AC Power Conditioning Urban Myths

White Paper

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J2 650 UPS

The J2 650 UPS is a DC, not an AC UPS. The UPS fits conveniently into the base of the unit. Unlike an AC UPS, the J2 UPS for the 650 works more like a notebook computer. In addition to running the 650 for up to one and a half hours, the UPS will also run all the POS peripherals attached to the 650, including the printer. Because of the unique design of the J2 UPS and power supply, the need for special AC power conditioning devices is eliminated.

Overview

This document will explain why the last sentence in the paragraph above is true, that separate AC power condition hardware is not needed. It will also try to dispel many myths associated with these devices. This is a difficult task considering the amount of false and misleading information out in the market by manufacturers of this equipment. The reasons given for the use of AC power conditioning hardware is no longer valid, or is just plain false and not based on scientific fact.

AC Power Problems

Types of AC Power Problems

Computer problems caused by AC power can be broken down into just a few types. These types go by many different and arbitrary names, such as Surge, Spike, Noise, Brownout, Glitch, and more. The list below uses the names the IEEE has defined:

1. Waveform distortion
2. Transients
3. Interruptions
4. Undervoltage / Overvoltage
5. Frequency variations

While it is true that AC power conditioning hardware will eliminate many of the above problems, it is no longer necessary as the modern computer (POS in our case) switching mode power supply acts as an AC power conditioner. The rest of the AC power problems can be avoided by including a UPS in the system configuration.

The strange thing is that the real cause of almost all computer problems caused by power are caused by ground loops, more correctly called inter-system ground noise. These problems cannot be cured by AC power conditioning hardware*. Ground loops will be addressed later in this document.

Note: * One exception to this is POWERVAR's Patented Ground Guard products.

Table 1 shows the type, symptom, cause and solutions for possible AC power problems and which device can prevent the problem.

Table 1

Type	Symptom	Probable Cause	Prevented by 650 Power Supply	Prevented by 650 UPS	Prevented by Power Conditioning
Waveform distortion					
Harmonics	numerous	Non-linear loads	Yes	NA	Yes
AC Offset	Hangs, data loss, unexplained	Bad Grounding, wiring	Yes[1]	NA	Yes[1]
Notching	Hangs	Arc welders, light dimmers, variable speed motor	Yes	NA	Yes
Normal Mode Noise	Hangs, data loss, unexplained	Bad grounding, EMI/RFI interference	Yes[1]	NA	Yes[1]
Common Mode Noise	Hangs, data loss, unexplained	Bad grounding, EMI/RFI interference	Yes[1]	NA	Yes[1]
Transient					
Pulse	Data loss, hang, damage	Lighting, AC line spike, static	Yes	NA	Yes
Voltage Spike	Data loss, hang, damage	Inductive/Capacitive loads on same AC line	Yes	NA	Yes
Interruption					
Blackout	Non graceful shutdown, disk crash, data loss	AC Power outage	No	Yes	No
Momentary AC Power Loss	Non graceful shutdown, disk crash, data loss	AC Line switch, circuit breaker trip	No	Yes	No
Undervoltage / Overvoltage					
Undervoltage	Non graceful shutdown, disk crash, data loss	AC Line Load Change	Yes[2]	Yes	Maybe[3]
Overvoltage	Damage	AC Line Load Change	Yes	NA	Yes
Frequency variations					
Frequency variations	Normally none[4]	Standby Generators	Yes	NA	NA

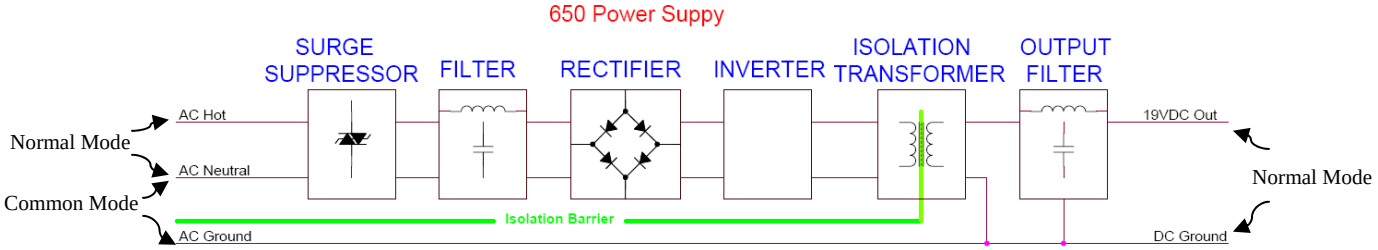
Notes: 1. Bad wiring is a big cause of common mode noise and should be addressed at the source, the wiring. This can be a safety issue as well.
2. The 650 UPS can handle Undervoltage down to 85 VAC independent of AC line voltage.
3: This depends on the AC line conditioning hardware used, most do not provide this protection.
. 4: This is normally not a problem for any switching mode power supply.

The Myth

It is often claimed that common mode noise can cause computers to malfunction and/or be damaged. In the early days of low quality personal computers and POS equipment this was certainly true and at that time the investment in costly AC line conditioning hardware was justified. Today this is simply not true; it is a myth and one that has gained true urban legend status. It is so ingrained into our industry that it causes a great deal of money to be spent unnecessarily. This myth also has the effect that a real power problem, ground loops, is ignored or overlooked with common mode noise being blamed. The common mode noise problem and other power problems were addressed a long time ago by computer manufactures and resolved.

J2 650 Power Supply

The 650 power supply is a 135 watt, 100~240 VAC input, 19 VDC output, notebook type switching mode power supply. As with most current generation computer switching power supplies, the power supply itself provides all the functions of AC line conditioning hardware. Below is a simple block diagram of the supply. This diagram is typical of most high quality computer power supplies used today.



The idea that noise or transients on the AC power lines can be passed through the power supply is just not the case. The very nature of the switching power supply design stops this. In addition, to meet the regulatory requirements for safety and EMI emissions the supply must not pass these transients. The DC output of the power supply has no physical connection to the AC line. It cannot, as dictated by international safety agency requirements, which stated there must be a 0.5cm (3/16”) of physical spacing between the AC line side and DC side of the power supply. The Isolation Transformer in the power supply accomplishes this. As you may note the AC Safety Ground from the block diagram is tied to logic ground. This is a safety requirement and no current should flow through this connection. This is the only physical connection to the AC plug and the power supply will work fine without this connection.

The power supply also has lots of filter stages on the input as well as the output. The fact is that for a switching power supply to work it must have a filter that can cope with voltages as high as 600 volt. The reason for this is simple, it is a switching mode power supply. The incoming AC voltage is rectified to DC then a switching invert changes this back to a very high frequency 20KHz~300KHz*, pulsing DC of 500 to 600 volts. This passes through the isolation transformer where the voltage is stepped down and filtered to DC. As can be seen, noise on the incoming AC line of even 20 or 30 volts is nothing when compared to the “noise, transients” the switching power supply creates itself. The noise is literally lost in the noise.

* The higher the frequency the smaller the isolation transformer can be.

This self produced noise has to be prevented from getting to the outside world, which is done by the filters which also prevent external noise and transients from passing through the supply. This is a must to meet FCC and CE EMI emission standards.

The CE and FCC regulations require that noise injected by the power supply must be less than 0.0005 volts. This means there must be an isolation of 1,000,000 to 1 to comply. This works both ways, it also stops voltage from the AC line from being injected onto the DC output. This means a 30 volt AC transient would produce a 0.00003 volt transient on the DC output. The true attenuation of the power supply is higher than 1,000,000 - it is more like 10,000,000,000.

AC Wiring

Although the 650 power supply does a very good job of blocking common mode noise and other AC power problems, this is not an excuse for ignoring the root cause of the problem which is normally bad wiring. In a correctly wired building the Safety Ground (green or green/yellow wire) and the AC Neutral wire (black wire) are connected together at the circuit breaker panel. This means that the Neutral wire and the Ground wire should always have zero volts differential between them. When they are not this is called common mode noise.*

Normal mode noise is noise or transients between the Hot and Neutral AC wires. These can be caused by many factors; like a motor turning on, oven thermostat switching, dimmer switch and the like. These potential problems are filtered by the power supply but it is still a good idea to keep these noise causing devices off the AC line used by the POS system.

Another myth is having the AC Neutral wire and AC Hot wire reversed will cause problems. The fact is that this will not cause any problems, the power supply treats both AC power lines the same. This does not mean it is OK to accept miss-wired AC connections, just that revered Hot/Neutral lines do not cause power problems for computer systems. (Using a Safety Ground as a Neutral line and vice versa can cause problems.)

It is still a very good idea to have a power line that is dedicated for the computer equipment, or that has as few noise creating derives on the circuit as possible. For safety reasons the ground connect of the AC power point should always be used and wired correctly.

* Note: In some countries there is no safety ground in which case there is no common mode noise.

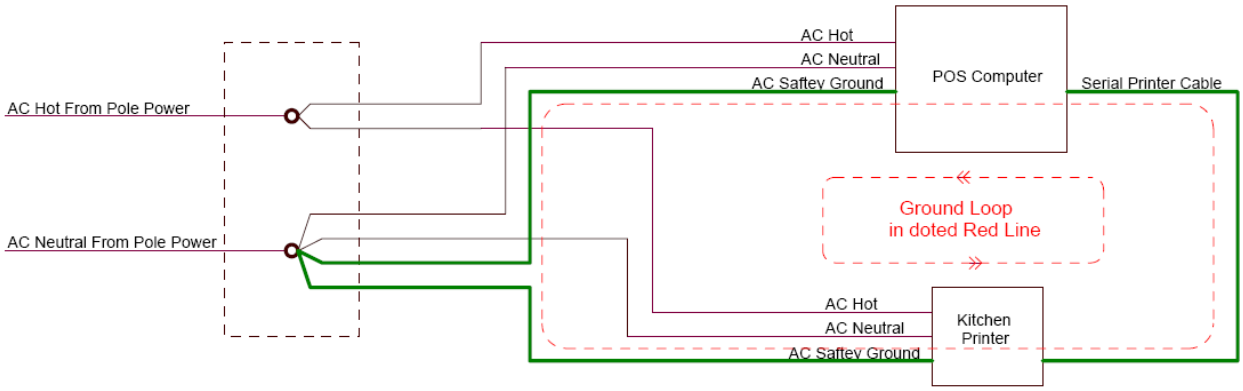
The Real Problem

Ground Loops

A really big power problem that is seen over and over again is ground loops; or more correctly called **Inter-System Ground Noise.** Ground loops are a major source of problems in the real world and are often blamed on common mode noise problems. There are normally caused by RS-232 connections between two devices that have different safety ground potentials. Ethernet connections do not present a ground loop problem as they have an isolation transformer and there is no DC connection between equipment.

As you can see in the drawing below the AC safety grounds and the serial data cable grounds form a loop circuit (the green wires). Remember that the computers logic ground and AC safety grounds are tied together. If the two AC safety grounds are both true grounds then there is no problem.

Figure 2 – Ground Loop



The problems come when the two AC safety grounds are not at the same voltage, relative to each other. If this condition exists it can cause all sorts of problems, including damaging the equipment and/or can cause a safety hazard. There are four main causes of ground loop noise (signal on ground wire). These are:

1: Ground Currents
2: Ground Noise Injection
3: Ground Faults
4: Lighting Induced Voltages

Ground Currents

Ground currents are the most common cause of ground loops. If the AC power of any device connected in the loop are wired to different circuit breaker panels problems can arise. The ground connection between different panels is not always very good. In fact, different circuit breaker panels in the same building may even connect to different power utility's power transformer. This can lead to large voltage differences between the grounds of different circuit breaker panels. The connection between the panels becomes part of the ground loop. Nearby lighting strikes, poor building grounding (common in sandy soil), heavy AC loads on one panel but not the other, can all lead to large voltage differences between systems grounds and can cause numerous problems.

Ground Noise Injection

The Logic Ground and Safety Ground of computer equipment are tied together. This is necessary to filter out EMI noise from the external environment. Some amount of noise will be injected onto the ground line by the filter present in the systems power supply. Normally this is not an issue, but if there is a large distance between interconnected equipment, the noise voltage will be larger and can cause problems.

Ground Faults

If two interconnected devices are on different AC circuits and a circuit breaker trips on one of the circuits, a momentary ground voltage surge will occur on the safety ground of the circuit. This surge voltage can be as high as one half the AC line voltage, 55 volts for an 110VAC circuit or 110 volts for a 220VAC circuit. This voltage will travel over the data cable to the computer on the other circuit because its ground line is still at zero volts. This will most likely cause the interface circuit on both sets of equipment to blow out.

Lighting Induced Voltages

Ground loops can act as an antenna. When there is a nearby lighting strike, its large electromagnetic pulse can induce a large current in the ground loop, causing a voltage differential across the interconnect devices data cable. This voltage can be high enough that it can damage any devices connected in the ground loop.

Avoiding the Problem

There are a number of things that can be done to eliminate ground loops. They are:

1: With the J2 650 unit, use the printer power port for the printer. This totally eliminates the possibility of a ground loop as there is only one connection to the AC power point.

2: Try to plug all interconnected devices into the same power point, or at the minimum, use plugs on the same circuit from the circuit breaker panel.

3: If a long data cable run to a printer is required, consider using an IP Printer (printer with Ethernet interface) as there are no ground loop problems with Ethernet devices. (Opto- isolators for RS-232 are available but are costly and normally only pass the data signals through, so X-ON/X-OFF hand shaking needs to be used.)

Advantages of DC UPS

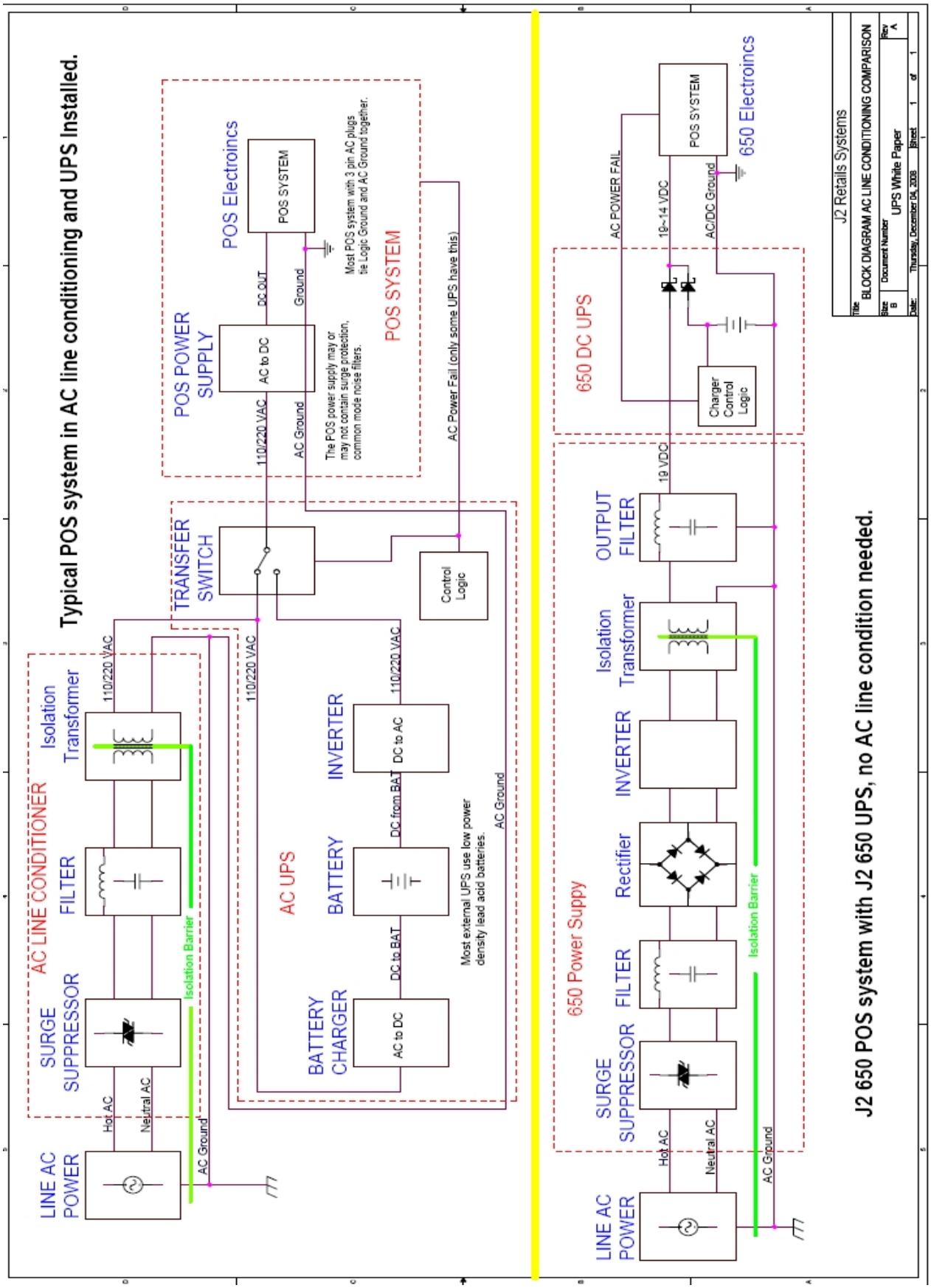
The common external UPS is an AC to AC device; its output voltage is the same as the AC line voltage in. This would be 110VAC in the USA. The J2 650 UPS is a DC device whose input is 19VDC and output is 19VDC~13.5VDC. As you can see in the block diagram at the end of this document, the 650 UPS acts as an extra filter to isolate the DC voltage of the 650 POS computer from the AC line voltage.

Most external UPS use low power density lead acid batteries. These batteries have a short lifetime when used in a high heat environment, like in a kitchen. Because of this weakness the batteries may fail when needed most. The Lithium Ion battery used in the J2 650 UPS does not have this problem.

The use of the Lithium Ion batteries and notebook charging technology allows the J2 650 UPS to be 1/8 the size of an external UPS while still having 3 times the battery run time of an external AC UPS.

Conclusion

When using the J2 650 with its UPS option, all potential power related problems can be avoided without the need to use expensive external AC line conditioning hardware. The J2 650 power supply and UPS combination will take care of these problems. The only other thing needed is to insure that ground loops are not created when installing the equipment.


Typical POS system in AC line conditioning and UPS Installed.
LINE AC POWER
Hot AC
Neutral AC
AC Ground
AC LINE CONDITIONER
SURGE SUPPRESSOR
FILTER
Isolation Transformer
110/220 VAC
Isolation Barrier
AC UPS
BATTERY CHARGER
AC to DC
DC to BAT
BATTERY
DC from BAT
INVERTER
DC to AC
110/220 VAC
Most external UPS use low power density lead acid batteries.
TRANSFER SWITCH
Control Logic
AC Power Fail (only some UPS have this)
POS POWER SUPPLY
AC to DC
110/220 VAC
AC Ground
DC OUT
Ground
POS Electroincs
POS SYSTEM
Most POS system with 3 pin AC plugs tie Logic Ground and AC Ground together.
The POS power supply may or may not contain surge protection, common mode noise filters.
POS SYSTEM
650 Power Suppy
650 DC UPS
AC POWER FAIL
19~14 VDC
AC/DC Ground
650 Electroincs
POS SYSTEM
Charger Control Logic
OUTPUT FILTER
19 VDC
Isolation Transformer
INVERTER
Rectifier
FILTER
SURGE SUPPRESSOR
Isolation Barrier
J2 650 POS system with J2 650 UPS, no AC line condition needed.
J2 Retails Systems
BLOCK DIAGRAM AC LINE CONDITIONING COMPARISON
UPS White Paper
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