ENABLING CUTTING-EDGE ELECTRIFIED POWERTRAIN SOLUTIONS USING MODEL-BASED DESIGN

IR. STEVEN Bervoets
CONTROLS ENGINEER
MATHWORKS AUTOMOTIVE CONFERENCE
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• Punch Powertrain
• ARMEVA
• Design workflow
• SR motor technology
• Model based design workflow
• Results
Punch Powertrain intends to become the leading independent provider of innovative clean powertrain technologies for car manufacturers.
Punch Powertrain: double digit growth


2006: few apps/30 kupa VT2 2016: 60 apps/400 kupa VT2/3

VT3 HS2 VT5 DT1
Market requirements and solutions

<table>
<thead>
<tr>
<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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Electric Drives
Electric hybrids
Flywheel based
DCT Transmissions
CVT Transmissions
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
ARMEVA research scope

- Cost
- Efficiency drive cycle
- Noise

Rotating motors

Synchronous machines

AC motors

Externally excited synchronous motors (ESM)

PMSM (Brushless DC)

DC motors

Asynchronous machines (ASM)

Reluctance motors

Switched reluctance motors (SRM)

Variable reluctance synchronous motors (VRSM)

DC excited flux switching machines (DCEFSM)

IM
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
• Simulate data types
• 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

Eval board desk test

MIL

Eval board HIL test

Final board HIL test

Test bench

Vehicle

Reuse models from left leg for validation
Results

- 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

• Workflow essential for:
  – Time to market
  – Quality
  – Cost
Thank you for your attention!

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

steven.bervoets@punchpowertrain.com