COURSE DESCRIPTION CARD - SYLLABUS

Course name
Metrology

Course

Field of study
Electronics and Telecommunications

Year/Semester
I/II

Area of study (specialization)

Profile of study
general academic

Level of study
First-cycle studies

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
30	30	
Tutorials	Projects/seminars	

Number of credit points

5

Lecturers

Responsible for the course/lecturer:
dr hab. inż. Maciej Wawrzyniak
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Responsible for the course/lecturer:
dr inż. Michał Maćkowski
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dr. inż. Jakub Pajakowski
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Prerequisites

A student has a basic knowledge in mathematics and physics. Is able to extract information from literature, databases and other sources. Is able to participate in collaborative projects.

Course objective

To present of the basic definitions and concepts of metrology, measurement methods and measurement equipment. To introduce students to the analysis and presentation of measurement data. Practical carrying out laboratory experiments involving the preparation and execution of measurements.

Course-related learning outcomes

Knowledge

1. A student knows and understands the basic measurement methods and general concepts used in metrology.

2. Has knowledge of measurement errors, determination of measurement uncertainty and correct reporting of measurement results.

3. Has a basic knowledge of the construction of measuring devices. Knows the function blocks included in the measuring devices.

Skills

1. A student can operate basic laboratory instruments: an analog oscilloscope, digital oscilloscope, ammeter, voltmeter, ohmmeter, frequency meter, power supply and generator. Can use the manuals of measuring devices.

2. Can correctly select the appropriate measuring instruments and method of measurement for a given measurement task. Can connect the measuring circuit and carry out measurements.

3. Can correctly interprets the measurement results. He knows the rules of reporting measurement results.

4. Apply the rules of correct and safe behavior in the measurement laboratory.

Social competences

1. A student demonstrates responsibility and professionalism in solving technical problems.

2. Is able to work in a group in a measuring laboratory and implement team projects.

3. Recognizes the legal, environmental and utilitarian aspects of measurements. Demonstrates responsibility for the presented measurement results.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lectures passing based on one written and/or oral test from content of the lectures. The written test contains 8 open questions and takes place at the last lecture. Passing threshold 50% of the sum of points for two tests. The issues for the test (40) are sent to students by e-mail. Grading scale: <50% - 2.0 (ndst); 50% to 59% - 3.0 (dst); 60% to 69% - 3.5 (dst +); 70% to 79% - 4.0 (db); 80% to 89% - 4.5 (db +); 90% to 100% - 5.0 (bdb). The passing threshold may change depending on the results of the tests.

Laboratory passing based on grades for reports, preparation for classes, behaviour and commitment during classes and tests. Grading scale: Sw>4,75 - 5,0 (bdb); 4,25<Sw<=4,75 - 4,5 (db+); 3,75<Sw<=4,25 - 4,0 (db); 3,25<Sw<=3,75 - 3,5 (dst+); 2,75<Sw<=3,25 - 3,0 (dst); Sw<=2,75 - 2,0 (ndst) where Sw – the weighted arithmetic mean of all partial grades.

Programme content

Lecture

Basic definitions and terms of metrology: the essence of measurement, mesurand, measurable quantity, measurement unit – simple and metrological definition, International System of Units, SI base units, revision of the SI, SI derived units, measurement standard (etalon), traceability chain for measurements,

primary, secondary, reference and working standards, custodian of national measurement standards. Measurement errors and uncertainty: measured quantity value, measurement result, absolute measurement error, relative measurement error, true quantity value, reference quantity value, measurement accuracy and measurement precision, systematic measurement error, correction and corrected measured value, random measurement error, normal distribution, population and sample, point and interval estimation, basic principles of the measurement results reporting, instrument error, accuracy class for analogue instruments, class index, digital multimeters - instrument error, standard uncertainty, type A evaluation of uncertainty, type B evaluation of uncertainty, combined standard uncertainty, the law of propagation of uncertainty, expanded uncertainty, coverage factor, number of significant figures, the correct way to write a measurement result, number of significant figures in a measurement result, determination of the expanded uncertainty in laboratory practice. Analog (analogue) oscilloscope: time-domain and frequency domain, types of oscilloscopes, cathode ray tube – CRT, block diagram of the analog oscilloscope, time base coefficient, time base generator, how the waveform is drawn on the oscilloscope screen?, stable display of waveforms, oscilloscope bandwidth, signal amplitude measurement, measurement of DC component, period and frequency measurement, models of measuring probes, compensation of the passive measuring probe. Selected methods of measurement: classification of measurement methods, direct and indirect measurement methods, measurements of periodic signal parameters, mean (average) value of a periodic signal, mean (average) rectified value of a periodic signal, root mean square value of a periodic signal, form factor, peak factor, form and peak factors for common voltage periodic signals, DC voltage measurement using a DMM, RMS voltage measurement using a DMM, True RMS multimeters, voltmeter-ammeter method of measuring resistance - correct current measurement and correct voltage measurement, absolute and relative systematic error, correction for systematic error, digital measurement of period, digital measurement of frequency, impulse reflectometry, measurement of signal propagation speed damage in transmission lines, characteristic impedance, measurement of signal attenuation in a coaxial cable, phase shift measurement, two-channel oscilloscopes, block diagram for phase shift measurement, sign of the phase shift, X-Y mode of the oscilloscope, phase shift measurement using the Lissajous figure. Introduction to analog-to-digital conversion: continuous analog signal, discrete analog signal, digital signal, signal sampling and quantization, accuracy and resolution, operational amplifier, inverting and non-inverting amplifier, analog voltage comparator, voltage follower, integator. Analog-to-digital converters: flash (parallel) converter, dual ramp (slope) integrating converter, R-2R digital-to-analog converter, digital ramp analog-to-digital converter. Digital oscilloscope: block diagram of the digital oscilloscope, sample and hold circuit, flash analog-to-digital converter, acquisition memory, digital oscilloscope cycle, trigger modes, automatic time and voltage parameters measurement, pre-trigger viewing, peak detect mode.

Laboratory

Basic circuits analysis: international standard for circuit symbols, Ohm's law, Voltage and current arrows, sign convention, Kirchhoff ’s current law, closed loop, Kirchhoff ’s voltage law, serial connection of resistors, parallel connection of resistors, voltage and current dividers, voltage divider rule, serial and parallel connection of capacitors, symbols of indicating and recording instruments. Basic principles of the measurement results reporting: instrument error, accuracy class for analogue instruments, class

index, digital multimeters - instrument error, standard uncertainty, expanded uncertainty, number of significant figures, the correct way to write a measurement result, rounding numbers, number of significant figures in a measurement result. Electrical signal parameters – sine wave, frequency, amplitude, peak to peak voltage, angular velocity, square wave, triangle wave, DC voltage source, AC voltage source, DC and AC components of a signal, mean (average) value of a periodic signal, mean (average) rectified value of a periodic signal, root mean square value of a periodic signal, form factor, peak factor, form and peak factors for common voltage periodic signals, digital multimeter, function selector rotary switch, probe connection terminals, capacitor socket, transistor socket, DC voltage measurement using a DMM, RMS voltage measurement using a DMM, True RMS multimeters, DC current measurement using a DMM, high-value DC current measurement using a DMM. Analogue (analogue) oscilloscope: AC/DC coupling selector switch, deflection coefficient, division and minor division, trigger system, trigger voltage level, positive and negative slopes, raising and falling edges, time base coefficient, time base generator, stable display of waveforms, signal amplitude measurement, measurement of DC component, period and frequency measurement. Direct and indirect measurement methods, voltmeter-ammeter method of measuring resistance - correct current measurement and correct voltage measurement, absolute and relative systematic error, correction for systematic error, digital measurement of period, two-channel oscilloscopes, block diagram fo phase shift measurement, sign of the phase shift, X-Y mode of the oscilloscope, phase shift measurement using the Lissajous figure. Operational amplifier, inverting and non-inverting amplifier, voltage follower, analogue voltage comparator, digital oscilloscope, trigger modes, automatic time and voltage parameters measurement.

Teaching methods

Lecture: traditional multimedia presentation (examples also on the blackboard) and conversational lecture.

Lab: traditional multimedia presentation (examples also on the blackboard) and performance of tasks given by the teacher - practical exercises.

Bibliography

Basic

1. Chwaleba A., Poniński M., Siedlecki A., Metrologia elektryczna, Wydawnictwo Naukowo-Techniczne, Warszawa 2003.

2. Rydzewski J., Pomiary oscyloskopowe, Wydawnictwo Naukowo-Techniczne, Warszawa 2007.

3. Arendarski J., Niepewność pomiarów, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2006.

4. Kester W., Przetworniki A/C i C/A : teoria i praktyka, Wydawnictwo BTC, 2012.

Additional

1. Dusza J., Gorat G., Leśniewski A., Podstawy miernictwa, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2002.

2. Barzykowski J., Domańska A., Kujawińska M., Współczesna metrologia. Zagadnienia wybrane, Wydawnictwo Naukowo-Techniczne WNT, Warszawa 2016.

3. Maloberti F., Przetworniki danych, Wydawnictwa Komunikacji i Łączności, Warszawa 2010.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,0
Classes requiring direct contact with the teacher	70	3,0
Student's own work (literature studies, preparation for laboratory classes, preparation for a test, preparation of reports). [1]	55	2,0

[1] delete or add other activities as appropriate