Common mode noise - the often neglected tenth problem

Computers and other electronic equipment play a key role in our lives. Everything from business to our personal enjoyment is addressed by these devices. As electronic equipment becomes more and more a part of our daily lives, the need for clean, quality, power to keep them operating at peak performance and efficiency becomes more and more important. Unfortunately, the quality of the power available can vary greatly from site to site and can affect how computers and other electronic equipment operate. Power issues can cause a computer to slow down due to a disruption of its data stream, or shorten the life, or even destroy electronic equipment. Within power quality, there are nine problems that are commonly defined and addressed (see "The other nine problems" at the end of this article). Unfortunately, this leaves one very serious problem that is usually overlooked – often to the detriment of the reliability of electronic systems. This neglected or tenth problem is common mode noise.

Common mode noise

What is common mode noise? In general, noise is any unwanted electrical signal superimposed on an electrical or electronic signal (Figure 1.).

Common mode noise is usually defined as electrical interference that is measurable between the neutral and ground legs of a typical AC power line. While this is the most classic definition, common mode noise can also be measured between the line (or hot) and ground legs (Figure 2.)

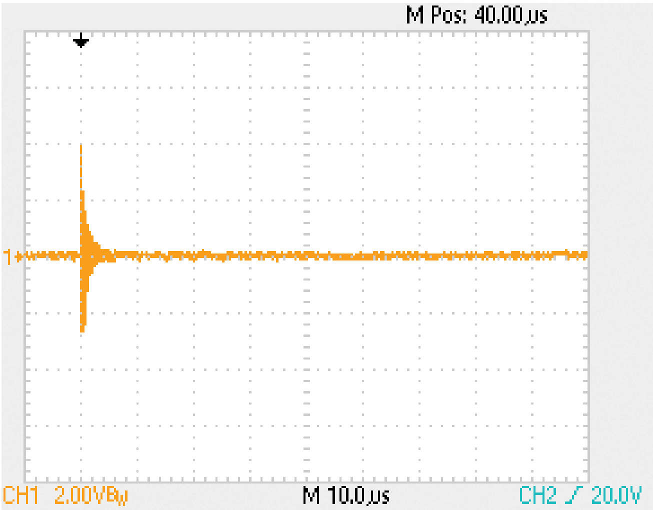


fig. 1. Noise captured on Tektronix oscilloscope

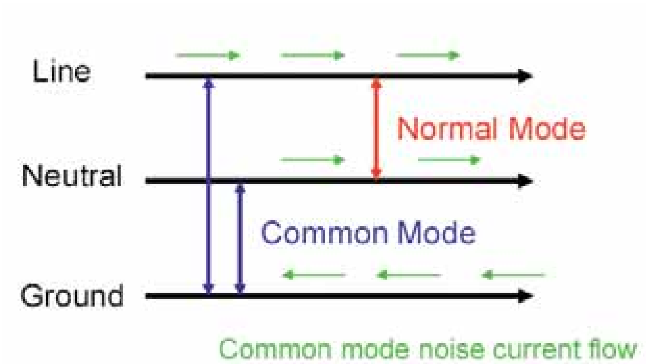


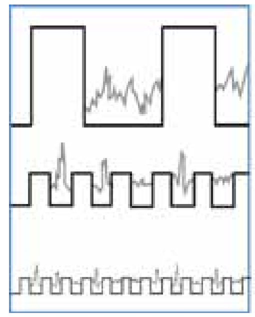
fig. 2. *Three wire AC conductor (normal mode versus common mode)*

Common mode noise - the often neglected tenth problem

Where does noise come from? Noise can be generated by multiple sources including nature, and other electrical devices. For example, fluorescent lights usually create high frequency noise, while motors, pumps, and fans create transient noise as they are turned on and off. Switch mode power supplies inside computers, monitors, and printers, cell phones and wireless phones are also sources of electrical noise that can interfere with other devices.

What does common mode noise affect? While common mode noise can affect the performance and life of any kind of electronic equipment, this article focuses on how it affects devices with computers. Today, computers are used in a wide variety of applications including ATMs, POS systems, medical systems, avionics and space systems, DVRs, copiers, and video game systems just to name a few. Virtually all computer based systems have two common components: semi-conductor chips - including CPU, memory and peripheral components and a switch mode power supply that converts line power to the voltages required by the CPU and supporting hardware.

How are semiconductors affected by common mode noise? The semiconductors used in today's products can be very sensitive to noise and transients. In some cases, just touching a semiconductor can result in permanent damage. Further, many of today's semiconductor parts are designed to work with a power supply voltage of either 1.5 or 3.3 volts. With this small voltage, the signals between such parts become more susceptible to distortion thereby potentially transmitting incorrect data. In some cases this simply slows down the system as some form of error correction routine is run, while in other cases, the data error causes the system to lock-up or crash. When noise finds its way into data transmission between computers, the noise level may be low enough not to damage the hardware but data may be corrupted (Figure 3.)



Computer Clock Speed	Chip Volts	100 Micro Seconds	Data Transfers Per ½ Cycle
4 MHz	5	400	33,333
33 MHz	5	3,300	275,000
66 MHz	3	6,600	550,000
100 MHz	3	10,000	833,333
160 MHz	1.5	16,000	1,333,333
300 MHz	1.5	30,000	2,500,000

fig. 3. How noise interferes with a data stream

This requires that the data be resent. If this happens often enough, the speed of the network slows down. It is in these ways that common mode noise can keep a computer network from operating at peak efficiency and speed.

How does common mode noise enter a Switch Mode Power Supply (SMPS)? The "common" side of the output of most Switch Mode power supplies is connected to the metal chassis of equipment that it powers. This is the same chassis that is connected to the incoming power line ground wire for safety. It is through this potential path that common mode noise often passes from the power line to the computer based equipment. There is a probability that some portion of this noise will pass through the power supply and into the system logic. While the SMPS itself can be damaged by the noise if it is too great, it is more likely that the semiconductor devices in the equipment will be disrupted or damaged by this noise.

Common mode noise (and all other electrical noise, for that matter) can also find unexpected paths through a system. The frequency of the noise (cycles per second, rate of change, dv/dt) can have a profound impact on the path noise takes, sometimes bypassing the intended conductors and causing unpredictable operation.

What is not a solution? A TVSS (Transient Voltage Surge Suppressor) is often suggested as a solution for noise problems on computer based equipment. While there are many different designs for Transient Voltage Surge Suppressors (TVSS) on the market today, none of them fully control common mode noise. In fact, many TVSS products are designed in a way that they (unintentionally) increase the common mode noise on a system by shunting the transient current to ground and thereby creating a common mode noise which can be more harmful than the normal mode noise which the TVSS is trying to suppress. Even an "All Mode" type TVSS will not eliminate common mode noise, and many TVSSs will make the common mode noise problem worse.

On-line UPS (Uninterruptible Power Supply) are sometimes recommended for common mode noise problems. While they can help solve other problems, they are unlikely to solve the common mode noise problem because most on-line UPS below 3 kVA do not have an isolation transformer in them. Because of this, the neutral and ground lines are common from input to output and common mode noise can pass directly through the UPS to the attached equipment.

What is the solution? The best solution for controlling common mode noise is a power conditioner or power conditioned UPS with a specially designed transformer and filter combination. Attempting to control common mode noise using just an isolation transformer, even with a grounded electro static shield, is by itself often not successful as the stray capacitance between transformer windings can allow a path for noise to pass through the transformer.

How is a power conditioning solution measured? Noise control solutions are measured by how much of the noise they let though their protection barrier. For power conditioners the measurements are usually provided as a "let-through" voltage which is a measure of how much of the voltage appears on the output of the power conditioner when a specified waveform is applied to its input terminals. The most commonly used input waveform for this test and specification is the ringwave (category A) that is defined in the IEEE C62.41 standard. While a let-through voltage of zero volts is ideal, a common mode (neutral to ground) let-through voltage of ½ volt or less, and a normal mode (line to neutral) let-through voltage of 10 volts or less is the established standard for the best products. Power conditioners that control the normal and common mode let-through voltages to these levels have been proven to resolve most power line noise issues in the field.

The other nine problems

While controlling common mode noise is critical to achieving a high level of system availability, there are also other, more talked about and easily measured problems that can negatively affect power quality. Below is a brief summary of these problems and some remedies for correcting them.

AC Blackout – A total loss of power occurring for more than two AC cycles. The blackout may only cause the lights to blink or the power may be off for hours. The solution is a UPS (Uninterruptible Power Supply) or Generator system.

Power Sag – A short term low voltage condition brought on by the starting of a large piece of equipment, utility switching, or temporary overload of the electrical system. The result is a low voltage condition that lasts a couple cycles to a couple seconds. The solution is an on-line or line-interactive UPS or voltage regulating power conditioner.

Brownout – A brownout has the same characteristics as a power sag but for much longer time duration. A brownout can last from minutes to days or even longer. The solution is an on-Line or line-interactive UPS or voltage regulating power conditioner.

High Voltage Spike – A quickly rising high amplitude voltage spike that lasts ½ cycle or less, but is capable of causing damage because of the high voltage and current potential. This could be the result of a lightning strike that can exceed 6 kV. A TVSS (Transient Voltage Surge Suppressor) can be used to suppress this spike but will typically clamp the voltage at 330 Volts or more. A better solution is a power conditioner or power conditioned UPS that meets a 10 V (Normal Mode) and ½ V (common mode) let-through specification.

Voltage Surge – A voltage that has increased RMS voltage amplitude for multiple cycles, it is usually of short time duration but could last for hours or even days. The solution is an on-line or line-interactive UPS or voltage regulating power conditioner.

Common mode noise - the often neglected tenth problem

Normal mode electrical line noise – A high frequency noise between line (L) and neutral (N) conductors that is superimposed on the main AC sinewave causing a distortion of the sinewave. The source of the noise can be either radiated RFI or induced EMI on to the line and neutral. Sources include transmitting devices, fluorescent lighting, computers and electronics, motors and pumps, etc. The solution is power conditioner or power conditioned UPS system.

Frequency variation - A random or periodic change from the nominal frequency (60 Hz or 50 Hz) that is expected from the power line or generator. While most of North America, Western Europe, and Japan have a fairly stable power line frequency, some parts of the world are more likely to suffer with this problem. Operation from generators that are old or not maintained can also produce frequencies that are unstable. The solution is an on-line UPS.

Switching Transient – is a fast high voltage spike with very short time duration. They are mainly caused by power factor correction capacitors being switched on and off the power grid. Not only can they cause damage to the load but the circuit breakers protecting the load as well. The solution to protect the load is an on-line UPS.

Harmonic Distortion – A distorted AC Sinewave that is a result of non linear loads such as rectifiers and similar circuits found in equipment with switch mode power supplies, and VFD (variable frequency drives). Common problems created by harmonic distortion include difficulty synchronizing equipment to the line and overheating of equipment and transformers. Solutions placed at the source include drive isolation transformers and Line Reactors. The solution placed to protect the load is an on-line UPS.

Conclusion

There are a large number of different devices designed to reduce the effects of nine of the ten power problems found in our world. The tenth problem, common mode noise is the most over looked power problem today and it can have devastating effects on computers and other equipment. In today's environment quality power is essential. Chloride | ONEAC markets a complete line of power conditioners and power conditioned UPS equipment to reduce the 3 Ds, Disruption, Degradation, and Destruction that common mode noise and the other nine power quality problems will cause over the life of your valuable equipment.

About the author

Michael Boyle

Michael Boyle is currently a Senior Application Engineer for Chloride North America. He has a BSEET from DeVry Institute of Technology.

Michael provides customers with pre-sales technical assistance on Chloride ONEAC products and has over 10 years experience in the power quality field.