Power Quality & Laser Devices

This white paper could be titled "how to damage equipment with voltage sags and transients" and as you read the white paper you will understand why.

You send a print command from your PC to a laser printer, your PC locks up and the lights in your work cubicle dim or flicker. Sound familiar? How about the air conditioner goes on in your home and the lights dim a little for a very brief moment?

The visible part is easy to explain; you just saw the effect of "power sag". The input voltage level to the PC and/or lights was lowered significantly for a brief time. The "inrush current requirement" of the laser printer or air conditioner starting up lowered the available voltage to the PC and/or lights. What you did not see is the damage done to the laser printer's fuser tube and electronics nor did you see the damage done to any other voltage sensitive device connected to the electrical system.

The simple way to explain how power is supplied to your equipment is as follows:

1. **Voltage is electrical pressure.**
2. **Current is the ability to do work.**
3. **Current is directly proportional to voltage.**

A more complicated and technical definition is: "The potential for an electrical system to do work is known as voltage. We define voltage as the work to be done by an electrical system in moving an electric charge (coulomb) from one point to another in a circuit, divided by the charge. We measure voltage in joules per coulomb (J / C), or volts (V). (A joule equals 1W of power applied for 1 sec.)

An electrical conductor has mobile electrons that move in response to electric forces. So, we describe current as simply charge in motion. We measure current in coulombs per second (C / sec), or amperes (A). The direction of the physical current in a conductor is opposite to the direction of electron motion."*

***(The above is from an article published in EC&M,* By John DeDad, Mike Eby, and Robert B. Morgan *December 1, 1999*)**

The more technical explanation would include:

1. **A detailed definition of electrical current.**
2. **A description of the ampere in relation to coulombs per second.**
3. **Explain the different current units and current values.**
4. **Explain why current travels at the speed of light.**
5. **Explain the difference between conventional current flow and electron flow.**
6. **List three rules to apply when measuring current.**
7. **Define electrical voltage.**
8. **List the various voltage units and values.**

9. **List three rules to apply when measuring voltage.**
10. **Relate the electrical system to a fluid system.**
11. **Describe why current is directly proportional to voltage.**
12. **Explain the difference between a conductor and an insulator.**
13. **Describe conductance.**
14. **Explain all the elements that make a good conductor and insulator.**
15. **Explain terms such as open circuit, closed circuit, short circuit.**

The non-technical explanation will be easier to understand for most people who read this article. If you would like a more technical explanation you may wish to do some web research or contact PSI.

Electrical and electronic equipment designers publish specifications that outline the voltage and current requirements of their equipment. Failure to comply with these specifications can create a life safety hazard, can void equipment warranties and can cause premature equipment failure.

A laser device is our example so we will focus on the electrical requirements of these devices and how to properly provide power to them. As our example a brand and model laser printer will be called "X". The input voltage of this device is 120 VAC (volts alternating current) under all modes of operation.

- **X has an idle state current requirement of .5 amps.**
- **X has a 14.8 amp inrush current requirement for a brief time.**
- **X has a steady state operation current requirement of 4.5 amps.**

Idle state current is the amount of "current" required to keep the laser printer in a standby mode. This is the lowest level of current drawn by the equipment.

Inrush current is the large amount of current (energy) the laser printer needs to warm up the fuser tube, start motors, etc. when it is preparing to print.

Steady state current is the "run" or normal run current to perform the print function. The idle and normal steady state operational currents are not high enough to be an issue for most 15-ampere and 20-ampere circuits unless the circuit is overloaded.

However, the "inrush" current is an issue unless the circuit is designed to support the device under inrush current conditions. The short-term inrush current demands of printer "X" can easily exceed the circuit's ability to provide the necessary current and maintain the required voltage. Under the "inrush current" requirements of printer "X", the circuit is strained past capacity to provide the current demanded by the printer and maintain adequate voltage. The result is a drop in voltage. Current is directly proportional to voltage. If the current demand of the circuit is greater than the ability of the circuit the voltage drops proportionally. Therefore, the circuit can be starved for voltage for a brief

time. This voltage starvation will cause excess current to be drawn by the device and as a result overheat the device. This overheating is momentary and degrades the equipment (electronic rust = premature device failure).

If you have ever experienced what happens while in a shower and a nearby toilet is flushed, you know from first hand experience what a "pressure" (voltage) drop in the cold water system is like.

Electrical and electronic systems have a similar experience when there is a voltage drop as a result of equipment in-rush currents. Their circuit is starved for voltage and during the inrush current event and when it is over they get a surge of voltage.

Over time these events are very erosive and documented cases have shown the life of laser devices is reduced significantly. One client of Power & Systems Innovations, Inc. (PSI) experienced a significantly higher than normal failure rate of laser printer fuser tubes. After several sites were studied the failure was traced back to inadequate electrical wiring and voltage drop issues. These were direct result of the inrush current requirements of the laser printer and the fact these printers were on "shared" under-wired circuits. The circuit lengths were commonly between 100 and 200 feet from the electrical panels and the wire size was only #12. In addition to the wire being undersized for the load, the customer was using the same circuit to power two PC computers with 17" monitors. The manufacturer of the laser printer told the customer the fuser tube would last for a minimum of 40,000 cycles. Most were failing between 9,000 and 11,000 cycles. This was many years ago when a color laser printer was first introduced and the fuser tubes were very expensive. This situation was corrected by a combination of solutions at the varied sites.

<u>Site #1 Casino in Las Vegas</u>
The circuits powering the computers and printers could not be rewired and a separate circuit could not be added due to the site lease and the property owner's unwillingness to make any electrical changes. Point of use surge protection devices (SPD) and an on-line UPS were added to power the computer systems. Point of use SPD and oversized (double system requirement) shielded ground conditioning isolation transformers were added to power the laser printers. Once the installation was completed equipment failures were reduced significantly. Once the equipment with latent damage was replaced the installation has had no issues.

<u>Site #2 Theme Park</u>
Laser printer and computer circuits' outlets were 125 feet from the electrical panel. The laser printer circuits were rewired to be isolated ground circuits using #10 wires and the computers were moved to a new circuit. The laser printers were powered by point of use SPD and shielded ground conditioning isolation transformers. A new circuit was added for the two PC's and file server. Point of

use SPD and on-line UPS were installed for the computers. The Laser printers and computers did not have any further issues after those with latent damage were replaced.

There were several other sites with similar issues that received similar treatment. The life of the equipment and the downtime have not been issues since corrective measures were taken at these sites. Laser printer fuser life increased to an average 55,000 cycles until the equipment was upgraded several years ago. The installations continue to be trouble free with the new equipment connected as outlined above. The only maintenance the customer has done is to replace the UPS batteries after 5 years.

PSI has worked with this customer for many years and we are happy to report that once the customer understood the equipment requirements they were more careful in wiring and selection of power equipment. This has resulted in almost "0" downtime and no equipment failure due to power issues.

The reason the "fix" worked for the installations is simple. The on-line UPS maintained output voltage of 120VAC even when the input voltage was reduced well below that level. Some on-line UPS will accept as low as <90VAC and maintain 120VAC at the output without using the battery by increasing the current taken from the circuit. (Current is directly proportional to voltage).

Transformers act as a storage device for energy. The field that is generated by the coils stores energy. When additional energy is needed by the connected equipment the field around the transformer can supply it for a brief period without what would be a significant voltage drop in the circuit without the transformer. By doing this action the transformer buffers the circuit from a significant voltage drop and still provides for the inrush current needed by the equipment.

Equipment manufacturers or their equipment are often blamed for electrical infrastructure issues beyond their control. PSI hopes this information and these examples will help your efforts to avoid similar problems.

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