COURSE DESCRIPTION CARD - SYLLABUS

Course name
Metrology

Course

Field of study
Electronics and Telecommunications
Area of study (specialization)
Level of study
First-cycle studies
Form of study
full-time
Year/Semester
I/I and I/II
Profile of study
general academic
Course offered in
English
Requirements
compulsory

Number of hours

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

Number of credit points

6

Lecturers

Responsible for the course/lecturer:
dr hab. inź. Maciej Wawrzyniak
(maciej.wawrzyniak@put.poznan.pl)

Responsible for the course/lecturer:
dr inż. Sławomir Michalak
(slawomir.michalak@put.poznan.pl)

Prerequisites

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. Has a basic knowledge of the fundamentals of metrology, which is necessary to measure the signal properties and the parameters of electronic and telecommunication systems components.

2. Has knowledge of measurement methods and measurement equipment.

3. Has knowledge of the correct reporting of 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:

(1 sem.) Lectures passing based on two written tests from content of the lectures. Each test contains 8 open questions. Tests take place at the 8th and the last lecture. Passing threshold 50% of the sum of points for two tests. The issues for each test (20) 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.

(2 sem.) Laboratory passing based on grades for reports, preparation for classes, behavior and commitment during classes. 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 arithmetic mean of all partial grades.

Programme content

Lecture (1 sem.)

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 circuits 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 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 – 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. Analogue (analogue) oscilloscope: time-domain and frequency domain, types of oscilloscopes, cathode ray tube – CRT, block diagram of the 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, saw tooth signal, 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. 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 fo 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 analogue signal, discrete analogue 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 analogue-to-digital converter, analogue voltage comparator, acquisition memory, reconstruction of the signal, digital oscilloscope cycle, trigger modes, automatic time and voltage parameters measurement.

Lab. (2 sem.)

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

Lab (2 sem.): 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	6,0
Classes requiring direct contact with the teacher	71	4,0
Student's own work (literature studies, preparation for laboratory classes, preparation for tests, raports preparation) [1]	79	2,0

[1] delete or add other activities as appropriate