NIDays09

WORLDWIDE GRAPHICAL SYSTEM DESIGN

CONFERENCE

NATIONAL INSTRUMENTS

How to Test Embedded Control Systems using Dynamic Test Methods

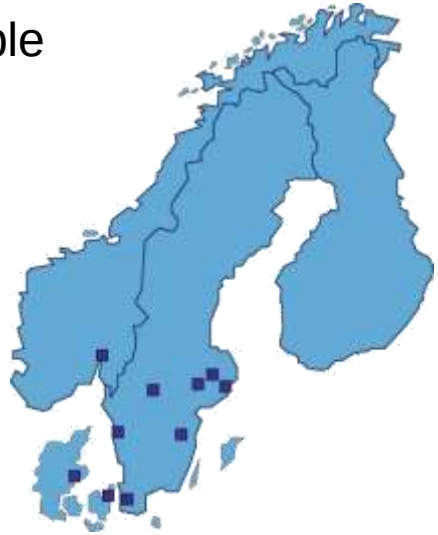
National Instruments and Prevas

Introduction of Prevas

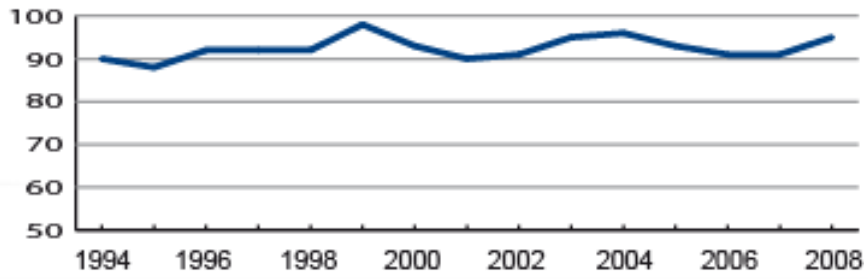
Prevas delivers what's promised

- Founded in 1985, >20 years experience of delivering profitable solutions to clients.
- Approximately 550 employees
- Listed on the Stockholm Stock Exchange since 1998.

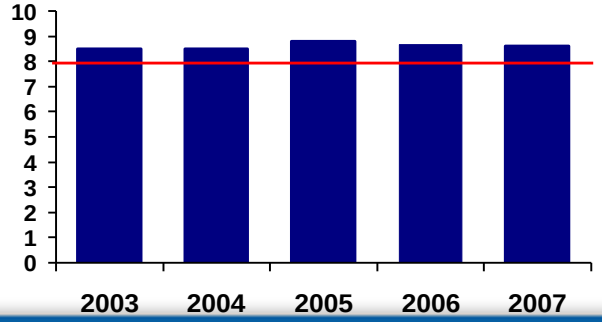
- Certified according to ISO 9001:2000. Using well documented and tested project and development models.



Reliability of delivery



Customer satisfaction



Prevas

History of designing Test Systems

HASSELBLAD

VOLVO AERO

ERICSSON

VOLVO

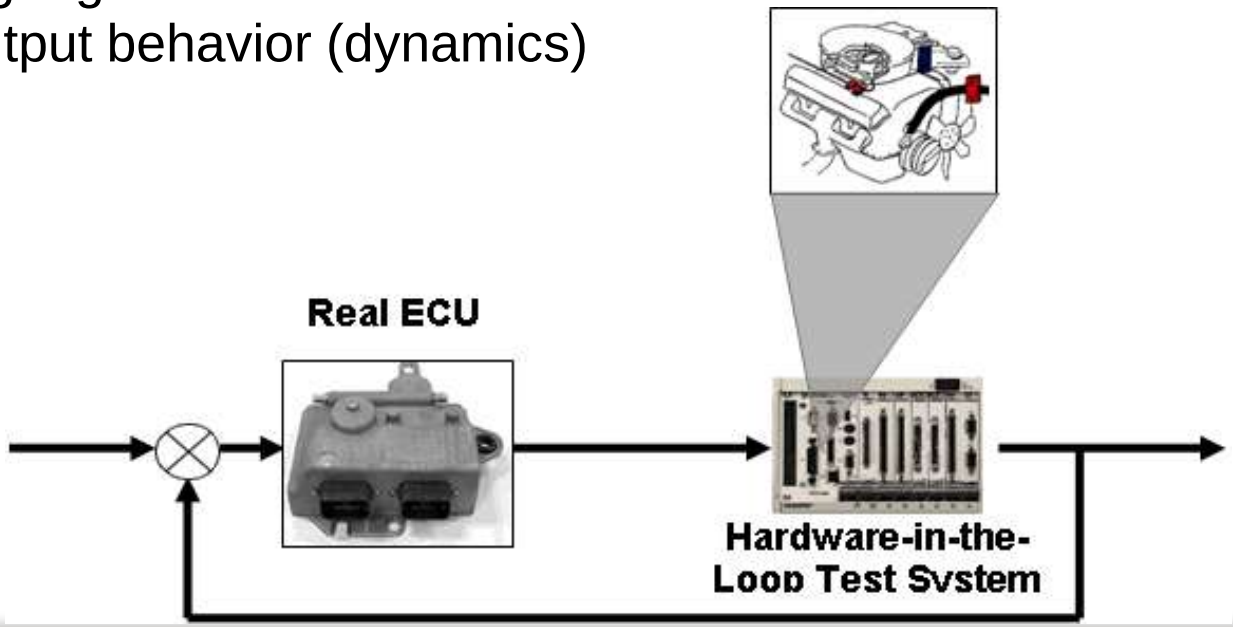
VOLVO PENTA

Ford

1994 — 2008

What is Hardware-in-the-Loop (HIL) testing?

- The use of real-time I/O hardware to simulate the dynamic behavior of a device that interfaces to the unit under test.
- The simulator may use programming languages, state charts, modeling languages or other methods to describe the input/output behavior (dynamics) of the device



Prevas

Case Study; HIL , Automotive

HIL test system for driveline (Engine and gearbox)

Main challenge:

- System shall be able to emulate all sensors and actuators normally connected to the ECUs
- System shall be able to generate all bus traffic normally flowing in a vehicle
- System shall be capable of running dynamic models simulating the behavior of the engine and gearbox as well as the rest of the vehicle and its environment

Solution in brief:

- Hardware built in a 19” rack based on xMove and PXI.
- The two ECU’s have in total about 300 pins connected to the HIL system, with complete fault injection on each pin.
- Custom sensor signals generated by software in the FPGA.
- All electrical loads are put in a separate load box for easy reconfiguration.

Main benefits:

Turn-key system delivery of an open architecture HIL-system, with excellent cost / performance ratio, expected lifetime and flexibility

Prevas

Case Study; HIL, Aerospace

Dynamic test system (**HIL**) for the Full Authority Digital Engine Control (FADEC) used in the Swedish JAS-39 Gripen Fighter Aircraft

Main challenge:

- Development of a real-time simulator test system to be used for developing and testing the FADEC-units for the Swedish jet fighter JAS-39 Gripen.
- The engine model should be executed faster than with the previous system in order to increase the accuracy of the engine simulation.

Solution in brief:

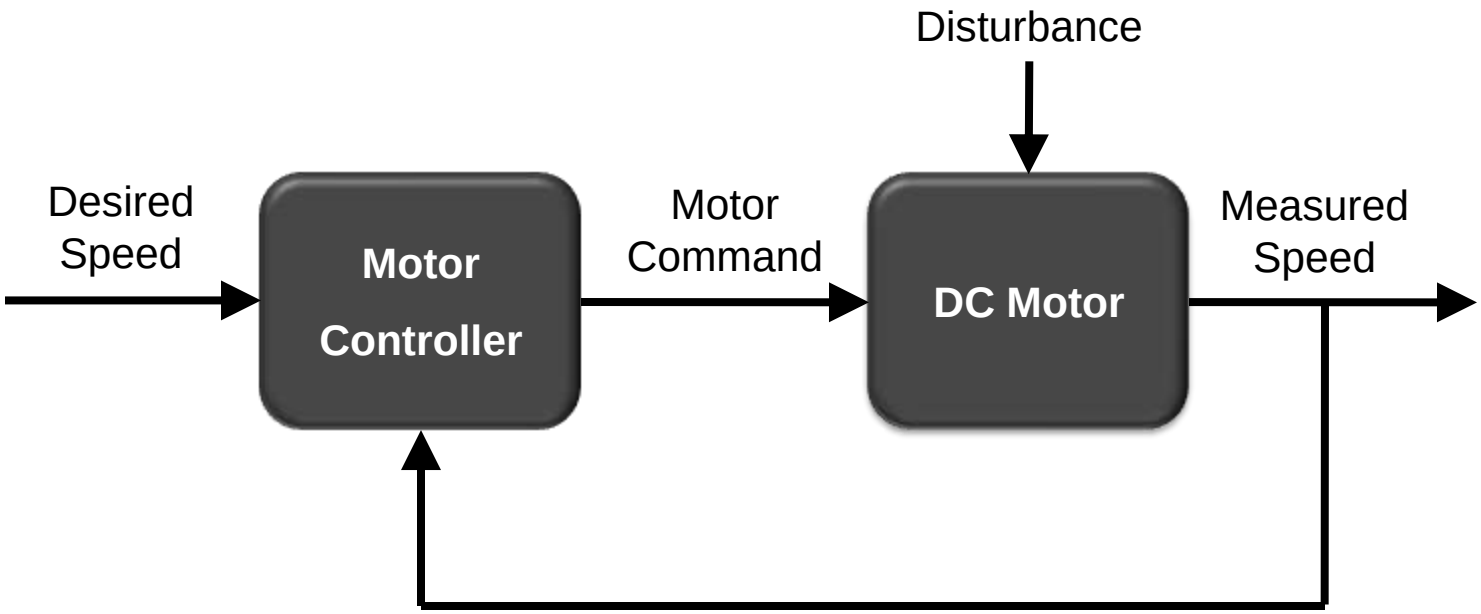
- Hardware build upon PXI with boards for the electrical I/O simulation and a large external GPIB controlled AC Power Source. Complex I/O signals were simulated using programmable FPGA PXI boards.
- All software in the system is developed using the graphical application development environment LabVIEW.

Main benefits:

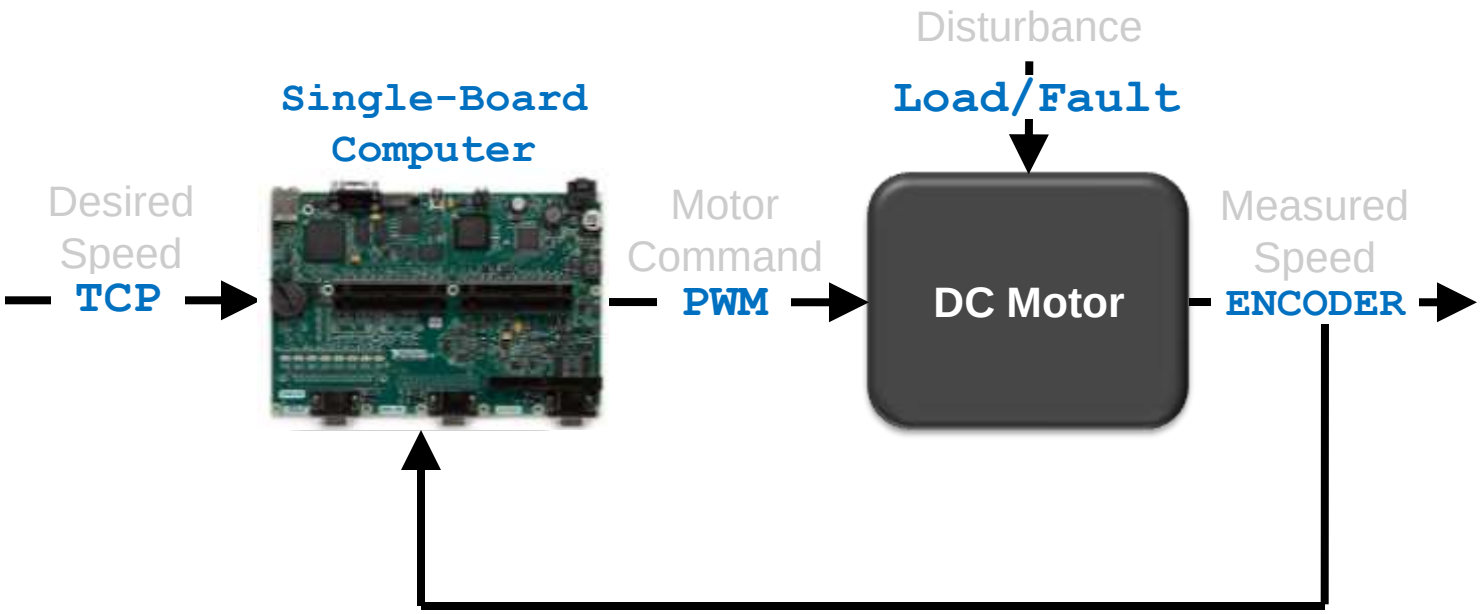
Turn-key system based upon industrial off-the-shelf components, with excellent cost / performance ratio, expected lifetime and flexibility.

Control Systems

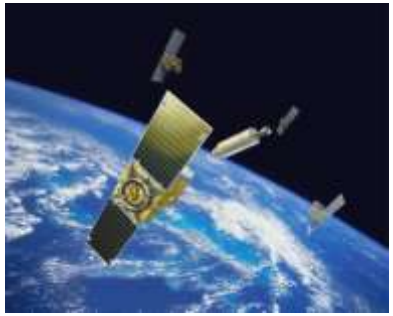
Closed-Loop Control



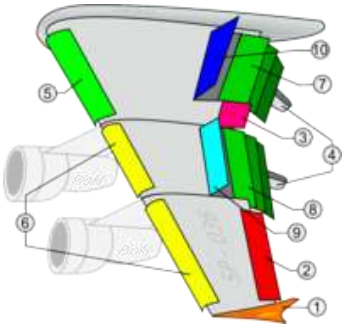
DEMO – Closed-Loop Control System



Closed-Loop Control



Navigation Control



Flight Control

Engine Control

Steam Turbine Control

Dryer Cycle Control

Print Head Control

Medical Device Control

Embedded Control System Challenges

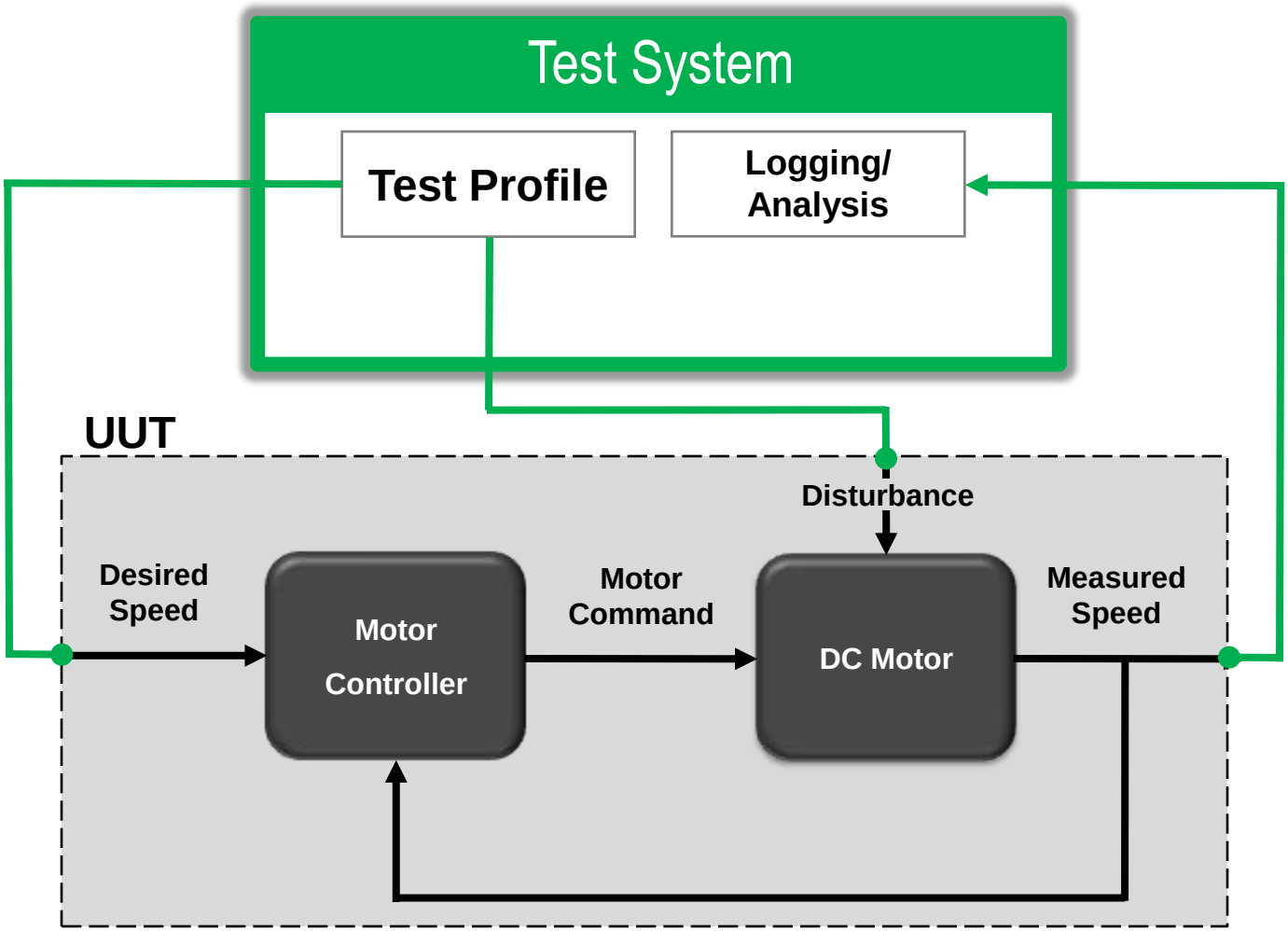
- Increasing application complexity
- Increasing reliability requirements

- Decreasing time to market
- Reducing development cost

Are these mutually exclusive?

Testing Embedded Control Systems

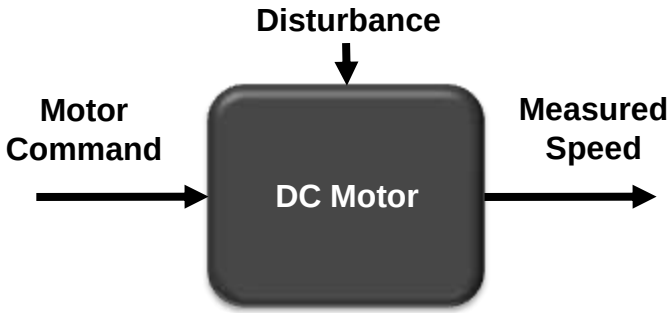
System Level Testing



Testing Embedded Control Systems

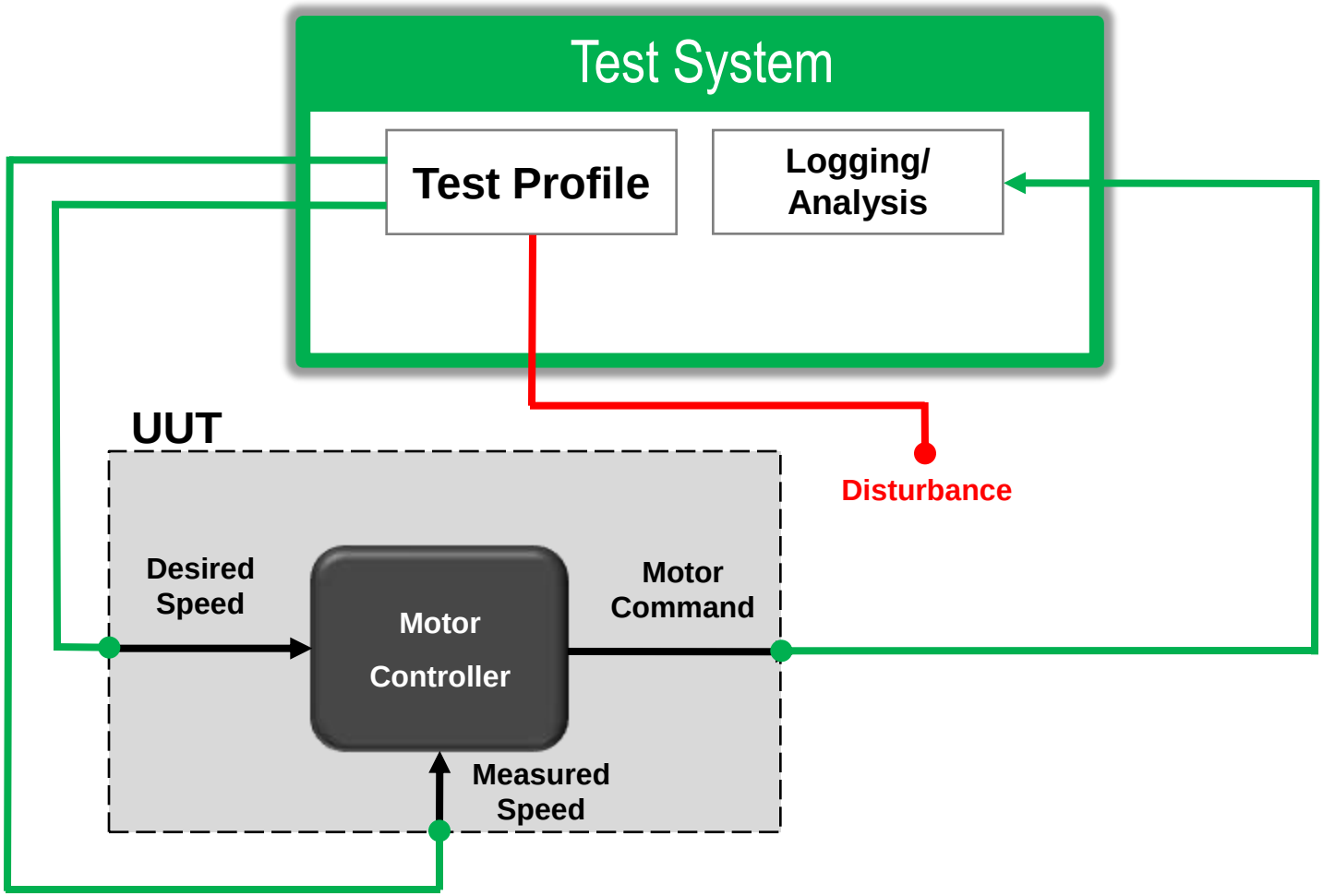
System Level Testing

- What if the "*DC Motor*" is **not available** yet?
- What if test failures could **damage** the *"DC Motor"*?
- What if the *"DC Motor"* is very **expensive** (capital, maintenance, operation, facilities)?
- What if *"DC Motor"* conditions are not **repeatable**?
- What if there are numerous *"DC Motor"* **variations**?



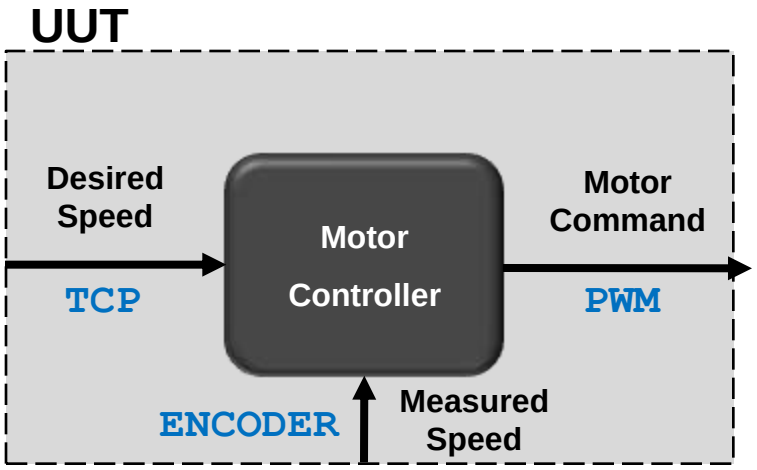
Testing Embedded Control Systems

Component Level Testing



Virtual Reality for Your UUT

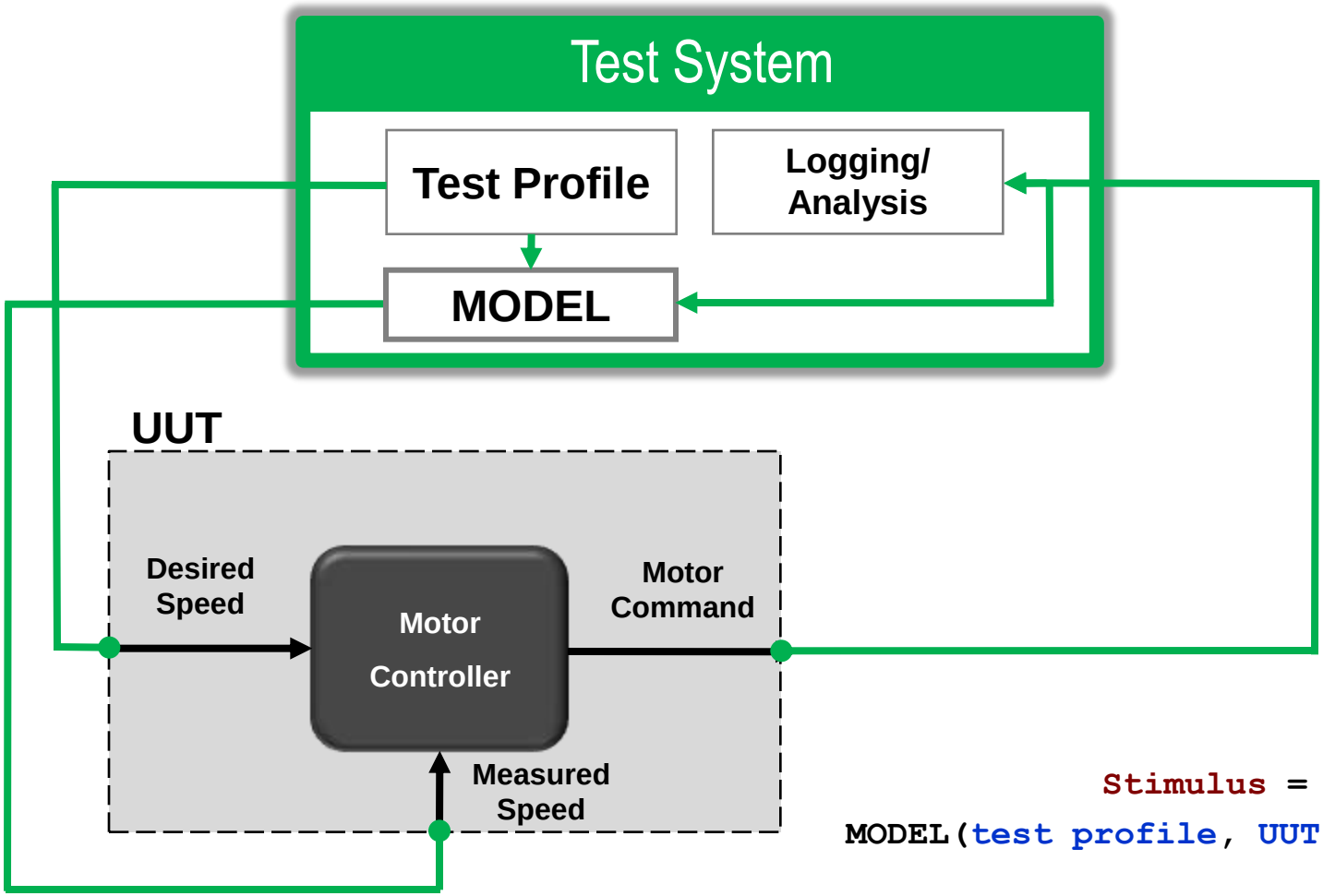
What does your UUT *know* about the world around it?



- Voltage
- Current
- Impedance
- Timing

Testing Embedded Control Systems

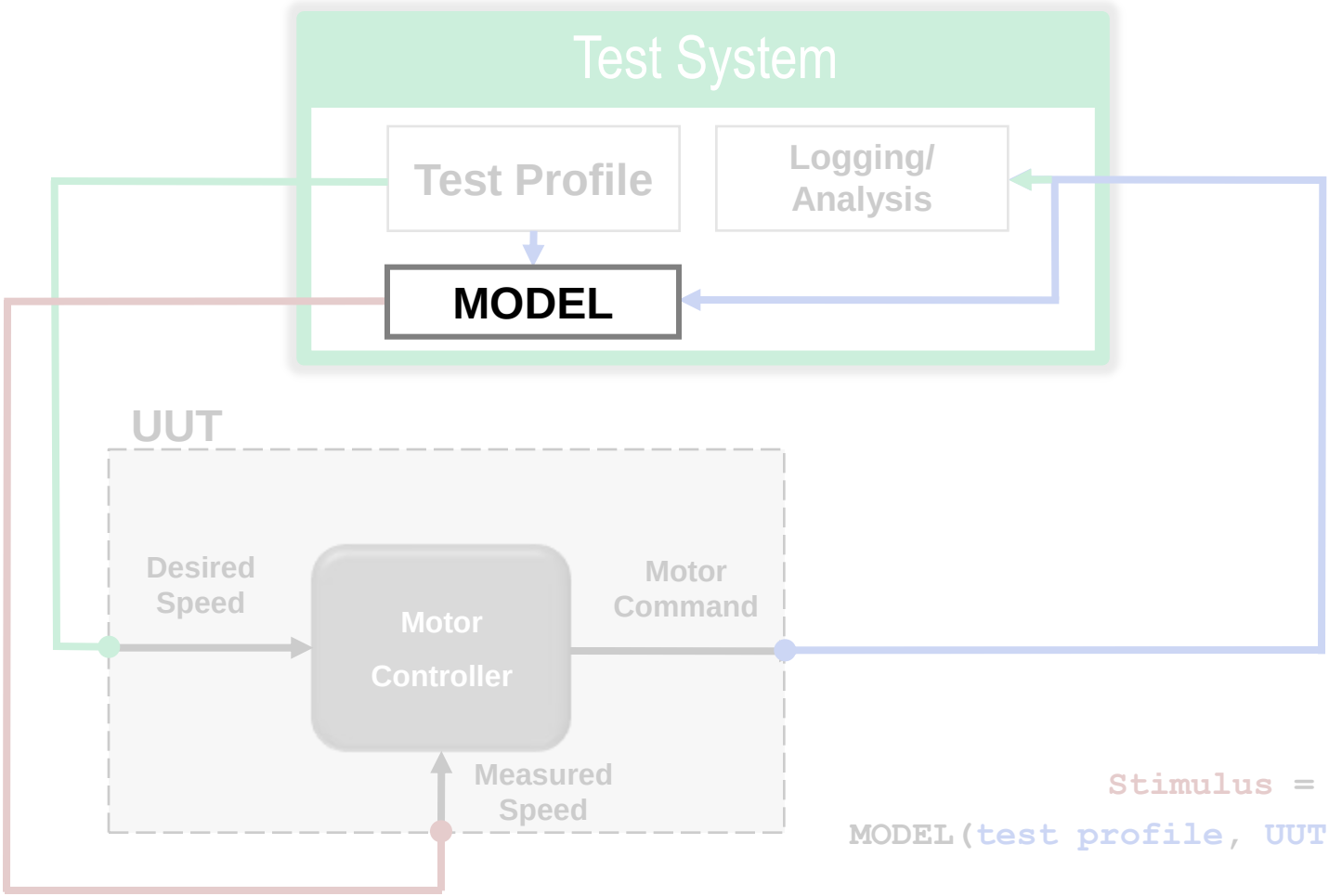
Virtual System Level Testing




```
Stimulus =
MODEL(test profile, UUT response)
```

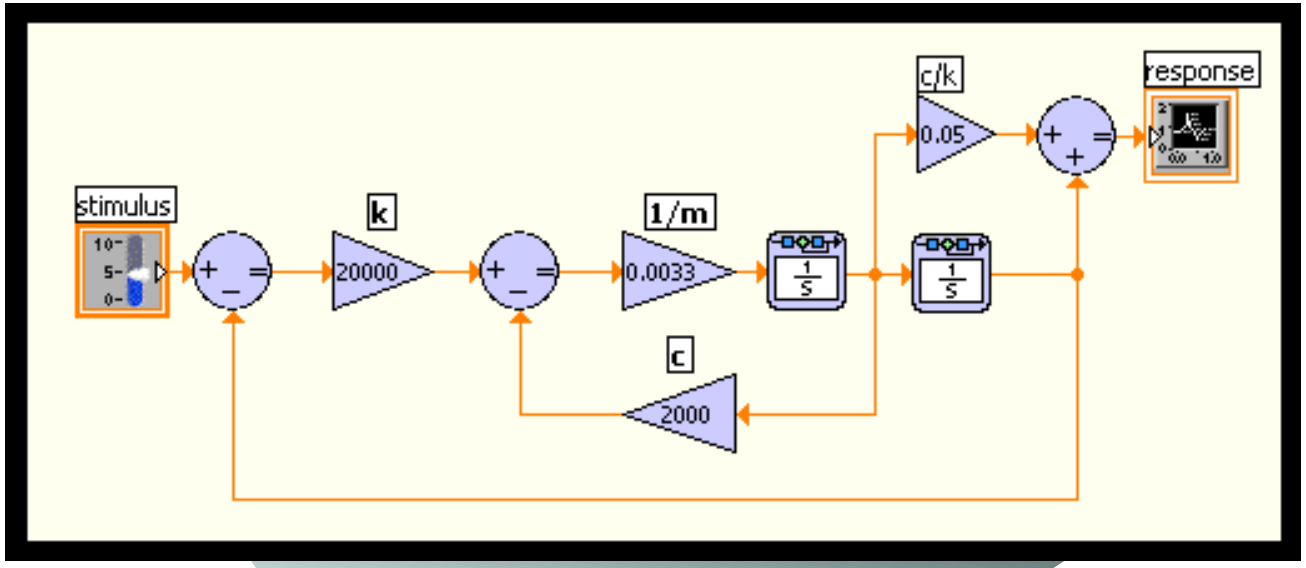
Testing Embedded Control Systems

Virtual System Level Testing

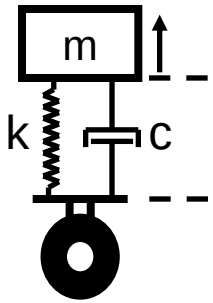



```
Stimulus =
MODEL(test profile, UUT response)
```

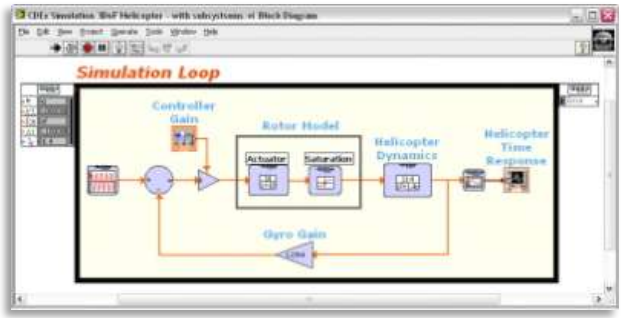
What Is a Model?



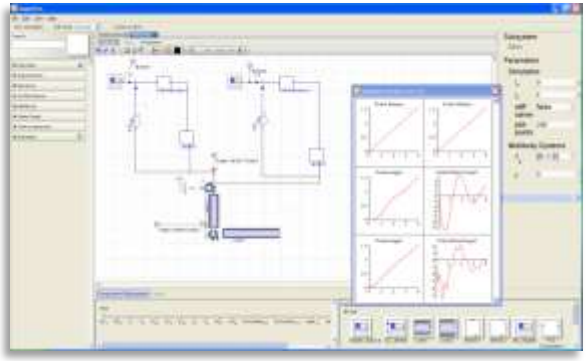
$$\frac{cs + k}{ms^2 + cs + k}$$



Dynamic System Models

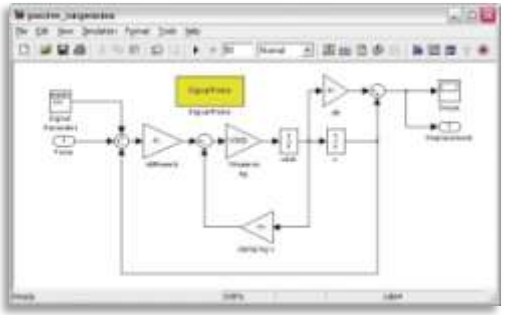


NI LabVIEW

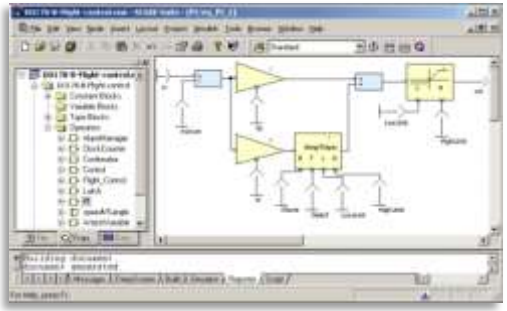


Maplesoft MapleSim

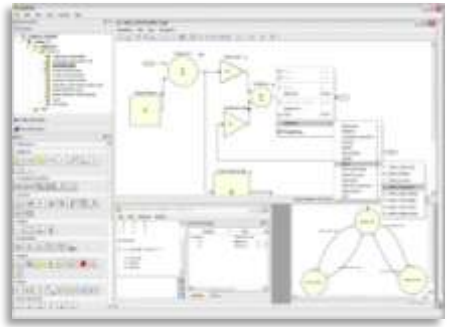
ANSI C



The MathWorks, Inc. Simulink® Software

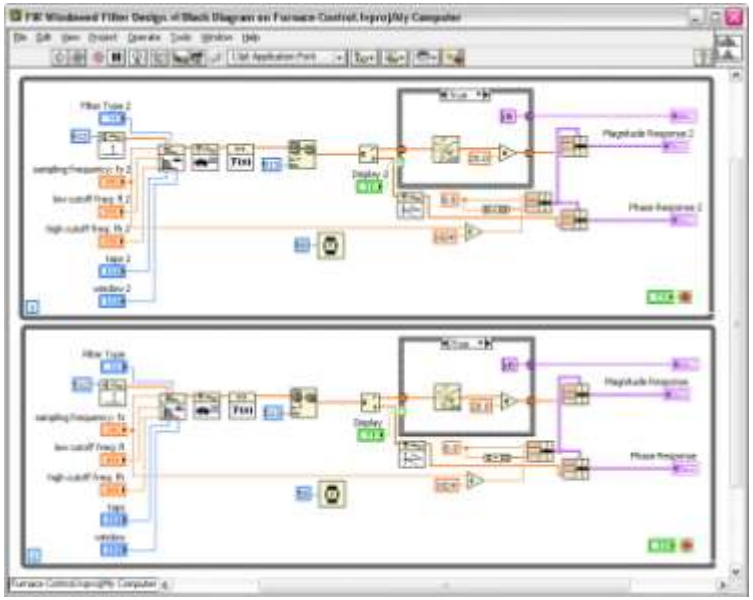


Esterel SCADE

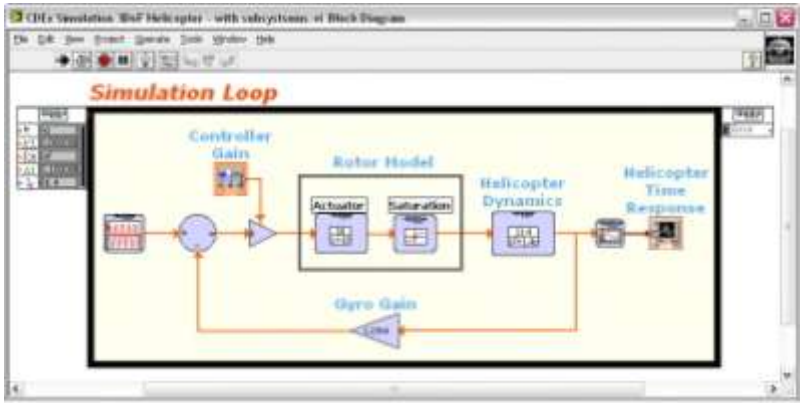


NI MATRIXx SystemBuild

Create Model Based on System Knowledge



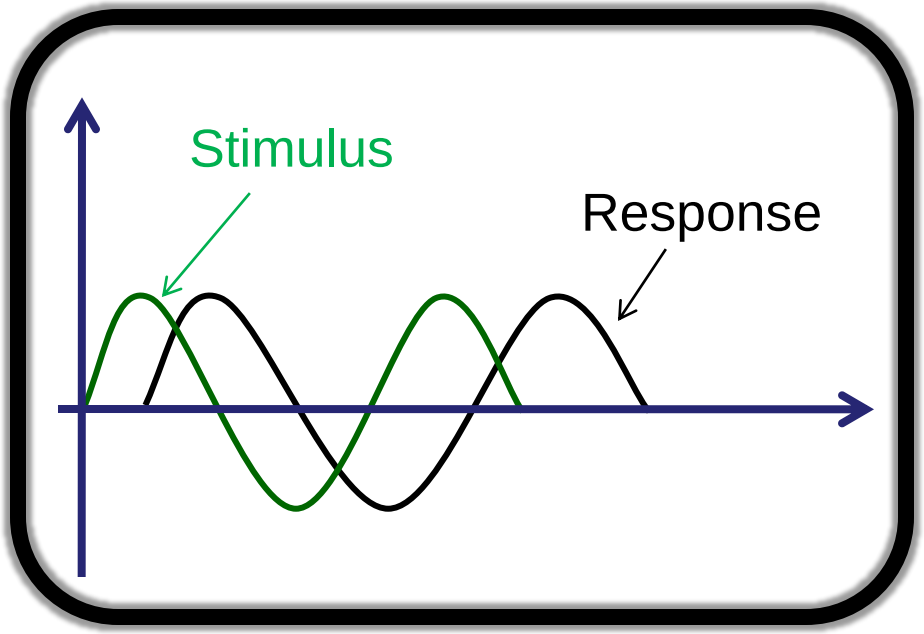
LabVIEW

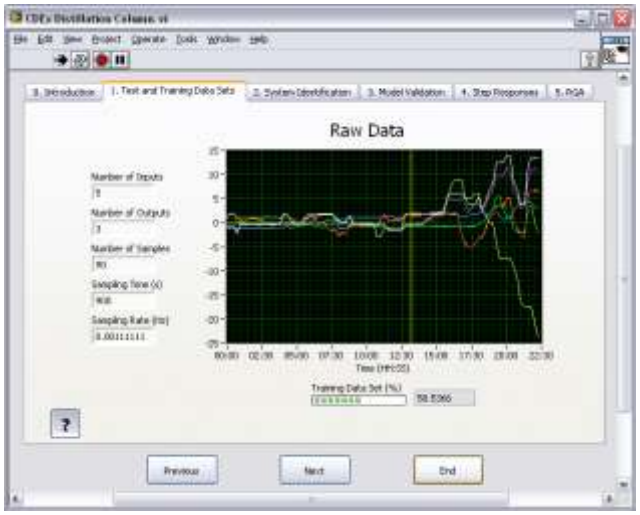


LabVIEW Control Design and Simulation Module

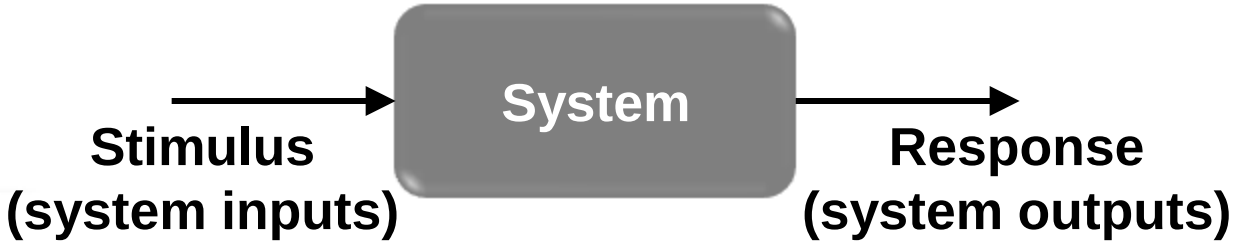
NI LabWindows™/CVI Software

Automatic Model Generation

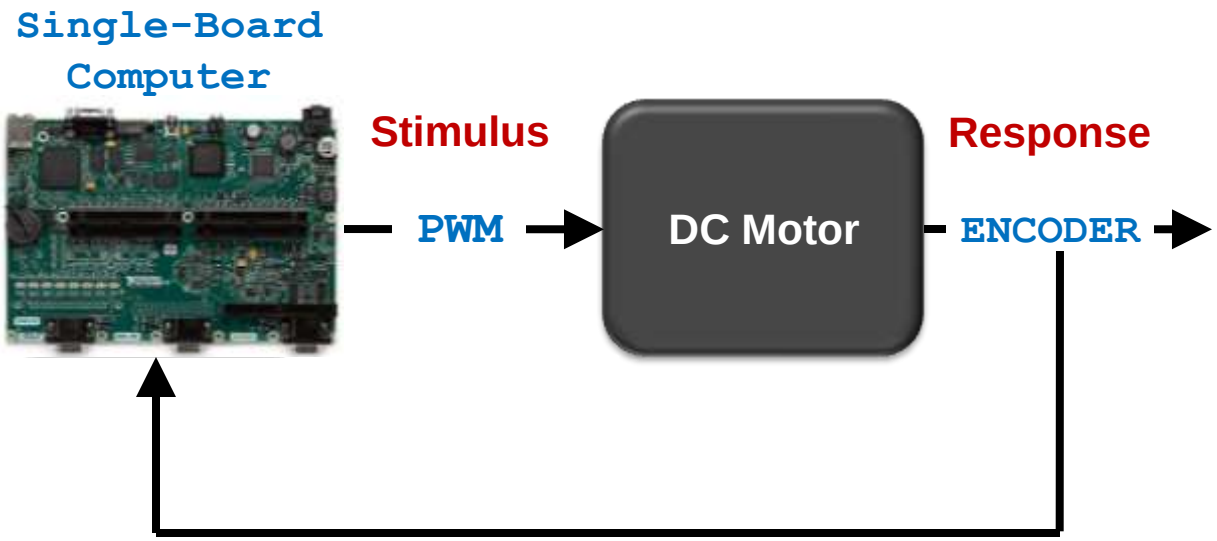




LabVIEW System Identification Toolkit

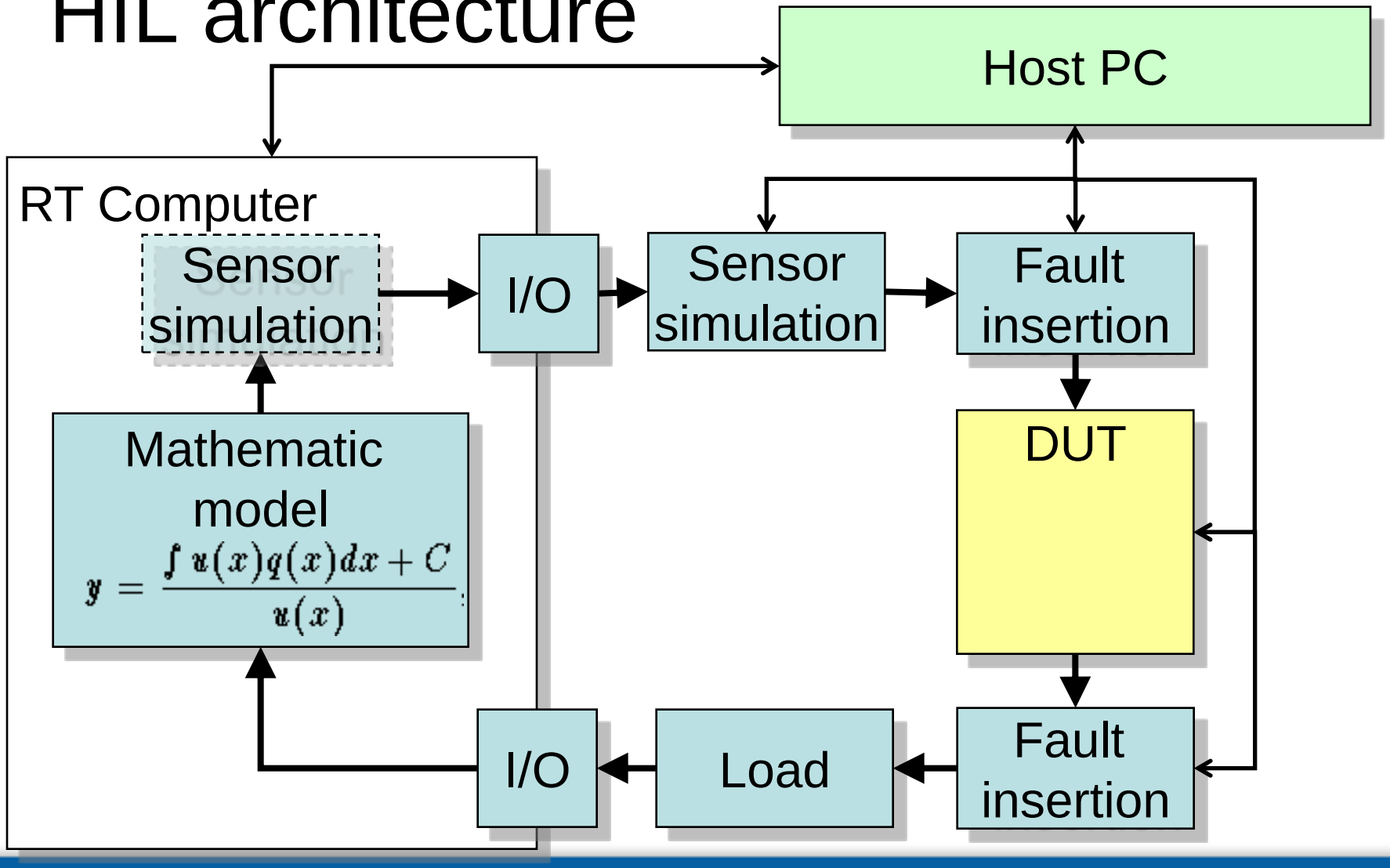


DEMO – System Identification



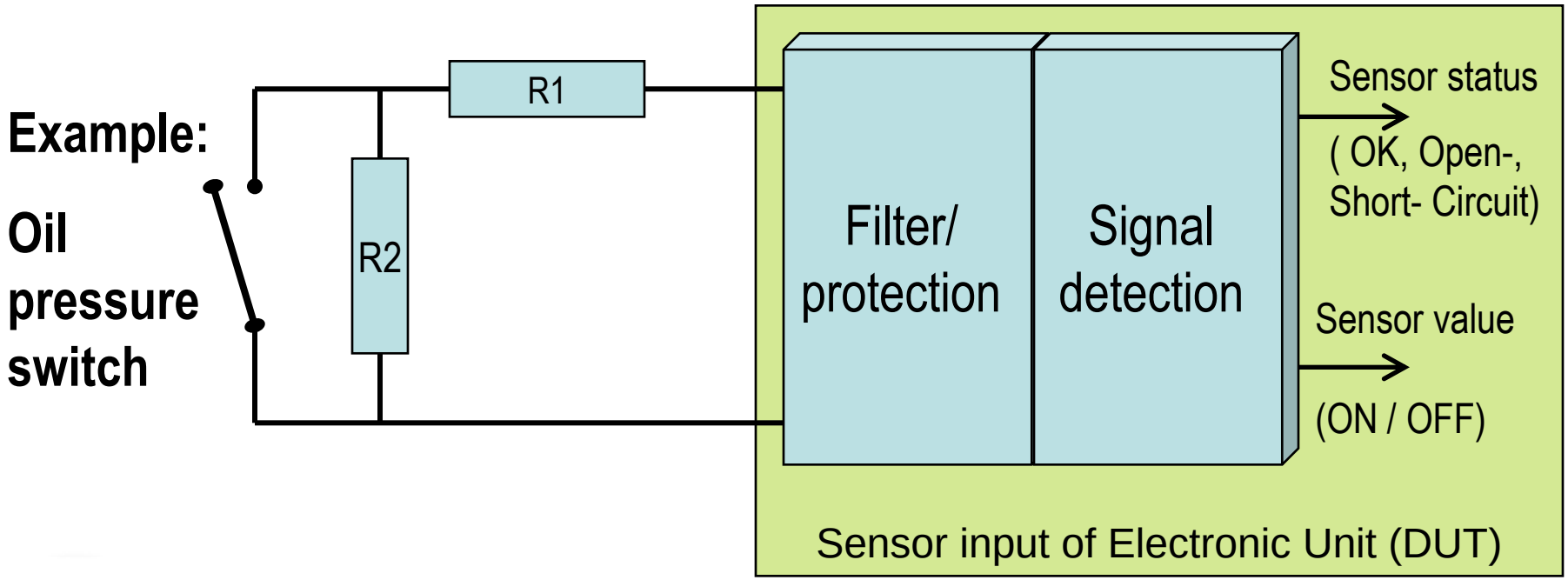
Prevas

HIL architecture



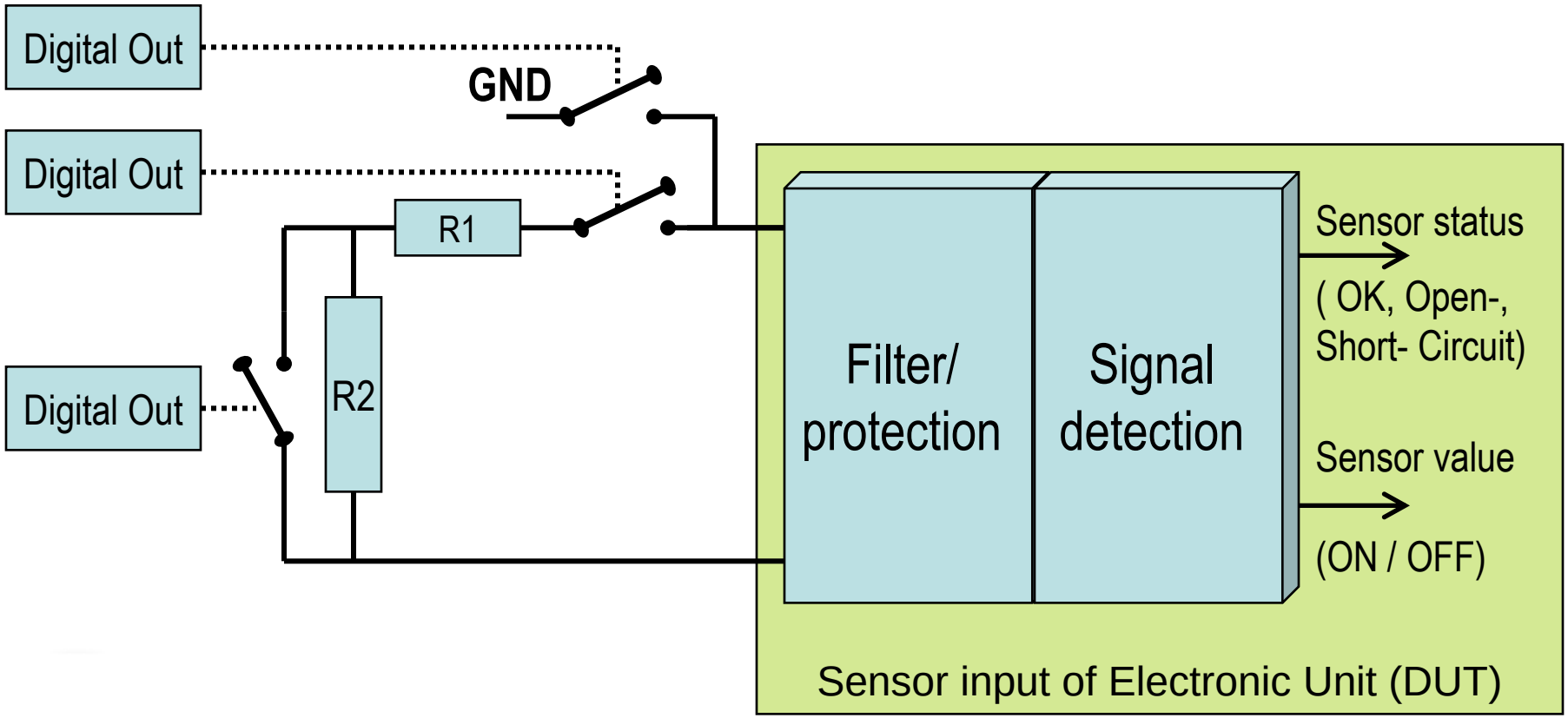
Prevas

Digital input signal with monitoring



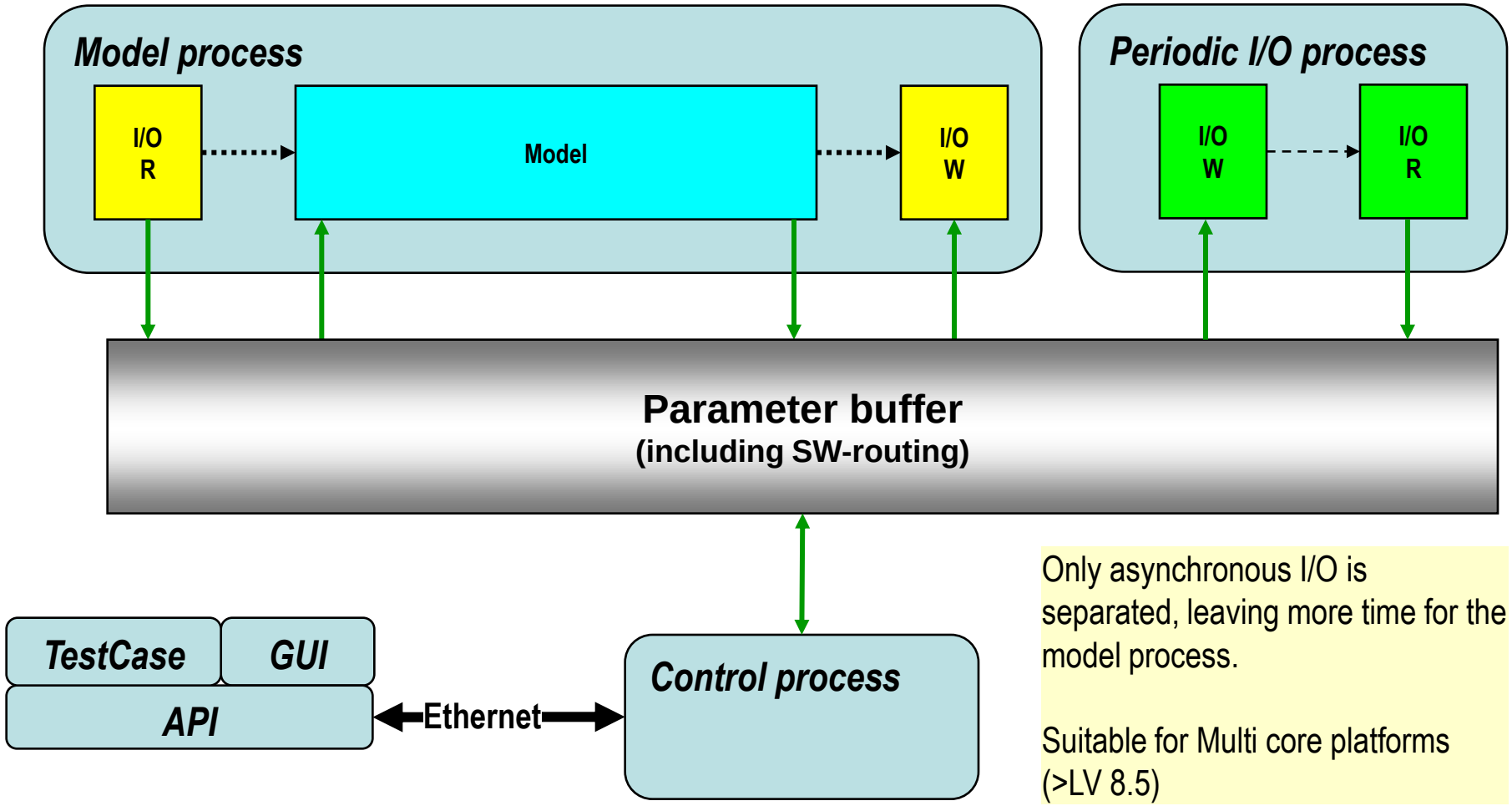
Prevas

Sensor simulation, digital input



Prevas

Software architecture

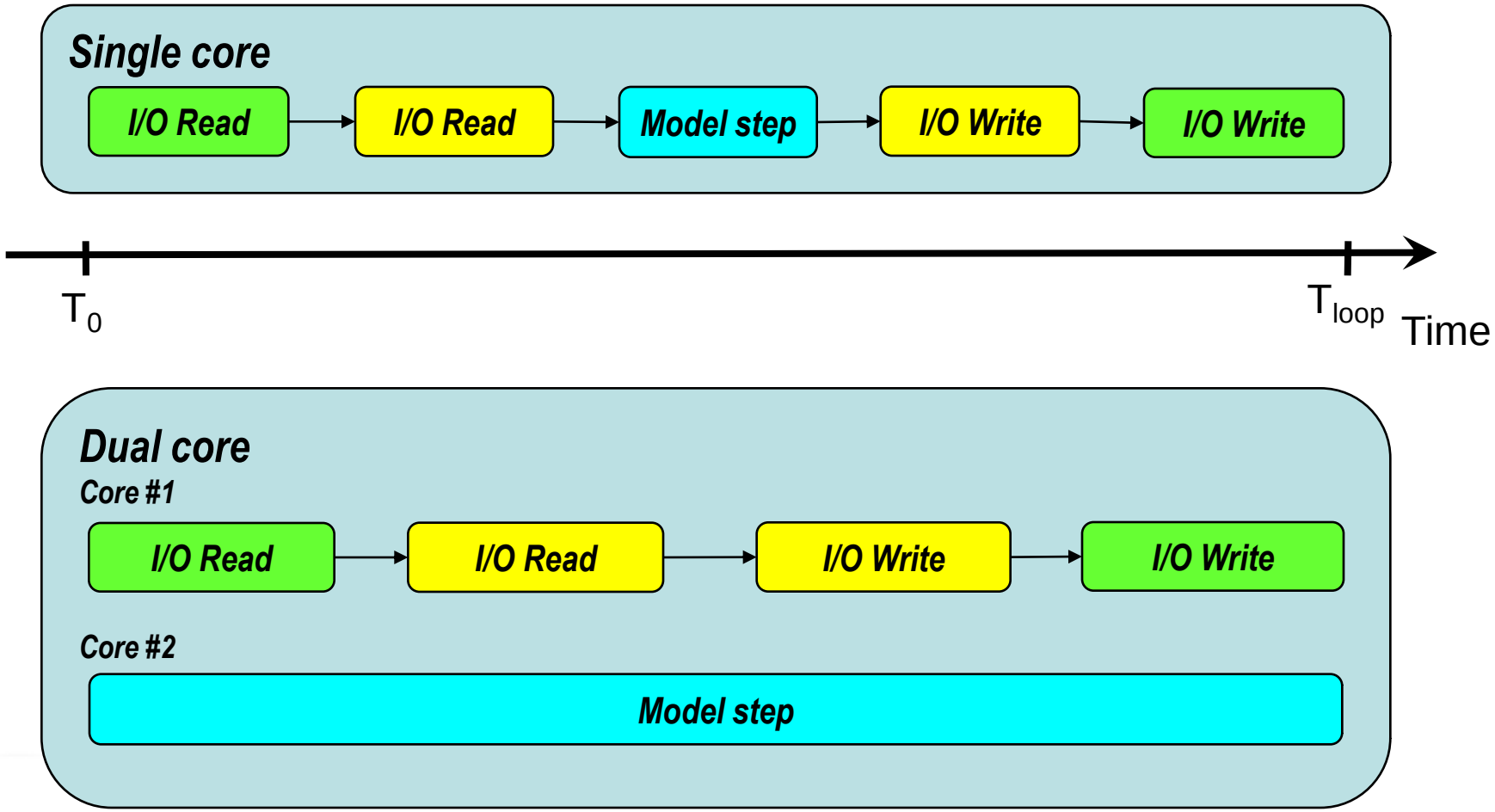


Only asynchronous I/O is separated, leaving more time for the model process.

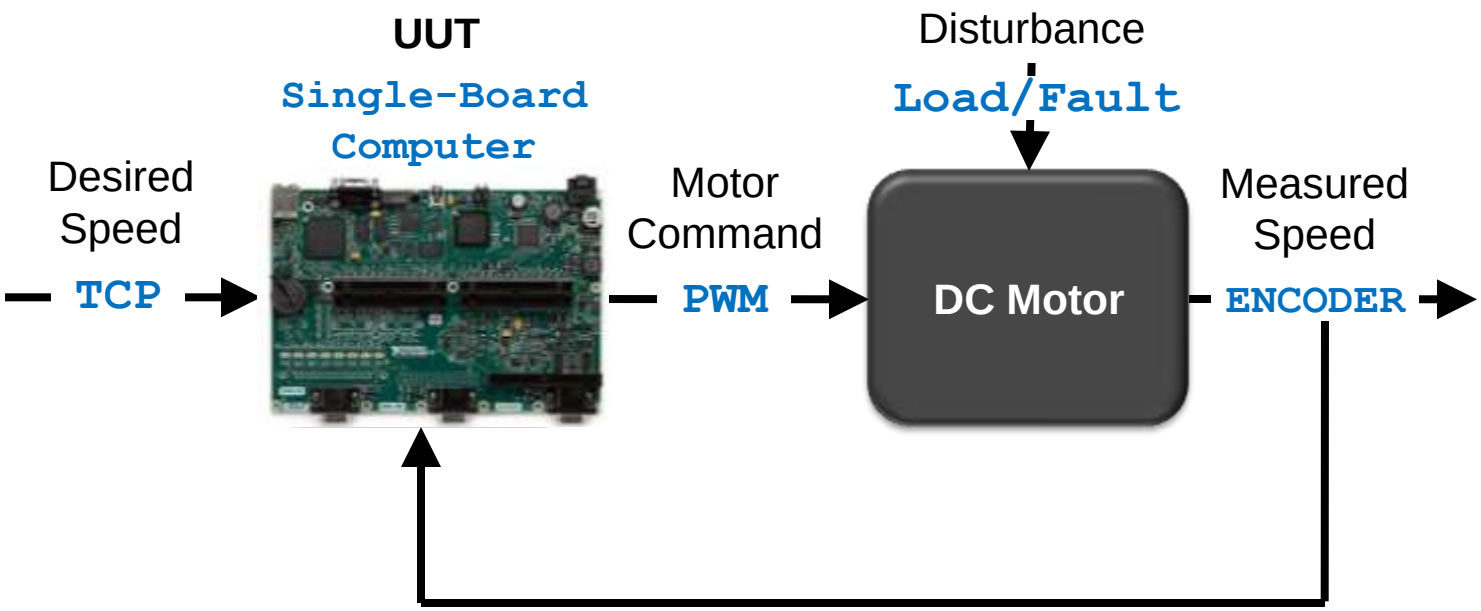
Suitable for Multi core platforms (>LV 8.5)

Prevas

Scheduling



DEMO – Testing with HIL Simulation



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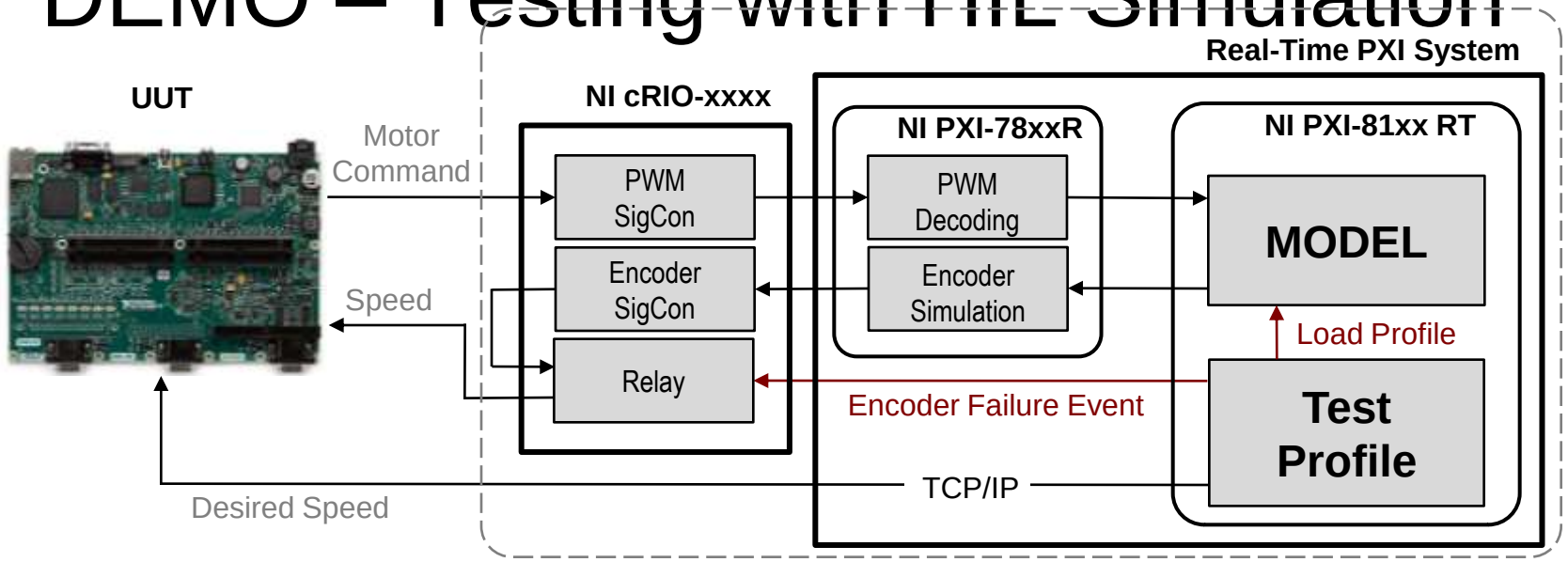
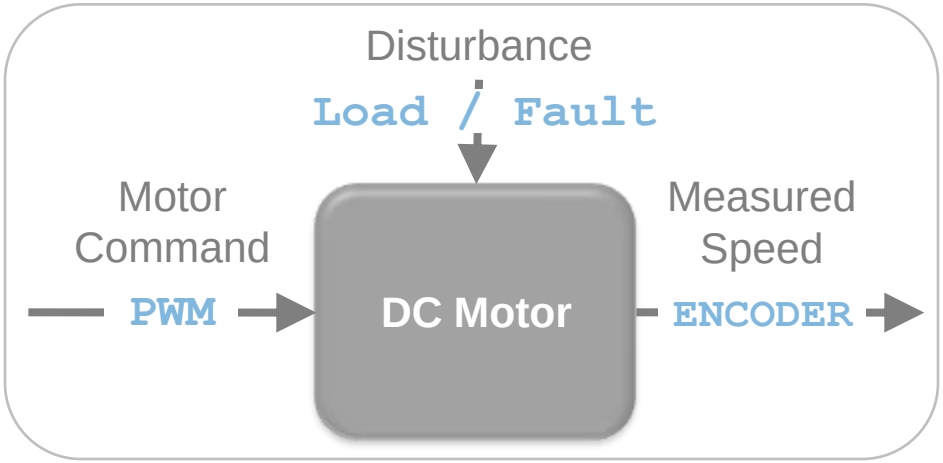
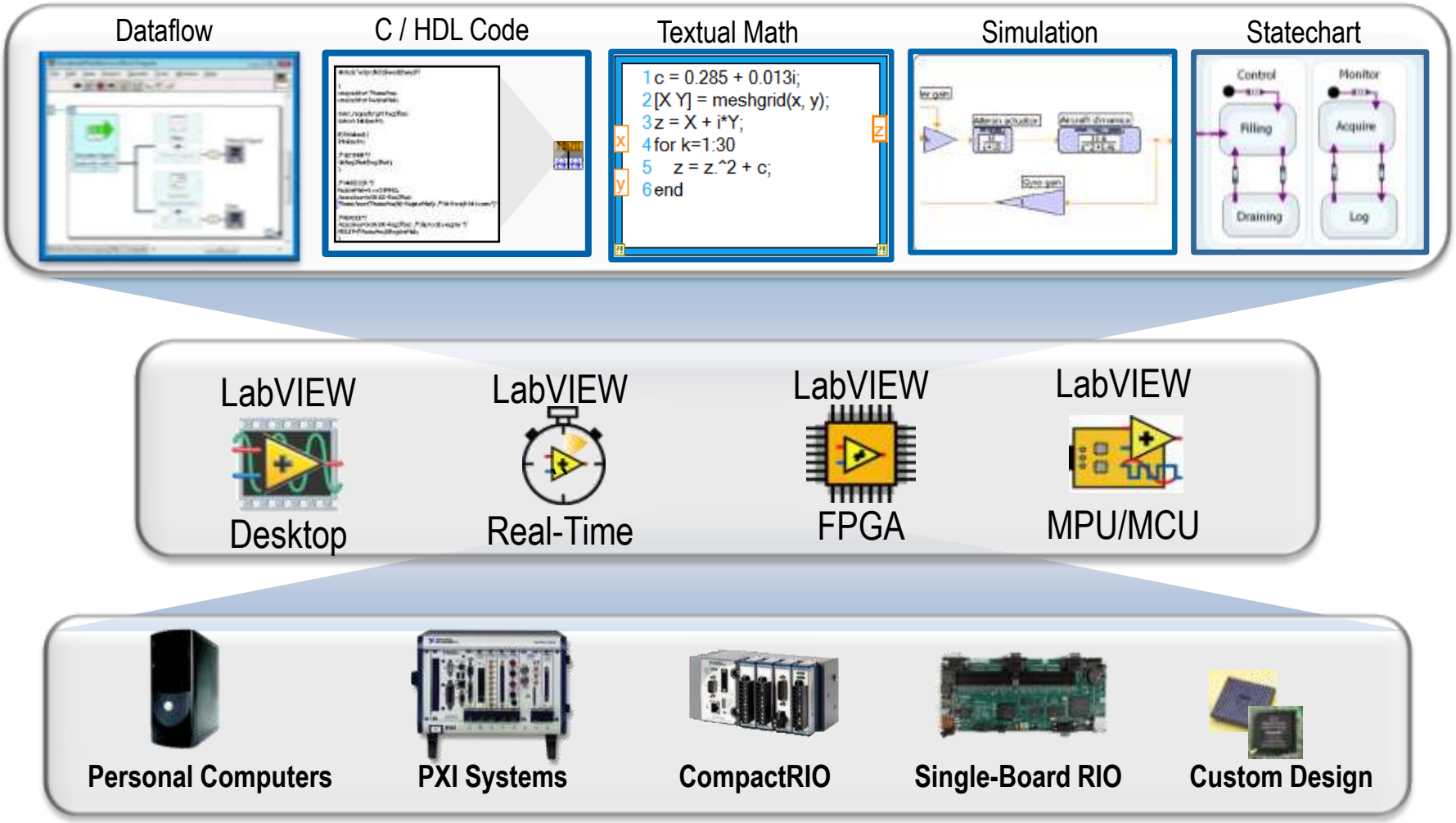


- Test response to encoder failure
- Test response to load on motor



Software and Hardware for Dynamic Testing

LabVIEW Software Platform for HIL



Hardware Platform for HIL

- PXI and PXI Express
- Input and Output Devices
  - Data Acquisition & SCXI
  - Intelligent Data Acquisition
  - Communication Busses
    - CAN, FlexRay, Lin, MOST, ARINC, …
  - DMMs, Scopes, Arbs, RF, HS DIO
- CompactRIO
  - New Deterministic Expansion Chassis for distributed HIL systems
- Vision and Motion
- 3rd Party Hardware Support

Summary

- HIL is a valuable test method for testing systems with embedded control
- Use LabVIEW to create models or use third-party models to implement HIL test systems

ni.com/hil

ni.com/embeddedcontrol