**Transient Voltage Surge Suppression - Surge Protective Device**

As we stated earlier, protection of today’s electrical and electronic equipment from destructive electrical transients in no longer an option, it is a necessity. The rapid evolution from our old “low tech” systems and controls to the “high tech”, computer controlled environment of today has left many of us dazed and confused and looking for solutions to problems that just a few years ago did not exist. The causes of these problems are Transient Voltage Surges (Surges, Impulses, Spikes, etc.).

Studies have shown that the cost of surge related damage and downtime in the US is over $26 Billion per year and the cost is going up. (Source: Business Week Magazine)

**What is the Magnitude of a Transient?**

Studies performed by the Institute of Electrical and Electronic Engineers (IEEE) have shown that transients on a 120-volt power line can reach as high as 5,600 volts. Other independent tests have shown even greater magnitudes.

**How often do Transients Occur?**

A conservative estimate of a moderate transient environment would be approximately one transient per cycle. This relates to 60 cycles per second x 60 seconds per minute x 60 minutes per hour for a total of 216,000 per hour. Power Quality Monitoring of a Variable Frequency Drive circuit showed 6 transients per cycle. This produces a total of over 1.2 million transients per hour. Another test performed by G E Instrumentation and Computer Service Laboratory revealed a total of 24 transients in excess of 1200 volts in a time span of less than 1 millisecond as a result of turning off a 2-bulb, 4-foot florescent light fixture.

**What are the Effects of Transients?**

1. Disruption of data transmission.
2. Computer malfunction.
3. Premature failure of electronic and electrical equipment.
4. Failure of process equipment to re-start after a power failure or shutdown.
5. Catastrophic damages due to lightning strike.

We know that the conductivity of a metal conductor is inversely proportional to the temperature of that conductor. We also know that the temperature of a conductor is directly proportional to the frequency and magnitude of the energy that is carried by that conductor. Hence, if the frequency and magnitude of the energy is increased (surge activity) the conductor heats up and becomes less effective.

Excessive heating and cooling of conductors causes the current carrying surfaces of those conductors to become pitted and the conductor itself to become brittle and more resistive. In computer chips and circuit cards, this can lead to poor or lost data transmission, and board failure. In inductive motors, the constant bombardment of transients in excess of the insulation rating of the motor windings causes the insulation to break down and short the windings which causes premature motor failure.
Because power quality analysts are becoming more and more aware of transients, there are articles monthly in the industry magazines describing some new problem that has been found to be caused by transient voltage surges.

**How do I Protect My Equipment from Transient Voltage Surges?**

Specifying and facilities engineers have a wide selection of power quality improving equipment from which to select. The following are brief discussions of some of the power quality equipment available.

1. Isolation Transformers:

There are three basic functions of isolation transformers as follows.
- To change or adjust system voltage levels
- To act as a separately derived power source
- To provide electrical isolation

Requirement for this type of equipment is generally more frequent in larger commercial and industrial facility distribution systems. Additionally, isolation transformers assist in isolating harmonics that are common when a delta-to-Wye configuration is used.

Isolation transformers do not address or provide protection against voltage anomalies such as sags, surges, undervoltages, or overvoltages. In fact, because of the inherent nature of a transformer, voltage variations impressed on the primary winding induce current in the transformer's secondary winding. This in turn develops a secondary voltage. Further, the inherent nature of a transformer may result in the generation of transient activity. A high quality shielded isolation transformer coupled with the use of high quality transient voltage surge suppression can usually resolve certain types of power anomalies. Resolutions to problems created by ground loops and multiple current paths in the ground circuit are examples of effective use of this combination.

2. Uninterruptible Power Supply (UPS):

In almost any facility today, one of the most popular power quality equipment items to be found is the UPS. The function of this equipment is exactly what the name implies, to maintain uninterrupted electrical power to a selected load, or combination of loads. In environments where power outages may be commonplace, the UPS combined with effective/reliable surge suppression may be the only solution. There are generally four basic types commercially available. UPS lines have a wide range in performance and cost. The four types are:

- Standby (line preferred)
- On Line - (single conversion)
- On Line - (double conversion)
- Rotary

With both the single and double conversion UPS systems, the use of transient voltage surge suppression is recommended on both the input to the UPS and on the output.
What is often overlooked but critical is the need for transient voltage surge suppression on the output of UPS systems when multiple loads are present. This serves to prevent the individual loads from causing transient damage from one to the another.

While some UPS systems contain some SPD capability as an integral component of the device and some are even UL Listed as such, there is no substitute for the application of quality SPD products dedicated to the protection of specific equipment that is critical to your operation. It is interesting to note that IEEE in their Emerald Book recommends surge protection for UPS equipment. However, in their protection mode recommendations they fail to include N-G mode effectively leaving a “backdoor” path for transients to get past the UPS.

3. Voltage Regulator: Voltage problems created by connecting or disconnecting heavy loads, motor in-rush, or utility brownout conditions during peak load hours can normally be controlled by a voltage regulator. These are long duration events that can last from several cycles to several hours. The function of voltage regulators is to maintain a constant voltage to a given load under abnormal input voltage conditions. Several types of voltage regulators are available, including fast response electronic tap switching and phase modulating thyristor control and voltage regulators with ferroresonant transformers.

Using more than one voltage regulator in the same electrical system (in series) may create instability problems. These problems are dependent on response times and regulator settings. The power supplies of most microprocessor-based devices are designed with a limited amount of voltage regulating capability. Additional regulation may or may not be necessary. Fast response electronic tap switching regulators combined with transient surge suppressors can also handle most voltage problems at an affordable cost. They should include the following:

• Isolation transformer

• Adequate range of voltage regulation

• High speed response

SCRs and voltage control circuitry, both used in electronic regulators, are vulnerable to damage from incoming surge voltages. These should be protected by high quality transient voltage surge suppression. Before selecting a voltage regulation device, it is imperative that the engineer knows the configuration of the existing electrical system as well as the nature of the problem to be corrected. Load tolerance to voltage levels and voltage step changes must also be considered.

4. Line or Power Conditioner:

The concept of the line or power conditioner has evolved over the years. They were developed in response to the desire to have a complete solution to all types of power quality problems in one neat package. Line conditioning packages come in sizes that range from a one or two pound box with outlets on the front, to a full 30 inch wide, 90 inch tall cabinet, with distribution panel and diagnostics. Line or power conditioners basic purpose is to modularize or combine several power quality conditioning functions such as isolation, voltage regulation, and distribution via outlet array or distribution panel. The
two most common types of power conditioners are regulating line conditioners and enhanced isolation transformer line conditioners. In typical regulating line conditioners, the manufacturer packages a ferroresonant voltage regulator or an isolation transformer with a +10%/-20% voltage regulator, along with a power distribution panel board or outlet group. Other features may include EMI/RFI noise filtering and perhaps simple surge suppression components. Quality transient voltage surge suppression is included on the output of line conditioners as almost all line conditioners are intended to serve multiple loads.

6. Transient Voltage Surge Suppression (TVSS) or Surge Protection Device (SPD):

There are many types of surge suppression designs available to the facility engineer, however selection and application must be made carefully so that the correct design is applied to the specific need. The ideal surge suppression system should be transparent to the normal operation of the circuit it is protecting. A couple of principles become clear when applying transient voltage surge suppression in any given facility.

- Consider specifically, service entrance panel suppression placement to address major incoming transients, with distribution panels covered to prevent internally generated transient damage. While point-of-use surge suppression is often needed, it should be as a compliment to, not instead of, panel protection. Additionally, panel protection gives you maximum protection for each dollar invested.
- Provide surge suppression suitable for various voltage and current levels throughout the entire facility to ensure adequate protection from all transient sources possible. A systematic application of surge suppression should be accomplished at strategic points throughout a facility.
- The installation of the transient voltage surge suppressor itself is critical to its performance.

Summary

All of the equipment discussed in this section may serve very well in a given facility and it is important to note that this is not a complete list of the power quality equipment that is available today. In the quest for improved power quality, it is a necessity to do the necessary research in order to determine the nature of the power quality issues to be addressed. Care should be given to the total facility power quality requirements and protection scheme.

Most facilities do not have adequate resources "in house" to accomplish this research in which case a qualified power quality consulting firm should be contracted to accomplish the research and provide recommendations and/or design solutions to rectify the problems that they find.

It is important to be aware that, while many devices other than SPDs may incorporate some of the features of a SPD, there is no way to get the protection from transient voltage surges that is necessary in today’s electrical environment except through the proper use of effective/reliable SPDs.