to determine the cause of the complaints and to investigate ways to reduce the causes. The results of these studies indicated that 80% of the complaints were caused by voltage sags. A recent survey of utilities in S.E. Asia (PQSynergy 2002) concluded 80% or greater of the PQ problems were caused by voltage sags.

II. Preventing Industry Losses Due to the Invisible Thief.

Actual loss per power quality incident is very difficult to quantify. The losses include equipment failure and repair, loss production time to restart automatic equipment, product waste, lost management time and many secondary costs. To reduce or eliminate these losses requires detailed data on the power quality incident, the process and financial consequences. The following examples provide the details of identifying the cause of the loss and way to prevent them from reoccurring.

A. Example 1: Product failure

A large electronics equipment manufacturer was experiencing abnormal product failure during final test and burn-in. The site study revealed the problem to be voltage surges. See figure 1

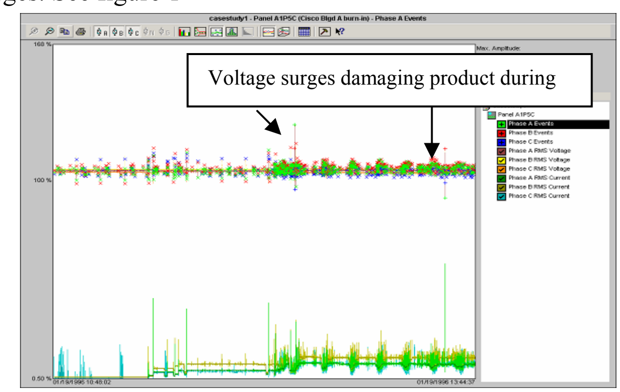

Fig. 1

Are the voltage surges from the utility or generated internal to the facility? A closer look at the data and the electrical system reveals the voltage surges are generated by a voltage regulator in the facility. See figure 2.

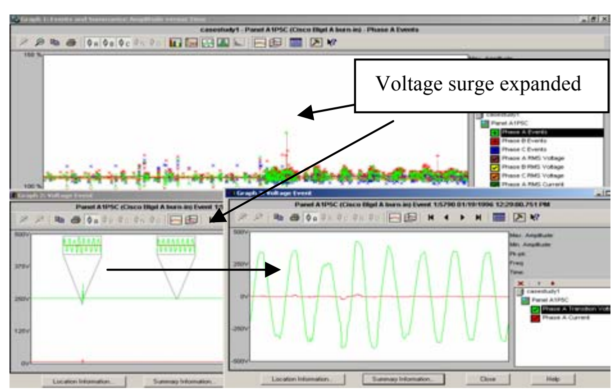

Fig. 2

Notice the detailed ac cycles shows the voltage surge preceded by a voltage sag. A close inspection of the electrical system revealed a voltage regulator that was reacting to the load changes. The regulator was performing to specification. The specification did not consider voltage changes caused by the sudden load switching. The incoming voltage was monitored for two months to verify if the regulation was operating within equipment specification. The solution to preventing the losses was removing the voltage regulator and monitoring the utility voltage to verify the voltage variations remained wit in the equipment specifications.

The losses of products were exceeding US$5000 per week not including the engineering time to resolve the problem. The cost to prevent the problem was less than $5,000 including all engineering time, monitoring costs and electrical system changes.

B. *Example 2. Variable Frequency Drives Tripping*

A large alumina refinery facility in South America was experiencing losses due to VFDs tripping off line whenever a motor not on the drive experienced a phase to ground fault. This is a common occurrence in this outdoor facility. Motors not powered by a VFD did not experience any problems and motors powered by a VFD that had a fault would not cause other VFD's to trip. This factory had plans to install hundreds of VFD's to lower costs and improve process control. All were put on hold.

The PQ monitors were installed and a faulted motor was connected to distribution system. The monitors captured the following data clearly showing the problem was caused by grounding one phase of a delta circuit, which caused a phase shift. The VFD's sensed the phase shift and tripped. See Figure 3.

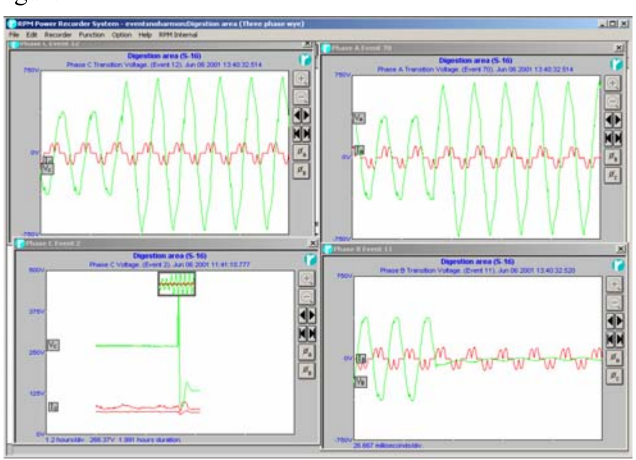

Fig. 3

Harmonic current and the distorted voltage at the buss and the grounding of one leg of the delta transformer caused a phase shift, which caused the VFD to trip due to phase shift error.

The solution to prevent the losses was to reprogram the VFD's to ignore the phase shift. The factory estimated this problem was costing US$10,000 per month and it was delaying a multi-million dollar facility upgrade program. The cost to document the problem and implement the changes in the VFD's was less than US$5000.

C. *Example # 3 Automatic machine shutting down.*

A large fully automatic cereal factory in the USA was experiencing severe losses due to unexpected shut of a large critical machine. The machine contained a 600 hp motor powered by a variable speed drive. The drive would shut down for no apparent reason. All critical control circuits were powered by large UPS systems so power quality was not considered a source of the problem.

The costs of this problem were estimated at US$10,000 to US$20,000 in lost product and lost production time as it took 8 hours to clean and restart the machine.

The power quality monitors were installed at the machine and distribution system. Figure 3 shows the details of the data captured. The short duration voltage sag causes the large load to shutdown.

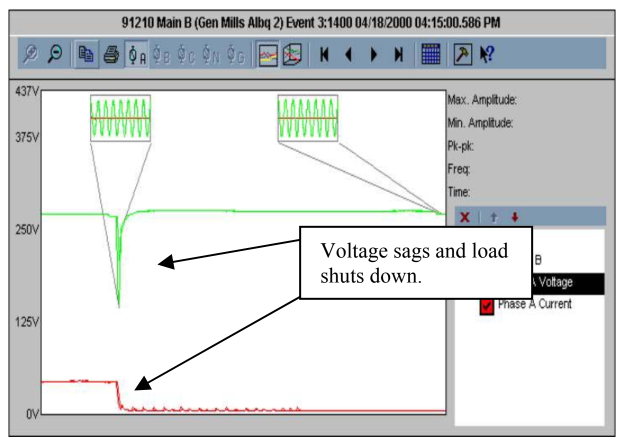

Fig. 4

In this case, the voltage sag originated at the utility. Further investigation showed the problem was the contactor for the motor. When the contactor was powered from the UPS the problem was prevented during voltage sags. Cost of the wiring change was less than US$100. Since a UPS was already installed.

D. *Example # 4 Losses due to harmonics*

A large electronics manufacturer in Bangkok was installing new laser marking equipment in the production area. When the third unit was installed, the automatic test equipment began malfunctioning. This caused a delay in the project of upgrading to laser markers. No exact dollar losses were calculated; the estimated costs were US$1000 per day.

The harmonics were measured at laser markers and at each electrical panel back to the transformer. After analyzing the data, we determined the problem could be resolved by installing line reactors on the laser markers. The cost was less than US$ 500 per laser marker. The problem was resolved.

III. The Economics of Power Quality

Power Quality is an economics problem. Reducing the losses taken by the invisible thief provide the funding for the engineering and solutions to stop the thief. The challenge for management is determining the costs and allocating the resources to capture the thief. The general costs have been reported by Electrical Power Research Institute (EPRI). A typical semiconductor fabrication facility loses as much as US$1 Million per incident. The automotive industry reports losses of more than $10 Million annually due to Power Quality Incidents. A typical Internet Service Provider measures downtime losses in the 1000's of Dollars per second.

As the examples demonstrate, the PQ thief can be stopped at a cost-effective price. The key to stopping the losses is in the data. The measurement and recording of the PQ parameters is the first step to cost-effective solutions. The data can be collected only when there is a problem (reactive) or the data can be continuously collected (proactive). The advantage of continuously monitoring is the ability to see trends and predict failures before they occur.

This predictive capability offers significant economic advantage. Preventing a single shutdown will return the investment of the automated monitoring and data collection system. In addition, the system can alarm and alert the user of any out of tolerance condition and record the power usage data for cost analysis.

There are several steps to ensure the most cost-effective methods of preventing and solving power quality related losses. During construction of new facilities or remodeling, the electrical design should be reviewed for delivery of quality and reliable power. The actual electrical system construction should be inspected and tested for the delivery of quality power. In cases where an existing facility is suffering losses, detailed studies will be required to determine which PQ parameter is the cause of the problem. After the parameter is determined then the selection of the most cost-effective solution is possible. The report from the PQ study should always offer alternative solutions.

IV. Conclusions

The cost of power quality losses is growing every year. The following chart in Figure 5 shows the growth of the losses due to power quality and the growth of semiconductor device sales. EPRI reports that in 2001, approximately 30% of all electrical power passes though power electronics and by the year 2010, 70% of all electrical power will pass through power electronics. This means the economic losses displayed in the graph will continue to increase at a similar rate.

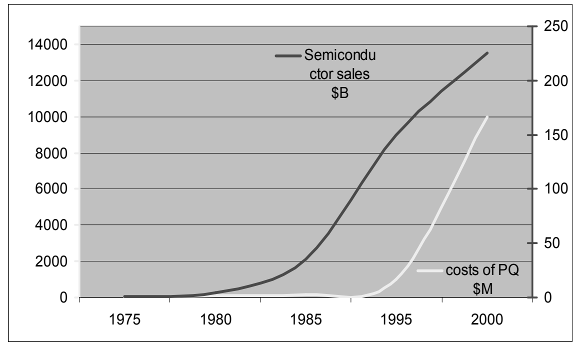

Fig. 5

The installation of permanent automated power quality recording systems provides the fastest and most cost-effective economic return. The automated data collection systems provide the user with easy to use graphs of all power consumption and power quality parameters. The user can review the data and take corrective action before a catastrophic shutdown occurs.

V. Acknowledgment

Mr. Buddy Groves, General Mills, coined the phrase, "the invisible thief."

VI. References

Electrical Power Research Institute Costs of Power Quality Incidents.
Dun & Bradstreet Network Losses and Costs
Contingency Planning Research Inc. Power Problem Costs

Papers Presented at Conferences (Unpublished):

[1] ***Harmonics Workshop 1998*** A one day tutorial on Harmonics presented to Electrical Generating Authority of Thailand July 1998, Provincial Authority of Thailand, June 1998

[2] ***Power Quality problems and solutions from the user perspective***, A one day seminar for users, presented in Mexico, May 1998

[3] ***Grounding for electronic systems***: Presented to AZ Power Quality Association April 1998

[4] ***Power Quality Classifications from the Utility Perspective***, Presented to Metropolitan Electrical Authority of Thailand 1997.

[5] Papers from Conference Proceedings (Published):

[6] ***Power Quality: A Problem or Opportunity?*** Presented and Published for Asia Institute of Technology 1997. A one day seminar on the Power Quality market for Asian utilities management. Attended by 45 managers from 15 utilities throughout Asia.

[7] ***PQincident™ A new classification of Power Quality***. Presented and published for SESCO, 1997.

[8] ***The Initial results of a new ongoing study to monitor the power line disturbances and their effect on telephone and computers in the 1980's***. Published and presented at Intelec87. Stockholm

[9] ***Power Quality - Monitoring, Analysis, & Mitigations***. A guidebook published by Tenaga Nasional Berhad, Malaysia Presented in a series of seminars in 1996.

[10] ***Protecting Computers and Electronic Instruments from Power Line disturbances.*** Published and presented PME Sept 1989

[11] ***Telecommunication systems protection from electrical disturbances.*** Published and presented at IEEE May 1986

[12] Protecting Micro-Chips from Megavolts. Published and presented Center for Management Technology Asia Lightning conference. 1996

[13] The Parameters of Power Quality. Published and Presented at CEPSI conference in KL Malaysia 1996

[14] ***Power Quality in Asia*** Published and presented at the Power Quality Conference in Santa Clara, CA 1998

[15] ***Assessing a Power Quality Program in South East Asia***. Published and presented at PowerSystems World 2000 in Boston, MA 2000

VII. Biography

Education: Terry attended the University of Maryland and the University of Minnesota. He regularly conducts seminars on Power Quality for companies and organizations around the world.

Experience: Founder and Director of Engineering of Power Quality Inc. A pioneer in the Power Quality Industry, he began his second engineering career in Power Quality in 1981, specializing in solving power quality problems for the semiconductor industry in Silicon Valley. He founded Power Quality Thailand LTD in 1986. With more than 20 years experience in the power quality field, Terry has studied all aspects of power quality, grounding and test equipment to monitor power quality.

Relevant Research, Responsibilities and Interesting Data on Patents, Projects, Publications, Etc.: Terry has presented numerous technical papers on power quality with special emphasis on grounding for electronic systems. He co-authored the book A Guidebook on Power Quality - Monitoring, Analysis & Mitigations, for Tenaga Nasional Berhad.