



WHITE PAPER

From Bolts to Bots:
Unlocking the Design Challenges of
Choosing Connectors for Robotics

By Jordy Jensky, LEMO USA



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It's difficult to think of an aspect of our life not touched by robotic automation. Everyday tasks such as driving to the store are increasingly incorporating robotics. Dig a little deeper into the systems that we interact with on a regular basis and we find robots at the heart of many underlying applications: industrial controls and robotic assembly lines that put together products we use; animatronics creating opportunities for our children to interact with lifelike popular cartoon characters; remote devices that can handle the harshest nuclear environments without putting people at risk; surgical robots that allow surgeons to remotely operate on a patient across the room or across the continent. Though ubiquitous as robotics has become in our lives, an aspect lately overlooked are the connectors that make everything come together, delivering necessary data, power, and fluids reliably in the most diverse environments including the critical application of surgical robotics.

The Critical Role of Connectors in Robotics

Before delving into the challenges, it's crucial to understand the role connectors play in the safe, reliable operation of robotics. Perhaps most obviously, connectors deliver electrical signals to and from various parts of robots. They provide the signal that tells a servo motor to engage and move an arm or send image data from an optical camera to a processor or an external port. As robotic systems increase in complexity the need for greater bandwidth in their communication



LEMO's M series High Power connectors provide robust and secure coupling in harsh environments with the ability to meet the significant power demands that emerging autonomous devices increasingly rely on.

connections increases exponentially. In addition to signals, connectors provide power that robots use to function.

Safely and reliably delivering the high voltage or high current power that robotic systems often require takes special consideration when evaluating connectors. Finally, in an increasingly modular robotic system where a component needs to be quickly swapped out for maintenance or changing task parameters, the ability to quickly disconnect and securely re-connect elements can prevent lengthy and expensive periods of inactivity.

Design Challenges in Industrial and Commercial Robotics

Industrial and commercial robots often find themselves stationed in an array of environments, each presenting its unique set of challenges. One of the most significant challenges is the exposure to harsh environments. For instance, robots deployed in sectors like manufacturing or on top of autonomous vehicles are subjected to the rigors of dust, moisture, and temperature extremes. These conditions mandate that the connectors must meet necessary ingress protection requirements to keep out dust and fluids, as well as handle the unique challenges vibrations and oscillations inherent in movement have in keeping connectors securely fastened.

Furthermore, the modern age has brought with it a relentless pursuit of speed, and data is no exception. Automation and real-time monitoring have become the industry standard, and this transformation underscores the need for connectors that can keep pace with high-speed data transfers. Any lag or bottleneck here could hamper operational efficiency, rendering the robot less



For demanding applications that require multiple connector types such as fiber optics, high voltage, and signal contacts in the same connector, [LEMO provides a number of hybrid connector options.](#)

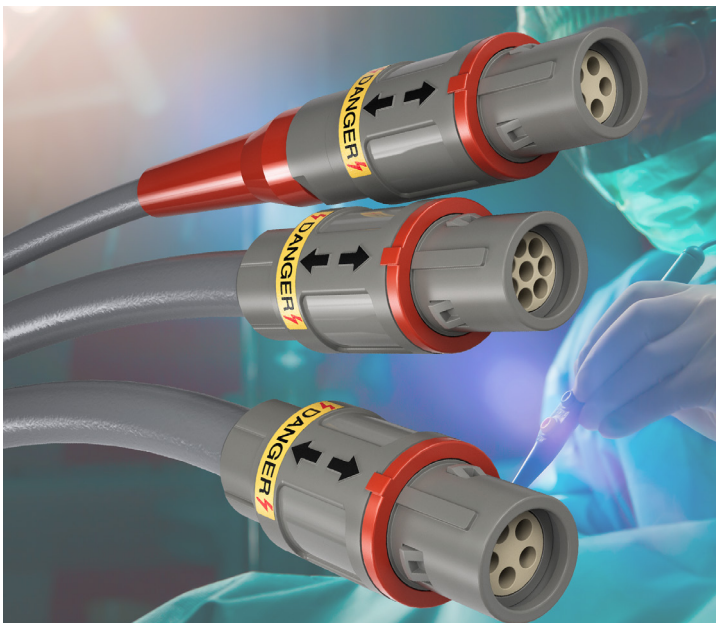
effective. Traditional copper wires and connectors with standard electrical contacts have evolved to keep pace with the ever-growing high-speed data requirements. Increasingly fiber optic wires and connectors are being incorporated into complex industrial and commercial robotic systems to meet speed and bandwidth needs.

Miniaturization is another significant trend shaping the robotics landscape. As robots are designed to be more compact and efficient, the onus falls on connectors to follow suit. These connectors must manage the delicate balance of being small in size while still retaining all the functional prowess expected of them. In addition, the ability to provide higher density contact configurations can free up panel space on ever-shrinking devices.

The challenges don't end with ensuring the robustness and efficiency of connectors. Factories and industrial spaces are bustling with electronic devices, which means connectors have another foe to contend with: Electromagnetic Interference (EMI). The connectors must be adept at shielding robotic systems from EMI, ensuring that data transmission remains accurate, and operations continue seamlessly. In a nutshell, while the tasks of industrial and commercial robots may vary, the need for resilient, efficient, and innovative connectors remains a common denominator across the board.

Special Challenges for Connectors in Surgical Robotics

Surgical robotics is an evolving field where technological marvels meet critical medical applications. The fusion of these two domains necessitates a careful selection of components, especially connectors, given their pivotal role in ensuring device performance and safety. In this context, connector selection focuses on three key areas: safety considerations, connector design, and sterilization requirements.



The new [REDEL 2P High Voltage](#) connector offers multiple conductors with test voltage higher than 100KV AC and compliant with IEC 60601-1 for safe operation in power-demanding, cutting edge surgical robotic applications



Both MOPP (Means of Patient Protection) and MOOP (Means of Operator Protection) are integral to ensuring the safety of patients and operators, respectively. They dictate the robustness of isolation barriers within a medical device. For surgical robotics, connectors must meet stringent MOPP standards, ensuring that even in unforeseen scenarios like circuit failures, patients remain shielded from potential electrical risks. Similarly, MOOP standards ensure the protection of medical professionals operating these robots.

The IEC 60601-1 standards provide benchmarks for safety and effectiveness of medical electrical equipment and underlines the importance of both MOPP and MOOP. Adherence to IEC 60601-1 ensures that connectors chosen for surgical robots not only meet electrical and functional specifications but also prioritize safety. From isolation requirements to risk management processes, the standard serves as a comprehensive guide for connector selection.

With these safety considerations in mind, choosing a connector for surgical robotics requires evaluating the specific role of the connector. Does the connector need to be robust and crush-proof to withstand heavy equipment rolling over it in a busy operating theater? And just as ingress protection is important in commercial and industrial robotics, the necessity of determining whether connectors come in contact with various fluids becomes a critical consideration of connectors in surgical robotics.

Surgical robots operate in sterile environments, and thus, their components, including connectors, need to withstand rigorous sterilization processes. The challenge with connectors lies in ensuring that their functionality and integrity remain uncompromised post-sterilization. This is achieved by carefully evaluating whether the connector material is compatible with the sterilization method required for the equipment. Metal plating and various plastics react differently to autoclaving, radiation, or chemical sterilants and must be considered when evaluating a connector.

Conclusion

The proliferation of robotics across various facets of our lives, from the most mundane to the most critically specialized, underlines the union of innovation with necessity. As we've seen, the unsung hero in these robotic applications often lies in the connectors, bridging intricate systems, enabling power and data flow, and often acting as the pivotal backbone ensuring efficiency, safety, and reliability. Industrial and commercial robots are advancing at an unparalleled pace, facing environmental and technical challenges. Their connectors must rise to these challenges, be it in battling external conditions, facilitating high-speed data transfer, or ensuring miniaturization without compromising efficacy.

When it comes to the medical frontier, surgical robotics pushes the envelope, not just technically, but ethically and practically. Safety isn't just a requirement; it's a solemn promise to the patient on the table and the medical professional at the helm. The connectors, in this context, need to be meticulously designed, respecting standards like MOPP, MOOP, and IEC 60601-1, while also accommodating the rigors of sterilization processes.

In sum, while the world marvels at the robotic arm's deft movement or a surgical bot's precision, it's crucial to acknowledge and appreciate the connectors' role. These connectors, though diminutive, bind complex systems, ensuring that as we march into an era of unprecedented technological synergy, our machines are as reliable as they are revolutionary.

[LEMO](#) is the industry pioneer in the design and manufacture of high-quality and high-performance interconnect solutions. LEMO's Push-Pull and ratchet coupling connectors are found in a variety of challenging application environments including medical, industrial & machines, automotive, test & measurement, defense, audio-video and telecommunications.

LEMO has been designing precision connectors for more than 75 years. Offering over 90,000 combinations of product that continue to grow through custom specific designs, LEMO and its brand REDEL, [NORTHWIRE](#) and COELVER currently serve more than 150,000 customers in over 80 countries around the world.

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Ch. des Champs Courbes 28
1024 Ecublens
www.lemo.com

