From Power Quality Solutions; Case Studies for Troubleshooters

Common-Mode Noise
A voltage or current signal which is measured between two electrical conductors where there should be no signal at all. Typically, this is measured from any phase conductor to ground, and may cause data transfer corruption or equipment lock-up.

Common mode noise is a power disturbance particularly troublesome to control. Common mode noise, as its name implies, is any unwanted signal that is common to all circuit conductors simultaneously. The other form of noise is normal mode noise (also known as transverse or differential mode noise) which is any unwanted signal that exists between the circuit conductors. In AC power systems, the difference in potential between neutral and ground is one form of common mode noise, since any change in neutral potential relative to ground also affects all of the other power circuit conductor potentials to ground. Another more troublesome form of common mode noise is the differences in ground potentials throughout an electrical system. When multiple electronic devices are interconnected by way of control, data or communication cables, any difference in ground potentials between the interconnected pieces of equipment is common mode noise to the control, data or communication circuits. It is virtually impossible to keep all of the (chassis) ground potentials of distributed electronic devices at the same potential under all possible circumstances.

Therefore, some level of common mode noise immunity must be designed into electronic devices intended to be interconnected. Further, the surge suppression, wiring, shielding and grounding of the building's electrical system (including the control, data and communication cabling) can have a pronounced effect on the levels of common mode signals to which the electronics are exposed.

Because equipment ground potentials (or changes in them) have been observed to affect the operation of certain electronic devices, designers, installers and service personnel often have very specific and sometimes special grounding requirements. Most of these special grounding techniques have evolved based on empirical (trial and error) testing rather than on detailed analysis. Some of the more creative grounding arrangements are devised in the name of noise reduction, but they often ignore the basic principles of electricity, such as electricity follows the paths of least impedance, electricity flows in complete paths and electricity flows because there is a potential difference. Further, when trying to reduce the effects of "noise," the fundamentals of noise coupling are sometimes ignored. For information on the fundamentals of noise control, see the references at the end of this article.

Intersystem Ground Noise and Common Mode Noise
One of the most widespread misunderstandings in the field of computer power protection is the difference between intersystem ground noise and common mode noise. Common mode noise is defined as noise existing between the hot and neutral, with respect to the ground conductor. Intersystem ground noise exists between the ground wires supplying interconnected computers. Freestanding computers not connected via any data lines cannot experience Intersystem ground noise. However, it is possible for a computer to experience severe common mode noise, while experiencing no intersystem ground noise, and vice versa. These two problems are completely independent.

Common Mode-Noise
During the initial phase of this investigation, the author constantly wrestled with the issue of the origin of these disturbance(s) in OPSCOM. As mentioned previously, the User was already reasonably convinced that they were coming from outside the building and simply wanted the engineering staff's support to confirm his suspicion. According to Key[8], the most common computer power problem is intermittent power line disturbances, particularly undervoltages or sags. With this in mind, steps were taken to mitigate this problem by installing uninterruptible power supplies to protect the computers and monitors. This was an added precaution because no sags were actually recorded during the monitoring period. Nevertheless, these efforts proved to be futile, at best, as the system disruptions and rampage of random damage to equipment continued.

Finally, it was surmised that perhaps the disturbances were "self-induced," coming from within the facility

itself. The previous BMI-4800 series strip chart recorded events showed abnormally high potential differences between the neutral and ground wiring terminals, often referred to as common-mode electrical noise. At this point, the investigation seemed to be taking a slightly different course of direction than from the onset and was becoming very interesting. After re-examining the OPSCOM grounding system and a thorough study of the IEEE Emerald Book[1], the following preliminary conclusions were reached regarding these disturbances:

• Grounding of equipment connected via data lines may give rise to potential noise coupling problems due to the common path shared between signal and power circuits.

• Data lines generally carry high-frequency signals, so impedance considerations from a power safety aspect may not always provide a desirable low impedance path at signal frequencies.

In addition, it was later discovered that common-mode noise can also originate from ground current coupled from other systems, as well as electromagnetic field coupling from typical dry-type transformers, and from high neutral conductor current due primarily to non-linear, single phase loading[9],[10]. Of course, these explanations were met with considerable resistance and cynicism from the User and even fellow colleagues; however, the investigation seemed to be finally taking some credible, logical direction. The bottom line here, as indicated by a power quality study by Key[8], is that unchecked common-mode noise can in fact disrupt data transmission and/or cause equipment error, such as what was indeed occurring in OPSCOM. This then appeared to be the binding tie to account for the equipment malfunctions...