

Cable: The Vital Link In Variable Frequency Drives

Variable frequency drives (VFDs) offer industry considerable economic and technical benefits, ranging from improved energy efficiency to more accurate process control. However, to fully exploit these advantages, designers, manufacturers, systems integrators and users of VFD-based equipment must ensure the cable system connecting the drive and load can provide reliable operation in often harsh electrical and mechanical environments.

In this article, Alpha Wire's National OEM Sales Manager, Norm Davieau, uses the development of the company's SERIES V Enhanced Design Variable Frequency Drive Cables to illustrate the unique challenges of designing, producing and operating VFD-based drive systems. By understanding these issues and specifying the optimum cable early in the design process, engineers can rely on a cable system that will provide a long, reliable and cost effective operating life.

Understanding VFD

In industrial AC induction motor applications, motors spin at a speed governed by the number of motor poles and alternating current frequency. Thus, by controlling AC frequency with a variable frequency drive, motor speed can be altered.

The benefits of this approach to motor control include; improved energy efficiency (savings exceeding 50 per cent are claimed when compared with other control techniques); accurate, digital speed control and high-speed/reversing operation. Also, any need for large, expensive and maintenance-hungry mechanical speed control systems is eliminated.

Given these advantages, VFDs are now regularly utilised in applications ranging from industrial robots and automotive assembly lines, to welding systems and conveyor networks.

Cable Issues

For the last two-decades, VFD growth has been rapid in industrial environments where energy efficiency and finite process control are important issues. In fact, some studies suggest that by converting existing drives to VFDs, 30-month capital payback is possible through energy savings alone.

However, in the push to apply VFD technology in an increasing range of applications, engineers involved in the design, manufacture and installation of such equipment must not overlook the importance of selecting the right power and signal cables. By appreciating the unique demands placed on VFD cables and choosing a VFD-optimised cable technology, engineers can significantly improve system reliability and performance.

About 10-years ago, VFD adopters started to recognise a need for more robust cables. Electrical 'noise' in the form of transients, reflected waves, harmonic power distortions and inrush currents were generating harsh electrical environments which were pushing conventional PVC insulated cables to their performance limits and beyond. Field failures increased as voltage irregularities generated corona conditions which damaged the PVC insulation and led to cable burn out or short-circuit.

VFDs typically convert a 480V, three-phase AC source to DC which is then switched at up to 20kHz using IGBT-based electronics. High speed switching, coupled with long cable runs, can cause waves to reflect and where they meet voltage can double or triple. With a 480V source and 700V operating voltage, spikes of 1.4kV and more are possible. These extreme voltages superheat the tiny airspaces inside the power conductors, leading to raised internal temperatures, ozone generation and corona/chemical reactions which degrade PVC insulators.

Cable Development

To help resolve these problems, Alpha Wire has developed a new cable technology designed to provide the electrical and mechanical integrity required by VFDs. SERIES V Enhanced Design VFD cable is characterised by resilient cross-linked polyethylene (XLPE) insulation and a round, uniform geometry which enhances the electrical characteristics and eases installation.

SERIES V cables comprise; finely stranded tinned copper power conductors with XLPE insulation; non-hygroscopic filler materials; a drain wire; aluminium/polyester/aluminium braided shield and industrial grade PVC jacket.

The finely stranded tinned copper power conductors within SERIES V cable are insulated with XLPE. By chemically cross-linking the polyethylene, its molecular chains are strengthened against meltdown during corona discharge and voltage spikes, thus safeguarding motors and system components.

By using a pressure extrusion technique during manufacture, filler materials, and experience gained from producing robotics cables, Alpha is able to offer a cable with a round, symmetrical profile. In addition to its aesthetic appeal, this accurate and consistent cable cross-section also offers significant mechanical and electrical advantages.

During the development of SERIES V it was recognised that low and high frequency signal issues (servos, general sensing, etc.) were becoming increasingly important to VFD systems designers. By combining XLPE's low capacitance properties with the cable's uniform end-to-end capacitance profile, signal propagation was improved. In fact, thanks to the cable construction, tests indicated a 10 to 12 per cent improvement in capacitance rating which translates into a corresponding increase in maximum cable run without signal degradation.

Easy Installation

The smooth, round outer jacket, manufactured from a specially formulated, industrial grade, oil resistant PVC, eases cable assembly during cable installation. For example, in applications ranging from automotive assembly facilities to water treatment plants, designers often need to seal VFDs from their working environments to IP67/68 or NEMA6.

To prevent damp and dirt entering the drive enclosure a tight, reliable seal is required, usually achieved with a compression cable gland or over-moulded seal. While traditional convoluted cable can be difficult to seal using these techniques, SERIES V's smooth, circular outer circumference provides an ideal sealing surface. The result is a reliable seal as cables pass through the walls of junction boxes and control cabinets, even in machine tool applications where cables are constantly sprayed with coolant.

With SERIES V cable regularly applied in electrically noisy or sensitive environments, ranging from welding bays to building control systems, shielding is important to prevent electromagnetic interference problems.

Stranded tinned copper drain wires are used to ground low frequency noise, while aluminium/polyester/aluminium braid shield (85 per cent tinned copper braid) guards against high frequency noise. Four symmetrical drain wires are used on 8, 6, 4 and 2AWG cable.

The shielding system helps contain device-to-device EMI by preventing extraneous noise currents from polluting either the external environment in immediate proximity to the cable or other control circuits in common trays or conduits.

The tightly fitting shield also reduces the likelihood of corona discharge.

Specifications

With a wet and dry operating temperature range of -25 to 90°C, SERIES V cable is available from 16 to 2AWG. The 16AWG cable measures 13.6mm diameter, has a conductor-to-conductor capacitance of 68.9pF/m and a maximum continuous current carrying capacity per conductor of 12A at 30°C. At the other end of the scale, the 2AWG cable measures 33.5mm diameter, has a conductor-to-conductor capacitance of 131pF/m, and a maximum continuous current carrying capacity per conductor of 130A at 30°C. SERIES V cable is also available with a brake pair.

Among its specifications, SERIES V is UL Listed TC-ER 600V and UL 1,000V Flexible Motor Supply Cable and Exposed Run (ER) compliant for use in and outside cable carrying trays without the use of conduit or metal clad cables.

Cables should not be the weak link in a VFD system and Alpha Wire's SERIES V cables are built to specifically withstand the rigours of the VFD environment. Motors last longer, connections are sealed and components are protected. System up-time is maximised so customers can realise the full cost savings of variable speed drives.

With the SERIES V Alpha Wire worked to create the ideal VFD cable, one that is easy to install, aesthetically pleasing and built to combat the continuous dielectric stresses that cause other cables to fail.

The wide acceptance of these new cables clearly reflects the industry's confidence in Alpha Wire's engineering capabilities and illustrates the need for this new generation of advanced-designed VFD cables.

Alpha Wire Industrial Series – Series V Enhanced Design Variable Frequency Drive (VFD) Cables are now acceptable for use with Allen-Bradley® ArmorStart Distributed Motor Controller Series with integrated variable frequency AC drives manufactured by Rockwell Automation. And are suitable for use with most manufacturers drives, including AA Electric, ABB, Baldor, Cutler-Hammer, Fivestar Electric Motors, General Electric, Hitachi, Magnetek, Mitsubishi Electric Automation, Motion Industries, Quality Drive Systems, Robicon, Siemens, Square D, Toshiba and TB Woods.

For reader enquiries, please contact:

Dave Watson Alpha Wire Company 711 Lidgerwood Ave. Elizabeth, NJ 07207	
☎:	908-587-4046
Fax:	908-925-6923
e-mail:	info@alphawire.com
website:	www.alphawire.com

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