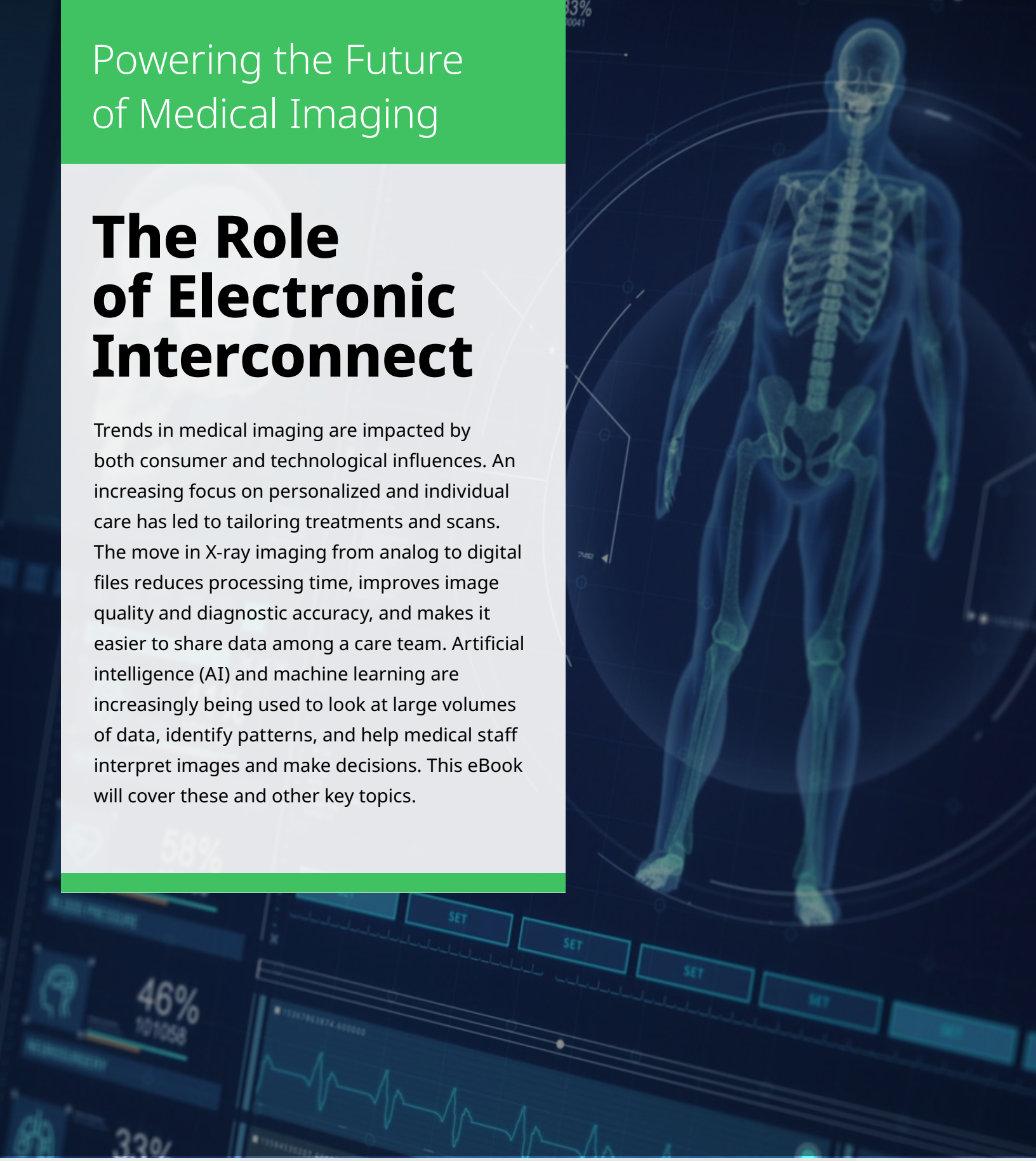
Powering the Future of Medical Imaging

The Role of Electronic Interconnect

Trends in medical imaging are impacted by both consumer and technological influences. An increasing focus on personalized and individual care has led to tailoring treatments and scans. The move in X-ray imaging from analog to digital files reduces processing time, improves image quality and diagnostic accuracy, and makes it easier to share data among a care team. Artificial intelligence (AI) and machine learning are increasingly being used to look at large volumes of data, identify patterns, and help medical staff interpret images and make decisions. This eBook will cover these and other key topics.



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POWERING THE FUTURE OF MEDICAL IMAGING

Electronic Design

INTRODUCTION

Medical imaging technologies are advancing rapidly, and, as a result, the industry is expected to outpace its previous growth. As the population ages and as preventive medicine grows, noninvasive techniques including X-ray, ultrasound, and magnetic resonance imaging (MRI) are helping to enhance positive diagnoses, treatment, and outcomes.

Trends in medical imaging are impacted by both consumer and technological influences. An increasing focus on personalized and individual care has led to tailoring treatments and scans. The move in X-ray imaging from analog to digital formats reduces processing time, improves image quality and diagnostic accuracy, and makes it easier to share data among a care team. Artificial intelligence (AI) and machine learning are increasingly being used to look at large volumes of data, identify patterns, and help medical staff interpret images and make decisions.

Electronic connectivity products are the link that integrates modern medical imaging systems.

These products can be found throughout imaging systems and enable higher-resolution images and displays, can acquire and process high-speed images, and transfer data rapidly.

The components inside the machines are small and compact for portable devices with easy-to-use interfaces.

It is essential that these electronic components work together seamlessly, and the designers of these machines know that using products sourced from one supplier ensures reliability, lowers cost, and minimizes risk.

THE ROLE OF ELECTRONIC INTERCONNECT IN ULTRASOUND

There is growing sophistication in ultrasound as the technology develops. First, let's look at the different kinds of uses for ultrasound: diagnostic and therapeutic.

Diagnostic ultrasound uses high-frequency sound waves to create images of structures within the body. Diagnostic interventional ultrasound uses real-time imaging to guide minimally invasive procedures. Both are used to help providers diagnose problems. An anatomical ultrasound creates images of internal organs and structures, while a functional ultrasound incorporates anatomical images with data such as blood flow, tissue hardness, and other physical characteristics to help visualize a course of action.

Therapeutic or interventional ultrasound also uses high-frequency sound waves but does not create images. Instead, it interacts with the body and helps the interventionalist place catheters or needles to deliver drugs or injections. High-intensity focus ultrasound (HIFU) is used to treat certain solid malignant and benign tumors including those in the prostate, kidney, and breast, and is also used to treat uterine fibroids, tremors, and thyroid nodules.

MEDICAL NEED

Ultrasound can visualize and diagnose:

- Blood clots
- Fetus development
- Abnormal growths, such as tumors
- Gallstones
- Kidney stones
- Joint inflammation
- Bone disease
- Uterus and ovary health during pregnancy
- Aneurysms
- Enlarged spleen
- Thyroid gland issues
- Breast lumps

HOW ARE MARKET TRENDS AFFECTING THE NEED FOR CONNECTIVITY?

The rapid adoption of consumer-friendly electronic devices such as health monitoring bracelets, watches, means patients and clinicians expect easy-to-use devices, interfaces, and outputs. Ultrasound machines are no exception and are built with users in mind, including ergonomic, user-friendly designs, and custom options. In addition, the shift to digital technology enhances image quality, gives immediate access to images, and lowers costs, enabling ultrasound usage outside of traditional hospital settings.

The quality of ultrasound images relies heavily on the display panel. Designers are incorporating high-resolution display panels with higher pixel densities. This ensures better visualization of anatomical structures and enhances diagnostic capabilities.

The demand for portable and handheld ultrasound devices leads to a focus on miniaturizing electronic components. This involves developing smaller and more efficient power supplies, compact transducer connectors, and lightweight control circuitry.

Modern ultrasound systems are increasingly being integrated into hospital networks and healthcare ecosystems. They incorporate networking capabilities, such as Ethernet, Wi-Fi, and DICOM compatibility to enable seamless data transfer, remote access, and telemedicine applications. This allows for real-time collaboration, remote consultations, and integration with picture archiving and communication systems for efficient storage and retrieval of ultrasound images.

Artificial intelligence (AI) and machine learning technologies are gaining significant traction in ultrasound, as well. This includes exploring the integration of AI algorithms within ultrasound systems to assist in image interpretation, automated measurements, and detection of anomalies. This can aid clinicians in faster and more accurate diagnoses, as well as provide decision support.

COMPONENT SOLUTIONS FOR ULTRASOUND

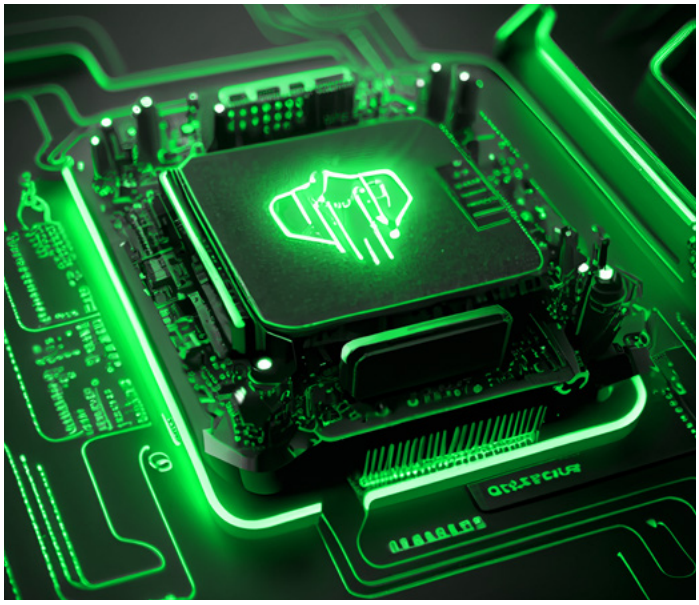
Miniaturized, ruggedized, and integrated solutions help meet the technical needs of more capable medical devices. As ultrasound devices continue to implement technologies first pioneered by the consumer and mobile industries, Molex and Avnet can guide manufacturers through the design considerations and development of various technologies. Medical grade connectors, flexible printed circuits (FPC) and flat-flexible circuits (FFC), board-to-board, board-to-flex connectors, antennas, and IOs are some of the electonic

components in ultrasound machines. Let's look a little closer at some of these products.

USB Product Solutions: USB Type-C connectors use high-temperature Nylon or Nylon 64 as housing material and a three-tier insert-molding process to ensure high-mating durability and electrical reliability of the connector.

SlimStack Board-to-Board Connectors: SlimStack Microminiature Plugs and Receptacles are available in a variety of pitch sizes, mated heights, and circuit sizes to deliver design flexibility while meeting tight-packaging needs. As users of these devices continue to demand smaller, portable, less invasive systems, the need for microminiature designs grows.

Silver Flexible Circuit Solutions: Designers need to fit increasingly small components and traces on limited real estate. Polyimide can accommodate small components and traces, but it is more expensive than PET. A PET substrate provides a flexible alternative to printed circuit boards. New silver ink technology and roll-to-roll printing methods can be customized by Molex to enable fine traces on PET.

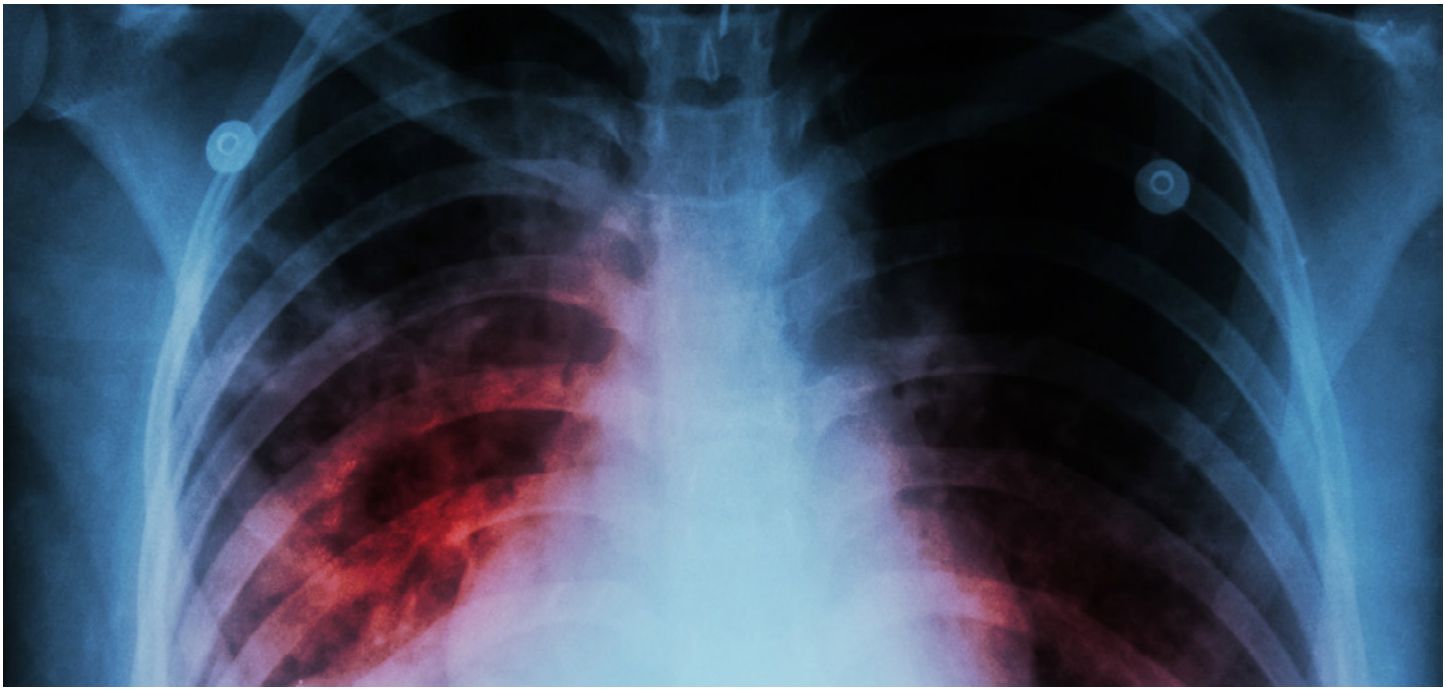


ULTRASOUND PRODUCT SPOTLIGHT: EDGE CARD CONNECTORS

Edge cards provide a connection between PCBs and another device or PCB. Features and benefits include:

- Variable pin count
- Multiple-use receptacle for generator connection
- Lower manufacturing cost than pin and socket
- Accommodates multiple configurations, PCB layouts, and other space constraints
- Capable of higher signal integrity for high-density applications
- Robust materials options for durability in demanding environments

THE ROLE OF ELECTRONIC INTERCONNECT IN MEDICAL X-RAY SYSTEMS



X-ray systems use electromagnetic radiation to pass through the body, creating images of tissues and structures. X-ray systems can be based on film or digital radiography. Film systems have analog output while digital systems display images on a screen.

HOW ARE MARKET TRENDS AFFECTING THE NEED FOR CONNECTIVITY?

The demand for X-ray systems continues to grow as the technology evolves. This is due to an increasing older population, a focus on early diagnosis of diseases, and the trend toward minimally invasive imaging techniques.

MEDICAL NEED

X-ray systems can visualize and diagnose:

- Arthritis
- Broken and fractured bones
- Internal organs
- Pneumonia
- Calcifications
- Foreign objects
- Dental issues
- Tumors
- Abnormal masses

Hospital systems continue to purchase new digital radiography machines and move away from analog film systems. Digital X-ray allows for faster patient visits and in larger numbers, dramatically increasing satisfaction and efficiency. Image files themselves can also be shared among providers for further diagnoses and take up little in terms of storage space compared to film.

High-frequency generators, which produce high-energy X-rays, provide improved energy efficiency, faster exposure times, and precise control over X-ray output. They also enable dose modulation, reducing radiation exposure to patients while maintaining image quality.

X-ray systems are being equipped with wireless connectivity options to seamlessly integrate with hospital networks, and picture archiving and communication systems. This allows for efficient image transfer, remote viewing, and storage, enhancing workflow efficiency, and facilitating remote consultations.

The integration of AI algorithms in X-ray systems assists in image interpretation, automated measurements, and detection of abnormalities. AI can help radiologists detect and diagnose diseases more accurately and efficiently, leading to improved patient outcomes.

X-ray systems use built-in dose optimization features. These systems use techniques such as automatic exposure control, optimized filtration, and iterative reconstruction algorithms to reduce patient radiation dose while maintaining image

quality. Dose monitoring and tracking capabilities ensure safe and appropriate radiation levels during imaging procedures.

A focus on improving the ergonomic design of X-ray systems enhances user experience and workflow efficiency. This includes features such as adjustable height tables, motorized movements, intuitive user interfaces, and automation of routine tasks, which reduce user fatigue and improve patient throughput.

Component Solutions for Medical X-ray Systems

From the physical X-ray device to the system's picture and archival communication system, Molex offers an array of communication and data management solutions. Operating as a large player in the data center industry, Molex, together with Avnet, have the expertise to consult upon the most complex data management systems. With advances in both fiber optic and copper systems, Molex provides expertise for virtually any system architecture. Optical connectors, backplanes, RF microwave products, high-speed IO, fiber optic components, and cable assemblies are some of the electronic components in medical X-ray systems. Let's look at some of these products in more detail:

Optical Connectivity Solutions. Advanced fiber optic components include connectors, adapters, and cables to backplanes and high-density interconnects. Molex's experience and resources provide customers with a wide range of design, manufacturing, and value-added services. Optical solutions are available for data center and medical markets.

Backplane Solutions. A variety of backplane/midplane solutions meet the demand for increased network bandwidth and advanced technology. Each solution is designed for high performance, increased density, and optimal data rates. These high-speed solutions offer customers a full range of backplane and midplane assembly solutions from concept to manufacturing.

RF Microwave Solutions. There are RF solutions for dozens of interface types, ranging in size from microminiature to large, and connectors that may be brazed, hermetic, laser marked or IP67 rated.

THE ROLE OF ELECTRONIC INTERCONNECT IN MRI SYSTEMS

Magnetic resonance imaging (MRI) is a non-invasive technique that uses magnetic fields and radio waves to make detailed images of the body's internal structures. MRI helps providers identify changes in organs, tissues, and blood vessels and is also used to detect and study abnormal masses. Compared to ultrasound and X-ray techniques which use radiation, MRI is better suited for imaging soft tissues and organs.

MEDICAL NEED

MRI systems can visualize and diagnose:

- Blood clots
- Enlarged spleen
- Tumors and abnormal masses
- Pneumonia
- Calcifications
- Dental issues
- Foreign objects
- Injuries
- Ectopic pregnancy
- Kidney or bladder stones

HOW ARE MARKET TRENDS AFFECTING THE NEED FOR CONNECTIVITY?

The demand for MRI systems comes from technological advances, an aging population, and general awareness of early diagnosis and treatment of disease.

The strength of magnet and magnetic field in the MRI machine influences the strength of the signal in the body. Most scanners are 1.5 Tesla to 3.0 Tesla, however a recent demonstration with a 7.0 Tesla was introduced. A higher Tesla number produces clearer and more detailed images.

Radiofrequency (RF) coils transmit and receive the radiofrequency signals necessary for MRI imaging. Improving RF coil technology includes developing specialized coils for specific applications (e.g., neuroimaging, cardiac imaging) and optimizing coil designs for better signal-to-noise ratio and improved imaging performance.

Parallel imaging techniques, such as sensitivity encoding (SENSE) and simultaneous multi-slice (SMS) imaging, allow for faster data acquisition by simultaneously acquiring multiple image slices. Advanced parallel imaging algorithms reduce scan times and improve patient comfort. These techniques are particularly beneficial in applications where motion artifacts are a concern, such as cardiac or pediatric imaging.

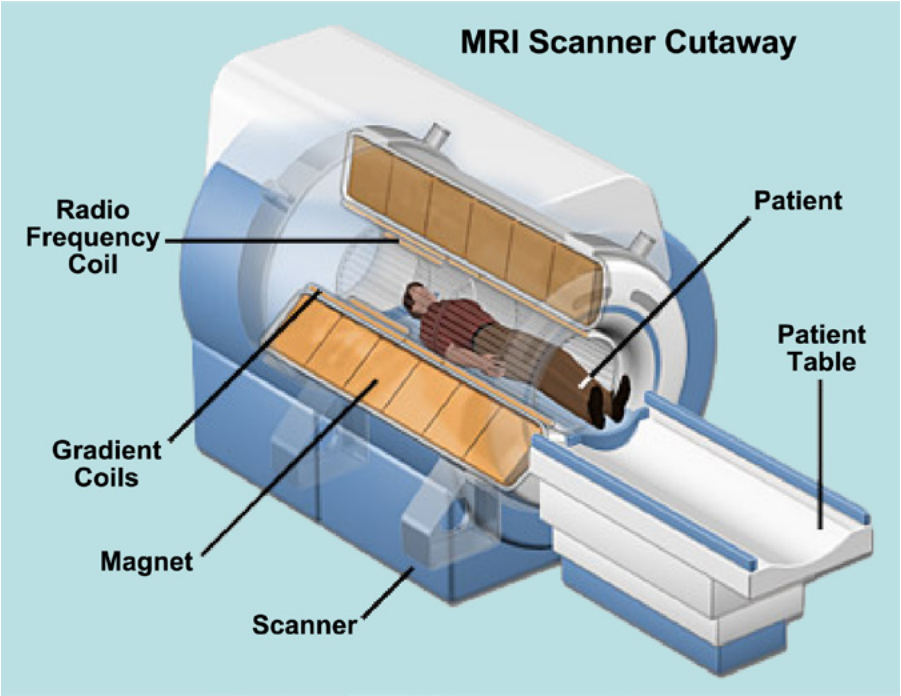
MRI systems are equipped with multi-channel receiver systems that capture the signals received from RF coils. OEMs are continuously enhancing receiver systems with increased channel counts and improved signal processing capabilities. This enables better image reconstruction, enhanced image quality, and the potential for more advanced imaging techniques, such as parallel imaging and dynamic imaging.

Achieving and maintaining a homogeneous magnetic field is crucial for high-quality MRI imaging. Investing in magnetic field shimming technologies and improved gradient systems enhances field homogeneity, minimizes susceptibility artifacts, and improves overall image quality.

The integration of AI algorithms within MRI systems can assist in image reconstruction, artifact reduction, and image analysis. AI can help improve image quality, reduce scan times, and assist radiologists in interpreting complex images. Examples include AI-based image denoising, motion correction, and automated lesion detection algorithms.

COMPONENT SOLUTIONS FOR MRI

MRIs require an array of instrumentation from heavy-duty magnets to high-speed communication lines, where all parts need to be non-magnetic. As capabilities increase within the machine, secure and reliable communication modes will continue to develop. Molex's offering in the MRI space spans various modes of communication from high-speed data signaling, such as QSFP+ or QSFP



DD, to RF connections such as SMA, coaxial, and micro-coaxial, all complying with the non-magnetic standards. Such connections are offered in multi-port, hybrid/mixed layout options, and can be offered as custom or off-the-shelf solutions to your MRI needs. Let's look closer at some of these products:

Non-Magnetic RF Solutions: In MRIs, non-magnetic coaxial connectors used near the magnetic core are critical to minimize image distortion. The use of non-ferrous materials and plating in the connector construction is required to meet the low permittivity necessary to avoid interference and reach a high signal-to-noise ratio (SNR).

FCT D-Sub Connectors: Customers often need connectors that have RF plus high current rating that fits in the same space as lower-current connectors. FCT D-Sub Connectors' machined contacts have increased current-carrying capacity over stamped contacts and are stronger mechanically, making them ideal for a range of applications.

RF/Microwave Multi-Port Connectors: Today, in addition to data, networks process video and voice, resulting in infrastructure densely populated with an increasing number of RF/microwave connectors. Meanwhile, markets demand smaller, more portable medical and smart devices, driving the need for ever-shrinking RF components. Molex RF Multi-port Connector Solutions help add RF channel density when required, in the smallest footprint possible, all while maintaining portability and ruggedness to withstand harsh environments.

Receivers: There are six or more receivers in a typical MRI system to process the signals. They include magnet, gradient coils, RF coils, and RF detectors. RF coils can be receive-only, or they can receive and transmit the RF signal.

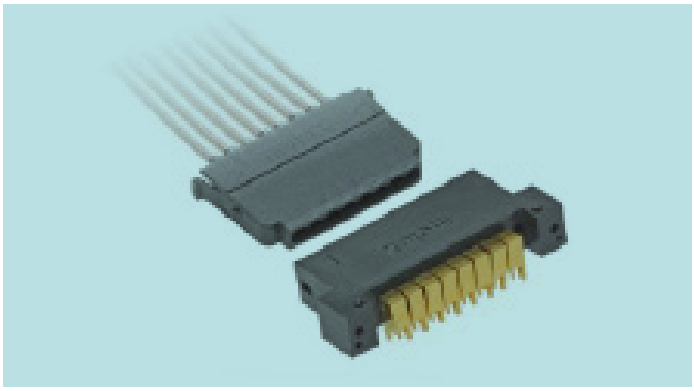
The various types of RF coils include:

- Surface Coils
- Phased-array Coils
- Volume Coils

MRI PRODUCT SPOTLIGHT: MULTI-PORT RF CABLE-TO-BOARD SOLUTION

Rugged and compact MPRF connectors help mitigate IO coax connection failure in high-vibration environments. Features and benefits include:

- 4, 6, and 8 port configurations offer design flexibility for applications with space restrictions
- 3.75 mm pitch, high-density compact array accepts 2.10 mm cable diameters (RG-316) for PCB space savings
- Integrated shell with dual side latches enhances

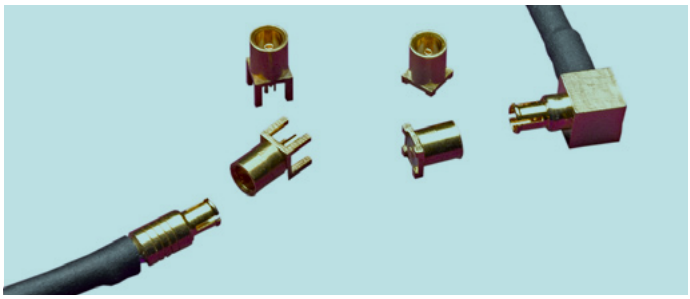


strain relief by preventing cable terminations from “rocking” within the mating interface
- Contact wipe of 1.00 mm nominal ensures high mating cycles and proper engagement under vibration
- One-piece cable block with removable, snap-in contacts provides cost savings via simple installation for customers who prefer to terminate assemblies themselves
- Robust outer nylon shell withstands a minimum of 500 mating cycles and maintains secure connections that support cable weight
- Frequency range DC to 6 GHz supports a broad range of potential applications
- Non-magnetic versions provide relative permittivity close to 1.0 and high signal-to-noise ratio

MRI PRODUCT SPOTLIGHT: SSMCX RF CONNECTORS AND ASSEMBLIES

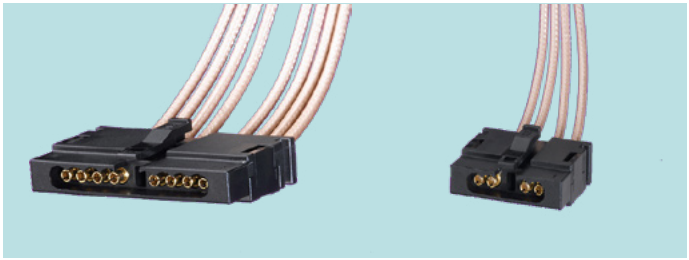
SSMCX ultra microminiature connectors are ideal for compact, low-weight, high-density applications. Individual pairs and ganged solutions both provide excellent RF performance up to 6 Hz.

SSMCX connectors are approximately 35% smaller than MMCX connectors and are available in 50 and 75 Ohm versions. The extremely small size makes them an ideal solution for high-density RF applications. SSMCX Coaxial connectors are also available in 4-, 6-, and 8-port layouts, with vertical and right-angle orientations. The coax



contacts have a 3.00 mm pitch and are available in standard and non-magnetic versions. Features and benefits include:

- High-density connector to minimize PCB space
- Metal PCB lock posts for strength and retention
- Low-loss cable version for higher signal strength
- Custom cable assemblies available
- Excellent electrical performance up to 6 GHz
- Provides a variety of options for design flexibility



THE FUTURE OF ELECTRONIC INTERCONNECT IN MEDICAL IMAGING

Electrical connector solutions are and will continue to be a vital part of medical imaging systems. In fact, these systems will continue to grow in complexity thanks to the developments and progress made possible by electronic components. Better quality image resolution and displays, faster processing of large amounts of data, and miniaturized and personalized devices — including portable scanners that can be used in remote locations — are all possible because of advances in electrical connector products.

Artificial intelligence and machine learning will continue to be applied at a bigger scale for interpreting images, noting trends, and assisting with diagnoses. This data will need to be stored securely and transmitted without loss of integrity, to ensure complete, consistent, accurate information.

As medical imaging moves to the future, we'll continue to see a trend toward personalized medicine as well as early detection, treatment, and monitoring of diseases, with the goal of improving healthy patients.