Protection Of Electronic Equipment from Electrical Phenomena

The computer file server or the main computer that supplies data to each of the PCs in a network, may require constant power supervision, depending on its functions.

Introduction
Various electrical phenomena, such as sags, blackouts, spikes, surges, and electrical noise, can affect and/or damage electronic equipment. The following is a breakdown of occurrences for various types of electrical phenomena responsible for various computer problems.

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<th>Electrical Phenomena</th>
<th>Percentage Accountable</th>
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<tr>
<td>Sags (Brownouts)</td>
<td>87%</td>
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<tr>
<td>Spikes</td>
<td>7.4%</td>
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<tr>
<td>Blackouts</td>
<td>4.7%</td>
</tr>
<tr>
<td>Surges</td>
<td>0.7%</td>
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(Data Compiled by AT & T Bell Labs)

Table 1: Breakdown of Electrical Phenomena Responsible for Various Computer Problems.

The computer file server or the main computer that supplies data to each of the PCs in a network, may require constant power supervision, depending on its functions. If an industrial process, for example, is controlled by PCs where data is constantly being recorded, the main file server requires protection against brownouts and blackouts to ensure the data is not lost by a sudden power reduction. UPSs are designed to provide the backup power needed to safely power down the computer, as sudden power outages can disable the PC’s data storage unit (hard drive).

Electrical Phenomena Affecting Electronic Equipment
The following descriptions cover most electrical hazard phenomena. Each of these hazards has the potential to severely damage electronic equipment and must be controlled. If these hazards are not controlled, large property and business interruption losses will often result because more people are turning to electronic equipment to control vital functions to optimize their operations.

UPS’s are designed to provide the backup power needed to safely power down the computer, as sudden power outages can disable the PCs data storage unit.
A. SAGS

Sags are defined as decreases in the standard voltage levels over the short term and are also referred to as brownouts. When they occur, they reduce the overall efficiency of electrical equipment as well as shorten their life span. In computers, the lower voltage levels can cause system "crashes", resulting in the corruption or loss of data.

Sags are caused by simultaneous start-up power demands of electrical devices on the same line such as compressors, electric motors, and tools. Especially during hours of peak hydro consumption (e.g. in summer with high air conditioning use), hydro companies will often select certain areas to lower the voltage. These are referred to as rolling brownouts and can last for hours or even days at a time.

B. SPIKES

Spikes are sharp and abrupt increases in voltage levels and are caused by lightning strikes to servicing hydro lines or downed lines during a storm. Spikes most often cause severe damage to electrical equipment as they exceed the electronic equipment's electrical tolerances. In the case of computers, a loss of data would also definitely occur.

C. SURGES

Different from spikes, surges are short-term increases in voltage levels with a life span extending over 1/120 of a second. Standard household appliances, air conditioners, electric motors, and other high-powered equipment cause these power surges when they are turned off.

The effects of surges are not as severe as those of spikes; however, their effects can be felt over the long run. Computer manufacturers are aware of the hazards of power surges and have built their units to withstand certain levels of power surges with surge protectors on the circuit boards. The computer may absorb the surge unharmed or may simply require resetting by being turned off and on. However, surges that occur beyond the designed limits will cause strain on the computer or any other electronic equipment, resulting in premature failure.

D. BLACKOUTS

Blackouts are a "total loss of utility power" resulting from lightning storms, downed hydro lines, and over-demand from the power grid. Any data being processed by a computer without special power backup, will be lost. In addition, the computer hard drive's file allocation table (FAT) may become damaged, and, as such, data on the hard drive becomes inaccessible.

The FAT controls the overall structure of the files on the hard drive. The hard drive is the computer device that holds programs and information. Unlike RAM, which is erased after a computer is turned off, data on the hard drive is still retained. Blackouts can make this data inaccessible.

E. NOISE

Noise includes electromagnetic interference (EMI) and radio frequency interference (RFI) caused by nearby hydro lines and broadcasting equipment. When this noise occurs, the power wave form (sine wave) servicing the equipment is altered and, as a result, errors can be introduced into "executable" programs (e.g. corruption).

If hazards such as sags, spikes, and surges are not controlled, large property and business interruption losses will often result...
**Uninterruptible Power Supply Systems (UPSS) For Electronic Equipment**

An uninterruptible power supply is designed to:

i) Provide backup power in the event of a blackout;

ii) Isolate the computer.

For data processing, a UPS provides the user with a source of power to save the data being worked on and allows for a controlled system shutdown. A controlled shutdown is necessary because a sudden loss of total utility power may damage a computer's hard drive file handling structure. This would make it inaccessible, as an abrupt stop in power flow would cause the hard drive(s) to stop and lock up. There are many types of UPS topologies, but the main ones are:

**A. THE STANDBY UPS**

The internal power transfer switch in this type of UPS is set to accept power from the unfiltered AC input line (wall outlet). Equipment connected to this UPS then relies on this line as the primary power source. Only when the primary power source (i.e., the AC line) fails will the UPS extract its power from the battery/inverter, which is the backup power source. (An inverter is a device that converts direct energy from the battery into AC power the equipment can use).

Although this UPS topology is perfectly adequate to guard electronic equipment from brownouts/sags and power surges, it is usually ineffective against power spikes caused by lightning. This is because the standby UPS relies on the standard building electrical entry for its normal power output. It only switches to backup power when the primary AC source fails. As a result, equipment connected to it is continually being subjected to electrical phenomena from incoming power lines. This type of UPS is best for protecting electronic equipment from power brownouts, blackouts, and moderate surges, but not from spikes caused by lightning.

**B. THE LINE-INTERACTIVE UPS**

Similar to the standby UPS system, the line-interactive UPS is designed to guard against power brownouts/sags. They are designed to provide power to the connected equipment without working off the UPS's battery. With line-interactive UPS systems, the battery/inverter typically begins to drain once the AC voltage dips to 98 volts.

The line-interactive UPS is designed to maintain the connected equipment on the primary building line as long as possible, to conserve battery power for future use. By conditioning and filtering the fluctuating power supply back to the nominal 120 volts, the equipment can continue to run off the AC line until the fluctuating power dips below the range that can be handled by the line-interactive UPS; at this point, the internal battery is activated to provide power. As with standby UPS, the connected equipment still has the disadvantage of relying on the standard building entry, which again makes it susceptible to more severe electrical phenomena. The difference between the line-interactive and the standby UPS is that the former can properly power connected equipment longer by running off the building entry and conditioning the fluctuating power whereas the latter switches to battery when the power dips below a certain point.
C. ONLINE, SINE WAVE UPS

The online, sine wave UPS is the most effective type of guard against all electrical phenomena. Unlike the standby UPS, the online UPS has its power transfer switch set with the battery/inverter as its primary source of power and switches to the standard building AC line if the battery/inverter fails. Some UPSs of this type convert the incoming AC power into filtered DC power before it is inverted back to AC power again for the connected equipment. This type of UPS provides complete isolation to the connected equipment, so that it cannot be affected by electrical phenomenon from incoming power lines. This is ideal for computer file servers.

Another advantage is that it provides continuous sine wave output. There are various types of power wave forms that can be generated by UPSs, but the sine wave form is the one provided by the standard AC line and the one that is required for equipment to operate at its best. The sine wave form also produces the least total harmonic distortion (THD) with a value of less than 5%. THD can cause overheating in circuitry, leading to premature equipment failure and the wearing out of the DC power supply.

Hazard Evaluation

A. ELECTRONIC EQUIPMENT SENSITIVITY

Electronic equipment, like the computer, is becoming more complex at a phenomenal pace. With this level of complexity, the need for more advanced electrical protection becomes increasingly important: without, the probability for large losses is high. The current drawn is relatively low and, as a result, any abrupt electrical spikes or other electrical phenomenon may severely damage the vital components of electronic equipment and, in the case of computers, cause a loss of data as well.

B. OUTLINE OF LIGHTNING PROTECTION REQUIREMENTS

Devices such as lightning arrestors (air/ground terminals and conductors) and equipment to dissipate electrically charged cloud formations are adequate to protect physical structures and electrical equipment from a lightning stroke. However, additional protection must be provided for electronic equipment because of their sensitivity to power fluctuations caused by lightning, switching, and load changing of lines and equipment.

NFPA 780 details the installation requirements for protecting physical structures and electrical equipment (e.g., transformers, wiring) from lightning; however, it does not focus on the protection of electronic equipment, which is particularly important for risks with data processing exposure.

C. LIGHTNING STRIKES TO OVERHEAD UTILITY WIRES

A direct lightning strike to an overhead hydro line will introduce a large current into the power distribution system. The first thing that can be done to avoid the resulting electrical damage to electronic equipment is to dissipate and prevent the lightning before it has the chance to enter a building's electrical entries. By installing a proper "shield" consisting of continuously and electrically grounded wires, also known as static wires, the current can be brought to ground instead of proceeding through the power distribution system where the electrical spikes will exceed the capacities of otherwise unprotected electronic equipment, thus causing damage.
D. LIGHTNING STRIKES TO BUILDINGS

When lightning strikes a building, the electrical potential energy of the building will sharply rise several thousand volts. However, if the electronic equipment's ground is isolated from the building's ground, the potential energy of the electronic equipment will not rise by the same amount the building's potential energy does.

As a result, the difference in potential energies between the electronic equipment's ground and the building's ground can be high enough to cause damage to the electronic equipment. However, if the electronic equipment and the building are connected to the same ground, then the rise in electrical potential energy for both the building and the electronic equipment after a lightning strike will be identical and no voltage differential will occur, thus avoiding damage to the electronic equipment.

CONTROL MEASURES

A. SAGS

A standby uninterruptible power supply (UPS) is adequate to compensate for unexpected voltage decreases; thereby, avoiding system crashes and data corruption in computers. This UPS compensates for decreased voltages once the output reaches a preset critical level.

B. SPIKES

Equipment should be connected to an isolated sine wave UPS. Electrical surge protectors do not provide adequate protection against abrupt spikes (such as those caused by lightning) because the voltages generated by a lightning strike arc through the surge protector and completely destroy equipment connected to it. More than 90% of the surge suppressors sold today are the "shunting" design that allows spikes to pass through to the equipment.

By having the UPS "isolated" from the main building electrical entry, the equipment connected to it does not run off the building line, which is constantly susceptible to various electrical phenomenon. Instead, this type of UPS contains its own battery cell that powers the equipment connected to it. This power is constantly being filtered and monitored to ensure that it is provided in the purest (sinewave) form, which the equipment expects. Power spikes cannot harm the equipment, as it does not operate on the standard line. Instead, it relies on the UPS's battery cell, which has its quality and voltage levels constantly controlled and monitored.

Isolated UPSs should be installed for areas subject to severe and frequent lightning storms, such as rural areas with above-ground hydro wiring.

C. SURGES

Surges are significantly different from spikes. Although surges result from increases in voltage, their magnitude and severity are not as great as those associated with spikes. Power surges can be guarded against using surge protectors. These are designed to protect the equipment connected to it from moderate voltage increases caused by the shutting down of high-powered equipment in the area. Surges are not as severe as spikes and do not necessarily require the use of an UPS.

D. BLACKOUTS

A standby UPS is adequate to guard against blackouts. A UPS is designed to provide sufficient power for the user to implement a controlled shutdown of the equipment to avoid losing any data being worked on at the time of the blackout.
E. NOISE

Various surge protector manufacturers also incorporate a noise filtering/reduction feature into their products. These units are designed to reduce the amount of electrical noise that can interrupt electronic equipment’s normal operation. In most cases, the manufacturer provides details of this noise reduction feature either stamped directly on the face of the unit or on an identification label on the back of the product.

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