RoboDrives for High-torque, Precision Robotics
RoboDrives: the high-torque, precision drive for next-generation robotic applications

As electric motors and drives are integrated into robotics systems, they are bringing new levels of efficiency and productivity to compact robotic solutions for medical, aerospace, and other applications. These designs demand lightweight drives with minimal footprint that can achieve accurate positioning and constant velocity. The new RoboDrives from TQ Group meet and exceed all these requirements, and are the ideal solution for your next-generation robotic applications.

RoboDrive was developed by the German Aerospace Center, DLR (Deutsches Zentrum für Luft- und Raumfahrt), to meet the exacting requirements for a small, light-weight, high-torque, precision drive to work outside the space station. After six years of continuous operation in space, RoboDrive exceeded the performance of any standard motor available in the market by a wide margin.

This superior technology and unparalleled performance is now available from TQ Group in North America through Convergence for robotic, aerospace, medical, and other applications. Call us today to discuss how to use RoboDrive and our design services to help you achieve excellent results in your next project.

Michael ImObersteg
Convergence Promotions
Director of Robotic Solutions

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TQ is a global leader in the design and manufacturing of products in the electronics and robotics industries

TQ is one of Germany’s Top 10 Full Service Electronics Companies
TQ manufactures at six locations in Germany (Seefeld, Durach, Allgäu, Murnau, Peissenberg, Peiting and Wetter an der Ruhr) as well as in Fontaines, Switzerland and Shanghai/China. TQ employs approximately 1,300 people with 150 engineers in electronic development at the following locations: Delling, Chemnitz, Leipzig, Durach and Peiting.

Certified Quality and Dependability
TQ stands for technology in quality, and that reputation is supported by the following certifications:
- **Quality Management** ISO 9001:2008
- **Medical** ISO 13485:2012 MDD (guideline 93/42/EWG)
- **Aviation** ISO 9100:2009
- **Automotive** ISO / TS 16949:2009
- **Environmental Management** ISO 14001:2004
- **Recognized Mark** Recognized by UL

TQ has been awarded several times for its capacity and business development:
- E²MS Award 2013: Winner of the category safeguarding the future
- E²MS Award 2011: Winner of the category Supply Chain Management
- 2015 Frost & Sullivan Manufacturing Leadership Award

Engineering Solutions
**CEM/E²MS I System services:** We design and produce custom electronic assemblies and ready-to-use units to your specifications from concept to the finished product. We also do the design and construction of your switch gear devices.

**OEM I Standard Products:** TQ embedded modules and Industrial PCs accelerate your time-to-market, and provide the ultimate in design flexibility. We provide modular products and solutions based on the leading MCU architectures, as well as drive systems, industrial and building automation, energy management and other solutions.

**Delivering Completed Products to the Marketplace:** From automation to traffic engineering, TQ manufactures finished products such as ticket printers for public transportation, central fire alarm systems, computer tomography, aircraft cabin controls, fork lift truck controls, medical devices, photovoltaic systems, etc.

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RoboDrive
TQ’s Hollow-shaft High-torque, Precision Drives for Robotics

Drives developed for aerospace applications
RoboDrive technology was developed by the Institute for Robotics and Mechatronics of the German Aerospace Centre (DLR). This technology, patented by TQ-Systems, combines a high torque curve and power density relative to the weight and installation space.

Features and Benefits
- Lightweight: ½ the weight of comparable motors
- High torque with compact design: ½ the size of comparable motors
- High power density through maximum copper fill factor
- Stator and rotor design reduces power loss
- Used as direct drive with reduced motor speed
- Highly precise controllability and positioning accuracy
- High efficiency with compact design
- Modeled drive, tool-based optimization over the entire drive train
- Hollow shaft design

Technical Overview
- Outer diameter range from 25 - 115 mm
- Largest hollow shaft on the market
- Torque 0.1 - 40 Nm
- Rotational speed up to 25,000 rpm
- No cogging
- Zero lash-back

Rotor and Stator Sets
Today’s robotic and medical applications demand high performance and precision drives in a small form factor.

The RoboDrive motors have been manufactured by TQ-Group since 2006. The product spectrum includes standard stators and rotor sleeves as installation sets for the highest possible user-specific integration.

Alternatively, the motors can be equipped with hall sensors or magneto-resistive position sensors, depending on the application and requirement profile for speed or motion detection.

Hollow-shaft precision drives
The RoboDrive motor meets and exceeds those requirements, plus the unique hollow shaft design provides access to an unlimited world of applications: the space facilitates the pass-through of lasers, supply cables, power transmissions and optics (and other media usually routed outside the motor casing in other motors).
RoboDrive
A breakthrough in robotic motor technology

The graphs on this page are from Experimental Robotics VIII, edited by Professor Bruno Siciliano and Paolo Dario, published by Springer. The information is the result of studies conducted on the RoboDrive motors by the Institute for Robotics and Mechatronics of the German Aerospace Centre (DLR).

Comparison of TQ’s RoboDrive motors with the best commercially available motors
The DLR results show TQ’s RoboDrive motors with only half the weight and half of the power losses of the best commercially available motors.

A Breakthrough in Motor Technology
In the past, robot manufacturers have taken the best available motors off the shelf for their robots, without being optimized for robotic applications (comparatively slow rotational speed through high dynamics, permanently reversing operation around zero speed) and aiming at minimal weight and power losses.

Two years of studies at the DLR in a concurrent engineering and optimization process took into account all the electromagnetic and other physical effects, short copper paths, optimal coil winding and coil filling aspects between the magnetic iron poles.

Out of this optimization process came the conclusion that the stator poles had to be subdivided and wound separately. This resulted in the technology for robotic applications that Robodrives excels in.

Concurrent-Engineering

Analytical model
motor parameters as function of geometric data
[k, n, M, ....] = F(L, D, Z, ....)

“Geometry”

“Analytical” optimization
goal parameters
sinus-flow
parameter couplings

FEM-computation
optimization for sinus-flow
airgap
pole and magnet form
parameter couplings
marginal effects

“airgap”

design-proposal
verification
prototype
RoboDrive
Designed to drive precision robotic and medical applications

Benefits
- Freedom of design
- Variable solutions for different drive tasks
- Small overall length, flat drive: e.g. for exoskeletons
- Hollow shaft e.g. for optical passage, cable, media, shafts, material, welding wire
- Light weight construction: weight reduction for aviation, mobile devices
- Accurate positioning and very constant velocity: e.g. for robotic, optic or analytic applications, surface processing
- Thermally safe overload, high peak acceleration, short cycle time
- Free from wear / long life time
- Quiet

Applications
- **Robotics**
  - Lightweight robot (LBR)
  - Robot axes
  - Gripper and clamp systems
- **Medical**
  - Actuated instruments
  - Guided optics
  - Mobile surgical devices
  - Intensive care
- **Aviation**
  - Seat actuator
  - Door / Latch
  - Bleed Air
  - Unmanned aerial vehicles
- **Optics**
  - Camera (aperture control)
  - Gimbal operation
  - Cableway propulsion
  - Laser (beam treatment)
- **Mechanical engineering**
  - Alternative for hydraulics / pneumatics
Examples of TQ Standard Motors with Gear Drives

**ILM-PG & Neugart Planetary Gears**
The ILM-PG motor-gear unit provides one standardized drive solution in combination with Neugart’s powerful planetary gears. Depending on the number of stages, we can cover transmission ratios from 1:3 up to 1:512. The gears offer a minimal backlash. The units are highly robust and have a lifetime lubrication.

All performance characteristics of the gear in speed and torque are achieved in the combination with RoboDrive technology. Combinations of RoboDrive motors and Neugart gears can be tailored to given requirements. It is also possible to use the Neugart precision gears and flange gear boxes.

- Large range of transmission ratios (1:3 - 1:512)
- Very high efficiency (97%)
- Low backlash
- High output torque
- Low noise level
- Lifetime lubrication
- Flexible assembly (Flange or Housing)

**ILM-CYK & Eppinger Cycloid Gears**
The ILM-CYK gear motor unit is the first compact drive system with a hollow shaft and a cycloid gear. The cycloid gear combines high precision with outstanding stiffness and overload resistance. The torsional stiffness is up to 3 times higher in comparison to planetary or Harmonic Drive® gears. The gear has a minimal backlash. The integrated output bearing can withstand high radial and axial loads and also withstands tilting torques. You can utilize all the advantages of the gear motor in combination with our RoboDrive technology, e.g. higher dynamics due to a stiffer powertrain. Combinations of RoboDrive motors and Eppinger gears can be tailored to customer requirements.

- Very high absolute and repetitive accuracy
- Large hollow shaft
- Very compact and low weight design
- Outstanding life-long precision
- High dynamics
- Optimal design-in solution

**ILM-HD & Harmonic Drive® Gears**
The integrated ILM-HD motor-gear unit with hollow shaft is a powerful and highly precise servo-solution in the low-voltage range. The gear technology of Harmonic Drive® provides highest precision without backlash in a compact lightweight construction. In combination with our RoboDrive technology, the Harmonic Drive® gears can be used up to their peak power. Due to the outstanding dynamics of this motor and the very low gear elasticity and inertia it is possible to precisely control the powertrain.

- Very high absolute and repetitive accuracy
- Large hollow shaft
- Very compact and low weight design
- Outstanding life-long precision
- High dynamics
- Optimal design-in solution
RoboDrive-based Actuators
Ideal for avionics applications

Highly-efficient actuators based on motors with RoboDrive technology

- High power density, and therefore, low weight
- High mechanical stability and high durability
- Minimum installation space and low power loss
- Energy-optimized position lock
- Low noise emission
- EMC-friendly design

In some areas of application such as aerospace, the actuators are intended to achieve as much dynamic force as possible and to withstand high static forces with a low weight and small installation space.

Due to the optimum calibration of the individual components like the motor, gear unit, control electronics and casing, as well as the integration of a special position lock, we have been able to develop highly-efficient yet light actuators. For example the biggest actuator can cope with dynamic forces of over 5,000N at movement speeds of over 10 mm/s. The electrical output is far below 100 W with a weight of only approximately 1,000g.

Application example:
An actuator for adjusting business class seats in airplanes.
RoboDrive and Pin-Ring Drives
TQ leads a new generation of high-torque off-road eBikes

High performance technology for Pedelecs and E-Bikes
Under the trademark “cleanmobile” TQ develops and produces customer-specific drive systems and components for Pedelecs, E-Bikes and electric cargo vehicles.

The core of the system is the patented pin drive. Thanks to this innovative technology, a high performance and a high torque with minimum dimensions can be achieved.

The cleanmobile pin drive consists of the following components:
- Electric pin drive
- Customer-specific lithium ion battery
- Cable harness
- Display
- Speed sensor
- Torque sensor

Key functionalities of the pinring drive
- Above-average power density and high single-stage reduction
- Rotationally symmetrical and compact dimensions
- E-drive, gear, sensors and power electronics in a single unit
- Low weight
- Low noise

The M1 Spitzing achieves a stunning 47 MPH with an acceleration from 0 to 30 MPH in 7.5 seconds!
Convergence Promotions LLC, is TQ Group’s sales and marketing partner in North America

For over three decades, Convergence Promotions LLC has been the premier provider of partner programs and ecosystems in the embedded wireless and power industries. We have designed and managed ecosystems and partner programs or a dozen of the world’s leading electronics companies, including Intel, Motorola, Microsoft, Siemens, Freescale, Infineon, AMD, ARM, and others.

Our partner programs serve as a catalyst, bringing like-minded businesses together. These programs create synergy for sponsors and partners by providing an environment that fosters business relations, create customer awareness to increase sales for both the sponsor and their partners and encourages technical discussion to improve products and services.

Partnerships with the leading Distributors and media channels

Convergence Promotions LLC also owns Embedded Developer, a joint venture with Arrow Electronics, and AspenCore, a leading network of electronic magazines, publications and websites in the US, Europe and Asia.

Engineering Tools Resources

We make it easy for over half a million engineers a month to find, compare and buy products through our web sites, magazines and monthly newsletters, and our design tools help their speed their time-to-market.

TQ Embedded Modules, RoboDrives and Energy Management Sales and Distribution

Convergence Promotions LLC, is TQ Group’s North America sales, distribution and technical support partner in North America. We operate TQ sales and distribution centers in Boston and Silicon Valley, and a network of manufacturing reps, FAEs and design centers coast-to-coast.
TQ North American Sales & Distribution
TQ Embedded Product sales, distribution, and technical support in North America is managed by Convergence Promotions LLC, with offices near Silicon Valley, California and Boston, Massachusetts, and sales Representatives throughout the USA.

TQ Embedded Products in North America can be found at: ConvergencePromotions.com

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