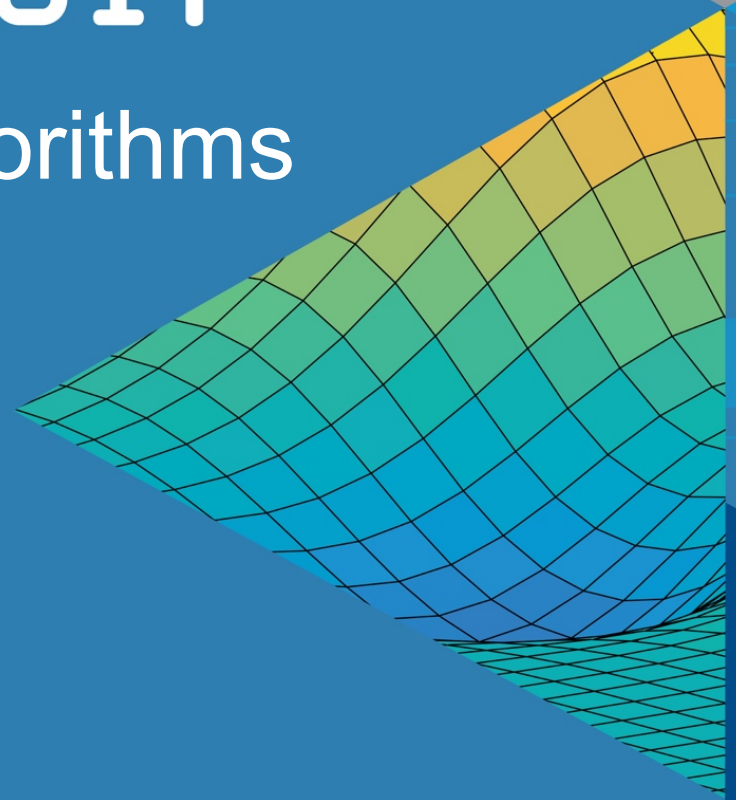
MATLAB EXPO 2017

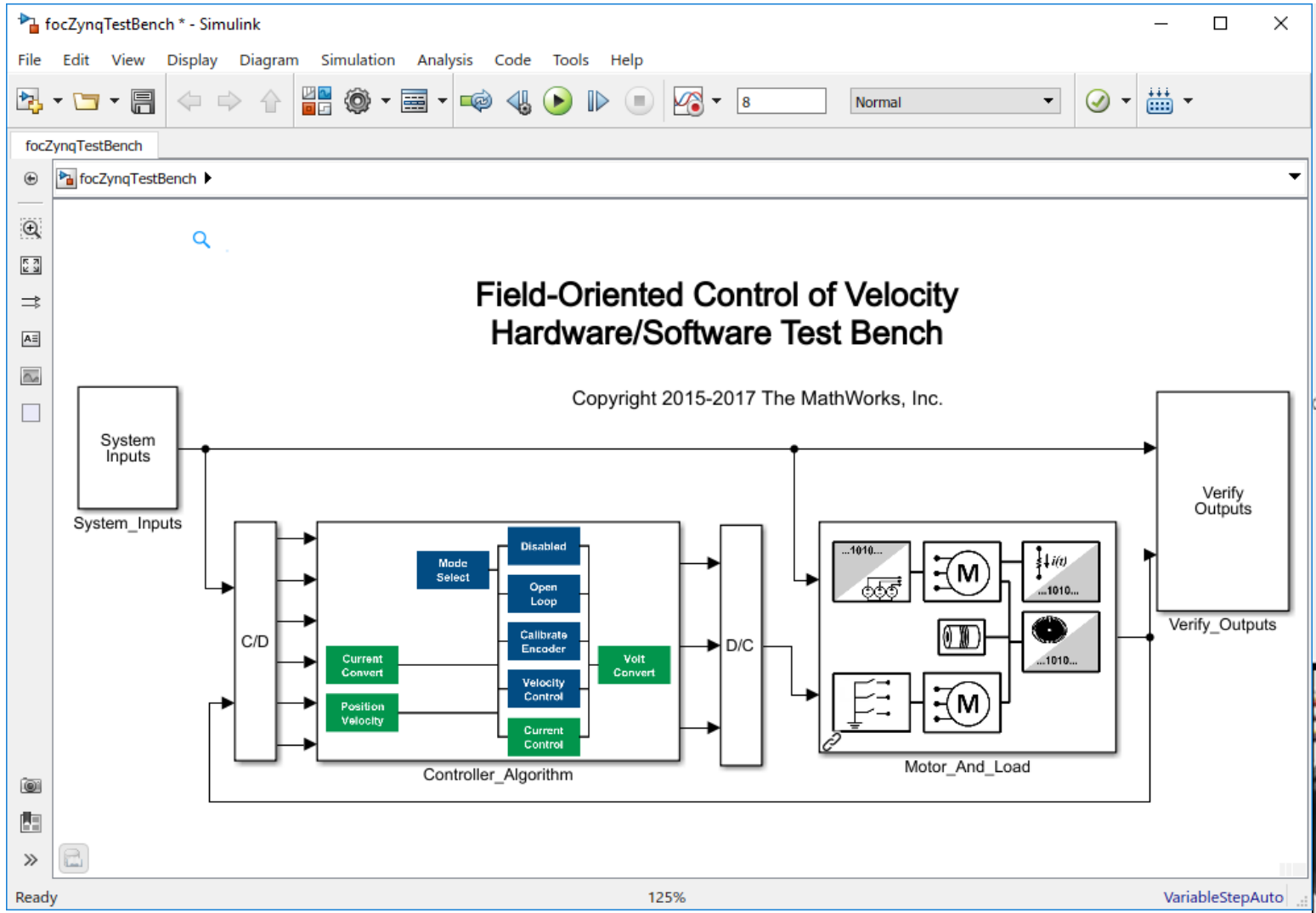
Targeting Motor Control Algorithms to System-on-Chip Devices

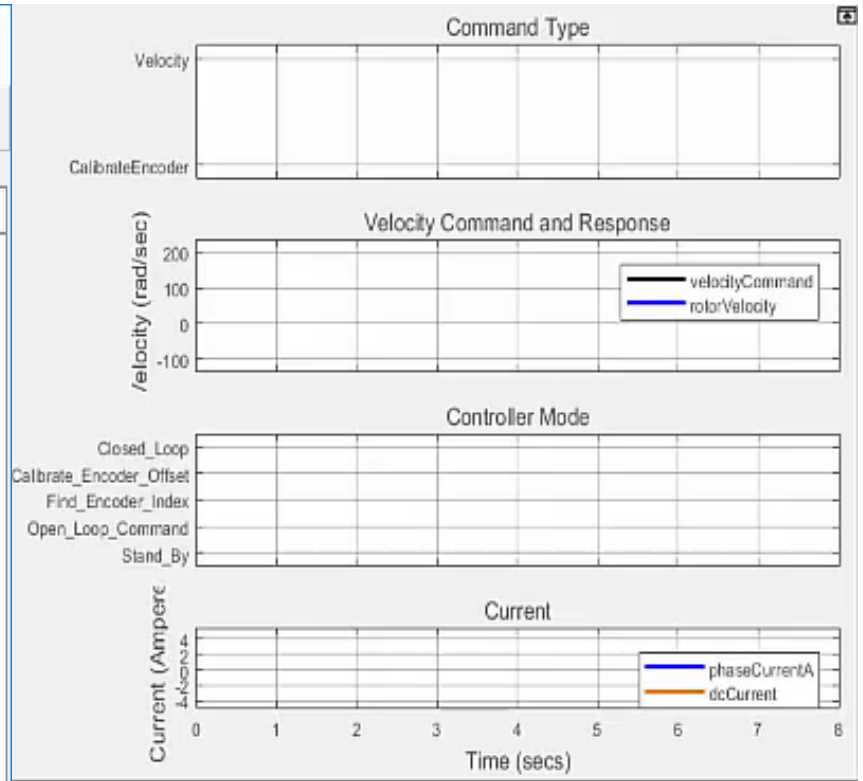
Dr.-Ing. Werner Bachhuber

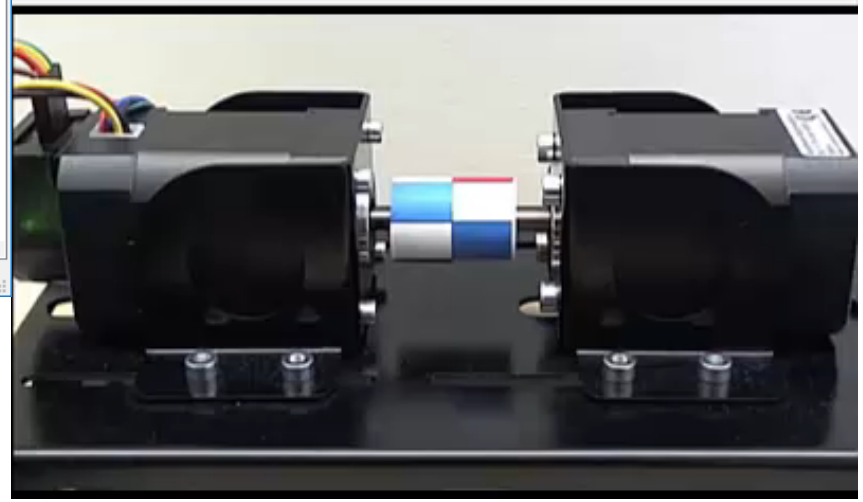


Why use Model-Based Design to develop motor control applications on SoCs?

- 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

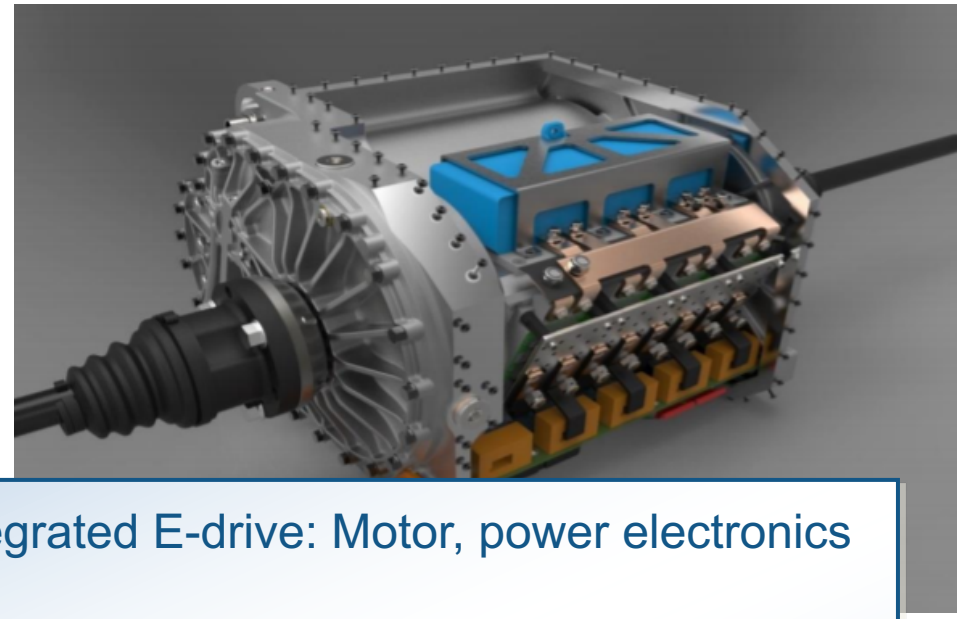

focZynqTestBench * - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
focZynqTestBench
Field-Oriented Control of Velocity
Hardware/Software Test Bench
Copyright 2015-2017 The MathWorks, Inc.
System Inputs
System_Inputs
C/D
Mode Select
Disabled
Open Loop
Calibrate Encoder
Velocity Control
Current Control
Current Convert
Position Velocity
Volt Convert
Controller_Algorithm
D/C
M
M
Verify Outputs
Verify_Outputs
Motor_And_Load
Ready
125%
VariableStepAuto


Command Type
Velocity
CalibrateEncoder
Velocity Command and Response
velocityCommand
rotorVelocity
Controller Mode
Closed_Loop
Calibrate_Encoder_Offset
Find_Encoder_Index
Open_Loop_Command
Stand_By
Current
phaseCurrentA
dcCurrent
Time (secs)



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!



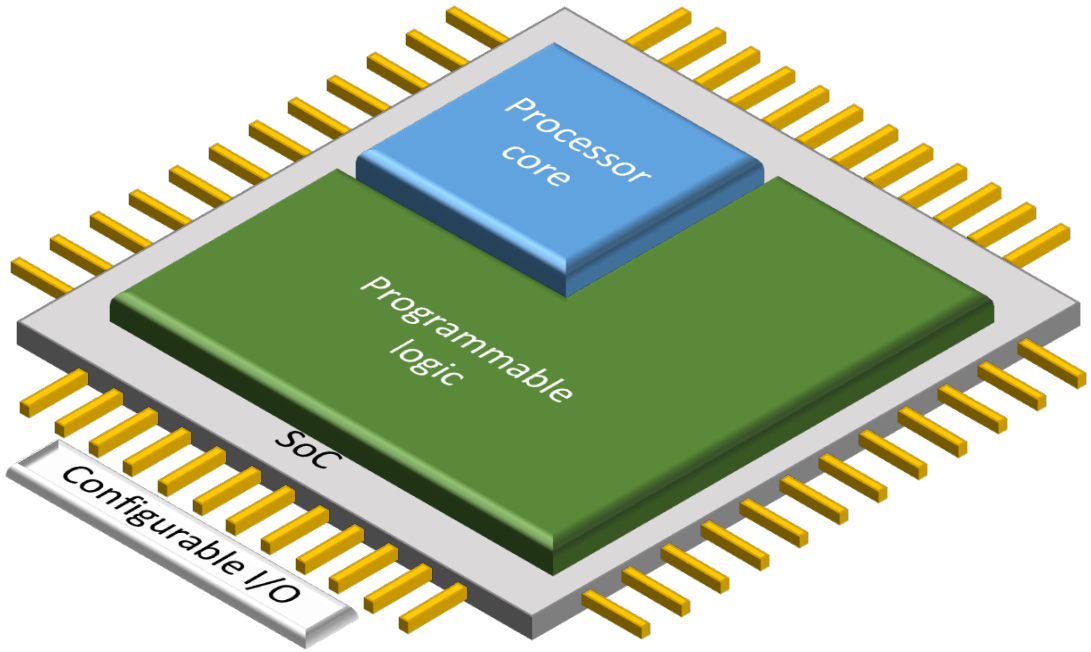
- ✓ Designed integrated E-drive: Motor, power electronics and software
- ✓ 4 different control strategies implemented
- ✓ Done in 1.5 years with 2FTE's
- ✓ Models reusable for production
- ✓ Smooth integration and validation due to development process – thorough validation before electronics are produced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

Link to video

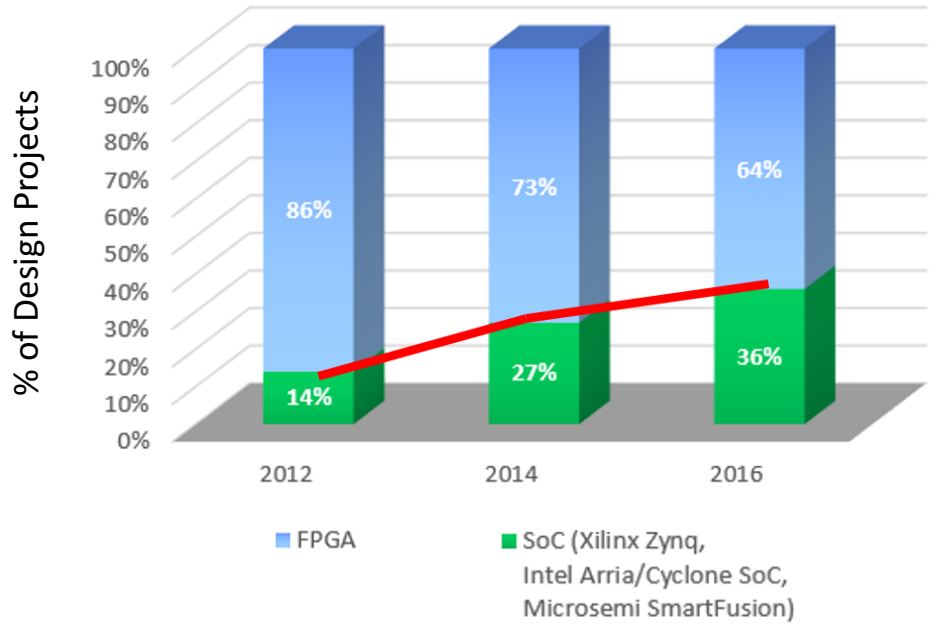
Key trend: Increasing demands from motor drives

- Advanced algorithms require faster computing performance.
  - Field-Oriented Control
  - Sensorless motor control
  - Vibration detection and suppression
  - Multi-axis control

What's an SoC?



SoC Key Trend:



Source: Wilson Research Group and Mentor Graphics, 2016 Functional Verification Study

Challenges in using SoCs for Motor and Power Control

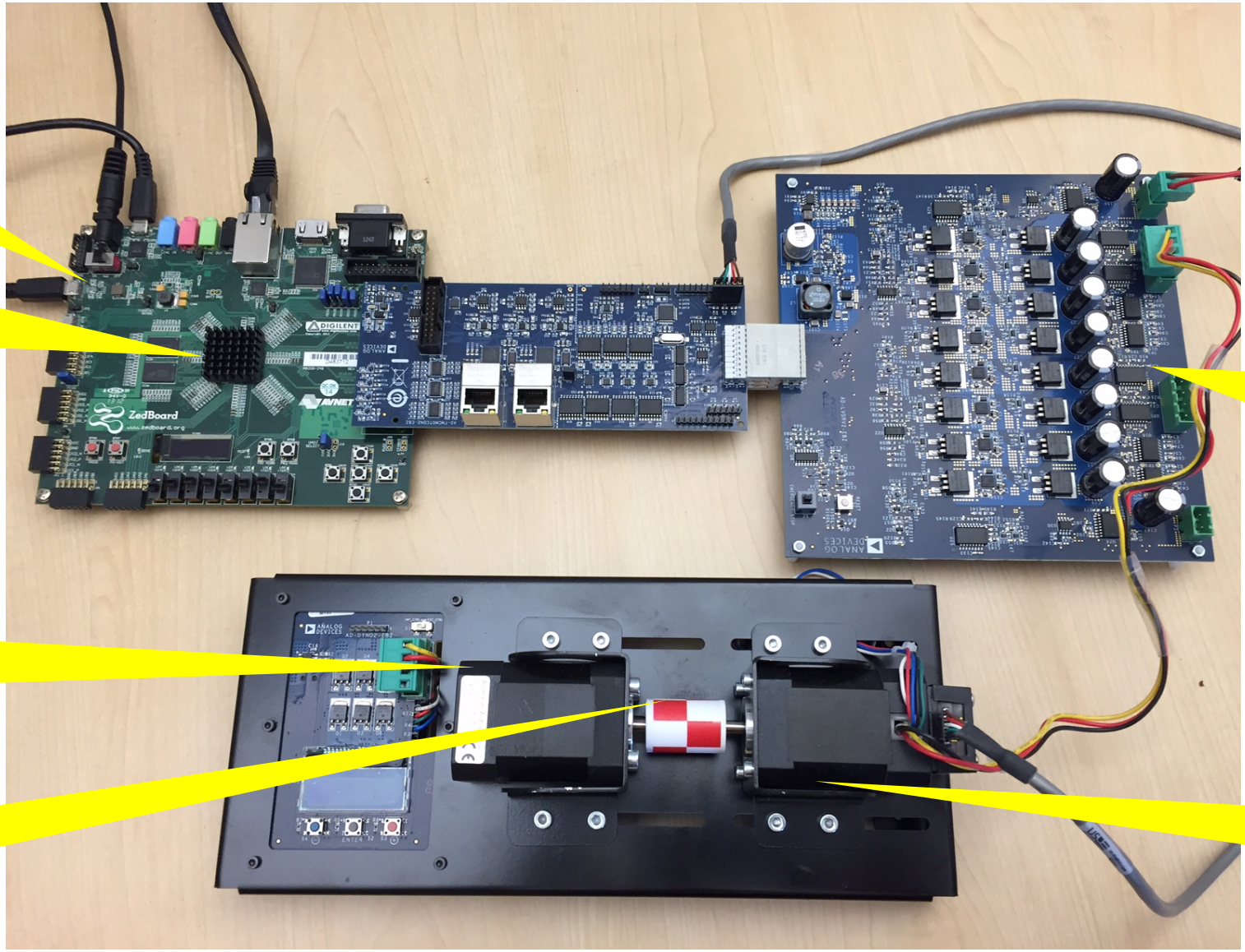
- Integration requires collaboration
- Validation of design specifications with limits on access to test hardware
- How to make design decisions?

ZedBoard

Zynq SoC
(XC7Z020)

Load motor

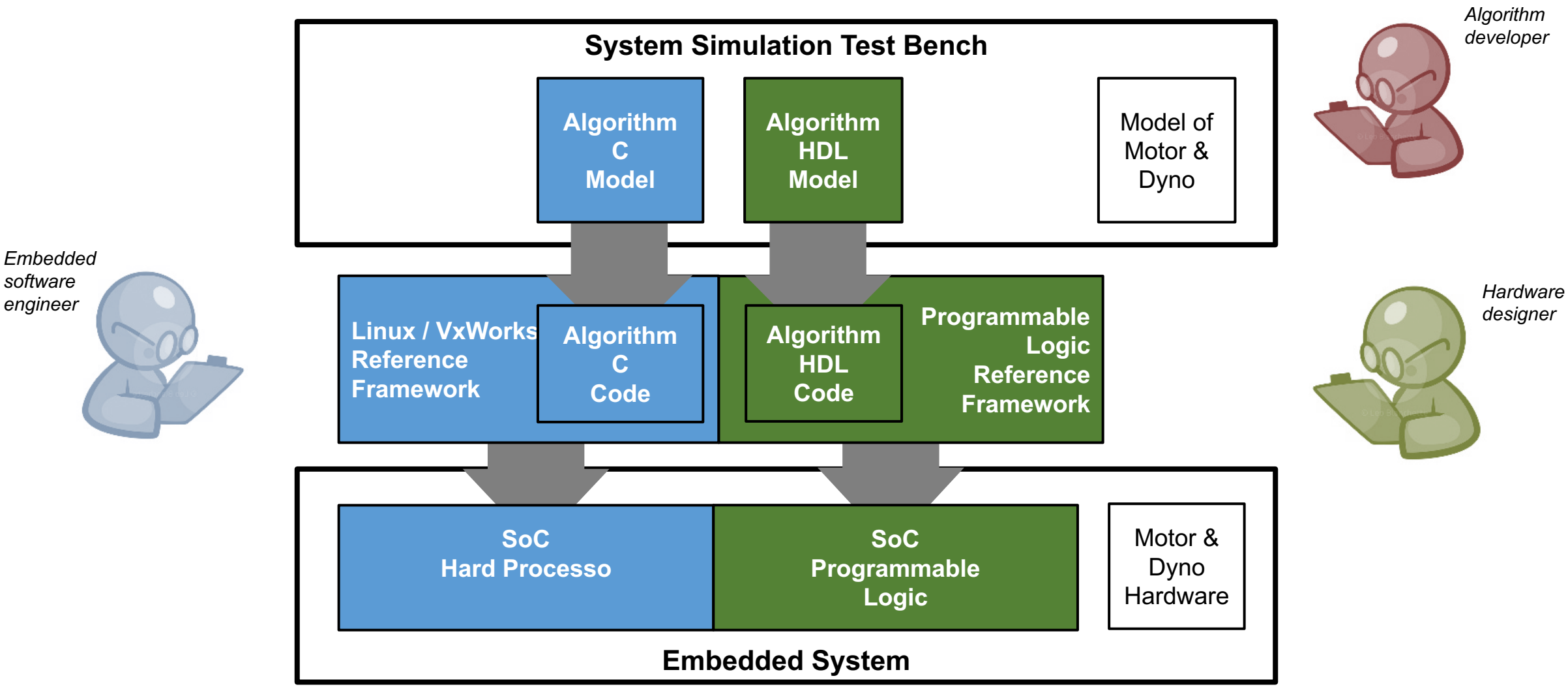
Mechanical coupler



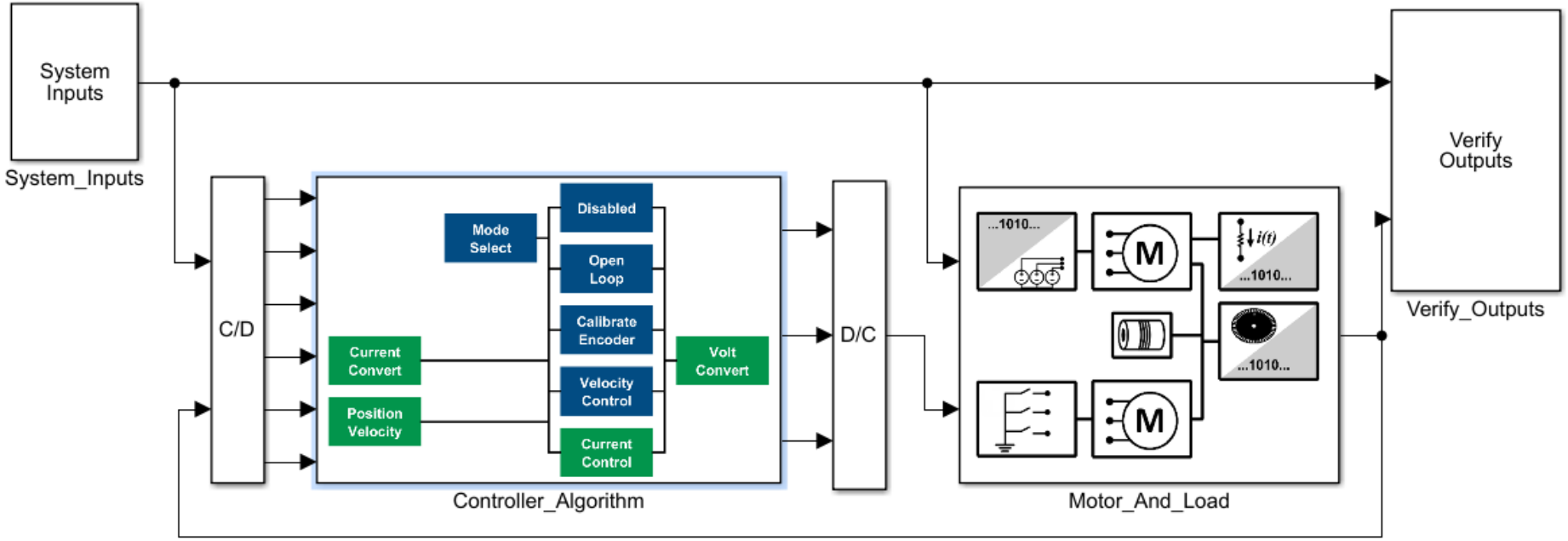
FMC module: control board + low-voltage board

Motor under test (with encoder)

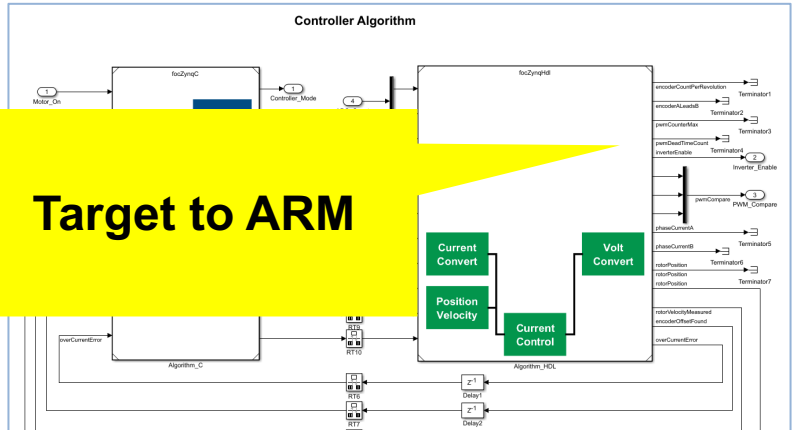
Conceptual workflow targeting SoCs



Hardware/software partitioning

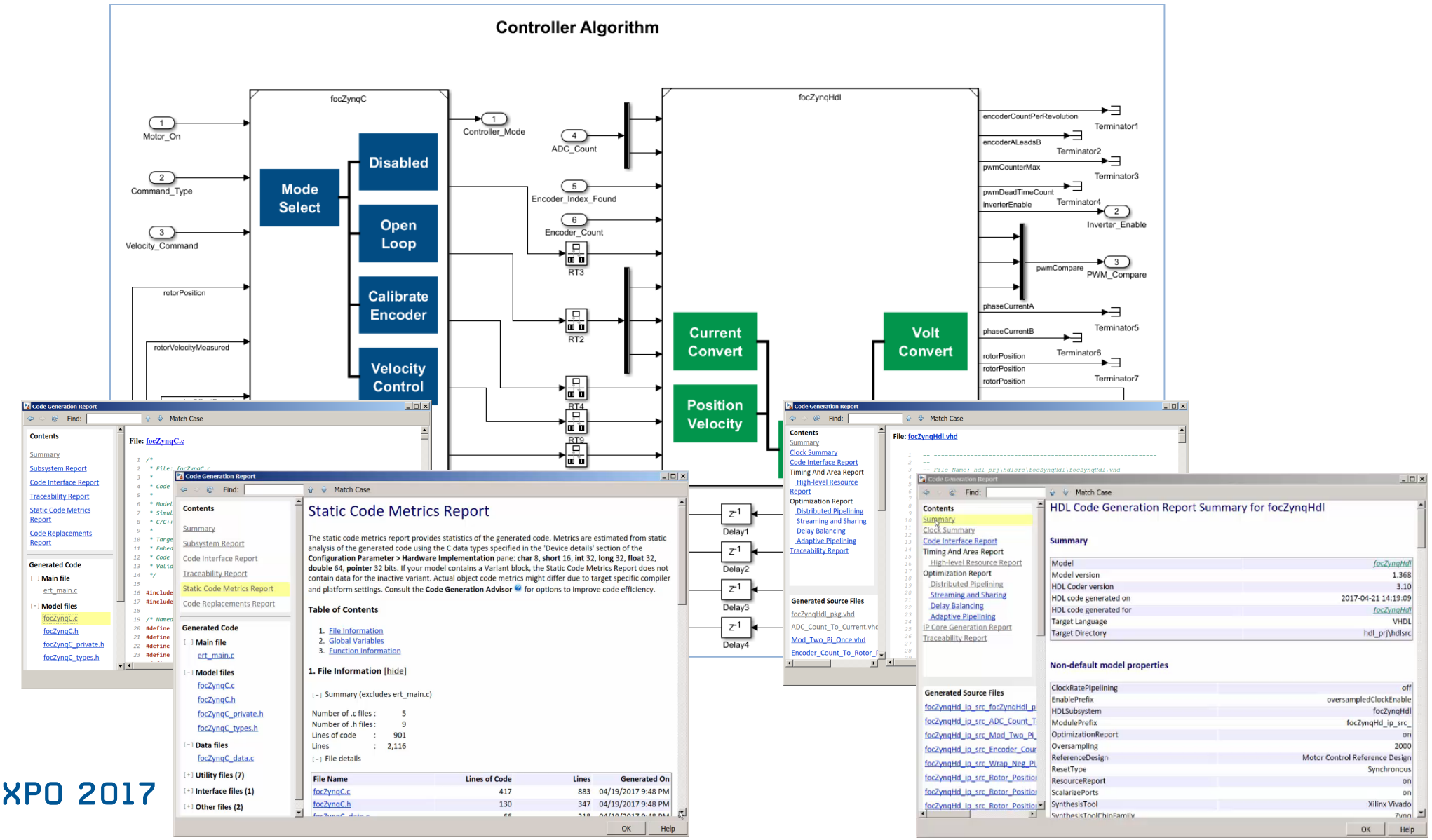


Target to Programmable Logic



Target to ARM

Code Generation



MATLAB EXPO 2017

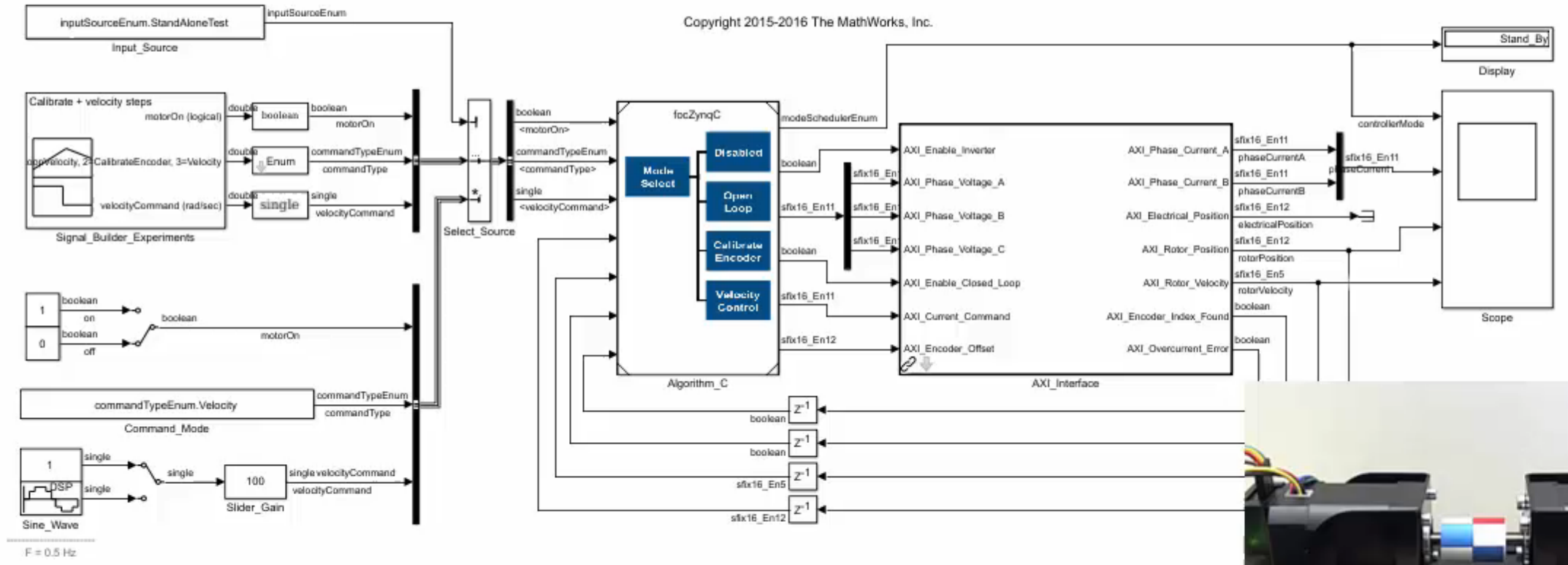
focZynqArmDeployment - Simulink

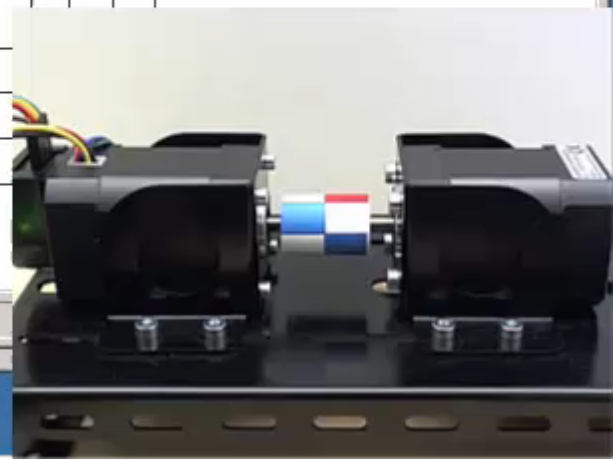
File Edit View Display Diagram Simulation Analysis Code Tools Help

focZynqArmDeployment

focZynqArmDeployment

Field-Oriented Control of Velocity
Zynq ARM Deployment for AD-FMCMOTCON2





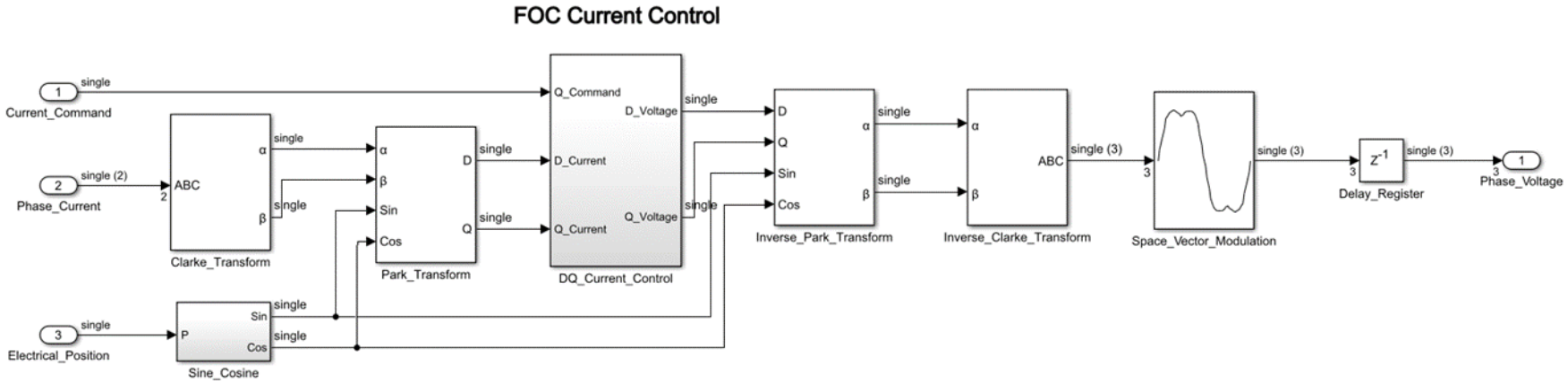
Ready

View diagnostics 61%

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

New: Award-Winning Native Floating Point



- Vendor-independent VHDL/Verilog for FPGA and ASIC design
- Full range of IEEE-754 features
  - Optional support for Denormals, INF, NAN, Rounding, …
- Extensive Math and Trigonometry Block support
- Videos
  - HDL Coder: Native Floating Point

embeddedaward2017 Winner–Tools

Learn More

- Get an in-depth demo in the Technology Showcase
- 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
- Training
  - Entwicklung von HDL Code aus Simulink
  - Programmierung von Xilinx Zynq SoCs mit MATLAB und Simulink
  - DSP für FPGAs