Reducing high frequency ground currents to zero

Patented system solution provides a more effective grounding method.

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Technology and the electrical/electronics industry have changed at a dizzying pace. Among these many changes is the growing use of adjustable speed drives (ASDs) or variable frequency drives (VFDs) with motors. An unforeseen consequence of using VFD's with motors is the production of high frequency ground currents. These ground currents can and often do affect sensitive devices—as well as causing costly unplanned downtime in ASD/ VFD applications. When these problems arise, technicians often take a trial-and-error approach, such as installing line and/or load reactors or EMI filters. Too often, these attempts prove ineffective and overly costly in terms of both time and dollars wasted.

ANALYZING THE PROBLEM

VFD technology today relies on very fast switching power semiconductor devices. VFD manufacturers have turned to insulated-gate bipolar transistors (IGBTs) as the semiconductor of choice. This preference arises from characteristics of IGBTs including cooler operating components, smaller footprints, quieter operating systems, and increased control of motors—all of which add up to major dollar savings by end users.

The IGBT generates a rapid turn-on and turn-off time needed to create the Pulse Width Modulated (PWM) waveform to control the motor. Specifically, a nuisance transient voltage occurs at the juncture of the turn-on/turn-off point. The faster the IGBT switches and the higher the DC bus voltage, the greater the sum effect of the nuisance high frequency transients. These high frequency ground currents (transients) often affect sensitive devices in all areas of industry. Eventually, these high frequency ground currents can lead to the degradation of dielectric insulation in motors and transformers, and in addition, motor bearing fluting. Bearing fluting is caused when an electrical discharge occurs between the bearing inner or outer races and the rotating balls. Bearing fluting reduces the life of the bearing, thereby reducing the life of the motor. Bearing fluting is NOT covered under warranty by any motor manufacturer. These ground currents (transients) can stray into other systems and devices—metal detectors, card readers, servo amplifiers, proximity sensors, communication hubs, robotic controls, wireless communications, and low voltage control wiring (0-1 mA, 4-20 mA, 0-10 Vdc, etc.). Other vulnerable equipment includes machine control protocols (Devicenet, Profibus, Modbus), video/security systems, machine vision systems, flow sensors, etc.

THE TRADITIONAL APPROACH

The conventional wisdom and standard practice of grounding electrical circuits to "physical earth" for safety (per the National Electrical Safety Code) began over 100 years ago. The past few decades have brought technological innovations in ASD/ VFDs, servos, and other computer-controlled systems that

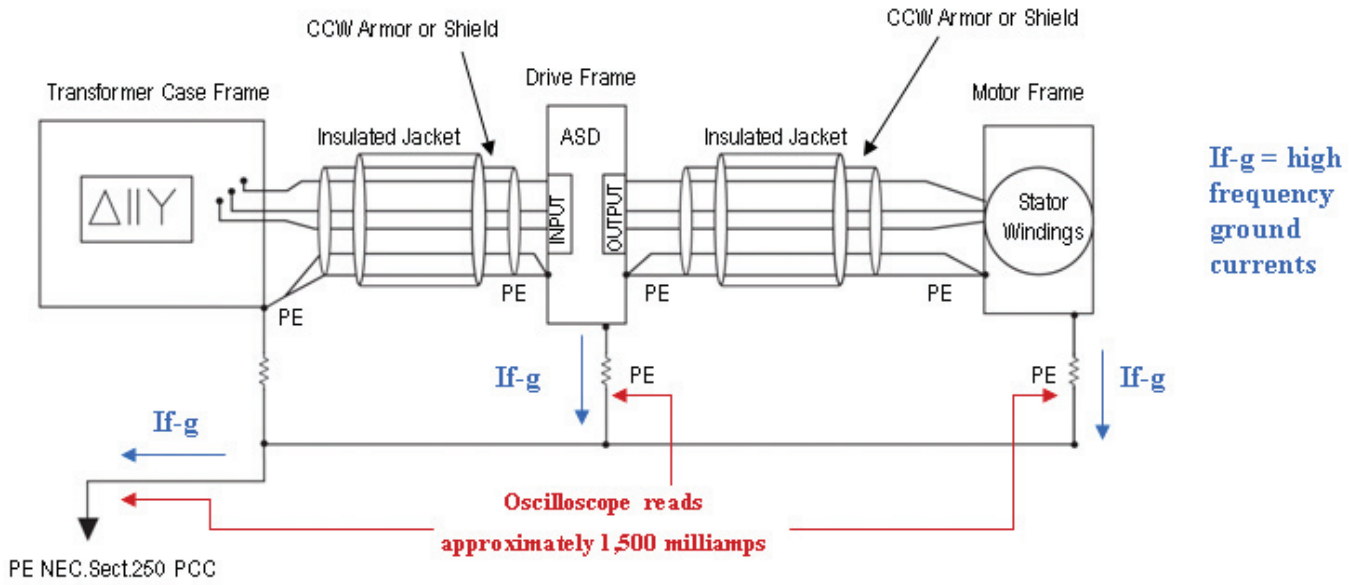

Figure 1. *A typical, traditional wired ASD/VFD system with ground currents shown.*

typically generate high frequency ground currents, which when grounded to "physical earth" can affect other sensitive electrical/electronic equipment (Figure 1). These troublesome high frequency ground currents must be dealt with since they cannot be eliminated.

THE NEW APPROACH

Still, these high frequency ground currents can be contained, directed, and controlled. A new system solution provides a more effective grounding method which reduces high frequency ground currents to zero, while reducing motor bearing currents which extends motor life, and minimizes crosstalk between adjacent cables. This new approach is designed to contain stray capacitance, inductively coupled energy, while directing fault currents away from hazardous locations, and eliminates both motor-to-frame and ASD/VFD-to-frame, voltage to ground. This highly effective grounding method, in turn, reduces unplanned downtime, lost production and increases the mean-time-between-failure (MTBF) ratio.

This system solution allows traditional grounding methods to "catch up" to the recent changes in today's high-speed electronic systems. For example, by replacing a standard wiring system in an ASD/VFD cell, the new system reduced 1,538 milliamps to zero. Zero was defined as five places to the right of the decimal point (Figures 2 and 3).

This system solution provides unsurpassed performance in reducing EMI/RFI caused by PWM or high frequency power supplies. The system solution has been engineered and designed as a complete wiring system to be installed between a source and an adjustable speed drive controller

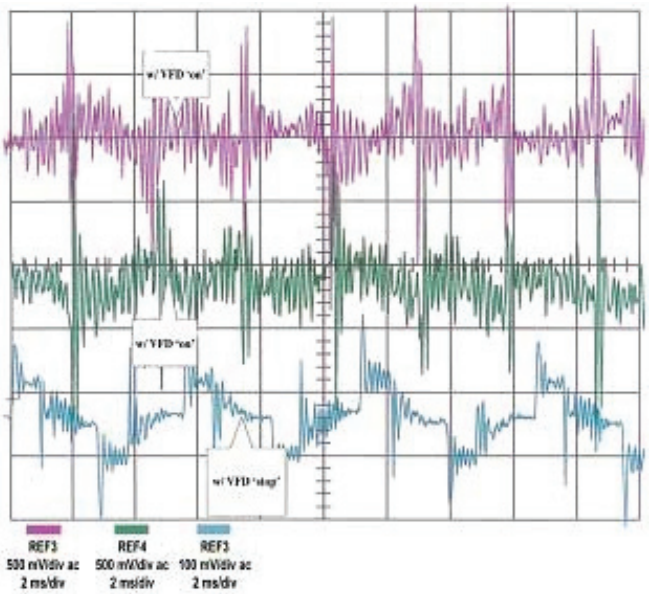

Figure 2."Electrical noise" measured before installation of new conduit system (Note: graph vertical divisions are 500 mA).

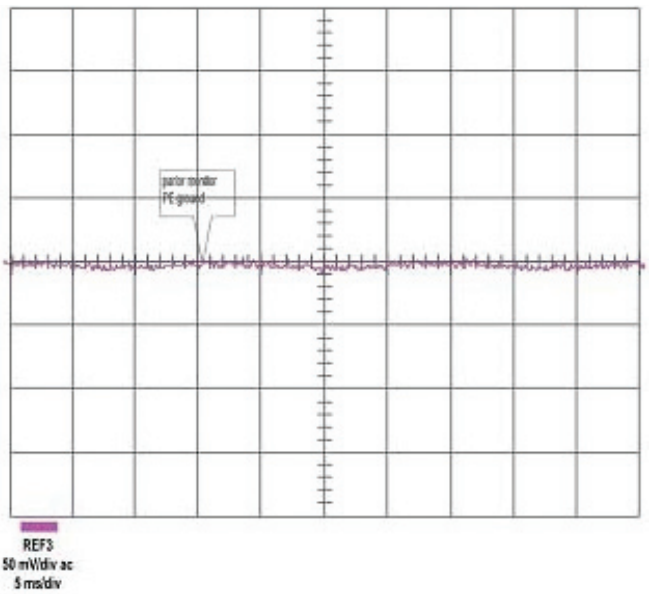

Figure 3. *"Electrical noise" measured after installation of new conduit system; (Note: graph vertical divisions are 50 mA).*

and an electric motor or in any wiring scheme in which high frequency voltages might stray. Patented cable/conduit components, coupled with a patented installation method, create a very low impedance return path for the high frequency ground current energy.

Unlike conventional ASD/VFD wiring systems that are grounded to earth, the new system solution assures grounding and safety in a very different manner. The system solution provides grounding via the cable system, not the components. No filters are needed to reduce ground currents to zero. Most drive manufacturers recommend that cable lengths should not exceed 50 feet. This grounding system solution works successfully with cable lengths exceeding 300 feet.

THE NEED FOR ADEQUATE GROUNDING

Today, many businesses and manufacturers are operating with outdated electrical distribution facilities, that plant managers may not be aware of. Many plants have electrical systems that need to be upgraded. A once effective electrical system, often, is compromised by changes over time. The addition of new machinery with ASD/VFDs (switching power supplies), changes in electrical service, and utility power spikes/surges, will bring about issues to the in-house grid. Overall, there is a significant probability that electrical distribution systems installed a decade ago now harbor major inadequacies that are unable to accommodate today's new electrical/electronic components and other sensitive controls.

Meeting all requirements of National Electric Code Sec. 250 is not difficult. Unfortunately, many systems that were initially grounded correctly are no longer in compliance. For example, many cities and industrial facilities have replaced aged metallic water supply meter mains with PVC. These mains, which were once effective in providing grounding, are now virtually useless since PVC is not a conductor. Bonds, where two different types of metals join, corrode. Grounds can and will corrode over time.

This grounding system specifically targets applications in which three-phase and single- phase motors are utilized, and any application in which EMI/RFI problems are a concern. Potential sites for this new system solution include HVAC systems (commercial buildings), medical facilities (*i.e.* surgery, intensive care), clean rooms, dairy farms, public marinas and mines—places where damaging leakage currents are unacceptable. For new or retrofit installations, some recommended applications include: water filtration, waste water treatment, pulp and paper mills, printing, glass, electro-plating and food processing. Industrial applications seeing nuisance issues include AC servos, automation/robotics, PLC and network communications, galvanic detectors, ultrasonic transducers and wireless communications equipment. Other likely candidates for installation of this system solution are government, security, defense, military, oil/petroleum and marine applications (onboard) for surface/subsurface vessels fitted with switching power supplies.

This system solution, in addition to addressing safety and interference (noise) issues, reduces high frequency ground currents, thus providing a significant impact on motor life. Recent industry testing on this system solution has verified a significant reduction in motor bearing currents, thus extending motor life. It is possible to run a motor on Utility-supplied power for years without issues. Similarly, it is possible to run a motor with a VFD for significant energy savings without incident. But take this same application and add a different VFD in the circuit and it can cause issues if proper precautions are not taken. The motor bearing(s) could fail in a matter of months. Since a minimum of 41% of motor failures are bearing related, using this system solution to reduce motor bearing currents could have a significant impact on efficiency and economy.

THE DETAILS

Developed in 1998, this system solution was in testing and development, with multiple site installations, until its 2005 market introduction. At present, there are system solutions offered for low voltage (1000 V) with ratings of (10 HP or less) 33 amps, (50 HP or less) 70 amps, (125 HP or less) 205 amps, and (250 HP or less) 410 Amps. The system has been used for the safe wiring of all input and output connections found in VFD (switching power supplies). All cables and conduits in the system solution are UL listed materials, and these systems meet all requirements of NEC 336 Power and Control Cable Type TC, NEC 350 Liquid Tight Flexible Metal Conduit Type LFMC, and NEC 250 grounding. The cables are rated for 2000V AC RMS and are dielectric tested to 12 kV–22 kV. Other than the cable/conduit, these systems utilize all standard off-the-shelf industry fittings and components. These systems received U.S. patents in 2005 for the components and installation method, respectively.

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