

Neutral-to-Ground Bonding: Not An Option

There you are, driving your brand new car off the dealer's lot. You get to the street and accelerate. Then the unthinkable happens! All four hubs fly off and your shiny new wheels hurtle down the street. Sure, your engine's running at full rpm – but you're not going anywhere without those wheels.

Kind of silly, right? Surely this wouldn't happen to you. You would certainly expect that the wheels and hubs would be bonded together according to the manufacturer's requirements. This "dead in your tracks" scenario has a lot more in common with surge protection devices (SPDs) than you might think.

The National Electrical Code® (NEC®) explicitly defines grounded conductors and grounding conductors as follows: *A grounded conductor is the wire common to all phases in a multi-phase system.* This conductor is more commonly known as the system neutral conductor.

A grounding conductor is the grounding electrode for the multi-phase electrical system. This is the conductor most often referred to as the ground conductor.

Article 250-26 discusses the grounding of a separately derived alternating current system and states that "...a bonding jumper shall be used to connect the equipment grounding conductor of the derived system to the grounded conductor. This connection shall be made at any point on the separately derived system or at the source of a system that has no disconnecting means or overcurrent devices. The intent of this section is to permit this connection at the transformer."

Why is a missing bond a problem?

If a short occurs between a phase and ground without the presence of a neutral-to-ground bond at the upstream transformer, the distribution system's neutral conductor will "float" or lose its reference to ground. The floating neutral condition can cause voltages to float to a maximum of 208 volts RMS relative to ground, subjecting loads to a sustained overvoltage condition.

Even if one assumes light or balanced loading, the electrical distribution system may operate without any apparent side effects for quite some

time. Should the loading become unbalanced or an electrical short occur, the phase voltages will fluctuate severely.

How does sustained overvoltage cause problems with SPDs?

Most SPD manufacturers include 25 percent "headroom" in their products to accommodate normal voltage fluctuations routinely generated by the local utility provider. By utilizing 150 Vrms MOVs (metal oxide varistors), the device should be safe from the 10 percent voltage deviation a utility is likely to produce.

However, any voltage exceeding the value would cause the components to conduct. The continuous conduction is what the SPD components are not designed to handle.

This condition is what causes the majority of SPD failures as explained by Dr. Francois Martzloff in his article "What Are the Lights on Your Surge Protector Telling You?" (*Power Quality Assurance, July 1998*). * Recently, a major printing plant and high school (which used different electrical contractors) reported their SPDs had failed during installation. Upon visiting the sites, engineers quickly discovered the problem. In both cases, the neutral-to-ground bond was not made at the transformers. A short occurred that caused at least two phases to encounter sustained overvoltages in excess of 150 Vrms.

It is very important to know that this short would have occurred regardless of the type of SPD product or particular manufacturer. That's because the MOVs (metal oxide varistors) used in SPDs are designed to share current at the microsecond time frame – and not to survive sustained overvoltages.

The amazing thing is that the electricians for the school and the printing plant were unaware that the NEC requires establishing the neutral-ground bond on the secondary side of the transformer.*

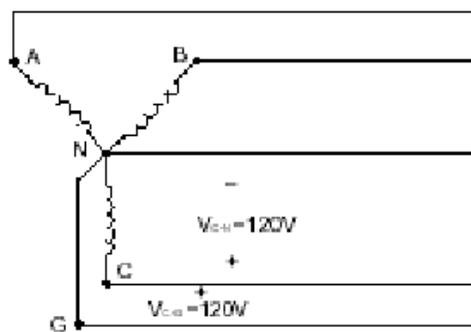


Figure 1: illustrates a typical 3-phase grounded WYE distribution system. With a solid neutral-ground bond, voltages should not fluctuate and should be approximately as follows:

$$\begin{aligned}
 A-N &= B-N = C-N = 120V \\
 A-G &= B-G = C-G = 120V \\
 A-B &= B-C = A-C = 208V
 \end{aligned}$$

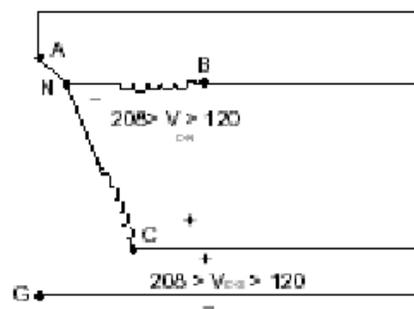


Figure 2: Illustrates one possible situation occurring due to the absence of a neutral-ground bond. Should phase "A" short to neutral or ground, the phase angle of the remaining phases will change. This allows the voltages referencing phases "B" and "C" to float, potentially reaching a magnitude equal to the available phase-to-phase voltage of 208V.