MEDIS: A Methodology for the Formation of Highly Qualified Engineers at Masters Level in the Design and Development of Advanced Industrial Informatics Systems

WP4 Deliverable 4.1 Advanced Industrial Informatics Specialization Modules: Industrial Computers Module

544490-TEMPUS-1-2013-1-ES-TEMPUS-JPCR

Authors: Domínguez, C., Hassan, H., Martínez, J.M.

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Project Co-ordinator

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Context

WP 4	Advanced Industrial Informatics Specialization Modules
WPLeader	Universitat Politècnica deValència (UPV)
Task 4.1	Industrial Computers Module
Task Leader	UPV
Dependencies	MDU, TUSofia, USTUTT, UP

Author(s)	Domínguez, C., Hassan, H., Martínez, J.M.
Reviewers	Perles, A., Albaladejo, J., Capella J.V.

History

Version	Date	Author	Comments
0.1	01/09/2014	UPV Team	Initial draft
1.0	29/09/2014	UPV Team	Final version

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MEDIS Project

Advanced Industrial Informatics Specialization Modules

Industrial Computers Module

Training

Saint Petersburg

MEDIS: A Methodology for the Formation of Highly Qualified Engineers at Masters Level in the Design and Development of Advanced Industrial Informatics Systems

Outline

1. Introduction
2. Aims of the Industrial Computers Module, Learning Outcomes and Prerequisites
3. PBL – Case of Study
4. Learning Resources in the Laboratory

1 Introduction

Training for Technicians

A laboratory technician is required to set-up all the hardware and software tools.

Technicians will provide support on the installation and configuration of the software and hardware used to develop the laboratories and projects.

Regarding the technicians, the training course shows how to use the necessary development tools (hardware and software) and their installation and configuration for the laboratory and project activities.

2 Industrial Computers Module

Goal

Development of a Controller based on Industrial Computers

Learning Outcomes

Specific Skills

- Programing Techniques and Tools
- Design, Development and Validation of an Computer-based Controller (Programming Aspects)
- Project Management and Documentation

General Skills

- Problem Solving
- Collaborative Learning – Work in Team
- Negotiation and Presentation

Prerequisites

- Basic C Programming
- Basic knowledge on Digital Electronics and Automatic Control

Program

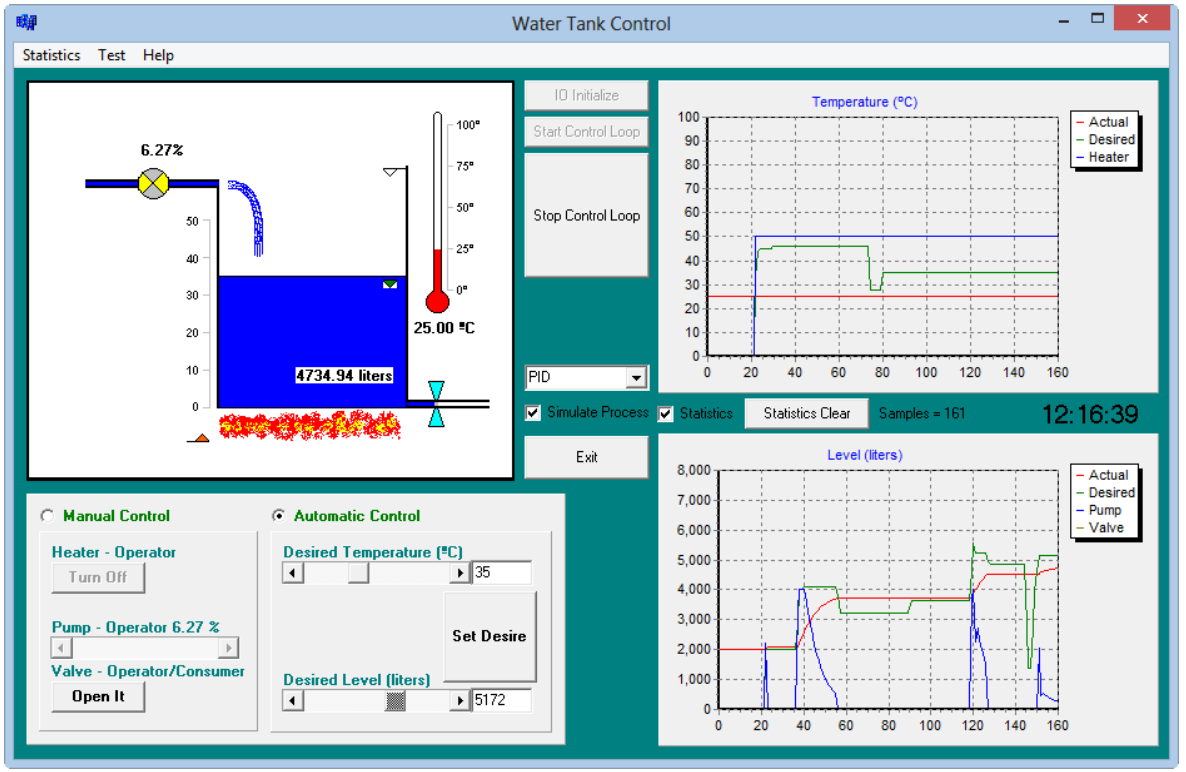
Chapter 1 – Introduction to Industrial Informatics
Chapter 2 – Computer
Chapter 3 – Project Planning
Chapter 4 – Programming + Common Variables
Chapter 5 – Process Interface
Chapter 6 – User Interface
Chapter 7 – Tasks
Chapter 8 – Control
Chapter 9 – Project Integration

3 PBL – Case of Study – The Water Tank Controller

Teaching Philosophy – Problem Based Learning

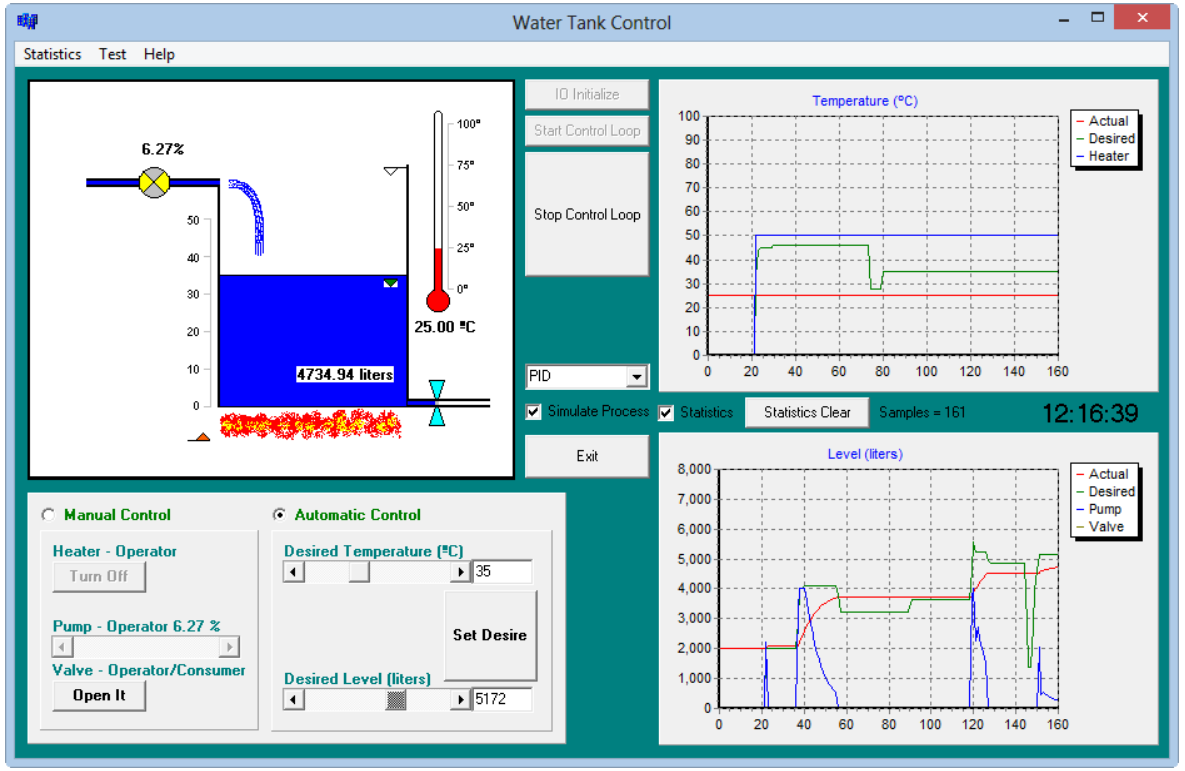
Water Tank

Water Tank Controller – Industrial Computer - based



Specification – Functionality

- Control of two variables: Water Temperature and Level
- Control Strategies: OnOff, PID, …
- Manual / Automatic Control
- Simulated / Real Process



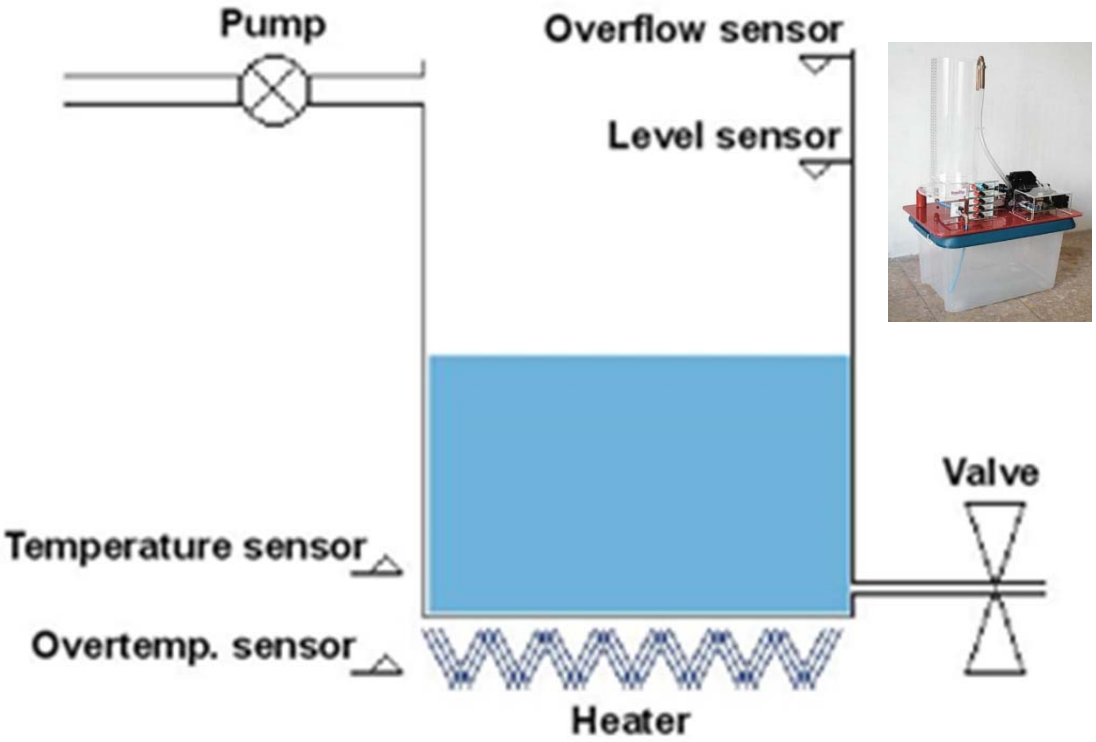
Specification – Process Interface

Sensors (Inputs):

Water Level (Analog)
Water Temperature (Analog)
Overflow Alarm (Digital)
Empty/Overheating Alarm (Digital)

Motors (Outputs):

Water Input Flow - Pump (Analog)
Water Output Flow - Valve (Digital)
Water Heater (Analog)



Specification – Event-based Control

Hot Water Service

After the initialization, when user orders a new service,

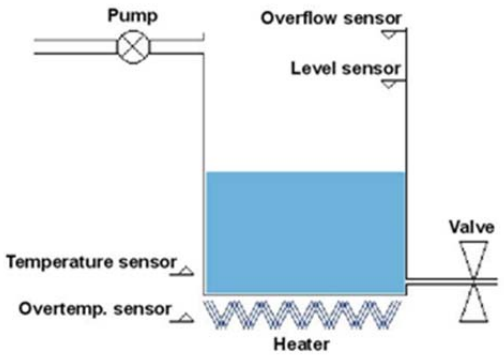
the tank is filled with cold water, using the input pump,
until a predefined level,

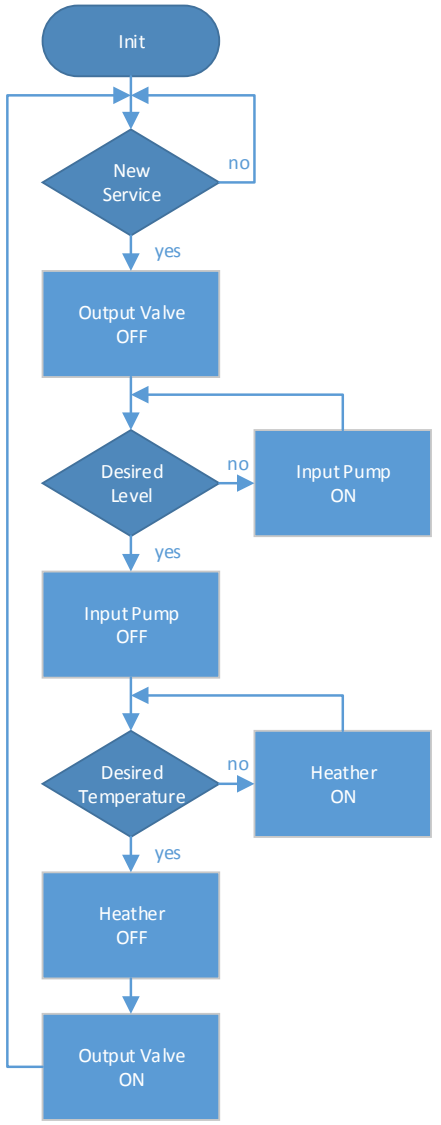
then

the water is heated, using the heather,
until a predefined temperature,

finally

the hot water is served through the output valve,
the controller waits until a new service request.





Specification – Continuous Control

Control Alternatives

Type of Control	Type of Driving Signal
On/Off	Digital (2 states)
	Analog (2 states)
P-discrete	Digital (N states)
	Analog (N states)
P	Digital PWM
	Analog
PID	Digital PWM
	Analog

4 Learning Resources in the Laboratory

Essential Resources

The resources absolutely necessary to conduct the learning activities of the Industrial Computers Module

Optional Resources

Resources that make the learning process easier

Essential Resources

- Physical Process – Water Tank
  Real Process, Simulated Process, Simulated Process' Signals – Symseny
- Industrial Computer (General Purpose Computing Platform) – Personal Computer
  Operating System – Windows (XP, 7, 8)
- I/O System – Data Acquisition Card – National Instruments USB-6008
- Integrated Development Environment (IDE) – Qt Creator
  Programming Language / Compiler / Libraries – C++, MinGW, Qt
- Documentation
  Reference Manuals, User Manuals

Optional Resources

- Third Party Libraries (Application Development)
  e.g. OpenSceneGraph (3D), OpenCV (Computer Vision), …

- Tools for Sharing and Communicating (Collaborative Learning)
  Remote Desktop – Windows Remote Desktop, TeamView
  Source Code Sharing - Pastebin
  Versions Control - GitHub
  Subject Web Site - PoliformaT (UPV Sakai System)

- Tools for Documenting
  Text – MS-Office/OpenOffice
  Bitmaps – GIMP
  Vector Graphics – InkScape

Physical Process – The Water Tank (or other Processes)

PBL: Control Problem

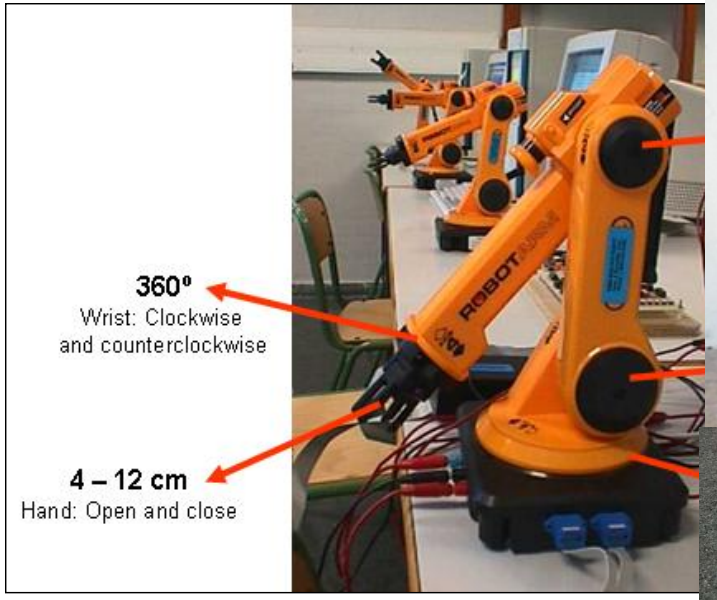
Real/Reduced-size Physical Processes vs Simulated

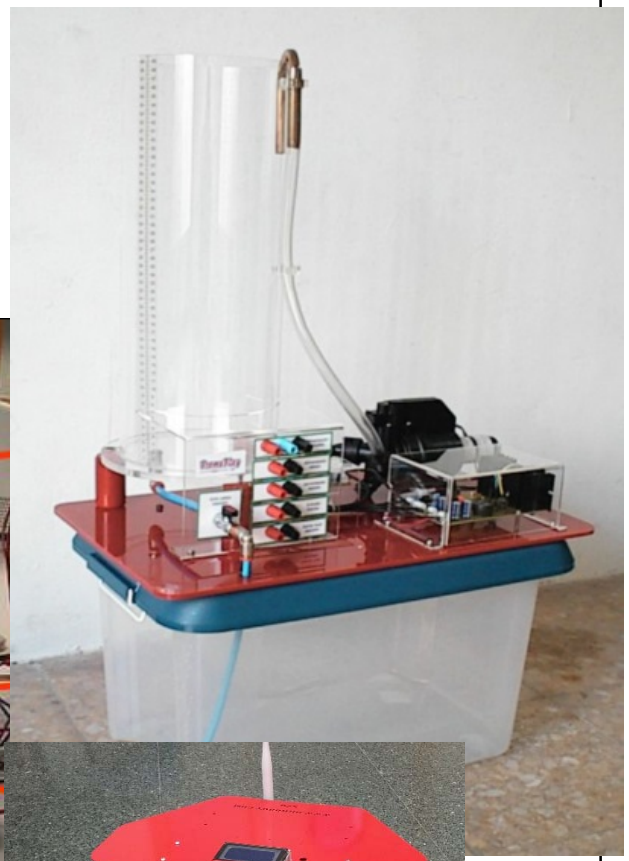
- More Expensive
- Room Needed

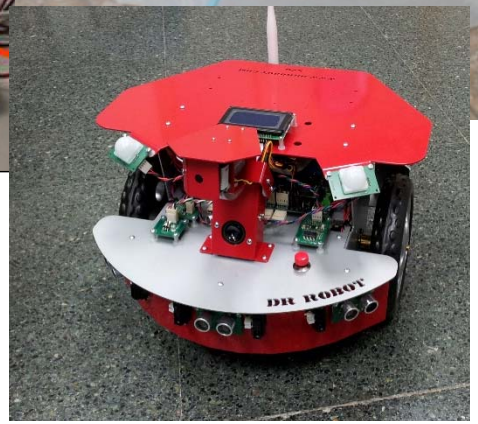
+ Let Address Real Issues
+ More Tangible (Motivating)

Technician Duties

- Installation
- Maintenance







Simulated Process – The Water Tank (or other Processes)

Simulating at physical model level

- As part of the Project activities, students develop simulators of the physical process' dynamics
- They use the simulators to test the controller
- The simulators run on the computer

Simulating at signal level

- SimSeny simulator

SimSeny

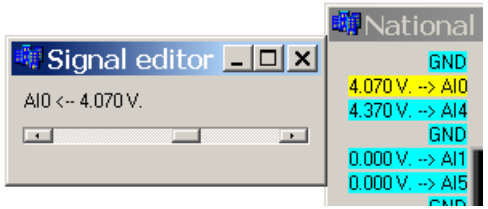
Simulation Tool Developed by Prof. Angel Perles

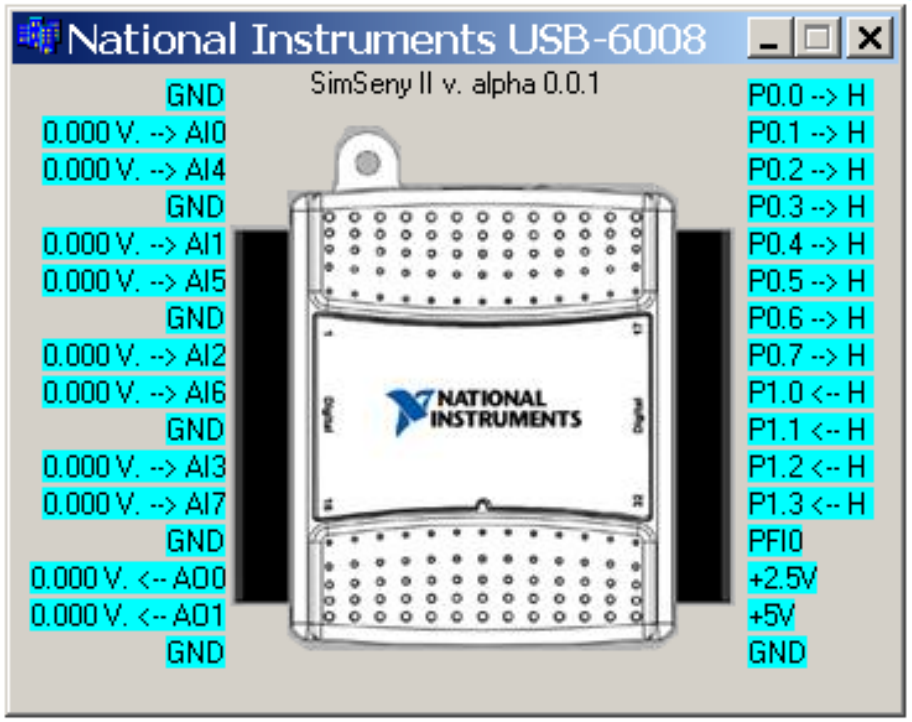
- SimSeny simulates at signal level
- Re-implements the API of a data acquisition card (e.g. NI USB-6008)
- It can be executed anyplace in the net (on a personal computer)

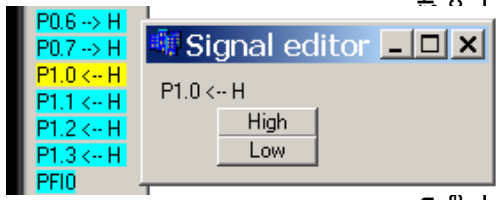
Web site:

http://www.disca.upv.es/aperles/simseny2/us_simseny2.html

SimSeny – Interface







Industrial Computer (Personal Computer)

PC Requirements

- Basic Configuration e.g. Dual Core
- USB frontal ports
- LAN and Internet Access

PCs in the laboratory

Technician Duties (installation, configuration, maintenance)

Students Laptop

Technician Duties (to provide recommendations and advice)

Data Acquisition Card – NI USB-6008

The National Instruments - NI USB-6008 (and USB-6009) are low-cost DAQ devices with easy screw connectivity and a small form factor.

With plug-and-play USB connectivity, these devices are simple enough for quick measurements but versatile enough for more complex measurement applications.

Web Site
http://sine.ni.com/nips/cds/view/p/lang/en/nid/201986

Operating System
Mac OS X, Windows 2000/XP, 7, 8, CE, Mobile, Vista

Driver
NI-DAQmx

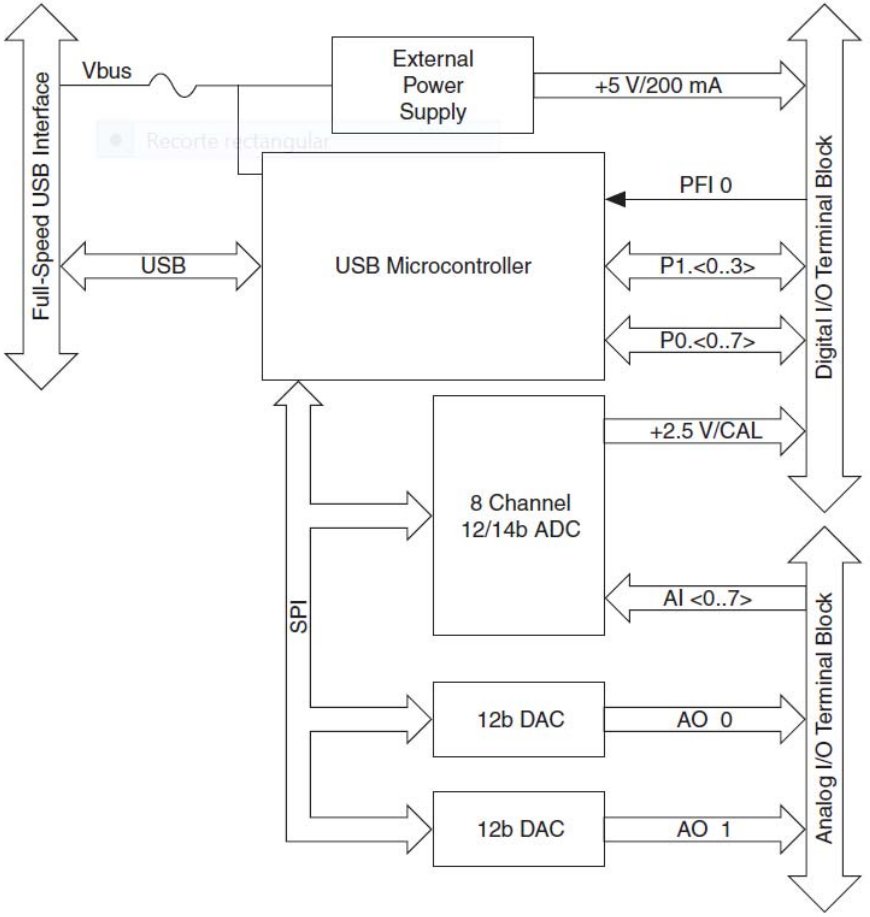
NI USB-6008 – Characteristics

8 analog inputs
- at 12 or 14 bits
- up to 48 KSamples/s

2 analog outputs
- at 12 bits
- software-timed

12 TTL/CMOS digital I/O lines

One 32-bit, 5 MHz counter

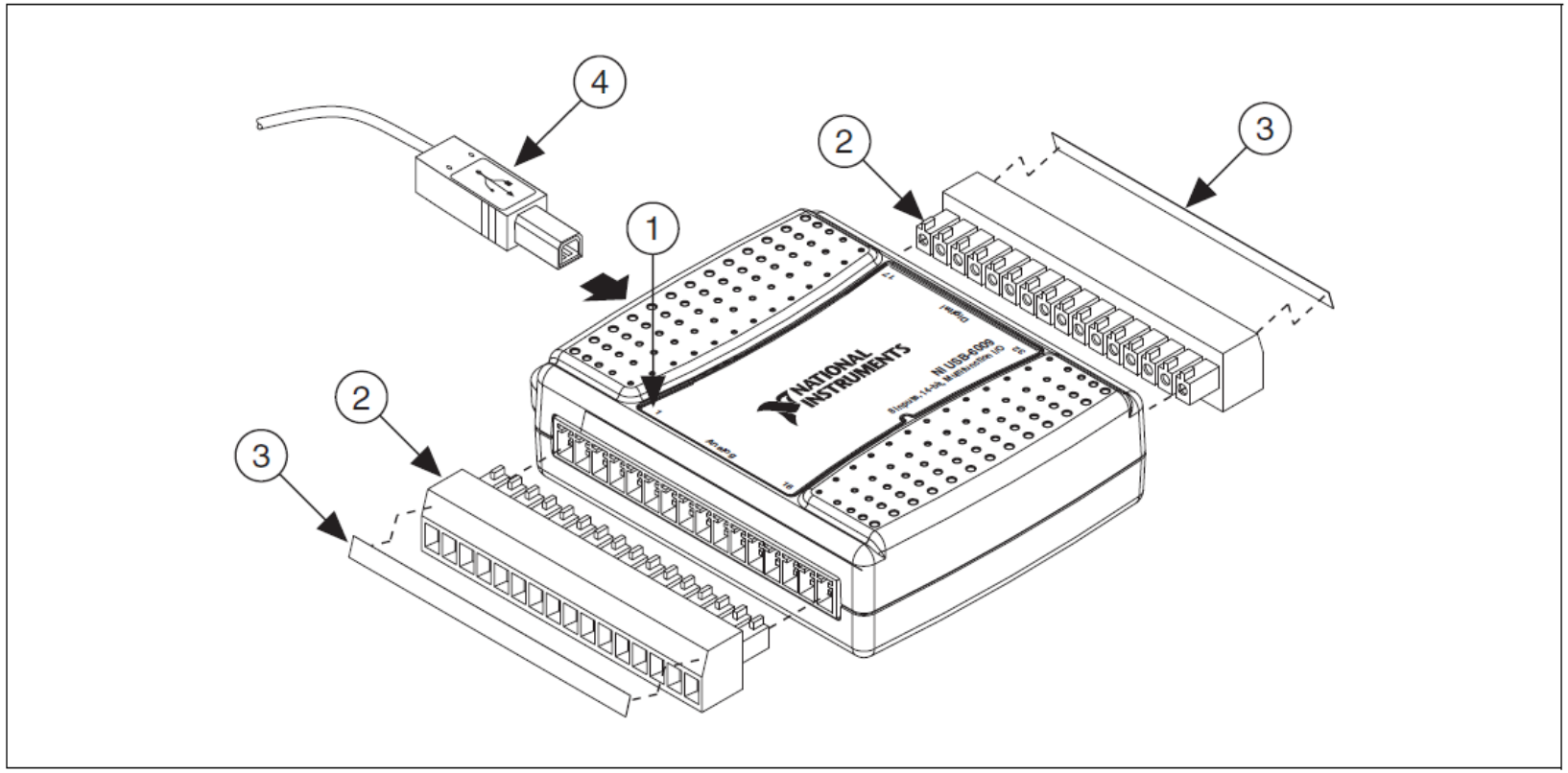


NI USB-6008 vs NI USB-6009

Comparison Tables

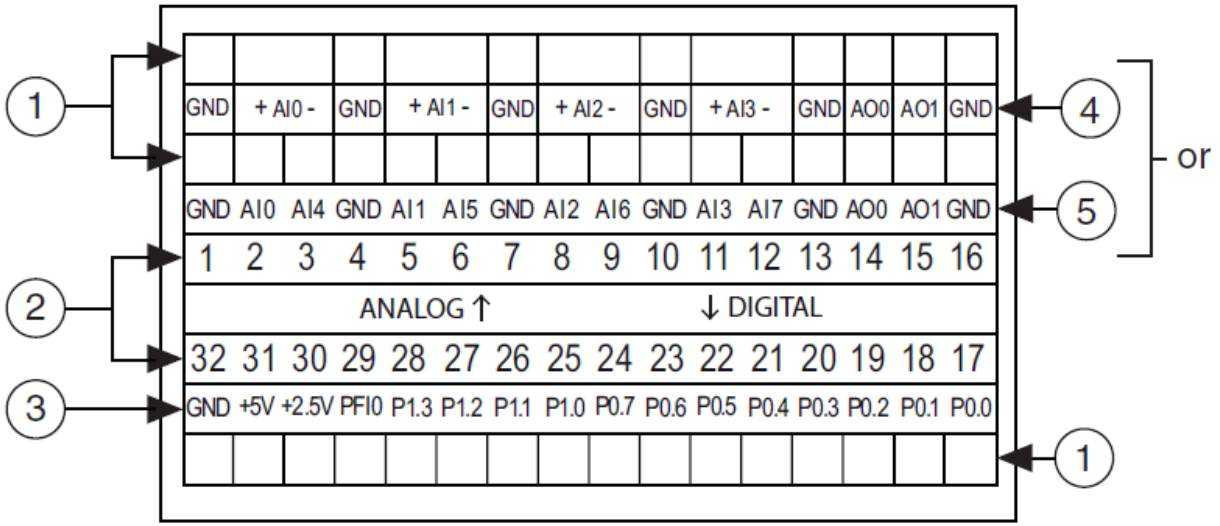
Product	Analog Inputs	Input Resolution	Max Sampling Rate (kS/s)	Analog Outputs	Output Resolution	Output Rate (Hz)	Digital I/O Lines	32-Bit Counter	Triggering
USB-6008	8 single-ended/4 differential	12	10	2	12	150	12	1	Digital
USB-6009	8 single-ended/4 differential	14	48	2	12	150	12	1	Digital

NI USB-6008 – Components



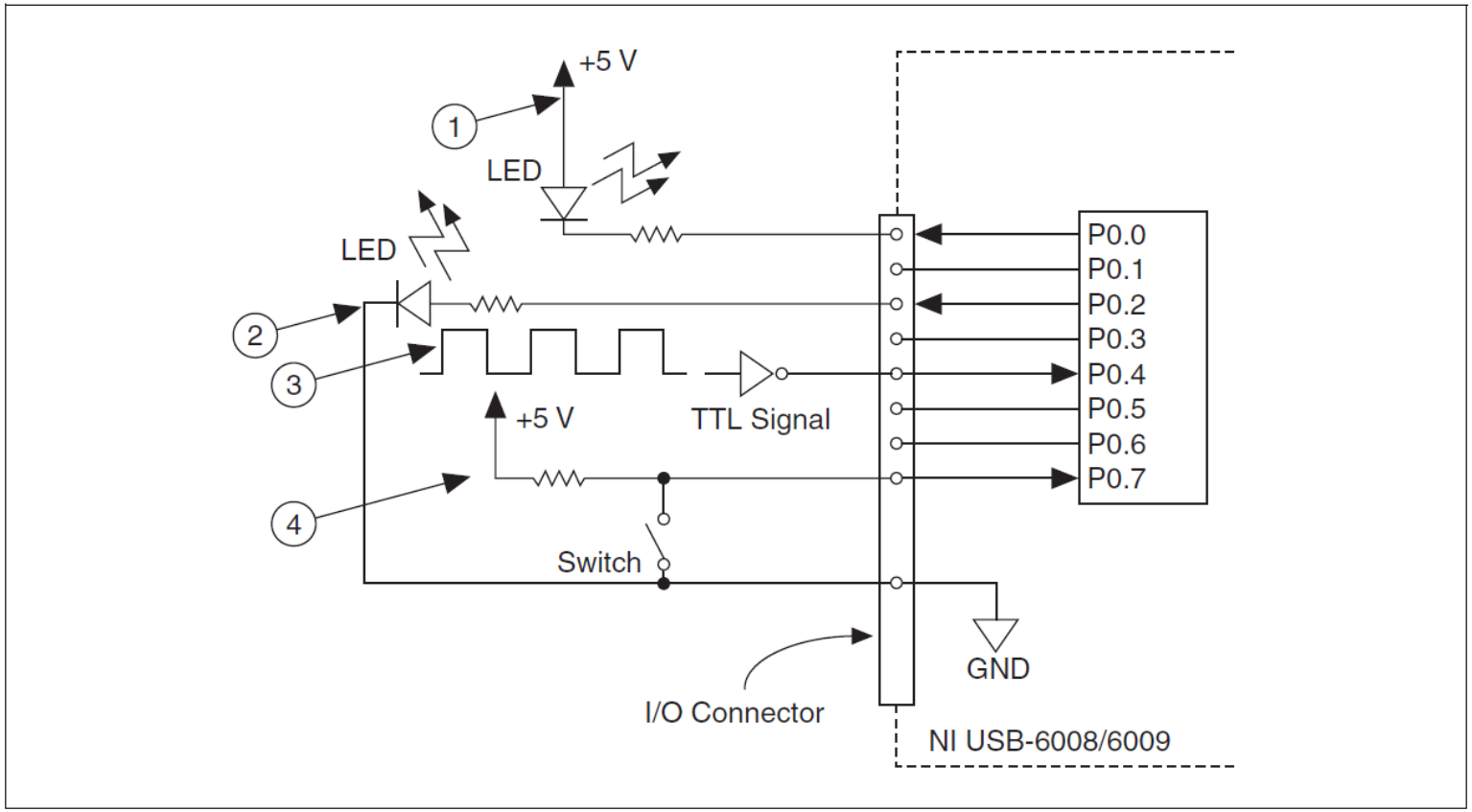
1	Overlay Label with Pin Orientation Guides	3	Signal Label
2	Screw Terminal Connector Plug	4	USB Cable

NI USB-6008 – Labels

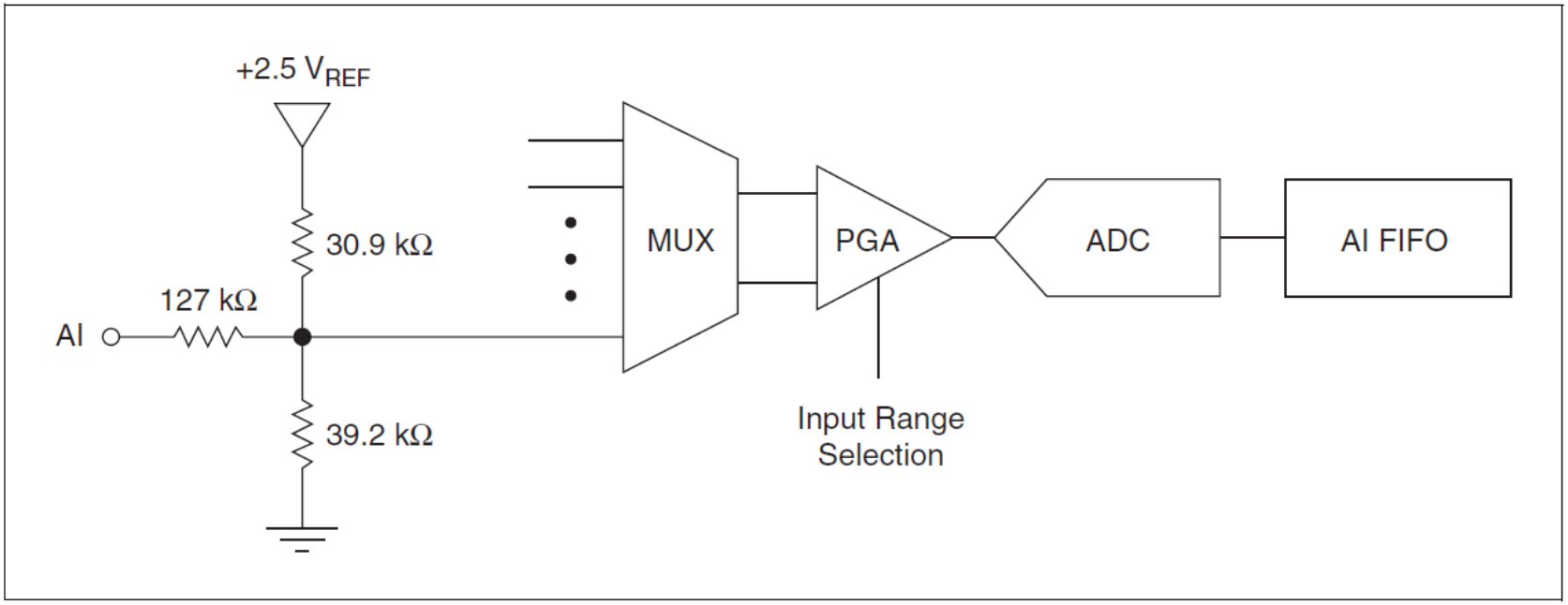


1	User-Defined Custom Label	4	Analog Input Differential Signal Name Label
2	Terminal Number Label	5	Analog Input Single-Ended Signal Name Label
3	Digital I/O Label		

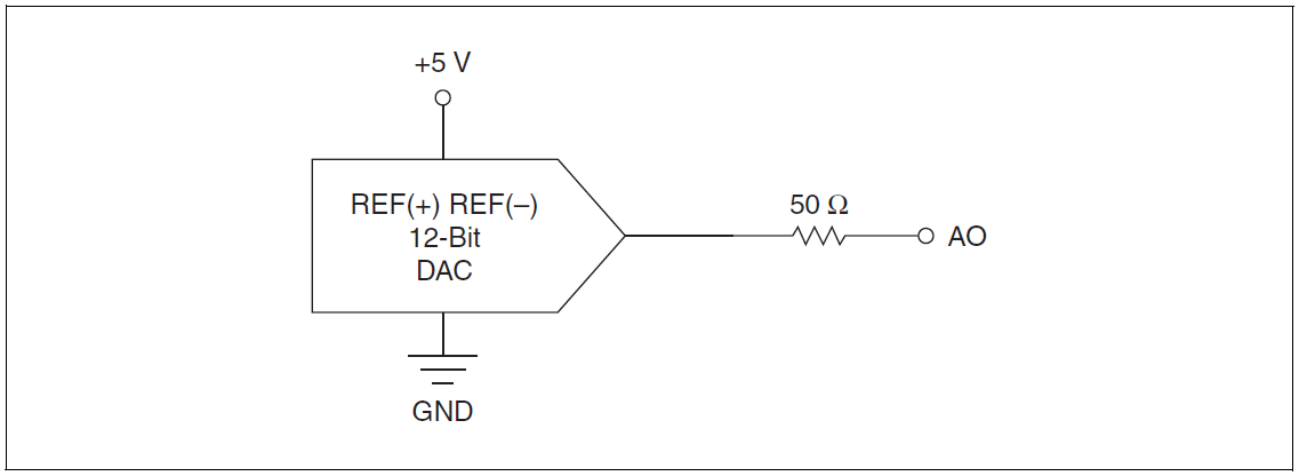
NI USB-6008 – Digital Input/Output



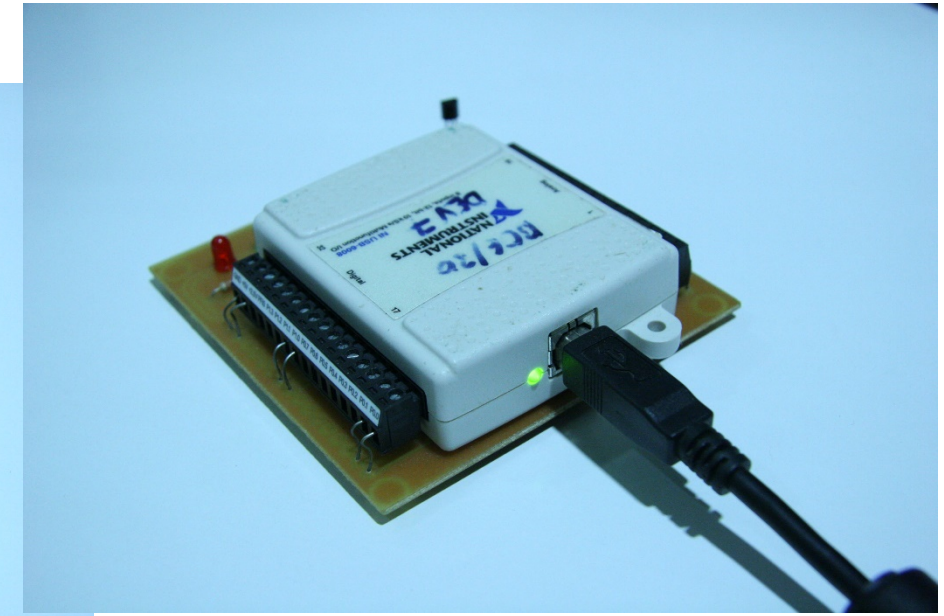
NI USB-6008 – Analog Input



NI USB-6008 – Analog Output



NI USB-6008 – Extensions – Simulators of Signals

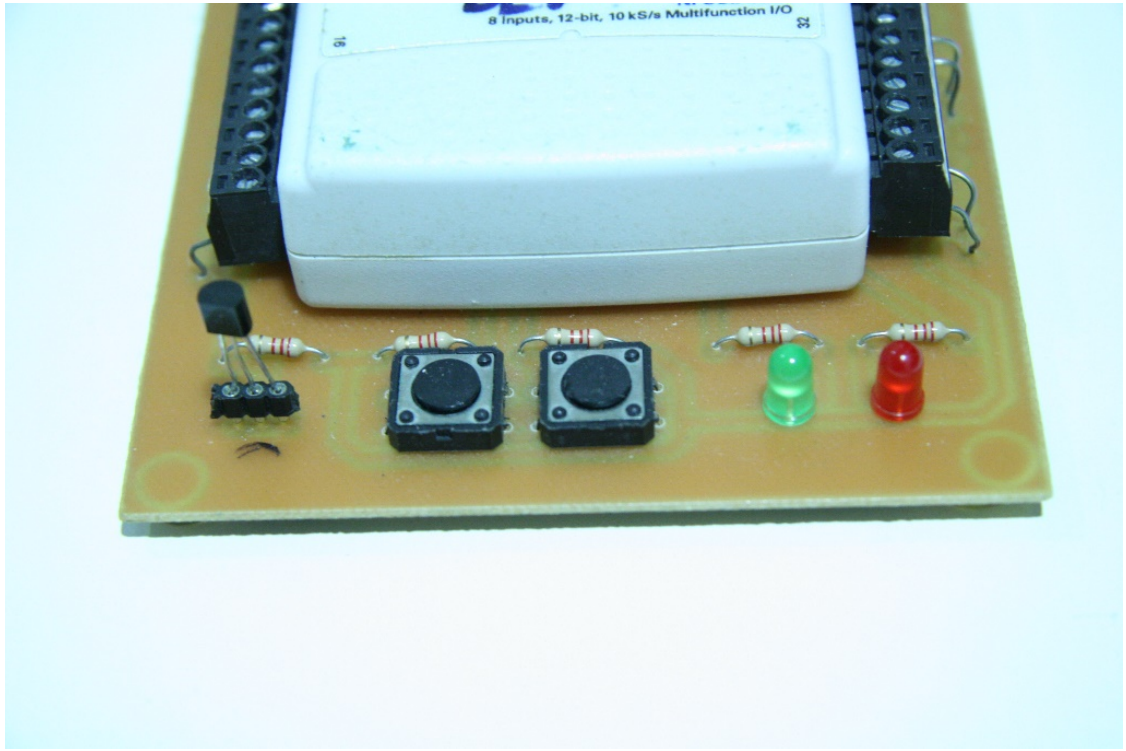


NI USB-6008 – Extensions – Simulators of Signals

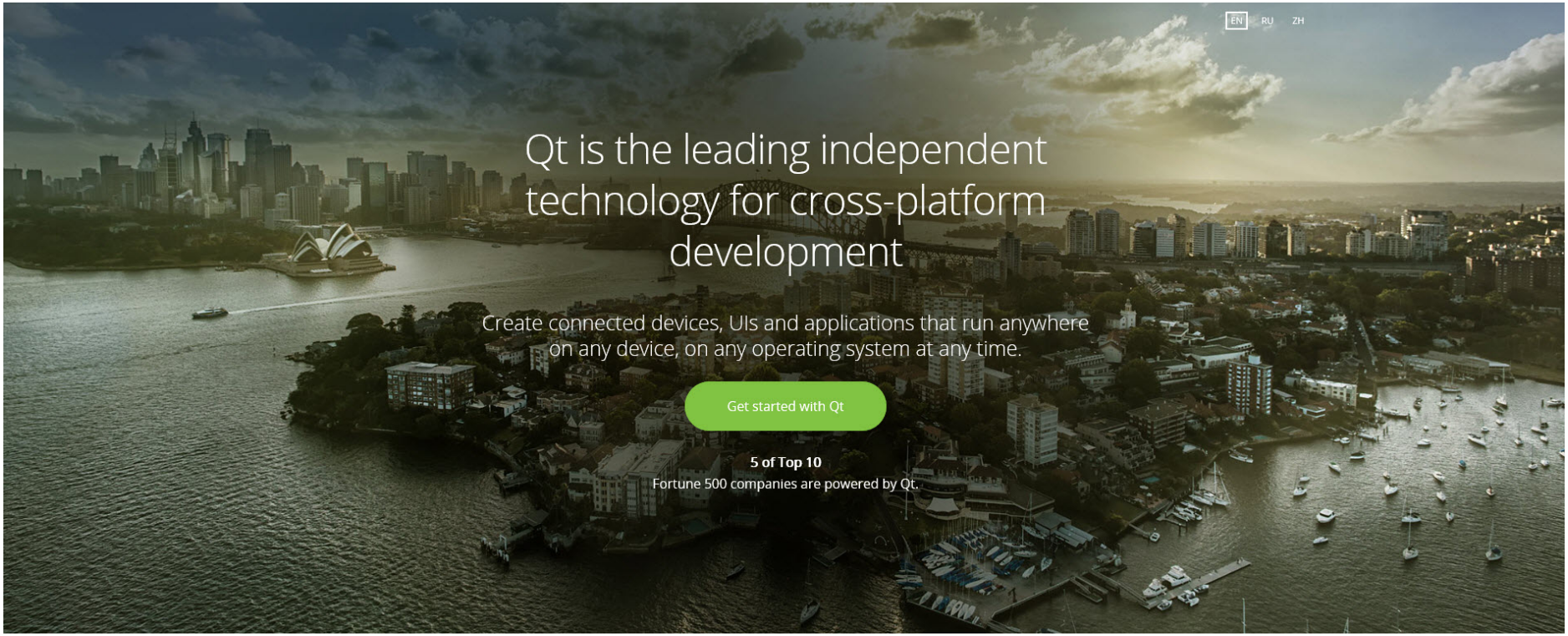
2 buttons
simulate sensors – digital inputs

2 LEDs
simulate motors – digital outputs

1 LM-335
temperature sensor – analog input



IDE – Qt Creator



Web site:

https://www.qt.io/

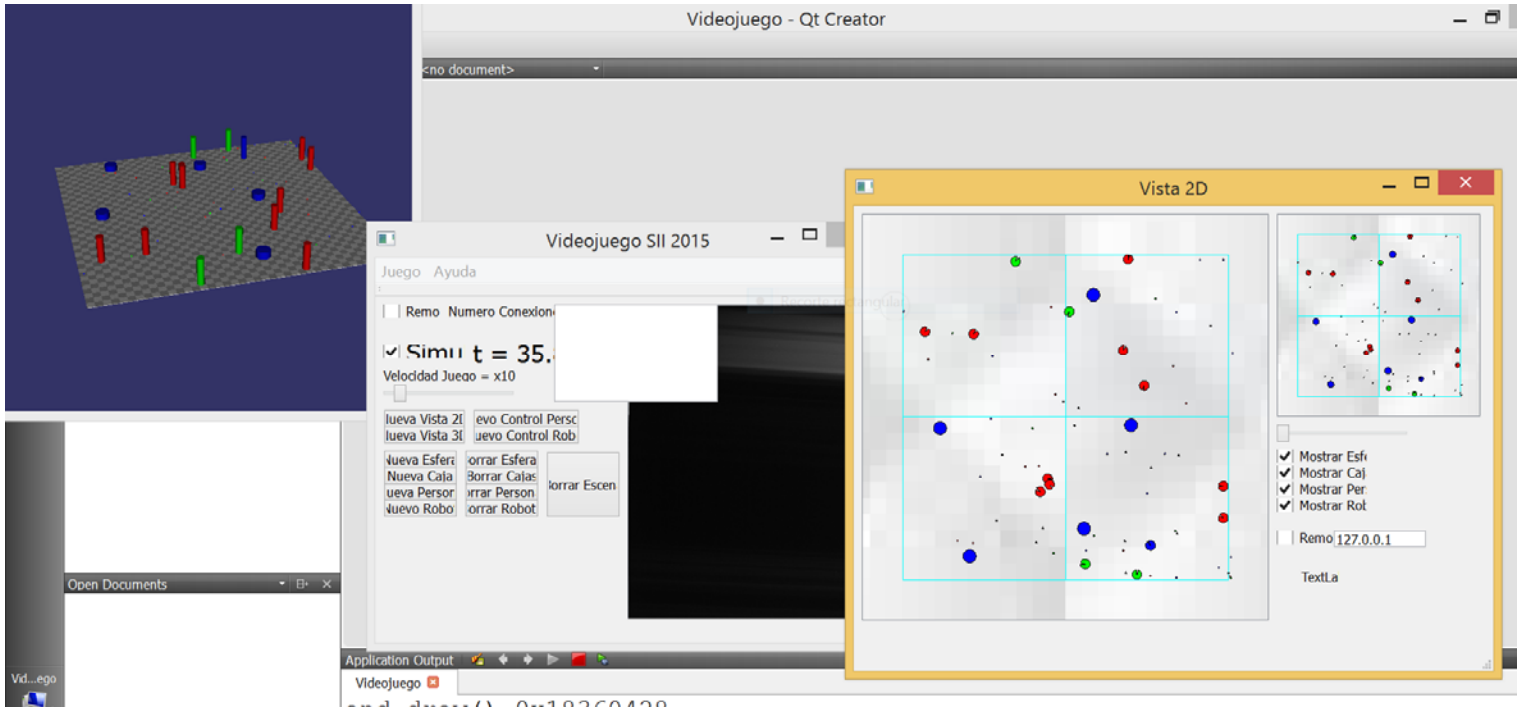
Qt Framework

Reasons for Qt

- Open Software
- Multiplatform
- C++ Native Code
- Big Community
- Many Success Applications

Optional Resources

- Third Party Libraries (Application Development)
  e.g. OpenSceneGraph (3D), OpenCV (Computer Vision), …



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  Versions Control – GitHub - https://github.com/
  Subject Web Site - PoliformaT (UPV Sakai System)

- Tools for Documenting
  Text – MS-Office/OpenOffice
  Bitmaps – GIMP - http://www.gimp.org/
  Vector Graphics – InkScape - https://inkscape.org/