Advanced Control of Electric Vehicle (ACEV)

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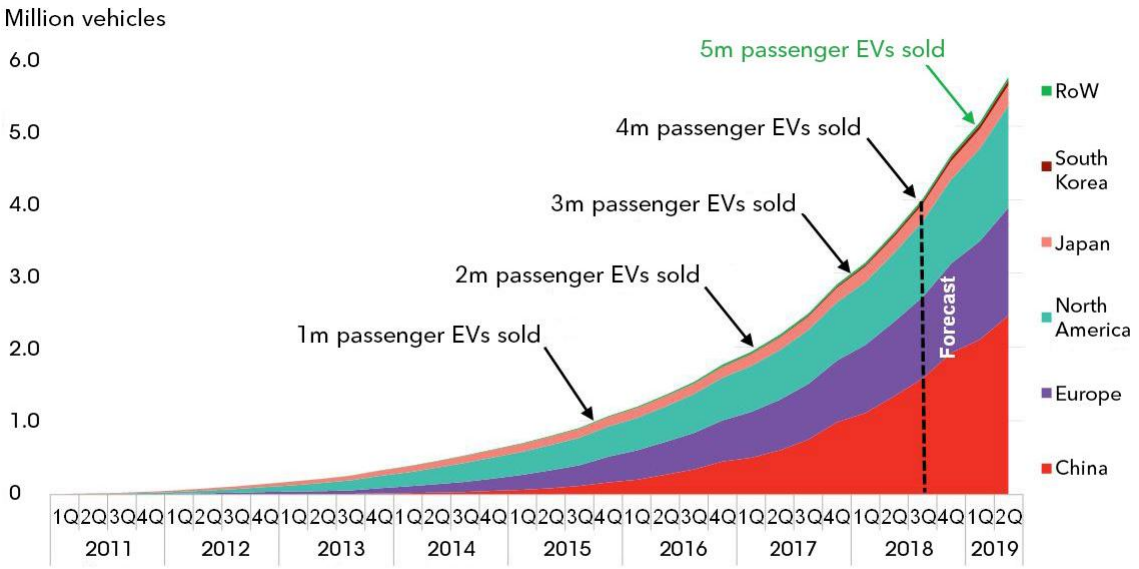
Advanced Control of Electric Propulsion System (ACEV)

- Overview on electric AC machine and their control
- Modelling of electric AC machine
- Advanced nonlinear control of electric AC machine
- Laboratory: simulation, experimental test bench

Electric vehicles

- 10 years the target was hybrid vehicles
- 2011 Nissan Leaf, Renault Zoé, Tesla
- Opportunities related to society changes
- Autonomous vehicle
- Charging stations



Trends in Traction Electric Machines

Electric Machines and Inverters ➔ Key components of Electric Powertrain

Objectives for traction machines

- High power density
- High efficiency
- High speed operation
- Low acoustic noise
- Low torque ripple
- Thermally stable
- Structural integrity
- Low $/kW design (US)

Exemple: Wide Band Gap (WBG) Drives

Trends

- IPMSMs: Most popular with Rare Earth (RE) PMs.
- Instability in RE's price propmotes R&D for alternative machines.
- Novel magnet or less magnet.
- Low acoustic noise

Traction motor choice

What electric motor should you choose for your project?

Many different angles:

- Electrotechnical
- Mechanical
- Practical
- Economic
- Environmental

Traction motor choice

What electric motor should you choose for your project?

Permanent magnet	Induction	Synchronous reluctance	Wound-rotor synchronous
Tesla model 3	Tesla model S	Holden/ECOmmodore	Renault Zoë
Nissan leaf	Renault Kango	Renault Fluence	Renault kongo
Toyota Prius	Cheverloet Silverdo		
Honda insight	BMW X5		
Volkswagen eGolf	Mahindra Reva e20		

M. Zeraoulia, M. E. H. Benbouzid and D. Diallo, "Electric Motor Drive Selection Issues for HEV Propulsion Systems: A Comparative Study," in IEEE Transactions on Vehicular Technology, vol. 55, no. 6, pp. 1756-1764, Nov. 2006, doi: 10.1109/TVT.2006.878719.

Induction Motor

- Magnetic field in the stator from electrified windings
- The most used motor
- Used in the Tesla Roadster and Model S and X

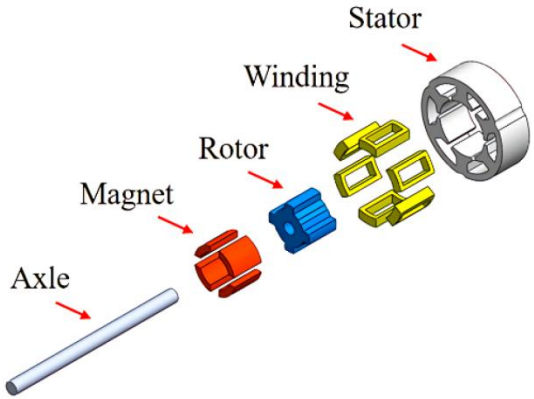
Advantages

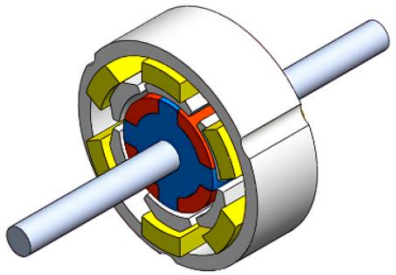
- Simple and rugged
- No bruches
- No permanent magnet
- No position sensor
- No starting mechanism
- Easy speed control

Disadvantages

- Induced current in rotor cause losses and heat
- Not the lightest and most compact motor

Permanent magnet motor





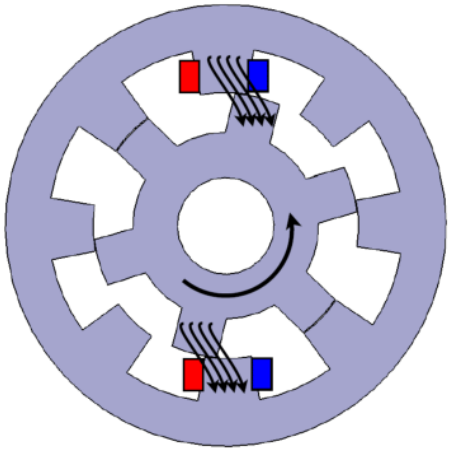
Advantages

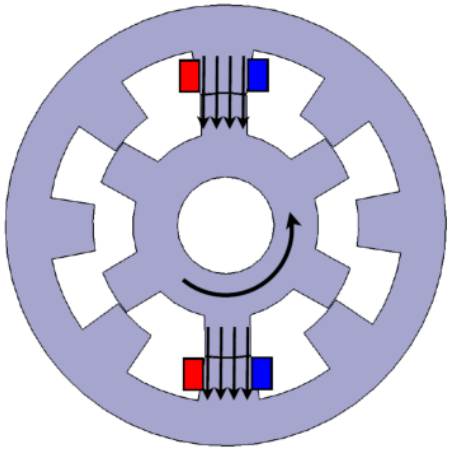
- Light and small
- Silent
- Efficient
  (especially at lower speeds)

Disadvantages

- Permanent magnets (cost + environment + can demagnetise)
- Position sensor
- Starter mechanism
- Electronic controller

Synchronous Reluctance Motor





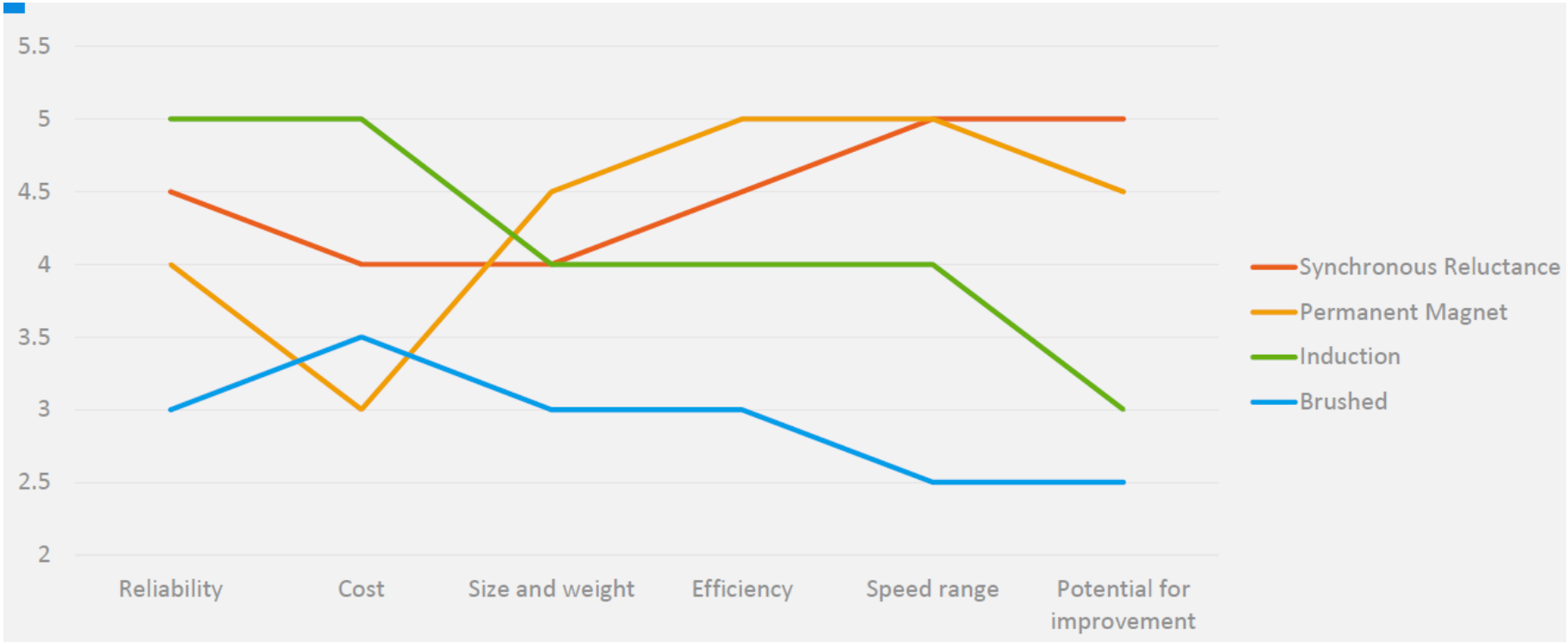
Advantages

- Torque comparable to permanent magnet motor
- Efficient at higher speeds
- Cheap and clean to produce (no permanent magnet)

Disadvantages

- Lower efficiencies at lower speeds
- Higher inherent noise and torque ripple (but increasingly dampened by advanced controllers)

Final comparison



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Control of electric motors

- Complex system leads to complicated task
- Power electronics, analog digital software (DSP), analog filtering, mechanics, thermal mechanics, heat transfering,…
- Motor control is not only model and control law
- Difference between simulation and experiments
- Difference between the electric vehicle environment and laboratory setup (inverters, DSP, DC bus,…)

Why advanced control of electric motors?

- The motors have the same topology since 1800
- The sychronous reluctance motor is invented in 1838
- The stepper motor is invented in 1930
- Development of digital system software and automatic control
- Develpoment of the control of electric motors
- Non modelled dynamics