Electrical Installation Guidelines Overseas

By John Dudeck

Electrical Installation Guidelines for SIM Computer Installations Overseas

September, 1986
Revised October, 2008

Introduction

The subject of electrical power problems in third-world computer installations is one in which everyone has a story to tell but no one seems to know the solution to the problems they have encountered.

It is true that problems arise in trying to use a computer or other complex electronic equipment in a location where electrical power is unstable, problems that may never occur in North America or Europe.

The manufacturers of "power protection" equipment have added much confusion to the subject by advertising the dangers of operating your computer without using their products. Often these products are expensive and yet ineffective.

I do not pretend to know all the answers, but I have made a study into some of the problems. I won't try to go into all the details here, but I want to share some guidelines and rules of thumb that may be of help to others.

What are the real problems?

It is necessary to evaluate the real risks involved, compared to their cost of prevention, in order to determine what steps should be taken. Often the best course of action will not be the most expensive one.

Electrically-caused problems that can arise in using a small computer fall into two categories:

- Physical damage to computer equipment caused by lightning strikes and power surges.
- Interruption of operation sometimes with loss of data caused by power outages, dips, and "line noise".

Let's look at these in more detail.

Physical damage to equipment

When the electrical voltage on the power input to a piece of equipment passes a certain level, the equipment may be damaged, due to arcing and burning, or overheating and destruction of electronic components. This high voltage may be in the form of a spike, such as produced by a lightning strike, or continuous, such as produced by plugging a 220-volt piece of equipment into a 380-volt circuit. Computer equipment is generally constructed to withstand a certain amount of high voltage on its power input. The exact limit, however, is difficult to determine.

Lightning strikes are the most difficult to deal with, because of the extremely high energy levels involved, and because of the unpredictable behavior of lightning. If lightning directly strikes the building in which the computer is located, there is no way to predict what might happen When lightning strikes nearby, there may be very high voltage spikes on the incoming power line. These spikes are destructive, and we need to find ways to prevent them from getting into our computer equipment. Unplugging equipment when it is not in use, and not operating during a lightning storm are low-cost strategies against lightning. Also installing lightning rods, lightning arrestors, and surge suppressors is recommended whenever possible.

A power surge is when the incoming voltage to the equipment is higher than normal for a duration of a fraction of a second to perhaps several minutes. This can occur in most third-world countries where local power generation is poorly regulated, or when operating from a small generator. In reality most power surges are harmless to computer equipment, and they occur without you ever knowing it. However, on occasion, there are can be an extreme voltage surge which can damage computer equipment. The "surge suppressors" that are sold, often for high prices, are advertised to protect your equipment from this type of situation. What is not said by the salesman is that a surge suppressor, when faced with such a condition, protects your equipment by sacrificing itself, and it is destroyed in the process. Thus, it can become very expensive to constantly replace surge suppressors in a place where power surges are common. Fortunately, there is a lower-cost alternative to buying pre-packaged surge suppressors, which I will describe in this article.

A special case of this problem occurs more often than one might expect. That is when equipment is connected to the wrong power line voltage. The most common cases are connecting a unit to 220 volts when the 120-volt setting is selected on the unit, or connecting a 220-volt unit to 380 volts in countries where three phase 220/380-volt power is common. I have even seen the electric power company in one city incorrectly connect a house, so that 380 volts was coming from to all the outlets. There is no fool-proof defense against this sort of error. Some units have an internal protection which will "self-destruct", preventing major damage to the main unit. Still, repair will be required if this happens. When setting up a new computer installation, utmost care should be taken to ensure that this sort of mistake is not being made, before the equipment is plugged in and turned on. Check the power line voltage with a voltmeter. Double check the voltage setting on each piece of equipment before plugging it in.

Data loss due to power interruptions

When the power coming into the computer is interrupted, even only for a fraction of a second, most computers will halt operation, and whatever was in the memory of the computer will be lost. Data that is written on disk usually is not lost, unless the program was in the process of writing at the moment that the interruption occurred. Loss of data can be very costly, and at best it is an inconvenience to the user. There are two areas of defense against data loss. One is to make frequent backup copies of your data. The other is to install standby or uninterruptible power supply equipment.

Data backup procedures are an absolute necessity in any computer operation, and are the only completely sure defense strategy against disaster. The computer user must learn to save his data, and make backup copies as often as necessary to avoid excessive loss of data. How often this is done depends on how much data one is willing to lose.

Standby or uninterruptible power supply equipment is relatively expensive, and its purchase needs to be weighed against the average number of interruptions and their duration per day or week, and the amount of inconvenience and that such interruption to work would cause.

The relative cost of lost work time and of restoring lost data must be considered. In general, a multi-user system in an office or linguistic center will require a standby power system, but for a single-user system, or an installation that has dependable power, it may be an unneeded waste to install such a system. One considers that interruptions to work and restoring lost data are less costly than the purchase of backup power equipment in such a case.

As a note on vocabulary, an uninterruptible power supply (UPS) is one in which the electric power used by the computer is continually furnished by the power supply, which is in constant operation. It is connected to batteries which are constantly being charged by the incoming power line, and when there is an interruption in the incoming power, the batteries continue to furnish power to the computer. Another type of unit is a Standby power system, which does not operate when the incoming power is stable, and will start operation only when there is an interruption in the incoming power line. At this point, the power furnished to the computer is automatically switched over to the standby unit. In general, this type of unit is less expensive than a UPS, and is quite satisfactory. It is true that at the moment of switchover, there is a small disturbance in the power supplied to the computer. But this disturbance is minimal, and is not a source of trouble for most small computers.

Data loss due to power line noise

Another cause of data loss and program interruption which may be experienced in some installations is an electrically "noisy" power line. This is where, for various reasons, there are spikes and variations on the electrical power which are great enough to cause the computer to halt (a system crash), but not great enough to cause damage to the hardware. This condition may be indicated by the occurrence of system crashes without apparent reason. Often there may be other electrical equipment operating nearby, which are the source of the electrical noise. The noise can be either in the form of spikes (short surges) or dips (low voltage). Normally the only precaution necessary against this problem is to install a separate electrical line from the incoming building power to the computer system, and to connect nothing else to this line except the computer system. However, if the condition persists, a special unit called a line conditioner is needed.

A line conditioner consists of a filter, which absorbs smaller spikes, a line voltage regulator which reduces the variations in the incoming line voltage, and a large surge suppressor, which absorbs any further large spikes before they get through to the computer. A good line conditioner is quite expensive, and should only be considered where system crashes due to power line problems are occurring.

Small "surge suppressors" and "line filters" which are built into a power outlet strip are basically ineffective against line noise problems. They may be helpful against a narrow range of problems. They contain nothing more than a small surge suppressor device known as a MOV. Some may also contain a small line filter device. The MOV may absorb certain small spikes, but mainly its only function is to self-destruct, causing a short circuit and blowing a fuse if there is a large surge or spike on the power line. These units are inexpensive to manufacture, and since they can be advertised to improve the security of a computer installation, the manufacturer can charge a higher price for the unit. The surge suppressor costs about 1 dollar, and if it has a small filter unit, that may add about 5 dollars to the cost. But the additional 40 or more dollars that is charged for one of these units is money wasted for the user.

Monitoring the electrical power supply

When a computer installation is to be made, it is wise to first study the power supply situation, to determine what obvious problems exist, before plugging everything in and possibly courting disaster.

An accurate voltmeter that can measure up to 600 volt alternating current (AC) is an absolute necessity. It may be either a digital type or a moving-needle type. I prefer the digital type because it is easier to read, but it is harder to detect rapid voltage changes with this type.

Each phase of the incoming electrical power line should be measured, preferably several times throughout the day for several days, and the voltage noted on a sheet of paper. This way, an idea of any patterns of voltage variation may be observed. Also, carefully observe the voltage reading for several minutes continuously, to see if there are any small or rapid variations. The average line voltage, and the minimum and maximum throughout the day or the week should be thus determined.

When you have an idea of the typical line voltage conditions, it is necessary to make a judgment as to whether they will be satisfactory. Of course it is impossible to give all the rules and considerations here, but a few rules of thumb are as follows:

- For a 120-volt installation, the average line voltage should fall between 105 and 135 volts. For a 220-volt installation, the voltage should fall between 210 and 270 volts. Dips in line voltage below these levels, and surges above these levels should be rare.

- Low voltage dips, which go temporarily below the limits mentioned above, will be corrected by a standby power supply. However, if the voltage stays low for long periods of time, the standby unit will be in operation too much, and will run down its batteries, which will not have a chance to recharge.

- High voltage surges will not be corrected by a standby power supply. If surges are being observed which exceed the limits mentioned above, additional measures must be considered.

- In the case where either dips or surges are occurring, it is necessary to determine what the high and low extremes of the line voltage are. If the average of these extremes is near one or the other limits of the allowable range it may be possible to install a voltage adjusting transformer, which will make a fixed percentage change in the line voltage. The goal is to bring the extremes of voltage variation within the ranges given above. If the range of variations is too great to be shifted into the acceptable range, then a line conditioner is needed.

Rules of thumb for lightning protection

Lightning is best protected against at the point where the electrical wiring comes into the building. Lightning always seeks a path to the earth. The strategy is to provide the shortest path to the earth for the lightning before it gets very far into the building.

The first requirement is a heavy-duty ground connection directly into the earth. The grounding rod should go two or more meters into the ground if possible, and as close to the electrical entrance to the building as possible. The preferred solution is to dig a hole as deep as possible (1 to 2 meters), then to force a smaller hole into the bottom of the dug hole, using a heavy bar for example, another meter or more into the ground. Then take a length of ordinary copper tubing, 6-12 mm in diameter, and push the end of the tube down the hole to make your ground rod. Run this tubing up the outside of the building to the entry point of the electrical wiring, and refill the hole. It is not necessary to keep the rod wet, or to impregnate the ground with salt, as some have suggested. The most important requirement is that the grounding rod be as close as possible to the point where the electric line comes into the building. Also, it should be heavy duty. It may be copper tubing or copper wire, but copper tubing is cheaper than copper wire, and will do just as well. Light gauge copper wire, less than about AWG 8 or 10 mm2 is insufficient.

The tube or wire coming from the ground should be connected to the electrical panel metal box if there is one, whether on the inside or the outside of the building. It also should be connected to the grounding lines if any are installed on the electrical outlets in the building.

In areas where the electrical wiring coming into the building runs above ground and through the air where it may be struck by lightning, it is recommended that some sort of spark gap lightning arrestor be installed at the point where the ground rod comes near to the incoming power lines. I do not have any experience with this type of unit, but its value is indisputable in this situation. Even if a lightning arrestor is not installed, the fact of having the ground rod located close to the electrical lines creates a sort of spark gap, which conducts direct lightning strikes to ground instead of letting them run freely into the building. In the case of a direct strike, there may be burn damage to the electrical wiring, but damage to the computer equipment may be avoided or reduced.

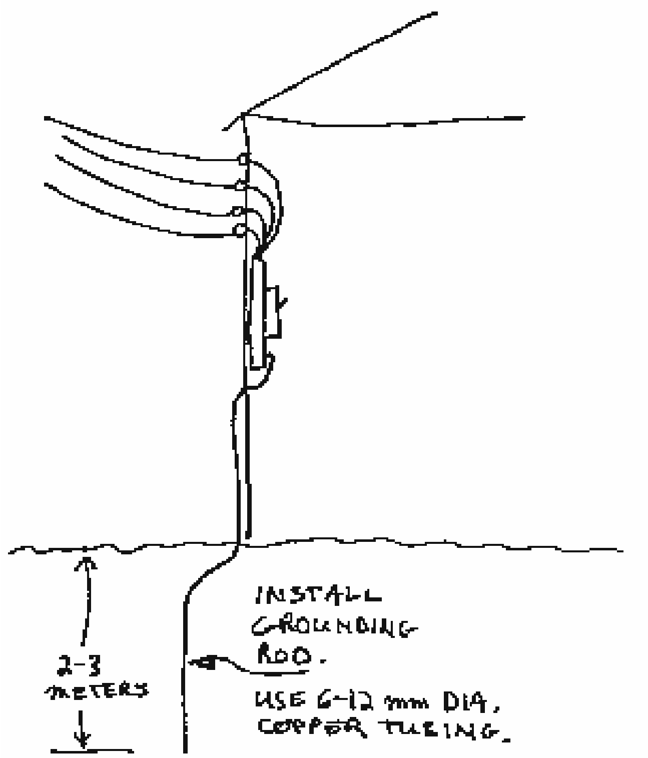

FIG 1. INSTALLATION OF GROUNDING ROD.

The dedicated power line for the computer

A "dedicated" power line should be installed for the computer. This line should connect to the incoming power to the building as close as possible to the point where the electricity comes into the building, such as at a circuit breaker or fuse panel where there is an electric meter. If there is a panel which has a number of branch circuits coming from it, a new branch circuit should be added for the computer if possible, or one of the existing branch circuits should be dedicated to the computer. A cable should be installed to the computer installation point, and nothing else should be connected to this line besides the computer equipment. The line should be heavy enough to handle about three times the expected current load. If it is not possible to determine this, use at least AWG 12 or 2.5 mm2 for runs up to about 20 meters, and heavier if it is a longer run. There should be three conductors, one being the grounding line, which has green or yellow/green insulation. It should of course be connected to the grounding rod that has been installed.

Usually there are two or three phases to choose from to which the new branch circuit may be connected. You should monitor the voltage on each phase for a time with a voltmeter, and select the phase with the voltage closest to the desired level or showing the least amount of variation.

The circuit breaker and surge suppressor

The least-cost solution to protection against power surges, large spikes, and other high-voltage destructive power problems is to install what are known as metal oxide varistor (MOV) units on the power line in conjunction with a circuit breaker. This can be installed at the point where the dedicated power line connects to the electrical power lines, which is the recommended location, or it can be installed at the other end of the line, where it comes into the room where the computer is to be installed.

The purpose of the MOV units is to absorb voltage spikes. This means that any voltage higher than the nominal line voltage will cause the MOV to conduct electricity, absorbing the spike. Of course when it conducts, it will heat up, and there is a limit to how much it can absorb. If it overheats, it then self-destructs and-causes a short circuit. This is why the circuit breaker is needed, to cut off the electric power in case of this kind of protective action. The MOV must be replaced when this happens. However, the advantage is that the MOV's are inexpensive, and the computer installation is well protected in this manner against destructive power surges.

The characteristics of the circuit breaker depend on the practices of the country where the installation is made. In a 120-volt installation, the breaker should probably be a 20-amp unit, and will most likely be single pole. In a 220-volt installation, the breaker should be a double-pole 10-amp unit, or may be a selectable 5/10/15 or 10/20/30 amp unit set for 10 amps. If a "differential" or "ground fault interrupting" breaker is available, it is recommended. In many countries of Africa, a 5/10/15 amp differential surface-mount breaker is available, either French or Italian made, which is suitable for this purpose.

Suitable MOV units may be obtained from digikey.com, Digi-Key, Box 677, Thief River Falls, MN 56701, USA. For 120-volt operation, order part no. P7229. For 220-volt operation, order part no. P7276. It is recommended that you order at least ten units per installation, in order to have spares.

The accompanying diagram shows how to connect the MOV units and circuit breaker.

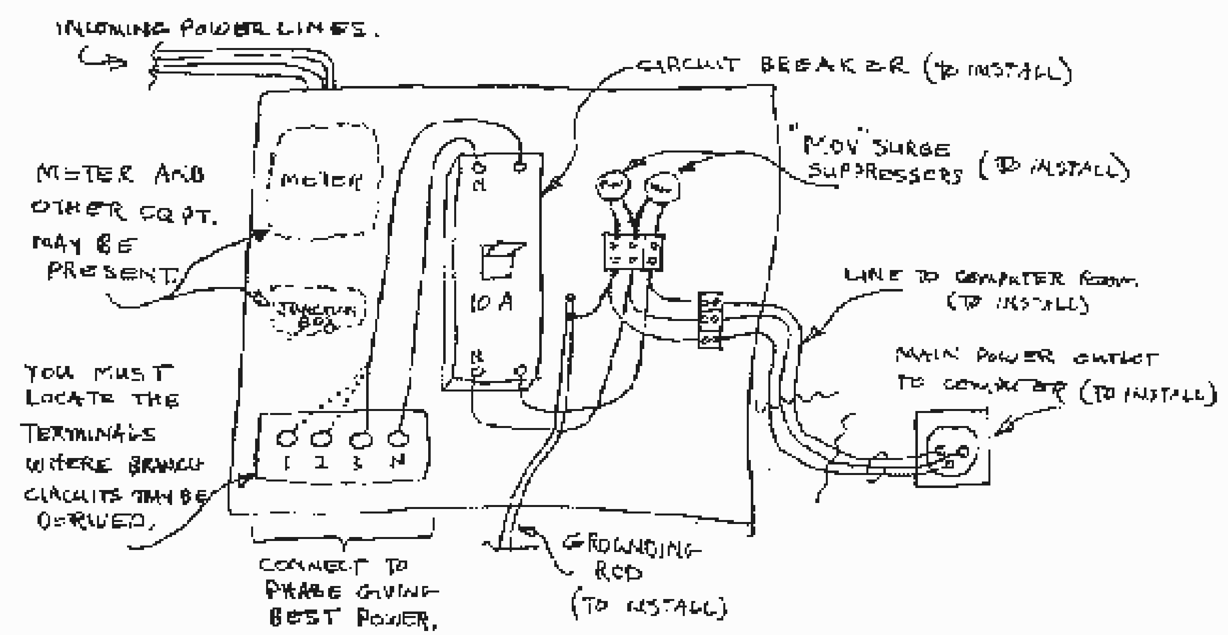

FIG2. INSTALLATION OF CIRCUIT BREAKER AND MOV UNITS. SUGGESTED ARRANGEMENT FOR 220-VOLT AFRICAN COUNTRIES.

Provision of a means for disconnecting the electrical system

As mentioned above, a "free" safeguard against damage when the equipment is not being used is to disconnect it from the power line. This may be by providing a convenient place to unplug the power line going to the equipment. Or it is acceptable to turn the circuit breaker off, if it has been mounted in a convenient location.

Line conditioners

If a line conditioner is to be used, as discussed above, it should be installed after the circuit breaker and MOV units, and before the standby power unit. There are many kinds of line conditioners. If a line conditioner is needed, further study should be made before selecting a unit.

In general I do not recommend the so-called ferroresonant constant-voltage transformer type of unit. This is because they only work correctly if the frequency (i.e. 50 Hz or 60 Hz) of the incoming power is precisely accurate. However in many areas of the world the frequency can very often be off by several percent. If power is being supplied by a local generator, its frequency is certainly not going to be accurate enough for use with a ferroresenant unit.

Standby power system

At some SIM installations, Wilmore 1000-watt standby power supply units have been installed. This unit connects to two large automobile or truck batteries, and is able to operate for several hours before the batteries run down. The batteries should be connected with heavy wire such as automobile starter cable, having at least a size of AWG 0 or 25 mm2.

FIG 3. INSTALLATION OF LINE CONDITIONER AND STANDBY POWER UNIT.

Note regarding Wilmore SPS units. There is a common failure of the battery charging circuit in these units, which causes them to overcharge the batteries. This is caused by a solder joint on the voltage regulator chip that fails due to heat over time. On the average the solder joint must be re-soldered every two years.

Electrical wiring

When installing power for the various elements of the computer system remember that the circuits for the computer equipment must be kept completely independent from all other electrical wiring in the building. Separate outlets should be installed for terminals, printers, etc., and they should be clearly marked so that nothing else will be plugged into them. Three-prong grounding outlets and plugs should always be used, and the grounding wire should always be connected.

In general, electrical wiring should follow the standard practices of the country, but special care should be taken to do a good installation. All wire connections must make positive contact, and not be just twisted and taped together. Double check all screws to make sure they are well-tightened. Cables should be attached to the wall or installed inside the wall, so that they will not be walked on or pulled out of place. All wiring should be done with at least the following wire sizes:

For 120-volt permanent installation: AWG 14
For 220-volt permanent installation: 1.5 mm2
For 120-volt flexible cords: AWG 18
For 220-volt flexible cords: 0.75 mm2

[Home] [Business Package] [E-Mail Systems] [Power Protection] [Helpdesk Chat]