

Fakulta strojní VŠB – TUO

Katedra automatizační techniky a řízení

**Control Instrumentation**

doc. Ing. Jaromír Škuta, Ph.D.

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Katedra automatizační techniky a řízení

**Lecture No. 3**

**Standardized signals and types of modulations for information transmission, A/D and D/A converters, serial interface, ...**

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Katedra automatizační techniky a řízení

**What do you find out?**

- Standardized signals
- Modulation
- A/D converters
- D/A converters
- The internal structure of the measuring card
- Internal structure of the control system
- Serial interface
- Parallel interface
- ...

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## Transfer of information

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## International System of Units

Symbol	Name	Quantity
s	second	time
m	metre	length
kg	kilogram	mass
A	ampere	electric current
K	kelvin	thermodynamic temperature
mol	mole	amount of substance
cd	candela	luminous intensity

Name	Symbol	Quantity	In SI base units	In other SI units
radian <sup>1)</sup>	rad	plane angle	dim	1
steradian <sup>1)</sup>	sr	solid angle	dim <sup>2)</sup>	1
hertz	Hz	frequency	s <sup>-1</sup>	1
newton	N	force, weight	kg·m·s <sup>-2</sup>	
pascal	Pa	pressure, stress	kg·m <sup>-1</sup> ·s <sup>-2</sup>	N/m <sup>2</sup> = J/m <sup>3</sup>
joule	J	energy, work, heat	kg·m <sup>2</sup> ·s <sup>-2</sup>	N·m = Pa·m <sup>3</sup>
watt	W	power, radiant flux	kg·m <sup>2</sup> ·s <sup>-3</sup>	dim
coulomb	C	electric charge	A·s	
volt	V	electric potential, voltage, emf	kg·m <sup>2</sup> ·s <sup>-3</sup> ·A <sup>-1</sup>	W/A = J/C
ohm	Ω	resistance	kg·m <sup>2</sup> ·s <sup>-3</sup> ·A <sup>-2</sup>	C/V = J/C <sup>2</sup>
siemens	S	electrical conductance	kg <sup>-1</sup> ·m <sup>-2</sup> ·s <sup>3</sup> ·A <sup>2</sup>	1/Ω
weber	Wb	magnetic flux	kg·m <sup>2</sup> ·s <sup>-2</sup> ·A <sup>-1</sup>	V·s
tesla	T	magnetic flux density	kg <sup>-1</sup> ·s <sup>-2</sup> ·A <sup>-1</sup>	Wb/m <sup>2</sup>
henry	H	inductance	kg <sup>-1</sup> ·m <sup>2</sup> ·s <sup>-2</sup> ·A <sup>-2</sup>	Wb/A
degree Celsius	°C	temperature relative to 273.15 K	K	
lumen	lm	luminous flux	cd·m <sup>2</sup>	lm
lux	lx	illuminance	cd·m <sup>-2</sup>	lm/m <sup>2</sup> = cd·sr·m <sup>-2</sup>
becquerel	Bq	activity referred to a radionuclide (decays per unit time)	s <sup>-1</sup>	
gray	Gy	absorbed dose of ionizing radiation	J·kg <sup>-1</sup>	J/kg
siemens	Sv	equivalent dose of ionizing radiation	J·kg <sup>-1</sup>	J/kg
becquerel	Bq	activity	s <sup>-1</sup>	

1) 1 = 1/360° The radian and steradian are defined as dimensionless derived units.

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## Signal measurement

Parallel arrangement of resistors

in general  $\frac{1}{R} = \sum \frac{1}{R_i}$

e.g.  $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$C = C_1 + C_2$        $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

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### Control systems interface



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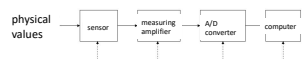
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### Interface

A/D (A/N) and D/A (N/A)



The fineness of signal quantization depends on the

$$\Delta u = \frac{u_{ref}}{2^n}$$

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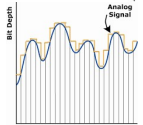
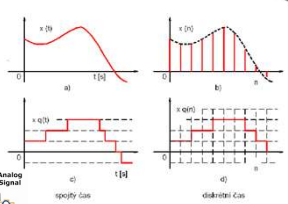
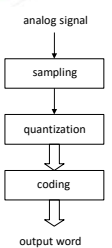
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### A/D and D/A conversion



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### Quantization of signals

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### Types of converters

- A/D
- D/A
- PWM
- f/U
- U/f

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### Principles of partial connections

$$U_{out} = -R_f \left( \frac{U_1}{R_1} + \frac{U_2}{R_2} + \dots + \frac{U_n}{R_n} \right)$$

$$U_{vyst} = \begin{cases} U_{S+} & \text{if } U_+ > U_- \\ U_{S-} & \text{if } U_+ < U_- \end{cases}$$

$Q^n$	D	$Q^{n-1}$
0	0	0
0	1	1
1	0	0
1	1	1

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### Comparison parallel A/D converter

- Resistive divider –
- Comparators –
- D –
- Decoder –

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### Comparative with stepwise comparison

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### Compensation counter

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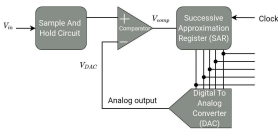
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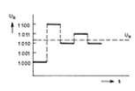


### Compensatory with gradual approximation

**Compensation A/D converter (feedback) with gradual approximation**



Block Diagram



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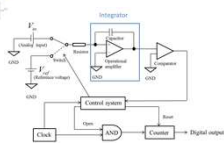
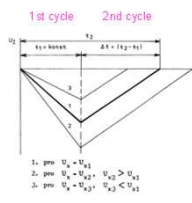
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### Integrative with double integration

**Integration A/D converter with double integration**

Diagram

1. pro  $U_x = U_{ref}$
2. pro  $U_x = U_{ref}$ ,  $U_{x2} > U_{x1}$
3. pro  $U_x = U_{ref}$ ,  $U_{x2} < U_{x1}$

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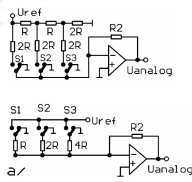
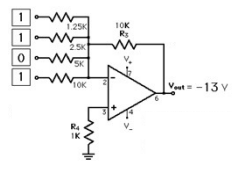
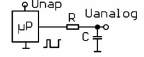
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### D/A converter

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### Transfer of measured data

Static characteristics of a three-bit converter

Quantization noise

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### PWM converter

PWM (Pulse Width Modulation) is

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### Modulation

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**What was the content of the lecture?**

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