LabVIEW Control Design and Simulation

Jiří Keprt
Radim Štefan
Control Design Process

- Research/Modeling
- Design/Simulation
- Verification/Validation
- Manufacturing
V-diagram

- Modeling and Design
- System Testing
- Targeting
- Rapid Prototyping
- Hardware-in-the-Loop Testing

ni.com
Modeling and design produce controller and plant models
Demo Bouncing Ball

- A rubber ball is thrown into the air with a velocity of 15 meters per second from a height of 10 m.
- Only gravitation is the force affecting the ball.
- The speed of the ball is decreased to 80 % when the ball hits the ground and the direction is reversed.
- The position of the ball is shown in the lower plot of the scope, and the velocity of the ball is shown in the upper plot.
Demo Bouncing Ball

• Differential equation of the model

\[ m\ddot{x} = -mg \]
\[ \ddot{x} = -g \]

• Initial condition

\[ \dot{x}[0] = 15 m/s \]
\[ x[0] = 10 m \]
Demo Bouncing Ball
NI LabVIEW Simulation Interface Toolkit (SIT)

- Use the LabVIEW Simulation Interface Toolkit to:
  - Build powerful user interfaces for models developed in the Simulink® environment, and deploy them to real-time hardware with LabVIEW Real-Time*
    *Requires The MathWorks, Inc. Real-Time Workshop
  - Use Models from MatrixX
How it works?
System Requirements

• The MathWorks MATLAB® 6.0 or later
• The MathWorks Simulink® 4.0 or later
• The MathWorks Real-Time Workshop® 4.0 or later
• Microsoft Visual C++ 5.0 or later
• Gcc WindRiver Compiler for VxWorks
• National Instruments LabVIEW 7.0 or later, Full or Professional Development Systems
• National Instruments LabVIEW Real-Time Module
• NI-DAQ
Simulation Model Conversion

– Convert your plant and controller models developed in The MathWorks, Inc. Simulink® environment into LabVIEW Simulation Module code
Little or No Learning Curve for The MathWorks, Inc. Simulink® Software Users

• LabVIEW Simulation Module

• The Simulink Software Environment

Simulink® is a registered trademark of The MathWorks, Inc. All other trademarks are the property of their respective owners.
Little or No Learning Curve for The MathWorks, Inc. Simulink® Software Users

LabVIEW Simulation Module

The Simulink Software Environment

Simulink® is a registered trademark of The MathWorks, Inc. All other trademarks are the property of their respective owners.
LabVIEW MathScript

- Powerful textual programming for signal processing, analysis, and math
  - More than 650 built-in functions
  - Reuse many of your m-file scripts created with The MathWorks, Inc. MATLAB® software and others
  - Partially based on original math from NI MATRIXx
- A native LabVIEW solution
  - Interactive and programmatic interfaces
  - Does not require third-party software
Control Design MathScript Plug-In

- Use a MathScript node to combine your existing m-files with a flexible LabVIEW user interface
- Use MathScript text-based interactive environment for design and analysis
- Integrate controls work with built-in numerical math and signal processing functions in MathScript or native LabVIEW VIs and toolkits
Little or No Learning Curve for Customers Familiar with The MathWorks Inc. MATLAB® Language Syntax

**LabVIEW MathScript Syntax**

```plaintext
>> num = [1 2];
>> den = [1 3 5];
>> sys = tf(num,den);
>> step(sys)
>> bode(sys)
>> pole(sys)
ans =
  -1.5 + 1.6583i
  -1.5 - 1.6583i
```

**MATLAB® syntax**

```plaintext
>> num = [1 2];
>> den = [1 3 5];
>> sys = tf(num,den);
>> step(sys)
>> bode(sys)
>> pole(sys)
ans =
  -1.5000 + 1.6583i
  -1.5000 - 1.6583i
```

MATLAB® is a registered trademark of The MathWorks, Inc. All other trademarks are the property of their respective owners.
Hardware-in-the-Loop (HIL) Simulation

Testing production controller with simulated plant
LabVIEW for Design, Prototype, and Deploy

LabVIEW conditional compiling technology provides for:

- Model reuse
- Test reuse

Design
Prototype Target
HIL Target
LabVIEW Control Design and Simulation

**Benefits**

- *Complete simulation and real-time implementation capability – stay in one environment from design to test to implementation*
- LabVIEW user interface to change and observe parameters as simulation or control system is running
- Use any LabVIEW VI or programming structure inside or outside of simulation loops:
  - Integrated design and simulation, batch simulation
  - DAQ, RIO, vision, or CAN for I/O and feedback
- Easily create parallel and multirate simulation or control loops
SIT / HIL Demo

Host Computer

LabVIEW

MATLAB®/Simulink®

Real-Time Computer

LabVIEW Real-Time Module

Driver VI

SIT Server

Model DLL

Ethernet Connection

CAN Demo Box

CAN
RPI Human Object Transporter

- Professor Kevin Craig, Rensselaer Polytechnic Institute (RPI)
- LabVIEW Simulation Module, CompactRIO, LabVIEW Real-Time, LabVIEW PDA
- Team of undergrads completed project in 4 months!
Děkujeme za pozornost