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

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Agenda

- Punch Powertrain
- ARMEVA
- Design workflow
- SR motor technology
- Matlab workflow
- Results

Punch Powertrain

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)	2016

Customers & Applications

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

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**

Products & Product Development


VT3

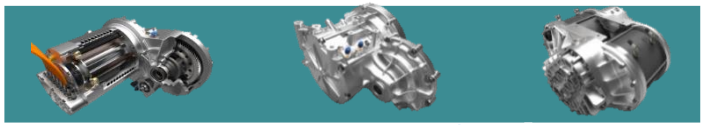

HS2


VT5


DT1

Market requirements and solutions

Conventional ICE	Stop-start	48V	Mild hybrid	Full hybrid	Plug-in hybrid	Range Extender	EV

Electric Drives	
Electric hybrids	
Flywheel based	
DCT Transmissions	
CVT Transmissions	

ARMEVA

Advanced Reluctance Motors for Electric Vehicle Applications

Goal:

To develop a new generation of rare-earth free electric motors based on magnetic reluctance.

punch powertrain	Punch Powertrain N.V.	Belgium
SIEMENS	Siemens SISW	Belgium
TU/e	Technische Universiteit Eindhoven	Netherlands
PRODRIVE TECHNOLOGIES	Prodrive B.V.	Netherlands
TeKshift	TeKshift GmbH	Germany
UNIVERSITATEA TEHNICĂ	Universitatea Tehnica din Cluj-Napoca	Romania
SIEMENS	Siemens SISW	France

ARMEVA
Advanced Reluctance Motors for Electric Vehicle Applications

Content

Electric Drive System including:

- Motors
- Power Electronics
- Controls

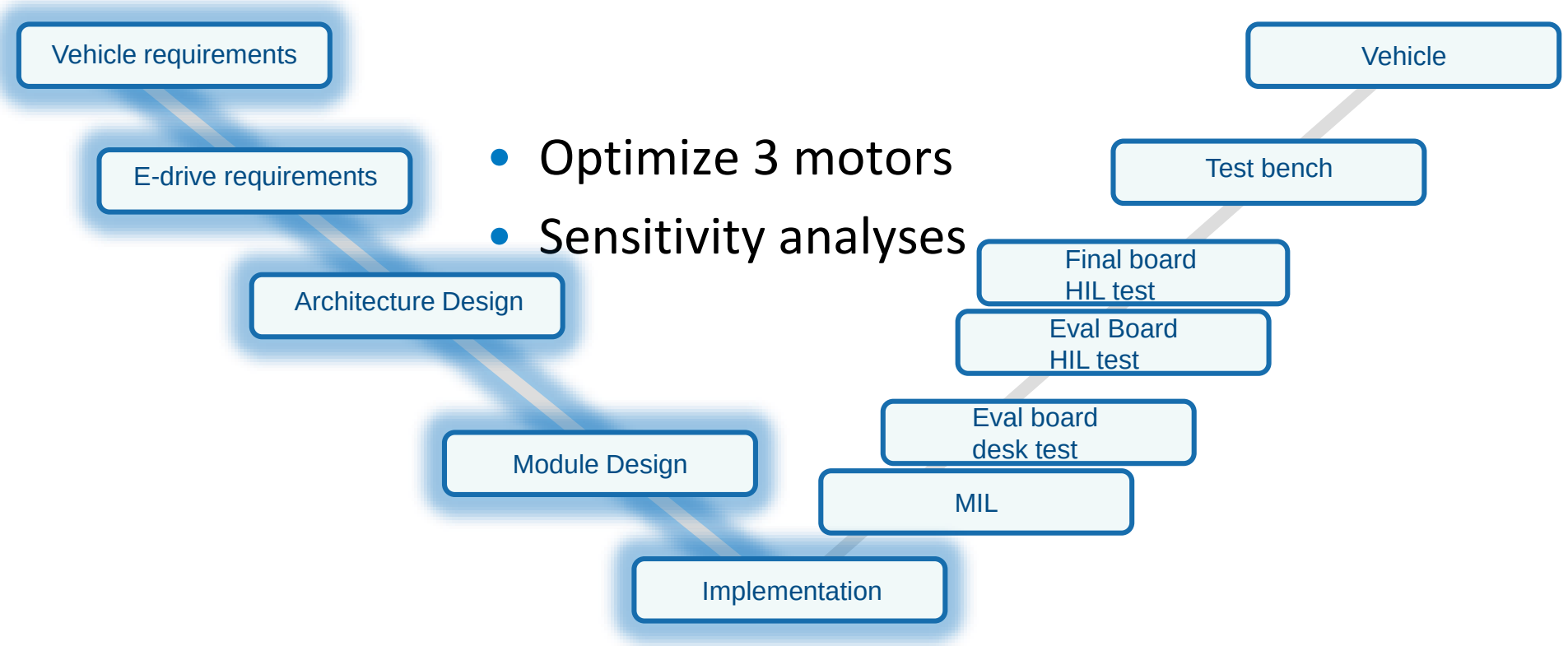
Focus

- power density increase
- Increased efficiency
- Smart packaging

Impact

- EV with increased efficiency at lower cost

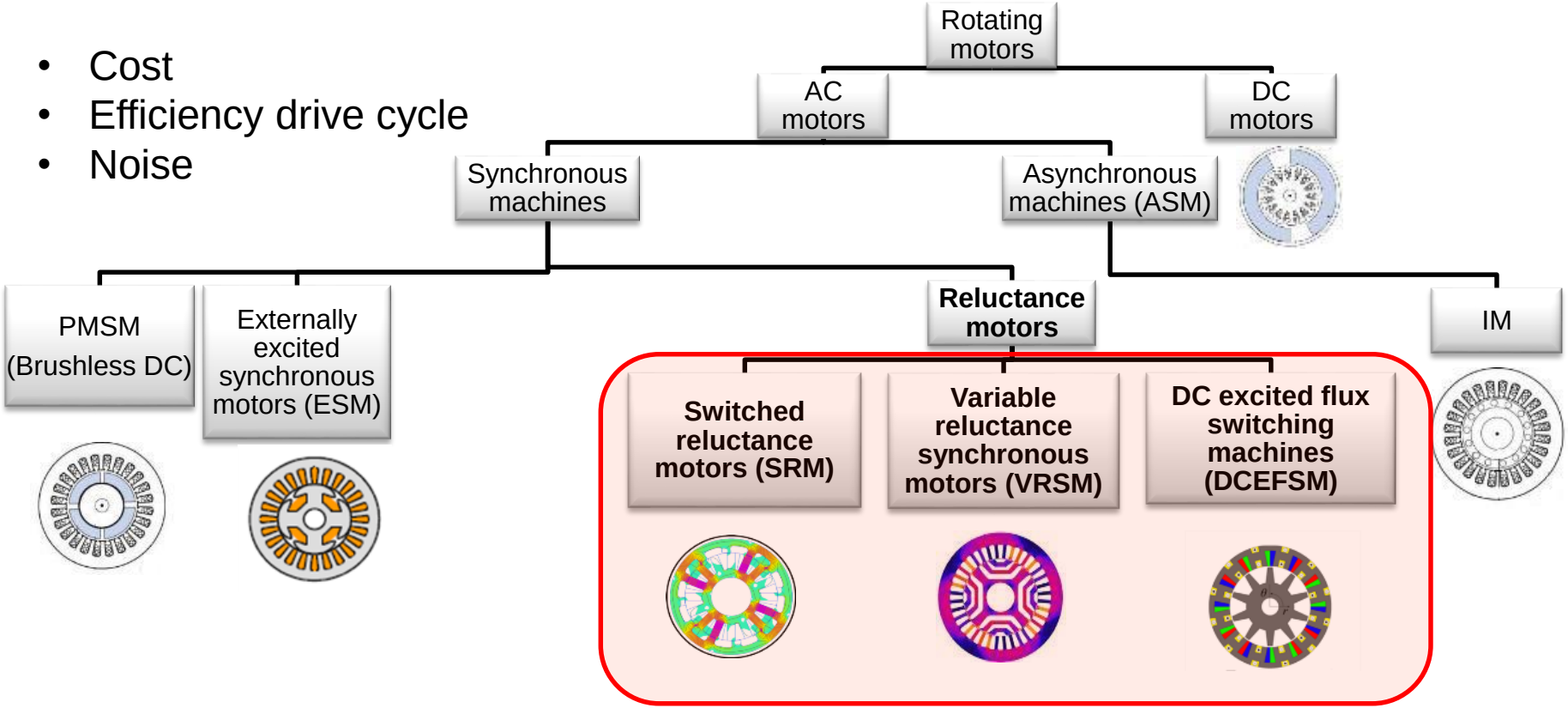
Development workflow



- Optimize 3 motors
- Sensitivity analyses

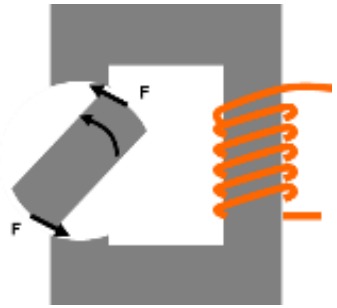
ARMEVA research scope

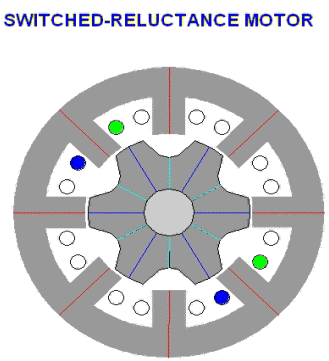
- Cost
- Efficiency drive cycle
- Noise



Switched Reluctance motor characteristics

Basic Principle: Magnetic Reluctance





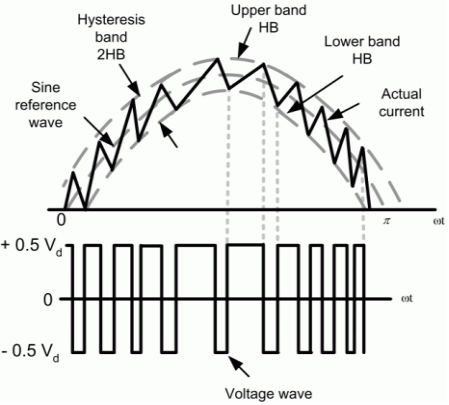
Advantages

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

Challenges:

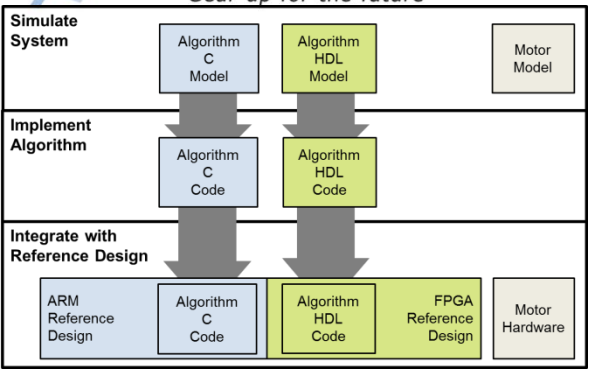
- Torque Ripple
- Controls
- Electronics
- Acoustics

Challenges SR in ARMEVA

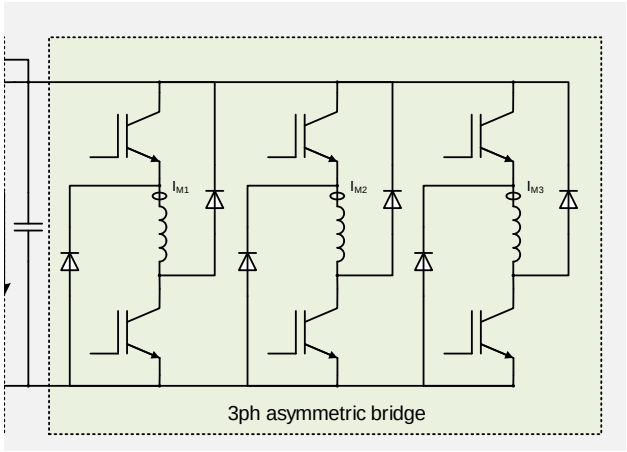


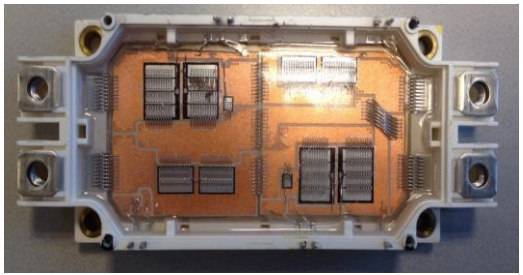
- Higher speed: 20 000rpm
- Less inductance: 8000A/ms
- Delay of 1µs -> error of 8A
- Interrupt based current hysteresis control in processor 14µs minimum
- New closed loop control strategies with fast and heavy calculations
- -> SoC device: Zynq 7045 device
- No FPGA knowledge within Punch

MATLAB workflow

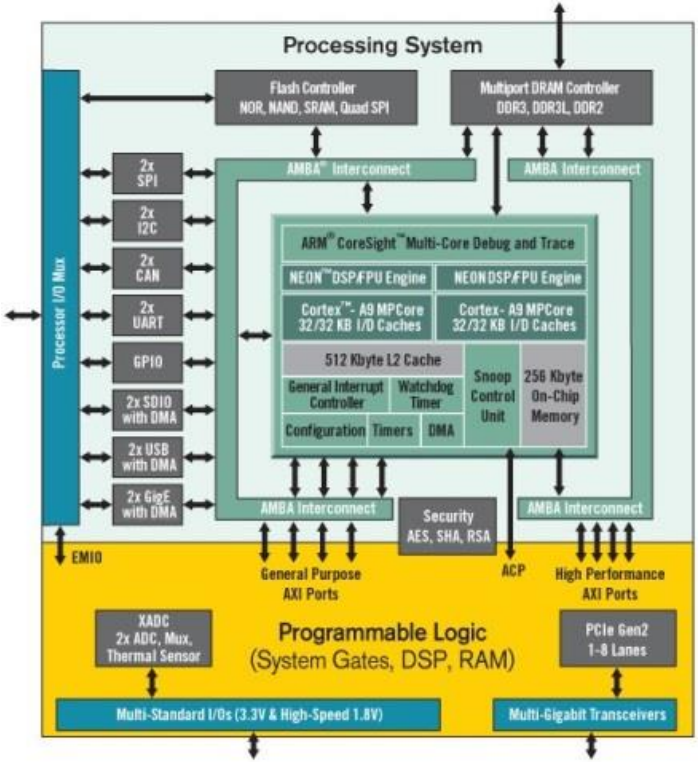


- Zynq 7045 device
- Fixed point workflow
- Embedded coder / HDL coder
- Vivado





Our experience workflow



- 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

MIL

Eval board
desk test

Eval Board
HIL test

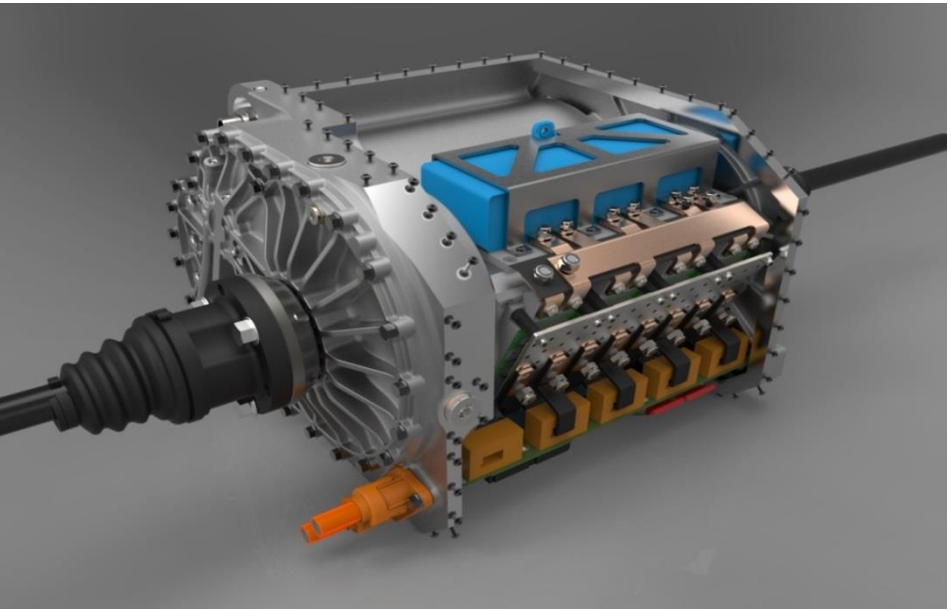
Final board
HIL test

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 loose 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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