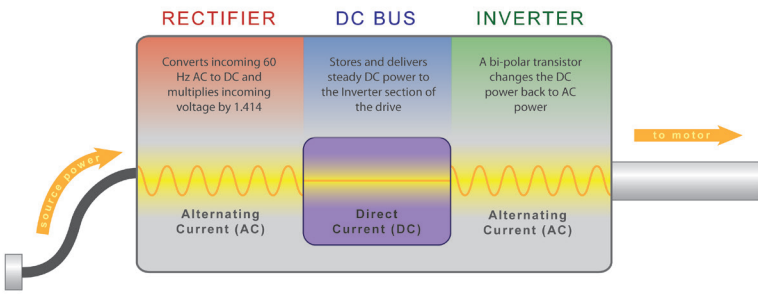
RELIABLE VFD CABLES BOOST PRODUCTIVITY, MINIMIZE DOWNTIME

By **John Gavilanes,** *Director of Engineering*

From fans and blowers to 24/7 production line equipment, variable frequency drives (VFDs) are a mainstay of the industrial world due to their remarkable ability to improve the efficiency of motor-driven equipment. As part of a complete VFD package, high quality cable is one of the most important components in terms of achieving maximum productivity and minimizing downtime. When designing a robust VFD cable, the materials used in its production are critical to ensuring that the cable's electrical properties will guarantee peak performance. For system engineers and others involved in specifying VFDs, cable quality should be one of the most decisive factors.

VFD THEORY SIMPLIFIED

Frequency is an electrical term describing power pulses of voltage and current over time. In the U.S., standard frequency is 60 hertz—or 60 power pulses per second. VFDs, also known as adjustable speed drives, have become increasingly prevalent in industrial applications where frequency is used to adjust motor speed.



A variable frequency drive performs three steps in order to adjust motor speed.

The VFD outputs a flow of AC power pulses at a certain frequency, which provides or maintains the desired motor speed via power supply cables. It is extremely important to select the appropriate cable for the application to avoid disruption in power pulses. This type of interruption leads to a drop in precise motor control, resulting in potential unscheduled downtime for maintenance issues.

THE PROBLEM WITH CABLE

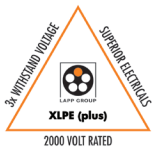
The cable itself is often considered the most critical component of the VFD system. In order to protect cables from power distortions during rectification, the 2015 National Electrical Code (NEC) requires the size of source power conductors to be 125% of the drive's full load current. Although filters, reactors and isolation transformers can be added to the drive to clean off harmonics, these can cause additional voltage drops from the power supply. Due to these and other issues, cable materials can make a big difference in the lifetime and reliability of the overall VFD system.

LAPP'S INSULATION MATERIALS: XLPE (PLUS) HELPS FORTIFY CABLES

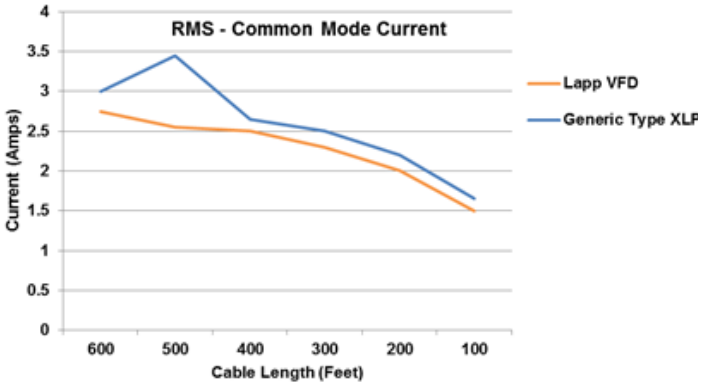
For VFD cables, insulation materials are key to reliable performance. Cables insulated with XLPE (plus) are recommended when electrical performance parameters are critical to ensuring proper operation of electronic equipment. Compared to standard generic Type XLPE, cables with XLPE (plus) are superior in several ways: Cable charging current is minimized, resulting in improved performance; cables tolerate three times the dielectric withstand voltage of the generic 600 volt cables, per UL 1277 (6000 volts); and XLPE (plus) cables can maintain continuous operation up to a maximum of 2000 volts (AC), per UL specifications.

In addition, use of XLPE (plus) insulation ensures minimal Common Mode Current along various cable lengths. Common Mode Current refers to the cable charging current that returns on the ground conductor or cable shield.

LAPP'S INSULATION MATERIALS: LAPP SURGE GUARD BOOSTS FLEXIBILITY



Lapp VFD cables with Surge Guard are smaller in diameter than standard generic Type B or THHN conductors used in conduit, and are also very flexible. Such attributes make these cables especially well suited for use in space constrained, restricted areas. Lapp Surge Guard features a thermoplastic semiconducting layer extruded over the conductor, along with dual PVC insulation and a nylon cover. Surge Guard insulation helps protect the cable from typical electrical phenomena that occur in VFDs during normal use, such as reflections, standing waves and voltage spikes.



When compared to generic Type XLPE cables, XLPE (plus) insulation provides superior results, as illustrated here. Note: RMS refers to Root Mean Square values. Graph is based on actual performance, independently tested by a leading VFD supplier using accepted standards for industrial equipment.

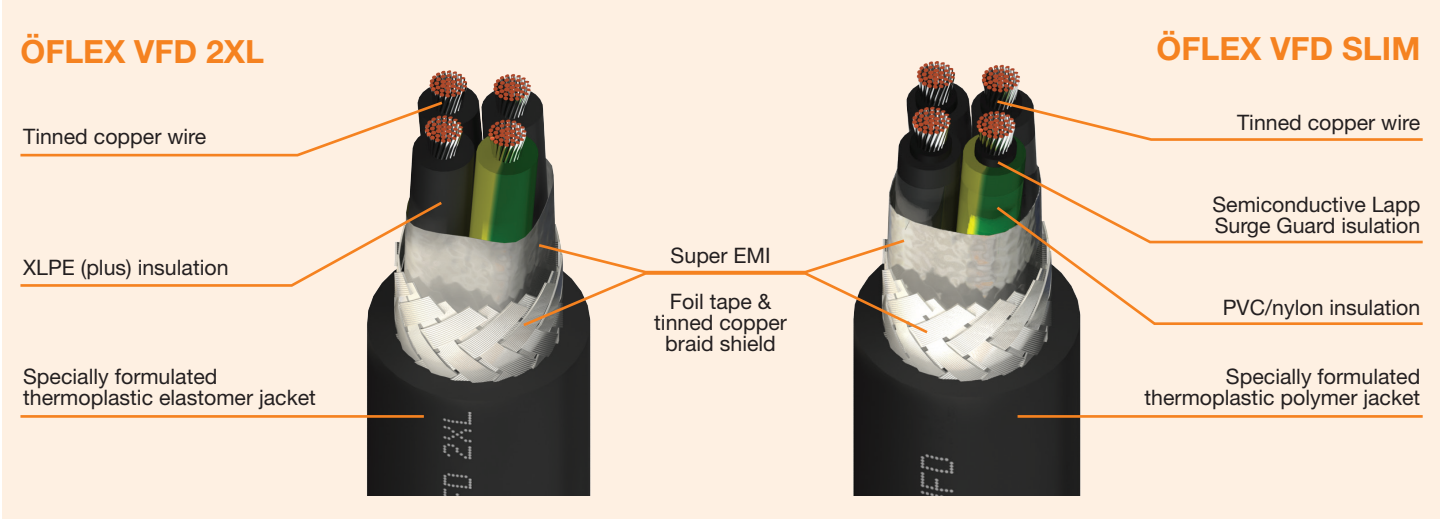
When faced with high voltage spikes, the semiconductive coating on the cable's copper conductors disperses the electrical stress experienced by the conductor and prevents insulation damage. Further, the extruded second layer of specially formulated PVC/nylon insulation allows the cable to maintain superior crush and impact resistance, supporting its UL TC-ER listing.

LAPP GLOBAL STRANDING WORKS EVERYWHERE

ÖLFLEX VFD cables automatically comply with both North American (UL, CSA) and Class 5 European (VDE) conductor stranding standards. The unique stranding provides a "one size fits all" global termination solution. In addition, the resulting Circular Mil Area (CMA) is greater when compared to North American Wire Gauge (AWG) sizes. Which means lower DC resistance, resulting in significantly lower voltage drop compared to cables with corresponding AWG sizes.

Cable Sample	AWG Stranding	Circular Mil Area	DCR (Ω/1000 ft.)	Current (amps)	Calculation: DCR x Current	Voltage Drop (volts)
ÖLFLEX® VFD 2XL	12 AWG; Class 5	7665	1.36	5	1.36 x 5 =	6.8
Generic VFD Type B	12 AWG; 65/30	6500	1.72	5	1.75 x 5 =	8.6

Table illustrates severity of voltage drop in a generic VFD Type B cable compared to Lapp's standard ÖLFLEX VFD cable. The ÖLFLEX cable exhibits approximately 25% less DC resistance than the generic Type B cable.



Exploded view of OLFLEX VFD 2XL and OLFLEX VFD SLIM cables. ÖLFLEX VFD 2XL is a reduced-diameter cable, which provides three different voltage ratings (600, 1000 and 2000V).

TESTING SUPPORTS LAPP ÖLFLEX VFD ADVANTAGES

Lapp products are tested in accordance with applicable agency standards in the company's state-of-the-art UL Client Test Data Program (CTDP) approved laboratory. Lapp employs the same methods, procedures, and types of equipment used by UL when testing its products.

The following table provides an overview of the improved features of Lapp VFD cables compared to traditional generic Type B cables:

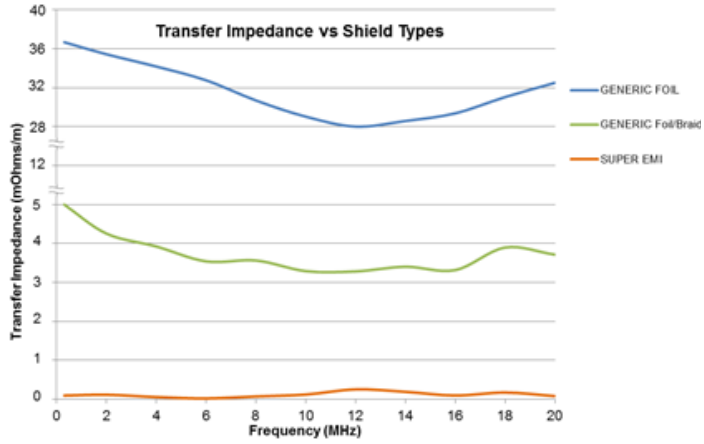
LAPP VFD ADVANTAGES

	Products		
	ÖLFLEX® VFD 2XL	ÖLFLEX® VFD SLIM	VFD Generic Type B
	.045 XLPE (plus)	Surge Guard	.045 XLPE
	Jackets		
	Specially formulated thermoplastic elastomer	Specially formulated thermoplastic polymer	PVC

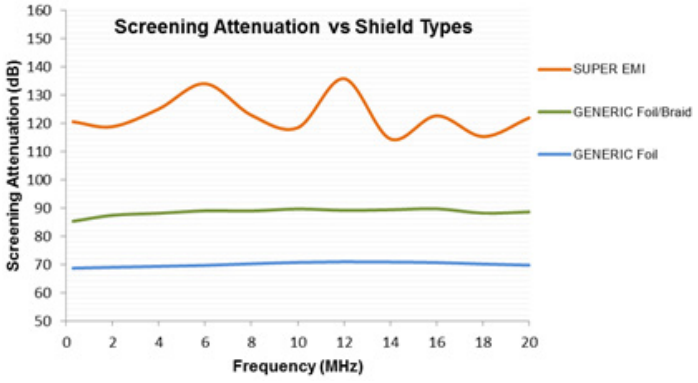
Property	Ratings			Comments
Voltage Rating *(volts)*	1	2	2	#1 - 2000V rated (UL TC-ER)
	1	1	2	#1 - WTTC 1000V FT4
	1	1	2	#1 - c(UL) CIC/TC 600V
Dielectric Withstand *(volts)*	1	2	2	#1 - 3x voltage
DC Resistance *(ohms/1000 ft.)*	1	1	2	#1 - Stranding meets UL & VDE
Voltage Drop *(volts)*	1	1	2	#1 - Lowest voltage drop
Longer Lengths *(feet)*	1	1	2	#1 - Longest lengths
Ampacity *(amperes)*	1	1	2	#1 - Highest ampacity
Corona Testing *(voltage)*	2	1	2	#1 - Highest inception/extinction
Capacitance *(conductor – conductor)*	1	2	1	#1 - Lowest capacitance
Impedance *(ohms)*	1	2	1	#1 - Higher impedance
Oil *(aging)*	1	1	3	#1 - Meets Oil Res II
Flexibility *(durometer)*	1	1	3	#1 - Highly flexible
Mechanical *(pound-force)*	1	1	3	#1 - Crush/impact force
Shield Effectiveness *(decibels)*	1	1	2	AMA tape vs. AM tape
Low Temperature *(degrees Celsius)*	1	1	3	#1 - Meets -25°C cold impact
	1	1	2	#1 - Meets -40°C cold bend
	1 = Best	2 = Average	3 = Fair	

SUPER EMI SHIELD PROTECTS CABLE INTEGRITY

All LAPP VFD cables are constructed with Super EMI shielding consisting of a tri-laminate foil tape combined with a high-coverage tinned copper braid.



Cables with the Super EMI shield offer excellent transfer impedance characteristics. Lower transfer impedance (mOhms/m) is preferable. Note: Transfer impedance is used to determine shield effectiveness against both internal and external interference signals; higher values indicate poor overall shield performance.



Shield effectiveness testing verifies the outstanding performance characteristics of Lapp Super EMI shield in comparison to other cable shield types. Higher screening attenuation (dB) is preferable. Note: Screening attenuation is the measurement of decibel ratio between the internal and external signals of a device. In short, it is a ratio of electric or magnetic field strength before and after placement of a shield. Screening attenuation readings of lower dBs indicate poor overall shield effectiveness.

REGULATORY CODES

In an ideal application, a VFD and motor would be installed in a protected environment and as close together as possible. However, industrial environments do not always allow for this ideal configuration. A cable may be exposed to uncontrolled conditions, such as hazardous atmospheres, temperature variations, chemicals or oils, and physical damage at continued intervals. Resilience to harsh surrounding environments is a primary concern; cable performance characteristics are key features during the selection process. In applications where the distance from the VFD to the motor is farther, the cable may require routing through the building's infrastructure. Where cable is routed through raceway track, NEC Code (NFPA 70) mandates that tray cable (TC) be used. Since tray cable will typically be unprotected by the raceway at one or more points throughout its installation, it must also be rated for Exposure Run (TC-ER) unless it's being routed through conduit. The cable's capacity to withstand crush and impact conditions, as well as chemical, oil, and temperature exposure is the primary focus for code compliance in industrial environments.

LAPP ÖLFLEX VFD JACKETS PROVIDE STRENGTH AND FLEXIBILITY

The jackets used for ÖLFLEX VFD cables consist of either specially formulated thermoplastic polymer or elastomer compounds that are environmentally friendly. These materials provide superior flexibility, ensuring easier handling and routing during installation, especially when tight dimensions require bends. ÖLFLEX VFD cables also provide exceptional flame resistance, as they comply with UL Vertical Tray and CSA FT4 flame tests. In addition, exposure to harsh coolant types of environments will not present any issues either, as all ÖLFLEX VFD cables meet with the stringent requirements of UL Oil Res I and II tests.

ÖLFLEX VFD jackets also feature exceptional resistance to crush and impact forces and maintain the UL TC-ER listing. This listing guarantees that cable is suitable for tray installation in the industrial infrastructure without requiring conduit. Further, the

LAPP GROUP VFD PRODUCTS

Product Name	Description	UL / CSA Approvals	UL Oil Res I	UL Oil Res II	-25°C Impact	-40°C Bend	FT4 Flame
ÖLFLEX® VFD 2XL	Flexible VFD Power Cable	600/2000V – TC WTTC 1000V & CIC/TC	X	X	X	X	X
ÖLFLEX® VFD 2XL with Signal	Flexible VFD Power Cable with Control Pair	600/2000V – TC WTTC 1000V & CIC/TC	X	X	X	X	X
ÖLFLEX® VFD SLIM	Reduced-Diameter VFD Power Cable	600V – TC WTTC 1000V & CIC/TC	X	X	X	X	X
ÖLFLEX® VFD with Signal	Flexible VFD Power Cable with Control Pair	600V – TC WTTC 1000V & CIC/TC	X	X	X	X	X
ÖLFLEX® FD VFD	Continuous Flex VFD Power Cable	600V – TC WTTC 1000V & CIC/TC	X	X	X	X	X
ÖLFLEX® SERVO 9YSLCY-JB	Flexible European VFD Power Cable	1000V – AWM IEC 600/1000V	X				

To provide the most effectiveness, the use of Lapp SKINTOP® MS-SC/MS-SCL or MS-SC-M BRUSH/BRUSH PLUS is recommended to achieve full 360° shield ground termination.

sunlight resistance attribute verifies that the cable is suitable for all weathering conditions presented by outdoor installations. For applications that require a wide operating temperature range, all ÖLFLEX VFD cables pass the severe low temperature extremes of -40°C (cold bend) and -25°C (cold impact) testing and can be used up to a maximum continuous operating temperature of 105°C.

REGULATORY COMPLIANCE ISSUES

Any cable installation in a building or structure may be subject to inspection by the local Authority Having Jurisdiction (AHJ). It is important to remember that interpretation of NEC code requirements and subsequent adoption of any new regulations can differ by state, city or county. No one wants to be held liable in instances of insurance claims, lawsuits, installation violations and the ensuing hefty fines. A printed legend on cable jackets is the only verifiable method that an inspector has to determine a cable's listings, ratings and application suitability.

Lapp's regulatory approvals are far superior to those of the competition's VFD generic Type B products and have the added benefit of being acceptable for Canadian building installations. In addition, the CE Marking indicates acceptability for use in the European marketplace.