

Fakulta strojní VŠB – TUO

Department of Control Systems and Instrumentation

**Automatic Control Devices
(notes)**

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Lecture No. 1

Overview of the principles of sensors and sensors, methods of evaluation, static, dynamic properties (follow-up to the subjects Automation technology, Measurement and sensor technology). (Question 2, 3, 4, 5, 6, 7).

2

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What do you find out?

- An overview of the principles of sensors and sensors
 - Position
 - Distance
 - Temperature
 - Vibration
 - Force
 -
- Ways of evaluation
- Static properties
- Dynamic properties
- ...

3

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Prerequisite knowledge

- In the subjects Automation technology in the bachelor's study –



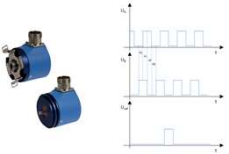
- In the subject Measurement and sensor technology in the master's study...

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Criterion I

- for measuring electrical quantities,
- ...



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Criterion I - according to the measured quantity

This is one of the basic criteria used by the

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Criterion II

- Capacitive

...

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Criterion II

Not all methods of evaluation may be

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Criterion III -

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Criterion III

The essence of this criterion is whether the given sensor **needs an external ...**

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Criterion IV –

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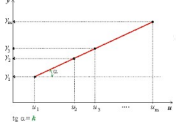
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Criterion IV –

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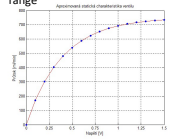
Static properties

- Static characteristic
-



$$\sigma_{TF} = \frac{|\Delta|}{X_p} 100\%$$

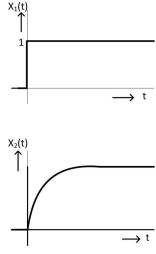
Δ_m maximum absolute error
 X_p the largest value of the measuring range



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Dynamic properties

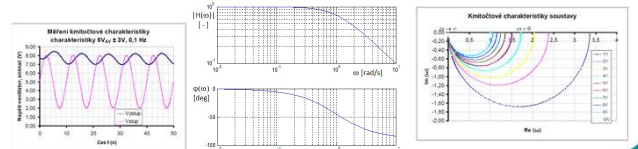
- Step respons–



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Dynamic properties

- Frequency characteristic



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Requirements

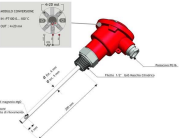
- Principle of sensor
- ...
- measurement of dimensions,
- ...

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Example sensor question

- Principle



°C	Ohm	°C	Ohm	°C	Ohm	°C	Ohm	°C	Ohm	°C	Ohm	°C	Ohm	°C	Ohm
-200	18.49	-187	45.31	-174	75.15	-161	91.49	151	110.76	138	143.86	127	157.21		
-189	18.85	-188	45.55	-175	75.33			152	110.98	139	144.17	128	157.52		
-188	19.06	-187	45.89	-176	75.63	-160	91.09	153	110.91	140	144.55	129	157.88		
-187	19.26	-186	46.25	-177	75.93			154	111.07	141	144.91	130	158.21		
-186	19.45	-185	46.62	-178	76.23	-159	90.87	155	111.22	142	145.23	131	158.46		
-185	19.63	-184	47.02	-179	76.53			156	111.36	143	145.53	132	158.68		
-184	19.80	-183	47.43	-180	76.83	-158	90.65	157	111.49	144	145.80	133	158.88		
-183	19.96	-182	47.85	-181	77.13	-157	90.44	158	111.61	145	146.04	134	159.07		
-182	20.11	-181	48.28	-182	77.43	-156	90.22	159	111.72	146	146.25	135	159.25		
-181	20.25	-180	48.72	-183	77.73	-155	90.00	160	111.82	147	146.44	136	159.41		
-180	20.38	-179	49.17	-184	78.03	-154	89.77	161	111.91	148	146.60	137	159.55		
-179	20.50	-178	49.63	-185	78.33	-153	89.53	162	112.00	149	146.75	138	159.68		
-178	20.61	-177	50.10	-186	78.63	-152	89.28	163	112.08	150	146.88	139	159.79		
-177	20.71	-176	50.57	-187	78.93	-151	89.02	164	112.15	151	147.00	140	159.89		
-176	20.80	-175	51.05	-188	79.23	-150	88.75	165	112.21	152	147.10	141	159.98		
-175	20.88	-174	51.53	-189	79.53	-149	88.47	166	112.27	153	147.19	142	160.06		
-174	20.95	-173	52.02	-190	79.83	-148	88.18	167	112.32	154	147.27	143	160.13		
-173	21.01	-172	52.51	-191	80.13	-147	87.88	168	112.37	155	147.34	144	160.19		
-172	21.06	-171	53.01	-192	80.43	-146	87.57	169	112.41	156	147.40	145	160.24		
-171	21.10	-170	53.51	-193	80.73	-145	87.25	170	112.45	157	147.45	146	160.28		
-170	21.13	-169	54.01	-194	81.03	-144	86.92	171	112.48	158	147.49	147	160.31		
-169	21.15	-168	54.51	-195	81.33	-143	86.58	172	112.51	159	147.52	148	160.33		
-168	21.16	-167	55.01	-196	81.63	-142	86.23	173	112.53	160	147.54	149	160.35		
-167	21.17	-166	55.51	-197	81.93	-141	85.87	174	112.55	161	147.56	150	160.36		
-166	21.18	-165	56.01	-198	82.23	-140	85.50	175	112.56	162	147.57	151	160.37		
-165	21.18	-164	56.51	-199	82.53	-139	85.12	176	112.57	163	147.58	152	160.38		
-164	21.18	-163	57.01	-200	82.83	-138	84.73	177	112.57	164	147.58	153	160.38		
-163	21.17	-162	57.51	-201	83.13	-137	84.33	178	112.57	165	147.57	154	160.37		
-162	21.15	-161	58.01	-202	83.43	-136	83.92	179	112.56	166	147.55	155	160.35		
-161	21.12	-160	58.51	-203	83.73	-135	83.50	180	112.54	167	147.52	156	160.32		
-160	21.08	-159	59.01	-204	84.03	-134	83.07	181	112.51	168	147.48	157	160.28		
-159	21.03	-158	59.51	-205	84.33	-133	82.63	182	112.47	169	147.43	158	160.23		
-158	20.97	-157	60.01	-206	84.63	-132	82.18	183	112.42	170	147.37	159	160.17		
-157	20.90	-156	60.51	-207	84.93	-131	81.72	184	112.36	171	147.30	160	160.10		
-156	20.82	-155	61.01	-208	85.23	-130	81.25	185	112.29	172	147.22	161	160.02		
-155	20.73	-154	61.51	-209	85.53	-129	80.77	186	112.21	173	147.13	162	159.93		
-154	20.63	-153	62.01	-210	85.83	-128	80.29	187	112.12	174	147.03	163	159.83		
-153	20.52	-152	62.51	-211	86.13	-127	79.80	188	112.02	175	146.92	164	159.72		
-152	20.40	-151	63.01	-212	86.43	-126	79.30	189	111.91	176	146.80	165	159.60		
-151	20.27	-150	63.51	-213	86.73	-125	78.79	190	111.79	177	146.67	166	159.47		
-150	20.13	-149	64.01	-214	87.03	-124	78.27	191	111.66	178	146.53	167	159.33		
-149	20.00	-148	64.51	-215	87.33	-123	77.74	192	111.52	179	146.38	168	159.18		
-148	19.85	-147	65.01	-216	87.63	-122	77.20	193	111.37	180	146.22	169	159.02		
-147	19.69	-146	65.51	-217	87.93	-121	76.65	194	111.21	181	146.05	170	158.85		
-146	19.52	-145	66.01	-218	88.23	-120	76.09	195	111.04	182	145.87	171	158.67		
-145	19.34	-144	66.51	-219	88.53	-119	75.52	196	110.86	183	145.68	172	158.48		
-144	19.15	-143	67.01	-220	88.83	-118	74.94	197	110.67	184	145.48	173	158.28		
-143	18.95	-142	67.51	-221	89.13	-117	74.35	198	110.47	185	145.27	174	158.07		
-142	18.74	-141	68.01	-222	89.43	-116	73.75	199	110.26	186	145.05	175	157.85		
-141	18.52	-140	68.51	-223	89.73	-115	73.14	200	110.04	187	144.82	176	157.62		
-140	18.29	-139	69.01	-224	90.03	-114	72.52	201	109.81	188	144.58	177	157.38		
-139	18.05	-138	69.51	-225	90.33	-113	71.89	202	109.57	189	144.33	178	157.13		
-138	17.80	-137	70.01	-226	90.63	-112	71.25	203	109.32	190	144.07	179	156.87		
-137	17.54	-136	70.51	-227	90.93	-111	70.60	204	109.06	191	143.80	180	156.60		
-136	17.27	-135	71.01	-228	91.23	-110	69.94	205	108.79	192	143.52	181	156.32		
-135	17.00	-134	71.51	-229	91.53	-109	69.27	206	108.51	193	143.23	182	156.03		
-134	16.72	-133	72.01	-230	91.83	-108	68.59	207	108.22	194	142.93	183	155.73		
-133	16.43	-132	72.51	-231	92.13	-107	67.90	208	107.92	195	142.62	184	155.42		
-132	16.13	-131	73.01	-232	92.43	-106	67.20	209	107.61	196	142.30	185	155.10		
-131	15.82	-130	73.51	-233	92.73	-105	66.49	210	107.29	197	141.97	186	154.77		
-130	15.50	-129	74.01	-234	93.03	-104	65.77	211	106.96	198	141.63	187	154.43		
-129	15.17	-128	74.51	-235	93.33	-103	65.04	212	106.63	199	141.28	188	154.08		
-128	14.83	-127	75.01	-236	93.63	-102	64.30	213	106.29	200	140.92	189	153.72		
-127	14.48	-126	75.51	-237	93.93	-101	63.55	214	105.94	201	140.55	190	153.35		
-126	14.12	-125	76.01	-238	94.23	-100	62.79	215	105.58	202	140.17	191	152.97		
-125	13.75	-124	76.51	-239	94.53	-99	62.02	216	105.21	203	139.78	192	152.58		
-124	13.37	-123	77.01	-240	94.83	-98	61.24	217	104.83	204	139.38	193	152.18		
-123	12.98	-122	77.51	-241	95.13	-97	60.45	218	104.44	205	138.97	194	151.77		
-122	12.58	-121	78.01	-242	95.43	-96	59.65	219	104.04	206	138.55	195	151.35		
-121	12.17	-120	78.51	-243	95.73	-95	58.84	220	103.63	207	138.12	196	150.92		
-120	11.75	-119	79.01	-244	96.03	-94	58.02	221	103.21	208	137.68	197	150.48		
-119	11.32	-118	79.51	-245	96.33	-93	57.19	222	102.78	209	137.23	198	150.03		
-118	10.88	-117	80.01	-246	96.63	-92	56.35	223	102.34	210	136.77	199	149.57		
-117	10.43	-116	80.51	-247	96.93	-91	55.50	224	101.89	211	136.30	200	149.10		
-116	9.97	-115	81.01	-248	97.23	-90	54.64	225	101.43	212	135.82	201	148.62		
-115	9.50	-114	81.51	-249	97.53	-89	53.77	226	100.96	213	135.33	202	148.13		
-114	9.02	-113	82.01	-250	97.83	-88	52.89	227	100.48	214	134.83	203	147.63		
-113	8.53	-112	82.51	-251	98.13	-87	52.00	228	100.00	215	134.32	204	147.12		
-112	8.03	-111	83.01	-252	98.43	-86	51.10	229	99.51	216	133.80	205	146.60		
-111	7.52	-110	83.51	-253	98.73	-85	50.19	230	99.01	217	133.27	206	146.07		
-110	7.00	-109	84.01	-254	99.03	-84	49.27	231	98.50	218	132.73	207	145.53		
-109	6.47	-108	84.51	-255	99.33	-83	48.34	232	97.98	219	132.18	208	144.98		
-108	5.93	-107	85.01	-256	99.63	-82	47.40	233	97.45	220	131.62	209	144.42		
-107	5.38	-106	85.51	-257	99.93	-81	46.45	234	96.91	221	131.05	210	143.85		
-106	4.82	-105	86.01												

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Example sensor question

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Example sensor question

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Example sensor question

dek. vzájemnosti	výstupní členy	výstupní členy	výstupní členy	výstupní členy
výstup	Q ₀	Q ₁	Q ₂	Q ₃
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

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Example sensor question

Outputs from the 4017 counter and display driver IC

Count	a	b	c	d	e	f	g
0	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1

7-segment display

Digitální počítadlo

dig. počítadlo
Najvyšší možná
hodnota 10¹⁰

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Example sensor question

$$\Delta R = f(\Delta t)$$

$$\Delta U \approx \Delta R$$

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Example sensor question

$R[\Omega]$

$t[^\circ\text{C}]$

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Example sensor question

The diagram shows a control loop starting with a reference w entering a summing junction. The output of the summing junction goes to a 'Regulátor' (controller) block, then to a 'P/O' (output) block, and finally to a 'C/A' (analog-to-digital) converter. The output of the C/A converter goes to a 'ZES' (zero-order hold) block, then to an 'A/C' (analog-to-digital) converter, and finally to a 'S1' (sensor) block. The output of S1 goes to an 'Analogový čítací obvod' (analog input circuit) block, then to an 'A/C' (analog-to-digital) converter, and finally to a 'S2' (sensor) block. The output of S2 goes to a 'Periféria' (peripheral) block, then to a 'Regulovaná veličina' (controlled variable) block, and finally to a 'V' (output) block. The output of the V block goes back to the summing junction. Below the diagram, there are three graphs: 'Kvantovaný a vzorkovaný signál' (quantized and sampled signal), showing a continuous signal $x(t)$ and its sampled version $x(t_k)$, and a graph showing the quantized signal $q(t)$.

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Example sensor question

The images show: 1) An industrial plant with tall chimneys. 2) A medical professional in a white coat using a sensor on a patient's forehead. 3) A person using a sensor on a machine.

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What was the content of the lecture

- An overview of the principles of sensors and sensors
 - Position
 - Distance
 - Temperature
 - Vibration
 - Force
 -
- Ways of evaluation
- Static properties
- Dynamic properties
- ...

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