VIRTUAL INSTRUMENTATION

Virtual instrument – an equimplent that allows accomplishment of measurements using the computer. It looks like a real instrument, but its operation and functionality is essentially different.

VI has 2 components:

- hardware interface
- software for signal acquisition and processing

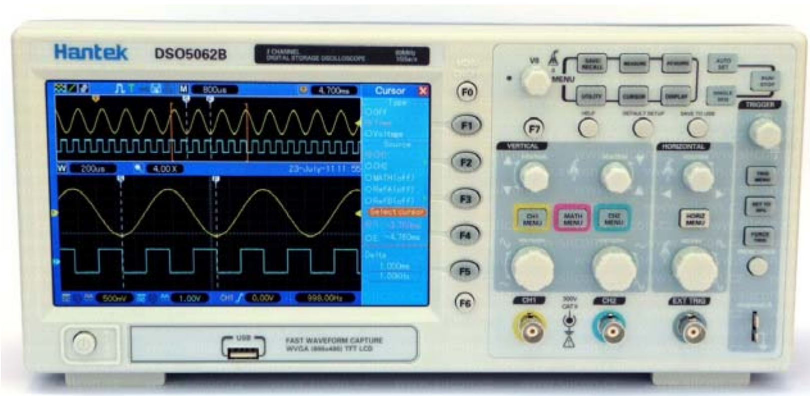
Functions:

- signal acquisition
- signal processing and information recovery
- information storing
- remote data transmission
- additional: implementation of algorithms for process monitoring and control

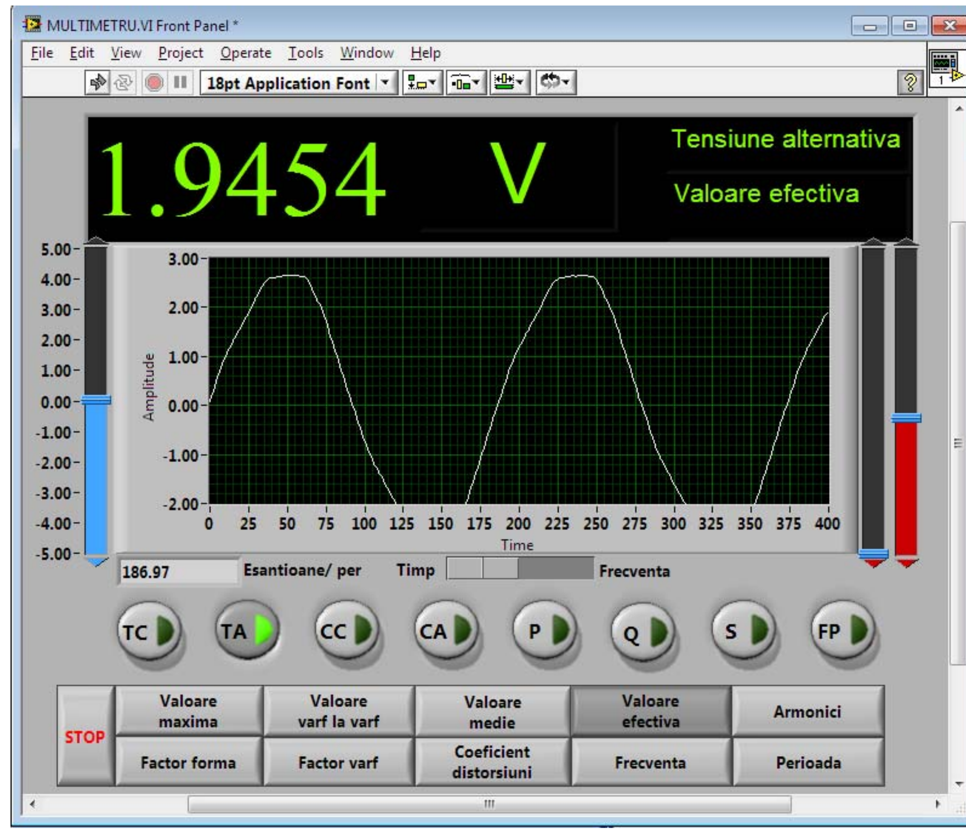
Titular: Prof.dr.ing. Cristian Foşalău

VIRTUAL INSTRUMENTATION

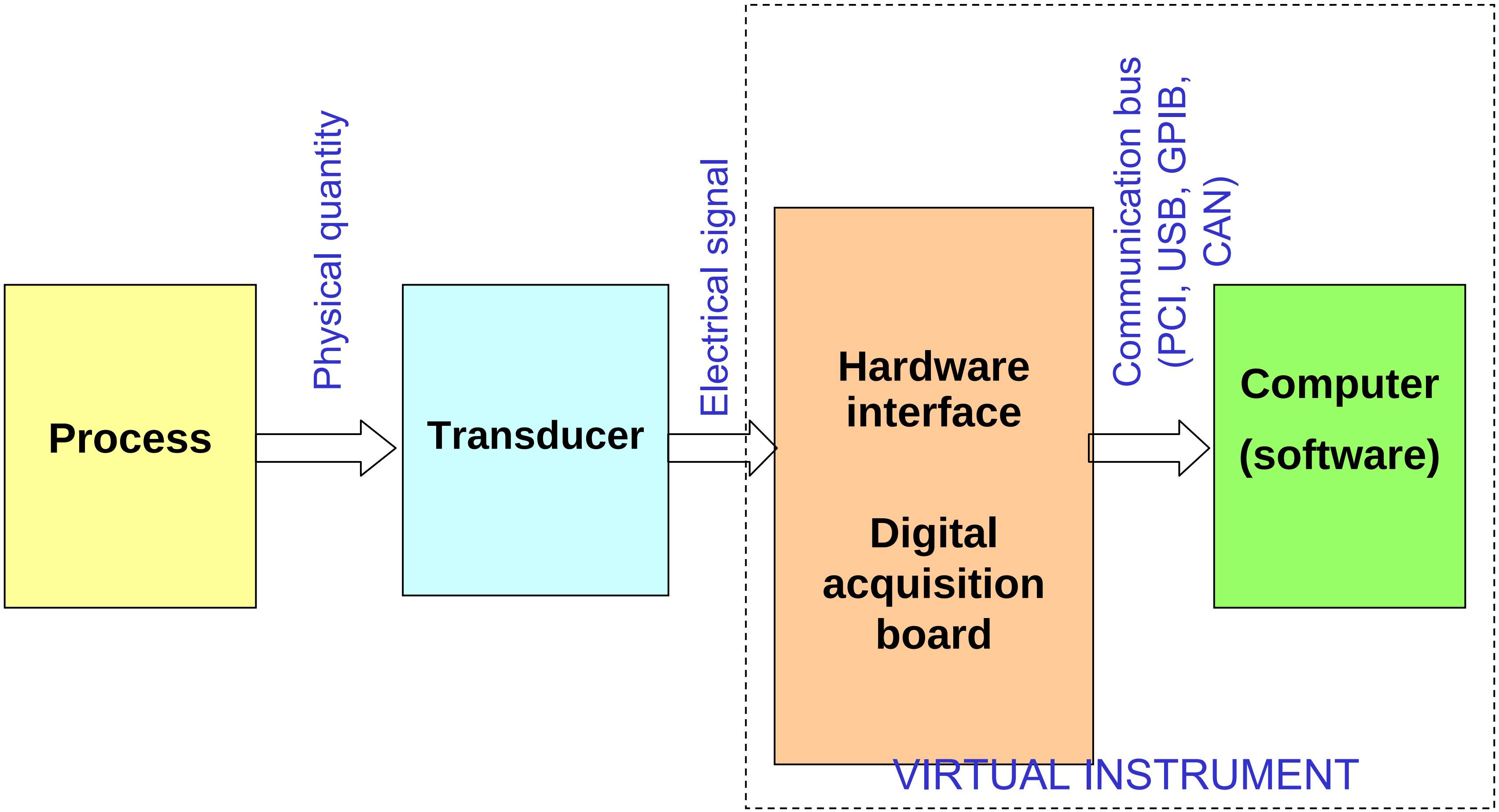
Real instruments



Virtual instrument



STRUCTURE OF A VI



Titular: Prof.dr.ing. Cristian Foşalău

STRUCTURE OF A VI

ADVANTAGES OF A VI

- Possibility of measuring on a large number of points and places
- Complex processing of data and of measurement information
- Local or remote data storing
- Remote transmission of data through wired or wireless communication
- Statistics and forecasts accomplishment
- Flexibility: possibility of extension or adding of new functions to the instrument by simple modifications of software
- Improving measurement accuracy by statistical processing and compensation of influence factors
- Possibility of adding of new functions for process testing, monitoring and control

Titular: Prof.dr.ing. Cristian Foşalău

MEASUREMENT SIGNALS

Signal = a variable on an energetic support containing information characteristic to a quantity or a phenomenon.

Examples: audio, video or biomedical signals, sounds, music, radar, measurement signals.

Measurement signal

- has a voltage or current support
- contains information regarding the measurement quantity (measurand).
- Is provided by the transducer (sensor)
- Depends on time
- Information is contained in: level, shape, frequency, phase, duty cycle.

In terms of continuity, signals can be:

- analog (they are continuous functions in time) – almost all natural signals

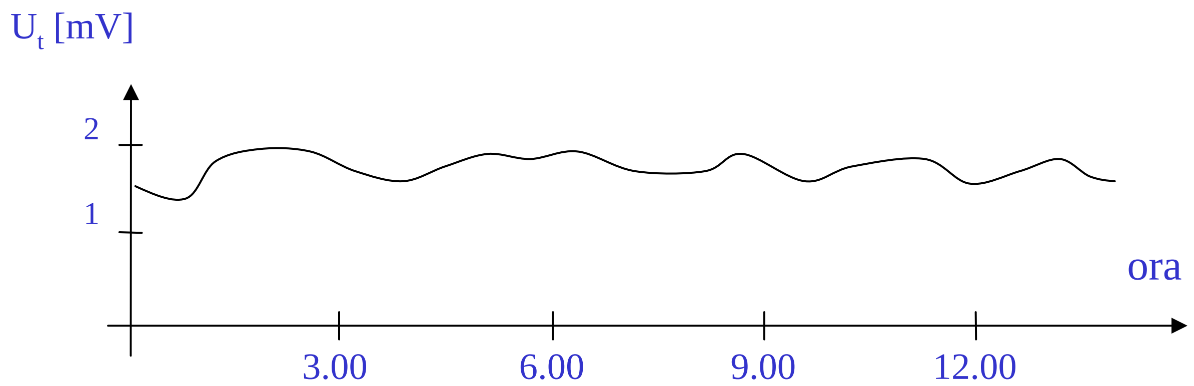
- discrete or digital - strings of numbers representing instances of the analog signal taken at equally spaced time intervals

ANALOG AND DISCRETE SIGNALS

examples

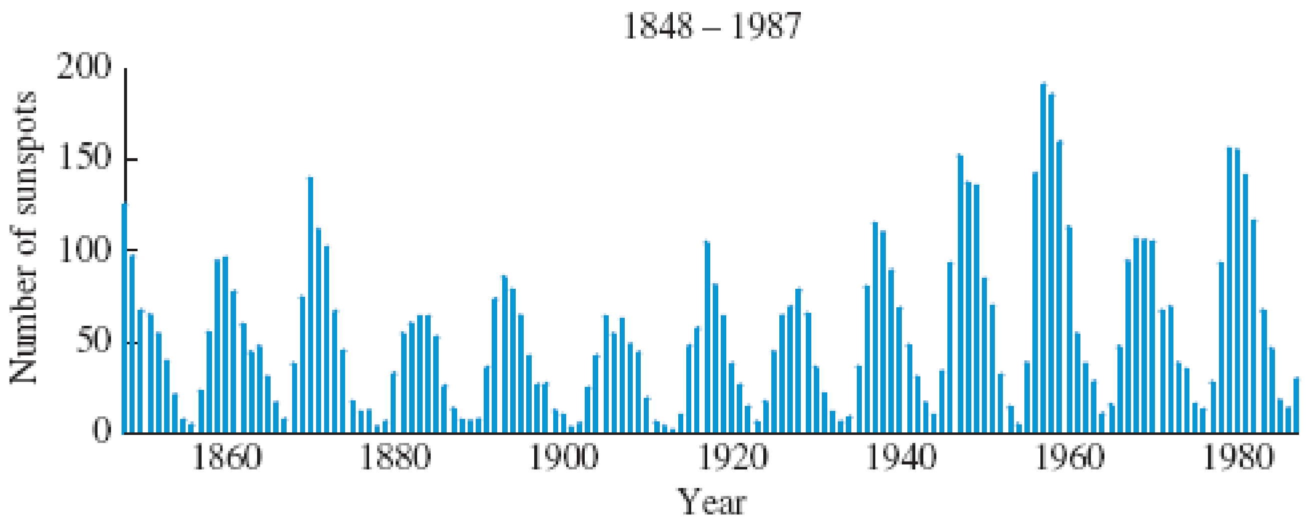
Analog signal

Voltage variation at a thermocouple terminals



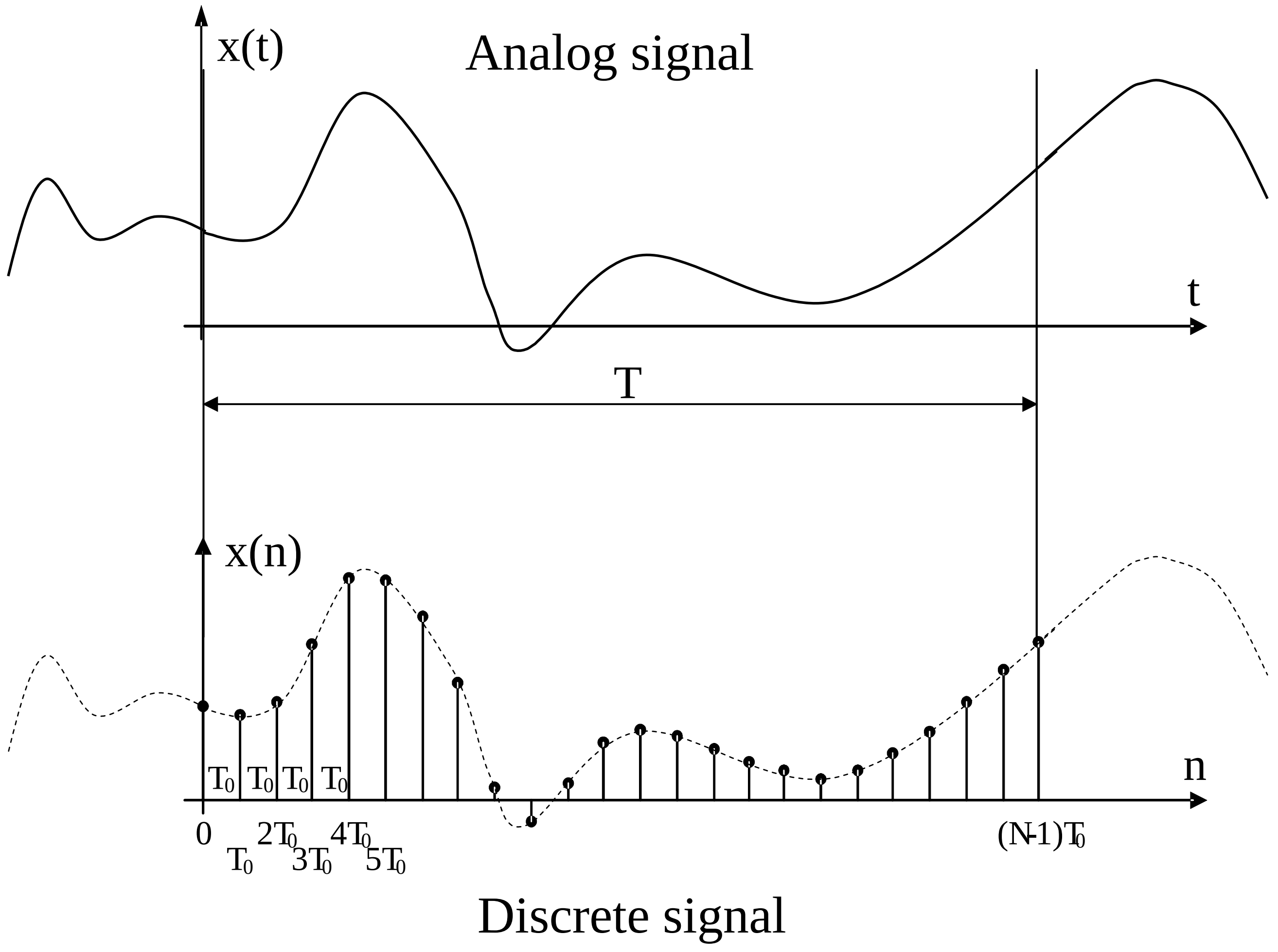
Discrete signal

Evolution of the solar spots number over time



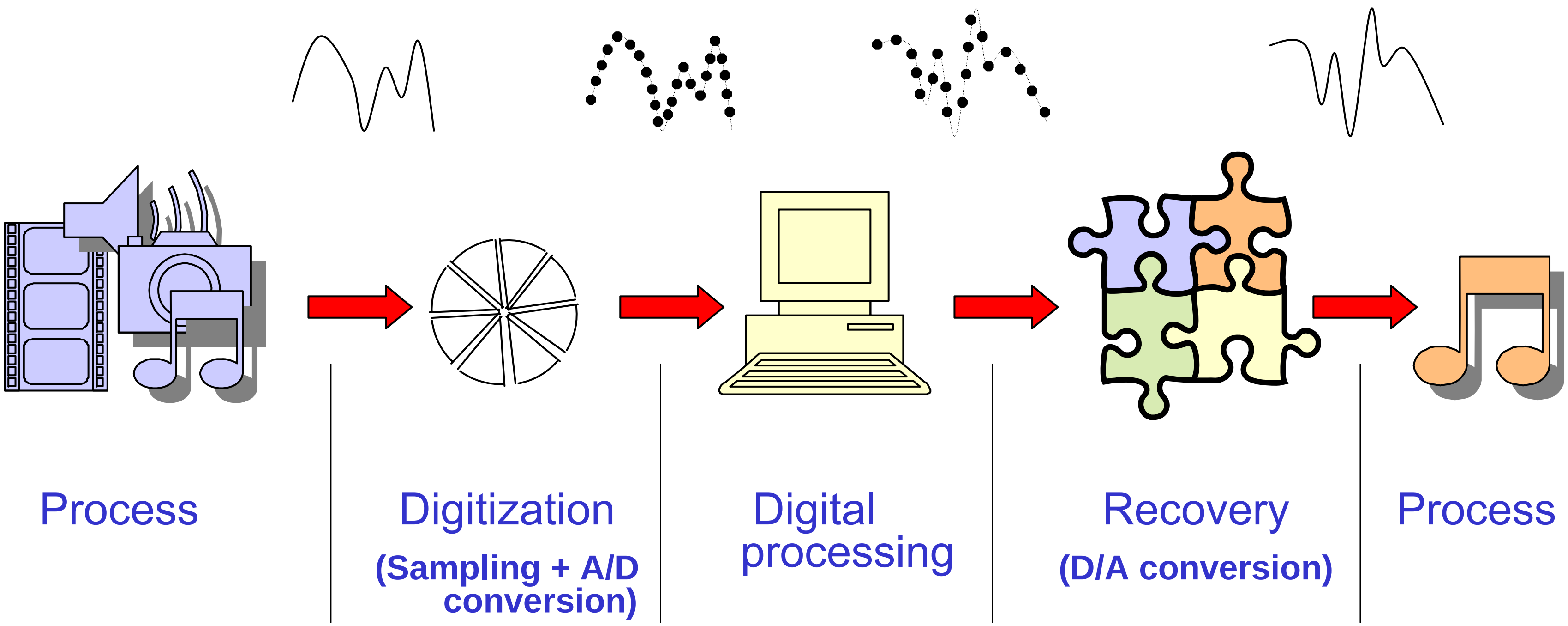
ANALOG AND DISCRETE SIGNALS

examples

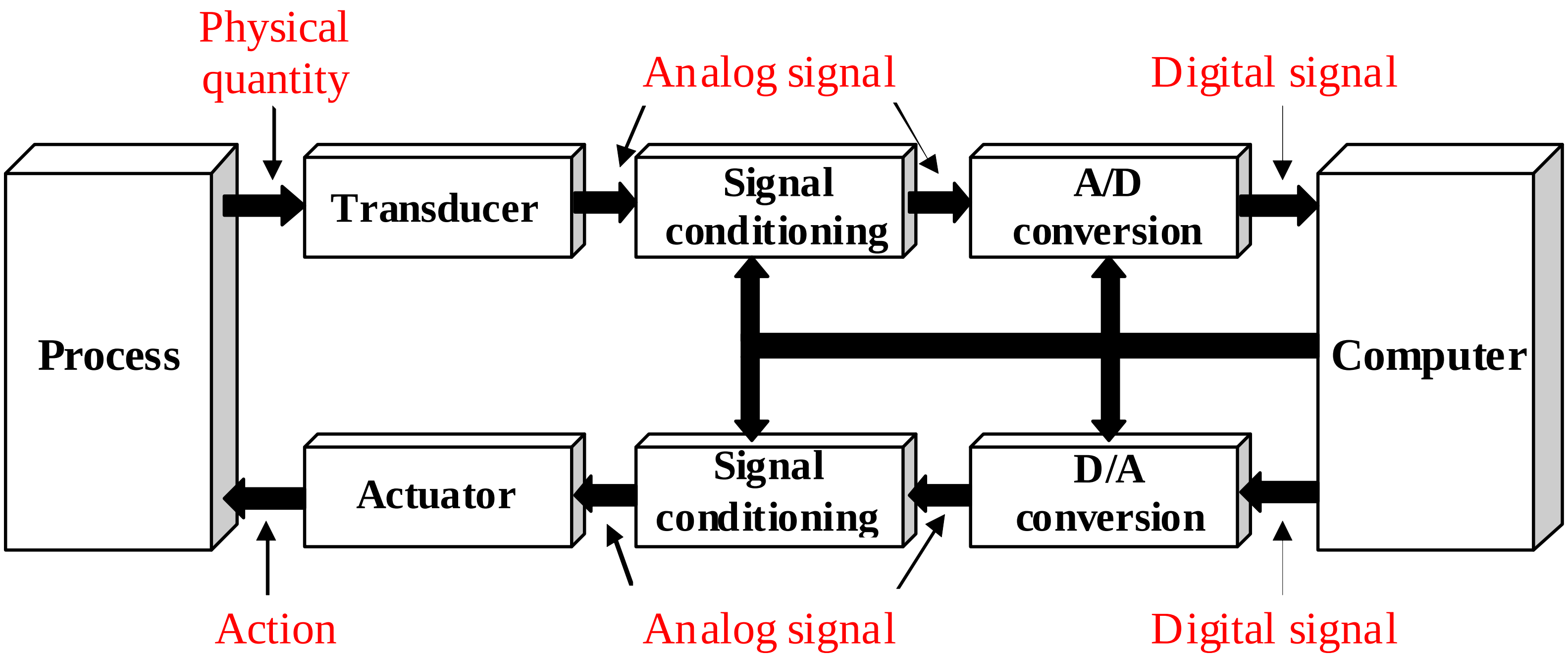


Titular: Prof.dr.ing. Cristian Foşalău

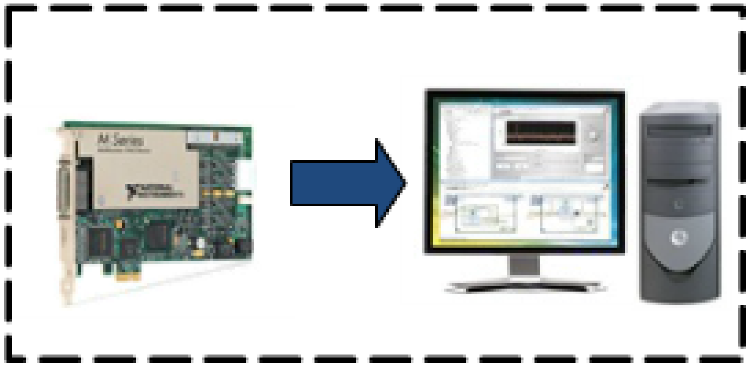
DIGITAL SIGNAL PROCESSING



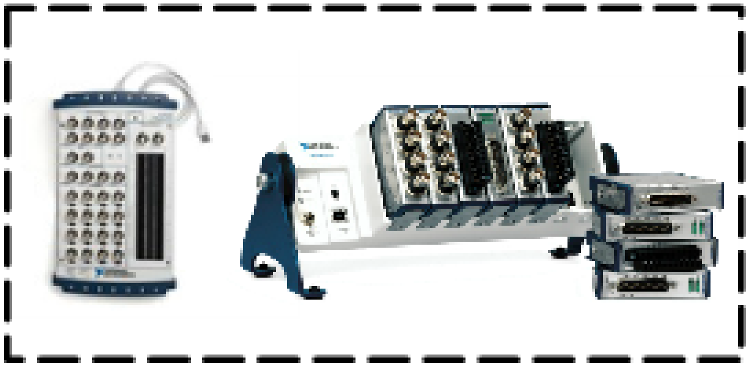
SIGNAL ACQUISITION USING THE COMPUTER



DIGITAL ACQUISITION HARDWARE OPTIONS



Desktop

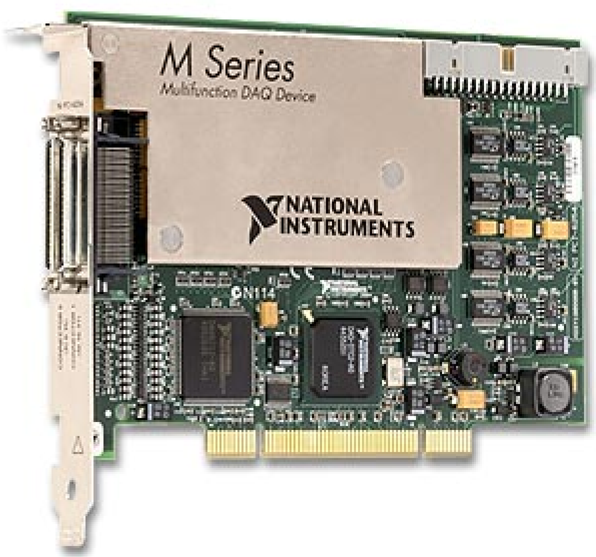


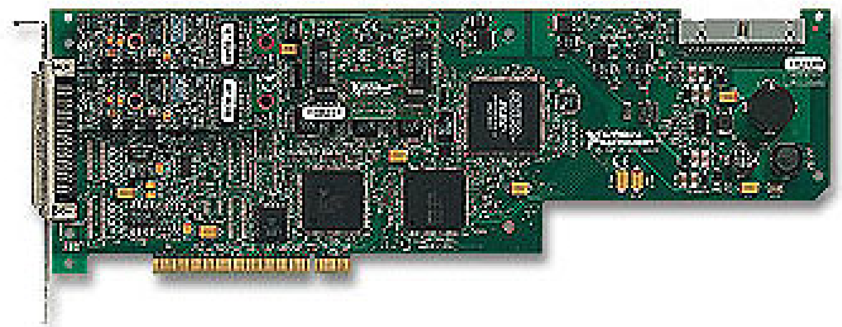
USB

Remote

PXI

DIGITAL ACQUISITION BOARD ON PCI BUS





Titular: Prof.dr.ing. Cristian Foşalău

DIGITAL ACQUISITION BOARD ON USB

DIGITAL ACQUISITION BOARD ON USB

DATA ACQUISITION USING COMPACT DAQ

Inputs

- Thermocouple
- RTD
- Resistor
- Voltage
- Current
- Digital (TTL)
- Accelerometer
- Microphone
- Strain gauge

Communication

- USB

PXI SYSTEM

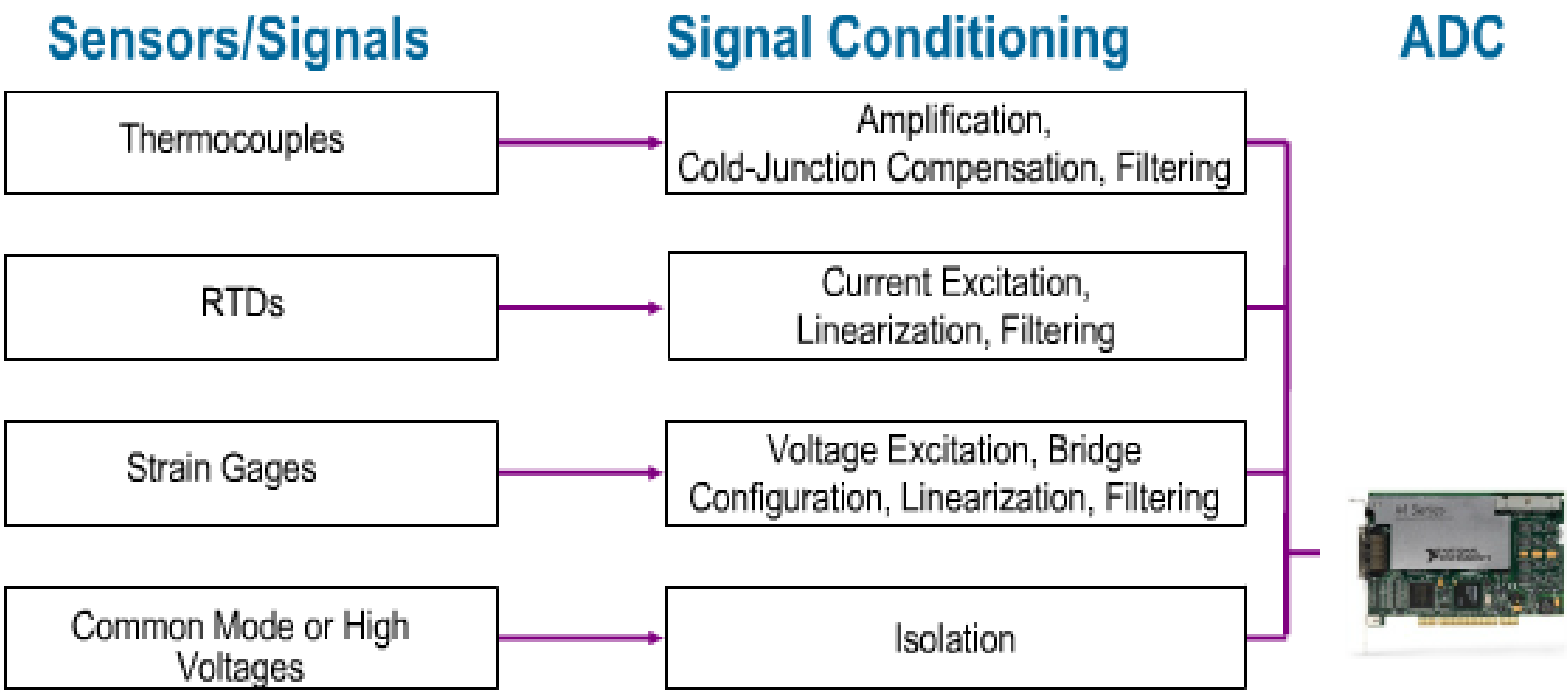
Industrial platform for measurement and control based on process computer

DIGITAL ACQUISITION BOARD ON PCMCIA

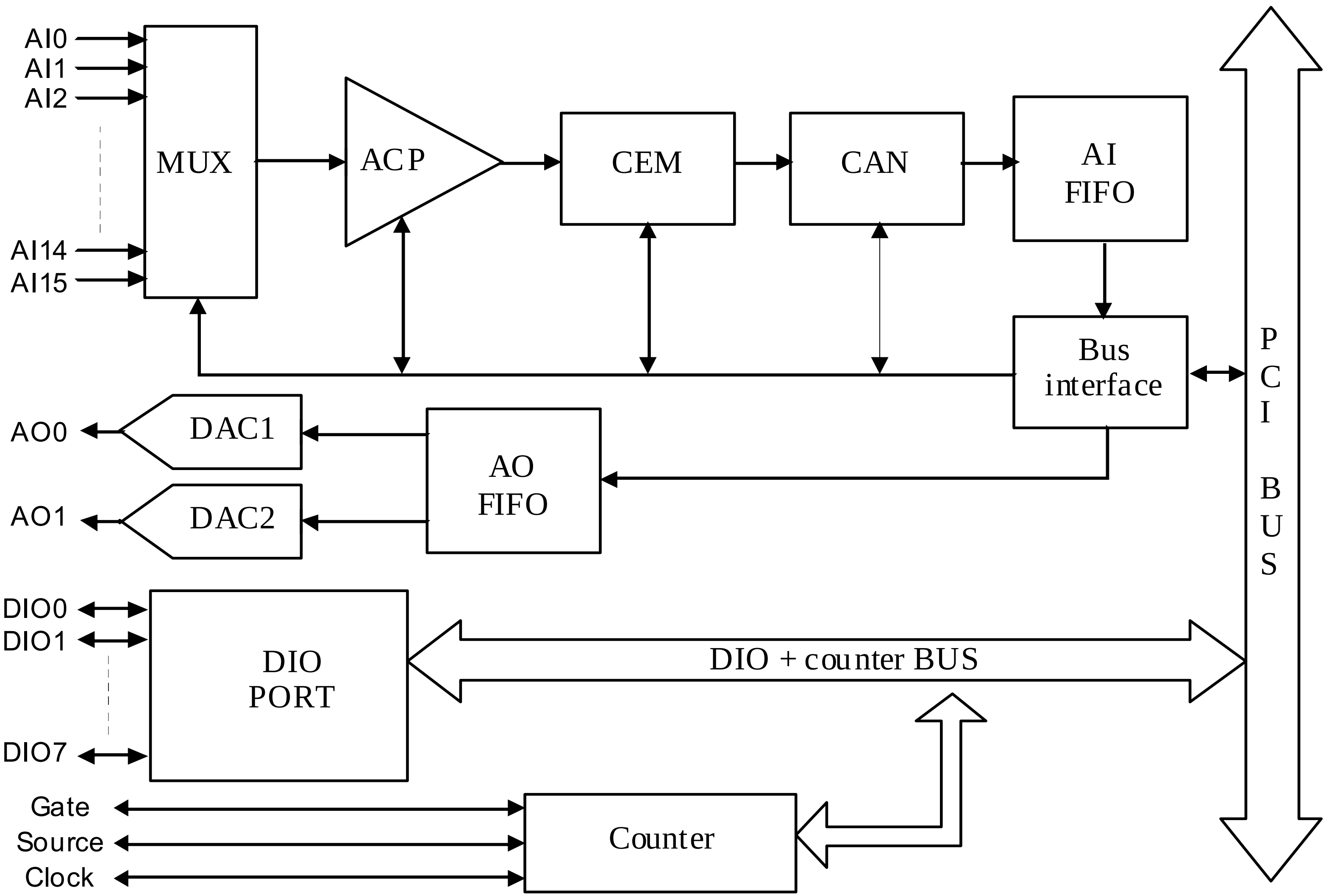
DIGITAL ACQUISITION BOARD FOR PDA

SIGNAL CONDITIONING

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



DATA ACQUISITION BOARD STRUCTURE



DATA ACQUISITION BOARD FUNCTIONS

Analog inputs module

- Analog signal multiplexing
- Analog signal amplification
- Sampling
- Quantization (analog-to-digital conversion)
- Data transmission to the computer

Analog outputs module

- Digital-to-analog conversion
- Information updating to analog outputs

Digital I/O module

- Acquisition / generation of digital signals

Counter module

- Event counting, frequency/period measurement, pulse train generation

TECHNICAL CHARACTERISTICS OF DAQ BOARDS

Bus	Model	Analog inputs (AI)	Sampling freq. input	Analog outputs (AO)	Sampling freq. output	Digital I/O lines	Triggering
PCI Express	6320	16	250 kS/s	0	-	24	Digital
PCI Express	6321	16	250 kS/s	2	900 kS/s	24	Digital
PCI Express	6323	32	250 kS/s	4	900 kS/s	48	Digital
PCI Express, PXI Express	6341	16	500 kS/s	2	900 kS/s	24	Digital
PCI Express	6343	32	500 kS/s	4	900 kS/s	48	Digital
PCI Express	6351	16	1.25 MS/s	2	2.86 MS/s	24	Analog, Digital
PCI Express	6353	32	1.25 MS/s	4	2.86 MS/s	48	Analog, Digital
PCI Express, PXI Express	6361	16	2 MS/s	2	2.86 MS/s	24	Analog, Digital
PCI Express, PXI Express	6363	32	2 MS/s	4	2.86 MS/s	48	Analog, Digital
PXI Express	6356	8 simultan	1.25 MS/s/channel	2	3.33 MS/s	24	Analog, Digital
PXI Express	6358	16 simultan	1.25 MS/s/channel	4	3.33 MS/s	48	Analog, Digital
PXI Express	6366	8 simultan	2 MS/s/channel	2	3.33 MS/s	24	Analog, Digital
PXI Express	6368	16 simultan	2 MS/s/channel	4	3.33 MS/s	48	Analog, Digital

SIGNAL DIGITIZATION

Digitization supposes 3 operations:

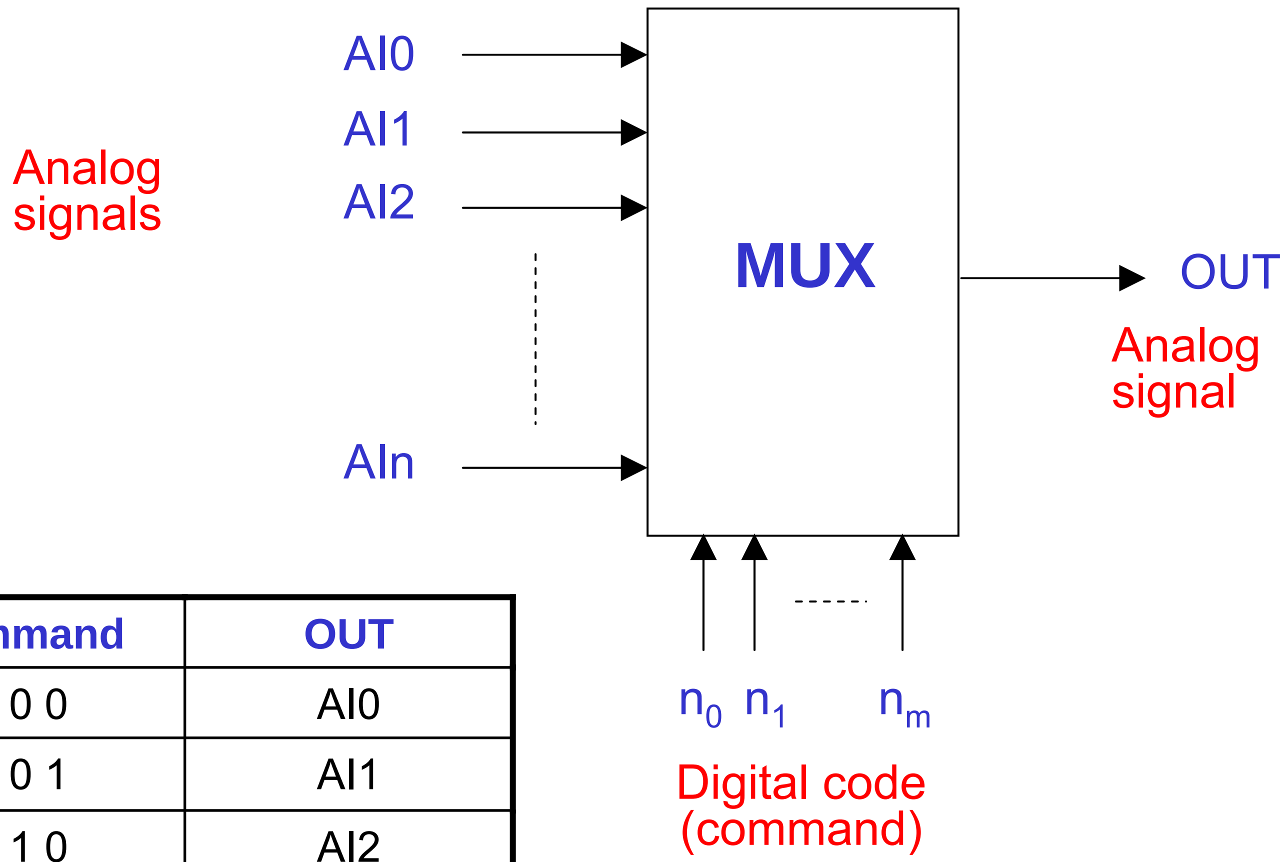
- **Sampling –** taking at equally spaced time intervals of instantaneous values from an analog signal (samples)

- **Truncation** – cutting from an infinite time signal of a piece finite in time (window)

- **Quantization (A/D conversion)** – conversion of the samples voltage levels into digital codes (bits succession)

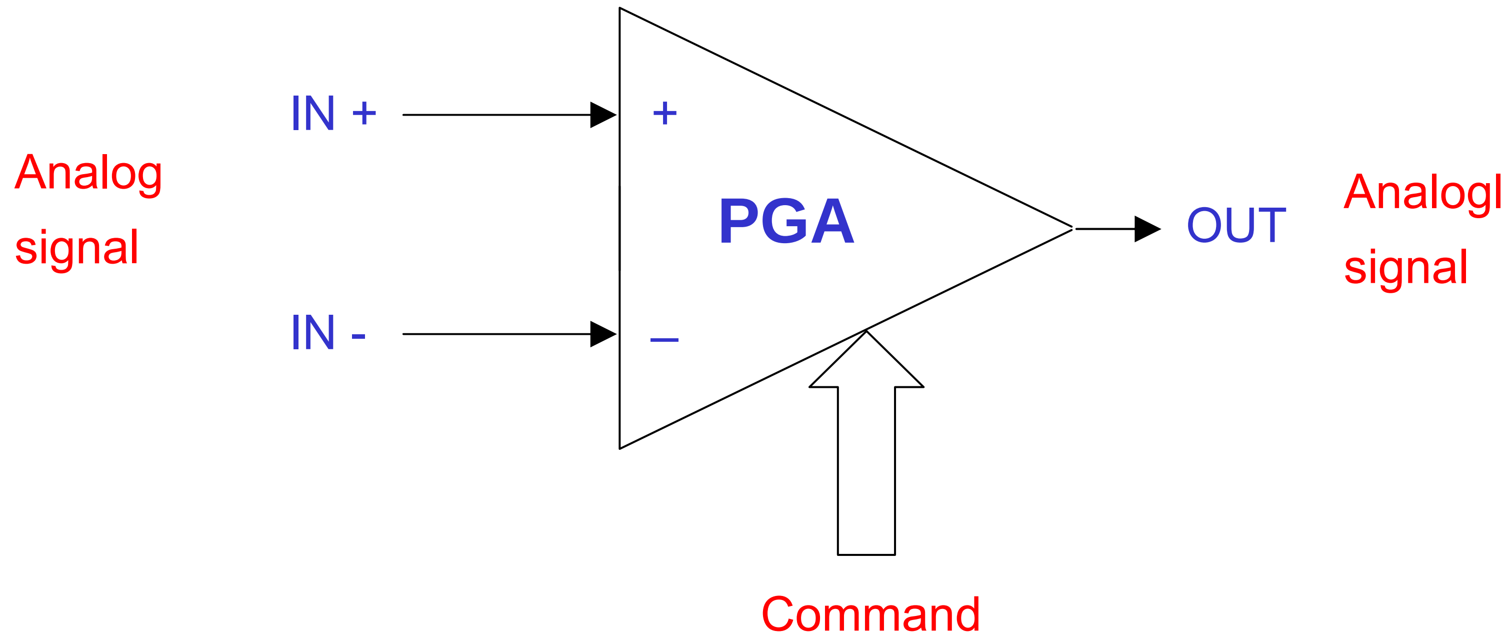
Titular: Prof.dr.ing. Cristian Foşalău

MULTIPLEXING



Command	OUT
0 0 0	AI0
0 0 1	AI1
0 1 0	AI2
----------------	----------------

PROGRAMMABLE GAIN AMPLIFIER

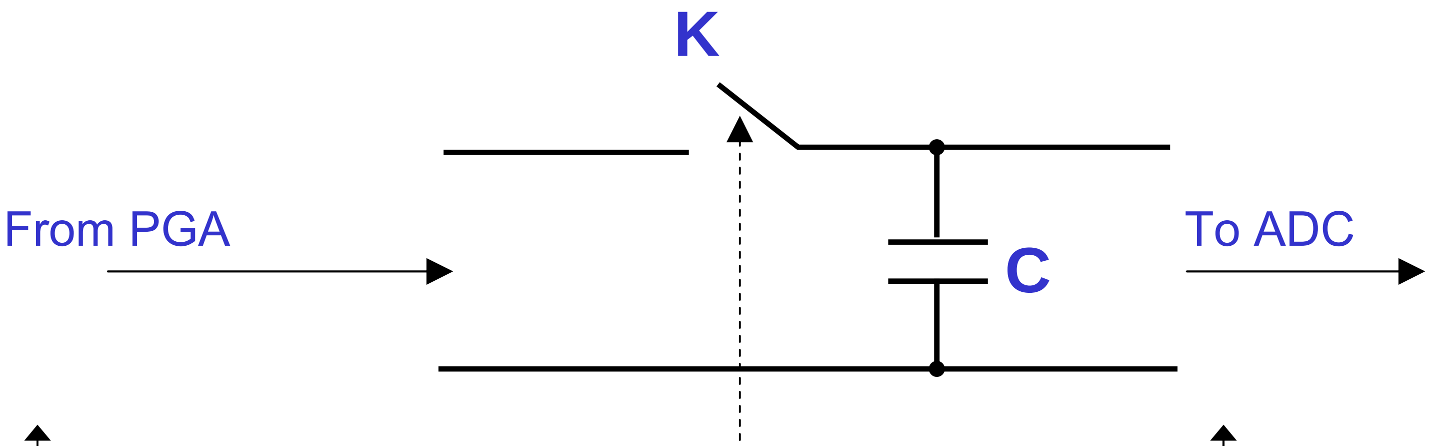


Command	Gain
0 0 0	1
0 0 1	2
0 1 0	5
-------------	-------------

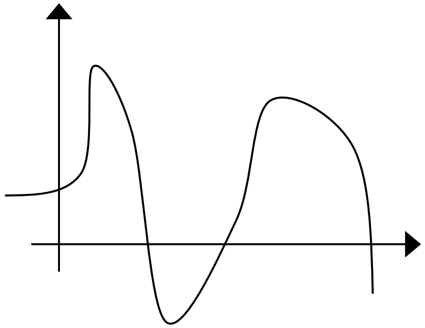
PGA = Programmable Gain Amplifier

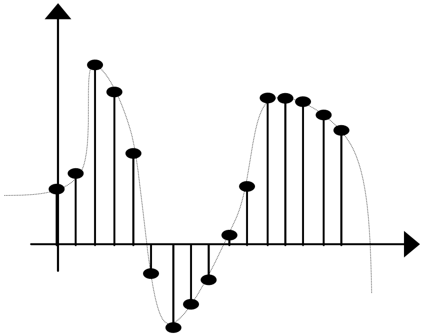
Titular: Prof.dr.ing. Cristian Foşalău

SAMPLE & HOLD



Command





T_0 – Sampling period

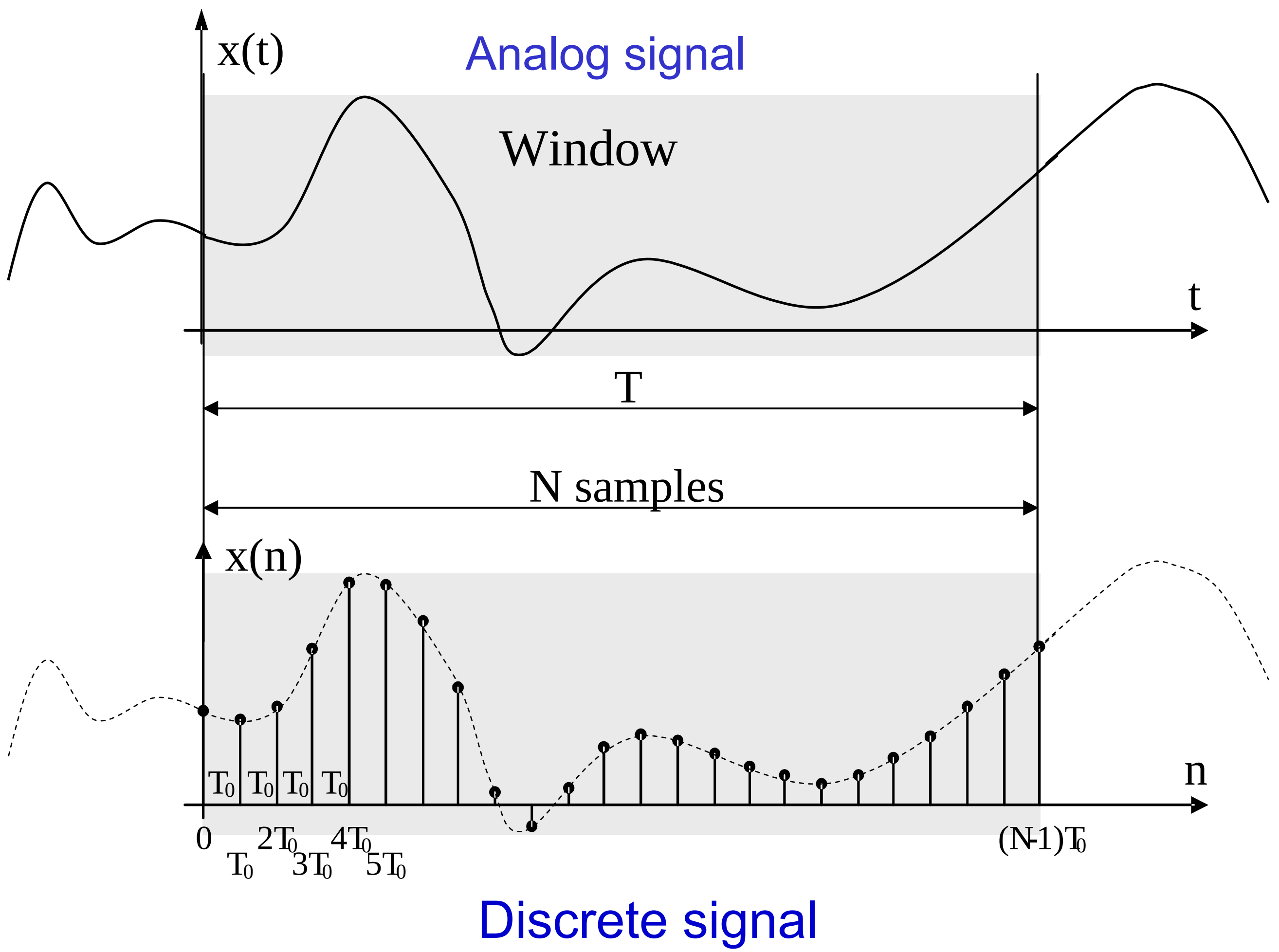
Continuous signal

$$f_0 = \frac{1}{T_0}$$

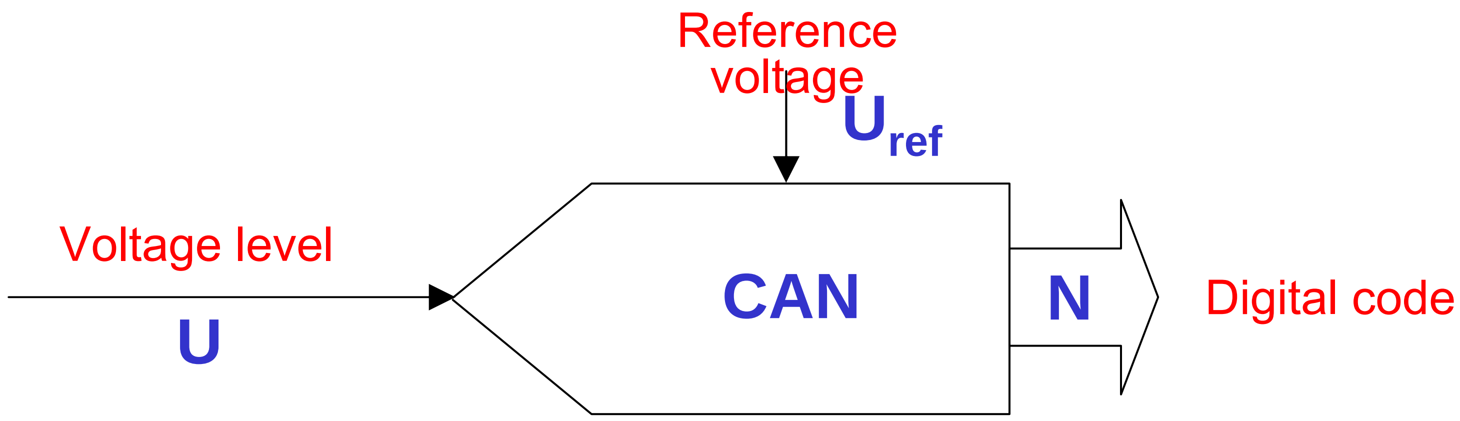
Sampled signal

Titular: Prof.dr.ing. Cristian Foşalău

SAMPLE & HOLD

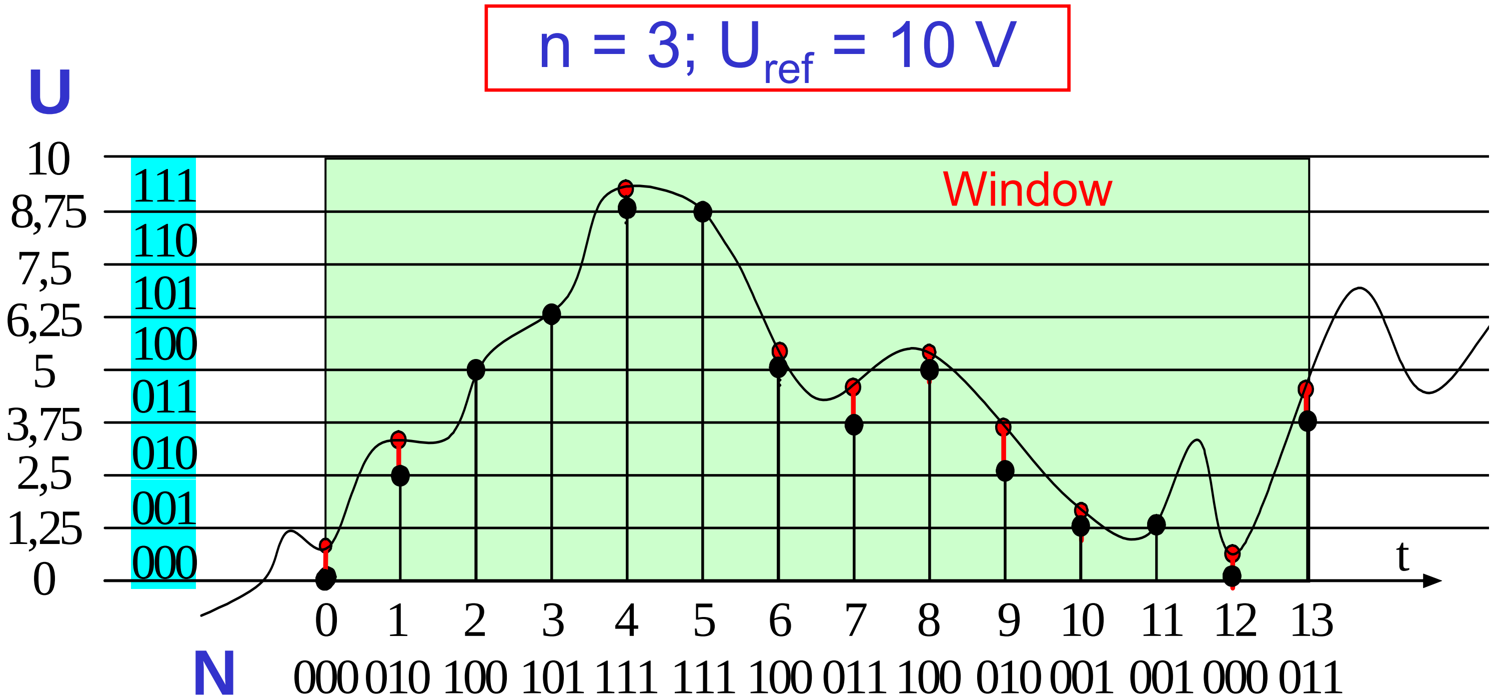

x(t)
Analog signal
Window
t
T
N samples
x(n)
n
T0 T0 T0 T0
0 2T0 4T0
T0 3T0 5T0
(N-1)T0
Discrete signal

ANALOG-TO-DIGITAL CONVERSION (ADC)



$$U = \frac{U_{ref}}{2^n} N$$

ANALOG-TO-DIGITAL CONVERSION (ADC)



$x(n) = \{0, 2, 3, 5, 7, 7, 4, 3, 4, 2, 1, 1, 0, 3\}$

Titular: Prof.dr.ing. Cristian Foşalău

ANALOG-TO-DIGITAL CONVERSION (ADC)
- example -

$n = 3;\ U_{ref} = 10\ V;\ U = 1,95\ V$

Without amplification

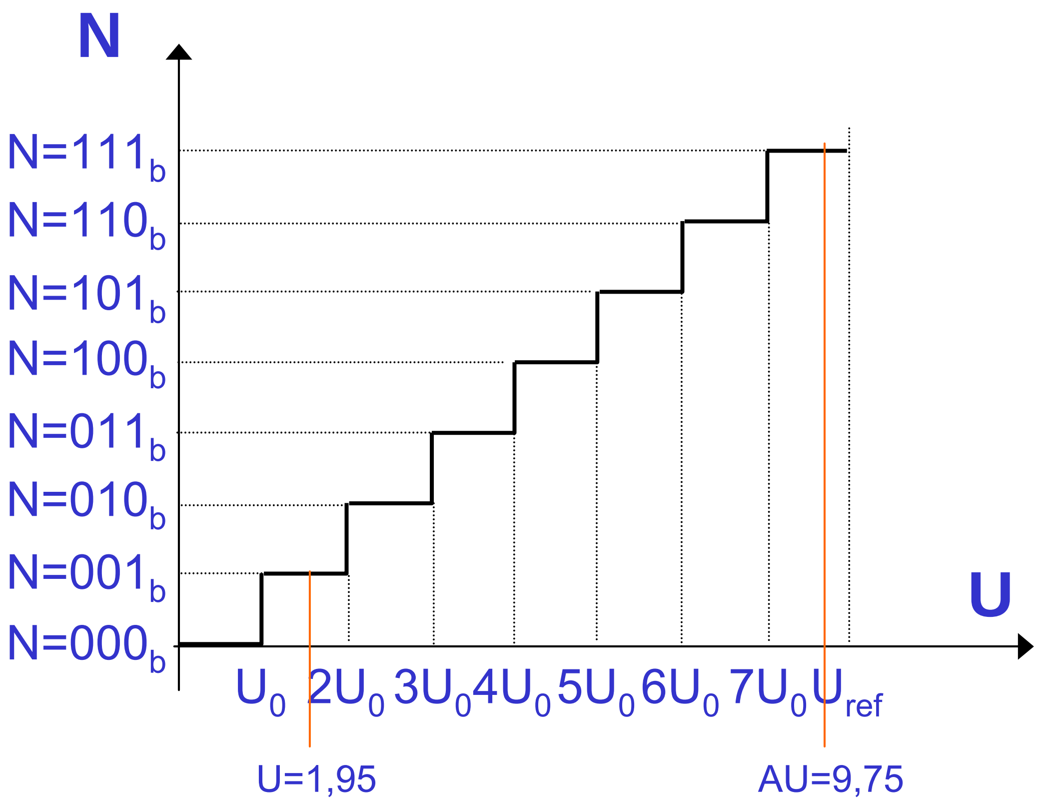
$$U = \frac{U_{ref}}{2^n} N \qquad U_0 = \frac{U_{ref}}{2^n}$$

$$\varepsilon = \frac{1,95 - 1,25}{1,95} 100 = 35,9\%$$

With amplification (A = 5)

$$U = \frac{U_{ref}}{A 2^n} N \qquad U_0 = \frac{U_{ref}}{A 2^n}$$

$$\varepsilon = \frac{9,75 - 8,75}{8,75} 100 = 10,25\%$$



Titular: Prof.dr.ing. Cristian Foşalău