MERNI INFORMACIONI SISTEMI

Profesor dr Miroslav Lutovac

mlutovac@viser.edu.rs

Data Acquisition with LabVIEW

- Computer-based data acquisition and a software
- Matlab and other software tools used to model and simulate dynamic systems are at times used in laboratory setting although their use is often limited to specialized applications such as real-time control
- LabVIEW is the **prevalence in laboratory** setting
- LabVIEW is as an **extensive programming platform**
- multitude of functionalities ranging from **basic algebraic operators** to **advanced signal processing components** that can be **integrated into sophisticated** and **complex programs**
- ... only main ideas from LabVIEW ... lab. environment

Learning objectives

- Structure of PC-based data acquisition (DAQ) systems, the purpose of DAQ cards, and the role of LabVIEW
- Development of simple virtual instruments (VIs) using basic functionalities of LabVIEW
- Construction of functionally enhanced VIs using LabVIEW program flow control operations, such as the while loop and the case structure
- Development of VIs that allow for interaction with external hardware as, for instance, acquisition of external signals via DAQ card input channels and generation of functions using DAQ card output channels

Computer-Based Data Acquisition

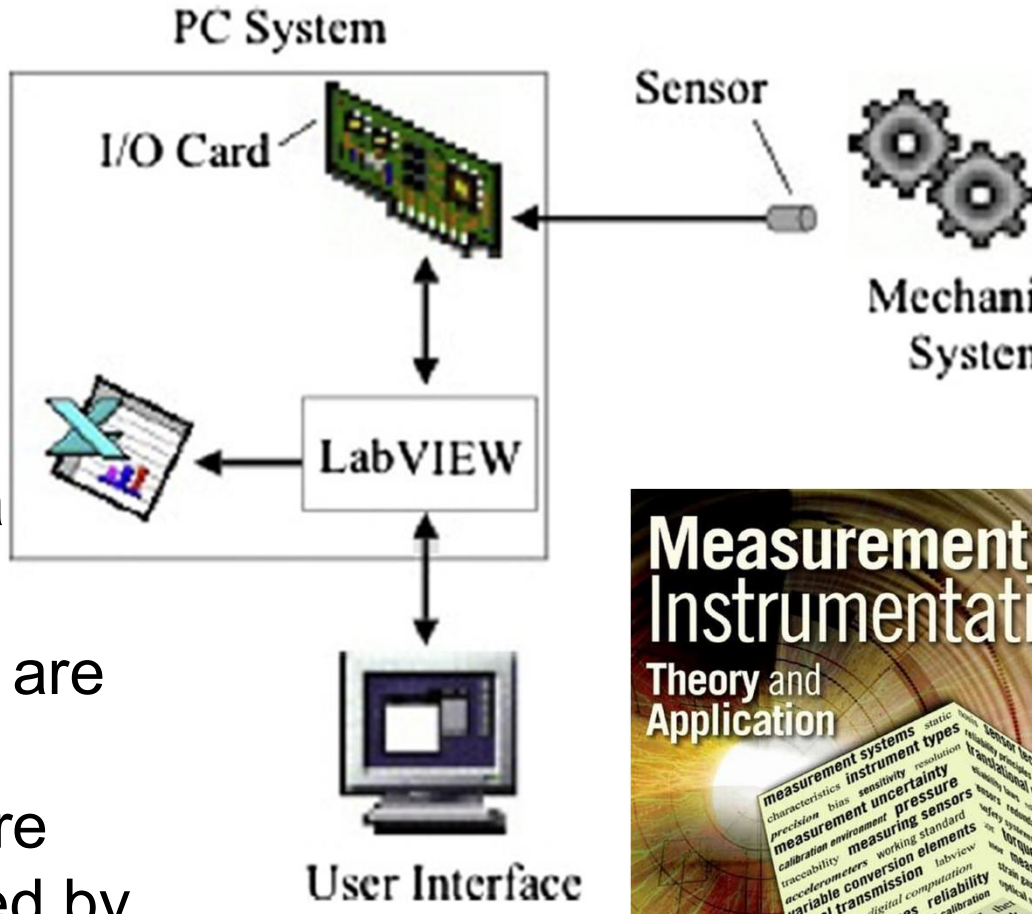
- In studying **verious systems**,
  use **electronic sensors** to measure certain variables,
  temperature - using thermocouples or RTDs,
  pressure - using piezoelectric transducers,
  strain - using strain gauges
- **Use PC to view and record** the data, using DAQcard
- Data can be stored and **converted to a format** that can be used by spreadsheets, Excel, or software packages, Matlab for extensive analysis
- **Digital processing** of data can be performed in real time via the same platform used to acquire the data
- **Real-time** data more useful for further processing

Acquisition of Data

- Conversion of analogue signals received from sensing instruments to digital representations that can be processed by the computer
- Incoming analogue data must be sampled at discrete time intervals and quantized to one of a set of predefined values accomplished using a digital-to-analogue (D/A) conversion component on the DAQ card inside the PC or interconnected to it via a Universal Serial Bus (USB) port
- Laptop computers and low-profile PCs generally require the use of USB-based DAQ devices

National Instruments LabVIEW

- LabVIEW is a software package that provides the functional tools and a user interface for data acquisition
- depicts a schematic of data flow in the data acquisition process
- certain measurements are taken from the given physical system and are acquired and processed by data acquisition system



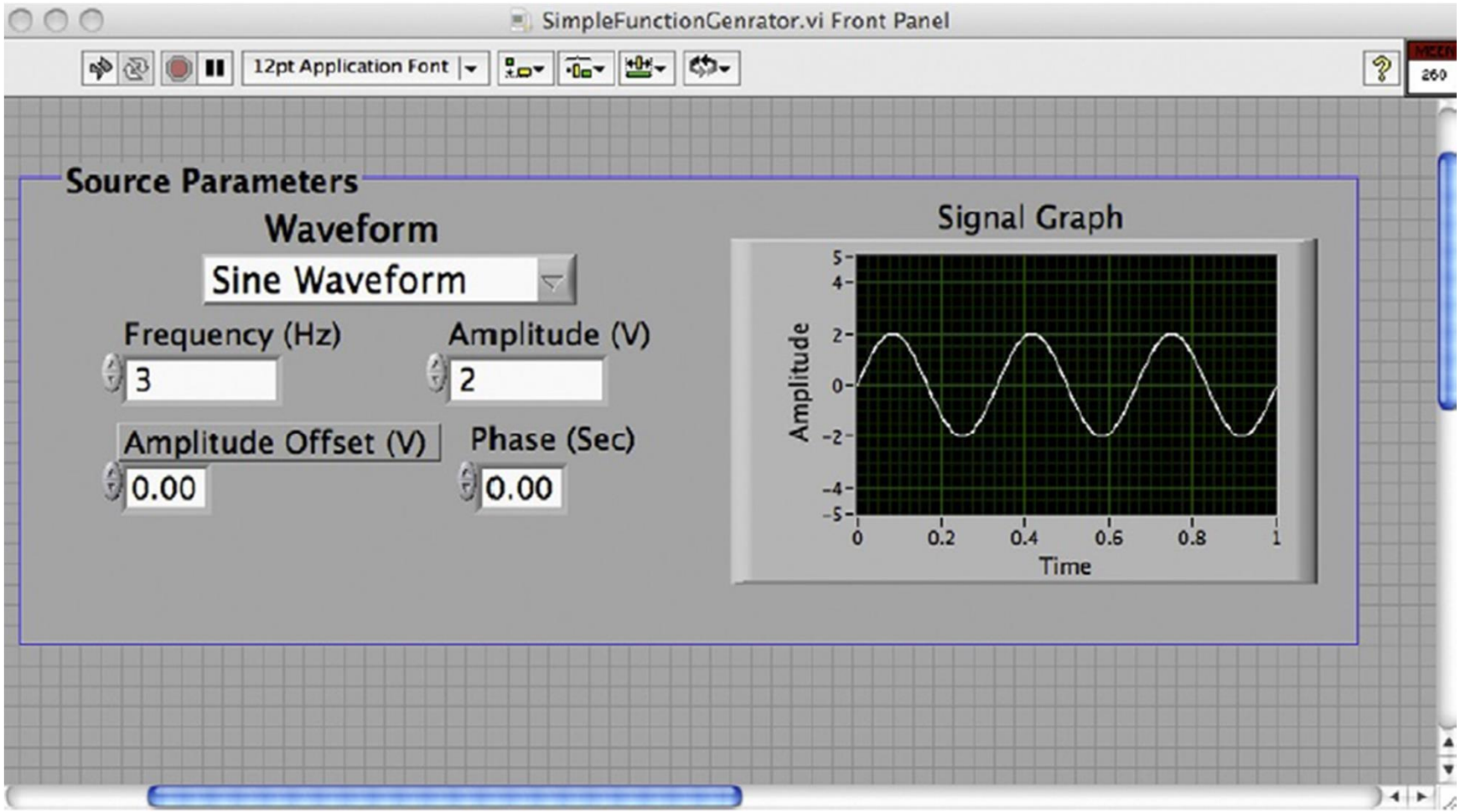
LabVIEW

- Through the use of VIs, LabVIEW directs the real-time sampling of sensor data through the DAQ card (I/O card) and is capable of storing, processing, and displaying the collected data
- Sensors transmit analogue readings to the DAQ card
- Analogue data are then converted to individual digital values by the DAQ card and are made available to LabVIEW
- To display to the user
- it is preferable to export the data to a spreadsheet for detailed analysis and graphical presentation

Virtual Instruments (VI)

- A VI is a program that simulates physical or hard instruments (oscilloscopes or function generators)
- The front panel acts as the user interface,
  while data acquisition (in this case the generation process) is performed by a combination of the PC and the DAQ card
- The front panel window contains controls (knobs and switches) that allow the user to modify certain parameters during the experiment
- include a selector to choose the type of waveform and numerical controls to choose the frequency and amplitude of the generated waveform, phase, amplitude, offset

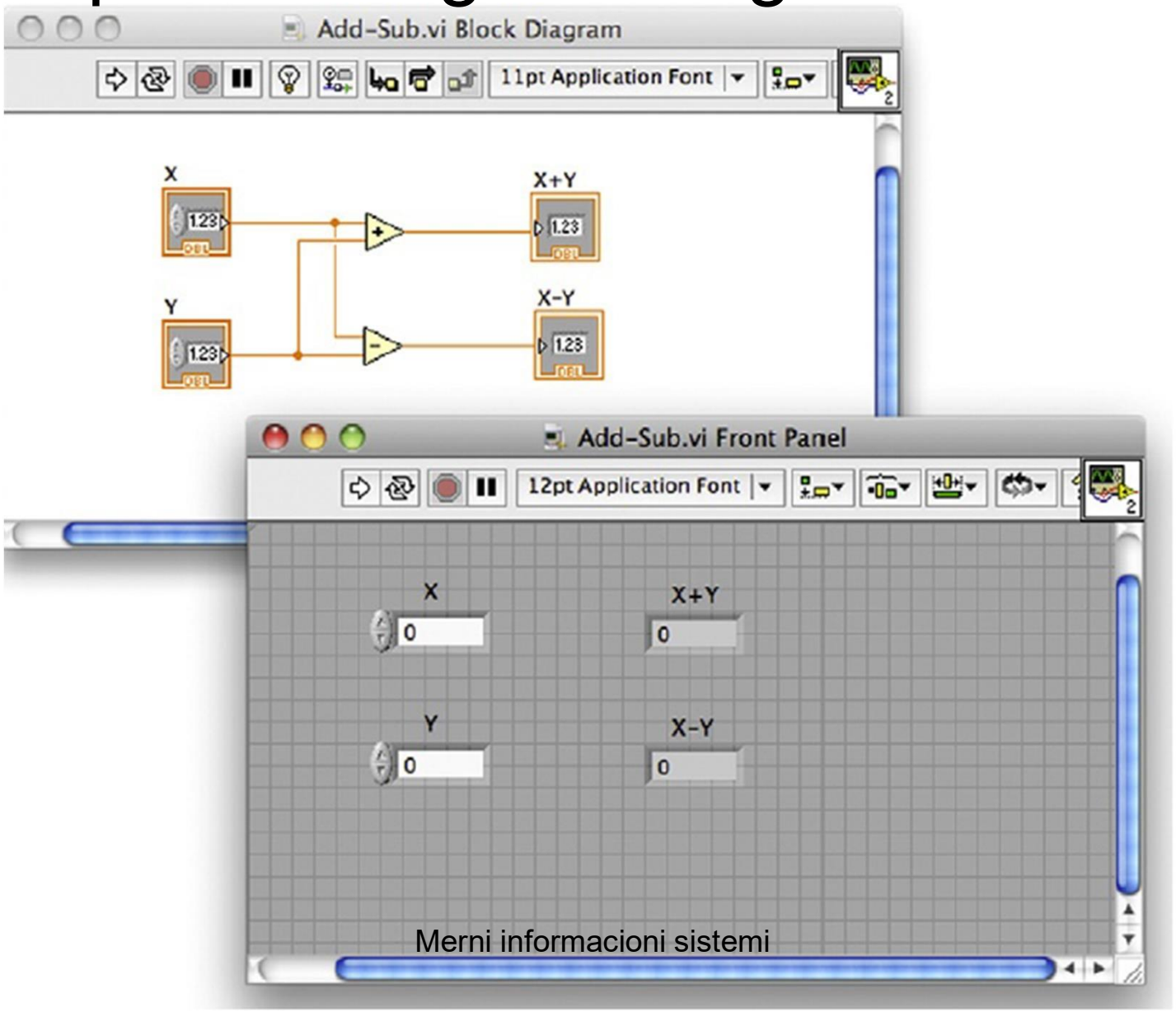
LabVIEW


SimpleFunctionGenrator.vi Front Panel
12pt Application Font
Source Parameters
Waveform
Sine Waveform
Frequency (Hz)
3
Amplitude (V)
2
Amplitude Offset (V)
0.00
Phase (Sec)
0.00
Signal Graph
Amplitude
Time
5
4
2
0
-2
-4
-5
0
0.2
0.4
0.6
0.8
1

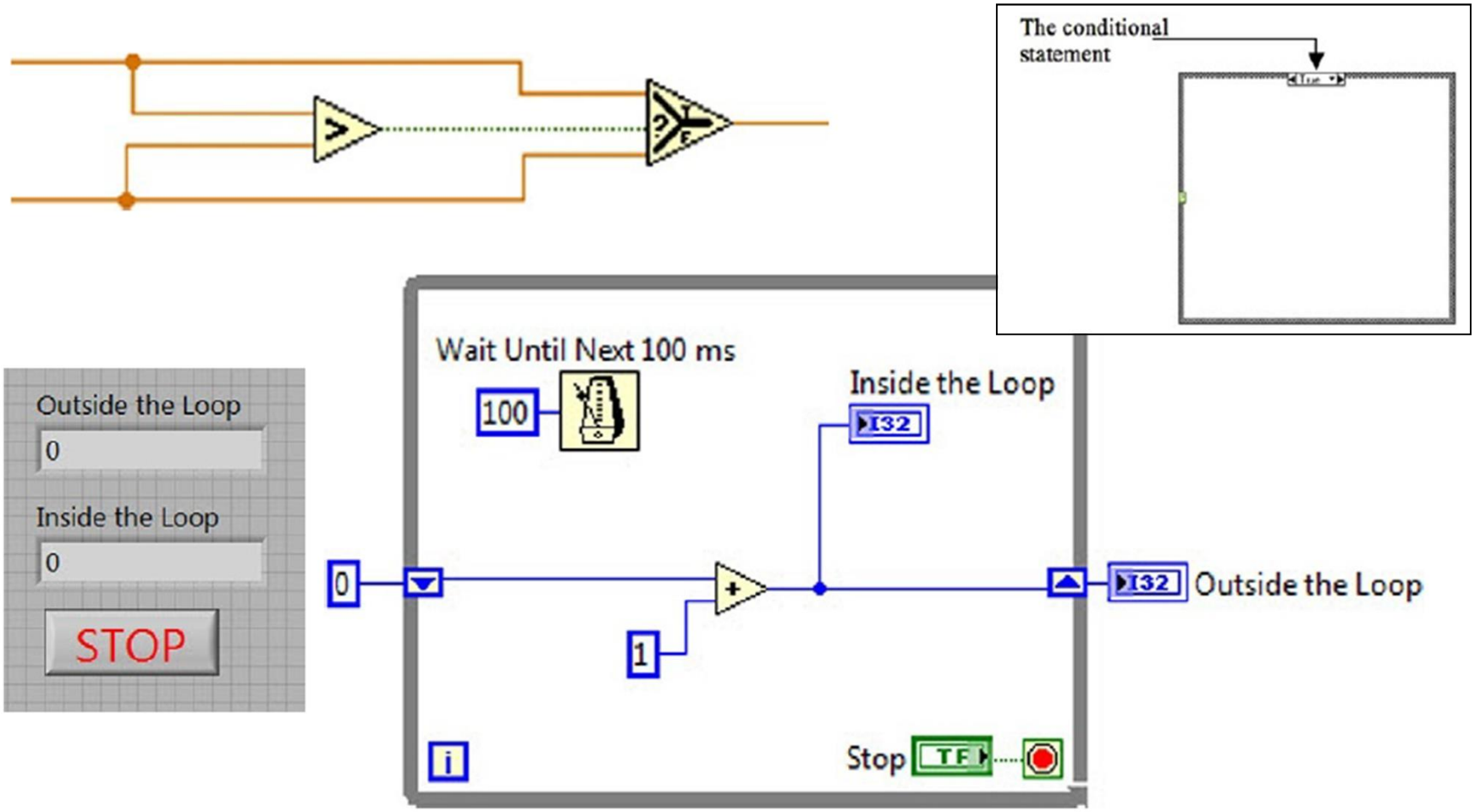
LabVIEW

- The front panel contains indicators that display data or other important information related to the experiment
- Graph is used to depict the waveform
- The block diagram is analogous to the wiring and internal components of a real instrument
- The configuration of the VI's block diagram determines how front panel controls and indicators are related
- It also incorporates functions such as communicating with the DAQ card and exporting data to disk files in spreadsheet format

Graphical Programming in LabVIEW



Graphical Programming in LabVIEW



Data Acquisition Using LabVIEW

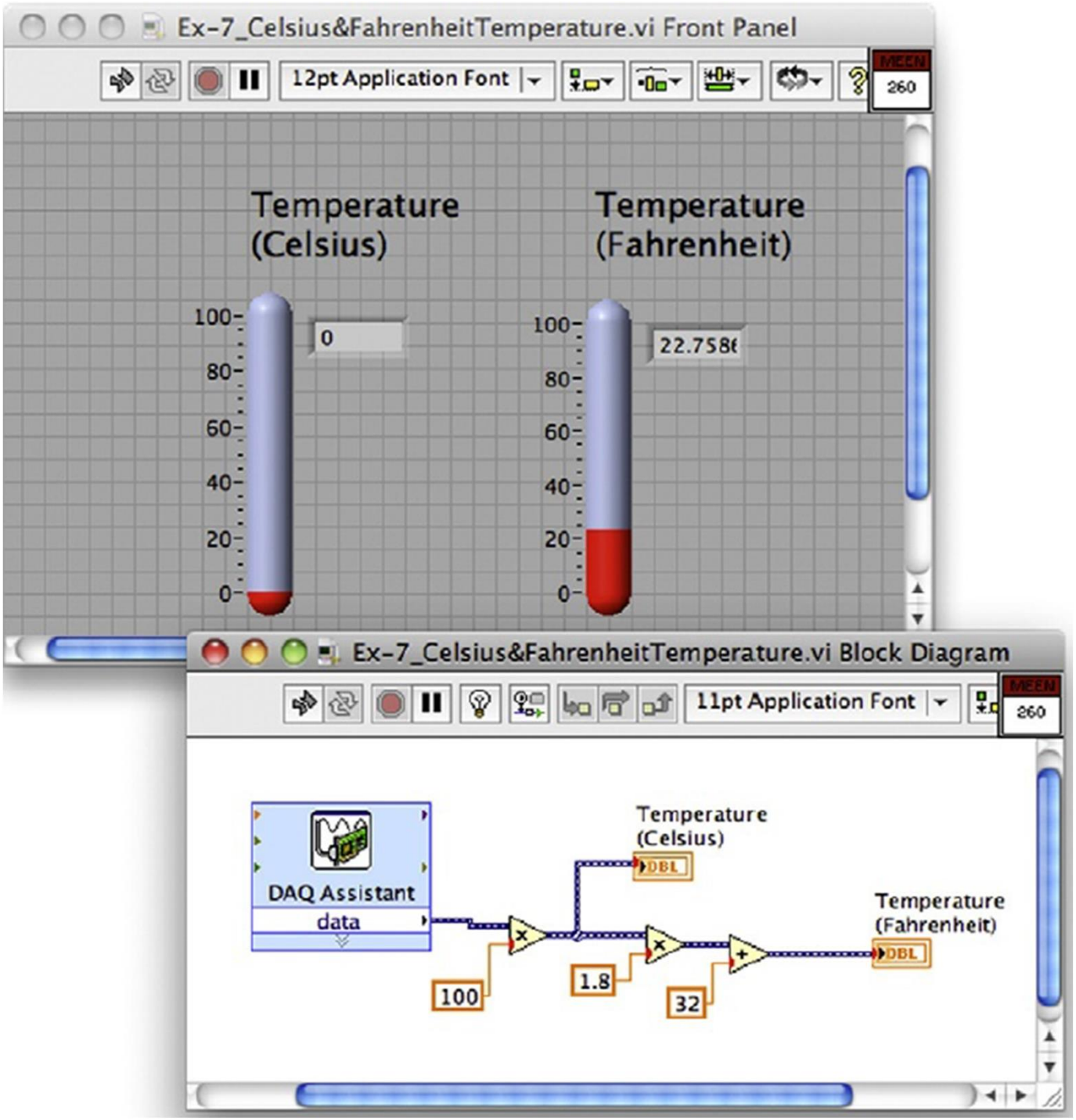
- LabVIEW is primarily a data acquisition tool
- The typical setup in the laboratory
- Terminal box is needed to obtain the input from sensors and to allow a way to produce output voltages from the data acquisition card

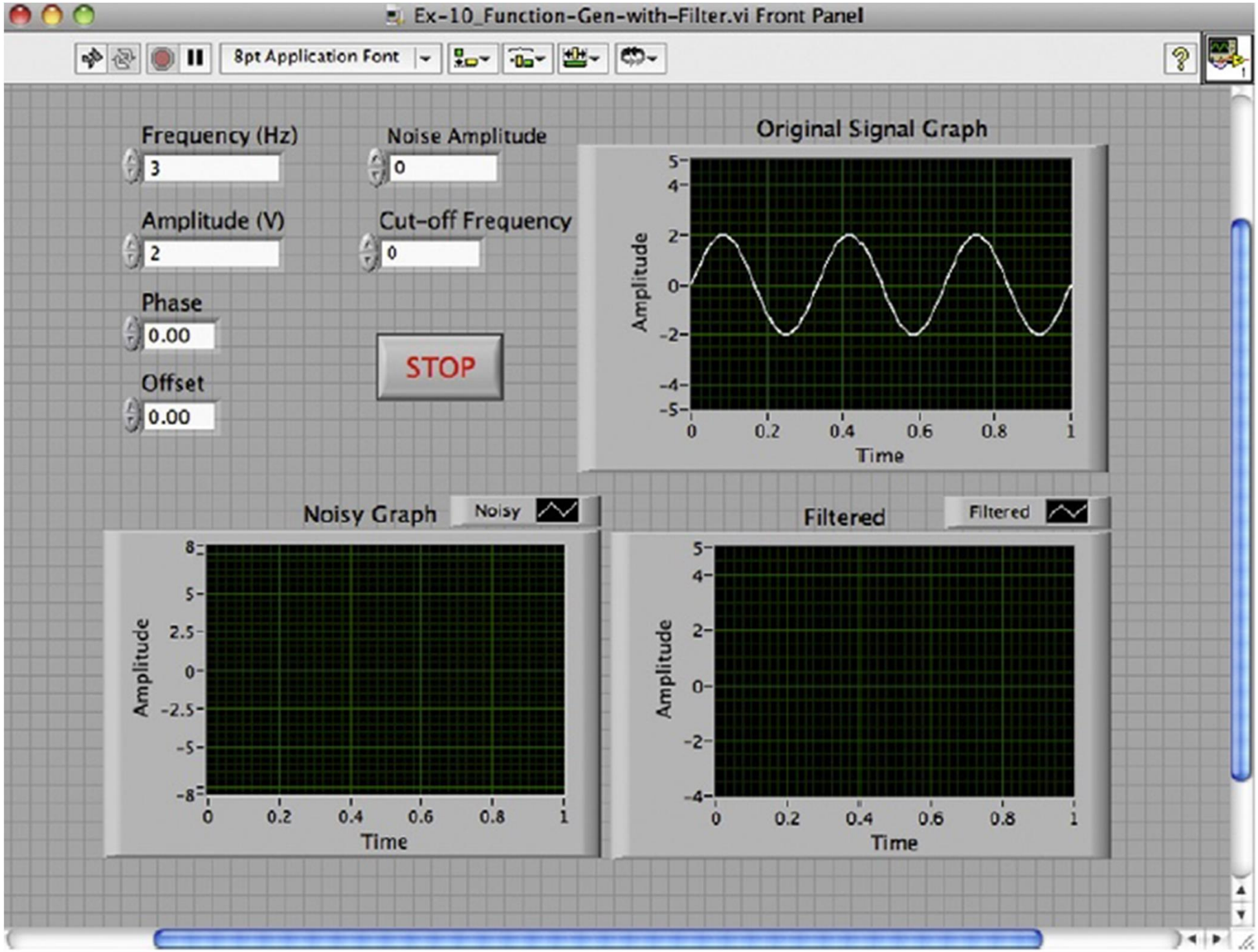
typical setup for LabVIEW-based data acquisition

NI BNC-2120 connector block

LabVIEW

- equipment is used to generate a sine, triangle, square wave
- The amplitude of the wave can be adjusted - amplitude knob
- The frequency of the wave - relevant buttons
- The main use of this device in the present context is to produce an external input to a custom VI, which converts the voltage produced by the function generator into a temperature reading
- Functions related to communication with the DAQ card are handled by the “DAQ Assistant” function
- The board ID and channel settings specify information about the DAQ card that tells the VI where to look for data


Ex-7_Celsius&FahrenheitTemperature.vi Front Panel
12pt Application Font
Temperature (Celsius)
Temperature (Fahrenheit)
100
80
60
40
20
0
0
22.758
Ex-7_Celsius&FahrenheitTemperature.vi Block Diagram
11pt Application Font
DAQ Assistant
data
Temperature (Celsius)
Temperature (Fahrenheit)
DBL
100
1.8
32


Ex-10_Function-Gen-with-Filter.vi Front Panel
8pt Application Font
Frequency (Hz)
3
Noise Amplitude
0
Amplitude (V)
2
Cut-off Frequency
0
Phase
0.00
Offset
0.00
STOP
Original Signal Graph
Amplitude
Time
Noisy Graph
Noisy
Filtered
Filtered

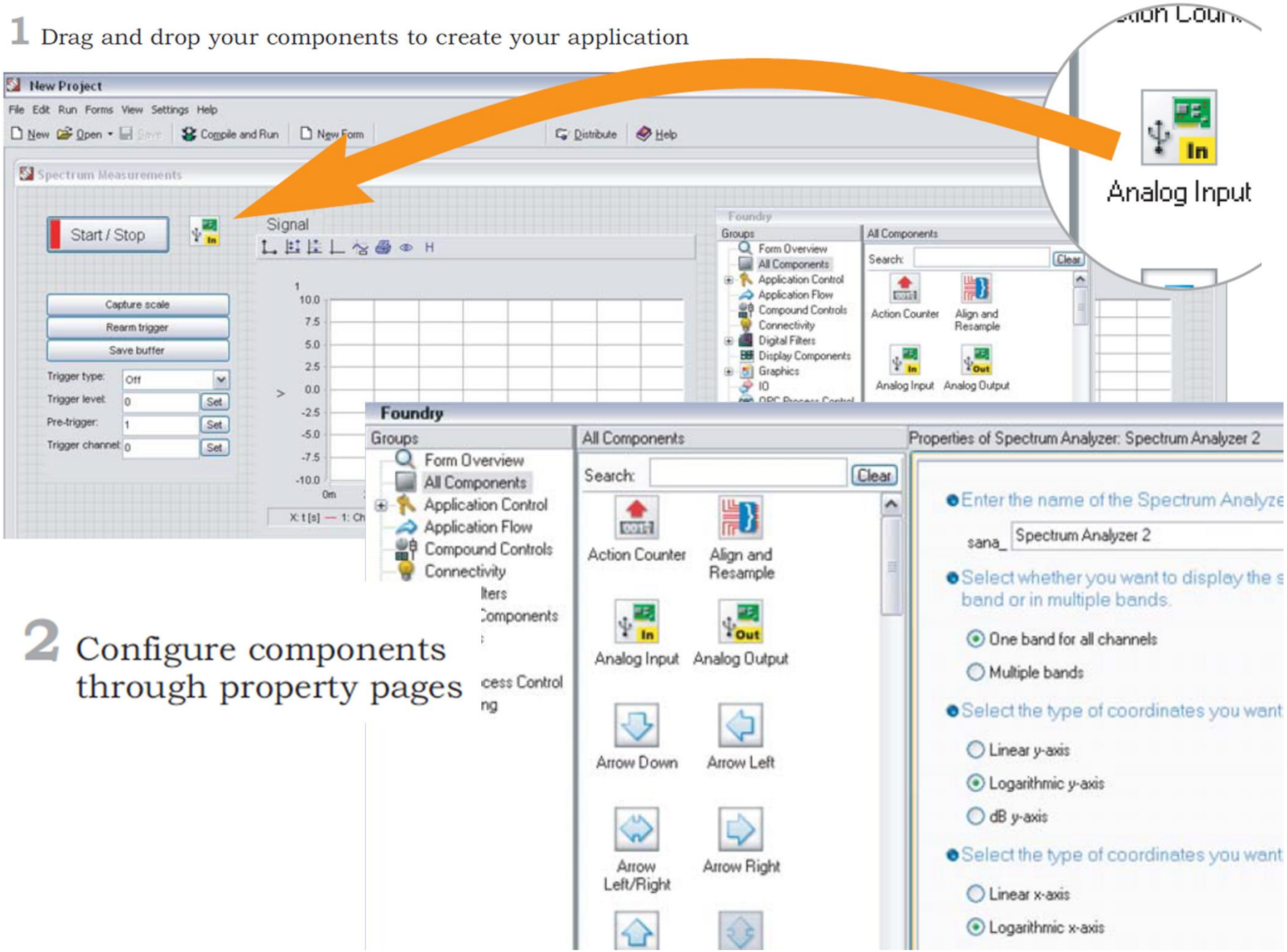
measure FOUNDRY™
Open. Powerful.
Application Builder for
Test & Measurement Systems.

Measurement Foundry

- Measurement Foundry is produced by Data Translation and has capabilities for rapid application development for .NET class library and compliant hardware
- It offers the ability to acquire, synchronize, and correlate data and to perform control loop operations
- It also features automatic documentation of programs and links with Excel and Matlab

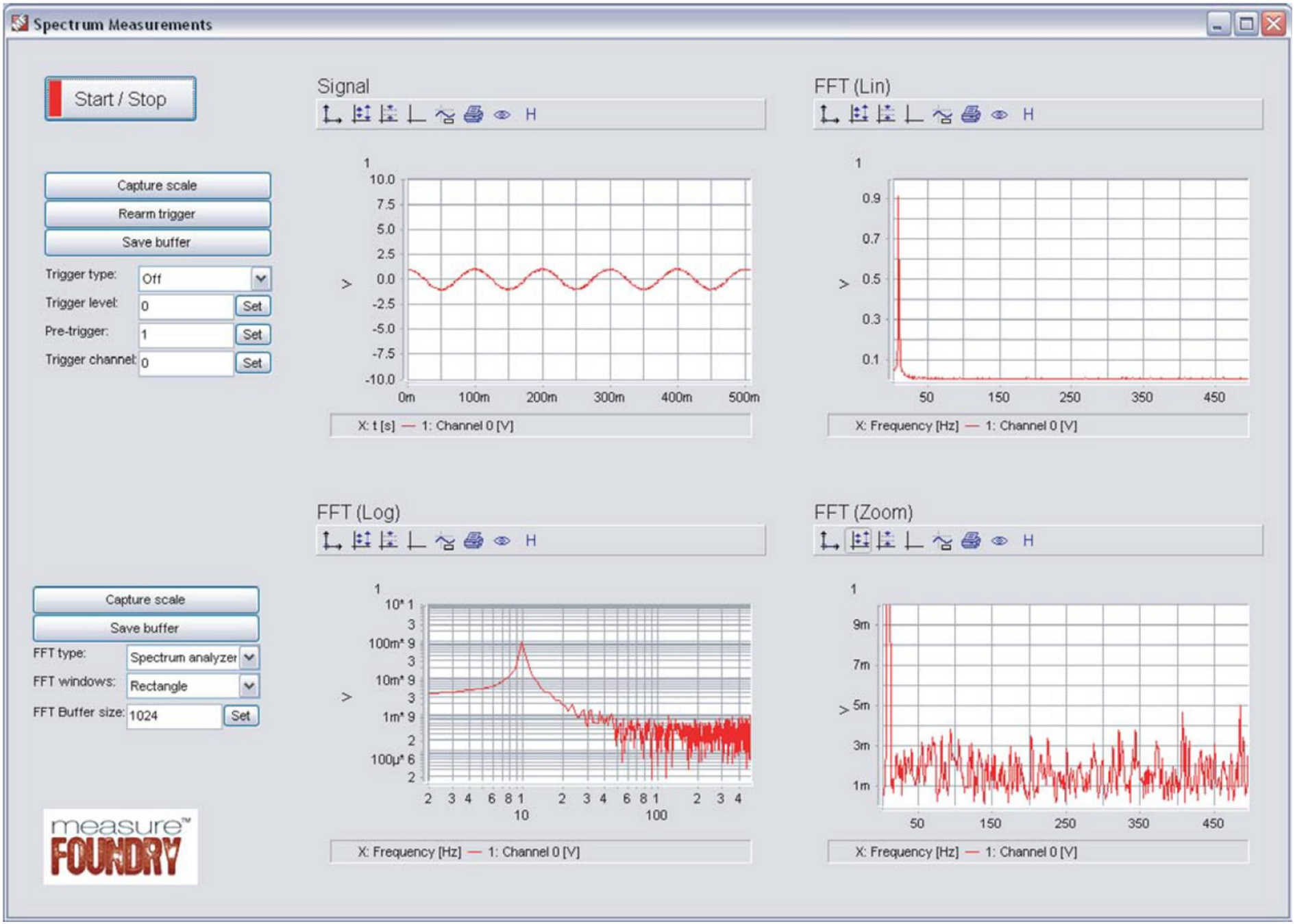
DATA TRANSLATION®
www.datatranslation.com

1 Drag and drop your components to create your application



2 Configure components through property pages

3 Compile and Run

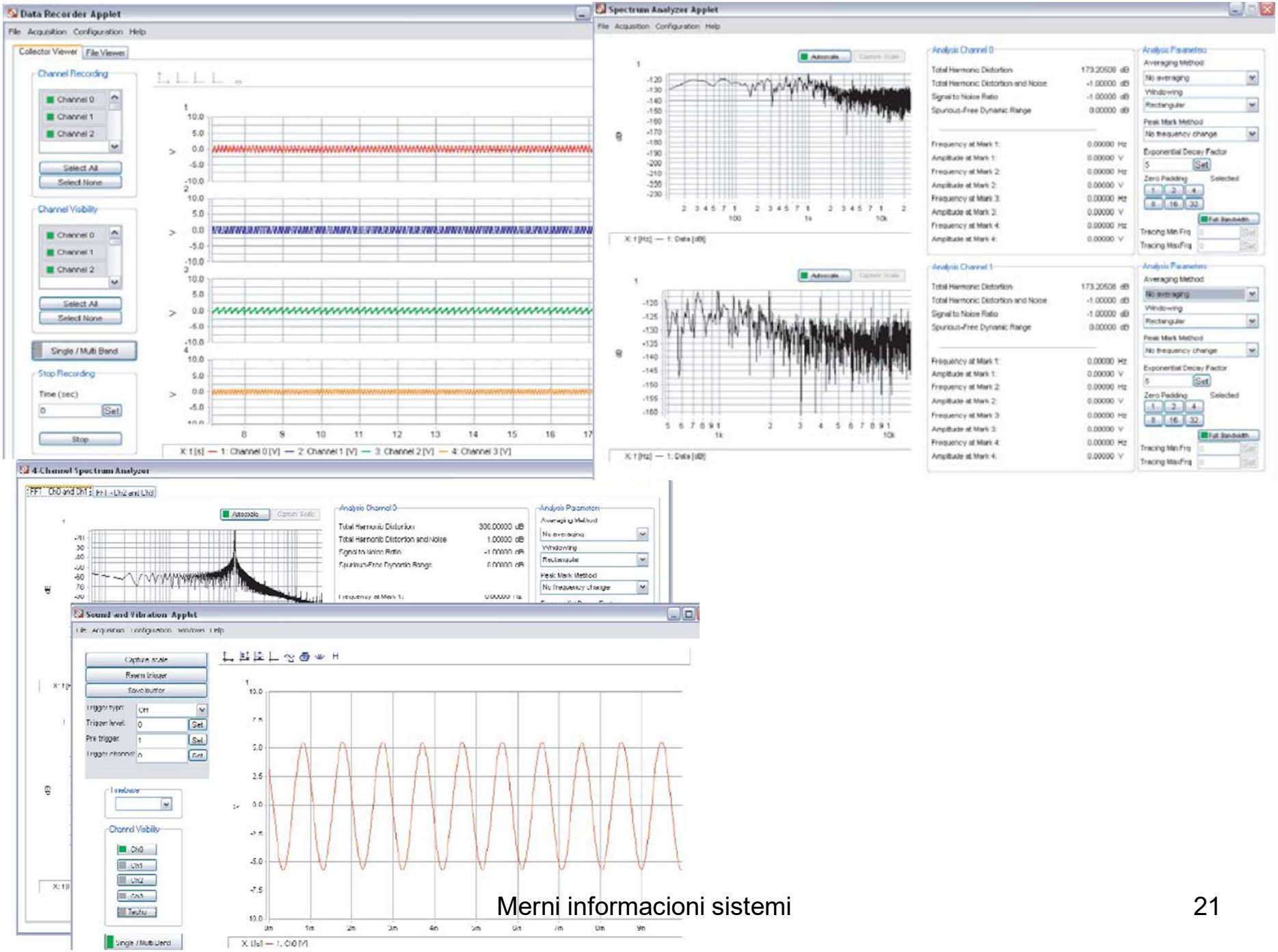


4 Distribute applications royalty-free to your end users

Development

One-Click Distribution

Deployment

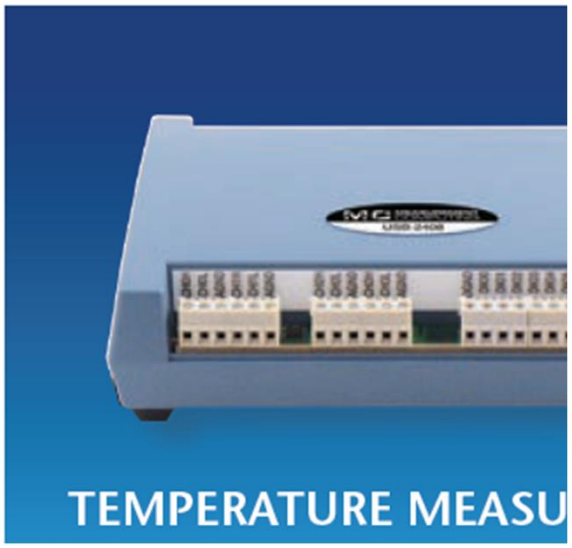

Data Recorder Applet
File Acquisition Configuration Help
Collector Viewer
File Viewer
Channel Recording
Channel 0
Channel 1
Channel 2
Select All
Select None
Channel Visibility
Single / Multi Band
Stop Recording
Time (sec)
Set
Stop
X: t [s] — 1: Channel 0 [V] — 2: Channel 1 [V] — 3: Channel 2 [V] — 4: Channel 3 [V]
Spectrum Analyzer Applet
File Acquisition Configuration Help
Autoscale
Analysis Channel 0
Total Harmonic Distortion
Total Harmonic Distortion and Noise
Signal to Noise Ratio
Spurious-Free Dynamic Range
Frequency at Mark 1:
Amplitude at Mark 1:
Frequency at Mark 2:
Amplitude at Mark 2:
Frequency at Mark 3:
Amplitude at Mark 3:
Frequency at Mark 4:
Amplitude at Mark 4:
Analysis Parameters
Averaging Method
No averaging
Windowing
Rectangular
Peak Mark Method
No frequency change
Exponential Decay Factor
Zero Padding
Selected
Full Bandwidth
Tracing Min Frq
Tracing Max Frq
Analysis Channel 1
4-Channel Spectrum Analyzer
Sound and Vibration Applet
Capture scale
Reset trigger
Save buffer
Trigger type
Trigger level
Pre trigger
Trigger channel
Channel Visibility
Ch0
Ch1
Ch2
Ch3
Trig/Ev
Single / Multi Band

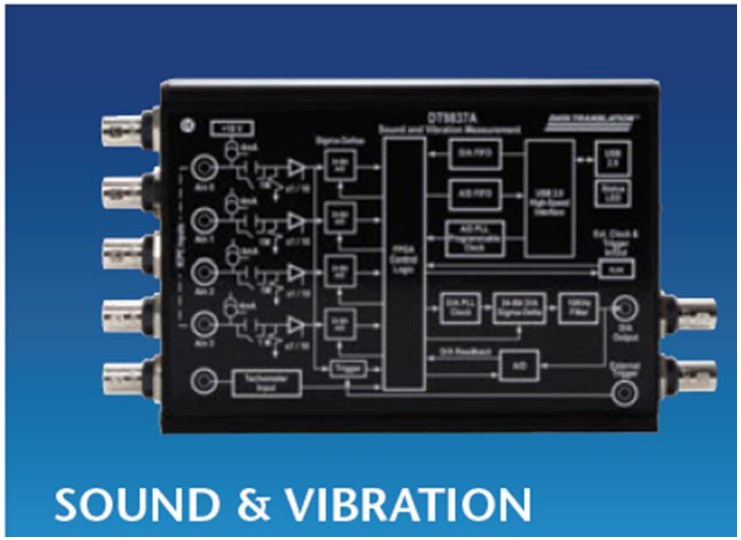
MEASUREMENT COMPUTING™

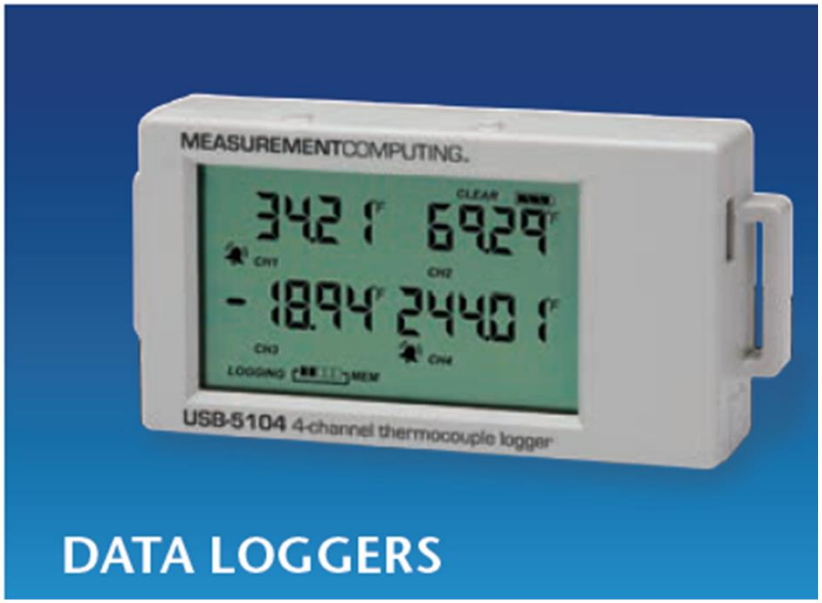
High quality Data Acquisition, and Data Loggers that are easy-to-use, easy-to-integrate and easy-to-support.

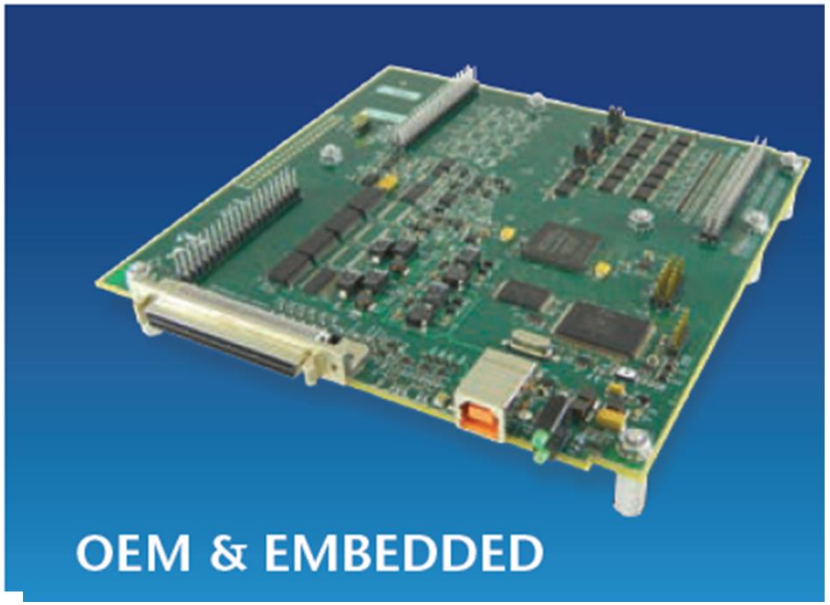
DasyLab

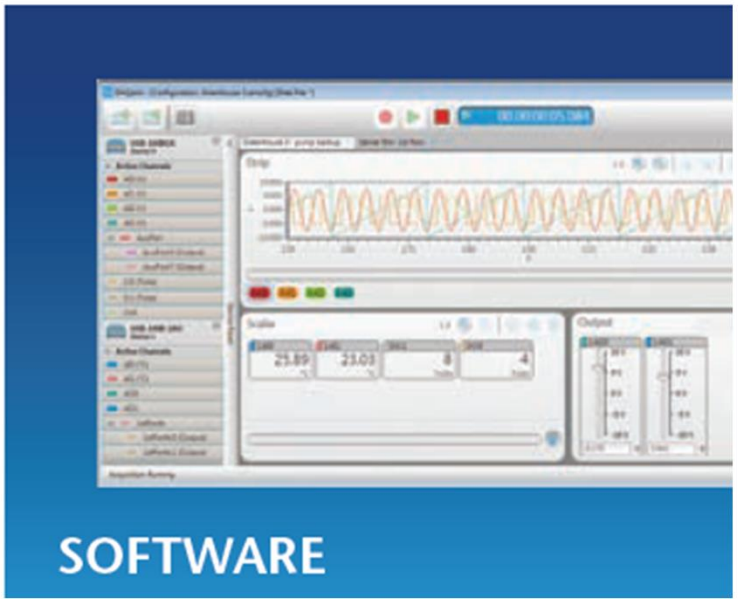
- DasyLab from Measurement Computing Corporation (MCC) allows for the integration of graphical functions, real-time operations, including PID control, and real-time display via charts, meters, and graphs, and incorporates an extensive library of computational functions
- It provides serial, OPC, ODBC, network interface functions and supports data acquisition hardware (MCC, Iotech)











16-BIT MULTIFUNCTION

From $26

USB-230 Series

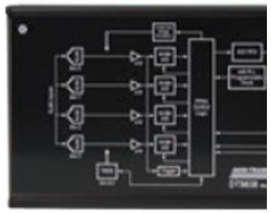
Analog Inputs	8 SE/4 DIFF
Resolution	16-bit
Sample Rate	Up to 100 kS/s
Simultaneous	—
Isolated	—
Analog Outputs	2
Digital I/O	8
Counters	1 x 32-bit

- Software support for Windows

BRIDGE-BASED SENSORS — Only

DT9838

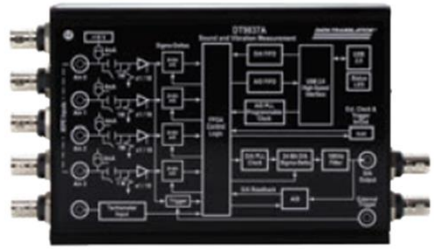
Analog Inputs	4 DIFF
Bridge Inputs	✓
Programmable Excitation	✓
Voltage Inputs	±250 mV
Resolution	24-bit
Sample Rate	52.7 kS/s/Ch
Simultaneous	✓
Digital I/O	1 Tachometer



PORTABLE USB — From $1,595

DT9837 Series

Analog Inputs	4 SE†
Resolution	24-bit
Sample Rate	Up to 105.4 kS/s/Ch
Simultaneous	✓
Isolated	—
Analog Outputs	Up to 1
Digital I/O	—
Tachometer	Up to 1

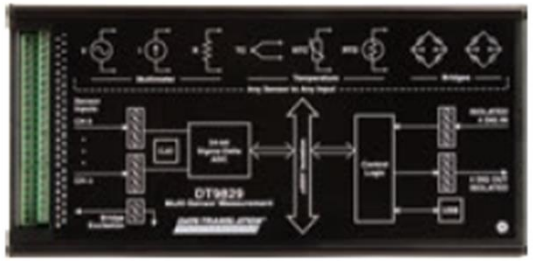


† Direct IEPE inputs, sync port for channel expansion

MULTI SENSOR — Only $1,870

DT9829-8

8 DIFF	
✓	
✓	
✓	
24-bit	
960 S/s	
—	
8	



- Software support for Windows

SIGNAL ANALYZER ARM — Only $2,305

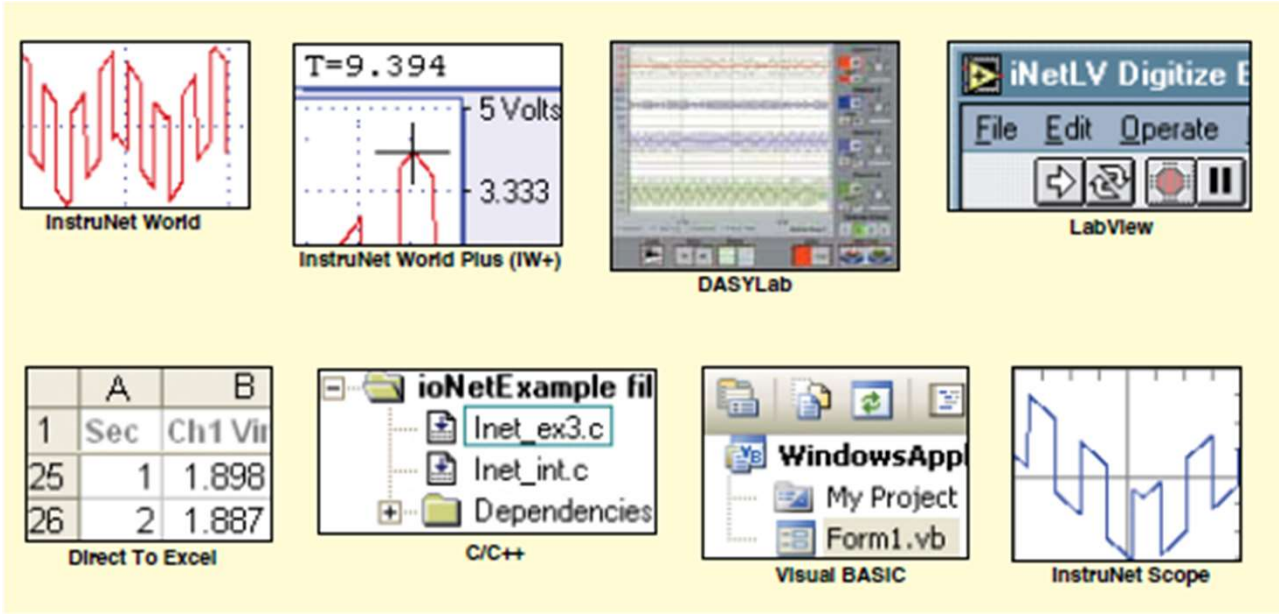
DT7837

Analog Inputs	4 IEPE
Resolution	24-bit
Sample Rate	105.4 kS/s/Ch
Simultaneous	✓
Analog Outputs	1
Digital I/O	16
Interface	Ethernet, USB, microSD

- Embedded ARM processor and Linux on-board

iNET-iWPLUS

- a distributor of DAQ cards and sensors, can be used to generate analogue and digital output waveforms and run feedback/control loops, such as PID, and has capabilities similar in concept to LabVIEW, which allow for the creation of custom virtual instruments

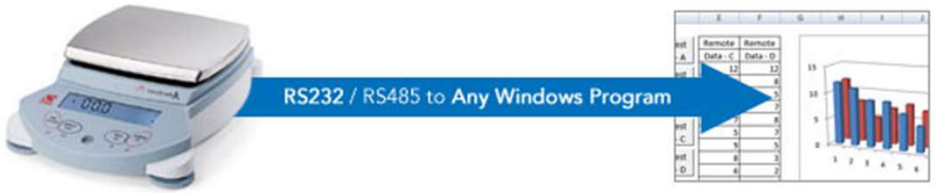


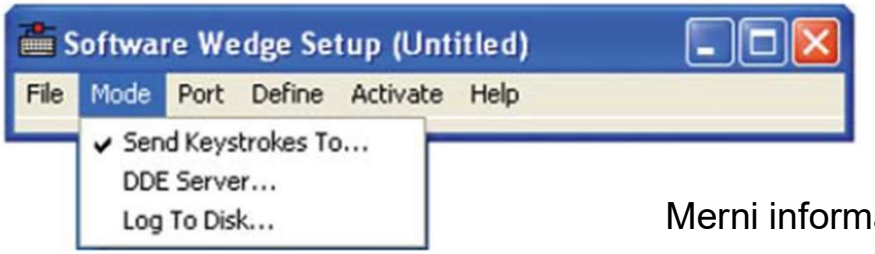
WinWedge® and WinWedge Pro

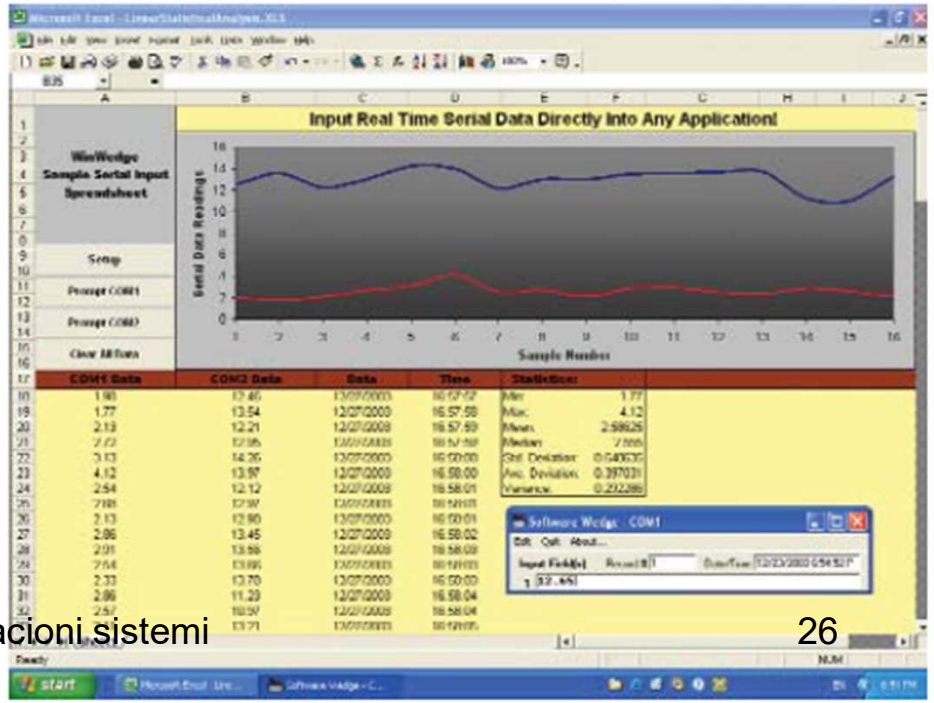
Capture Any RS232 Data Directly Into Any Windows Application

WinWedge

- WinWedge is data acquisition software that uses a Microsoft Windows Dynamic Data Exchange mechanism to provide data acquisition and instrument control in conjunction with Microsoft Excel, Access
- It provides a menu-driven configuration program and is used mainly in conjunction with serial data streams.

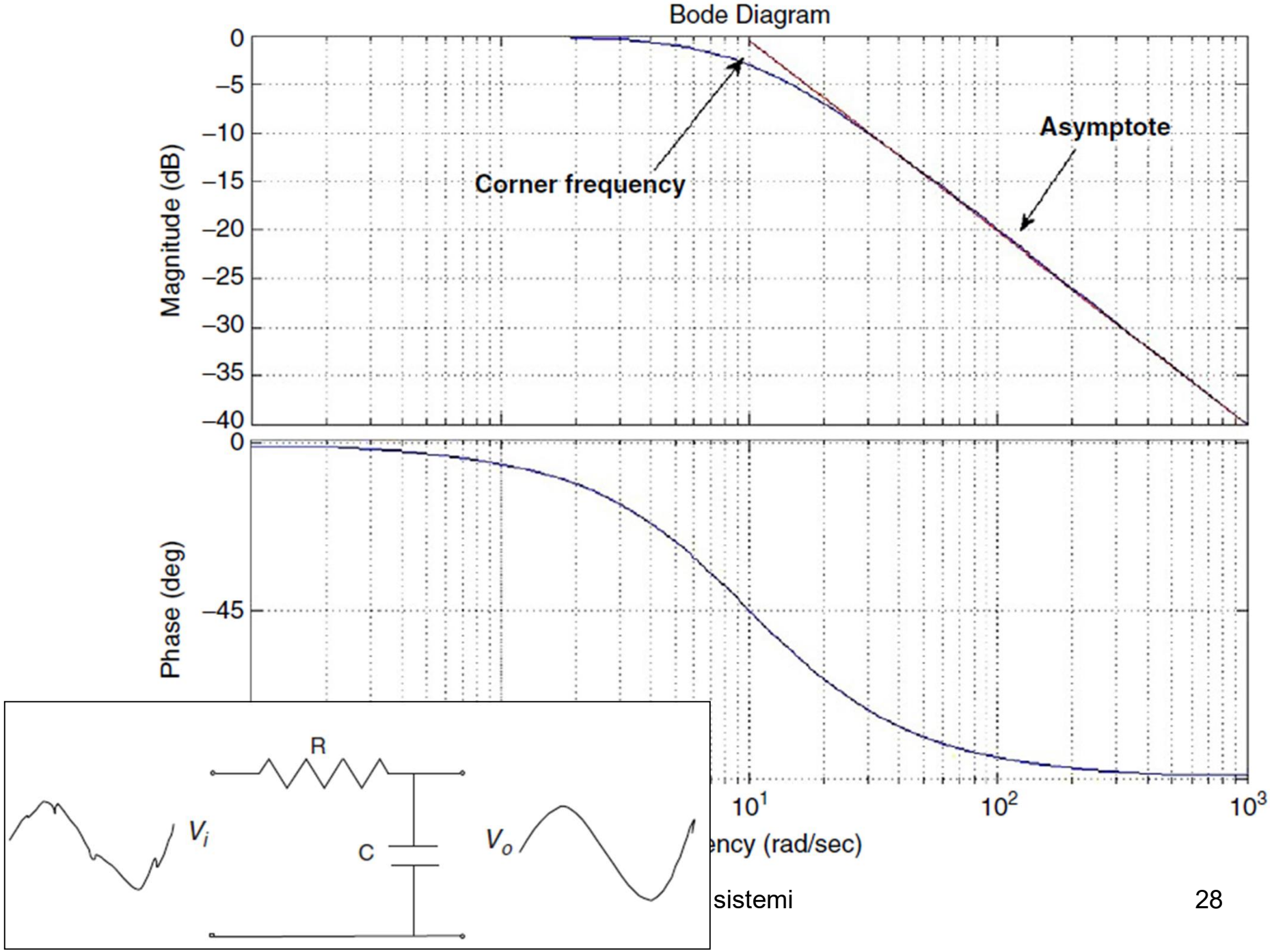


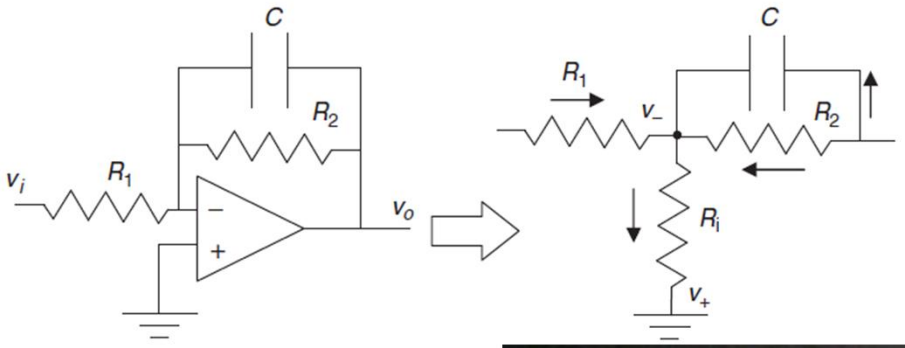


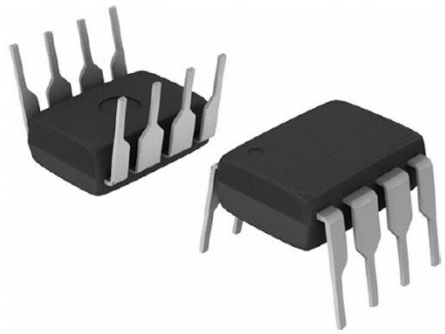


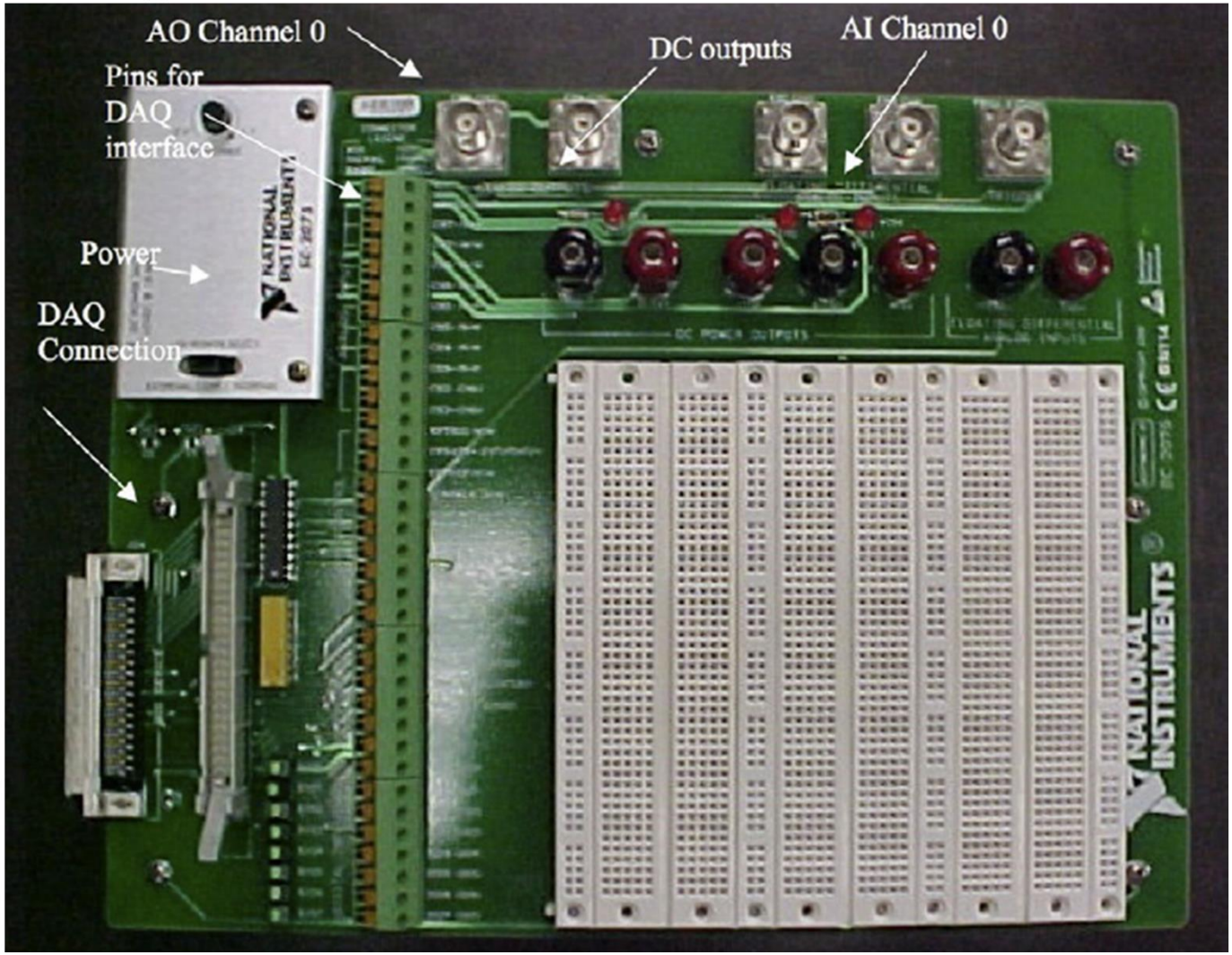
Data Processing with LabVIEW

- Analogue Filters - passive (resistors and capacitors) and active components (operational amplifiers)
- Digital Filters
- Analogue and digital filters are used extensively in sensor signal processing
- pre- and post-processing of sensor signals
- Analogue filters - the so-called aliasing phenomenon
- Digital filters are generally used to post-process acquired signals
- DF can be used in conjunction with sophisticated digital signal-processing techniques such as Fast Fourier Transform to perform spectral analysis of acquired signals


Bode Diagram
Magnitude (dB)
0
–5
–10
–15
–20
–25
–30
–35
–40
Corner frequency
Asymptote
Phase (deg)
0
–45
10^1
10^2
10^3
ency (rad/sec)
R
C
V_i
V_o

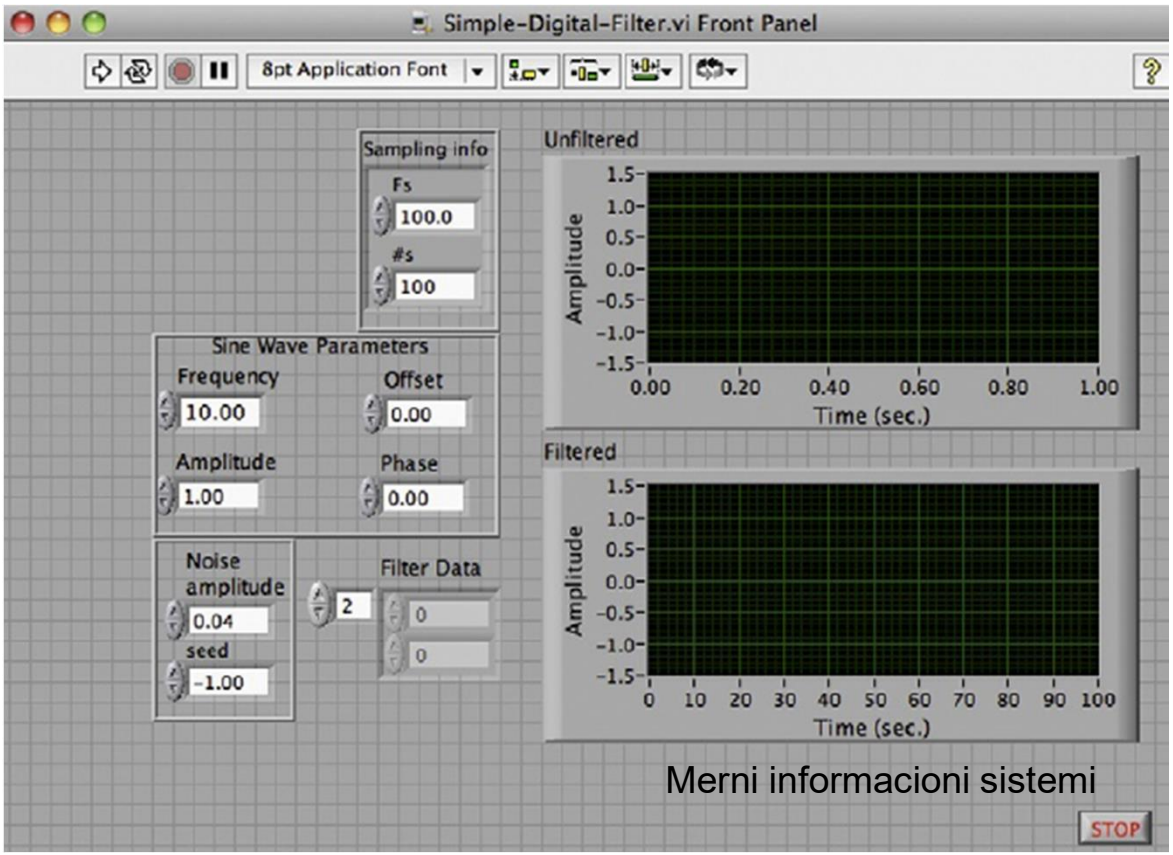

C
R2
vi
R1
vo
C
R1
v–
R2
Ri
v+



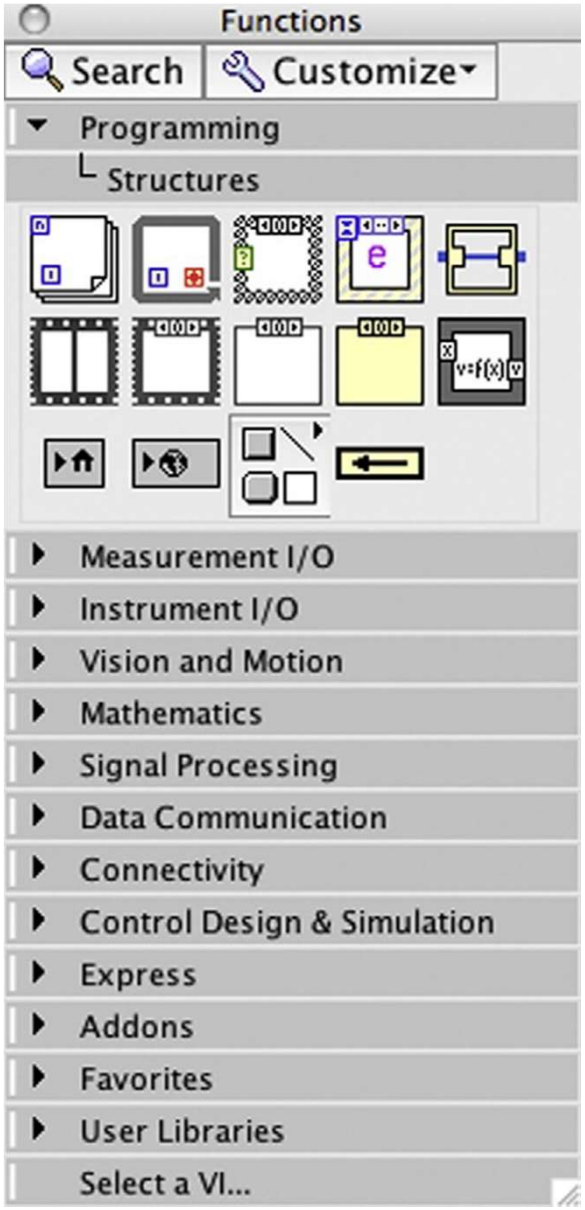

AO Channel 0
Pins for
DAQ
interface
Power
DAQ
Connection
DC outputs
AI Channel 0
NATIONAL INSTRUMENTS

LabVIEW Implementation

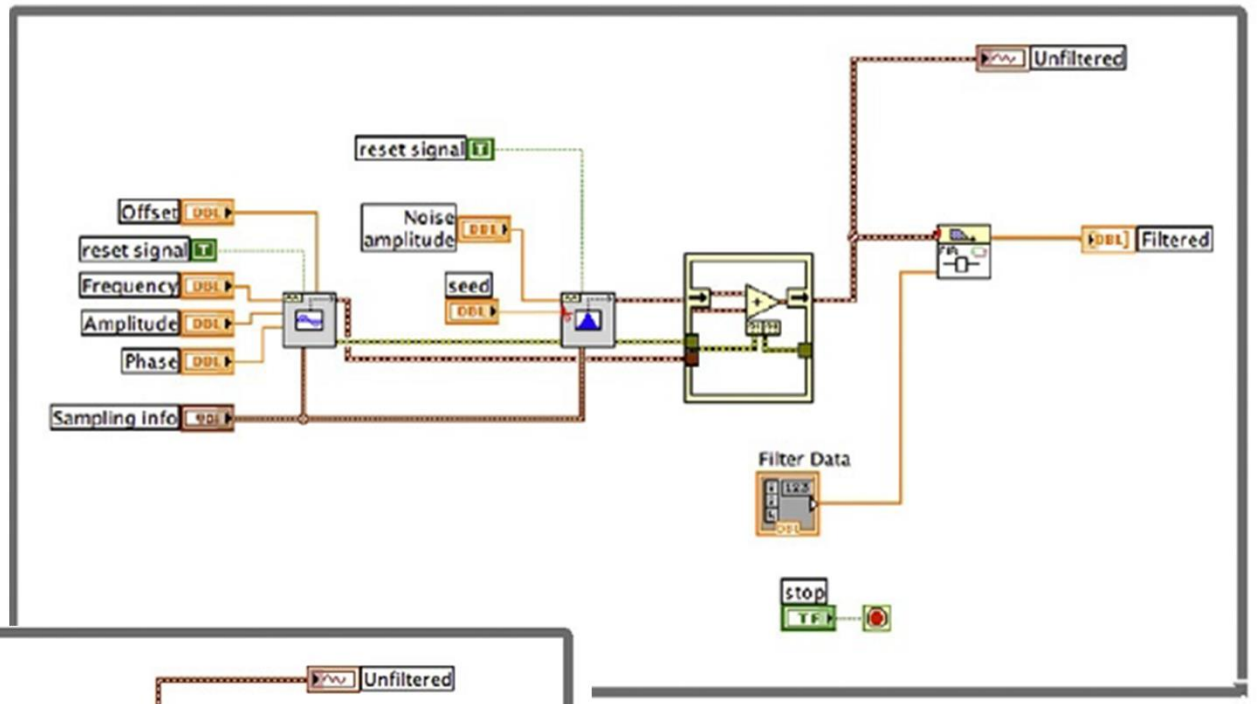
- Implement digital filter in LabVIEW
- sinusoidal signal generator + noise generator
- addition of individual data elements

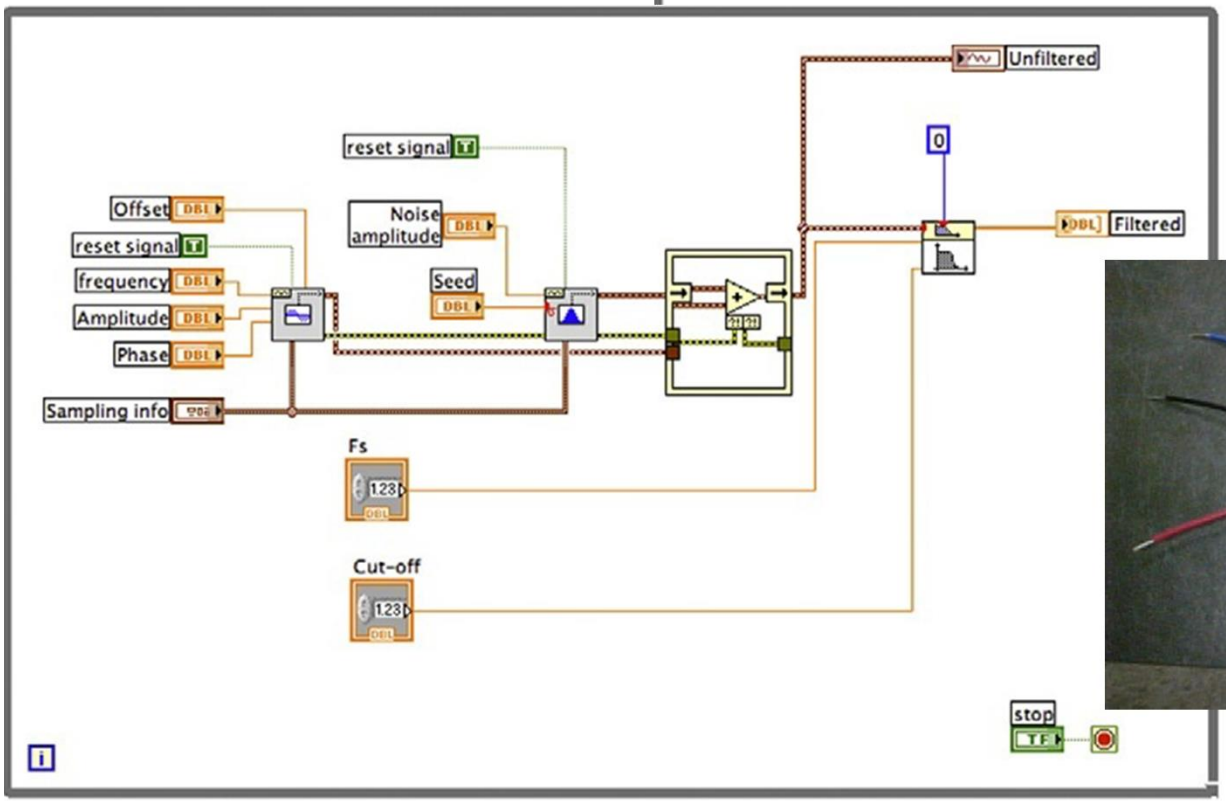


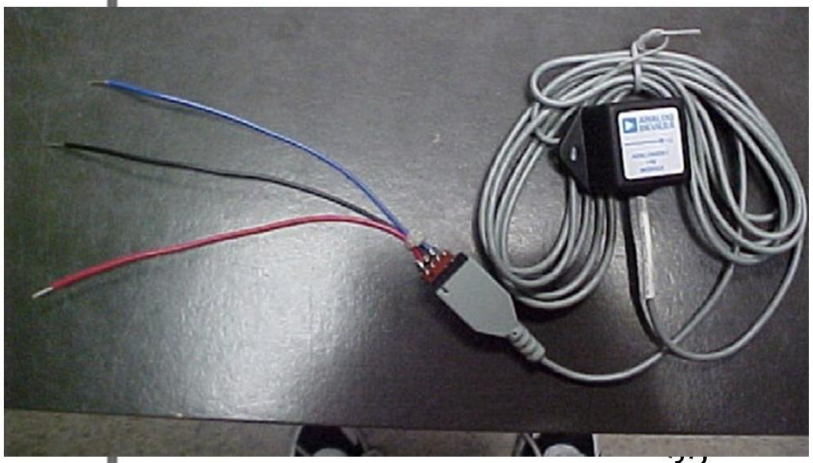
LabVIEW Implement digital filter



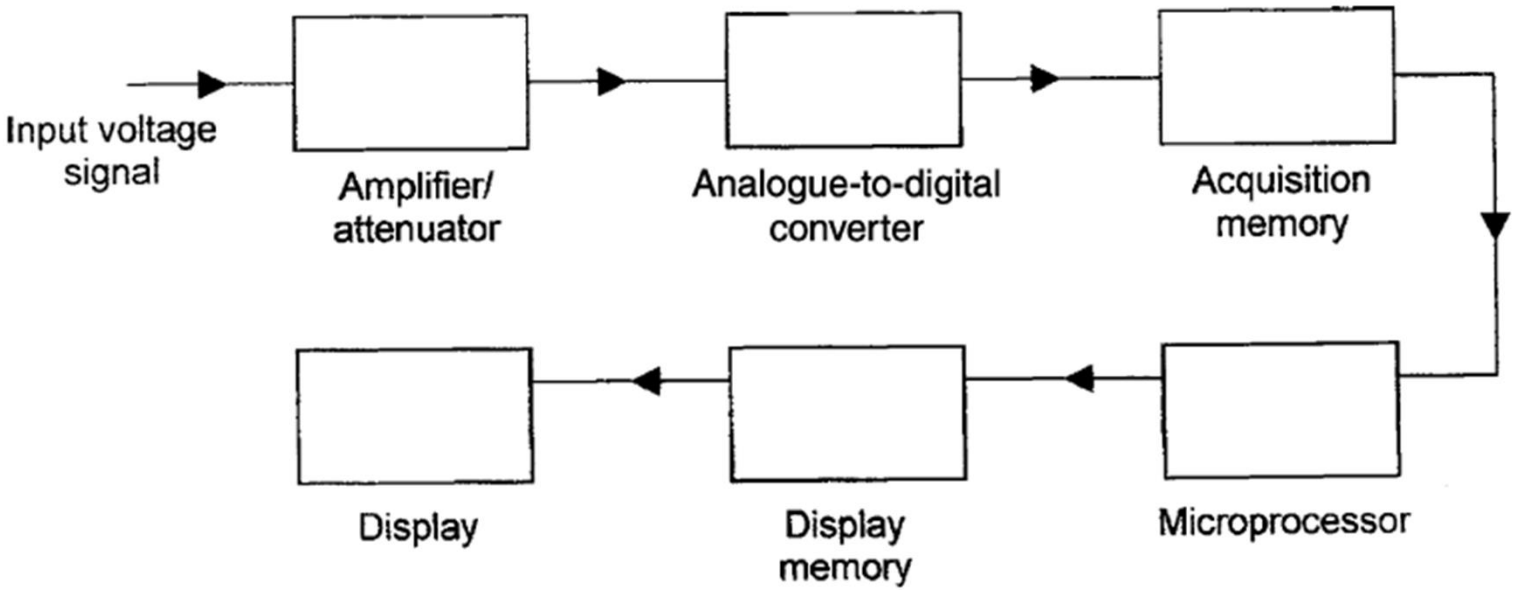
- Sub-palette of the functions palette


Unfiltered
reset signal
Offset
Noise amplitude
reset signal
seed
Frequency
Amplitude
Phase
Filtered
Sampling info
Filter Data
stop


Unfiltered
reset signal
0
Offset
Noise amplitude
reset signal
Seed
frequency
Amplitude
Filtered
Phase
Sampling info
Fs
Cut-off
stop



Digital storage oscilloscope



Personal Computer-Based Oscilloscope

- PC-based oscilloscope consists of a hardware unit that connects to a standard PC via either a USB or a parallel port
- The hardware unit provides signal scaling, analogue-to-digital conversion, and buffer memory functions found in a conventional oscilloscope
- Expensive PC-based oscilloscopes also provide some high-speed digital signal processing functions within the hardware unit
- The host PC itself provides the control interface and display facilities

Personal Computer-Based Oscilloscope

- Advantages of a PC-based oscilloscope over other types is cost; the cost saving is achieved because use of the PC obviates the need for a display unit and front control panel found in other forms of oscilloscopes
- output display easier to read
- laptop plus add-on hardware unit is usually smaller and lighter than a conventional oscilloscope
- facilitate the transfer of output data into standard PC software such as spreadsheets and word processors
- Disadvantages: electromagnetic noise originating in PC circuits, signal sampling rates can be limited by the mode of connection of the hardware unit into the PC

Studija slučaja: pikoATLAS Modularni uredjaj za daljinsko i lokalno upravljanje procesima

- PikoATLAS i pATLAS (“piko”, 10^{-6}) su imena za uredjaje malih dimenzija familije ATLAS, koji su razvijeni i proizvode se u Institutu “Mihajlo Pupin”
- za lokalni i daljinski nadzor i upravljanje, optimalno prilagodjen za primenu u prostorno ograničenim objektima upravljačkih sistema (elektroenergetski sistemi, sistemi za napajanje vodom, sistemi za distribuciju gasa, industrijski upravljački sistemi)

pATLAS

- Akvizicija pogonskih podataka (iz procesa)
- Lokalna online obrada podataka u realnom vremenu
- RTU (i opciono PLC) upravljanje pogonom (procesom)
- Daljinski i mrežni prenos podataka i komunikacija
- On-line testiranje i dijagnostika
- Kastomizacija i lokalno programiranje
- Obrada GPS podataka i sinhronizacija vremena
- SCADA i druga funkcionalna nadgradnja

Akvizicija podataka iz procesa

- **Analogni ulazni podaci** – različite fizičke i električne veličine (temperature, pritisci, nivoi, naponi, struje itd.) se pretvaraju posredstvom odgovarajućih senzorskih aparata i mernih pretvarača u normalizovane naponske i strujne signale, i u takvoj analognoj formi se skaniraju i uvode u uredjaj
- Svaka skanirana analogna veličina se nadalje konvertuje u svoj numerički (digitalni) ekvivalent (tipično korišćenjem 12-bitne AD konverzije) i smešta u bazu pogonskih podataka PDB za potrebe daljih obrada i prenosa

Akvizicija podataka iz procesa

- **Digitalni ulazni podaci** – različiti pozicioni i status podaci o pogonskoj opremi (dvopoložajni aparati, prekidači, rastavljači, indikatori stanja: otvoreno, zatvoreno, gornje i donje prekoračenje i krajnjih pozicija, različiti limiteri, itd.), signali upozorenja i alarma se prihvataju kao jednostruki ili dvostruki naponski signali, skaniraju i smeštaju u bazu pogonskih podataka PDB za dalju lokalnu obradu i daljinski prenos

Akvizicija podataka iz procesa

- **Brojački ulazni podaci** – različiti impulsni signali i sekvencijalne merne veličine koje treba sumirati (brojati), a koji odgovaraju različitim mernim kvantitativnim podacima (proizvodnja, razmena i potrošnja električne energije i drugih energenata, protoci, merenj vremena, itd), se prebrojavaju i smeštaju u bazu pogonskih podataka PDB za potrebe daljih obrada i prenosa. Iako su ovi podaci po svojoj prirodi digitalni podaci, poreklo i značaj samih podataka, i način njihove akvizicije čini ih dovoljno specifičnim da se oni tretiraju odvojeno

Upravljanje procesom

- **Analogni izlazni podaci** – naponski ili strujni signali koji predstavljaju referentne, postavne ili merne vrednosti za odgovarajuću regulacionu i indikatorsku pogonsku opremu izvan samog uredjaja pATLAS.

Upravljanje procesom

- **Dvostepene** [uključi/isključi] **komande** – dvostruke komande fiksne širine komandnog naponskog impulsa za komandovanje prekidačima, rastavljačima, pokretačima, diskretnim indikatorima, i sličnom dvopozicionom pogonskom opremom.
- SBO komande (SBO je engleska skraćenica za: “select before operate”, u prevodu “odaberi pre aktiviranja”) i obavljaju se u dva koraka (stepena)
- Prvi korak predstavlja izbor komandnog izlaza (komandovanog aparata), koji se nastavlja sa neposrednim izvršenjem komande u drugom koraku (izdavanje impulsnog naponskog signala), ali tek posle potvrde pravilno obavljenog izbora

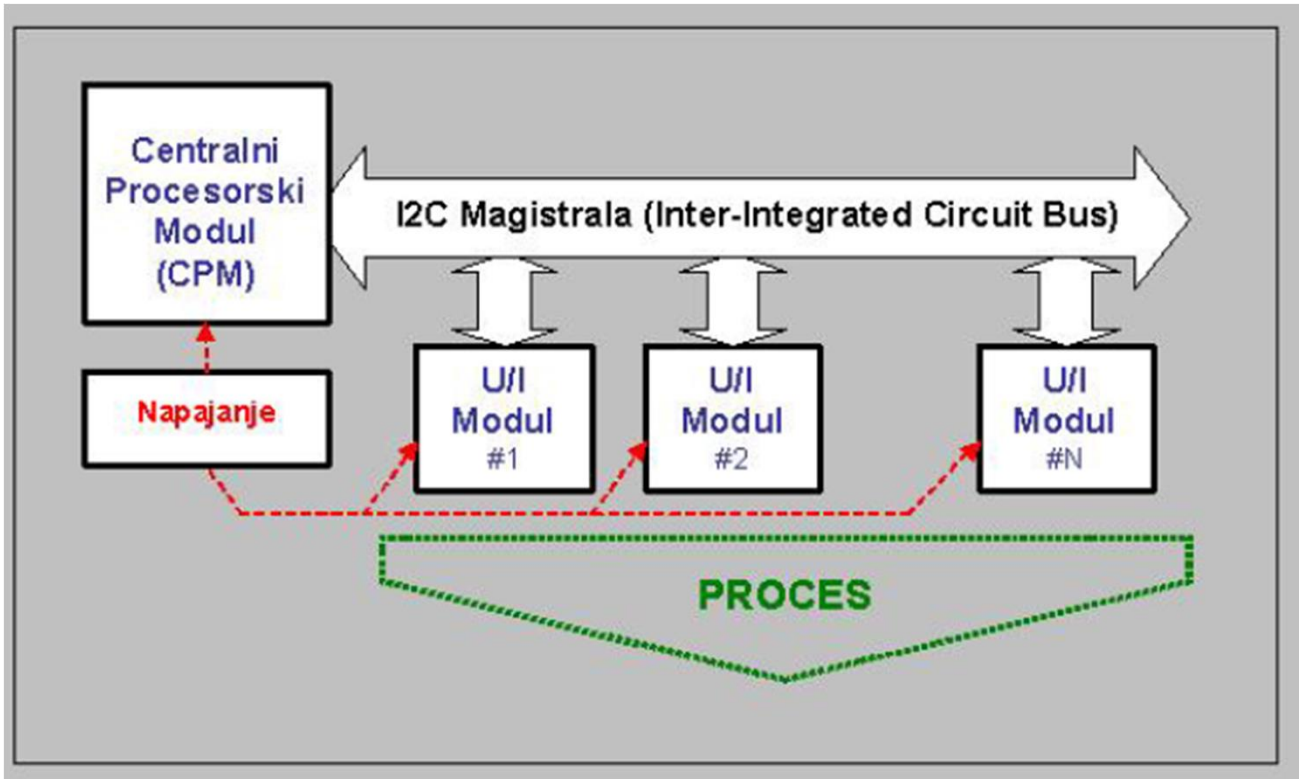
Upravljanje procesom

- **Jednostepene** [impulsne] **komande** – jednostruke komande programabilne širine komandnog naponskog impulsa za komandovanje pokretačima, diskretnim indikatorima i kompatibilnom višepozicionom pogonskom opremom. Ove komande su poznate i kao “izaberi-i-izvrši” komande (engleski naziv odgovarajućeg standarda: “select-and-execute”), ili kao direktne impulsne komande (alternativni engleski naziv standarda: “direct execute controls”), jer se sve obavlja samo u jednom komandnom koraku. Trajanje (širina) komandnog naponskog impulsa je programabilna na nivou pojedinačnog komandnog izlaza, a jednovremeno izvršenje većeg broja komandi je dozvoljeno.

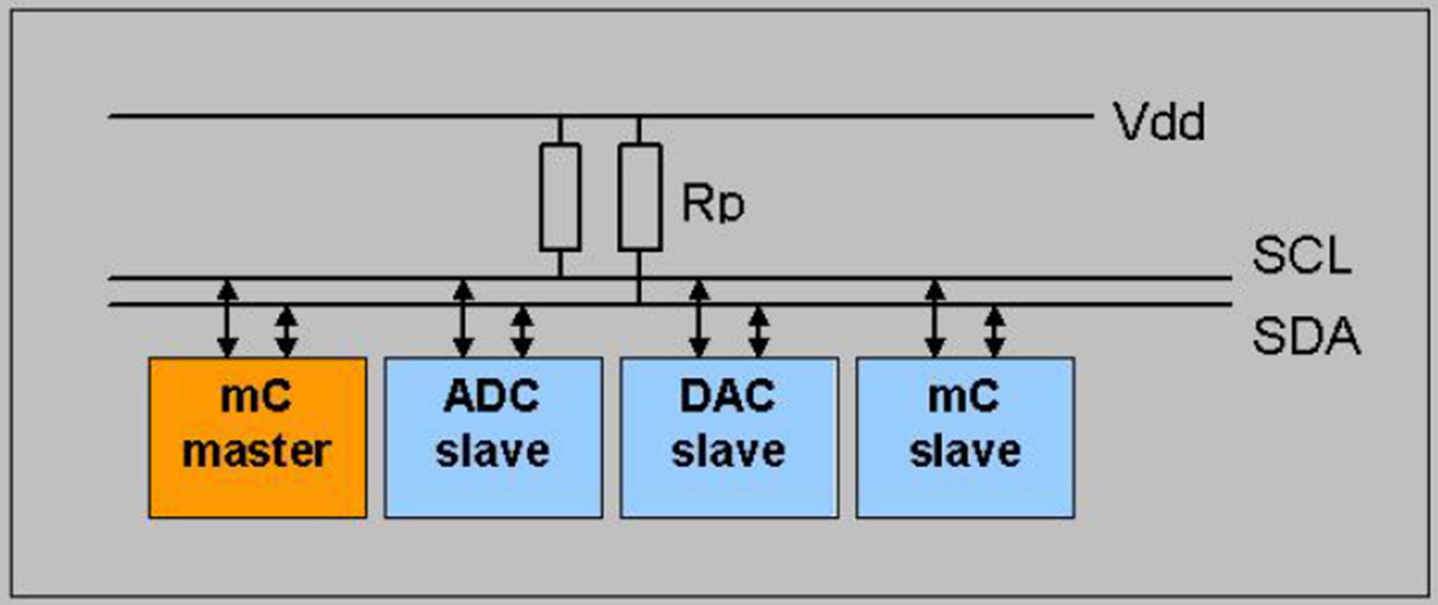
Upravljanje procesom

- **Trajne komande** – za direktno komandovanje odgovarajuće kontrolabilne pogonske opreme (čiji je dvopoložajni status direktno odredjen samim komandnim izlazom), leder dijagrama i slično.

Organizacija uredjaja pATLAS



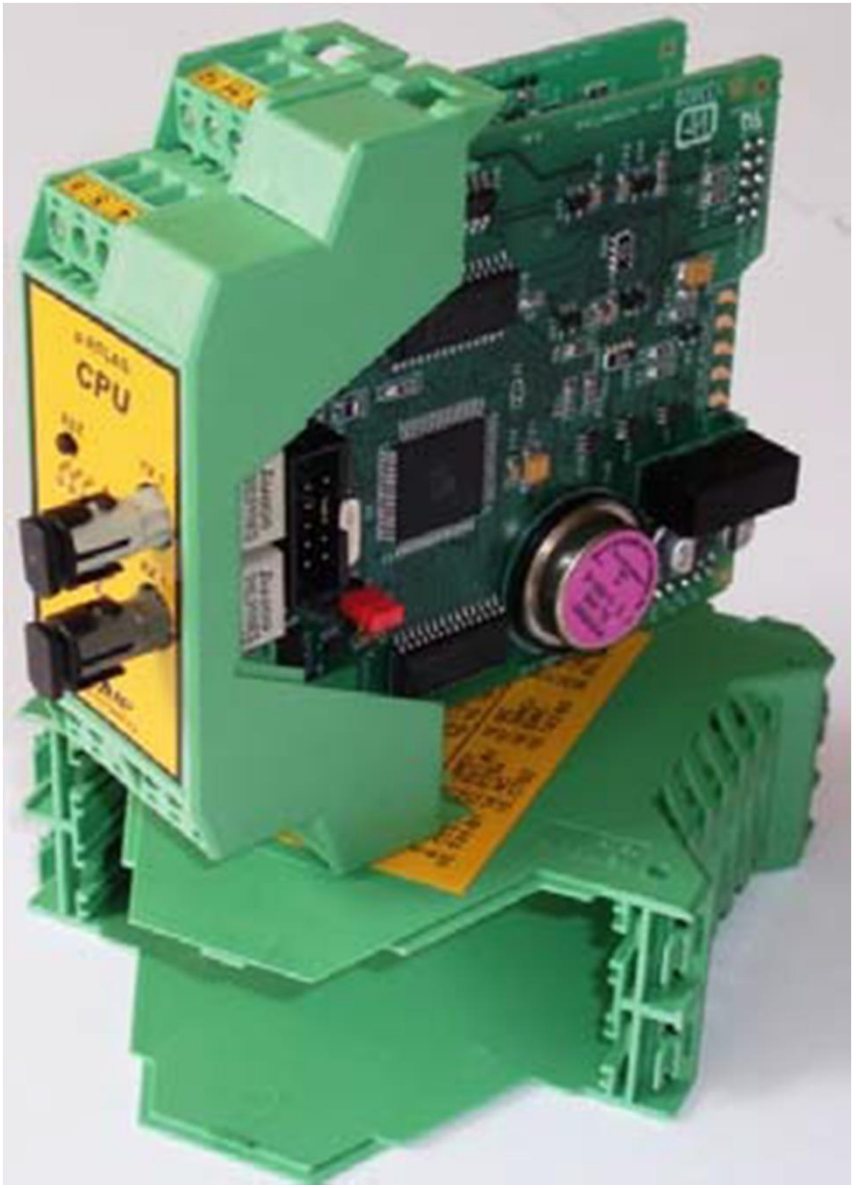
Organizacija uredjaja pATLAS



Jedan I2C primer: I2C magistrala sa jednim master čvorom (mikrokontroler mC) i tri “slave” čvora (po jedan ADC, DAC i drugi mikrokontroler mC)

napojne jedinice uredjaja

Centralni procesorski modul

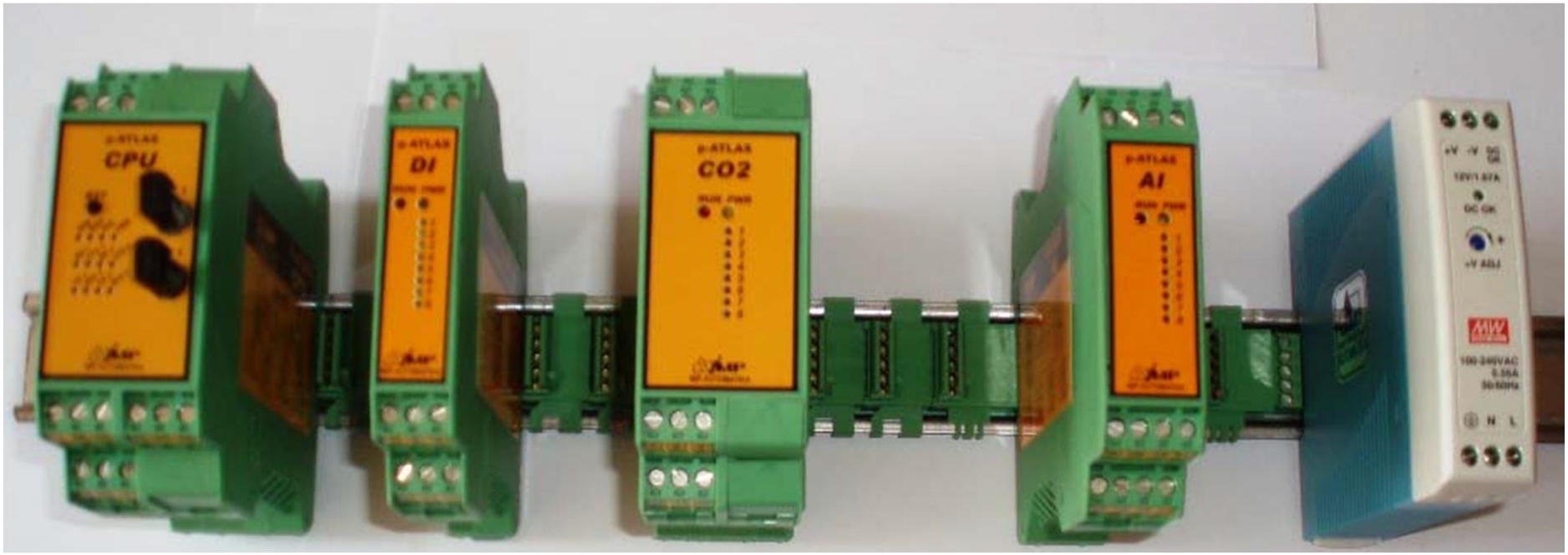


Eksterno povezivanje

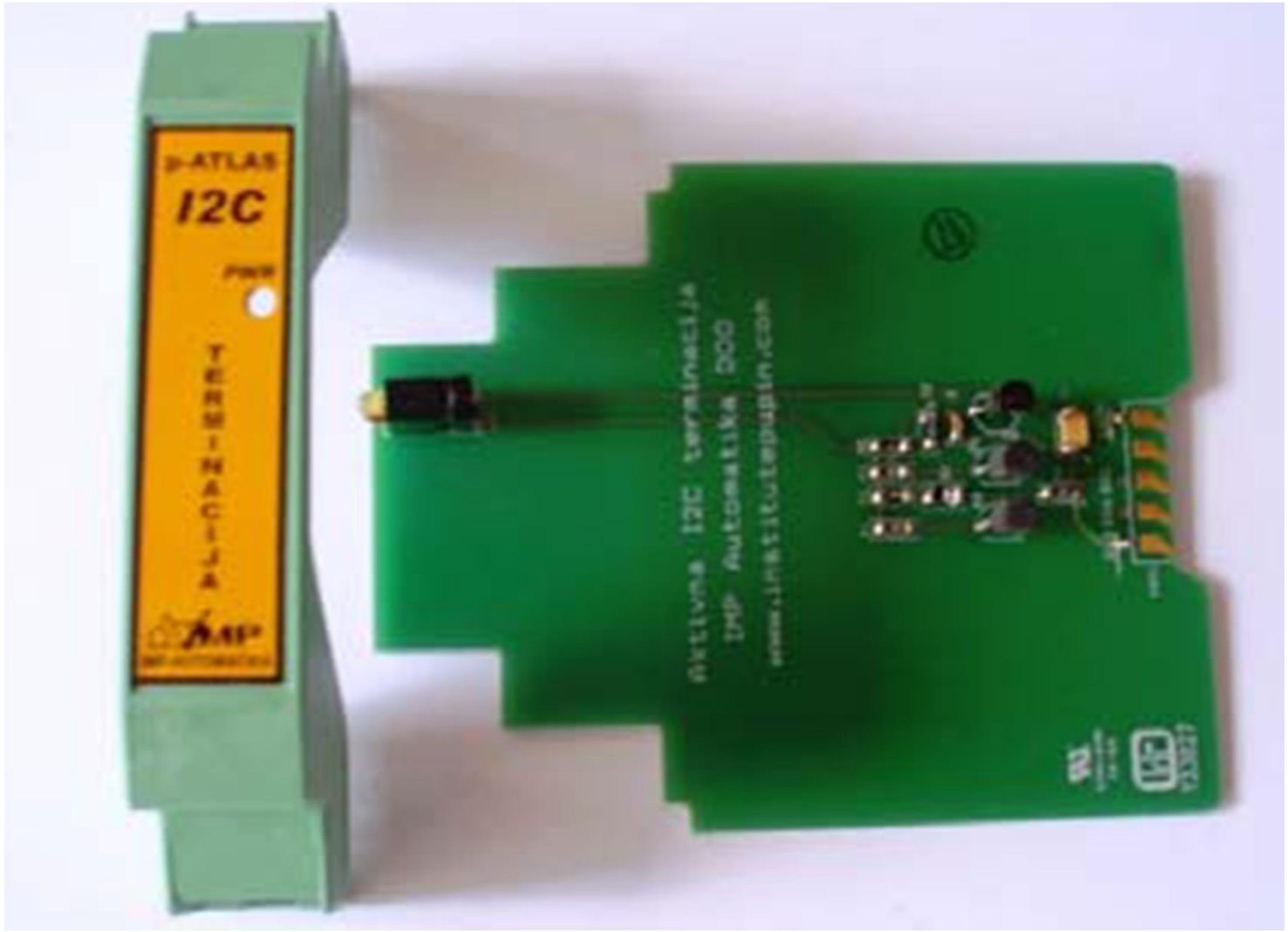
3-polna klema	Klema	Opis signala
1	1	N.C. – ne koristi se
	2	N.C. – ne koristi se
	3	N.C. – ne koristi se
2	4	RTS1 – zahtev za slanje (port 1)
	5	N.C. – ne koristi se
	6	CTS1 – dozvola za slanje (port
3	7	N.C. – ne koristi se
	8	N.C. – ne koristi se
	9	N.C. – ne koristi se
4	10	TX1-B1 – predaja (port 1)
	11	N.C. – ne koristi se
	12	RX1-A1 – prijem (port 1)

3-polna klema	Klema	Opis signala
5	13	RTS2 – zahtev za slanje (port 2)
	14	N.C. – ne koristi se
	15	CTS2 – dozvola za slanje (port 2)
6	16	N.C. – ne koristi se
	17	SYNC+ – GPS sinhronizacija
	18	SYNC- – GPS sinhronizacija
7	19	TX2-B2 – predaja (port 2)
	20	N.C. – ne koristi se
	21	RX2-A2 – prijem (port 2)
8	22	N.C. – ne koristi se
	23	N.C. – ne koristi se
	24	N.C. – ne koristi se

TBUS razvodna šina

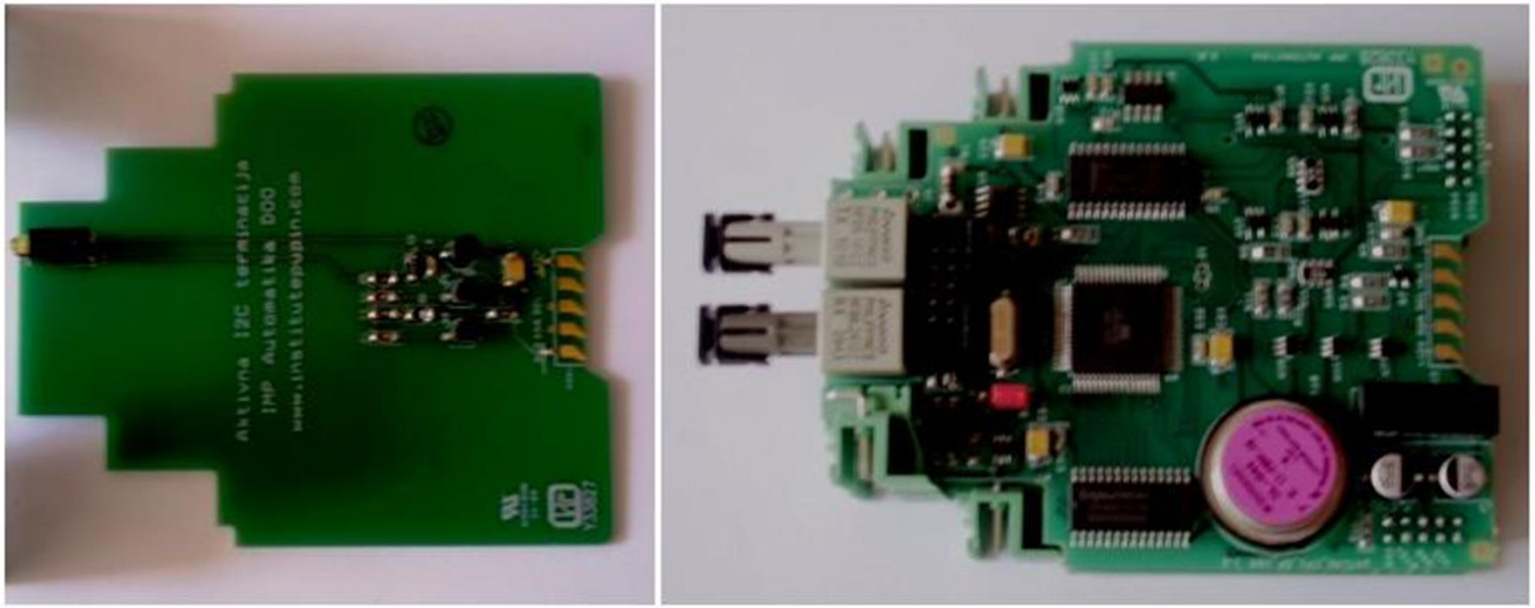


Modul za I2C terminaciju

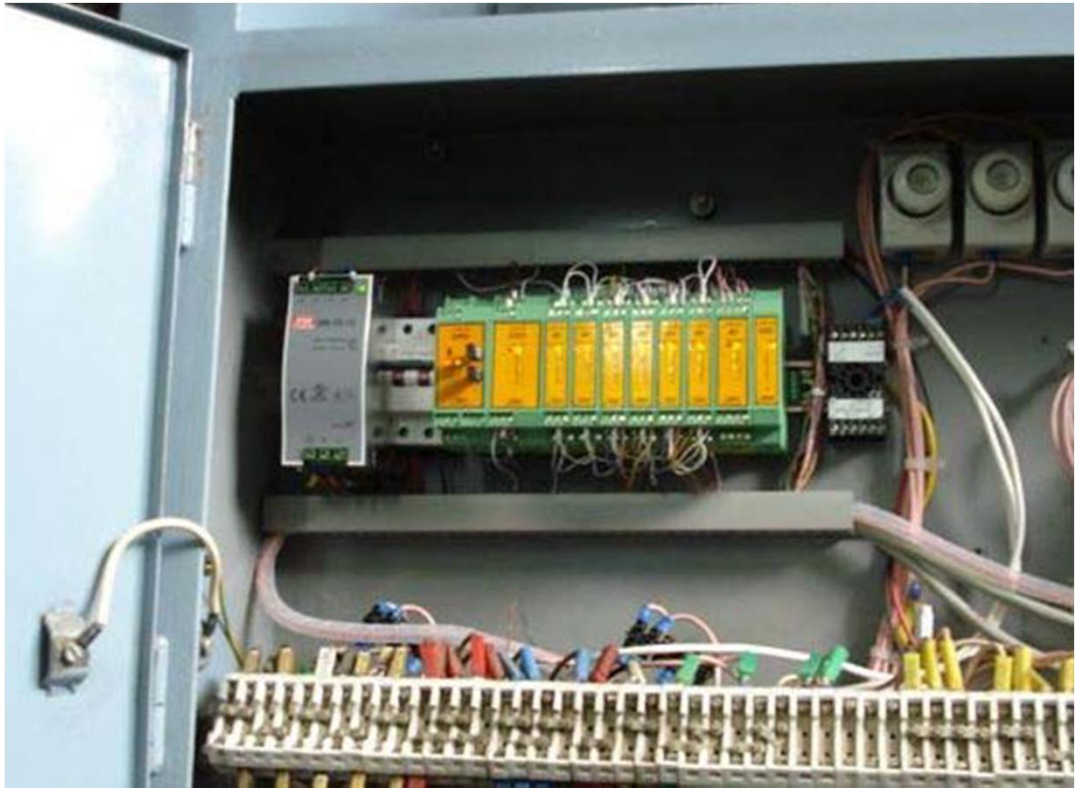


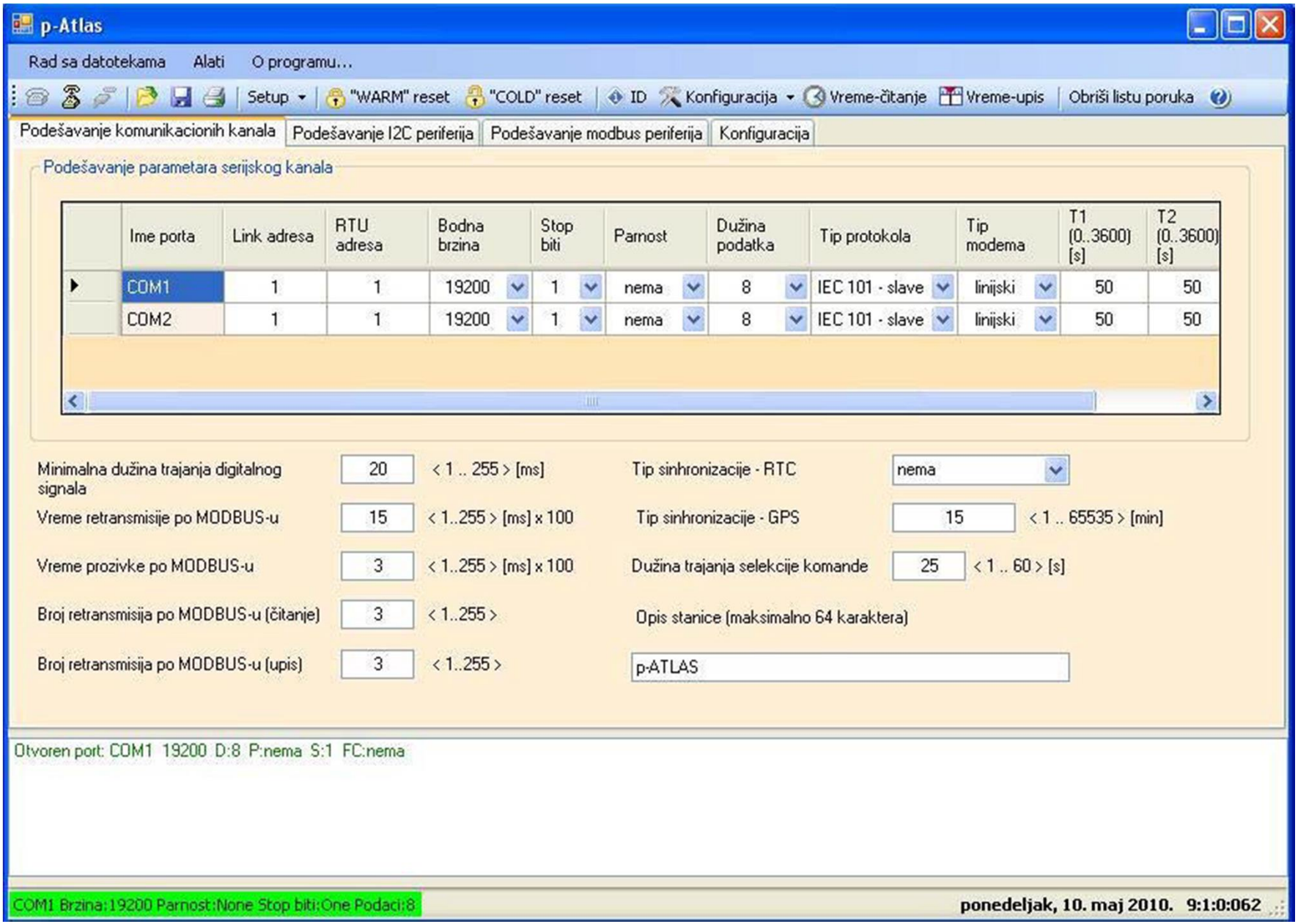
Fiber-optičko čvorište

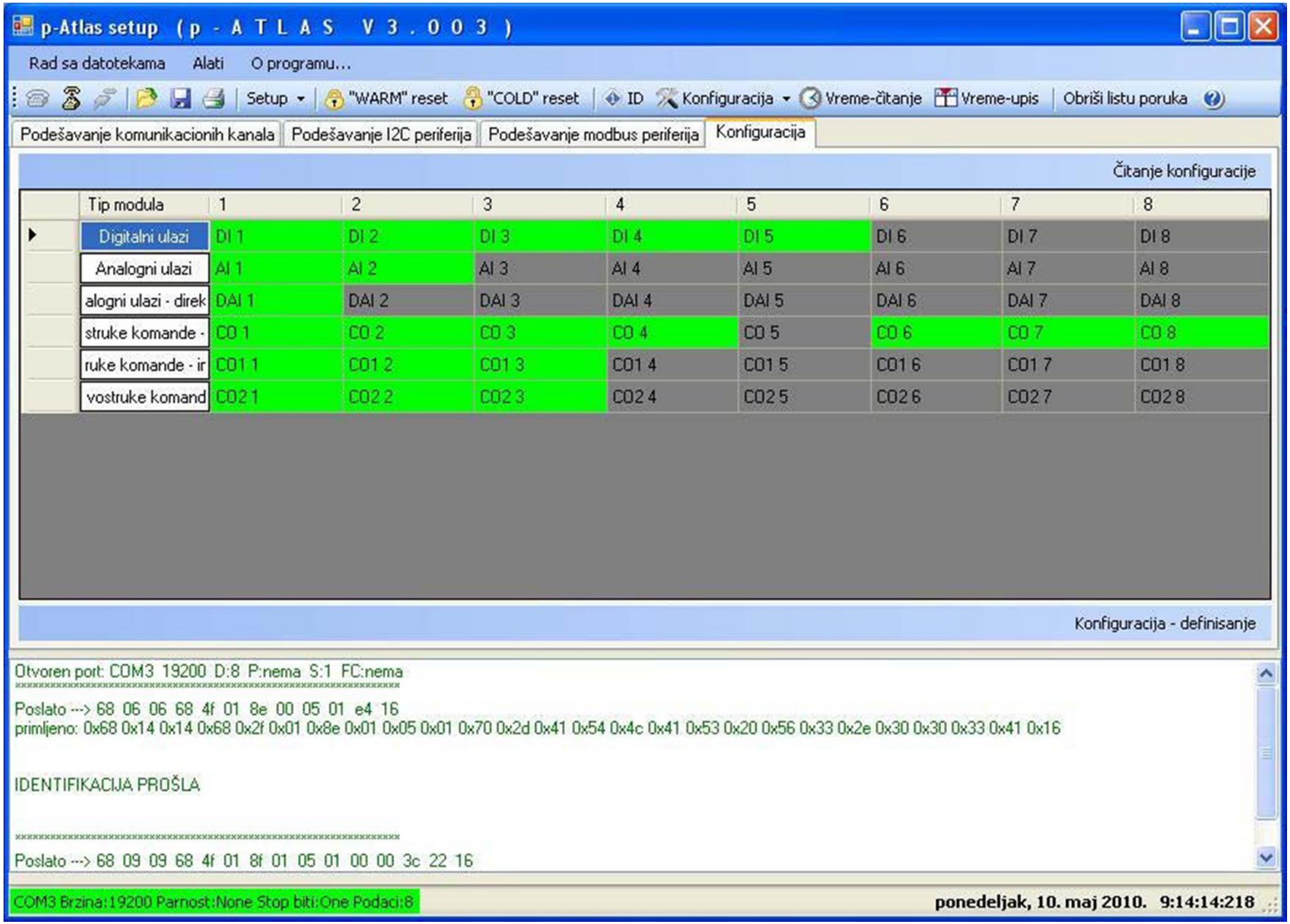
Primeri asembliranih štampanih ploča



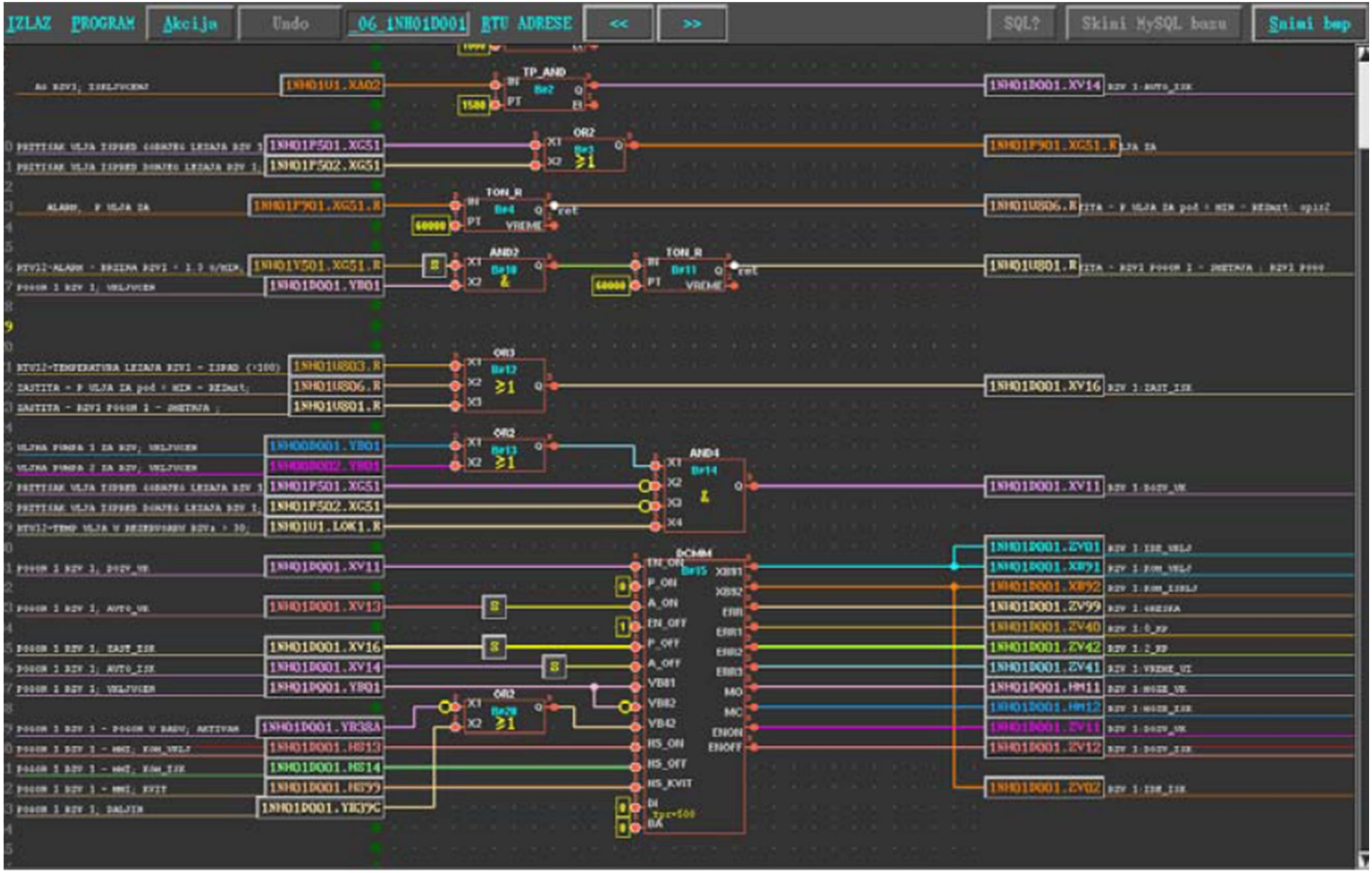
Unutrašnjost jednog ormana sa uredjajem




p-Atlas
Rad sa datotekama
Alati
O programu...
Setup
"WARM" reset
"COLD" reset
ID
Konfiguracija
Vreme-čitanje
Vreme-upis
Obriši listu poruka
Podešavanje komunikacionih kanala
Podešavanje I2C periferija
Podešavanje modbus periferija
Konfiguracija
Podešavanje parametara serijskog kanala
Ime porta
Link adresa
RTU adresa
Bodna brzina
Stop biti
Parnost
Dužina podatka
Tip protokola
Tip modema
T1 (0..3600) [s]
T2 (0..3600) [s]
COM1 1 1 19200 1 nema 8 IEC 101 - slave linijski 50 50
COM2 1 1 19200 1 nema 8 IEC 101 - slave linijski 50 50
Minimalna dužina trajanja digitalnog signala
20
< 1 .. 255 > [ms]
Tip sinhronizacije - RTC
nema
Vreme retransmisije po MODBUS-u
15
< 1..255 > [ms] x 100
Tip sinhronizacije - GPS
15
< 1 .. 65535 > [min]
Vreme prozivke po MODBUS-u
3
< 1..255 > [ms] x 100
Dužina trajanja selekcije komande
25
< 1 .. 60 > [s]
Broj retransmisija po MODBUS-u (čitanje)
3
< 1..255 >
Opis stanice (maksimalno 64 karaktera)
Broj retransmisija po MODBUS-u (upis)
3
< 1..255 >
p-ATLAS
Otvoren port: COM1 19200 D:8 P:nema S:1 FC:nema
COM1 Brzina:19200 Parnost:None Stop biti:One Podaci:8
ponedeljak, 10. maj 2010. 9:1:0:062


p-Atlas setup (p - A T L A S V 3 . 0 0 3)
Rad sa datotekama
Alati
O programu...
Setup
"WARM" reset
"COLD" reset
ID
Konfiguracija
Vreme-čitanje
Vreme-upis
Obriši listu poruka
Podešavanje komunikacionih kanala
Podešavanje I2C periferija
Podešavanje modbus periferija
Konfiguracija
Čitanje konfiguracije
Tip modula
1
2
3
4
5
6
7
8
Digitalni ulazi
DI 1
DI 2
DI 3
DI 4
DI 5
DI 6
DI 7
DI 8
Analogni ulazi
AI 1
AI 2
AI 3
AI 4
AI 5
AI 6
AI 7
AI 8
alogni ulazi - direk
DAI 1
DAI 2
DAI 3
DAI 4
DAI 5
DAI 6
DAI 7
DAI 8
struke komande -
CO 1
CO 2
CO 3
CO 4
CO 5
CO 6
CO 7
CO 8
ruke komande - ir
CO1 1
CO1 2
CO1 3
CO1 4
CO1 5
CO1 6
CO1 7
CO1 8
vostruke komand
CO2 1
CO2 2
CO2 3
CO2 4
CO2 5
CO2 6
CO2 7
CO2 8
Konfiguracija - definisanje
Otvoren port: COM3 19200 D:8 P:nema S:1 FC:nema
Poslato ---> 68 06 06 68 4f 01 8e 00 05 01 e4 16
primljeno: 0x68 0x14 0x14 0x68 0x2f 0x01 0x8e 0x01 0x05 0x01 0x70 0x2d 0x41 0x54 0x4c 0x41 0x53 0x20 0x56 0x33 0x2e 0x30 0x30 0x33 0x41 0x16
IDENTIFIKACIJA PROŠLA
Poslato ---> 68 09 09 68 4f 01 8f 01 05 01 00 00 3c 22 16
COM3 Brzina:19200 Parnost:None Stop biti:One Podaci:8
ponedeljak, 10. maj 2010. 9:14:14:218

Primer leder dijagrama



Profesor dr Miroslav Lutovac
mlutovac@viser.edu.rs