

Imagine if you lost your sense of 'Touch'

Tying a knot. Peeling an orange. Picking up a glass. Holding the hand of someone you love. Now imagine the same things if your sense of touch was taken away from you. It's hard to truly consider something so integral to our lives gone. How much more difficult would those tasks become? For surgeons that operate on patients using robotic surgical suites, that is in many ways their reality. They cannot feel the surgical instruments in their hands. Instead the surgical system provides visual and auditory feedback on the contact forces of the end effector of the robotic instrumentation. For men and women who spent years of their lives honing their sense of touch, the loss means having to relearn how to operate on a patient. While visual and auditory feedback combined with extensive training is "good enough" to operate these capital robotic systems, when has "good enough" ever been enough? The solution to make these surgical equipment systems complete lies in providing physical, haptic feedback to the operator, thus restoring their sense of touch.

But what is Haptic Feedback? Haptic Feedback or Haptics refers to sensing and manipulation through touch. (Srinivasan) Such tactile technology adds an edge to the use of the medical capital equipment, allowing the surgeon to get a great feel of the end effector of the instruments inside the body. Utilizing a load cell and torque sensor based solution, we can measure and transmit high precision and resolution force and/or torque feedback. This can be synchronized with vision, end effector, and haptic actuators to provide real load feedback of the end effector to the surgeon. These capabilities

dramatically improve the quality of the surgery, minimizes tissue and organ damage and improves ease of use in both laparoscopic and tele-operated robotic environments.

Over the past few decades the technological advancement and financial investment in minimally invasive surgical technology has grown at an incredibly rapid pace. To enable continued growth and increase ease of use, FUTEK based sensor solutions can be designed and developed in different forms and incorporated in different parts of the medical device:

- Ultra-miniature inline solution ([LCM100/LSB200](#)) to monitor tension force on strings and/or rods manipulating the motion within the capital equipment. Such methods are commonly used to engage with laparoscopic tools.
- Custom micro-torque sensors to provide high precision torque feedback for closed loop control on high speed, brushless DC motors. For years, current loop measurements have been the accepted method to monitor the torque and program high speed, brushless motors from well-known brands: Maxon, Micromo, Faulhaber, etc. FUTEK developed miniature custom sensors ([QTA141](#)) that could close the loop and improve the 5%-10% accuracy of the current loop to 0.25% or better. Such advancements will make the process smarter, more reliable, and more accurate, resulting in smoother motion control.

- Utilizing multi-axis sensors, such as the [MBA500](#) to measure torque and thrust on the arms of the capital equipment or surgical robot.
- Bespoke multi-component solutions to provide feedback on 3DOF or 6DOF systems.
- Custom ultra-miniature force sensors to monitor thrust on ball screw mechanism. High cycle duty, accuracy, and great repeatability are main targets to achieve for repetitive motion.
- Imagine a sensor surviving high PH level, high pressure and high temperature while consistently maintaining sensitivity, zero stability, and repeatability. In recent years, FUTEK has developed autoclave-able sensor solutions. This advancement reduced the cost significantly allowing utilization of the force/torque feedback on applications where sterility is critical.
- By embedding force sensor solutions in equipment and monitoring the mass flow, allows for the detection of any accidental overload on patient's body, sending a signal to the main controller aborting the action. This critical safety feature enabled by load cell and torque sensor technology increases patient safety by mitigating operator error.
- Blood pressure is constantly monitored in many infusion medical devices. Contamination, along with the cost of the pressure sensors consumed per procedure, is a huge concern. Instead, by employing indirect force measurement techniques enabled by miniature load cells, a

monitoring system with a high level of confidence can be developed, while sensors can be used for years without any need of replacement. Additionally, as the sensor will not come into contact with patient's blood, safety is significantly increased.

For more than 30 years, FUTEK has invested its resources to innovate and lead the market as a pioneer in miniature solutions. The blue ocean strategy implemented half a decade ago motivated the core team to educate themselves and seek new solutions filling the gaps in the market instead of competing. The core team took advantage of the knowledge acquired from the wide range of industries supported. As an example, we learned how to overcome high pressure challenges required by the oil & gas industry with applications up to 1200 PSI pressure. Innovating solutions for the aerospace industry taught us how to deal with high vacuum and extreme temperatures while supporting the sensors for Mars Rover Curiosity program. We learned how to scale production for high volume manufacturing in order to support the Semiconductor and consumer electronic market. Last but not least, the medical market taught us that failure is not an option. As a result, we've been able to find solutions that enrich the lives of people around the world on a daily basis.

As an ISO 13485 organization, every team member understands the importance of source control at every level of the supply chain. The risk mitigation aspect is considered at every level of the process from design, MFG process, to detailed documentation. It takes a well-organized, collaborative, experienced team to focus its

innovation and create reliable solutions. Dealing with Aerospace and medical markets for years, we have faced a variety of applications and mad scientists. We have applied our vast experience to our products and services and as our records and statistics show, our product quality is second to none with no field rejections and superb supplier score sheets from top 500 fortune companies on a quarterly basis.

Bibliography

Srinivasan, M. A. (n.d.). *What is Haptics?* Retrieved from Geomagic:
http://www.geomagic.com/files/7713/4857/8044/what_is_haptics.pdf