Application Note

VFD Cables – A Safe Bet

Did you know that, if you run cables that connect your variable frequency drives (VFDs) to your motors, you could have a significant safety risk in your plant or factory? Fear not, there is a simple solution to this potential problem.

It's a fact. Non-shielded cables send out interference – it's called electromagnetic interference (EMI). In many cases, this is not a significant problem. Most of us have heard that 60 Hz hum that happens when a phone line is run too close to a standard 600 Volt power cable. It's really nothing more than a nuisance with standard power. But the same physics behind that hum may be creating a safety issue in your facility.
VFDs change standard 60 Hz power into variable frequency power that allow us to experience significant energy savings, better control of our equipment, and reduced maintenance costs. However, like most things in life, there are trade-offs. The downside of a drive system is that it generates lots of high frequency voltage waveforms that can cause problems with motors, drives, and other plant equipment. These same high frequency waveforms can also cause safety issues. Let's look at how.

Many people use lower cost non-shielded cables between their VFDs and their motors. THHN is the most common cable used, but the situation is the same even if you have upgraded to a thermoset insulation like the RH and XH types. The problem is caused because VFDs output pulse width modulated (PWM) waveforms that trick motors into thinking they're seeing a nice clean sine wave at one of a variety of frequencies (now, I know motors don't really think, but stick with me here). These waveforms have frequency components up to and over 30 MHz. When you energize a cable with such high frequencies, you create a large-loop radiating antenna. This antenna is not pumping out Top 40 hits like your favorite radio station. It's pumping out EMI!

EMI can cause things to go wrong in sensitive electronics that are located too close to the EMI source, but that's not what we are talking about today. Today, we are focused on safety.

Let's say you have a couple of VFDs and a couple of motors. You power the motors with a couple of cables of the unshielded variety. You run the cables together in tray or conduit for a fair distance. This can create an unsafe situation. Now, with power cables that are carrying standard 60 Hz traditional power, the energy level is low enough that this does not create an issue, but with drive cables things are different. EMI is proportional to the square of the frequency and we are dealing with frequencies in the tens of Megahertz. With this high frequency comes high energy. Enough energy, in fact, to create an unsafe

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combination of voltage and current to cause a shock hazard or even death in someone working on a locked-out cable circuit nearby. Basically, the couple of cables couple!
There is even an IEEE paper that documents this. It states:

> *"This problem arises when two or more inverter–motor circuits are physically located adjacent to each other for relatively long distances in trays, raceways, or conduits. The induced voltages/currents from one circuit to another may lead to destructive voltage stress to either the motors or the inverter equipment or cause intermittent performance of one or more of the involved systems. The other problem associated with this crosstalk between drive circuits relates to personnel safety. A typical case in which this problem may pose a safety hazard would be when one drive system is energized and operating a motor, while a second drive may require motor maintenance, such as motor replacement, wherein an electrician is required to handle the bare cable termination at the motor end to change out the motor with a spare. If these two motor circuits travel a considerable distance together in a tray, for example, the open circuit (1000Ω to ground was used, in accordance with IEEE Standard 80-1986) may receive enough electromagnetic/electrostatic coupling from the energized circuit to produce a driving voltage and current flow that could be dangerous or potentially fatal."*

So, what's the solution? Use a VFD cable instead of non-shielded cable. VFD cables have a shield over the three-phase conductors which minimizes the coupling effects providing you with a safer working environment. The overall shield of a VFD cable acts like a Faraday cage over the conductors. The conductors are still emitting EMI, but the shield absorbs these transmitted EMI signals, transforming them into a current flow in the shield, which is drained off to ground at the shield's termination point (which should be at both ends of the shield if you want to maximize the performance of your system). A shielded VFD cable is able to reduce this EMI by over 90% as shown in the same IEEE paper quoted above. Using VFD cables between your inverter and motor when longer lengths of cable are run in tray creates a safer working environment.

In addition to creating a safer workspace, VFD cables help mitigate a variety of issues from motor failures to PLC problems to drive damage to other issues in other plant equipment. To learn more, read Southwire's application note titled "About VFD Cables".
VFD cables not only protect equipment, they protect people.

1 "Evaluation of Motor Power Cables for PWM AD Drive" (IEEE Transactions on Industry Applications, Vol 33 No 2) https://ieeexplore.ieee.org/document/567793

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