COURSE DESCRIPTION CARD - SYLLABUS

Course name
Metrology [S1EiT1E>METR2]

Course

Field of study
Electronics and Telecommunications

Year/Semester
1/2

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
English

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
0

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

The 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

Presentation of basic definitions and concepts in the field of metrology, measurement methods, and measuring equipment. 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. The student possesses a fundamental knowledge of metrology, which is necessary for measuring signal properties and parameters of components in electronic and telecommunication systems.
2. Demonstrates knowledge of measurement methods and measurement equipment.
3. Exhibits knowledge of accurately reporting measurement results.

Skills:
1. Is able to measure typical parameters of signals, systems and devices, in particular those used in telecommunication.
2. Is able to choose appropriate methods to measure given electrical quantities and parameters of signals and devices.
3. Is able to plan and perform measurements and analyze the results.

Social competences:
1. 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. Demonstrates responsibility for the presented measurement results.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

(1st semester) Passing the lectures is based on two written tests covering the lecture content. Each test consists of 8 open-ended questions. The tests are scheduled for the 9th and last lecture. The passing threshold is set at 50% of the total points possible for both tests combined. The questions will be prepared based on the slides published on the Metrology course website. Grading scale: <50% - 2.0 (fail); 50% to 59% - 3.0 (satisfactory); 60% to 69% - 3.5 (satisfactory plus); 70% to 79% - 4.0 (good); 80% to 89% - 4.5 (good plus); 90% to 100% - 5.0 (very good). The passing threshold may be subject to change based on the test results.
(2nd semester) Laboratory assessment will be based on grades for reports, class preparation, behavior, and engagement during classes. Grading scale:
Sw > 4,75 - 5,0 (very good);
4,25 < Sw <= 4,75 - 4,5 (good plus);
3,75 < Sw <= 4,25 - 4,0 (good);
3,25 < Sw <= 3,75 - 3,5 (satisfactory plus);
2,75 < Sw <= 3,25 - 3,0 (satisfactory);
Sw <= 2,75 - 2,0 (fail).
where Sw represents the arithmetic mean of all partial grades.

Programme content

Basic Definitions and Terms of Metrology.
Basic Circuit Analysis.
Basic Principles of Measurement Results Reporting.
Electrical Signal Parameters.
Analog and Digital Oscilloscopes.
Selected Methods of Measurement.
Operational Amplifier.

Course topics

Lecture (1st semester)
Basic Definitions and Terms of Metrology: International Vocabulary of Metrology, categories of metrology, measurable quantity, International System of Quantities, measurement unit – simple and metrological definition, the essence of measurement – block diagram, 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, measured quantity value, measurement result, absolute measurement error, relative measurement error, true quantity value, reference quantity value, measurement accuracy and measurement precision, measurement uncertainty, systematic measurement error, correction and corrected measured value, random measurement error.
Basic Circuit Analysis: international standard for circuit symbols, passive components, resistor and resistance, capacitor and capacitance, voltage and current sources, DC current circuit, 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, connections

and connectors.
Basic Principles of Measurement Results Reporting: instrument error, accuracy class for analogue instruments, class index, digital multimeters - instrument error, standard uncertainty, expanded uncertainty, the number of significant figures, the correct way to write a measurement result, rounding numbers, the number of significant figures in a measurement result.
Electrical Signal Parameters – Definitions and Measurements: signal waveform, voltage and current signals, common voltage periodic signals, 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.
Analog (Analogue) Oscilloscope: time-domain and frequency domain, types of oscilloscopes, cathode ray tube – CRT, block diagram of the analog 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, sawtooth signal, how the waveform is drawn on the oscilloscope screen?, stable display of waveforms, oscilloscope bandwidth, signal amplitude measurement, measurement of the DC component, period and frequency measurement.
Selected Methods of Measurement: classification of measurement methods, 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, digital measurement of frequency, shaping circuits, asynchronous flip-flop, reference frequency generator, phase shift measurement, two-channel oscilloscopes, block diagram of phase shift measurement, sign of the phase shift, X-Y mode of the oscilloscope, phase shift measurement using the Lissajous figure.
Digital Oscilloscope: block diagram of the digital oscilloscope, continuous analog signal, discrete analog signal, digital signal, input signal conditioning and trigger system, operational amplifier, inverting and non-inverting amplifier, signal sampling, sample and hold circuit, voltage follower, memory capacitor, signal quantization, flash analog-to-digital converter, analog voltage comparator, acquisition memory, reconstruction of the signal image, digital oscilloscope cycle, trigger modes, automatic time and voltage parameters measurement.
Lab. (2nd semester)
Basic Circuit 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 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, the 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.
Analog (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.
Selected Measurement Methods: 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 of 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 (1st semester): Traditional multimedia presentation (examples also on the blackboard) and conversational lecture.
Lab (2nd semester): 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.
Additional
1. Bucher J. L., The metrology handbook, ASQ Quality Press, 2012.
2. Sydenham P. H., Thorn R., Handbook of Measurement Science vol. 1 and vol. 2, Wiley, 2013.
3. Czichos H., Tetsuya S., and Leslie E. S., eds, Springer handbook of metrology and testing, Springer, 2011.

Breakdown of average student's workload

	Hours	ECTS
Total workload	150	6,00
Classes requiring direct contact with the teacher	71	4,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	79	2,00