

Supporting Commercial Vehicle Production Through Modular Innovation

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The electrification of commercial vehicle fleets continues to take place at a rapid pace. This is certainly true in China and Europe, where politics is forcing change. The zero-emission city bus market in Europe alone grew by 45 percent within the first six months of 2024, according to ACEA.¹ At the same time, over 42 percent of city buses are now zero emission, which is close to three times more than the 15 percent on the streets only five years ago.¹

Simultaneously, the sales of electric trucks remain on the rise, too, with the market set to be worth approximately \$20.25 billion by 2032.² This reflects steady growth spotted over several years. For example,

the ICCT reported that light- and medium-duty electric truck sales in Europe increased by 200 percent in 2023 as users continue to steadily pivot away from internal combustion engine vehicles.³

The growing popularity of commercial electric vehicles (EVs) has followed the rollout of several ambitious "green" policies and regulations across the globe. One prominent example of this is the European Commission's recent climate target, which recommended a reduction of the European Union's net greenhouse gas emissions by 90 percent by 2040.⁴ This target is intended to help the region reach climate neutrality by 2050 and the use of electric trucks and buses can play a pivotal role in achieving this.

THE CHALLENGES TO OVERCOME

Bus and truck manufacturers are increasing their efforts to deliver EVs to the mass market for all vehicle segments. This is especially true for those involving heavy-duty, long-haul operations. As might be expected, this has resulted in higher production volumes, which will only continue to increase as these vehicle types grow in popularity.

This has placed growing pressure on manufacturers to meet ever-increasing customer demands. This is not only true in terms of expected delivery lead times but also pertains to performance. Not only must manufacturers find a way to reduce the overall assembly manufacturing times and optimize the cable

assembly process to get vehicles on the roads faster, but they must also find innovative methods of obtaining the maximum performance levels out of cables and connectors.

In the age of electrification, electromagnetic compatibility issues must be overcome. These occur when key electrical systems, components and equipment interfere with one another, preventing them from working together simultaneously. Therefore, new ways of connecting cable screens must become a reality.

Usually, vehicle manufacturers are focused primarily on the direct costs of the solutions. As a result, not enough attention has been paid to indirect production costs such as assembly, test and production equipment or even reworks. Recently, a number of manufacturers have realized this challenge and have started to turn toward modular solutions as the best approach to EV production.

THE MODULAR ERA FOR CONNECTIVITY

HUBER+SUHNER has been developing high-voltage solutions since the start of this new age of electrification. In the beginning, many pressing issues had to be overcome. First and foremost, manufacturers must ensure that all cables and connectors deliver their maximum performance. These issues raise other questions. What is the best way to avoid any electromagnetic compatibility issues? How can the process time and effort during assembly be reduced? For HUBER+SUHNER, the adoption of a modular approach answers all these questions.

THE LATEST GENERATION OF HIGH-VOLTAGE CABLE ASSEMBLIES

Modular cable assemblies have become crucial to modern production practices. Because modular manufacturing requires production from pre-assembled parts, these ready-to-install assemblies are helping to reduce production times. This is due, in large part, to OEM manu-

facturers no longer needing the extensive knowledge and experience with increasingly complex harnesses.

Solutions like the HUBER+SUHNER RADOX® modular automotive cable assembly (mCAY) now come with end-of-line testing proof. This means that manufacturers can install one of these assemblies immediately into their commercial EVs. **Figure 1** shows an example of where high-voltage cable assemblies are used in commercial vehicles.

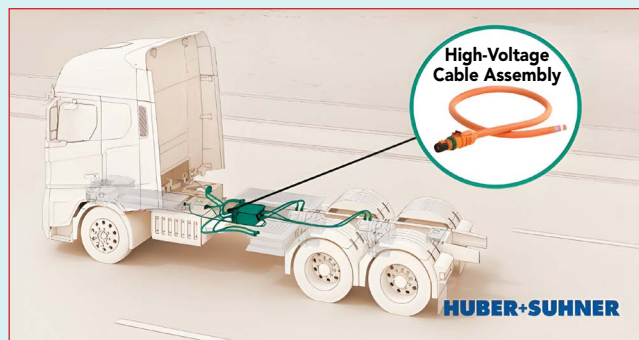
EVOLVING PARTNERSHIPS, NOT JUST TECHNOLOGIES

As modular technologies have become a reality, they have changed the way HUBER+SUHNER operates within the market. This is evidenced by the transition from a cable-only supplier to a complete solutions provider in this high-voltage field. This change in positioning helps suppliers and it also gives OEM manufacturers access to new solutions, like the RADOX technology. The result is innovative EVs and high-quality final products.

MAKING OPTIMAL CONNECTIONS WITHIN VEHICLES

One significant benefit of the mCAY solution is the implementation and use of electromagnetic pulse technology (EMPT). The investment to build in-house assembly capabilities using EMPT has been substantial, but it has been recognized and adopted through its market acceptance. EMPT, which applies short, high-power electric currents to join and form conductive materials, has allowed companies that use the technology, like HUBER+SUHNER, to move beyond traditional crimp technology, which poses some technical limitations under current loads.

The EMPT process does not introduce significant heat into con-



▲ Fig. 1 High-voltage cable assembly and RADOX HV cables in an application.

nection points. This means that the materials used retain full strength and are perfectly suitable for harsh environments. This also helps ensure that these materials and connection points deliver high-quality electrical performance over their lifetimes. The latest connectors on the market, combined with RADOX high-voltage cables, form a reliable cable assembly that acts as the connecting core for high-power applications.

A COMPLETE SOLUTION FOR COMMERCIAL EVS

A modular approach is not a one-size-fits-all approach to vehicle production. Many manufacturers want to use solutions with some level of personalization. Product personalization is essential for delivering tailored customer experiences to different user segments, including "off-the-road" or other industries. Suppliers in this segment of the industry, like HUBER+SUHNER, have been supporting customers with tailored designs to ensure that solutions meet their needs. The goal of this modular, customized approach is to become a one-stop shop for commercial EV systems.

SUPPORTING INTENSIVE VEHICLE APPLICATIONS WITH RADOX TECHNOLOGY

RADOX cable technology was first introduced to the automotive market several years ago. Standing for "radiation X-linked," RADOX makes use of the cross-linking process. In this process, the cables are exposed to controlled electron beams that penetrate the polymer structure. This creates crosslinks that improve the material's properties

without affecting its overall composition. This enables notable improvements in the thermal, mechanical and chemical properties of the cable insulation material, making them a suitable solution for heavy-duty vehicle applications.

RADOX materials are designed to withstand extreme heat, especially temperatures that cause overheating and degradation or may even lead to components melting. At the same time, these materials can also work optimally in extremely cold conditions that may lead insulation to become brittle, frozen or fall off entirely. They can also handle moisture and humidity, which typically can result in short-circuiting and corrosion.

Vehicles may encounter chemicals while in use. This exposure can quickly affect the insulation performance and the likelihood of electrical overloads that cause system failures. The RADOX materials have also been shown to be effective in overcoming these challenges.

In addition, screened RADOX high-voltage cables can carry high AC loads, ensuring powertrain systems work effectively throughout the vehicle's lifetime. The RADOX cables have a robust design; they will meet the flame resistance standards of ECE R118 and are Accord Dangereux Routier (ADR)-compliant. ADR is the European treaty regarding the transport of dangerous goods. Additionally, the RADOX process enables high UV and resistance to weathering for applications directly exposed to different environmental conditions.

DISTRIBUTING HIGH-VOLTAGE EFFICIENTLY

Based on well-defined inter-

faces and internal architectures, components of the HUBER+SUHNER modular high-voltage distribution unit (mHVDU) can be tailored to customer specifications with short lead times. This is helping OEMs bring new EVs to the market much faster while maintaining a high level of quality with what is essentially an off-the-shelf solution. The modular systems and components are tested and validated against various global automotive regulations and standards.

The mHVDU incorporates the modular concept to achieve greater flexibility and scalability than traditional power distribution solutions, including input, output and fuse applications. This unit also plays a vital role as part of a complete system solution. The mHVDU is compatible with other key elements of the HUBER+SUHNER high-voltage portfolio, including the RADOX cables and the EV-C connection system. It is also highly adaptable, as the design uses standardized components that are commonly available in the market. **Figure 2** shows an illustration of how the mHVDU and RADOX cables can be used in a variety of commercial vehicle applications.

Recognizing that the mHVDU will be exposed to the same harsh environments and conditions as the RADOX cables, the unit has been designed to withstand major temperature fluctuations, vibrations and other mechanical loads. This was done to provide a reliable solution that ensures the best performance in heavy-duty applications. Pairing the mHVDU with high-voltage cables and connection systems has led to significant improvements in

powering and distributing energy across various systems.

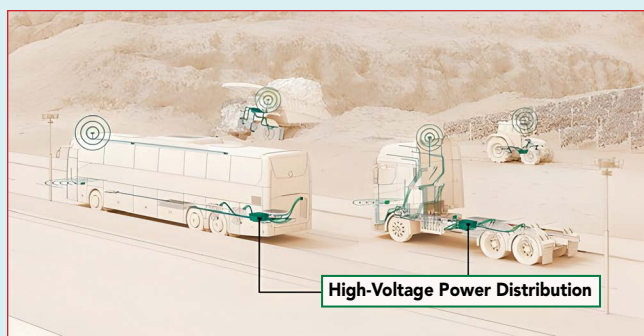
CONNECTIONS WITH GREATER RESISTANCE TO SHOCK AND VIBRATION

To make high-voltage connection systems capable of withstanding vibration and shock during actual vehicle use; it is necessary to ensure superior reliability and enhance the solution's vibration resistance. HUBER+SUHNER has developed the EV-C 2 high-voltage connection system to mitigate these concerns and meet the demanding conditions that may disrupt the performance of heavy-duty EVs. This enhanced connection system is designed for ambient temperatures between -40°C to 140°C. The whole system is classified in accordance with the defined voltage ranges of voltage class B. This includes the HV circuits that use AC or three-phase current components, such as the electric drive system. EV-C 2 also offers an insulation resistance of greater than 200 MΩ when measured at 1000 VDC, in accordance with DIN EN 60512-3-1. When plugged in, the connection system fulfills IP6K9K and IP6K7 protection ratings.

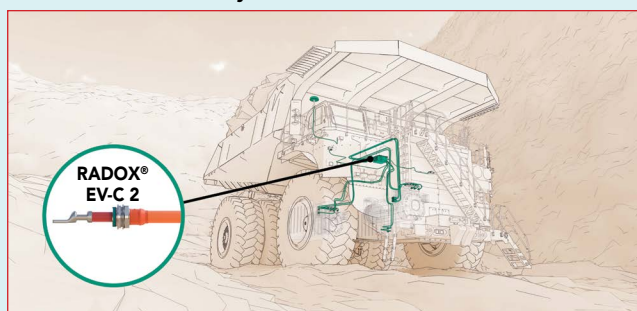
The EV-C 2 has a precoated thread to increase tightness and mechanical resistance. It also has an improved sealing concept for a stronger, more rugged design. The EV-C 2 product line was launched



▲ Fig. 3 RADOX high-voltage cable used in RADOX® EV-C 2 connection system.



▲ Fig. 2 The use of the mHVDU and RADOX cables.



▲ Fig. 4 RADOX® EV-C 2 connection system application illustration.

in March 2024. When it was launched, care was taken to ensure that selected materials would enable manufacturers to use a connection system that complies with the latest directives laid out in the “Restriction of Hazardous Substances in Electrical and Electronic Equipment RoHS 3” (EU 2015/863) directive. To simplify the installation process for this modular approach that is proving effective in vehicle production, a shorter thread runout has been implemented for thin-wall applications. The EV-C 2 connection system with RADOX cables is shown in **Figure 3** and a typical application is illustrated in **Figure 4**.

CONNECTIVITY: TODAY AND BEYOND

As the use of fuel cells and electric commercial vehicles continues to grow, it is becoming essential that the automotive industry evolves

to ensure reliable high-voltage connections over the lifetime of the vehicle and connection system. Through the development of RADOX® and modular technologies, HUBER+SUHNER continues to drive this evolution within the commercial vehicle segment, focusing on energy flow and its distribution. In this segment, flexibility is crucial. Solutions need to be customizable to address specific individual project needs as well as broader market needs. That is why suppliers like HUBER+SUHNER are moving beyond single-function commodity components to supply complete solutions for the end users, teaming with customers from the design phase to the finished product. In today's market, this is the best way to support the ongoing transition into modular systems that will enable alternative powertrains. ■

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