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NORCOMP

# CONNECTORS IN MEDICAL ROBOTICS APPLICATIONS

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Applications for medical robots have expanded far beyond their initial use helping surgeons perform procedures. In addition to surgery, medical robots now provide radiotherapy and rehabilitation services, work in medical analysis, and much more. This white paper will discuss these new applications, the requirements placed on connectors in the medical environment, and how Norcomp is helping suppliers design better products.

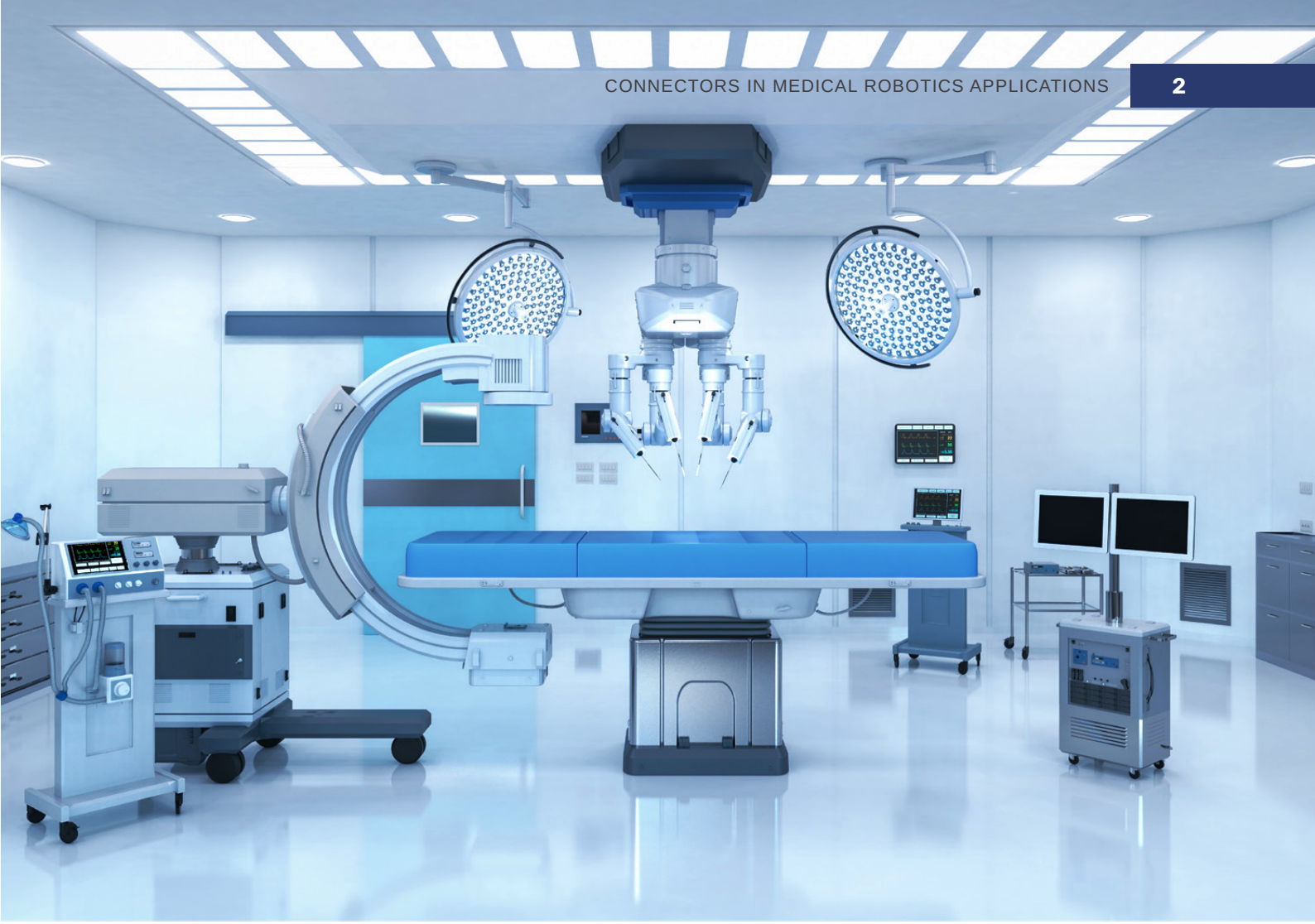

**Figure 1:** Medical robotics is expanding into numerous areas of healthcare (Source: Norcomp)

# INTRODUCTION: THE HISTORY OF ROBOTS IN MEDICAL APPLICATIONS

The first use of robotics in the medical field can be traced back to the 1980s. In 1985, the PUMA 560 robotic surgical arm was used to perform a neurosurgical biopsy, a procedure previously subject to errors caused by unwanted movement due to hand tremors.

The early 1990s saw the emergence of robotic-assisted surgical systems, laying the foundation for future advancements. Researchers began exploring the integration of robotic systems with imaging technology to enhance surgical precision. Over the next twenty years, the field of medical robotics underwent considerable research and innovation. New robotic platforms, instruments, and techniques were continually being developed to address specific surgical challenges and expand the scope of robotic-assisted procedures.

Medical robotics steadily expanded its scope In the ensuing decades. In 2000, the FDA approved the da Vinci Surgical System for use in general laparoscopic surgery, followed by approvals for other systems in a wide variety of fields, including radiation therapy, hip replacements, endovascular procedures such as angioplasty, spinal surgery, reconstructive microsurgery, and many others.



# CURRENT TOP APPLICATIONS

Medical robotics today has expanded into numerous areas beyond the operating room. Some of the top applications are:

- Surgical robots / robot-assisted surgery
- Robotics for radiotherapy
- Rehabilitation robots
- Laboratory robots
- Robotic prosthetics
- Hospital robots
- Social robots

# EMERGING AND FUTURE APPLICATIONS

The field continues to evolve and take advantage of developments in other fields. The rollout of 5G communications has led to the rise of remote surgery where the surgeon can be thousands of miles from the patient. Developments in artificial intelligence (AI) and machine learning (ML) hint at a future in which autonomous robots can perform diagnostic imaging and carry out remote surgery, surgical subtasks, or even entire surgical procedures. The adoption of AI-powered prosthetic limbs is also just over the horizon.

# KEY REQUIREMENTS FOR CONNECTORS IN MEDICAL ROBOTICS

Connectors play a critical role in medical robotic applications, facilitating the transmission of power, data, and signals between different components. We'll first consider the requirements that must be met in any robotics application, then look at some requirements specific to the medical environment.

Some of the key requirements faced by connectors in any robotic application include:

**Mechanical Durability.** Robotic systems involve repetitive motion, vibrations, and mechanical stresses. Connectors need to withstand these conditions without failure or degradation over time. They must be designed to be mechanically robust, ensuring secure connections even with constant movement and environmental impacts.

**Size and Weight Constraints.** In robotics, space and weight are often limited. Connectors need to be compact and lightweight to fit within the robotic system's constraints. This requires careful design optimization without compromising functionality or reliability.

**Electrical Performance.** Connectors must maintain proper electrical performance, including low resistance, signal integrity, and adequate shielding against electromagnetic interference (EMI). They should minimize signal loss, crosstalk, and EMI to ensure accurate data transmission and reliable power delivery.

**Flexibility and Range of Motion.** Robotic applications involve various types of joints and moving parts, which demand connectors capable of flexing, bending, or accommodating the robot's range of motion. Connectors need to be flexible enough to allow movement without causing strain or disconnection.

**Mating and Unmating under Load.** In some cases, connectors need to be mated or unmated while under load or power. This presents challenges in terms of electrical safety, avoiding arcing or short circuits in the presence of flammable gases such as oxygen, and maintaining a reliable connection during dynamic operations.

**Quick and Easy Maintenance.** Robotic systems often require frequent component replacement. In a medical setting, the manipulator arms may change to accommodate different procedures. Connectors should be designed for easy access, simple mating and unmating procedures, and quick replacement to minimize downtime and simplify maintenance tasks.

# THE MEDICAL ENVIRONMENT IS A HARSH ENVIRONMENT

Although a harsh environment might bring to mind thoughts of oil rigs and factory production lines, the medical environment is also a harsh environment, and one with unique challenges for connectors.

**Sterilization and infection control.** In healthcare settings, connectors need to be sterilized or cleaned regularly to maintain proper infection control. Connectors must be designed to withstand the sterilization methods used in hospitals, such as high-temperature autoclaving or chemical methods that use Ethylene Oxide (ETO) or Vaporized Hydrogen Peroxide (VHP).

**Biological contamination.** Connectors can be exposed to biological contaminants, including blood, bodily fluids, and microorganisms. If connectors are not adequately cleaned or sterilized, they can serve as potential sources of contamination and contribute to the spread of infections. VHP and autoclave are used, together with ultraviolet (UV) light sterilization, or ozone decontamination, and the connector performance must not be affected by these methods.

**Chemical Exposure.** Connectors are likely to come into contact with a range of chemicals used in healthcare settings, such as disinfectants, cleaning agents, and medications. Prolonged exposure to certain chemicals can degrade connector materials, leading to reduced performance, weakened connections, or compromised safety. It is important to select connector materials that are compatible with the chemicals used in the hospital environment.

**Durability and Reliability.** Connectors in the hospital environment are subject to frequent use, handling, and physical stress. They may experience wear and tear, leading to issues such as loose connections, intermittent faults, or signal degradation. Ensuring the durability and reliability of connectors is crucial to prevent disruptions in medical device functionality or data transmission.

**Radiation Exposure.** In certain healthcare settings such as radiology departments or radiation therapy facilities, connectors may be exposed to ionizing radiation. Prolonged radiation exposure can degrade the performance and integrity of connectors, leading to compromised electrical conductivity, insulation breakdown, or mechanical failure. Connectors designed for use in radiation-rich environments should be shielded or constructed from materials that can withstand radiation exposure.

To address these challenges, connector manufacturers need to consider biocompatibility requirements, select appropriate materials, incorporate shielding for radiation exposure, and ensure connectors can withstand mechanical stress and cleaning protocols. In this regard, IP67 and IP68 ratings provide assurance on the level of protection connectors offer against dust and water, helping to ensure that they can maintain reliable connections and withstand the environmental demands of medical robotics.

# NORCOMP CONNECTORS RECOMMENDED FOR MEDICAL ROBOTICS

We can distill the requirements discussed above into the following key features to look for when considering a connector for a medical robotics application:

- Hazardous-environment capability
- IP67/68 ratings
- Keyed connectors
- Quick connect/disconnect (application-specific)

Norcomp offers several families of IP-rated connectors that meet these requirements and are recommended for medical robotics applications. These are:

- Vulcon™ Circular Connectors
- Quik-Loq™ Push-Pull Connectors
- Seal-D® waterproof D-Sub Connectors
- Nanook Flanged Waterproof D-Sub Connectors

# VULCON™ METRIC CIRCULAR CONNECTORS


**Figure 2:** A selection of VULCON™ metric circular connectors (Source: NorComp)

The VULCON™ connector family conforms to the long-established industry-standard form factor for circular connectors with a screw fitting. The VULCON™ M-series connectors are rated to IP67/IP68 requirements.

The VULCON™ M12 circular connector has become a leader in harsh environment applications in many fields. VULCON™ M12 connectors are now available in stainless-steel versions; these connectors provide upgraded corrosion resistance for the most rugged medical robotics applications.

The VULCON™ M8 circular connector is a smaller more compact version of the M12. M8 connectors are used in applications requiring a rugged and robust fully shielded metal shell able to withstand shock and high vibration. VULCON™ M5 connectors are recommended for medical robotics applications that require the most compact connector solution.

# QUIK-LOQ™ PUSH-PULL CONNECTORS

QUIK-LOQ™ Circular Push-Pull Connector systems are rugged, sealed connectors ideal for high-reliability waterproof applications where quick connect / disconnect and environmental protection are required.

**(a) 820k** **(b) 821k**

**Figure 3:** QUIK-LOQ™ push-pull connectors (Source: Norcomp)

There are several families of QUIK-LOQ™ connectors. Metal shell connectors are available with both IP67/IP68 ratings for harsh environments and IP50 ratings for less demanding environments. Metal shell connectors feature 360° shielding for full EMI / RFI protection. Plastic shell connectors are also available.

Norcomp also offers several families of industry-standard D connectors with IP67/68 ratings.

SEAL-D® connectors are designed for applications that require both the d-sub form factor plus IP67/IP68-rated protection from heavy spray or short-term submersion.

The SEAL-D® family are drop-in replacements for standard unsealed connectors; this eliminates the need to change PCB and sheet metal designs when upgrading to IP67 standards. They maintain the same footprint as the standard d-sub product offering but are sealed internally. NorComp's proprietary sealing technology allows any existing d-sub product to be manufactured in an IP67-rated version. These connectors are ideal where a medical robotics design must upgrade to IP67 capability while still keeping to the original schedule.

SEAL-D® connectors are available in vertical and right-angle board mount types as well as solder cup for panel mount cable applications.

NANOOK flanged waterproof d-sub connectors provide robust IP67-rated performance in standard, high-density, and mixed layout configurations.

# CHOOSING BETWEEN NANOOK AND SEAL-D FOR YOUR IP-RATED D-SUB APPLICATION

NANOOK and SEAL-D are both d-sub connectors, but there are subtle difference in specifications. The SEAL-D® connector uses the same footprints as standard d-sub products and emphasizes flexibility; it uses a modular design with separate seals and hardware. The NANOOK connector employs a larger footprint than standard. It focuses on ease of installation; it is a turn-key solution that includes all seals and hardware.

The following table summarizes the two feature sets.

| Feature | SEAL-D® | NANOOK |
|---|---|---|
| IP Rating | IP67/IP68 | IP67 |
| Shell Size | E / A / B | E / A / B / C |
| Standard density contacts | 9/15/25 | 9/15/25/37 |
| High density contacts | 15/26/44 | 15/26/44/62 |
| Combo-D variations | 11 | 18 |
| Operating Temperature | -55° to +105°C | -25° to +85°C |
| Mount Options | Cable Mount, Vertical Solder, Right-Angle Solder Board | Solder Cup, Vertical Solder, Right-Angle Solder Board |

# D-SUB BACKSHELLS PROVIDE IMPROVED PROTECTION AND EMI/RF SHIELDING

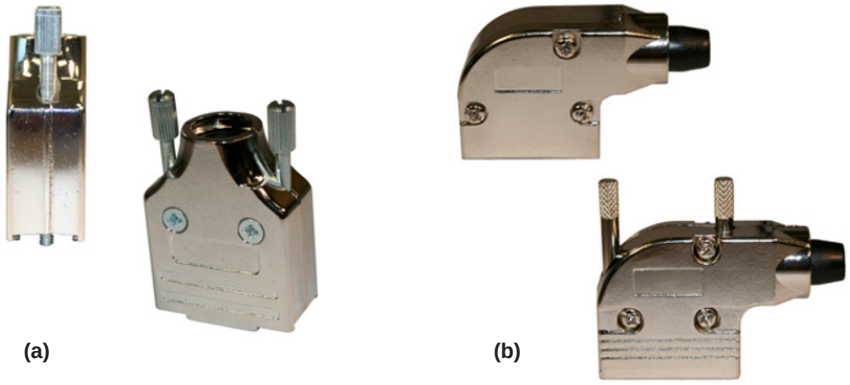
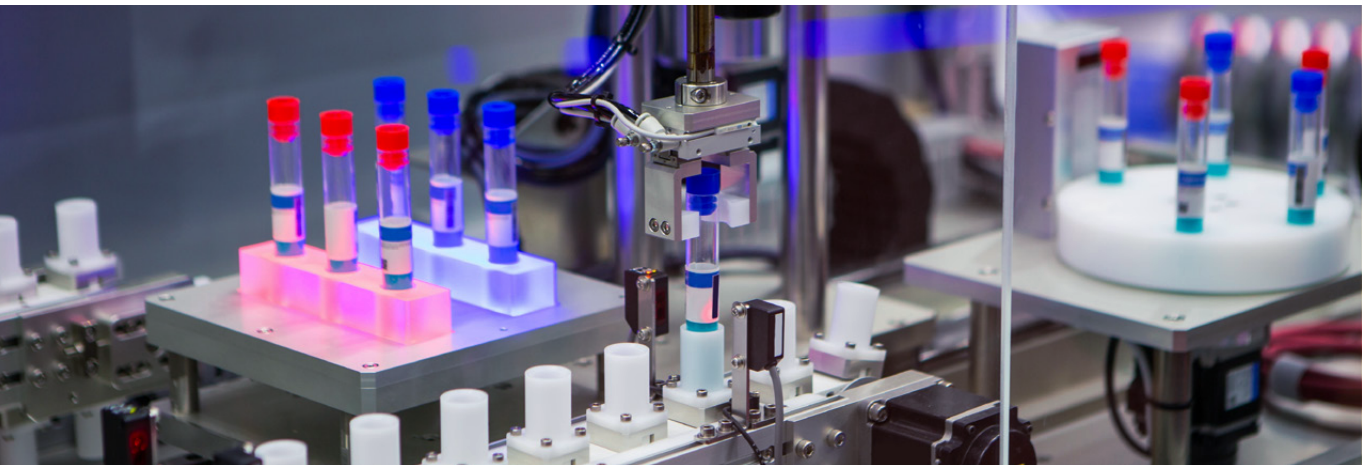



**Figure 4:** D-sub backshell examples (a) 952 series ARMOR (b) 981 series (Source: NorComp)

There is a comprehensive selection of d-sub backshells designed to address several of the harsh environment factors discussed above.

ARMOR D-Sub hoods are designed for rugged / robust applications. Where EMI is a concern, diecast D-sub backshells are plated with high quality nickel and undercoated with copper to provide excellent EMI/RFI shielding.



For high-levels of vibration and shock, a variety of products include options that improve connection stability while maximizing cable strain relief to prevent damage to wires and contacts.

The 967 series backshells provide IP67 rated protection with the help of SEAL-D® technology.

A wide range of d-sub hood systems is available, including Die-Cast, Metalized Plastic & Plastic versions. A backshell selection guide details the various options.

# POWER D SEAL-D® CONNECTORS

Power D SEAL-D® connectors are designed for harsh environment applications where both power & signal are required from a single connection. These connectors can carry both signal (5 amp) and power (20 / 40 amp) contacts within the same connector body. Featuring “Solid-Pin” machined contacts, these connectors offer high reliability performance for the most challenging design applications.

**Figure 5:** A SEAL-D 684M series IP67 Mixed Contact D-Sub connector (source: NorComp)

This diverse combo d-sub product offering includes up to 12 industry-standard contact configurations.

Custom or semi-custom Combo-D connector solutions are also available; these are suitable for applications with unique combinations of signal and power pins.

# WORKING WITH NORCOMP

NorComp engineers have years of experience with medical robotics applications. The standard products discussed above can fulfill the majority of needs, but the team can also provide fully customized solutions and meet demanding schedules.

# CONCLUSION

Medical robotics is a rapidly-growing field that poses a twin set of environmental challenges to connectors: the robotic environment and the medical environment. Norcomp has several families of connectors that are ideally suited to this application, plus a long history of helping medical suppliers with both standard and customized solutions.

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**CONNECTING INDUSTRY 4.0**


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