Ducommun Engineered Products
Motion Control Devices
Ducommun Profile

• Ducommun Incorporated (NYSE symbol – DCO) Founded in 1849. Recognized as the Oldest Operating Company in California

• Serving the Aerospace & Defense Industry and select Industrial Markets

• Year 2019 Net Revenue $721.2 Million

• Ducommun current has 16 operating locations:
  – Headquarters: Santa Ana, California
  – US: Arkansas, California, Kansas, Missouri, New York, Oklahoma, Wisconsin
  – International: Saraburi - Thailand
# Motion Control Devices (MCD)

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Space Industry - Latest Programs

- Juno mission to Jupiter - 2011
- Tracking and Data Relay Satellites (TDRS-K/L) – 2012/13
- Nuclear Spectroscopic Telescope Array (NuStar) - 2011
- Intelsat 22 - 2012
- Wideband Global SATCOM (WGS)
- Soil Moisture Active-Passive (SMAP) mission - 2013
Ducommun Space Heritage

Space Shuttle Orbiter
- Motors and Resolvers on Remote Manipulator Arm
- Switches, Data Entry Control Panels
- Cargo Bay Door Lock Mechanism

International Space Station
- RF Communications Modules
- UHF/VHF Comm Panel
- Air Lock Control Pushbutton Switches

Mars Exploration Rover
- BLDC motor with gear head and lead screw

Satellites
- Solar Array Stepper Motors/Resolvers
- Solar Array Deployment Motors
- RF Switches
- Positioning motors and resolvers for Antenna Pointing System

Project Constellation
- Ares I Upper Stage
  - LH2 and LOX Tanks Manufacturing Demonstration and Test Articles
- Ares V Heavy Lift
  - Program Support, Conceptual Design, and Architecture

Original supplier of Aluminum Gores, O-Gives and Barrel Panels for the External Tank
Oil Exploration Industry

Up to 6 miles deep

Oil & Gas Exploration at temperatures of up to 250 Deg C and pressures up to 30,000 psi.
Defense Industry

Ducommun’s highly specialized AC and DC electric motors, position sensors (resolvers), and electro-mechanical actuators are found in antennas, waveguide systems, gimbals for azimuth and elevation positioning.

Ducommun continues to lead the industry as a manufacturer of high quality, reliable products that have proven successful in demanding applications for commercial and military aircraft, submarines, ground defense and weapons systems.
Environmental Bandwidth

**Space Exploration**
Low Pressure: (Vacuum)
Low Temp: < 100° K (-280° F)

**Oil Exploration**
High Pressure: >30,000 psi
High Temp: >500° F (260° C)

*High Reliability at extreme environment*
We offer a complete line of angular position sensors that provide solutions to the most challenging motion control requirements.

- Sizes: OD 0.8 up to 13.4 inches
- Housed or Pancake
- Brush or Brushless
- Rotary Transformers
- Single and Multi-Speed
- High accuracies (up to 5 arc seconds)
- Frequency: 400-100,000 Hz
- Redundant designs
- Variable Reluctance Resolvers
- Standard and Custom Designs
MCD Products – Variable Reluctance Resolvers (VRR)

We offer a complete line of VRR resolvers that provide solutions to the most challenging motion control requirements.

- Sizes: OD 0.8 up to 8.75 inches
- Housed or Pancake
- Up to **30% mass reduction** since no rotary transformer required
- Reduced envelop size
- Enhanced reliability
- Single and Multi-Speed
- Electrical Redundant designs
- Standard and Custom Designs
Application – Satellite Antenna Gimbal

Challenge:
- Custom redundant multispeed resolver for a gimbal that positions the antenna on a satellite
- Tight tolerances

Solution:
- Improved accuracy from 30 arc sec to 20 arc sec.
- Met critical impedance requirements.
Ducommun offers a wide range of high-performance Stepper Motors for space mechanism. Typical applications are for deployment, orientation, accurate pointing or positioning mechanism (solar panels, antennas, optical devices, etc) as used on Satellites and other Space Exploration Vehicles.

- Permanent Magnet Stepper Motors
- Variable Reluctance (VR) Stepper Motors
- Hybrid Stepper Motors
- 2, 3, and 4 phase
- Unipolar or Bipolar
- Bifilar or tandem designs
- With Planetary Gear Heads or Harmonic Drive Gears, Low backlash gear heads
Brush Type and Brushless DC Motors, Torquers

We offer a line of special DC motors that provide solutions to the most challenging motion control requirements. Whether the design requires high-speed continuous operation or low speed/high torque.

- Brush or Brushless
- Housed or Rotor/Stator assemblies
- Low cogging designs
- With Resolver or Tachometers
- Gear heads: Harmonic Drives, Spur Gears, Planetary Gears
- Brakes and Clutches
- Standard and Custom Design
Space Mechanism
Mars Exploration Rover Standup Operation

Challenge:
• Linear actuator with lead screw to hold up to 920 lbs at – 60 Deg and dusty environment.

Solution:
• Complete assembly including custom BLDC motor with gear head 1:100, bearing assembly, lead screw with Torlon® nut.
Ducommun’s high temperature AC induction motors have been utilized in downhole drilling tools for oil exploration operations throughout the world.

- AC single phase or 3 phase
- Output: Up to 1.5 HP single phase at continuous duty
- Fully Operational at 500°F (260°C)
- Pressure Range: Up to 30,000 PSI
- Immersed in Hydraulic Oil Per MIL-H-83282C
- 115 to 600 Volts / 60-600 Hz
MCD Products - Downhole alternators

We offer a complete line of brushless permanent magnet alternators (BLDC) that are designed for the severe environments experienced during oil drilling operations. Typical capabilities include:

• 0°C to 200°C Operational Range
• Capable of Withstanding Pressure to 25,000 PSI
• Designed to Operate While Immersed in Hydraulic Oil Per MIL-H-83282C
• Driving Speed Range: 2,000-10,000 RPM
Ducommun LaBarge Technologies, Inc. is vertically integrated with complete manufacturing, assembly and test capabilities supported by 50 years of experience in space flight components and assemblies.

- Dedicated Lean Manufacturing Operation Cells
- ISO 9001, AS9100
- Soldering NASA-STD-8739.3 certified
- Continuous Improvement with LEAN / Six Sigma
- Certified skilled personnel for component and system assemblies
Engineering Capabilities

- Electrical & Mechanical Design
- Electromagnetic Design
- Quality Engineer
- Systems Engineering
- Manufacturing Engineering
- Optical Engineering
- Test Engineering
- Reliability Engineering
- Configuration / Document Control
- Logistic Support Field Engineering

- CAD / CAM Capabilities:
  - SolidWorks and AutoCAD
  - Innoveda (PADS) PCB CAD
- Maxwell – Finite Element Electromagnetic Field Simulation
- Speed – Motor Design Software
- LabView - Functional Test Program
Test Capabilities

- Index stand to test resolver accuracy up to 5 arcsec
- Dynamometer
- Random & Sine Vibration
- Thermal cycle
- Thermal Vacuum cycle
- Clean Room Class 100,000 (ISO 8), Class 10,000 (ISO 7)
  Flow Benches Class 100 (ISO 5)
- Computerized Automatic Test Equipment
- Equipment to perform full, customer-approved acceptance test
Manufacturing Capabilities

- Complex Electrical Sub-Assemblies
- Electronic Circuit Assemblies
- Wire Harnesses
- NASA Certified Soldering
- State of the art Capabilities
  - Machining Centers
  - Laser Cutting /Marking
  - Stamping / Forming
  - CNC Lathes and Jig Borers
  - Tool making Center
  - Turning
  - Injection Molding
  - Vulcanizing
  - Structural Bonding
  - Spot and Heli-arc Welding
  - Painting
  - Chemical Filming
- Material & Component Traceability
Aerospace References

- JPL
  - Mars Pathfinder (6 BLDC Motors)
  - Mars Rovers
  - Cassini
- Hubble Rescue
- Space Shuttle
- MILSTAR Satellites (40 resolvers)
- Linear Actuators on the Mars Exploration Rovers (MER) for the Rover Stand-up Operation.
- Hughes Space System Microwave Group
- International Space Station (55 resolvers)
- TRW
- Melco
- Astrium / Matra Marconi
- Polar Platform
- Skynet
- Space Telescope
- TDRS Satellite
- ESA Rosetta
- ESA Venus Express
- NASA Dawn mission
- NASA Galileo Spectrum analyzer in JIRAM program
- NuStar Satellite
- Intelsat, Inmarsat, Mexsat
Ducommun has deployed more than $500 million in the last three years completing multiple strategic acquisitions.
DLT Business Unit-Engineered Products

Broad-based Specialized Products

Radio Frequency Products
Millimeter Wave Components & Microwave Switch Products

Motion Control Devices
Motors, Resolvers, Actuators, & Mechanisms

Human Machine Interface
Integrated Panels and Assemblies, Bezels & Pushbutton Switches

Engineered Products are valued-added services with the full capability to design, testing, and manufacturing custom and standard solutions.
Manufacturing capabilities are backed by value-added services, including engineering and design support, new model introduction, DFM/DFT, prototyping, test development, component engineering and program management.
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