Labview As a Teaching Aid for Control Systems

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Summary

- Introduction

- Labview’s contributions in Process Control teaching
  - Dynamics systems Modeling and Simulation
  - Designed experiments and applications using Labview and NI DAQ

- NI technology’s contributions in Embedded Systems teaching
  - Designed experiments and applications using Labview and CompactRIO
  - Comparison between the graphical and VHDL code using Spartan 3E card

- Conclusion
Introduction

- Process Control
- Embedded Systems
Introduction

Challenges

• How to create an attractive and interactive environment in order to accelerate their learning.
• How To find a balance between theoretical concepts and practical aspects

Solution

• NI Technology adopted since 1995 (3.1 version of Labview)
Labview’s contributions in Process Control teaching
Labview’s contributions in Process Control teaching
Labview’s contributions in Process Control teaching

Skills required

• Modeling, Identification, Simulation processes
• Implementation of algorithms
• Design Control systems,
• Perform Tuning
• Etc...
Labview’s contributions in Process Control teaching

It is very difficult to implement this architecture with the classical programming languages.
Labview’s contributions in Process Control teaching

- An ease of implementation of architectures and algorithms,
- A modeling and simulating dynamics systems in real time
- A visualization of the systems' behavior,
- A nice graphical interface
Labview’s contributions in Process Control teaching

Labview modules and Toolkits for Control and Simulation systems
Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

- Construct plant and control models using transfer function, state-space, etc…
- Analyze system performance with tools such as step response, and Bode plots.
- Analyze open-loop model behavior, design closed-loop controllers,
- Simulate linear, nonlinear, discrete, online and offline systems
- Develop Quickly programs for automated control

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Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

PID Control Algorithm

Using Point by Point Integral and Derivative functions
Labview’s contributions in Process Control teaching

Dynamics systems Modeling and Simulation

PID Control Algorithm

Using blocks of Simulation Toolkit

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PID Control Algorithm

Using one of PID functions (PID Control Toolkit)
Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

PID Control Algorithm

Using Formula Node
Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

Closed Loop Simulation using Control Design toolkit

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Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

Closed Loop Simulation using Control Design toolkit:

Proportional Gain (Kc)
Integral time [s] (Ti)
Derivative time [s] (Td)
Numerator
Denominator

Closed Loop TF
Step Response Graph

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Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

Closed Loop Simulation using Simulation toolkit

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Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

In 1995, Control Design Module was not implemented yet in Labview 3.1

Closed Loop feedback control system

\[ k_p \left( 1 + \frac{1}{T_i p} + T_d p \right) \]

\[ \frac{b_0 + b_1 p}{a_0 + a_1 p + a_2 p^2} \]

Disturbance

Set point

Measured error

Controlled value

System Output

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Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

Transfer Function Algorithm (3.1 version of Labview)

$W(p) = \frac{b_0 + b_1 p}{a_0 + a_1 p + a_2 p^2}$

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PID Algorithm (3.1 version of Labview)

$$C(p) = k_p \left( 1 + \frac{1}{T_i p} + T_d p \right)$$
Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

Block Diagram closed loop modeling and simulation (3.1 version of Labview)
Labview’s contributions in Process Control teaching

Dynamics systems Modeling and Simulation

Front panel closed loop modeling and simulation (3.1 version of Labview)

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Labview’s contributions in Process Control teaching

Dynamics systems Modeling and Simulation

Front panel closed loop modeling and simulation (3.1 version of Labview)

Frequency response behavior

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Labview’s contributions in Process Control teaching
Dynamics systems Modeling and Simulation

Learned skills

- Modeling and simulating dynamics systems
- Implementation of algorithms
- Design Control systems,
- System Performances

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Labview’s contributions in Process Control teaching

Designed experiments and applications using Labview NI DAQ
Labview’s contributions in Process Control teaching

Voltage control, RC circuit

First order system with disturbance
Labview’s contributions in Process Control teaching

Voltage control, RC circuit

A practical control loop with NI technology can be implemented in less than the time needed to fry an egg!

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Labview’s contributions in Process Control teaching
Level, Temperature, Flow control

home made Input/output Standard Interface Card (ISA bus)
Labview’s contributions in Process Control teaching

Level, Temperature, Flow control

Practical design setup

Labs:
- Level, Temperature, Flow control
- simultaneous acquisition of signals
Labview’s contributions in Process Control teaching

Level control using PID and Fuzzy Controllers

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Labview’s contributions in Process Control teaching

**Level control using PID and Fuzzy Controllers**

Practical design setup

**Labs:**
- Systems' Identification
- Level control using PID and Fuzzy Controllers

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Labview’s contributions in Process Control teaching

Level control using PID and Fuzzy Controllers

Labview graphical interface

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Labview’s contributions in Process Control teaching

Level control using PID and Fuzzy Controllers

Learned skills

- Process Identification
- PID Tuning: Ziegler Method
- System Performances
- Comparison between PID and Fuzzy Logic controllers

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NI Technology’s contributions in Embedded System teaching

Designed experiments and applications using Labview CompactRIO
NI technology’s contributions in Embedded System teaching

Goals
- Design real-time embedded applications
- Design Rapid Prototyping and deploying applications

Skills required
- Multi-tasks programming
- Real-Time programming
- Data Communication and Synchronization between tasks
NI technology’s contributions in Embedded System teaching

1. Develop the Application on the Host Computer
2. Download Code to the Target hardware via Ethernet Connexion
3. Execute Code on Real Time (RT) Target

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NI technology’s contributions in Embedded System teaching

Embedded Systems Modules and toolkits

- FPGA Module
- RT Module
- Data communication and Synchronization techniques (Queue, Notifier Semaphore, Rendezvous, Occurrences)
NI technology’s contributions in Embedded Systems teaching

Temperature control (CompactRIO)

NI CompactRIO

NI 2911 Module

Power interface card designed by students

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NI technology’s contributions in Embedded Systems teaching

Temperature control (CompactRIO)

Practical design setup

Labs:
- CompactRIO's configuration
- Process Identification
- Temperature control
- Comparison between PID and industrial controllers
NI Technology’s contributions in Embedded Systems teaching

Multi-tasks, real time programming (CompactRIO)

Practical design setup

Labs:
- Multi-tasks programming
- State Machine programming
- Real Time programming
NI Technology’s contributions in Embedded Systems teaching

Multi-tasks programming (CompactRIO)
NI Technology’s contributions in Embedded Systems teaching
Multi-tasks programming with State Machine (CompactRIO)

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NI Technology’s contributions in Embedded Systems teaching
Real Time programming using Timed Loop (CompactRIO)
NI Technology’s contributions in Embedded Systems teaching

PLC Workcell 34-120 Automation
NI Technology’s contributions in Embedded Systems teaching

PLC Workcell 34-120 Automation

Practical design setup

Labs:

• programming,
  Operation of PLC
NI Technology’s contributions in Embedded Systems teaching

Learned Skills

- Multi-tasks programming
- State Machine Programming
- Real time programming
- Tasks communication and synchronization
- Understanding of programming and operation of PLC
NI Technology’s contributions in Embedded Systems teaching

Comparison between the graphical (Labview) and VHDL code

Labview FPGA Compile Farm Toolkit

Spartan 3E card

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NI Technology’s contributions in Embedded Systems teaching

Comparison between the graphical (Labview) and VHDL code

Spartan 3E Card

Supply

ADC

DAC

Ethernet controller

Static memory

Flash Memory

FPGA

LCD Display

Nor Flash Memory

RS232

VGA port

LEDs

Flash Memory
NI Technology’s contributions in Embedded Systems teaching

Comparison between the graphical (Labview) and VHDL code

Practical design setup

Labs:
- Compare the graphical to VHDL code
NI Technology’s contributions in Embedded Systems teaching

Comparison between the graphical (Labview) and VHDL code
NI Technology’s contributions in Embedded Systems teaching

Comparison between the graphical (Labview) and VHDL code

VHDL Code
260 lignes
## NI Technology’s contributions in Embedded Systems teaching

**Comparison between the graphical (Labview) and VHDL code**

### Labview’s advantages

- Labview allows Quick deployment of embedded applications
- No required VHDL programming language skills
- Ease of implementation (260 lines VHDL code vs few programming blocks in Labview)
- Ease of debugging in Labview graphical environment
Research using NI Technology

Project: Renewable energies

- To design an experimental stand using Compact RIO to control a photovoltaic system
- To locate and track the maximum power point of a photovoltaic (PV) network
Conclusions

• Throughout the course of presentation, we have demonstrated that Labview and NI Technology is a valuable aid for teaching many aspects of process control engineering.

• In addition to modeling, simulation, control, supervision aspects, Labview easily prompts the students because it allows a real interactivity that students really appreciate.