

North America packaged drive wiring practices

Best practices

This technical note focuses on electrical panels containing pulse width modulated (PWM) variable frequency drives (VFD). It is intended for packaged drive products used in HVACR, water, and industrial applications. Product designers can use the information to design packaged drive products; installers can use this information to prevent field wire routing issues; and technicians can use this information to troubleshoot potential installations with electrical noise issues.

This document only covers internal wiring and layout practices for industrial control panels containing AC drives intended for general industrial use, operating at a voltage of 1000 volts or less. This document is focused on US installation based on UL 508A Industrial Control Panels and the Canada equivalent CSA-C22.1. Internal component selection, wire gauge requirements, terminal sizing, and other engineering requirements are not addressed in this document. This document is intended for use by qualified personnel who design industrial control panels containing PWM AC drives.

Recommendations are aimed at providing information on industrial control panels to reduce the potential for electrical noise issues. Due to the large number of potential configurations, ABB does not guarantee that all potential issues will be resolved by following the recommendations contained in this document. The intent is to reduce potential electrical noise issues. Panel configurations addressed are for North American panels. Other standards, such as Europe CE, C-Tick, and others, require higher standards of EMC compliance and are not part of this document.

PWM drives create motor voltage and current using output switching devices. The output of the drive consists of DC pulses and can be the source of electrical noise. This source of electrical noise can cause issues through radio frequency interference (RFI) or be transferred as conductive electrical noise. If not shielded, the RFI electrical noise can transmit, affecting other electrical devices. If not separated or shielded, conductive noise is transferred through electrical-magnetic field coupling.

All individual component instructions for installation should be followed if they exceed the recommendations in this document. Proper environmental conditions for internal components, wire insulation, temperature rating, current capacity, sizing, separation, and other requirements per UL 508A in the US and CSA-C22.1 in Canada should be followed. UL 508A requires all internal wiring to be copper.

Enclosure

Steel enclosures can suppress radiated noise from the system and into the system. Internally, properly grounded component mounting plates can be painted or zinc-plated. Care should be used for the removal of painted surfaces used for grounding points to prevent corrosion where the paint is removed. Zinc-plated panels have the ability to bond with the device chassis and resist corrosion. Mild steel panels are better than stainless steel because of the lower ohms per square of resistance and lower cost.

Drive digital I/O

Drive digital I/O such as start, stop, and interlock commands can be wired in a variety of ways. Shielded cabling provides the highest noise protection. Control wiring should be separated from power wiring by 0.3 meters (12 inches) when possible. For short runs, the recommended distance can be reduced, but at no time should the control be in contact with the power wiring. For 120V/230V AC, 24V AC, and 24V DC control, 24mm (1 inch) separation from each other is preferred. Never mix 24 V DC and 115/230 V AC signals in the same cable. Extra care should be taken to keep control wiring and drive output wiring separated as much as possible. If control wiring needs to cross power wiring, cross at right angles. Electrical noise transferred to the digital I/O can affect drive control and PLC logic.

Analog signal

Analog signal wiring should be shielded. Twisted pairs wire encased in foil shield cable can reach 100% RF isolation, unlike only braided shielding, which can offer 45% to 98% coverage. Analog signal wires should preferably be wired directly to the devices installed in the panel. Panel builders should provide customer routing locations for analog control wiring that is field installed. Analog signal wires should be separated from power wiring by 0.3 meters (12 inches) when possible. Extra care should be taken to keep analog signal wiring and drive output wiring separated as much as possible. If analog signal wiring needs to cross power wiring, cross at right angles. Do not use a common return for different analog signal. Analog connection points should have the least amount of unshielded wire possible to prevent noise from entering. An analog signal shield should be grounded at the source of the analog signal. If the shield cannot be grounded at the source, then grounding at the end location is an option. To prevent a ground loop, the shield should not be grounded at both ends. If internal analog devices are wired to customer connection terminals, a terminal for the shield connection should be provided to allow for the continuation of the shield. To keep the inductance as low as possible and to decrease high frequency coupling the relation between the length and width of a grounding conductor (twisted shield) should be less than five as shown in Figure 1. Below is an example of electrical noise on analog input and output wiring between a drive and PLC. Figure 2 is un-grounded shield cable, and Figure 3 is grounded shielded cable.

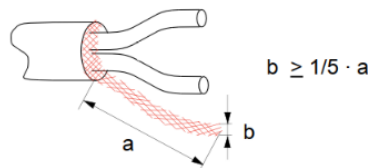


Figure 1 Optimal maximum shield connection length

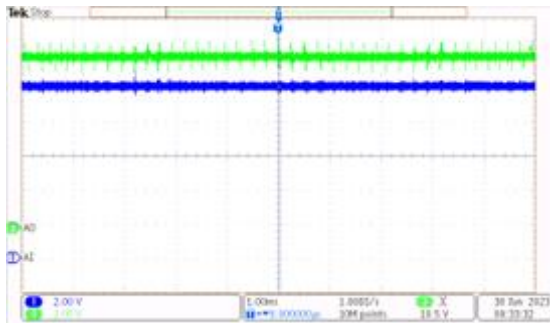


Figure 2 Un-grounded shield analog cable noise

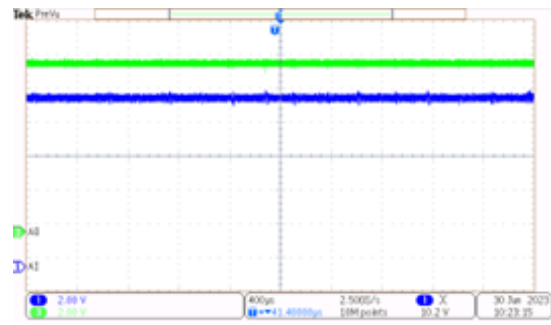


Figure 3 Grounded shield analog cable noise

Communication cables

Communication cables should be shielded and routed away from all AC wiring. Communication wiring should preferably be wired directly to the device, and customer routing locations should be provided for field installed wiring entering and leaving the panel. Communication cables should be separated from power wiring by 0.3 meters (12 inches) when possible. Extra care should be taken to keep communication cables and drive output wiring separated. If communication cables need to cross power wiring, cross at right angles. Communication cable shields should be grounded at the source of the communication signal unless directed by the communications device's installation instructions. If customer connection terminals are provided, terminals for the shield connection should be provided to allow for continuation of the shield into and out of the enclosure.

Wire loops

When routing communications, analog signal wire and digital I/O wire avoid the creation of wire loops. Wire loops can create an antenna effect, allowing for the receiving or transmission of electrical energy. Route wiring together and, if needed, twisting wiring as a pair will reduce the antenna effect. If possible, wire lengths should be trimmed to fit the system. If cables cannot be trimmed, excess wiring can be bundled in a figure-eight pattern, not looped. Figure 4 shows different wire configurations.

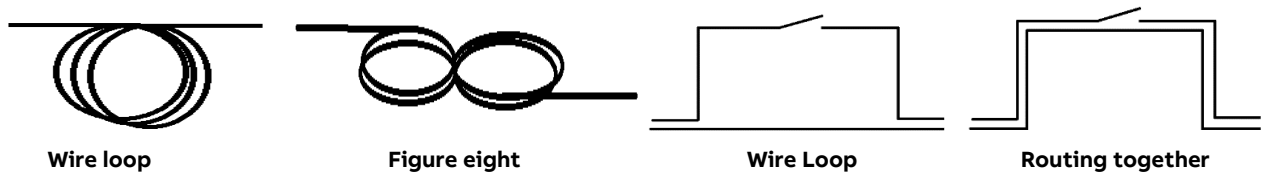


Figure 4 Wire configurations

Component Layout

Component layout is important to allow for the separation of noise-generating components like drives and noise-sensitive devices. By grouping the input and output power wiring and power components on one side and noise-sensitive equipment and wiring on the other side of the panel, it allows for better wire routing and can reduce the effects of induced electrical noise. See Figure 5.

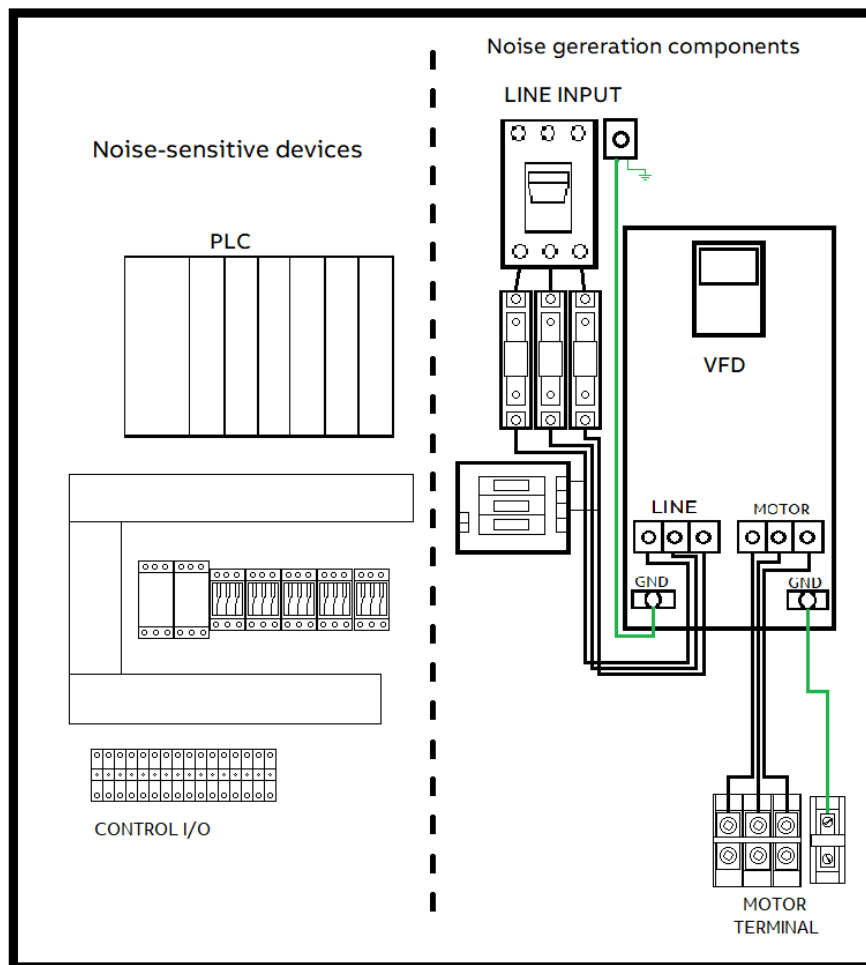


Figure 5 Separation of components and power wire routing

Input power wiring

Input power wiring could be shielded, but in most US installations, it will be supplied through conduit. For best grounding, the input ground wire should be routed to the drive from the panel's input PE terminal and the conduit bonded to the enclosure. The panel should not be used as the only ground path. Supplying direct ground wiring to the drive allows for the lowest resistance path for electrical noise created by the drive to return to the drive. Figure 6 is for systems that have direct metal-to-metal contact and Figure 7 is for isolated ground terminals with panel ground wire and drive ground wiring. Unshielded input power wiring should not be run with drive output wiring and use a separation of 0.3 meters (12 inches) when possible.

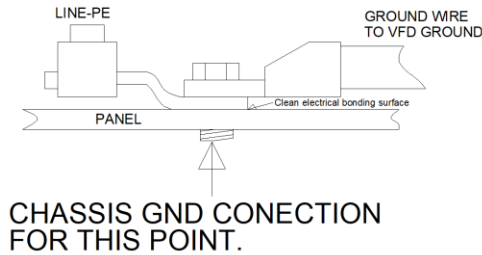


Figure 6 Input ground lug and wiring

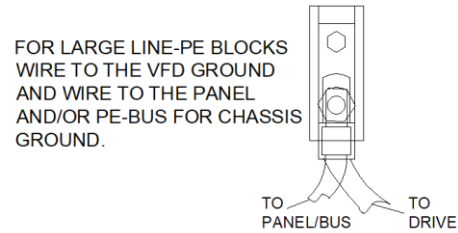


Figure 7 Isolated input ground lug

VFD motor wiring

The use of shielded cable has the advantage that it will contain most of the electrical noise created by the output of the drive. If the package contains sensitive equipment and the output of the drive or multiple drives is routed inside the enclosure, the use of shielded cable should be considered. The cable shield should be 75% copper-braided or better. An additional foil shield provides 100% shielding and greatly improves the electrical noise suppression ability of the cable.

The use of armored cable is great for external wiring and provides excellent electrical isolation, but due to its rigidity and difficulty to install in package drive systems, it is not the best solution for internal wiring in the panel.

The use of perpendicular ground metal barriers to separate motor wiring from other wiring that does not fully surround the motor wire does not provide full noise suppression internally in the enclosure. Metal barriers in a U shape as dividers can block conductive effects, allowing for closer runs of wiring. If the barrier is fully enclosed, it acts as a metal conduit and will suppress RFI and conductive electrical noise.

Wiring directly to the drive output with continuous shielded wiring is the best solution, but in many packaged systems, motor connection terminals are supplied for the field motor wiring. Motor shielding or metal conduit runs should be grounded at the drive and motor locations. Motor ground wiring should be connected directly to the motor frame and routed directly to the drive motor ground terminal. When internal motor connection terminals are used, the motor ground terminal should be isolated from the panel to prevent electrical noise from transferring to the panel. The field motor ground terminal should be wired directly to the drive motor ground terminal. See Figure 5 for motor terminal wiring. For un-shielded motor wiring, separate 0.3 meters (12 inches) from all other wiring when possible.

Multiple options are available for shielded motor cable and grounding options. Connections in Figure 8 are for shielded cable with one ground wire, and connections in Figure 9 is for three ground wires. For the lowest electrical noise interference, ground the motor cable shield with a 360 degree clamp and ground the flattened twisted shield (width > 1/5 · length), as shown in Figure 10 and 11. View ABB document "3AFY61201998: Reference Manual: Grounding and Cabling of Drive Systems" for detailed information on motor wiring.

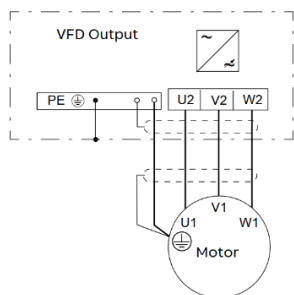


Figure 8 Shielded cable one ground connection

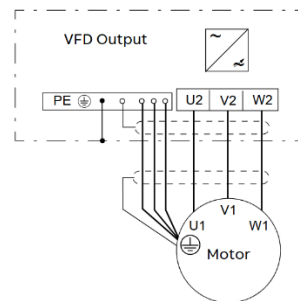


Figure 9 Shielded cable multiple grounds connections

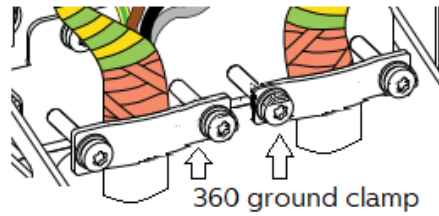


Figure 10 Optimal 360 degree Shield clamp

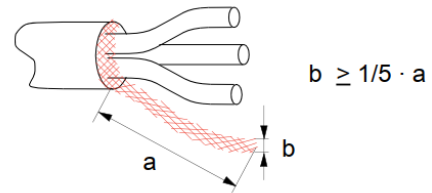


Figure 11 Optimal Shield length

For multiple drives in one enclosure, each un-shielded drive output should be bundled and routed separately, with 72 mm (3 inches) of spacing for short internal runs if possible. When one drive is supplying multiple motors with the motor protection devices in the enclosure, the motor connections should include ground terminals for each motor that are isolated from the panel and continue the drive motor ground from the drive to the motor. See Figure 12 for multi-motor connections.

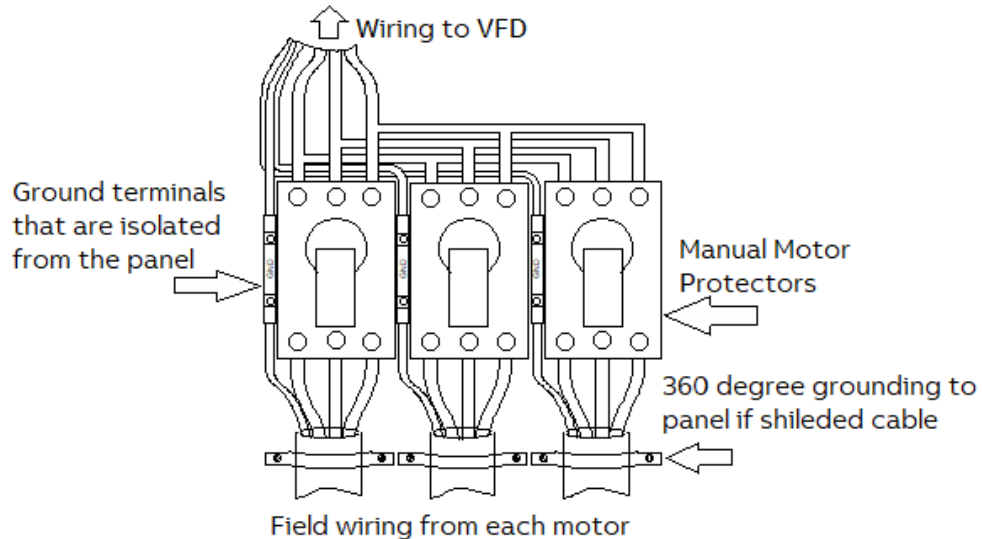


Figure 12 Multiple motor MMP with ground connections

Summary

Not all panels contain noise-sensitive components like PLCs and/or network controllers, but following good practices can reduce the possibility of electrical noise issues. Noise issues can start in the panels and cause external problems with external noise-sensitive devices, so isolation of electrical wire signals is important and should be followed.

Other related ABB documents:

- 3AFY61201998 - Reference manual - Grounding and cabling of drive systems.
- 3AXD50000044839 - ACH580-01 drives (0.75 to 250 kW, 1 to 350 hp) hardware manual for frames R1-R9
- 3AXD50000044862 - ACQ580-01 drives (0.75 to 250 kW, 1.0 to 350 hp) hardware manual for frames R1-R9
- 3AXD50000044794 - ACS580-01 drives (0.75 to 250 kW, 1.0 to 350 hp) hardware manual for frames R1-R9
- 3AXD50000037066 - ACH580-31 hardware manual
- 3AXD50000045935 - ACQ580-31 hardware manual