KENDRION

KENDRION WHITEPAPER

Holding Technologies for Surgical Devices & Robots

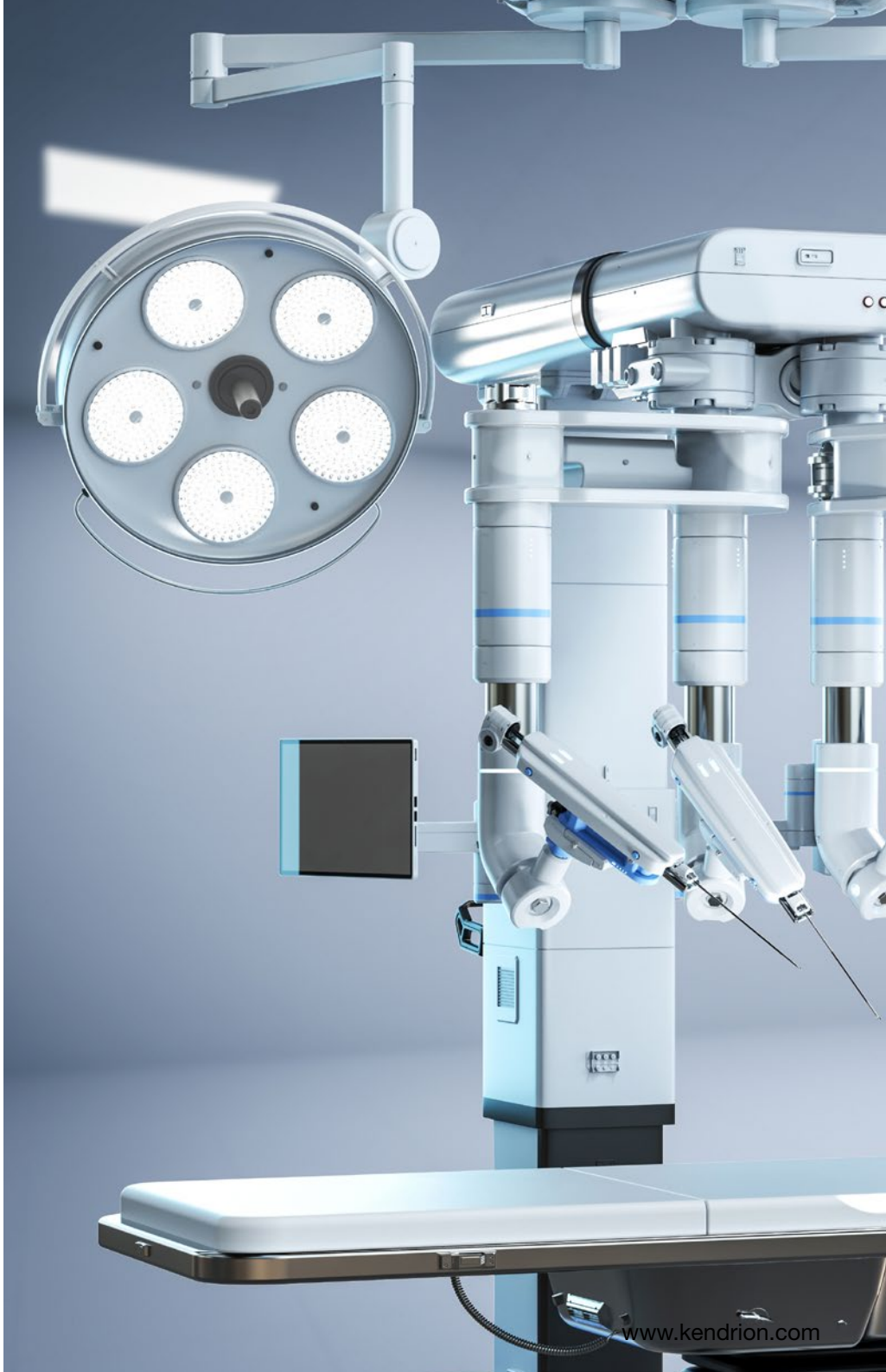
PRECISION. SAFETY. MOTION.

Extreme precision and relentless repeatability are two key requirements that describe surgical robots.

The late 1980's saw the first usage of robotics in surgery. From their first bulky and limited positioning flexibility, they have evolved to their current stage and they will undoubtedly continue to evolve in a similar pace to that of other technologies. Through advances in robotics they will be applied to other surgical procedures.

Designers of surgical devices need to have a broad knowledge of technologies which are used within the devices.

This whitepaper explains the application of position holding technologies which contribute a major part to the functionality of the surgical device.



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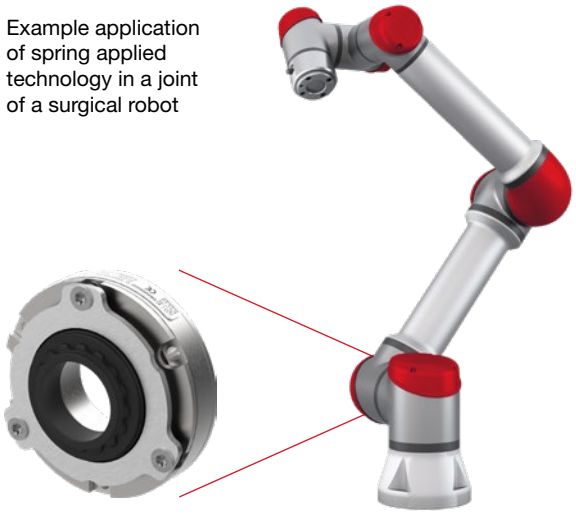
Key takeaways

- Understand the different types of holding technologies and their features
- Application within surgical devices
- Selection and project integration

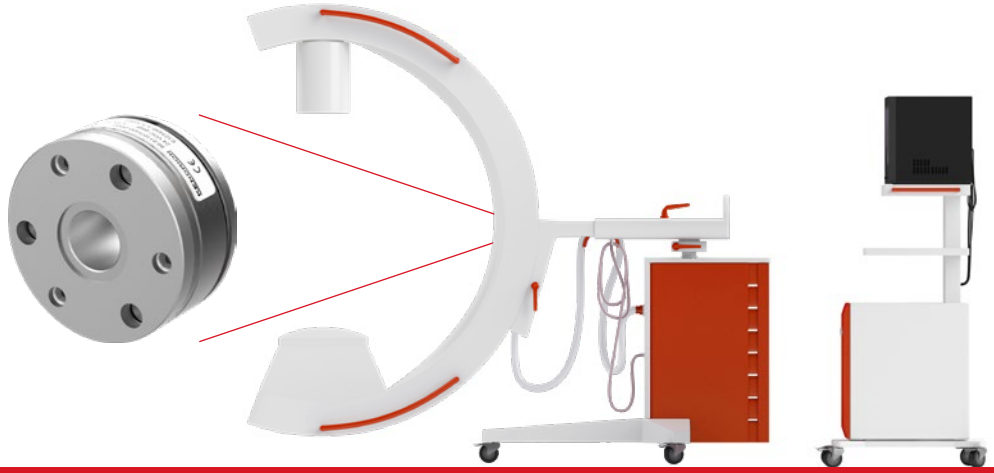
Example application of spring applied technology in a joint of a surgical robot



Introduction

The holding technology is based on electromagnetism, which, in turn, results in two design principles: Permanent magnet technology and spring-applied technology. These brakes possess emergency stopping capabilities. In the normally closed condition, they are designed to prevent rotational movement. To allow movement, the brake must be energized. The brakes are available in different sizes, each offering different holding torque. For easy integration, they come with various interface options.

The following sections focus on several topics of the technology and how they are applied to surgical devices.



Example application of permanent magnet technology in a mobile X-Ray device

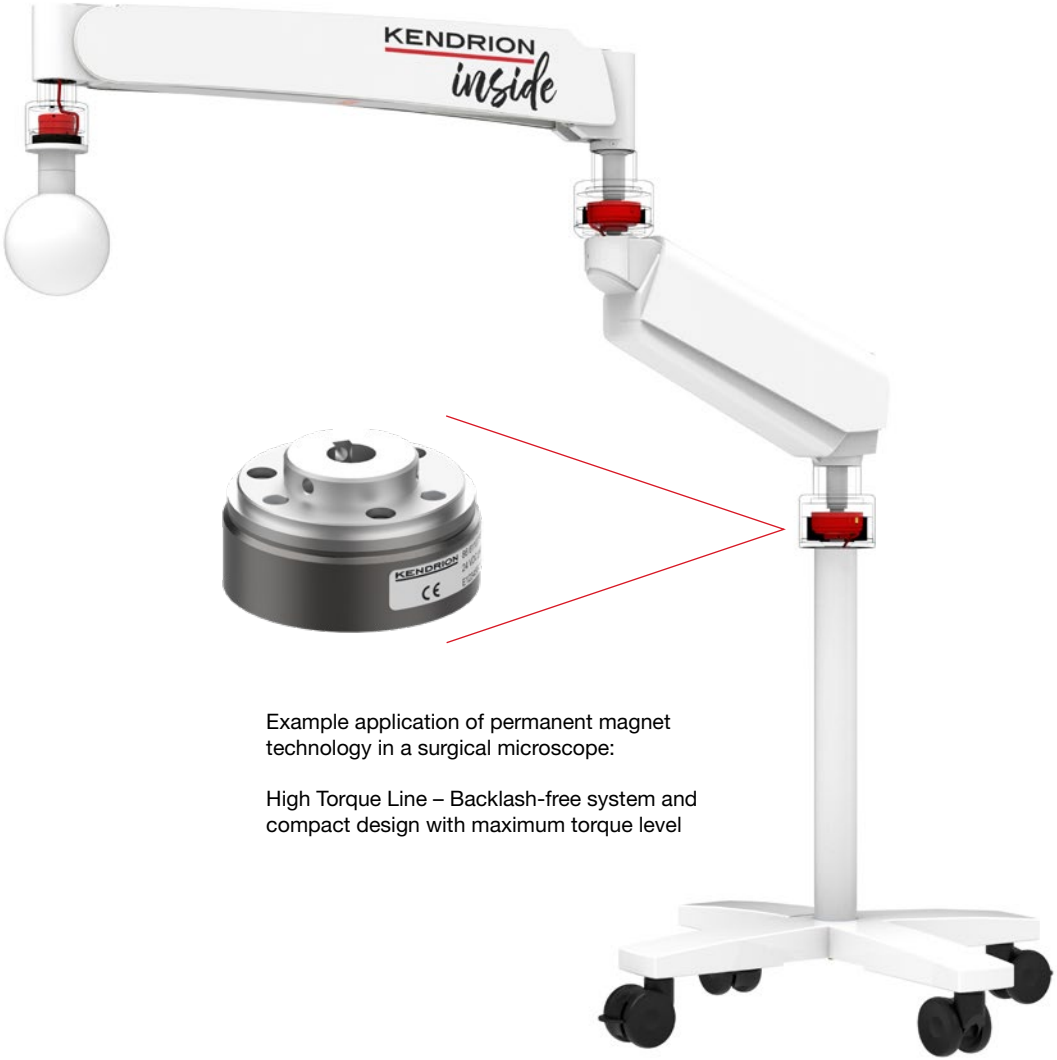
Where are the brakes used?

When the electromagnetic brake is closed (i.e. powered off – nominal voltage = 0 Volts), the brake inhibits rotational movement. The brakes are integrated into joints of electromechanical systems designed for surgical procedures. Depending on the design, they can be integrated into the drive chain with the gearbox and electrical motor, or integrated as a standalone someplace within the application.

Technology integration

This section shows an example integration using permanent magnet technology. Each arm of the stative has an electromagnetic brake, which holds the arm in the holding position.

When a central button is pressed, all of the brakes are simultaneously opened. This allows freedom of movement in all axes. Once the operator has adjusted the instrument to a new position, the button is released and all brakes close simultaneously and the instrument is held in the new position.



Example application of permanent magnet technology in a surgical microscope:

High Torque Line – Backlash-free system and compact design with maximum torque level

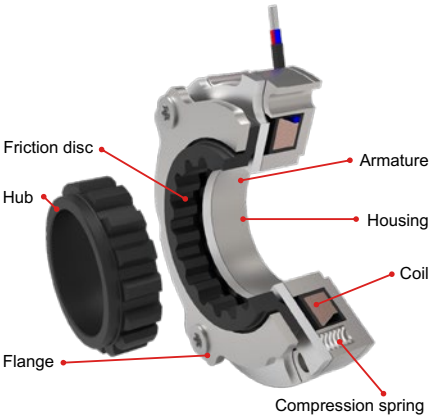
Design principles

Generally, two brake technologies are suitable for medical applications – spring-applied brakes and permanent magnet brakes. Both brake technologies offer specific advantages. This section will explore their design and working principles.

Spring-applied technology

Design principle

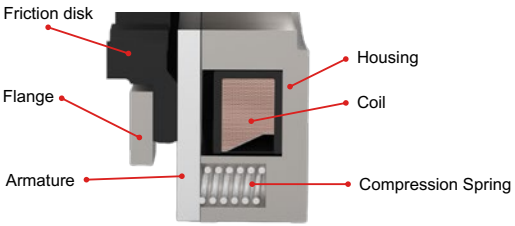
One-piece brake with a separate hub. Brake is preconfigured and therefore no air gap has to be set by the operator when mounting the brake.



The magnetic circuit consists of electromagnetic coil, armature and housing. Compression springs act as a counter force to the electromagnetic force.

Working principle

The brake has two states – closed (normally closed) and open.



Closed condition (no rotation is possible): Coil voltage = 0V. The compression spring force pushes the armature plate to the friction disk, which is pressed against the flange and inhibits rotation.

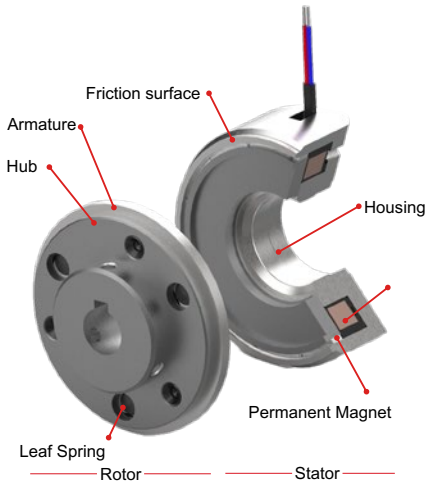
Opening condition: As voltage is applied, the electromagnetic force of the coil is built up. The compression spring force is overcome and pulls the armature against the housing. The brake is open, and the rotor is free to rotate.

Open condition (rotation is possible): As long as voltage is applied to the coil, the brake remains open.

Permanent magnet technology

Design principle

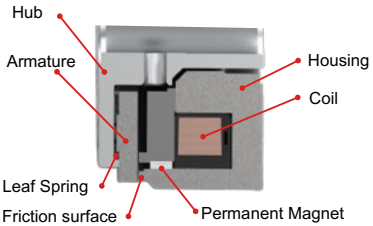
Two-piece brake consisting of stator and rotor with integrated hub. When mounting the brake, a defined airgap has to be considered by operator.



The magnetic circuit consists of permanent magnets, housing, electromagnetic coil and armature. Leaf springs act as a counter force to the magnetic force.

Working principle

The brake has two states – closed (normally closed) and open.



Closed condition (no rotation is possible): Coil voltage = 0V. The magnetic force of the permanent magnet is strong enough to overcome the leaf spring force of the armature. The armature contacts with the stator friction surface.

Opening condition: As electrical voltage is applied, the electromagnetic force of the coil is built up and neutralize the magnetic force of the permanent magnets. The leaf spring force becomes the dominated force and pulls the armature off the stator. The brake is open, and the rotor is free to rotate.

Open condition (rotation is possible): As long as voltage is applied to the coil, the brake remains open.

Differences in key features

The two technologies offer different features. These play an important role in the selection of the technology for the given application.

Technology feature	Spring-applied technology	Permanent magnet technology
Backlash: This is the radial movement, that the application shaft may move when the brake is closed.	1° ± 0,5°	= 0°
Residual torque: In vertical installation position, the rotor of the brake can generate a minimum residual torque by its own weight.	Exists	Does not exist
Large inner diameter: Specifically designed for routing of cables through a hollow shaft.	Available	Limited availability
Power density: Refers to the holding torque that can be generated from the available brake dimension.	Good	Highest
Low thermal generation: To keep the brake open, a continuous holding voltage need to be applied. To minimize heat generation, a concept for reducing the holding voltage is available.	High potential	Medium potential
Noise cancellation: The opening and closing of the brake generates a “clicking noise”, this can be reassuring that the application is providing feedback. An noise reduction concept is available to reduce switching noise.	Only for closing	Optionally available for opening

Depending on the product requirements, space availability and the above technology features, a trade-off may be necessary for certain requirements.

Lifetime of the brake

At Kendrion, the technical data of the brakes is qualified for the entire life time. This allows surgical device designers to concentrate on the integration and other crucial aspects of the solution design, relying on the brake specification.

When is the end of life of the electromagnetic brake reached? Both technologies have a normally closed condition (i.e. nominal voltage = 0V and rotational movement is inhibited). The brake has reached its end of life when the air gap has achieved the specified maximum operational air gap value. The air gap is increased through wear on the friction surface.

Kendrion's patented brake technologies ensure the best performance levels and product lifetimes.

Technology dependability

To establish the end-of-life parameters, all brakes are subject to rigours life time testing under worst case testing conditions of temperature, load, rotational speed, deviations in supply voltage and emergency stopping. In addition, the safety parameters are also determined during the process of testing.

Brake selection

This is application specific and is dependent on many factors. From experience we encounter the following questions during the design decision phase.

Design question	Decision support response
Proposed braking technologies for very precise application requirements?	Permanent magnet brakes are backlash-free. Therefore, these brakes are the perfect solution for applications without gearbox. Applications with gearbox can achieve precision by using a spring-applied brakes.
Are there possibilities to route power cables and related supporting cables through the centre of the brake?	The Servo Slim Line spring-applied brake with its large shaft diameters is the perfect solution for hollow shaft applications and robot joints.
Are there opportunities to save energy?	The nominal voltage of 24 Volts is required to open the brake. After a short period of time, the voltage can be reduced to a lower voltage which conserves energy.
What is fail-safe operation?	When a power failure occurs, the brake automatically closes and remains closed. Both the permanent magnet and spring-applied technologies are fail-safe.

Product options

Kendrion has four product lines of electromagnetic brakes that has been successfully integrated into the surgical devices.

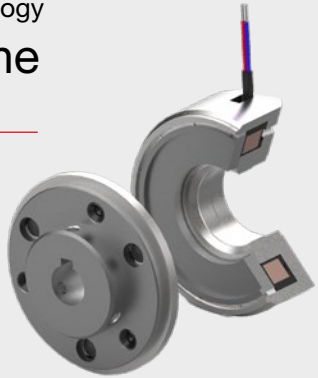
Spring-applied technology

Servo Slim Line

- Fail-safe spring applied-brake
- High power density in a flat and space-saving design
- Holding brake with emergency stop function
- 7 Sizes from 32 mm to 127 mm (outer diameter)
- Static torque range from 0.27 Nm to 8 Nm

Permanent magnet technology

High Torque Line



- Fail-safe permanent magnet brake
- Highest power density by patented brake design
- Holding brake with emergency stop function
- 13 Sizes from 19.3 mm to 205 mm (outer diameter)
- Static torque range from 0.1 Nm to 280 Nm

Spring-applied technology

Servo Line

- Fail-safe spring applied brake
- High variability by different hub types and mounting options
- Holding brake with emergency stop function
- 10 Sizes from 32 mm to 164 mm (outer diameter)
- Static torque range from 0.27 Nm to 70 Nm

Permanent magnet technology

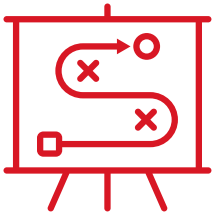
PM Line

- Fail-safe permanent magnet brake
- High variability due to modular design
- Holding brake with emergency stop function
- 10 Sizes from 14 mm to 200 mm (outer diameter)
- Static torque range from 0.01 Nm to 240 Nm

Components of a successful project

Once the brake technology design decision has been made the next step is the integration of the brake into the application. Kendrion provides support through a technical single point of contact who is responsible for all aspects of the project.

We see ourselves as an extended part of the customer's design team taking responsibility for upholding of schedules for possible changes to 3D drawings, participation in integration reviews, and on time delivery of various stages of prototypes. When needed, we conduct extended testing and, if required, assist with obtaining compliancy certifications. Towards production we advise in assembly and production related questions of the application.



Conclusions

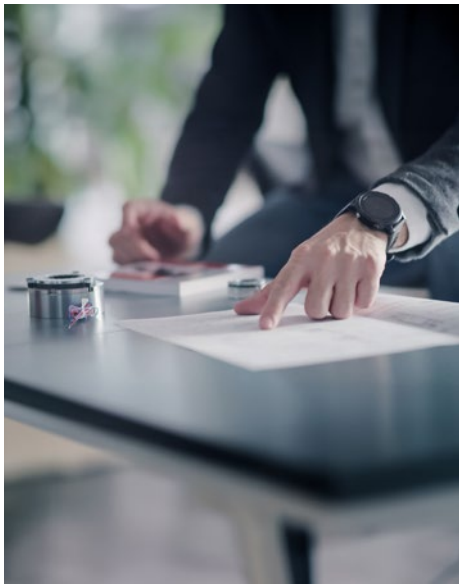
The application and complexity of surgical procedures will continue to evolve. One of these important technologies is the precise holding of the application during delicate procedures. Kendrion has two technologies that fulfil different requirements for holding applications.

This whitepaper presented a comparison between the two technologies and their features. Discussed important quality aspects such as the meaning of life-time and how the designer can rely on these parameters.

Other aspects such as product integration and having a competent technical advisor all play an important role in the successful translation of a product idea into a highly reliable device for high precision surgical procedures.

What to do next?

- Visit our landing page for more **technical data** about our brakes: www.kendrion.com/surgical-devices-robots
- **Download the 3D models** of our brakes from our website that suit your application best.
- Do you need help? Please **contact our brake experts** directly. They will be happy to answer your questions and provide support: info-atlanta-ib@kendrion.com



Worth knowing about Kendrion

Kendrion is a full-line provider of electromagnetic brakes based on spring-applied and permanent magnet technologies. Our product portfolio ranges from brakes mounted on the outside of the motor housing (with various IP protection classes) to highly integrated brakes inside the motor housing and standalone brakes (mounted along the drive train).

We can look back on over 100 years of experience in the field of electromagnetism and are pioneers in the field of electromagnetic brakes. Details of our history and a comprehensive product overview can be found at www.kendion.com.

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Your Brake Experts

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