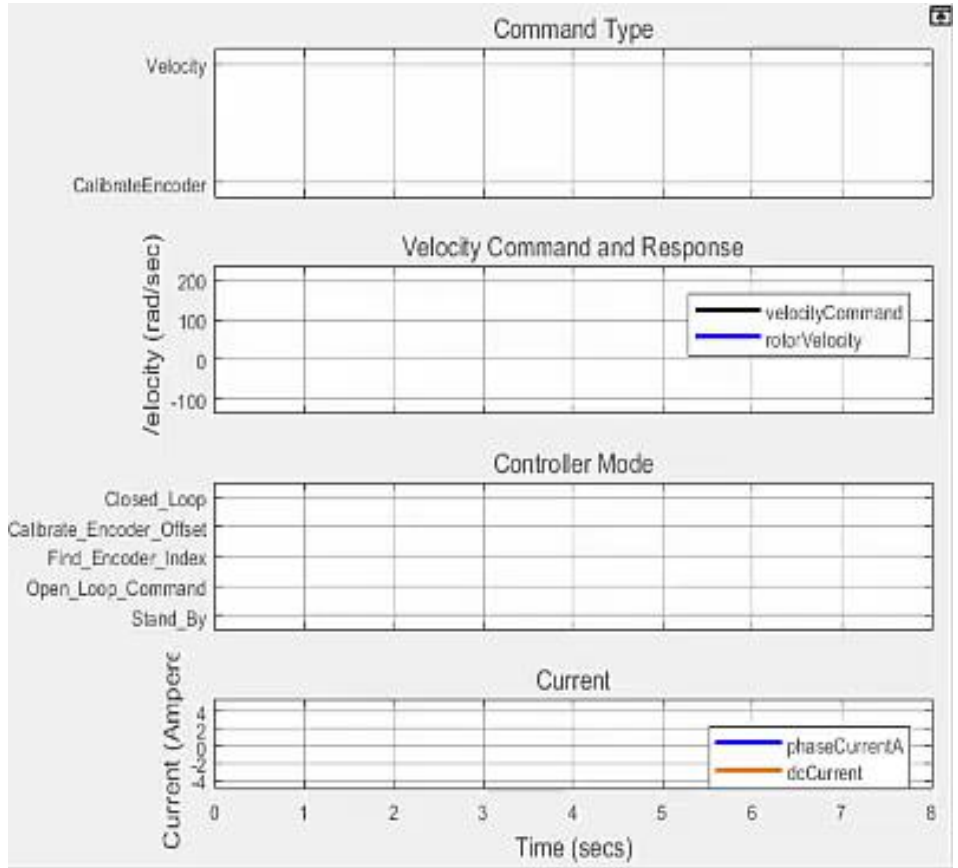
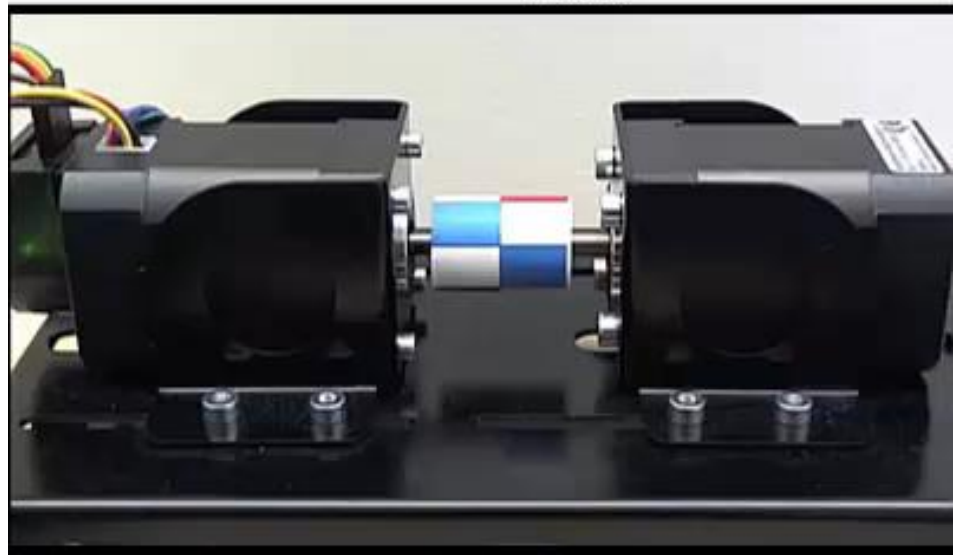
馬達控制演算法之建模與快速原型化

Hardware and Software Co-Design for Motor Control Applications

Jerry Tung





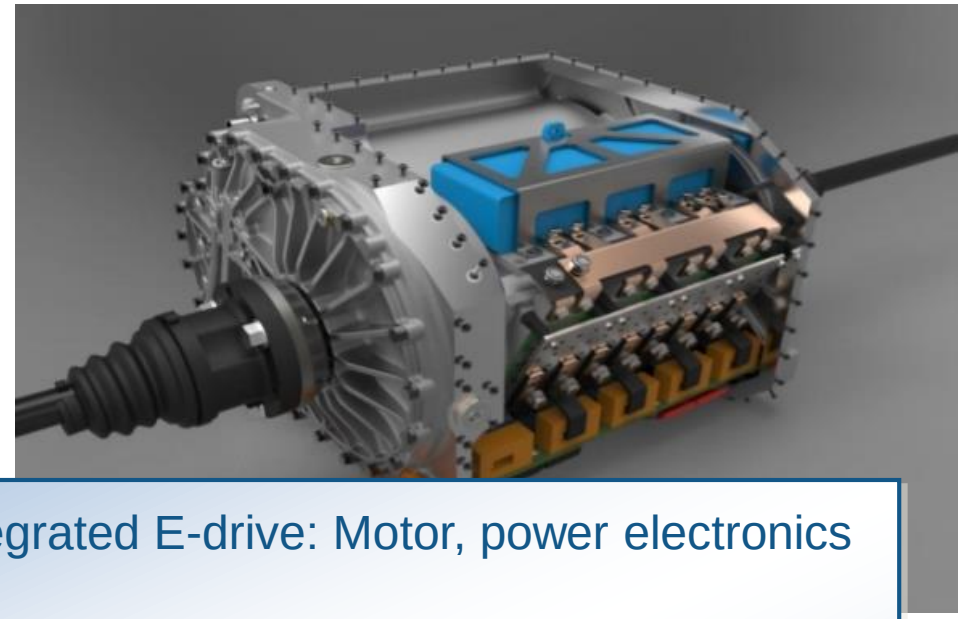
Takeaways

Model-Based Design for SoC FPGAs

- Enables early validation of specifications using simulation
- Improves design team collaboration and designer productivity.
- Reduces hardware testing time by 5x

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
- No experience designing FPGAs!



- ✓ Designed integrated E-drive: Motor, power electronics and software
- ✓ 4 different control strategies implemented
- ✓ Completed 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 of presentation

Key trend: Increasing demands from motor drives

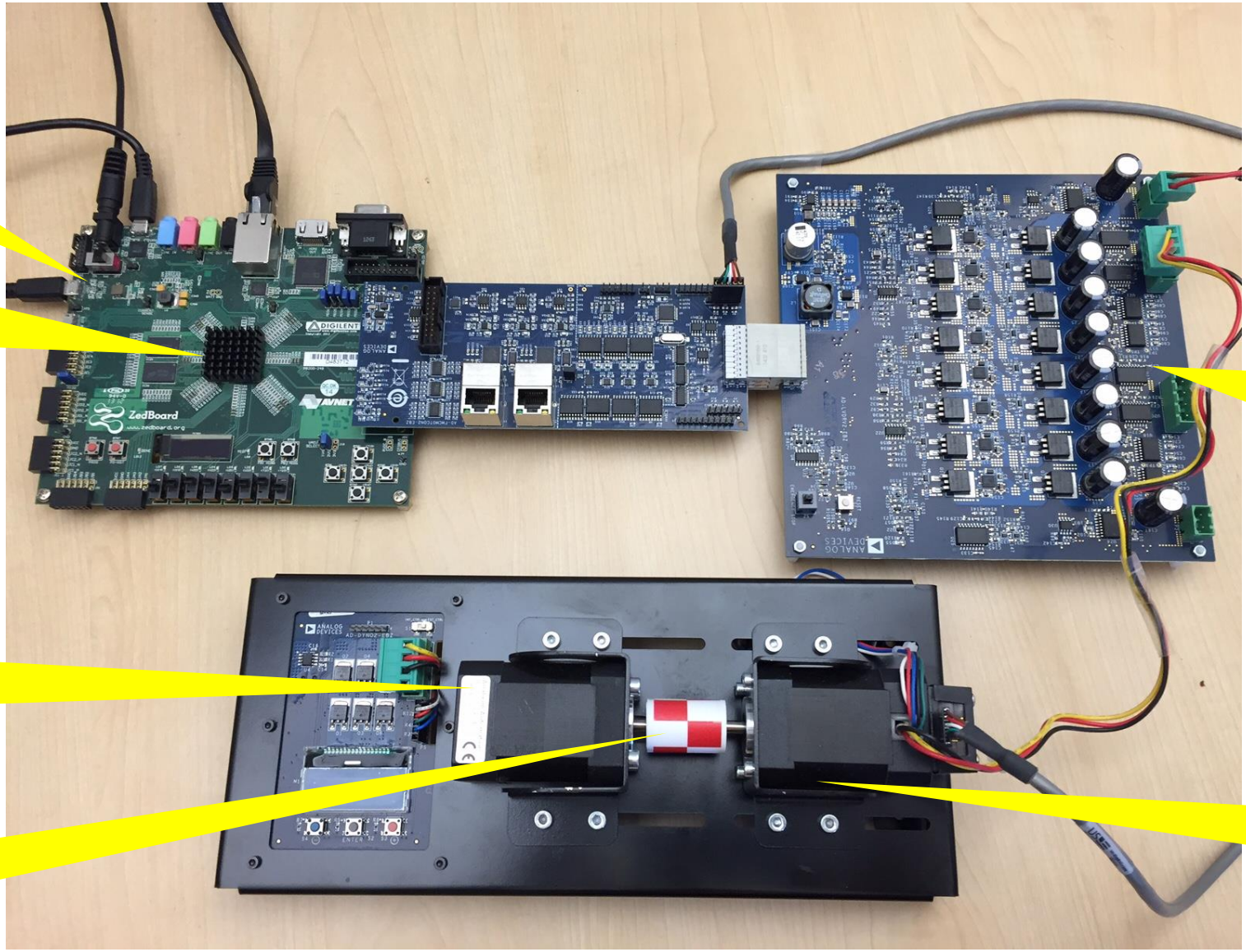
- Advanced algorithms require faster computing performance.
  - Field-Oriented Control
  - Sensorless motor control
  - Vibration detection and suppression
  - Multi-axis control

ZedBoard

Zynq SoC
(XC7Z020)

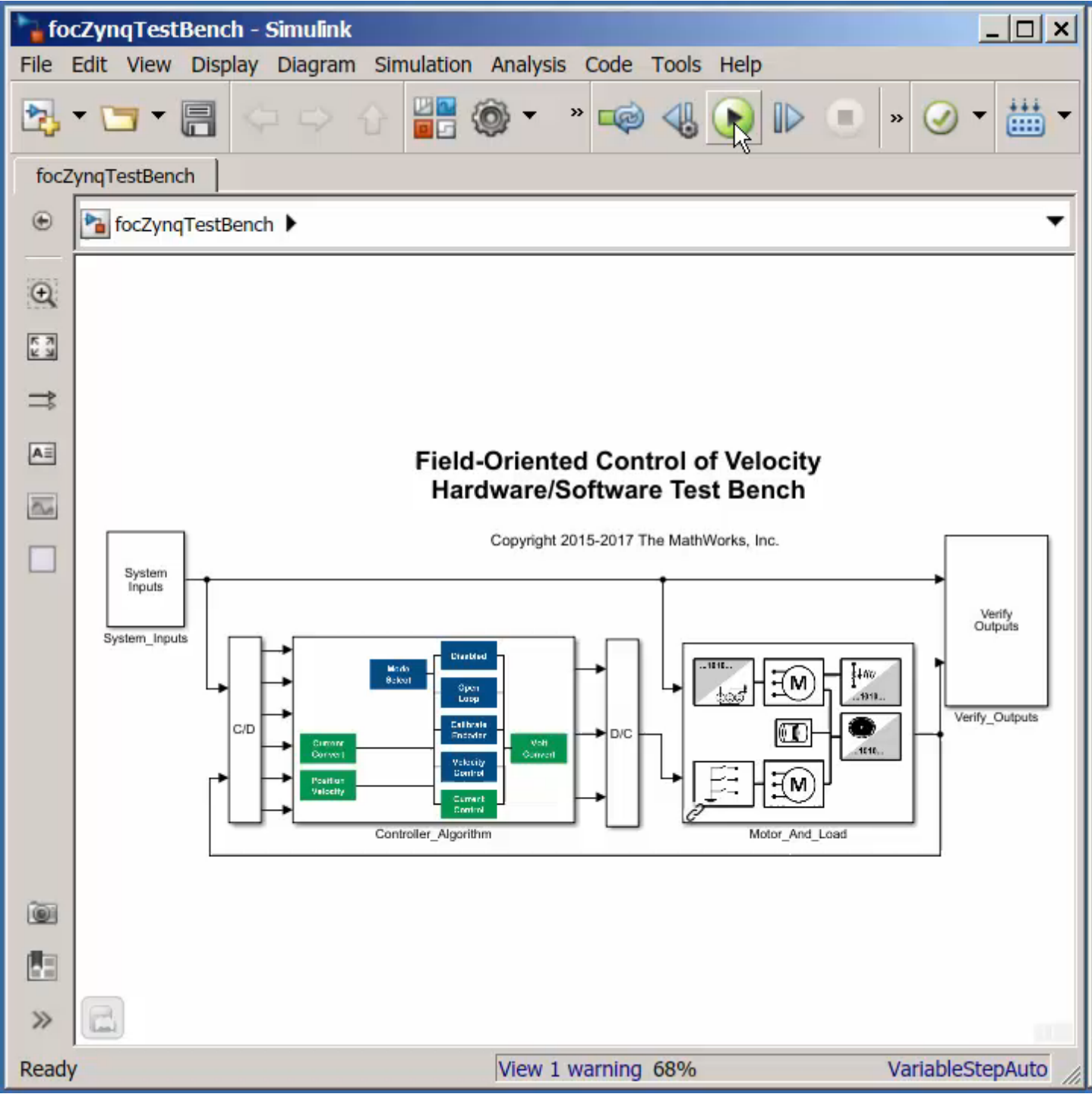
Load motor

Mechanical coupler



FMC module: control board + low-voltage board

Motor under test (with encoder)


focZynqTestBench - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
focZynqTestBench
focZynqTestBench
Field-Oriented Control of Velocity
Hardware/Software Test Bench
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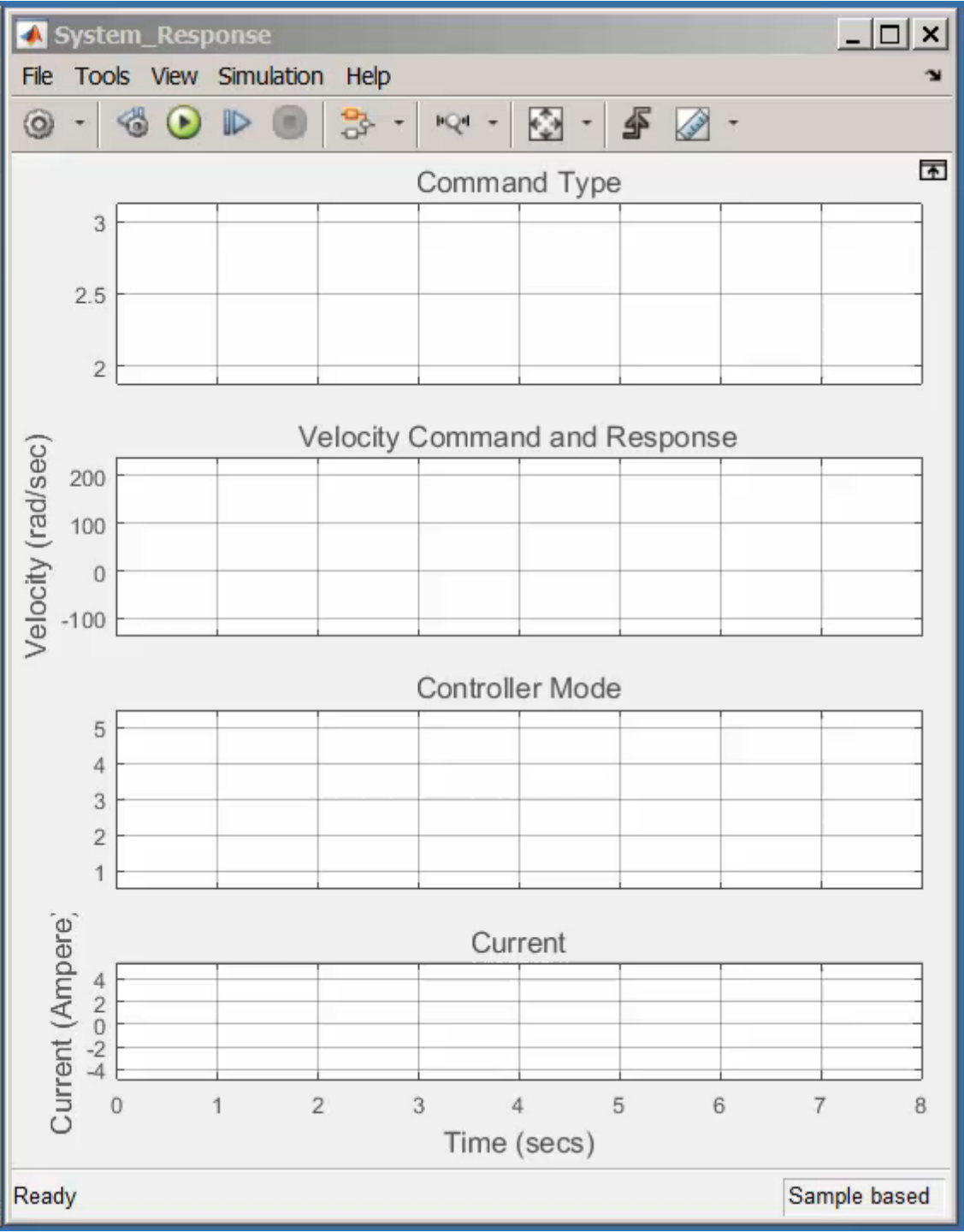
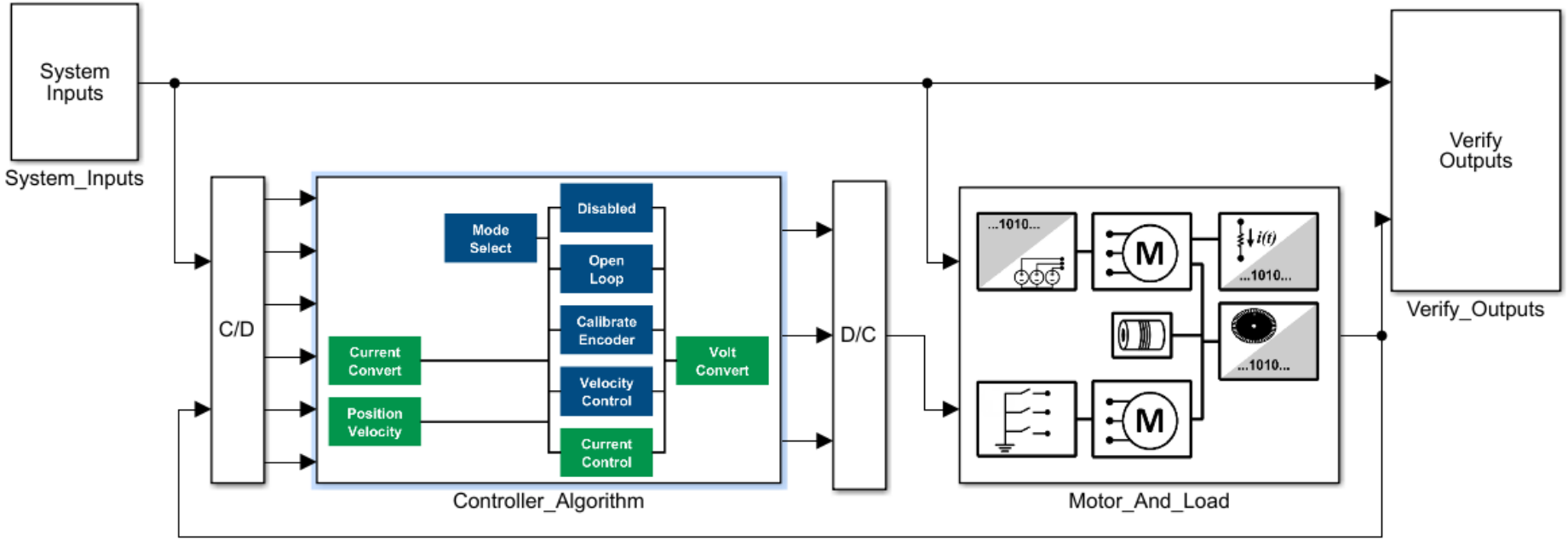
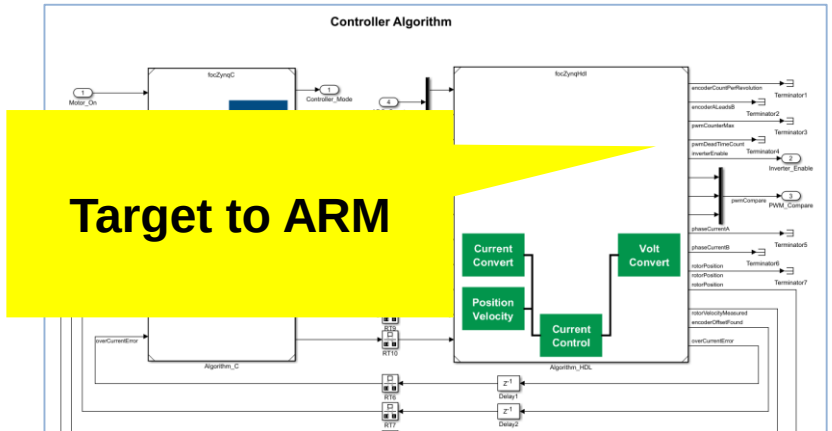
System Inputs
System_Inputs
C/D
Controller_Algorithm
D/C
Motor_And_Load
Verify Outputs
Verify_Outputs
Ready
View 1 warning 68%
VariableStepAuto


System_Response
File Tools View Simulation Help
Command Type
Velocity Command and Response
Velocity (rad/sec)
Controller Mode
Current
Current (Ampere)
Time (secs)
Ready
Sample based

Hardware/software partitioning

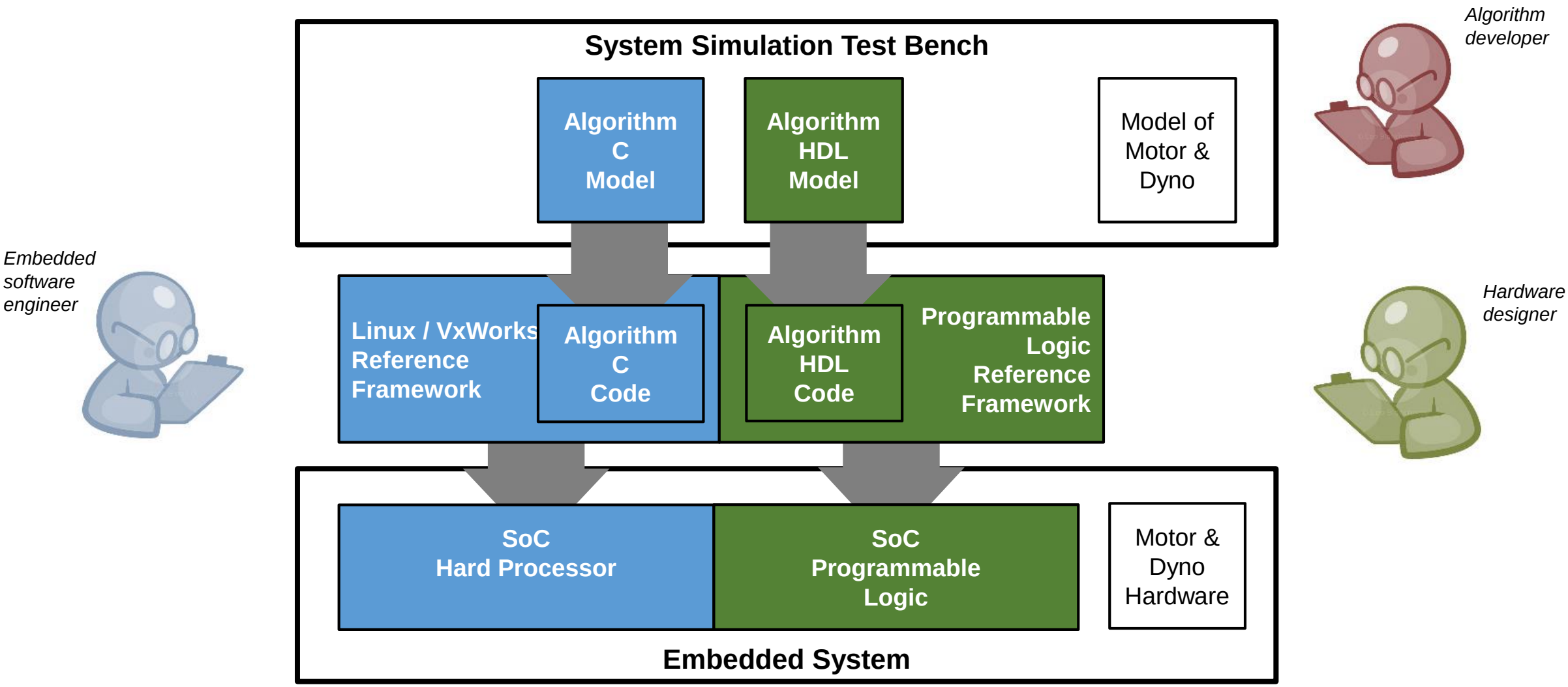


Target to Programmable Logic



Target to ARM

Conceptual workflow targeting SoCs



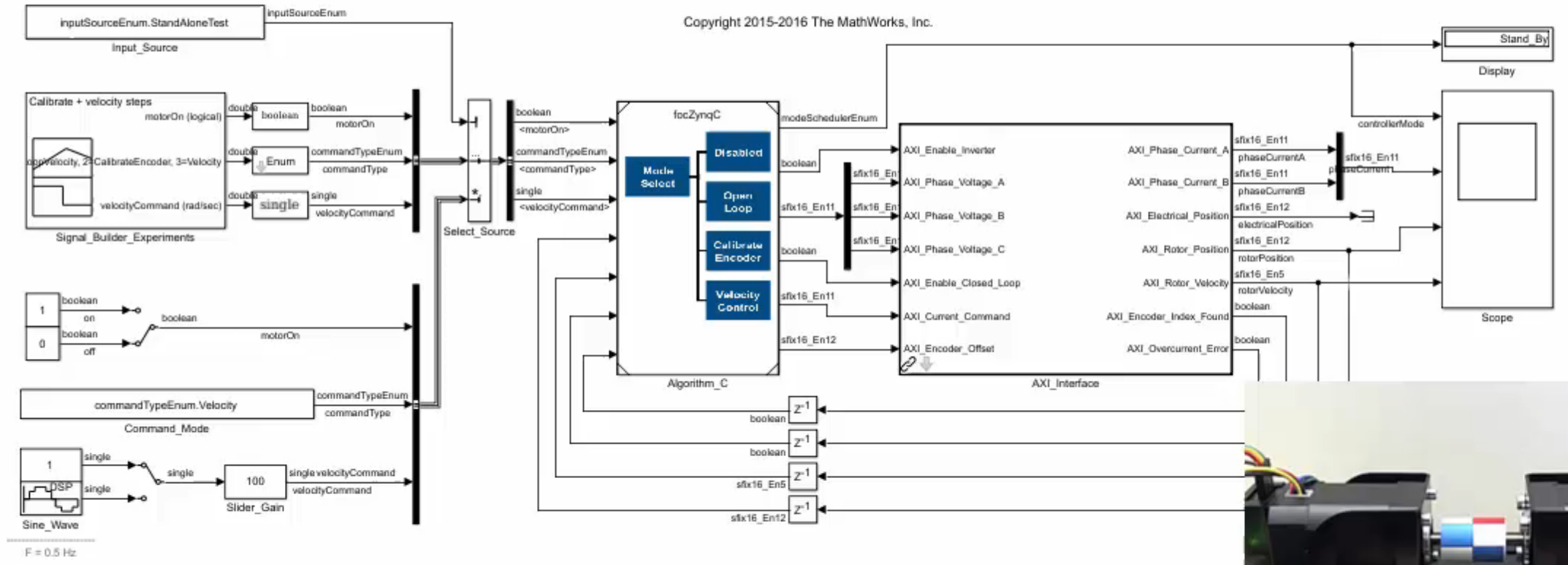
focZynqArmDeployment - Simulink

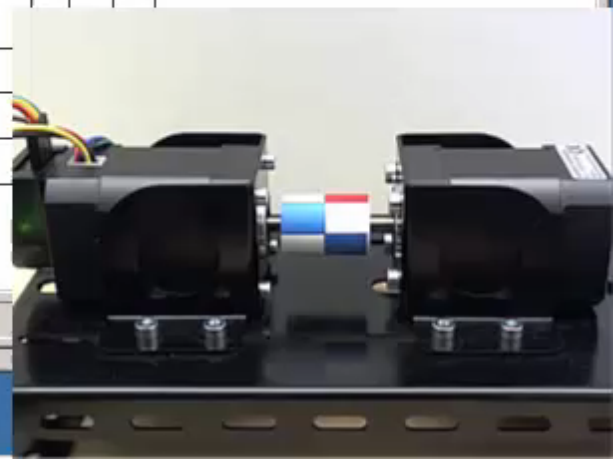
File Edit View Display Diagram Simulation Analysis Code Tools Help

focZynqArmDeployment

focZynqArmDeployment

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





Ready

View diagnostics 61%

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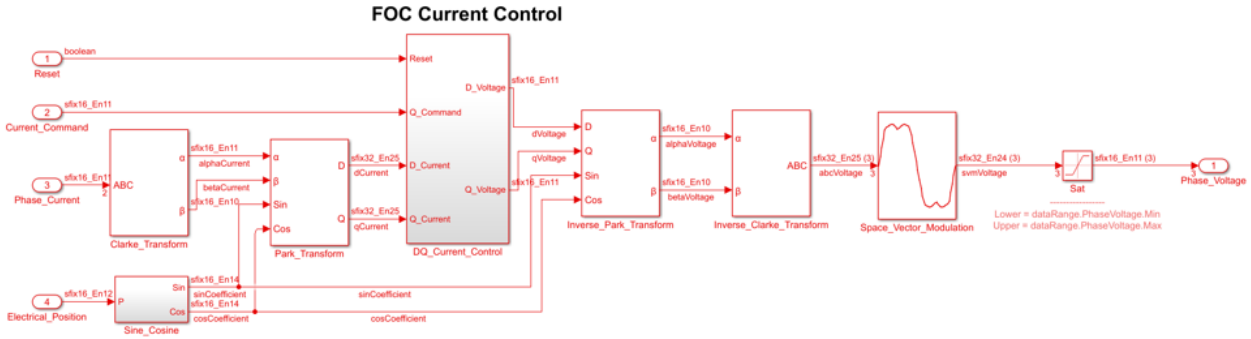
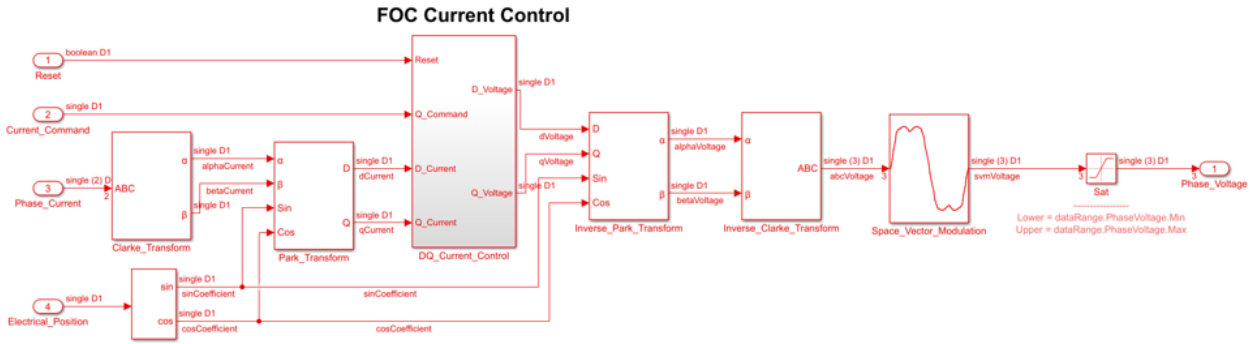


Fixed-point design



Floating-point design

oCs (MATLAB Digest)

tware Journal)

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