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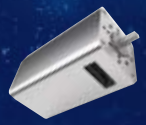
1956

IRONLESS MOTOR

1985



BRUSHLESS DC MOTOR

TUBULAR LINEAR MOTOR

1987

SMART MOTOR

CONNECTIVE MOTOR

1999

CANopen®

AXIAL FLOW MOTOR

MOTOR CONTROL PLATFORM

2005

2017

2018

MAGAZINE OF **MOTOR TECHNOLOGY**

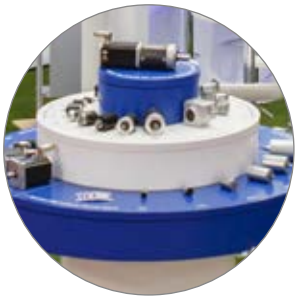
INNOVATION IN MOTION

Content

Trade Fair Participation 2019

Intec – Leipzig/ Germany	05.02. – 08.02.2019
MD & M West – Anaheim/ USA	05.02. – 07.02.2019
LogiMAT – Stuttgart/ Germany	19.02. – 21.02.2019
productronica – Shanghai/ China	20.03. – 22.03.2019
Smart Industries – Lyon/ France	25.03. – 27.03.2019
HMI – Hanover/ Germany	05.03. – 08.03.2019
Automate – Chicago/ USA	01.04. – 05.04.2019
LET-a CeMAT ASIA event – Guangzhou/ China	08.04. – 11.04.2019
Smart Automation Austria – Linz/ Austria	14.05. – 16.05.2019
SPS IPC Drives – Parma/ Italy	28.05. – 30.05.2019
Motek – Stuttgart/ Germany	07.10. – 10.10.2019
Agritechnica – Hanover/ Germany	10.11. – 16.11.2019
Compamed – Düsseldorf/ Germany	18.11. – 21.11.2019
SPS IPC Drives – Nuremberg/ Germany	26.11. – 28.11.2019


dunkermotoren
AMETEK
LINEAR SYSTEMS
World champion 2018
in smart motors'
dunkermotoren



Editorial

Uwe Lorenz | Managing Director
Dunkermotoren GmbH

Dear Readers,

in our private life, we experience the connection of our surrounding stronger than ever. Beginning with our smart phones which accompany us daily, to the programming of the heating in our smart home to the autonomously driving cars.

In the industrial field, the connection already plays an important role. For more than ten years, our brushless DC motors have been communicating with surrounding components and autonomously performing driving tasks. With the development of the new motor control platform, our intelligent motor solutions get a new brain. Our Product Manager Michael Burgert explains in this issue which features are new.

With our BG 66 dMove another motor is launched whose electronics is based on the new motor control platform. With more than 100.000 sold motor units, the predecessor of the BG 66 dMove – the BG 65 SI – is probably the most sold industrial DC servo motor with completely integrated motor electronics. Get informed about how our high runner developed further.

But not only our motors make the world moving. We as a company would also like to make a difference in our region. So, we feel encouraged to realize different projects with schools or other institutions. Here we can achieve great things together. Nothing is more valuable than a bright face of a child.

We also saw bright faces at the beginning of the year in Berlin. Our apprenticeship cooperation 'HeDu' won the first IHK apprenticeship award. The responsible persons were visibly proud of the work which was achieved with our neighbor company Hectronic.

Not only the apprenticeship cooperation opens our apprentices and student's doors to another company. But also, our motors provide access to different buildings, trains and many more all over the world. Our motor solutions cross your way almost daily. Where exactly – Matthias Tidelski, Key Account Manager Building tells you about it.

Look forward to many other interesting topics around the motor technology. Enjoy reading it.

Yours sincerely, Uwe Lorenz

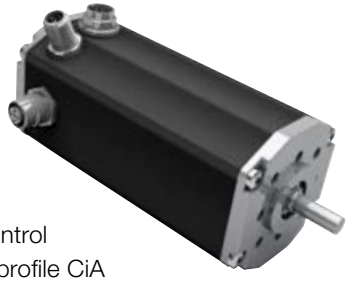
News

BG 66 dMove - Revolution inside

With more than 100.000 sold units, the BG 65 (S) from Dunkermotoren is probably the most sold industrial DC servomotor with completely integrated motor electronics. With the BG 65/ BG 66 dMove Dunkermotoren launches successor products now. They completely replace the present products BG 65 (S) SI and BG 65 (S) CI motors with low encoder resolution.

The outward appearance of this series with simple control electronics, formerly represented by 'SI' motors, now called 'dMove' differs just by a more powerful plug. Inside the motors, there is a completely new control electronics. Already in I/O version it allows to assign functions to the digital inputs - from simple speed control, using analog input or fixed speed via digital inputs to combinations of current and speed control. Also, digital outputs can be assigned to other functions. With this innovative design, the motor can produce higher output power.

Compared to the former 'SI' motors, it is possible to integrate dMove CO versions as slaves in CANopen networks and to control them via profile CiA 402. These dMove CO motor can also be controlled with simple Dunkermotoren quick start commands. Here are all functionalities including positioning, speed and current operation available. For projects, Dunkermotoren offers versions of the motor which are parameterized and controlled via an RS 485 interface. The newly developed commissioning software 'Drive Assistant 5' helps to set up the motors intuitively.



The dMove series is suitable for many applications which do not require a high-resolution encoder. For applications with more sophisticated requirements, the BG 65 (S) PI, MI and CI are still available.

Author: Michael Burgert I Product Manager Brushless DC Motors

New main catalogue

Order simple and quickly our new main catalogue

Just send a short mail with your contact data and the required number of catalogues to: **Sales.Dunkermotoren@ametek.com** or fill out the order form at **www.dunkermotoren.com/en/service-support/order-main-catalogue/** and get caught by the Dunker spirit.

News

KG 90 – Efficiency around the corner

Dunkermotoren launches designed-to-cost solution

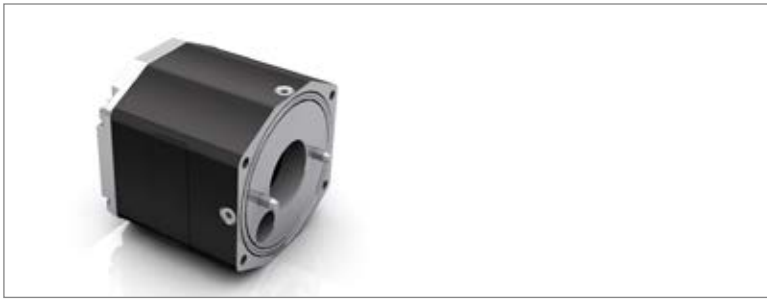
Dunkermotoren listens to the voice of the railway industry regarding a solution for an economic, efficient and long life technology, when introducing the KG 90 gearbox to the market. This gearbox solution, with a right-angle output shaft, is available for other applications now.

The KG 90 uses bevel gear technology. The characteristic is on the one hand, the economic production of the gearing parts, on the other hand the combination of the market established and spread planetary gearbox PLG 52. With the planetary gearbox, the reduction ratio is easy to adapt to the application. The bevel gearbox stage deflects the power in a 90° angle. At the same time, it's the output shaft which can be loaded with momentum of 8 Nm permanent I 16 Nm acceleration I 24 Nm emergency switching-off. With the output shaft, which is rotated through 90° to the motor axis, the drive works extremely short in the application. This predestines the gearbox not only in applications for train doors but others as well. Also, positive for the required installation space, is the bevel-gearbox-typical offset-free construction (decussate axis).

Author: Stefan Tröndle I Product Manager Brushed Motors and Gearboxes

AE 38 – Dunkermotoren launches its latest generation of fully integrated absolute encoders

Single and multiturn absolute encoders are simply indispensable for industrial automation. Especially in big machines, the encoders save referencing and allow a quick machine start. With absolute encoders, reference switches and limit switches as well as the associated cabling are no longer necessary.



Now, Dunkermotoren launched its latest generation of fully integrated absolute encoders. The AE 38 can also be integrated into the BG 45, unlike its predecessor, the AE 65. Instead of 12-bit multiturn, the AE 38 realizes 16-bit multiturn, and even 32-bit on request. With 16-bit multiturn resolution it's already possible for the motor to run for almost 24 hours in one direction with nominal speed, without overflow of the multiturn revolution counter. The AE 38 works using the energy harvesting principle. This means it does not need a life-time limiting battery or a mechanical gearbox.

Within the modular system of Dunkermotoren, the AE 38 can be integrated into the BG 45, BG 65(S), BG 75 and BG 95 series. Besides this encoder, the Dunkermotoren modular system offers a wide range of additional encoders, brakes and gearboxes. These compatible components can be combined as required and are delivered as a complete motor solution to the customer.

Author: Michael Burgert I Product Manager Brushless DC Motors

Optimization GR 80

Products such as the GR 80, that have been on the market for a long time, need to be adjusted in design from time to time; to adapt the product to the changed normative requirements or to cover increased customer requirements also in the generic area. With the current galvanic surface coating of the GR 80 the requirements of the railway and food industry regarding corrosion protection and hygiene requirements could not have been covered. For quite a long time, for those applications were used housings with cathodic dip coating (CDC). It passed the salt spray test according to DIN EN ISO 9227 with more than 192 hours successfully.

Due to the black colour of the CDC, the thermal emission is improved. This leads to a higher continuous torque of the motor. With some versions, the nominal torque increases by up to 10 percentage. To offer this technology to all customers, this surface coating has been carried over to the generic product. To increase the security of supply an alternative material for the brush plate is used. With these actions, the GR 80 is well prepared for the future. Nothing prevents the future sales growth.

Author: Stefan Tröndle I Product Manager Brushed Motors and Gearboxes

The BG 95 Profinet

‘Sweetie. If you want to become someone, you need to learn languages.’ What applies for children, applies also for electro motors. The more languages they speak, the more successful they are. Already now, Dunkermotoren is successful with motors which communicate to other gadgets or among themselves.

The languages that are spoken are not like Spanish, Russian or Bantu. Rather it concerns digital languages which get usually transferred via cable. These languages are called e.g. CANopen, Profibus or EtherCAT. Via these languages, the machinery controls the communication with the components. For example, electro motors receive commands for the speed they should run at or motors communicate with a control to inform of the actual temperature the motor end level is.

In the automation technology, there are currently several different digital languages available. Almost every control manufacturer has developed a language that suits to its requirements and gets accordingly pushed. Components as e.g. sensors or electro motors, need to speak the same language as the control of a machinery that they can get integrated in it. One example: A beer bottling plant manufacturer controls its machinery with a control from Beckhoff®. Consequently, several assembly lines, bottle grippers or valves need to be addressed with the EtherCAT language. Same situation with a control from Siemens® and the language Profinet.

As a manufacturer of drive solutions which are perfectly applicable for the automation technology, Dunkermotoren already offers interfaces to many common digital languages. The latest product of the linguistically talented motors is the BG 95 dPro PN. On the face of it its hardly distinguishing to the standard motor BG 95 dPro with CANopen interface. Only the communication plugs are D coded M 12 plus, instead of A coded.

But inside of the motor there’s a complete communication module which speaks Profinet. It forwards commands from the external machinery control to the internal BG 95 dPro motor control. These commands are obeyed and information about the motor status gets transferred back to the machinery control in Profinet language. So, the communication module is also the interface from motor to the outside. All data from the motor are interchanged via this interface. So, in case of failure, the motor is also programmed, adjusted and analyzed.

At first glance, one could think the Profinet interface is simply another bus interface. But far from it. Physically it’s an Ethernet interface, a very common computer interface. Many millions of computers are already networked with this interface. Due to the wide diffusion, the cost is low and the acceptance is high. For Profinet the Ethernet language was adjusted in speed to the high requirements in the industrial automation. Therefore, Profinet belongs

among with other languages of Powerlink and Ethernet IP to the Industrial Ethernet languages.

In the future, the interface can be used not only for Profinet but also for other Industrial Ethernet languages. It's also conceivable that the motor is directly linked to the internet. Via this way, it would be possible to analyze, install and update it with the latest firmware from all over the world. Already today, it is technically feasible but the associated safety risks need to be reduced to a minimum.

For the motor, this new communication interface is the gateway to the world. Therewith it is not only possible to communicate with the machinery controls or with other motors. But also, to exchange data with superior systems as e.g. a production control system or to save data directly in the cloud or in a data lake. From there data can be analyzed and help to select even better products. For this data exchange, motors revert to cross-system languages as OPC UA or MQTT.

With the new motor BG 95 dPro PN, Dunkermotoren speaks not only a new language, but it is also the base for a variety of new communication possibilities.

Author: Michael Burgert I Product Manager Brushless DC Motors

Get blazingly fast to your perfect motor solution

With million of product combinations, Dunkermotoren offers the right motor solution for almost every application in the range of 1 – 4000 W. With the new online configurator Dunkermotoren enables a simple search and selection of motors, integrated controls and gearboxes.

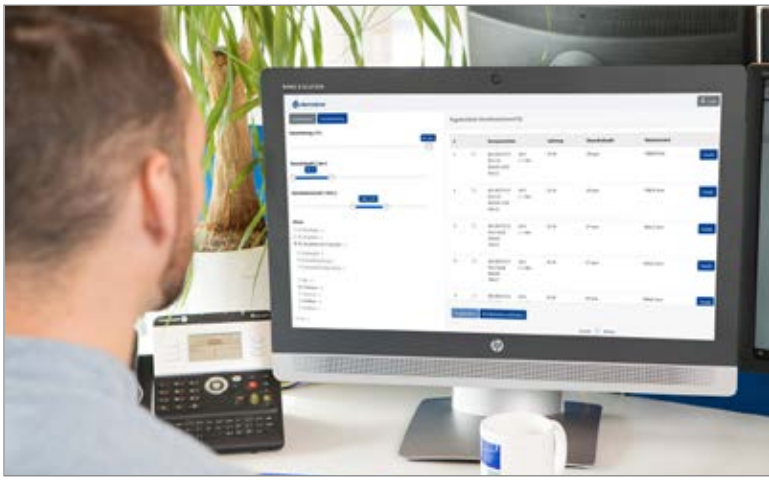
The configurator suggests suitable products and product combinations for the user entered parameters. Possible search criteria are e. g. necessary torque and speed, the available power supply, the requirements to the motor control and the communication interface as well as the requirement of additional accessories as brakes or IP protection covers.

For the selected product combinations, the product specifications as well as drawings and 3D CAD models are shown to the user online and as a download link. Then the customer receives specifications and characteristic diagrams also for the product combination of motor and gearbox. So, the customer saves time and effort required to manually calculate the performance data, resulting from the gearbox ratio and efficiency. Moreover, the risk of misconfigurations is almost eliminated. For saved configurations, the customer can easily request an offer at any time with one click.

Be efficient and configure your demand of drive technology with Dunkermotoren!

The configurator will be available soon on our website:
https://www.dunkermotoren.com/en/products/

Author: Tobias Pfendler I Director Product Strategy and Marketing



Dunkermotoren goes Instagram

Social Media – a term which is nowadays well known and lived. Meanwhile several of our pictures are also tagged with the #smartmotorsforsmartfactories. Cos, Dunkermotoren goes Instagram. The new Instagram account is currently filled with impressions from different events. If you want to participate in our events – just follow us!

Author: Janina Dietsche I Marketing Public Relations

Facts & Figures

+ 50%
upper continuous output power of the BG 65 dMove compared to the predecessor product BG 65 SI

+ 15%
Sales growth in 2017

+ 64%
Increase in unit numbers of BG 75 in 2017

8 Mio.
ball bearings – 32.000 pieces per working day

> 300 km
Sales of BG accessory cable

12 Mio.
of screws - 48.000 pieces per working day, only one part number of it: 3 Mio.

2,4 Mio.
printed circuit boards

170 Mio.
GR armature metal (in total) 680.000 pieces per working day. Approx. 8 GR armature metals are produced per second for Dunkermotoren

New Technologies

Motor Control Platform (MCP) Firmware

10111001000100010010000100110011
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00001110110001100110000100010010
11000110010011101111111001000100

11000110010011111111111001000100
10111001000100010010000100110011

Number chains of zeros and ones are the flow of information through the circuits of microcomputers. There they are acquired, computed and output as data. Microcomputers (processors) are also included in every BG motor with integrated electronics. They receive information from a variety of sensors and interfaces and use it to calculate the status of the motor. In addition to the current position and the speed, this also includes information such as: 'Will the motor soon overheat at the current load?', 'Has the last adjusted current already resulted in a necessary speed change?' or 'Which digital inputs are currently set?'.

Customers of Dunkermotoren do not want to deal with these questions, nor with any number chains. They want the motor to rotate and deliver power when required by the machine in which the motor is installed. For this to succeed, the microcomputers must be programmed accordingly. The lower the effort for the customer, the more time-consuming the programming is. Dunkermotoren is committed to keeping the customer's effort as low as possible. The effort invested in the development of the software is correspondingly high.

The software program that allows the motor to rotate, monitors permanently its status and compensates for faults or delivers messages, is called firmware. Nothing works in the motor without this software. It is the core, so to speak, the holy grail of motor control. Its programming is correspondingly complex. Nothing should go wrong here. Many man-years of work have gone into a professional motor firmware.

Currently about 650 different motor parameters can be read out and/or adjusted with the Dunkermotoren firmware. These are e. g. maximum currents, homing method, settings for absolute encoders, PID tuning parameters, just to name a few. And these are only the parameters of interest to the customer. Internally, significantly more values are reliably processed. This illustrates how sophisticated and complex an effectively working firmware must be.

So far, depending on the motor processor used, a dedicated firmware has been developed. Due to the different processors, in the past the same work had to be done multiple times, namely for several hardware versions. This is no longer necessary, because with Dunkermotoren's new Motor Control Platform (MCP), there is only one software core left that runs on all motors. Its an added feature, all motors will equally benefit from it.

The challenges in developing this software were that the features of all previous motors, also had to be available in the MCP, that the firmware had to be extremely robust and at the same time, so flexible that new features could be easily implemented.

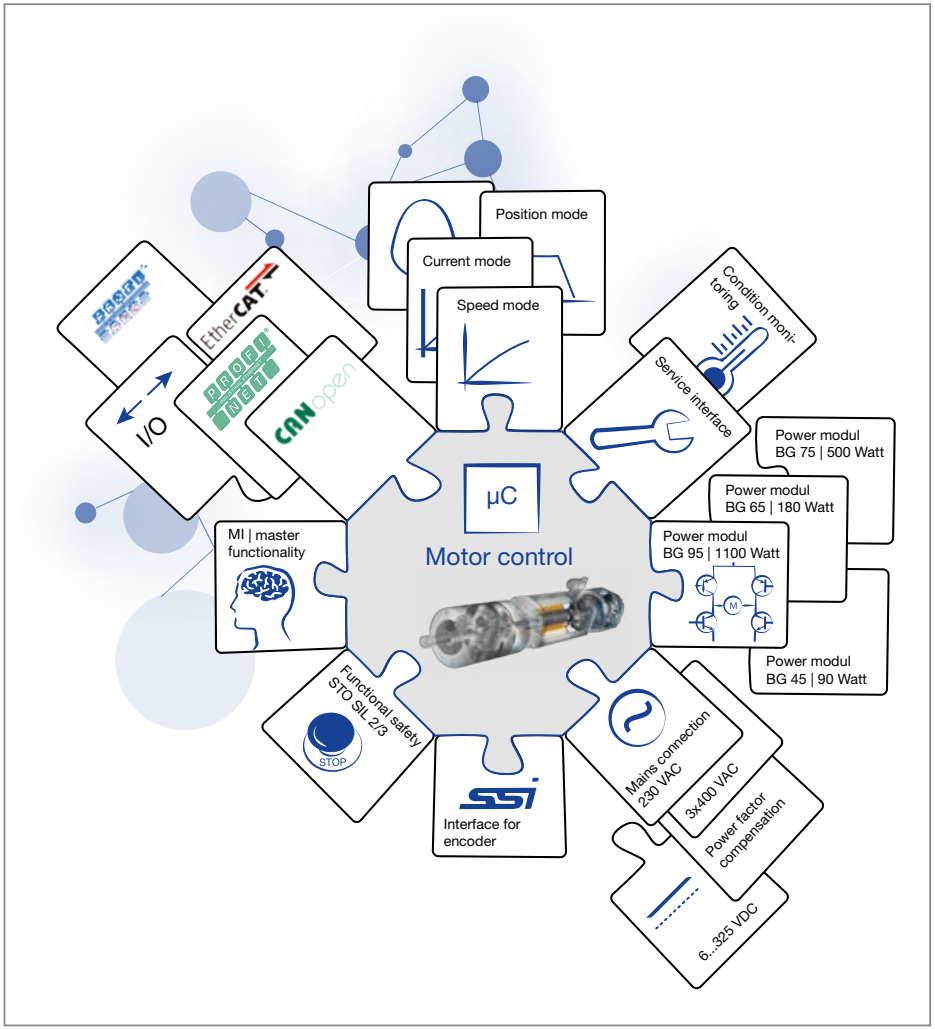
To this end, a programming method was implemented that follows the strict MISRA-C programming guidelines. These guidelines are used i. e. for programming in aircraft construction, medical technology and rail transport. In addition, methods such as static code analysis, code review, module and system tests are implemented in the development process. This appears

in a firmware that meets the highest quality standards. This firmware is modular and object-oriented and has precisely defined interfaces. This makes it easy to perform extensions without having to change the core of the software. Thanks to 20 years of experience in motor software development and even significantly longer experience with customer applications, previous requirements could be combined and effectively implemented on an MCP basis. To be future-proof, the programming code was implemented in a way that it can also be transferred to future generations of processors.

For customers, it remains the same: BG motors from Dunkermotoren run all the time. Customers can use digital or analog inputs or the bus interface to decide when the motor shall rotate and deliver power, namely when the machine requires it in which the motor is installed. Good to know that the software used inside the motor, diligently and constantly does its complex work, and you know as a customer: Motors from Dunkermotoren are running!

Drive Assistant 5 (DA5)

BG motors with integrated electronics



are called 'intelligent' because they react autonomously to commands, they autonomously recognize fault conditions and provide information about their status. But this intelligence must be controlled, so that the motor does exactly what it is supposed to do. And if it does not do that, you must find out why. For both control and fault analysis, smart motors have a computer interface. Of course, a computer program that communicates with the motor is needed for these commissioning and service functions.

For this purpose, Dunkermotoren provides the 'Drive Assistant' and 'SI configurator' programs. SI motors can be adjusted easily and intuitively with the "SI Configurator", e. g. fixed speeds or acceleration ramps. So far, several versions of the Drive Assistant are available: when using the Drive Assistant 2.7, CANopen (CI) motors can be conveniently set and analyzed. With Drive Assistant 3.3, PI motors are set so that they can be positioned, speed-controlled or operated via current control without a higher-level controller. In addition, for BG 95 dPro CO motors there is a Drive Assistant, with tuning, analysis and Python script function.

Drive Assistant Today

- Several different versions
- Communication only via CANopen
- Uploading the parameterization takes several seconds
- Fixed assignment of digital inputs and outputs
- Rather number-oriented design

Drive Assistant 5

- A single version for all motors
- Communication via CANopen, RS 485, Ethernet
- Uploading the parameterization takes approx. 1 second
- Flexible assignment of digital inputs and outputs
- Rather graphically oriented design

All programs are working properly and are highly valued by customers. But why can't a single program set and analyze all types of motors? It depends, among other things, on the different electronics of today's motors. The Motor Control Platform (MCP) eliminates this problem. The processors used in the different motors and the new firmware, basically work in exactly the same way. Therefore, in the future, only a single tool will be needed for commissioning and service.

A completely updated version of the Drive Assistant has been developed for all MCP motors: Drive Assistant 5. This version can be used for all new motors, whether the simple dMove or the dPro, which was developed for demanding tasks. Customers can use it to comfortably set up bus motors (e.g. CANopen, Profinet, ...) as well as stand-alone motors (like today's SI, PI and MI motors). In stand-alone mode, these are set up once and then react independently to digital and analog input signals and output information about operation and malfunctions via digital outputs.

Drive Assistant 5 has been completely redeveloped and is therefore 'all of a piece'. This also affects the installation time, which has been greatly reduced. In addition, the duration of data transmission for the parameterization is significantly shorter. This is mainly because positioning, speed and current modules are already integrated

in the MCP motor (Quickstart Plus). Thus, only a small amount of information has to be transmitted.

Even the design of the drive assistant has been redesigned. Where appropriate, a graphical view has been added and windows can be faded in and out as needed, to show only the information that is required. For the succeed of the operation and without having constantly consult the documentation, additional information are displayed in the corresponding boxes.

Like the MCP firmware itself, the Drive Assistant 5 software has been designed in a modular way, so that extensions can be made at any time. In the future, functions such as predictive maintenance, data analysis or auto-tuning will be easily integrated into the Drive Assistant.

Flexible Software

Flexibility is becoming more and more important for customers. The keyword 'mass customization' is on everyone's lips. The term is a mixture of 'mass production' and 'customization'. Production must become increasingly flexible, because the products are also becoming more and more individual. There is an increasing need for drives, not only to perform a single function throughout the entire product life, but also to be able to flexibly perform different motion sequences when manufacturing different products.

Accordingly, the software must also be flexible. Even in the early days of intelligent motors, they had an interface to a higher-level computer. This enabled the motor to execute a wide range of commands received from a central intelligence, e. g. a machine controller. The central intelligence was flexible and could bring about the most diverse motion sequences.

In the meantime, motors have their own intelligence and a higher-level control system can be completely dispensed with. This intelligence, and thus the flexibility, come from the software inside the motor. During the changeover to MCP, Dunkermotoren attached particular importance to flexibility. It is possible that motors can be programmed in a complete different way and adapted to new requirements at any

Michael Burgert | Product Manager Brushless DC Motors

time. A nice side effect for the customers is that they have lower storage costs. Service technicians must keep less material available because the respective motors do not have a fixed function assignment but are not assigned to a function until commissioning. A motor can be adjusted for a wide range of applications. But what makes the motors so flexible?

On the one hand, the flexibility is based on the modular firmware, which allows extensions without any problems. On

the other hand, two new features were introduced: Quickstart Plus and free programming of MotionApps. This allows to implement simple parameter adjustments or completely autonomous programs with PLC functions.

Quickstart Plus

Isn't it super convenient to switch on a switch and the motor runs, regulated, at a constant speed? Another fixed speed is set with another switch. If required, the speed can also be adjusted via an analog voltage. One of the most successful products of Dunkermotoren, the SI Motor, already works in this way today. Many hundreds of thousands of these motors are already driving customer applications.

Of course, Dunkermotoren also serves wishes that deviate from the standard. These are, for example, more than two fixed speeds, digital outputs that switch when events are combined, or the customer specific assignment of digital inputs to certain functions. So far, either firmware adjustments were necessary, or motors were used with more powerful processors, such as PI or MI motors.

With the MCP, the Quickstart Plus feature was introduced, which allows customers to make adjustments themselves. Digital inputs can be freely assigned functions. Thus, a fixed speed can be assigned to a combination of digital in-puts, to the next combination a position and to a further combination a maximum current, thus limiting the torque of the motor. Thus, with a simple and very cost-effective motor, standard functions are possible now, which were previously reserved only for programmable motors of Dunkermotoren.

Example: To lift castings in a foundry, a BG motor is started via digital inputs in speed mode. A cable winch driven by it unwinds a steel cable with a hook, until the hook can be attached to the casting. When the hook is attached, the rope is tightened in the current control mode with a certain force, which is set so that the casting is still on the ground, but the rope is taut. Now it is possible to check whether the hook is really tight without lifting the casting. Thereafter, with a further digital input combination, a relative positioning can be triggered, which lifts the casting to a defined height.

This complex function would have been possible in the past only with a specially programmed motor. When using Quickstart Plus, this can be done by the simplest regulated BG motor by default. The parameters and the assignment are set by means of the Drive Assistant 5 commissioning and service software.

Not only the inputs can be freely configured, but also the outputs. There are a variety of deviations from normal operation, e. g. 'peak current exceeded', 'contouring error', 'overtemperature', 'undervoltage'. Not all of these states need to be displayed in each application. If, for example, the supply voltage of a motor is intentionally switched off, the detected under voltage should not be interpreted as an error. With Quickstart Plus, one of its standard function in the new generation of motors, you can freely choose which states are interpreted as faults and which ones are tolerated. The error message can then be assigned to any digital outputs.

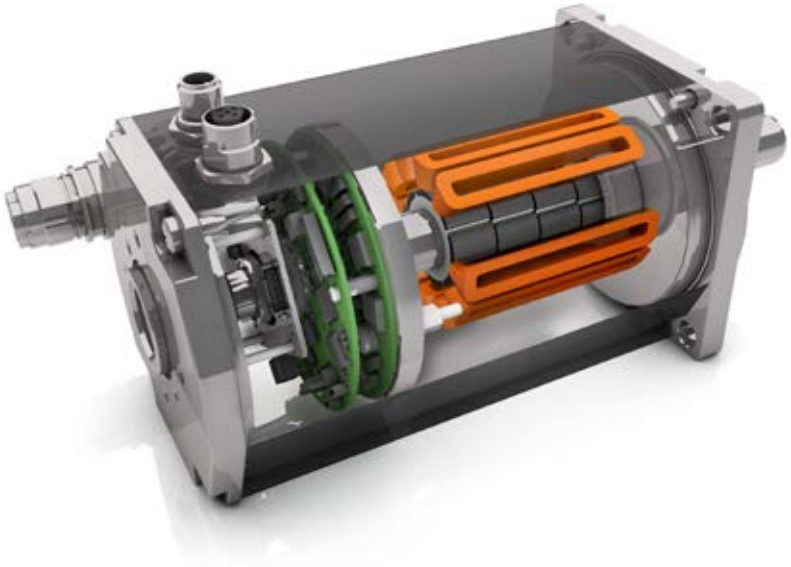
Quickstart Plus makes even the simplest motors very flexible. If even more flexibility is required, or if the motor has to carry out complete tasks autonomously, MotionApps offer the right conditions for doing this.

MotionApps

MotionApps are tools for motor programmers like stonemason's hammers and chisels are tools for stonemasons. MotionApps allow the functions of motors to be completely customized. Shall the motor rotate 4.5 turns counter clockwise every full hour? Shall it calculate a braking profile based on the weight, length and speed of an object that comes to rest exactly in the middle of a driven belt? Shall it control a complete packing station including some sensors, belts and other auxiliary motors? This is all possible with MotionApps.

MotionApps are sequential programs for motors that a programmer writes for specific customer applications. He can rely on a huge stock of motor parameters, calculating functions and logical links. He can program sequence loops that are interrupted under certain conditions, define tables that specify which action has to be performed under which conditions or send commands to other devices and receive feedback from these devices.

With so much freedom in programming, mistakes can sometimes happen. It can happen that the motor stops or suddenly changes its speed when the programmer would just not have expected it. A so-called 'bug', i.e. an error has crept into the sequential program. Therefore, the development environment in which the MotionApps are written provides the so-called 'debugging' tool. This means



that the sequential program can be stopped at any time and the parameters read out. In this way, errors can be detected and corrected comfortably and very quickly.Even if many BG motors with integrated electronics look almost identical after more than 20 years, their interior can no longer be recognized. In addition to completely new electronics with a powerful processor, the motors feature software functions that would have been unimaginable 20 years ago.

Author: Michael Burgert I Product Manager Brushless DC Motors

Locations

Subotica – Center of many Dunkermotoren employee's life

Subotica is located in the northern part of the Republic of Serbia, just few kilometers from the Hungarian border. The city is situated between two rivers: Danube and Tisa. What attracts people around the globe to this unique city are rich cultural heritage, ornate buildings and multicultural spirit which all combined gives this amazing city its own charm. Subotica is known for its friendly people, good food and quality wines. The city and its neighboring Lake Palic offer many interesting activities such as film festivals, salas which are farms typical for the northern part of the country, horse-farms, forests, hunting areas, lake activities, running and bike trails, sports events and much more.

Subotica was first mentioned in the written document on May 7, 1391 by the name of Zabadka. It is also believed that the settlement is much older than that. The city has changed its name several times since its first mentioning to Sobotka, Sancta Maria, Maria Tereziopolis, Szabadka, to its final and today's name, Subotica, in 1918.

Throughout the history, many migrations brought people to this city. This is why the city has been a melting pot of over 20 nationalities such as Serbians, Bunjevci, Croatians, Hungarians, Germans, Slovaks, Jews and others. The diverse population gives this city one unique appeal, reflected in many attractive churches, remarkable architecture and assorted food.

The City Hall – a Masterpiece of Art Nouveau is the largest and, to many, the most beautiful building. The building was designed by Budapestian architects, Marcell Komor and Dezso Jakab. It was built from 1908 to 1910, and decorated for two more years thereafter. The City Hall was built in the Hungarian Art Nouveau style with patterns dominated by flowers. This blend of art and craft beauty spreads a full 76 m in height and has an amazing view which can be seen from the building's own observation deck with its 276 steps which you can climb and see Subotica from 'bird's eye perspective'.

Raichle Palace is another striking building. Built in 1904 by the architect Ferenc Raichle to be his home and his design studio, the Palace is in the city center. Expensive materials, the unusual combination of colors, the

vibran-cy of forms, the lavish interior and the backyard make this luxurious house an exceptional example of the Art Nouveau architecture. At present, it hosts the Modern Art Gallery 'Likovni susret'.

Today, Subotica and its surrounded municipalities have about 150.000 inhabitants encompass of the city itself and its own 18 settlements. Due to its superb geographical position, currently, Subotica is considered a center of industrial, administrative, tourist and transportation leader in the northern part of Vojvodina.

Only few short kilometers away lays The Lake Palić. It is located 8 km from Subotica. One of the legends says that the lake is

Lake Palić

Raichle Palace

rest of Pannonian Sea, while the other one states that the lake was established by shepherd Paul's tear who pastured his flock.

The town of Palić is an extension of its neighboring city's remarkable architecture. Outstanding facilities from the beginning of the 20th century: The Water Tower, The Grand Terrace, The Women's Lido and The Music Pavilion are just few of the noteworthy buildings. Palić also charms with its parks, the well-known lake and its peace and silence make Palić an ideal space for rest and relaxation. These are one of the reasons why so many tourists find it an exceptional vacation spot.

Palić provides high category hotels, regenerated luxury and comfortable villas in the so called 'Palić style', several lodgings and private boarding houses. Additionally, there are excellent restaurants and cafés, wine villas and tours, sport and recreational fields, three arranged beaches, a thermal pool, a zoo, cycle lanes, walking paths, a set of versatile events and much more.

Author: Biljana Kovacevic I Marketing Analyst Ametek d.o.o. Serbia

Social Responsibility

Dunkermotoren moves an entire city!

A weekend full of sporting events, health tips and above all fun.

The days from 6 to 8 July 2018 in Bonndorf, where Dunkermotoren succeeded in moving young and old, can be summarized in this way. A variety of highlights, such as bicycle tours or a fun tournament ensured that numerous inhabitants of Bonndorf and the surrounding area united to form a community. Although the fun was clearly in the foreground of the event, the renowned benefit event also supported projects in the region. The proceeds from the participation fee, donations and subsidies from the Dunkermotoren company will be used this year for youth work in the local clubs of Bonndorf. They were also actively involved in the sporting weekend.

On Friday afternoon, all inhabitants were present when the referee opened the soccer match between the trainees of the HeDu apprenticeship cooperation and the trainees of the Mesa Parts company. Sports enthusiasts were then able to prove their footballing skills at the tournament. The family bike tour on Saturday morning was particularly popular, the approximately 30-kilometer-long route of which started after a joint breakfast on the sports field in the direction of Lenzkirch. The athletes could recover from the efforts of the innumerable activities on the so-called health day, at which various health insurance companies were represented and offered insights into health training. A sports car with a bouncy castle and children's make-up made sure that even the youngest ones felt at home. Meanwhile, the big guests could indulge themselves with culinary delicacies such as coffee and cake or grilled food. At the end of the successful weekend on Sunday everyone started sweating again. While the little ones could really let off steam at a children's Olympics or a mini triathlon, sports enthusiasts adults were able to show off their skills again at a triathlon. The athletes had to master almost 15 kilometers running, cycling and swimming in the Bonndorf outdoor pool, individually or as part of a team.

Despite the efforts and the sweat that the participants had to muster this weekend, the event was again a complete success for Dunkermotoren as well as for all participants.

Author: Nina Zoller | Human Resources - Apprenticeship Affairs

Doing good things together

Together with the hunter's association registered it was possible that Dunkermotoren sponsored three therapy bikes worth 6.000 € to the Wutach school in Tiengen. With the custom-built bikes, the mobility can be encouraged and conjures a smile on the kids' faces.

How did this sponsoring come around?

1st Bike:
Our Director Human Resources Renate Heizmann received a letter from the pediatrician of Bonndorf Dr. Christian Spitz. He asked for a donation of a therapy bike for the Wutach school in Tiengen. The bike would be of high importance especially for the pupil Jeremy Kupka from St. Blasien as it would encourage his mobility. The management from Dunkermotoren agreed to this great project and was immediately willing to bear all the costs of the bike for Jeremy.

2nd Bike:
CIP (Continous Improvement Process) Teams of our company (four teams of the GR production, two teams of the gearbox production and one team of the tool shop) were immediately willing to donate their money which they received through CIP suggestions for the second therapy bike. The amount of the CIP suggestions was increased to the cost of the second bike by the management of Dunkermotoren.

3rd Bike:
Klaus Wildemann (Director IT department) received an inquiry from the pupil Samuel Mauch if he and three other classmates could implement a technical school project together with the company. Whereas the drives of the shooting range of the hunter's association Hochschwarzwald were legacy, Klaus Wildemann hit on the idea to renew the shooting range with drives of Dunkermotoren. So, Samuel and his classmates developed together with apprentices from Dunkermotoren, a new pressure drive technology and installed it to the shooting range. The hunter's association was very satisfied and donated 2.000 €, which were donated to the Wutach school in Tiengen.
In July 2017, the involved parties participated in the handover of the donation to the school and the presentation of the first bike. The highlight of the event was that Jeremy Kupka could try his new bike the venue. You could see the immense joy in his eyes.

Author: Nina Zoller I Human Resources - Apprenticeship Affairs

dunkermotoren

Who or what's the Wutach school?

The Wutach school in Tiengen is a special educational and advisory center with the focus on supporting, physical and motoric development of children.

It's an elementary school with five school years. It offers all educational programs which can be fulfilled by pupils with a physical handicap at this age. Depending on the individual abilities and skills, the curriculum can be adapted to the one of the elementary school, the special-needs school, or the school for mentally handicapped pupils. In the building of this school, there's also a school kindergarten integrated. This school kindergarten is a preschool institution for children at the age from two to six years, which have special educational needs due to a physical or multi-handicap or a psychomotor development delay.

Also, an early intervention is offered by the Wutach school. Early intervention is an offer of assistance for handicapped, handicapped threatened and development delayed children. It is only performed with the accordance and collaboration of the parents.

With the early intervention, the individual special educational needs are diagnosed and according to this different assistance and therapy methods are used, as e. g. linguistic consultation assistance, assistance of fine motor skills and perception or supporting the mobility and motor skills with young children swimming. The whole family gets advised and accompanied through attendants, educators, and teachers.

Author: Nina Zoller I Human Resources - Apprenticeship Affairs

In 2018 Dunkermotoren gains again a price with its apprentice ship cooperation HeDu: The first IHK educational award 2018

In 2018, this apprenticeship concept was prized with the IHK educational award 2018 for the first time on a federal level. In the category medium-sized and large companies Dunkermotoren and Hectronic won through more than 100 other companies. Every finalist presented itself in a short video to a 400-headed jury existing of the IHK honorary office. Afterwards the audience jury decided about the winner of each category via TED procedure. The price money of 6.000 € will be donated to a non-profit organization. The managing directors Uwe Lorenz (Dunkermotoren GmbH), Stefan Forster and Eckard Fechtig (Hectronic GmbH) as well as the training supervisors of the companies Nina Zoller, Andreas Koliska (both Dunkermotoren GmbH) and Alexander Ebi (Hectronic GmbH)

were obviously proud of the award and the thereby appreciated work.

Author: Janina Dietsche I Marketing Public Relations

Apprenticeship

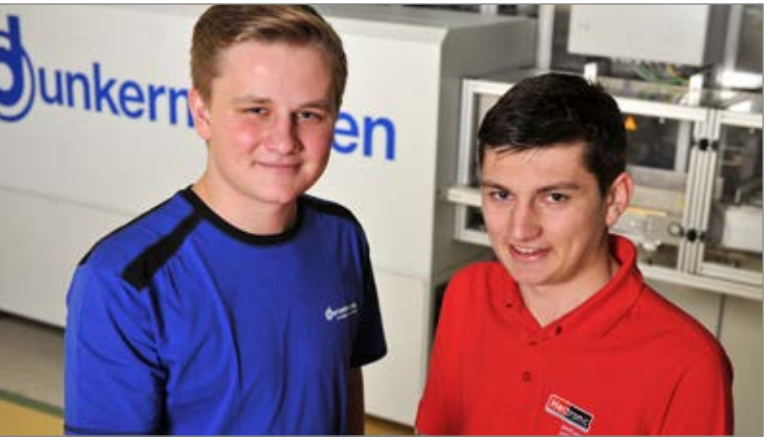
HeDu apprenticeship cooperation - Together into the future

HeDu is an apprenticeship cooperation which was initiated at Dunkermotoren. HeDu stands for the companies Hectronic and Dunkermotoren which are neighbors in the Allmendstreet in Bonndorf.

The apprentices of both companies gain from the knowledge of the neighbor company. Training content as well as training units are included for several weeks in the neighbor company. In this way, the apprenticeships in both companies is more valuable as the normal apprenticeship because it's enriched by the core competence of both companies: Mechanic meets electronics.

With this cooperation, the HeDu apprenticeship days were implemented. Since 2009, these days take place every year. For the first HeDu apprenticeship days both companies needed to canvass to convince especially schools from the importance of our locally apprentice ship days and the uniqueness of the apprenticeship in our companies. In the beginning the apprentice ship days took place in the buildings of the companies. The pupils got the chance to know the companies locally and experience close to the action which job fits for them. Meanwhile the high information content of the venue got around so that both companies could welcome about 700 pupils from surrounding schools this year. The pupils experienced how many different possibilities for their job are available around the corner. The apprenticeship days developed to a venue where in 2016 not only the founder companies (Dunkermotoren and Hectronic) took place but also other surrounding companies. With the support of many companies from Bonndorf a wide range of different apprenticeship opportunities from different branches e. g. craft, trading, social affairs, and service could be presented.

This concept was very successful and in 2017 the days were expanded and the venue was relocated to the town hall in Bonndorf. Beside numerous booths where the pupils could inform their self about the different job descriptions, there were also workshops and company tours offered. The companies were presented locally and the visitors could experience the everyday working life. Many exhibitors offered practical tasks so that the visitors could directly do it and demonstrate their abilities.



The offer was topped off by the participation of different high schools, vocational schools and universities. Also, pupils who do not have any specific plans for their future yet, were supported by professional careers consultants.

Every visitor of the HeDu apprenticeship days received a certificate of attendance, which can be used to upgrade their application. Meanwhile 90 percentage of the applications which are sent to our company include this certificate of attendance. This shows: It's the right way!

Author: Nina Zoller I Human Resources - Apprenticeship Affairs

Engineering

BG motors with field-oriented control

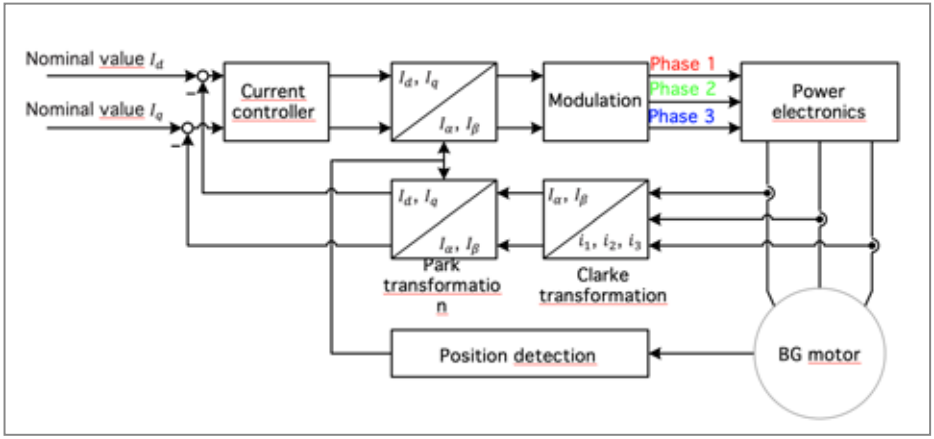
The integration of the power electronics in a brushless DC motor (BG motor) not only enables the control of the motor in a very simple and elegant manner, but also offers a large variety of control algorithms that can be implemented. The state of the art is field-oriented control (FOC), based on the mathematical description of the motor and the conversion of alternating quantities into direct quantities. The FOC offers advantages for power electronics, improves the dynamic behavior and delivers optimum torque.

From the control engineering point of view, the FOC is comparable to the control of a brushed DC motor. The typical behavior of a brushed DC motor (GR motor) is achieved by decoupling magnetic flux and torque. The basic concept of the FOC is the consideration of temporal momentary values. Thus, the electrical alternating variables of a three-phase motor are not treated as fixed in space but rotate with the rotor. This means that the three phase currents measured at the stator are converted into rotor coordinates. Since the reference system is static, the controller can operate with direct current quantities instead of alternating quantities.

The direct quantities are divided into a field-forming (d) and a torque-forming (q) component. Since the magnetic flux in the air gap is generated exclusively by the permanent excitation, the stator currents have virtually no flux-forming components. Due to the surface magnets of the rotor, the setpoint for the field-forming current (I_d) is set to zero. The output of the current controller represents the reference voltages in the rotor coordinates. To control the three-phase stator current, the FOC algorithm generates a three-phase voltage vector. The basis for this is the conversion of the rotor fixed d/q values into stator fixed α/β values. The conversion of the physical current into a rotation vector using the Clarke and Park transformations turns the torque and the magnetic flux into time-independent variables. An extended proportional-integral (PI) controller with the proportional gain and reset time parameters is used as the control algorithm. These parameters depend on the motor inductance, the winding resistance and the complete signal processing chain.

Dr. Bruno Basler
Head of R&D Predevelopment

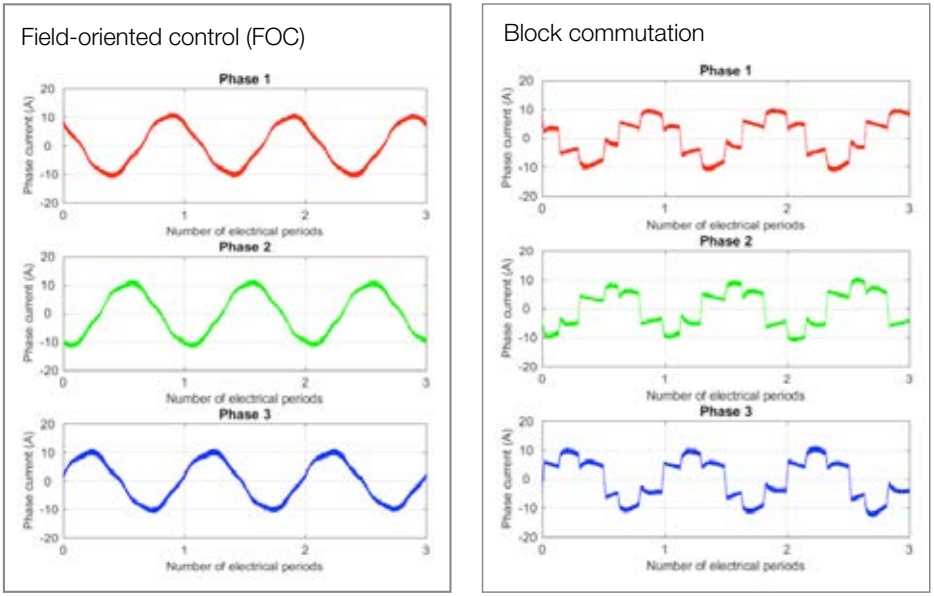
DC motors are designed in a way that the magnetic flux in stator and rotor are offset by 90° to each other, whereby the motor generates maximum torque. FOC technology transforms motor currents into two-axis vectors that are comparable to those in a DC motor.



The process starts with a measurement of the three phase currents of the motor (i_1, i_2 and i_3). Because the sum of the three current values is always zero; in practice only two of the three currents are measured and the value of the third current can be calculated from the obtained measured values. This appears in an immediate reduction in hardware costs, as only two current sensors are required. With the information of the stator currents and the rotor angle, the values are transformed into a coordinate system in order to calculate the polar coordinates, consisting of magnitude and angle. This means that measured motor currents are mathematically transformed from a three-phase static reference system of the stator winding, into a rotating reference system. The rotating system consisting of the d and the q component can be processed very easily by a PI controller. Similarly, the voltages to be applied to the motor are mathematically transferred from the d/q system of the rotor into a three-phase reference system. If a sinusoidal input current is supplied to the stator, a rotating magnetic flux is generated. The speed of the rotor is directly related to the rotating magnetic flux.

With the aid of pulse width modulation (PWM), the magnitude and angle values are converted into three-phase currents by controlling the inverter's high and low-side switches accordingly. With the FOC method, the PWM signals of the modulation are fed sinusoidally to the three-strand winding of the motor. Due to the basically finite switch-on and switch-off times of the power semiconductors, their control signals are artificially delayed in order to not to cause a bridge short circuit when switching between positive and negative DC link voltage.

Field-oriented control requires a relatively long computing time, since the rotating va-



Comparison of control modes using the example of a BG65Sx25 24 V

riables must first be converted before they can be used in the control loop and then the actuating variables must be converted back. The disadvantage here is the high computing effort for the microcontroller, whose performance limits the dynamic behavior of the closed-loop control. However, with the FOC it is possible to control separately torque and flow. In this way, BG motors have the same advantages as DC motors. Compared to direct current control, field-oriented control enables a higher voltage utilization and reduces current proportional losses for the same power. Thus, this method enables better efficiency than direct current control.

Compared to block or trapezoidal commutation, the FOC generates a maximum torque that is better aligned to the rotor field. The efficiency can be increased by the sinusoidal voltages and currents of the FOC. The transitions between the stator states are homogeneous, which eliminates the torque drops during block commutation and improves the dynamics of the overall system.

Author: Dr. Bruno Basler I Head of R&D Predevelopment

“What exactly is a Servo motor?”

“Dad, where do the babies come from?” Do you know what to answer here? But this is not the only question. The following one can even be an inconvenience for specialists: “What exactly is a Servo motor?” And indeed, there are different definitions of what a servo motor exactly is. In this article, we try to outline several terms around the topic servomotor.

The term 'Servo' comes from the Latin word 'Servus' that means slave[1]. 'Motor' comes from the Latin 'moto', 'I move'[2]. Even if the origin of the term 'servo' is unattractive, it seems to fit perfect to a diligent servant that fulfills his tasks unconditionally.

If there were no further requirements, this definition would also include an unregulated belt drive or a simple blower motor. But this is not the case.

In general, a servo motor is meant as a motor with at least one controller or rather a feedback possibility about their rotational or linear position. Below there is a definition from the literature and the internet:

- Servo motor (drive technology): servo motor, servomotor. A random drive system with good controllability[3].
- A servo motor is an electric motor that is power-, rotation speed-, and/or position regulated. The motor enables the configuration of predefined currents, rotation speeds and/or rotation angles[4].
- Defined as a servo motor is a specific kind of electronic motors that allows the regulation of the motor shaft´s angular position, the rotational speed as well as the acceleration. It consists of a motor which is additionally equipped with a sensor for positioning. The determined rotational position of the motor shaft, which is defined by the sensor, is transmitted continuously to a controller that usually is mounted outside the motor. This so-called servo controller regulates the motion of the motor according to one or more adjustable target points – e.g. target angular position of the shaft or set rotation speed – in a control loop[5].

The so-called 'servo' which only describes the model construction servo, and adjusts a predefined rotational position is excluded from the term servo motor in most of the cases.[6]

'Servo motor' therefore does not only describe a specific motor type, but it can also describe diverse types of motors. Even electrohydraulic or electro-pneumatic motors are partly named servo motors (in contrast to the definition of Wikipedia). For this article, only electronic motors are defined as servomotors.

Permanent magnet synchronous motors, asynchronous motors and brushed direct current motors are very popular as servo motors. But for these motors, there are also several terms that are used differently. Here, we give an overview list of frequently used terms and their explanations:

AC and DC Servo motors

An AC motor is defined as a motor that operates on supply voltages generated through rectification of an alternating (AC) voltage (single-phase or three-phase). This are usually direct currents from around 230 VDC up to 600 VDC. In contrast to this definition, DC motors are defined as servo motors that can operate directly on low-voltages up to 48 VDC.[7] A statement about the motor type based on this classification is not possible. According this definition, permanent magnet servo motors are used as AC as well as DC synchronous motors. Asynchronous, as well

as reluctance motors, are primary used as AC servo motors. Permanent magnet- or separately excited brushed direct current motors are used as DC servo motors.[8] Even if it does not seem to be useful in the first moment, the market also provides stepper motors that enable a position feedback and therefore can be offered as DC servo motors.

BLDC and EC Servo motors

From a technical point of view, BLDC (Brushless Direct Current) and EC (Electrically Commutated) servo motors are permanent magnet servo motors. These terms are still connected with small, block-commutated motors that operates in low-voltage ranges. Nowadays, the BLDC labelled EC motors are mostly driven field-oriented, so that they provide the same standards as the 'AC-Servo' in terms of dynamics, noise characteristics and energy efficiency.

Servo motors, Servo Amplifiers and Servo Drives

Many motors offered as servo motors, cannot rotate on their own because there is no integrated servo amplifier. Only servo motors with integrated servo amplifier can regulate their torque, rotational speed or position without external components after connecting to a supply voltage in servo operation. This works via a bus interface or via digital or analogue inputs.

In common usage, it is generally accepted that motors which need an external servo amplifier are also named as servo mo-

tors. Those still represent the biggest part of the servo motors. The combination of motor and amplifier is labelled as servo drive.

Dynamic

Are all servo motors highly dynamic? Many definitions of servo motors do not discuss that point. But if people think about a servo motor, they expect a highly dynamic drive. Mechanical time constants like – the duration of stops until 63% of maximum rotation speed without load – are one to a few milliseconds. A high dynamic is achieved through several factors. Besides a high flux density and a low rotor inertia, the servo motor needs to be attuned to the motor winding to be able to operate highly dynamically.

Motor Feedback

For a long time, resolvers were like art for motor feedback systems of servo motors. But with the digitalization, magnetic and visual systems with digital output signals are on the rise. Here, it is important that the feedback system selected fits to the servo amplifier regarding the robustness, accuracy and interface. Motors with integrated feedback system and servo amplifier have the advantage that the feedback system automatically fits to the controller.

Now you can at least answer the question what exactly a servo motor is. The question with the babies will you solve on yourself. With this in mind: 'Servus!'

Author: Michael Burgert I Product Manager Brushless DC Motors

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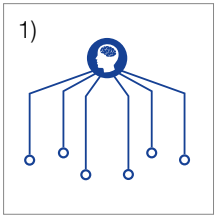
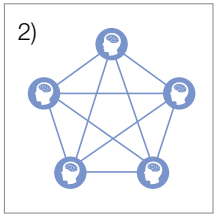
Interconnected motor technology – decentralized and centralized

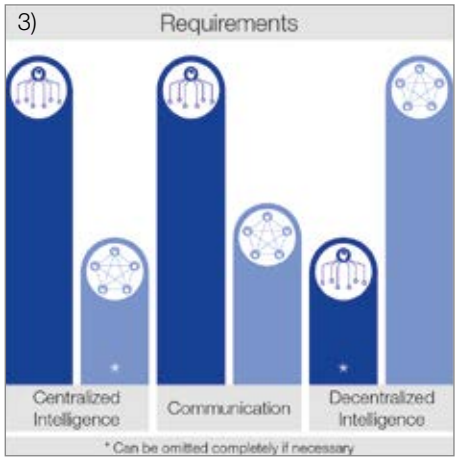
The diligent bees simulate it to us: Every bee performs small tasks autonomously by itself. With smart and little communication, it is possible to organize themselves and compensate errors in the whole organization. Is the decentralized intelligence an example for the interconnected motor technology or rather the centralized nerve system of the living organisms among us, were all information converge at one point, get handled and cause actions? We try to illuminate this questions from the point of view of a motor technology manufacturer.

For the motor, it seems to be clear at first sight: A servo motor just obeys orders. It drives with defined speed, satisfies defined torques and positions as per specification. The superior control working as centralized nerve system looks after everything. Disturbance values are recognized and compensated by the centralized control.

Many current, interconnected systems e. g. production machineries work according to the principle of the centralized system. The advantages are obvious: the programming takes place via a centralized system and







the debugging is also at a centralized place. Also, when a superior entity e. g. an ERP system needs data from the latest production or needs to transfer information, there's a centralized place where information gets exchanged.

Mirrored to the centralized nerve system of a living organism e. g. of a mouse it means: Organs are centrally controlled, muscles for movement are activated, eyes, ears and skin monitor the environment. The brain looks after subordinated tasks as breathing and the heart beat but also after more complex tasks as e. g. the escape from an enemy.

A beehive would not work according to this principle. Hundred different decisions as e. g. 'Should I either fly to the red flower field or to the yellow one?' or 'Are we 20 bees able to chase away the hornet?' would need to be decided from a remote brain. Therefore, the communication lines are too long and the tasks are too complex to transfer them with simple communication tools to the bees.

Did we already find the answer that decides if a decentralized or a centralized system is the right one? So, the following would apply: Stationary systems – centralized; versatile systems – decentralized?

It is worth taking a closer look. Would the bees have a 5G mobile connection to a centralized 'brain', they could pass decisions and need less intelligence. Conversely, the heart, stomach, lungs and muscles of a mouse would have their own intelligence. So, the centralized nerve system could have taken the pressure of for simple tasks. The nerve system could focus on more complex tasks ask e. g. to search for food.

In nature as well as in motor technology the following applies: With an effective communication between centralized intelligence and components, the components need less intelligence. But if the components are intelligent, the communication can be easier and the centralized intelligence is relived or can be completely omitted.

If you look at the motor technology market, you will recognize that there is a choice: there are powerful centralized systems with an effective communication to the motor components. On the other hand, there are intelligent and powerful decentralized drive systems available. Both solutions can easily be implemented and put into operation. The following criteria are important when deciding a centralized or decentralized system:

Complexity of the task

The low cost of processor power allows simple decentralized drive systems to become intelligent systems, so that a variety

of little to medium complex tasks can be performed without a superior control. They read analog and digital data from sensors and communicate with each other. Tasks are distributed among the motors. Settings are done with a human-machine-interface (HMI). Many packaging machines, test equipment and special machines meanwhile work without a superior control. Every component of the machinery monitors itself. The communication can be reduced to a minimum. Economic classic fieldbuses are enough for communicating among each other.

For more complex tasks, e. g. in case of many machinery parts are interconnected, and there are high requirements to synchronize – the inventory to centralized machinery control is worth it in most of the cases. But also in these cases it can make sense to implement decentralized components for autonomously performed processes. One example is a solar thermal energy machinery: the permanent adjustment of single mirrors can take place completely decentralized.

What is used up to now?

Pragmatic reasons often decide if a machinery is constructed centralized or decentralized. A system is well-known and the design is oriented towards the existing one. So, the new system will be constructed similarly. An engineer understandably doesn't like to study the communication types and system architectures for every new machinery concept. Especially in times of full order books companies are more focused on a quick implementation than on the perfect solution. This is clear. Nevertheless, it can be worth it because the total costs are not always obvious.

System cost

The system costs are hard to define, because some of the costs are not visible or economic solutions can bring high follow-up costs with it. Here are two less obvious but nevertheless relevant cost factors:

- Electric cabinet: How much space is needed inside the electric cabinet? Which dimensions are needed for it? Here a decentralized solution can be the right one. In decentralized solutions, heat loss is also distributed and therefore does not require forced cooling.
- What seems to be the most reasonable solution at first sight, can turn into a bottomless pit if the entire system isn't taken into consideration from the beginning. Are all the components for the planned system available? Are the components needed which cannot be implemented directly into the network? Depending on this it is possible that expensive gate ways need to be sour ced or to do sophisticated special programming.

How is Dunkermotoren as a motor technology manufacturer prepared?

Prepared for both parts

With regards to the connection, Dunkermotoren is prepared for both parts. Motors of Dunkermotoren can be implemented in centralized architectures as simple slaves and can also perform decentralized tasks. In both cases a monitoring of motor functions and the protection against permanent damage takes place in each motor. That makes sense. Every motor knows its characteristic and knows how overload situations can be tolerated. Hardware and software protection mechanisms which are directly mounted

in the motor can enable the motors to be used to their physical capacity, without being damaged.

Dunker motors speak several of the most important communication languages. At the moment are included, CANopen, Profibus, Profinet and EtherCAT. As with the most of the component manufacturers, Dunkermotoren needs to face the babble of diverse fieldbus and industrial Ethernet communication. To join in the centrally steered communication systems, Dunkermotoren needs to implement the respective interfaces. Dunkermotoren is the same as many other component manufacturers, we are looking forward to having manufacturer-independent standards.

Interconnection of the future

Dunkermotoren asked themselves how motors need to be interconnected in the future, both in decentralized and centralized solutions. It is not enough just to say that all common fieldbus, industrial Ethernet and all wireless standards need to be covered. The question is which data to which place and how quick must be transmitted. Topics like predictive maintenance, cloud-based application analysis, remote service and pay-per-use will be very important. In these cases, data needs to find its way from the machinery to a cloud or directly to the manufacturer. It remains exciting, if Ethernet-based systems without the accompanied safety risks come to the top, or mobile-communication-based systems without the associated problems of network coverage and cost. In fact, the customer benefit of the so called 'IoT' features are very high if these problems can be solved.

Interconnection and intelligence

With the launch of the BG 65 CI, almost 20 years ago, Dunkermotoren laid the foundation of today's wide product portfolio of decentralized motors. Since then, not only the product portfolio, but has also grown massively the market for decentralized solutions. The market requires more and more complete drives, not only with gearboxes, brakes and high-resolution encoders but also with preferably integrated intelligence. It should be able to recreate the main processes or to perform tasks completely autonomously. With the lower cost and smaller construction per processor power decentralized motors can meet the expectations of more intelligence. This trend will move on. Decentralized motors will not only perform tasks autonomously, they will also collect data from the applications, directly analyze them or forward them to external analyzing tools which are stored at the final customer, the OEM or at the manufacturer. Collecting data currently has negative connotations in the press. But regarding motor data, the end-customer, OEM and the component manufacturer can take advantage because the application becomes transparent due to its use. Thereby, processes can be optimized, new machineries can be designed better and bugs can be found quicker.

No matter if a centralized or decentralized system is implemented, interconnection and intelligence must never be considered isolated. Both the more powerful communication systems and the more intelligent components provide more possibilities in the future. These will move centralized, decentralized as well as hybrid solutions going forward.

Author: Michael Burgert I Product Manager Brushless DC Motors

Application Service – Support from the first minute on

Since the formation of the company, Dunkermotoren GmbH has been living by the motto of supporting its customers after buying a motor solution. 'After Sales' is not only lived by the Sales Department but also in the whole company.

Especially in times of digitalization and industry 4.0 service and service competence is very important. Often, 24 hours production and seven days a week must be ensured without any interference. The principle applies: 'The supplier is the solution provider'.

Not only facilities and end products are becoming more and more intelligent, but also the components within the facilities – e. g. the DC servo motors with integrated logic and power electronics from Dunkermotoren. The major part of the sold motors from Dunkermotoren are customer specific motor solutions that are individually configurated according to the customer's application. Here it is important to not only sell the motor solution but also to give advice, support and to train the customer during his project.

To give a successful advice to a customer project, it is important to think within the customer's application. Thinking about a project from the customer's point of view, makes it possible to identify conceivable weaknesses and sources of error earlier and to define solutions. Only then it is possible to successfully advise on a customer project. It is necessary, to be at the customer's side at every stage of the business process. In the daily business routine, this means intensive communication and cooperation with the customer. This sharing of information is extremely knowledge intensive.

A significant role belongs to the central administration of the customer application. To keep everybody on the same level of knowledge, precise documentation is hugely important. If these conditions are met, an increase of efficiency, regarding a perfect implementation of the application at the customer is possible. 'Not only do the right things, but also do things right.'

Support over the course of time

With the increase in networking, not only in the everyday life of all of us, but also within the industry, many support tasks are not done on-site, but remote. This remote support offers many advantages to the customer and to us as supplier as well. So, it is possible to switch to the customer's computer, whereby many simple errors can easily be solved. With the distribution of the technical support to different Dunkermotoren locations, a worldwide service is possible at any time, despite differences in time. Local technical support offers the advantage, not only to be available at opening hours, but also to communicate in the same language and for bigger difficulties.

Flexibility – a keyword that not only applies to our approx. 15 million drive combinations from the Dunkermotoren modular system, but also to our technical support.

Author: Peter Konitzer I Head of Application Technics Services, Janina Dietsche Marketing Public Relations

Door Automation

Dunkermotoren – The gold standard in door automation

If you are a modern shopping addict who strolls from time to time around the shopping aisles, you are unknowingly accompanied on every step by Dunkermotoren. If you enter in a shopping mall or in a supermarket around the corner the door opens automatically – naturally. Even if you visit low budget markets such as ALDI, doors open automatically, too. If you visit the Swedish Living Expert IKEA you enter the showroom via a revolving door.

But what's unknown to most of the people is that most automatic doors – especially in Europe – are run by just one brand which is in the Black Forest: Dunkermotoren. Over the last four decades Dunkermotoren's most known product – the GR 63 DC-motor – has been established in the market. In combination with market related gears such as SG 80 K, SG 65 K or the latest inventions SG 85, drive solutions have been developed, which are both efficient and compact. Speaking of which, have become over a period, a kind of 'gold standard' in door automation.

Premium Doors rely on Dunkermotoren

Even though standardized, automatic door systems are still a significant investment in buildings, this is especially true for revolving doors, which are always made to measure and built to order. These highly prestigious door systems require extremely high demands in terms of reliability, life time and control behaviors.

The more simple and standardized door systems, such as sliding doors or swing doors also require the same high demands. If someone spends several thousand Euro for such an automatic door system and builds it into his doorway, he has the expectation to receive a product which works for a very long time without any complaints. It is expected that premium automatic door operators perform more than one million cycles as standard, which will be realized by our drives with ease. Reserves in power allow the application to be run under extreme environmental conditions such as the Metro in Dubai, the Maracanã in Rio de Janeiro or the public bus stops in mass transportation system of Monterey, Mexico. For sure these are areas of operation where the frequency of pedestrians is high and the expectation regarding reliability allow no compromise at all.

Safety Doors – Obviously Dunkermotoren

If an automatic door is in use at an escape route, for sure high reliability is requested for the door drive system. To operate in such special door systems both the door drive and the door control system must be adjusted to fulfil the high requirements in terms of reliability. To name just one challenging part, it is required to provide a redundant system to open the door under all circumstances. To provide such redundant motor solutions and/or if requested redundant encoder systems, is no problem at all due to the modularity of the flexible Dunkermotoren system. Another request is to manually open a powerless double winged sliding door, weighing 200 kg per wing. This is no problem, by using highly efficient polymeric gear materials, which can be easily back-driven, even with high efficiency mechanics, such an application can be solved quite easily.

On the other hand – for a fire protection door – the requirements are totally different. The door drive must shut immediately, without fail, to avoid the spread of fire. A robust drive

technology, paired with high quality standards also enables you to solve such highly demanding applications.

Platform Screen Doors – A wide subject for Dunkermotoren

Another market – public mass transportation systems – require more and more higher safety standards for the passengers. This trend, started in Asia when passenger numbers soared, especially on subways and train systems. In Megacities, having several million inhabitants such as Shanghai, Peking, London and Paris, the highest priority is passenger's security. To achieve this, the so-called Platform Screen Doors (PSD) are used to seperate the passengers from the track and platform. These doors open only when the train has come to a full stop.

In Shanghai for instance, a train arrives every two to five minutes every day at each station, during the operational hours from five in the morning to midnight – just to mention one example. The period for maintenance obviously is reduced to five hours while no train operates. As there are up to 30 door installations per platform, maintenance becomes a logistics' challenge.

So, this little example shows already why train operators are interested in a reliable drive solution, operating on a minimal maintenance level. All of this is no challenge for Dunkermotoren, by having an Asian subsidiary, service can be provided everywhere. Specific requirements such as, fire control by using halogen-free cabling which doesn't support fire and smoke distribution is not un-known in these circumstances, and is therefore predestined for the application.

Elevator Doors – High rise with Dunkermotoren

Not just in building exits and entrances, but also inside the building, e. g. on vertical transport systems aka elevators, it is probable that we open the door for you. No need to say that we move telescopic elevator doors in the same way as sliding doors. As the lifetime of an elevator system is linked to a building – expectation is that elevator operates for a minimum of 30 years – the door system in the cabin should operate with maintenance. Beyond the safety inspections, which have to be done on a regular basis, the door system will be problem free, even though the numbers of door's cycles can easily reach six to seven million

cycles over the lifetime; so a robust and long living system is essential.

Safety Solutions – with Dunkermotoren for granted

Besides the task of entrance control, controlling building access is becoming more prominent in discussions. Both the access to restricted areas and the supervised control of leaving such areas, is requested. The latter is experienced by a lot of people when they are heading back from vacation without knowing that once again Dunkermotoren is highly involved. If you leave the airfield on the airport to the baggage claim, you typically walk through a safety gate. The so-called, flip-flow-gate separates the safety area from a public area. This gate operates as a normal one but allows a pedestrian flow just in one direction. The attempt to return will be prevented by closing doors.

Another place in the airport is passport or boarding control at new e-gates. Some of these gates are driven by Dunkermotoren. And don't forget – even though you may not like it – the access control to restrooms on motorway service stations also operate with Dunkermotoren support.

Dunkermotoren – The entrance to an open world

It is true that Dunkermotoren is present at many places where you enter or leave a building to open the door. By using both high quality components and highly sophisticated solutions Dunkermotoren is the reliable partner in door automation. The experience over several decades is setting the gold standard in door applications.

Author: Matthias Tidelski I Key Account Manager Building Automation

Matthias Tidelski | Key Account Manager Building Automation

Powerful and compact – the new drive solution of Dunkermotoren

Dunkermotoren developed a new drive combination within the modular system due to the requirement of some customers. The new drive solution consists of a brushed DC motor GR 53 with a compact gearbox SG 80 which combines the advantages of a slim motor with a strong worm gearbox.

The well-known market-proven combination of the brushed DC motor GR 63 with the worm gearbox SG 80 has been developed for the door automation for decades. This led to a customized version for the door automation branch. Therefore interference suppression filters were developed and integrated in the GR 63 motor. As a result of this, in a system with customer door controllers, they comply with all relevant standards regarding electromagnetic compatibility. With the same target, the component mounting technology was extended by versions with shrouded wirings. Are available versions with protection classes up to IP 65 in leads design or with customer-specific plugs at the mounted cover. Encoders and brakes of the Dunkermotoren modular system can also be protected from environmental impacts under the cover. To prevent overheating of the motor in peak hours, it is possible to integrate temperature sensors to customer requirements.

Imagine a gas station where many gas pumps are running. Several customers go the cash register to pay – that means the door gets open and closed every ten seconds. To prevent the motor from overheating, the controller regulates with longer door-open times and slower closing speeds. In this way, an overheating of the drive is impossible.

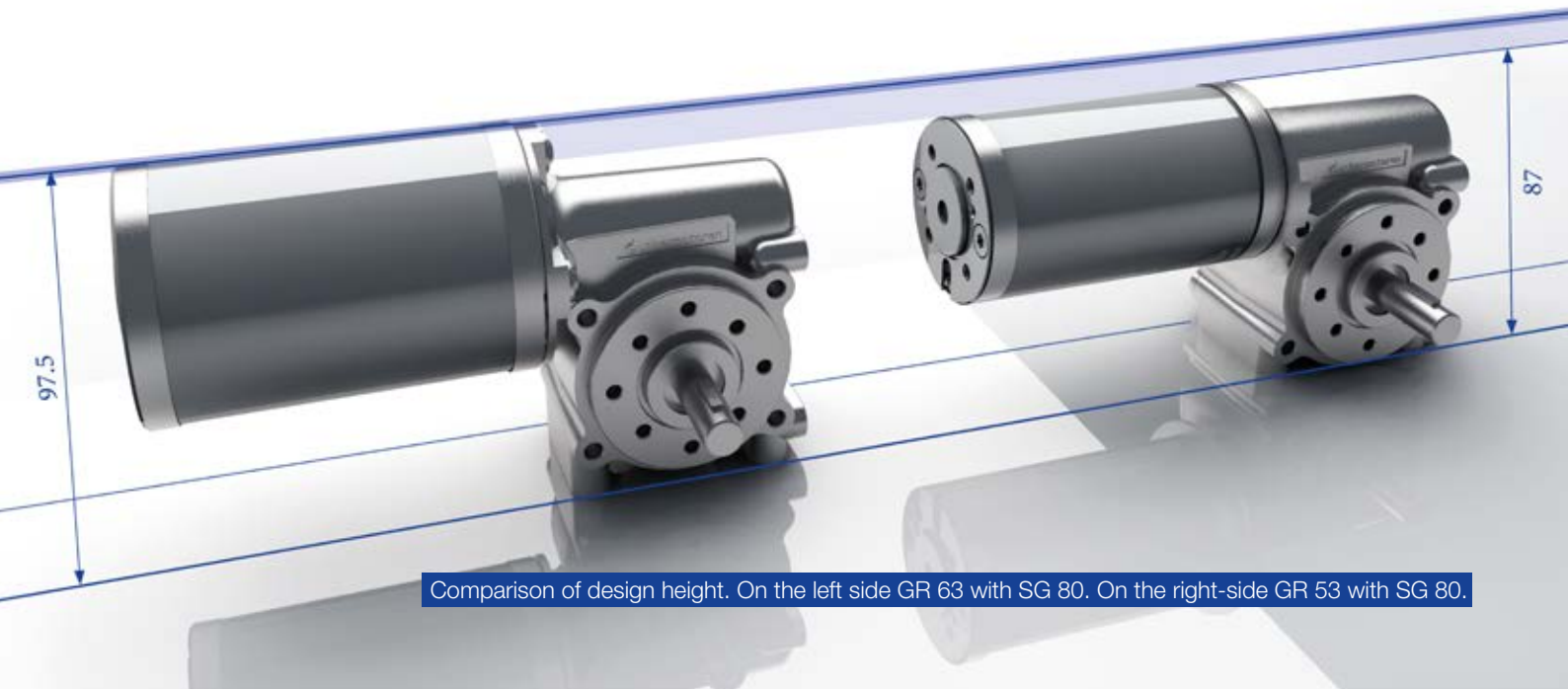
From gearbox-side, the classical worm gearbox SG 80 was developed further to an SG 80K which in the strictest sense is a cross-helical gear for the technicians among us. The combination of materials ensures that the gearbox is lubricated with adhesive grease whereby churning losses in the lubricant disappear. So, no dragging, dynamic seal elements are needed on the shaft. The results are high efficiency, excellent back drive and minimal breakaway momentum. These are the parameters which are significant in door automation – in building doors as well as in elevator doors, platform door systems and also in bus and train doors.

On customer requirement, the aim was to create the same performance in a smaller profile, without increasing the cost. With the new combination of GR 53 and with the more compact SG 80, Dunkermotoren has been successful. So that the motor could withstand the forces of the gearbox reliably, the diameter of the shaft had to be increased from 6 mm to 8 mm, the bearing had to be increased accordingly as well. The trumpet area of the gearbox received a new housing to minimize the installation space, so that it goes perfectly to-

gether with the GR 53. Dunkermotoren relinquished the possibility of foot mounting. The result is a compact, high-torque and highly-efficient drive unit, which can be compared to the peak load capacity of the top dog GR 63 with SG 80.

The variability of the drive goes from varied sizes and supply voltages of the GR 53 up to different shafts of the SG 80 as well as reductions from 5 up to 75 to 1. For sure, this compact cost-minimized combination will also find applications beyond door automation, for example for conveyors or solar trackers. Furthermore, the GR 53 with a shaft of 8 mm, can also be obtained without gearbox for applications where higher bearing force is needed directly at the motor shaft.

Author: Stefan Tröndle I Product Manager Brushed Motors and Gearboxes



Comparison of design height. On the left side GR 63 with SG 80. On the right-side GR 53 with SG 80.

Products

New motor control platform rolls out

Dunkermotoren faces the task of changing the wheels of a train at full speed. Although this is meant only as a symbol, it shows what challenges must be overcome to continue running ahead and to be able to increase speed even further into the future.

The wheels are the software and hardware of a DC servo motor. Without them, no servomotor moves and all functionality rests on it. So, core components are exchanged while demand is high. And here begins the challenge. Backward compatibility must be guaranteed, but at the same time, the drives must have new features, to ensure that they remain state-of-the-art technology over several years. A task that companies repeatedly set themselves. But how did Dunkermotoren solve it?

Dunkermotoren has been developing and producing integrated DC servomotors, based on brushless DC motors for about 20 years. During this time, a variety of functions has been created, developed and optimized. All these existing functions, now called 'features', were examined carefully in a first step. Already this step has made it clear how extensive a new motor base must be. The demands of many hundreds of customers have flowed into previous developments and had to be mapped in a new world. But are all these features still required or can new features replace the original ones as well? How do we prepare ourselves for newly requested features in the future?

This question has led to a new way of thinking. Away from a rigid system that adds one function after another to a modular system where features can be combined when required. This system was not only shown in the software, but also for the hardware. Flexibility came out during development. This resulted in a motor control platform that, on the one hand, reflects all previous functions and, on the other hand, can react flexibly to new requirements.

The latest generation of 32-bit processors were chosen to create a future-proof platform. This allows us to use existing functions, even more effectively and new ones, previously not possible functions, to be introduced. Electronic labels are only the beginning. In addition to the motor data, the labels also indicate the overall data of the whole drive, including the gearbox, encoder and brake. Also, possible in the future are drives with functional safety, many versions of the high-performance Industrial Ethernet or the free assignment of digital inputs and outputs, fast inputs and outputs for encoder signals – fully integrated into the motor housing.

Does the question come to mind, who should pay for it? After all, Dunkermotoren has been synonymous with very economical drive systems. This balancing act was also recognized and incorporated into the platform development. In the future, there will be two types:

dMove – are designed for economic efficiency, dMove drives can control speed, positioning without high-resolution encoders and can assign functions to digital inputs and outputs. Even CANopen communication with profile CiA 402 is possible. On request,

even less demanding communication via an RS 485 interface is possible.

dPro - Customers who want to outsource all or only parts of their PLC functions to the motor will find their solution in dPro drives. dPro drives are also used for interpolation, communication via Industrial Ethernet, jerk-optimized ramps, absolute encoders and high-end motion functions.

The development of this motor control platform has now been largely completed. Talking about the comparison of the moving train, the new wheels were designed from previous experience and future challenges, qualified to the smallest detail, tested and prepared for the conversion. Gradually, all wheels are replaced now. Back to the DC servo motors, this means: At last, the product launch can begin.

Already available is the BG 95 dPro. A very powerful motor with integrated electronics and a maximum output power of 4.0 kW, which offers the maximum functionality with the "dPro" characteristic. It can operate as a slave in the CANopen network, can be controlled directly via digital inputs without a communication interface or, can similarly to a PLC, be freely programmed. The BG 95 dPro has already demonstrated that the concept of the new Motor Control Platform has proven itself in practice. Whether in fully automated intralogistics applications, in electromechanical presses, in mechanical test equipment, in door drives, in special pumps and in many other applications, the requirements could be precisely met.

The next products to be rolled out are BG 65 and BG 66 dMove. These two DC servo motor series have the same size but different output power. BG 65 is around 120 W continuous and 260 W peak line. Due to high-quality neodymium magnets, the BG 66 is in the range of 170 W continuous output power and more than 400 W maximum output power. For the first time, the modularity of the motor control platform has been fully exploited in these series. Both software and hardware modules from the dPro series could be specifically omitted, to bring an easy-to-use and economically very attractive motor into the market.

In the medium term, BG 65 and BG 66 dMove will primarily replace the hundred thousand times proven Dunkermotoren classic BG 65 SI. In addition to the basic functionality, namely the speed control, functions such as fixed speeds, pre-set positions or values for current limitation can be assigned to the digital inputs

in the future with the new "Drive Assistant 5" commissioning software. Since the control is done via the digital inputs, this version is called dMove IO. If even greater flexibility is required, dMove CO motors (CO - CANopen) can operate as a slave via a CANopen interface. If no high-resolution encoder is required, in many cases it is also possible to replace existing BG 65 CI motors.

The modularity does not end with the motor's electronics. Gearboxes, encoders and brakes from Dunkermotoren modular system also turn a DC servo motor into a DC servo drive. The electronics adapts perfectly to the expansion components, protecting the complete drive and the application against critical operating conditions. Sophisticated algorithms ensure that the drives can be overloaded by a multiple of the continuous output power for a certain period, without getting damaged.

This makes, Dunkermotoren perfectly prepared to roll out the new generation of DC servo motors. The customers and the passengers of the train, in full speed, will notice a smooth change to the new wheels of the train and then can drive even more.

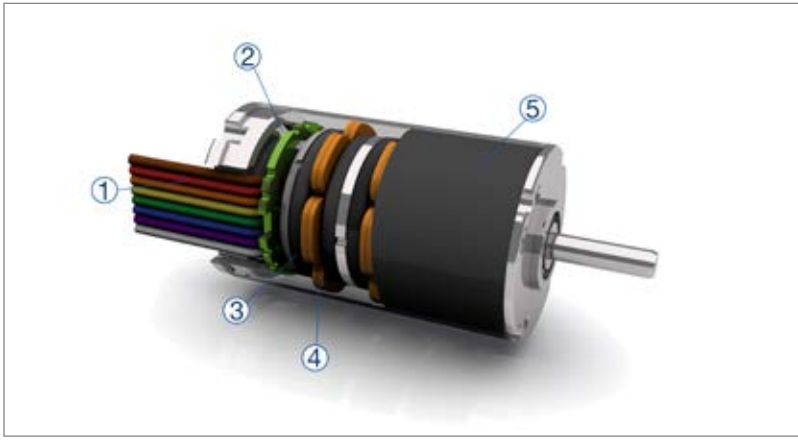
Author: Michael Burgert I Product Manager
Brushless DC Motors

BG 95 dPro

BG 66 dMove

BLDC motor with axial flux principle convinces in small space

You do not hear it, you can hardly see it, even when touched you can only guess at it. What is it? A question that is answered different to fairy tales with a real product for drive technology - the ironless DC motor BGA 22, which is constructed according to the axial flux principle.



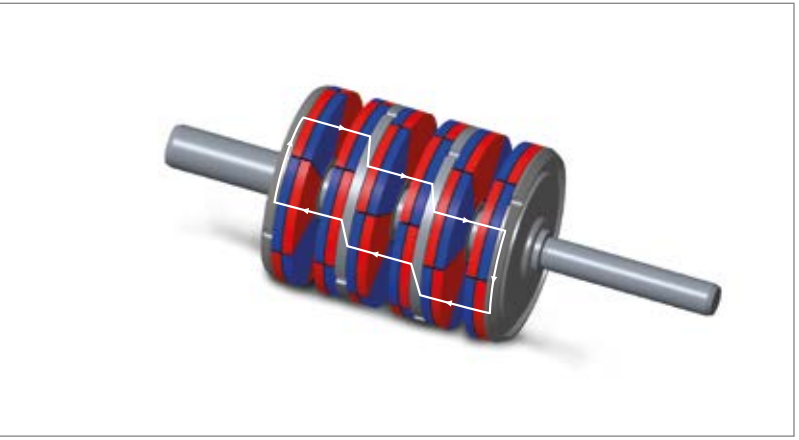
Wanted and found, a motor that combines the demand for high torque with small construction diameter, quiet running and low self-heating. This is the work of Dunkermotoren. The BGA 22 is strong, quiet and hardly heats up even under total load.

The operating principle

In the case of the axial flux motor, the magnetic fields are formed in the axial direction, this means parallel to the motor shaft, while in conventionally built motors, the magnetic field is formed radially. The motor is ironless, cogging and resetting losses are thereby eliminated or heavily reduced. This basic principle is already known from the so-called "Printed Motors", which are used, among others, in consumer electronics. However, in Dunkermotoren several combinations of winding and permanent magnets are stacked one behind the other. The structure is shown in the graphic at the top right. The following plates occur in turns: Pos. 4 - the plate carries the winding for a motor phase and is connected to the housing and Pos. 3 - the plate consists of magnets which are mounted on a steel plate and rotate with the motor shaft. The magnets thus transmit the torque to the shaft and rotate with it. These steel plates form a solid fixation of the magnets on the shaft and allow the rotation of the magnets whereby a rotation of the three winding plates with each other (to form the three motor phases) is no longer necessary, whereby the engine structure is significantly simplified. Because the motor is constructed in three phases, at least three such stacks are needed to get a functional motor. The number of packages with three stacks makes it possible, with a corresponding increase in the overall length, to increase the performance of the motor while maintaining the same construction diameter.

What gives the BGA 22 its power?

Because of the axial flux principle, the housing of the BGA 22 has only the purely mechanical task to keep the motor in its shape. Therefore, the housing itself can be constructed with a very thin-wall. This allows the magnetic plate to be provided with a larger diameter. Different types of ironless motors need



an inference at the external diameter consisting of ferromagnetic material for the radial flux. This reduces the external diameter on which the motor torque is built up. Since the magnetic forces act on a larger diameter in the axial flow principle, a large torque can be generated with relatively little magnetic material. This ensures material savings in terms of sustainable construction and so reduces dependence on raw material suppliers for neodymium and dysprosium. If you are looking for a high-power density, you can choose a type that turns up the motor speed from the existing portfolio and with the appropriate planetary gearbox, reduce it to the desired speed again. The efficiency afforded to the BGA 22 by the axial flux principle, ensures high overload capability in short-time operation.The motor heats up more slowly than the conventionally constructed ironless motors of the same size and shape. The practical benefits become visible when it comes to move high loads at longer intervals. As an example, the lifting and opening of a glazed and thus heavy balcony door from the locking. The motor, which is integrated in the door frame and so limited to the diameter of 22 mm, is thus loaded with three times nominal torque, i. e. approximately 6 Ncm. If one assumes a starting temperature of 25°C, the conventionally built motor reaches the limit temperature of 155°C in less than two seconds in its winding, while the BGA 22 reaches the limit temperature of only 120°C after 30 seconds. The BGA 22 can provide three times the rated torque for 15 times longer and does not reach the limit temperature of the comparable motor of 155°C.

What makes the smoothness of the BGA 22 possible?

There are no brushes in the structure of the motor because the BGA 22 belongs to the BLDC motors. Missing cogging forces and also the missing resetting, enable together with the brushless structure an extremely high level of smoothness. Only the ball bearings and the commutation are noticeable during operation, if only slightly. When integrated into a device, it is difficult for the user to assess whether the motor is operating or not. Theoretically, the BGA 22 has no imbalance. In the field, a small imbalance arises due to manufacturing tolerances. This can be tolerated in some applications, but usually the rotor is fine balanced on specially developed machines. Thus, the motor is low in vibration and gives to its environment e.g. to the housing, which surrounds him, virtually no vibrations. The device remains calm and shows no resonance phenomena even with simple

Stefan Tröndle | Product Manager
Brushed Motors and Gearboxes

block commutation if the speed is varied. In this size, the rarely encountered vector commutation further improves the behavior.

Why is the BGA 22 not warming up as much as comparable motors of its size?

Unlike other ironless motors of the same size, the BGA 22 has a high power density at relatively low winding temperatures. Manufacturers, who prefer the construction of the self-supporting winding, go along with the temperature class F (155°C). Dunkermotoren could limit this to class E, which corresponds to a temperature of 120°C. This is possible because of the good heat dissipation. The windings, which are the hottest point in the motor, are connected directly to the housing in a heat conductive way. Thus, there is no heat flow-insulating air gap between the winding and the environment. The heat is dissipated optimally. A less hot operated motor allows an extended service life of the ball bearings and provides multiple benefits in the application. Attachments such as gearboxes and encoders, which are available from the Dunkermotoren modular system, are less loaded, which allows a longer service life. Other materials that are used here are not exposed to such a high temperature and can therefore be optimized from another point of view, e. g. the acquisition costs. Devices which have a BGA 22 integrated, will remain cooler during operation, providing the user with a pleasant feel in case of direct contact with the motor. The target of Dunkermotoren is to extend this motor to a sterilizable version. Its low level of warming will be appreciated when in contact with cell tissue and will be preferred for use in temperature-sensitive applications.

Conclusion

The BGA 22 is a brushless, ironless motor on the market which can be exposed to large loads, offering a quiet running and less heat than previously known motors with comparable dimensions. With the available winding variance and the modular construction kit, it can be designed and configured for almost any application.

Stefan Tröndle I Product Manager
Brushed Motors and Gearboxes

Is pneumatic the correct solution for today's energy requirements?

Due to statutory provisions, many companies are legally bound to score the actual state of their energy consumption and to determine improvement potentials. This can be done with an energy audit according to DIN EN 16247 or alternatively with the introduction of an energy management system according to ISO 50001.

The energy management system which is already introduced by many companies leads to many advantages. The focus of it is on the continuous improvement of energy based performances – meaning improvement of energy efficiency (e. g. less energy per produced piece), the use of energy (where do I need energy e. g. for lightning) and energy consumption (e. g. reduction of energy quantity). Also, Dunkermotoren decided to implement an energy management system according to ISO 50001, to keep resource-saving delivering of high-tech products made in Germany.

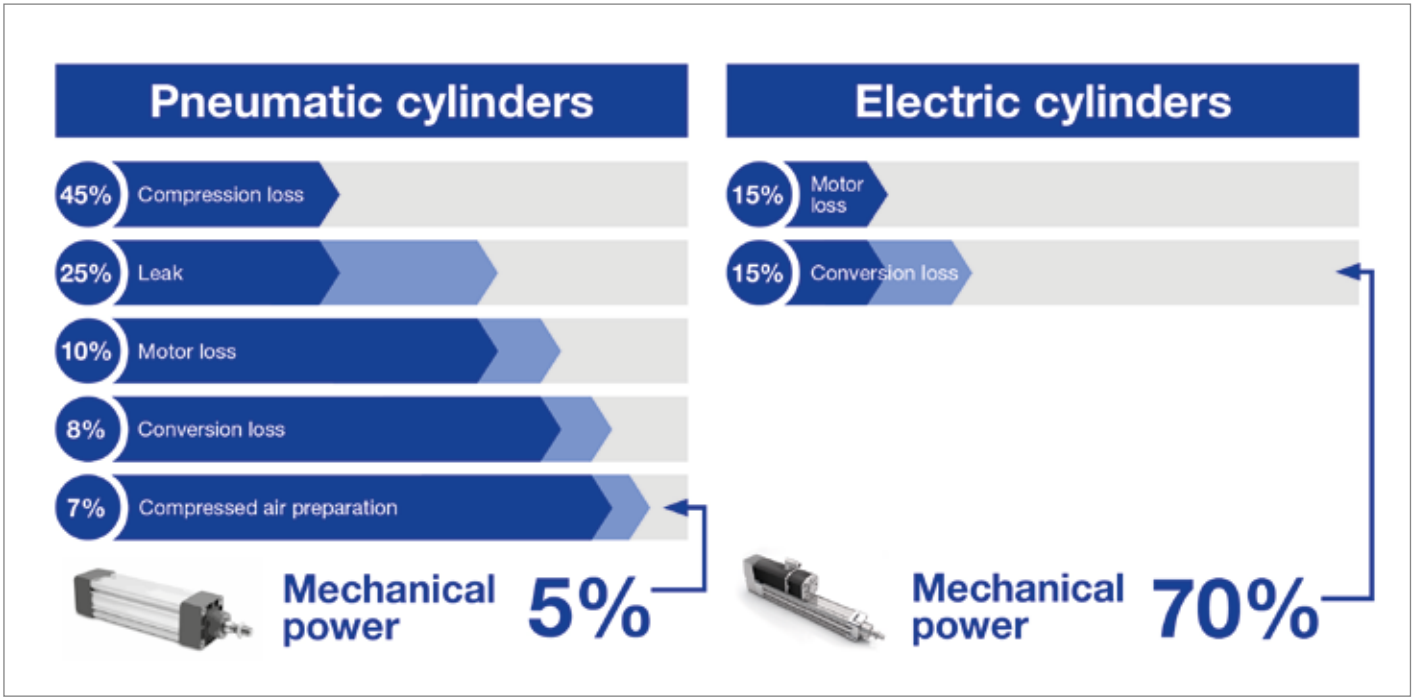
A systematic procedure reaches the optimization of energy based performance. First, an energetic evaluation of the company needs to be done. Energy consumption and usage as well as the main applications are determined. One application is e. g. compressed air generation. Furthermore, possibilities for improvements of energy based performances are determined and measures for their improvement are defined.

The next step is to implement the defined measures and to validate and analyze their efficiency in regular intervals. If the expected improvements do not materialize, the measures must be adjusted accordingly. The energetic evaluation shows in many producing companies the same result. A main energy application is the compressed air generation. An amount of up to 25 % of the electric total energy expenditure for compressed air generation is not unusual. An analysis shows that the energy consumption for compressed air often offers the greatest savings potential. An estimated savings potential of ca. 16 % can only be reached with the elimination of leakages in the compressed air system and pressure reduction. With maintenance of plumbing and a reduction of the operating pressure of one bar, yearly energy cost of ca. 40.000 € can be saved. A small hole of only one millimeter diameter can adversely affect an air system. In numbers this would be called at six bar pressure approx. 29,000 m^3 lost compressed air per year (8,000 operating hours), which means in total 725 € at energy costs. 0.025 € / m^3 for processed compressed air was used as the basis for calculation. Even an electric motor with 300 W (e. g. BG 75x50) in continuous operation does not achieve such high operating costs.

Dunkermotoren offers already better solutions in form of electric systems which can replace pneumatic systems one-to-one and work more efficient. The dependence of compressed air of a production plant with using these components can be easily reduced. For an electric actuator, an efficiency of ca. 80% is not unusual, whereas a pneumatic cylinder has an efficiency of only 50 % (this does not include losses for compressed air generation). Compared to the pneumatic cylinder the energy demand of the electric cylinder CASM is depending on load and not on cylinder volume. Considering the total system, it results in an efficiency of even 70 % compared to 5 %.

With the help of design tools, air consumption for pneumatic actuators in applications can be calculated in advance. These values are the base for a direct comparison with an electric system. If a pneumatic cylinder is permanently in operation (24/ 7), the changeover to a CASM cylinder pays off for the plant operator after a very short time. Even if the installation cost of an electric system is higher than of a pneumatic solution, the maintenance cost is up to 80 % lower. If we transfer this to our above-mentioned medium-sized companies and it would thus be possible to reduce air consumption in production to a minimum, the total energy consumption of compressed air generation would fall to a single-digit percentage - in contrast to the previous 25 %. This would mean a saving of several thousand kilowatt hours per year in terms of energy consumption.

In conclusion, the above-mentioned savings only occur when all pneumatic systems, where possible, are reduced by electric systems. The advantages of reduced maintenance intervals compared to the pneumatic solution should also be emphasized. Despite many technical advantages of an electric system (predictive maintenance, condition monitoring, positioning, current limitation, bus interfaces etc.), pneumatic systems will still have their



authorization in machines for simple positioning and short-term operation. Electromechanical units not only reduce operating costs, but also the flexibility and connectivity of a brushless BG motor integrate the smart linear units into the industry 4.0 network for the future.

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