Motion Control Solutions for Industrial and Robotic Applications

From small brushless DC servos to integrated motors and CANopen masters with ROS interface, Nanotec offers innovative drive solutions for diverse industries.

Integrated Motors – it’s Plug & Drive

- Brushless DC servo systems
- Programmable
- Controlled by fieldbus, step & direction and analog I/O
- Precise position, speed and torque control
- New: PD4-E with battery-free multiturn absolute encoder and Ethernet-based fieldbuses

All-In-One!

www.nanotec.com
Integrated Brushless DC Servos

Integrated brushless DC servo motors from Nanotec are available in three sizes from Nema 17 to Nema 34 and different stack lengths. They feature:

- Precise position, velocity and torque control
- Integrated fully programmable controller
- Singleturn absolute encoder
- Controlled by fieldbus, step & direction and analog I/O
- USB or CANopen and CiA 402
- Digital and analog inputs, digital outputs

Flange size 42 mm (NEMA 17)  Flange size 56/60 mm (NEMA 23/24)  Flange size 86 mm (NEMA 34)

PD2-C  High-Pole Servo (Stepper)  Operating voltage: 12–48 V  Holding torque: up to 0.5 Nm
PD4-C  High-Pole Servo (Stepper)  Operating voltage: 12–48 V  Holding torque: 1–3.5 Nm
PD6-C  High-Pole Servo (Stepper)  Operating voltage: 12–48 V  Holding torque: up to 8.8 Nm

PD2-CB  Brushless DC Servo  Operating voltage: 12–48 V  Rated power: 105 W  Rated torque: 0.25 Nm  Peak torque: 0.75 Nm  Rated speed: 4,000 rpm
PD4-CB  Brushless DC Servo  Operating voltage: 12–48 V  Rated power: 135 W  Rated torque: 0.37 Nm  Peak torque: 0.92 Nm  Rated speed: 3,500 rpm
PD6-CB87S  Brushless DC Servo  Operating voltage: 12–48 V  Rated power: 220 W  Rated torque: 0.7 Nm  Peak torque: 2.1 Nm  Rated speed: 3,000 rpm
PD6-CB80M  Brushless DC Servo  Flange size: 80 mm  Operating voltage: 12–48 V  Rated power: 534 W  Rated torque: 1.7 Nm  Peak torque: 5 Nm  Rated speed: 3,000 rpm

PD2-C-IP and PD4-E Expand Applications for Plug & Drive Motors

At the SPS 2016 in Nuremberg, Nanotec presents two new series of its Plug & Drive motors: the PD2-C-IP with a flange size of 42 mm (Nema 17) and the PD4-E, both rated in protection class IP65. The PD2-C-IP is a drive based on the PD2-C series but designed for harsh environmental conditions, the PD4-E is based on the PD4-C motors but has more field bus interfaces and more options than the PD4-C.

**PD2-C-IP**

The new PD2-C-IP motors have the same features as the PD2-C series and are also available as DC motors or high-pole servos (steppers). By means of field-oriented control, based on an integrated encoder, both motor types are controlled the same way and are only distinguished by their working point (rated speed/rated torque).

Both motor types are available in a USB or CANopen version. In the USB version the motor can be parameterized and programmed via USB. In operation, the USB port is protected by a watertight cap and the motor runs on the basis of digital and analog input signals in combination with the stored program. In the CANopen version the drive can be controlled by means of the standardized fieldbus profile CiA 402. All interfaces except for USB use M8 connectors.

**PD4-E**

In addition to protection class IP65, PD4-E motors expand the concept of the PD4-C series to additionally include a large bandwidth of technical options:

- **Motor**
  - High-pole servo (stepper) with 56 mm or 60 mm flange size and a holding torque of up to 3.5 Nm (such as PD4-C)
  - Brushless DC servo with a flange size of 56 mm and a rated power of up to 220 W
- **Encoder**
  - Magnetic singleturn absolute encoder with 12-bit resolution
  - Battery-free multiturn absolute encoder with 16-bit single-turn and 18-bit multiturn resolution
  - Input for additional external encoder (e.g. linear scale)
- **Communication/Field buses**
  - USB
  - CANopen
  - EtherCAT
  - Modbus RTU
  - Modbus TCP
  - Ethernet/IP
- **Brake**
  - Integrated holding brake optional
- **Inputs and outputs**
  - 6 digital inputs, switchable 5/24 V
  - 1 analog input, switchable 0-10 V/0-20 mA
  - 3 digital outputs

All interfaces except for USB use M12 connectors. Samples of selected types of the PD2-C-IP and PD4-E series will be available at the beginning of December. The series rollout of both models is planned for the second quarter of 2017.
Technology

Plug & Drive Studio

A new software is now available for easy setup and programming of Nanotec’s motor controllers: Plug & Drive Studio. The controller can be accessed from a PC via a variety of field buses (CANopen, EtherCAT, Modbus). For setup, the object directory holding the controller configuration can be read and written via a table. Pre-defined filters enable the user to only display the parts of CiA 402 objects that pertain to a certain task, such as setup or a certain operating mode, i.e. the speed. Experienced users can configure the objects via an integrated command line. The entire communication can be recorded and played back later so that lengthy command sequences only need to be entered once during setup. To tune the controller parameters, an integrated oscilloscope displays up to eight objects simultaneously with a resolution of up to one millisecond.

Oscilloscope with target and actual positions and following errors

Recording can be controlled by freely configurable start and stop triggers that define conditions for the displayed objects, such as the reaching of a certain position or the activation of a digital input. Oscilloscope settings that contain required objects such as following errors, target positions and actual positions are predefined for a standard tuning. These settings can be adjusted at any time. To program the controller with NanoJ V2, an integrated development environment is available that consists of a source text editor with automatic code completion, a compiler and a debugger. The debugger allows programmers to set up breakpoints in the program at which values of variables can be read out. Because all of the Plug & Drive Studio functions can be used simultaneously, controller behavior can be examined during program execution using the object directory and oscilloscope. As a result, customer-specific functions can be easily and quickly programmed.

Object directory

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 fieldbus communication can be operated in parallel, time-critical tasks can be processed directly in the controller.

For brushless DC and stepper motors
- Closed-loop (FOC) control with encoder, sensorless or hall feedback
- Precise position, velocity and torque control
- Quick to parameterize and easy to program with NanoJ V2
- Controlled by fieldbus, step & direction and analog I/O
- No step losses

Operating voltage

<table>
<thead>
<tr>
<th>Model</th>
<th>Operating Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>12-48 (high current)</td>
</tr>
<tr>
<td>C5</td>
<td>12-48 (high current)</td>
</tr>
<tr>
<td>C5-E</td>
<td>12-48 (high current)</td>
</tr>
</tbody>
</table>

Rated current

<table>
<thead>
<tr>
<th>Model</th>
<th>Rated Current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>10 A (low current)</td>
</tr>
<tr>
<td>C5</td>
<td>18 A (high current)</td>
</tr>
<tr>
<td>C5-E</td>
<td>10 A (low current)</td>
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Peak current

<table>
<thead>
<tr>
<th>Model</th>
<th>Peak Current (A)</th>
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</thead>
<tbody>
<tr>
<td>NS</td>
<td>40 A (high current)</td>
</tr>
<tr>
<td>C5</td>
<td>6 A (low current)</td>
</tr>
<tr>
<td>C5-E</td>
<td>30 A (high current)</td>
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</table>

Encoder input

<table>
<thead>
<tr>
<th>Model</th>
<th>Encoder Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>yes</td>
</tr>
<tr>
<td>C5</td>
<td>no</td>
</tr>
<tr>
<td>C5-E</td>
<td>yes</td>
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</table>

Brake output

<table>
<thead>
<tr>
<th>Model</th>
<th>Brake Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>no</td>
</tr>
<tr>
<td>C5</td>
<td>yes</td>
</tr>
<tr>
<td>C5-E</td>
<td>yes</td>
</tr>
</tbody>
</table>

Interfaces

<table>
<thead>
<tr>
<th>Model</th>
<th>Interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>EtherCAT, CANopen, Ethernet/IP</td>
</tr>
<tr>
<td>C5</td>
<td>USB, CANopen</td>
</tr>
<tr>
<td>C5-E</td>
<td>USB, CANopen</td>
</tr>
</tbody>
</table>

Inputs/outputs

<table>
<thead>
<tr>
<th>Model</th>
<th>Inputs/Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>6 digital inputs, 2 analog inputs, 2 digital outputs</td>
</tr>
<tr>
<td>C5</td>
<td>3 differential inputs, 3 digital inputs, 2 analog inputs</td>
</tr>
<tr>
<td>C5-E</td>
<td>5 digital inputs, 3 digital outputs</td>
</tr>
</tbody>
</table>

CL3-E

- Operating voltage: 12-24 V
- Rated current: 3 A
- Peak current: 3 A (low current)
- Encoder input: yes
- Interfaces: USB, CANopen, Modbus (RS485, RS422)
- Inputs/outputs: 5 digital inputs, 2 analog inputs, 3 digital outputs

NPS

- Operating voltage: 12-48 V
- Rated current: 6 A
- Peak current: 10 A
- Encoder input: yes
- Interfaces: USB, CANopen
- Inputs/outputs: 2 encoder inputs, 7 general I/O, 2 A/D converter, 1 brake output

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 fieldbus communication can be operated in parallel, time-critical tasks can be processed directly in the controller.
Stepper motor technology was long considered to be merely a cost-effective alternative to applications that do not demand the high performance delivered by servo motors. Machine designs in particular, had applications that were increasingly changed over to servo motors, whose ease of integration in small spaces counters their higher procurement costs. This trend was reversed by the development of field-oriented, closed-loop controlled stepper motors. The core of closed-loop technology is the field-oriented control of stepper motors via encoder signals. This corresponds to the control of a brushless DC motor, turning a classic stepper into a high-pole servo. The resulting system continuously achieves twice or three times the torque at 20-50% of the nominal speed of a servo motor of the same size. In addition, this motor gets rid of the disadvantages of classic open-loop control, such as resonance or excessive heat generation.

However, these advantages of field-oriented control do not justify the higher price for the required encoder in classic stepper motor applications, such as small table-top CNC machines used for engraving, dosing, marking or milling. The positioning accuracy of the open-loop stepper motor is often sufficient, and developers simply require better running behavior and less heat generation to be able to benefit from the advantages of field-oriented control in these applications. Nanotec has developed a sensorless (i.e. encoder-free) control for stepper motors in which the current position and speed of the rotor are calculated by a “virtual encoder” in the controller. An autosetup routine measures the connected motor and automatically determines the required parameters. The sensorless algorithm recognizes 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 control and positioning continues in this mode. 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.

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New Brushless DC Motors and Gears

Nanotec offers a number of new three-phase brushless DC motors with high-energy permanent magnets that provide rapid acceleration and high speeds, paired with excellent efficiency. They are ideally suited for applications that demand very smooth running and a long service life.

Nanotec has developed a number of new gears specially suited for medical, industrial and robotic applications:

- **GPLK** gears are especially well suited for applications where the motor will be moved. They are made of plastic and therefore considerably lighter and much quieter than comparable gears made of metal.
- **GPLEP** planetary precision gears are equipped with reinforced output bearings and withstand high radial and axial loads.
- **GPLEF** flange planetary gears offer a reasonably priced high-efficiency alternative to cycloidal or harmonic gears with a standard ISO 9409 compliant mounting flange.

### New: DF32, DF45, DB41, DB43, DB80

<table>
<thead>
<tr>
<th>Model</th>
<th>Size (Ø mm)</th>
<th>Rated voltage (V)</th>
<th>Rated power (W)</th>
<th>Peak torque (Nm)</th>
<th>Rated torque (Nm)</th>
<th>Rated speed (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF32</td>
<td>32</td>
<td>24</td>
<td>7.4</td>
<td>0.025</td>
<td>0.025</td>
<td>2,760</td>
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<tr>
<td>DF45</td>
<td>43</td>
<td>24</td>
<td>22</td>
<td>0.15-0.39</td>
<td>0.15-0.39</td>
<td>4,840</td>
</tr>
<tr>
<td>DB41</td>
<td>17</td>
<td>24</td>
<td>24</td>
<td>0.07-0.36</td>
<td>0.07-0.36</td>
<td>3,000</td>
</tr>
<tr>
<td>DB43</td>
<td>17</td>
<td>24-48</td>
<td>53-139</td>
<td>0.24-1.2</td>
<td>0.24-1.2</td>
<td>3,000</td>
</tr>
<tr>
<td>DB80</td>
<td>80 x 80</td>
<td>48</td>
<td>283-942</td>
<td>2.5-8.5</td>
<td>2.5-8.5</td>
<td>3,000</td>
</tr>
</tbody>
</table>

### New: GPLK42, GPLEP50, GPLEP70, GPLEP90, GPLEF64

<table>
<thead>
<tr>
<th>Gear</th>
<th>Characteristics</th>
<th>Range size (ø/mm)</th>
<th>Rated torque (Nm)</th>
<th>Max. load radial/axial (N)</th>
<th>Max. input speed (rpm)</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPLK42</td>
<td>low noise, low weight</td>
<td>4/2/17</td>
<td>6</td>
<td>up to 65/40</td>
<td>up to 5,000</td>
<td>min. 70%</td>
</tr>
<tr>
<td>GPLK50</td>
<td>high radial and axial loads</td>
<td>4/2/17</td>
<td>up to 15</td>
<td>up to 800/100</td>
<td>18,000</td>
<td>min. 95%</td>
</tr>
<tr>
<td>GPLK70</td>
<td>high stiffness</td>
<td>4/2/17</td>
<td>up to 33</td>
<td>up to 1,050/1350</td>
<td>13,000</td>
<td>min. 95%</td>
</tr>
<tr>
<td>GPLK90</td>
<td></td>
<td>4/2/17</td>
<td>up to 97</td>
<td>up to 1,900/2,000</td>
<td>13,000</td>
<td>min. 95%</td>
</tr>
<tr>
<td>GPLF64</td>
<td></td>
<td>4/2/17</td>
<td>up to 44</td>
<td>up to 5,500/1,200</td>
<td>13,000</td>
<td>min. 95%</td>
</tr>
</tbody>
</table>

Nanotec offers solutions for service robotics and transportation systems that meet a broad spectrum of load, speed, and braking requirements. These include small brushless DC motors for pipe inspection robots, Plug & Drive motors with an output of 50 W that drive a Mecanum platform via planetary gears, or drives for autonomous transportation systems with an output of several hundred watts per wheel.

All of our standard products can be combined according to our customers' requirements and supplemented by application-specific components. With our integrated motors and GPLEP planetary gears, we offer a standard solution for a variety of wheel drive requirements. Our product range is complemented by custom solutions, from actual wheels delivered with the gear motor to active safety brakes, bringing an AGV from full speed to a complete standstill in no time.

### Turnkey For Your Application

From standard solutions to customer-specific designs, Nanotec will supply the perfect drive system for your application. Our motors, linear actuators, gears, brakes and encoders are part of a modular system with over 4,000 possible combinations. The online configurator at www.nanotec.com will assist you in finding the right product.

In addition, you can order our motors with application-specific shafts and cable assemblies. We also develop completely new solutions based on your individual requirements. When designing a new product, we always keep economical production in mind. From first samples through ramp up and up to high volume series. Let us know how we can make it turnkey for your application!
Linear Actuators and Positioning Drives

The performance curves on our website www.nanotec.com show the thrust as a function of speed. This helps in comparing different motor sizes and lead screw pitches in order to find the right combination for your needs.

High Force and Resolution

Linear actuator with lead screw
In standard linear actuators, a thread nut made of thermal high-performance plastic is integrated in the hollow shaft of the motor. This thread nut converts the rotary motion of the motor to linear motion. In this version, the lead screw must be additionally secured from the outside against rotation to achieve linear motion.

Linear actuator with linear slide
Linear actuators with a linear slide have a flanged thrust rod unit that is linearly guided internally and locked against rotation. This gets rid of the need for an external anti-rotation lock in the connection design. Linear adjustment tasks can be easily implemented without additional mechanical systems. The achievable stroke depends on the length of the linear slide. Nanotec linear actuators with linear slides are available up to a stroke of 50 mm.

Linear positioning drive
Unlike linear actuators, linear positioning drives feature an extended motor shaft with a thread. A thread nut externally mounted on this thread performs the linear movement. The nut is made of high-performance plastic and is nearly maintenance free. An additional bearing is not required due to the double ball bearings in the motor. The linear slide can be omitted in case of small loads and load capacity.

Flange size 20 mm 28 mm 35 mm 42 mm 56 mm
Max. thrust 40 N 80 N 140 N 400 N 1000 N
Lead screw pitch 1.8 mm 2.5 mm 10 mm 1.2 mm 2.5 mm 10 mm 2.6 mm
Min. resolution (full step) 0.005 mm 0.001 mm 0.005 mm 0.005 mm 0.01 mm
Optional encoder yes yes yes yes yes

Nanotec Electronic GmbH & Co. KG in Feldkirchen near Munich (Germany) 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 and in medical devices.

Early on, we recognized that power electronics are at the heart of efficient and effective drives and pushed the development of motor controllers. In 1996, Nanotec came out with the first Plug & Drive motor with an integrated controller, thereby setting a cornerstone that would ultimately be central to the company’s growth.

Still to this day, Nanotec focuses heavily on research and development to create drive solutions that closely meet the needs and requirements of our customers. For additional information, technical assistance and off-the-shelf delivery, please contact us at info@nanotec.de

From Development to Series Production

About us
Please check out our website at www.nanotec.com for a complete list of our sales partners.