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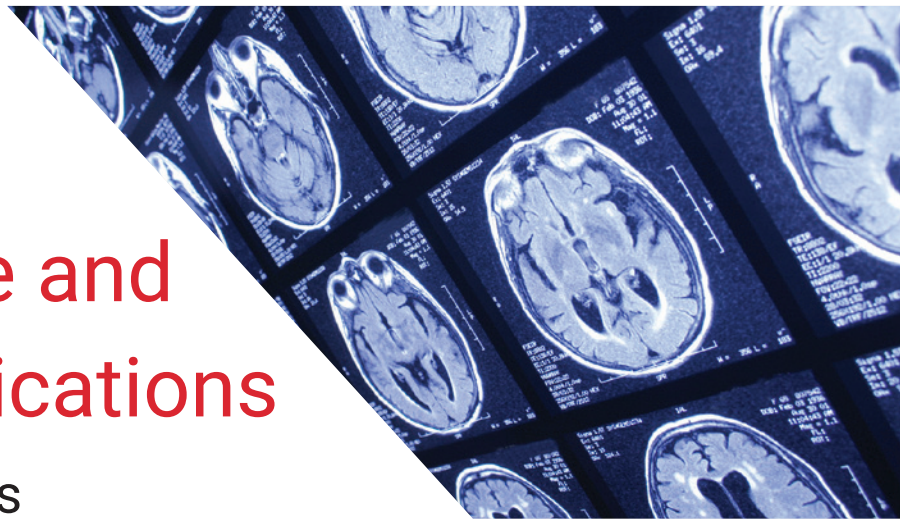


Medical Device and Scanning Applications

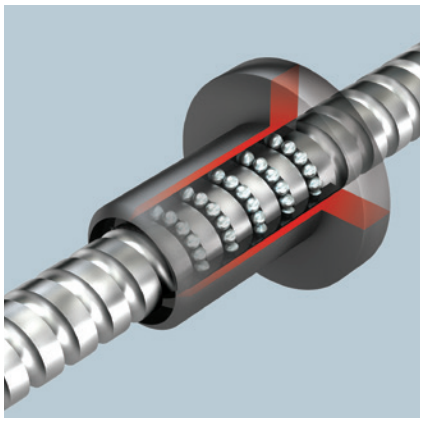
Linear Motion Solutions

Drive systems enable a variety of medical device, imaging, and scanning applications.

A wide range of medical device and digital imaging or scanning applications rely on linear motion. The use of such systems is increasing rapidly, and linear motion control systems have become crucial for the successful development, progress, and deployment of these vital medical tools.

Medical and digital imaging or scanning applications pose distinctive obstacles, which include ensuring accurate, consistent, and repeatable motion, handling diverse dynamic loads in ever-shrinking spaces, functioning in sterile environments that require minimal wear debris, and reducing noise, vibrations, and mechanical interruptions to instruments while in operation.

While linear motion plays a crucial role in various medical device, digital imaging, and scanning applications, choosing a linear drive for such new or existing applications is difficult for two reasons. First, such applications typically must meet a variety of requirements, including reliability, accurate and repeatable movement, size constraints, and noise limitations. Second, there are now numerous linear motion devices available to choose from, adding to the complexity of the task.



Linear Drive Technologies

The most prevalent drive technologies for linear motion include lead screw, ball screw, and belt drives. When it comes to demanding applications that require higher-speed transport and longer travel distances, belt-driven modules are ideal. On the other hand, screw drives are better suited for applications that require a high level of accuracy and repeatability at the end point. Screws also offer more precise alignment, whereas belt drives are usually easier to integrate because of their tension adjustment capability.

Leads Screws Versus Ball Screws

Most medical device, digital imaging, and scanning applications reply on linear electric actuators with either lead screw or ball screw drives. Lead screws use a sliding motion on flat surfaces to transfer loads. In contrast, a ball screw is a highly efficient screw that has matching helical grooves on both the screw and the nut and uses a system of balls that create rolling contact between the screw axis and the nut. Compared to a regular sliding screw, the ball screw has a drive torque of one-third or less, which makes it a suitable option for applications where size and energy efficiency are paramount.

Stepper Motors Versus Servo Motors

Engineers frequently specify stepper or servo motors when they need precise rotary motion for driving a lead screw or ball screw actuator. Stepper motors move in small increments within a closed loop system using a consistent pulse, without the need for a feedback encoder. In contrast, servo motors employ an encoder to adjust pulses for position control. While servo motors offer better performance, stepper motors can be a cost-effective alternative for applications that don't require high speeds, and other scenarios that demand accurate and reliable positioning.

Equipment designers often pair stepper motors with lead screws in low-speed, high-torque motion control applications that involve ergonomic adjustability — such as patient assistance lift devices, hospital beds, and gurneys — as well as for some robotic and imaging applications. Ball screws are best suited for high-speed and high-precision applications, which is why they typically require the advanced capabilities of a servo motor. Applications that demand both high speeds and high torque — such as fluid pumping devices used in medical settings, surgical robots, and some scanning systems — typically rely on ball screw and servo motor configurations.

Medical Devices that Benefit Most from Linear Motion

The increased availability of different types of linear actuators on the market has extended the scope of applications that can benefit from linear motion. These medical device applications, for instance, can greatly benefit from linear motion:

Surgical Robotics. Surgical robots require precise and smooth linear motion, which means they need to be able to move in a straight line with accuracy and consistency. This is critical because surgical robots are used in delicate procedures where even small errors can have grave consequences. Surgical robots also require highly controlled linear motion, with minimal vibration or jerking, to ensure that the robot can move accurately within the patient's body. Additionally, linear motion needs to be repeatable, meaning that the robot moves to the same position with the same accuracy every time it performs a procedure.

Ergonomic Adjustability. The ergonomic adjustability mechanisms used in patient-movement assistance equipment, hospital beds, and gurneys all require smooth, accurate linear motion — they need to be able to move up and down, back and forth, and side to side with precision and consistency. This is important because these mechanisms are used to adjust the position of the patient in order to provide comfort and aid during medical procedures.

Ensuring that the patient's position is adjusted in the desired manner also requires mechanisms that provide smooth motion, free from jerks or sudden movements, to avoid causing discomfort or injury to the patient. Additionally, the linear motion needs to be repeatable so that the patient can be adjusted to the same position every time it is needed. The linear motion of these mechanisms is critical to ensuring that patients can be moved safely and comfortably while receiving medical care.

Robotic Dispensing Applications. Robotic dispensing applications used in pharmacy automation, such as automated pill counters, also require precise, consistent linear motion. In automated pill counting, for example, the robotic arm needs to move pills from one location to another with exact precision. The linear motion needs to be smooth and controlled to avoid spilling or dropping the medication, which could result in incorrect dosages and potentially harm patients. The linear motion of these robots also needs to be fast and efficient to manage massive quantities of medication quickly. This is particularly important in busy hospital pharmacy settings where there is high demand for medication dispensing. The linear motion requirements of robotic dispensing applications used in pharmacy automation center on accuracy, precision, speed, and efficiency to ensure safe and effective medication dispensing.

Medical Instrumentation. Medical instrumentation — such as fluid separation devices used in surgery and axial pumps used to move blood through a dialysis machine — also require precise, consistent linear motion. In the case of fluid separation devices, the linear motion requirements focus on accurately and gently separating different fluids, such as blood and plasma, during surgical procedures. The linear motion needs to be precise and controlled to avoid damaging the separated fluids or creating turbulence, which could lead to clotting or other complications. In the case of axial pumps used in dialyzers, the linear motion requirements center on controlling the flow of blood through the dialyzer with accuracy and consistency. The linear motion of these pumps needs to be smooth, precise, and consistent to avoid damaging the blood cells and creating turbulence, which could result in clotting or other complications that could harm the patient.

Medical Imaging and Scanning Systems that Benefit Most from Linear Motion

Medical imaging and scanning systems are now essential in various clinical specialties such as cardiology, oncology, neurology, and trauma care. To cater to the increasing demand for these systems, original equipment manufacturers (OEMs) need to adopt efficient and modular linear motion solutions to reduce costs, simplify production processes, and stay ahead of their competitors.

Computed Tomography (CT) Scanners. These devices create 3D images of internal organs, bones, and tissues by capturing a series of 2D x-ray images. Lead screw assemblies drive the gantry, a single-axis rotating structure. CT scanners require linear motion control systems to move the patient into the scanner and rotate the gantry around the patient to acquire the 2D x-ray images from multiple angles; those images are then processed to create 3D imagery. The motion control system needs to be precise and reliable to ensure that the images obtained are accurate and can be used for diagnosis. So, the lead screw assemblies used in CT scanners play a crucial role in providing the necessary motion control for the gantry rotation.

Magnetic Resonance Imaging (MRI) Scanners. MRI uses powerful magnets to create a magnetic field that aligns hydrogen atoms in the body to produce human physiological images. MRI machines distribute radio frequency energy throughout the body, which is interrupted by different body tissues, producing an image. MRI scanners require linear motion control systems to position the patient within the scanner and create images of the body's internal structures non-invasively. The motion control system needs to be precise and accurate to ensure that the images produced are clear and can be used for diagnosis. The linear motion control system also needs to be quiet to avoid interfering with the imaging process.

Positron Emission Tomography (PET) Scanners. These scanners measure radiation emissions from the body that are generated by radioactive elements consumed by the patient. PET scanners require linear motion control systems to move the patient into the scanner and position them accurately in order to detect the radiation emitted by the radioactive elements in their body. PET scanners use this radiation to produce images of specific organs or tissues, which are then used to diagnose and monitor the progression of diseases such as cancer. The motion control system needs to be precise and repeatable to ensure that the scanner detects the radiation emissions accurately. The linear motion control system also needs to be dependable and have a fast response time to ensure that the scanner operates efficiently and can perform scans quickly.

Ultrasound Machines. These devices use high-frequency sound waves to create images of the inside of the body, which can be used for diagnostic purposes or, in obstetrics, to view a developing fetus. Ultrasound machines require precise, repeatable linear motion control systems to move the transducer probe smoothly and accurately over the patient's body, ensuring the machine captures clear images of the targeted area. The linear motion control system also needs to be quiet and gentle to avoid causing discomfort or pain to the patient during the imaging process.

X-Ray Machines. While X-ray technology has been used in medicine for a long time, the digital availability of x-ray images is revolutionizing diagnostic radiology and leading to a growing number of applications, particularly in dentistry and surgery. X-ray machines are commonly used for such diagnostic purposes as detecting fractures, tumors, and other abnormalities in the body. X-ray machines require precise, repeatable linear motion control systems to move the X-ray tube and detector smoothly and accurately around the patient's body to capture clear images of the targeted area. The linear motion control system also needs to be fast and efficient to ensure that images can be obtained quickly, reducing the time that the patient needs to remain still during the imaging process. Additionally, the system needs to be safe and reliable to prevent overexposure to radiation and ensure the safety of both the patient and medical staff.

Working With a Linear Motion Solution Provider

As medical device, imaging, and scanning technologies continue to advance, so too will the linear motion technology enabling them. By understanding the essential needs of your application as outlined in this article, you will be better positioned to communicate confidently with a manufacturer. This will help ensure that you receive a ball screw that precisely meets your application requirements. However, to guarantee that you have not missed any crucial details, consider working with a seasoned manufacturer to obtain the product and performance that you need. If you have any questions or want to learn more about PBC Linear products, please don't hesitate to contact us. Our team of experts is here to assist you in any way possible.

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