FAULHABER

motion

02.2014

THE MAGAZINE WITH DRIVE

HOW TO CATCH A COMET?

Dear readers,

In this issue of our FAULHABER motion magazine we illustrate in no uncertain terms the variety of applications our products find a home in. Applications of FAULHABER products from deep space to industrial automation to model train sets to precision laser optics are featured in this issue. It is the challenge and the joy of our employees to be of service to the thousands of customers worldwide, none of whom do exactly the same thing with our products. Although we operate as a normal corporation, we do occasionally take on projects simply for the challenge and the new knowledge we can gain.

Over the last 60 years that we have been making our products, the challenges and demands from the ever accelerating knowledge society have grown dramatically. As the needs for higher performance, more precision and failure free strategies have grown, it has been our task and motivation to continuously provide smaller, more powerful, more precise and above all innovative products. Many of our customer's products and devices were unimaginable 10 years ago. We have been privileged to be a part of making the future happen and firmly intend to stay that course.

Please enjoy this edition of FAULHABER motion and the wonderful applications described in these pages. And as you peruse these pages and find one of the largest model displays in the world, you can see that for us it's not only business but a lot of fun as well.

With very best regards,

Dr. Fritz Faulhaber
Managing Partner

IMPRINT

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GET A GRIP on PRECISION

New small parts gripper from SCHUNK functions without compressed air

A small gripping system that is both quick and powerful – up to now, that was often only possible with pneumatics. Because with compressed air, large amounts of pressure can be conveyed virtually without any time lag. A compressed air supply requires a complex infrastructure, however, and having to provide it for every production step is difficult and expensive. Fortunately, this is no longer necessary – thanks to the mechatronics-based EGP 40 from SCHUNK. The new gripper from the leading expert for workholding technology and gripper systems easily achieves the same performance of its pneumatic counterparts. The drive that makes this performance possible is a Brushless DC-Servomotor from FAULHABER.

FAST GRIPPING INCREASES PRODUCTIVITY

Pick & Place is the term used for this classic application for small parts grippers. Picking up items and putting them elsewhere in the proper place is a standard task that occurs in many handling and assembly processes – but not only there. For instance, in modern, large-scale laboratories which analyse thousands of blood, DNS or active agent samples; these are dispensed on intricate pipetting plates at high speeds. These plates are grasped by small robots and conveyed to the respective next step of the analytical procedure. Another typical application area is the assembly of circuit boards for power electronics, used in electrical machinery or switching systems, for example. The SCHUNK grippers pick up the components and place their contacts in the intended sockets on the circuit board. They must firmly grasp an item but may not, of course, damage the workpiece. In addition to a precise, finely-tuned force, in most processes it is especially the speed that plays a role: rapid gripping increases the productivity.

In the case of industrial grippers, pneumatically actuated systems have dominated up to now. This is attributable to both tradition and practical aspects. Pneumatic actuators have a high power density, which means that they can deliver relatively high force with a compact mass. This force is available virtually without time delay. As soon as the control valve is opened, the supplied compressed air can immediately accomplish the desired lifting work – in this case the grasping.

Pneumatics require their own infrastructure

Fundamentally, pneumatic actuators only have two states though: open or closed, full-power or no force at all. An incremental control is only possible with substantial control-technology-related effort and expense. Along with the electrical contacts for the control unit, a pneumatic gripper additionally requires connections for the compressed air lines. Under cramped conditions, which are not uncommon in the processing of small parts, this can certainly present a problem.

The greatest disadvantage, though, is the compressed air system itself. It requires at least one compressor and an air purifier, its own supply network, and a complicated control system in order that consistent pressure is available continuously and at all points. Therefore, particularly in new facilities, the proprietors are increasingly more inclined to do without this additional infrastructure and rely entirely on electrically operated actuator systems.

BRUSHLESS DC-SERVOMOTORS WITH 4 POLE TECHNOLOGY

- High speeds and high torque in the most confine installation spaces
- Low weight
- High dynamics
- Optimum speed and torque control by means of a compact Speed Controller
- Optional integrated solutions, such as Encoders, Speed or Motion Controllers

Proactive motor power

Thanks to the new electrical small parts gripper EGP 40, this can now be done on a purely electrical basis and, in fact completely without any trade-offs in terms of performance. With 140 Newtons, it develops an even greater closing force than its pneumatic counterpart the MPG-plus 40 – also manufactured by SCHUNK. This powerful performance is delivered by a 4-pin Brushless DC-Servomotor of the BX4-series from FAULHABER. The motor has an optimised, exceptionally high-power density. In other words, it provides a maximum of torque and power with respect to its mass. The compact, rugged design can be economically and automatically manufactured.

Because the motor runs cogging-free, its torque output does not depend on the position. By the same token, thanks to its minimal rotating mass, it attains a very high dynamic response. Already when setting into motion or in the lower rpm range, the full torque is immediately available. That is particularly important for this application, because the gripper fingers often only move a very short distance. A desirable side effect of the top-quality motor technology is its low energy consumption.

With these features the FAULHABER motor has become an important technical platform for the development of these electrical small parts grippers. "The gripper is conceived for easy, uncomplicated handling and integration in customer applications. Previously, motors with such performance as this were simply too expensive for installation in this type of device", relates development engineer Matthias Quaas from SCHUNK. "This motor type is based on an inexpensive concept, which made it possible for us to consider using a bought-in electrical drive in the first place. Moreover, it was very important to us to be able to rely on a sturdy and well-proven technology. And, this motor had already proven its reliability and long service life in many applications."

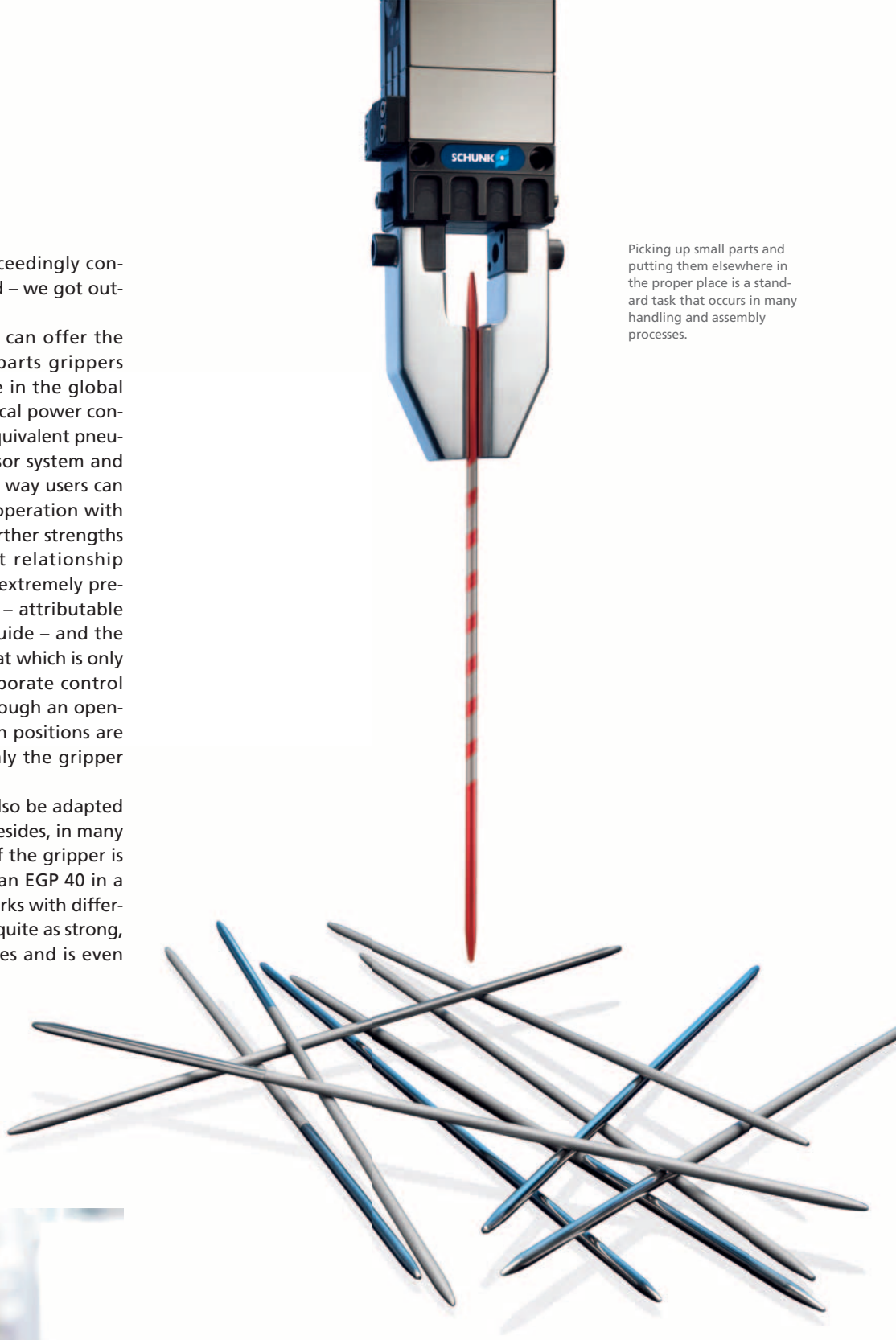
Customised electronics

Due to space reasons, however, the control electronics had to be adapted to the requirements of SCHUNK. In order to fit in the gripper, the shape of the circuit board and the arrangement of components had to be optimised. They received a customer-specific connection and an EMC protection circuit to protect against electromagnetic interference. Furthermore, the software was adapted to the function of the gripper. "From my point of view, FAULHABER is not a supplier but a development partner", Matthias Quaas emphasises.

"The cooperative efforts were exceedingly constructive and always solution-oriented – we got outstanding support here."

Today, with the EGP 40, SCHUNK can offer the most powerful mechatronic small parts grippers with integrated electronics available in the global market. Its housing design and electrical power connections correspond to those of the equivalent pneumatic product MPG-plus 40. The sensor system and control signals are also identical. This way users can switch from pneumatic to electrical operation with a minimum of expense and effort. Further strengths of the gripper include an excellent relationship between clamping time and lift, the extremely precise operation of the gripper fingers – attributable to a high-performance cross-roller guide – and the fourfold adjustable gripping force. That which is only possible for pneumatics with an elaborate control system is incomparably easy here: through an opening on the side of the housing, switch positions are selectable for determining how firmly the gripper should grasp.

With this, the gripping force can also be adapted to formable or delicate workpieces. Besides, in many manufacturing processes the speed of the gripper is also crucial. In this case there is also an EGP 40 in a speed version. Within it, the motor works with different gear reduction. Although it is not quite as strong, it achieves incredibly short cycle times and is even quicker than the pneumatic versions.



Picking up small parts and putting them elsewhere in the proper place is a standard task that occurs in many handling and assembly processes.

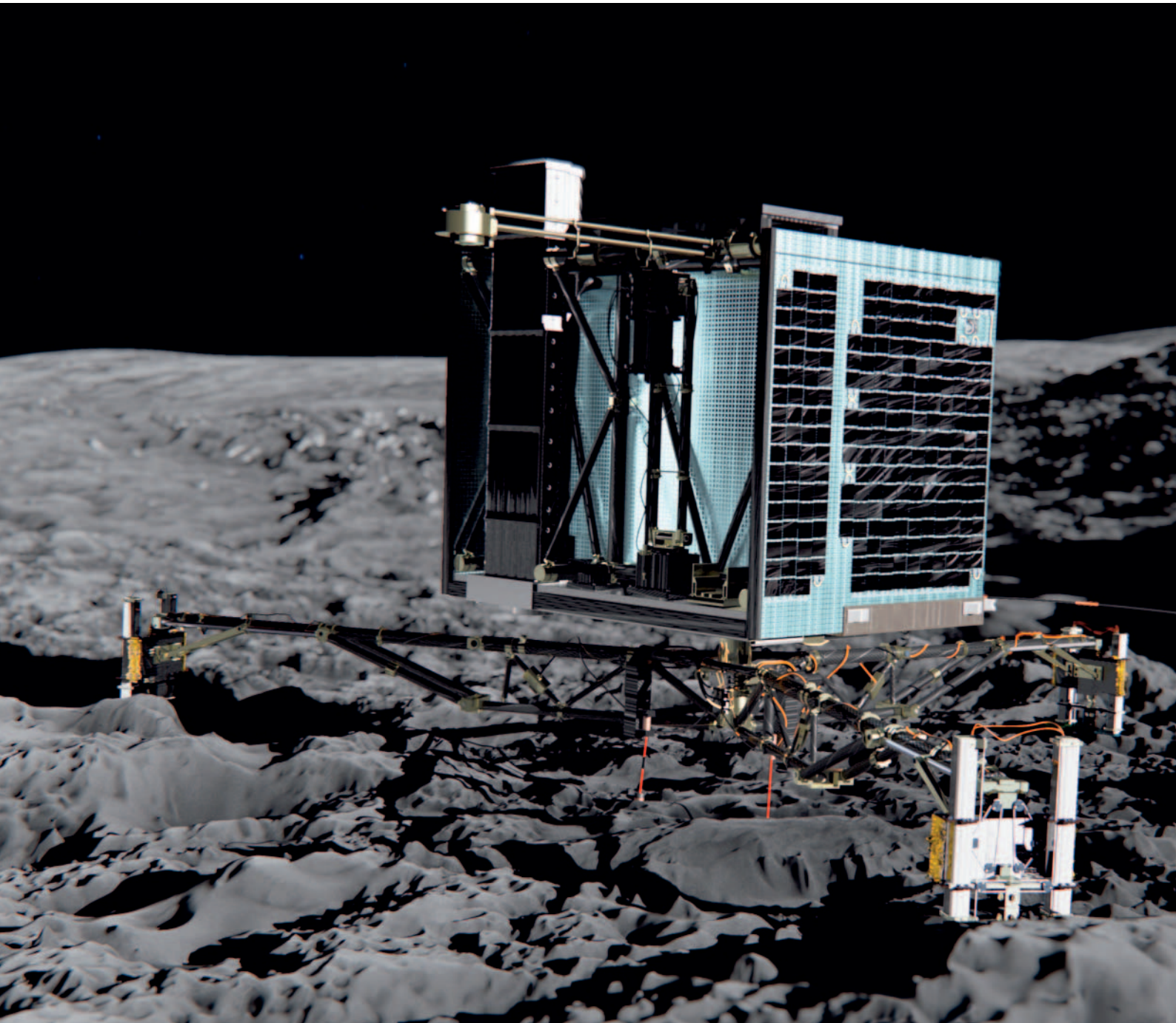
Use of an electric SCHUNK 2-finger parallel gripper EGP for precise handling of electronic components.

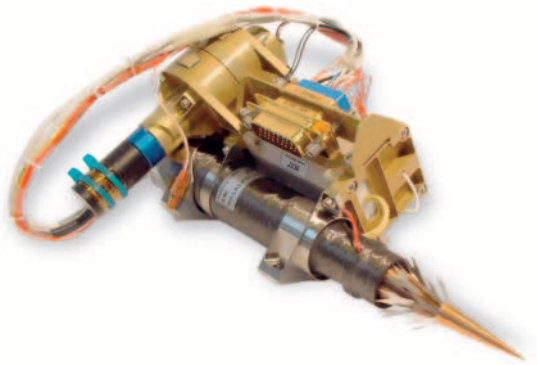
FURTHER INFORMATION

SCHUNK GmbH & Co. KG, Lauffen/Neckar
www.schunk.com

FAULHABER Germany
www.faulhaber.com

HOW TO CATCH A COMET?

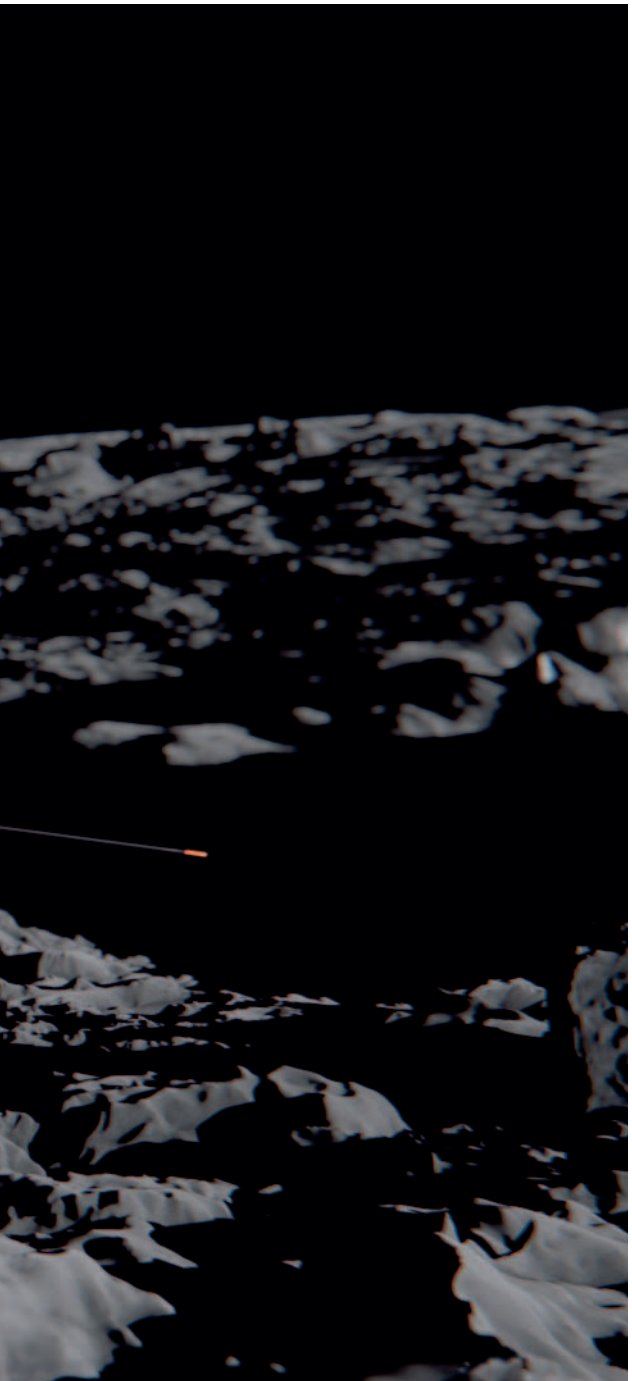




Harpoon unit for secure anchoring on the surface of the comet

Compact drive systems on an adventurous journey

At the end of May 2014, the Rosetta space probe will swing into an orbit around the comet 67P/Churyumov-Gerasimenko in order to, after more closely approaching it in August, map its surface and thus prepare for the landing of Philae. This ballistic lander, weighing 100 kg, is supposed to land on the comet in November and – thanks to FAULHABER drives – securely position itself. After an adventurous journey of over 10 years through outer space, this is a first in the history of space travel.



The Rosetta mission lander unit Philae at work.

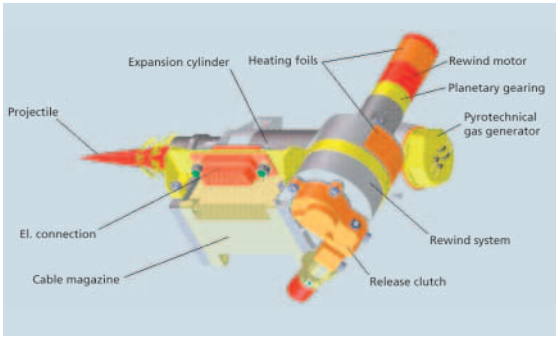
Picture: ESA-C. Carreau/ATG medialab

As is the case with asteroids, comets (or shooting stars) are considered to be the remnants of the genesis of our solar system. They are formed in the cold outer reaches. In proximity to the sun, the comet nuclei – which are usually just a few kilometres in diameter – are surrounded by a nebulous shroud, the so-called coma; this is what gives them their typical appearance. Comets have always fascinated mankind. In the antiquity, ancient Greeks and Romans thought them to be divine omens; in the Middle Ages, they were considered to be harbingers of fate. And now, European scientists are close to landing a spacecraft on a comet to – for the first time in history – observe and examine one first-hand and gain new insights into the origins of our solar system. An endeavour such as this places high demands on the technology that is employed, though. Consequently, the ballistically-propelled lander makes use of an entire series of compact drives, which must reliably fulfil their functions after the spaceflight of many years. For example, they must operate during the landing and while analyses are being performed on the surface of the comet.

Anchor system, landing gear and sample analysis

Because of the low gravity of the celestial body, it is difficult find firm footing on the surface and to also ensure a secure stance during the entire operating period. Thus, under the auspices of the DLR (Deutsches Zentrum für Luft- und Raumfahrt; German Aerospace Centre), the Max-Planck-Institut for Extraterrestrial Physics (MPE) developed a special anchor system for the probe: immediately after ground contact upon landing, two harpoons are shot by propellant charge into the surface of the comet and lodge into it. Barbs prevent these anchor fittings from coming loose again. Each harpoon pulls a tethering cable from a reel behind it. After the shot, this cable is wound up on a drum by the micromotor until taut, which firmly anchors the probe on the surface. Once the cable has been tightened, the DC motor also applies tension to a coil spring positioned on the reel shaft. This provides for a slight pretensioning of the anchor cable and absorbs any possible sinkage of the harpoon or the landing legs of the sensor. Other motors fulfil important roles during and after the landing, though:

In order to transform the kinetic energy (approx. 50 J) generated by the landing into electrical energy and finally into heat, it is transmitted by way of a spindle drive to a small bell-type armature motor, connected directly through an external resistor, and operated as a generator. Additional drives are also in use on the three-legged landing gear of the lander, e.g. in order to swivel or rotate the upper part of the lander by means of a cardan joint in such a manner that the solar panel is optimally oriented. And, microdrives are also needed for taking the samples: the lander has a drill that feeds core samples into a small oven for pyrolysis. Small motors drive a cam via a worm drive, which feeds to a breech piece made of ceramic on the respective oven and simultaneously closes the electrical contacts for the oven heating element. The gas is routed through thin tubes in the oven latch to the scientific instruments for analysis.

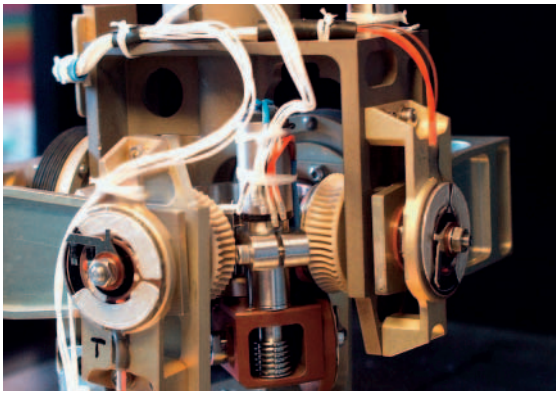


Top: Structure of the harpoon anchor.

Left: With the space probe through space.

Picture: ESA-C. Carreau/ATG medialab

BRUSHLESS DC-SERVOMOTOR
Ø 16 mm, length 28 mm
Torque 3.3 mNm



The lander's legs are connected with the top part by way of a cardan joint in which three motors are integrated: two for both of the tilting axes and one for adjusting the brake force of the multi-plate clutches.

Outer space and its demands

The demands that outer space place on these drives are high: every kilo of mass that is shot into space costs energy, i.e. fuel – hence money too. Therefore, small, light solutions are sought. At the same time, however, they must also be able to withstand the enormous vibration and acceleration forces during take-off, as well as the constant very-low temperatures and the many years of vacuum conditions prevailing in outer space.

Because the cost factor also plays a major role in all considerations when selecting components for space projects, the developers wanted to do without costly custom developments if at all possible. Accordingly, they first looked for series products which complied with as many of their specifications as possible. They found what they were looking for in the comprehensive drive systems product range from FAULHABER. Standard drive solutions they offered fulfilled all mechanical requirements. The special conditions in space could then be met by making comparably few modifications that entailed negligible additional costs.

Tuning for standard drives

For example, a Brushless DC-Servomotor with Precision Gearheads served as the initial motor for driving the anchor harpoon. Motor and gearhead together measure only 16 mm in diameter and 55 mm in length. Low drive play of less than 1° also allows for much more precise positioning. Thanks to their compact dimensions, the drive solutions could be easily integrated. Their low power requirements were also ideally suited to the application.

As was the case with the other drives used in the lander, their lubrication was also adapted to the conditions in space. Greases or oils are ineffective under these circumstances; they either solidify in the cold of outer space or vaporise in the vacuum. Which is why it was decided to use molybdenum disulphide (MoS2) for the space mission, which also has a graphite-like layer structure. With it, the lubrication also functions in a vacuum and in the frigid temperatures of outer space, but also at temperatures of up to several hundred degrees Celsius. This solid lubricant was therefore applied to the surfaces of the special bearings to be lubricated and the standard gear wheels.

The gearhead housing had to also be made suitable for deployment in outer space. Deep temperatures of less than -100 °C and different materials can lead to thermal expansion problems with precision parts due to blockage. For this reason, the standard nickel-plated brass housing of the drive was replaced by a steel housing, which is matched to the thermal expansion rates of the steel gears. It was possible to manufacture the steel housing in FAULHABER's standard production facility. This in turn helped assure the precisely-fitting interchangeability. Thanks to the easily-assembled individual drive parts, the spaceworthy "reinforced" parts could then be easily put together. The modified standard drives will prove their performance during the landing, just as they have already in many other extreme applications, such as with high-vacuum electron microscopes and in chip production.

FURTHER INFORMATION

Deutsches Zentrum für
Luft- und Raumfahrt e. V. (DLR), Cologne
www.dlr.de/rosetta/

www.esa.int/Our_Activities/Space_Science/Rosetta

Max Planck Institut für Sonnensystemforschung
www.mps.mpg.de

Max Planck Institut für extraterrestrische Physik
www.mpe.mpg.de/809839/mech_rosetta

FAULHABER Germany
www.faulhaber.com

THE WORLD in MINIATURE

FAULHABER in the Miniatur Wunderland

Visit the most diverse regions of the world in just a single day: explore Las Vegas, the Alps or the Norwegian fjords in only a few hours – it is possible in the Miniatur Wunderland. Located directly along the Elbe river in Hamburg's Speicherstadt (traditional warehouse district), it features the largest model railway in the world and is one of the most exciting tourist attractions in Germany. Far more than ten million visitors have marvelled at this wonderland in the meantime, which – in an area that is some 1,300 m² large – replicates in miniature sights from Scandinavia to the USA, from quayside to the mountains peaks of our world.

The reason being that Miniatur Wunderland offers much more than 'just' a huge model railway.

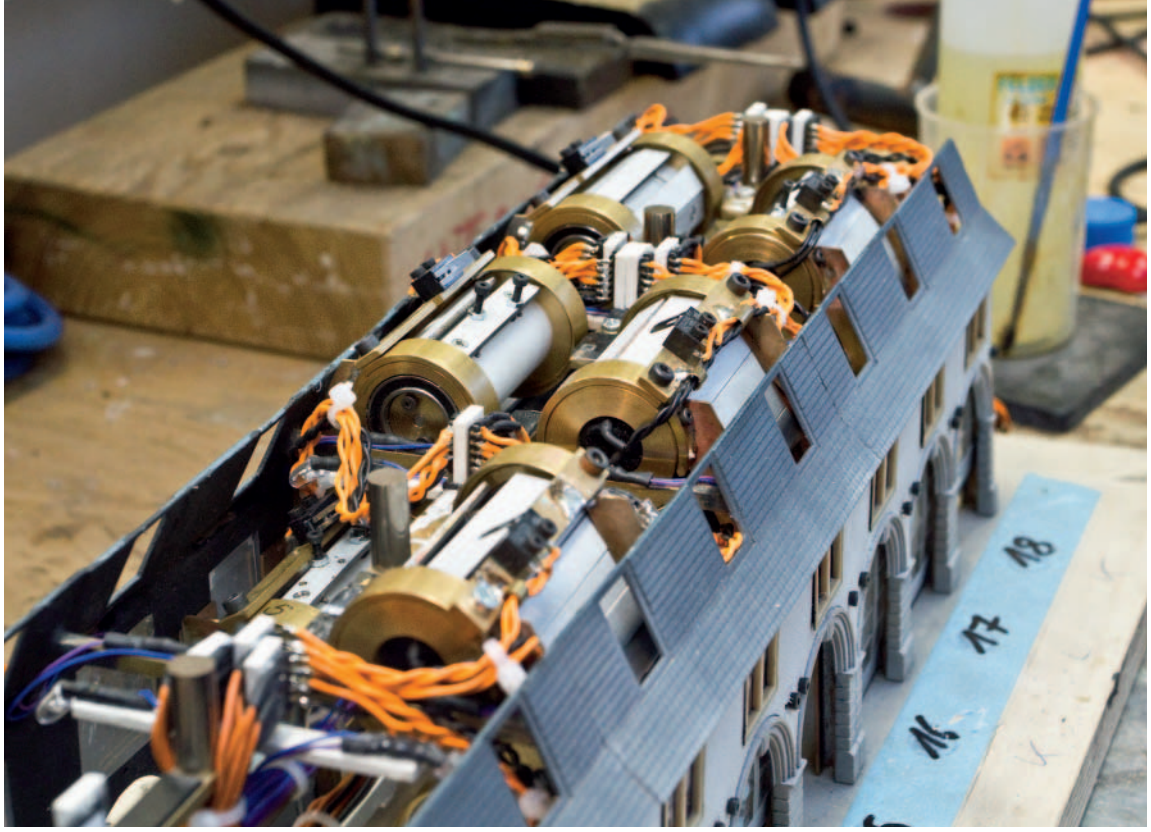
Life in all its facets.

The reason being that Miniatur Wunderland offers much more than 'just' a huge model railway. In addition to the 930 trains, which travel several hundred kilometres each day, visitors of all generations can observe the 8,850 automobiles and ships and even more than 200,000 tiny residents. They visit big festivals or memorial ceremonies, police set up radar traps and chase after criminals, the fire brigade is constantly responding to calls – life in all its varied facets can be seen in Wunderland. Among the most recently completed sections is the Knuffingen Airport. From the engineering hangar to the arrivals and departures terminal, the airport amazes with its many dotingly meticulous details. 40 airplanes start and land here daily.

Unique technology.

The impressive scenery conceals one-of-a-kind high-tech: "One of our key principles has always been to face every technical challenge, no matter how hopeless the situation might seem at the outset. With this attitude we have managed to create technologies which cause amazement among visitors", says Gerrit Braun, who founded Miniatur Wunderland together with his brother Frederik. Some 335,000 lights, which dynamically switch on and off, combined with a self-developed light control system provide for a nearly perfect day and night simulation. Numerous vehicles and aircraft are computer-controlled or can be set in motion by visitors with one of the more than 200 pushbuttons.

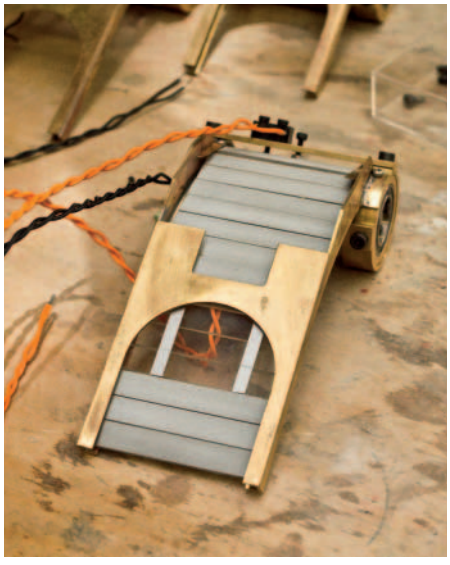
At Knuffingen airport, over 40 different vehicles taxi to the runway, accelerate and take off.



Right: The little fire brigade and many trains are also driven by FAULHABER motors.

Top: The motors provide for the movement of a roll-up gate.

Right: There, the motor is internally integrated and upwardly winds the gate around itself.



Drives from FAULHABER.

For many of these pushbutton-activated functions, the DC-micromotors from FAULHABER provide for the movement. "We employ various FAULHABER series depending on what the purpose requires", explains system technician Mathias Stamm. For the aircraft models of the Knuffingen Airport, motors of the 1717 series are utilised. The little fire brigade of the airport and many trains are also driven by FAULHABER motors. For example, the intricate 1524 motors provide for the movement of a roll-up gate. "There, the motor is internally integrated and upwardly winds the gate around itself", describes Stamm.

Reliable and professional.

What speaks in favour of FAULHABER motors, in Mathias Stamm's opinion, is for one thing the technical reliability. "The FAULHABER motors are of the utmost in quality and run maintenance-free", emphasizes the technician. For another thing, it is the professional support, that has also convinced him. "We order somewhat smaller quantities", mentions Stamm. "Nevertheless, when questions arise we have direct access to the telephone support of FAULHABER."

Miniature train races in British television.

In 2011 the Miniatur Wunderland was also able to score points at a special event for British television thanks to FAULHABER technology. The well-known BBC presenter James May appeared in a miniature

WORLD'S LARGEST MODEL RAILWAY COVERING OVER 1,300 M²

train competition against Miniatur Wunderland in his Sunday evening show. The task was to most quickly travel the nine miles (which corresponds to roughly 15 kilometres) of railway line from Bideford to Barnstaple, which is no longer in use today, with a model railway. Accordingly, the stretch was first laid with small rail tracks before the start of the race. For the show, Miniatur Wunderland came up with a special gag. "We developed a train that ran on sauerkraut fuel. We then had it dramatically blown up half way there, but with another train we were first to cross the finish line", recounts Gerrit Braun. The locomotives for this race had been first refitted with FAULHABER micromotors in order to be up to the demanding task.

Two brothers and one idea.

The early days of the impressive Miniatur Wunderland go back to the summer of 2000. It was Frederik Braun who, during a stroll through the Alpine metropolis of Zurich, had the flash of inspiration. He was ambling through the back alleyways of downtown Zurich and stumbled upon a model train shop that rekindled his childhood memories and inspired him to a vision. On the very same day he called his twin brother Gerrit and proposed building the world's greatest model railway. The project was born. Soon, construction began on the Miniatur Wunderland in Hamburg's Speicherstadt district, and the work continues to this date. Up to now, the facility has grown to eight sections covering over 1,300 square metres. 300 employees build and maintain it, and take care of the visitors.

Outlook.

By 2020 four further sections will be added. Presently an Italian section is being built. Over the space of 150 square metres, well-known Italian cities, dreamy vistas and mountain panoramas, architectural masterpieces and the Roman tramway are now evolving in small-scale. In addition to the Italian capital city of Rome, parts of Venice – with the golden Saint Mark's Basilica – are being planned, just as well as the volcano Vesuvius and the buried city of Pompei. The opening is planned for the end of 2015.

Facts and figures on the facility

Surface area
Miniatur Wunderland leased floorspace: 6,400 m²
Model area: 1,300 m²

General data
Construction time: approx. 580,000 work hours
Employees: 300
Sections: 8
Construction costs: EUR 12,500,000

Railway data
Total track length: 13,000 m
Trains: 930
Rail carriages: over 14,450
Longest train: 14.51 m
Signals: 1,270
Switches: 3,050
Computers: 46
Lights: approx. 335,000
Buildings & bridges: 3,660
Human figurines: 215,000
Automobiles: 8,850
Aircraft (flying): 40
Trees: 228,000

(as at November 2013)

FURTHER INFORMATION

Miniatur Wunderland Hamburg GmbH
www.miniatur-wunderland.com

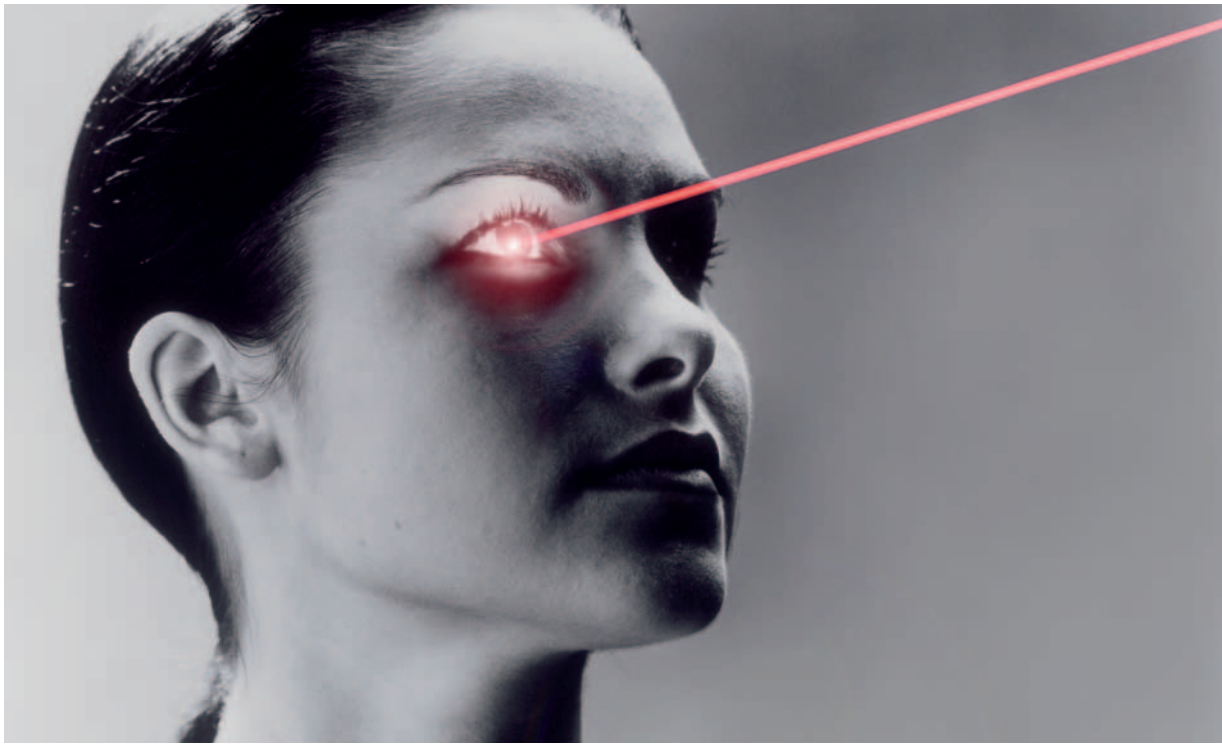
FAULHABER Germany
www.faulhaber.com

BRIGHT

power pack

Actuators for the precise alignment of pulsed-laser beams

If you turn on your pocket torch for just a second and point it towards the sky, your beam reaches all the way to the moon. How fast would you need to switch the torch on and off in order for the beam to be shorter than the thickness of a human hair? It's not something you could accomplish with your thumb, that much is certain. Ultra-short beams, or pulses, of this order of magnitude are emitted by so-called femto-second lasers, which split the laser light into compressed, high-energy wave packets. They can be used to work on any material – from the cornea of the human eye to super-hard ceramics – with micron accuracy. The French manufacturer of precision devices, ISP System, produces the actuators with which the prisms, mirrors and filters in such high-performance lasers are precisely aligned so that the light pulses reach the right point with the right power. Reliable drive is ensured by the stepper motors from FAULHABER.



Femtosecond lasers are today state-of-the-art and are used in many areas.

Stimulated emission

How a laser functions is explained, in principle, by the word itself, as it is an acronym for Light Amplification by Stimulated Emission of Radiation. Explained in simplified terms, the light is amplified and bundled in the laser through the input of energy and optical tricks. The result is the thin but powerful beam which can read CDs and barcodes, treat cancerous tumours or weld metal. Needed for the optical tricks are, among other things, prisms, filters and mirrors. These split the beam, concentrate certain wavelengths and – for amplification – reflect the beam back and forth many times between two mirrors. While the constant beam of, e.g., a laser pointer is relatively weak, the energy in pulsed lasers is highly compressed into small packets by manipulating the frequencies and delaying the emission of light.

It doesn't get much shorter

Lasers with pulses in the attosecond range (0.000 000 000 000 000 001 seconds = 10^{-18} sec) have already been used in research. With their ultra-short pulses, even extremely fast dynamic processes in the atomic nucleus can be made visible. For industrial or medical uses, the pulses can be a bit longer, lasting a fraction of the time it takes to blink. A femtosecond (10^{-15} sec) is one quadrillionth of a second. In this fraction of a blink of the eye, the light travels a path of just 0.3 microns – a human hair is about two hundred times thicker. Femtosecond lasers are today state-of-the-art and are used in many areas. These include multiphoton microscopy, microsurgery, the processing of the finest structures, e.g., in medical technology, chemical analysis or in forgery-proof micro-marking.

The femtosecond laser can generate up to a hundred million laser pulses per second. The material struck by these pulses has no time to melt – it is transformed directly to the gaseous state and can simply be extracted. Layers that are just a few millionths of a millimetre (nanometre) can thereby be removed with high accuracy without producing melting residues or heating neighbouring material. Material properties such as homogeneity, absorption capacity, vaporisation temperature or hardness play practically no role – the laser can be fired at nearly anything.

Drive variants

This "cold processing" leaves behind no residues and does not affect the quality of the work piece. It is only a matter of selecting the correct pulse duration, pulse energy, pulse frequency and correct focussing in order to achieve the desired results. And this is where the actuators from ISP System come into play.

They move the prisms, filters and mirrors inside of the laser and give the light pulse its highly defined quality. Three different types of drive come into question here: electromagnetic, piezoelectric and mechanical. "In some application areas, such as research, the first two drive types can draw on their particular strengths. In day-to-day industrial use, however, mechanically driven actuators are superior in many respects", says Sébastien Theis from ISP System, who qualifies this with: "provided the devices are of suitable quality and first-class motors are used. They must function very precisely, but their drive electronics cannot be too complex."

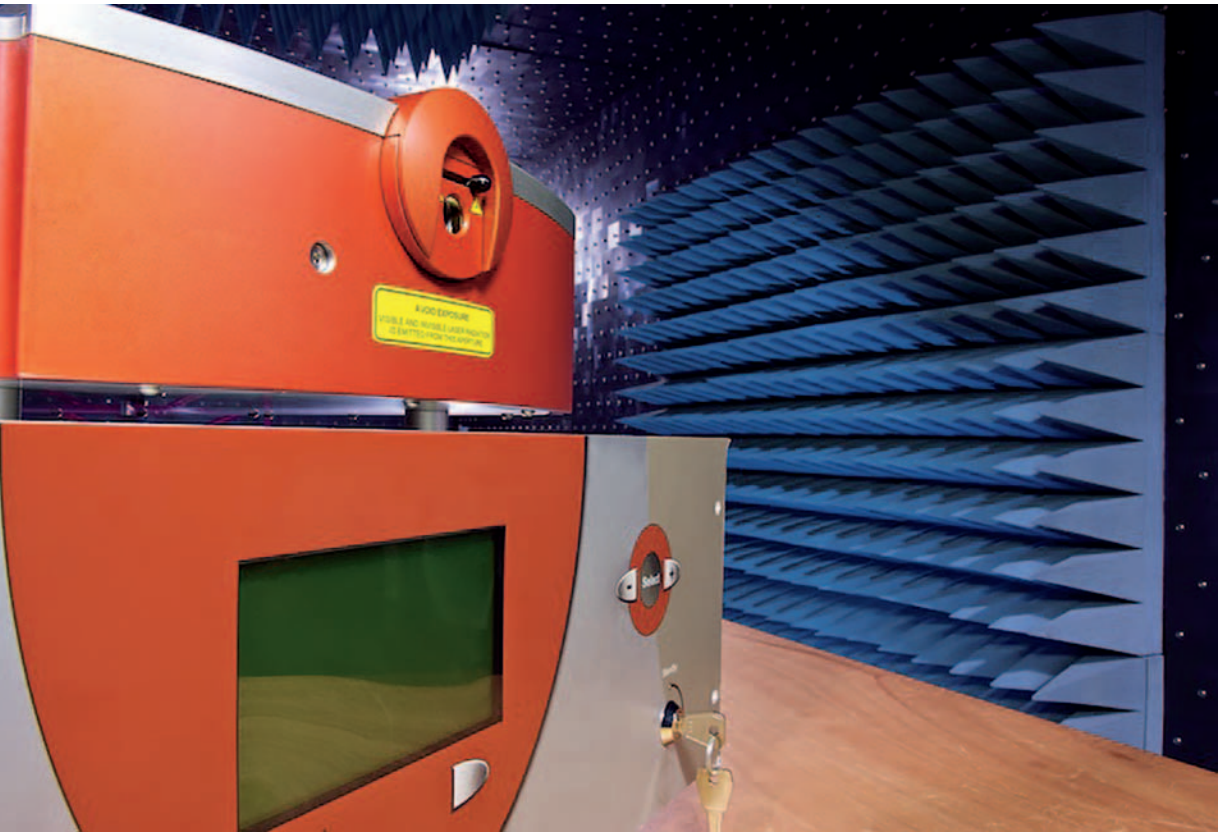
Superior mechanics

It is here, in particular, that piezoelectric and electromagnetic drives have a decisive disadvantage: they can only achieve their high precision in a closed control loop. This means that a measurement unit (sensor) is needed that measures the movement and passes the values on to the drive electronics, which then adjust the movement accordingly. The closed control loop means a relatively high level of complexity and requires additional electronics. This makes the solution not only more expensive, but also considerably more complex and bulkier.

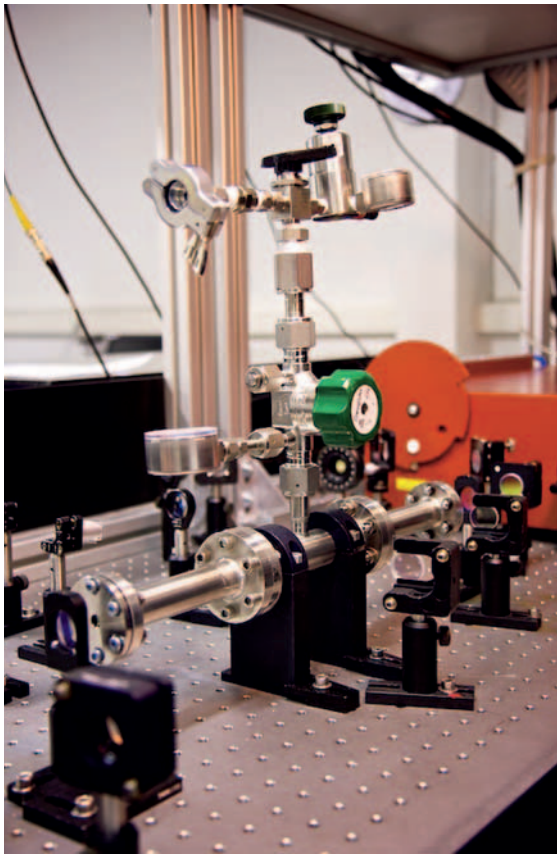
Stepper motors, on the other hand, can also be operated in an open control loop, do not need a sensor and are, for these reasons alone, more compact. "The motor itself counts the steps. Using this value, it is possible to derive a very exact position. Thanks to the quality of the FAULHABER motors, we can be certain that no step is lost, provided there are no obstacles in the way. Even then, it is sufficient to move the drive back to the zero position to obtain a reliable calibration", explains Sébastien Theis.

Undeviating, even without power

Another advantage of the stepper motor is that it reliably holds its position even without power. During operation in the enclosed laser box, this is important because each laser pulse is accompanied by an electromagnetic discharge. A closed control loop, consisting of actuator, sensor and drive electronics, can only function if power is supplied. In such a unit, the electrical discharge can cause interference. This, in turn, can cause, e.g., an adjustable mirror to move out of its specified position. This would be fatal for the precision of the laser if used, for example, to make a correction to the cornea of a short-sighted eye. With the stepper motor, which remains fixed in place when there is no power, such interference is, fortunately, not possible.



The laser is testing for CEM in test laboratory.



In addition to these design-related characteristics and the high quality, there were other reasons why ISP System selected motors from FAULHABER: "We found no other manufacturer who could as easily and as quickly accommodate our requirements. We can select from an incomparably wide range of motors and gearheads. Moreover, FAULHABER is able to specifically develop motors according to our requirements. Thanks to short delivery times, we can respond very quickly to the requests of our customers. And we always have highly competent contacts who know our technology and who contribute to its further development", says Sébastien Theis.

UP TO A HUNDRED MILLION LASER PULSES PER SECOND

STEPPER MOTOR

Two phases, 20 steps per revolution
PRECIstep® technology

FURTHER INFORMATION

ISP SYSTEM, Vic en Bigorre, France
www.isp-system.fr

AMPLITUDE SYSTEMS
www.amplitude-systemes.com

FAULHABER France
www.faulhaber-france.fr

Innovation – A PROCESS REQUIRING as many good minds AS POSSIBLE

Drive systems, precision systems and microsystems have always been inseparably linked to the name FAULHABER. As a pioneer and founder of this high-tech branch of industry, FAULHABER is today one of the most innovative companies in Germany. But how does innovation at the limits of what is technically feasible actually work?

REINER BESSEY
FAULHABER, SCHÖNAICH

Head of Development
Platforms and Technology

Mr Bessey, how large is the R&D department at FAULHABER?

Worldwide there are almost 200 employees active in research and development. About 120 of them are here at our headquarters in Schönaich. 43 of these work in my department which focusses on our technology portfolio and system platforms as well as process and production technology.

Which components from your product portfolio are ordered most frequently?

The sale of individual components is more of an exception. The orders we receive are mostly for complete drive systems consisting of several components. Here we make a distinction between standard drive systems, modifications and custom solutions. Standard drive systems are the product platforms that can be found in our FAULHABER catalogue. This range of products has more than 25 million different combination possibilities and serves as the basis for modifications to allow us, in a relatively uncomplicated way, to provide customer-specific solutions, for example special stranded wires, plugs, customised lubrication, customised flanges, adapted shafts or system design for a specific operating point. Such modifications make up the lion's share of our turnover. Custom solutions are drive systems which are specially developed for a customer application. Of course, we also try to utilise our platforms in such applications, but sometimes a custom solution consists completely of customer-specific components so that the solution is optimally configured and designed for the application in question.

Recently, FAULHABER was once again presented with the "Top 100" award for being one of the most innovative companies in Germany. What is your innovation management like? In other words, how do you manage to permanently generate innovations?

Naturally, we are very pleased to receive awards like the "Top 100" or "Best Innovator". After all, it's not everyday that a medium-sized company is nominated alongside award winners such as Audi, BMW, SAP and other large concerns.

We supply markets with typical model cycle times of 5 to 30 years. Now, one might ask whether such long-term applications actually require innovations. But it is exactly here that the continuous development of new and better solutions is necessary. Our customers want "completely new" solutions for the very reason that their products are used over a long period and therefore need to be sustainable. On the other hand, it is not enough for the products used in many applications to just be new – they must also be fully developed and perfected in order to minimize the risk. Together, these requirements make permanent innovation a necessity.

Our innovation management comprises a clear innovation strategy, an innovation portfolio consisting of technology maintenance, market pull and technology push. The associated innovation process with the necessary supporting tools and methods is, of course, a must. At FAULHABER, this is embedded in the process landscape of the entire company.

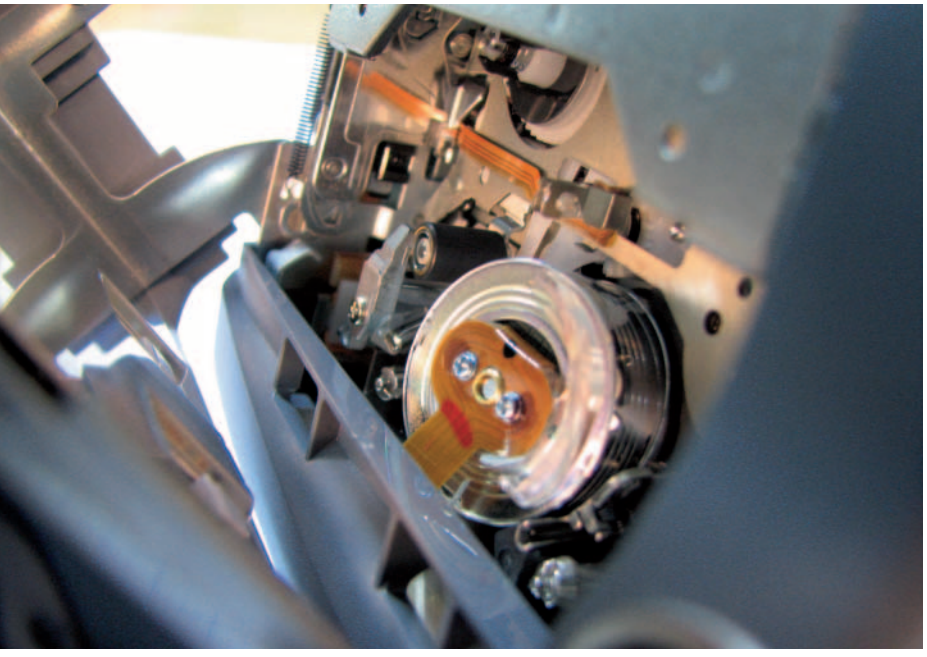
Tool with
FAULHABER EC winding

Innovation and development management must be seamlessly integrated in order to ensure later market success. How is that achieved at your company?

Here there is a clear procedure and clear responsibilities for idea generation, selection, testing in our Advanced Engineering department, and the final transfer to the classic development process.

How high do you estimate the administrative costs from idea to product?

Our innovation database supports us in idea generation and selection. Technologies, product ideas and benchmark results are documented in this database. This keeps the administrative costs within a reasonable limit and we can focus on the creative work. We also have tools for the classic development process with the appropriate project management. However, considerably higher administrative costs are necessary here. After all, the documentation for all projects must comply with the standards ISO 9001 and ISO 13485.



During solution screening, technologies from other markets, e.g. a camcorder drive, are also examined.

You have, among other things, a creative room. What is the thinking behind this?

We regard knowledge management as a pacemaker for innovation. The objective is to make knowledge, which is often trapped inside the heads of individuals, accessible to a large number of people in the company. One way of doing this is our creative room. It contains a collection of technology samples and known drive solutions from our own company and from competitors. These samples are available to every employee. Here, he or she is not only able to grasp concepts with their head but also, quite literally, with their hands. We also use the creative room for creative workshops. Here too, it is good to be able to quickly refer to example solutions and to combine various solution approaches.

How do you make sure during development that no patents are infringed?

We regularly view the patent classes that are relevant to us. After an initial preselection by our patent officers, the new patent applications are assessed as part of a monthly patent review by a team of experts. This ensures that we do not infringe any patents of other persons or companies. Additionally, dealing with patents encourages creativity and gives us ideas.

You also analyse non-competing products from related industries and markets. What have been the greatest learning effects that have resulted from this?

Attractive technologies and solutions are often not really new – they are only new for a particular industry or on a particular scale. At our solution screenings, we therefore also analyse products from markets that we ourselves do not supply. It has been shown that the learning effect from dismantling and handling is greater than that achieved from studying documents and attending training courses. We often come across technologies in use today about which the whole team agrees that "we would never have designed it like that". It helps us to look beyond our own noses and to think outside the box.

WE REGARD KNOWLEDGE MANAGEMENT AS A PACE-MAKER FOR INNOVATION.

You have your own in-house technology, parts and material experts. Can you give an example of how the experts manage to work together without getting in each other's way?

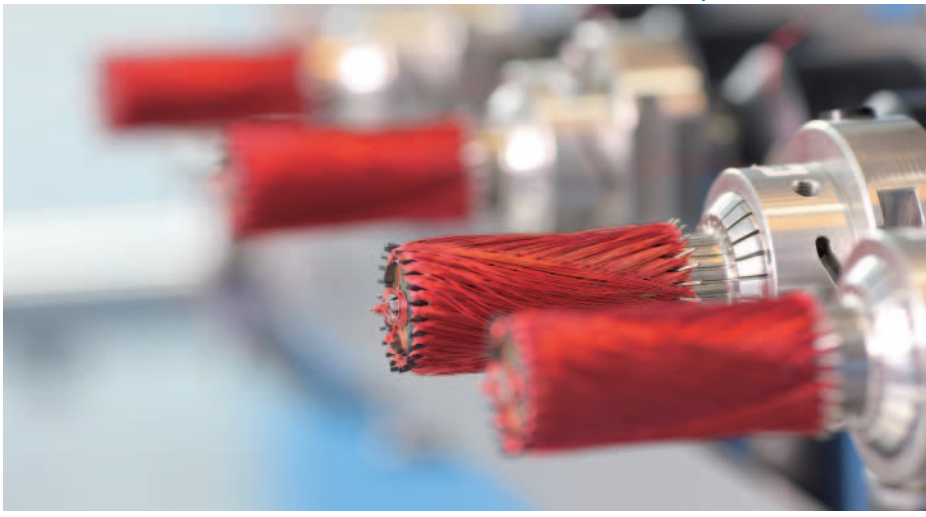
The realms of expertise within FAULHABER allow the formation of distinct and competent scopes of responsibility. The experts practise targeted knowledge building in their particular realm of expertise. Information is collected and is then made available to colleagues. This counters "uncontrolled creative growth" and increases product quality.

A direct conversation is more constructive than 1000 emails. This is why you called the "Round Table" events into being.

That's right – innovation is not a matter for individual people, but is the task of the entire company. That's why around ten to fifteen people from Sales, Business Development and R&D meet to discuss a preselected key topic. Customer requirements, market opportunities and product possibilities are discussed in an informal atmosphere using sample parts from our own product portfolio as well as competing products.

Apart from pure product development, the further development of in-house production technology is surely also a key aspect?

Of course! What's the point of a wonderful design if the product cannot be produced reliably? No point at all! This is why the interplay between process and production technology and the design departments is of particular importance.



NATURAL FEELING

FAULHABER drives in prosthetics

Grasping with suitable pressure, without damaging or dropping objects, touching and feeling the shape and texture of something: healthy people do this hundreds of times each day without having to consider it. However, these movements embody a complex sequence. Artificially reproducing this sequence amounts to a real challenge, which a team of researchers have now successfully mastered for the first time with the LifeHand 2 project – supported by micromotors from FAULHABER.

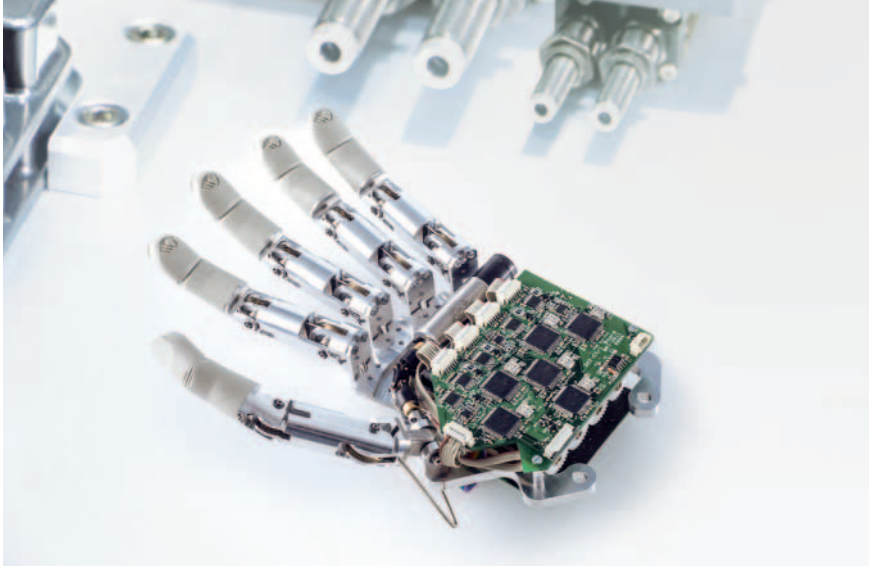
Prosthetics with disadvantages.

If one follows the sports competitions for disabled persons, such as the Paralympics, it is amazing to see the level that prosthetics have attained these days. For example, in the summer of 2014 the German long jumper Markus Rehm was not allowed to travel to the European Athletics Championships because the German association was afraid that, with his carbon leg prosthesis, he would have an advantage in jumping vis-à-vis non-disabled sportsmen. And yet the sophisticated prosthetics made of carbon and other materials have a decisive disadvantage: the bearer cannot truly use them just the same as he would the missing part of the body. The hand prostheses available on the market detect muscular movements in the residual limb somewhat, and enable the bearer to open and close the hand as well as to grasp objects. But without any sensory feedback to the nervous system, the bearer cannot feel what he is attempting to grasp and must therefore keep an eye on his prosthesis so that he does not crush the objects.

Comparable with a natural hand.

A major step in progress was achieved with the LifeHand 2 project. The artificial hand makes fascinating things possible for the bearer: he can grasp objects with suitable pressure and, via contact sensors, feel which attributes they have. The bearer can even feel which exact fingers have contact with the object. The size and the weight of the prosthesis are thereby comparable with those of a natural hand. LifeHand 2 is equipped with sensors which register tactile sensations by measuring the tension in the artificial tendons and controlling the finger movements. These data are then transformed into electrical signals which are then transmitted to the nerves. This is made possible through electrodes to the nerve fibres, which convey signals to the bearer's brain. A computer translates the signals from the sensors into pulses which the nerves can interpret. They are further transmitted via electrodes to the median nerve (nervus medianus) and the ulnar nerve (nervus ulnaris).

An international research team developed the bionic hand prosthesis at the École Polytechnique



Top: The finely-detailed workmanship, which the LifeHand thumb and fingers put into effect, are implemented with DC micromotors from FAULHABER.

Left: Grasping with suitable pressure, without damaging or dropping objects.

Fédérale de Lausanne (EPFL). Six research institutes in Italy, Switzerland and Germany were involved. Professor Silvestro Micera and his team from the Scuola Superiore Sant'Anna (SSSA) in Italy developed the sensory feedback system, thanks to which a patient can feel something again when touching and moving objects.

In February of 2013, a prototype of the LifeHand 2 was tested in the Gemelli hospital in Rome within the scope of a clinical study supervised by Paolo Maria Rossini. The Dane Dennis Aabo Sørensen volunteered to be the first test person for the LifeHand 2. Nine years ago he had lost his left hand in an accident. Four microscopic interfaces were grafted onto the main nerves of his left arm. After the electrodes had been surgically implanted and the wounds had healed, the prosthesis could be connected. When Sørensen touched objects, the sensors of the prosthesis generated signals which were processed by a computer and relayed through a stimulator to the electrodes implanted in the nerves and, ultimately, to his brain. This all took place in less than 100 milliseconds. With such minimum time intervals, human beings don't sense any delay in transmission. Sørensen was able to recognise the shape, consistency and position of objects in real-time and use this information in order to grasp the objects with the proper grip and appropriate application of force by controlling his fingers.

The research team was surprised just how quickly Sørensen was able to control the prosthesis. For the tests, the researchers blindfolded Sørensen and then asked him to pick up objects with the LifeHand. He succeeded in not only controlling the strength of his grip, but also in describing the shape and texture of the objects – although he could not see them.

Sophisticated motors from FAULHABER.

The finely-detailed workmanship, which the LifeHand thumb and fingers put into effect, are implemented with DC micromotors from FAULHABER. With a motor diameter of 13 millimetres and a motor length of 31 millimetres, the motors are lightweight and compact. A unique aspect of the FAULHABER DC motors is their rotor, which is not wound around an iron core, but instead consists of a copper coil manufactured with a self-supporting, skew-wound design. The FAULHABER rotor has also proven itself convincingly in the Lifehand project with its extremely low inertia torque and cogging-free running properties.

FURTHER INFORMATION

Università Campus Bio-Medico di Roma
www.unicampus.it

PRENSILIA s.r.l.
www.prensilia.com

FAULHABER Germany
www.faulhaber.com

THE flyweight THAT PACKS A HEAVYWEIGHT PUNCH

Plenty of power – and cuts a slim figure on the scales

In the fight for high performance with minimum weight, FAULHABER with the development of its series 3274 BP4 has put a new champion in the ring. The brushless DC servomotor, measuring 32 mm in diameter and 74 mm in length, has a huge continuous torque of 165 mNm. Furthermore, it weighs in at just under 320 g, which is half that of conventional motors with comparable power.

The new series 3274 BP4

The four-pin brushless DC servomotor is ideal for applications in which high power and dynamic start/stop operation with the lowest possible total weight is an important factor, for example in link drives of humanoid robots, electric grippers used in process automation or high-performance traction drives used in inspection robotics.

The 3274 BP4 is overload-resistant and operates without wear-prone mechanical commutation. As a result, its operational lifetime is many times longer than that of a conventional DC micromotor. The slope of the motor characteristic curve is just 3 rpm/mNm with a stall torque of 2.7 Nm. The 3274 BP4 can reliably deliver what the application demands even under the harshest ambient conditions, such as at low temperatures or high mechanical loads (e.g. in aerospace applications). This is made possible by, among other things, a robust stainless steel housing and the omission of adhesives which are otherwise usually used for assembly.

One particularly interesting feature of this motor series is the high flexibility in its design. The FAULHABER series 3274 BP4 is equipped as standard with digital hall sensors. High-resolution optical and magnetic encoders can be attached simply to the rear multifunction flange. As an option, the motor is also

available with analogue (linear) hall sensors that can replace an encoder in many application cases. Finally, a large selection of performance-optimised precision gearheads rounds off the complete drive system.

FURTHER INFORMATION

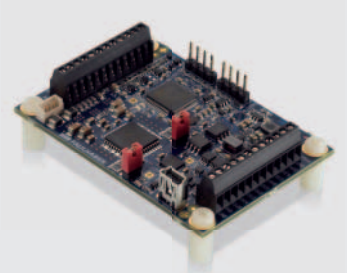
FAULHABER
www.faulhaber.com/news

THE MOST COMPACT 3-CHANNEL ENCODER OF ITS CLASS.

Integrated encoder series IEH3-4096

The integrated encoder series IEH3-4096 is a further development of the successful single-chip design used for the IEH2. Thanks to the thermally robust module, it was possible to extend the operating temperature range of the IEH3 considerably to -40 to +100 degrees Celsius. Unlike encoders with a separate add-on housing that require much more space, the IEH3-4096 increases the length of the motor by just 1.4 mm and can be combined with numerous precious-metal commutated DC micromotors of the FAULHABER SR series measuring 15 to 22 mm in diameter. The new model delivers two square-wave signals as well as an additional index channel. It offers a resolution of up to 4096 pulses and improved speed control, especially in the low speed range. The IEH3-4096 integrated encoder can be used in application areas including, among others: in equipment technology, such as in measurement devices, for valve adjustment, in camera technology, and in precision optics, for example for mirror positioning or lens or filter adjustment.

OPTIMUM CONTROL. FLEXIBLE PROGRAMMING.



Drive electronics MCST 3601 series

Searching the multitude of available programmable motion controllers for a controller that is ideally suited to miniaturised stepper motors with phase currents of sometimes less than 100 mA was once a real challenge. The MCST 3601 series has now emerged from the cooperation between FAULHABER and Trinamic GmbH, the motion controller specialist for stepper motors. This controller is compact and flexible and, above all, is perfectly suited to the whole range of FAULHABER micro stepper motors. The series, which is equipped with a microcontroller and a driver, can precisely regulate phase currents from 10 mA to 1.1 A and, at the same time, can be operated with a supply voltage that can vary between 9 and 36 VDC. Thanks to simple and fast communication with a PC via USB 2.0, all types of movements can be programmed using the available software. Since the controller is designed as a test electronics system, users can adopt the predefined architecture according to their requirements and integrate the components in the platform of their specific industrial application.

PREVIEW

FILIGREE

CRAFTSMANSHIP meets DRIVE TECHNOLOGY

The complex inner workings of outstanding timepieces have always amazed watch enthusiasts. Models with sophisticated additional functions, such as chronograph, perpetual calendar, second time zone or moon phase indicator, are masterpieces of precision engineering and often consist of hundreds of filigree components that have to be manufactured and assembled with the highest precision. How FAULHABER drives contribute to the manufacture of these elaborate timekeeping instruments is explained in the next edition of FAULHABER motion - the magazine with drive.

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