Be Prepared

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With the approaching "storm" of deregulation in the United States, exactly what will happen has been the subject of numerous articles, papers and presentations with just about the full spectrum of opinions. The best advice that a facility manager or plant engineer can follow comes from the Boy Scout motto, "Be Prepared". Being prepared includes knowing what the present quality of the electrical supply provided by your current provider is as well as the susceptibilities of the equipment in your facility.

This preparation starts with determining if the cause of power quality phenomena is from the source or load side, upstream or downstream, from the electrical utility or the result of equipment within the facility. One of the best places to determine this is by monitoring at the service entrance or point-of-common-coupling (PCC). This is generally where the electrical supplier and the consumer's responsibilities meet. The data collected at this point, whether it is harmonics, RMS variations such as sags and swells, or transients, can be quickly analyzed to determine the direction of the disturbance in most cases.

The data collected can also be statistically processed and compared against the results of the baseline surveys done in North America. These include the EPRI Distribution Power Quality (DPQ) project, Canadian Electric Association study, and the National Power Laboratories project. Each of these surveys collected data over several years on the distribution system, the PCC, and the point-of-utilization, respectively. Plotting the probability of occurance of the power quality phenomena of concern versus the susceptibility of equipment can help predict how many problems per year can be expected, as well as see if your particular facility is having an "abnormal" amount of problems.

The basic rules based on Ohm's Law and Kirchoff's Law. Ohm's law equates voltage to current multiplied by impedance. Kirchoff's Law states that the sum of the voltages around a closed loop should be zero. A simplified diagram can be seen in Figure 1. The power system can be thought of as: an ideal source, which generates an undistorted voltage; a source impedance, which is the equivalent value of the inductance, resistance and capacitance looking back to the source from the load; and the load itself, which can have an impedance that is a combination of inductance, resistance and capacitance. It also may be a non-linear load, which is one where the current draw is not directly proportional to the voltage waveform. The most common type of non-linear load is the rectified-input of power supplies in equipment such as information technology equipment (PCs, laser printers, copy machines) and adjustable speed drives.

The key is usually to watch the load current changes as related to the voltage changes, whether the current and voltage are RMS variations, harmonics or transients. The same basic concept applies. If the source of the disturbance originates on the load side, then the current will usually get significantly higher during the disturbance. Conversely, if the problem originates on the source side, then the current will usually increase slightly, decrease or go to zero, depending on the type of load. Since problems originating within a facility are more common (according to most surveys), it is usually easier to look for that condition first.

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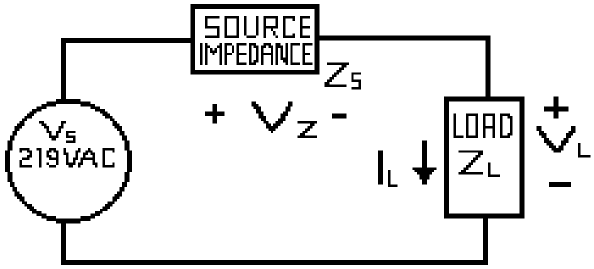

Figure 1. Simplified Circuit Diagram

To illustrate this concept, refer to Figure 1. Vsource should equal Vz plus Vload. If the source impedance is 1 ohm, and the load impedance is 100 ohms, Ohm's Law says that 2.2 Amps of current will flow around the circuit (219V / 101 ohms). Ohm's and Kirchoff's Laws state that the voltage drop across the source impedance will be 2.2 volts (1 ohm * 2.2 A), leaving 216.8 volts for the load (219 – 2.2) .

If the disturbance originates from a load-side event, such as a motor start which may have an in-rush current during start up of 6-10 times the steady state value, this momentary increase in current will cause a much larger voltage drop across the source impedance. This results in less voltage available for the load, hence, the voltage sag. For example, if the current is 20 Amps, the source impedance will drop 20 volts across it, leaving only 199V at the load. This equates to a voltage sag to 90% of nominal. This is illustrated in similar example shown in Figures 2 and 3.

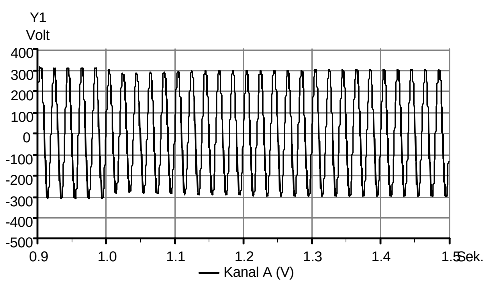

Figure 2. Voltage Sag

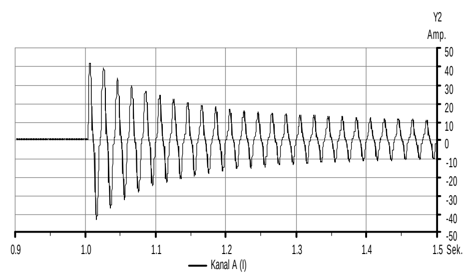

Figure 3. Current Causing Voltage Sag

If the disturbance originated on the source side, the current change would be much different. If the load was a linear load, a voltage sag to 90% of nominal would result in a current of 1.95A for a 100 ohm load, which is a slight decrease from the original 2.2 Amps. If the load was a rectified input which is used to charge a storage capacitor that feeds a switching power supply, such as found in most PCs, then the voltage sag may have been low enough to make the input voltage be lower than the voltage on the storage capacitor. If this happened, then no current would flow until the voltage on the capacitor was reduced by the energy required by the switching supply and/or until the input voltage was higher than the capacitor voltage.

By monitoring for particular harmonic(s), the same rules can be applied for determining the source of harmonic currents and voltages. This can be a little more complex with the possible cancellation of harmonic currents due to phase shifts, the concepts are the

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same. Likewise for transients, if the voltage transient is of the opposite polarity from the current transient, then the origin is probably downstream, on the load side. If they are the same polarity, look up stream for the source.

In summary, gathering information on what type of disturbances are typically occuring at your facility and sorting out where the disturbances originate from (whose responsible) before the effects of deregulation take place, will not only improve your productivity, but also allow you to determine if things are getting better or worse. Be Prepared!

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