Ground Loops

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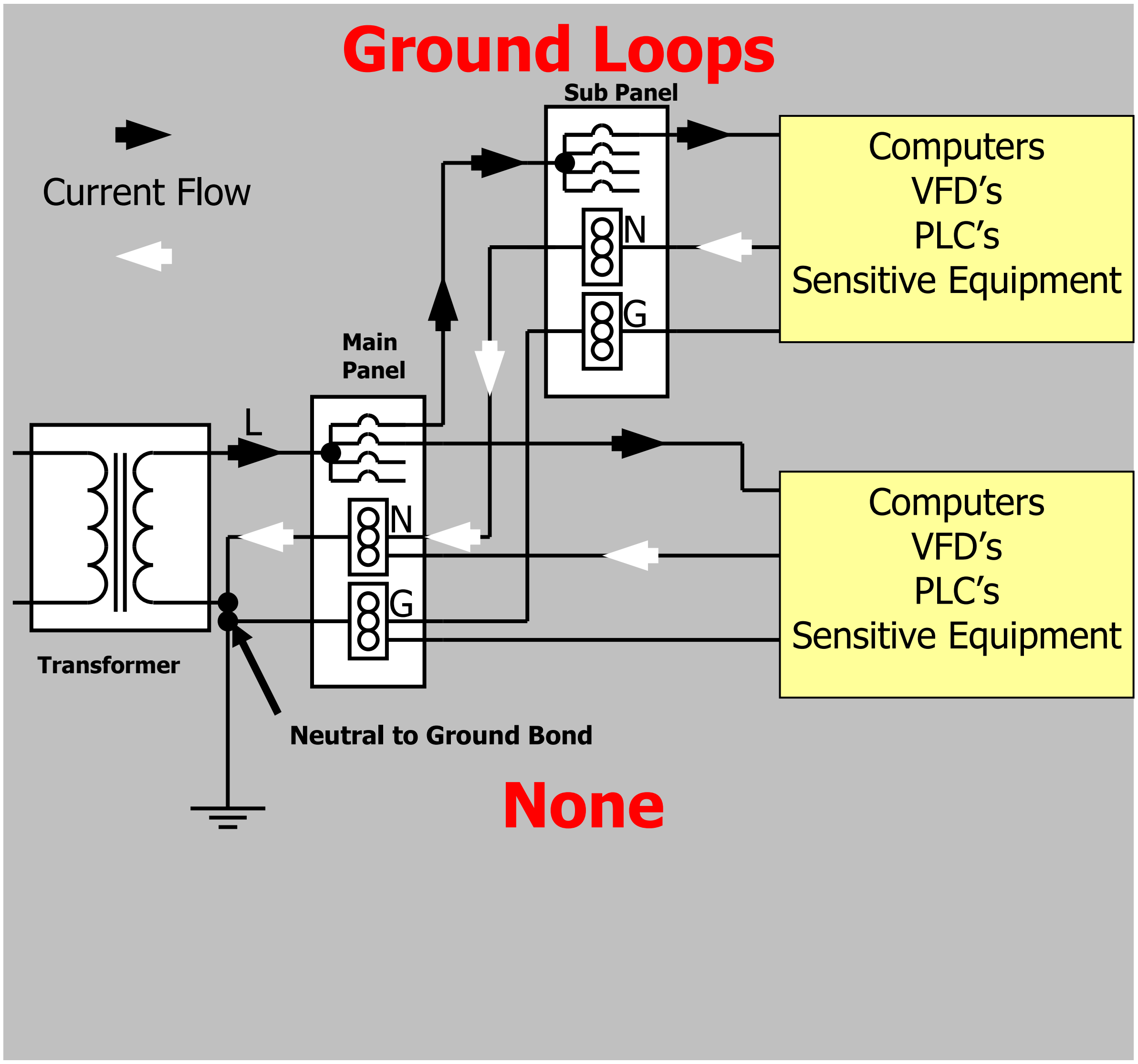
Quite often we hear this term “Ground Loop” when searching for causes of equipment damage or malfunction. Many equipment manufacturers and troubleshooters determine that ground loops are causing their equipment to fail or not work properly. With this article we are going to explain exactly what a ground loop is how a ground loop can damage equipment and how to avoid ground loops.

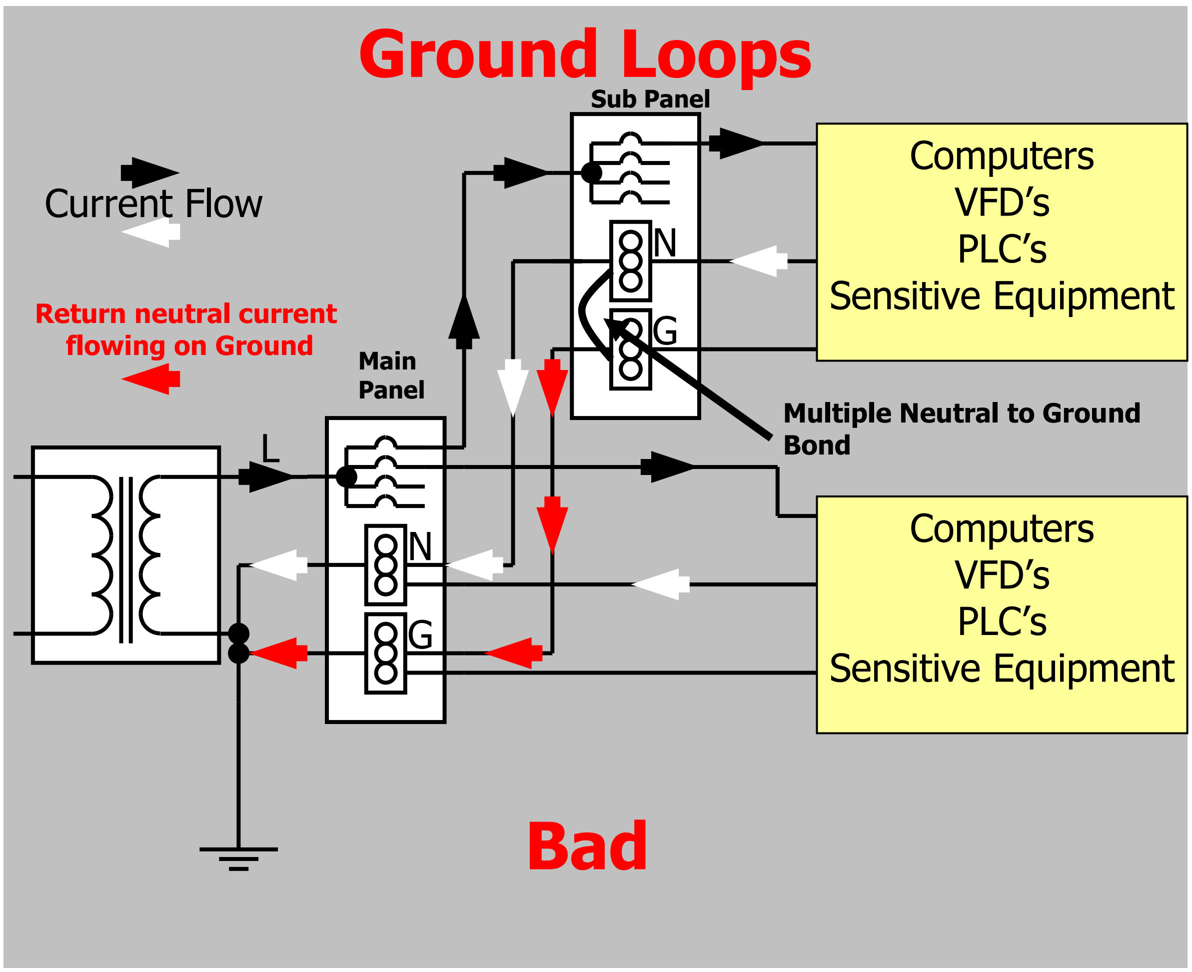
A ground loop occurs in a power system when a path is provided for neutral current to flow into your grounding system outside a proper neutral to ground connection. To illustrate this we will start with the following power system diagram without a ground loop.



With this diagram we can see a transformer feeding a Main Panel which also feeds a sub panel and equipment. The sub panel also feeds equipment. At the output of the transformer we have the neutral to ground bond as required by the National Electrical Code and by IEEE standards. This bond is very important for both safety and power quality purposes.

Under normal operation the current flow in this system is as follows. Current leaves the transformer (Black arrow). Flows through the Main Panel and its circuit breakers (Black arrow). Through the sub panel into the equipment so that it may operate (Black arrow). Neutral current then flows back from the equipment (White arrow). To the sub panel neutral bar (White arrow). Back to the Main panel neutral bar (White arrow). And finally back to the transformer via the neutral to ground bond. This is the proper way to design and build a power system.

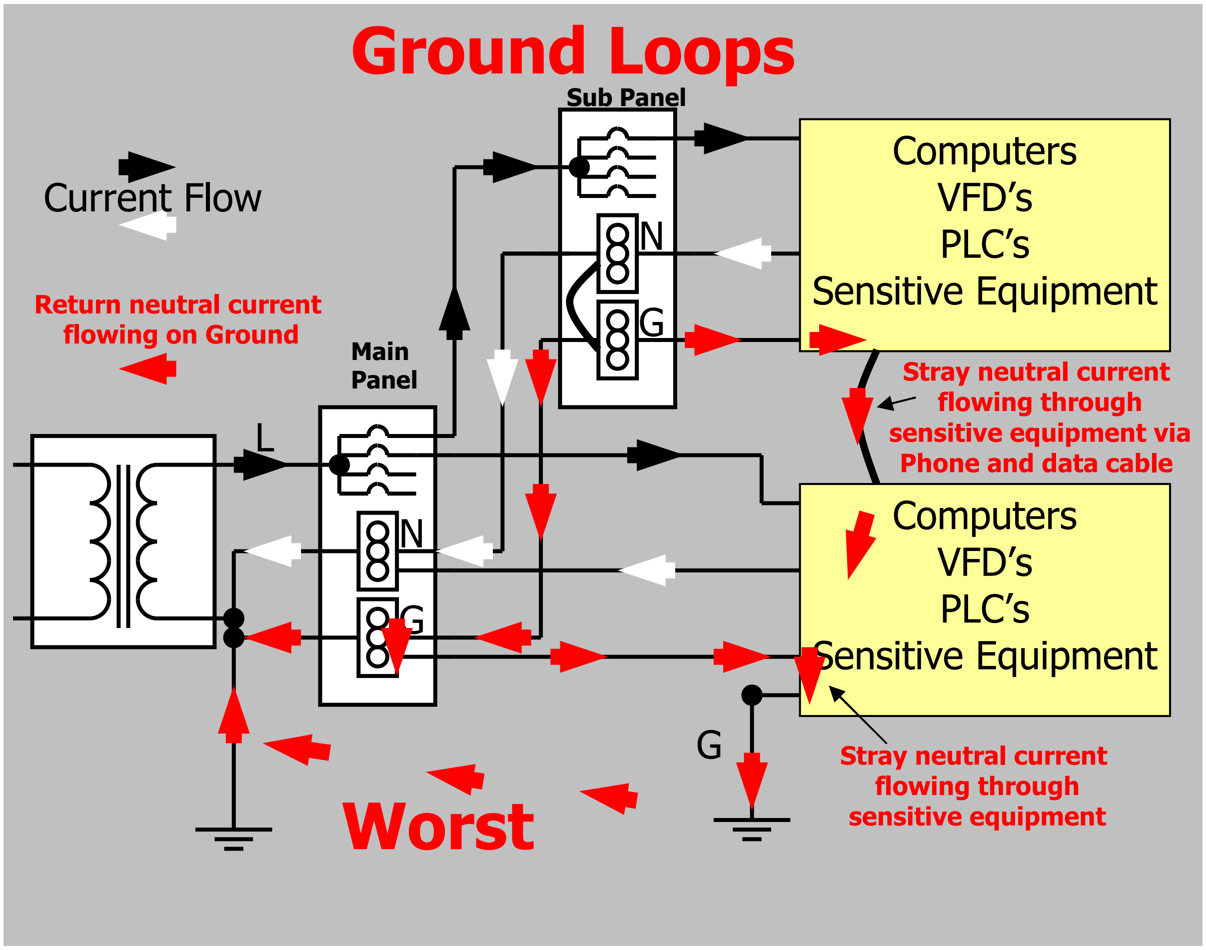
The "ground loop" problem appears when multiple neutral to ground bonds are made. These other bonds may be intentional or by accident. Let's look at an example of a ground loop.



Notice at the sub panel a neutral to ground bond. This is in addition to the neutral to ground bond located at the transformer. This is not only a National Electrical Code violation but also a power quality problem. By adding the multiple neutral to ground bond we alter the path for neutral current in our system. Current now flows in the following manner.

Current leaves the transformer (Black arrow). Flows through the Main Panel and its circuit breakers (Black arrow). Through the sub panel into the equipment so that it may operate (Black arrow). Neutral current then flows back from the equipment (White arrow). To the sub panel neutral bar (White arrow). But now we have introduced another path for current flow. Current not only flows back to the transformer via the original route but also flows on our ground conductors from the sub panel to the main panel back to the transformer (Red arrow). This is not a good situation. With any current flow through a resistance we WILL have a voltage appear. This is ohms law. All ground systems have resistance. When we introduce current into a ground system with resistance we WILL have voltage appear on the ground system. **These voltages can and do cause equipment failure, equipment malfunction and data signal problems.**

This current flow on the ground is not limited to flowing through our facility ground. Many other paths for this misdirected neutral current exist. The following diagram shows current flow (Red arrow) from the power system ground flowing into the ground of sensitive equipment. Not only will this current flow into the power systems of this equipment it will also make its way into the data and phone grounds causing damage and lost data.



With the above information we can see that the elimination of multiple neutral ground bonds is very important when addressing power quality problems. Multiple neutral to ground bonds can occur in many areas. Quite often not only one sub panel has a multiple bond but all sub panels in a facility. Many wall outlets are mis-wired with the neutral connected to the ground. Some equipment manufacturers mix the neutral with the power system ground. These are just a few of the examples of multiple neutral to ground bonds. In small facilities it can be a very tedious endeavor to eliminate all improper multiple neutral to ground bonds. In a large facility is can be almost impossible. Therefore, the use of harmonic cancellation isolation transformers, all mode Transient Voltage Surge Suppression with Neutral to Ground protection, and low harmonic UPS Systems are a viable solution to ground loop problems.