

Fakulta strojní VŠB – TUO

Katedra automatizační techniky a řízení



Control Instrumentation

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1

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Lecture no. 2

Static and dynamic characteristics of measuring and control circuit members (static characteristics, sensitivity, accuracy, reliability, transient and frequency characteristics, dynamic error, identification of dynamic characteristics, reasons for identification, ...)

2

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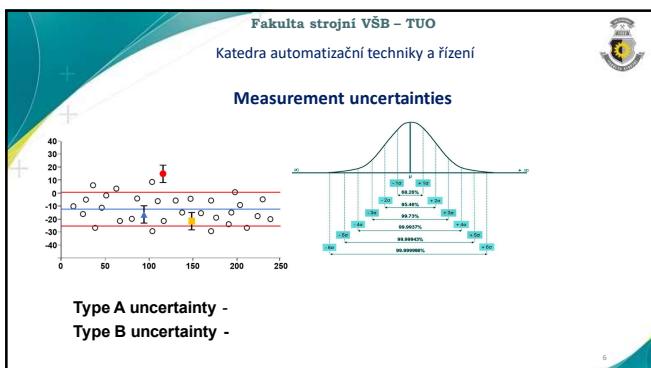
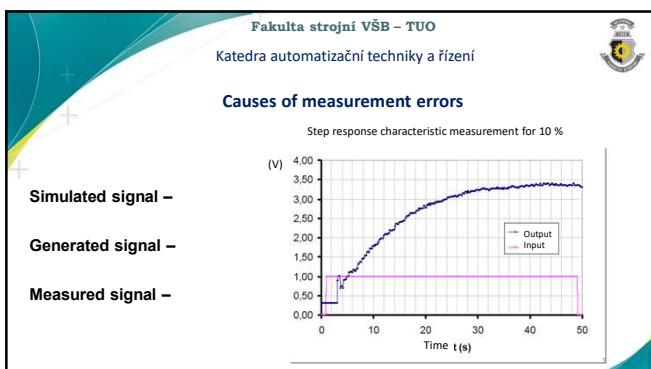
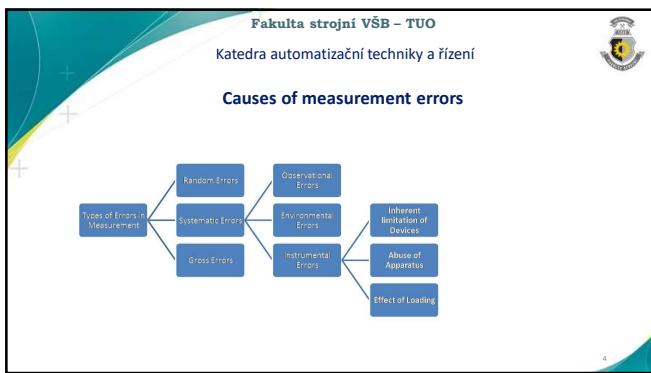
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What do you find out?

- Use of knowledge about static and dynamic properties of elements.
- Types of measurement uncertainty.
- Minimization of measurement errors.
- What is the instrument's accuracy class?
- What is it and how to measure the static characteristic?
- What is it and how to measure the step response?
- What is it and how to measure the frequency characteristic?
-

3



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Measurement uncertainties

The resulting uncertainty consists of several sub-uncertainties. From the most general point of view, they are divided into two components.

Type A –

Type B –

$$u_C = \sqrt{u_A^2 + u_B^2}$$

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Measurement errors

Gross measurement errors -

Systematic Measurement Errors -

Statistical Measurement errors -

methods of processing measurement results:

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Formal recording of the measurement result

$$x = (\tilde{\mu}_x \pm u_{c,x}) [x]$$

$$u_{c,x}$$

$$\tilde{\mu}$$

$$[x]$$

$$u_c^2 = u_A^2 + u_B^2$$

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Decimal prefixes

10^{12}	tera	T	bilón	1 000 000 000 000	fec. týžec – „setkací“	TW – terawatt
10^9	giga	G	miliarda	1 000 000 000	fec. výšec – „obrovský“	GHz – gigahertz
10^6	mega	M	milion	1 000 000	fec. výšec – „velký“	MeV – megaelectronvolt
10^3	kilo	k	tisíc	1 000	fec. výšec – „jako“	kN – kilonewton
10^2	hektá	h	sto	100	fec. desetv – „sto“	HPa – hektopascal
10^1	déka	da	deset	10	fec. deset – „deset“	dag – dékagram
10^0	—	—	jedna	1		m – metr
10^{-1}	deci	d	desetina	0,1	lat. decimus – „desetý“	dB – dekibel
10^{-2}	centi	c	sedma	0,01	lat. centum – „sto“	cm – centimetr
10^{-3}	mil	m	taisina	0,001	lat. milles – „jedna“	mm – milimetr
10^{-4}	mikro	μ	milionina	0,000 001	fec. myriac – „mily“	μA – mikromampér
10^{-9}	nano	n	milardina	0,000 000 001	fec. novac – „spousták“	nT – nanotesla
10^{-12}	piko	p	biliontina	0,000 000 000 001	lat. piccolo – „malý“	pF – pikofarad
10^{-15}	fento	f	biliontina	0,000 000 000 000 001	dan. fenten – „pærnæst“	fm – femtometr
10^{-18}	atto	a	triliontina	0,000 000 000 000 000 001	dan. atten – „zomrænt“	as – ottosekunda

10

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Principles for recording the measurement results

$\alpha = 0.001234 \rightarrow 4$ significant digits

$\alpha = 0.6070120 \rightarrow 7$ significant digits

$v = (3.86 \pm 0.03) \text{ ms}^{-1}$

$P = (8.706 \pm 0.054) \text{ mW}$

11

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Class of accuracy

Class of accuracy

Class of accuracy

Class of accuracy

$\Delta_i = |X_i - X_0|$

$P = \frac{\Delta_{i_{\text{max}}}}{R} \cdot 100\%$

12

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Class of accuracy	
P	Category
0.1	normal
0.2	normal
0.5	laboratory
1	laboratory
1.5	operating
2.5	operating

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Compensation sensor method

measured value error value

measuring sensor

$y = Kx + z - K'z$

compensation sensor

K, K'

x, z

$y = Kx + z - K'z$

K, K'

$K'z$

$y = Kx + z - K'z$

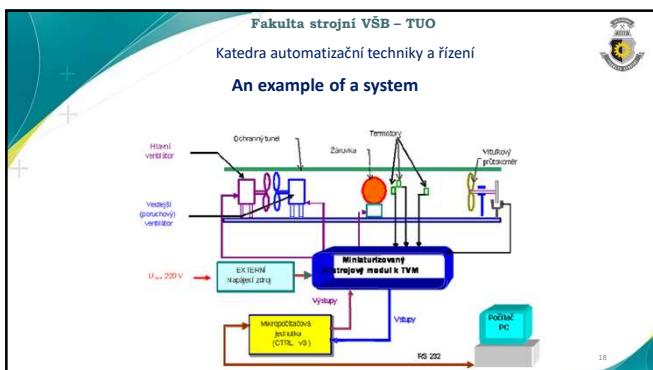
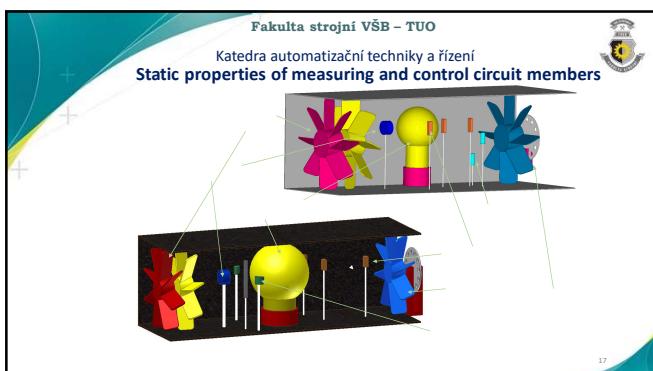
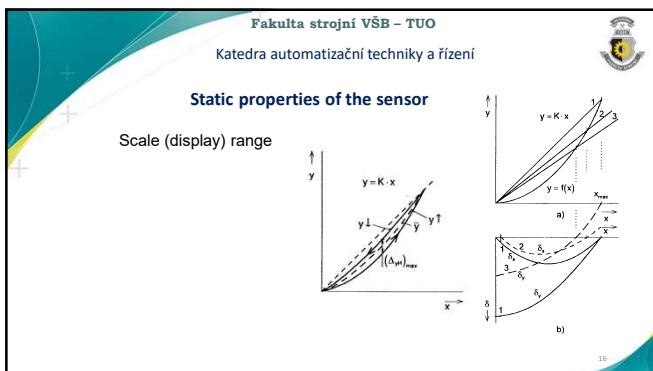
R_1, R_2, R_3

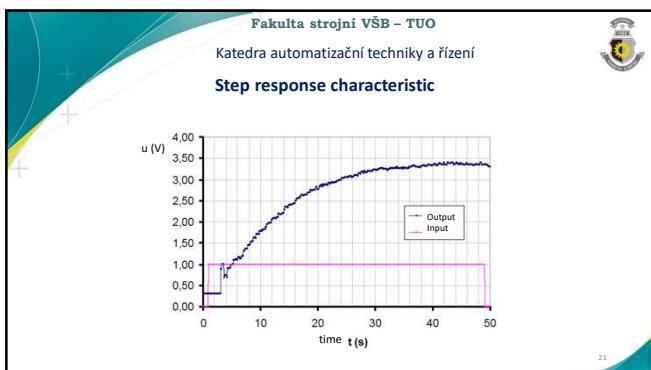
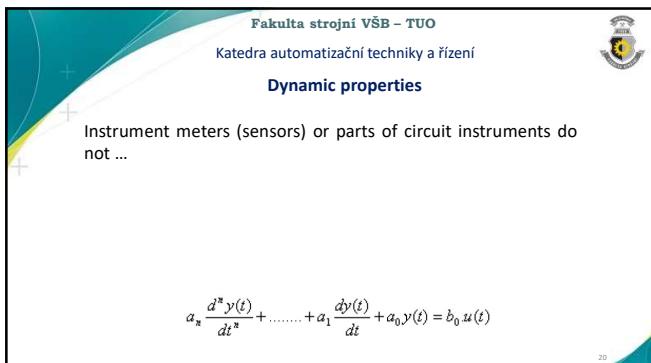
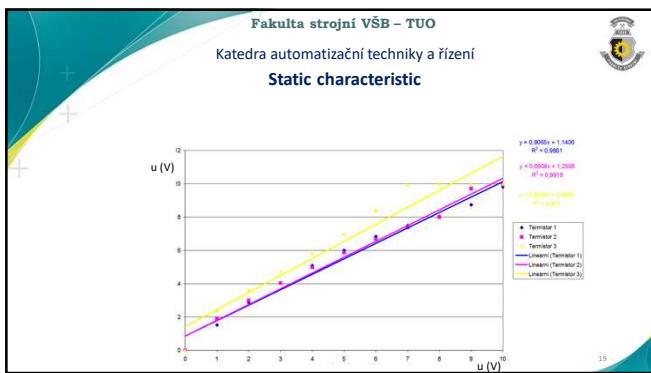
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R_1/R_2

kompenzační snímač

měřená hodnota





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Frequency response (domain)

$u(t) = u_0 \sin \omega t$

$y(t) = y_0 \sin(\omega t + \varphi)$

$u(t) = u_0 e^{j\omega t}$

$y(t) = y_0 e^{j(\omega t + \varphi)}$

The figure contains several plots and a block diagram:

- Top Left:** A Nyquist plot showing magnitude $|T(j\omega)|$ versus frequency ω . It features three nested closed curves representing different system orders: 1. order, 2. order, and 3. order.
- Top Right:** A Nyquist plot showing magnitude $|T(j\omega)|$ versus frequency ω . It includes labels for poles $P(j\omega_p)$ and zeros $Z(j\omega_z)$, and shows the effect of feedback gain B/A and load resistance R_L .
- Middle Left:** A block diagram of a system. The input is $u(t)$, which passes through a summing junction labeled S to produce the output $y(t)$. The error signal is $u(t) - y(t)$. The system has two parallel branches with resistors R_1 and R_2 and capacitors C_1 and C_2 .
- Middle Right:** Two Bode plots. The top plot is the amplitude characteristic $|M(j\omega)|$ versus frequency ω , showing a curve with corner frequencies ω_1 and ω_2 . The bottom plot is the phase characteristic $\varphi(j\omega)$ versus frequency ω , showing a curve with corner frequencies ω_1 and ω_2 .

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Static characteristic (effect of working point)

Static characteristics of the system

u_o	u_p	K_p	T_1
0	0.00	1.00	10
1	3.36	1.00	3.0
2	4.77	2.39	10.0
3	6.18	2.08	7.5
4	6.92	1.73	6.3
5	7.57	1.51	5.5
6	8.19	1.30	4.7
7	8.75	1.24	4.6
8	9.22	1.15	4.2
9	9.60	1.05	4.0
10	9.99	1.00	4.0

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