FASTER AND MORE ACCURATE CONTROL OF SWITCHED RELUCTANCE ELECTRIC MOTORS USING ZYNQ SOC

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• Punch Powertrain
• ARMEVA
• Design workflow
• SR motor technology
• Matlab workflow
• Results
Punch Powertrain intends to become the leading independent provider of innovative clean powertrain technologies for car manufacturers.
Punch Powertrain: double digit growth

past

2006-2015 (10 yrs of double digit growth)

In 2015 the domestic Chinese OEMs adopt:
- 71% of all their CVTs from Punch
- 11% of all their ATs as Punch CVTs

2016

Demand rises also from other regions
- Wider spread of applications
- Design for global market coverage

2006: few apps/30 kupa VT2

2016: 60 apps/400kupa VT2/3

Customers & Applications

Products & Product Development

VT3  HS2  VT5  DT1
## Market requirements and solutions

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<th>Conventional ICE</th>
<th>Stop-start</th>
<th>48V</th>
<th>Mild hybrid</th>
<th>Full hybrid</th>
<th>Plug-in hybrid</th>
<th>Range Extender</th>
<th>EV</th>
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Goal:
To develop a new generation of rare-earth free electric motors based on magnetic reluctance.
Content
Electric Drive System including:
- Motors
- Power Electronics
- Controls

Focus
- power density increase
- Increased efficiency
- Smart packaging

Impact
- EV with increased efficiency at lower cost
- Optimize 3 motors
- Sensitivity analyses
• Cost
• Efficiency drive cycle
• Noise
Switched Reluctance motor characteristics

Basic Principle: Magnetic Reluctance

Advantages

• Simple, robust construction
• No permanent magnets
• High efficiency
• High speed capability
• Low cost
• Safe Operation

Challenges:

• Torque Ripple
• Controls
• Electronics
• Acoustics
• Higher speed: 20 000rpm
• Less inductance: 8000A/ms
• Delay of 1μs -> error of 8A
• Interrupt based current hysteresis control in processor 14μs minimum
• New closed loop control strategies with fast and heavy calculations
• -> SoC device: Zynq 7045 device
• No FPGA knowledge within Punch
- Zynq 7045 device
- Fixed point workflow
- Embedded coder / HDL coder
- Vivado
• Easy to split SW architecture for µproc and FPGA
• Reuse of legacy code
• Automatic communication HW-SW
• Ecosystem Zynq for more specialized drivers not available: CAN
• Fixed point conversion not yet push button
• Vivado workflow fully automated
Development workflow part 2

Vehicle requirements

E-drive requirements

Architecture Design

Module Design

Implementation

Final board
HIL test

Eval Board
HIL test

Eval board
desk test

MIL

Test bench

Vehicle

Reuse models from left leg
for validation
• Integrated E-drive:
  – motor, PE and SW
• 4 different control strategies
  – 1,5 years with 2FTE’s
• Models reusable for production
• Smooth integration and validation due to development process
  – Validation before electronics are produced
  – Do not lose critical test bench time
Future

• Growth in:
  – Products
  – Staff

• Time to market
• Quality
• Cost
Thank you for your attention!

For more info about us, please visit our website  www.punchpowertrain.com

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