

motion

01.2020

THE MAGAZINE WITH DRIVE

WITHOUT

MICROMOTORS

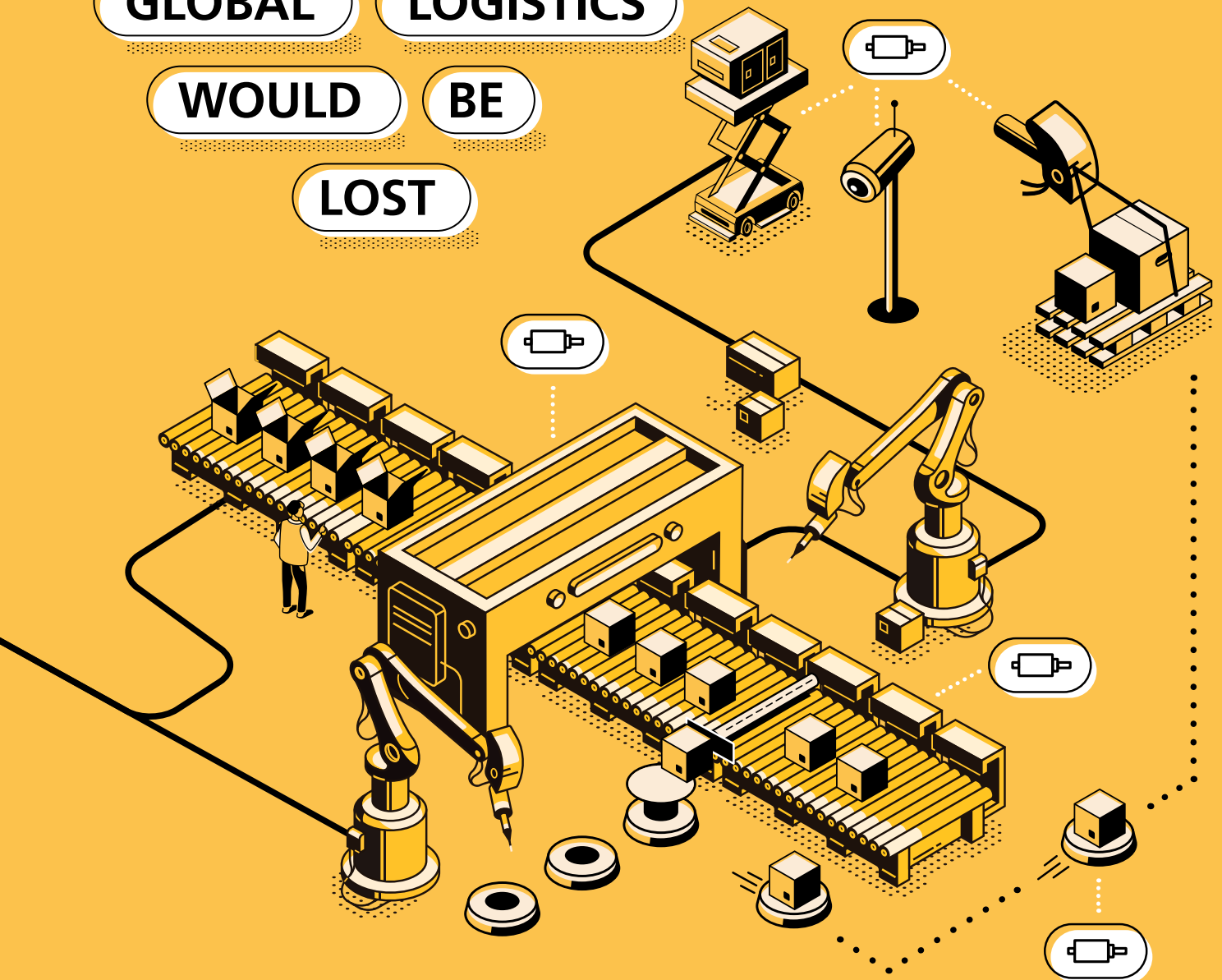
GLOBAL

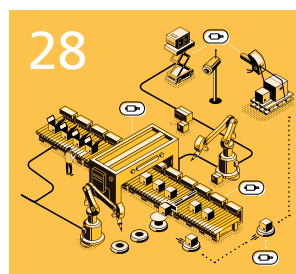
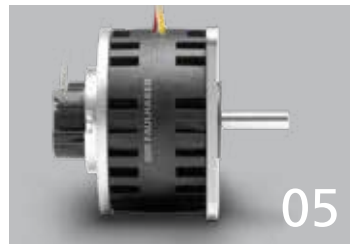
LOGISTICS

WOULD

BE

LOST





- 05** **NEWS**
High resolution meets overwhelming acceleration
 The new IE3 encoder series for disc magnet stepper motors

- 06** **ENVIRONMENTAL POLICY**
Active contribution to safeguarding the future
 The FAULHABER location in Schönaich produces on a totally climate-neutral basis

- 08** **WE CREATE MOTION**
Drive Systems, evolved
 A FAULHABER drive system is more than just the sum of its components

- 12** **OPTICS & PHOTONICS**
Reliable eye in the electromagnetic storm
 DC-MICROMOTORS from FAULHABER ensure precise camera movements in the EMC lab

- 16** **CYBATHLON**
Racing to overcome limits
 FAULHABER drive technology motorises the wheelchair of the HSR team for the Cybathlon competition

- 24** **HUMAN AUGMENTATION**
Ironhand
 Robotic glove strengthens the human grip

- 28** **FACTORY AUTOMATION & ROBOTICS**
Always more, always faster, always further
 Without micromotors, global logistics would be lost



Dear Readers,

The coronavirus pandemic has severe consequences for daily life around the world and also presents us in the FAULHABER Group with very serious challenges. We have implemented the maximum preventative health protection measures at all locations of the FAULHABER Group and are working intensively under these conditions to fulfil our customer orders. We are especially committed to meeting the needs for the additional high demand for drive systems in medical and laboratory technology for ventilators, infrared cameras for temperature measurement, and automated sampling, analysis and laboratory systems and thereby making our contribution to medical care and in finding a solution to the Covid-19 situation.

We will, of course, continue to provide you with information on current interesting application topics during this time in our customer magazine FAULHABER motion.

One focal point is the innovative area of human augmentation, or support through technical solutions – both at work and in daily life. How people with disabilities perform daily tasks using assistive technology can be experienced at the Cybathlon. Following its premiere in 2016, ETH Zurich is once again organising this spectacular competition. More than 90 teams from around the world will compete against one another in six disciplines. Due to the corona crisis, the event originally planned for March has been postponed until 19-20 September. The winning team of the wheelchair obstacle course in 2016, Enhanced from the HSR University of Applied Sciences Rapperswil (HSR), will once again be participating with support from FAULHABER Drive Systems. We'll keep our fingers crossed as they work to defend their title!

With Ironhand, Bioservo from Sweden offers an innovative approach for more ergonomically performing manual tasks through the use of technical support. Via a system consisting of a lightweight backpack and flexible glove, FAULHABER provides assistance to the gripping force, which can be finely calibrated to the given task.

Learn more about these and other exciting topics in this issue of FAULHABER motion – our magazine with drive.

I hope you enjoy reading this issue.
Stay healthy!

Sincerely

Gert Frech-Walter
FAULHABER GROUP Management

SPECIAL PUBLICATION COVID-19
www.faulhaber.com/covid19/en



Issue 01.2020

Publisher / Editor:

DR. FRITZ FAULHABER
GMBH & CO. KG
Schönaich · Germany
Phone: +49 (0)70 31/638-0
Fax: +49 (0)70 31/638-100
E-Mail: info@faulhaber.de
www.faulhaber.com

Layout:

Werbeagentur Regelmann
Pforzheim · Germany
www.regelmann.de

Picture credits & copyright:

All rights reserved. The rights for the graphics and pictures used as well as brand names mentioned are held by the respective owner. The copyright for the articles is held by the editor. Reproduction or electronic processing of content, even sections thereof, is only permitted with the explicit written consent of the editor.

Publication frequency & subscription:

FAULHABER motion is published twice a year and is delivered to customers, interested parties and employees of FAULHABER free of charge.

FAULHABER motion is also available as an app.



www.faulhaber.com/motion

FAULHABER TOOK OVER SALES AND SERVICE IN THAILAND



FAULHABER Asia Pacific Pte Ltd
© FAULHABER



FAULHABER took over sales and service in Thailand from its long-standing sales partner Autoflexible at the start of the year. Going forward, FAULHABER Singapore Pte Ltd will operate under the name FAULHABER Asia Pacific Pte Ltd, thereby emphasising the importance of the region.

Effective as of 1 January 2020, FAULHABER Singapore Pte. Ltd changed its name to FAULHABER Asia Pacific Ltd. At this time, FAULHABER also took over sales in Thailand from its long-standing sales partner Autoflexible. Thereby, customers will be able to profit even more than before from the know-how and services offered by FAULHABER. "Thailand is an important market in which we would like to expand our presence," explains Vester Tan, Regional Sales Manager.

FAULHABER Asia Pacific will function as the service centre for the Asia-Pacific region and thus optimally support customers in Australia, India, Taiwan and South-East Asia. Customers can thereby easily draw upon FAULHABER's extensive know-how and service. "With the new service centre, we can offer our customers in the Asia-Pacific region great advantages, such as in providing support when selecting the optimum drive system for the desired application or by together developing a customer-specific drive solution."



faulhaber.com/news

HIGH RESOLUTION MEETS OVERWHELMING ACCELERATION

The extremely high dynamic of large Disc Magnet stepper motors is often also relying on closed loop control to maximize performances while limiting power dissipated in the motor. The IE3 encoder is a high quality magnetic encoder which can be combined with a large variety of FAULHABER products from Ø22mm. This encoder is now also available on DM40110R, DM52100N and DM52100R Series.

With an extended length of about 13mm this new combination will offer high positioning resolution up to 1024 lines per revolution together with extremely fast acceleration capabilities in a short and light package! The encoder is connected with a ribbon cable; suitable connectors are available. Typical applications are found in textile, semiconductor and medical industries.

The advantages at a glance:

- Ideal for boost mode operation combined with high resolution positioning
- Programmable with resolution from 32 to 1024 lines per revolution
- Compact and light, mounted in a robust package



faulhaber.com/news

NEW CATALOGUE DRIVE SYSTEMS EVOLVED

A FAULHABER drive system is more than just the sum of its components. On its own, each product already satisfies the highest requirements for quality and performance. When application engineers combine these products with one another, the overall performance of the system increases. This is the result of perfectly optimised parameters and interfaces for the compact, integrated and high-performance drive solutions from FAULHABER.



On more than 650 pages, FAULHABER presents the most comprehensive portfolio of highly developed miniature and micro drive technology that is available from a single source worldwide in the new 2020 - 2021 catalogue.



[faulhaber.com/en/support/documentation/
faulhaber-catalogue-shortform/](https://faulhaber.com/en/support/documentation/faulhaber-catalogue-shortform/)

ACTIVE CONTRIBUTION TO SAFEGUARDING THE FUTURE

Environmental protection is among FAULHABER's key values. With the core competency of the company – the development of high-efficiency drive systems with low energy requirements – the technology from FAULHABER is already making a contribution to responsible and sustainable handling of natural resources. The location in Schönaich recently became one of the first production companies to produce on a totally climate-neutral basis.

Since 2019, all business trips by car are climate-neutral.



Fuel consumption
Company fleet

In partnership with Atmosfair, FAULHABER supplies the local population with highly efficient cookstoves, helping to effectively reduce the demand for illegal firewood collection in Rwanda and thereby compensate for CO₂ emissions on business trips.

Climate-neutral power production

Over the course of many years, Dr. Fritz Faulhaber GmbH & Co. KG invested in climate-neutral power production at the Schönaich location. In addition to expanding the photovoltaic system, a cogeneration unit was among these investments. The cogeneration unit produces power and heat with the help of natural gas and, thus, operates much more efficiently than conventional heating systems are capable of. Additional power is only purchased from renewable sources (also known as green electricity). To also compensate for the portion of CO₂ produced through the combustion of natural gas, climate-neutral compensation was included in the gas price agreed upon with the utility company.

Carbon offsetting of business trips as well

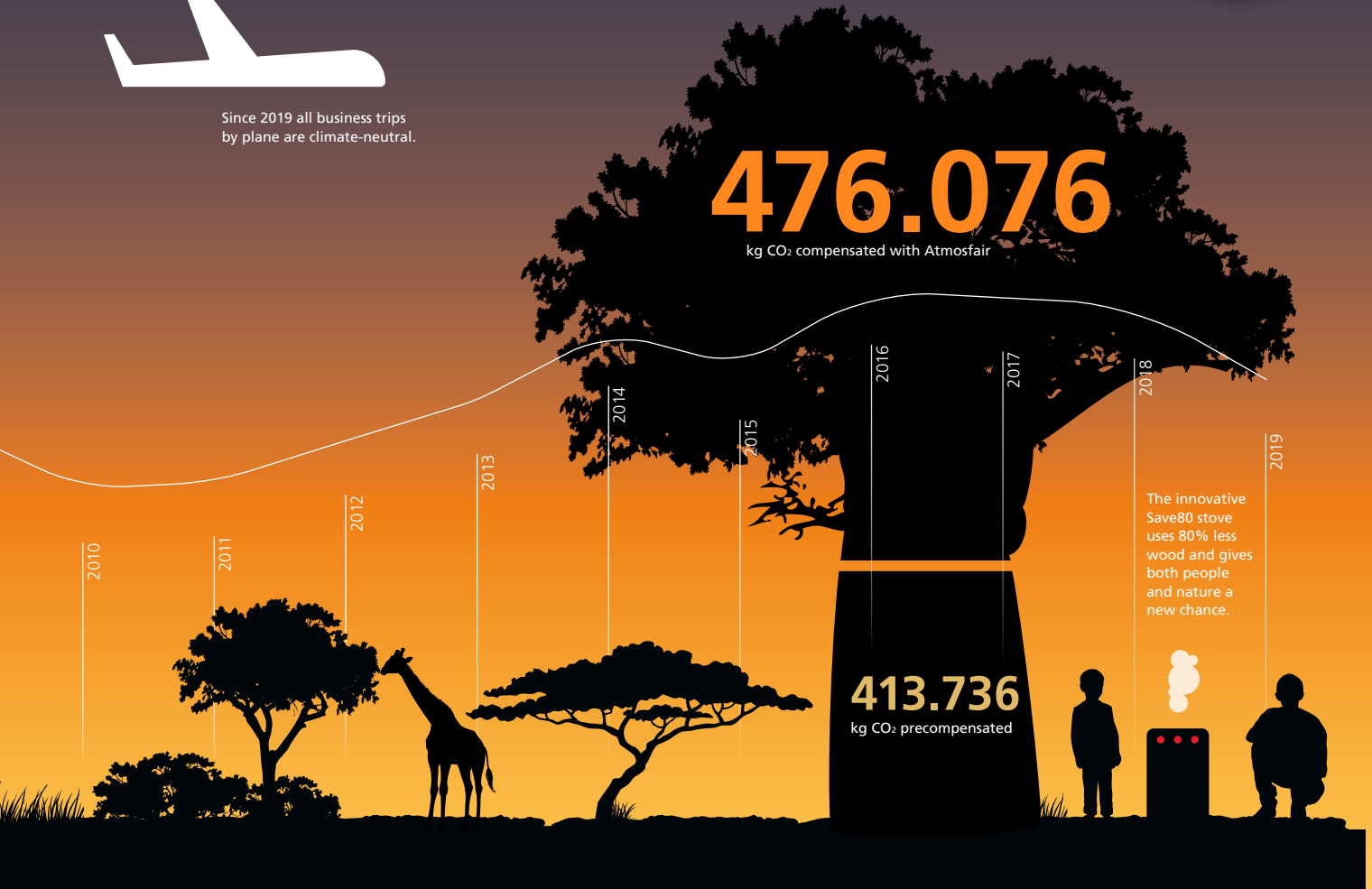
"This was a big step towards making us a climate-neutral company," explains Jörg Rittker, who is responsible for quality & environmental management at FAULHABER. "However, in the context of the ongoing discussion on the protection of the climate and environment, we considered what additional contribution we could make to become completely climate neutral." After all, CO₂ emissions occur not only in production or in administration but also during business trips by car or by plane. "We therefore decided to offset this remaining amount of CO₂ as well," says Rittker.



Since 2019 all business trips by plane are climate-neutral.

476.076

kg CO₂ compensated with Atmosfair



Atmosfair project in Rwanda



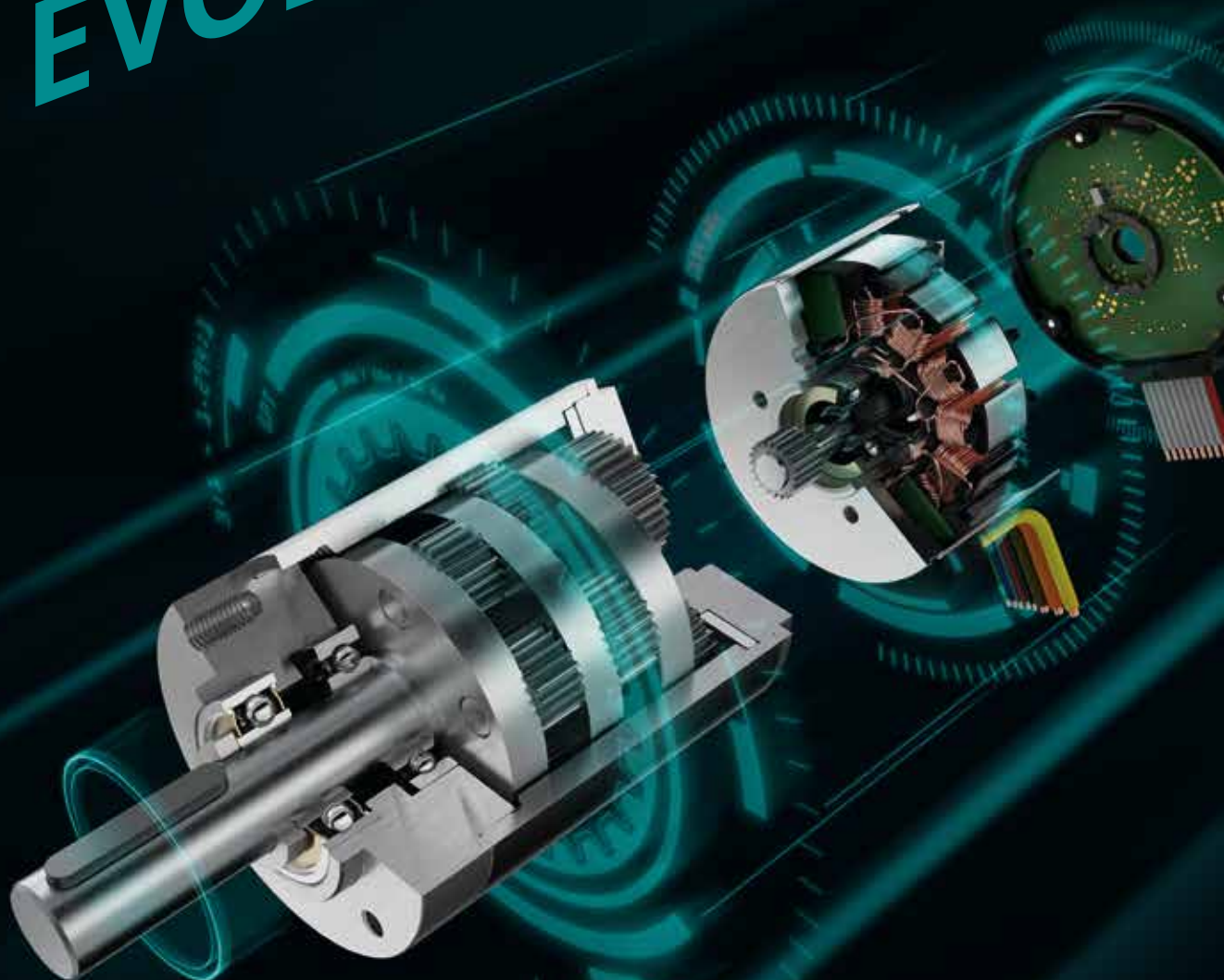
With the non-profit company Atmosfair, a partner was found that is able to carry out the compensation in a targeted and serious manner. FAULHABER supports the Atmosfair project "Efficient cookstoves 'Save80' in Rwanda". Rwanda is among the least developed countries in the world. The high demand for firewood combined with inefficient use is a driving force behind the deforestation of the remaining forests in Rwanda. With the Save80 cookstove, 80% less firewood is required compared to a conventional cookstove. This is good for the climate and avoids deforestation. The savings achieved through the reduced wood demand also allow families to cover other expenses, such as school fees.

FAULHABER is thereby among the first production companies to produce in a carbon-neutral manner. "We are happy to make an active contribution to safeguarding the future and to maintain the wealth of natural ecosystems for future generations," emphasises Rittker.



atmosfair.de/en/climate-protection-projects/energy_efficiency/rwanda/
faulhaber.com/en/about-faulhaber/environmental-policy/

DRIVE SYSTEMS EVOLVED

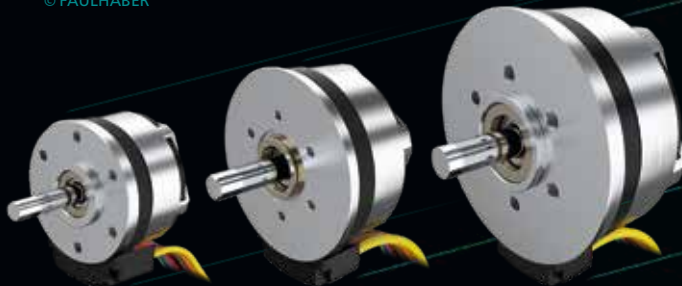


A FAULHABER drive system is more than just the sum of its components. After all, electric motors, gearheads and encoders are not lone fighters, but must rather work together perfectly. It therefore makes sense to purchase the individual components as a complete solution. Thanks to perfectly optimised parameters and interfaces, the overall performance of the system increases when one combines the compact, integrated and high-performance drive solutions from FAULHABER with one another.

The drive specialist FAULHABER has once again demonstrated its competence as a system provider and has extended its BXT flat motor series by adding corresponding gearheads and integrated encoders as well as speed controllers that are also exceptionally short in the axial direction. All components have been optimised to ensure that they function perfectly together. The three sizes can solve many different drive challenges. In the case of a lower-arm

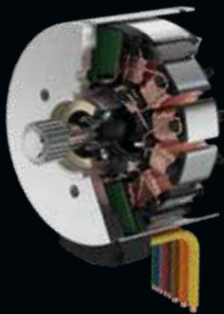
prosthesis, for example, the smallest drive with a diameter of 22 mm would be ideal for the hand and the 32 mm long motor for the elbow. Other possible applications for the small compact drive systems are robot grippers, industrial automation, humanoid robots and even bio-robotics for motorised – i.e. power-assisting – hand exoskeletons. Thanks to their precise speed control properties, they are also suitable for e.g. dialysis machines or medical pumps.

The BXT motors deliver considerably higher torques than those usual in this drive class.
© FAULHABER



Innovative winding technology for more torque

The motors were developed based on the classic external rotor design. Thanks to innovative winding technology and optimised construction, the brushless DC-servomotors produce torques up to 134 mNm within a diameter of 22 mm, 32 mm and 42 mm and deliver a continuous output of up to 100 W with a high level of efficiency. This means the compact motors significantly exceed the standards usual in this drive class. Particularly the ratio of torque to installation space and weight is much better than what is common on the market. Thanks to the high copper filling factor and the design of the pole shoes, the magnetic field is strong and the cogging torque very small. The motors, which operate at speeds up to 10,000 min⁻¹, are available with or without a housing, which again extends the range of potential applications.



BXT drive system:
Motor, gearhead, encoder or –
alternatively – speed controller
as super-compact, perfectly
optimised unit.



Metallic planetary gearheads with numerous reduction ratios

The GPT metal planetary gearhead family, which also impresses with compact dimensions and high torque, is suitable for speed reduction of the flat motors. The pure metal gearheads achieve performance values that are comparable to those of significantly more expensive technologies available, such as those that use ceramic components. The gearheads are available with motor-compliant diameters and offer reduction ratios from 3:1 to 1,294:1 with extremely fine graduations in up to four stages. Each stage was optimised for high performance with respect to torque and speed. Depending on the diameter, the gearheads achieve continuous torques of 1, 8 and 18 Nm. Higher torques are also possible for a short period.

Furthermore, the gearheads are extremely robust and tolerate continuous loads as well as rapid load changes. They have been developed for limited axial installation space and are significantly shorter than other models with the same diameter. The single-stage 22 mm version, for example, is only approx. 18 mm long and the four-stage version approx. 37 mm. With the 42 mm gearhead, the lengths are just under 31 mm and approx. 68 mm respectively.



Housed encoder with high positioning accuracy

All BXT motors are equipped with digital Hall sensors and, thanks to their large number of poles, their speed can be controlled very precisely. The IEF3-4096 magnetic encoder is available for precise positioning tasks. The encoder is fully integrated in the housed motor variant, thereby increasing the length of the overall drive by just 6.2 mm. Despite of the flat design, it offers three channels with index function, a Line Driver and a high resolution of up to 4,096 lines per revolution. The combination of motor and encoder is an ideal system solution in cases where extremely precise positioning must be performed in constrained spaces and, at the same time, high torques are required, e.g. in robotics, medical technology, laboratory automation or industrial automation.

Integrated speed controllers complete the product range

New in the portfolio are speed controllers for the BXT motors. The speed controllers are integrated in the housed versions of the BXT motors and increase the length of these motors by just 6.2 mm. The well thought-out design concept enables both the encoder and the speed controller to be installed in the same housing and also permits a large number of common parts to be used. Speed control is performed by the digital Hall sensors integrated in the motors. Thus, a wide speed range from 200 min^{-1} to $10,000 \text{ min}^{-1}$ is available. The compact combination of motor and speed controller is ideal for space-critical applications and simplifies installation and commissioning.



Compact design, wide range of applications

In cases where installation space is extremely tight and where high-torque drives are required which need to be as short as possible in the axial direction, there is a system solution with the FAULHABER BXT series that is especially suitable for applications in robotics, prosthetic joints, laboratory automation, pumps, medical technology or aircraft cabin equipment.



Medical pumps



Laboratory automation



Robotics (© Schunk)

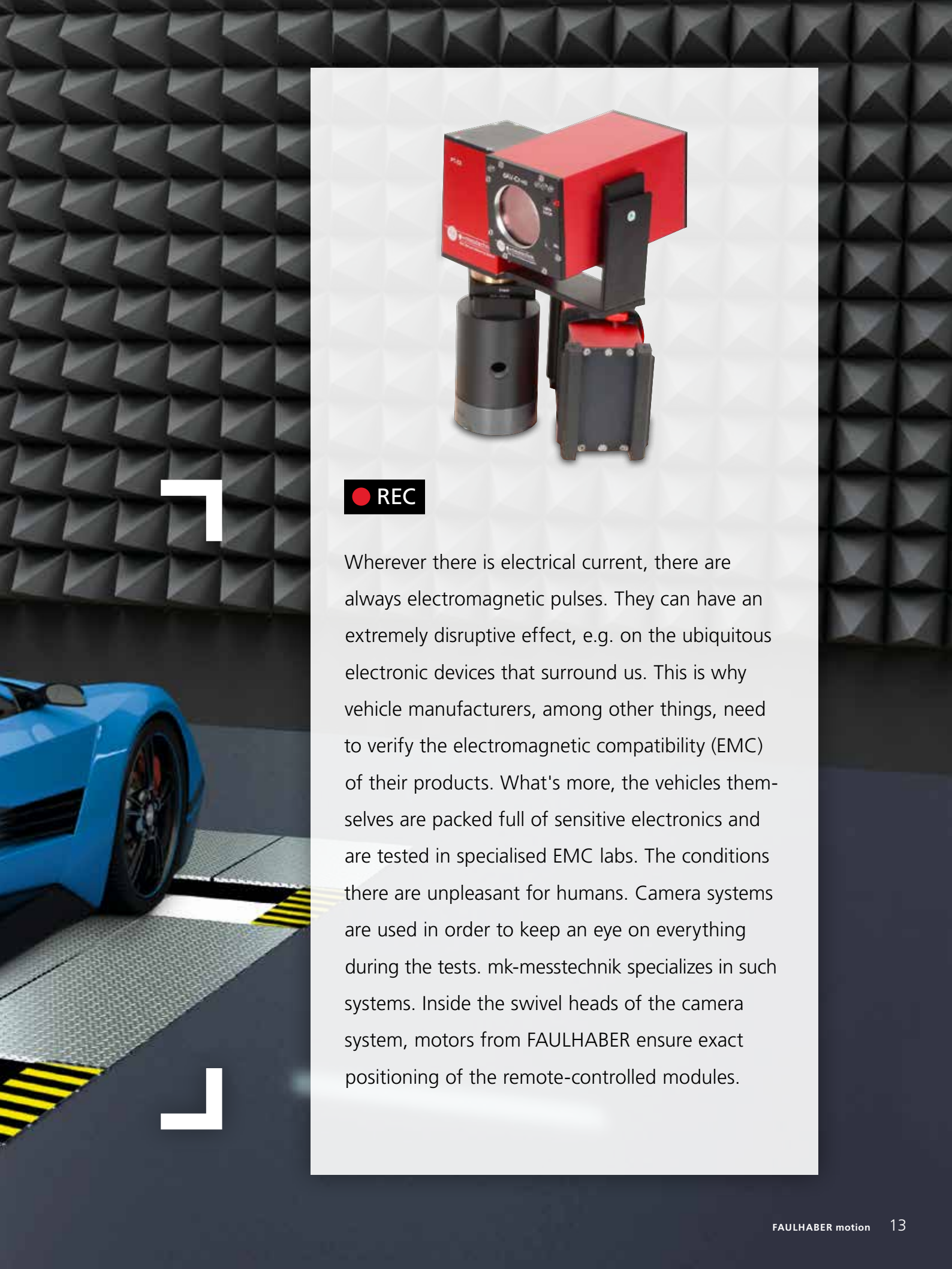


faulhaber.com/evolved/en

RELIABLE EYE IN THE ELECTROMAGNETIC STORM

┐

└



● REC

Wherever there is electrical current, there are always electromagnetic pulses. They can have an extremely disruptive effect, e.g. on the ubiquitous electronic devices that surround us. This is why vehicle manufacturers, among other things, need to verify the electromagnetic compatibility (EMC) of their products. What's more, the vehicles themselves are packed full of sensitive electronics and are tested in specialised EMC labs. The conditions there are unpleasant for humans. Camera systems are used in order to keep an eye on everything during the tests. mk-messtechnik specializes in such systems. Inside the swivel heads of the camera system, motors from FAULHABER ensure exact positioning of the remote-controlled modules.

"It all started when a car radio was no longer the only device installed in the vehicle," recalls Dr. Martin Kull, founder and managing director of mk-messtechnik. "The number of electronic devices steadily increased over time – from ABS and airbags to mobile telephony and navigation." The individual systems must not disturb each other, nor must they impair other systems outside of the vehicle. In addition, they must be as insensitive as possible to pulses from outside. The electrical engineer began carrying out measurements at Daimler's test lab back when he was a student at the University of Stuttgart.

Some of the electromagnetic waves generated in such labs are extremely strong and well over the applicable limit values. For this reason, the lab chambers are hermetically sealed during the tests. What goes on inside can only be observed using cameras. "This is when the first enquiries came with regard to building monitoring devices intended for this purpose. However, demand was for fewer than 100 cameras per year, which meant that larger companies withdrew from this niche market."

Dr. Kull saw an opportunity and in 2006, together with his wife, founded his own company. The couple initially made everything single-handedly, for example in 2008, when a vehicle manufacturer in the USA ordered a system with 20 cameras. "We soldered and assembled every component ourselves and were very proud to be supplying a global corporation," recalls the founder. Demand grew and with it the company. The year 2010 saw the recruitment of the first additional employee; today there are more than 60 because the camera systems made by mk-messtechnik from Notzingen near Stuttgart are used by almost all vehicle manufacturers for EMC testing.

Seatbox or wall mounting

The cameras can be permanently mounted to a wall or secured on various tripods. mk-messtechnik also offers a so-called seatbox that is placed on the driver's seat and can accommodate up to six cameras. It allows the entire dashboard, all displays and control elements of the vehicle inside the chamber to be monitored. The trend towards electromobility is a positive development for mk-messtechnik because electromagnetic compatibility in the case of electric vehicles plays an even more important role than it does for vehicles with combustion engines. Furthermore, the electronics used in trains, aircraft and ships must also undergo EMC tests.

Dr. Kull comes from a family with Swabian inventor tradition. "My hobby is model-building, so for as long as I can remember, I've been fascinated by anything that moves on land, sea or in the air. Although my specialize area is electrical engineering, I've always also been extremely interested in the mechanical aspects." mk-messtechnik profits from this double talent with respect to product development too: "From 2008, we increasingly began to receive requests for wall-mounted cameras with remote control. This is when the basis for the optimum solution with respect to size, weight and control emerged."

Dr. Kull strives for maximum functionality with the minimum of hardware and software as well as outlay for development. For example, he relies on commonly available standard parts like the anodized aluminium tubes that mk-messtechnik uses as housings. What seems simple is in fact a custom-made solution resulting from a finely balanced interaction between various components: "When designing the PCB, for example, it is also important to bear the housing in mind so as to avoid the need for adjustments at a later stage."



Programs, remote control and infrared

The company in Notzingen does not shy away from complex assembly work and attaches the necessary components to the PCBs itself. "We sometimes assemble more than a hundred different PCBs per week," explains Dr. Kull. "This makes lead and retooling time a crucial factor. With the commonly available software, it was impossible to achieve an acceptable speed. We therefore wrote our own data processing program for the automatic placement machines. As a result, we were able to reduce the lead time for each PCB from several minutes to around five seconds."

To simplify the processes during the EMC test, swivel-mounted cameras with remote control were added to the product range. They were originally intended for wall mounting only. However, demand for the adjustable variant soon also grew for the mobile systems. "We therefore had to deal with the issue of mechanical stability from a completely different perspective. Our systems are extremely robust, but if a stand with an 800 gram camera adapter falls over or this adapter is rotated too roughly, the material can suffer. We have solved this problem with a kind of friction coupling."

Cameras from mk-messtechnik monitor not only the vehicle electronics, but also thermal characteristics. The opto-LWIR infrared camera has been developed for this purpose. The electromagnetic fields that are generated during the tests pose a certain fire hazard. Extremely strong fields can cause the test objects or parts of the system to overheat. A further heat source arises when electric vehicles are tested, as Dr. Kull explains: "On the test rig, electric vehicles recharge their batteries by means of recuperation. If the batteries are fully charged, the vehicle brakes are activated. The brakes can overheat and, at worst, can even start to burn. Installing a test rig runs into the double-digit million range. The prototypes that are tested have an inestimable value. Monitoring using infrared cameras allows these investments to be protected through timely intervention." For its development of the camera, mk-messtechnik was nominated for the Esslingen district Innovation Award 2019.

Micromotors for precise alignment

To ensure precise positioning of the cameras, mk-messtechnik uses drives from FAULHABER. "We have experimented with servomotors and motors used in model-building, but they were not precise or robust enough. At FAULHABER we found the right motors."

In the swivel/tilt head that positions the camera, two DC-micromotors of the 1516 ... SR series with precious metal commutation are used in combination with a spur gearhead of the 15/8 series and the 900:1 transmission. "At first we tried a 500:1 transmission, but that was too fast; although the swivel head turns more slowly with the 900:1 transmission, it can move greater weights and also has optimum electrical shielding." The high level of efficiency was another reason for choosing the drive because the power required for swivelling is supplied by the batteries of the cameras. With the exception of the actual camera module and the drives, which were outsourced, mk-messtechnik develops and manufactures the entire system themselves for the benefit of their customers, as Dr. Kull stresses: "When tasks become complex or individual modifications are necessary, developing and manufacturing products ourselves allows us to react extremely flexibly. For us, there is no such thing as impossible – at least not within the boundaries of physics."



DC-MICROMOTORS COMBINED WITH A SPUR GEARHEAD

1516 SR ... 15/8 SERIES

STOP



faulhaber.com/en/markets/optics-photonics/mkmc.com



PARTICIPANT

LIMITS **RACING** TO OVERCOME

The motors don't roar and the pace is somewhat slower. Apart from that, there are many similarities between Formula 1 and the Cybathlon competition of ETH Zurich:

The driver controls a high-tech vehicle that is subject to continuous further optimisation by a team of top-class specialists. The sporting competition is also intended to promote further development of the technology – to the benefit of people with physical disabilities.

FAULHABER is on board – with high-performance motors in the wheelchair and as a sponsor of the HSR team.



THE LONG PATH TO

War, accident, illness or old age – disabilities can affect anyone. Since time immemorial, people have been searching for technical solutions to help make life easier for those affected. The pioneers were the Chinese, who are said to have used a sort of chair with wheels already in 1300 BC. In the Middle Ages, attempts were made that ranged from simple, pushcart-like vehicles to imaginative – though cumbersome – drive solutions with tackles around the year 1420.

DRIVER'S SEAT

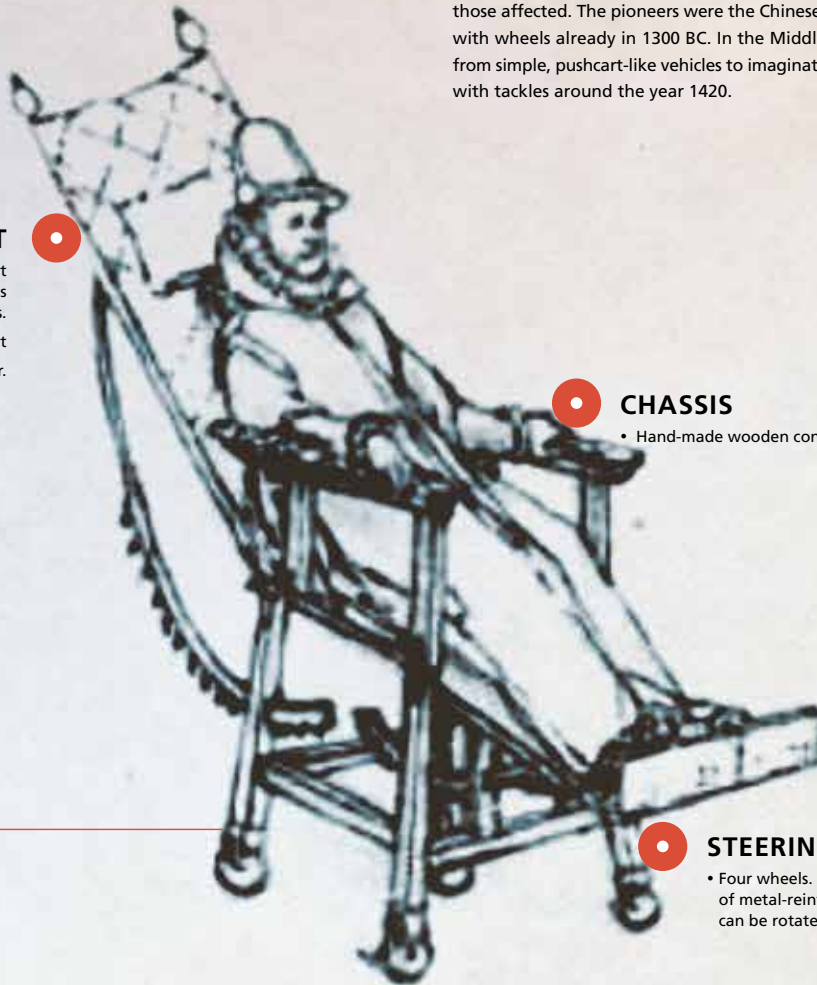
- Backrest and foot support with adjustable slope by means of two locking mechanisms.
- Padded seat
- Back section with fabric cover.

CHASSIS

- Hand-made wooden construction.

STEERING

- Four wheels. Front wheels made of metal-reinforced hardwood that can be rotated by 360 degrees.



1595

King Philip of Spain ruled his kingdom from a wheelchair

1655

Stefan Farfler invents the self-propelled wheelchair

1783

With the "Bath wheelchair", Briton John Dawson invents a wheelchair with large wheels in the rear and small wheels in the front.



HIGH-TECH SPORTS EQUIPMENT

One of the oldest pictorial documents is from 1595. It shows King Philip of Spain in a vehicle similar to a wheelchair which, in spite of his serious gout condition, allowed him to carry out his governmental affairs. The first self-propelled construction was developed in 1655 by Nuremberg watchmaker Stefan Farfler, who himself suffered from polio. The timeline below shows other milestones on the way to the motorised racing wheelchair.

DRIVER'S SEAT

- Longitudinal adjustment
- Displacement of centre of gravity
 - Traction control
- Variable chassis dimensions

7-AXIS ROBOT ARM

- Pre-programmed movements
- Passive gripper
- Suction cup

COCKPIT

- 2-joystick control
- Smartphone app for selecting the operating mode
- Arm and torso stabilisers

STEERING

- Single-wheel steering

CLIMBING MODULE

- Caterpillar drive
- Lowering mechanism



FAULHABER CR
DC-MICROMOTORS
WITH GRAPHITE COMMUTATION



FAULHABER BXT
BRUSHLESS FLAT DC-MICROMOTORS
WITH EXTERNAL ROTOR TECHNOLOGY



1932

American engineer Harry Jennings develops the first folding wheelchair made of steel tubing



1956

The electric wheelchair, developed by Canadian inventor George Klein, goes into series production



2010

Modern, hand-driven racing wheelchair with lightweight construction

THE CYBATHLON RACE TRACK: A TRUE HERCULEAN TASK

Like the Olympic Games, the Cybathlon competition is held every four years. The athletes participate in six different disciplines. Races are also held in between competitions, usually within the scope of trade fairs.

In the "Wheelchair Race" category, pilots with a severe walking disability complete a defined obstacle course in a motorised wheelchair. The individual stations involve considerable technical challenges. Having already won two first place trophies, this is the main discipline for the **HSR Enhanced** team of the University of Applied Sciences Rapperswil. Many teams opt for caterpillars for stair climbing. HSR Enhanced, however, uses a hybrid drive concept consisting of caterpillars for the stairs and individually steered wheels for all other obstacles, which make the wheelchair extremely manoeuvrable.

To overcome the stairs, the wheelchair has a lowerable supplementary module called 'Herkules' installed under the chassis. This module converts the wheelchair from a wheeled vehicle to a caterpillar vehicle. To ensure that the driver sits securely when the wheelchair is in an inclined position, the seat and therefore also the centre of gravity is shifted. This shift also affects traction and handling. It is also a useful feature for the wheelchair user in everyday situations: When the seat is at the

forward position, the user's feet are lowered so that he can comfortably approach a table. In the rear position – the standard position for moving over level terrain – the legs of the driver are raised and stretched out, which makes the combination of driver and wheelchair shorter and more compact. Motors from FAULHABER are used in the stair module, for seat adjustment and for steering the individual wheels. 'Herkules' is lowered using two powerful, brushed motors that lift the total weight of around 180 kg from the wheels onto the caterpillars. The same

motor type, here with gearhead and lead screw, is also used to move the seat. The wheels are steered by four BXT brushless motors with passive gearhead. Thanks to their innovative winding technology and optimised design, they are able to achieve an extremely high torque. Their performance and efficiency significantly exceed other motors of similar size. With a speed of up to 10,000 rpm, they can perform the steering movement practically instantaneously. Their digital Hall sensors, integrated as standard, can be used for extremely precise speed control.



1. TABLE

Challenge:
Size and seat height of the wheelchair
Max. points: 101

2. SLALOM

Challenge:
Size of the wheelchair; precise control
Max. points: 102

3. UNEVEN TERRAIN

Challenge:
Grip of the wheels; ground clearance; power
Max. points: 108

Interview with Professor Dr. Christian Bermes from the Department for Laboratory Automation and Mechatronics at the University of Applied Sciences Rapperswil (HSR).

FAULHABER: Do you recall the first time your university took part in the Cybathlon?

Prof. Dr. Bermes: When the first Cybathlon was organized in Zurich in 2016, we learned of it quite late on. Our goal was to be accepted as a participant – to do this we had just ten months to develop a competition-ready wheelchair from scratch. But the task was appealing and the technical challenge was extremely interesting. Our team was highly motivated and we were able to win the "Powered Wheelchair Race" category, thereby fulfilling an extremely ambitious dream.

FAULHABER: At last year's Cybathlon Wheelchair Series in Kawasaki (Japan), your team again won the gold medal. How do you see your chances this year?

Prof. Dr. Bermes: We will probably be among the favourites, but just like in motorsport, the rules and regulations change to reflect technical progress, and the bar is being raised continuously. For example, while only three steps needed to be mastered at the first competition in Zurich, the number had increased to six in Kawasaki. The door on the obstacle course was no longer allowed to be opened by the driver himself, but instead a robot arm had to open the door and then close it again after the pilot had passed through. I expect another exciting competition.

FAULHABER: What challenges does the competition place on the electric drive systems of the HSR enhanced wheelchair?

Prof. Dr. Bermes: The motors must fulfil some pretty extreme demands. We can't use any bulky parts in or on the wheelchair; we therefore always try to keep the dimensions of the modules to a minimum. The same, of course, also applies to the weight – every gramme saved makes the vehicle more manoeuvrable and improves handling. Furthermore, we don't want to waste battery power, which is why we want to use drives that have the highest possible degree of efficiency. The motors from FAULHABER simply provide the best technology.

FAULHABER: Aside from the sporting success, how do you benefit from the Cybathlon competition?

Prof. Dr. Bermes: Our Rapperswil Department for Laboratory Automation and Mechatronics focuses on applied research. The competition is, so to speak, an acid test for our newly developed technologies. Around one hundred teams from all over the world participate. A great deal of professional exchange takes place there – all with the objective of making people more independent through technology that is suitable for everyday use. The complex interaction between pilots and machines can also be transferred to other areas, however, such as automation and robotics in industrial production: here, too, man and machine solve complex tasks together.

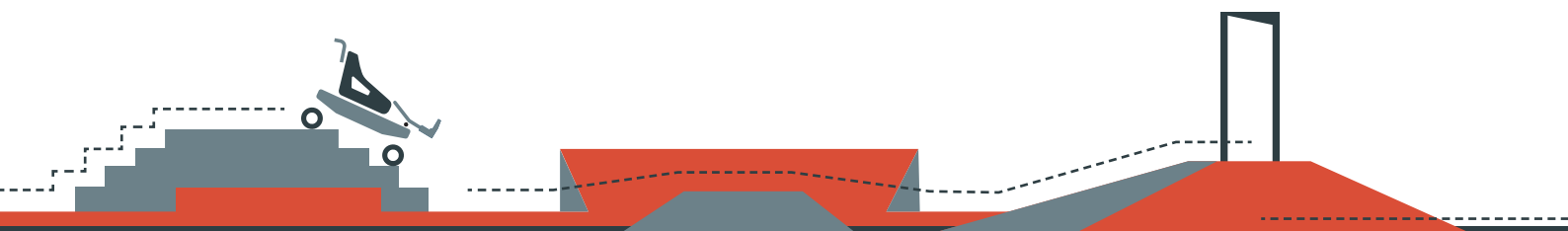


Professor Dr. Christian Bermes



FAULHABER: You describe yourself as being passionate about sport. What role does sporting spirit play with the driver and in the team?

Prof. Dr. Bermes: Our pilot, Florian Hauser who has been paraplegic since a motorbike accident, is an ambitious sportsman who always gives his all. The same spirit can be found in the team made up of bachelor's and master's degree students and engineers. Everyone shares the excitement of the race because once the start signal is given, our intervention is no longer allowed. It's just like in Formula 1: We try to fully exhaust the technical possibilities. If we have done our work well, we provide the ideal conditions for success. During the race, however, it is the pilot alone who is responsible for getting the best performance when out on the track – to stay with the motor racing analogy. In Florian, we have the perfect pilot for the task.



4. STAIRS

Challenge:
Function for overcoming steps, descending stairs
in a controlled way
Max. points: 115

5. SLOPING RAMP

Challenge:
Tracking stability and tipping stability; power
Max. points: 104

6. RAMP & DOOR

Challenge:
Precise control and monitoring of the robot arm;
manoeuvring in tight spaces
Max. points: 130

ANYONE WHO WANTS TO PUSH LIMITS MUST GO TO THE LIMIT

In a challenging technological competition like the Cybathlon, all participants grow with their tasks. This applies for the Swiss developers at the University of Rapperswil just as it does for the German engineers at FAULHABER in Schönaich. There, the valuable synergy effects from the experiences and solutions acquired at the limit of what is technically possible are directly used for the optimisation and development of new products in the application areas of human augmentation and prosthetics. Benefiting from this technology transfer are first of all the application engineers and later people with disabilities around the world. Whether myoelectric hand prostheses, arm and leg prosthetics or even exoskeletons and workbots. The list of application areas for which FAULHABER has suitable drive solutions available standard or develops custom solutions is long. Due to this expertise, Team HSR Enhanced opted for drive systems from FAULHABER.



FAULHABER BXT
BRUSHLESS DC-SERVOMOTORS
4-POLE TECHNOLOGY



FAULHABER BP4
BRUSHLESS DC-SERVOMOTORS
4-POLE TECHNOLOGY



FAULHABER SR
BRUSHLESS FLAT DC-MICROMOTORS
WITH EXTERNAL ROTOR TECHNOLOGY



GOAL: INDEPENDENCE

Challenge:

Precise myoelectric control of a lightweight exoskeleton.
Highest requirements on the drive systems.



MYOELECTRIC HAND PROSTHESES

Challenge for drive system:
Narrow installation space, weight,
dynamics, noise development

ARM PROSTHETICS

Challenge for drive system:
Flat installation space, weight,
dynamics, noise development,
torque.

EXOSKELETONS

Challenge for drive system:
Flat installation space, weight, dynamics,
noise development, torque.

LEG PROSTHETICS

Challenge for drive system:
Flat installation space, weight,
dynamics, noise develop-
ment, torque.

**POWER
ON**





IRONHAND SUPERPOWER UNDER CONTROL

Musculoskeletal disorders are a common occupational disease in the EU and North America and are one of the most common causes for long-term absence from work. Work-related upper-limb disorders annually cost 2.1 billion euros across the EU and are responsible for 45% of all occupational diseases. Wearables, clothing enhanced through technology, offer an approach for reducing these injuries. Ironhand® from the Swedish company BIOSERVO TECHNOLOGIES is a soft robotic glove that strengthens the human grip with help of the company's patented SEM™ technology. The gripping force support of the individual fingers is made possible with FAULHABER drives.

At the EU level, repetitive work is the greatest risk factor. 74% of employees in the EU spend at least 25% of their working time performing repetitive arm or hand movements. According to the German Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin), musculoskeletal disorders are the most common cause for limited capabilities on the job, severe disabilities, early retirement and temporary incapacity to work. According to a survey performed by the European Agency for Health and Safety at Work, 45% of those surveyed suffer from painful or fatiguing positions at work, 25% from back pain and 20% from muscle pain. Studies show that, every second worker could be affected by musculoskeletal-related disorders by 2030.

80 N

More Power in the Hand

Ironhand® from the Swedish company BIOSERVO TECHNOLOGIES is a soft, active exoskeleton for the hands and fingers. Normally, a gripping action is made possible by the muscles in the lower arm and hand. These muscles pull on tendons, thereby moving the fingers. Ironhand® functions in a similar way: pressure-sensitive sensors in the fingertips of the glove detect the gripping action that the user performs with his or her hand. A computer integrated in the system calculates the additional gripping force that is necessary and small servomotors pull thin cables in the fingers. The higher the pressure on the sensors, the more power delivered by Ironhand®. The settings of the glove can be adapted according to personal preferences as well as the type of work being performed. Data functions enable a digital risk assessment of the hand and the integration of the user in an Industry 4.0 / factory-of-the-future concept. Grip-intensive applications with high ergonomic risk can be identified by analyzing the data during practical work and users can take appropriate countermeasures.

Work-related disorders of the neck and upper extremities affect the throat, shoulders, arms, hands, wrists and fingers and cause tingling, numbness, discomfort or pain. The use of vibrating tools or coldness can worsen these problems. The effects are reduced mobility or grip strength. Both can cause additional dangers during work, for example if an employee can no longer safely hold or operate a tool.

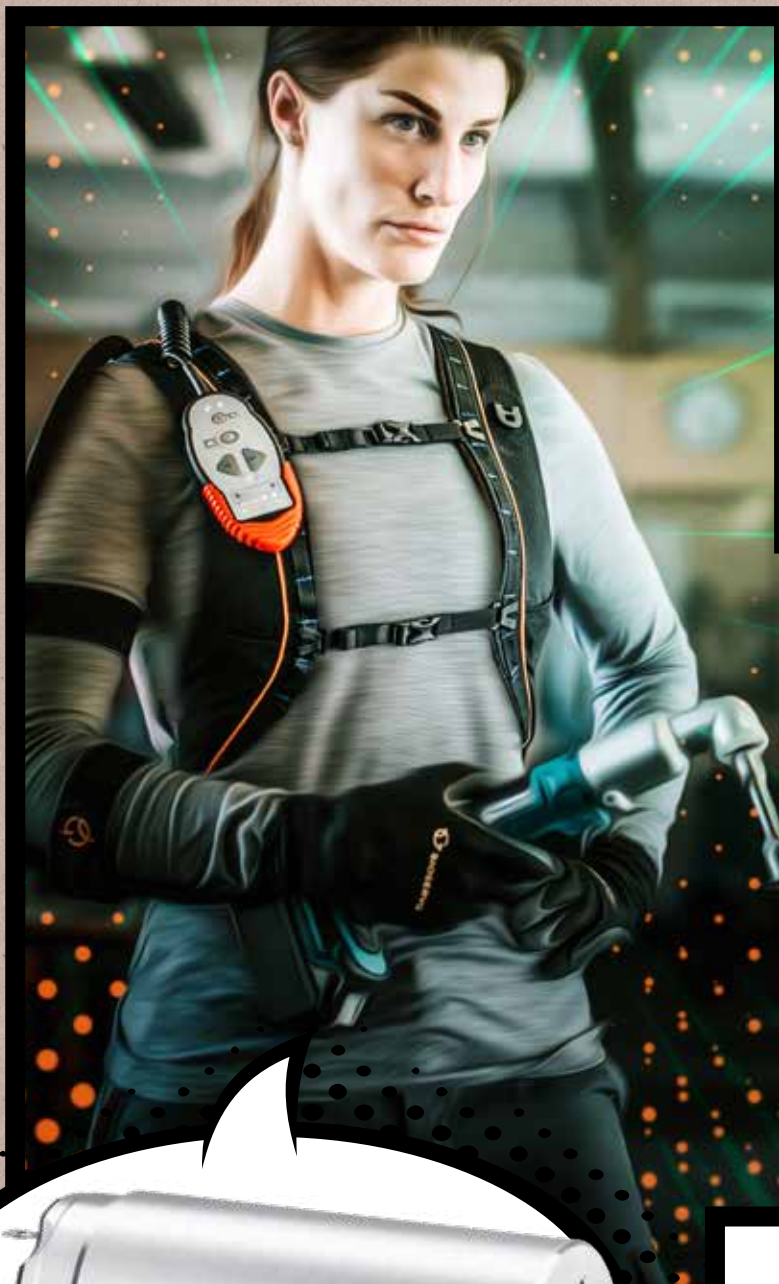
Furthermore, demographic change means that society is becoming older as a whole and will remain in active working life longer. Improved ergonomics at the workplace are therefore increasingly important – both for healthy people as well as for those who are already physically disabled. In addition to solutions that make the actual workplace, e.g., the workbench, the desk or the assembly line, more ergonomic, companies increasingly rely on solutions that can be used to augment people. Exoskeletons which are worn on the body like clothing, are one solution.

Individual and Versatile

The glove is available in four different sizes and can be worn by left- and right-handed users. The battery pack, which is worn like a backpack, contains both a computer unit as well as the motors that control the individual fingers. Users can preset various profiles that contain different combinations of sensor sensitivity, force, finger symmetry and locking tendency. To change the profile, the user only needs to press a button on the remote control, which is located in the chest area.

By means of this profile, it is possible, for example, to flexibly respond to different requirements encountered during the course of the workday. Such as if a person performs slightly stressful tasks during the morning followed by activities in the afternoon that place heavy strain on the muscles. This also allows both male and female users to work with one system. Within milliseconds, the system can provide up to 80 N of gripping force.

The system is designed so as not to impede the wearing of personal protective equipment (PPE), such as gloves, fall-protection devices, helmets or warning clothing. For breaks, it can be put on and taken off without external help. The capacity of the batteries in the power supply is designed for a typical working day.



Powerful Drive

To control the individual fingers, BIOSERVO uses DC-micromotors with graphite commutation of the 1741 ... CXR series in their Ironhand®. The series combines power, robustness and control in a compact form. This is ensured by graphite commutation, high-quality neodymium magnets and the tried-and-tested winding of the FAULHABER rotor. The powerful neodymium magnet gives the motors a high power density with a continuous torque ranging from 3.6 to 40 mNm. The impressive performance data and the compact size open up a wide spectrum of possible applications at an optimised price/performance ratio.



DC-MICROMOTORS
1741 ... CXR SERIES

Martin Remning Wahlstedt, Development Director at BIOSERVO, is satisfied with FAULHABER: "We decided on the 1741 ... CXR for the Ironhand® because we have had very good experiences with FAULHABER drives in our products and have a long-standing cooperation with the drive specialist and its Swedish sales partner Compotech."



faulhaber.com/en/markets/industrial-tools-equipment/bioservo.com

WITHOUT

MICROMOTORS

GLOBAL

LOGISTICS

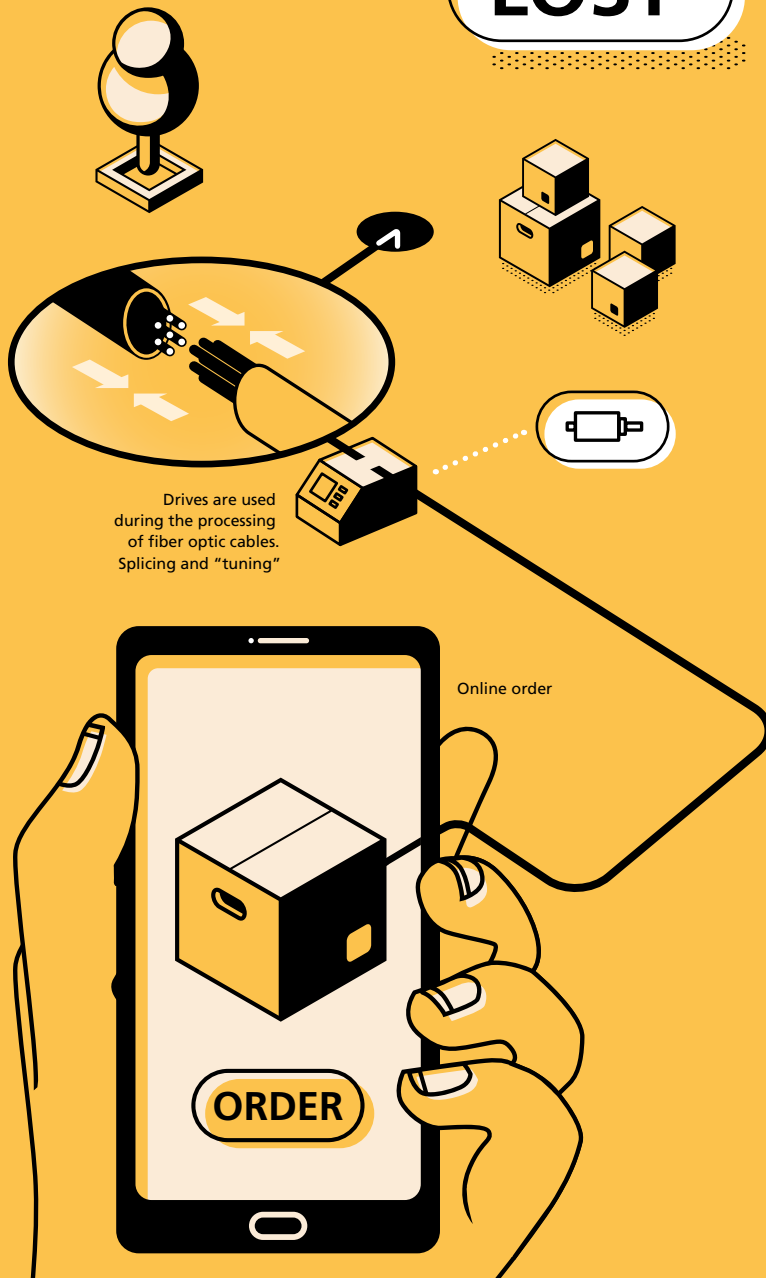
WOULD

BE

LOST



Camera systems for monitoring / documentation (zoom/focus)



Drives are used during the processing of fiber optic cables. Splicing and "tuning"

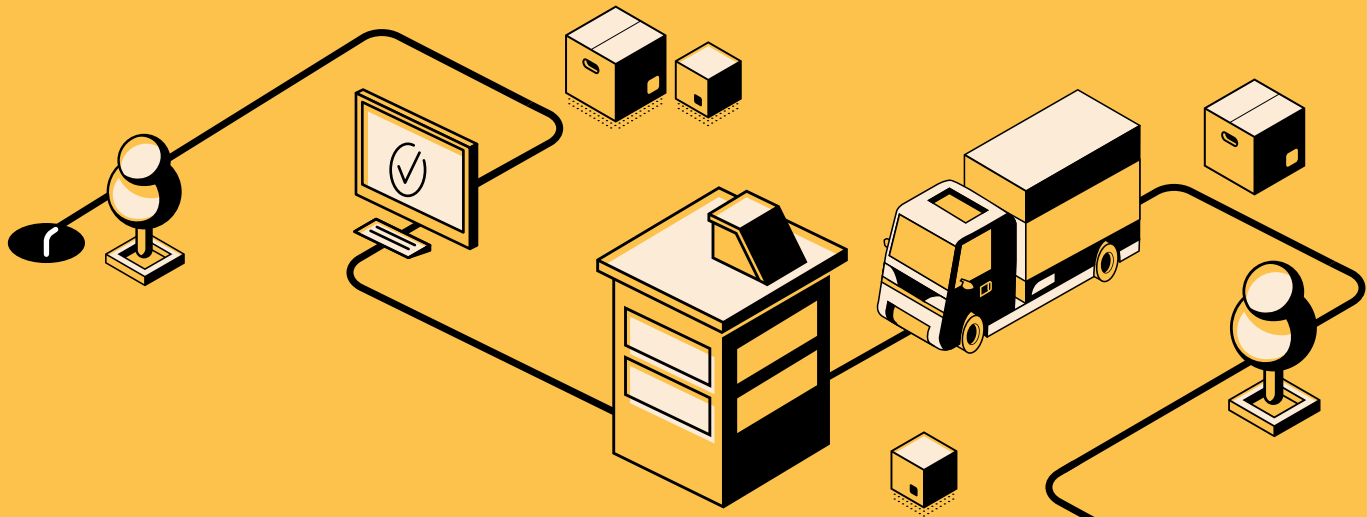
Online order

Always more, always faster, always further – everything needs to arrive at the right time at the right place – the global goods cycle keeps the economy running and is a challenge for everyone involved.

This only functions through the use of extensive automation within the logistics chain, which would be unthinkable without an armada of high-performance micromotors. These motors often need to generate considerable forces under extremely confined conditions and, above all, must always work reliably in continuous operation. This is why drives from FAULHABER can frequently be found in these challenging applications.

Despite sounding similar and being closely related, the term "logistics" does not originate from the same ancient Greek root word as "logic", but rather from French military jargon. Since the end of the Middle Ages, the "maréchal de logis" – the quartermaster – was responsible for providing marching and fighting troops with somewhere to sleep and rest. The quartermaster's range of tasks grew with time and began to extend to many other parts of the overall supply chain. So what started out as simply providing "logis", i.e. accommodation, became extremely complex military logistics.

The quartermasters originally belonged to the cavalry because the transmission of information has always been key to logistics. Until the 19th century, horses were used to relay information as fast as possible. Nowadays, electromagnetic waves that are propagated through the ether and along cables perform this task somewhat more quickly. Today, the largest data volumes are transmitted using fiber optic cables. They form the backbone of the global logistics network: The cables pass on the necessary information by means of light signals – from the online order, through shared just-in-time production in smart factories to express doorstep delivery.



Connections with nanometre precision

Two fiber optic cables must be joined together fibre for fibre. This is extremely delicate work because each individual optical fibre is as thin as a human hair. The optical core is even thinner and has a diameter of just five microns.

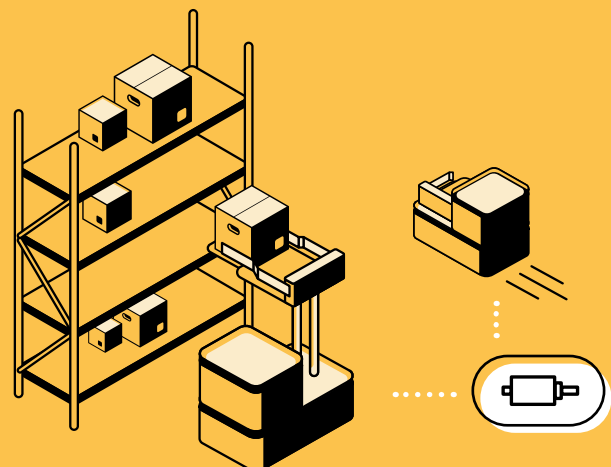
When two such optical fibres are joined together, the two ends must line up precisely with each other so that the signal can then later be transmitted cleanly without impairment. On construction sites, the precise alignment is carried out by small mobile machines. The individual fibre ends are first cut to length with an exact 90 degree cut, the protective insulation is stripped away and the fibres are then placed in the device. The device automatically and accurately aligns the two pieces with each other in three dimensions so that the flat ends meet precisely. They are welded together and then insulated again. Connection of the fibres and unimpeded flow of the signals are now guaranteed. The nanometre-precise alignment is performed by means of positioning drives from FAULHABER, e.g. with DC-micromotors of the 1524 ... SR series, with gearhead and lead screw as well as a high-resolution encoder. Drives that work with high-precision stepper motors are also used here.

Today, an increasing number of work steps involved in storing items in warehouses as well as retrieving these items and preparing them for dispatch are being taken over by automatic storage and retrieval machines, driverless transport systems and intelligent logistics robots. The computer-controlled machines receive a work order and then move automatically to the target rack space in order to deposit or collect an item there. To enable this, they are – depending on the type of rack system – equipped with lifting columns, telescopic arms or grippers which grip and move the packages or trays.

On board these automatic devices, there normally is not much space for the motors that are needed to drive them. The motors are frequently installed directly in the handling elements. There, despite their delicate proportions, the motors often have to lift considerable weights. Speed also plays a role: In the huge storage facilities of e-commerce companies, many thousands of orders are processed every day. Therefore, the individual steps must be performed rapidly.

High degree of automation in warehouse systems

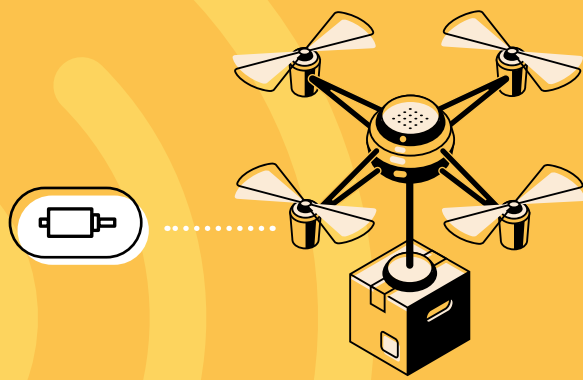
Thanks to this technology, the fibre optics can transmit the signals for a digital order over long distances without errors and at the speed of light. Orders can be sent by an end customer to an online shop, but just as easily by a production plant to a supplier. In both cases, a whole series of processes are set in motion. Ultimately, these processes result in products being retrieved from a storage facility and made ready for shipping.



A typical unit comprising a lifting column and gripper used on a robot contains a drive unit consisting of brushless DC-servomotors of the BX4 series with Motion Controller and planetary gearhead from FAULHABER. When used in the lifting column, for example, this combination ensures precise positioning, exact retrieval and reliable processes during continuous operation with constant load changes. The automated processes are monitored to some extent by camera systems. FAULHABER motors are again frequently used to drive high-quality moving cameras.

Packing systems / tape strapping machine

30 01.2020 FACTORY AUTOMATION & ROBOTICS



DELIVER

Delivery to customers with delivery robots
(drone, autonomous delivery vehicle)

Economical packaging

The items are transported to the packing station where they are put into a shipping box. In modern systems, however, "where they are packed in a made-to-measure shipping box" would be more accurate because automated packing stations use sensors to detect the dimensions of the item to be shipped and fold an appropriately sized box from a cardboard sheet. This not only saves material, but also shipping costs because the logistics service providers set their prices according to volume as well as weight. The actual folding work is performed by small levers and paddles in the packaging machine. Servo drives with integrated Motion Controller from FAULHABER are optimally suited for moving these elements.

If packages are stacked on pallets for shipment, they need to be fixed securely in place. Straps made of fibre-reinforced plastic are usually used for this. They are attached using so-called strapping tools. These tools tension and weld the strap so that it is tight against the stack and holds it securely. Individual packages can also be additionally stabilised in this way. As the tools are handheld, weight is a particularly important factor – every gramme saved helps protect the health of employees. For this reason, the motors used for tensioning need to be as small as possible, e.g. the 3274 ... BP4 brushless DC-servomotor. It weighs just 320 grammes, but can achieve a peak torque of over 1 Nm, which ensures that even heavy loads are secured safely.

"Our motors are used in virtually every area of the logistics chain," says Rolf Schmideder, Business Development Manager at FAULHABER. "Our drives and the typical requirements – maximum power, speed and precision with minimum volume and weight – are simply the perfect match. And the range of possible applications will be even greater if in future drones and robots are also used for delivering individual items."



FAULHABER BX4
BRUSHLESS DC-SERVMOTORS
4-POLE TECHNOLOGY



FAULHABER BP4
BRUSHLESS DC-SERVMOTORS
4-POLE TECHNOLOGY



FAULHABER CR/CXR
DC-MICROMOTORS WITH
GRAPHITE COMMUTATION



FAULHABER SR
DC-MICROMOTORS WITH
PRECIOUS METAL COMMUTATION



faulhaber.com/en/markets/factory-automation-robotics/

MEETING THE CHALLENGE

COVID-19



Covid-19, caused by the Corona virus, still has the world in its grasp. The numbers of sick people and positive test results keep rising. To stop the further spreading of the pandemic, drastic measures are enforced worldwide. At the same time, laboratory and testing capacities are being increased to speed up on testing and to work on vaccinations and antidotes. Furthermore, the protection of those, who work at the front line, fighting for patients' lives, must be consistent and operate as reliable as the ventilators for patients suffering. FAULHABER develops and delivers key components for those important, in some cases life-supporting, systems.

Read more about our drive systems for those and other medical applications in our special publication or online at www.faulhaber.com/covid19/en



Ident-Nr. 000.9122.20

Further information:



faulhaber.com



[faulhaber.com/facebook](https://www.facebook.com/faulhaber)



[faulhaber.com/youtubeDE](https://www.youtube.com/faulhaber)



[faulhaber.com/linkedin](https://www.linkedin.com/company/faulhaber)



[faulhaber.com/instagram](https://www.instagram.com/faulhaber)



FAULHABER motion is also available as an app.

You can get the free download with this QR code.

