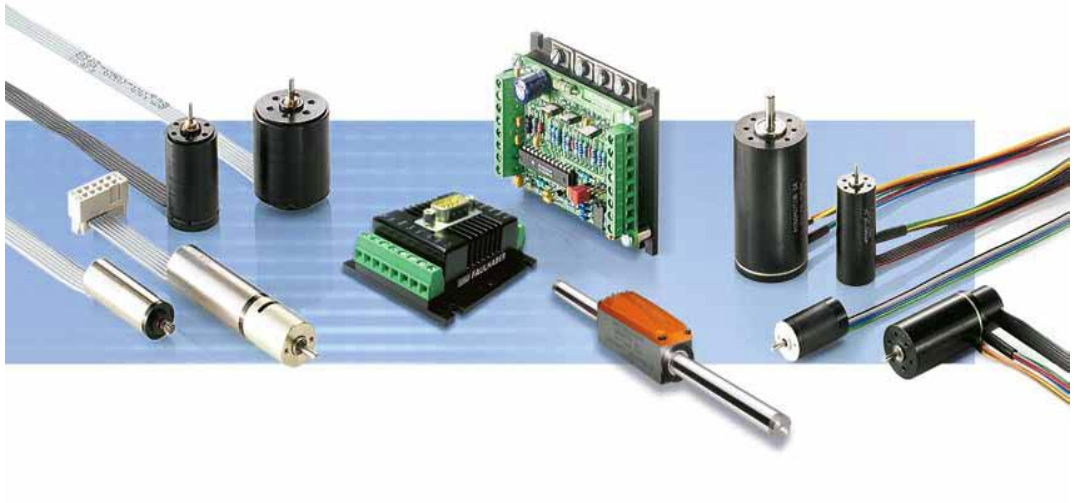
MICROMO

MICRO MOTION SOLUTIONS

DC Motor Selection
George Hunt



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November 4, 2009

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Agenda

- Simplicity: The linear characteristics of Motors
  - Iron core brushed dc motors
  - Coreless brushed dc motors
- Going for longevity: Brushless technology
  - Driving brushless motors
- Positioning with PMDC steppers
  - Driving Steppers
- Linear motion with actuators
- Feedback
- About MICROMO
- Contact Information

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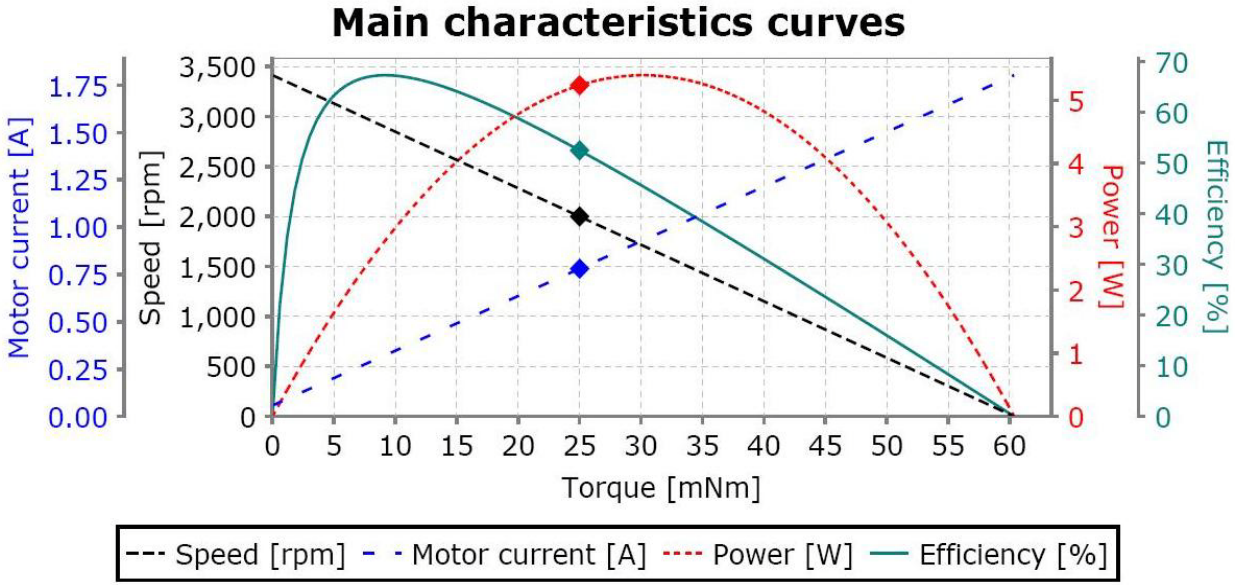
Linearity



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- Voltage and Speed
  - ✓ Directly proportional
- Current and Torque
  - ✓ Directly proportional

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Linearity

$$P_{rot} = M \times \omega$$

$$P_{dis} = I^2 \times R$$

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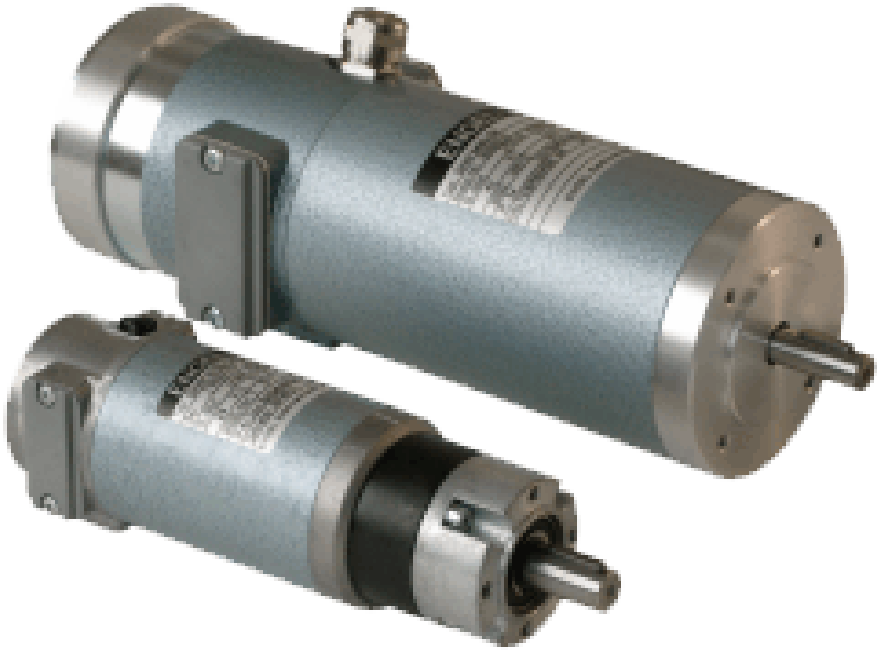
Iron core DC motor

- Iron core DC motors with copper graphite brushes
  - Powerful
  - High torque
  - Rigid design

- Downside to Iron Core
  - Poor acceleration
  - High inductance
  - Cogging and arcing



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Coreless DC motor

- Coreless DC motors with carbon graphite brushes
  - High speed / faster acceleration
  - No cogging
  - Reduced arcing
  - Long life
  - High current density
  - High torque constant

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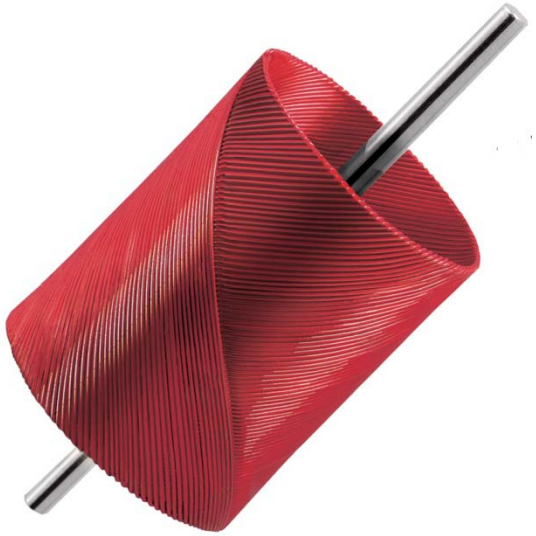
Coreless DC motor

- Coreless motors with precious metal brushes
  - High speed / faster acceleration
  - No cogging
  - Reduced arcing
  - Low mechanical sliding friction between brush and commutator
  - Can be driven at low voltages and low speeds
  - Long life and smoother commutation signal
  - Great for aerospace applications



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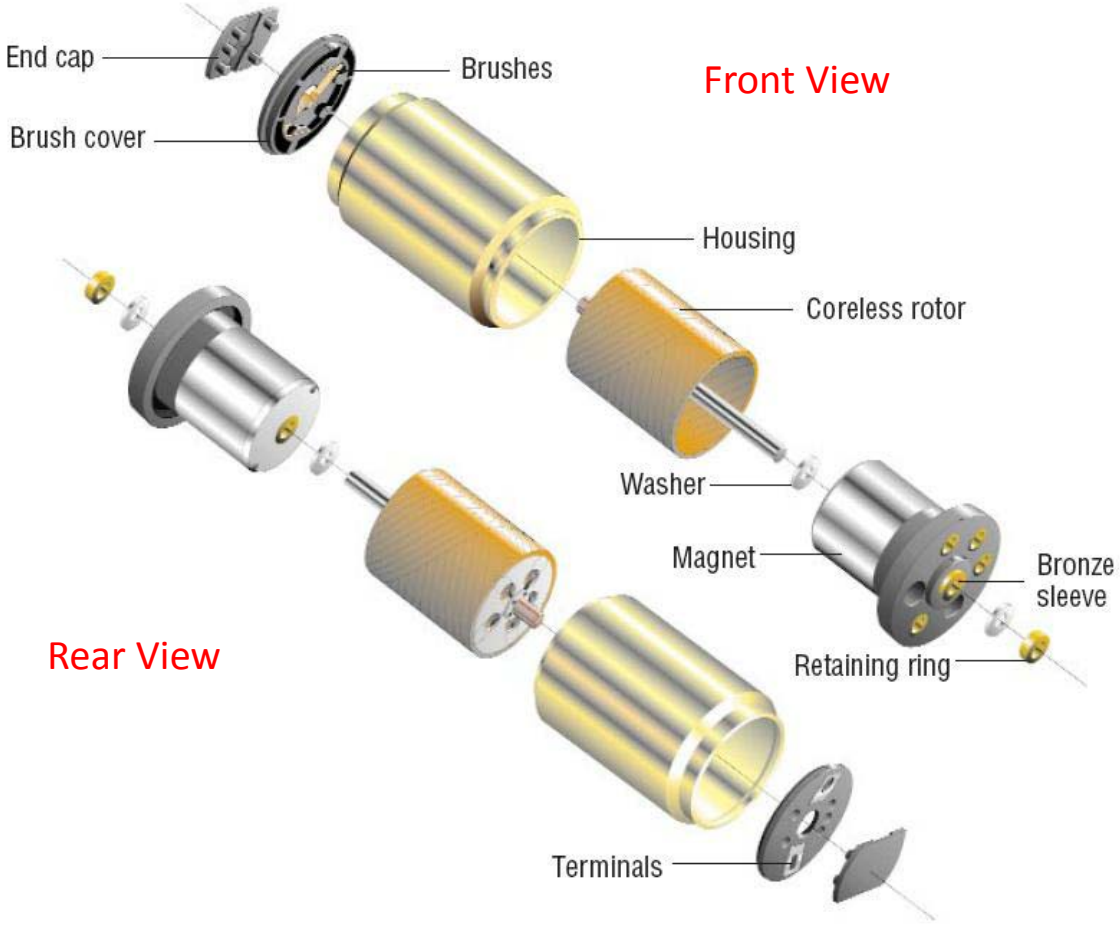
Coreless DC motor

- Coreless motor construction
  - Precious metal commutation shown here
  - Self-supporting skewed windings
  - Sleeve bearings shown here



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Brushless DC motor

- Brushless DC motors
  - Capable of very high speeds
  - Lower EMI than most brushed
  - Very long life when driven properly
  - No mechanical commutation, no arcing!
  - Different varieties: 2 pole / 4 pole / 8 pole

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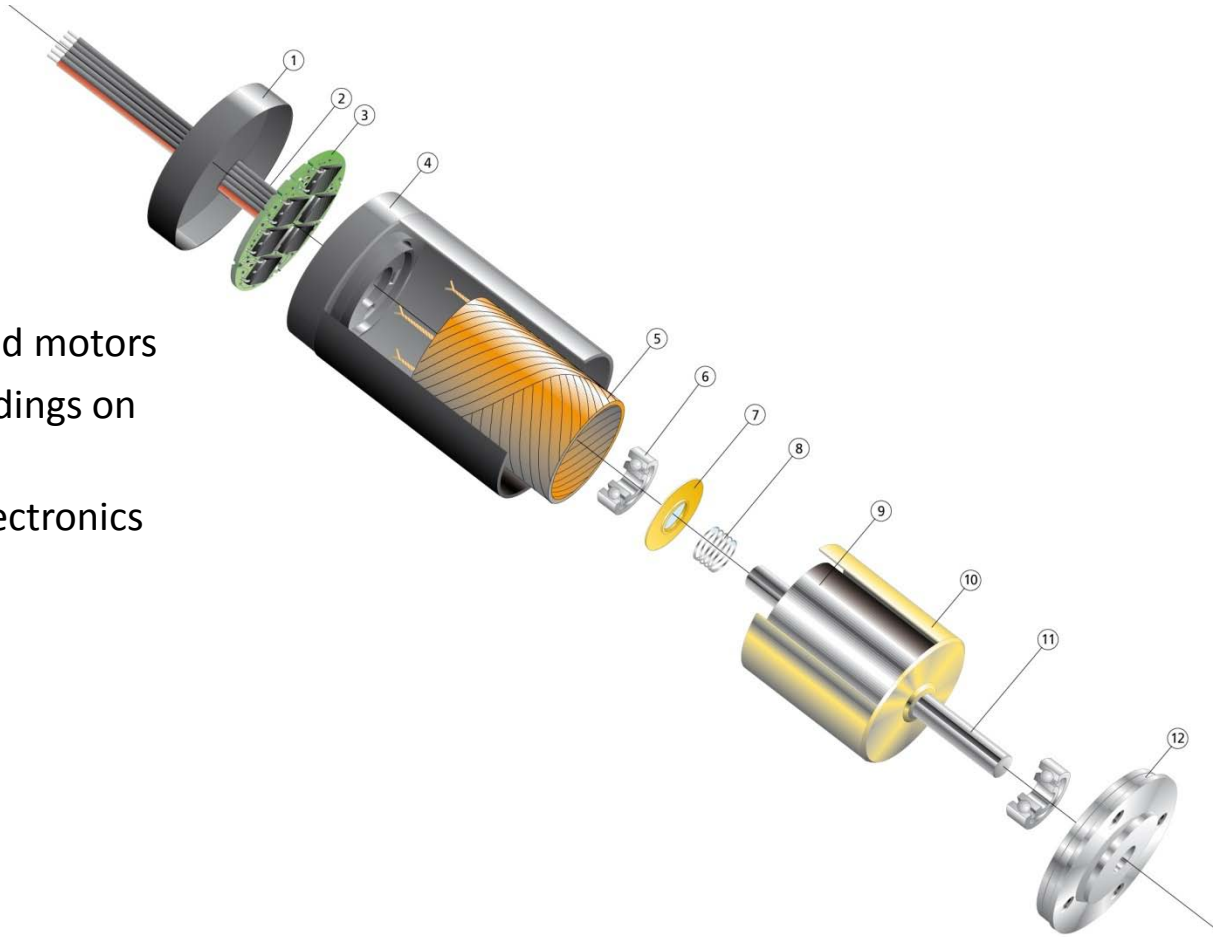
Brushless DC motor

- Construction
  - Opposite of brushed motors
  - Rotor magnet, windings on stator
  - Integrated drive electronics shown here



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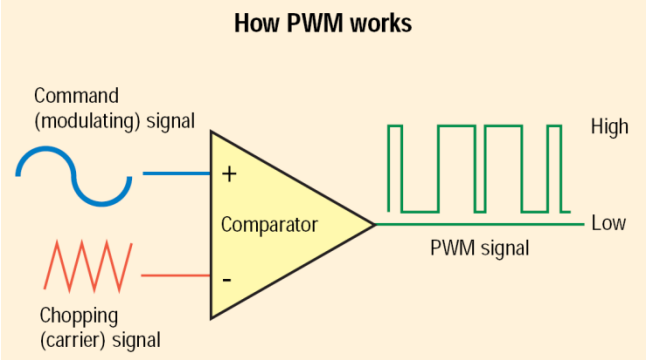
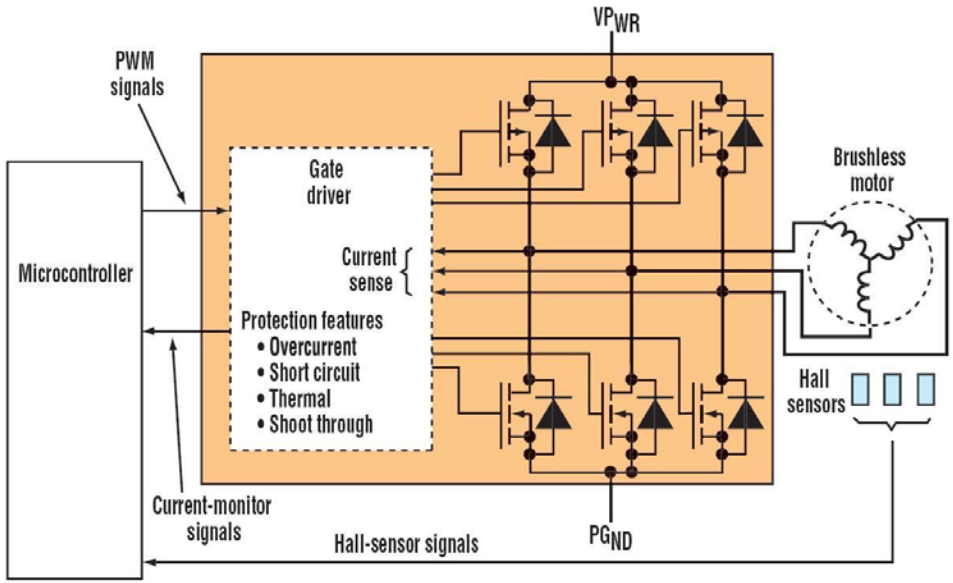
Brushless DC motor

- BLDC motors must be driven with a 3 phase power signal
  - PWM or pulse width modulation
  - PWM is more efficient than linear voltage
  - Power stage delivered by 6 MOSFETs
  - Hall sensor feedback





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Stepper Motors

- 2-phase stepper motors with neodymium magnets
  - Steppers are simple and reliable
  - Micro-stepping capabilities
  - Great for positioning (cameras)
  - Open loop so no need for feedback (cost savings)
  - Excellent holding torque (no power-off brakes needed)

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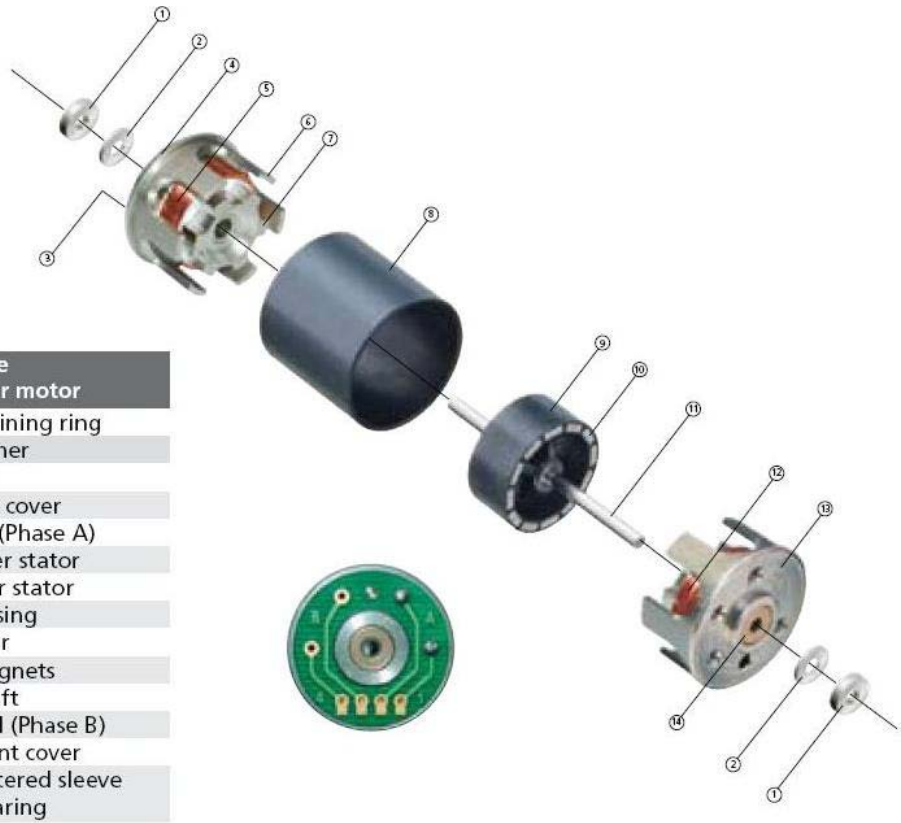
Stepper Motors

- Stepper Construction
  - Brushless
  - Usually 12 pole pairs
  - 2 phase shown here



2-phase Stepper motor
1 Retaining ring
2 Washer
3 PCB
4 Rear cover
5 Coil (Phase A)
6 Outer stator
7 Inner stator
8 Housing
9 Rotor
10 Magnets
11 Shaft
12 Coil (Phase B)
13 Front cover
14 Sintered sleeve bearing

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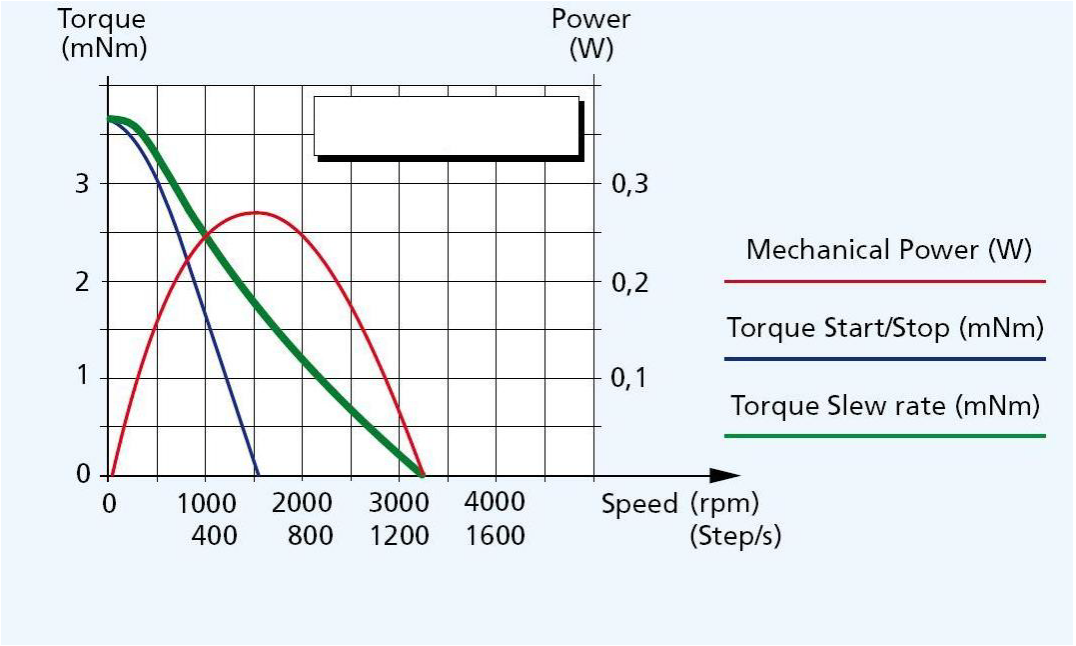
Stepper Motors

- Driving a stepper
  - Start and stop region
    - instantaneous
  - Pull out curve
    - Must be ramped



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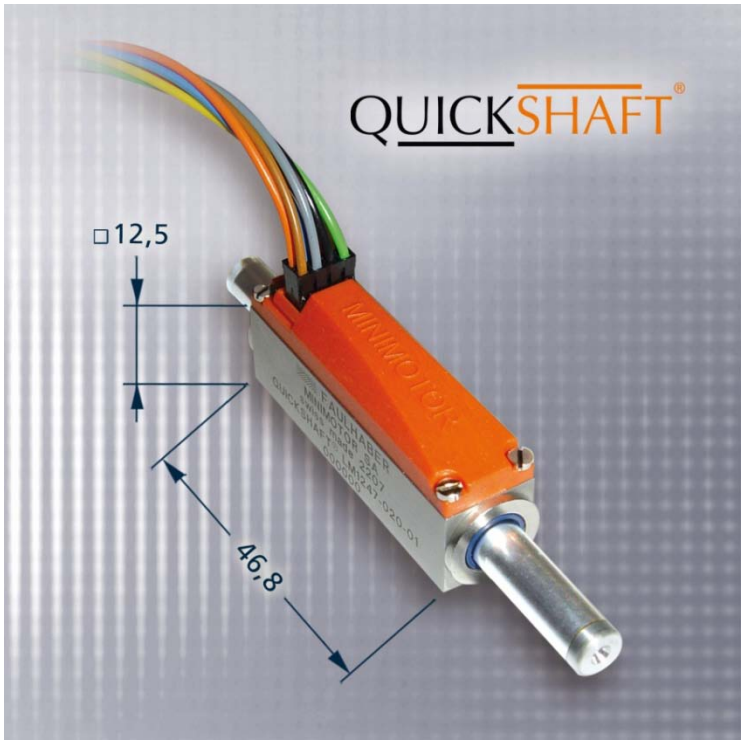
Linear Motors

- Direct drive linear actuation
  - Linear servo motors
    - Excellent acceleration
    - High resolution
    - Excellent repeatability
    - High precision
    - High efficiency



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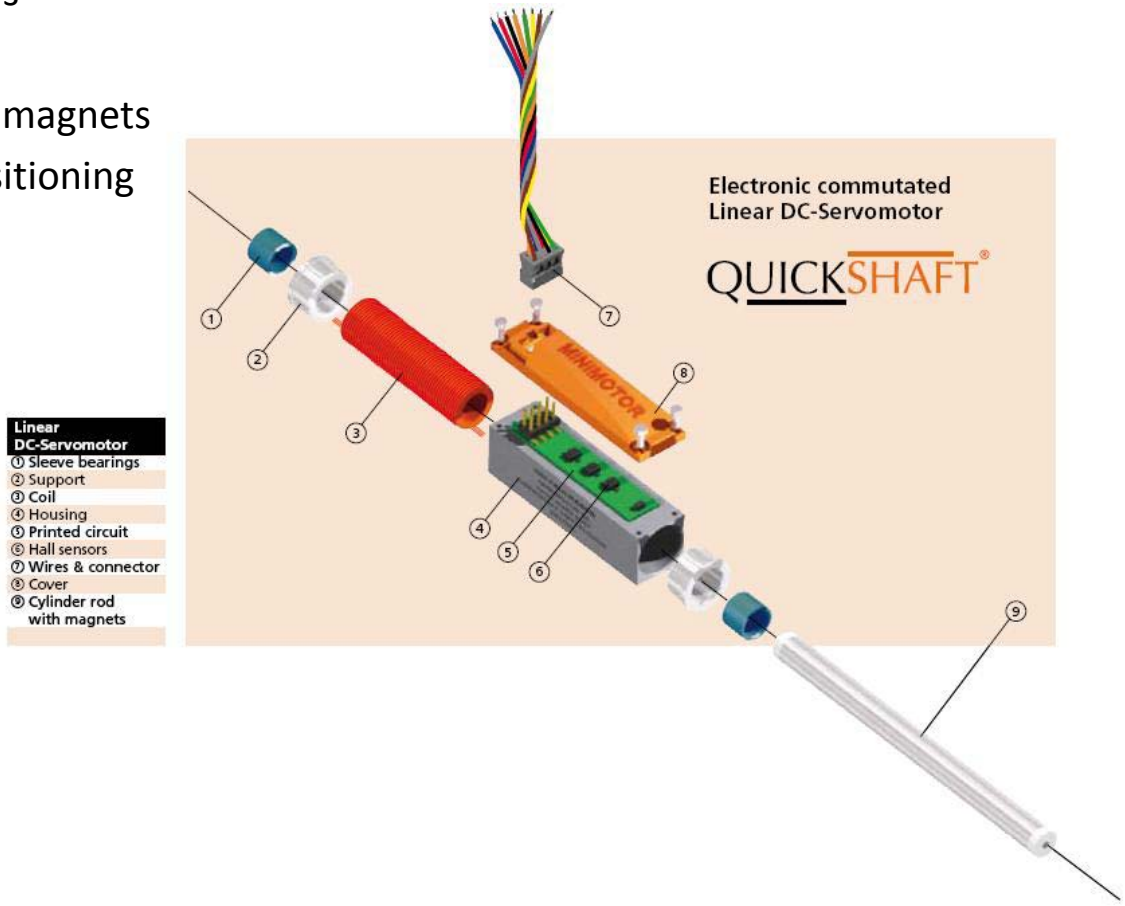
Linear Motors

- Brushless linear servo motors
  - Construction
    - Drive rod contains magnets
    - Linear halls for positioning
    - Sleeve bearings



Linear DC-Servomotor
① Sleeve bearings
② Support
③ Coil
④ Housing
⑤ Printed circuit
⑥ Hall sensors
⑦ Wires & connector
⑧ Cover
⑨ Cylinder rod with magnets

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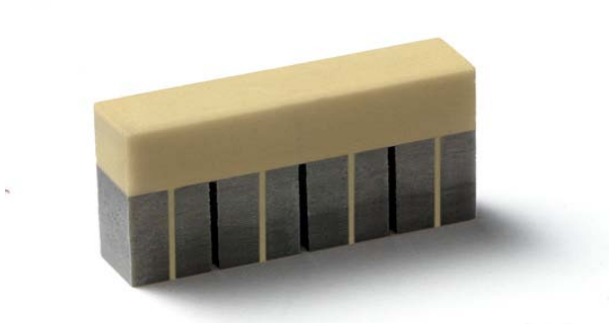
Linear Motors

New technology enables OEMs to develop new solutions for today's market:

- The Application: Microscope stages for drug discovery, cell manipulation, DNA testing
  - Piezoelectric actuators
    - Nano-positioning resolution!
    - No E/M emissions
    - Back-drivable without harm
    - Backlash free
    - Simple drive electronics
    - Rotary and linear versions
    - Vacuum compatible
    - Non-magnetic versions



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Feedback

- Optical Encoders
  - 1024 lines per revolution – direct read
  - Modular and replaceable
- Magnetic Encoders
  - Fits on small motors
  - Cost effective solution
- Digital Hall effects
  - Commutation and feedback all in one
  - Fine for speeds > 1000 RPM
  - Noise immunity
- Linear Hall effects
  - Commutation / Feedback
  - Positioning capabilities
  - Susceptible to noise

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Who Is MICROMO?

MICROMO, founded in 1962 and based in Florida, represents FAULHABER products in the Americas. A member of the FAULHABER Group, MICROMO is a leader in miniature motor and encoder technology and design customization.

MICROMO brings together value-added services and cutting-edge technologies from around the world through high-efficiency, high-performance offerings such as brushed, brushless, stepper, thin-profile DC and piezoelectric motors for diverse applications.

Our benchmark contributions with motion solutions are a part of leading products and applications in markets such as medical devices, optics, photonics, automation, aerospace, defense and security systems.

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