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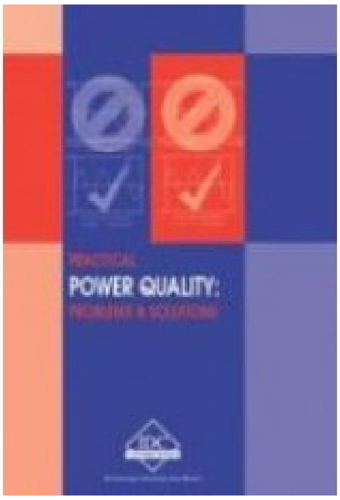
PQ-E - Power Quality Problems & Solutions



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Short Description

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First Chapter

Overview of Power Quality

Chapter 1

Overview of Power Quality

The name Power Quality is actually a misnomer. It implies that there is something wrong with the quality or characteristics of the electric power being delivered by the electric company in your area. We have found in the United States, particularly over the last twenty years, that as we have examined what changes there may be in the delivery structure from the electric utility company, we find very little that contributes to what is implied by the name Power Quality. Conversely, we have found that a great deal of change has taken place in the equipment which we call the load equipment in a given commercial or industrial climate. That equipment is now characterized by digital electronics, something we have not had until comparatively recently. Most of our loads have been resistive or inductive and have consisted of analogue control devices. The behavior of the analogue control device is far different from the modern digital control equipment. In fact, the difference is so great that we might rather call this workshop a course in problem solving for load quality problems. It would sound very foolish, however, to come into a commercial or industrial establishment and begin talking about the "load quality " conditions.

But, consider the following simple story that is quite accurate in today's climate. Supposing I was to come to the facility that you were involved with and I had the ability to talk to the machines and the various production equipment that was in that facility and in doing so I told them how wonderful it was that the management of this company had invested hundreds of thousands of dollars in apparatus that would allow these machines to continue to run even when the power from the power company was out. In the course of this fictitious conversation with the machinery on location, I would get some questions from the various pieces of equipment. They might say, "What kind of long-term power support are you talking about?" I would say to them, "This is an uninterruptible power supply, what we know as a UPS, complete with a battery backup and support for 15-20 minutes and even including a long-term diesel driven generator. As we continued this fictitious discussion, the machinery would ask, "What kind of characteristics does the UPS have?" I would answer, "Why this is one of the finest producers of sine wave power that you have ever seen. Absolutely precise. 60 Hertz. It simply beats it with regularity that you can count on." The response of the machine is, "Well, why don't you just tell the owners to just save their money. We don't use pure 60 Hertz anymore!" You might say, "What do you mean you don't use pure 60 Hertz?" Or even in that part of the world where 50 Hertz would be the standard usage. They would say, "What we need is some 300 Hertz, possibly some 180 Hertz, some 420 Hertz, and a little bit of 660

Hertz. This would be a fine mix for us. That is what we need to run on.”

Now you may stop me at this point and say, “What a fanciful story that is”. No. It is, in fact, the exact problem with load quality; the current characteristics that the load demands from the source of energy.

One might say, “That’s preposterous!” In fact, as I would be continuing my conversation with the machines I would say, “Please tell me more. I do not understand. I thought you were a 50 Hertz or a 60 Hertz machine.” The machine would say, “No. You don’t seem to understand that what we need is a shopping list. We need a variety of frequencies.” In order to explain this we will have to go into that section of our Power Quality Problem Solving Workshop that we will get to on day two to discuss the harmonics interaction problems that take place with the new digital devices. But suffice it to say here that what we are listening to is the actual spectrum of frequencies that is expected to be supplied by a power supply running a modern-day piece of computer equipment or a modern-day electronic ballast. Or perhaps a variable speed or a variable frequency drive system or something of that order. Almost all of the identifiable load objects are those which use some type of a switching or switched power supply and no longer using 50 or 60 Hertz exclusively.   But now demanding from the power source a mixture of frequencies. Certainly, one of the more unusual case studies that we run into when we have all been schooled on single frequency devices regardless of which country we are talking about.

This is only one of the various case study stories that we will be discussing in this manual to explain the various portions of the workshop title: Practical Solutions to Power Quality Problems. Let us take a look at how we will go through the organization of these sections in order to understand more about the issues of power quality and what they do in your place of business.

We will begin in Chapter 2 (Introduction to Power Quality and EMC) by explaining in the introduction what power quality actually is and what kind of standards are evolving, particularly, those that have begun in the United States and now are affecting the standards bodies throughout the world. Most notable of those bodies in the United States is the Institute for Electrical and Electronic Engineers known as the IEEE and secondly, in the international environment, the International Electrotechnical Commission (IEC) which is forming standards on the European continent. We must understand that so far these standards are recommendations for the practices that we should involve ourselves in. We do not have a set of laws or rules other than at a recommended level. One of the documents that we will be talking about in this course will be a group of books which are known as the IEEE Color Books. These each have specific subjects or recommended practices and many of them, as they have been introduced, have been adopted by the American National Standards Institute (ANSI). These developing standards are leading each country to examine more closely the interactions that occur because of the unusually high speed and high efficiency products that we use to power the process control lines and, in many cases, the computers at processing centers throughout the world.

In Chapter 3 (Recommended Design and Installation Practices) we will examine the interfacing that you, as a user of electricity, need to be aware of with the supplier of that electricity. You may make your own electricity on site by what we call a generation or cogeneration process. You may buy your electricity from the municipality or larger power company. Or you may actually have some type of independent power producer that will supply electric energy to your facility. In any of these cases knowledge of the working parameters of the electrical supply and the needs and specifics of the load devices will go a long way to understanding how to make these two work together.

In Chapter 4 (Earthing and Noise Control) we will consider wiring and earthing procedures. This will include the way in which we do the electrical wiring of the facility and then the way in which we design the grounding or earthing practices and the way in which those particular grounding practices might impact on the transmission of digital logic over a signal transmission system. This will be the first of four general categories in which we will prioritize the process of identifying and solving Power Quality problems.

We will also talk about methods of grounding that go beyond the safety of personnel and equipment. We will be using some of the United States safety codes as an example of how we need to go beyond these, making reference to the various forms of earthing or grounding in order to obtain what is called a zero signal reference for the transmission of digital logic. This is well beyond the need for just the safety of personnel and equipment. It now becomes a question of operational integrity as opposed to the equipment/safety problem. In this chapter we will include some non-recommended practices. For example, how the electricians sometimes take shortcuts in the methodology for wiring and earthing in such a way that it not only takes away from the safety provisions for personnel, but may compromise and cause severe problems for the transmission of very low voltage level logic signals across the signal system.

After the wiring and grounding issue, we will examine the importance of surge protection in Chapter 5 (Surge and Transient Protection). We will be talking about SPD’s or surge protection devices, as they are becoming known throughout the world. They are devices which limit and shunt away from the sensitive equipment any dangerous overvoltage transients. These transients or surges might come from lightning, electrical power switching surges, or even the turning off and on of certain loads such as capacitors on the system. The third category that we will be looking at is what harmonics interactions are, how they take place, and where we would find them most often. Finally, the fourth category is the selecting of power conditioning equipment.

The reasoning here is that if we discuss the way in which we have wired a facility, protected it in an earthing process and then discuss the transient protection process that we have gone through and thirdly, look at the demands of the load in terms of its harmonics interactions, then we will be prepared to solve any further problems that may be necessary in the power equation. In other words, do we need some type of a voltage regulator, do we need a blocking device such as motor generator with a shaft, or do we need a solid-state uninterruptible power supply? What is available to use to solve the line to line power delivery problems that may be necessary for our particular digital logic system? We may find that as we examine each of the first three conditions, the wiring and grounding, the transient phenomena, and the harmonics interactions phenomena, that we may solve our problem without the need for an expensive power conditioning device.

As we mentioned above, we will talk about surge and transient protection, the application of SPD's (surge protection devices), the basics of the lightning phenomena, what does this travelling wave do on an electrical wire, what kind of switching surges can we expect and then what ways of mitigation do we have to protect ourselves from these.

In Chapter 6 (Conducting a Site Analysis), we will talk about how to conduct a site analysis to examine for power quality problems. We will discuss ways that we have of performing various procedures, the types of monitoring and analysis instrumentation there is available to us.

Appendix A is a description of a software package marketed by RPM in San Jose, California, that is supplied with this course. Some of the data bases it contains will be used during the course presentation to help illustrate some of the more unusual P.Q problems that can occur in real life. This is a demonstration software package and guide along with a sample report that this type of software will produce. The demonstration sample is yours to examine and see if it will be of any help to your facility personnel in their examination and conducting of site surveys on your own property. The power of this particular software is that it takes the things which you find and develops a rationale for what has caused them and also how you may mitigate the problems by applying some type of a device whether it be for wiring and grounding, transient protection, harmonics reduction or even power quality conditioning itself.

This demonstration software will allow you to decide whether you have a power quality problem, where the cause of that problem might be, perhaps what type of equipment will be affected and what typical solutions you may be able to use in solving this problem. It stores a package of expert knowledge software using the artificial intelligence tools to assist you in pointing the way for how to make the most of your site analysis projections.

The remainder of the manual focuses on the principles of harmonic analysis and the various items of equipment which we call conversion equipment. Chapter 7 (Harmonic Sources and Their Effects) commences this examination. When we deal with variable speed drives we know we are looking at the conversion of AC power into DC and then DC back into variable frequency AC in order to control the speed of a particular rotary device. We will look at the different kinds of conversion equipment and what that means to us and the way they are constructed.

In Chapter 8 (Power System Capacitive/Inductive Relationships), we will also spend time looking at the power system capacitive - inductive relationships or, more directly the power factor. The power factor has an effect on the energy efficiency and the handling efficiency of electrical power. Now we will add another element to the old fashioned power factor equation, something that is do with the loading up of electrical circuits with higher frequency demands.

Chapter 9 (Harmonic Site Analysis Procedures) provides a clear understanding of the harmonic interaction relationship. We will spend some time looking at harmonic site analysis procedures, the kinds of measurements we make, how we go about predicting what will take place from those measurements, understanding the signatures of various wave shapes, what they represent and how we may look at our facility to determine what the harmonic analysis consists of.

We will come, finally, to the power conditioning aspect in Chapter 10 (Power Conditioning) looking at the various types of power conditioners, which are devices which simply reject noisy power supplies. We will look at the addition of voltage regulating or stabilizing devices and then go on to a variety of larger and more complex technologies leading to the uninterruptible power system itself. Then we will consider some of the power quality source alternatives, new technologies that have come about which are coming into use throughout the world as resolutions to problems that might not need the most expensive form of solution. We will make some characteristic cost comparisons between these items so that you will have an idea of the performance that they might give and then proportionately what amount of relative cost each one of these devices have. As we conclude, we will take a look at various case studies in Chapter 11 (Case Studies). We will look at the check list for powering, earthing, and communications to acquaint you with some of the questions you might be asking. This will ensure that these things have been addressed before the project budget becomes exhausted.

Please Note Although the main body of the manual uses the term “earthing” to describe the common signal/power reference point, there are many parts of the appendix that use the term “grounding or ground” due to the difference in terminology around the world. In the majority of cases the two terms “earthing and grounding or earth and ground” may be interchanged as the interpretation is meant to be the same.