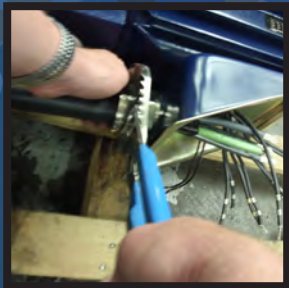




Unarmored Variable Frequency Drive (VFD) Cable Termination Guide



Be Certain with Belden®

**A Step-by-Step Look at
the Connection/Termination
of Unarmored VFD Cables**

Terminating Unarmored Variable Frequency Drive (VFD) Cables Foil-Braid or Copper-Tape Shield Constructions

Belden VFD Cables are designed for quick and easy termination.

This Belden VFD Cable Termination Guide takes a step-by-step approach to the connection/termination of unarmored VFD cables with either foil-braid or copper-tape shield constructions. The instructions cover the termination of the cables in external and self-contained enclosures, at the motor junction box or using an alternative method.

VFD Cable Installation Location Considerations

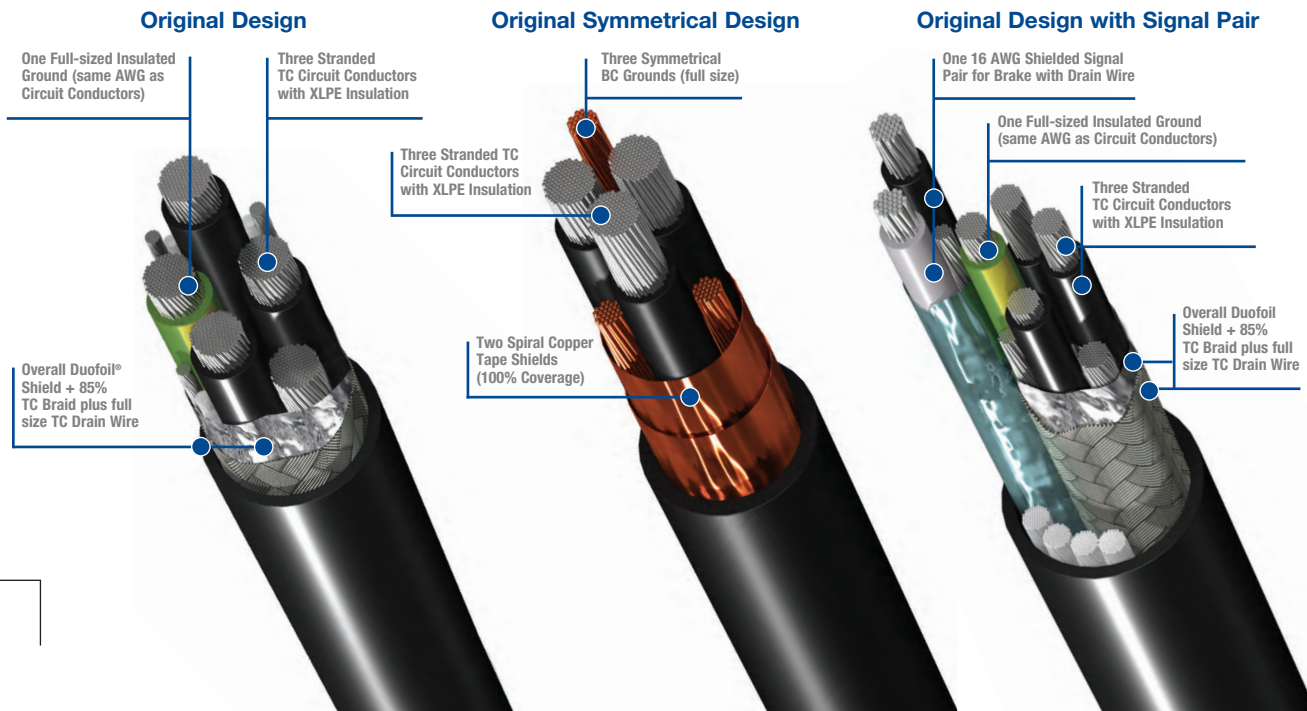
It is advisable to maintain as much separation as possible between noise-susceptible cables and VFD cables – a minimum of one foot for shielded instrumentation cables and three feet for unshielded instrumentation cables. If the two types of cable must lie close to each other, it is best to minimize the amount of parallel runs between them, limiting these stretches to 10 feet or less to reduce the likelihood of radiated noise pickup. Also, if the two types of cables must cross, it is preferable to cross them perpendicularly at a single point.



As you use this step-by-step VFD Cable Termination Guide, please note the references to the drive or motor manufacturer's recommendations. You should be familiar with the manufacturer's termination guidelines as well. If you have specific questions on the instructions given within this guide, please contact Belden Technical Support at **1.800.BELDEN.1 (1.800.235.3361)**.

Belden's Variable Frequency Drive (VFD) Cable Offering

See VFD Cable Matrix (page 3) for additional information.





Belden VFD Cable Matrix

Physicals						Ratings									
Cable Type	No. of Circuit Conductors	Conductor AWG	Tinned Copper (TC) Conductor	No./Type of Grounds	Shielding	Circuit Conductors feature Heavy XLPE Insulation	Full-sized Drain Wire	PVC Jacket	ER Rating	1000V Flexible Motor Supply Rating	600V UL 1277 Type TC	2000V UL 1277 Type TC	Underground (burial)	MSHA	UL-WTTC
Original	3	16-2	Yes	1 - Full-sized Insulated	Overall 100% Duofoil® + 85% TC Braid	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes
Original Symmetrical	3	1-4/0	Yes	1 - Full-sized Segmented Into 3 - Bare CU Symmetrical	Dual Spiral Overlapping Copper Tape (100% Coverage)	Yes	-	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes
Original with Brake/Signal Pair	3	16-10 (16 AWG Signal Pair)	Yes	1 - Full-sized Insulated	Overall 100% Duofoil + 85% TC Braid	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes
Original for 2kV Applications	3	14-2	Yes	1 - Full-sized Insulated	Overall 100% Duofoil + 85% TC Braid	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes
Original Symmetrical for 2kV Applications	3	1-4/0	Yes	1 - Full-sized Segmented Into 3 - Bare CU Symmetrical	Dual Spiral Overlapping Copper Tape (100% Coverage)	Yes	-	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes
Original with Haloarrest® Low Smoke Zero Halogen Jacket	3	16-2	Yes	1 - Full-sized Insulated	Overall 100% Duofoil + 85% TC Braid	Yes	Yes	LSZH	Yes	Yes	Yes	-	Yes	Yes	Yes
Original Symmetrical with Haloarrest Low Smoke Halogen Jacket	3	1-4/0	Yes	1 - Full-sized Segmented Into 3 - Bare CU Symmetrical	Dual Spiral Overlapping Copper Tape (100% Coverage)	Yes	-	LSZH	Yes	Yes	Yes	-	Yes	Yes	Yes
Original Interlocked Armor	3	16-2	Yes	1 - Full-sized Insulated	Overall 100% Duofoil + 85% TC Braid	Yes	Yes	Yes	Meets MC	Yes	Yes	-	Yes	Yes	Yes
Original Symmetrical Interlocked Armor	3	1-4/0	Yes	1 - Full-sized Segmented Into 3 - Bare CU Symmetrical	Dual Spiral Overlapping Copper Tape (100% Coverage)	Yes	-	Yes	Meets MC	Yes	Yes	-	Yes	Yes	Yes
Basics Symmetrical	3	16-4/0	No	3 - Bare CU Symmetrical	Dual Spiral Overlapping Copper Tape (100% Coverage)	Yes	-	Yes	Yes	-	Yes	-	Yes	-	-

CU = Copper • TC = Tinned Copper

VFD Cable Termination Instructions – Foil-Braid Constructions External and Self-Contained Drive Enclosures

General Termination Instructions

To properly and effectively terminate a VFD cable system, first ensure the following:

- Ideally, the shield and jacket should be intact all the way back to the drive so they do not introduce any jumping off points for the common mode currents carried on the common mode current containment system. In this case, no special tools, materials or termination kits are required.
- Shield grounding cable glands should be avoided at the enclosure ingress as they may introduce jumping off points for the common mode currents into the metal work – in addition to undesirable and uncontrolled electrical noise.
- Intermediate termination of the cable elements on terminal blocks should be avoided as the terminations may significantly reduce the ability of the shielding system to conduct and contain harmful high frequency currents.
- The cable's outer jacket system serves an important role in isolating the common mode current containment system. The outer jacket should not be removed before the cable enters the drive proper as this introduces the potential for uncontrolled ground currents. Care should be taken to minimize contact between exposed cable shield, and any enclosure metal, especially in the close vicinity of sensitive equipment that is likely present near the drive.

How to Terminate an External Enclosure *(For Self-Contained Drive Enclosure Instructions - Nema 1,4,4x - skip to Step 2).*

STEP 1



- Ingress the enclosure using an isolating cable gland with a suitable protection rating for the enclosure and the environment. Allow a sufficient length of cable to easily reach the drive without unnecessary cable strain. Do not remove the outer cable jacket.
- Secure the cable with suitable cable ties, or through cable duct as appropriate.
- If the drive is open style, route the jacketed cable assembly back to the drive vicinity.

STEP 2



- If the drive is in an internal enclosure, ingress the drive through a suitable insulating cable gland. Measure and mark the cable to determine the jacket strip location and cutoff length.
- If possible, remove the measured cable and place the end for preparation on a suitable work surface.

STEP 3



- Neatly remove the outer cable jacket, exposing sufficient conductor to reach the drive terminals, while still leaving some excess conductor length for trimming (after neatly routing to the drive terminals).
- It is desirable to combine the shielding drains and braid for termination intact at the ground terminal of the drive.

STEP 4



- Push the exposed braid back over the cable jacket.

STEP 5



- Remove the exposed shield and cable fillers where exposed.

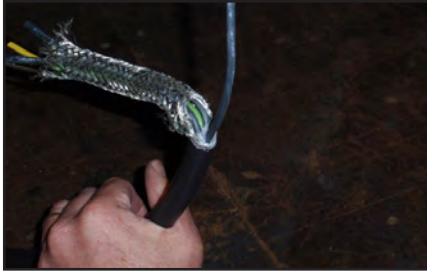
STEP 6



- Push the remaining braid forward, and use a tool to open the braid.

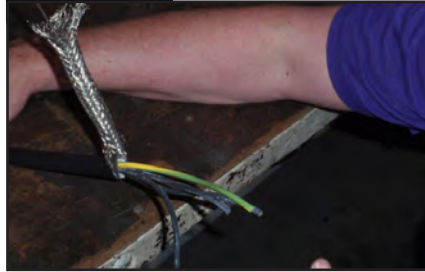


STEP 7



- A. Push the primary conductors and ground through an opening in the braid, separating the intact braid system from the conductors.

STEP 8



- A. Leave the drain wire inside the braid system.

STEP 9



- A. Apply heat shrink tubing to the drain and braid.

STEP 10



- A. Apply 3-5 inches of heat shrink tubing over the entire cable assembly, centered at the jacket strip point. Shrink this piece completely.
- B. Secure the cable jacket to the drive (or enclosure) if it is not secured by a cable gland.

STEP 11



- A. Route and trim the conductors to the power terminals, leaving sufficient material for phase reversal, if necessary.

STEP 12



- A. Terminate the motor leads per the drive manufacturer's recommendations.
- B. Trim the ground wire to sufficient length to reach the drive ground terminal.

STEP 13



- A. Terminate the ground and drain per manufacturer's recommendations.

VFD Cable Termination Instructions – Foil-Braid Constructions

Motor Junction Box

How to Terminate at the Motor Junction Box

STEP 1



- A. Ingress the motor junction box through an isolating cable gland with a suitable protection rating for the enclosure. Do not remove the outer cable jacket. Measure and mark the cable for length. When possible, it is desirable to remove the cable from the motor junction box for ease of preparation.
- B. Neatly remove the outer cable jacket, exposing sufficient conductor to reach the motor leads and ground lug, while still leaving some excess conductor length for trimming (after neatly routing to the motor terminals).
- C. Follow the cable preparation instruction above as specified for the drive end connection.
- D. Secure the cable jacket to the motor by tightening the isolating cable gland.

STEP 2



- A. Route and trim the conductors to the motor terminals, leaving sufficient material for phase reversal, if necessary. Use the termination system recommended by the motor manufacturer.
- B. Terminate the motor leads per the motor manufacturer's recommendations, or trained practices of a qualified electrician.
- C. Trim the ground wire to sufficient length to reach the motor ground terminal.
- D. Heat shrink the drain wire covering and trim to length for connection to the drive ground terminal. Strip to expose conductor as necessary.
- E. Terminate the ground and drain using a standard lug, or on the provided connection point.



VFD Cable Termination Instructions – Foil-Braid Constructions

Alternate Method: Conductive Cable Gland

How to Terminate in a Conductive Cable Gland

Note: It may be more desirable to terminate the braid in a conductive cable gland at the motor connection. If so, suitable conductive cable glands are available through your Belden Distributor. It should be noted, however, that

this will be no more effective for common mode current containment than terminating the braid intact, and will involve a more expensive connector. This connection may provide additional mechanical security, depending on

the connector selection, and could reduce EMI in very close proximity to the motor junction box.

STEP 1



- A. Ingress the motor junction conduit box through the conductive cable gland.

STEP 2



- A. Prepare the cable per the gland manufacturer's recommendations.

STEP 3



- A. Trim the foil at least back to the prepared edge of the braid.
- B. Secure the cable to the gland per gland manufacturer's recommendations, and pass the cable into the motor junction box.

STEP 4



- A. Secure the cable jacket to the motor by tightening the cable gland lock nut.
- B. Route and trim the conductors to the motor terminals, leaving sufficient material for phase reversal if necessary. Use the connection system as recommended by the motor manufacturer.
- C. Trim the ground wire to sufficient length to reach the motor ground terminal.
- D. Heat shrink the drain wire(s) covering and trim to length for connection to the drive ground terminal. Strip to expose conductor as necessary.

STEP 5



- A. Terminate the ground and drain using a standard lug, or on the provided connection point.

STEP 6



- A. Terminate the motor leads per the motor manufacturer's recommendations, or trained practices of a qualified electrician.

VFD Cable Termination Instructions – Copper Tape Shield Constructions

External and Self-Contained Drive Enclosures

How to Terminate a Drive Mounted in an External Enclosure (For Self-Contained Drive Enclosure Instructions - Nema 1,4,4x - skip to Step 4).

STEP 1



- A. Ingress the enclosure with an isolating cable gland with a suitable protection rating for the enclosure and the environment. Allow a sufficient length of cable to easily reach the drive without unnecessary cable strain. **Do not remove the outer cable jacket.**
- B. Secure the cable with suitable cable ties, or through cable duct as appropriate.
- C. If the drive is open style, route the jacketed cable assembly back to the drive vicinity.

STEP 2



- A. If the drive is in an internal enclosure, ingress the drive through a suitable insulating cable gland.
- B. Neatly remove the outer cable jacket, exposing sufficient conductor to reach the drive terminals, while still leaving some excess conductor length for trimming (after neatly routing to the drive terminals).

STEP 3



- A. Remove the exposed copper tape shield.
- B. De-cable the exposed conductors and grounds.

STEP 4



- A. Combine the exposed ground wires by twisting them together.

STEP 5



- A. Apply heat shrink tubing to the grounds.

STEP 6



- A. Apply 3-6 inches of heat shrink tubing over the entire cable assembly, centered at the jacket strip point. Shrink this piece completely.
- B. Secure the cable jacket to the drive (or enclosure) if it is not secured by a cable gland.



STEP 7



- A. Route and trim the conductors to the power terminals, leaving sufficient material for phase reversal, if necessary.
- B. Terminate the motor leads per the drive manufacturer's recommendations. Use lugs and ferrules as appropriate. No special pieces are required.

STEP 8



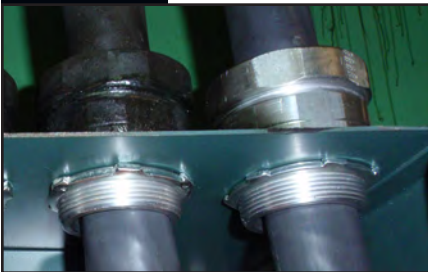
- A. Trim the ground wire(s) to sufficient length to reach the drive ground terminal.
- B. Terminate the ground per the drive manufacturer's recommendations. Note that there is no shield termination for copper tape shielded constructions.

VFD Cable Termination Instructions – Copper Tape Shield Constructions

Motor Junction Box

How to Terminate at the Motor Junction Box

STEP 1



- A. Ingress the motor junction box through an isolating cable gland with a suitable protection rating for the enclosure. **Do not remove the outer cable jacket.**
- B. Measure and mark the cable for jacket removal inside the motor junction box.
- C. Neatly remove the outer cable jacket, exposing sufficient conductor to reach the motor leads and ground lug, while still leaving some excess conductor length for trimming after neatly routing to the motor terminals.

STEP 2



- A. Trim back the copper tape shield, and any fillers in the cable.
- B. De-cable the exposed conductors and grounds.

STEP 3



- A. Combine the ground wires by twisting them together. Apply heat shrink tubing to the combined grounds.
- B. Secure the cable jacket to the motor by tightening the isolating cable gland.
- C. Route and trim the conductors to the motor terminals, leaving sufficient material for phase reversal, if necessary. Use the connection system as recommended by the motor manufacturer.
- D. Terminate the motor leads per the motor manufacturer's recommendations, or trained practices of a qualified electrician.
- E. Trim the ground wire to sufficient length to reach the motor ground terminal.
- F. Terminate the ground using a standard lug, or on the provided connection point.

Belden VFD Cable Termination FAQs

Commonly asked questions about Belden VFD cables.



Does Belden require a proprietary connector for VFD cables?

Belden VFD Cables are 100% compatible with a wide variety of popular, commercially available connectors from most established suppliers. Because the connector needs of each application are specific to the application requirements and codes, your Belden distributor can help select the most appropriate connector options available.



Do I terminate the shield at both ends?

Drive cable shields should always be terminated at the motor and at the drive. Intermediate termination of the ground or shield is not recommended. The shield acts as a conductor for common mode current containment. Failure to terminate the shields and grounds properly could result in harmful electrical noise or destructive common mode currents flowing in the ground grid. Intermediate grounding of the shield can cause the unintended release of shield currents and resulting electrical noise.



My drives are pre-wired to terminal blocks should I connect there?

While you can terminate at prewired terminal blocks, the use of unshielded conductors from the terminal block to the drive can create significant electrical noise, which may affect other sensitive components, or networks within the enclosure. Connections on terminal blocks can also reduce the effectiveness of the shielding and should be avoided when possible.

A photograph of three customer support representatives in a professional office setting. A woman in the foreground is smiling and wearing a headset. Behind her, a man in a suit is looking at a laptop, and another man is looking at a document.

More Questions?
Contact Belden
Technical Support
at **1.800.BELDEN.1**
(1.800.235.3361).



Can I use parallel runs for ease of installation?

Parallel runs can be used for most VFD installations, and provide easier pulls and terminations for the installer. Care should be taken to ensure balanced loading in the cables, and where multiple motor winding sets are present (for example in a 12 lead motor which has 4 sets of windings) individual cables should carry a dedicated motor winding set. If this cannot be determined, then common phases should be bussed together at the motor junction box. All T1 leads should be bussed together in the motor junction box, all T2 leads bussed together in the motor junction box, and all T3 leads bussed together in the motor junction box. Failure to balance the loads through bussing, or winding alignment will result in additional cable shield currents and potential cable heating.

When cables are adequately space in a cable tray, no additional de-rate should be required.



Can I run multiple motor cables in a conduit or cable tray without capacitive losses?

Belden VFD Cables will eliminate the potentially significant current losses associated with cable charging of nearby conductors.



Will Belden VFD cables eliminate reflected wave voltages?

No, but the lower capacitance conductors will effectively increase the distance before the buildup of reflected waves, in some cases the difference in critical cable length can be as much as 3 times farther with Belden VFD Cables compared to THHN in Conduit. This can lead to significant differences on motor and cable insulation stresses, and may result in longer motor or cable life. The critical distance is different for every drive, cable, and motor combination.



Are Belden VFD Cables suitable for applications with moderate flexing?

Belden Original Foil Braid VFD Cables are tested to over 1 million flexes with a bending radius of not more than 10 times the cable diameter.



VFD Cables overcome the challenges found in the toughest of environments.

Additional Information

If you need information on the type of VFD cable that is appropriate for your specific installation, or if you have questions related to the instructions given within this guide, please contact Belden Technical Support at **1.800.BELDEN.1 (1.800.235.3361)**.

Additional information is also available on Belden's website at www.belden.com. Here, you can view VFD Cable Procurement Documentation, or you can download Belden's VFD Cable Size Selection Guide (Based on Motor HP), VFD Cable Product Bulletin #316, and a Capabilities Overview for 2000V VFD cables.

GLOBAL LOCATIONS

For worldwide Industrial Sales
and Technical Support, visit:
www.belden.com/industrial



UNITED STATES

Division Headquarters – Americas

2200 U.S. Highway 27 South
Richmond, IN 47374
Phone: 765-983-5200
Inside Sales: 800-235-3361
Fax: 765-983-5294
info@belden.com
[web: www.belden.com](http://www.belden.com)

Contact for Belden Brand

2200 U.S. Highway 27 South
Richmond, IN 47374
Inside Sales: 1-800-BELDEN-1
(1-800-235-3361)
Phone: 765-983-5200
Fax: 765-983-5294
info@belden.com
[web: www.belden.com](http://www.belden.com)

Contact for Hirschmann and Lumberg Automation Brands

1540 Orchard Drive
Chambersburg, PA 17201
Phone: 717-217-2200
Fax: 717-217-2279

CANADA

National Business Center

2280 Alfred-Nobel
Suite 200
Saint-Laurent, QC
Canada H4S 2A4
Phone: 514-822-2345
Fax: 514-822-7979

LATIN AMERICA and the CARIBBEAN ISLANDS

Regional Office

6100 Hollywood Boulevard
Suite 110
Hollywood, Florida 33024
Phone: 954-987-5044
Fax: 954-987-8022
salesla@belden.com