MATLAB EXPO 2016
KOREA

4월 28일 (목)

등록 하기 matlabexpo.co.kr

Product Code Generation and Real-Time Testing

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Agenda

- Production Code Generation
  - MathWorks' Code Generation Products
  - Embedded Coder
  - Equivalence Test with SIL and PIL

- Integration Test
  - What's Simulink Real-Time
  - Automation of Real-Time Testing

Code Generation Products

MATLAB Coder

Generate C and C++ code from MATLAB code

Simulink Coder

Generate C and C++ code from Simulink and Stateflow models

Embedded Coder

Generate C and C++ code optimized for embedded systems

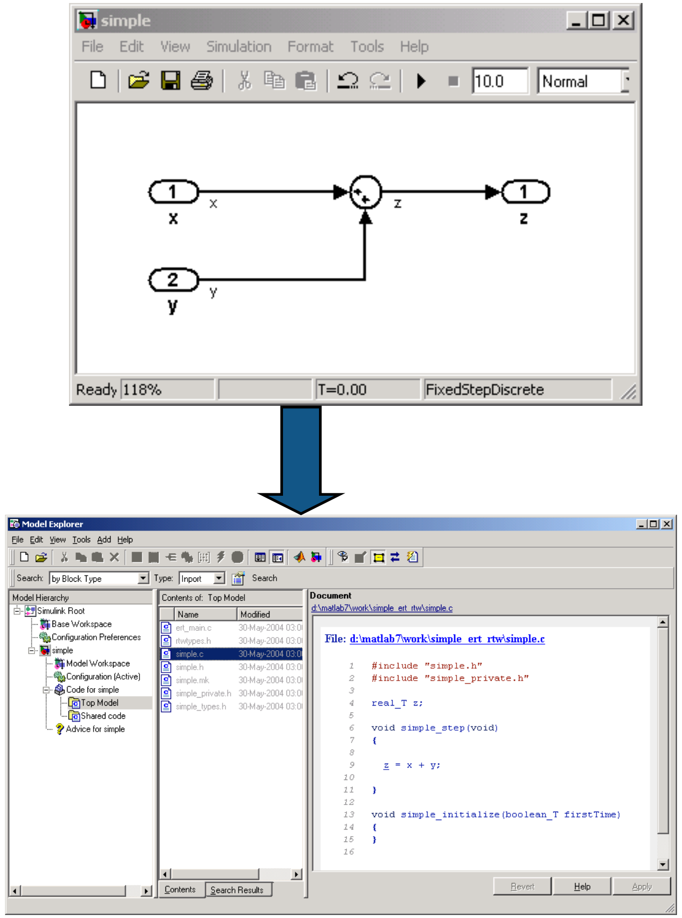
Code Generation Products:
Simulink Coder and Embedded Coder

Simulink Coder

- Generates code for use in simulation and prototyping applications
- Comes with Generic Real-Time (GRT) based targets

Embedded Coder

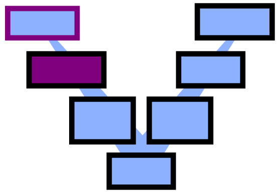
- Generates efficient code that can be customized to look like hand code for production
- Comes with Embedded Real-Time (ERT) based targets

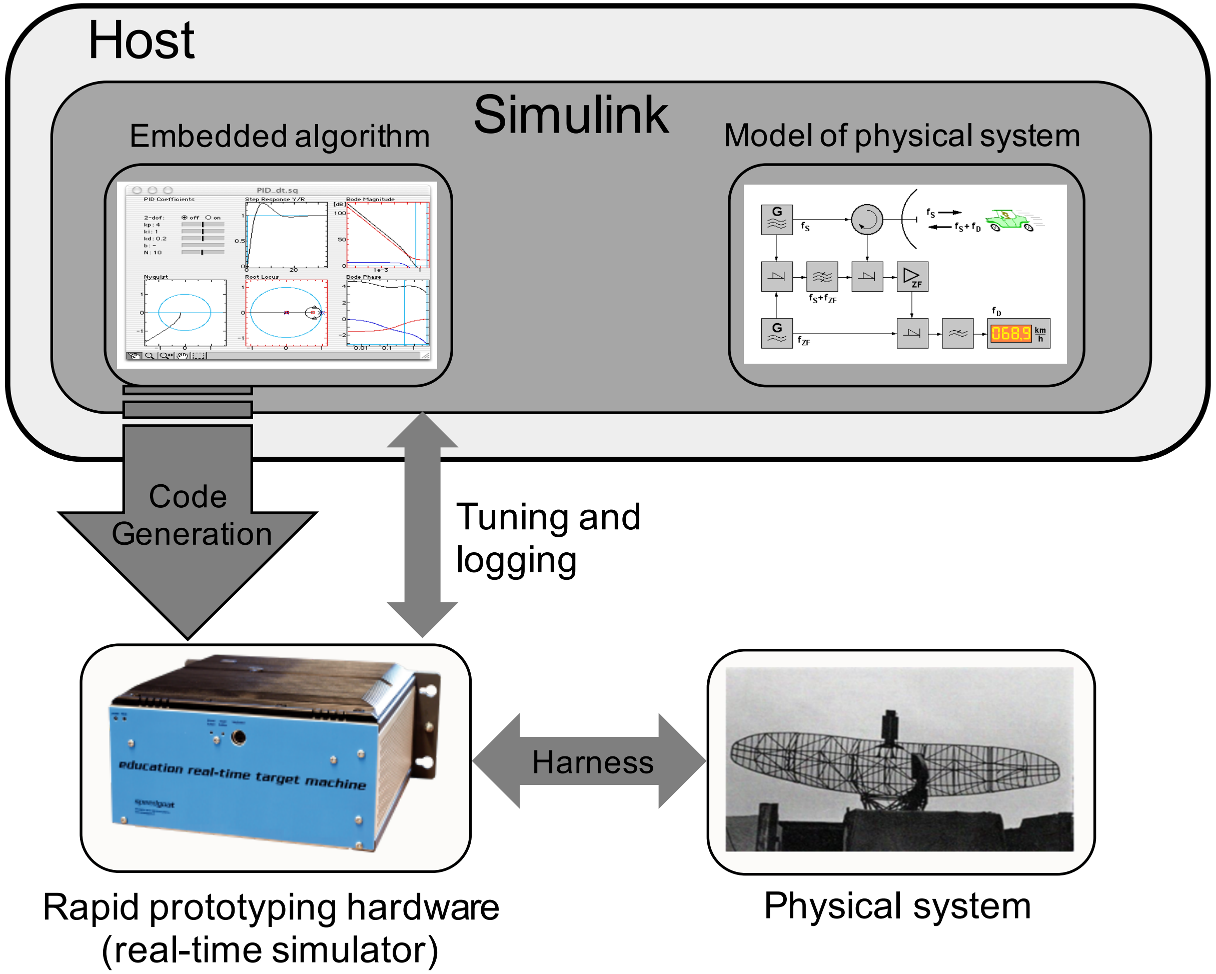


Rapid Prototyping

Simulink Coder with Simulink Real-Time

Generate, deploy, and tune code for a component (algorithm or controller) on a real-time simulator connected to system hardware

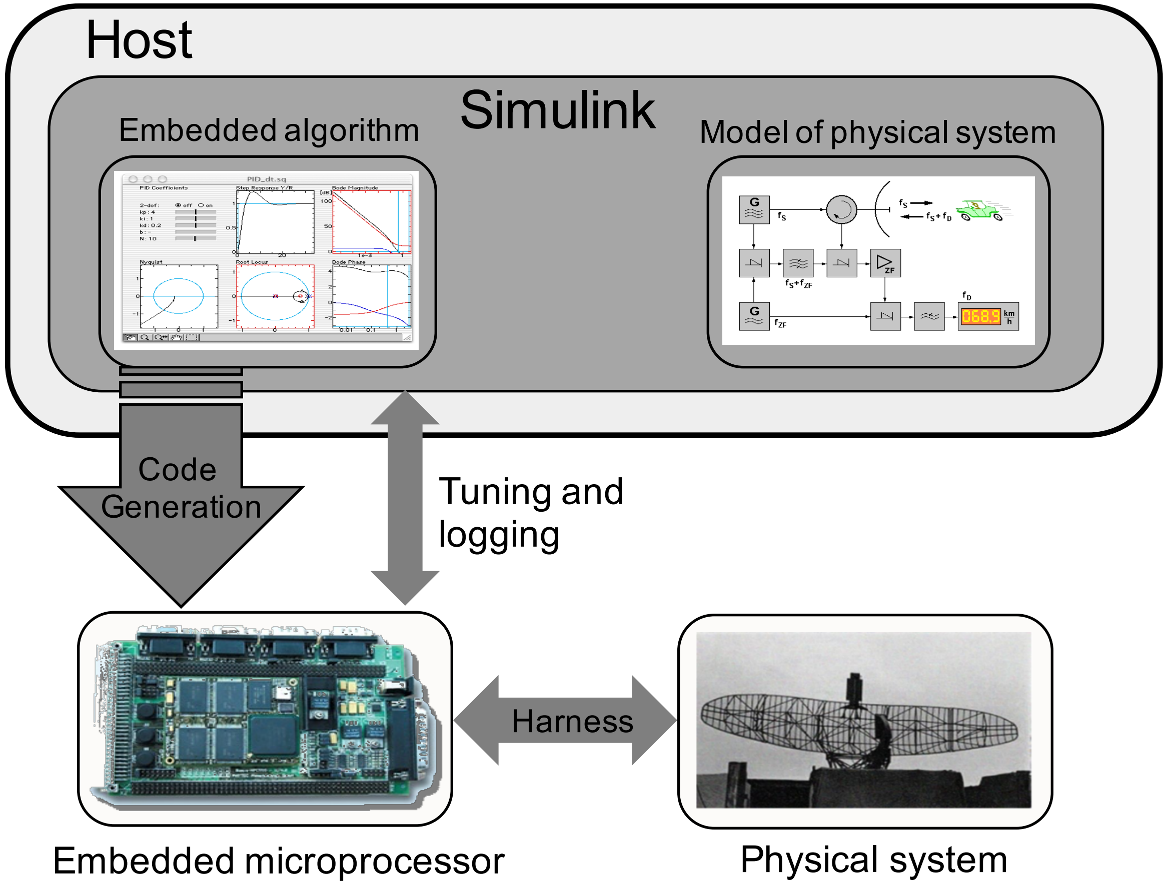




Rapid Prototyping on Embedded Processors

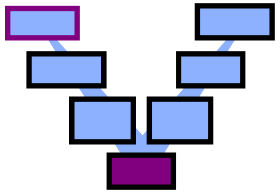
Embedded Coder

Run the generated code in real time, tune parameters, and monitor real-time data on the same processor you plan to use in mass production, or a close equivalent to it.

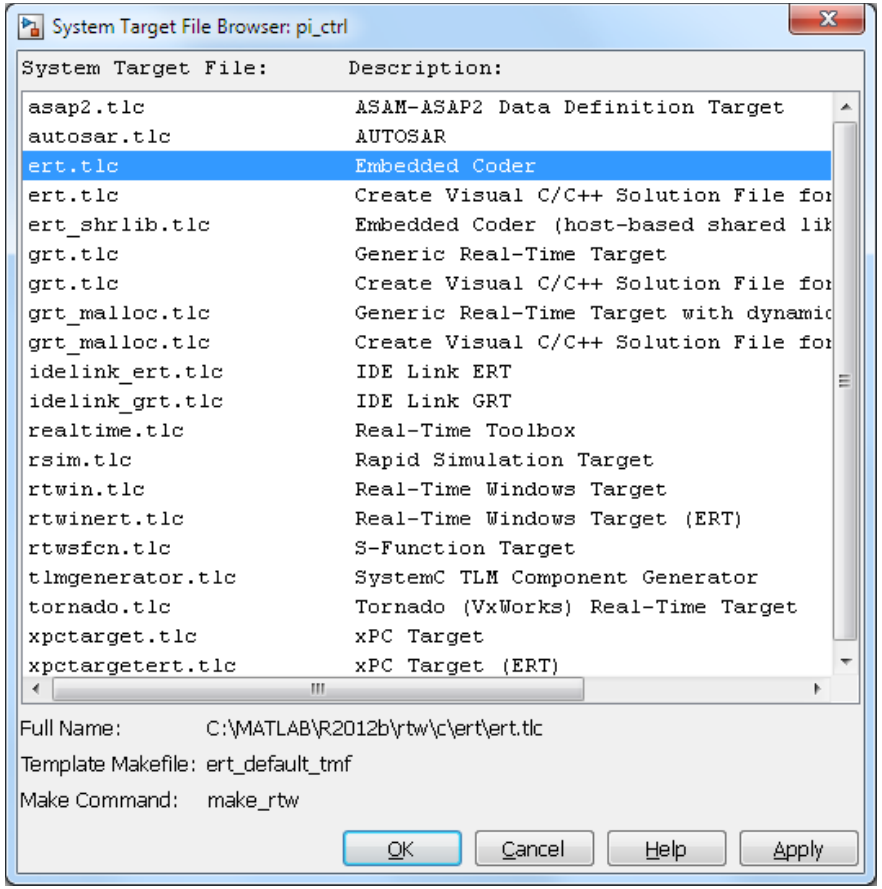


Production Code Generation

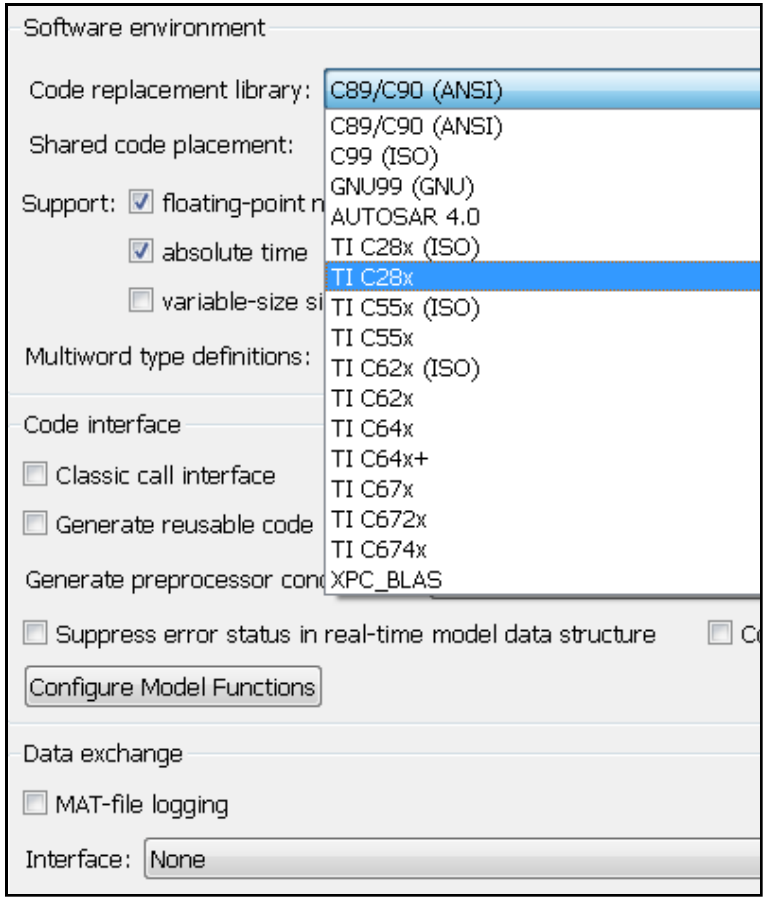
Embedded Coder



Select Target

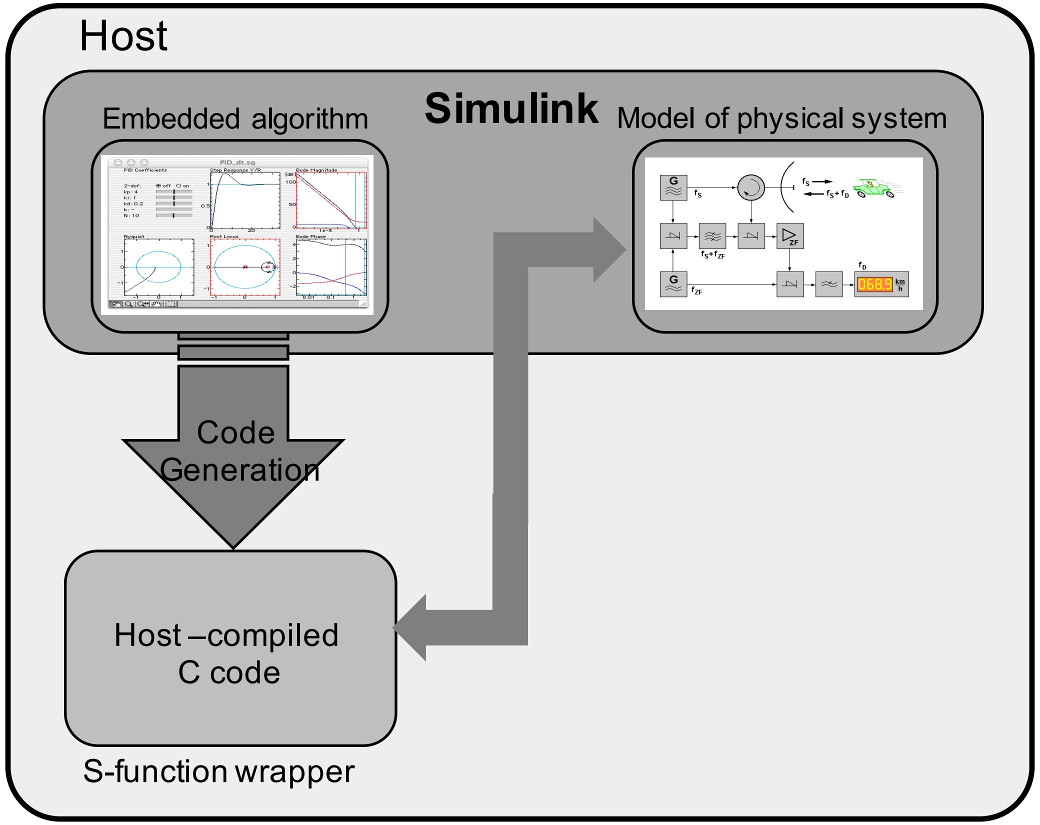


Choose Optimizations and File Packaging



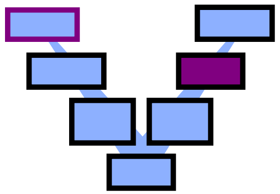
Software-in-the-Loop Testing
Embedded Coder

Test generation production code with your environment or plant model to verify a successful conversion of the model to code.

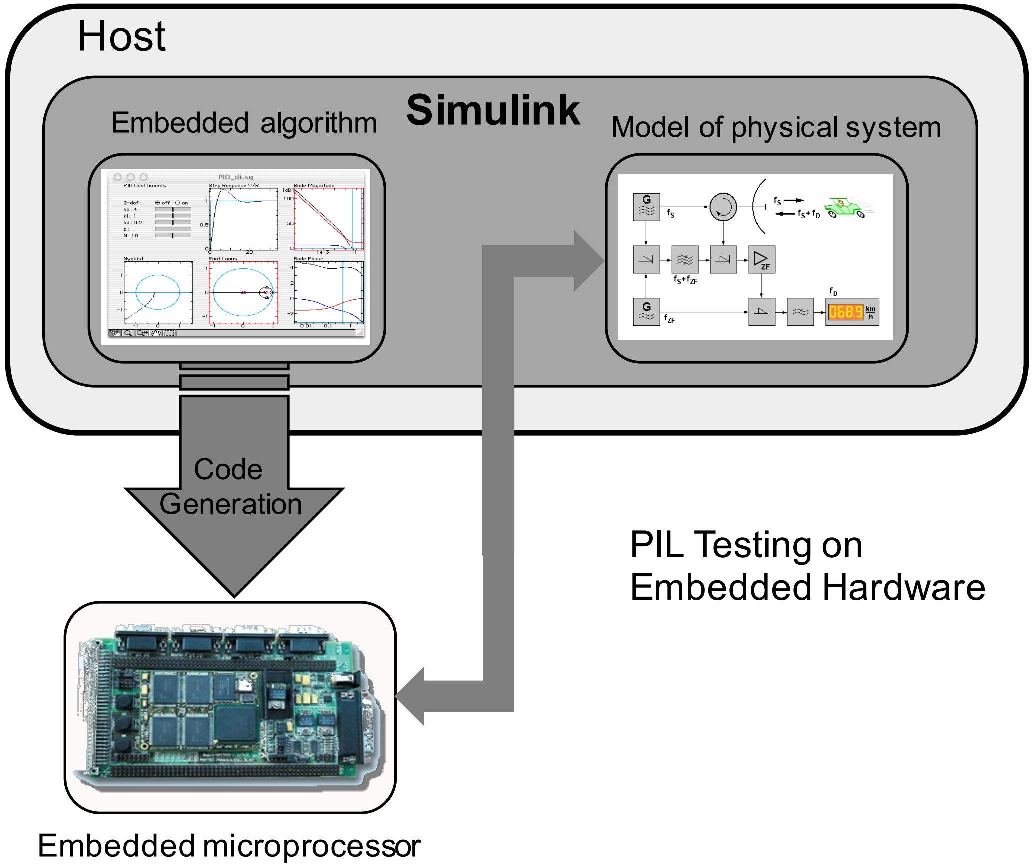


Processor-in-the-Loop Testing

Embedded Coder



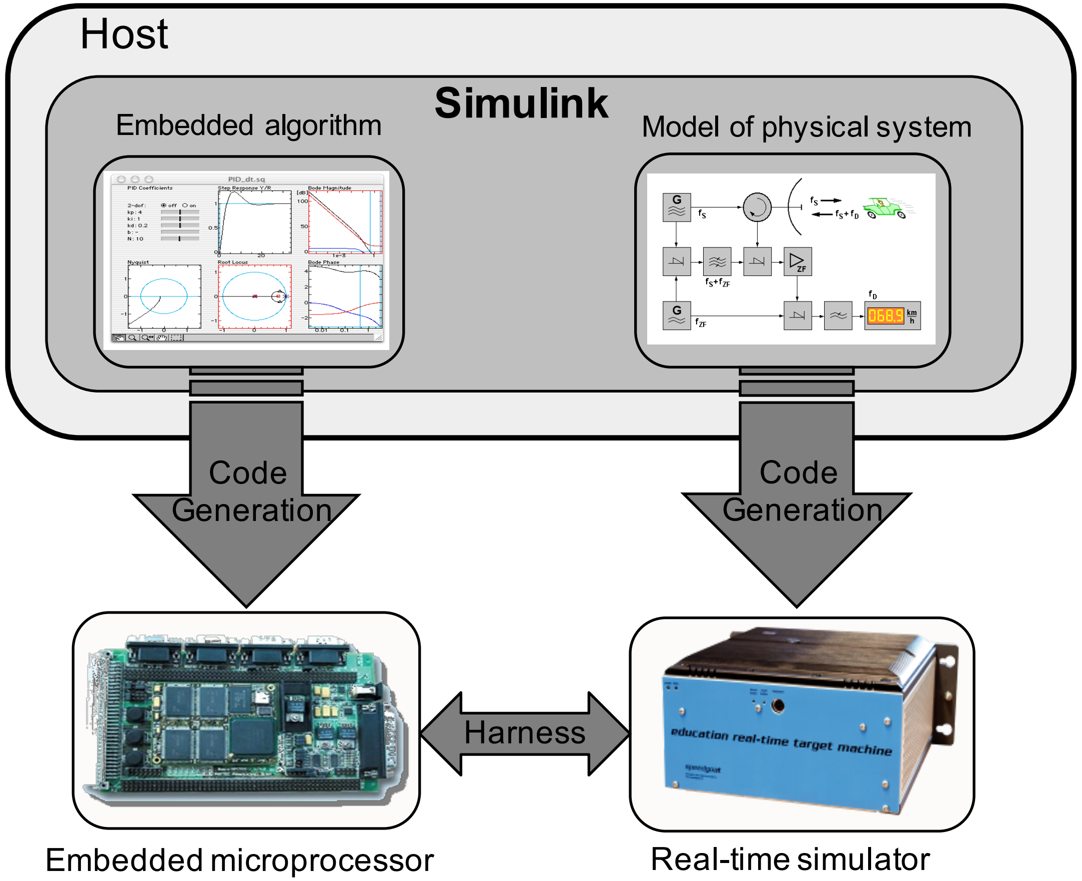
Use processor-in-the-loop PIL to evaluate the behavior of a candidate algorithm on the target processor.



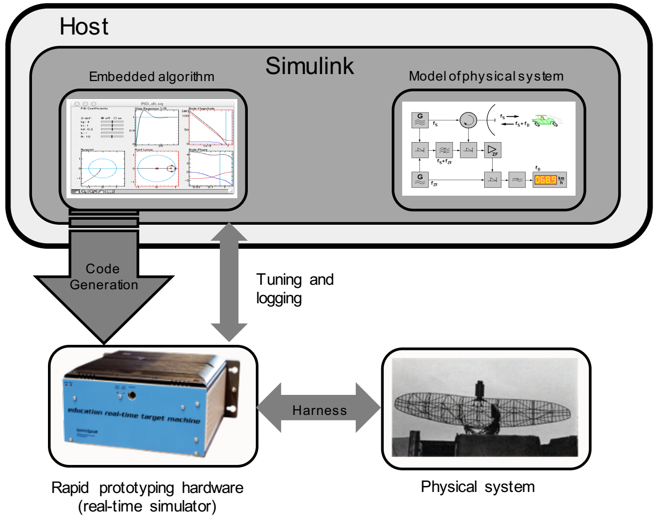
Hardware-in-the-Loop Testing

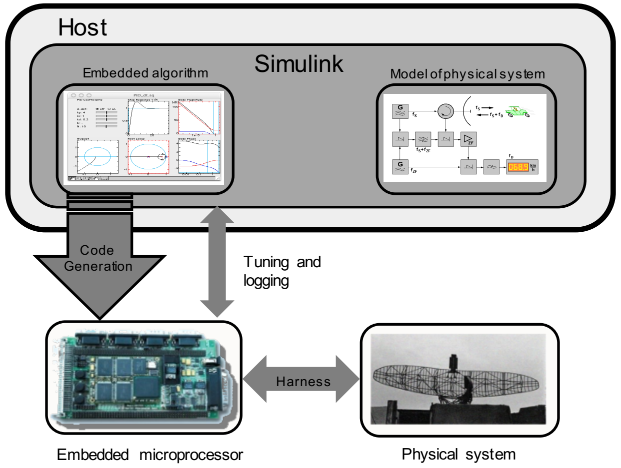
Embedded Coder and Simulink Coder with Simulink Real-time

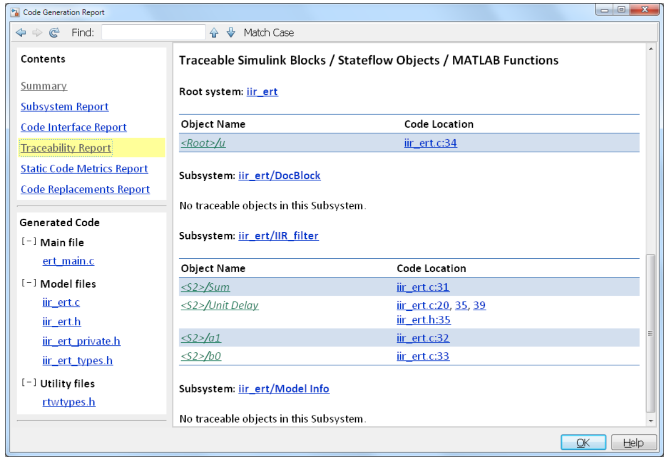
Final test before integration using simulated plant executing in real time.

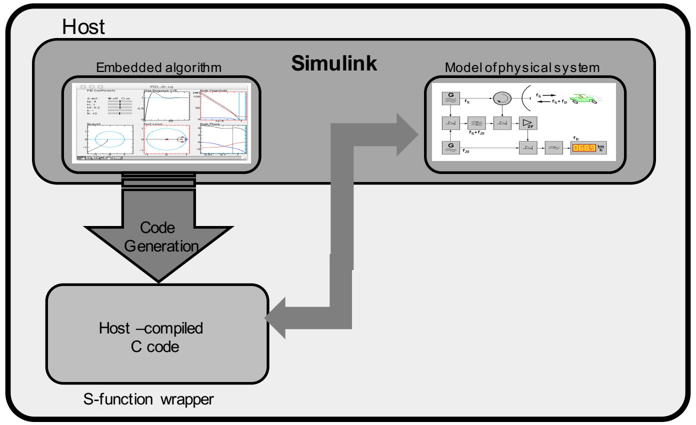


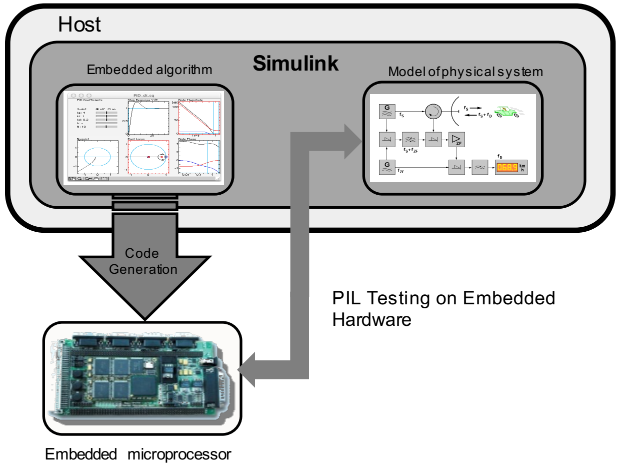
Usage of Code Generation Products

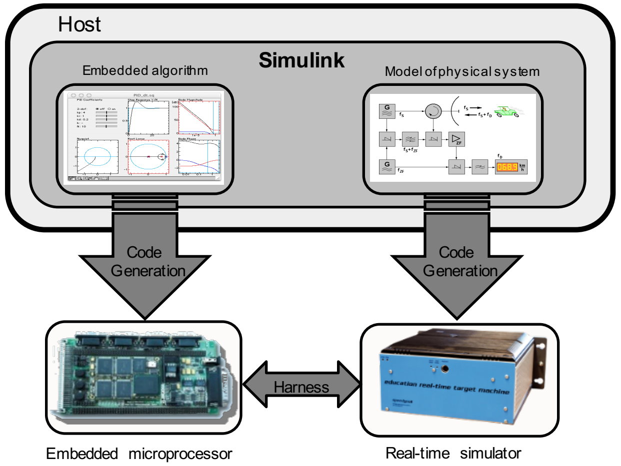












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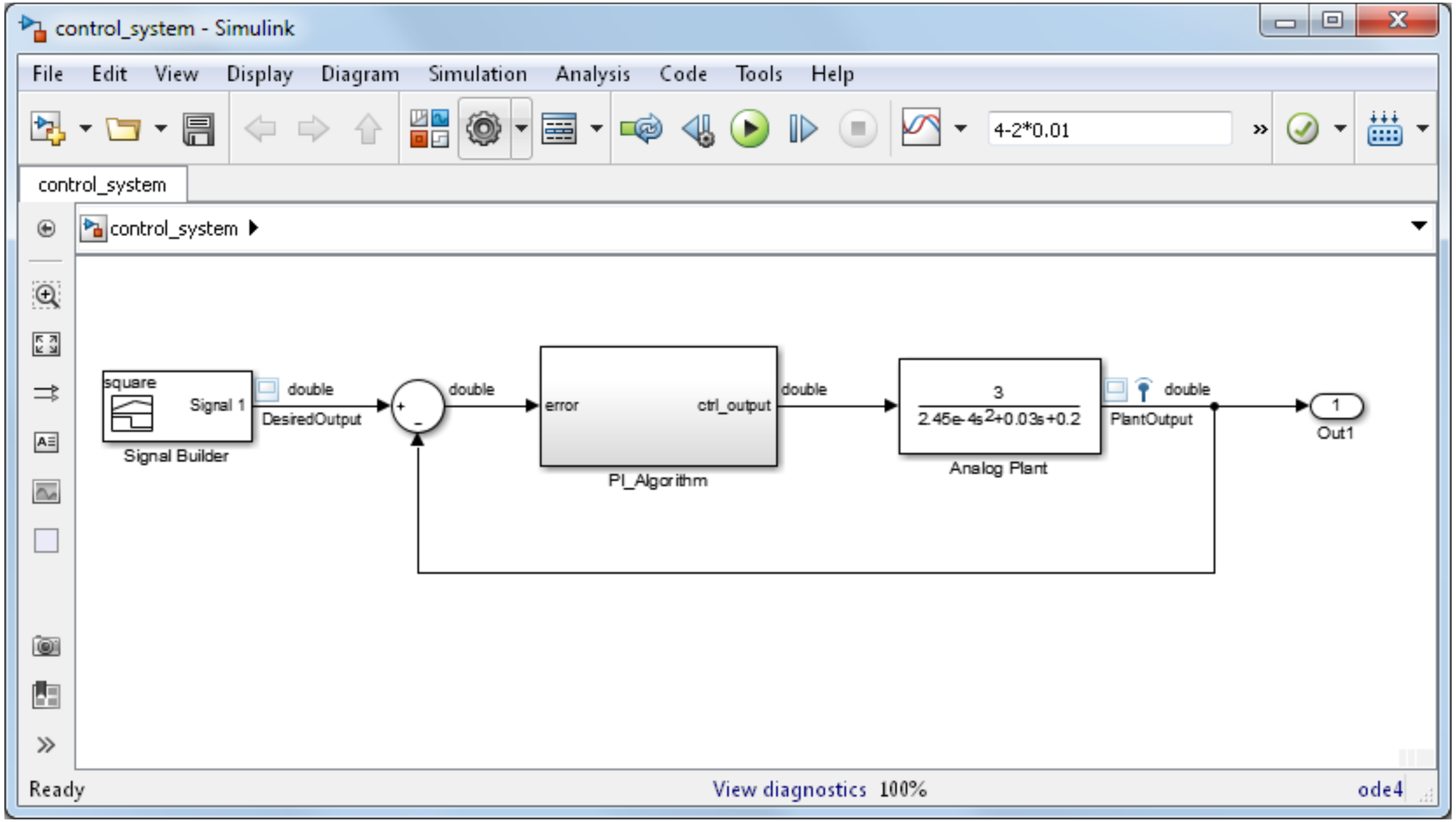
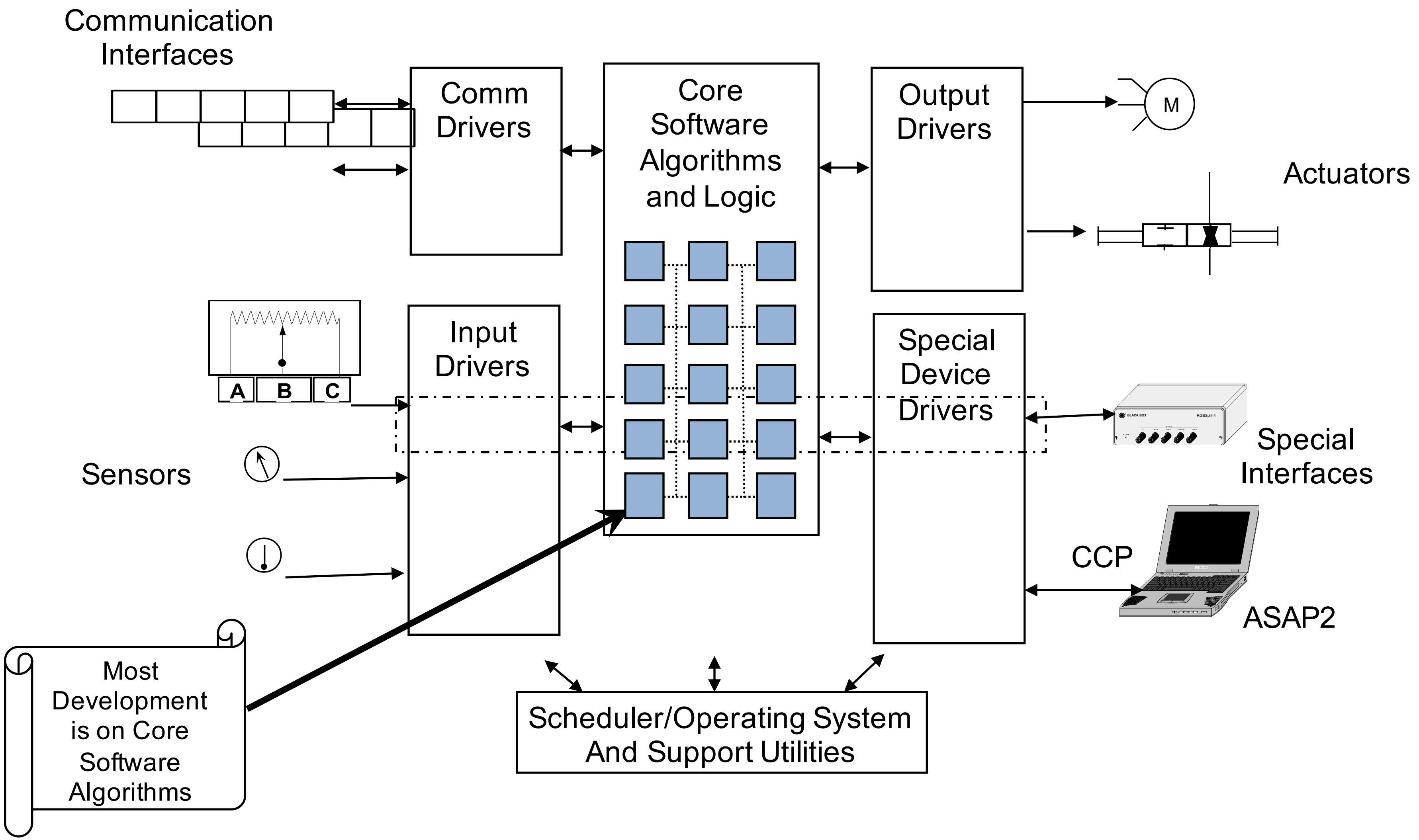
Example) Controller of Landing Gear

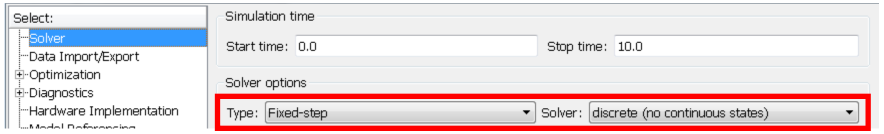


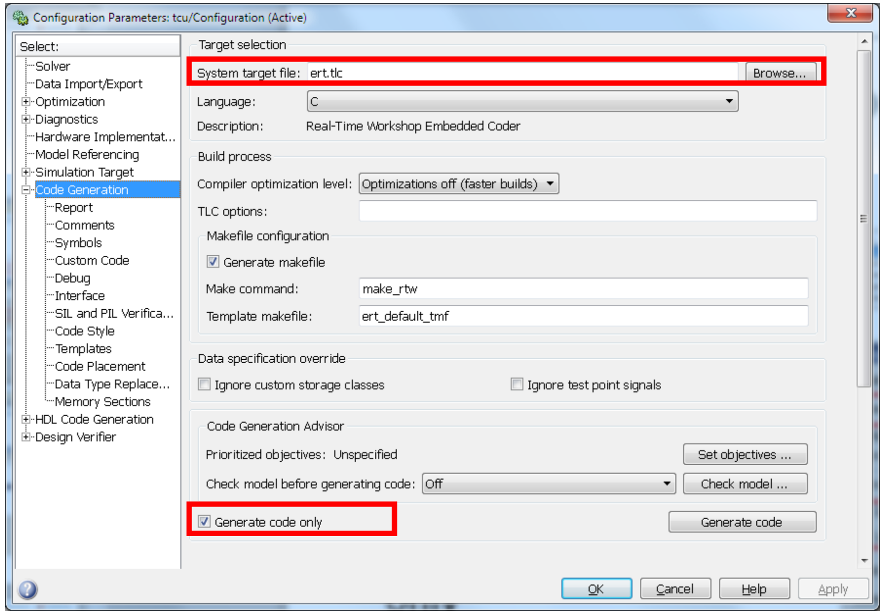
Simple Software Architecture

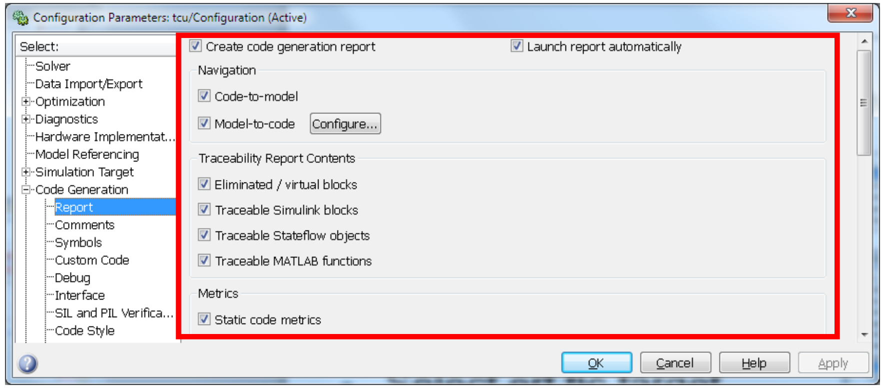


Basic Code Generation Workflow for Embedded Target

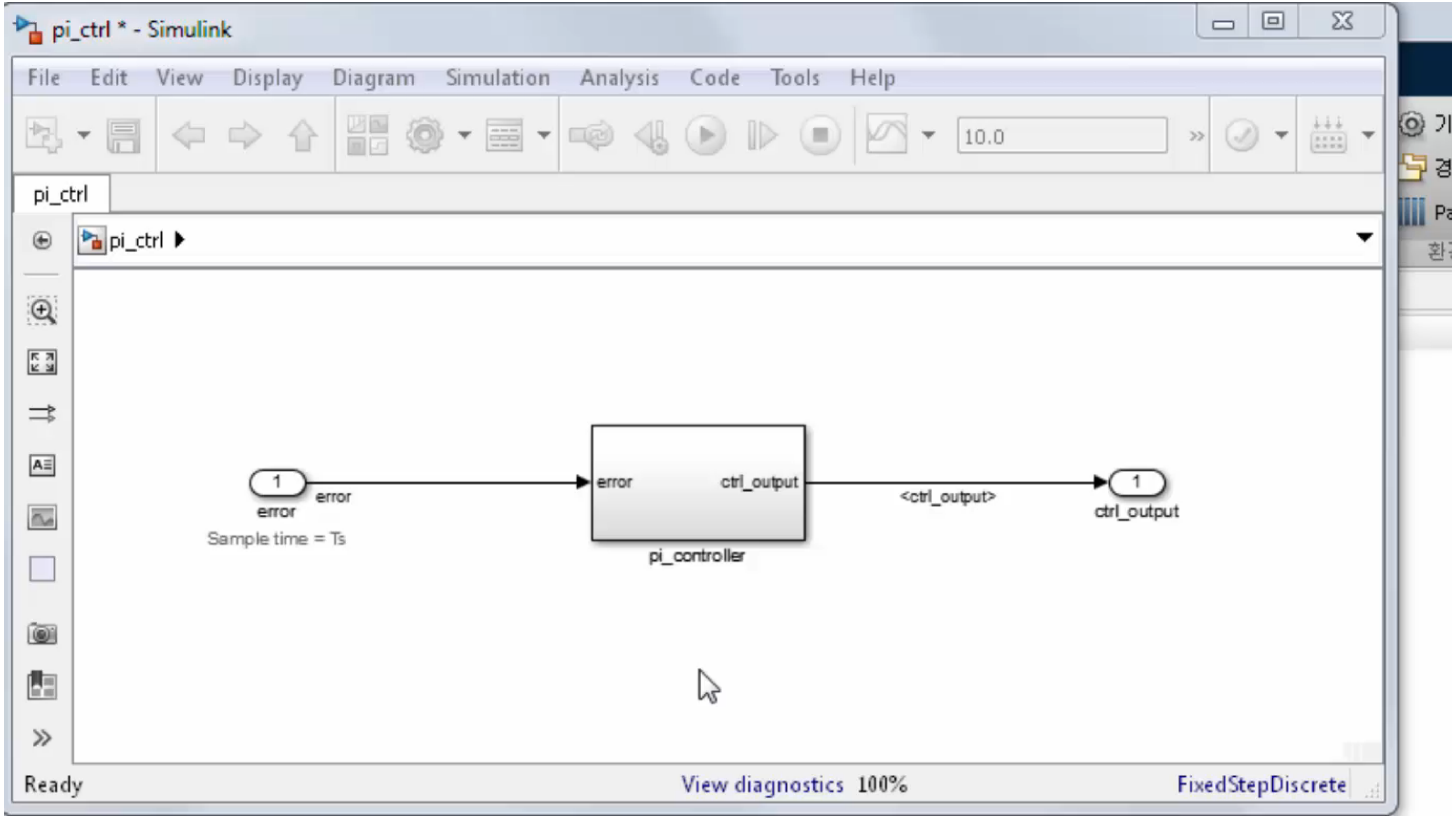
- Select solver to be fixed step with discrete
- Select ert.tlc target
- Select generate code only
- Select HTML Report for easy review
- Generate code for model
- Review code in browser





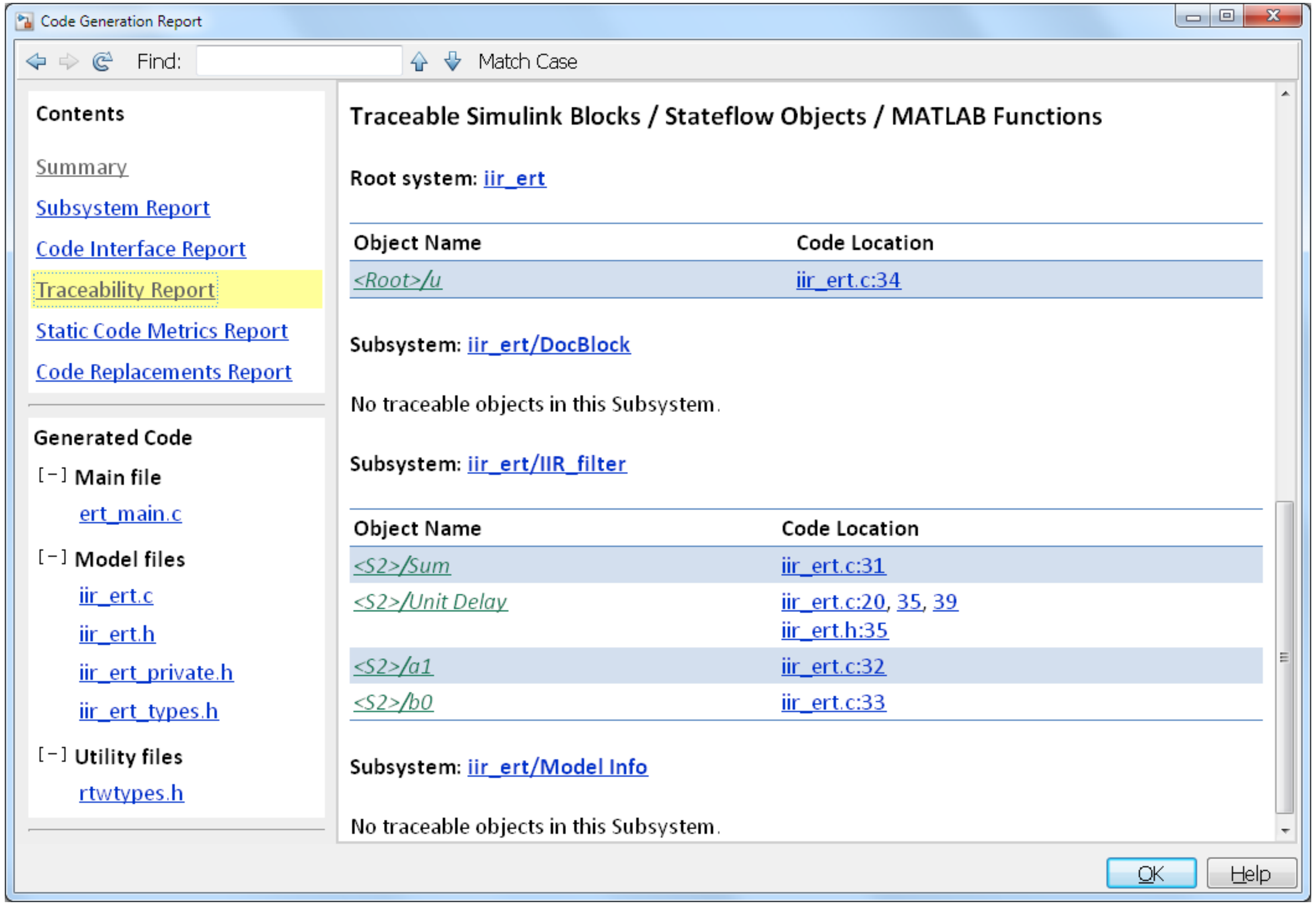


Demo: Code Generation Workflow

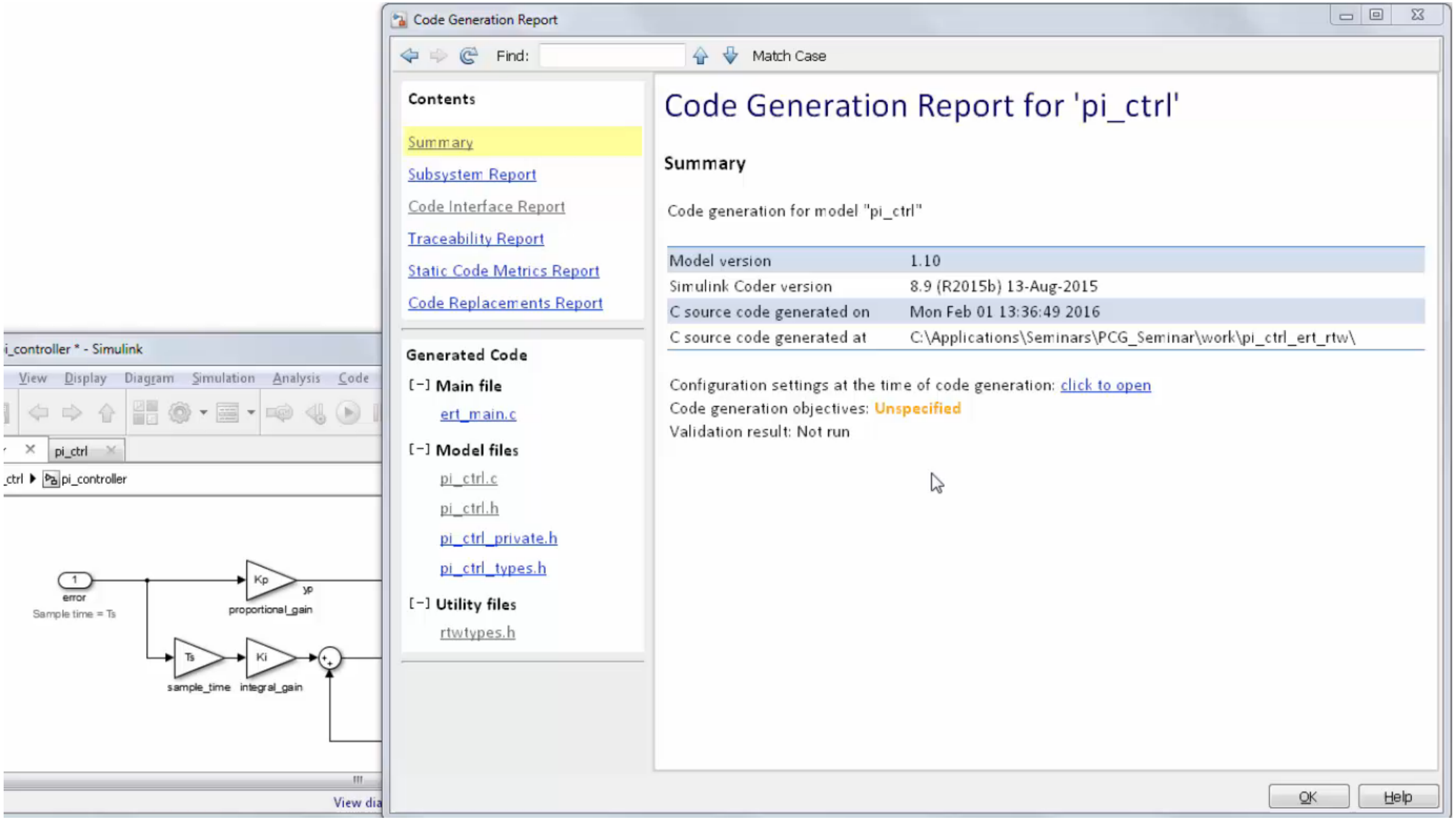


Code Generation Reports

- Subsystem Report
- Code Interface Report
- Traceability Report
- Static Code Metrics Report
- Code Replacements Report



Demo: Code Generation Reports

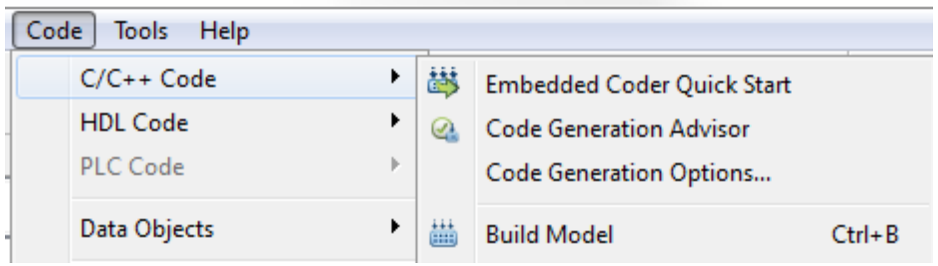


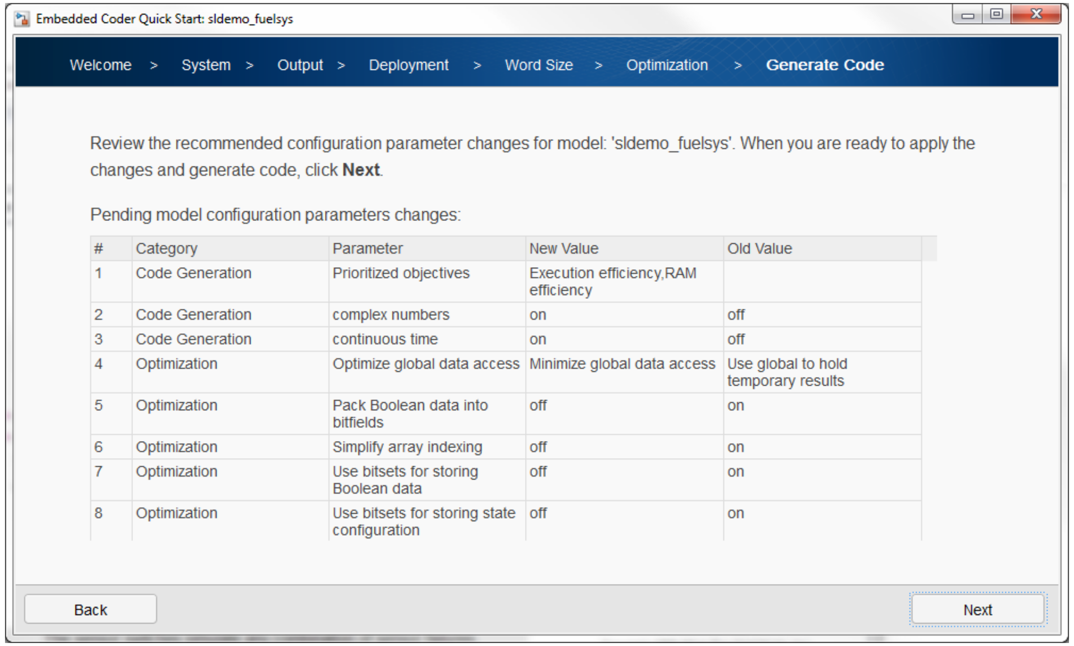
Embedded Coder Quick Start

R2015b

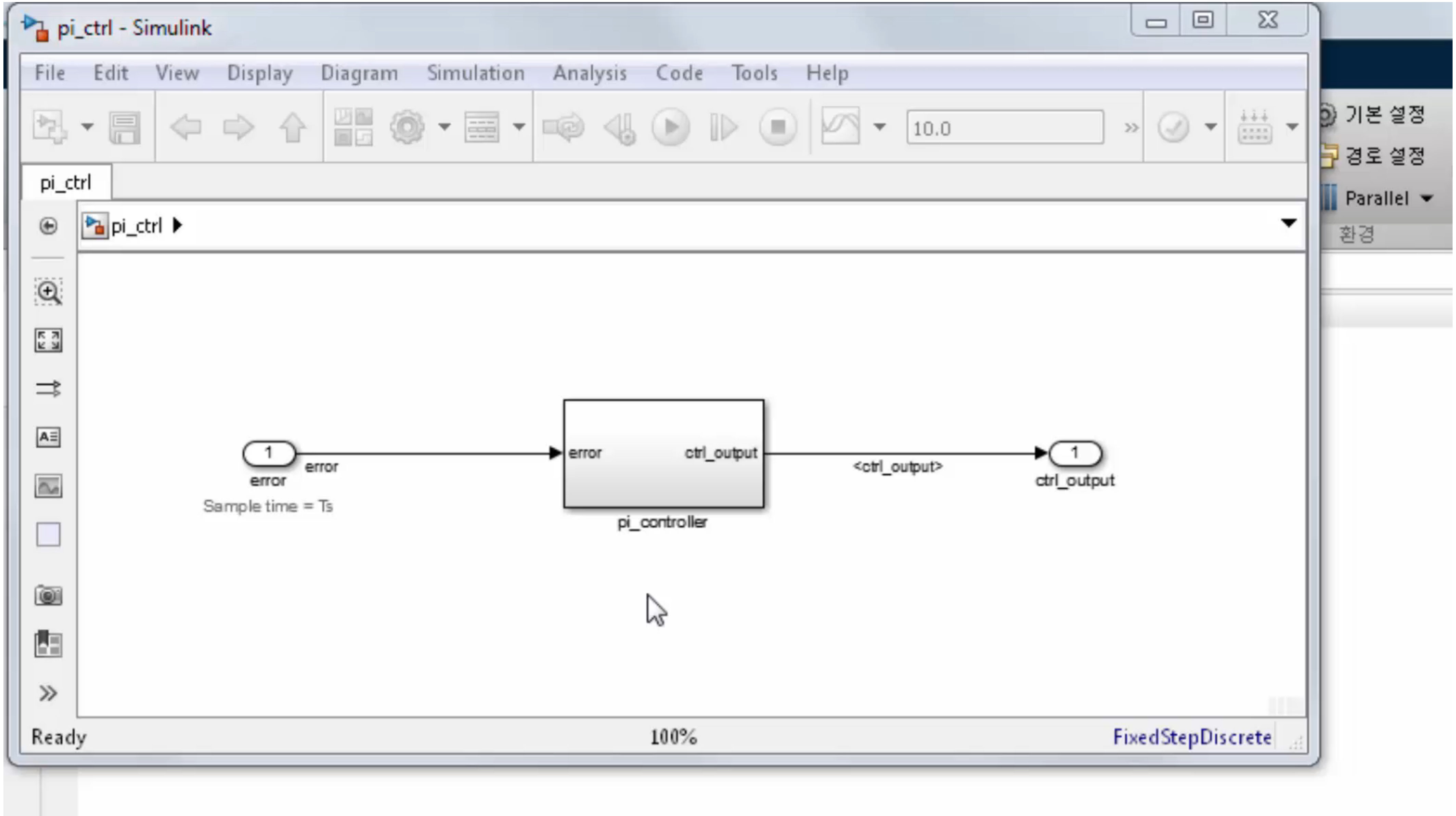
Easily configure Simulink Model to generate production code

- Ask questions about code generation goals
- Auto configure and validate model against the selections
- Show recommended configuration changes
- Apply configuration changes and generate code

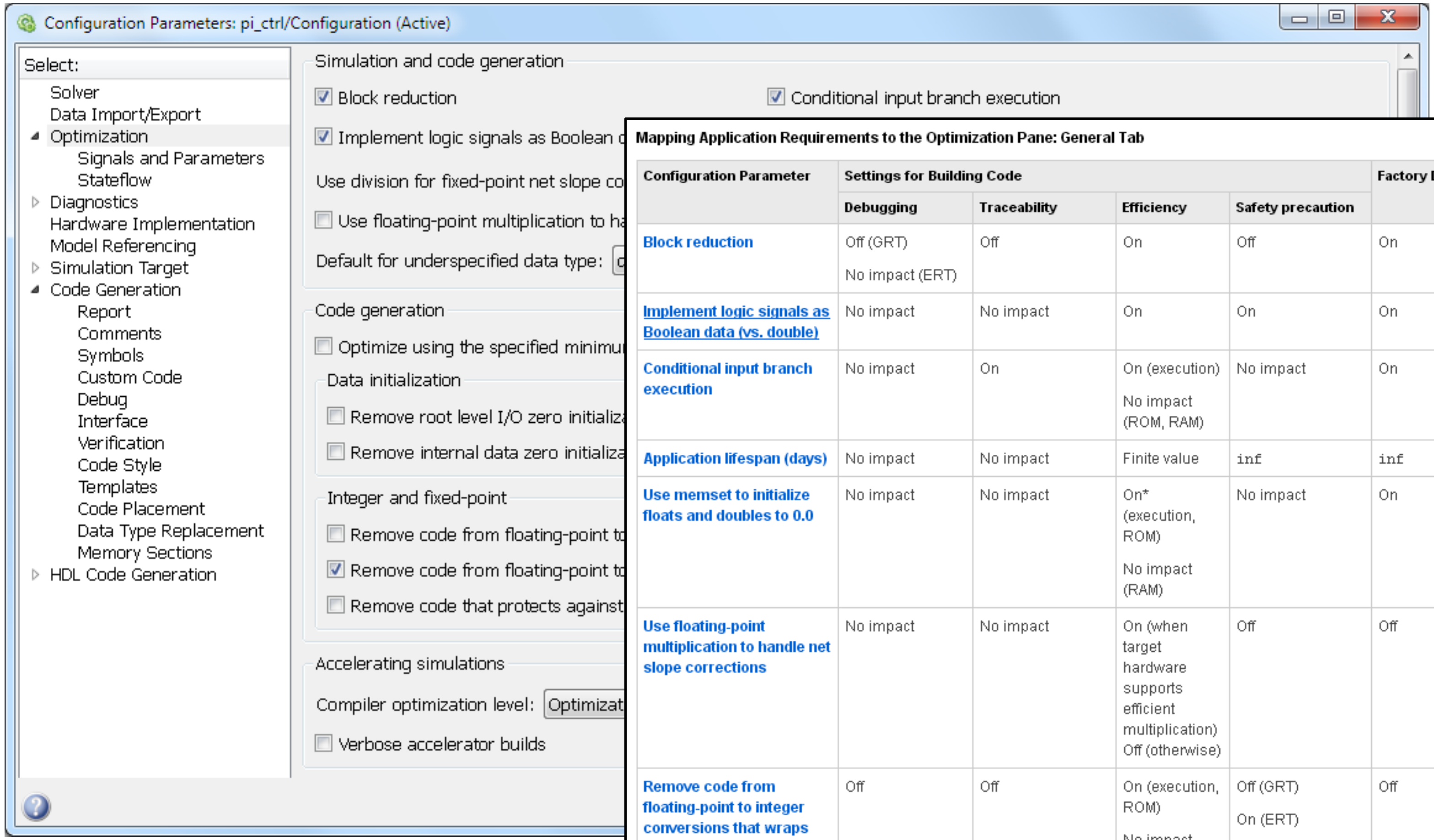




Demo: Embedded Coder Quick Start



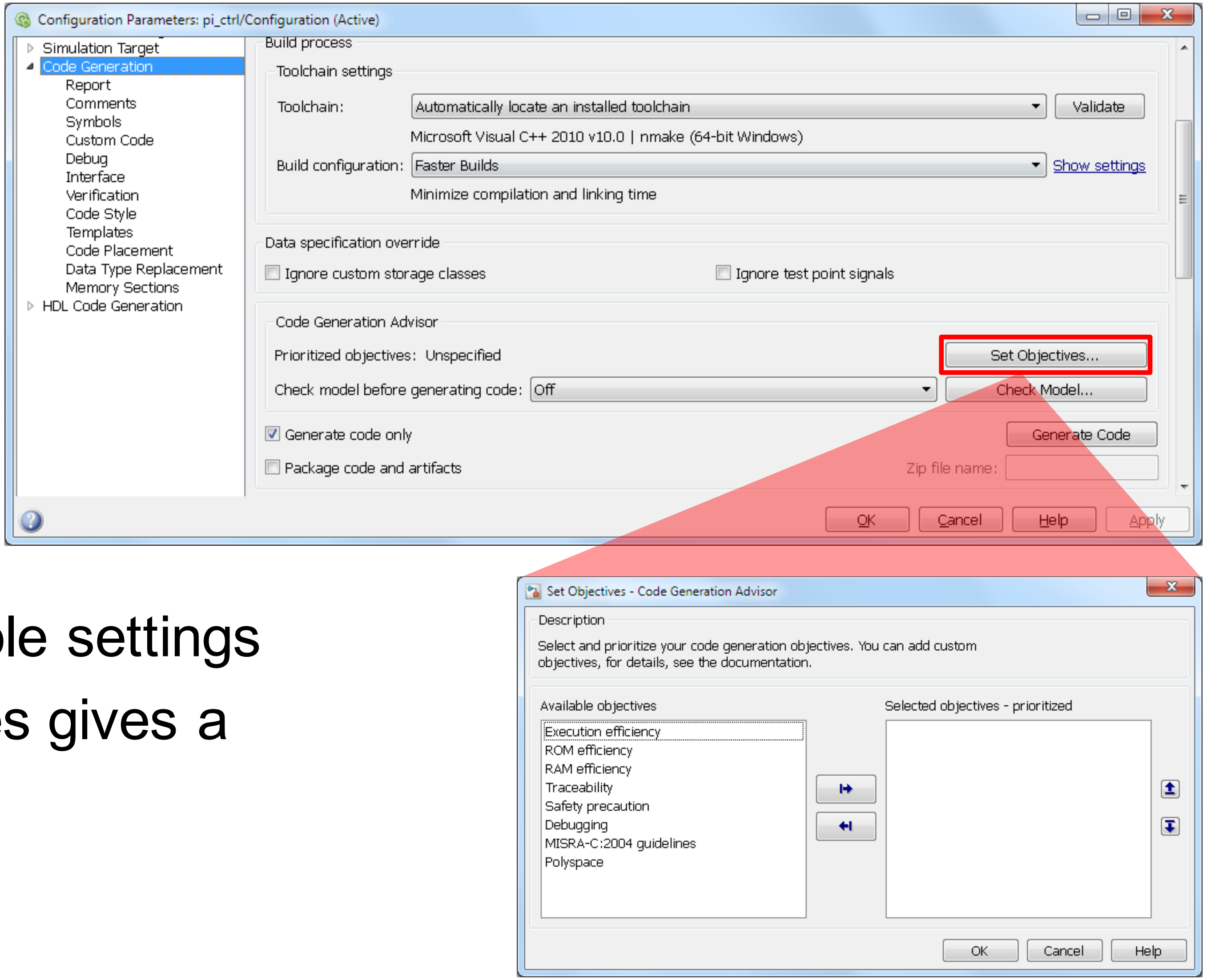
Optimization Considerations



Mapping Application Requirements to the Optimization Pane: General Tab

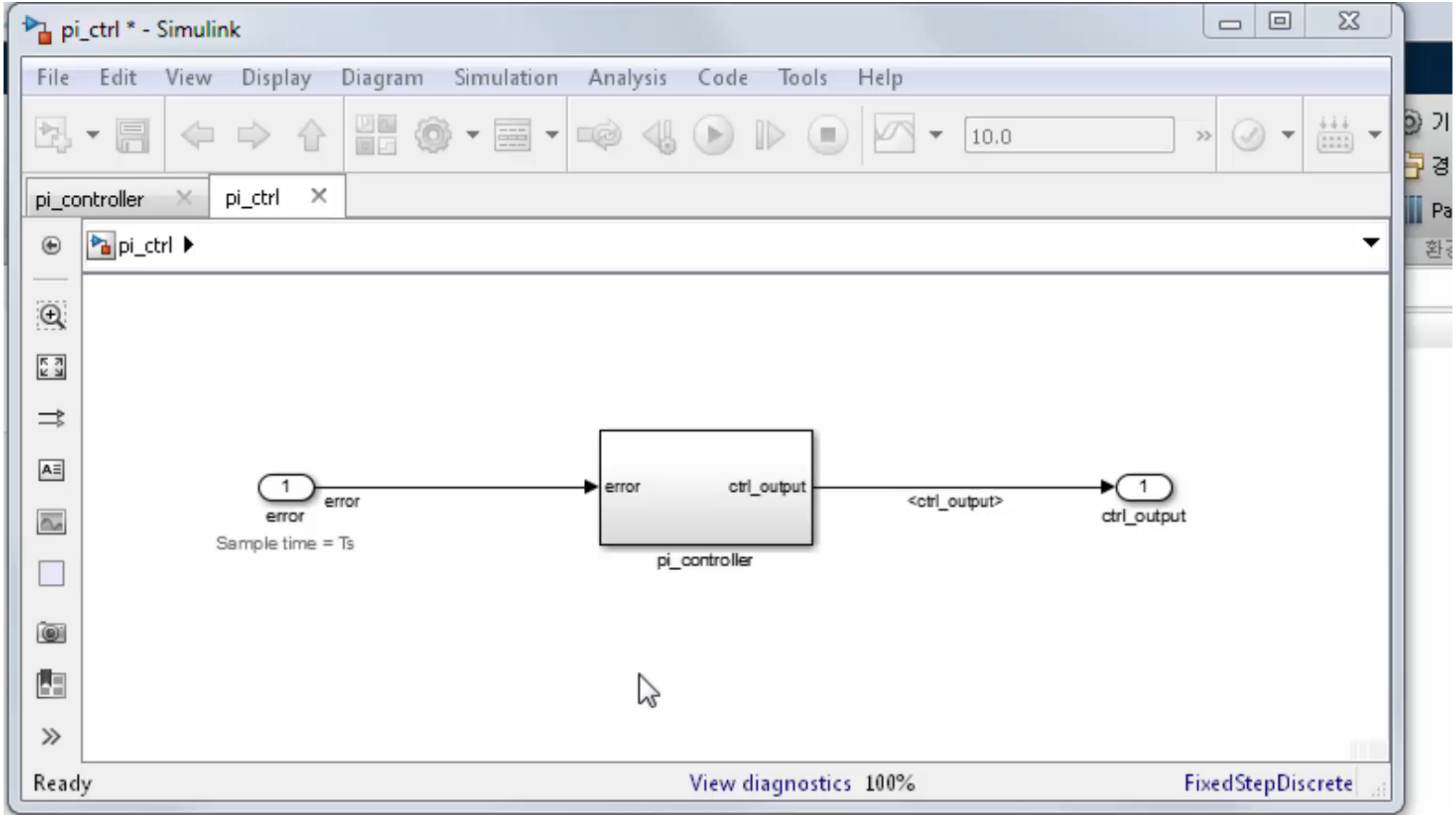
Configuration Parameter	Settings for Building Code				Factory Default
	Debugging	Traceability	Efficiency	Safety precaution	
Block reduction	Off (GRT) No impact (ERT)	Off	On	Off	On
Implement logic signals as Boolean data (vs. double)	No impact	No impact	On	On	On
Conditional input branch execution	No impact	On	On (execution) No impact (ROM, RAM)	No impact	On
Application lifespan (days)	No impact	No impact	Finite value	`inf`	`inf`
Use memset to initialize floats and doubles to 0.0	No impact	No impact	On* (execution, ROM) No impact (RAM)	No impact	On
Use floating-point multiplication to handle net slope corrections	No impact	No impact	On (when target hardware supports efficient multiplication) Off (otherwise)	Off	Off
Remove code from floating-point to integer conversions that wraps out-of-range values	Off	Off	On (execution, ROM) No impact (RAM)	Off (GRT) On (ERT)	Off
Remove code from floating-point to integer conversions with …uration that maps NaN	Off	Off	On		

Code Generation Objectives



- Models have a lot of possible settings
- Code Generation Objectives gives a starting point

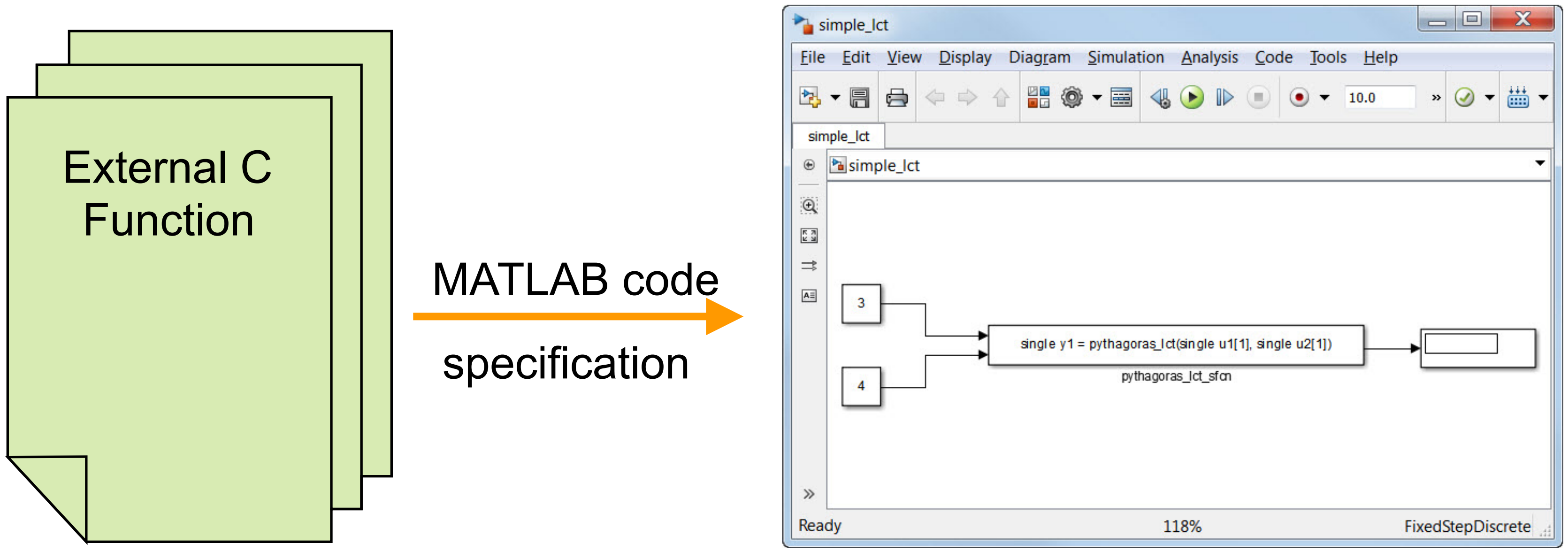
Demo: Optimizing Generated Code



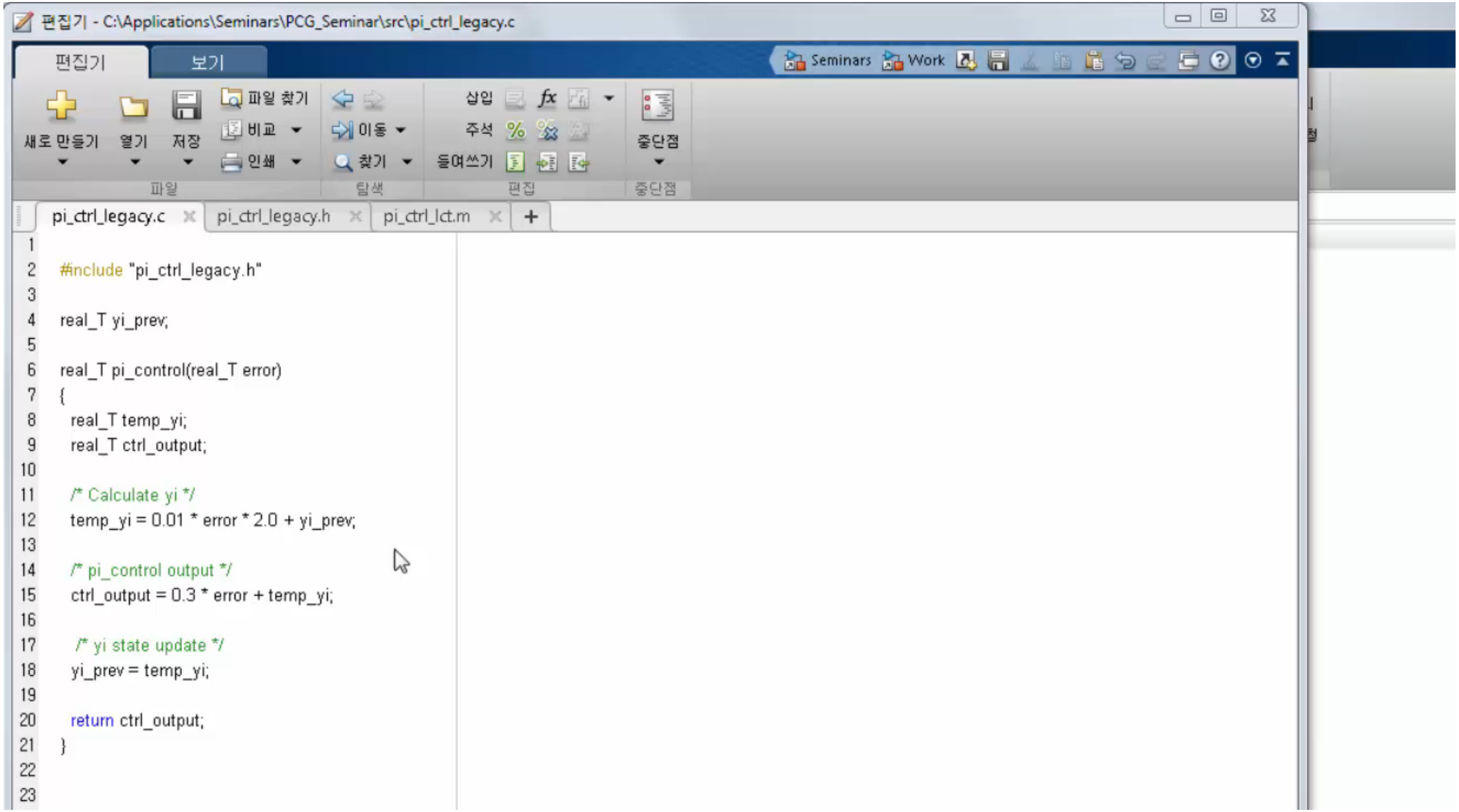
Legacy Code Tool

Legacy Code Tool

- Legacy Code Tool is a utility that generates an S-function automatically from existing C code
- It can also insert an appropriate call to generated code



Demo: Code Generation with Legacy C Code



Agenda

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Equivalence Test

SIL (Software-In-the-Loop) and PIL (Processor-In-the-Loop)

SW Design

Design Model

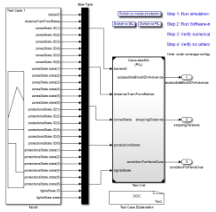
generate

generate

simulate

Source Code

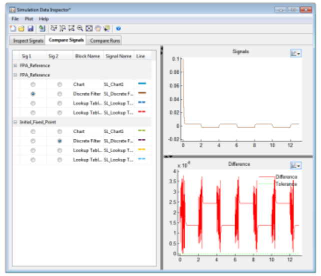
Model Test Harness for 100% model coverage

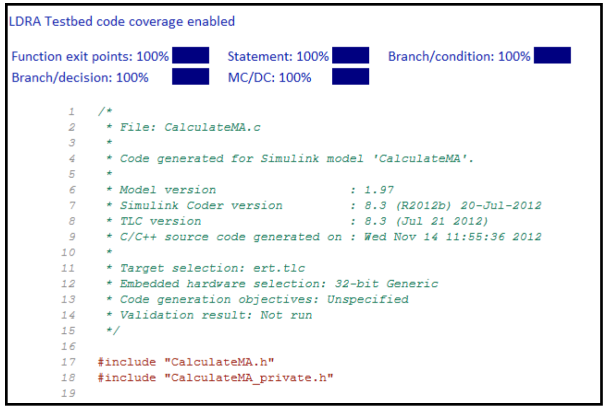


generate

Object Code

Test (with and without instrumentation)




LDRA Testbed code coverage enabled

Function exit points: 100% Statement: 100% Branch/condition: 100%
Branch/decision: 100% MC/DC: 100%

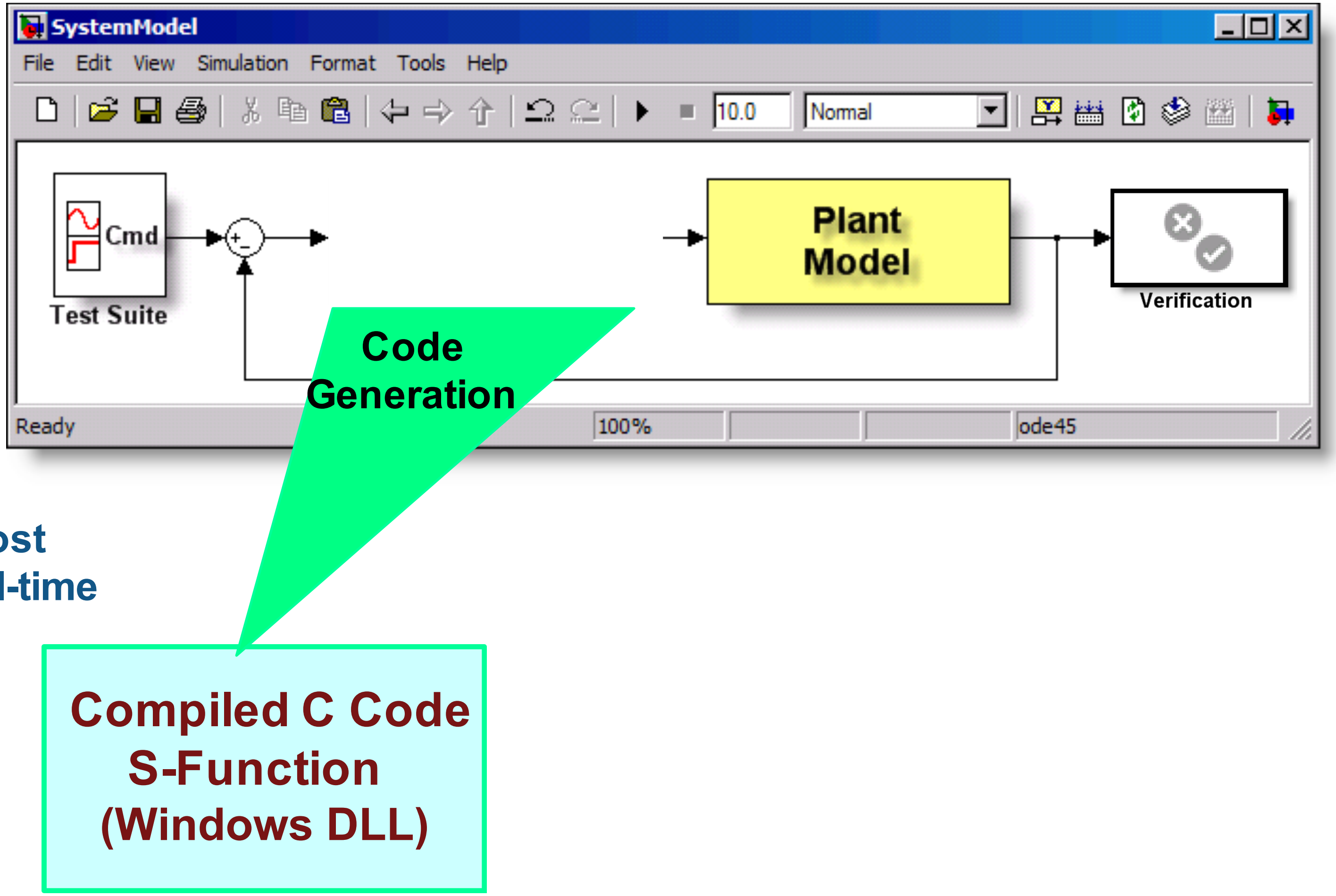
```
/*
 * File: CalculateMA.c
 *
 * Code generated for Simulink model 'CalculateMA'.
 *
 * Model version                  : 1.97
 * Simulink Coder version         : 8.3 (R2012b) 20-Jul-2012
 * TLC version                    : 8.3 (Jul 21 2012)
 * C/C++ source code generated on : Wed Nov 14 11:55:36 2012
 *
 * Target selection: ert.tlc
 * Embedded hardware selection: 32-bit Generic
 * Code generation objectives: Unspecified
 * Validation result: Not run
 */

#include "CalculateMA.h"
#include "CalculateMA_private.h"
```

verify numerical equivalence with simulation

verify 100% code coverage (for traceability)

Software-in-the-Loop (SIL) Testing:

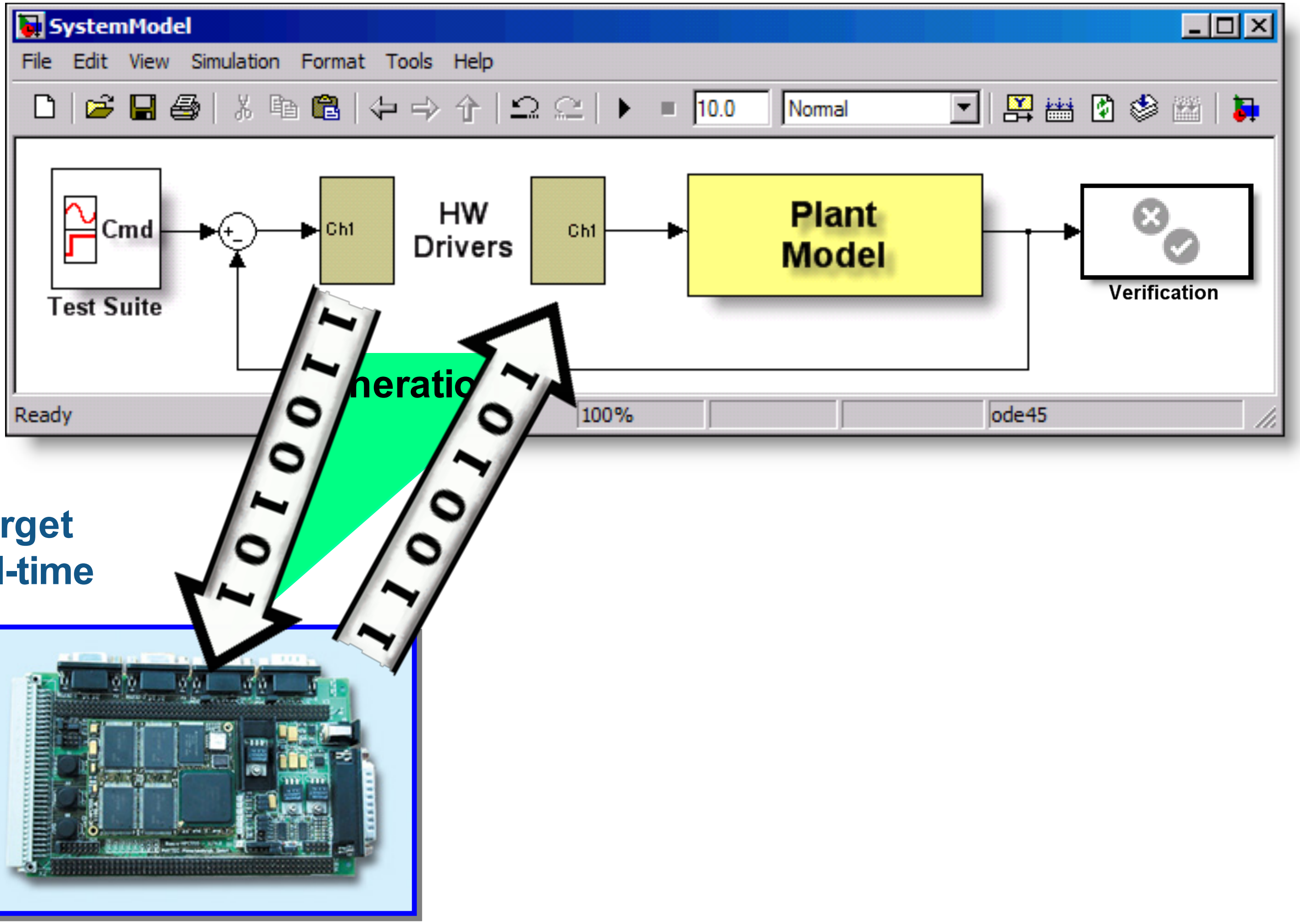
Verify Production Controller with Software-in-the-loop



Execution
- Host/Host
- Nonreal-time

Processor-in-the-Loop Testing:

Verify Production Controller with Processor-in-the-loop



Execution
- Host/Target
- Nonreal-time

Production Processor

Processor-in-the-Loop (PIL) API

Problem

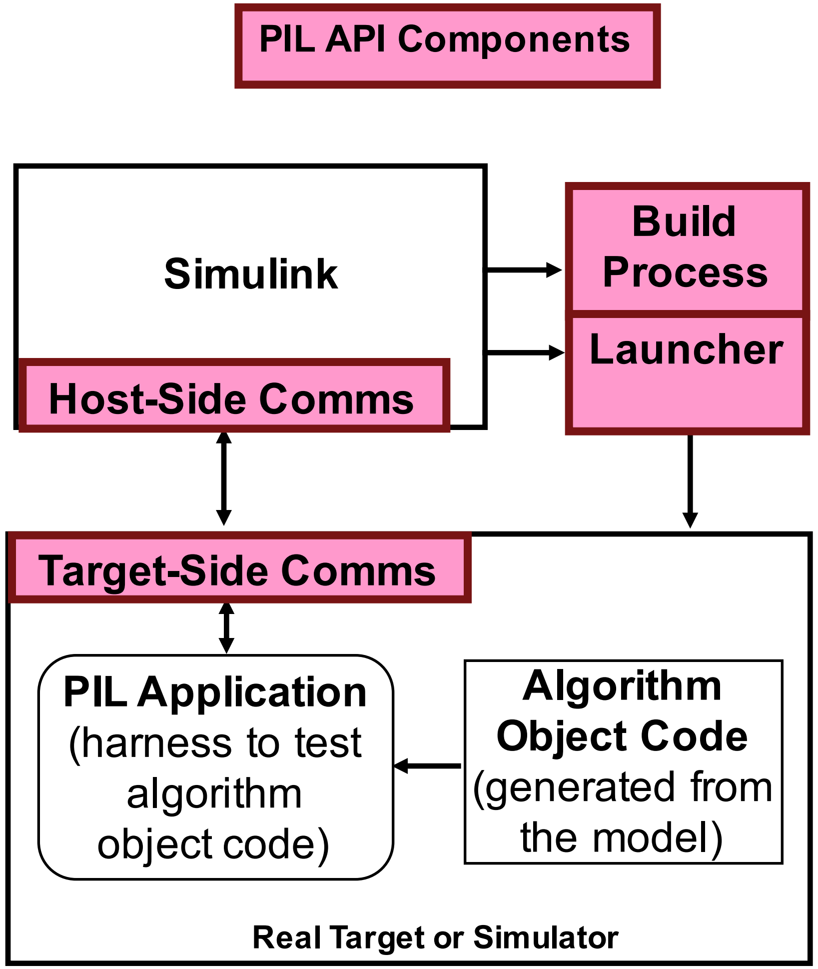
- Embedded IDE Link does not support PIL for an arbitrary combination of
  - Processor
  - Compiler
  - Debugger or download utility
  - Communications channel

Solution

- Provide an API that allows integration of third-party or customer tools for
  - Building the PIL application
  - Downloading and running the application
  - Communicating with the application

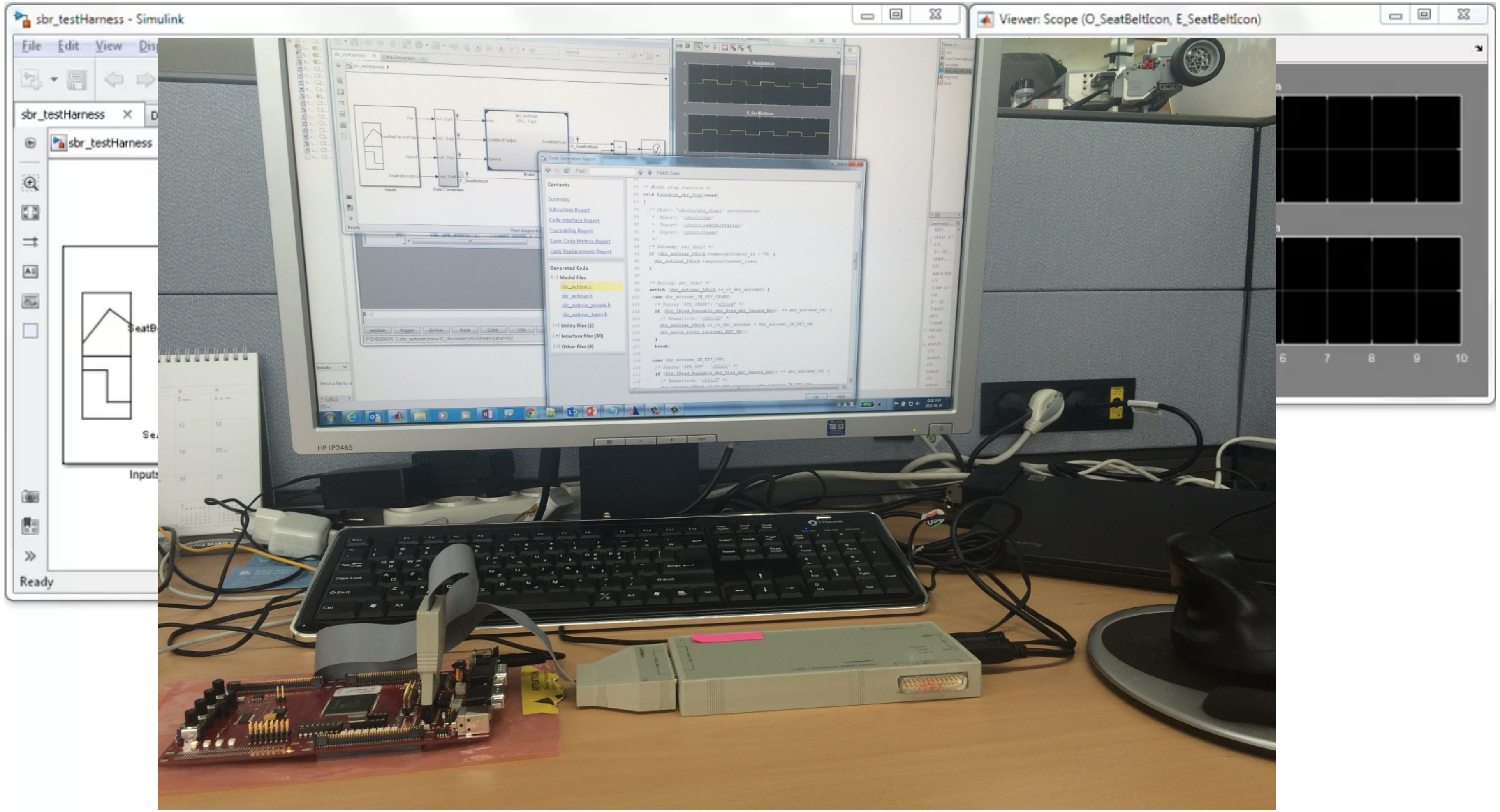
Benefit

- The power of PIL verification is easily adaptable for any target environment
- A fully documented API is stable across MathWorks releases



PIL Testing Example

Infineon Tricore with Trace32 Debugger



Key Benefits of SIL and PIL

- Reuse test vectors for simulation, SIL and PIL
  - Verify correct execution behaviour of compiled code (including on production hardware)
  - Collect metrics for the generated code
    - Code coverage
    - Execution profiling
    - Stack profiling
- Evaluate hardware specific optimizations
- Generate artifacts for IEC-61508, IEC-62304, ISO-26262, EN-50128, and DO-178 certification
- Early verification and fixing of defects reduces cost

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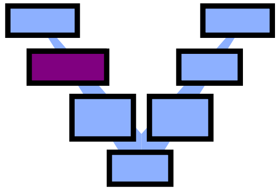
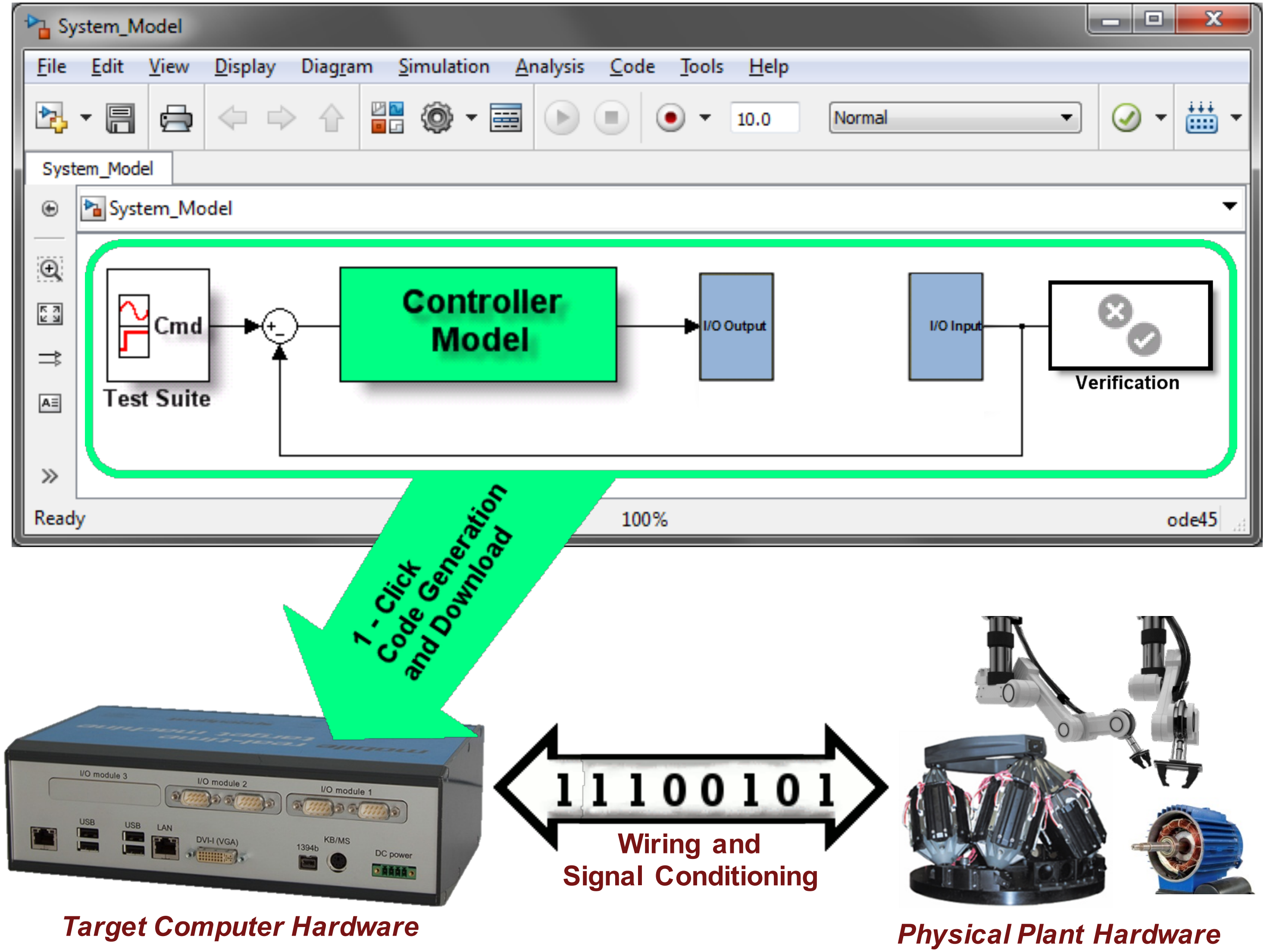
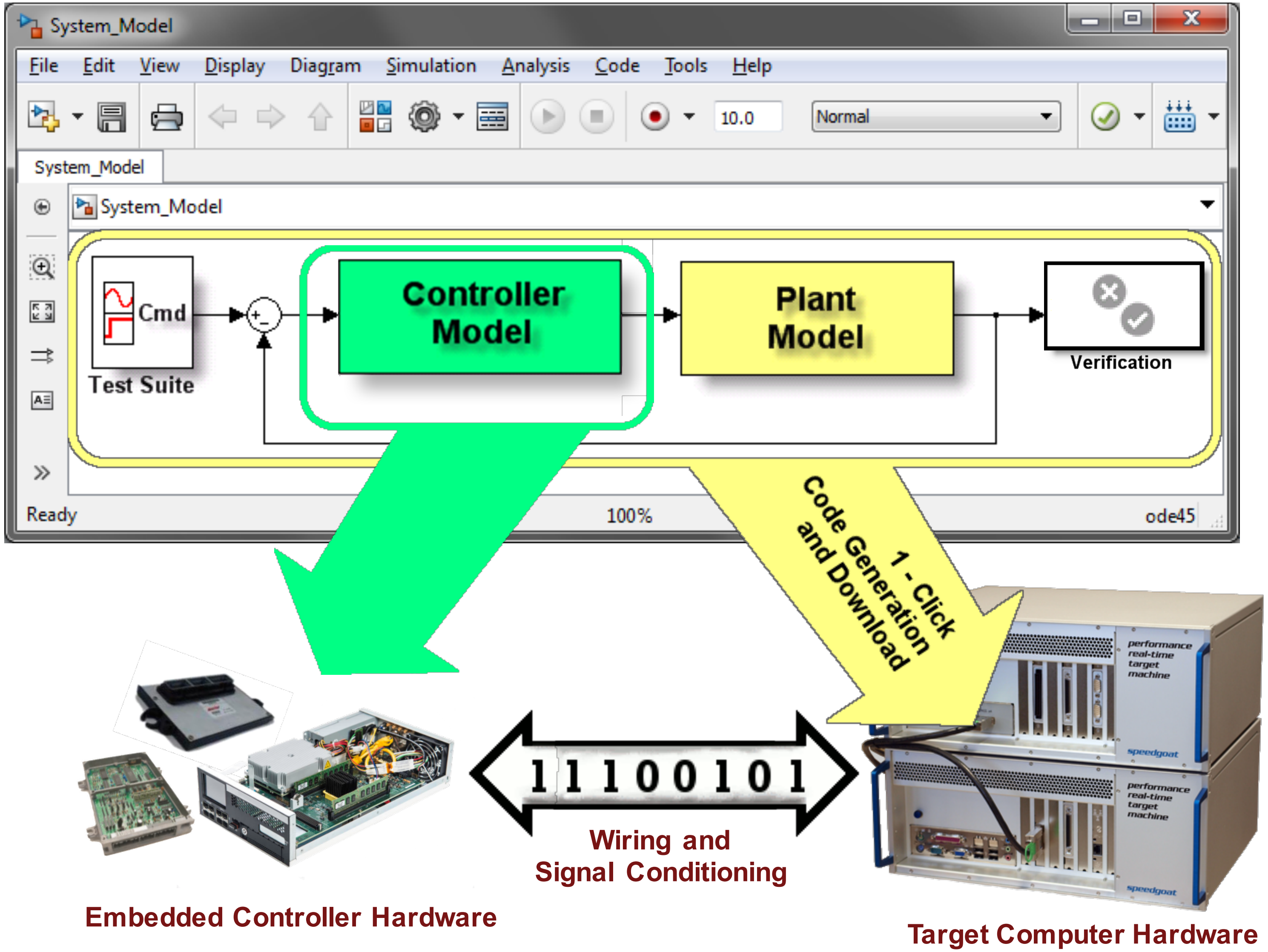
Real-Time Simulation and Testing Tasks:
Rapid Controls Prototyping



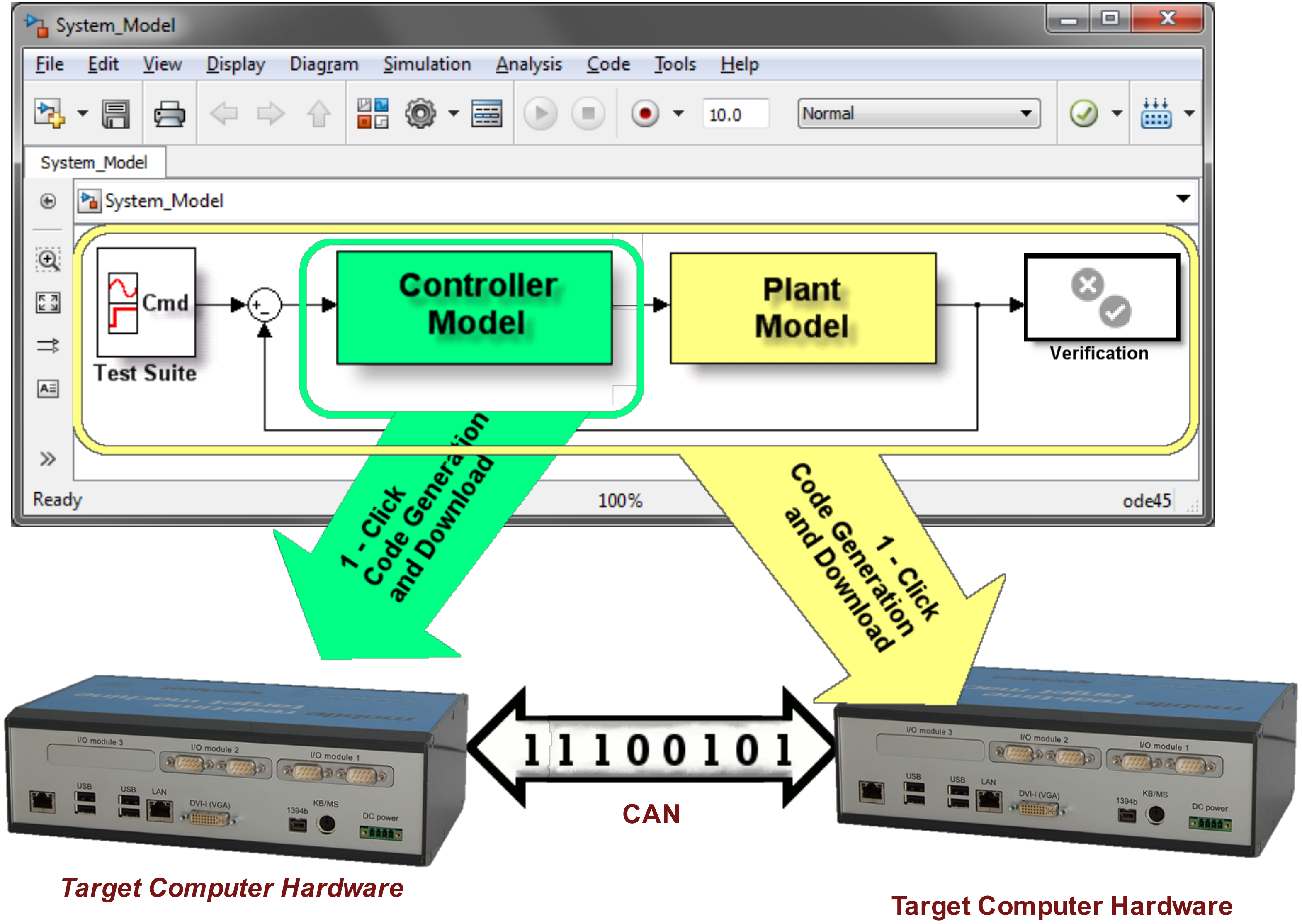


Real-Time Simulation and Testing Tasks:

Hardware-in-the-loop (HIL) Simulation

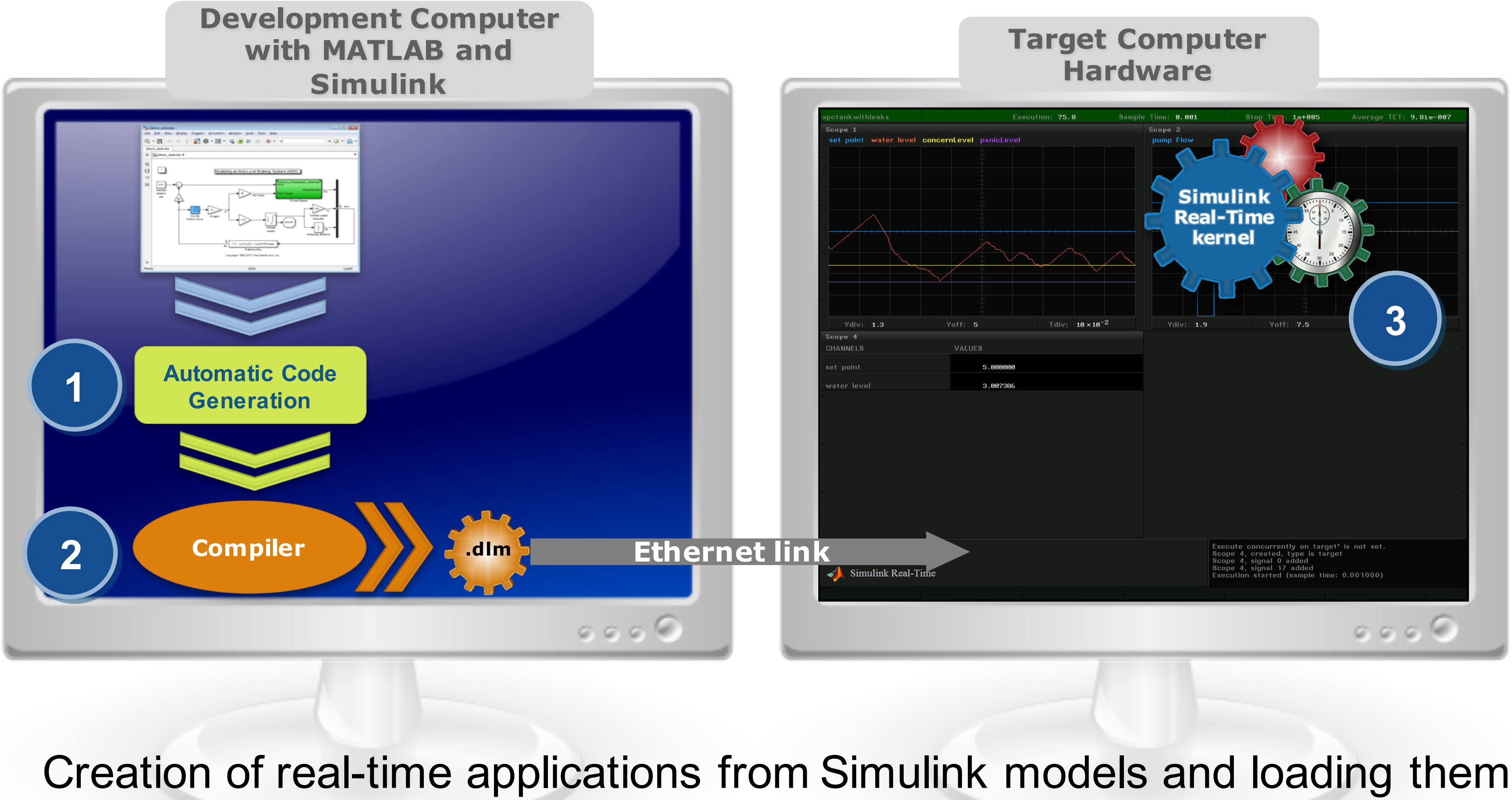


Today's Configuration



What is Simulink Real-Time?

From desktop simulation to real time

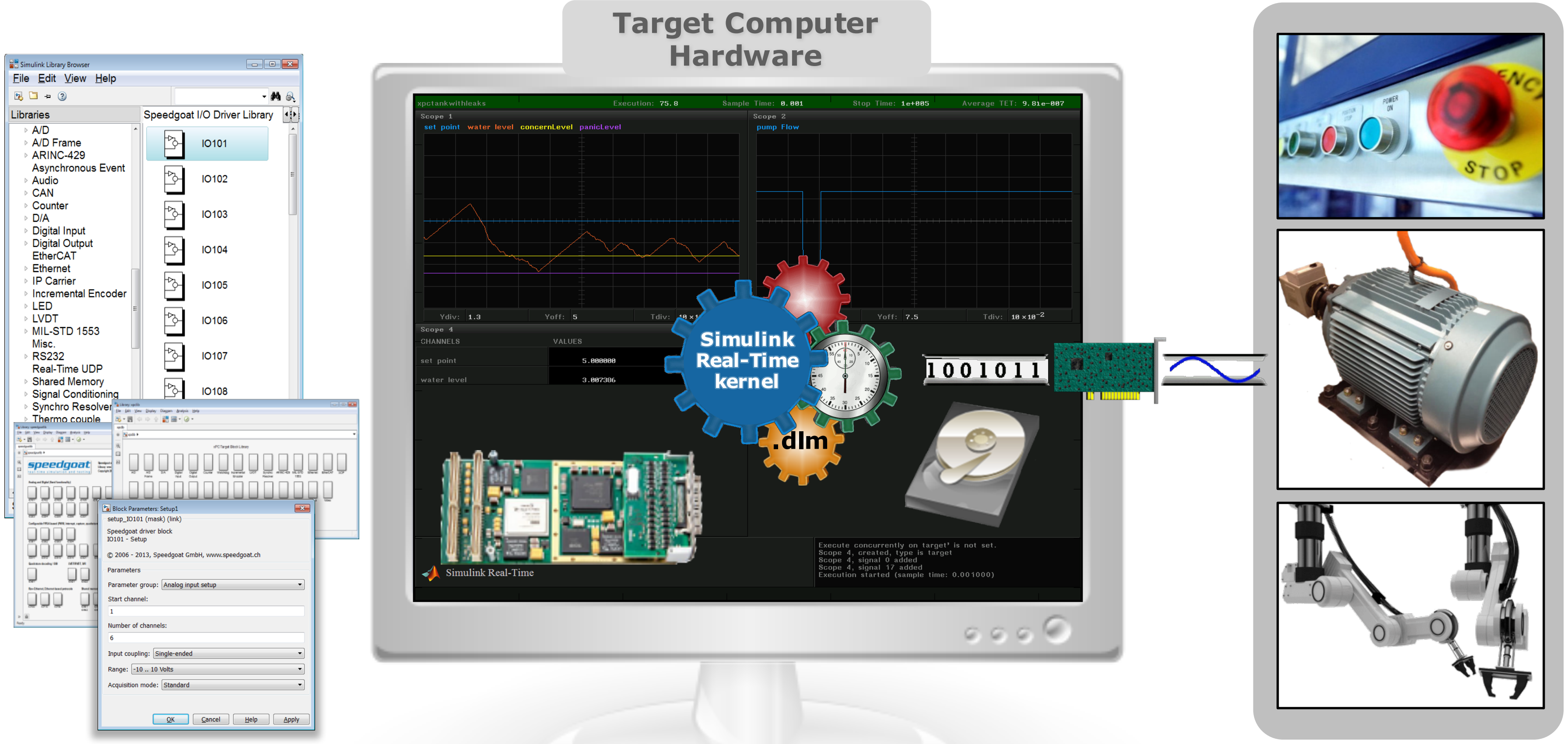


Creation of real-time applications from Simulink models and loading them onto dedicated target computer hardware in 3 automated steps:

1 Code Generation 2 Compile and Link 3 Download and Ready to Run

What is Simulink Real-Time?

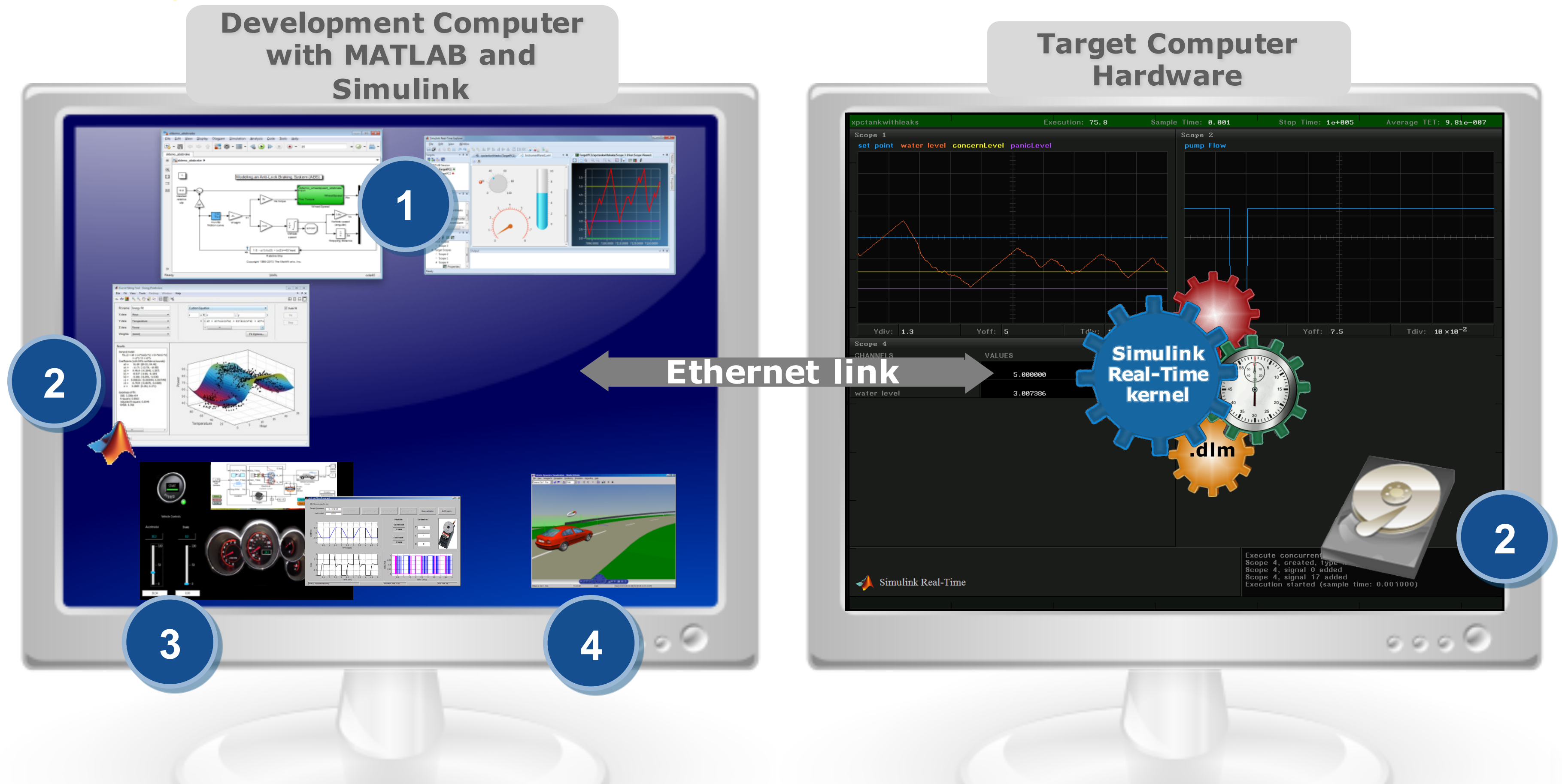
Connect to your physical system



- Support for a broad range of I/O types and communication protocols
- Easy drag and drop and configuration within a Simulink model

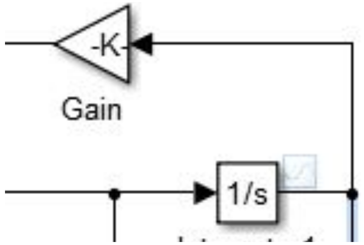
What is Simulink Real-Time?

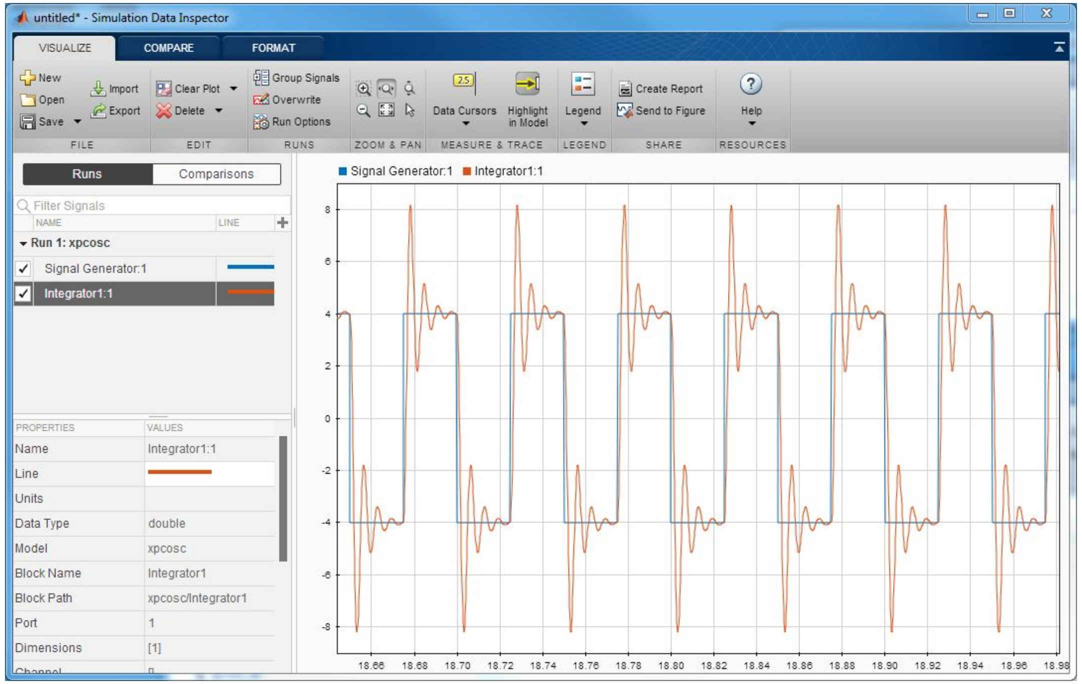
Extendable, integrated, and interactive



1. Live parameter tuning, signal monitoring, and execution control
2. Data logging for offline analysis in MATLAB
3. UI/HMI connectivity
4. Extensibility with other software tools (e.g. virtual reality)

Streaming to the Simulation Data Inspector



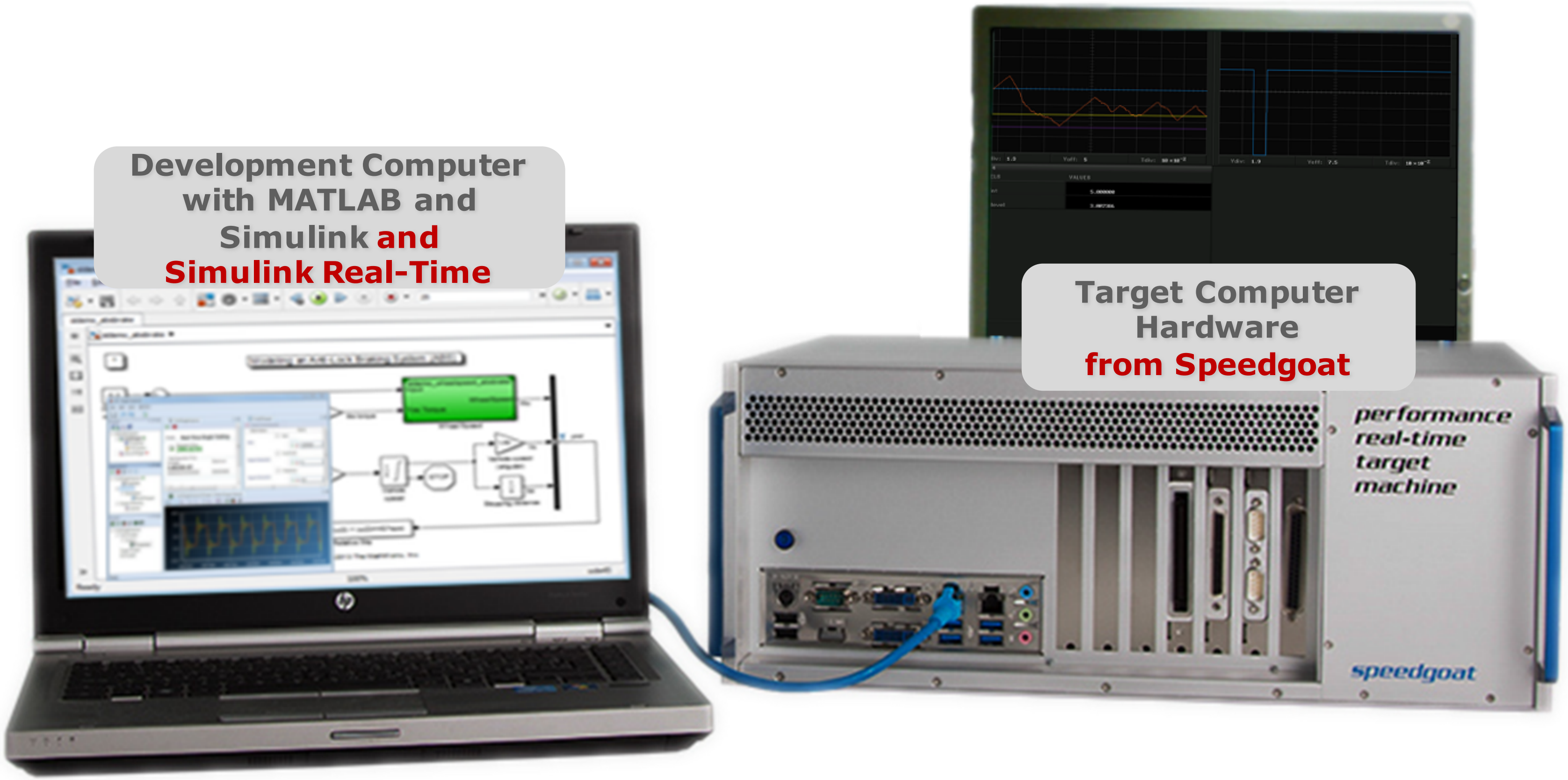


1. Select the signals to stream
2. Connect to the running target computer
3. Visualize in the Simulation Data Inspector

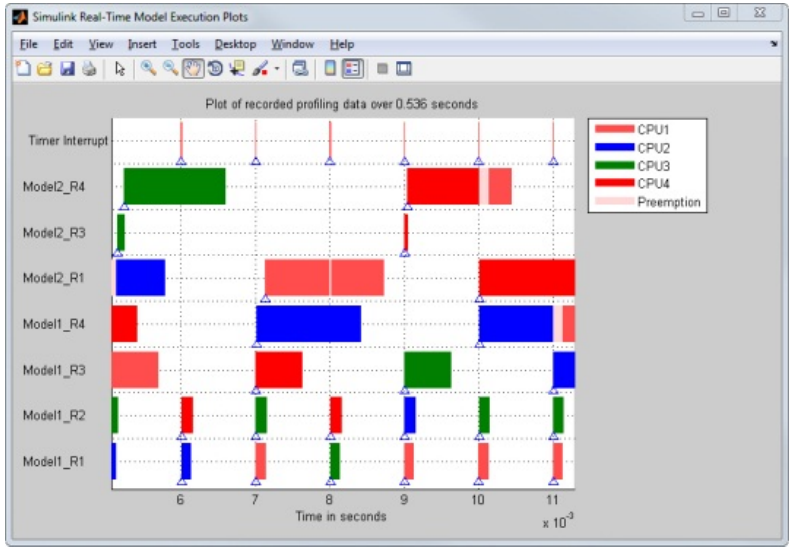
R2015b

What Hardware is used with Simulink Real-Time?

Development computer + target computer



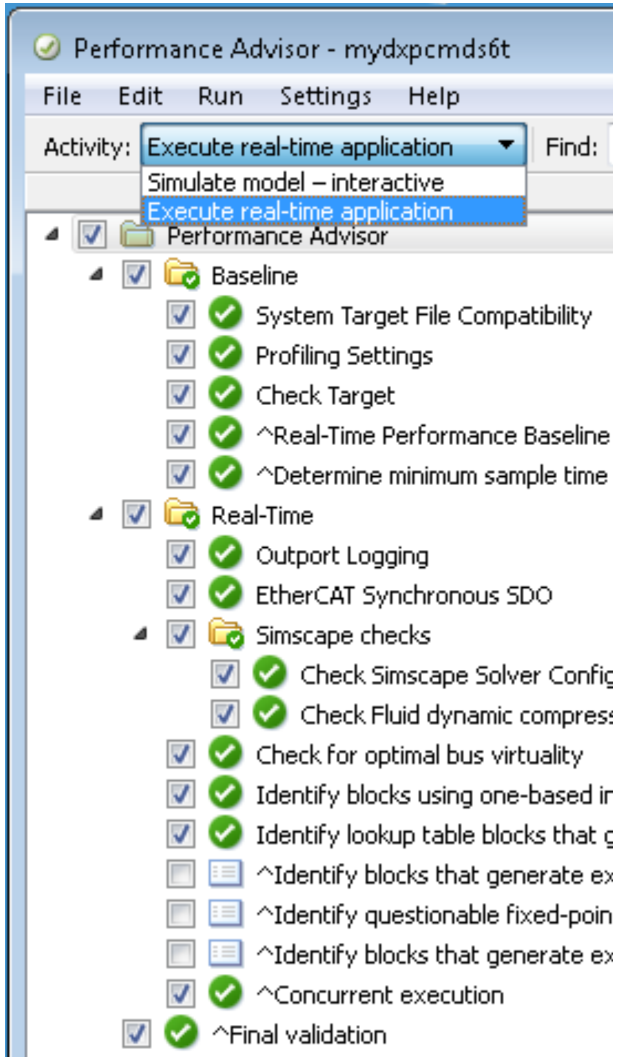
Current Performance Level



real-time
multi-core
scheduler

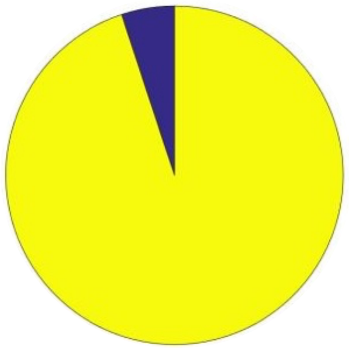
- 25 microsecond minimum sample time
- < 1 microsecond sample time with FPGA's
- High performance quad core Intel processors
- Expandable, low latency I/O

Performance Advisor for Real-Time Execution

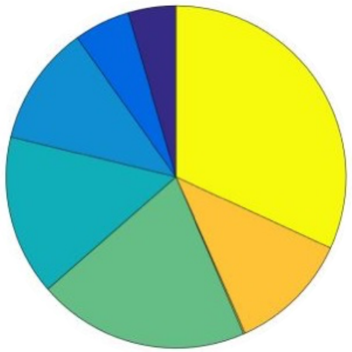


- Encodes best practices for transitioning to real-time
- Adds testing on the target computer.

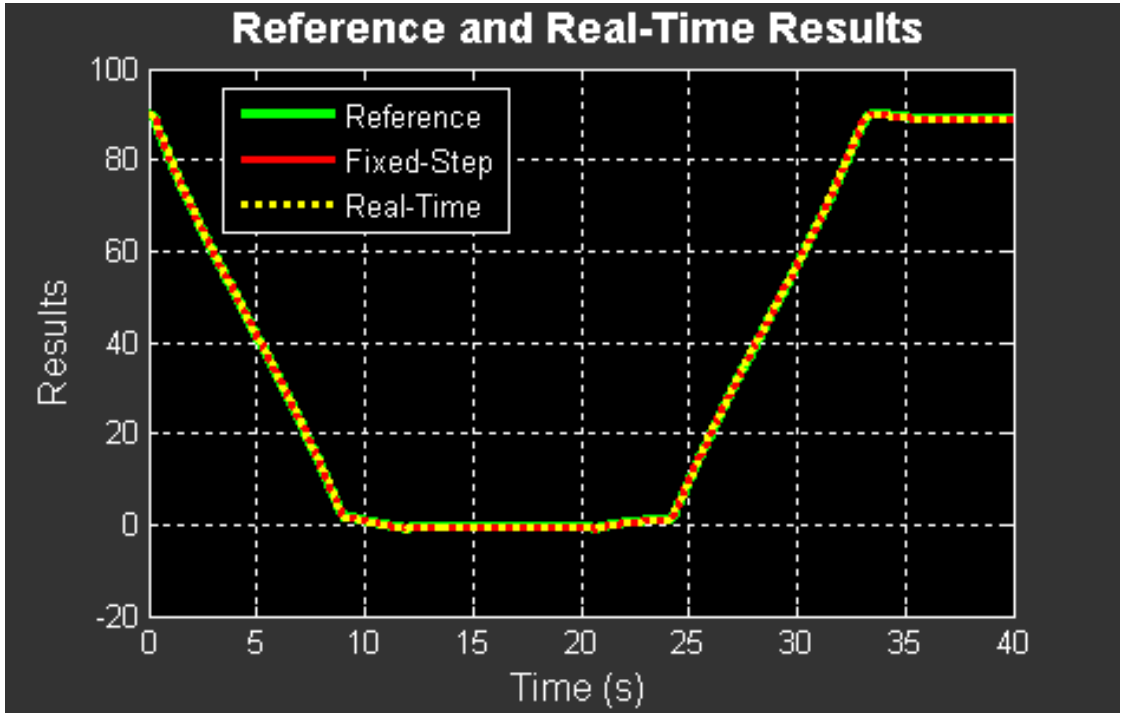
Before:
4000 µSec



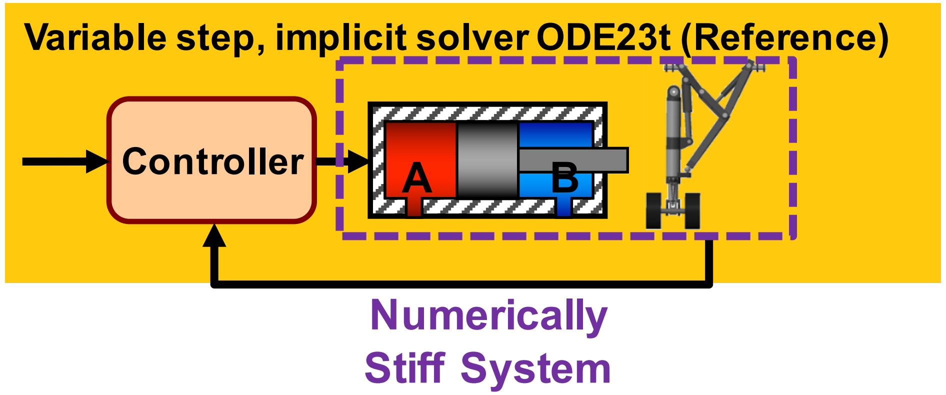
After:
300 µSec



Configuring Landing Gear Model for HIL Testing

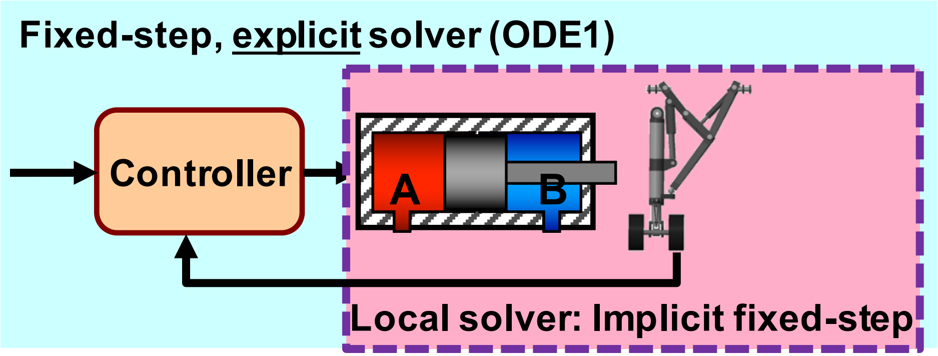


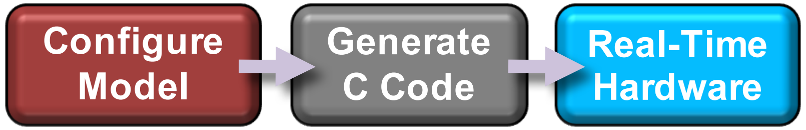
Model:



Problem: Configure solvers to minimize computations so the model can simulate in real time

Solution: Use local solvers on stiff physical networks and explicit solvers elsewhere





Agenda

- Production Code Generation
  - MathWorks' Code Generation Products
  - Embedded Coder
  - Equivalence Test with SIL and PIL
- Integration Test
  - What's Simulink Real-Time
  - Automation of Real-Time Testing

Let's remind Simulink Test….

Tool for authoring, managing, and executing simulation-based tests

Test Harness

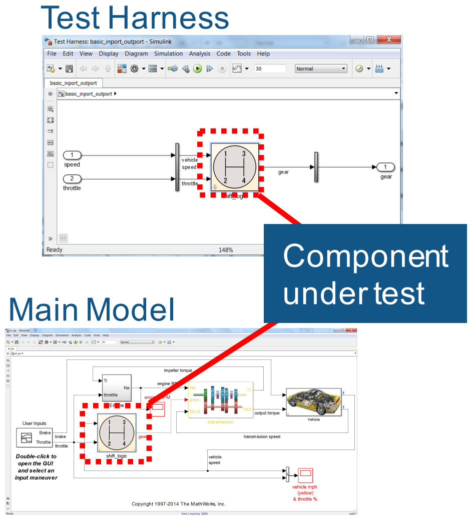
Embedded canvas for isolation testing of components

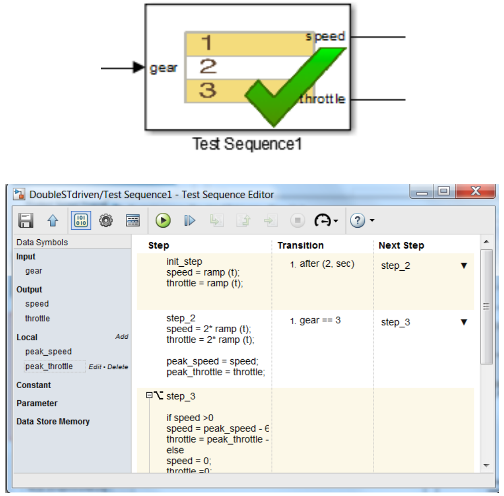
Test Sequence

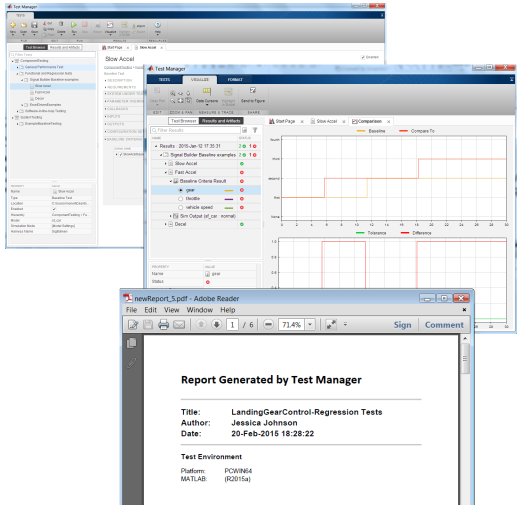
Easily express logic-based tests

Test Manager

Systematic authoring and management of test cases

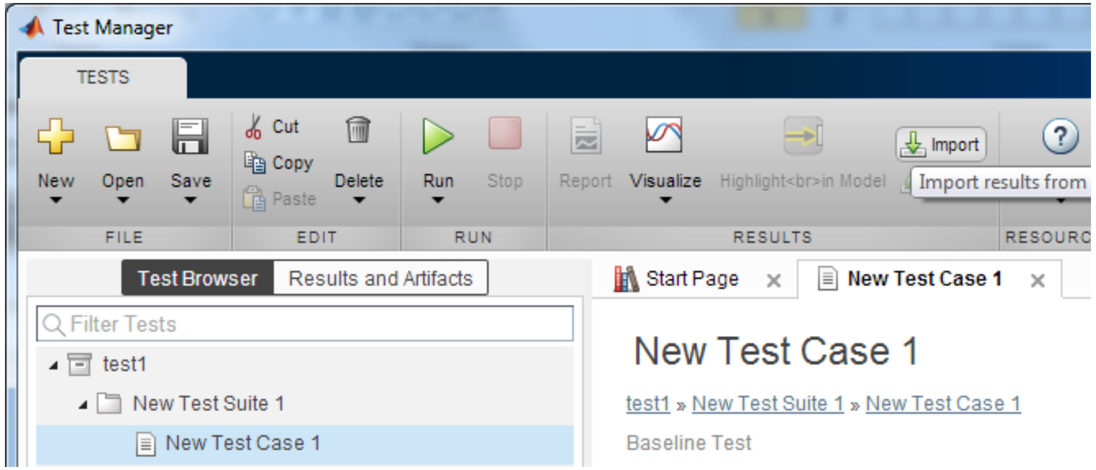


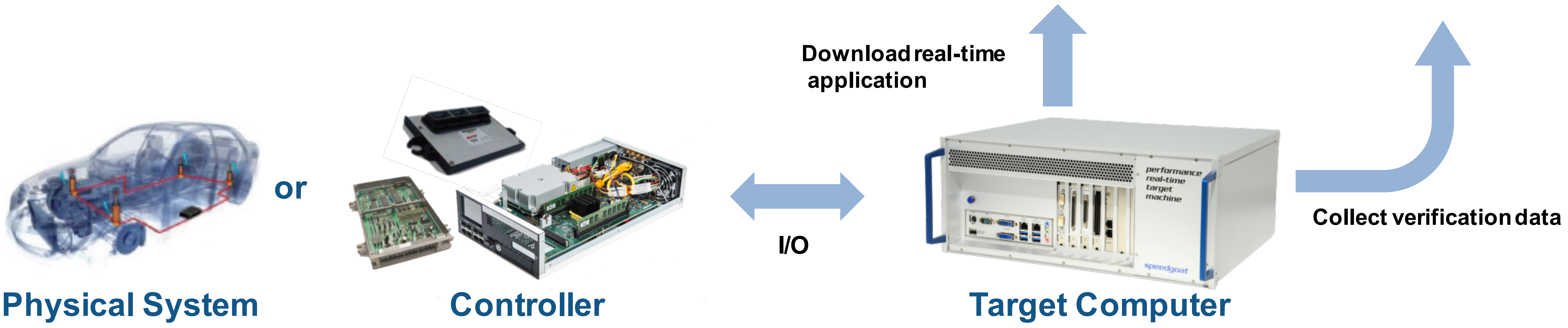




Test Automation with Simulink Test

- Available to verify algorithm in real-time
  - Reusing Test Harness and Test Sequence in Simulink Test
  - Avoiding multiple build/download to target
  - Avoiding additional programing to access test results



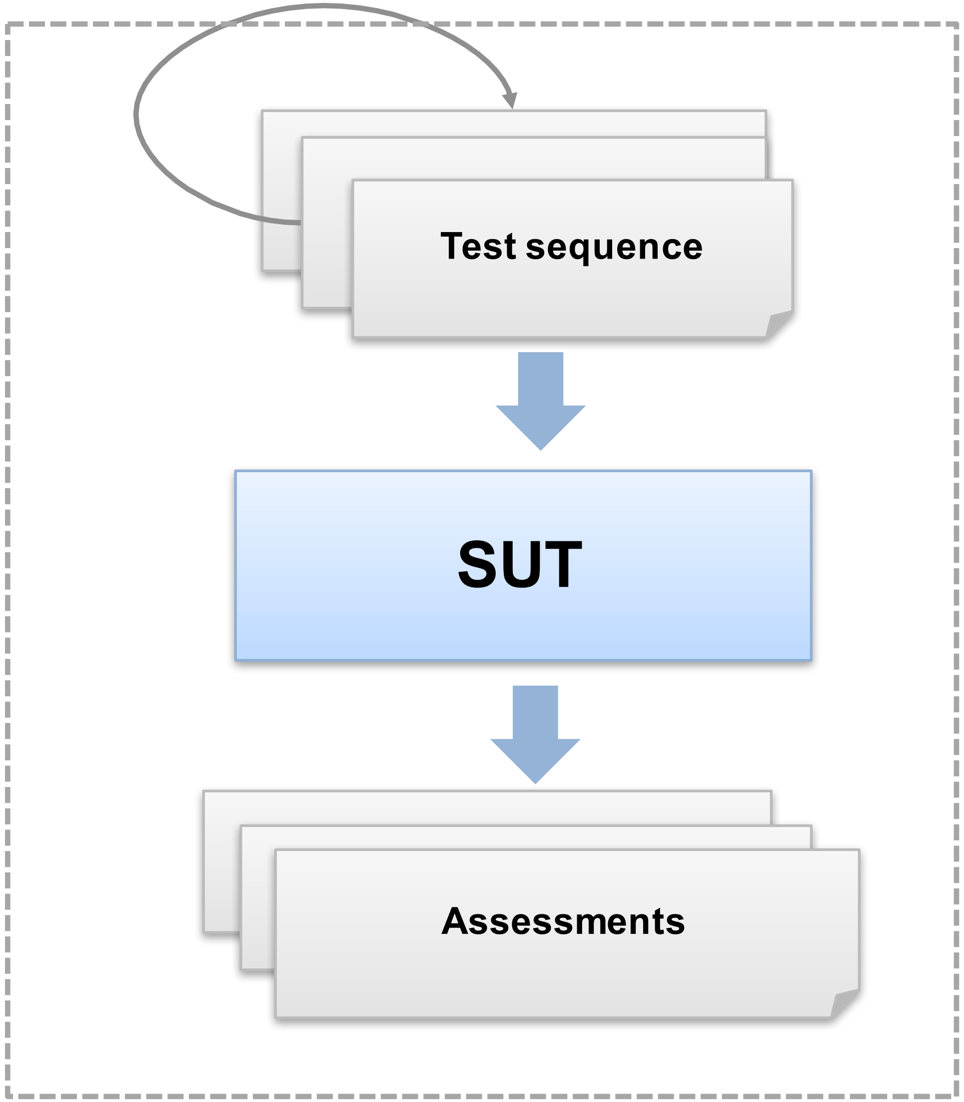


Key Design Principles

- Use Test Sequence Block for Assessments
  - Evaluated in real-time on target
  - Non-fatal verification language
    - Failure does not stop execution
  - Language constructs for fault recovery
    - Prevent hardware damage

- Runtime variants
  - Avoid multiple build/download to target

- Rapid Iterations
  - Over runtime variants on target hardware



Summary

- Production Code Generation
  - You can get a code for production without human error.
  - Embedded Coder provides “Quick Start” for beginner to try code generation easily.

- Real-Time Testing
  - You can get many benefits with real-time testing
    - Reduce hardware testing
    - Avoid breaking expensive equipment
    - Improve product quality
  - You can do real-time testing in one environment with Simulink.
  - For real-time testing, you can reuse all test cases developed to verify models.