design FAQs

Variable Frequency Drive Cables

FREQUENTLY ASKED QUESTIONS

Q: Why are variable frequency drive (VFD) systems subject to electromagnetic interference (EMI)?

A: A VFD's output signal consists of a series of chopped dc pulses to induce motor motion. As those pulses travel through motor cables and into the motor, they can cause electrical interference that can damage surrounding components and degrade overall system performance. These high frequency dc pulses can also trigger false instantaneous-over-current (IOC) faults in VFDs of 5 hp or less by charging the capacitance between the conductors and drawing more current from the drive. Cables with thicker insulation should be used since they will have lower dielectric values reducing this charging.

Q: Are newer drives more susceptible to noise problems?

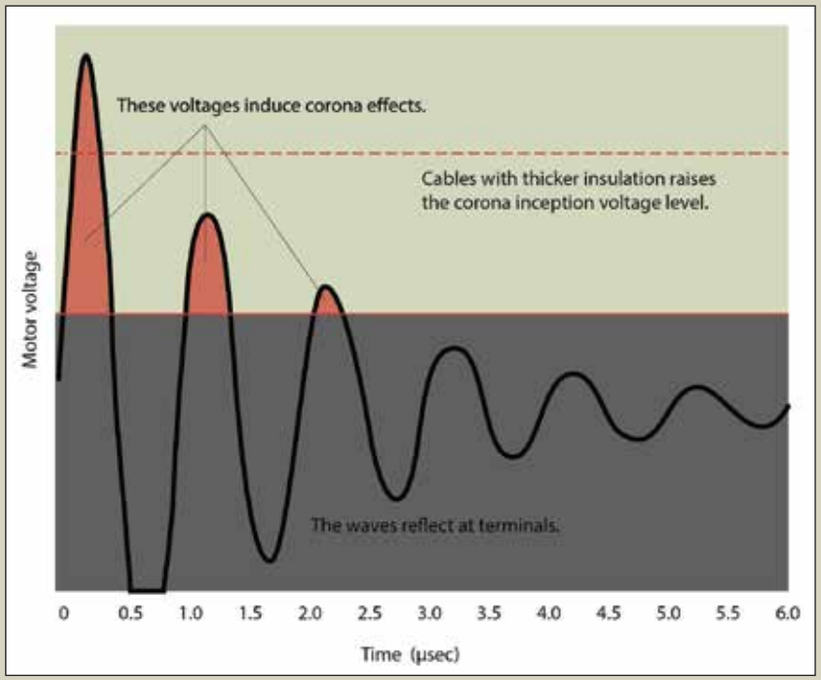
A: Newer VFDs that use insulated gate bipolar transistors (IGBTs) have a faster dc pulse rise time, dv/dt. Faster pulse switching provides finer motor control but the dc pulses also have voltage overshoots which translate into noise. In addition to this noise, there are also reflective waves at the cable-to-motor junction which can create unwanted noise in the cables. Reflective waves are created because the motor's stator windings are an inductor. As such, a magnetic field must first build in order to generate current in the windings. The result is an impedance mismatch between the cable and the motor that causes a portion of the voltage waveform's leading edge to reflect back through the cable.

Q: What about proper grounding?

A: Without proper grounding, a VFD system can experience unwanted ground loops. Ground loops are unintended paths through an electrical interconnection system in which potentials, or voltages, measured with respect to ground at either end of the path differ. Using unshielded cables in metal conduit can cause ground loops and is, therefore, not recommended.

To combat ground loops, make sure both enclosure and motor are properly grounded and that the VFD cables are properly shielded, forming a Faraday cage. A Faraday cage, first invented by Michael Faraday in 1836, is an enclosure formed by conducting material that blocks external static and non-static electric fields. It works by channeling electricity through the enclosure to ground and providing constant voltage on all sides of the enclosure so that no current flows through the space.

Ground wires can be subject to the skin effect—the tendency of the current to flow near the outer surface of the conductor—at high frequencies. This effect becomes more pronounced with increasing frequency, so grounding wires in VFD systems are particularly susceptible. Using a ground strap instead of a solid round wire to ground the system will better conduct this high frequency noise.



Fast voltage rise time (dv/dt) can lead to voltage overshoots, reflected waves, and coronal discharge when voltage exceeds that of coronal inception.

Q: Should cable insulation be cross-linked polyethylene or PVC?

A: Both PVC and XLPE are good electrical insulators. When using PVC for a VFD system it is important to increase the insulation thickness to increase the corona inception voltage (CIV) level and prevent corona discharge.

In addition, each insulating material must be used for its proper application. It is important to note that per the National Electric Code (NEC) Article 310.10, THHN PVC insulated cables should be used for dry and damp locations while cross-linked polyethylene (XLPE) XHHW or RHW-2 should be used in wet locations.

Depending on the voltage rise time and the length of the cable, reflective waves can build up to the point that they surpass the CIV. A corona discharge where moisture is present generates nitric acid which melts the PVC insulation. When XLPE insulation reacts with nitric acid, it actually forms a thermally-isolating charred layer on the surface that can prevent further degradation. Thicker insulation also lowers the cable dielectric constant and reduces capacitance between wires.

Q: What is the best way to connect the cable to the motor and drive?

A: To prevent EMI in VFD systems, ground the shield with 360° contact at the enclosure entrance and at the motor. The shield acts as a ground path for electrical noise, so proper termination is essential. Also pigtail the braided shield directly to the PE terminal on the drive to avoid the skin effect that can occur with a drain wire. Some cable manufacturers offer grounding connectors that provide 360° contact with the shield at the entry of the enclosure and motor.

How can I find a cable that meets the requirementsofmymotormanufacturer? When choosing cables for your VFD system, take application variables into account. Will the cables have be in a dry, damp, or wet environment? Are the cables suited for VFDs in that they have a thicker insulation? Also take a look at the recommendations of the motor manufacturers and the NEC. Finally, consult a cable manufacturer whose experts can recommend the proper cable for your system. ■