QM POWER

Peak Power At Peak Efficiency

SMMA Fall Technical Conference
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Parallel Path Magnetic Technology (PPMT™) is an enabling electric motor, generator and/or actuator technology that provides Higher Power Density and Higher Efficiency

Customer Pain Points

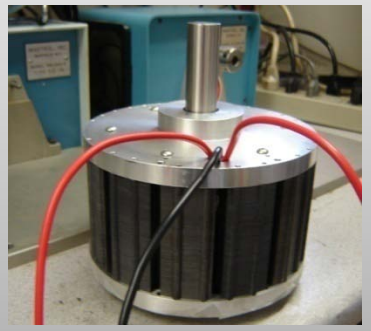
- Need to cut capex and/or component costs
- Need to reduce energy/battery costs
- Weight or size limitations

"PPMT is The biggest leap in motor and generator design logic in more than a hundred years."

- Jamie Childress, Boeing Research and Technology

QM Power Solution

- Higher power density
- Higher efficiency
- Higher reliability
- Lowest Cost Solution



PPMT™ was invented and patented and is being commercialized by QM Power and its development partners.

PJ Piper, CEO
Finance and Business Development
Boston, MA

Joe Flynn, CTO
Research and Development
Kansas City, MO

John Lebo, COO
Manufacturing and Engineering
Baltimore, MD

Blue Chip Partners

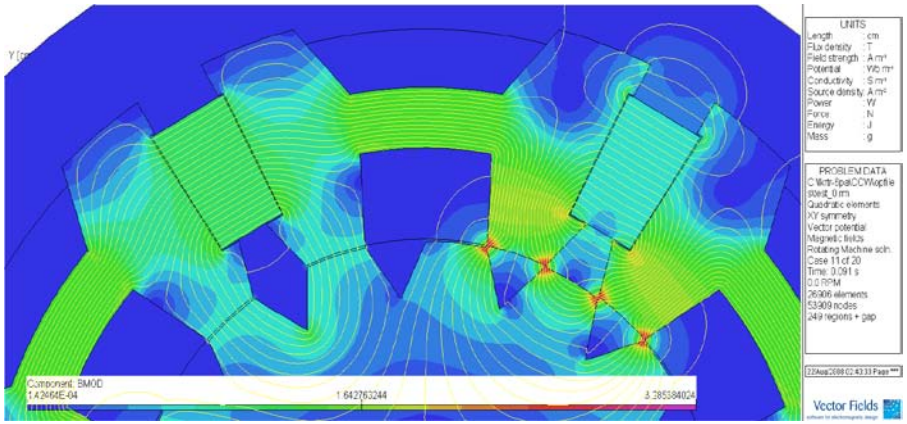
Large Markets

- Variable Speed Motors
- Generators
- Linear Motion Devices
- Fixed Speed Motors

Important Applications

- Electric Vehicle
- HVAC
- Wind/Hydro Power
- Portable Power
- Robotics Manufacturing
- Industrial
- Consumer

PPMT™ obtains the benefits of using permanent magnets while minimizing the historical trade-offs/limitations found in conventional permanent magnet designs.



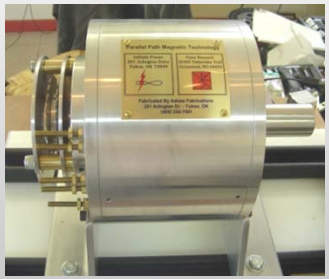
Recent Awards

- 2008 Missouri Innovator of the Year – SBTDC
- 2008 NREL Industrial Growth Forum - Venture Finalist
- 2009 New Energy Symposium Clean Energy Investment Finalist

IP Positioning

US Patents issued: 6,342,746
6,246,561

US and PCT Applications:
PCT/US2008/058521 & 056240



QM Power's advantage is its proprietary, cost effective and higher performing magnetic circuit

Permanent magnets are used in rotating machines to replace the field coils that produce static magnetic fields to provide :

Higher Power Density

- A reduction in the size of the machine since the magnets are physically smaller than the coils they replace; and
- A reduction in the weight of the machine since the magnets are physically lighter than the coils they replace.

Higher Efficiency

- The elimination of the I^2R losses attributed to the field coils, thus reducing heat losses and therefore improving the overall machine efficiency.

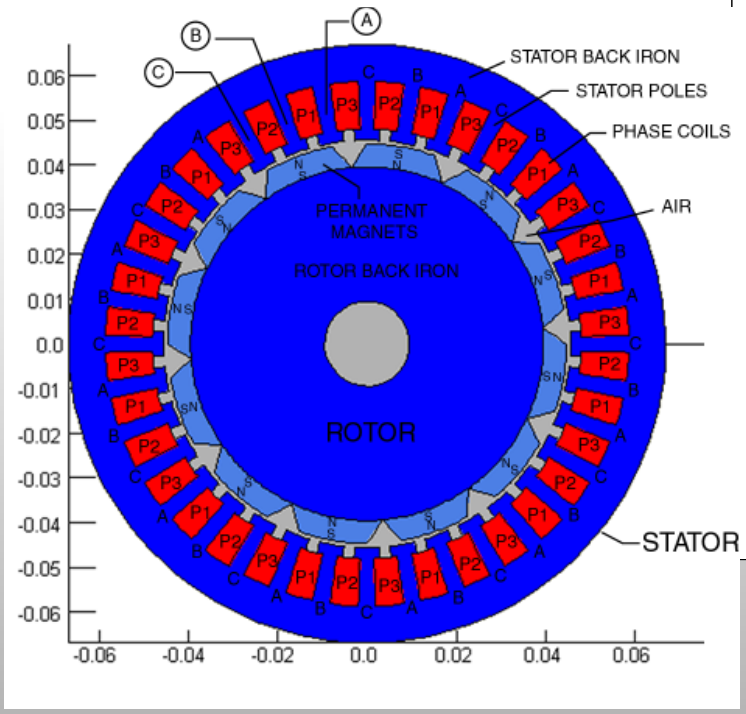
However, replacing a rotating machine's field coils with permanent magnets has the following trade-offs/limitations:

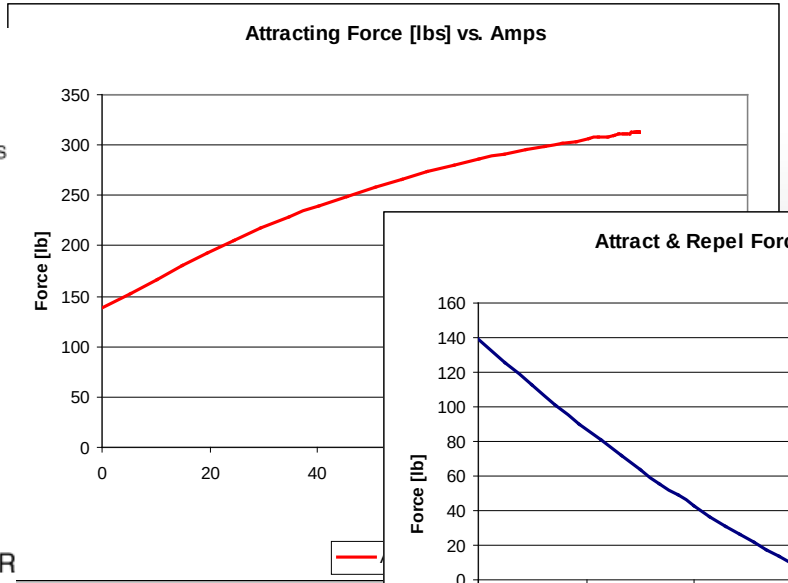
- The energy product of a permanent magnet is fixed, thereby limiting the controllability of the static magnetic field;
- State of the art permanent magnets cannot achieve the gap flux densities that can be achieved with wound field coils;
- Permanent magnets do not make good structural components and can create bonding issues when placed on a machine's rotor; and
- Permanent magnets are more sensitive to temperature.

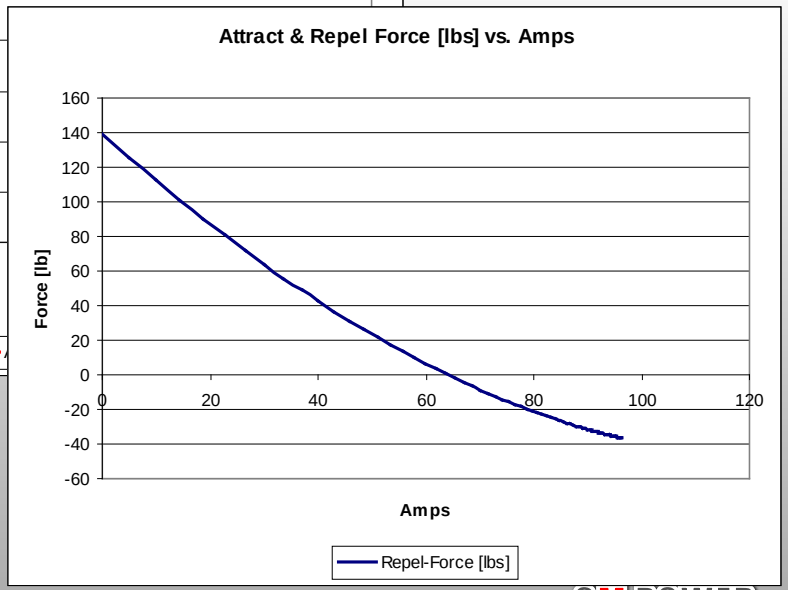
Major Design Limitations with Brush and Brushless PM Motors

LIMITATION 1:

The Maxwell stress integral in the air gaps for the same amount of applied phase coil current is different for an electromagnetic field that is attracting a permanent magnet than one repelling a permanent magnet.



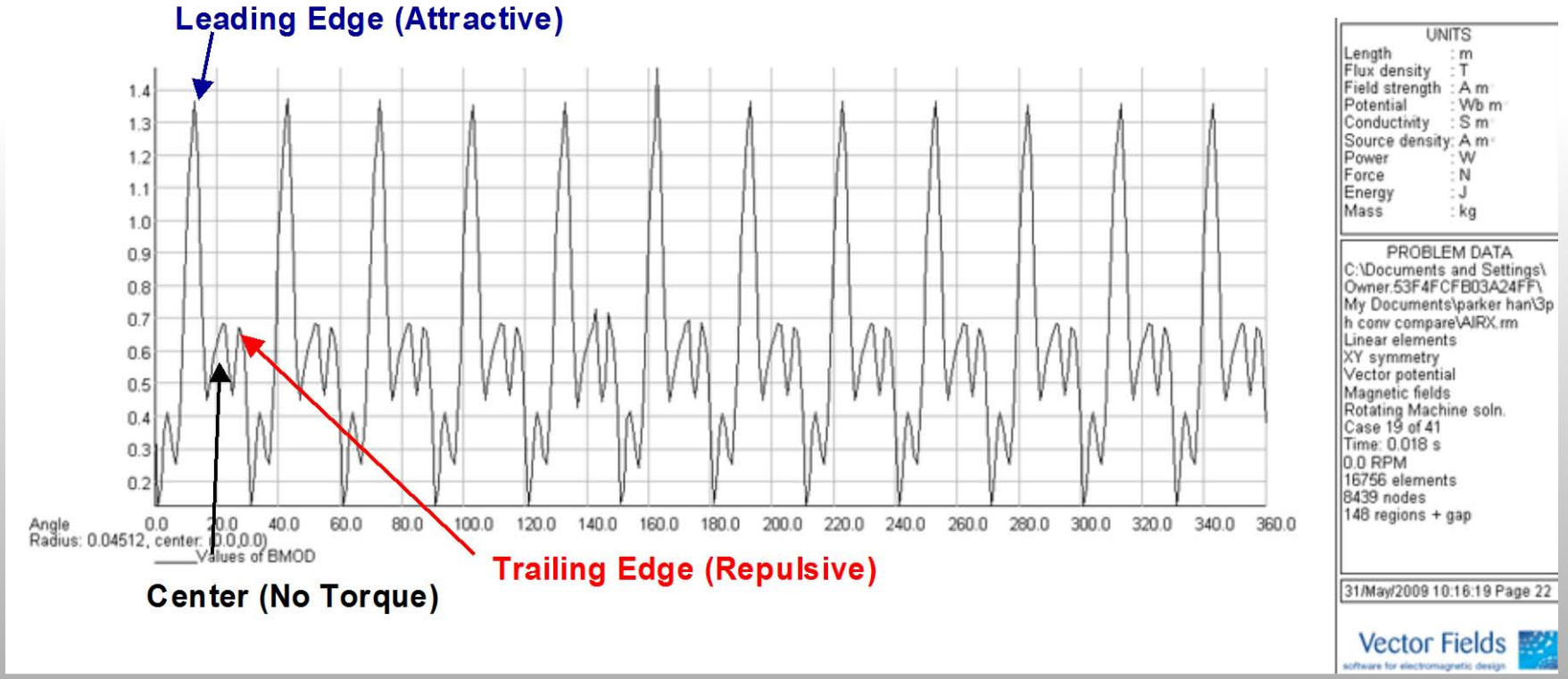




Major Design Limitations with Brush and Brushless PM Motors

LIMITATION 1:

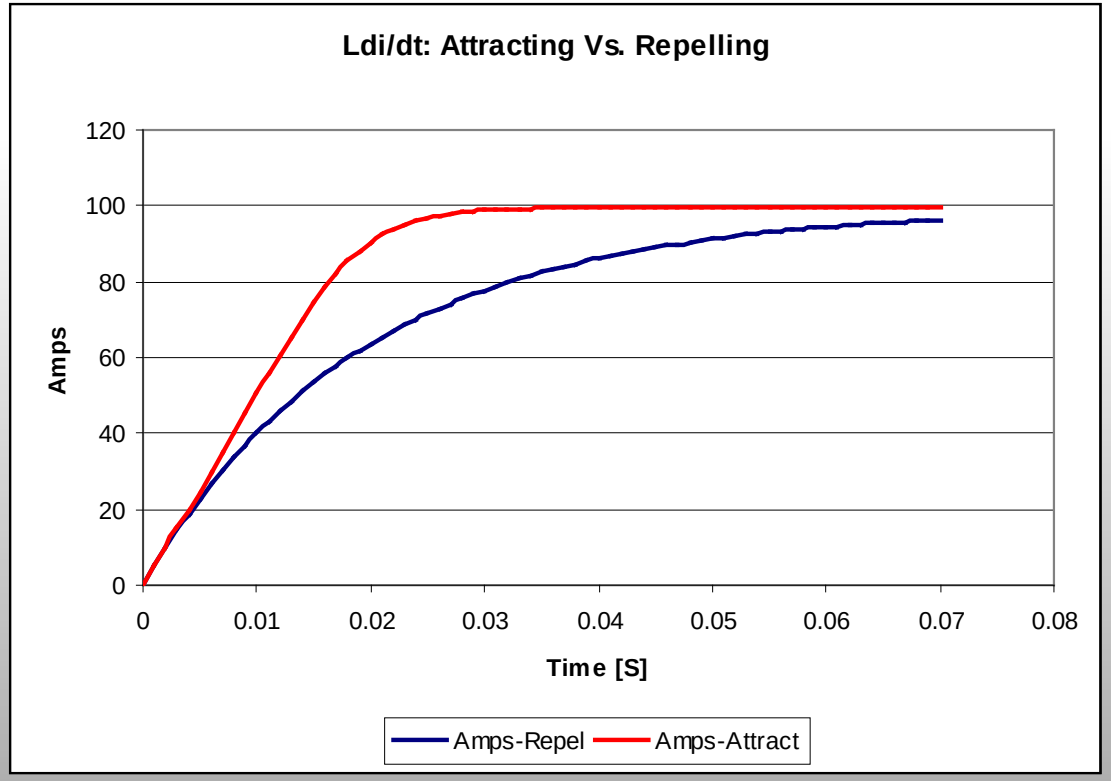
Since the torque delivered to the shaft is the sum of all the attractive and repelling forces, the mean flux density in the air gap is less than half the Br of the permanent magnets.



Major Design Limitations with Brush and Brushless PM Motors

LIMITATION 1b:

The exponential rise time for the phase coils to obtain I_{max} is different when a phase coil is energized to attract a permanent magnet than when repelling a permanent magnet. Torque versus speed is a function of the current through the BEMF.

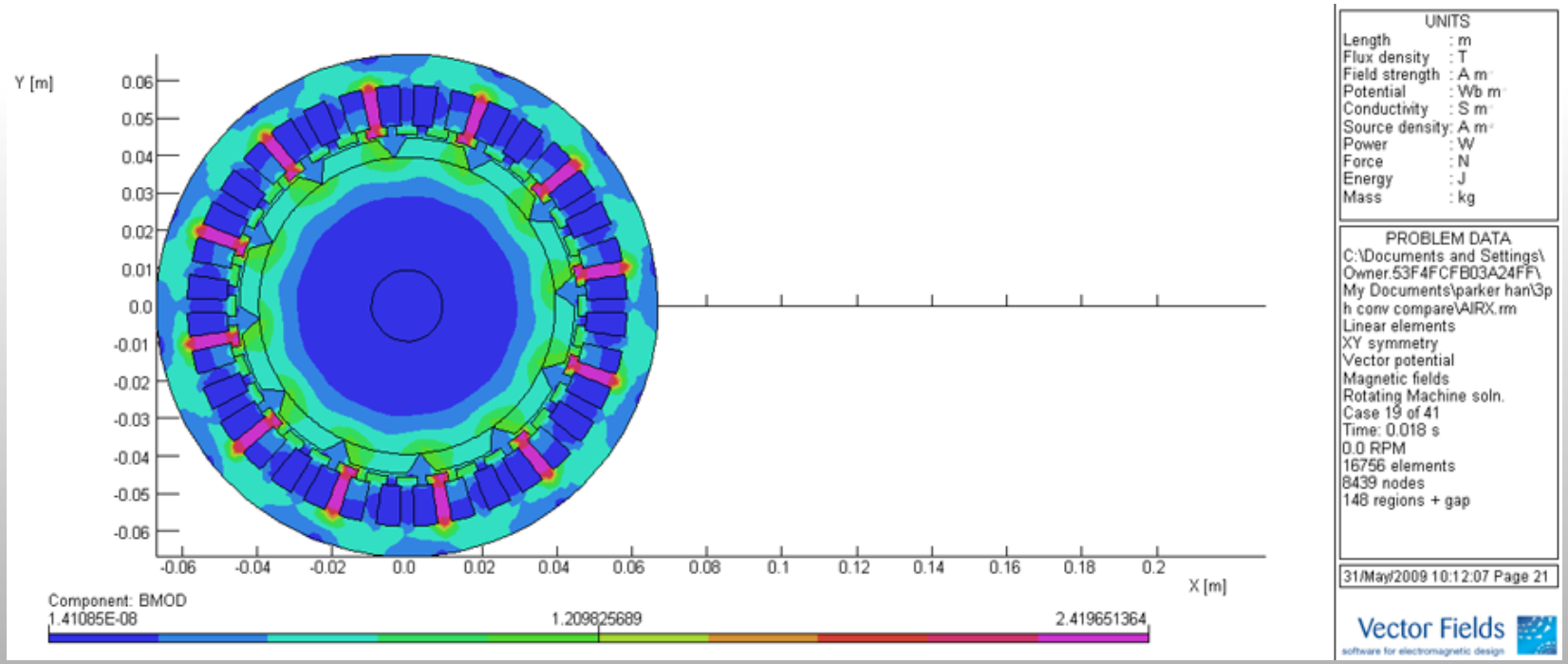


$$i = \left(\frac{Ea - E_{bemf}}{R_{coil}}\right) \cdot \left(1 - \xi^{-t \cdot \frac{R_{coil}}{L_{coil}}}\right)$$

Major Design Limitations with Brush and Brushless PM Motors

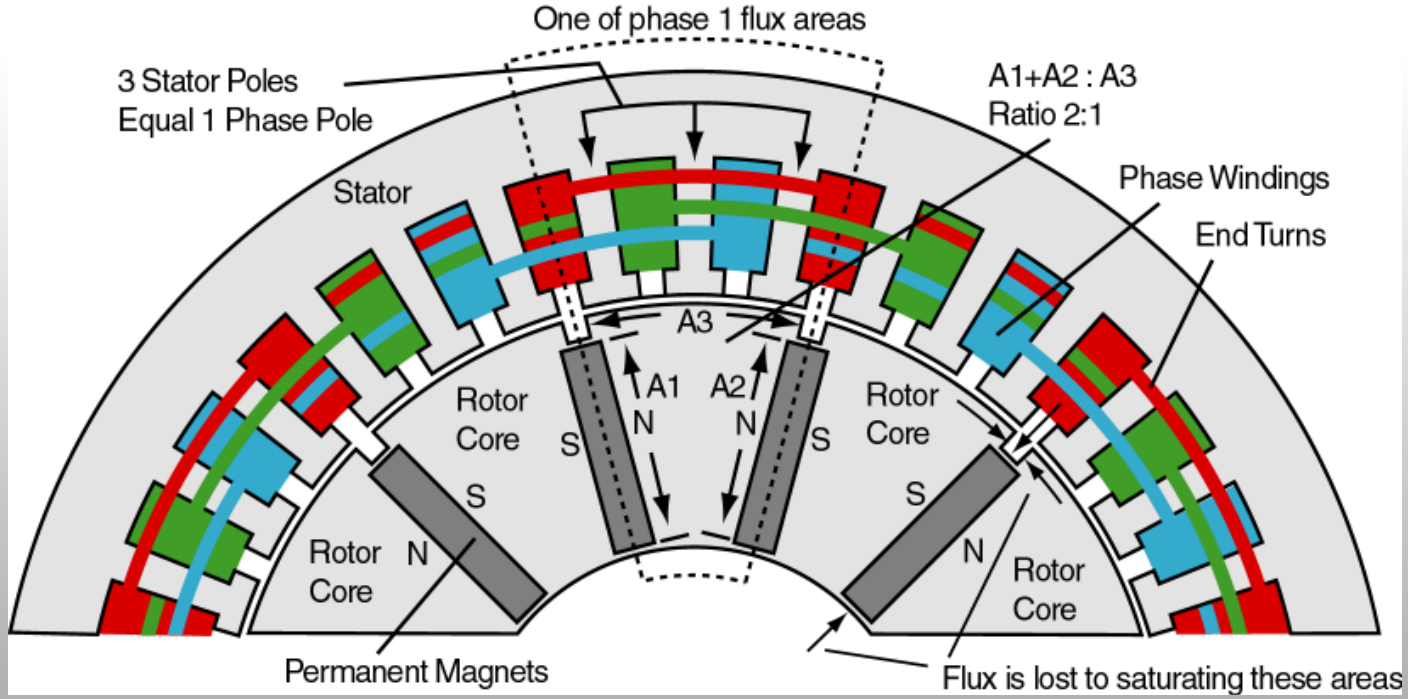
LIMITATION 2:

Due to overlapped phase winding slots, only about 30% of the area of the rotor to stator air gap interface is utilized to produce a majority of the torque.



Possible solution for increasing the gap flux density of a PM motor to that of a field wound motor

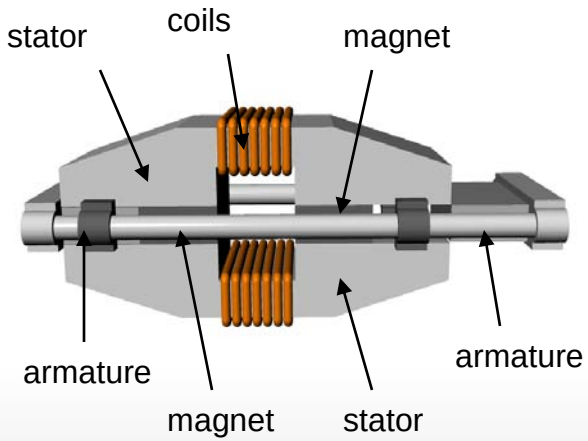
Increasing the pole face area of the the rotor permanent magnet to be greater than the pole area (areas A1+A2>A3 by 2:1). This is done by placing more than one magnet in the slots in the rotor or alternatively by shaping one magnet into a "U" shape (not shown) toward a stator pole. This still does not address limitations 1 or 2 above and results in a more complicated and costly rotor design.

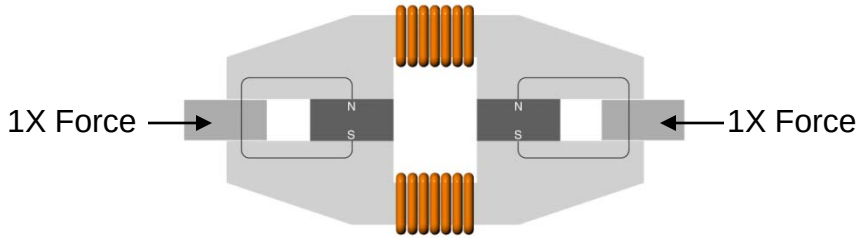


PPMT™ realizes weight and volume benefits of displacing field coils with permanent magnets while increasing torque and efficiency by achieving torque generating gap flux densities equal to those of a field wound motor (at the material limits).

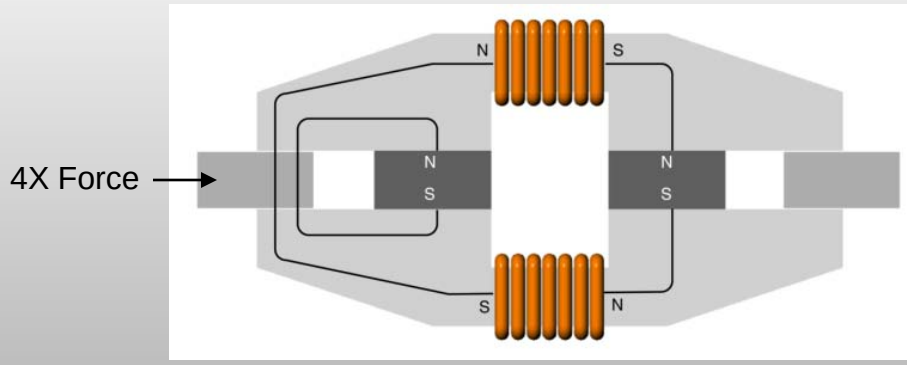
QM Power Parallel Path Magnetic Technology™

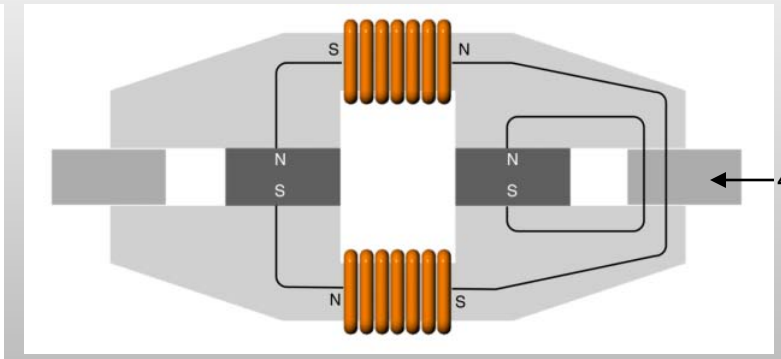
QM Power Controlled Permanent Magnet Flux Division and Squaring





$$F = \frac{\beta^2 A}{2\mu_o}$$

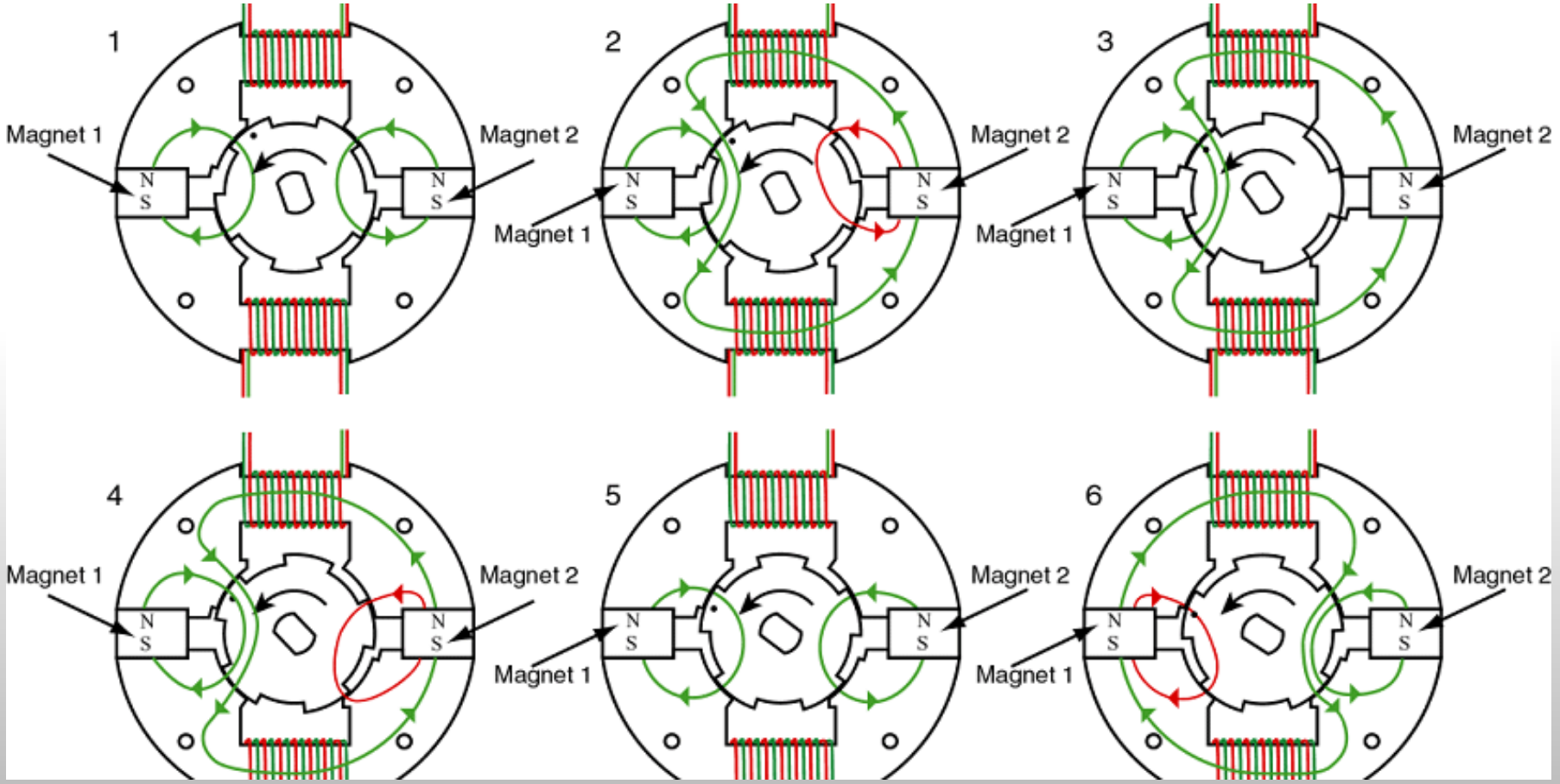




All force is generated with attractive permanent magnet flux.

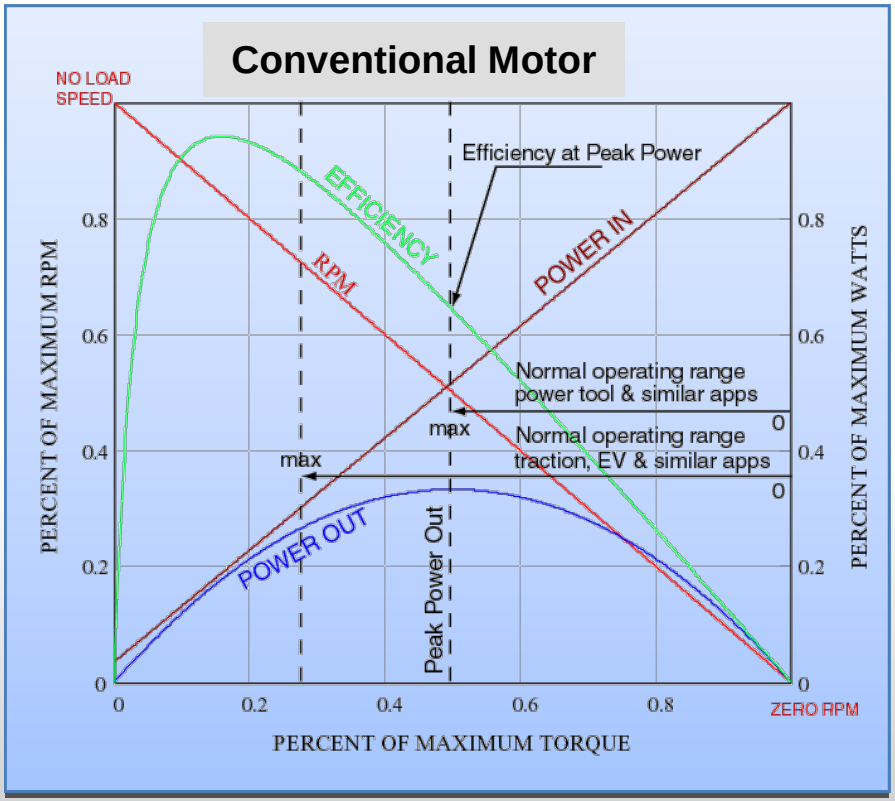
QM Power Parallel Path Magnetic Technology™

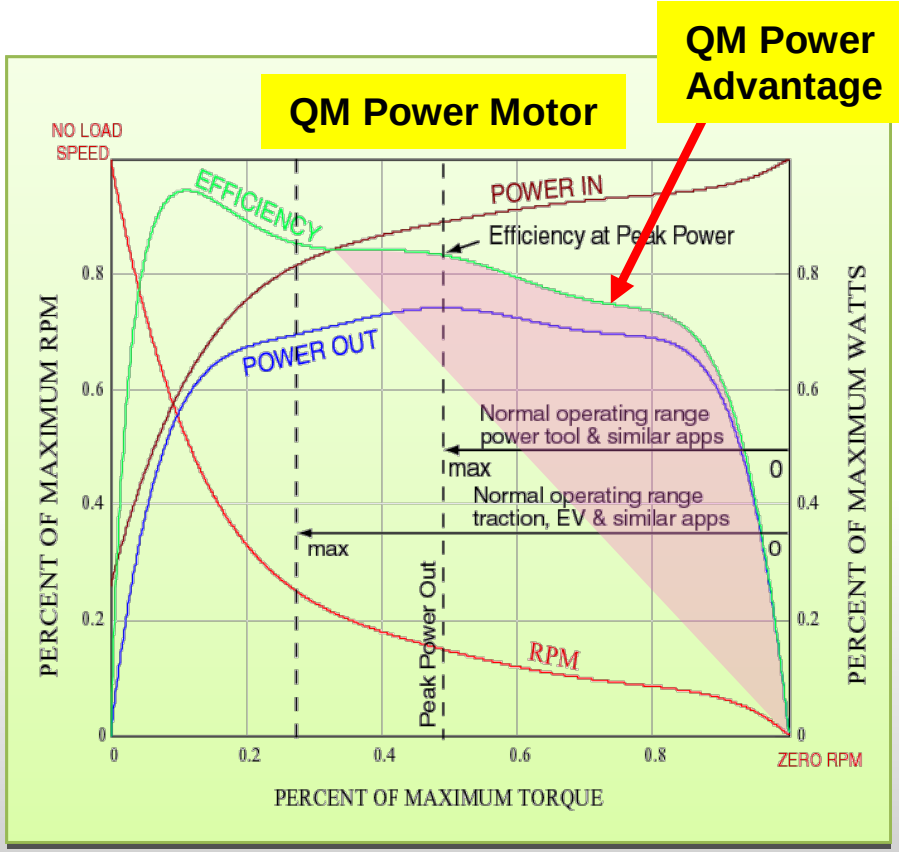
QM Power Single Phase Geometry



All torque is generated with attractive permanent magnet flux.

Conventional motors only operate near their peak efficiency in a narrow range of operating speeds. QM Power's PPMT provides higher efficiency over a broader range of operating speeds and loads.





QM Power does not have to oversize its machines and use control electronics to operate at or near its peak power with high efficiency.

QM Power Parallel Path Magnetic Technology™

PPMT Characteristics -> Greater Power Density and Greater Efficiency:

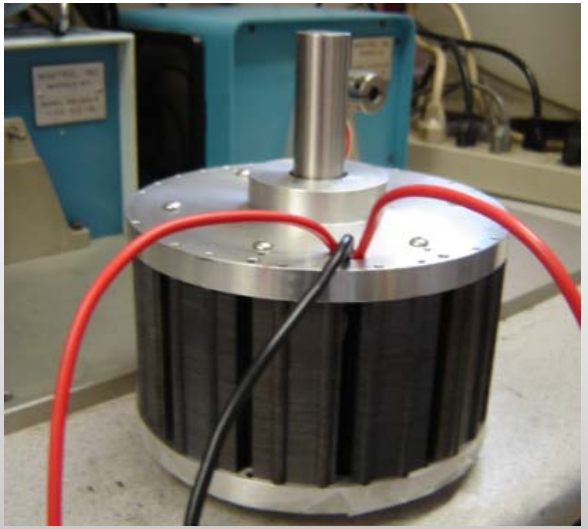
- Permanent magnets only attracting, utilizing over 50% of rotor-stator interface (versus 30%) increasing average gap flux density over conventional designs

- Unidirectional current and torque

- High starting torque

- No active components on rotor

- No cross rotor flux



- Fixed commutation without controls resulting in hyperbolic speed-torque curve and higher square power out and efficiency curves

Reducing the Total Cost of Ownership

QM POWER

QM Power has a patented breakthrough technology that uses permanent magnets in a novel yet simple design that significantly increases power density and efficiency in electric motors, generators and actuators.

Greater Power Density	*Greater Efficiency*	*Lower Up-front Cost*
Higher Low End Torque	*Lower Weight and Volume*	*Greater Reliability*

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