Product innovations 2014/2015

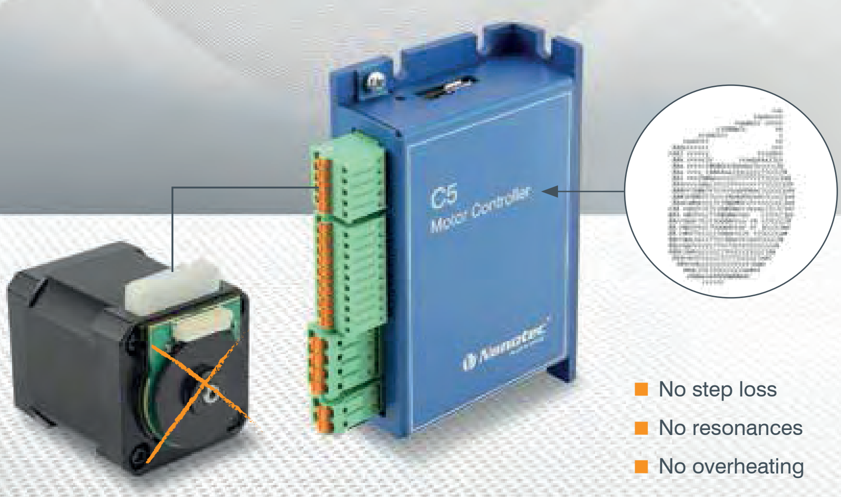
Nanotec® PLUG & DRIVE

## Tailor-made drive solutions

- Stepper motors
- IP65 stepper motors
- Hollow shaft motors
- Brushless DC motors
- IP65 brushless DC motors
- Linear actuators
- Plug & Drive motors
- Motor controllers
- Encoders/gears/brakes

## Closed-loop stepper motor without encoder

The new sensorless control for stepper motors calculates a virtual encoder signal that enables servo operation of motors beginning at just a few rotations per second. This module is available either as a plug-in board for integrating in the customer's own device solution or as a stand-alone controller.




- No step loss
- No resonances
- No overheating

sps ipc drives

Nuremberg, 25–27 November 2014
Hall 4, booth 4-582

25 JAHRE

all about automation dortmund

Dortmund, 11 – 12 March 2015
Hall 8, booth 316

www.nanotec.com

## EXACT POSITION CONTROL, NO STEP LOSSES

Specifically for applications that require high performance and efficiency, Nanotec has developed a new generation of Plug & Drive motors with field-oriented control in which the controller and encoder have already been integrated. These motors are controllable via clock-direction, analog input or the CANopen field bus and can be programmed with NanoJ V2.

### TECHNICAL DATA:

PD4-C: High-pole DC servo (stepper motor)
12–48 V/max. 5 A rms/1–3.5 Nm torque

PD4-CB: Low-pole DC servo (BLDC)
12–24 V/8 A rms continuous/20 A rms peak,
torque: 0.27 Nm/1.1 Nm peak

## PROGRAMMABLE MOTOR CONTROLLERS FOR MORE FLEXIBILITY

N5

The new N5 controller, which can be used with both BLDC and stepper motors, now makes a uniform control architecture possible. The motor supports Ethernet-based field buses such as Ethercat and Ethernet/IP, as well as actuation via standard Ethernet and CANopen.

### TECHNICAL DATA:

12–70 V/10 A (stepper motor, rms rated current) or 12–48 V/18 A (BLDC, rms rated current)

6 digital inputs, 2 analog inputs, 2 transistor outputs

CL3-E

Designed as a housing-free board, the CL3-E controller is intended for stepper and BLDC motors with a continuous output of up to 70 W. With a size of only 40x60 mm, this controller is ideal for laboratory automation, where it covers a wide variety of applications with various motors and interfaces. These range from open-loop stepper motors that autonomously respond to digital inputs to highly dynamic BLDC motors with an encoder that is interpolation-controlled via the CAN network.

### TECHNICAL DATA:

12–24 V/3 A rated current/6 A rms peak current

5 digital inputs, 2 analog inputs, 3 digital outputs

Configurable via USB, CANopen, RS232, RS485

Plug & Drive
Nanotec PLUG & DRIVE

## NEW CONTROLLERS FOR HIGH DYNAMICS AND SMOOTH RUNNING

C5

The motor controller C5 was specially designed for the open-loop control of stepper motors sized Nema 17 to Nema 34 and can be quickly and easily configured and programmed via USB. Because of the possibility of sensorless control, the motor controller C5 is primarily suitable for applications that do not require an encoder but demand highly dynamic performance and smoothing running.

### TECHNICAL DATA:

12–48 V/6 A rms rated current

3 differential inputs for clock-direction, 3 digital inputs, 1 analog input, 2 digital outputs

C5-E

Demanding closed-loop applications are the target group of the new C5-E motor controller. This controller is equipped with a CANopen field bus interface and an encoder input. It comes in two versions – either with a current range of 6 A and thus an adequate current resolution even for small motors, or with a peak current of up to 30 A for BLDC motors with a continuous output of 500 W at a supply voltage of up to 48 V.

### TECHNICAL DATA:

12–48 V/10 A rated current/30 A rms peak current

5 digital inputs, 2 analog inputs, 3 digital outputs

## APPLICATION-SPECIFIC PROGRAMMING WITH NANOJ V2

For the programming of our controllers, we developed NanoJ, a C++ based programming language in which the user program runs in a "sandbox", which is executed in a fixed cycle of 1 ms. This method is used to read out the controller settings and status values (I/O status, actual current, speed, position, etc.) after every 1-ms cycle. As a result, users can react to changes with just a few lines of code. They can also solve complex technical requirements, such as tracking a special acceleration ramp according to a mathematical function or changing the control parameters of a motor while it is running. Because field bus communication can be operated in parallel, time-critical tasks can be processed directly in the controller.

NanoJ V2

## Closed-loop stepper motors as an alternative to BLDC motors

Stepper motor technology was long considered to be a cost-effective alternative to applications that do not demand the high performance delivered by servo motors. Due to their attractive production price and comparatively high torque-to-size ratio, they continued to be used in device engineering. For auxiliary axes in mechanical engineering, however, servo systems began to be given preference. Although servos were often more expensive to procure due to the tedious testing of ramps to avoid resonance bands and because of the more complex sizing on account of the lack of feedback, they were easier to commission, and this made them more attractive for limited lot production.
This trend has been halted and even reversed in recent years by the development of field-oriented closed-loop controlled stepper motors. The heart of closed-loop technology is a power-adjusted current control and control signal feedback. These stepper motors are controlled in exactly the same way as servo motors: the rotor position is detected using the encoder's signals and sinusoidal phase currents are generated in the motor windings. The vector control of the magnetic field ensures that the stator magnetic field is always perpendicular to the rotor magnetic field and the field strength corresponds precisely to the required torque.
Thus, a closed-loop stepper motor is basically nothing more than a high-pole brushless DC servo motor (BLDC). All of the disadvantages traditionally associated with stepper motor technology, such as resonances and excessive heat development, are no longer an issue. Instead, we now have a system that can continuously achieve a torque that is 2 to 3 times than that of a servo motor of the same size at 20–50% of the rated speed.
Combined with the more favorable price of a stepper motor system, closed-loop stepper motors are an economical alternative to servo systems. Nevertheless, closed-loop systems have not always succeeded in supplanting open-loop systems in traditional stepper motor applications, such as in laboratory automation or small CNC milling machines. While closed-loop technology does offer advantages here as well, the high cost of the encoder, which usually far exceeds that of a small motor, is generally prohibitive to widespread use of this technology in these applications. Moreover, the positioning accuracy of stepper motors without an encoder is usually sufficient in these applications.

## A virtual encoder replaces a real encoder

To be able to benefit from the advantages of field-oriented control in these applications, Nanotec has developed a sensorless, i.e. an encoder-free, control for stepper motors in which the actual position and speed of the rotor is determined by a "virtual encoder" in the controller.
Sensorless systems have been in use in BLDC motors for many years, especially in fans and pumps that do not require position control. All sensorless systems utilize the physical effect that the motor induces a counter voltage (counter EMF) during operation that is proportional to the speed.
The simplest sensorless actuation is to directly measure the counter EMF while a coil is de-energized in the commutation cycle. Compared to a standard actuation, however, this method requires special hardware and is only stable at approx. 10–20% of the rated speed of the motor, below which the measurement signal is too small. For this reason, demanding applications now rely on systems that, using an "observer", reconstruct values that cannot be measured directly, such as the speed or counter EMF, from other values that are measured by the current controller. The core of this type of system is a precise model of the motor that, in parallel with the real motor, calculates the values, such as the current in the winding, from the known input values, such as the set PWM. These calculated values are measured as well. The calculated values are then compared to the measured values in every cycle. On account of the observation error determined in this way, the internal values of the motor model are permanently adjusted. Thus, correct estimates can be obtained for the values that are not actually measured, such as the speed.
Although this method only works because the reaction of the winding changes as a function of the speed on account of the induced voltage, the directly measured values can be readily measured even at small speeds. The result is a "virtual encoder" that delivers the position and speed information beginning at a certain minimum speed with the same precision as a real optical or magnetic encoder.

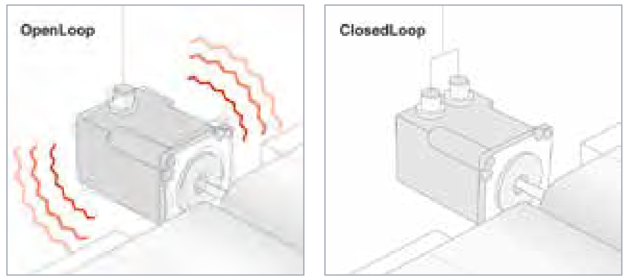
### ClosedLoop - one step ahead with field oriented control

All Plug & Drive motors from Nanotec implement field-oriented control (closed loop). BLDC and stepper motors are controlled on a field-oriented basis as a function of the load and differ only in terms of the working points resulting from the differing number of poles. Thus, both of these motor types behave like DC servos. The rotor position required for control, or the field angle, can be established using either an encoder or a sensorless method, which is described below.

**Smooth operation**
**No resonance**
**Precise positioning**
**No step loss**

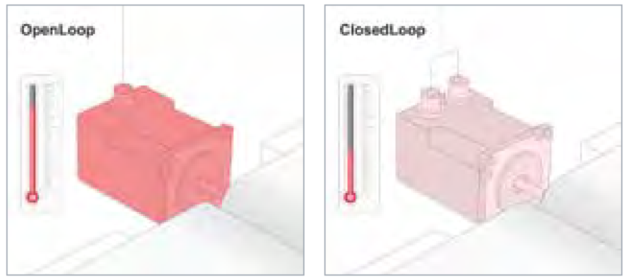
Our website at **www.nanotec.com** provides white papers and animations that visualize the principles of closed-loop control, stepper motors and BLDC motors.

### Resonance behavior




In closed-loop mode, the motor receives only as much energy as needed for the external load, so that almost no resonances occur.

### Service life

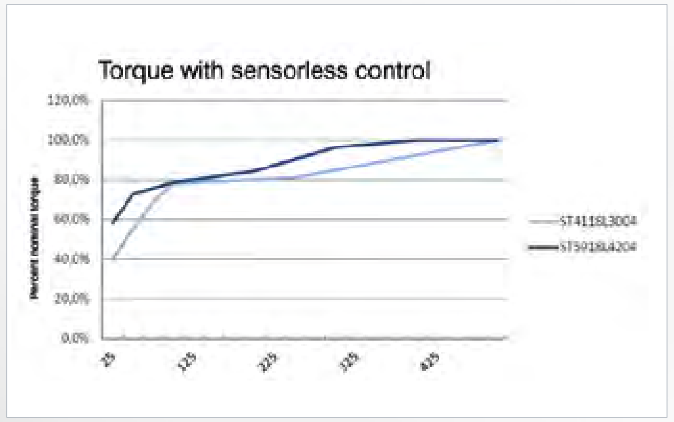



Because the current is efficiently controlled, there is less heat loss in the motor and it remains considerably cooler. This protects the motor bearings and increases service life.

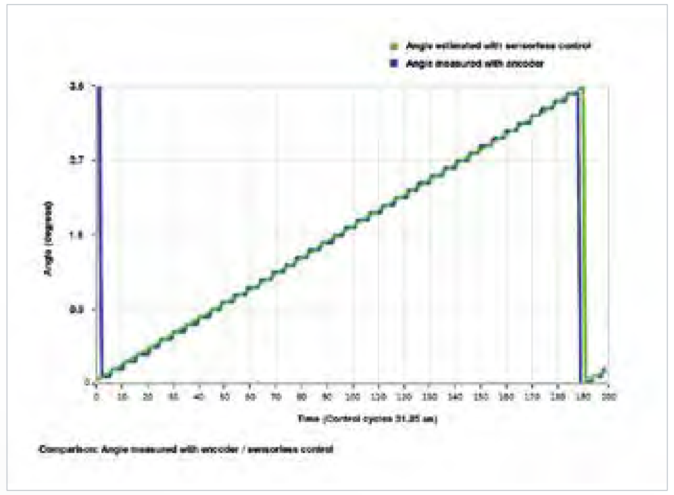


## No step losses, no resonance

A critical factor for the quality of the observer-based controller is a good model of the motor in use, both in terms of the mathematical formulas and the motor constants of the connected motor.
Thus, the task at hand was to find a sufficiently precise mathematical model of the motor that can be fully calculated in every control cycle, even in a small microprocessor. In principle, stepper motors are mathematically similar to BLDC motors, but have only two instead of the usual three phases of the BLDC and also exhibit some special features in the model at higher speeds because of the higher pole count.
Another important aspect regarding the practical use of a sensorless controller is the identification of the parameters of the model. BLDC controllers frequently require a large number of motor-dependent parameters that are often not specified on the data sheets but need to be determined with considerable effort. This also applies to systems that do not implement "true" control but only have a blocking detection mechanism or a simplified control that reduces the rated motor current as a function of load. Even in these cases, motor-dependent threshold values must be recognized and configured.
The sensorless system from Nanotec, in contrast, operates with very few parameters, which do not actually have to be known to the user: an auto setup routine measures the connected motor and automatically determines all of the required parameters.
Depending on the motor type, the speed and positioning information is obtained between 100 and 250 rpm. This information is equally precise as that of an optical encoder with 500 or 1000 increments. The resulting motor control is of the same quality and torque as that of a motor controlled via an encoder. Even below this threshold value, sensorless control still operates down to approx. 10–25 rpm. However, its accuracy decreases with the speed, and the achievable torque drops as well.




At high speeds, in contrast, the sensorless system actually works better than an encoder, which always exhibits a run-out tolerance that leads to a sinusoidal angular error. In standard encoders without their own bearings, this error can reach a magnitude of up to ±1°, which will lead to vibrations in closed-loop mode at higher speeds. In virtual encoders, on the other hand, the error at high speeds is on the same order as the step angle error of the motor (±0.09°). In addition, the real encoder always delivers digital, discrete position values. Especially at low resolutions, this leads to constant speed fluctuations of the motor. The virtual encoder value, in contrast, is continuous and constant.



The observer-based control makes it unnecessary to use motors with a very high counter EMF but with the disadvantage of a high inductance and consequently with poorer dynamics. On the contrary: motors with very low inductance and low resistance – and thus a high rated current – work far better.

## Open-loop and closed-loop combined

Sensorless control is particularly appealing for stepper motors because it can be used not only for speed applications, but also for positioning when used in combination with open-loop control. The sensorless algorithm is able to detect the accuracy with which the speed is currently being estimated. If the signal becomes too imprecise as the speed decreases, the system automatically switches to open-loop mode and positioning continues to be possible. Because only few steps are generally traveled at low speeds in open-loop mode, resonances are not an issue here. When restarted from a standstill, only a few degrees are needed to return to closed-loop mode. Thus, sensorless technology makes it possible to benefit from the advantages of field-oriented control in almost all traditional stepper motor applications.

## RELIABLE AND LONG-LIVED – BLDC FLAT MOTORS

These motors of the DF45 series are 16-pin outrunners with a standard diameter of 45 mm and a length of 27 mm. The new members of the series come in the sizes S and M with outer lengths of 18 mm and 21.6 mm. Their nominal output is 30 watts for size S motors and 50 watts and 65 watts for the sizes M and L, respectively.
In DF45 series motors, the permanent magnets are located on the rotor bell revolving around the internal stator with the windings. In addition to the shorter design, the advantage of this construction compared to internal rotor motors comes from having the same output with a lower torque ripple due to the rotor's higher moment of inertia.
The motors are available in two models – either with a cable or an integrated connector.

DF45

### TECHNICAL DATA:

24 V rated voltage, 30–65 W (depending on size)

45 mm diameter, length 18–27 mm

## NEW OPTIONS FOR THE DB59 SERIES

DB59

The BLDC motors of the DB59 series with a diameter of 56 mm (Nema 23) have an output of up to 220 W. They also exhibit a higher efficiency, are particularly smooth in operation and come with or without hall sensors. In addition to the model with a rectangular Nema 23-compatible flange, these motors are now also available with a round flange designed for mounting planetary gears GPLL59. The compact gear motors then reach continuous torques of up to 24 Nm.

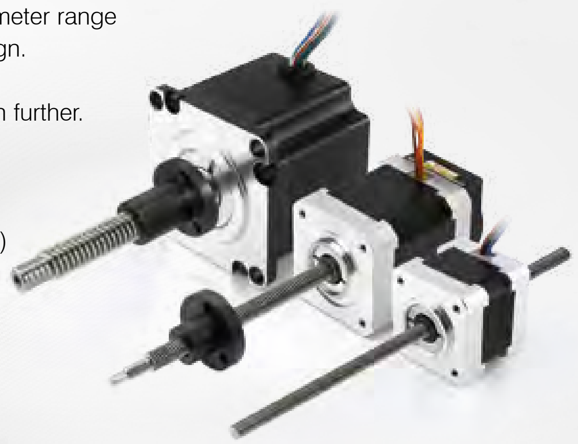
In addition, all motors are also available with a built-in NME1 magnetic encoder with 1024 CPR (4096 PPR).

## NEW PITCHES FOR LINEAR ACTUATORS

Linear drives from Nanotec enable a fine adjustment of large forces while keeping energy requirements low. They offer highly reproducible resolutions in the micrometer range and reduce system costs on account of their simple and flexible motor design.

Four new screw pitches now expand the range of possible applications even further.

Screw T3.5x8 for Nema 8 motors (L20 & LS20)
Screw T5x2 for Nema 11 (L28 & LS28)
Screw T5x10 for Nema 11, 14 and 17 (L28 & LS28, L35 & LS35, L41 & LS41)
Screw T10x6 for Nema 23 (L59 & LS59)



High torque, high precision

## MODULAR MOTOR CONFIGURATION SYSTEM – OVER 4000 POSSIBILITIES AVAILABLE IN STOCK ...

When drive systems with high precision, reliability and extensive functionality are required to fit in small spaces, Nanotec supplies the necessary technology – either as standard solutions or individualized designs. Our stepper and BLDC motors, linear actuators and linear positioning drives, in sizes beginning at 10 mm, together with a variety of gears and encoders, are combinable into a modular system with over 4000 possible combinations.

Our online configurator under www.nanotec.com leads you step-by-step to the motor combination you need.

## ... OR DEVELOPED SPECIFICALLY FOR YOU

### Brushless motor for climate control

The DB80 brushless motor was designed specifically for a climate control application (air humidifier). Following the implementation of the EU Ecodesign Directive, it has become increasingly important in climate control to replace the AC motors used up until now with highly efficient electronically commutated motors. At the same time, cost efficiency needs to be retained. Therefore, the design of these motors was specifically matched to the required external dimensions. Because a large fan impeller is mounted directly on the shaft, the front bearing was reinforced to be able to take up the higher axial and radial loads. On account of the high humidity and condensation that can arise inside the device, the stator and rotor are dip-painted on the inside for corrosion protection.

### Valve drive for liquid chromatography

Due to the limited installation dimensions in a new customer application, a maximum edge length of only 28 mm was possible for the motor. Despite this, the application required a torque of 0.55 Nm. Until that point, this had only been achieved with a motor with an edge length of 40 mm. The answer was a planetary gear with a gear reduction ratio of 19:1. The NOE1 encoder was installed on the gear output shaft to enable positioning with 100% accuracy despite backlash from the gear. In this way, a resolution of 0.045° could be reproducibly achieved using quadrature evaluation.

**Do you have questions on our products? Your contact in sales will be glad to help:**

**Harald Bär**
Netherlands, Denmark
Phone: +49 (0) 89/900 686-55
or +49 (0) 160/702 57 97

**Florian Geiger**
Switzerland, Liechtenstein
Phone: +49 (0) 89/900 686-649
or +49 (0) 160/98 10 16 27

**A complete list of our sales partners can be found at http://en.nanotec.com/company/locations**

# From development to series production

Nanotec Electronic GmbH & Co. KG is among the world's leading manufacturers of motors and motor controllers for high-quality drive solutions. The company has been developing and marketing a broad range of products since 1991. Nanotec technology is primarily used in automation systems, automatic laboratory equipment, medical devices and semi-conductor production.

By controlling and monitoring all stages of manufacture – from prototype construction to pre-series and final production – Nanotec is able to quickly and efficiently produce customized solutions in series production. Fully trained employees and high-quality machinery ensure stable processes and high in-house production depth.

Nanotec Electronic GmbH & Co. KG has its company headquarters in Feldkirchen near Munich with subsidiaries in Changzhou, China, and Medford/MA, USA.

Further information about us and our products as well as technical support can be obtained at +49 (0) 89 900 686-0 or by e-mail: info@nanotec.de. You can also request your individual quotation or order directly via our website: www.nanotec.com

**Nanotec Electronic GmbH & Co. KG**
**Kapellenstraße 6**
**85622 Feldkirchen near Munich / Germany**

**Tel.: +49 (0) 89 900 686-0**
**Fax: +49 (0) 89 900 686-50**
**E-mail: info@nanotec.de**