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Absolute Power

By
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The past year has been an absolutely momentous eye-opener for the broadcasting industry. 2003 offered up an abundance of AC power problems. Most stations dealt directly with a plague of electrical troubles. It appears to be a worldwide phenomenon. Here are a few examples of other unrelated major blackouts.

- **Sunday, September 28, 2003 – Italy** – "Blackout cuts power for hours in Italy; 57 Million left in the Dark"
- **Tuesday, September 23, 2003 – Sweden and Denmark** – "Faulty line puts Swedes and Danes in the dark; Nearly 4 million people without power for more than three hours"
- **Monday, September 1, 2003 – Malaysia** – "Blackout disrupts Malaysia; Maintenance Work Suspected Cause"
- **Thursday, August 28, 2003 – England** – "London Blackout; Largest loss of Supply to the Grid in Ten Years"
- **Thursday, August 14, 2003 – North America –** "Largest Blackout in North America's History; Electricity was Cut to 50 Million People"

Specifically, the August 14, 2003 blackout that shut down numerous States in the American northeast and several Canadian Provinces was an extraordinary event. Lessons learned from this major incident, as well as from several other smaller episodes, need to be shared, understood, documented, and archived; so we can all gain from this valuable knowledge and renewed awareness about the importance of AC power to our businesses.

Mitigating the risks for any future major blackouts is clearly in the hands of the Utilities and the various levels of Government. But, dealing with the direct impact of this sort of event at our stations is in the best interest of all broadcasters. We must learn how to best protect ourselves. We must learn how to stay "on-the-air" throughout these events. The public view broadcasters as an essential service during, and especially after, these major power failures.

Many broadcasters take power for granted. This laissez faire attitude can no longer be tolerated. Understanding AC power is vital to the successful operation of any television or radio technical environment. But, where do we start? How do we gain the knowledge necessary to be better equipped when the next power malfunction happens? The first step is to understand the primary language of AC power.

You may have read an article or even attended a seminar discussing electrical issues, where terms like spike, surge, brown-out, etc., may have been used without any real meaningful definition of these terms. So, to help you enhance your understanding of these modern power problems, here is a list of definitions for you to familiarize yourself.

- **Blackout**: a total power failure lasting several seconds to many hours.

- **Brownout**: a planned and usually announced region-wide reduction of available steady-state voltage. Typically associated with an impending expectation for heavy electrical consumption.

- **Dip**: a faster sag. Dips are short decreases in the nominal line voltage, but are much quicker than a sag. Usually only visible in an incandescent light bulb.

- **Dropout**: a portion of the sine wave that has a lower value or is missing altogether, but only for a small portion of any given cycle.

- **Impulse**: a very short disturbance of either polarity, (up or down), superimposed on the AC sine wave that lasts between 0.5 and 100 microseconds. In-phase impulses which instantaneously increase the voltage are called spikes. Out-of-phase impulses which decrease the voltage are notches.

- **Notch**: similar to a dropout though typically too fast to see. They can be up to several milliseconds in duration and usually come in pairs. For every notch there is usually an immediate spike following behind. A notch is simply an out-of-phase impulse.

- **Power Failure**: a zero voltage condition lasting for more than one cycle (1/60 of a second). From a power grid standpoint, it could happen on any of the three phases being delivered.

- **Sag**: a cycle-to-cycle reduction of power line voltage of at least 10% of the average voltage for half of one cycle or longer. A sag might occur when an induction load motor first turns on, as in an air conditioner. Sags are detrimental to all electronically controlled devices.

- **Spike**: an in-phase, over-voltage impulse ranging from 400 volts to well over 5,600 volts! Such an impulse is superimposed on top of the AC sine wave and typically lasts for less than 1/000 of a second (one millisecond). Any spike over 600-volts can be very damaging. Spikes contain high amounts of energy and are most detrimental to sensitive circuitry.

- **Steady-State Voltage:** normal voltage planned for a system that stays constant for ten seconds or longer. In North America, stations require 120-VAC at a frequency of 60-Hz, the amount of amps is dependant upon the loads. (Hertz or Hz is the unit of electromagnetic frequency for the change in cycle in alternating current.)

- **Surge**: the opposite of a sag, surges are cycle-to-cycle increases in the voltage on any of the three phases above the normal voltage, but typically below 500 total volts. The lasting time of a surge is equal to its duration for the number of 60-Hz cycles that the power line disturbance is above normal.

- **Swell**: basically a series of long term surges that lasts from a few seconds to several minutes.

- **Transient**: any short-term power disturbance on the power line. All the above disturbances are transient by definition. Transients can either be oscillatory, varying consistently with the frequency, or they can be of the impulse variety.

Common problems that can result from these AC power impacts can include:

- **Line Noise:** two basic types of noise can appear on a line within a facility – normal mode and common mode. Normal-mode is the potential difference that exists between pairs of power or signal conductors. Common-mode is the difference that appears between the power or signal conductors and the local ground reference.

- **Harmonics:** the most common sine waves that distort a power system are whole number multiples of the fundamental 60 Hz power frequency, commonly known as harmonics. Nonlinear loads can introduce significant levels of harmonics into the system. Harmonic energies combine with the fundamental to form distorted waveforms. Ratings for transformers and generators are based on the heating created by load currents of an undistorted 60 Hz sine wave. When the load currents are nonlinear, they cause more heat than the specified ratings for these devices, which results in circuit fatigue or out right failure. The single largest source of problems generating harmonics is switching power supplies. Switching power supplies are common to computers, personal UPS, servers, routers, and of course, all kinds of broadcast equipment. A typical station has many pieces of equipment that create these harmonic distortions. Other examples may include fluorescent lighting ballasts, adjustable speed drives, static UPS, and controlled rectifiers.

- **Ingress / Egress:** Radio Frequency Interference (RFI) and Electrical Magnetic Interference (EMI) is becoming a major problem for all stations. Especially due to the newer video / audio / voice over IP wiring schemes based upon Category 5e / 6 / 7 cable and connectors. Power can radiate into signal cables and cause undesired effects that can distort or even completely interrupt the proper flow of a signal in the wire. Proper grounding and a professional installation that separates conflicting cable types are essential procedures to ensure a clean broadcast operation.

Oscillatory transients are usually caused by;

- **Lightning strikes -** the most common cause of spikes and surges. Lightning is most common and most severe during the summer months, though lightning has been observed during snow storms! Lightning strikes can render sophisticated electronics useless or operationally intermittent. In either case, costly. Surprisingly, lightning does not need to strike nearby to reap havoc. A storm miles away could induce spikes that can ultimately reach your station. Lightning between clouds, never directly striking power lines or phone lines will create large magnetic fields that can also cause surges and spikes in your equipment.

- **Utility grid switching -** your friendly power utility company can be responsible for creating spikes and surges simply by switching high power distribution lines. Power lines can also pick up transients from Power Company operating equipment.

- **Grid Connections(s)** - even your station's connection to the power grid located just outside your facility can be the source of transients. Many stations were constructed some time ago when demand for current was not as prevalent as today. Stations of yesteryear rarely used the volume of power or needed the extensive service of today's modern facility. With larger, multi-channel stations demanding more power to operate, many older power supply connections to the grid are simply electrically undersized and outdated. When demand is high for current in an overloaded station, the power sags or dips drastically. Power line transformers on the grid compensate when low voltage is sensed by raising the voltage. When the demand for power sufficiently loads that transformer, all is well, but when the load is slightly higher, the voltage could remain at dangerously high levels.

Impulse transients are usually caused by: faulty wiring (aka loose connections), motor load switching, and improper grounding or bonding of power lines**.**

According to some electrical industry studies, voltage transients represent 12% to 15% of all AC power line problems with only about 35% of those problems originating from outside on the utility grid. Most problems are therefore inside the facilities. In the broadcast station, transients can occur simply from a ground voltage differential between improperly bonded grounds during electrical faults. It is important to understand that given the state of the art of the technology we now employ in broadcast stations, all AC power lines, video, audio, IFLs, telephone, cable TV and data communication lines must all be commonly grounded or bonded together to prevent transients voltages from entering sensitive equipment.

One study shows that surges and impulse spikes can occur as frequently as twice per hour in any typical residence; some with peak values at 1,500 to 2,500 volts. In industrial applications, they can be more frequent and more severe with spikes as high as 5,600 volts as recorded during lightning storms.

A study by IBM in various locations across the United States revealed an average of 50.7 voltage spikes per month. Another study showed that many locales will experience approximately twenty-five power line disturbances per year, 87% of which will probably be sags below 96-VAC. Voltages below 105-VAC can be very damaging to induction loads as used in some equipment and station technology, for example, air conditioners.

The bottom line is that electrical disturbances, the so-called "power line problems" are severe, they occur often and the damage can be substantial, which usually equates to expensive. What goes mostly unnoticed is the accumulative effect on sensitive equipment in the station after of enduring spikes, surges, dips, notches, etc. The long term performance deterioration of some delicate components may not surface until later; all the while the equipment performs at a sub-standard level until failure occurs.

So, what can be done? The first step is to identify the problem. There are many solutions available today to help manage your AC power concerns. Securing the services of a qualified electrical consultant is always the smart way to proceed. They may recommend solutions using one or more of the following strategies: surge arrestors, surge suppressors, uninterruptible power supplies (UPS), standby power from diesel generators, power monitoring and energy usage measuring equipment, regular maintenance, testing and analysis, safety and protection systems, multiple grid connections, ingress and egress RFI / EMI review, code adherence evaluation, distributed power segmentation, and, isolated technical ground redesign. Each electrical problem is unique and will require a solution that best fits its requirements concerning cost, schedule, performance, quality, and functionality.

Power is the lifeblood of the broadcasting business. We all learned firsthand this past summer how vital it is and what the outcome will be if it is interrupted. So, we must take necessary steps to ensure that our facilities receive a stable, clean, constant supply of AC power in order to accomplish our mandate for TV and radio communications. Your audiences depend on you to provide your services to them in the face of adversity, so let's not let them down due to poor AC power design, maintenance, and management. It has never been as important as it is today.

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This article was created with direct references from:

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