

COMPUTER POWER

PROBLEMS, SYMPTOMS AND SOLUTIONS

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PREFACE

Increased speed and complexity make present and future data processing equipment highly sensitive to the quality of the electrical power supplied.

The following pages will identify the problems, symptoms, causes and solutions.

POWER PROBLEMS AND DISTURBANCES

NORMAL SINE WAVE - A sinusoidal wave shape with a frequency of 60 Hz in North America or 50 Hz internationally. Totally clean noise free AC power is necessary for the reliable operation of all microprocessor-based equipment. The AC power supplied by your local utility company becomes contaminated by atmospheric conditions such as lightning, and by other equipment within the same building.

NORMAL MODE NOISE - is electrical noise between the hot and neutral wire, which can result in the destruction of a microprocessor chip or other components on the circuit board. Less severe noise on a continual basis can cause damage to sensitive components or erode the chip entirely.

COMMON MODE NOISE - is electrical noise between the hot and ground wire and between the neutral and ground wire. Common mode noise will disrupt the memory logic of the processor. Noise between neutral and ground creates problems since the theoretical zero voltage between neutral and ground is utilized by microprocessors and digital logic control systems as zero voltage reference. A voltage on the ground wire will disrupt the stored memory variables of today's fast microprocessors. Common mode noise can be incorrectly interpreted as data. This noise can cause what appears to be "software glitches", erratic performance of the equipment and partial or complete memory loss. Poor grounding also contributes significantly to common mode noise and this dynamic situation can change with building age, material corrosion, soil conditions and construction.

SPIKES - or transients are random, high energy, high amplitude surges of a microsecond duration or less. These spikes of electricity may be as large as 6000 volts. Transient voltages can originate from numerous sources at any time of the day or night, and can cause board damage, burned chips and memory loss.

BROWNOUTS (Undervoltage) - are a voltage level below the operating specifications of the equipment's power supply for an extended period of time. When the RMS voltage drops below a system's operating parameters, the system will "crash".

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OVERVOLTAGE - Voltage levels above the operating specifications of the equipment's power supply are considered overvoltage. When this situation does occur, the components of the power supply are operating beyond their tolerance and are subject to undue stress.

BLACKOUT (Power Failure) - This condition is a result of the complete lack of electricity due to interruption from the utility company. These interruptions can last from several seconds to several hours. Short-term outages may be caused by utility grid switching, or by fault clearing equipment. This type of disturbance is rare but results in computer data loss as well as head crashes of hard discs and data loss to floppy discs.

HARMONICS - These are multiples of the fundamental frequency of the voltage and current, which create a distorted sinewave. Harmonics in industrial power systems are mainly caused by non-linear loads such as switching power supplies, transformer cores, and arcing loads such as welders, furnaces, arc lamps, rectifiers, fluorescent lighting controls (i.e. ballast's) and variable frequency drive motors (VFD's).

PROBLEMS

The following illustrates the various power problems.

SYMPTOMS

Power line disturbances often escape detection because their symptoms are typical of most problems dealt with on a daily basis.

Software

Transient voltage disturbances (which we will discuss later) once on the logic board have the effect of resetting memory values. Transients can easily switch memory locations from the low state to the high state. The effect, however, is not necessarily immediately obvious or even predictable.

If the disturbed location is not presently being used, then no problem will occur. If the disturbed location is in the array storage area, the stored information will be disturbed. This will not, however, become apparent until that information is recalled or used. If the disturbed locations form part of a program sub-routine or the operating system, then a hang up or crash will occur when that sub-routine or portion of the operating system is next used. An example could be a disturbance at 8 a.m. disrupting part of an invoice print routine, which is not used until sometime in the afternoon. The system will operate normally all day and then hang up later for no apparent reason.

Similarly, data that has been disturbed in the computer memory can be written incorrectly on the disk. It could be days or even months before an "unexplained" proof error suddenly appears. The symptoms described above usually have people screaming "software" and many hours can be wasted looking for glitches in the software which, in fact, do not exist. A good clue pointing towards a power related problem is the re-boot. The re-boot resets memory

locations to their proper state and the system will operate normally until it is disturbed again. The key point is this: **IF YOU ARE WORKING WITH A PROVEN SOFTWARE PACKAGE AND A SIMPLE RE-BOOT SOLVES THE PROBLEM, THEN YOU ARE DEALING WITH A TRANSIENT PROBLEM.**

Hardware

Assuming that the hardware has not been damaged by static electricity during installation, and if the components survive the initial burn-in period of two to three minutes, consider it a good component and it should be expected to last a normal lifetime of 20 to 30 years. If it fails before that time, it has been subjected to some abnormal abuse such as spikes and transients from the power line. Input or data from keyboards and other peripherals is unlikely to cause any undue stress on the component.

Transient voltages which may make their way to the logic circuits cause burning and pitting of the chips. If a transient is large enough, it can instantaneously destroy any component it hits causing an immediate catastrophic failure. However, what may be of more importance is the fact that continual bombardment by spikes as low as 50 volts causes pitting, often referred to as a "micro bullet hole". This erosion drastically shortens component life. The important thing to note here is that **COMPONENTS DO NOT WEAR OUT - THEY ARE DESTROYED.** When you are required to replace boards, you should be considering that spikes and transients are the probable cause.

I/O, Read Errors

Another common symptom of power line disturbances is "read errors" and other error messages associated with transfer and recovery of data from disk storage. If a transient enters either the CPU or the drive when the system is writing and the magnetic field on the write head is suddenly increased to ten or twenty times its normal value, a splash effect occurs in the magnetic media. The result is a "read" or "disk error" when the effected track and sector are read.

In the case of floppy disk, it is most often the disk, which is assumed to be defective. Customers may not even report such problems because the relatively low unit value of the disk leads them to believe that it is normal for disks to give this type of problem.

This situation is not the same, however, with hard disks. The identical problem with a hard disk, because of the high cost of the item, will generate a service call. Occasionally, software is blamed for the problem, but more often you probably suspect a malfunction in the drive and start searching for a problem in the logic circuits and drive head alignments. This can be a frustrating and fruitless exercise because, in fact, there is nothing wrong. Everyone has had experience at one time or another with a system that performs perfectly in the shop yet gives no end of aggravation on the customer's site. If operator error or incompetence has been ruled out then this is a strong indication of a power problem.

Summary

Aside from the frustration involved in chasing problems that cannot be identified, often referred to as "ghosts", they can become extremely expensive to fix, unless you ensure that the power your system uses is correct, clear and noise free. Certainly there are many other causes of the problems described, but WE MUST EMPHASIZE THE IMPORTANCE OF CONSIDERING POWER WHENEVER YOU RE-BOOT A SYSTEM OR REPLACE A BOARD.

CAUSES

Transient power problems originate outside buildings from ground faults, lightning and public utility switching, while inside the buildings transients are more than likely caused by inductive loads. Photocopiers, air conditioners, compressors, motors, light switches, and fluorescent lighting circuits are all common sources of power line disturbances. In a nutshell, any collapsing magnetic field or any arcing in a switch will create transient wave fronts which appear at the receptacles in various modes with various consequences. We will try to describe briefly some of the more common power line aberrations and give some suggestion as to the possible, if not probable, consequences.

Undervoltage (Brownout)

This is a situation where the public utility either voluntarily or involuntarily drops the RMS voltage below the normal parameters for an extended period of time. Should the RMS voltage drop and stay below the "crash" voltage of a system, you are dealing with a power fail situation and the system will act accordingly. Certain older models of equipment, which use a linear (transformer) type of power supply, will develop power fail symptoms at RMS voltage between 103 and 110 volts. However, the modern switching power supplies used in most of today's equipment will operate as low as 90 volts before power failure symptoms become evident. Consequently, brownout problems are a relatively rare occurrence. Steady state voltage levels below 100 volts are not common in the environment.

Overvoltage

Overvoltage is a steady state RMS voltage level which exceeds equipment tolerance. Generally, any voltage level above 125 volts would be considered overvoltage. Although such circumstances are relatively infrequent, the consequences have some significance in the overall picture. When this situation does occur, components of the power supply are operating beyond their tolerance and are subject to undue stress. Premature failure can be expected. Overvoltage situations are easily detected with a multi-meter and where ever there is a failure within a power supply you should be checking the voltage as a matter of course.

Sags

Sags are drops in the RMS voltage for one or more cycles. Such disturbances are often caused by heavy loads being turned on (motors, heaters, etc.) and will run from as little as one cycle to several hundred cycles, with the most typical being between one to five cycles. The

consequences of sags are more or less the same as "low voltage". As long as the RMS voltage does not drop below the "crash voltage" of the equipment, sags are of little significance. Older linear power supplies may show power failure symptoms if the voltage sags to around 100 volts. However, as previously mentioned, the switching power supplies common to current equipment will operate efficiently on as low as 90 volts, and will display no significant symptoms until the sag drops below that level. Fortunately, such occurrences are relatively rare (around five percent of the total picture), and their symptoms are a relatively obvious reaction to a power fail situation.

Surges

Surges are short periods of overvoltage from one to several cycles in duration, with the most typical being one to three cycles. They are caused by heavy loads being switched off, and external disturbances such as lightning and public utility switching. Again, this is a rather common disturbance, which is a problem only in its extreme form. As long as the surge is within the tolerance of the equipment (which most are), it is of no significance. Massive surges of one or more cycles of very high voltage (over 135 to 140 volts), although rare, are quite destructive. Their effects will be obvious in burned components of the power supply. Surges are not detectable with a multi-meter, as special equipment designed to monitor power line disturbances is required to detect them. Destructive surges, however, are relatively rare compared to transients and should not be considered as a significant problem unless there is obvious "burn" in the power supply or logic boards.

Dropouts

Dropouts are absolute power fail situations of less than one cycle anywhere from a few microseconds to almost a full cycle. Such disturbances are not uncommon but will not be evident to an operator looking at the screen, nor will it be noticeable in the room lighting. They do not, however, go unnoticed by the microprocessor logic. Short-term dropouts seldom cause equipment to display power failure symptoms, but they do raise havoc with logic operations. For example, if there is inadequate or no voltage on the logic circuits for the duration of a transaction which is supposed to put a memory location in the high state, the transaction will be completed but that memory location is likely to end up on the low state. The result obviously is disturbed data, and eventually a hang-up, or an error flag will occur when that location is again accessed.

Transients

By far, the most troublesome and destructive power line disturbances are transient overvoltages. Such disturbances are commonly referred to as "spikes", "impulses", "oscillatory transients", "glitches" and even "voltage fluctuations" or more formally as "Oscillatory decaying transients". It all boils down to the same thing - a sudden and extreme increase in voltage. Such disturbances can be as short as a few nanoseconds to as long as almost half of a cycle and may occur between line and neutral, line and ground, or neutral and ground. Their effect is to simulate the symptoms of virtually any other problem you are dealing with, which can erode or cause total failure and/or breakdown of the electronic components.

The propagation of these voltage wave fronts does not follow conventional "electrical" theory. Their effect is neither predictable nor immediate and depends as much on what the computer

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happens to be doing at the time, as it does on the amplitude, frequency, and mode of occurrence.

As we have seen logic problems resulting from transients might not be detected for days or even months, and the cumulative physical damage to electronic components may not become evident for months or even a year. Such transients occur on virtually all power lines, regardless of how "clean" they are supposed to be. **"Remember the utility companies supply clean power" - "Users Pollute"**.

NORMAL MODE transients, between the line and neutral wires result from external disturbances such as lightning, ground faults, and public utility switching, but the most frequent are those generated within the building. Virtually any switching action, which creates an arc (ie. light switches), and any collapsing magnetic field will create a voltage wave front, usually oscillatory in nature, with magnitudes from a few volts to many thousands of volts.

Large transients can instantly destroy any electronic components they hit. Logic problems resulting from large transients of this nature are inconsequential, because when a component is destroyed it will bring down the entire system. Often, such failures can be found in the power supply system, but frequently large transients will pass through the power supply to destroy components on logic circuits.

Far more common, however, are lower amplitude transients (50 to 500 volts) which pass through the power supply with little, or no, attenuation to reset memory values on the logic circuit as well as "eroding" components both on the power supply and/or on the logic circuits. These transients (energy) will concentrate on the point of greatest impedance in both the logic board and power supply.

Although the total energy of a transient is relatively low, it is severe enough to cause a burn at the point of highest impedance. This burn now adds to the impedance at that point and subsequent transients however small will tend to concentrate there, and gradually enlarge the burn spot. Eventually, this continual pitting will burn through the circuit causing hardware failure, or worse they can also reset the logic values creating the "ghost problems" previously discussed.

COMMON MODE disturbances, typically measured between neutral and ground, are in fact disturbances that are induced into the line and neutral wires at the same time, and travelling in the same direction. They are not, therefore, measurable between line and neutral and can be detected only by taking measurements between line and ground and neutral and ground. Typically, measurements between neutral and ground are sufficient to indicate the presence of common mode disturbances. Transient voltages on the neutral wire have the effect of creating a variable "logic 0".

Simply speaking, if zero is not always zero, logic problems can be expected. A momentary drop in logic zero level can result in a low state when the high state is the expected result, and vice versa. In addition, transients of apparent insignificant voltages not only cause logic problems, but also create pitting and eventual failure of the chips. **NORMALLY, ANY**

VARIATION IN VOLTAGE ON THE NEUTRAL LINE WHICH EXCEEDS FIVE VOLTS WILL HAVE A DISRUPTIVE EFFECT ON THE LOGIC OPERATIONS.

Static Electricity (Electro-Static Discharge)

Static Electricity is another problem for the microprocessor base industry, but the effects are most often misunderstood.

On the site, the effect of static electricity is usually obvious. Typically, an operator touches the equipment and there is an immediate failure and/or the screen goes blank. This type of problem is relatively insignificant compared to the other less visible effect of static discharge.

Static discharges to light switches, floor receptacles and any part of the electrical system in the building, become, "spikes" which would have the same effect as disturbances caused by other types of equipment. Power line protection placed as close to the equipment as possible is the only avenue of escape from such problems.

Static electricity is a far more significant factor for the service technician, than the operator of the equipment. Handling electronic components and boards without taking proper grounding precaution can immediately destroy or severely damage them even before they are installed in the equipment. Immediate or early failure is the usual result. Field service people should not touch boards and components either in a system or in shipping packaging without insuring they are properly grounded.

Power Failure

Obviously, this is a total interruption of supplied power. The effects are more or less predictable with all information being stored in the computer memory being lost. "Head crashes", are common with hard discs and information of a floppy disc is often disturbed to the point where it cannot be read.

Less obvious but perhaps more important are the extreme "spikes associated with the power coming back on". These spikes can totally wipe out operating systems by destroying any components they hit.

SOLUTIONS

The following is a brief description of product types available and their effectiveness in eliminating power disturbances.

Built-in Filter

Most equipment available has some power line filtration built into the power supply. These filters are primarily designed to stop disturbances emanating from the equipment into the

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power line, rather than protecting the system from spikes on the power line. They cannot be relied on to provide any acceptable level of protection from power line transients.

Dedicated Lines/Isolated Grounds

Dedicated lines and/or isolated grounds are probably the most frequently encountered measure designed to minimize power line disturbances. Usually, these are separate lines running from a panel to the microprocessor installations. The ground wire is insulated and runs directly back to the panel ground. In some instances, it may only be a separate circuit with the conduit being used as a safety ground. Such circuits are most often identified by an orange receptacle.

Dedicated lines provide some measure of protection for the equipment by ensuring no other "noise generating" equipment is on the same circuit. They are deceptive in their efficiency, however, because they provide no protection against any disturbances, which emanate from other equipment connected to the same panel. Disturbances loop back from a noise source through the panel and down the dedicated line. Consequently, DEDICATED LINES AND/OR ISOLATED GROUNDS SHOULD NEVER BE CONSIDERED AS SUITABLE PROTECTION AGAINST POWER LINE DISTURBANCES. Power disturbances should still be considered as a likely problem even though a dedicated line has been installed. Proper and correct grounding is always a prerequisite to any installation.

Regulation Transformers

Regulation transformers are designed to maintain the RMS voltage within certain levels. Generally speaking, they will accept input voltage of plus or minus 15% from the normal, and provide output voltage of plus or minus 5% from the normal. They deal with RMS voltage, however, they have little or no effect on transient disturbances or common mode noise. The usual reaction time is one or two cycles. Their application is to maintain the RMS voltage at a steady state and would be useful where the RMS voltage swings below the crash voltage of the equipment. But, as previously mentioned, because most of today's equipment will run as low as 90 volts, the use of regulation transformers is not often necessary.

Isolation Transformers

Isolation transformers incorporate special Faraday shielding and grounding to eliminate common mode noise. These are useful in breaking ground loops, but do not attenuate normal mode disturbances. In fact, recent studies by General Electric indicate that Standard 1 to 1 Isolation Transformers actually output a larger transient than what was at the input. In addition, if more than one piece of equipment is connected to the output side of an isolation transformer, ground loops will occur.

Ideally, there should be one isolation transformer for each piece of equipment needing protection. The notable point is WHERE ISOLATION TRANSFORMERS HAVE BEEN INSTALLED AS A PROTECTIVE DEVICE, POWER DISTURBANCES SHOULD NOT UNDER ANY CIRCUMSTANCES BE RULED OUT AS THE SOURCE OF THE PROBLEMS.

Saturated Transformers

Saturated transformers are designed to operate with the primary coil in full saturation. If they are operated at the recommended rated load, they can be expected to eliminate normal mode disturbances for the most part, but they do not provide protection against common mode noise. Load matching is paramount to within 75% of the designed power rate.

Ferro-Resonant Transformers

Ferro-resonant transformers are designed to operate in saturation with suitable capacitors on the output coils to create a sine wave at 60 hertz, if operated at a suitable load level, which will give acceptable protection against normal mode disturbances, but they do not provide protection against common mode noise.

Ultra Isolation Ferro-Resonant Transformers

Such transformers incorporate the features of the isolation transformer and the Ferro-resonant transformer. They can be expected to give excellent protection in both normal and common modes. It is important to note, however, that such transformers are both load and frequency sensitive. If they are not operated at a minimum of 75% of their rated load, they will not be saturated and will offer no protection. Although frequency swings are relatively uncommon, it should be noted that even slight swings in frequency will cause significant variations in output voltage. The size, heat and noise generated by these transformers often make them unsuitable for an office environment. Various types of switching loads also badly distort the sine wave output, and these transformers most often provide no protection whatsoever if the line and neutral wires are reversed.

Line Conditioners

Line conditioners usually incorporate the features of regulation transformers and isolation transformers. Often, clamping devices are added to the circuit in an attempt to reduce "spikes".

Typically, such products can be expected to provide regulation of RMS voltage and good ground isolation from common mode noise. They do not, however, give adequate protection from normal mode transients.

Such products are effective in reducing massive physical damage from extreme voltage transients and surges, but they **ARE NOT EFFECTIVE IN DEALING WITH THE PROBLEMS YOU NORMALLY CONTEND WITHIN THE OFFICE ENVIRONMENT ON A DAILY BASIS.**

Firstly, clamping devices have a reaction time (35 nanoseconds in the case of varistors) during which a portion of the transient will overshoot the device and enter the equipment. If the transient has a very short rise time, a very large portion of the transient will overshoot. In any case, any voltage levels below the clamping voltage will be permitted to pass. If a transient occurs at the peak of the positive cycle, at least 230 volts will pass into the equipment. A positive transient occurring at the bottom of the negative cycle will not be clipped until the transient exceeds 400 volts positive. Consequently, as much as a 570-volt impulse can pass by the device (varistor), before it becomes effective. Any aberrations on the sides of the sine wave pass through unimpeded, with the expected negative consequences. In addition, the portion of

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the disturbance that may be shorted onto the neutral wire will appear in the equipment as common mode noise. In this instance, the disturbance is partially blocked from "going in the front door", but allowed to enter the system "through the back door". It should also be noted that this type of device offers no protection against common mode disturbances and the disturbances which are induced into the neutral wire.

Backup Power Supplies (Standby, Transformer Based)

These devices consist of a standby battery, and an inverter, which comes into operation when the AC power supply is interrupted. Often such products incorporate a clamping device on the line to "attenuate" power line disturbances. During normal operation of these devices, the equipment is powered directly from the AC line, which may be polluted by spikes, transients, harmonics etc. This equipment is deceiving in its effect.

Firstly, the clamping devices incorporated into the AC circuit do not remove the disturbances as required so they cannot be relied upon to give clean power under normal operating circumstances. Secondly, when the AC power is interrupted, the collapsing field of their battery charging transformer circuits direct a large impulse into the equipment. This impulse is followed by a very heavy sag, perhaps to almost zero voltage, while the inverter switches into operation. This impulse and sag, although unnoticeable to an operator, will nevertheless have the effects previously discussed.

Electronic UPS (Line Interactive, Uninterruptible Power Supply)

The Always "On" UPS Systems Inc. Electronic UPS has been designed to provide UNINTERRUPTIBLE COMPUTER GRADE AC POWER for normal operating conditions, WITHOUT INTERRUPTION during blackout and brownout conditions. **The Always "On" UPS Systems Inc.** Electronic UPS will supply AC power, which is free of electrical noise and voltage disturbances.

UPS (Dual Conversion Online, Uninterruptible Power Supply)

As the name implies, an UNINTERRUPTIBLE POWER SUPPLY will maintain a continuous AC output when the AC lines supply is interrupted. With such systems, the equipment also draws its power from the battery but there is no switching time involved when the line power is interrupted. The battery system also isolates the equipment from incoming noise, but these UPS's generate low frequency harmonics and inverter noise, which can become major problems to the industry.

ELECTRONIC UPS FEATURES

Total clean AC power while the **Always "On"** UPS is offline.

No power consumption.

Will not create additional low frequency harmonic problems in the incoming line.

An **Always "On"** UPS is offline while the utility AC is being supplied.

True sine wave output.

An **Always "On"** UPS has filters. No switching spikes - interference - converters/inverter noise.

Low threshold switching voltage 110% + or - 2%.

High threshold switching voltage 115% + or - 2%.

Electronic Filters

Conventional filter theory is certainly well known to all of us. Such technology can be used effectively to deal with recurrent RFI problems but tends to fail when dealing with voltage transients over a broad frequency spectrum. Broad band voltage wave fronts that precede the current, pass directly through conventional filters unimpeded. The current involved in transients may be more or less insignificant, but since components are voltage sensitive, conventional filters do not provide the protection required.

However, the **Always "On"** line filter has overcome the limitations of conventional filter theory. It is a known fact the **Always "On"** line filter is the most effective method of removing transients over the entire range of frequencies which can have an effect on the computer's operation. The filter does not clip or suppress, but follows both sides of the sine wave and attenuates over 99% of all spikes and transients, and is equally effective on both common mode and normal mode noise.

Board replacement due to component failure will virtually be eliminated.

FEATURES AND APPLICATIONS OF AN ALWAYS "ON" UPS SYSTEMS INC. AC LINE FILTER

When considering the disadvantages and limitations of the devices described in the preceding text, it becomes apparent that with the exception of a Electronic UPS system, the only other logical approach would be the application of an **Always "On"**, power protection device which has the ability to overcome the limitations of conventional designs, by exceeding the protection requirements of today's systems.

Always "On" UPS Systems Inc. manufactures **Always "On"** line filters.

Always "On" line filters are "**State of the Art**", manufactured in Kelowna, B.C. , Canada. The **Always "On"** line filter utilizes finely tuned circuitry incorporated into a **series design configuration**, which means all the power must pass through the filter. The series design is not voltage dependant and responds immediately to frequency changes introduced by the transient. **Spikes, transients and noise are effectively attenuated in both normal and common mode, NO MATTER WHERE THEY APPEAR ON THE SINE WAVE.** The **Always "On"** series filter also protects equipment against destructive massive impulses, as well as those of lesser magnitude, which disrupt logic and deteriorate electronic components to the point of failure.

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SUMMARY

To summarize briefly, there are only two practical approaches to providing the disturbance-free power required by your equipment - **the ELECTRONIC UPS, or the ELECTRONIC POWER FILTER** both manufactured by **Always "On" UPS Systems Inc.**

Considering the size, price, effectiveness and through extensive field testing by major service groups, we are confident that **Always "On" UPS Systems Inc.** provides the best method of protecting your equipment and its operation, while reducing the number of service calls and board repairs with the resulting increase in profits. For those areas experiencing problems, it is essential that a filter be installed to prevent future damage, information loss, errors, costly re-boots and all related problems.

All **Always "On" UPS Systems Inc.** products incorporate the low pass series design filter with added features to meet your specific requirements.

INDUSTRY TEST STANDARD

The ANSI/IEEE C 62.41 - 1980 surge tests are the accepted industry standard for determining the effectiveness of power protection devices.

ANSI/IEEE C 62.41 - 1980 SURGE TEST

The KeyTek Model 711 A/J system is used to generate the following waveforms:

- a) Category A Ring Wave
 - .5u 100 kHz, 600 V Open Circuit Voltage
 - .5u 100 kHz, 500 A Short Circuit Current
- b) Category B-1 Ring Wave
 - .5us 100 kHz, 6000 V Open Circuit Voltage
 - .5us 100 kHz, 500 A Short Circuit Current
- c) Category B-2 Impulse
 - 1.2*50us, 6000 V Open Circuit Voltage
 - 8*20us, 3000 A Short Circuit Current

The three waveforms mentioned above are surged on the power line in one of the three modes:

- Normal Mode - Line to Neutral
- Common Mode - Line to Ground
- Common Mode - Neutral to Ground

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Conversion Formula

To determine filter sizing in AMPS when given operating load in terms other than amps, the following conversions should be applied.

a) Single Phase

<u>Given</u>	<u>To Find Amps</u>
--------------	---------------------

Watts	$\frac{\text{Watts} \times 1.42}{\text{Volts}}$
-------	---

VA	$\frac{\text{VA}}{\text{Voltage}}$
----	------------------------------------

KVA	$\frac{\text{KVA} \times 1000}{\text{VOLTAGE}}$
-----	---

b) Two Phase 4 Wire

<u>Given</u>	<u>To Find Amps</u>
--------------	---------------------

KVA	$\frac{\text{KVA} \times 1000}{2 \times \text{VOLTAGE}}$
-----	--

c) Three Phase

<u>Given</u>	<u>To Find Amps</u>
--------------	---------------------

KVA	$\frac{\text{KVA} \times 1000}{1.73 \times \text{VOLTAGE}}$
-----	---

The above conversions are based on the North American Operating Standard of 115 to 120 volts at a frequency of 60 hertz (cycles per second)

Should terminology other than that stated above be encountered please consult the factory.

In Rush or Power Up Current

Always "On" UPS Systems Inc. UPS's and filters are designed to handle initial IN RUSH OR POWER UP current under normal circumstances. However, for those installations which may involve prolonged power up conditions in excess of ten seconds please consult the factory.

ALWAYS "ON" UPS SYSTEMS INC. LINE FILTERS

Introduction Always "On" line filters

Basic Sizing Guidelines

Introduction

Normally the information for FILTER SIZING can be obtained from the data or rating plate usually located on the rear of the equipment housing. Another reliable source for sizing information, is the operating or maintenance manual for the equipment.

Sizing of the filter is based on the OPERATING CURRENT LOAD requirements of the equipment, and the filter selection should match this current load requirement.

Examples

Operating Load 3.0 Amp/120V
UPS Selection GES-421V or GES-425V

- Lan-file servers
- personal computers
- network workstations
- automatic teller machines
- telecommunication systems
- laboratory & medical equipment
- point-of-sale equipment

Operating Load 6.0 Amp/120V
UPS Selection GES-800V or GES-701L

System Future Expansion

Consideration should be given to the possibility of FUTURE EXPANSION to the system, which would increase the operating current load and require an initial over sizing of the filter. **Always "On"** UPS's and filters are NOT "load sensitive", and have no maximum or minimum load requirement. The possibility of future expansion should always be anticipated.

Terminology

Normally the customer will provide the necessary OPERATING CURRENT LOAD directly in amps. However from time to time it is necessary to deal with, and size filters based on other common electrical terminology. Such terminology is described as follows.

- a) Watts - a measurement of power equal to the line voltage X current X .707
- b) Volts Amps - (VA) - measurement of power equal to voltage X current.
- c) Kilovolt Amps - (KVA) - arrived at by dividing VA by 1000.

Installation

The following installation criteria should be followed when applying **Always "On"** products to your system.

- a) Avoid the use of additional multi-receptacle power bars.
- b) Protect each system component with its own individual filter and or UPS.
- c) Install the UPS or filter as close to the operating load as possible.

The above installation practice will eliminate a possible LOOP BACK from system modules that generate spikes, such as printers or disc drives, external CD's, and tape drives.

The exception to the above is the standard PC's which may include a CPU, internal disc drive and monitor which can be connected to a single UPS.

The basic Always "On" UPS Systems Inc. installation philosophy is for maximum protection and although the customer may deviate for economic considerations, he should always consider Always "On" UPS Systems Inc. products as they are the "Most Efficient Power Protection Products" manufactured in the world today.