Remote Control of Experiments (RCE)(202001416)

Information session

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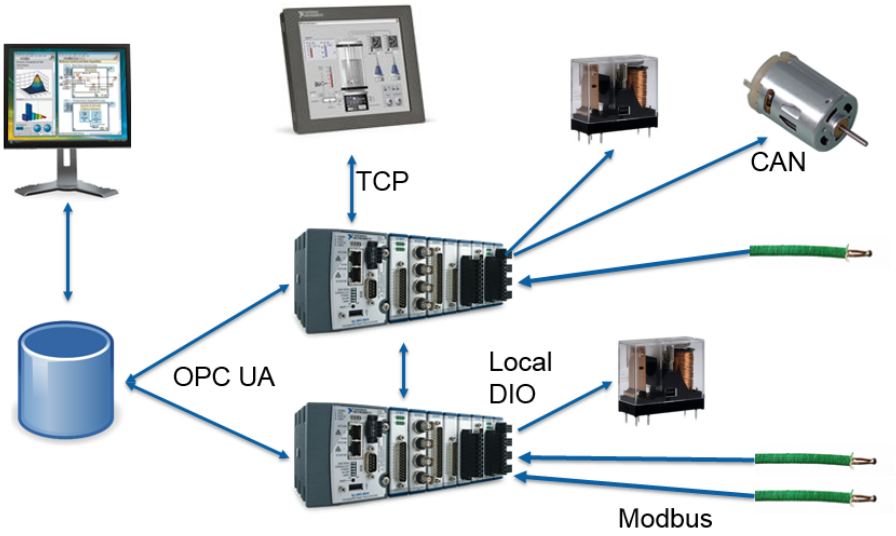
Motivation

- Modern techniques for an engineer: Control via computer.
- Inspired by the Covid-19 virus: Work remote!
- Implemented in own experiments in the SLT-laboratories.
- Experimental counterpart of Computational Physics.

The context

- Hardware:
  - Your laptop.
  - An embedded system, with interface to the real world.
  - A set of sensors and actuators
- Software:
  - NI LabVIEW: a graphical programming language.
  - A large library of functional objects.
  - A measurement explorer application.
  - optional FPGA-programming.
- Communication:
  - Network
  - Bus: i2C or SPI
  - USB


TCP
CAN
OPC UA
Local
DIO
Modbus

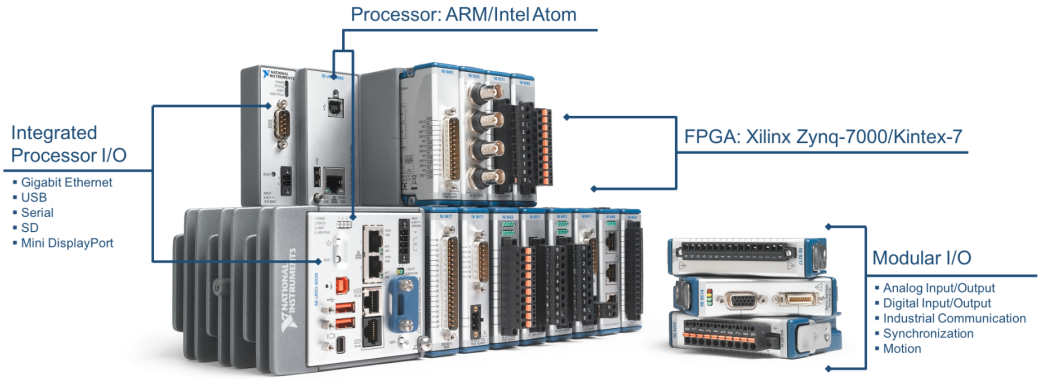
Introductory problems

- Introduction to Graphical Programming
- Realize basic functions in VI's
- programming structure:
  - Front panel: controls and indicators
  - Wire panel: graphical programming
  - Connections
  - Loops
  - Cases
  - Data structures
- Interfacing with the real world

DAQmx

- Introduction DAC, ADC and DIO
- Concept of local limited intelligence and control from program
- Explore structure of interface
- Explore and test limits of the interface hardware – software
  - timing
  - resolution
  - control

The cRIO system



Figuur: The cRIO system.

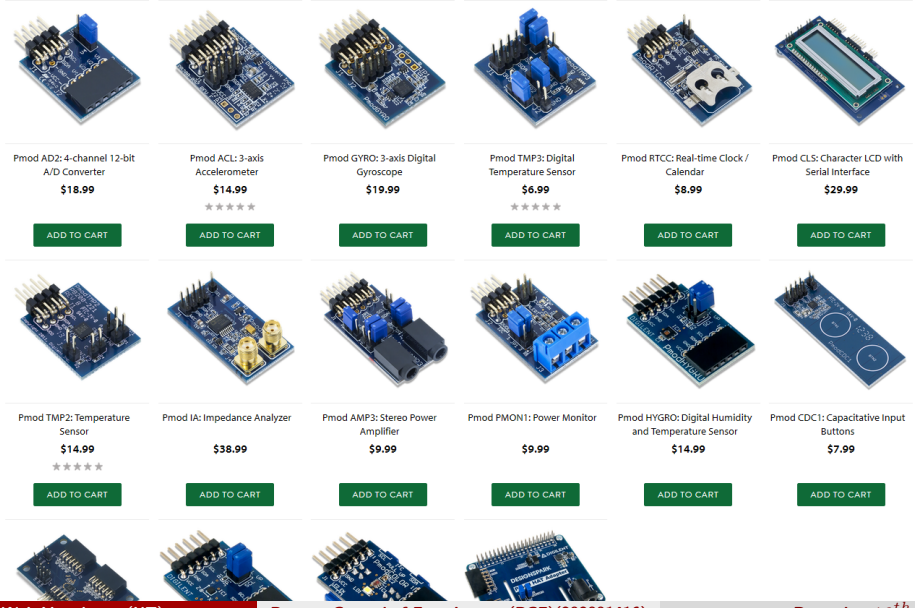
The cRIO system

- Introduction to cRIO system: embedded computer + FPGA
- Bus-rack with dedicated interface modules
- Real-time programming
- Communication between computer and embedded CPU
- Principles of distributed computing and control
- FPGA programming (limited)

Remote system: myRIO

- Introduction to the myRIO system
- Explore myRIO and parallels with the cRIO
- Real-time programming
- Communication between computer and myRIO
- FPGA programming (limited)
- myRIO – smart-sensor/actuator communication (I2C-protocol)

Pmod Modules with I2C protocol



Pmod AD2: 4-channel 12-bit A/D Converter
$18.99
ADD TO CART

Pmod ACL: 3-axis Accelerometer
$14.99
ADD TO CART

Pmod GYRO: 3-axis Digital Gyroscope
$19.99
ADD TO CART

Pmod TMP3: Digital Temperature Sensor
$6.99
ADD TO CART

Pmod RTCC: Real-time Clock / Calendar
$8.99
ADD TO CART

Pmod CLS: Character LCD with Serial Interface
$29.99
ADD TO CART

Pmod TMP2: Temperature Sensor
$14.99
ADD TO CART

Pmod IA: Impedance Analyzer
$38.99
ADD TO CART

Pmod AMP3: Stereo Power Amplifier
$9.99
ADD TO CART

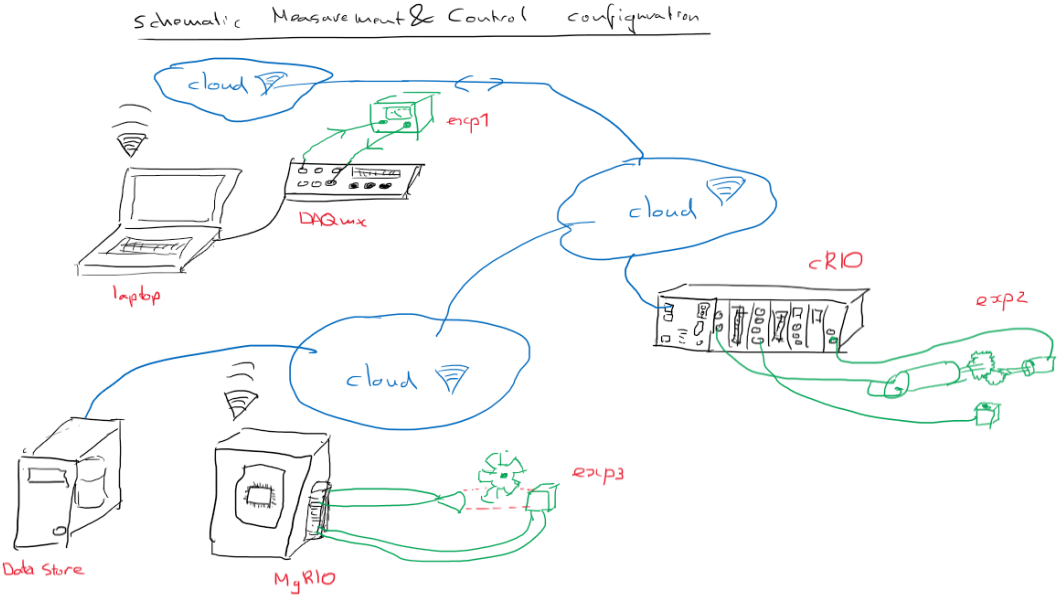
Pmod PMON1: Power Monitor
$9.99
ADD TO CART

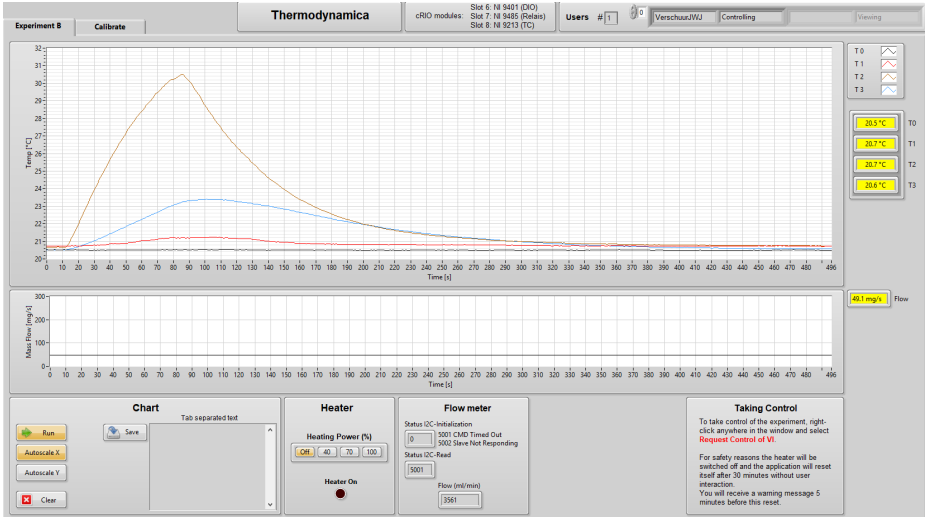
Pmod HYGRO: Digital Humidity and Temperature Sensor
$14.99
ADD TO CART

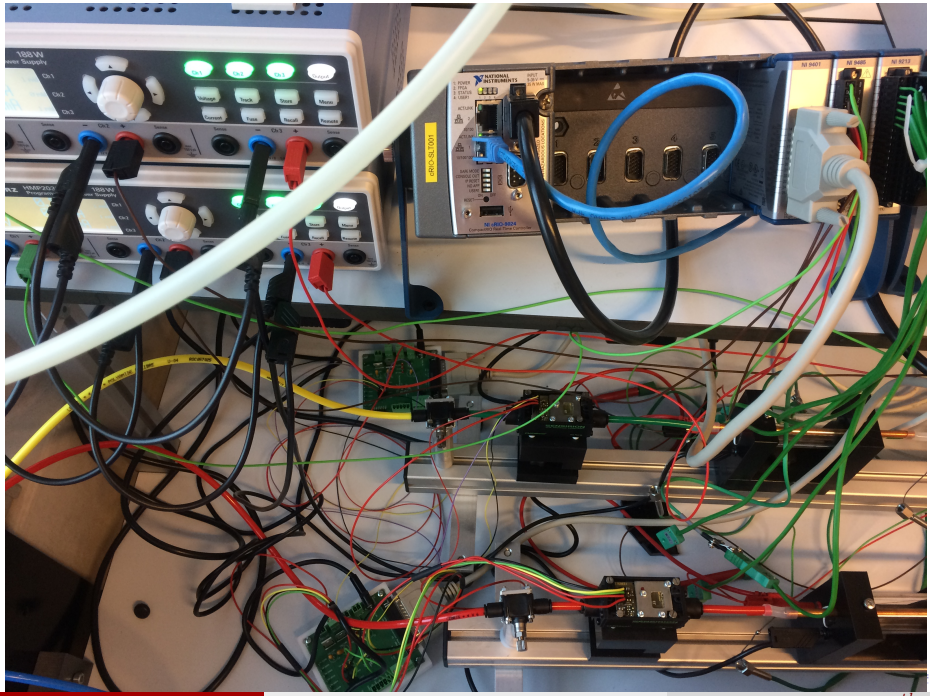
Pmod CDC1: Capacitative Input Buttons
$7.99
ADD TO CART

Use of sensors in real-time programming

- Explore smart-sensor modules: Pmod
- Explore communication protocols between myRIO and Pmod's
- Realize a simple Pmod project
- Explore the limits of the system
  - Timing and speed issues
  - Resolution
  - Controllability


Schematic Measurement & Control configuration
cloud
cloud
cloud
exp1
DAQmx
laptop
cRIO
exp2
exp3
Data Store
MyRIO


Experiment B
Calibrate
Thermodynamica
cRIO modules:
Slot 6: NI 9401 (DIO)
Slot 7: NI 9485 (Relais)
Slot 8: NI 9213 (TC)
Users #1
VerschuurJWJ
Controlling
Viewing
Temp [°C]
Time [s]
T 0
T 1
T 2
T 3
20.5 °C
20.7 °C
20.7 °C
20.6 °C
Mass Flow [mg/s]
49.1 mg/s
Flow
Chart
Tab separated text
Run
Save
Autoscale X
Autoscale Y
Clear
Heater
Heating Power (%)
Off
40
70
100
Heater On
Flow meter
Status I2C-Initialization
5001 CMD Timed Out
5002 Slave Not Responding
Status I2C-Read
5001
Flow (ml/min)
3561
Taking Control
To take control of the experiment, right-click anywhere in the window and select Request Control of VI.
For safety reasons the heater will be switched off and the application will reset itself after 30 minutes without user interaction.
You will receive a warning message 5 minutes before this reset.


cRIO-9074
NI 9401
NI 9485
NI 9213

Final Assignment

The final assignment:

- Short assignment (2.5 EC variant) or Extended assignment (5 EC variant)
- You can propose your own final assignment
- Combinations with work for your Bachelor assignment are possible
- We have a collection of possibilities for a final assignment (mainly short ones)

Learning outcomes

Computer as tool:

- Control of laboratory equipment.
- Computer interfacing with experiments for measurements (automation).
- Analysis and presentation of measurement data.
- Set up measurement-control-steer loops.

Programming environment LabVIEW:

- Graphical programming – diffusing the hardware–software interface.
- Design and realise a functional user interface to control an experiment.
- Communication & synchronisation of processes.
- Set-up distributed control & measurement structures.

Engineering:

- Design a (remote) measurement-control system.
- Realise the system using the appropriate hardware and software.
- Test the system, make a performance report and compare with the design criteria.

Scheduling & Grading

Scheduling:

- Choose between 2.5 EC (8 x 4h) and 5 EC (16 x 4h) variant
- Sessions scheduled in cooperation with coordinator and availability of lab
- The two versions differ in the extend of the final assignment

Grading:

- Compact journal of the introductory problems
- Report on the final assignment
- Discussion of the work and results

end