

Developing Embedded Software for Induction Motor Control Using Model-Based Design

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1. CAF Power & Automation
2. Towards a model-centered approach
3. Model-Based Design
4. Hardware-In-the-Loop environments
5. Conclusions



Introduction

CAF Power & Automation is a leading company in the design and manufacture of solutions for the Railway Market

We develop traction, control and energy storage systems

Part of CAF Group, founded in 1892, a global leadership in the manufacture and supply of high-tech, exceptionally reliable rolling stock

CAF Power & Automation designs and manufactures electric traction systems, control & communication systems and energy storage systems

Focused on the Railway Market and Urban Transport Market

Solutions for Locomotives, EMUs, Metros, Tramways, High Speed and Urban Buses



Introduction



Traction Systems

Traction Converters for rolling stock

Energy Storage Systems

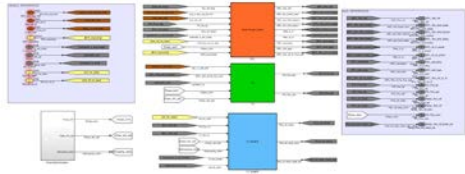
Catenary – free operations
Energy efficiency
Optimum energy consumption

Control Systems

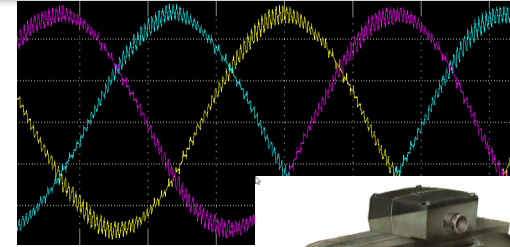
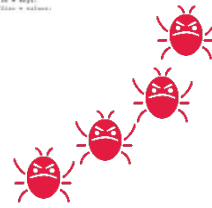
Control, Monitoring and Logging Systems
Train-Land Communication Solutions



The Problems



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Control



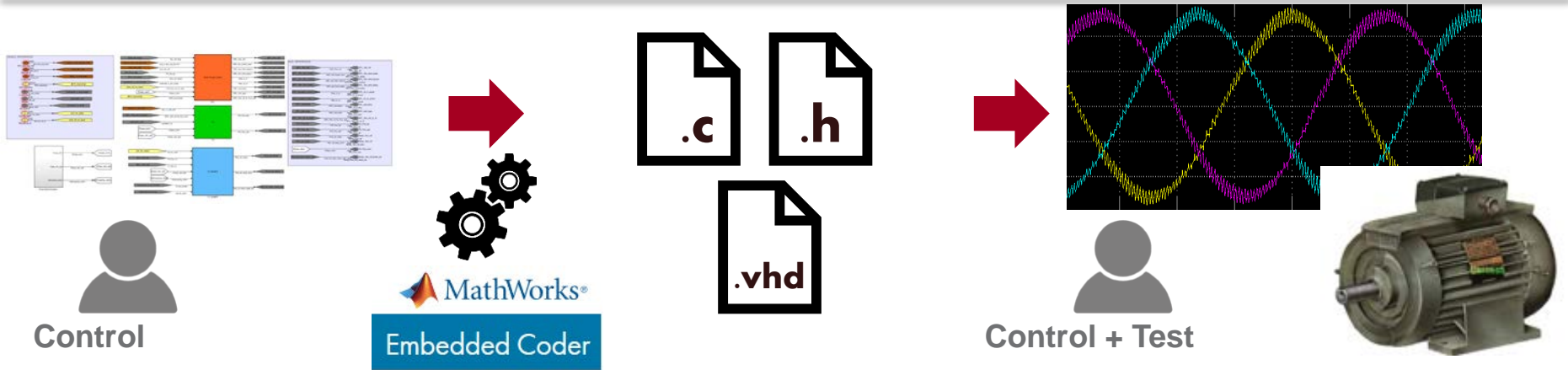
SW



Control + Test

- Know-how is divided in power-electronics experts and programmers
- Hand coding: time-consuming error-prone activity
- Errors detected late in the development cycle
- Need for laboratory or HIL equipment to test the source code

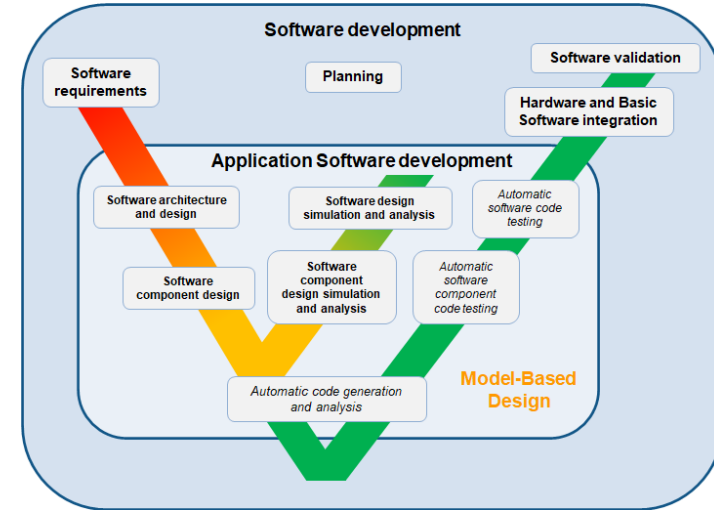
The Solution – Model-Based Design



- Dependence on software programmers removed for control algorithm development and testing
- Code generation is automated using MATLAB & Simulink
- Possibility for Software-In-the-Loop (SIL) simulations

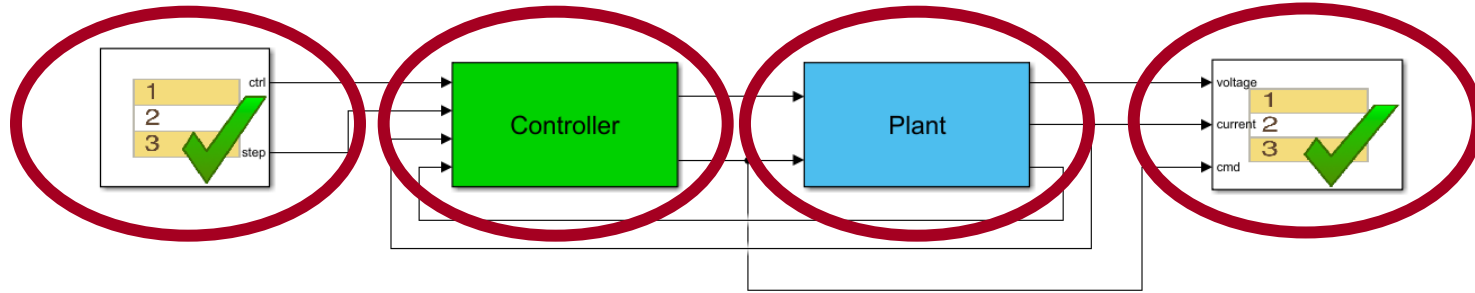
Model-Based Design

- Software component designs tested in a simulated environment
- Automatically generated code tested with the same test specification
- Design errors detected early in the development cycle
- Tests reused in the HIL environment
- Lifecycle based on MathWorks methodology and workflows → Project SQAP approved for safety development



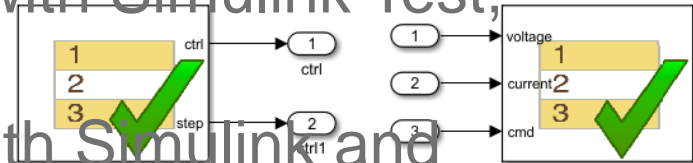
IEC Certification Kit

Model-Based Design – Testing

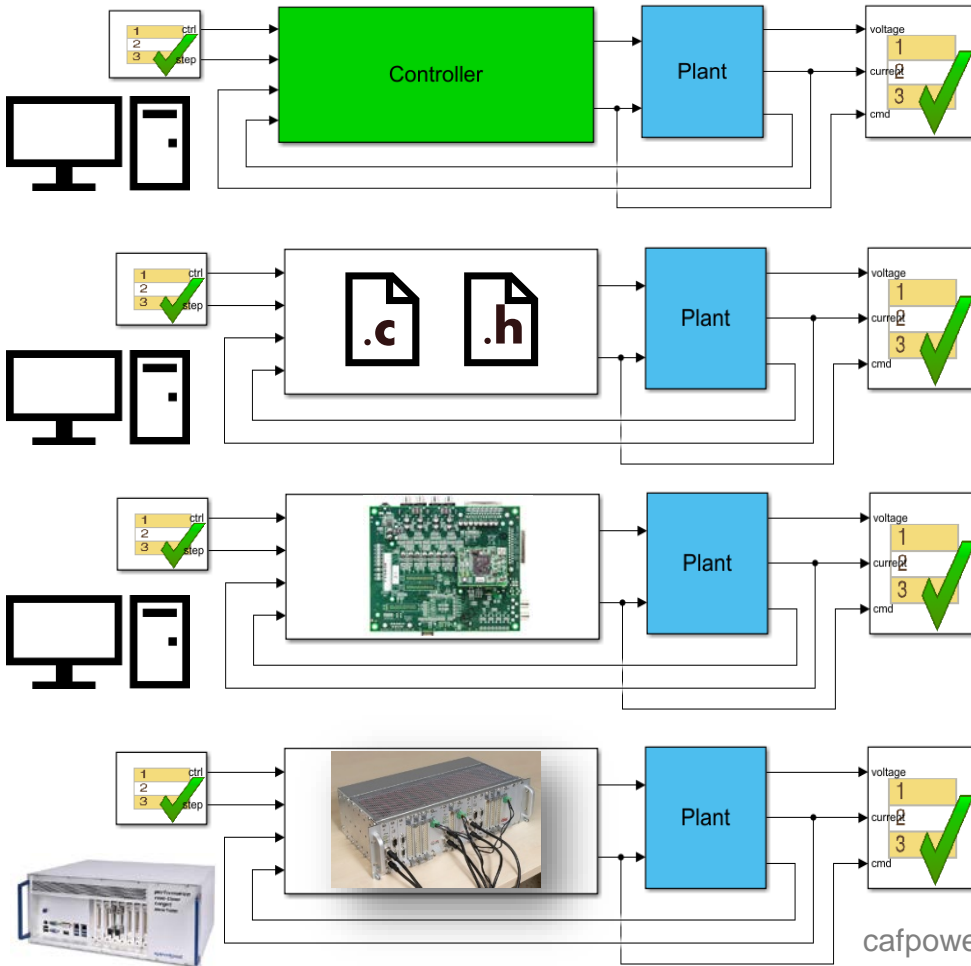


Full reuse in HIL environment!

- Tests are implemented with Simulink Test, using Simulink models
- The plant is modelled with Simulink and Simscape Electrical
- Full test execution in simulation is done using Simulink



Model-Based Design – Testing



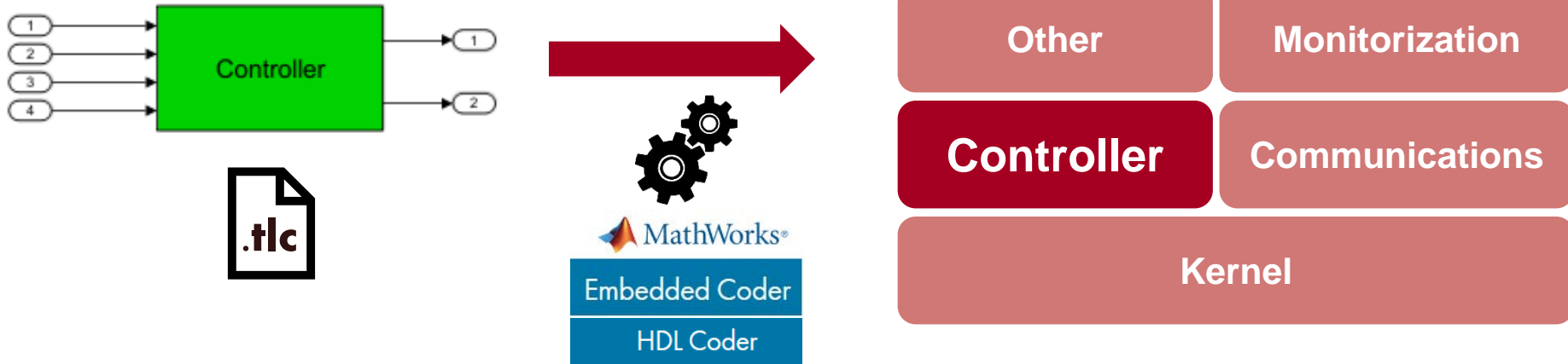
Model-In-the-Loop

Software-In-the-Loop

Processor-In-the-Loop

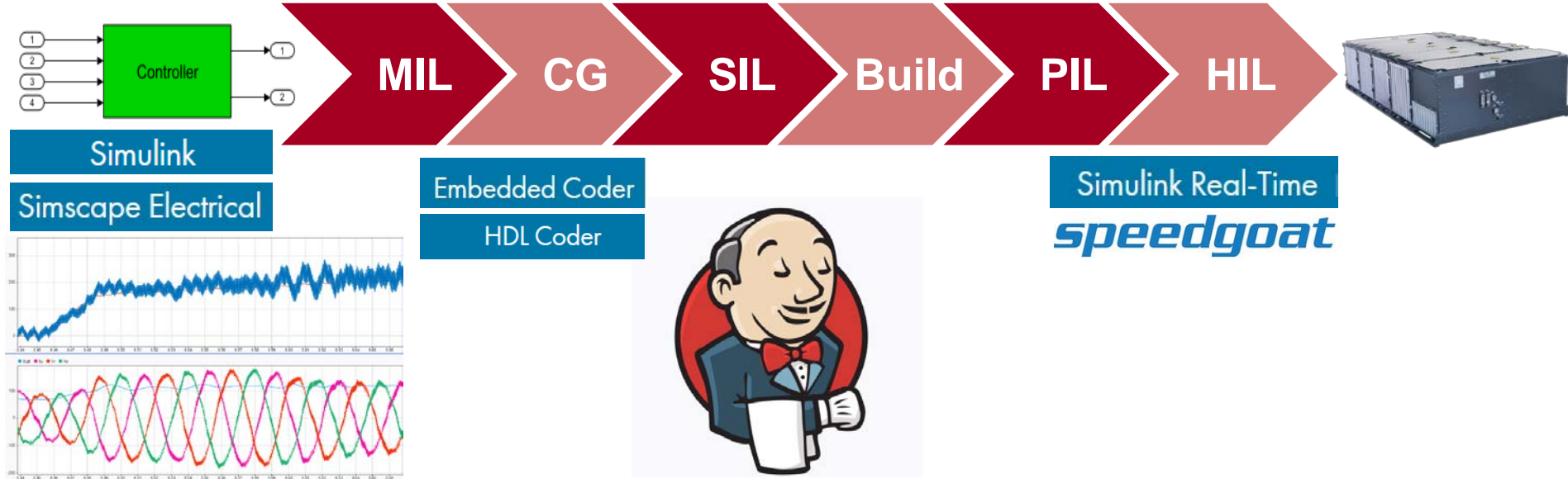
Hardware-In-the-Loop

Model-Based Design – Code Generation



- Source code interfaces are adjusted with specialized TLC files
- Generated software integrates seamlessly with other components running on target
- Code programming effort down from 4 weeks to 4 minutes
- 0 bugs introduced when coding

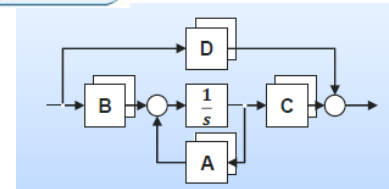
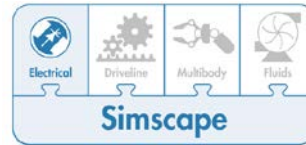
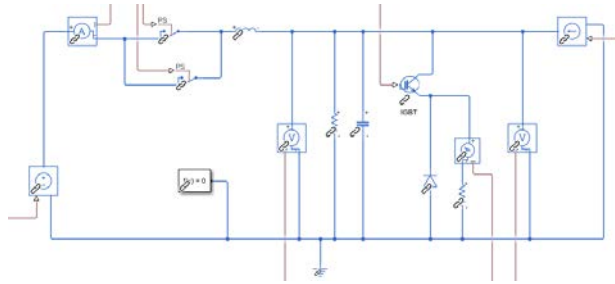
Model-Based Design – Next Steps: CI



- Development activities past design and first simulations are automatable
- PIL and HIL electronics managed by Continuous Integration
- Engineering effort focused on value-adding activities

Hardware-In-the-Loop

- Speedgoat target machine with main processor and FPGA
- Simscape models must be converted for FPGA deployment
- Close collaboration with MathWorks
 - Switched-linear systems managed by conversion tools available with Simscape



- Working on non-linear elements: motors



Conclusions

Development of a new induction motor control strategy:

- ✓ A more efficient motor control → energy savings
- ✓ More efficient algorithms → less CPU usage

Introduction of Model-Based Design (MBD):

- ✓ Higher code quality → no hand coding for control algorithms
- ✓ Full reuse of test and plant models → MIL, SIL, PIL, HIL
- ✓ Lifecycle validated for safety function development (EN 50657)
- ✓ Tool ecosystem based on MathWorks environment
- ✓ A shorter development cycle

Deployed and in service on a tramway line

- ✓ Positive feedback from the field
- ✓ Significant improvement in commissioning time due to no bugs introduced during coding phase





Thanks for your attention