(pieczęć wydziału)

KARTA PRZEDMIOTU

1. Nazwa przedmiotu: MEASUREMENT SYSTEMS	**2. Kod przedmiotu:**
3. Karta przedmiotu ważna od roku akademickiego: 2012	
4. Forma kształcenia: studia pierwszego stopnia	
5. Forma studiów: studia stacjonarne	
6. Kierunek studiów: AUTOMATYKA I ROBOTYKA; WYDZIAŁ AEII	
7. Profil studiów: ogólnoakademicki	
8. Specjalność:	
9. Semestr: 4	
10. Jednostka prowadząca przedmiot: Instytut Automatyki, RAu1	
11. Prowadzący przedmiot: prof. dr hab. Jerzy Frączek	
12. Przynależność do grupy przedmiotów: przedmioty wspólne	
13. Status przedmiotu: obowiązkowy	
14. Język prowadzenia zajęć: angielski	
15. Przedmioty wprowadzające oraz wymagania wstępne: Circuit Theory, Physics, Probability and Mathematical Statistics.	
16. Cel przedmiotu: Objectives of the course is to acquaint the students with measurement systems. A measurement system is recognized as an information system which presents an observer with numerical value corresponding to the variable being measured. The course is intended as a reference for users of sensors, sensors systems, transducers and transducers systems. The scope of this course presents the basic principles of advanced sensor and transducers systems.	

17. Efekty kształcenia:[1]

Nr	Opis efektu kształcenia	Metoda sprawdzenia efektu kształcenia	Forma prowadzenia zajęć	Odniesienie do efektów dla kierunku studiów
W1	Zna zasady oceny niepewności pomiaru.	EU	WT, WM	
W2	Zna zasady wyboru metod pomiaru wielkości mierzonych zależnie od ich charakteru i dopuszczalnych niepewności pomiaru.	EU	WT, WM	
W3	Zna sensory i przetworniki do pomiaru wielkości nieelektrycznych metodami elektrycznymi.	EU	WT, WM	
W4	Zna zasady budowy „przetworników inteligentnych” i ich wykorzystanie w systemach hierarchicznych.	EU	WT, WM	
U1	Potrafi ocenić niepewność pomiaru.	CL, OS	L	
U2	Potrafi zrealizować program pomiarowy wielkości nieelektrycznych z wykorzystaniem wybranego systemu pomiarowego.	CL, OS	L	
K1	Rozumie potrzebę oceny niepewności pomiaru oraz zasady trasabilności.	EU, OS	WT, WM	
K2	Potrafi określić właściwy dobór elementów łańcucha pomiarowego dla uzyskania wymaganej dokładności pomiaru.	CL, OS	L	

18. Formy zajęć dydaktycznych i ich wymiar (liczba godzin)

[1] należy wskazać ok. 5 – 8 efektów kształcenia

W. : 30 Ćw.: - L.: 30

19. Treści kształcenia:

Lectures

Introduction: scope of lectures, literature; integration of intrinsically safe field instrumentation into industrial communication networks; intelligent sensors; institutions: IMEKO, IFAC, EUROSENSORS, PSST – Polish Society of Sensors Technology, COE – Optoelectronic and Electronic Sensors.

Smart sensors: Measurement of fluid flow by means of pressure differential devices - orifice plates and Venturi tubes. Smart interface. The essential sub-systems; list some of the main sensor defects. Zener Barriers (Ex).

The general measurement system: purpose, general structure,. elements of system. Definition of sensor; sensor classifications. Example: "Weight measurement system" – elements of system; strain gauges (conventional and silicon).

Vocabulary of Basic and General Terms in Metrology: static characteristics - range, span, zero, zero drift, sensitivity, resolution, response, linearity, hysteresis, calibration, accuracy… ; dynamic characteristics.

Specialized measurement system: gas chromatography – column, carrier gas, solid particles, thin layer of liquid composition, HETP – Height Equivalent to a Theoretical Plate, chromatogram, retention time. Detectors: TCD – Thermal Conductivity Detector (katharometer), FID – Flame Ionisation Detector, ECD – Electron Capture Detector.

Non–Dispersive Infra-Red (NDIR) gas analyser: IR transmission characteristics, one path system, two path system, IR emitters, rotating chopper disc, reference cell, sample cell, radiation detectors (selective or non-selective), transfer equation.

ITS-90 – The International Temperature Scale of 1990: triple points, freezing points, melting points, interpolation instruments – platinum resistance thermometer, gas and vapour thermometers, radiation pyrometer; interpolation equations; thermodynamic (Kelvin) and empirical (Celsius) scales.

Thermal radiation measurement system: high temperatures, moving body, temperature distribution over a surface; "black body", Planck's law, emissivity of real body, characteristics of transmission medium; general form of thermal radiation measurement system, optical focusing system without and with lens, transmission characteristics, detectors – thermopiles, bolometers; total detected power, output signal.

Pressure (pneumatic) measurement system: elements of system; metal resistance Strain Gauge - tensile stress, compressive stress, longitudinal strain, transverse strain, elastic modulus, Young's modulus, Poisson's ratio, GF – Gage Factor; characteristics of system.

Review of sensors: conventional, thick, thin and semiconductor technologies; Strain Gages, Zirconia Cell (ZrO_2), magnetic (mechanical) sensors, electromagnetic sensors, chemical sensors, gas sensors, resistance and thermocouple sensors.

Reliability of measurement systems: reliability, unreliability, MTBF - Mean Time Between Failures, failure rate, variation of failure rate during lifetime of equipment – "bathtub" curve, reliability of a system of n elements in series or cascade, availability, methods of improving the reliability of measurement systems.

Laboratory

Practical works in laboratories concerning instrumentation as a coherent , integrated subject of measurement systems. Examples of exercises:

1. LabVIEW
The introduction to the National Instruments graphical environment – LabVIEW. Front and block diagram (source code) creation, application debugging, array and matrix operation, graphical presentation of measurement/calculation results.
Equipment: PC with LabVIEW graphical environment.

2. LabVIEW + DAQ
Functional overview of the Data Acquisition boards architecture. Signal generation and acquisition with LabVIEW application – close look at how the signal is generated and acquired by the DAQ board.
Equipment: PC with DAQ board and LabVIEW graphical environment, HP33120 arbitrary waveform generator, HP56003B digital oscilloscope.

3. Digital to analog converters
Investigation of the metrological characteristic of the D/A converters (zero and gain errors, differential and integral linearity, sensitivity to temperature, dynamic properties).
Equipment: DAC tester, voltmeter, analogue oscilloscope,muffle furnace.

4. Strain gauges
Investigation of the strain gauge factor for conventional and piezoresistive strain gauges.

5. Flow measurements
Familiarize with the properties of some of the measurement sensors used in flow measurements (turbine,

electromagnetic, ultrasonic and orifice plate flowmeters)

6. Gas chromatography

Familiarize with the gas chromatography. Investigation of column temperature and flow rate of carrier gas on chromatogram.
Equipment: gas chromatograph wit TCD (thermo-conductive) detector

7. Temperature measurements

Familiarize with the widely used in industry temperature sensors – RTDs and thermocouples. Calibration of temperature sensor in one of the fixed point of the ITS-90 (freezing point of tin).

8. GPIB Interface

Familiarize with the modern measuring instruments used as test equipment in laboratories and industry, equipped with dedicated measuring interface – GPIB.

9. Profibus DP

Investigation of the metrological parameters of chosen measuring modules. System configuration, sensors connection (2, 3 and 4 wire RTD measurements, thermocouple cold junction compensation, current loop operation with HART protocol).

20. Egzamin: tak; ustny.

21. Literatura podstawowa:

1) Bentley J. P.: *Principles of Measurement Systems*; Longman, London and New York 1985.
2) Fraden J.: *AIP Handbook of Modern Sensors; Physics, Design and Applications*. American Institute of Physics, 3rd ed., Springer-Verlag, New York, Berlin, Heidelberg, 2004.
3) *International Vocabulary of Basic and General Terms in Metrology*. ISO 1993.
4) *Guide to the Expression of Uncertainty in Measurement. ISO 1993.*

22. Literatura uzupełniająca:

1) Webster J. G.: *Measurement, Instrumentation and Sensors - HANDBOOK*. Chapman & Hall/CRCnetBASE, 1999.
2) Gerard C.M. Meijer (Editor): *Smart Sensor Systems.* John Wiley & Sons, Ltd., 2008.
3) Göpel W., Hesse J., Zemel J. N. (Editors): *Sensors – A Comprehensive Survey.* Eight volumes, VCH Weinheim; New York; Basel; Cambridge; 1989 – 1994.
4) Michalski L., Eckersdorf k., Mc Ghee J.: *Temperature Measurement.* J. Willey & Sons, 1991.
5) Sydenham P. H. (Editor): *Handbook of Measurement Science;* Vol. 1 (Polish translation 1988), Vol. 2 (Polish translation 1990); J. Wiley & Sons; Chichester, New York, Brisbane, Toronto, Singapore.
6) *Laboratory of integrated solid-state sensors*; (Multi-author work). Publishers of the Silesian Technical University, Gliwice 1997.

23. Nakład pracy studenta potrzebny do osiągnięcia efektów kształcenia

Lp.	Forma zajęć	Liczba godzin kontaktowych / pracy studenta
1	Wykład	30/10
2	Ćwiczenia	0/0
3	Laboratorium	30/15
4	Projekt	0/0
5	Seminarium	0/0
6	Inne	10/30
	Suma godzin	70/55

24. Suma wszystkich godzin: 125

25. Liczba punktów ECTS:[2] **5**

26. Liczba punktów ECTS uzyskanych na zajęciach z bezpośrednim udziałem nauczyciela akademickiego: 3

27. Liczba punktów ECTS uzyskanych na zajęciach o charakterze praktycznym (laboratoria, projekty): 2

[2] 1 punkt ECTS – 25-30 godzin.

26. Uwagi:

Zatwierdzono:

…….
(data i podpis prowadzącego)

……
(*data i podpis dyrektora instytutu/kierownika katedry/ Dyrektora Kolegium Języków Obcych/kierownika lub dyrektora jednostki międzywydziałowej)*