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White Paper

Picking the Right VFD Cable

Reduce problems and increase reliability

Variable-frequency drives (VFD) allow sophisticated control by AC motors by allowing their speed and torque to be precisely adjusted. Control is achieved by varying the frequency to the motor. It does not, however, send a pure sine-wave frequency to the motor. Rather it sends a series of pulses, whose width varies, to the motor. This technique—pulse-width modulation (PWM)—supplies the drive with the same power profile as a sine-wave frequency. PWM also allows the effective voltage to the motor to be varied.

While PWM provides an excellent way to control a motor's speed and torque, it creates several phenomena that can affect the power, create noise, reduce the life of the cable, and disrupt operation of the drive system. Understanding these phenomena explains why selecting the proper VFD cable is important to maintaining reliable, long-term operation.

Standing waves

When the PWM pulse train meets a different impedance, part of its energy is reflected backwards. A VFD motor can have an impedance of several hundred ohms. The cable, on the other hand, has a lower impedance of around 85 to 120 ohms. This mismatch between the VFD motor and the cable results in significant reflected energy. The resulting increase in voltage can degrade the cable's insulation, leading to eventual failure.

Corona Discharge

Corona discharge is caused by the intense electrical field surrounding the conductors. Discharge occurs when nitrogen gets into the air space between conductors causing them to ionize. Discharge harms the cable by degrading the insulation material and damaging the cable's shield. Corona discharges can also damage the drive electronics and cause power losses. A corona discharge can generate enough heat to melt the conductor insulation. Thermosetting insulations such as cross-linked polyethylene provide much better resistance to corona discharges than PVC.

Harmonic Distortion

All signals contain energy at multiples of its frequency, in addition to energy at its operating frequency. These signals result in wave distortion due to a generation of harmonic energy.

In-rush current

When the motor is first started it can draw very high current levels, at this point an in-rush current occurs. You have probably seen this effect when lights dim when an air conditioner or other heavy electrical load turns on. Large VFD systems can actually affect the power grid when they turn on. While it is normal practice to ramp up motor speed slowly to minimize in-rush current, it can still occur.

EMI

EMI is a natural byproduct of a digital system is the creation of energy that radiates as electromagnetic interference. This energy can transfer to other circuits, causing signal degradation, false signals, and other problems.

Designers of VFD drives and motors go to great lengths to control and minimize the effects discussed above. Although they cannot be completely eliminated, their effects can be reduced by selecting components specifically designed for VFD systems.

Anatomy of a VFD cable

Figure 1. VFD Cable

Cable used to connect the VFD drive to the motor affect how well the VFD system handles the phenomena with potential to disrupt operations. Cables designed specifically for VFD applications (see Figure 1) withstand the aforementioned phenomena. And, equally important, they do nothing to make the situation worse. If generic motor supply cable is not designed with the specific requirements of VFD system, problems can arise. Here are some of the things to look for in a VFD cable:

Insulation

The insulation must have excellent dielectric properties to prevent breakdown from the stresses of voltage and current spike, corona discharges, and so forth. Cross-linked polyethylene (XLPE) has the required properties, making it a better choice than standard polyethylene or PVC. XLPE insulation helps reduce the potential effects of harmonics and corona discharge, therefore providing stable electrical performance which prolongs the life of the cable. This reduces the need for costly downtime due to cable failure.

Shielding

Shielding serves the double purpose of keeping noise generated by the VFD cable from escaping, and preventing noise generated outside the system from being picked up. There are three types of shields typically used:

Foil shielding uses a thin layer of aluminum, typically laminated to a substrate such as polyester to add strength and ruggedness. It provides 100% coverage of the conductors it surrounds. Foil shielding is small which helps keep cable diameters small, but its size makes it hard to work with, especially when applying a connector.

A woven braid provides a low-resistance path to ground and is much easier to terminate by crimping or soldering when attaching a connector. Depending on the tightness of the weave, braids typically provide between 70% and 95% coverage. Because copper has higher conductivity than aluminum and the braid has more bulk for conducting noise, the braid is more effective as a shield. But it adds size and cost to the cable.

A third approach combines both foil and braid shields in protecting the cable. Each supports the other, overcoming the limitations of one with its own compensating strengths. As shown in Figure 2, this presents shielding effectiveness superior to either approach alone.

One purpose of the shield is to provide a low-impedance path to ground because any noise on the shield passes to ground. A poor ground connection can increase the impedance, which also increases the potential for noise to be coupled to nearby cables or equipment.

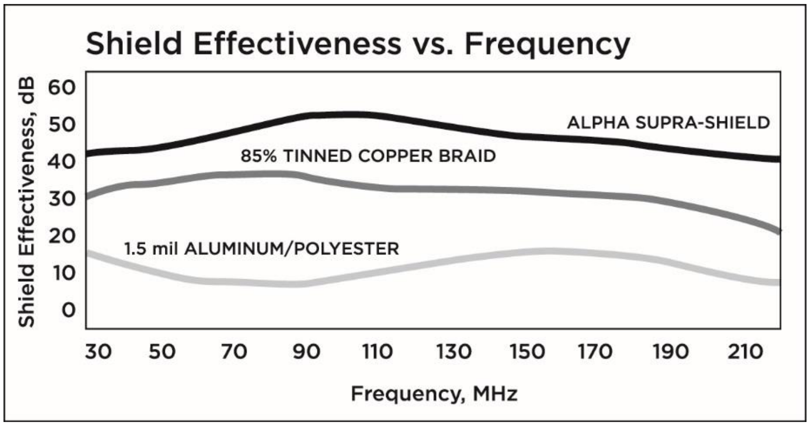

Figure 2. Foil-braid shielding yields the best shielding effectiveness

Cable Geometry

A round, symmetrical cable provides the best electrical performance because round symmetry creates more uniform electrical characteristics in the cable. The electrical characteristic of one conductor doesn't differ significantly from another thus creating a more balanced system and reducing the potential for harmful effects.

The right cable prevents problems

The cable selected for interconnecting a variable-frequency drive to a motor can significantly influence the reliability of the system. The wrong cable can increase problems and lead to premature failure. The right cable, on the other hand, can reduce the risk of potential problems like corona discharge or standing waves.