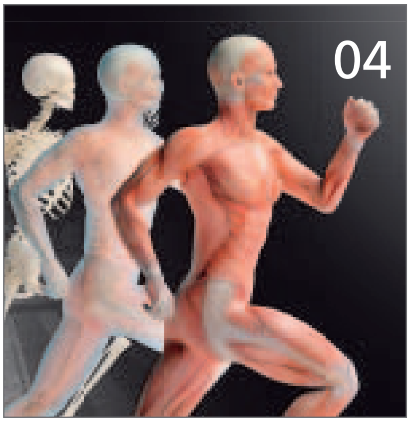
FAULHABER

motion

01.2014

THE MAGAZINE WITH DRIVE

↘ EVOLUTION
humanoid ROBOTICS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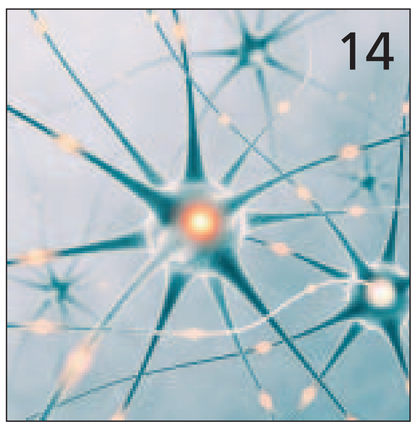
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18


22


24

EDITORIAL

Dear readers,

Reality or fiction? Enrichment or threat? Man or machine? Even if our relationship with machines appears to be fundamentally positive in today's highly technical world, robotics remains a topic characterized by strong contrasts. In the areas of manufacturing and production equipment, the use of robots or, rather, automated machines has become essential. There, they perform tasks that are too strenuous, too time-consuming or simply too monotonous for human workers. But in areas that require a high degree of precision and reliability, such as in medical and laboratory technology, robotics has also become a topic of central importance. FAULHABER has supported the development of such applications for many years. In addition to the use of our products in industry, we support young engineers and students in their research work both financially as well as by providing drives and components free of charge.

In this issue of FAULHABER motion, you can read about how the high-performance DC-micromotors advance the evolution of humanoid robotics step-by-step. You will also learn about the key role our brushless DC-motors play in automation in medical laboratory diagnostics and how they contribute to the treatment of neurological diseases.

Sincerely

Dr. Fritz Faulhaber
Managing Partner

IMPRINT

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Evolution of humanoid ROBOTICS

Robots explore other planets, produce car parts and vacuum dust and are today almost omnipresent. They do not, however, usually look like the science fiction fan might imagine: they move around as a flat trolley on wheels or are permanently installed as bulky machines in industrial halls. Humanoid robots with eyes and ears, arms and legs are still in their early stages of development. A division of Dongbu Robot is working in this field. As muscles for its mechanical people, the Korean company uses motors from FAULHABER.

Humanoid robots – copied from nature, but still with limited freedom of movement

Industrial robots from Dongbu are used in, among other places, semiconductor production, where they collect the highly sensitive silicon wafers following a production step and precisely position them for the next step. For such tasks, the machines are immovably anchored at the production site. In addition, the company produces robots for use in daily life: robots that clean floors, patrol rooms as automated guards or guide and inform visitors. These travel on wheels and have a box-shaped housing. What both types of robots have in common is their computing capacity and their motor power for completing a small number of narrowly defined tasks. In doing so, they use their resources very efficiently. They are not, however, particularly versatile.

Humanoid handicap

Even in their basic movement, humanoid – human-like – robots are at a decisive disadvantage compared to the specialists of their species: walking on two legs is far more complex than precisely controlled movement on wheels. Even humans need a good year before this seemingly trivial sequence of movements is mastered and the interplay between some 200 muscles, numerous complicated joints and various specialized regions of the brain materialies. On top of this is the fact that human biomechanics leave much to be desired in terms of energy efficiency. The unfavourable lever ratios of arms and legs require high power effort for relatively modest results.

Up to now, humanoid robots have therefore only been used as research objects, as toys or as both. Technical universities around the world have been

High-performance HerkuleX servo modules based on FAULHABER drive technology

holding robot football tournaments since the 1990s in which research, technical development and fun form a productive unit. There is a separate league here for humanoid robots. Moreover, there is a massive international community of robot enthusiasts who test their programming skills with self-made robots or robots made from prefabricated kits and, in doing so, also advance the knowledge about the possibilities of humanoid robots.

Power and intelligence package

The Hovis series from Dongbu Robot has many supporters in this community. This is due not least of all to the so-called servos, which put the approximately 35 centimetre mechanical men into motion. The servos, which are also sold separately, are very popular among the ambitious hobbyists. A servo is a compact unit which – to continue the comparison to humans – sits as a muscle-tendon-nerve packet in the limbs. It converts battery power and control signals into independent movement. For small humanoid robots, Dongbu Robot developed the servo units of the HerkuleX series. They consist of a drive motor, a high-performance gearhead, an electronic feedback system (encoder) and a communication interface, all of which are accommodated together in a sturdy plastic housing.

The encoder ensures that the servo always exactly knows its current position. It also translates the control signal, for example, for the command "step forwards", and tells the motor how many revolutions are needed in order to perform the task. An optimally coordinated interaction between motor, software and control unit gives the robotic joint a certain degree of autonomy in the sequence of movements. With HerkuleX servo units, the machines are able to precisely control both simple as well as complex mobility patterns independently. Thanks to the sophisticated software in the encoder and its high-performance communication interface, the signals are transmitted quickly and exactly.

Compact efficiency

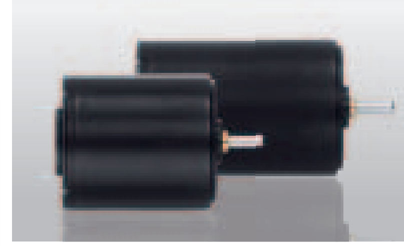
The movement itself comes from the motor. Due to the – see above – unfavourable humanoid lever ratios, it must develop as much torque as possible with minimal dimensions. "Following a detailed comparison of the motors that are available on the market, Dongbu Robot selected the DC-micromotors of the 2224 SR and 2232 SR series from FAULHABER", explains D.S. Choi from Dongbu Robot. "The extreme compactness and high power generation of the motors were the decisive factors. In terms of dynamics and power density, they were the undisputed leaders. Furthermore, the name FAULHABER is synonymous with outstanding quality for robotics enthusiasts."

The DC-micromotors of the 2232 SR series achieve a continuous torque of 10 mNm with a motor diameter of just 22 millimetres. To accomplish this, they need very little power and begin their work even with a very low starting voltage. With an efficiency of up to 87 percent, they use the battery reserves with maximum efficiency. D.S. Choi: "This is extremely important for a long running time per charge. In addition, the linear characteristics of the motor simplify control for us."

With regard to their utility value, humanoid robots are still far from their stationary industrial colleagues and the rolling domestic servants. With advances in technology, their disadvantage could be transformed into a key advantage, however. Humans, too, were able to celebrate their evolutionary triumph on account of their comparatively unstable upright gait. From their non-specialisation grew virtually limitless possibilities which ultimately made them so successful. In any case, the robo-footballers have set the goal of being able to defeat the reigning human world champions by 2050.

DC-MICROMOTORS

- Coreless, self-supporting copper coils with skew winding technology
- Minimal moment of inertia of rotor
- Precious metal commutation
- High dynamics
- Cogging-free, precise running



The complex mechanics of human movements are replicated with 20 servo units

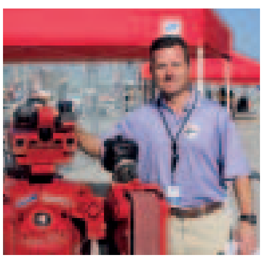
INTERACTION BETWEEN MOTOR, SOFTWARE AND CONTROL UNIT

FURTHER INFORMATION

Dongbu Robot Co., Ltd., Korea
www.dongburobot.com

FAULHABER Germany
www.faulhaber.com

Support OF young researchers IN robotics



Dodd Disler, COO of MICROMO, at the DARPA Robotics Challenge in Florida

The CHIMP robot is designed for versatile use under harsh and dangerous environmental conditions

Their precision and efficiency makes FAULHABER motors ideal for driving robots, which is why we have become a major supplier of the growing robotics industry. FAULHABER also supports education and technical development in the field of robotics by providing both financial assistance and free motors to many teams and for many activities.

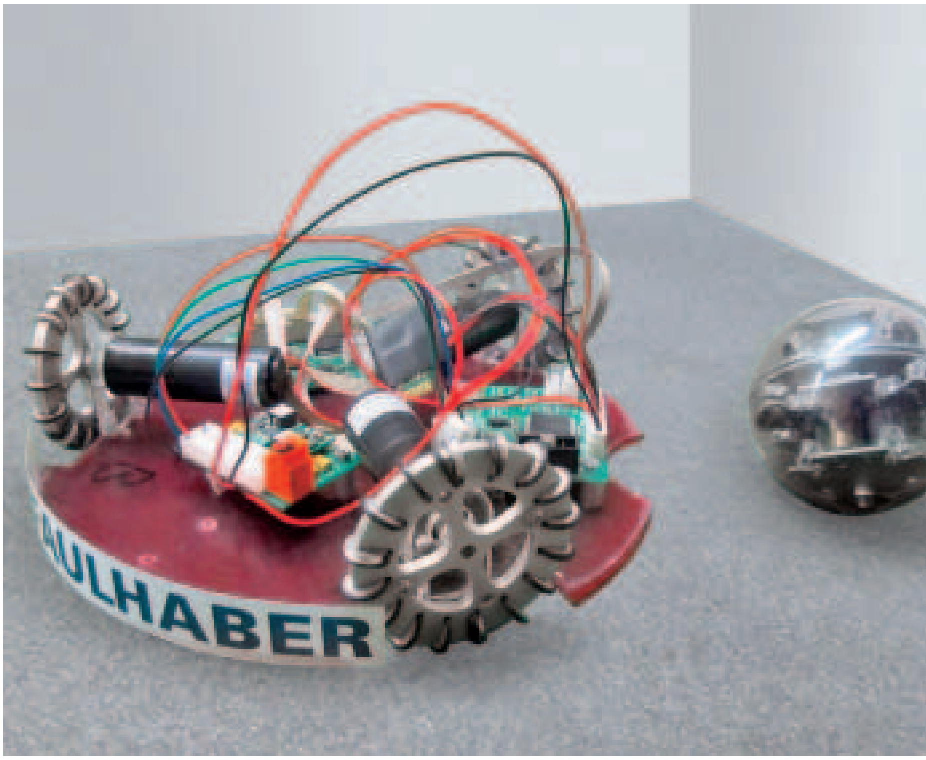
One example is our involvement in the 2013 DARPA Robotics Challenge (DRC), held at the Homestead-Miami Speedway in Florida. The DRC is a competition of robot systems and software teams vying to develop robots capable of assisting humans in responding to natural and man-made disasters. Participating teams, representing some of the most advanced robotics research and development organizations in the world, collaborate and innovate on a very short timeline to develop the hardware, software, sensors, and human-machine control interfaces that will enable their robots to complete a series of challenge tasks selected for their relevance to disaster response. The team of the Carnegie Mellon University in Pittsburgh, Dr. Fritz Faulhaber's alma mater,

The World Cup team: Florian Schäfer, Gian Jörimann, Michael Baumann

achieved a third place with its Tartan Rescue CHIMP (CMU Highly Intelligent Mobile Platform). The 90 kg robot is designed for executing complex tasks in dangerous, degraded, human-engineered environments.

FAULHABER also sponsors Helveticrobot, a non-profit organization aiming at educating Swiss youngsters in robotics. It encompasses a number of teams working on complex robotics problems, including questions of mechanics, electronics and software. Since 2009 Helveticrobot has participated in the international Robot Soccer World Cup (RoboCup) championships where the team successively achieved a third, a second and finally the first place. Last year in Eindhoven, thanks also to the built-in FAULHABER DC-Micromotors, the soccer team won the Best Robot Award. This year, the RoboCup championships will be held in João Pessoa (Brazil) in July. Helveticrobot will be participating with a new team, improved robots and new chances for success.

Another recipient of FAULHABER's support is the Robo-Si association, also from Switzerland, whose objective is to involve children in robotics. Amongst other activities, the Robo-Si team regularly takes part, as organizer, in the First Lego League Challenges, where children between the ages of 9 and 16 compete, building robots from standard parts and operating them at regional, national and international events.



A robotic footballer from the Helveticrobot team with FAULHABER drives

FURTHER INFORMATION

DARPA Robotics Challenge (DRC)
www.theroboticschallenge.org

Helveticrobot
www.helveticrobot.ch

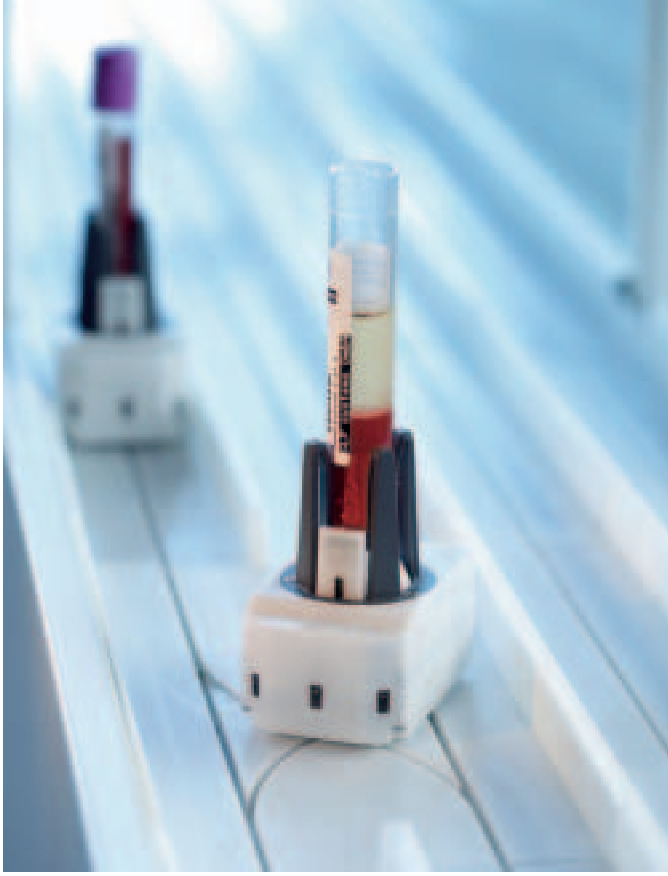
Association Robo-Si
www.robo-si.ch

FAULHABER Germany
www.faulhaber.com

Smooth SAILING through the LABORATORY

Automation in medical laboratory diagnostics.

Most of us have probably had to provide a blood or urine sample as a patient at the doctor for preventive medical check-ups, prior to operations or for diagnostic purposes. The samples are placed in small test tubes, labelled, taken to the laboratory and – a couple of days later – we, the patients, are informed of the result; we learn our blood, sugar, liver or kidney values. But where is this laboratory located in which our health is analysed, and what exactly happens there?



The track switches are set by the primary control system. Each track switch performs an average of 4,500 sorting processes per hour

Our doctor certainly doesn't operate his own laboratory. The analysis of our blood and urine samples has instead been taken over by highly-specialized laboratories that perform many thousands of analyses every day. They, too, can benefit from state-of-the-art automation technology today. As with many other automation tasks, high-performance microdrives play a key roll here as well. They convince above all with good efficiency, high torque in a small design, reliability and low power consumption.

Many laboratories that perform medical sample analyses still use manual distribution systems even today. This means that first the data for the incoming samples is captured. The samples are then placed in racks in batches, carried by employees to the various analysis stations and, if necessary, resorted from time to time for further analyses. With thousands or even tens of thousands of material samples per day, this is not only a laborious and monotonous task, but is also prone to errors. Troubleshooting then necessitates additional time and effort. More time is required if individual samples need special handling, e.g., because they must pass through several stations for step-wise diagnostics. The same applies for the dilution of samples for certain analyses or for splitting samples for different analyses; the production of so-called aliquots. Disruptions to an orderly workflow are therefore inevitable. This process is made more difficult by the current trend towards collecting only one sample from patients for all of the necessary analyses where possible. There is no relief for the situation in sight. Rather, the problem will become more acute in the future, particularly through the centralization of laboratory services.

What must an automatic sample distribution system be able to do?

The use of practically oriented automation technology that frees employees from monotonous activities and eliminates sources of error will therefore become unavoidable in modern laboratories. An automatic sample transport system ideally transports the samples directly to the appropriate analysis system and, while doing so, performs other tasks along the way: following delivery, the sample identification can be used to plan and optimise the route through the laboratory, whereby many parameters can be taken into account, e.g., the type of container, the preparation, the filling level and, of course, the sequence of the individual analysis steps. For the duration of the analysis and the evaluation, all samples currently to be processed should then remain accessible, i.e., several hundred samples are ideally underway in the distribution system simultaneously. Analyses can then be quickly repeated or additional analyses performed and any subsequently necessary assessments undertaken. Upon completion of the analysis, the samples should be automatically ejected, disposed of following a storage period of a couple of days or, if necessary, transferred to a suitable container for long-term archiving.

Thus, the requirements placed on an automatic sample distribution system are high – not only with respect to capacity and reliability – but particularly in terms of flexibility, and that in two ways: the distribution system must be able to handle alternating tasks and changes to the workflow. It must also be easily expandable so that, e.g., new or modified analysis devices can be integrated even at a later point in time without considerable effort. With the development of the lab.sms® fully automatic sample distribution system, GLP Systems has demonstrated that these requirements can be met today. It transports each sample (specimen) separately, as this is the only way to achieve flexible, custom, and optimum organization of individual samples. Thus, it differs fundamentally from systems that transport racks with five or ten specimens.

High flexibility during transport and distribution

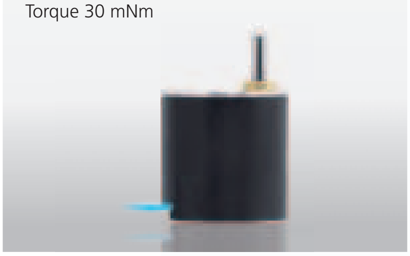
In the sample distribution system designed by the Hamburg-based specialists, the identity of the specimen is linked to the identity of the moveable sample carrier upon delivery to the allocation point. The distribution system therefore knows the sample and knows on which trolley it is currently being transported and which analysis are necessary. Changes to the sequence can even be made retroactively without problem since random access is possible. For this purpose, the position of the specimen and the assignment to the trolley are checked periodically during transport at identification points. The trolleys with the specimens then move fully automatically over plastic rails to the respective analysis stations. The track switches which they pass over while underway are appropriately set by the primary control system.

Each track switch handles an average of 4,500 sorting processes per hour: 4,500 specimens per hour can be recognized and individually guided in one of two directions. Since all track switches are able to operate simultaneously, in an example system with 50 different track switches this yields a sorting capacity of 225,000 sorting operations per hour or more than 60 per second. This capacity is necessary, since many specimens are in a waiting queue before and

THE DRIVING FORCE OF THE SPECIMEN TAXI

BRUSHLESS DC-MOTOR

Ø 15 mm, length 15 mm
Torque 30 mNm



Underway with the specimen taxi: the trolleys with the specimens move fully automatically over plastic rails to the respective analysis stations after the analysis and thus move over track switches frequently. The high sorting capacity of the track switches thereby satisfies an important prerequisite for the organizational flexibility in laboratory operation. Also important for smooth operation are the "small trolleys" on which the samples travel through the laboratory. Speed and reliability have top priority here.

Compact drives for fast, reliable transport

The compact trolleys, i.e., "specimen taxis", actually have a very simple design. Drive, battery, electronics and proximity switch are all integrated, allowing the taxis to very precisely accelerate, decelerate or stop, e.g., at the analysis stations. Chosen for the drives were brushless DC-gearmotors. The motors from the comprehensive FAULHABER product range are designed for high reliability and a long service life; they can thus travel many, many kilometres in the automatic distribution systems without wear being a concern. Moreover, they also convince in this application with their smooth, cogging-free running properties. This is particularly important, as the blood samples are usually transported without a cover. In addition, the drives operate very quietly. The rare earth magnet of the rotor and the coreless winding also ensure high performance and dynamics in a compact size.

The drives, which deliver approx. 0.3 W and a torque of up to 6 mNm with a diameter of about 15 mm and length of 15 mm, drive the wheel of the "specimen taxi" via a diameter-compliant spur gearhead (reduction 1:10) at the ideal operating point. Thanks to their compact dimensions, they could be easily integrated, and their low power requirements were ideally suited to the application; the charging intervals of the batteries are sufficiently long. To ensure that the trolleys are always ready for use, the charge state is constantly monitored by integrated electronics so that they can be recharged before they come to a standstill. The electronics perform still other tasks, however. The identification number of the "taxi" is stored here and they evaluate the signals of the proximity switch. The motor electronics can appropriately adjust the speed of the brushless DC-motors, i.e., reduce the speed or stop the motor.

The solution has already proven effective in practical use in a large medical laboratory in Hamburg. Some 3,000 haematology specimens are processed here daily with 19 online analysers. Additional applications are planned. Modern miniature drives have thereby proven their versatility once again. It may also be possible to apply the "specimen taxi" principle to other application areas. Similar automatic distribution systems are conceivable, for example, wherever small parts pass through different production or inspection stations separately.

Highly flexible automatic sample distribution system: it transports each sample (specimen) individually, as this is the only way to achieve flexible, custom, and optimum organization of individual samples

FURTHER INFORMATION

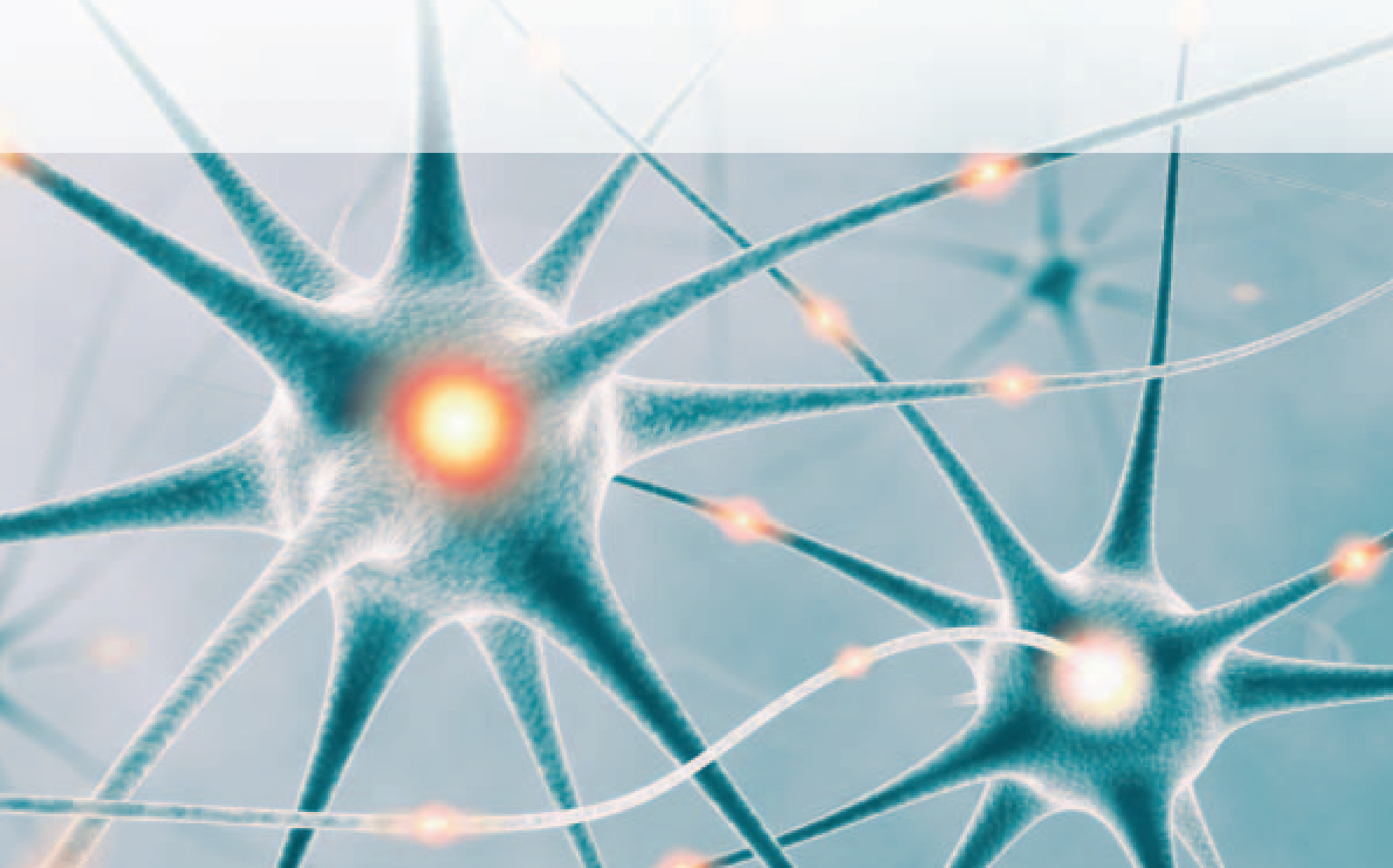
GLP systems GmbH, Hamburg
glp-systems.com

FAULHABER Germany
www.faulhaber.com

High-tech INSTEAD of medical TREATMENT

Stimulation of parts of the brain.

Transcranial magnetic stimulation, abbreviated TMS, is a type of medical treatment in which focussed, strong magnetic fields can be used to both stimulate as well as inhibit areas of the cerebral cortex. With certain neurological and psychological illnesses, this can be used as an alternative to medicinal treatments and offers the advantage of being neither invasive nor painful. Thanks to microdrives, this new technology has been automated and integrated in a compact housing. It offers a high level of safety and, compared to manual control, is much more precise.



A MAGNETIC FIELD WITH A STRENGTH OF UP TO 3 TESLA

Not only is TMS a useful tool in neuroscientific research, it is also used in the diagnosis and treatment of neurological and psychological illnesses, particularly with depression. With this technology, a strong magnetic field is produced in the cerebral cortex. This magnetic field can be used to stimulate or inhibit the electrical activity of the neurons. The coil that produces the focussed magnetic field must be exactly and reproducibly positioned and directed at the correct points in the brain. With this in mind, the French company Axilum Robotix, together with their partner Streb & Weil, developed the world's first robotic assistant specifically for TMS. The system positions the TMS coil very precisely and safely on parts of the brain which are specifically defined for each patient in advance. With the goal of producing a compact and precise device, the developers worked together with the application engineers from FAULHABER to create a drive which can achieve highly reproducible positioning through the integration of zero backlash gearheads in the guide arm for the coil.

New medical method

The first transcranial magnetic stimulations were performed by doctor and physicist Jacques-Arsène d'Arsonval at the end of the 19th century at the Collège de France in Paris. At the University of Sheffield, Anthony Barker worked on the modern version of the transcranial magnetic stimulation in 1985. Considerably smaller coils that stimulate only a small region of the cerebral cortex improved the results. Magnetic stimulation of the part of the cortex located near the cranium is today performed with nearly no discomfort for the test subjects or patients. However, the small coils require highly precise positioning of the magnetic field source. The principle is simple: a TMS coil, which is connected to a stimulator, is positioned tangentially on the cranium and delivers a magnetic field with a strength of up to 3 tesla for a few milliseconds. The resulting change in electrical potential in the part of the cortex located near the cranium causes a depolarisation of neurons and the triggering of action potentials. The strength of this electric field decreases exponentially with distance to the coil. This decrease is another reason for placing the coil as close as possible to the brain area that is to be stimulated, i.e., in direct contact with the cranium, without reducing the precision of the positioning.

Compact system design thanks to the small size of the FAULHABER drives

Compact robot guides the coil

Starting from these requirements, the experts from France developed a robot that can very precisely and reproducibly position the TMS coil around the head of the test subject. The patient sits in a comfortable, electrically adjustable chair with head rest to minimize head movements. The robot is controlled by a neuronavigation system, whereby an optical monitoring system is used to detect and compensate for any head movements. The coil is equipped with a contact sensor and can thereby be safely brought into contact with the cranium.

The hemispherical structure of the robot arm with seven axes guarantees good accessibility. The gearheads and drives are located as close as possible to the axes. The power regulators are also placed very close to the drives to ensure the shortest possible connection to motor and encoder. The power regulators are equipped with shared power supply and bus connection for communication with the control and operating system (central processing unit with processor). In addition, the control and operating system performs safety management for, among other

The world's first TMS robotic assistant for targeted magnetic stimulation of the cerebral cortex

The control system and high-performance motors facilitate the precise and dynamic positioning of the TMS coil

things, emergency stopping as well as all primary control tasks, such as the calculation of the kinematics of the robot arm, position control with the help of the contact sensor, etc.

Due to technical and medical restrictions, the gear motors and their actuators must meet special requirements. The pulsed magnetic fields, which are emitted by the TMS coil, require very high EMC immunity (electromagnetic compatibility) at the height of the robot arm. The electronic unit generally produces only very low emissions in order to keep from interfering with nearby medical devices. The lines must therefore be as short as possible and be shielded to eliminate data errors caused by the therapeutic magnetic fields. Shielding of the cables is also important, as they will otherwise act as antennas and can interfere with other devices. To quickly compensate for head movements, the motors must have a high starting torque and yet not overheat. Encoders with high resolution and gearheads with reduced backlash ensure precise positioning.

In detail

In practice, the robot specialists use various brushless motors in the arm. These motors are dimensioned so that they can deliver the required torque and still be as small as possible. Consequentially, two 44 mm motors and four 32 mm motors are housed in the robot arm. There is also a 22 mm gear motor consisting of motor and planetary gearhead of appropriate diameter. The small, four-pole motor delivers about 9 W and its encoder generates 1,024 pulses per revolution, thereby yielding a resolution of 4,096 points per revolution. Together with the reduction of the three-stage, planetary gearhead of 86:1, this results in a very high resolution of the rotary movement and enables highly precise coil positioning. The six larger motors deliver 33 or 210 W at the output shaft and are also equipped with high-resolution encoders. Pretensioned, maintenance-free ball bearings ensure a long, backlash-free operating life. In addition to the special requirements of the TMS with regard to safety and compliance with standards, the drives satisfy all conditions for use in the medical sector.

To optimally match the drives to the special conditions, the engineers from Axilum worked closely together with the specialists from FAULHABER. As a result, they were together able to quickly clarify questions regarding electromagnetic compatibility, cable lengths and shielding and integrate special plug connectors. This approach accelerated the development and testing of the TMS robot without needing to make compromises in safety or reliability.

FURTHER INFORMATION

Axilum Robotics, Strasbourg, France
www.axilumrobotics.com

FAULHABER France
www.faulhaber-france.fr

SMALL PUMPS that save lives

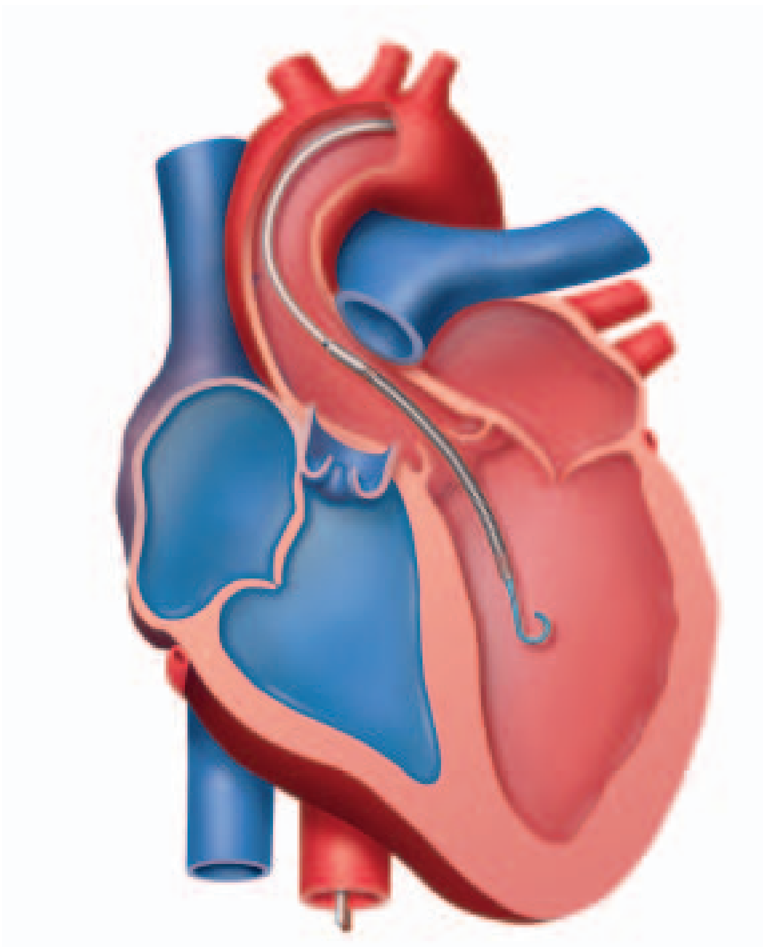
"This experience has changed my life", reports Michelle Kellim, 33 years old, from Florida. "I have always led a healthy life. I had never once considered that I could suffer from heart disease at my age." The mother of two children used to run five miles every day and had always had a healthy diet. But one night her husband, Erik, woke up next to her and noticed that Michelle had stopped breathing. It was a minimally invasive cardiac pump called Impella® 2.5 that saved Michelle's life.

Five litres of blood per minute

"Our Impella® pumps have already been used over 16,000 times worldwide", explains Ronald Lutz, Marketing Manager of ABIOMED Europe GmbH (Aachen, Germany) which produces these remarkable miniature blood pumps – with components, experience and expertise from FAULHABER. Basically, the Impella® pump mimics the natural cardiovascular system which transports oxygenated blood from the left ventricle through the aortic valve and into the ascending aorta, from where the blood enters the coronary vessels and the systemic circulation. The heart can recover because the Impella® pump actively relieves the strain on the left ventricle. The pump can deliver up to five litres of blood per minute.

Diameter of just a few millimetres

Using a guide wire inserted via the femoral artery, the Impella® pump is positioned in the left ventricle and ascending aorta. There the blood is transported through the inlet area via the cannula towards the outlet, following the natural flow direction of the blood. The diameter of just four millimetres (e.g. the Impella® 2.5 model) means that the aortic valve leaflets can fully close around the cannula. The Impella® pump is controlled using an external console which is also used to optimise settings and to monitor the



Pump placement directly in the heart

Impella® Controller drive console

Feared complication

Whether in an acute emergency or during a planned operation, so-called haemodynamic instability ("haemodynamic" relates to the movement of blood) is a feared and serious complication which can occur when occluded coronary arteries are opened. The pumps are therefore used both in cardiac surgery during or following operations and also during procedures in cardiac catheter laboratories. Depending on the Impella® model, the pump can support the heart for up to ten days. This gives the heart time to regenerate.

effect of the pump. The preparation time required before the pump can be put into action has in the meantime been reduced to under three minutes. "Patients can be treated without delay, even in acute emergencies", says Lutz.

Drive from FAULHABER

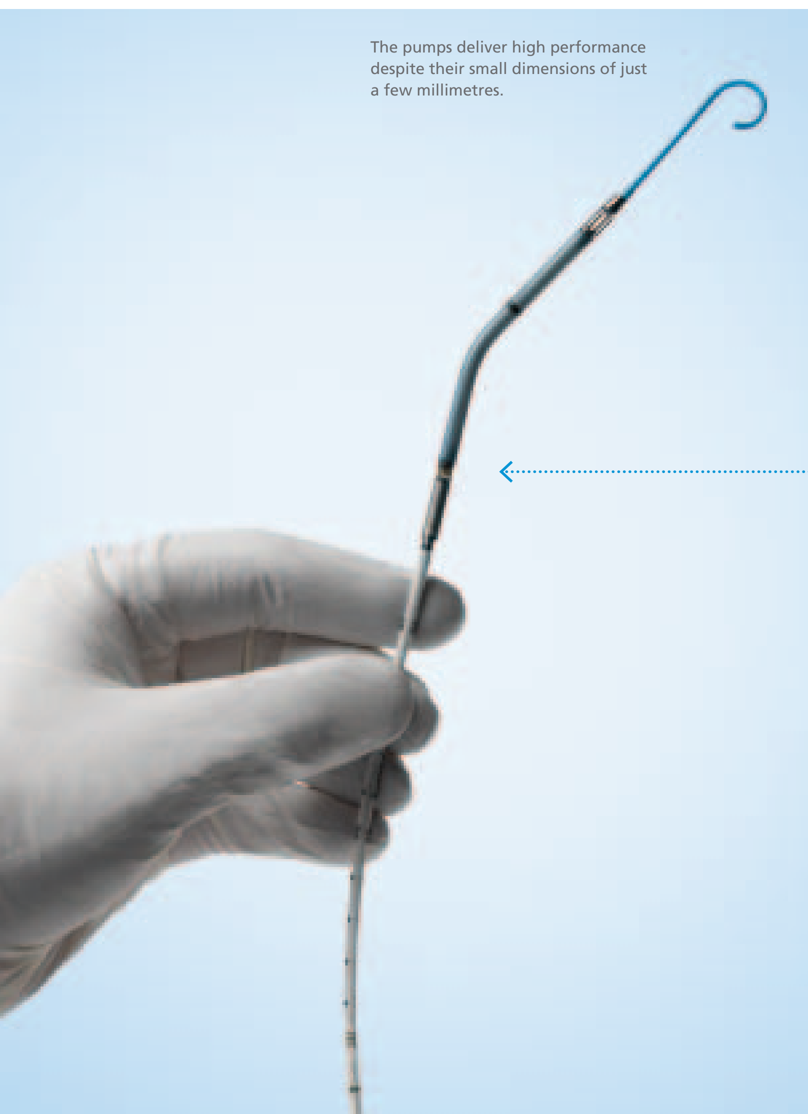
From a technical viewpoint, the pump drive consists of a brushless, electronically commutated DC-motor with a diameter of just 4 millimetres in the case of the smallest pump (Impella® 2.5) and 6.4 mm in the case of the larger pump (Impella® 5.0) and a stator length of 12 and 18 millimetres respectively. The pumping performance of the heart is supported with a speed of up to 51,000 revolutions per minute. The drive is based on a self-contained coil and essentially consists of a three-phase winding and a bipolar permanent magnet. The position of the rotor is detected by measuring and evaluating the retroactive generator voltage, making Hall sensors unnecessary.

Single-use application

An impressive feature of the motors is their high level of efficiency. The pressure sensors on the larger pump, which are required in the case of positioning inside the ventricles, have a thickness of 300 µm and are positioned in a flat area on the outside of the motor housing. Apart from the compact dimensions and the high reliability, the comparatively favourable cost/performance ratio is another important factor because each Impella® pump can be used only once.

Reliable and flexible partner

"With the Impella® pump, we are working at the very limits of the possible", stresses Ronald Lutz, ABIOMED Marketing Manager. The demands placed on a medical product used in life-critical situations are extremely high. FAULHABER has been a reliable partner from the very beginning (i.e. since 1998). "There were no "off-the-shelf" motors that we could have used", explains Lutz. "FAULHABER was flexible and prepared to pursue this path with us and, working as a team, to develop the components exactly as we need them. We are extremely happy with the outstanding level of cooperation."



The pumps deliver high performance despite their small dimensions of just a few millimetres.

5 LITRES OF BLOOD PER MINUTE

Continuous dialogue

To this day, relentless further development continues to shape the collaboration between ABIOMED and FAULHABER. "This is one of our great strengths", says Jan-Christopher Mohr from FAULHABER who provides support for ABIOMED from the company headquarters in Schönaich (Germany). The development, modification and enhancement of products precisely according to the needs of the customer are all part of the service that FAULHABER offers. "A process such as this can only be successful if there is continuous dialogue", says Mohr. The continuous exchange of information with the customer allows specific requirements to be understood and optimum solutions to be found.

The pumps are available in numerous sizes for various pumping capacities

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"The situation was very serious"

Two simultaneously used Impella® pumps saved Eduard Böhler's life.

It was a pleasant winter evening on January 10, 2012; then, suddenly, 54-year-old Eduard Böhler felt sharp pains in his chest. Suspecting a heart attack, he was transported to the hospital in Lörrach. "The situation was very serious", Böhler recalls. "Because the doctors had to perform resuscitation measures, at first it seemed uncertain whether or not I would survive the night."

The physicians decided to move Eduard Böhler to a nearby special clinic that is part of the University of Basel hospital in Switzerland. "There, the Impella® 2.5 pump was immediately implanted in me for left ventricular support", as was later explained to Böhler. However, all other life-essential organs failed: the lungs, the kidneys, the liver. "That's why the attending specialist Professor Hunziker decided to use an additional Impella® RP for right ventricular support", says Böhler. With this, the doctor – highly-experienced in the usage of the Impella® system – ventured a first: no one before him had implanted two Impella® pumps at the same time in Europe. In fact, an exceptional approval by Swiss authorities was necessary for this.

Thanks to the biventricular support, his heart was soon able to recover. After eight days, both Impella® pumps were removed. "My condition remained quite critical for a long time; I experienced many setbacks", relates Böhler. Only after six months was he released from the post-operative treatment in Freiburg to go home.

To this day he must still undergo physiotherapy and ergotherapy. Yet, Eduard Böhler is not the least bit discouraged: "Thanks to Impella®, my heart has fully recovered. I was given a second chance, and I am happy to be with my family again.

EDUARD BÖHLER

A look into the use of the Impella® systems from the patient's perspective

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FURTHER INFORMATION

ABIOMED Europe GmbH
www.abiomed.com

FAULHABER Germany
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ROBOT-ASSISTED OPERATION WITH tactile dexterity

Miniaturized endoscopy robots make possible even the most delicate operation within the human body, without an incision and in the most inaccessible locations as well. However, a surgeon not only wants to see through a camera, but to feel what he is doing as well. For this purpose, master's student Florian Klug at the Institut für Elektromechanische Konstruktionen (Institute for Electromechanical Design) of the Technische Universität Darmstadt (Darmstadt Technical University) developed a force-feedback user interface.

FLORIAN KLUG

studies in a master's programme at the Institute for Electromechanical Design of the Darmstadt Technical University. The user interface resulted from his bachelor's study programme.

What is a force-feedback user interface?

The interface is that boundary where the surgeon's hand contacts the robot which carries out the surgical procedures within the body during an invasive operation. It is a manually-operated control device, in principle similar to a joystick. Furthermore – as indicated by the term force-feedback – it also provides a haptic response as to what the controlled instrument, in this case the endoscopy robot, is actually doing.

What exactly does the robot do?

It can grasp, cut, sew – essentially, all that which a surgeon would also do with conventional instruments or a mechanical endoscope. Its miniature instruments are moved by means of three push rods that are connected to the user interface.

How is the interface designed?

In principle it is constructed similar to a pincer and has two degrees of freedom, meaning the grasping and turning movements. The interface is controlled by the thumb, index and middle fingers. The index finger moves a lever to which a force can be applied opposite the direction of finger movement by means of a cable-pulley linkage and an electric motor from FAULHABER. The grasping distance between the thumb and index finger is determined by the encoder integrated in the motor with an accuracy of 0.004 mm. The actuation and analysis of the measurement signals is accomplished by a FAULHABER motion controller.

How is the feedback conveyed to the surgeon's hand?

Let's use the example of tweezers, with which he wants to grasp a piece of tissue. The encoder in the user interface registers the position and movement of the fingers, and correspondingly the opening or closing of the tweezers. The position information is passed on to the robot, which moves its griper accordingly. At the same time, the pressure that is being applied between the tissue and jaws is measured at the jaws. This force is further conveyed by the motor in the user interface to the fingers of the surgeon. Therefore, if the robot grasps something and thereby encounters resistance, then the motor transmits corresponding resistance against the fingers. In this manner the surgeon can directly sense what is going on in the operation area.

Which technology is employed there?

The transmission of force is provided by brushless DC-motors from FAULHABER, which have relatively high torques while evincing minimum weight. Whenever a pincing action is made, the surgeon's movements are transmitted by a cable-pulley linkage. Here, a static gripping force of up to 6.3 N is translated and output opposite the direction of gripping. A brushless

direct current motor also serves as a source of torque for rotational motion. A coupled toothed-belt drive delivers the desired gearing. The rotational angle is measured in the range of 0 to 180 degrees, with a resolution of 0.02 degrees, by the absolute encoder integrated in the motor.

How is it controlled?

In addition to actuating the motors, the electronics must also handle the power management so that the precisely defined torques can be steplessly output. Moreover, a position fix is required. The Motion Controllers from FAULHABER optimally handle these tasks. The electronics feature an RS232 interface and can therefore be programmed and read out using the FAULHABER Motion Manager.

What distinguishes the user interface that you have developed from already existing systems for controlling robots?

Because there is very little play available in the operation area for working precisely, proper tactile dexterity is indeed crucial. The objective of my efforts was therefore to convey an adequate sense of touch to the surgeon for actuating the robotic hand. He should have the feeling that he is essentially operating with his own fingers. Previous interfaces have only partially succeeded in doing this.

What is different about your device?

Preliminary tests showed that a steel cable most effectively conveyed applied force in terms of sensory perception. For the electric motor, the steel cable is a substitute for the gearhead at the operating unit and makes it possible for the operating surgeon to develop an exact sense, via the interface, of how much force the robotic pincer is actually exerting. The electronic coupling of robot and control unit also enables an adjustable transmission of the movements, allowing the surgeon to in fact work with more delicate precision than would be possible if he was using his hands directly. Thus, the surgeon is made capable of performing the most minuscule incisions with the greatest possible precision in anatomically inaccessible sections.

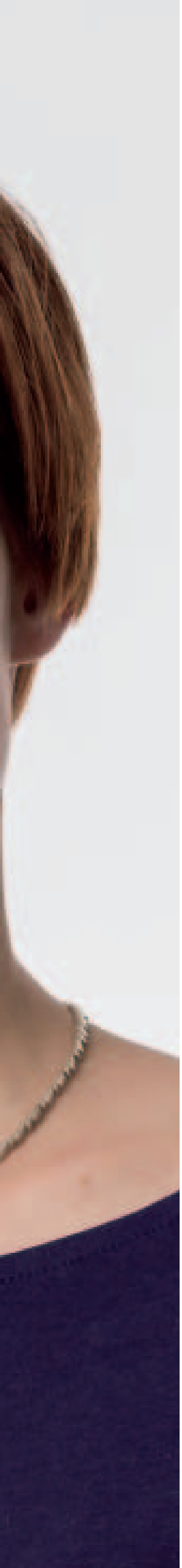
Why did you choose FAULHABER motors?

Because an operation can take several hours, the weight of the user interface is critical. The entire interface only weighs 257 grams – to no small extent thanks to the motors from FAULHABER. Relative to their weight, they deliver the greatest torque. Moreover, the motors and encoders have a very high resolution and work with extreme precision. Also, last but not least, the AES encoder requires an absolute minimum of wiring. Because all of the wires must be accommodated in a finely-detailed structure, that is a significant benefit.

CONTROLLED MOVES. FOR PRECISION APPLICATIONS.

LISA MUNDLE

Dipl. Eng. FH, has been in electronics development at FAULHABER since 2006 and is responsible for encoders



Hall sensor and electronics are housed in a single-chip off-axis component

Fantastic range of functions.
Without alternative in its compactness.
The IEH2-4096 in the segment of integrable encoders from FAULHABER convinces not only with high resolution in minimalist single-chip design, but also through numerous technical innovations and an expanded temperature range.

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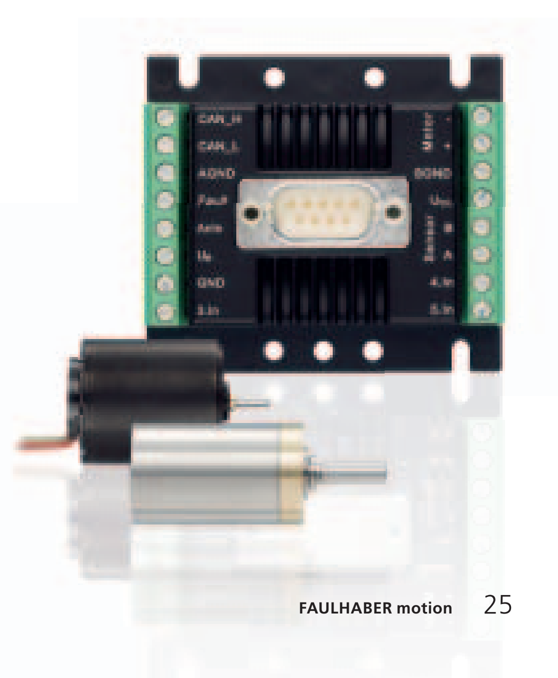
The miniaturization in mechanisms of high-tech applications, such as mirror positioning or lens or filter adjustment of precision optics, was developed in parallel with technical progress. Such complex, highly developed fields of application, which are characterized by sophisticated technology, thus require the smallest possible, space-saving – yet highly efficient – parts and components. The new, integrable IEH2-4096 encoder in the FAULHABER SR system satisfies all aspects of these special requirements. It can be combined standard in diameters from 15 to 22 mm with all precious-metal commutated motors of the FAULHABER SR system.

Instead of a separate mounting housing, the IEH2-4096 is directly integrated in the respective motor, thereby lengthening it by just 1.4 mm. Critical installation space can thereby be saved and used elsewhere without any loss of performance. This is made possible by, among other things, the innovative design of the new encoder in which the previous components, sensor and circuit are replaced by one single-chip Hall device. Another benefit of this newly developed circuit board is that it is more resistant to extremely high or low temperatures than the previously used magnetoresistive sensors and integrated circuits. As a result, the operating temperature range could be expanded considerably to -40 to +100 degrees Celsius. At 4,096 pulses, the encoder has a resolution four times higher than the previous model, which leads to improved control dynamics. The model offers considerably improved speed control, particularly at low speeds.

In spite of these numerous technical developments, the IEH2-4096 remains mechanically compatible with the previous models.



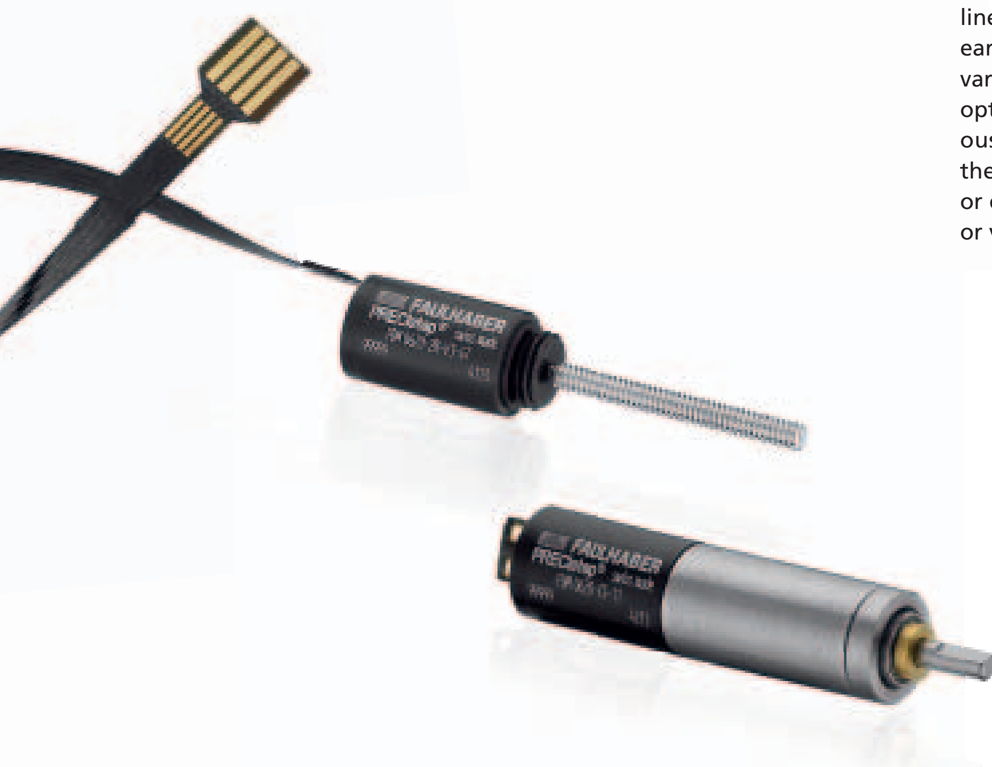
So SMALL so POWERFUL

Series FDM0620
FAULHABER PRECIstep system

With the new FDM0620 series, FAULHABER presents a stepper motor with minimal size: contained in a housing measuring just 9.7 mm in length and 6 mm in diameter are all components (including the connections). This motor thereby sets new standards in the field of compact drive systems. With this combination of minimum space requirements and maximum power, reliability and production quality, FAULHABER continues its success story in the field of miniaturized drives and expands the FAULHABER PRECIstep system in the diameter range from 6 to 22 mm with another member.

With a static torque rating of 0.25 mNm and a dynamic torque of up to 0.2 mNm, these stepper motors are predestined for applications in which high power is required in a small space – such as with portable devices. The open-loop operation enables fast and simple implementation, the static torque rating and the precise angular accuracy make this product the ideal solution for applications with high requirements on angular and linear positioning, particularly in optics, photonics and medical technology.

The innovative and patented flex PCB system is suitable both for LIF plugs with grid dimensions of 0.5 and 1.0 mm as well as for wiring via supply lines. A wide selection of metric lead screws for linear movements as well as a planetary gearhead with various reduction ratios round out the configuration options of the FDM0620 series. On request, numerous other modifications are available with which the motors can withstand special mechanical loads or environmental influences (e.g., low temperatures or vacuum).



High Speed.

LOW VIBRATION.

Series 2057 ... BHS

The new FAULHABER 2057...BHS are designed to address the specific requirements of the medical and dental hand piece markets. The high efficiency slotless design features smooth speed control with a wide continuous duty speed range up to 40,000 rpm while remaining cool to the touch. The motors are capable of handling intermittent overload conditions to address highly dynamic motion over shorter cycle times. Low vibration which reduces user fatigue and low audible noise are ideal for long periods of use in sensitive medical and dental patient environments.

The new motors come standard with digital Hall sensors and analogue Hall sensor feedback is available on request. This option is ideal to eliminate the need for an additional encoder for slower speed operation for dental implant or endoscopic positioning applications, which can also significantly reduce cabling complexity within the handpiece itself. Preloaded ball bearings insure that the motors are able to withstand the radial (22N) and axial loads (75N) in a hand piece. The extremely long service life can be extended even more through the easy replacement of the front bearing.

A wide variety of high precision gearheads, high resolution magnetic and optical encoders and drive electronics are available in order to complete the drive system.

FURTHER INFORMATION

FAULHABER Germany
www.faulhaber.com/products

PREVIEW

WITH THE SPACE PROBE through the UNIVERSE

At the end of May 2014, the ESA space probe Rosetta will swing into an orbit around the comet 67P/Churyumov-Gerasimenko in order to, after more closely approaching it, map its surface and thus prepare for the landing of Philae. As part of the ESA mission started in 2004 this ballistic lander, weighing 100 kg, is supposed to land on the comet in November and begin experiments which make it possible to draw conclusions about its composition. In the anchor system for the safe landing, Brushless DC-Servomotors – which have been modified for working in space – are utilised: a harpoon is fired off and bores its way into the surface of the comet; then the drive system from FAULHABER – after a ten-year journey through space – lashes down the probe on the surface with a rope.

Image: ESA–C. Carreau/ATG medialab

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