HEAVY DUTY CONNECTORS IN INDUSTRIAL ROBOTICS APPLICATIONS

Providing for Safety, Reliability, and Productivity in Particularly Harsh Environments

The number of applications for state-of-the-art industrial robots is growing constantly. From automotive and aircraft construction to the pharmaceutical industry, logistics, and metal processing, the latest generation of industrial robots can handle more complex tasks than ever before — with no sign of slowing down. TE Connectivity (TE) designs and develops precise solutions that connect and protect the flow of power and data to meet a wide range of challenges.

In harsh environments with high vibration, dust intrusion, temperature challenges, and mechanical impact, TE's Heavy Duty Connectors (HDCs) help ensure flexible design options with dynamic inserts and power, signal, and data connectivity.

TE's Heavy Duty Connectors are rectangular industrial connectors designed to transmit power, data, and signal in very tough conditions. Our HDC portfolio consists of hoods, housings, and bases available in different protection degrees, including IP65, IP67, IP68, and IP69k. Approved according to EN/IEC 61984 standard, the HDC portfolio ranges from 10A to 650A and is available with up to 288 contacts.

TE designs multiple products that fit into industrial robotics applications, giving our engineers a better perspective on how to help optimize your design for harsh conditions. Heavy Duty Connectors help ensure that the enormous quantities of data from the robots and their manufacturing environment are gathered and routed at significant speed with virtually no interruption. Reliable connectivity supports higher productivity, efficiency, and safety — all of which are critical in harsh environments where employees and robots work side by side.

Heavy Duty Connectors provide flexibility, convenience, and high-density solutions in robotics applications to enable automation in minimal space through:

- HMN series: modular design; easy for interface configuration; integrated solution to transmit power, signal, and data
- HDD/HEEE/HQ series: high-density solution, space-saving compact design
- EMC version hoods and housings: 360-degree electromagnetic interference (EMI) protection
- Heavy Duty Connectors that are engineered to resist the highest temperature range at around 105°C

Application Types for Heavy Duty Connectors

Robot manipulator/arm and base

The increasingly high rate of industrial automation is the main driver behind new developments in robotics. The range of applications robots need to handle is expanding to include high-speed precision, driving the demand for versatile, flexible, and intelligent end-of-arm tooling that adds value to the overall production system. TE offers a broad portfolio, from industrial communications, sensors, and power to motor connectivity solutions complemented by standard and customized cable assembly solutions to meet the requirements of different end-markets.

Robot controller

The main task of robot control technology is controlling industrial robots' motion in the workspace position, attitude and trajectory, operation sequence, and time of action. As a manufacturer of robot control technology, you need to be ready for the future — a future where smaller size, flexibility and modularity, optimum configuration options, and high productivity and efficiency are the key factors determining your customers' success. TE's wide range of power, data, and signal interconnect products help to achieve critical and reliable connections to precisely control robots. One example is the HDCs, which provide high-quality solutions for reliable and safer connectivity in harsh environment.

Teaching Pendant Unit (TPU)

Through a variety of device options, the Teaching Pendant Unit maps the trajectory and function of the robot through digital "teaching." Once the robot is "taught," this programming unit can be detached to provide remote control. However, this requires high-speed connectivity to maintain efficient operation and safety.

Accounting for Harsh Environments

One of the primary challenges of engineering for industrial robotics applications in comparison to other application types is designing for harsh environments. Not only do the robots need to function reliably, but the level of volatility can differ from one factory to another. In short, there is no standard environment for industrial robotics.

When the environment can range from a highly controlled, clean-room atmosphere to a dusty, dirty, and potentially contaminated factory floor, there are a lot of factors to take into consideration. Robots need to be able to withstand anything from aggressive cleaning agents to sparks from welding applications, gaseous environments, and even electromagnetic interference. Through it all, engineers have to ensure that data communication will not be interrupted.

Temperature

Industrial environments typically include areas of concentrated high temperatures. For example, injection molding machines can experience temperatures up to 220°C. Temperatures like these can easily wear away at connection components, potentially compromising the flow of power and data.

Chemicals

Processing areas are quickly and frequently treated with cleaning agents (usually with high pressures and high temperatures) to help prevent the spread of bacteria. Depending on the environment, these cleaning agents can be extremely abrasive and require a highly specialized design solution. Consider the differences in the same robotics application in a dairy processing facility compared to a meat processing facility — it is the same action but with different cleaning agents due to different bacteria types.

While IP69K-rated components are typically used for chemical resistance, some environments may require additional testing to confirm compliance and ensure that connectors and cables are resistant to specific cleaning agents.

TE CONNECTIVITY TESTING

As experts in designing for harsh environments across industries — including rail, marine, rolling stock, food processing, and more — TE integrates a rigorous testing process for all of its components.

For example, our HDCs are used in rail applications that are subject to shock and vibration and require connection systems with an extremely high level of reliability. We test for durability and reliability in our in-house laboratory to check that they meet high application standards. We can prove high levels of reliability that easily translate to other applications outside of the rail market.

TE also designs HDCs to withstand the vibration experienced in rocket applications. The international norm requires 6 G resistance from the acceleration. TE can provide from 20 G up to 30 G resistance.

From concept to distribution, we test our products against the highest standards.

Water

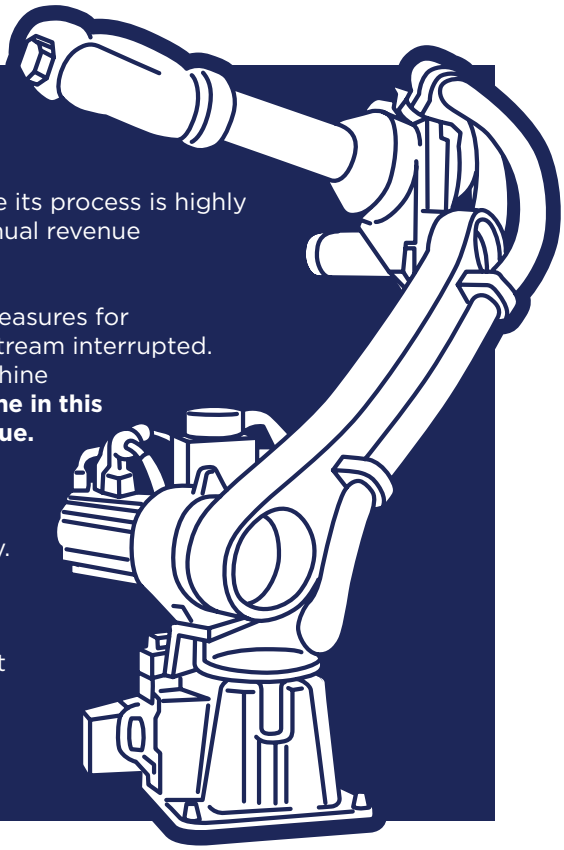
To protect components and systems from water ingress, IP67 compliance is necessary. This level of protection is often coupled with IP69K compliance, as cleaning procedures usually involve some level of moisture, but it involves a different set of standards.

Electromagnetic interference

Motor and motor control functions on robots produce the most electromagnetic interference (EMI) on the factory floor. This is due to the incredibly strong power signal of the rectangular tape that is typically used — up to 600 watts (20A). These conditions require a specialized shield on the cable. This helps ensures that the EMI emitted by the motor and motor control will not impact the overarching environment. Shielding is also important for the termination of the data stream, which applies to HDCs and RJ45 inserts.

Magnetic interference is also common in environments where electrical welding is used. Magnetic interference can corrupt data, which can result in significant productivity losses or, even worse, damage to the equipment or harm to surrounding employees. For example, in order for a robot to perform within specified parameters and be productive on the factory floor, the controllers need accurate, real-time information on the position of the robot. If the position data flow is interrupted, the computer cannot accurately measure the position of the robot, leading to inaccurate assumptions and overreaching or overcompensating while a production line is in motion.

Any interruption of the data stream is unacceptable — from both a productivity and a safety standpoint. Therefore, providing a reliable data stream regardless of environment is critical.



THE COST OF LOST COMMUNICATION

Company A produces 500,000 electric vehicles per year. Because its process is highly automated, the factory floor is running 24/7/365. If estimated annual revenue is $25 billion, that comes out to about $68 million per day.

If that factory floor is not equipped with the correct protective measures for a harsh environment, a machine could be bumped and the data stream interrupted. One robot arm crashes into the one next to it, rendering one machine completely useless until repaired. **Every minute of system downtime in this electric vehicle plant will cost Company A $47,500 in lost revenue.**

Company B is a cutting-edge medical facility and utilizes cobots in the operating room. If the cobot suffers from electromagnetic interference, lack of precision could render it unusable for surgery. Because this cobot is used on complex procedures, minimizing patient downtime and increasing overall safety, the procedure is postponed until the machine is fixed. **This can cost Company B around $200,000 per day in lost revenue** when the system is not functional.

Industrial Robotics Application Needs

Besides designing for challenging environments, engineers must also take varying application needs into account for the safety and productivity of industrial robots. Just as the environment differs greatly between industries, so do the application needs. Therefore, components must not only be durable for the environment but also specialized for robotics.

Flexibility and durability

Because the robot is designed to be a piece of moving equipment, cable flexibility is a key aspect for continuous data and power flow while the robot is moving. However, the most flexible cable is rendered ineffective if the connectors are not designed to work with the cables, resulting in increased maintenance intervals.

How often this cabling needs to be replaced depends on the application and how often the robot is moving during a typical work cycle. Cable manufacturers can build cables that last up to 30 million cycles — but it is important to note that those numbers are an estimate under perfect conditions. For example, if cables are installed incorrectly, they could experience wear and tear around 300,000 cycles rather than 30 million.

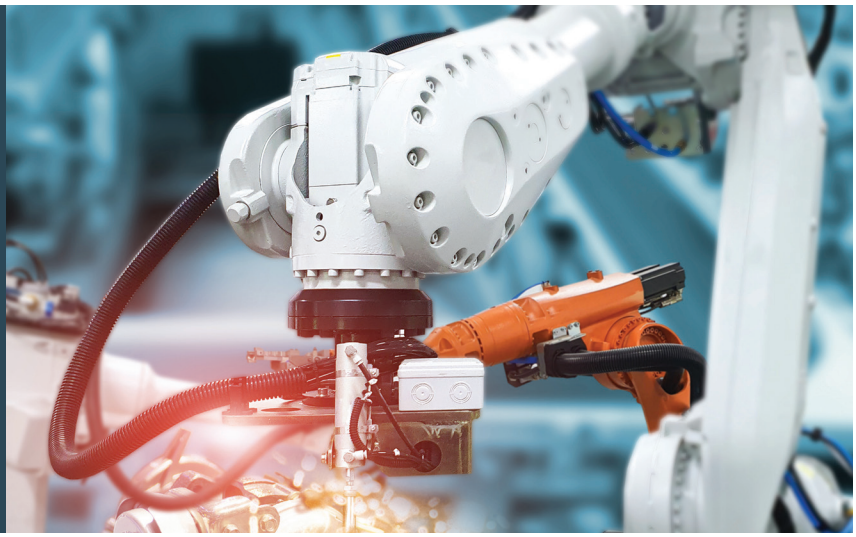
Compact for miniaturization

The miniaturization trend is extremely relevant to robotics, especially considering the small amount of space available for cabling and connector systems.

Take a robotic arm application, for example. Arm tooling must be connected with a data flow, power source, and potentially hydraulics or air pressure — all within a small space on or within the robot arm. Multiple connectors and cables must be fitted together within one cable tray, which can be difficult to manage. HDCs from TE are designed to achieve a higher contact density. This increases reliability of the connector system while still operating within space constraints.

FLEXIBLE, DURABLE, COMPACT CONNECTORS

TE designed our Dynamic Series contact system into our line of HDCs, creating a modular dynamic range of inserts that can go up to 48 positions per module. Using six modules in one frame allows up to 288 positions in one HDC interface.



Dual-purpose cabling ability

Hybrid cable constructions — where one cable is used to transmit power, data, and signaling — are growing in popularity for robotics applications. They reduce the number of connections needed and space required to perform the same function. This helps increase reliability and mechanical performance.

An example of hybrid cable use is in a robot's motor feedback system or control system. This is typically run over industrial Ethernet or with a digitalized two-wire system, using a mix of power signal, power safety, and/or brake wires. Using a hybrid cable structure simplifies the design and makes it easier to protect it against EMI, as there are fewer components that are susceptible to interference.

While the benefits are easy to see, combining power signal and data in one cable assembly can be challenging. Making a hybrid cable assembly successful comes down to the quality of the connectors used. Data transmission and a reliable termination are a must, as well as the proper EMI and environment shielding.

COMBINE AND SAVE

Hybrid cabling systems are becoming more common in next-generation designs. Not only do they help manufacturers meet demands for miniaturization and increased speeds, but they also reduce total cost of ownership. Fewer components mean a reduced cost for materials overall.

Plus, when you are confident in the repeatable quality of the connectors used, you can order in bulk from a manufacturer to drive down costs while increasing performance.

Interoperability

Not only should components be physically flexible, but it is important that they are able to operate within various software systems. Every manufacturer has its own software, which can be based in industrial Ethernet, analog, a two-wire digitalized feedback system, etc. Because there is not yet a universal standard for communication, components must be flexible enough to operate in a variety of platform designs.

TE is experienced in designing custom solutions that meet the requirements of varying product lines and platforms. This could include integrating a hybrid connector system or modular connector types.

SINGLE PAIR ETHERNET

Single Pair Ethernet (SPE) is the technology on which the future success of IIoT will be built, including robotics applications. In the absence of a universal communications standard, TE and the SPE Industrial Partner Network are collaborating to standardize components and applications to integrate SPE, providing virtually barrier-free communication from components to the cloud.

Modularity

Another key requirement for components used in industrial robotics is overall modularity. By sourcing a few select components that are designed to work together, design engineers can create a wide range of application setups that feature various pinnings, cable diameters, etc. Modular HDCs are a highly reliable complement to single-cable technology systems.

Modularity is particularly important for the robotics industry because it allows manufacturers to customize a tried-and-true solution. Once a system is designed for a certain robotics application, engineers can configure those components differently to achieve the same impact for another use case. This also increases commonality across the entire robot and system design, streamlining maintenance and the supply chain.

Heavy Duty Connectors for Harsh Environments

Although RJ45 is an industry classic, it is not the best choice for industrial robotics applications. This is due to overall reliability and durability.

A standard RJ45 was designed for office applications with very little variation, not for harsh environments. Therefore, it was designed with low-cost materials to keep the price point very cheap. However, cheaper plastic tends to be unreliable, which can cause significant safety and productivity issues. Customers could experience a communication breakdown within minutes due to lost contact or signal.

There are industrialized RJ45 components on the market that provide a similar interface with additional ruggedization and shock-resistant properties. These additions help meet the specific requirements of industrial robotics applications, but additional shielding and IP certifications are still needed.

TE has integrated the industrialized RJ45 interface into a line of HDCs. This combination provides the necessary protection needed in any environment — whether it be water, chemicals, temperature, EMI, or vibration.

HDCs from TE also use specialized termination technologies. This eases the amount of work and time needed from installers, increasing their productivity and reducing the need for maintenance. TE's HDCs offer integrated mechanical features that improve the performance of the industrialized RJ45 against shock and vibration. Being able to use the industrialized RJ45 interface with the heavy-duty housing of HDCs provides the necessary communications interface and IP compliance.

Leverage Leading Expertise

As a market leader in connectivity across a wide range of applications, markets, and environments, TE has the specialized expertise that can help streamline and improve your industrial robotics design. TE engineers are experts in one-cable technology, power connectors, hybrid system integration, and much more. Our team knows how to create a reliable system within electrical interference, a wide temperature range, high levels of shock and vibration, and general mechanical challenges. We know that every connection counts.

Customers around the world rely on our solutions: 70% to 75% of the motor manufacturing market trusts TE components and engineering in their applications due to the high levels of reliability. We deliver highly specialized and highly engineered solutions that meet specific application requirements — and can then be leveraged to streamline your specific application design.

Our industry-leading expertise can help ensure that your products are at the forefront of innovation and technological advancements. It all starts with a heavy-duty connection.

Connect With Us

Dial 1.800.CALL.TTI to chat with a Product Specialist.