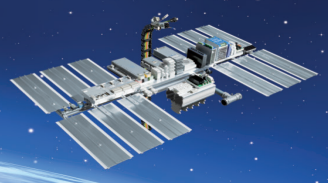
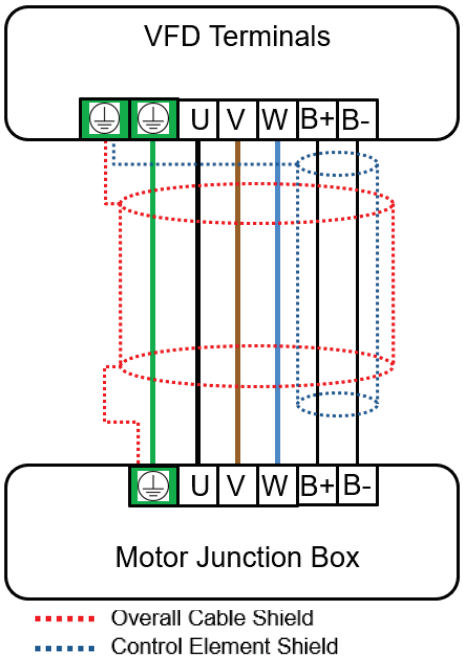


Shield Termination and Grounding in VFD Circuits

Variable Frequency Drives (VFDs) can provide motor control and significant energy savings for industrial applications. They also have the potential to introduce unwanted electrical noise and common mode currents to the circuits they supply. To mitigate this potentially harmful noise, most drive manufacturers recommend using shielded cable on the output of a VFD. This paper discusses common grounding and termination practices when using shielded VFD cable.

How should cable shields generally be terminated in VFD circuits?

Most drive manufacturers provide cable and system grounding guides specific to the drive being installed, which should be the designer's first resource when deciding on a shielding and grounding scheme. However, there are some generally accepted best practices for shield termination and grounding. These can be divided into two categories: shielding for power circuits and shielding for control circuits.



Power Circuits: Shielding for power circuits (U/V/W in the diagram at right) is typically accomplished using an overall cable shield, shown in red on the diagram. Under ideal circumstances, this shield should be terminated at the PE terminals on the VFD and at the motor terminal junction box, and should be continuous from the motor directly back to the drive with no interruptions or intermediate terminations.

Control Circuits: Shielding for control and signal circuits is generally recommended to be terminated at the source end only. When signals originate from the VFD – i.e., in motor brake (see B+/B- in the diagram above) or 24VDC auxiliary contact applications – the shield would be terminated at the PE terminal on the drive and left floating at the device end, as shown in blue on the diagram. A signal pair in a VFD cable may also be used to send a signal to the drive from an external controller, such as a signal from a PLC to a VFD. In this example, the shield should be terminated at the PLC, as it is the source of the signal being sent, and not at the VFD, which is the receiving device.

While this rule for control shield termination holds true for most VFD installations, there are cases where a control shield may be terminated at both ends. Preassembled feedback cables, for example, often specify shield termination to a shielding clamp at the drive and have the shield terminated to the connector shell at the motor end. Other manufacturers have recommended terminating signal shields at both ends but using a capacitor at one termination to avoid ground loop formation[1]. For this reason, system designers should always refer to the equipment manufacturer's recommended grounding scheme when designing circuits.

[1]ABB Drives, "Reference Manual, Grounding and Cabling of Drive Systems, 3AFY61201998 Rev C (EN) 2013-03-25"

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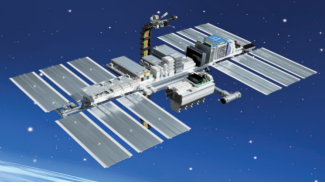


Why is the power circuit shield terminated at both the drive and motor?

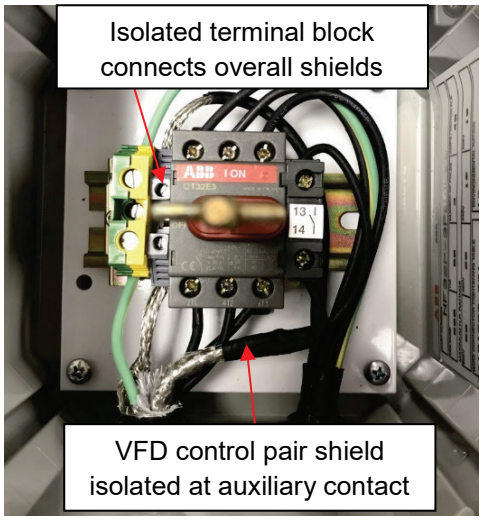
By nature, Power Width Modulated (PWM) AC drives generate common mode noise on the output of the inverter circuit, which is carried through the circuit conductors to the load and contributes to a variety of issues if not mitigated properly. These issues can include, among others, bearing currents, interference with sensitive electronic circuits, induced ground voltage, and nuisance trips. Using shielded cable on the drive output and terminating the shield at both ends of the circuit provides a dedicated low-impedance pathway for common mode currents to return to their source at the drive. This pathway minimizes the risk that common mode noise will find alternate, potentially harmful paths back to the drive. The shield also serves as a short, low-impedance path for external, non-common-mode noise that may be present along the cable route or at the motor end of the circuit.

How should cable shields be handled at local motor disconnects?

Most drive manufacturers recommend a direct, uninterrupted shield connection from the motor directly back to the VFD. This is often difficult in practice due to the presence of a motor disconnect between the VFD and driven machinery. Motor disconnects are required in sight of the motor per section 430.102(B)(1) of the National Electric Code (2017 edition), and while exceptions exist, the requirements are written so that the disconnect must often be positioned between the drive and motor. When this is the case, system designers must find a way to carry the cable shield through the disconnect, ideally without introducing an intermediate termination point with an unpredictable grounding path.

Termination Methods

There are several methods to pass a shield through a local disconnect, and LUTZE customers have addressed the issue with a variety of solutions. Most solutions begin with creating a terminable conductor out of the shield using the “pigtail” method. By forming a proper “pigtail” conductor using both the braided shield and drain wire, the shield can be easily terminated to a terminal block or lug while still offering a low-impedance pathway for noise. If the braided portion of the shield is removed and only the drain wire is terminated to a lug or terminal block the impedance of the shield is raised significantly, due to the loss of the copper in the braid. For this reason, both the braid and drain wire should be used to create a “pigtail” type conductor. LUTZE offers additional white papers and resources that detail shield termination methods, including how to create an effective “pigtail” using a cable shield[2].



Isolated Terminal Block: An isolated terminal block can be used to pass a cable shield from VFD to motor. Using an isolated terminal block effectively acts as a splice and has the benefit of avoiding any intermediate termination points, creating direct, uninterrupted continuity from motor to VFD.

[2]LUTZE Inc., www.lutze.com/downloads/file/shield-termination-guide-for-lutze-vfd-cables

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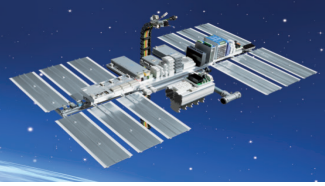
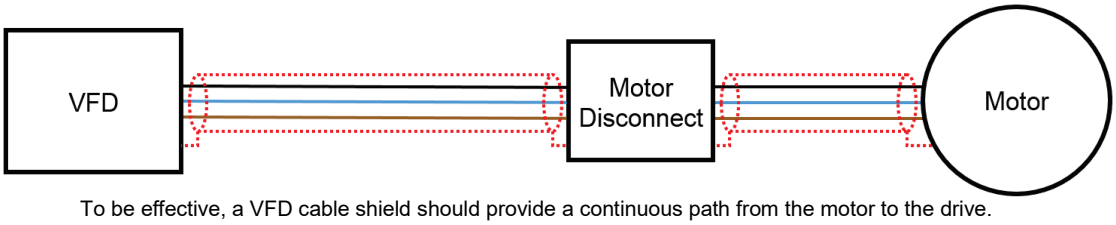


Shield Termination Fittings: EMC-type shield termination fittings can be used to pass cable shields through motor disconnects with conductive housings. This method is specifically recommended by Rockwell Automation[3], one of the few drive manufacturers to address the issue of cable shields at disconnects. The potential downside to this method is that termination to a housing, which is grounded to the larger facility ground grid, introduces a jumping-off point for noise to inhabit the ground grid and create interference issues in other circuits.

Other Considerations

Cases exist where shielded cable has been used to connect VFD output terminals to the motor disconnect, but not for the final connection from the disconnect to the motor. This can happen for any number of reasons; the installer may make a last minute decision to use unshielded single conductors for the last few feet, the motor may come with pre-installed, unshielded leads, or the contractor may be unsure of how to pass a shield through the disconnect. Whatever the reason, this is a common mistake that should be avoided. By terminating the shield at the disconnect and not extending it to the motor, the benefits of using shielded cable are lost and common mode currents present at the motor end of the circuit will find unpredictable, potentially harmful paths to ground. One example of this involves common mode currents passing through motor bearings, causing bearing erosion and premature failure.



To be effective, a VFD cable shield should provide a continuous path from the motor to the drive.

Disclaimer

While the information in this paper is helpful in understanding general rules for the termination of cable shields in VFD circuits, the primary resource for VFD circuit design should be the drive manufacturer's installation manual. In addition, be sure to consult all relevant codes and standards when designing any electrical installation to ensure compliance with local regulations, and secure approval from the responsible project engineer and AHJ for your specific jurisdiction.

Additional resources about VFD cable specification and installation are available for download at www.lutze.com and www.driveflex.com and can be provided by your local LUTZE representative. Please contact our corporate office with any additional comments, questions, or concerns at 1-800-447-2371 or by email at info@lutze.com.

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[3]Rockwell Automation, "Wiring and Grounding Guidelines for Pulse-width Modulated (PWM) AC Drives, Publication DRIVES-IN0010-EN-P – February 2017"

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