White Paper # 250

The Truth about Ground Loops and Ground Guard® in POS Applications

POWERVAR
Solutions for Power Quality®

Introduction

This white paper discusses the function of POWERVAR's Ground Guard® power conditioner in the POS and networked environment and specifically corrects false information that is being distributed regarding the product's function and capability. Supporting information is included, where relevant, for easy reference.

An attempt to mislead

Recently, a power protection manufacturer has been distributing a reprint of an article authored by Mark Waller of Waller and Associates and originally appearing in the April 2000 issue of Smart Power Quarterly. A copy is included with this white paper for reference.

While not naming POWERVAR in particular, the Waller article is being provided to POS resellers and OEMs as a means of disparaging POWERVAR's patented proprietary Ground Guard power conditioning technology. Waller's article factually describes the nature and origin of ground loops and then arrives at the following two conclusions:

1. Ground conditioning technology should not be employed because the action of transient voltage surge suppressors will result in a voltage drop across the ground conditioning inductor which will itself create the very voltage differential that causes ground loops.

2. Ground loops no longer exist within modern network topologies due to the universal use of either fiber optic cable or Category 5 UTP.

The first of Waller's conclusions is founded upon two easily overlooked but clearly misleading premises as illustrated in Figures 2 and 3 of his article. Waller states, *"For simplicity sake, we have left out the power conditioning sections and only shown the choke and how it fits in the ground circuit."* With reference to Figure 3, Waller continues, *"Figure 3 shows what happens if we add this choke into the safety ground path along with the addition of a Transient Voltage Surge Suppressor."*

Waller's attempt to "simplify" the situation for the reader is clearly disingenuous for two reasons. First is that his simplification has conveniently eliminated the isolation transformer that is at the heart of all POWERVAR power conditioning technology. The isolation transformer's low impedance design makes it the perfect inductive buffer between the computer load and any line-side generated transient voltage. As a result, the voltage clamping and equalizing current that Waller so ominously describes never take place. Neither does the line driver destruction he warns about.

Second, Waller's illustrations clearly show ground conditioning technology in place on only one component of the network. POWERVAR installation guidelines clearly state that for total effectiveness, Ground Guard must be installed on every node of the network. Again, Waller's explanation of ground conditioning deployment is more misleading than accurate.

Ground Guard technology is always manufactured as part of a hybrid power conditioner incorporating a low impedance isolation transformer. It is never available as part of a transient surge suppressor (TVSS) product. Ground Guard must always be installed on all network nodes. If, for some reason, a node cannot be protected with Ground Guard, it should be isolated from the network with an opto-isolator or fiber optic cable.

If Ground Guard technology were deployed as Waller describes, his first conclusion would be true. The conclusion is not true, however, since his basic premise is false.

Waller's second conclusion is that ground loops are a non-issue. His statement is based on the assumption that all modern networks use either fiber or Category 5 unshielded twisted pair (1000BaseT).

In fact, not all installations use these communication topologies. Shielded data cables are still common in non-Ethernet communications environments and, in fact, shielded Category 5 cable is also found from time to time.

In addition, it should be noted that Category 5 UTP will migrate toward Category 6 cable, which is referred to a STP (Shielded Twisted Pair) or ScTP (Screened Twisted Pair). Specifications are also under development for Category 7 cable, which is referred to as SSTP (Shielded Shielded Twisted Pair).

Finally, it's important to note one final premise in the article. Waller states, "*In rare instances, there may be a shield, but even then, the shield is only bonded on one end.*" Floating one end of a data cable's shield is a hazardous proposition. High energy transients caused by lightning as well as lower power disturbances associated with electro-static discharge, can create harmful open circuit voltages when one end of a shield if floated. These voltages can disrupt or destroy data ports as a result of "flashover" into the data conductors themselves.[1]

For this reason, as well as concerns surrounding radiated emissions, Category 6 and Category 7 wiring specifications restore the shield to the data cable and furthermore will require that the shields for these cables be terminated on <u>both</u> ends of the data cable.

Conclusion

Parts of the Waller article are factual. However, the article displays a number of faulty premises leading to equally faulty conclusions. POWERVAR's Ground Guard technology does not resemble the illustrations used to arrive at the article's conclusions, and therefore, the conclusions do not apply to Ground Guard. In addition, the article ignores future technological developments, which are likely to reintroduce ground loops into almost all network installations.

Ground Guard is the only field proven alternative to dedicated/isolated electrical wiring. We can only conclude that those distributing this article as a sales tool do so because they misunderstand the design, how it works, and how it is to be applied.

[1] Shielding Continuity and Grounding, Tom Shaughnessy, PowerCET Corporation, Pg. 79-80, Power Quality Magazine, May/June 1998

Ground Loops - Truth or Consequences

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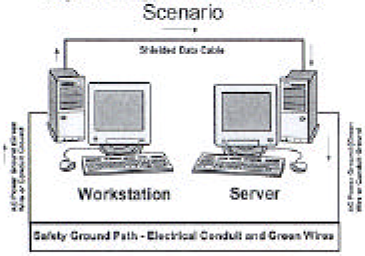
The history of computing is littered with sites where ground loops have cause no ends of headaches for data center and facility managers. That was then – this is now. The simple fact is that ground loops are a decreasing and fast disappearing problems. Yet, despite this, there are products on the market that purport to solve the ground loop problem. This article addresses why you do not want to solve a problem that no longer exists. Why? Because the way these devices solve the problem creates another, more sinister problem – damage to the data port of the device that is supposed to be protected. But before we get into all of that, let's define "ground-loop."

Looking at figure 1. We can see that if the data cable represented a continuous electrical ground path, then a loop between the server ground and the workstation ground would be formed. How would this happen in real life?

Figure 1: Typical Ground Loop Scenario



Consider that the workstation is on the floor above the server and at the opposite end of the building. Separate transformers would most likely serve the two, but there would be a continuous ground path between them. The National Electrical Code requires that the ground path in a building be continuos and integrate the green wire grounding conductors, conduit, electrical panels, even building steel. So the safety ground path would tie the two systems together regardless of the power source.

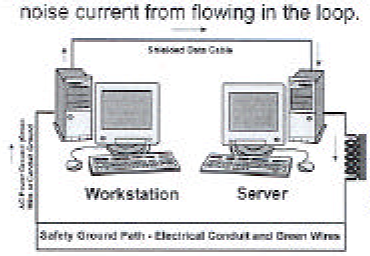
The data cable, in days of old, would have been a shield cable of some kind with both ends bonded to the chassises of the networked devices. This grounded shield would have provided the ground path that would have completed the loop circuit. Now whenever some large load cycled or something is turned on, it is easy to see that either transient or steady state ground potential differences could appear between these two systems. In order to equalize this potential current would flow through the loop. The current flowing though the data cable can itself be the source of voltage differences that are presented across the line driver chips at either end other the data cable.

In essence, the attempt to solve the ground loop problem has made the LAN more vulnerable to surge voltages!

This ground loop problem was especially bad when the systems were a long distance away. Separate buildings made the situation virtually unsolvable. Because of this scenario it became the goal of many power quality solution manufacturers to address this issue in their power conditioning designs. The logical thing to do was to try an block the flow of this unwanted current in the ground path. But it was difficult to design a circuit that would accomplish this without also blocking the fault current that was supposed to be able to flow through a low impedance ground path to open breakers.

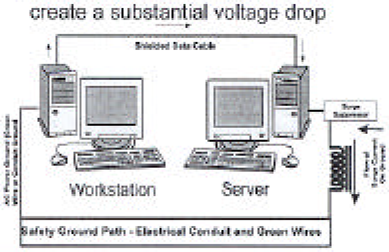
Finally, someone was able to design a choke that presented a high impedance to the loop current but was still at a low impedance to 60 Hz fault current. This was inserted into the ground of a power conditioner to provide the added protection from unwanted ground loop current. We have shown this concept in figure 2. For simplicity sake we have left out the power conditioning sections and only shown the choke and how it fits in the ground circuit.

Figure 2: The insertion of a choke blocks noise current from flowing in the loop.



A choke is nothing more than a coil of wire wound around a core of iron or steel. As the loop current flows through the device the magnetic field from this current induces a current that is opposite in polarity from the original current. The result is that the two currents want to cancel one another thereby blocking the flow of ground loop current.

Figure 3: Surge current flowing through the local grounding conductor will create a substantial voltage drop



This seems like it solves the ground loop problem for good, doesn't it? But there are two reasons why you do not want to use this approach. Let's look at the more technical of the two issues first.

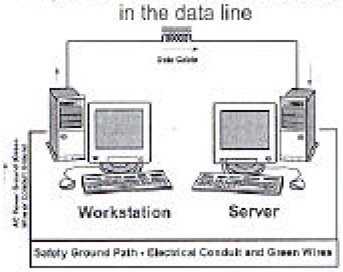
Figure 3 shows what happens if we add this choke into the safety ground path along with the addition of a Transient Voltage Surge Suppressor. This TVSS might be on a data line or a power line. When a voltage difference appears between the line that the TVSS is tied to an ground, the surge suppressor clamps the line to ground. At this point a current flowing to ground equalizes the voltage difference between the line and ground. The arrows in the diagram show this.

The choke becomes a high impedance to this surge current. What happens? A large voltage drop is created and the server, in this illustration, would appear to rise with respect to the workstation connected on the other end of the cable. In other words data will suddenly go high because of the voltage drop through the ground path. This would happen in any event, but the effect is going to be much more dramatic do to the introduction of the choke. This is determined by the formula E=L (di/dt) where E equals the voltage drop, L is inductance, and di/dt is the rise in current over time. By introducing the choke we are dramatically increasing L which has a direct relationship to the voltage, E.

Now, there is a line driver chip on the other end of the data cable that is expecting to see logic level of less than 5 to 15 volts. All of a sudden the line goes high with respect it its ground by dozens – even hundreds of volts. If this is a TTL line driver and the voltage difference is over 40 volts, the chip will be destroyed. In essence, the attempt to solve the loop problem has made the LAN more vulnerable to surge voltages!

There is a way of solving the ground loop problem without creating the issue we have just described and stay out of the safety ground path at the same time. This solution is shown in figure 4. Here we have moved the current opposing

Figure 4: The Insertion of a Choke in the data line

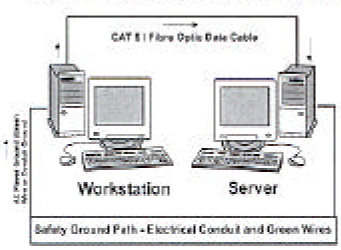


choke to the data cable. There are several ways of doing this. We might be able to get rid of the ground loop noise merely by coiling up the data cable. This forms a crude choke by adding inductance to the ground path. If that doesn't work we can coil the data cable around a core. Ferrite forms or jigs of various sizes have been around for years to serve exactly this purpose. There are also manufactured chokes for various kinds of coax and other shielded cable types that have been available.

Clearly, we can see in figure 4 that the insertion of a choke in the data cable is not going to increase safety ground path impedance. Therefore, surge energy will not cause increased voltage drops between systems.
Finally, having dealt with the more technical of the two reasons we do not want to use additional impedance in the ground path, lets look at the amazing truth. This problem is not a problem. What? That's right. In modern LAN installations there are no ground loop issues for one reason. As shown in figure 5, there is no ground path in the data cable. This is because we are going to use either fiber optic cable or Category 5 cable.

The benefit of fiber is clear. Electricity can't flow through glass, therefore no ground loop. Category five cable, on the other hand, is metallic. However, there

Figure 5: Cat 5- or Fibre Optic Cable has no metallic ground connection



is no ground! In rare instances there may be a shield, but even then the shield is only bonded on one end. So basically the "choke in the ground" solution to loop current solves a problem that no longer exists.

Granted, in older installations using RS 232 cable or coax there may occasionally be a loop problem. Modern installations simply are immune to the issue. The question comes up then: why buy a product that only serves to increase system vulnerability to surges? Good question. We recommend that money spent on ground loop protection is better spent elsewhere.

Mark Waller is a leading authority on Power Quality. He is the Author of Computer Electrical Power Requirements, as well as PC Power Protection, and frequently lectures, trains and consults Utilities and Power Quality Organizations.