Lab VIEW – Tehnološki procesi

Fond časova **3P+0V+1L.**

Broj ECTS kredita ***6,0***

Ime i prezime nastavnika i saradnika:

Prof. dr Milovan RADULOVIĆ - nastavnik,

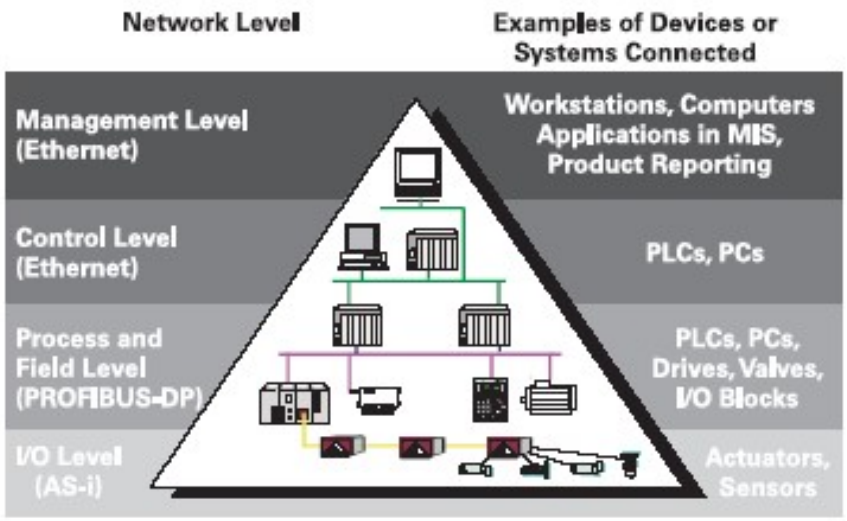
Oblici provjere znanja i ocjenjivanje:

- Dva kolokvijuma -Teorijski dio - po 15 poena (ukupno 30 poena)
- Dva testa - Praktični dio - po 15 poena (ukupno 30 poena) u okviru laboratorijskih vježbi)
- Završni ispit 40 poena.
- Materijali sa nastave na web stranici fakulteta

Zašto TEHNOLOŠKI PROCESI?

O MEHATRONICI

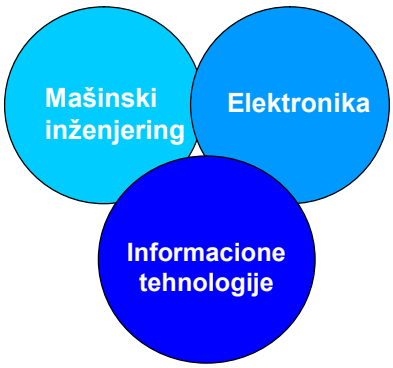
- Poslednjih decenija u svijetu uočava se potreba za multidisciplinarnim prilazom inženjerskim disciplinama.
- Pri projektovanju novih proizvoda se integrišu klasične inženjerske oblasti: mašinstvo, elektrotehnika, automatsko upravljanje i računarske tehnologije.
- Tradicionalna podjela na naučne i obrazovne oblasti (npr. mašinstvo i elektrotehnika) je dovela do nerazumijevanja inženjera različitih struka pri zajedničkom projektu. Svaka struka vidi samo svoj aspekt.



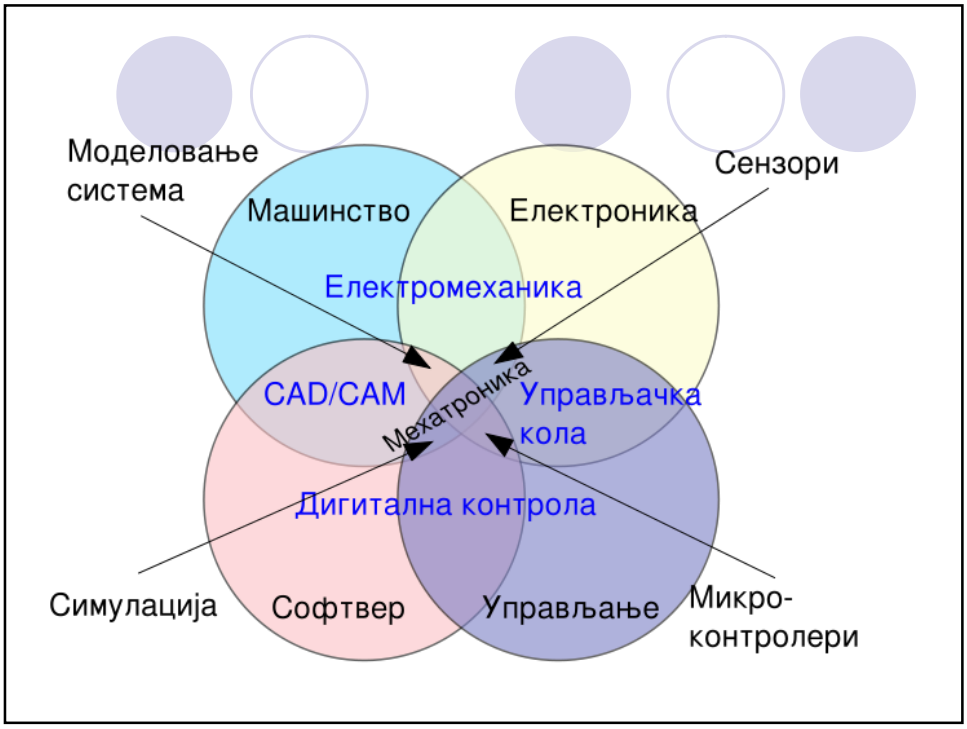
Definicija mehatronike

Mehatronika predstavlja okvir i metodologiju za integraciju tehnologija (mašinstvo, elektrotehnika, upravljanje i informaciono računarske tehnologije) koje su tradicionalno bile razdvojene

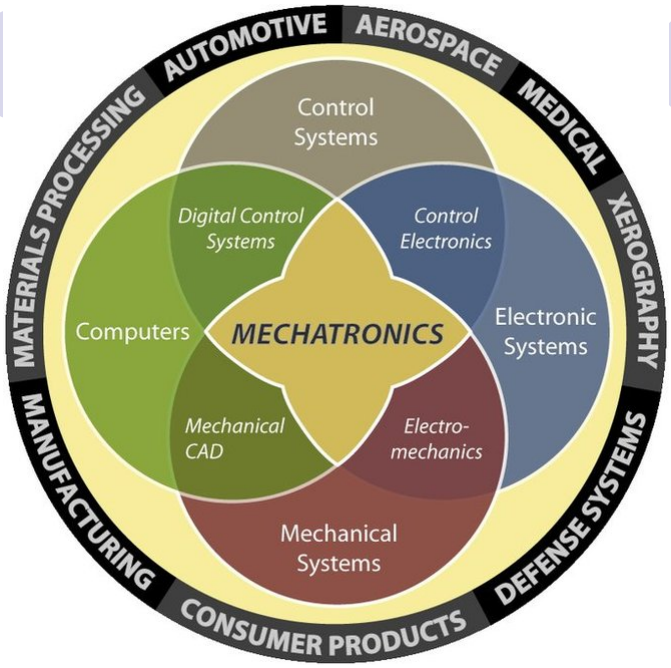
Opšta definicija



Više precizno

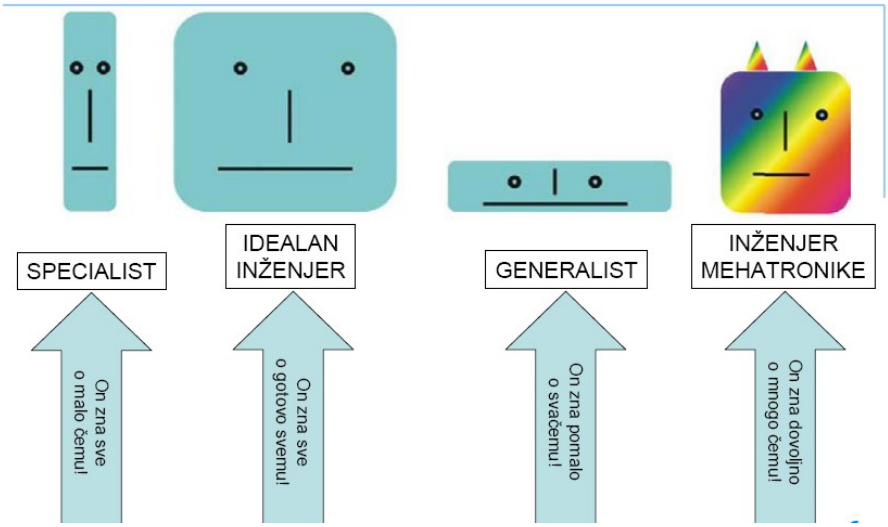


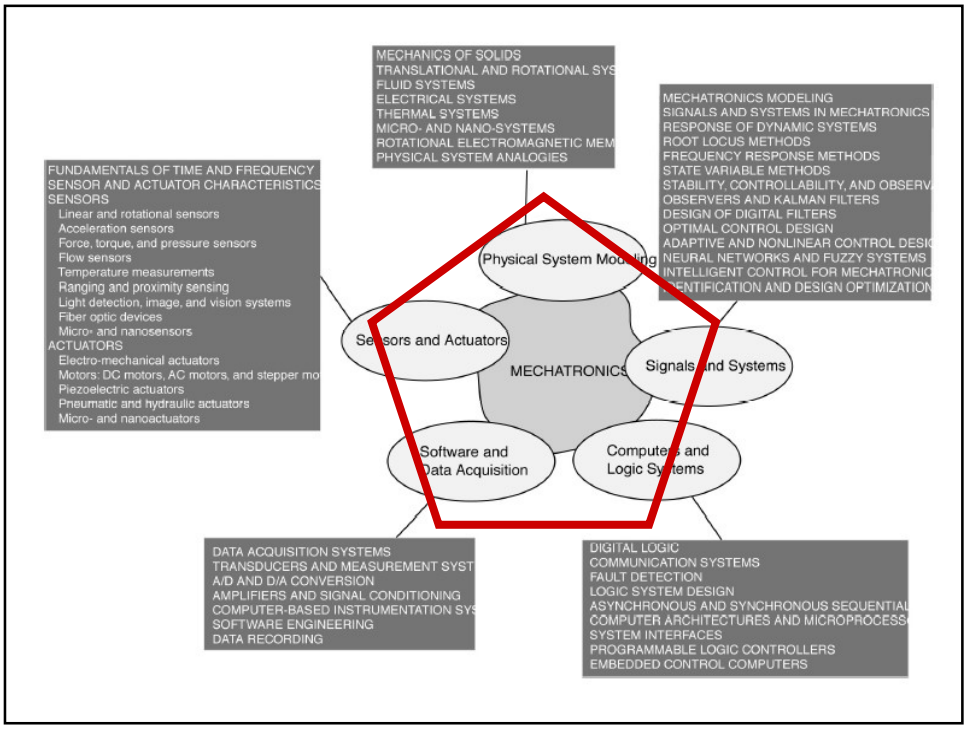
- Obzirom da ovakvi sistemi postaju sve brojniji, složeniji i sofiscitiraniji (stepen ‘‘ugradjenog’’ automatskog delovanja ili kako se često kaže- stepen intelegencije svakim danom postaje sve veći) tako da pri njihovom kreiranju neophodno pored znanja upravljanja i znanje iz računskih tehnologija.
- **Na taj način se konstituiše nova oblast nazvana mehatronikom, koja ne predstavlja novu inženjersku oblast već novi koncept kojim se naglašava potreba za integracijom i intezivnom interakcijom izmedju različitih inženjerskih disciplina.**



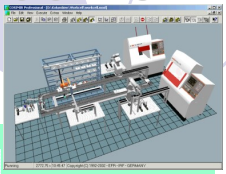
- **Mehatroniku u obrazovnom smislu treba posmatrati kao studijski program koji omogućava studentima da u dovoljnoj mjeri posjeduju znanja i razumiju osnovne fizičke principe iz svih oblasti koje su neophodne za realizaciju savremenih sistema!**

Ko je ko u tehnici?





Najvažniji elementi mehatronike

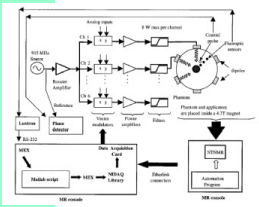


Sistemsko modeliranje

Aktuatori i senzori

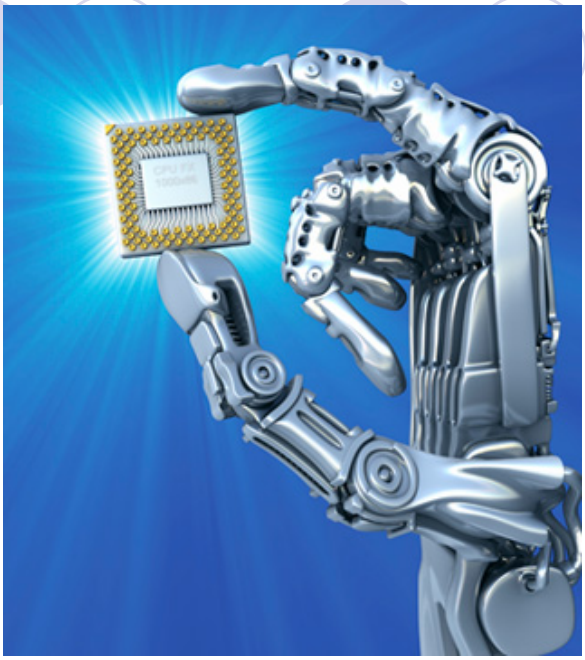
Pentagon Mehatronike

Signali i sistemi

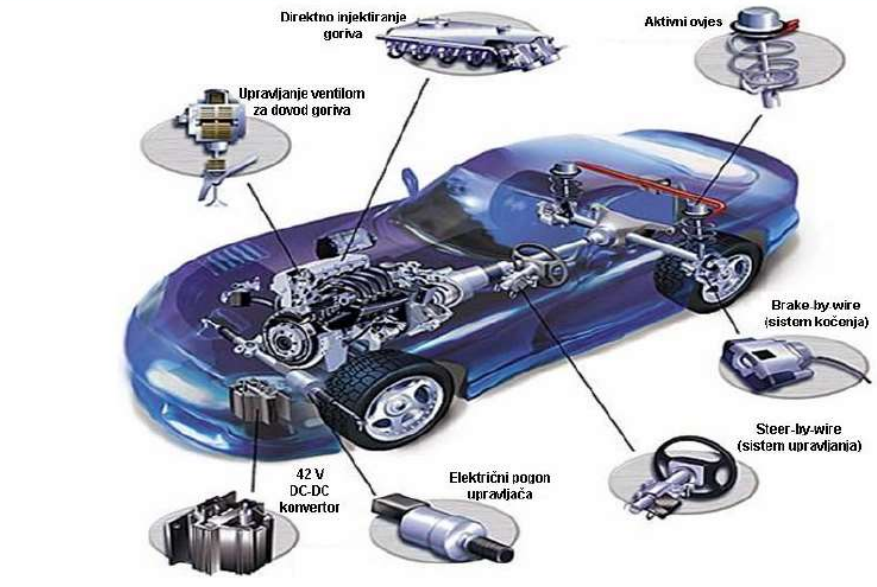


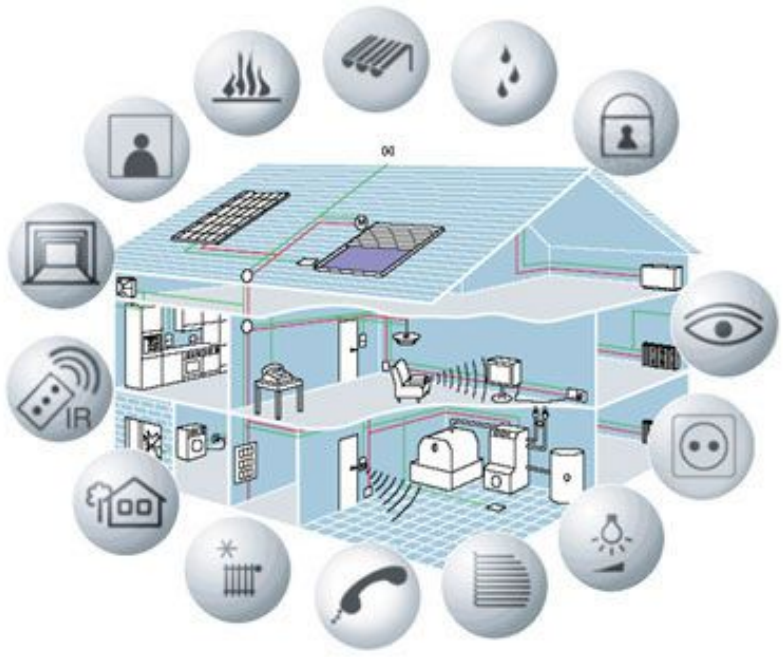
Software i skupljanje podataka

Kompjuteri , mreže i logički sistemi



Savremeni automobili





Mehatronički sistemi

- Proizvodnja ima karakterizaciju automatizacije na svim nivoima.
- Mrežni rad i integracija kompjutera
- Nisko budžetna automatizacija sa intiligentnim senzorima
- Elektronska kontrola
- Jednostavno podešavanje parametara sistema upravljanja i
- PLC-a

Prehrambena industrija

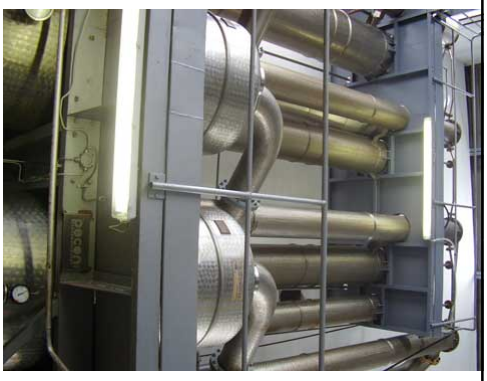
mašine za vakumsko pakovanje

mašine za pakovanje brašna

linije za punjenje sokova, vode i drugih napitaka

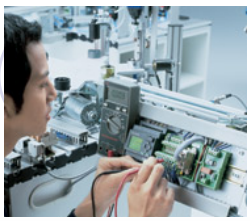
proizvodnja prerađevina od mesa

prerada mlijeka



Šta se može očekivati?

- Dalji napredak i pojeftinjenje mikroprocesora i mikrokontrolera, senzora i aktuatora.
- Razvoj mrežnih i bežičnih tehnologija, primjena Interneta u kombinaciji s bežičnom tehnologijom.
- Napredak u razvoju MEMS-a, adaptivnih upravljačkih metodologija i metoda programiranja u realnom vremenu
- Vrlo intenzivan razvoj mikro i nano mehanike.



Trendovi ili šta slijedi ?

- Većina tehničara zaposlenih poslednjih godina morali su steći određena “mehatronička” znanja (uglavnom tokom rada “On The Job Training”) kako bi ostali kompetentni za obavljanje svog posla

Pristup i stav “ja svoje znam” neće biti dovoljan – sve je veći naglasak na važnosti i potrebi cjeloživotnog obrazovanja i usvajanju novih, multidiciplinarnih vještina

VIRTUELNA INSTRUMENTACIJA - VI

1986 američka kompanija National Instruments je uvela LabVIEW 1.0 sa ciljem da obezbjedi software-ski alat koji bi naoružao inženjere da razvijaju aplikacije za specifične (customized) sisteme, na isti način na koji je spreadsheet omogućio svima onima koji su u businessu da analiziraju finansijske podatke.

NI je na neki način pionir revolucije u virtuelnoj instrumentaciji, revolucije koja mijenja način korišćenja instrumentacije i kod testiranja, mjerenja i automatizacije procesa, smanjujući značajno troškove a bez žrtvovanja tačnosti i kvaliteta mjerenja.

NATIONAL INSTRUMENTS

•Virtuelna instrumentacija predstavlja metodologiju za projektovanje instrumenata, koja koristi standardni PC računar, specijalne hardverske komponente za akviziciju i digitalnu konverziju signala, i računarske programe koji omogućuju prikupljanje, obradu i prikaz signala na računaru

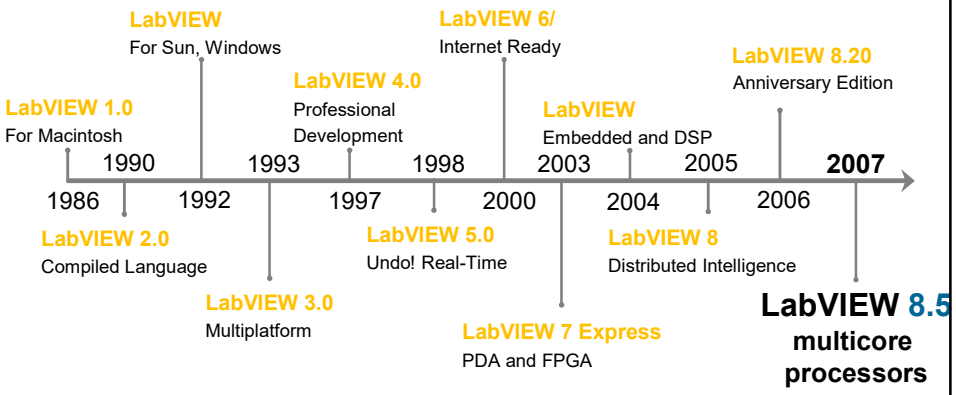
• Virtuelna instrumentacija omogućava objedinjavanje različitih tipova instrumenata u jedan insturment – PC računar

•Obezbjeđuje lako programiranje instrumenata, reprogramiranje i nadogradnju potojećih instrumenata

• Omogućava iskorišćenje postojećih resursa PC računara: memorijski prostor, brza obrada velike količine podataka, baze podataka, Internet, e-mail, LAN...

•Olakšana je upotreba instrumenata jer su zasnovani na PC korisničkom interfejsu

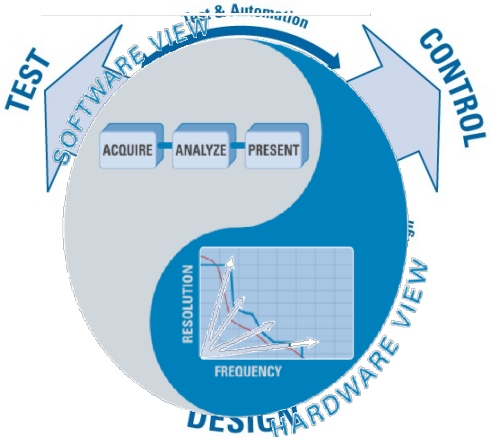
Over 20 Years of Innovation



National Instruments Overview

- More than 30 Years of Leadership in Computer-Based Measurement and Automation
- 4300 Employees, 2000 Engineers
- Corporate Headquarters in Austin, Texas
  - Direct Operations in 40 Countries
- Over 600 Alliance Partners

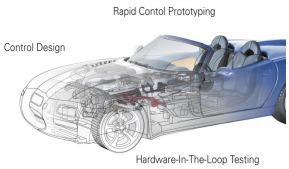
What is Virtual Instrumentation?



Virtual Instrumentation Use in Industry

Consumer Electronics

Military and Aerospace



Automotive

Communications

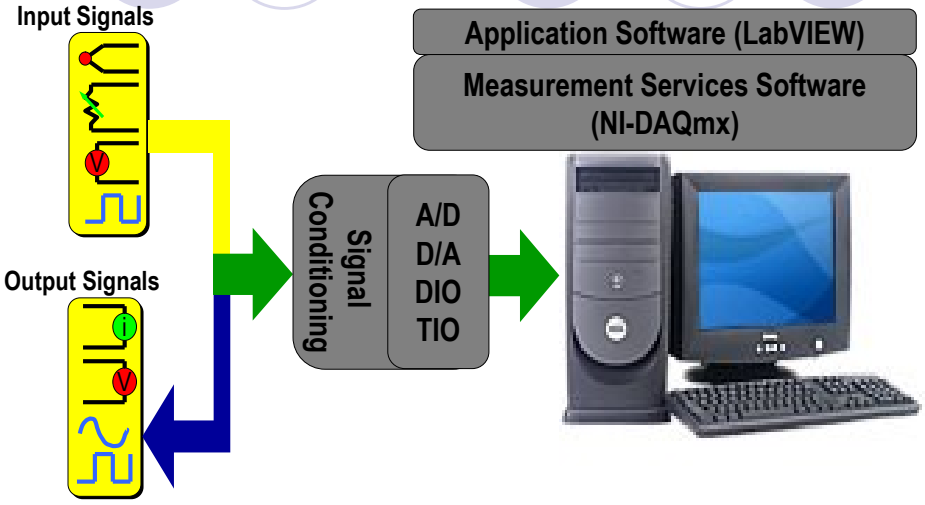
Semiconductor

Medical

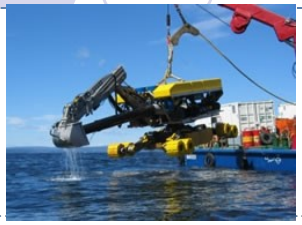
Diversity of NI Customers

- More than 25,000 Customers in more than 90 countries
- 95% of Fortune 500 in manufacturing

What is a DAQ System?



DAQ Hardware Options



Distributed

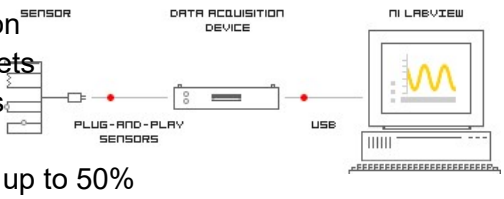
Desktop

Rugged and Modular Test

Portable

Plug&Play DAQ Systems

- **USB DAQ**
  - Plug-and-play installation
  - Automatic driver association
  - No rebooting computer
- **Sensors Plug&Play**
  - Based on IEEE 1451.4
  - Confirm sensor connection
  - Eliminate paper data sheets
  - Remove data entry errors
- **Faster setup**
  - Decrease setup steps by up to 50%



Considerations for USB DAQ in Industrial Environments

Reliability of USB Bus

- Flimsy connectors
- Short cable length
- Low cost, high volume
- Consumer peripherals
- Noise Immunity
- Reliable Protocol

NI CompactDAQ – Simple, Complete, USB Data Acquisition

Advanced ADCs and Isolators

Modularity with Direct Connectivity

Convenience and Performance of USB

Flexible, Easy-to-Use Software

Analog I/O, Digital I/O and Sensors

Industrial Measurements

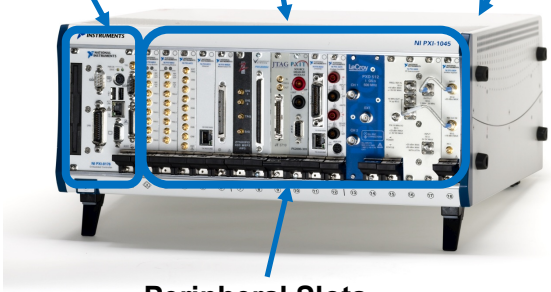
- ✓ Accelerometer
- ✓ Strain Gauge
- ✓ Load Cells
- ✓ Digital I/O
- ✓ Thermocouples
- ✓ 4 to 20mA
- ✓ High Voltage (60V)
- ✓ RTD

PXI Combines Standard Technologies

PXI Controller
•OS Technology
•ADEs

Chassis

PXI Backplane
•Bus Technology
•Timing
•Synchronization

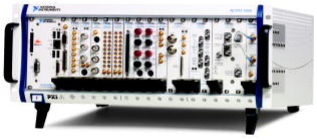


Peripheral Slots

Rapid Pace of Growth – NI Averaging 1 New PXI Product per Week

PXI Chassis

- 3U, 6U, and 3U/6U combo
- 4 through 26 slots
- Portable, benchtop, and rack mount
- AC and DC power options
- Application specific
  - Ultra rugged, integrated signal i



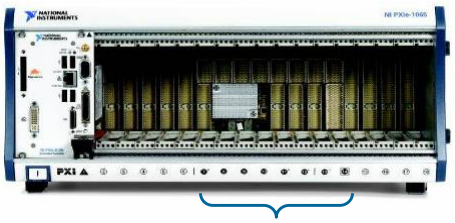
PXIe-8130

Embedded Controller

- **2.3 GHz AMD Turion dual-core processor**
- **4 GB/s system bandwidth**

PXIe-1065

Hybrid Chassis

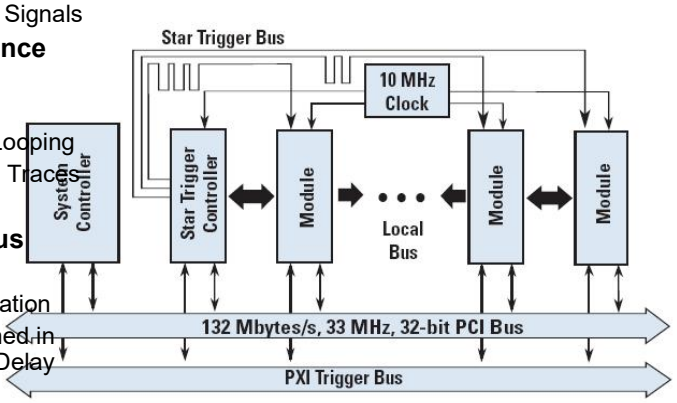


PXI Express

- Up to 8 PXI Express slots, 9 PXI slots
- Up to 1 GB/s per-slot dedicated bandwidth

Timing and Synchronization Features of PXI

- **PXI Trigger Bus**
  - 8 TTL
  - Trigger, Clock, and Handshaking Signals
- **System Reference Clock**
  - 10 MHz TTL
  - Phase Lock Looping
  - Equal-Length Traces
  - < 1 ns Skew
- **Star Trigger Bus**
  - 1 Per Slot
  - Star Configuration
  - Traces Matched in Propagation Delay
  - < 1 ns Skew



PXI Products. . .Over 1,500 and Counting

Data Acquisition and Control
Multifunction I/O
Analog Input/Output
Digital I/O
Counter/Timer
FPGA/Reconfigurable I/O
Machine Vision
Motion Control
Signal Conditioning
Temperature
Strain/Pressure/Force/Load
Synchro/Resolver
LVDT/RVDT
Many More. . .

Modular Instrumentation
Digital Waveform Generator
Digital Waveform Analyzer
Digital Multimeter
LCR Meter
Oscilloscope/Digitizer
Source/Signal Generator
Switching
RF Signal Generator
RF Signal Analyzer
RF Power Meter
Frequency Counter
Programmable Power Supply
Many More. . .

Bus Interfaces
Ethernet, USB, FireWire
SATA, ATA/IDE, SCSI
GPIB
CAN, DeviceNet
Serial RS-232, RS-485
VXI/VME
Boundary Scan/JTAG
MIL-STD-1553, ARINC
PCMCIA/CardBus
PMC
Profibus
LIN
Many More. . .

Others
IRIG-B, GPS
Direct-to-Disk
Reflective Memory
DSP
Optical
Resistance Simulator
Fault Insertion
Prototyping/Breadboard
Graphics
Audio
Many More. . .

Modular Instruments for Electronics Test

- Baseband and IF
  - **NI 5421 and 5422** 16-bit, 100 MS/s arbitrary waveform generators and 16-bit, 200 MS/s AWGs
  - **NI 5122 and 5124** 14-bit, 100 MS/s digitizers and 12-bit, 200 MS/s digitizers
  - **NI 5152 and 5922 –** 8 at 3GSa/s and 24 at 500kSa/s digitizers
- RF
  - **NI PXI-5661** 6.6 GHz RF streaming vector signal analyzer
  - **NI PXI-5672** 6.6 GHz RF streaming vector signal generator
- Audio
  - **NI 4461** 2-input/2-output, 24-bit, 204.8 kS/s, differential, antialiasing protection
  - **NI 4498** 16-input, 24-bit, 204.8 kS/s, antialiasing protection
- Digital
  - **NI 6552/1** - 100/50 MHz digital waveform generator/analyzers
  - **NI 6562/1** - 400/200 MHz LVDS digital waveform generator/analyzers
- Voltage, Current, Power
  - **NI 4071** - 7½-digit DMM with 1.8 MS/s digitizer
  - **NI 4110** - 3 output power supply
- Switches
  - **NI PXI 2536** - 544-Crosspoint FET Matrix Switch
  - **NI PXI 2597** - 26.5 GHz 6x1 Terminated Multiplexer

PXI Express Data Streaming

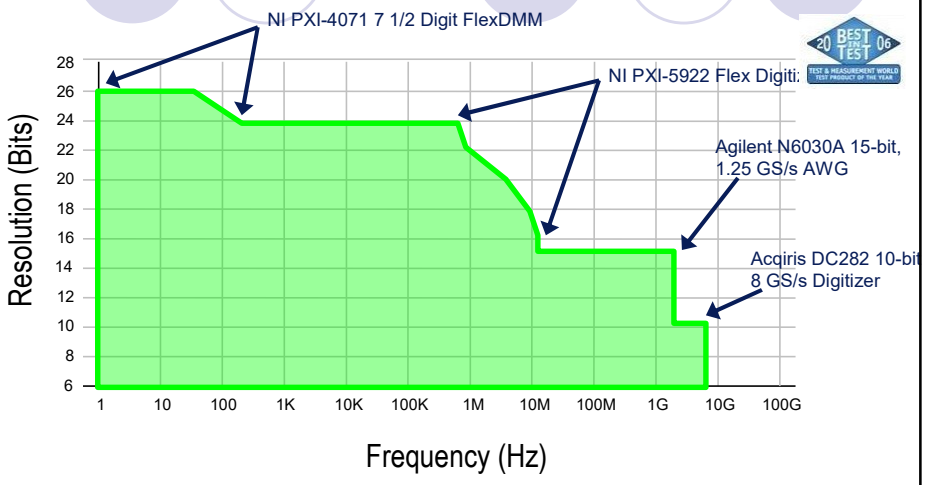
NI 8263
4-drive RAID

NI 8264
12-drive RAID

- High performance RAID controllers
- Enterprise class hard drives
- Active anti-vibration technology

NI 8262
x4 Cabled
PCI Express

PXI Platform Baseband Capabilities



DAQ Software Options

Test and Data Management Software
NI TestStand, DIAdem

Interactive Tools

SignalExpress
VI Logger

Application Development Software

LabVIEW
Graphical Development

LabWindows/CVI
ANSI C Development

Measurement Studio
Visual Studio Components

Measurement and Control Services:
NI-DAQmx or NI-DAQmx Base

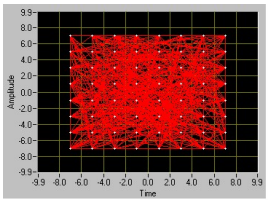
Data Acquisition Hardware




Modulation and Spectral Measurement Tools

Modulation

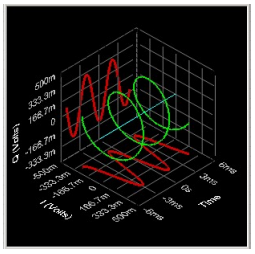
- 4, 16, 64, 256 QAM
- BPSK, QPSK, 16-PSK
- ASK, FSK, MSK, GMSK
- AM, FM, PM
- OFDM
- EVM, MER
- Quadrature Skew
- IQ Imbalance/DC Offset
- Frequency Offset
- Rho
- Bit Error Rate Testing



Signal Processing

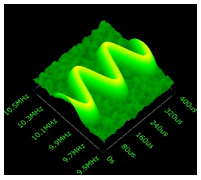
- 9 Windowing Functions
- 3 Averaging Modes
- Digital IIR and FIR Filters
- Pulse Measurements
- Transition Measurements
- Resampling
- Up/Down Conversion
- CCDF

…

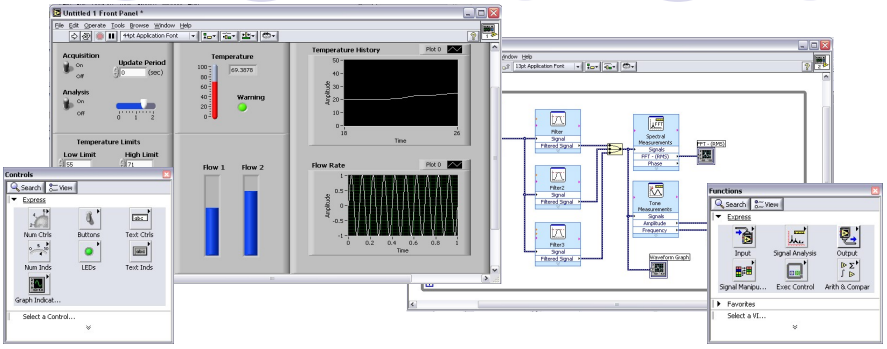


Spectral Measurements

- THD, SINAD, SNR, SFDR
- Specific harmonic level
- Power in band
- Adjacent channel power
- Occupied bandwidth
- Peak detection
- Zoom FFT
- Frequency Response
- Joint Time Frequency Analysis …



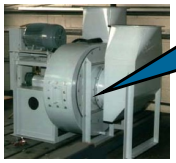
LabVIEW Graphical Development Environment



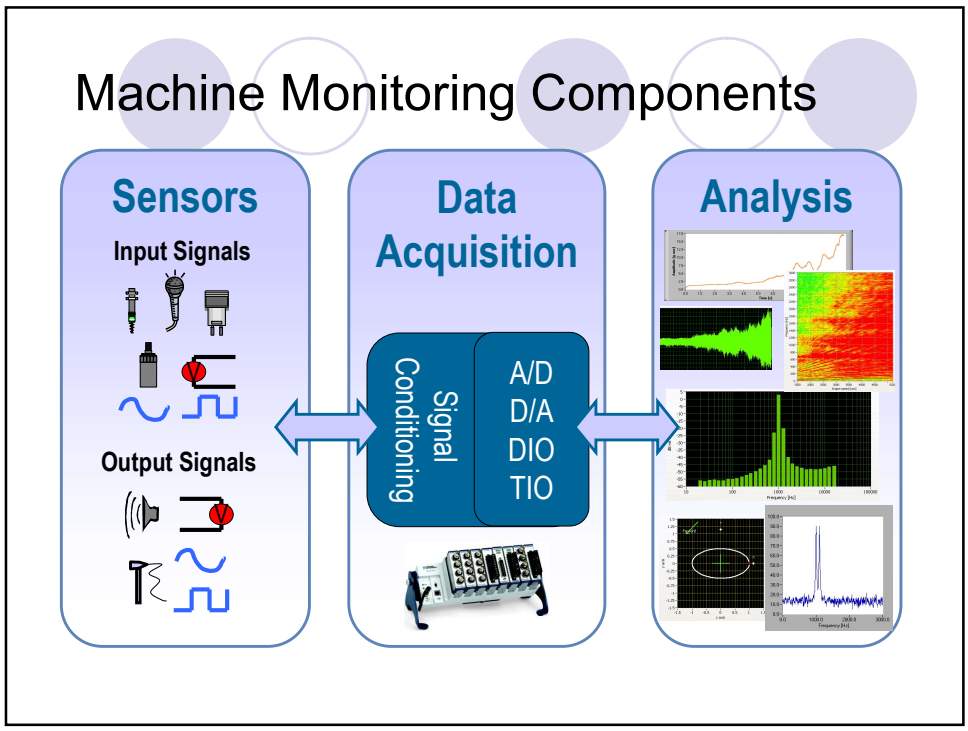
- Compiled graphical development environment
- Development time reduction of four to ten times
- Tools to acquire, analyze, and present your data

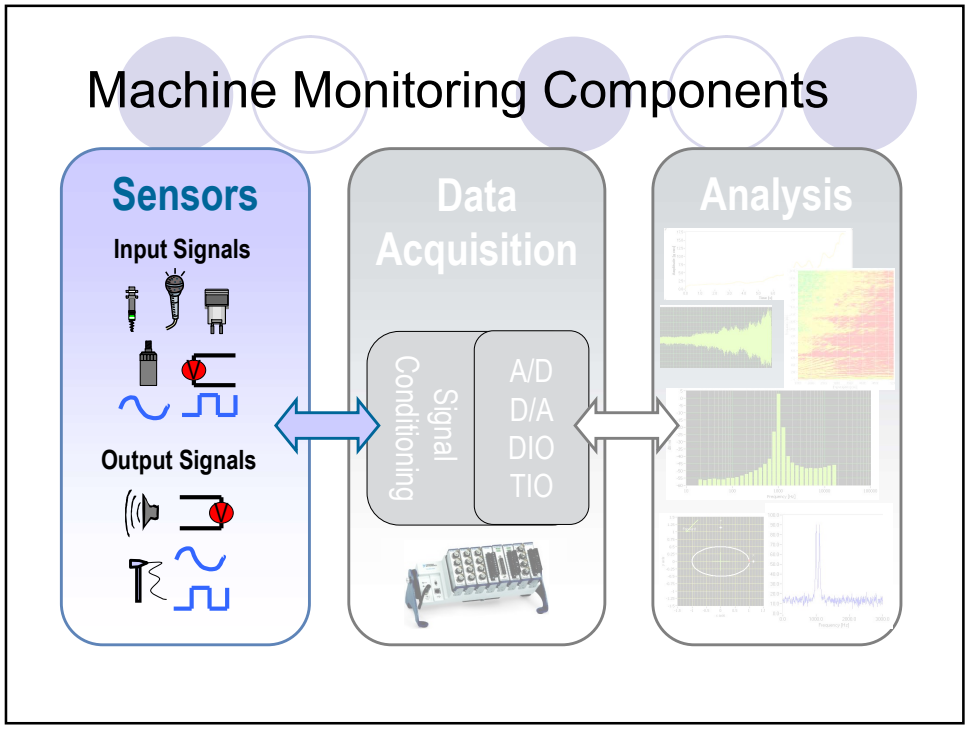
Insight a DAQ system for a Machine Condition Monitoring system using NI CompactDAQ

What would a machine say to you if it could?

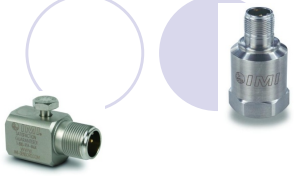


So what does it take to “talk” to your machinery?


Machine Monitoring Components
Sensors
Input Signals
Output Signals
Data Acquisition
Signal Conditioning
A/D
D/A
DIO
TIO
Analysis


Machine Monitoring Components
Sensors
Input Signals
Output Signals
Data Acquisition
Signal Conditioning
A/D
D/A
DIO
TIO
Analysis

Accelerometers



- Measure
  - Acceleration
  - Velocity and displacement (via integration versus time)
- Result is expressed in units of *g* or m/s^2
  - 1 g = acceleration at the surface of Earth
  - 1 g = 9.81 m/s^2
- Construction
  - Stainless steel, welded, isolated, sealed
- Sensitivity ranges
  - 50 mV/g, 100 mV/g, 200 mV/g, 500 mV/g

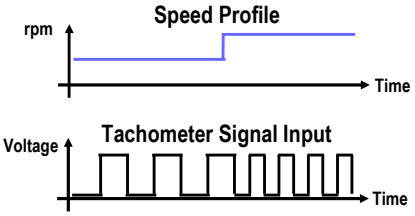
Proximity Probe

- Measure
  - Distance or displacement
- Result is expressed in *mils* or *mn*
  - 1 mil = 0.001 in.
- Uses
  - Journal bearing vibration, imbalance, misalignment
- Sensitivity ranges
  - 50 mV/mil, 200 mV/mil

Image courtesy of Metrix Corp.

Tachometers

- Measure
  - Angular position and speed (rpm)
- Output
  - Square wave/pulse train (analog tachometer)
- Used for
  - Order analysis
  - Order tracking
  - Angular averaging

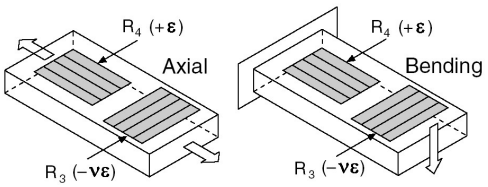


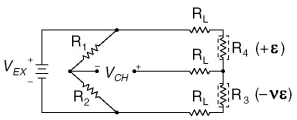
Laser tachometer courtesy of PCB Piezotronics

Bridge Terminology - Configuration

- **Quarter-bridge:**
  - **Quarter Bridge I**
  - **Quarter Bridge II**
- **Half-bridge:**
  - **Half Bridge I**
  - **Half Bridge II**
- **Full-bridge:**
  - **Full Bridge I**
  - **Full Bridge II**
  - **Full Bridge III**

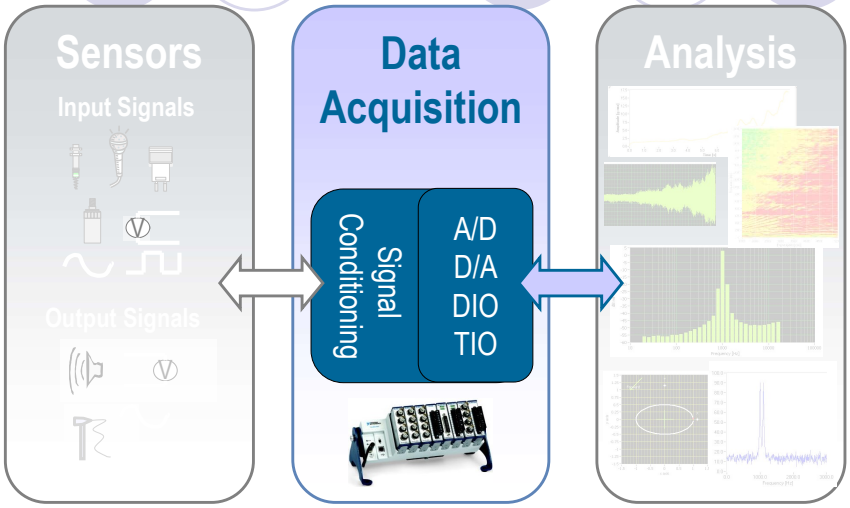
Half Bridge I





- **R4 is mounted in the direction of axial strain –**
  measures tensile strain (+ε)
- **R3 measures compression from Poisson effect (-ε)**

Machine Monitoring Components



Considerations for Acquiring Dynamic Signals

D High **D**ynamic Range

Ensures that you won't miss low-amplitude components

S Multichannel **S**imultaneous Sampling

Preserves phase information for order analysis and balancing

A Anti-**A**liasing

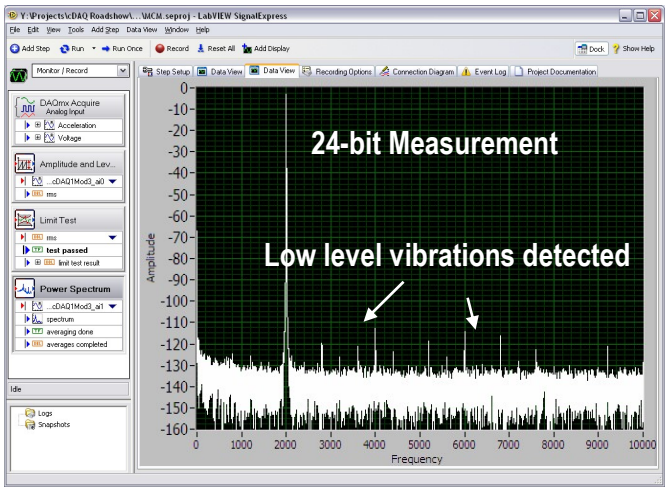
Avoid adding false signal components to your measurement

A/D Resolution and Dynamic Range

With high dynamic range, you can detect both strong and weak signal components at the same time.

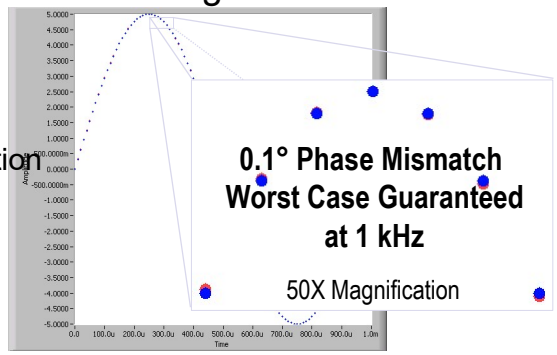
90 dB →

140 dB →



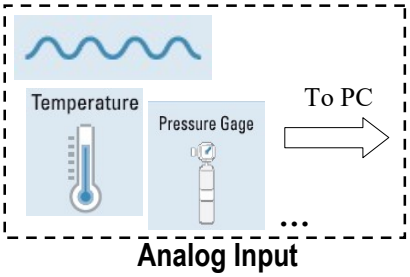
Multichannel Simultaneous Sampling

- A/D conversion is performed at the same instant from 2 to 5,000 channels
- No skew between channels to guarantee phase matching
- Required for
  - Orbit plots
  - Tacho synchronization
  - Balancing
  - Order analysis



Analog Input - Measuring Analog Input Signals

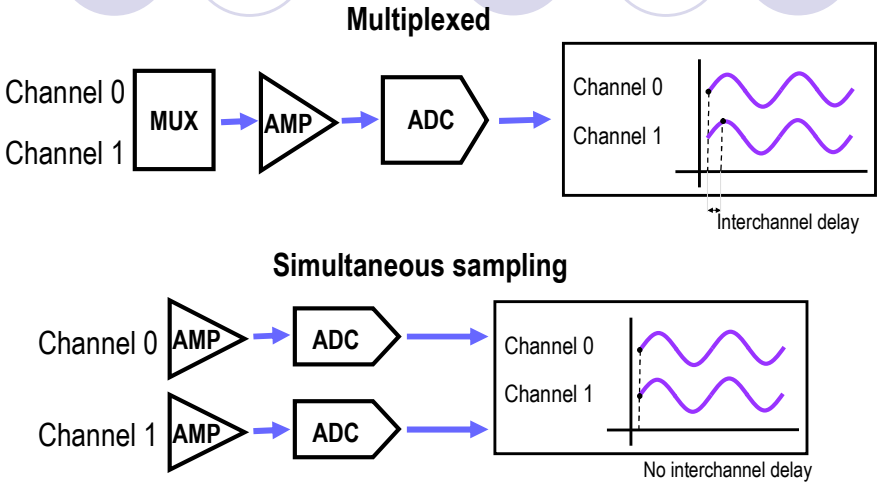
Important Factors to Consider



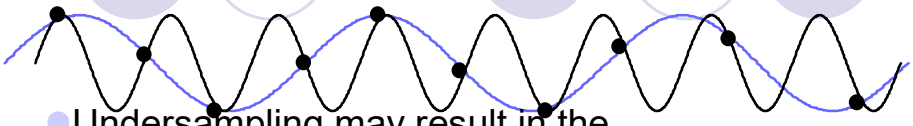
Architecture
- multiplexed
- simultaneous sampling

- **Sampling rate**
- **Accuracy**
  - Resolution
  - Absolute accuracy
  - Range and amplification
  - Noise and filtering
- **Sensors and high voltage measurements/Signal Conditioning**

Analog Input - Architectures



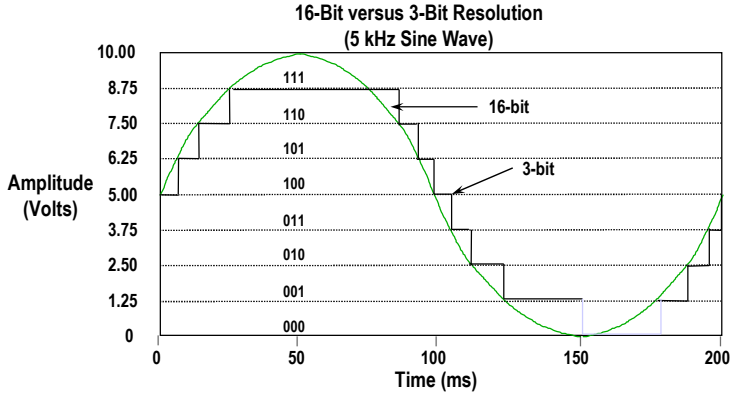
Analog Input - Sampling Rates



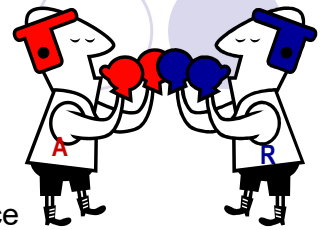
- Undersampling may result in the misrepresentation of the measured signal (aliasing).
- After a signal is aliased, it is impossible to reconstruct the original signal.
- For accurate frequency representation:
  - Sample at least 2x the highest frequency signal being measured.
- For accurate shape representation
  - Sample 5–10x the highest frequency signal being measured.

Analog Input - Resolution

- Number of bits analog-to-digital converter (ADC) uses to represent a signal
- Higher resolution – detect smaller voltage changes



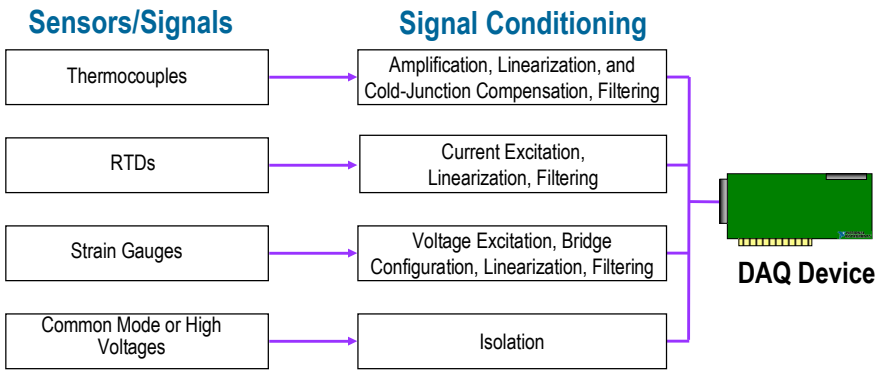
Analog Input - Accuracy versus Resolution



- Resolution
  - A property of the ADC
- Accuracy
  - A specification of the entire DAQ device or system
  - Includes many components and factors
    - ADC nonlinearities
    - Temperature
    - System noise
    - Amplifier gain and offset errors
- Higher resolution does not always equal more accurate!
  - Look for **Absolute Accuracy** specification

Analog Input – Signal Conditioning

High voltage signals and most sensors require signal conditioning to properly read the signal



Signal Conditioning Hardware Options

Modular Signal Conditioning

SCC

SCXI

FieldPoint

Integrated Signal Conditioning

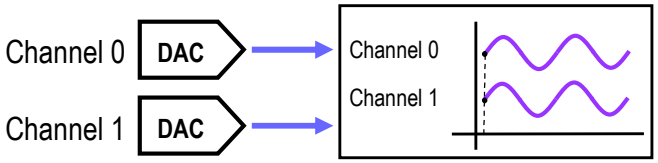
PXI Instruments

SC Series

USB-9200 Series

Analog Output – Considerations

- Accuracy: digital-to-analog converter (DAC) resolution
- Update Rate: settling time and waveform frequency
- Range: fixed or adjustable output voltage/current



- 16-bit
- 100 kS/sec
- ±10 VDC, 0–20 mA

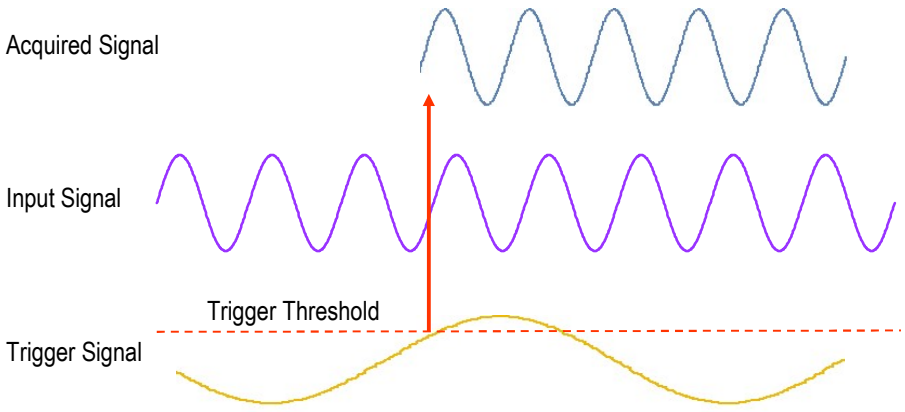
Digital I/O – Terminology

- General Terminology
  - Bit – The smallest unit of data. Each bit is either a 1 or a 0.
  - Line – One individual signal in a port. *Bit* refers to the data transferred. *Line* refers to the hardware.
  - Port – A collection of digital lines.
- M Series digital I/O
  - 10 MHz digital pattern I/O
  - Synchronization with AI and AO
  - Up to 48 digital I/O lines

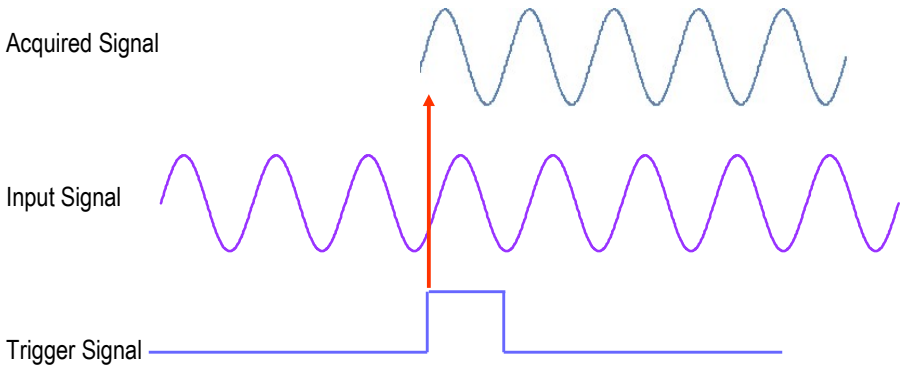
Counter/Timers – Applications

- Edge Counting
  - Simple Edge Counting
  - Time Measurement
- Pulse Generation
  - Single Pulse Generation
  - Pulse Train Generation
- Pulse Measurement
  - Period Measurement
  - Pulse Width Measurement
- Frequency Measurement
- Position Measurement
- Quadrature Encoder Measurement

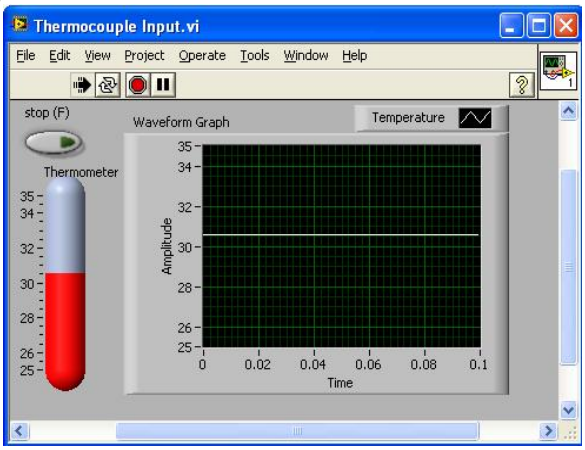
Triggering – Analog Triggering



Triggering – Digital Triggering



Demonstration:
Measuring Temperature using CompactDAQ and LabVIEW



NI Platforms for Machine Monitoring

Machine Diagnostics: NI CompactDAQ

For online machine performance data acquisition

- *Easy to use*
  - Plug-and-play Hi-Speed USB for continuous data transfer
  - Perform analysis on your PC and store transient or long-term vibration data
- *Portable*
  - Small form factor (25 by 9 by 9 cm)
  - <1.5 kg

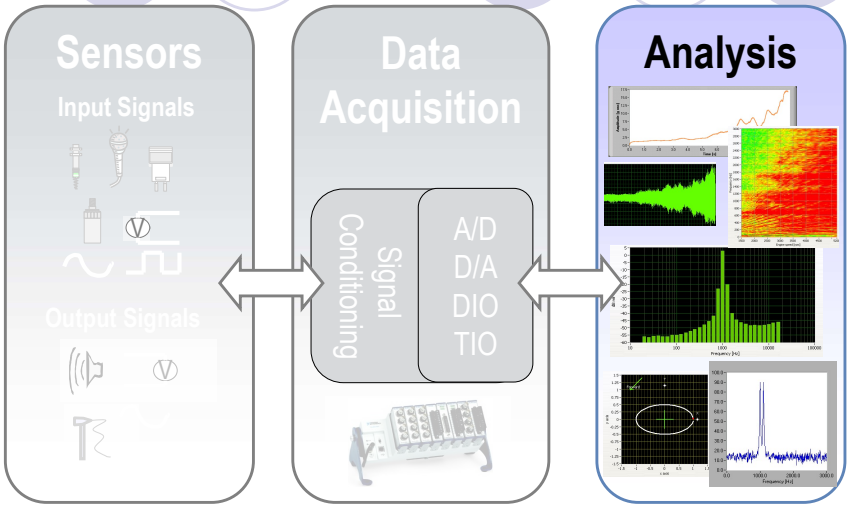
- *Measurement Capabilities*
  - Up to 32 IEPE accelerometer and proximity probe channels
  - 24-bit A/D with up to 20 kHz analysis frequency

Embedded Monitoring: CompactRIO

For installed machine protection and shutdown

- *Rugged, ready to deploy in harsh environments*
  - Class 1, Div 2 with ATEX certification
  - 50 g shock rating
- *Embedded*
  - Reliable FPGA control
  - Real-time processor for stand-alone analysis

Machine Monitoring Components

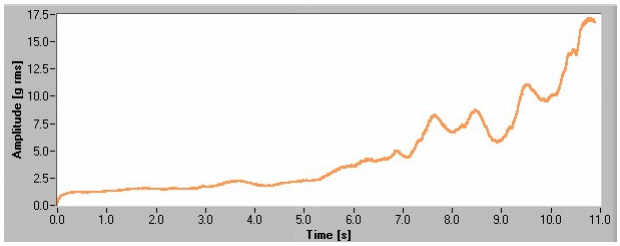


Machine Monitoring Analysis

- Time-Domain Measurements
  - Vibration Level
- Frequency-Domain Measurements
  - Power Spectrum
- Order Analysis
  - Order Spectrum
  - Order Tracking

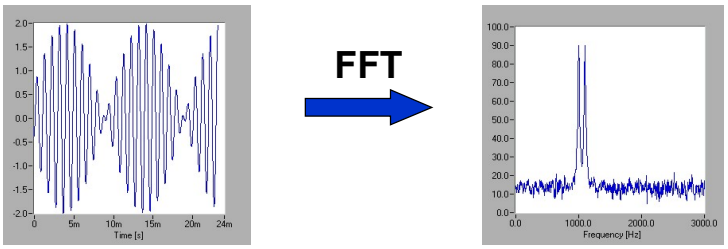
Vibration-Level Measurements

- Single and double integration (velocity and displacement calculations)
- g_{rms}
- Peak (true or calculated)
- Peak-to-peak (true or calculated)
- 1 µg reference



Frequency Analysis

- The fast Fourier transform (FFT) converts the time-domain signal into the frequency domain



Time-Domain Signal **Spectrum**

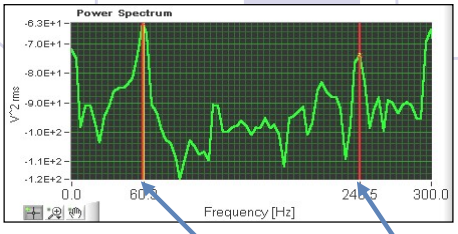
- Baseband, zoom, and subset FFT
- Achieve >800 lines of resolution

Order Analysis

- Like frequency analysis, it is used to examine frequency content
- Order analysis, however, normalizes the measurements to rotating speed of machinery to better dissect these signal components
- Many vibration signal components are directly related to running (rotating) speed:
  - Imbalance, misalignment, gear mesh, bearing defects, loose couplings

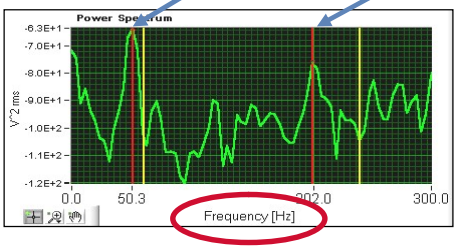
Power Spectrum

Rotating Speed: 60 Hz (3,600 rpm)



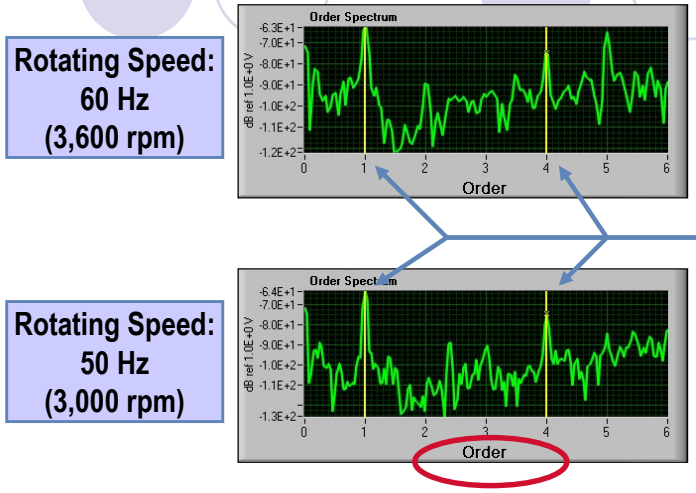
Frequency Components Shift with Speed Change

Rotating Speed: 50 Hz (3,000 rpm)



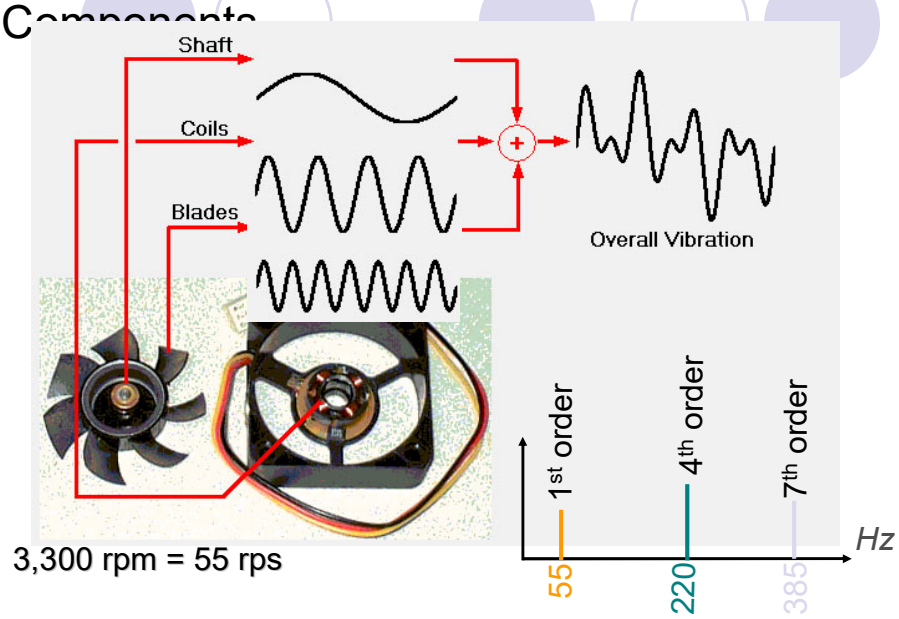
Frequency measures how many times per *second* an event occurs

Order Power Spectrum



Orders measure how many times per *revolution* an event occurs

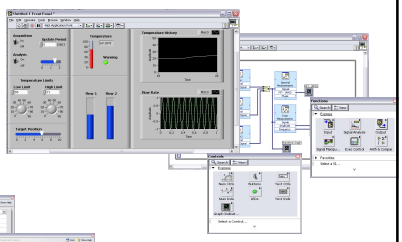
Using Order Analysis to Identify Components



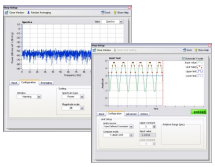
3,300 rpm = 55 rps

Analysis with NI LabVIEW & LabVIEW SignalExpress

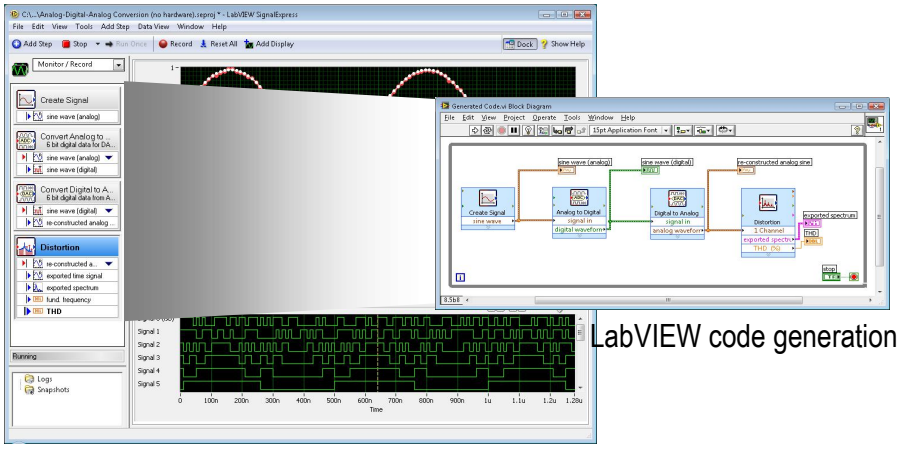
- ***LabVIEW***
  - Sound & Vibration Toolki
  - Order Analysis Toolkit



- ***LabVIEW SignalExpress***
  - Signal processing
  - Time/ Frequency domain measurements
  - Statistics

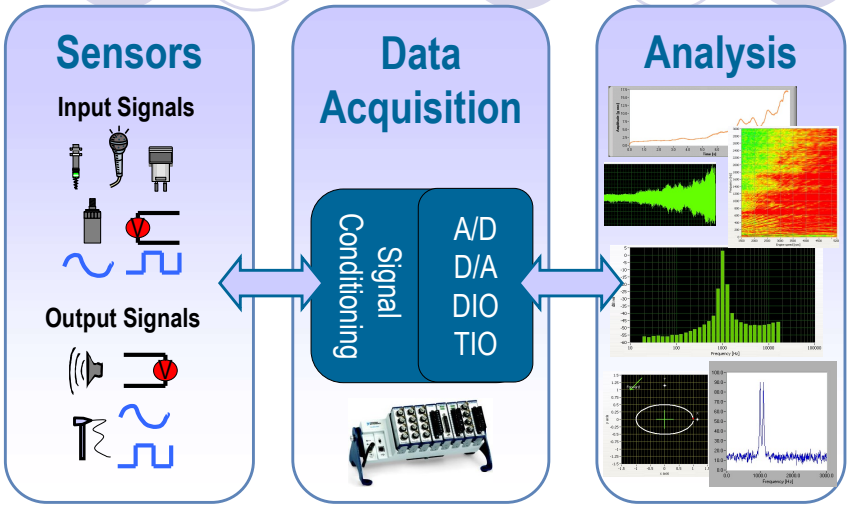


Demonstration: Sound&Vibration demo with LabVIEW SignalExpress and LabVIEW



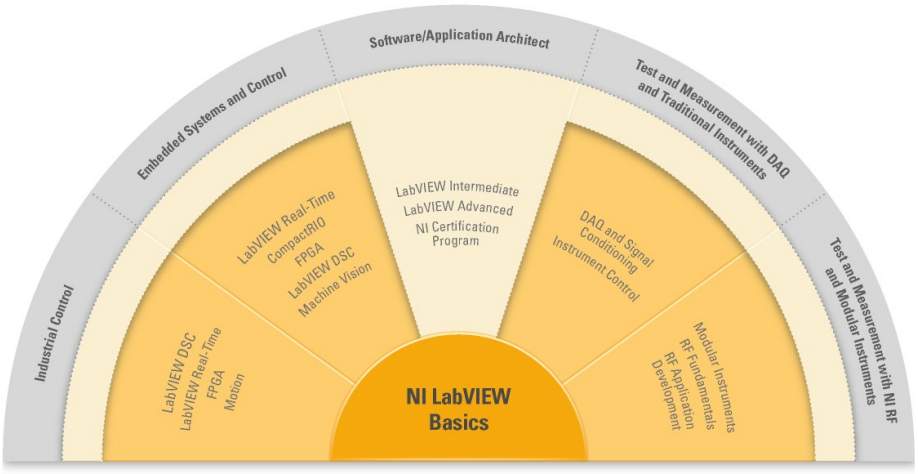
LabVIEW code generation

Machine Monitoring Components



So what are your machines saying now?

LabVIEW Training Paths



ni.com/slovenia/training