Targeting Motor Control Algorithms to System-on-Chip Devices

Eric Cigan
Punch Powertrain develops complex SoC-based motor control

- Powertrains for hybrid and electric vehicles
- Need to increase power density and efficiency at a reduced cost
  - Integrate motor and power electronics in the transmission
- New switched reluctance motor
  - Fast: 2x the speed of their previous motor
    - Target to a Xilinx® Zynq® SoC 7045 device
  - Complex: 4 different control strategies
- Needed to get to market quickly
- No experience designing FPGAs!

✓ Designed integrated E-drive: Motor, power electronics and software
✓ 4 different control strategies implemented
✓ Done in 1.5 years with 2FTE’s
✓ Models reusable for production
✓ Smooth integration and validation due to development process – thorough validation before electronics are produced and put in the testbench

Link to video
Key trend: Increasing demands from motor drives

- Advanced algorithms require faster computing performance.
  - Field-Oriented Control
  - Sensorless motor control
  - Vibration detection and suppression
  - Multi-axis control
What’s an SoC?
Key Trend: SoCs are now used in 36% of new FPGA projects

Challenges in using SoCs for Motor and Power Control

- Integration requires collaboration
- Validation of design specifications with limits on access to test hardware
- How to make design decisions?
Why use Model-Based Design to develop motor control applications on SoCs?

- Enables early validation of specifications using simulation months before hardware is available.

- Dramatically improves design team collaboration and designer productivity by using a single design environment.

- Reduces hardware testing time by 5x by shifting design from lab to the desktop
Load motor

Mechanical coupler

ZedBoard

Zynq SoC (XC7Z020)

FMC module: control board + low-voltage board

Motor under test (with encoder)
Field-Oriented Control of Velocity
Hardware/Software Test Bench

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Conceptual workflow targeting SoCs

System Simulation Test Bench

- Algorithm C Model
- Algorithm HDL Model
- Model of Motor & Dyno

- Linux / VxWorks Reference Framework
- Algorithm C Code
- Algorithm HDL Code
- Programmable Logic Reference Framework

- SoC Hard Processor
- SoC Programmable Logic
- Motor & Dyno Hardware

Embedded System

Algorithm developer

Hardware designer

Embedded software engineer
Hardware/software partitioning

Target to ARM

Target to Programmable Logic
Code Generation
Simulation

Hardware test
3T Develops Robot Emergency Braking System with Model-Based Design

**Challenge**
Design and implement a robot emergency braking system with minimal hardware testing

**Solution**
Model-Based Design with Simulink and HDL Coder to model, verify, and implement the controller

**Results**
- Cleanroom time reduced from weeks to days
- Late requirement changes rapidly implemented
- Complex bug resolved in one day

“With Simulink and HDL Coder we eliminated programming errors and automated delay balancing, pipelining, and other tedious and error-prone tasks. As a result, we were able to easily and quickly implement change requests from our customer and reduce time-to-market.”

Ronald van der Meer
3T

Link to user story
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Learn More

- Get an in-depth demo in the Technology Showcase
  - New: see award-winning Native Floating Point in HDL Coder!

- Videos
  - HDL Coder: Native Floating Point

- Webinars
  - Prototyping SoC-based Motor Controllers on Intel SoCs with MATLAB and Simulink
  - How to Build Custom Motor Controllers for Zynq SoCs with MATLAB and Simulink

- Articles
  - How Modeling Helps Embedded Engineers Develop Applications for SoCs (MATLAB Digest)
  - MATLAB and Simulink Aid HW-SW Codesign of Zynq SoCs (Xcell Software Journal)

- Tutorials:
  - Define and Register Custom Board and Reference Design for SoC Workflow
  - Field-Oriented Control of a Permanent Magnet Synchronous Machine on SoCs