MICROMOTORS IN MODEL-MAKING

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Next-generation XL telescope
State-of-the-art stepper motors in astronomy
Modern astronomy is struggling with the same problems as the first celestial explorers did centuries ago. The stars shine only faintly, and the further away the star, the less light hits the Earth. This issue can only be addressed by focusing the light – in other words, the telescopes keep getting larger. Today’s technology is so advanced that dealing with the ever-growing scale of telescopes is relatively simple. However, giant telescopes with stationary lenses are inflexible. Hence flexible solutions are increasingly being used, specifically the mirrors are becoming thin and adjustable and the objective lens itself is designed through individual components to be movable. Micro-drives are used to adjust the optics in order to minimise material variances, gravitational distortion or refraction fluctuations of the atmosphere. The focus is on miniature drives with backlash-free gears and long-term reliability.
Not every scientist can afford a giant telescope. On the other hand, anyone can develop ingenious ideas. Therefore, data from telescopes is becoming increasingly accessible to all interested scientists around the world. China has also been contributing to the “collection of knowledge” – with LAMOST (Large Sky Area Multi-Optic Fibre Spectroscopy Telescope). Technically speaking, the principle of the telescope is very well established, based on the ideas of the Schmidt telescope. In this case, the collected photons are transferred over 4,000 individual optical fibres to the spectral analysis system. For the precise setup of the fibres, the engineers have relied on the expertise of the Swiss manufacturer PRECiStep SA.

**Giant telescope**

The larger the optics are, the larger the amount of collectible incident light. In the case of LAMOST, the first mirror has a diameter of 4 m. The light is then focused on a second mirror 20 metres away and reflected from there to the analysis unit.

This unit contains 4,000 individual optical fibres, which then transfer the light. The mirrors and optical fibres are designed to transmit all light within wavelengths between 370 and 900 nm. In other words, the telescope has sufficient sensitivity ranging from ultraviolet to infrared.

In order to be able to evaluate the incident and gathered light in a useful way, it has to be measured exactly at the location in the detector that corresponds to the actual position in the sky. Thanks to flexible optical fibres, one is no longer bound by rigid optical limitations. On the other hand, this creates the problem of exact mapping and adjustment. The solution was a combination of 4,000 single, flexible optical fibres. These can be individually adjusted by precision motors. One major problem within this area is size: the drives have to be as small as possible. After all, the laboriously collected light has to be concentrated on the smallest possible area and with high luminance in order to analyse and recognise even the smallest, weakly illuminated objects. The key to solving this problem was provided by the stepper motor specialists of the FAULHABER GROUP. Backlash-free precision miniature drives are a trademark of this company, which can draw on decades of expertise in the construction of micro-drive systems and even longer experience in clock-work production.

**Precise and durable mighty minis**

Each single fibre strand is divided into two separately adjustable axes. This requires two drives for each, totalling 8,000 individual drives. Given the high quantity and compact packing of the drives, only 10 mm “thick” including the gears, maintenance or replacement would, of course, be extremely difficult. The “control cable” alone consists of over 32,000 individual strands and measures about 30 cm in diameter. In addition to the required utmost precision, the engineers placed particular emphasis on long-lasting reliability – without the need for subsequent intervention. This is made more difficult by operational conditions that often involve no change in the adjustment for an extended period of time but may then require specific minute movements. Thanks to experience in the mechanical telecommunications sector with similar requirements for precision stepper motors, the FAULHABER GROUP was able to meet this challenge without any problems – by deploying standard products. Owing to the low-wear bearings used in the motor and gears, in conjunction with optimised lubricants and backlash-free planetary gears, the overall solution delivers superior precision and outstanding reliability. Today’s mega structures are often dependent upon the reliability of miniature drives, especially in the field of optical alignment for measuring devices, sensors and other precision applications. Backlash-free micro-drives are the method of choice, providing the basis for reliable computerised settings of parameters. Just as in the „big world,“ small-footprint precision drives are the reliable link between electronics and mechanics.

The parallel controllable optical fibre positioning system allows a simultaneous adjustment of the fibres.
Model steam locomotive meets demanding requirements

Steam engines and model train sets are classic model-making applications. Whereas previously items were roughly moulded from tin, today fine detail is called for. As well as appearance, the focus is increasingly on realistic handling. Modern electronics allow a large number of locomotives to be controlled digitally with no complex wiring or different power supplies. A microdrive in the model locomotive provides the link between the electronics and the mechanisms, enabling delicate shunting operations and interurban journeys with many wagons to be replicated accurately to scale.
These days, model train sets are popular with adults and children alike. Depending on the use, a wide choice of toy trains and exceptionally faithful replica models is available. As one of the leading providers of high-end model train systems, Nuremberg-based Fleischmann has now developed a new model. Their miniature replica in N gauge of the Bavarian 70 series locomotive (BR 70) from 1930 is both convincing and highly detailed. Even the lettering measuring just tenths of a millimetre high can be read perfectly with a magnifying glass. Naturally, this passion for perfection does not stop when it comes to the drive technology. Major strides have been made in development here, with the professional model makers at Fleischmann bringing microdrive specialist FAULHABER into the developer pool for buffer to buffer. Weight is also low at just 36 g. It is nevertheless essential that every detail is accurate and that the model’s driving performance is appropriate. The locomotive’s undercarriage and body are die-cast in metal with added plastic parts. This allows even the smallest details to be faithfully replicated in series production. To match the original, realistic lights are integrated using tiny, warm-white LEDs. The lighting switches to the direction of travel automatically.

When it comes to the drive, certain mechanical and physical conditions need to be considered. As on large locomotives, traction (and, on the model, power transmission) between the wheel and the track is a crucial factor. A small motor generates only low torque, but requires a high engine speed. The engine speed must now be geared down relative to the model scale and the size of the drive wheels. Other electronic components can transmit digital control signals to the drive or lights and auxiliary equipment, for example. All this must function reliably out of sight for many years while taking up minimal space.

A small locomotive that makes a big impression

Building a model train system on scale 1:160 (N gauge) involves working with very small units. In this case, the BR 70 locomotive in N gauge is only approximately 57.8 mm long when measured...
High-performing microdrive
In the case of the model locomotive featured here with a weight of just 36 g and a relatively high engine speed, quiet running is a particular issue. Even the slightest imbalance in the rotor on this lightweight locomotive will cause vibrations and possible resonance within the model railway system on which the rails are laid. The issue was resolved by deploying a high-precision flywheel on the motor shaft. Flywheel wobble is just 0.03 mm. Thanks to this exact design, the motor and flywheel are as large as the locomotive body permits. The advantage of this approach is that the large flywheel, which stores kinetic energy, delivers excellent running performance over points and sets of points, even during very slow shunting operations. This is particularly important when there are brief inter-

Modern microdrives can be customised for virtually any deployment scenario. The sooner drive specialists are involved in developing an application, the smoother the process of integrating the drive. In this way, specific key characteristics such as special configurations, short-term overloading, extremely quiet running, etc. can mostly be achieved with ease.

Although ready-made drives meet many requirements, for high-end and specialised applications, customisation is the answer. Microdrives are no longer limited by technology – instead it is up to developers to find new creative possibilities, not just in model making.

ruptions to the power supply due to the track. A version of this locomotive with an integrated digital decoder is specially adapted to the drive motor running in this way to make the slowest movements appear more realistic. Effortlessly absorbing the axial forces of the first worm gearing stage, the motor’s durable, lifetime-lubricated bearings enhance this microdrive, which has been optimised for model making.

Miniaturized drive for quiet operation and high power even during shunting operations
Ultra-compact customised belt conveyors

The trend towards ever-smaller products is increasing. For this reason, assembly technology equipment is now also operating with ever-smaller components. Belt conveyors just like those that work with standard-sized components are now being offered for transporting high unit loads safely. Optimised to meet the special requirements of transporting small items, in many cases they are the product of choice. Robust materials and durable, maintenance-free components guarantee high operational functionality over long periods.

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In the world of manufacturing there are still a few areas in which it is quite sufficient to transport components manually from one section to the other, but, for high unit loads, automated solutions have become essential. With this in mind, Henry Ford deployed belt conveyors for mass production even back in his day. The Vetter engineering company is proving with its micro belt conveyors that this principle is transferable to assembly technology for small components. And their compact, modular concept can also be tailored to accommodate special user requirements.

A compact design also requires compact drives, and for this reason the manufacturer works with the microdrive specialist FAULHABER, based in Schönaich. This has given rise to a whole range of standard and customised compact belt conveyors.

Enclosed design
Conveyance means movement. Small components in motion, however, tend to “go astray” once in a while. In order to ensure smooth production, it is essential that nothing gets jammed in the conveyor belt. To avoid any such disruptions and at the same time facilitate easy, rapid integration into existing or new installations, the manufacturer utilises a completely encased, “motorless” conveyor belt. All key components of the conveyor system are completely enclosed, with a smooth outer surface, and are almost completely covered by the actual belt itself. This in turn provides usable area only, without any awkward (drive) attachments. The cleverly designed modular structure makes assembly much easier, and even variants for special requirements can be supplied virtually on a ready-to-use basis.

A belt conveyor must provide the right user-specific width and length. On top of this there is automatic pre-tensioning of the belt and a drive. The modular design meets these requirements perfectly: the idler roller for the conveyor belt is connected to an aluminium-section “supporting element” that can be cut to the individual length required. The belt is driven by another module comprising a microdrive and a roller drive on the other side of the supporting element.

If the supporting element (which is only needed for the variable length) is omitted, the overall length of the conveyor unit can even be scaled down to 200 mm – with a height of just 30 mm and a width of 60 mm. The drive integrated into the belt conveyor has none of the troublesome, protruding components that make installation more difficult.

All this can only be achieved by using extremely compact drives that are much narrower than the diameter of the transportation unit or the idler rollers. Depending on the conveyor design, the manufacturer uses either 16-mm EC servomotors or DC drives of 23 mm to 35 mm diameter from FAULHABER.

These motors come with a long-life planetary gearhead as a pre-assembled unit, thus combining motor and gear mechanism. The drives can be integrated well into the standard belt conveyors in sizes 20 – 40, 30 – 60 and 40 – 80 (installation height – installation/belt width in mm). Wider conveyors too, such as the 40 – 120 and 40 – 160 versions, are available, as are special solutions based on the same principle, such as ascending conveyors.

The motors are supplied with 24 V. The belts can be operated at different speeds thanks to variable gear reduction. For special cases requiring infinitely variable speeds with very sensitive adjustment, there is an additional speed controller and, for the variants with EC servomotor, the speed control comes as standard.

All moving parts of the belt conveyors and of the drive are completely enclosed, with lifetime lubrication, thus ensuring maintenance-free operation.
Compact drive power

The drive is key in determining the reliability of the belt conveyor. Micro-drives, however, follow their own rules. Drawing on their many years of experience, the specialists from Schönaich are able to supply drive units that are optimised down to the last detail. The drive unit comprises inexpensive, durable graphite-commutated DC motors that can be controlled easily in combination with planetary gears. Particularly with microdrives, it is the special design that is key to a long service life.

High input speeds and a high output torque make special demands on materials, tooth geometry, bearing positions and above all on the lubricant. When properly dimensioned, these drives provide many years of maintenance-free service.

If something even smaller is required or if continuous operation is a priority, then the preferred option is electronically commutated motors (EC motors). They are not subject to any brush wear, can be mass-produced all the way down to 1.9 mm diameter and can be equipped with gears with a diameter corresponding to the motor. The drive unit is either integrated into the motors or is external and, as with DC motors, affords sensitive, infinitely variable control of speed and torque.

FAULHABER supplies state-of-the-art microdrives in a vast array of designs for any application. If the drive specialist is involved in project development from the outset, optimised, perfectly adapted solutions can be implemented. In addition to standard drives, tailor-made and modified specialist solutions can be created at a reasonable price if planning begins early on.
In many industrial handling and automation tasks, workpieces or tools have to be rotated into position. This places great demands on swivel units, with requirements spanning everything from high speed and precise movement to powerful operation and low maintenance. In practice, it is difficult to combine these various requirements, since powerful pneumatics fail to reach the necessary positioning accuracy, while compact electric drives lack the required power. A novel combination of both drive concepts is now setting new standards for swivel units.
When two pneumatic cylinders act via the piston rack on a shaft with pinion, the result is a simple, powerful rotary motion. Depending on the piston surface and pressure, substantial force can be introduced to the shaft. The disadvantage of this approach is that gases are compressible, meaning that it is almost impossible to home in on a very specific position rapidly – even if you spend significant amounts on control valve technology. And if you switch to electric drives, small-footprint solutions usually lack the necessary power.

Schunk, a German-based company specialising in industrial handling, has now solved this primary dilemma with a combination of both drive variants.

For the electric drive components, they have brought micromotor experts FAULHABER, based in Schönaich, on board. The result is a compact, precise and efficient swivel unit.

**Powerful high-precision rotation**

In the new drive concept, the pneumatics and electromotor complement each other. The pneumatics provide the high power density required, while the electric motor contributes the fast response times and fine controllability. In the SRU 40 Masterdrive, designed according to this concept, in addition to the drives, the necessary control electronics are also integrated, making optimal use of both drives according to their key strengths.

The intelligent drive selection permits short cycle times even with different loads. The servomotor is activated directly after the signal to start from the PLC. With the inherent delay, the pneumatics act as a “turbo” to provide the required torque. This ensures an immediate, soft start-up and powerful acceleration. When decelerating, the pneumatics are responsible for ending the forward movement, and the electromotor moves the unit precisely into position. Additionally, for the braking process with high loads, the pneumatics act as a soft brake that is adjustable to specified parameters; hydraulic shock absorbers subject to wear are no longer necessary with this design.

Despite the elaborate control system, the swivel unit manages with only two connections: a compressed air connection for filtered air and a control cable from the drive to the control cabinet. Here, a control box takes over the connection to the PLC and the standard 24 V power supply. Thus up to five positions can be set easily via digital inputs and outputs without the need for programming. The impulse from the PLC is then sent to the position in question, and the drive gives a feedback signal after reaching the position. Here, the pneumatic drive ensures a high torque of 13 Nm. The simple control of the DC micromotors means that a swivel range of 180° with positioning accuracy of an impressive 0.03° can be achieved.

**Easy to adjust**

Modern DC microdrives are well-priced, durable, reliable and – thanks to pulse width modulation (PWM) of the supply voltage – easily adjustable. In this application, a 24 V motor of around 100 W ensures the necessary “smooth precision”. At only 4 A current consumption, the drive also permits compact, low-loss activation. Since the motors in four-quadrant operation assume both the drive and braking functions, they are well-suited for positioning tasks. The soft start-up with low loads and the high short-term overload capacity are also advantageous for many drive applications.

The drives with permanently lubricated bearings are completely maintenance-free. Due to the great variety of micromotor models, a standard drive can often be used, as in this case. For special tasks, the motor models in question can be specially tailored to the application as required. Here, it is advisable to involve FAULHABER as early as possible, the aim being to achieve a maximum level of efficiency for the drive solution – with a minimum of effort. Users can concentrate fully on their core area of expertise, while the engineers in Schönaich/Germany draw on their many years of experience to address all the challenges relating to drive technology.

Modern micromotors are suited to a great variety of tasks, the main focus being on setting objects in motion. Whether as the sole drive source or in a hybrid design together with another drive concept, the only limit placed on state-of-the-art microdrives is the imagination of product developers.

**WWW. schunk.de**

**WWW. faulhaber-group.com**

Hybrid drive in a compact housing knows how to do a good turn
With the introduction of the BX4 series of brushless DC servomotors, FAULHABER once again underscores its position as an innovative market leader in highly integrated miniature drive systems. Using the latest production methods, some specially developed by FAULHABER, the company has come up with a modular design that is limited to just a few components and entirely eliminates the need for adhesive-bonded joints.

Despite the compact dimensions, the new four-pole concept of the series ensures a high continuous torque of up to 12.2 mNm, with a flat gradient of the n/M characteristic curve.

Notable features are the smooth running characteristics and the particularly low noise level. Thanks to its electronic commutation, the brushless servo motor series is characterised by a much longer service life than mechanically commutated drives. Whilst in the basic version the commutation is provided by an external control, the flexible motor concept of the BX4 series also offers versions with integrated speed controller or integrated encoder. The encoder version is available in four different preset resolutions: 32, 64, 128, or 256 quadrature impulses per revolution. It is available with an optional line driver and differential output signal.

In addition to mechanical speed adjustment, the new planetary gearheads of the 22F series also allow a temporary torque increase up to 1500 mNm. Designed with one to four stages, the precision gearhead in steel 21 offers finely graduated reduction ratios, and the diameters can be combined in conformity with the BX4 drives.
**For both DC and brushless motors**

FAULHABER motion control series
SC 1801 and SC 2804

The new software-controlled PI controller series enables the universal operation, with one and the same controller, of either electronically commutated drives (BL) or brush-type DC motors with sensors for speed measurement or without sensors, with retroactive generator voltage.

Users can freely reprogram the controller characteristics for their purposes. The new „Motion Manager 4“ software generation allows specific programming in an easy-to-use application. Current limitation, controller parameters, fixed speed, encoder resolution, setpoint input via PWM signal and maximum speed can be adjusted just as variably as the operation of the DC and BL motors with or without sensor.

Pre-programmed controllers are available ex-works for applications with less demanding adjustment requirements. In plug-and-play design, these controllers need neither a programming adapter nor the Motion Manager software.

Thanks to their compact design, the new speed controllers can be used in many applications with little cabling required.

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**With integrated encoder**

FTB series 15 ... SR IE2-8 and 26 ... SR IE2-16

The two new thin-profile micromotor series with integrated encoder are just 2.3 mm longer than the standard versions. In addition to the small housing length, the drives excel thanks to their low starting voltages and their extremely low energy consumption, which makes them particularly suitable for battery operation, e.g. in portable devices.

Each drive is available as a gearhead version with the same motor diameter, which allows a continuous torque of up to 100 mNm. The new integrated encoders ensure perfect control behaviour and positioning of the drive shaft, while the ironless rotor ensures high dynamics and smooth running. Two perfected drive series, which can show their advantages to full effect in demanding drive applications with small installation space.
**Also available as linear actuator**

smoovy series 0515 ... B

Despite compact dimensions of 5 mm outer diameter and a length of 15 mm, the new smoovy series 0515 ... B offers ample power, with minimal current consumption. The standard version of the brushless DC micromotor can achieve a max. speed of 15,000 rpm and a continuous torque of up to 0.2 mNm. The proven ironless FAULHABER coil technology with skew winding ensures precise, smooth running.

A robust planetary gearhead with different reduction ratios is available, matched perfectly to the series. In addition, the gearhead variant of the micromotor series is also available in a design with preassembled spindle, as a linear actuator.

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**Precision speed control at very low rpm**

penny-motor 2209T005B SC 12 bit

In addition to its compact design, the new brushless thin-profile micro-motor with integrated encoder is particularly attractive due to its broad speed range, which – thanks to the high-precision control – also allows minimal speeds without any problem, whilst achieving a continuous torque of up to 0.16 mNm.

The integrated positioning mode with encoder output makes the drive particularly interesting for applications such as medical, information, communication and automation technology. The optional use of the encoder signal as quadrature signal or via serial interface allows the new penny motor to be adapted to customer-specific requirements in a matter of minutes.

The new 2209T005B SC 12 bit penny motor thus provides a light, compact and quiet drive for the most diverse fields of application.
Cutting-edge technology and futuristic thinking are an integral part of the FAULHABER corporate philosophy, which is not only reflected in the products and services of the company. Its recently commissioned new building in Schönaich is an impressive testimony to these ideals – particularly from an ecological perspective.

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In planning and constructing the 10,000-square-metre, four-storey complex, special attention was paid to energy efficiency and environmental care. To achieve this, FAULHABER made use of the latest innovations in low-energy construction methods that are otherwise commonly applied to residential homes and apartments.

Special insulation of the dual-shell facade, for instance, allows the maximum amount of heat to be stored in the building during the colder months of the year, making supplementary heating almost unnecessary. By the same token, the sun’s rays are reflected through the specially insulated glass in the summer to prevent the rooms from overheating. In addition to the insulation system, thermal capture of waste heat and condensation keeps the need for thermal energy to a minimum without putting any additional strain on the environment. This concept of “double usage” of actual waste products is consistently applied throughout the new building.

Moreover, the use of fluorescent ballasts in the lighting achieves a 15% reduction in electricity consumption, which in conventional buildings of this size can fluctuate enormously. Pollutant-free rainwater drainage – often a critical factor in industrial buildings – is achieved by special, multiple-layered trenching, which filters the water for optimal purity. Distinctive for its clear lines and the light relief afforded by bands of glass, this quadratic-shaped building also has optical appeal that accentuates its “inner qualities”.

With its latest building, FAULHABER has set new benchmarks for attractive, efficient and sustainable construction, particularly in view of its responsible approach to the environment and natural resources.
Need more info? No problem.

Whether micro-diameter or ultra-flat design, DC micromotor or stepper motor, mechanically commutated or brushless – the FAULHABER GROUP offers best-in-class drive solutions tailored to your specific application.

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Hägar the Horrible

LOOK AT THIS MESS! IF THERE WERE A CONTEST TO DISCOVER THE WORLDS MESSIEST MAN, YOU’D WIN, HANDS DOWN!!

AND YOU SAY YOU NEVER WIN ANYTHING!

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