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### **Common mode electrical noise can cause system shutdowns relating to signal transmission problems.**

Over the years, we've spent considerable time in covering electrical noise phenomena that travel around wire pathways. In past discussions, we've reviewed the effects of electrical noise circulating in our NEC wiring systems and their impact on digital signal systems. The name for this bothersome culprit, the mystery noise not easily understood or identified, is common mode noise. Let's look more closely at this problem area.

#### **What's it about?**

By definition, common mode noise is electrical noise that occurs on all conductors of an electrical circuit at the same instant. You'll see that it's illusive since, when you measure line-to-line or line-to-neutral voltages, there will be no voltage difference at any point in time. But, while you're reading zero volts on your measuring device, there may be significant voltage between a conductor or neutral and the safety ground connection.

One effective way to "see" this noise is to measure between the power system neutral in a panelboard and the case ground (signal reference) of a load device having a digital signal system. A system where the power system neutral and the equipment case ground are not referenced to the same potential may experience very sharp surges or spikes.

The level of regular ambient noise in the wiring system (perhaps 1V to 2V) can even interfere with the low level signal voltages of the digital systems. The character of this disturbance can be described in terms of a signal-to-noise ratio. In addition, as newer digital systems with lower and lower power and logic voltages are coming into our marketplace, and this ratio is being reduced. What is a very positive ratio of 30V signal: 1V noise, or 15:1, or even 5:1, is getting close to a 1:1 ratio. Or even less, in some instances, perhaps 1:2! At this level, our digital signal system tries to run on the noise voltage level (which appears higher) instead of the correct logic voltage. Finding no secure signal interface, the system now "reports" to the main processor that there is no signal. As a result, the overall system shuts down rather than attempting to run when its operational integrity is at risk.

#### **How do we eliminate the problem?**

Since we can't monitor this noise by connecting our disturbance analyzer line-to-line or line-to-neutral, we have to make a phase-to-ground or a neutral-to-ground connection. The latter connection may seem like nonsense, since the steady state voltage reading of neutral-to-ground is supposed to be zero. However, this connection shows us when ground loops are active in our wiring circuit. Remember, this measurement between the power system neutral and the case ground of a piece of digital signal equipment is the best way of finding out what's going on in our signal reference circuit.

#### **Noise coupling: How does it get there?**

Are there any other ways to inject electrical noise into wired circuits or sensitive equipment? If only 60-Hz power conditions are considered, we might answer, "No, since the power follows the wires." Even with such a simple answer, we would have forgotten about the electrical and magnetic fields associated with 60-Hz currents, and how they might "couple" their influence into other metallic circuits. Also, the effects of different frequencies, especially the high frequencies associated with high-speed transmissions, must be considered. While this subject matter is vast and worthy of extensive study, let's look only at some of the basics to get a handle on the dangers of neglecting noise coupling overall.

Many site visits and case studies have shown that forgetting the different means of injecting noise leads to "weak links" in our noise rejecting and protecting methods. Let's begin with noise coupling through the wires of our facility.

One of the valuable tools used to cancel or slow the effects of high frequency noise traveling in a wiring system is the coil or choke. Remember that an electrical coil resists a very fast voltage spike trying to force

itself through the circuit. The term used for the coil's performance is inductive kick. Actually, the coil develops a voltage that opposes the high-speed spike's travel, thus softening or reducing its effect on the circuit. The usual application of a choke or coil is in series in a circuit where such a dangerously high spike might damage or destroy sensitive components.

The same results are obtained when we make an air core coil. This is done by simply coiling six to seven loops of an extension cord that may be in the power circuit of a sensitive device experiencing circulating spikes coming down the ground wire in an actual ground loop. A suggestion is given to make the temporary coil to determine if the problem is really a high-speed voltage traveling down the grounding conductor.

### **Case history**

Several years ago, we were asked to help a man trying to make a final test facility "keep running." When we examined the conditions, the man said he needed to have an uninterrupted four-hour period of operation in order to validate the final production test for his product. He was bothered by power quality problems, which he assumed were due to unstable power delivery from the local electric utility.

With the assumption of a power problem, the man bought all kinds of power conditioners: Voltage stabilizers, line conditioners, even a small battery-supported UPS. (With the UPS, he reasoned that "surely nothing would get through to the test equipment.")

If the problem was on the power line, he would have been correct. But it turned out the disturbances were coming out of the ground reference for the digital signal drivers and receivers in the test circuit. Thus, all of the "cures" (in the form of power equipment), while doing fine for line-to-line noise, did nothing for common mode noise.

We disconnected the test equipment and made temporary coils in the cord sets to see if we could stop any high-speed traveling spikes on the grounding conductor. As we suspected, the disruption stopped, and the test equipment did its job while running without interruption, even with all the power conditioning devices removed.

Notice that this is a neat diagnostic trick, even if you don't see the same results seen in our example here. What do we mean? Well, if you do see the same kind of improvement, you know that the disturbance is traveling down the ground wire. You then use a transformer or a balun as a permanent fix.

But would you learn anything if you did not get results? The answer is YES; you would have settled the issue of noise spikes coming down the wires. In other words, this method gives you an answer in either case. Either you know what's there and can fix it, or you know what's not there. If no results are obtained, you don't need to continue to look for the "wired" form of noise, but can look for some other means for the noise to be disturbing to the host equipment. This is invaluable as a quick check on where to start. Consider the following example for a practical study of this quick check idea.

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