COURSE DESCRIPTION CARD - SYLLABUS

Course name
Fundamentals of Measurement Techniques [S1Teleinf1>PTP]

Course

Field of study
Teleinformatics

Year/Semester
1/1

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

5,00

Coordinators

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Lecturers

Prerequisites

A student starting this subject should have a basic knowledge of mathematics and physics. They should also have the ability to gather information from specified sources and be prepared to engage in teamwork.

Course objective

To present the basic definitions and concepts of measurement techniques, measurement methods, and measurement equipment. To introduce students to the analysis and presentation of measurement data. To practically conduct laboratory experiments involving the preparation and execution of measurements.

Course-related learning outcomes

Knowledge
1. A student has a basic knowledge of the construction of measuring devices. Knows the function blocks included in the measuring devices.
2. Has knowledge of measurement errors, determination of measurement uncertainty and correct reporting of measurement results.
3. Knows and understands the basic measurement methods and general concepts used in metrology.
4. Has basic knowledge of a / c converters. Understands their role in measurement technology,

telecommunications, consumer electronics, etc.
5. Knows the current state and trends in measurement techniques.
Skills
1. A student can operate basic laboratory instruments: an analog oscilloscope, digital oscilloscope, ammeter, voltmeter, ohmmeter, frequency meter, power supply and generator.
2. Can correctly interprets the measurement results. Knows the rules of reporting measurement results.
3. Can correctly select the appropriate measuring instruments and method of measurement for a given measurement task.
4. Can connect the measuring circuit and carry out measurements. Can use the manuals of measuring devices.
5. Apply the rules of correct and safe behavior in the measurement laboratory
Social competences
1. A student is open to learning and understands the need to improve professional competencies.
2. Is able to work in a group in a measuring laboratory and implement team projects.
3. Can formulate opinions on the basic challenges faced by an engineer.
4. Recognizes the legal, environmental and utilitarian aspects of measurements. Demonstrates responsibility for the presented measurement results.
5. Is aware of the importance of professional action and adherence to professional ethics.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The knowledge acquired during the lecture is assessed through a written and/or oral test. The written test consists of 8-12 questions with varying point values. The oral test involves answering 4-6 questions of different point values posed by the instructor. The passing threshold is 50% of the total points. The test questions are prepared based on the slides published on the course website. If both the written and oral components are passed, the points are combined. 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 quiz results.

The skills acquired during the laboratory are assessed through a written or oral test, report preparation, and evaluation of preparation, behavior, and engagement during the sessions. The written test involves solving 8-12 tasks with varying point values. The oral test consists of solving 4-6 tasks with different point values, presented by the instructor. The test questions are prepared based on the slides published on the course website. The final grade is determined based on a weighted average: Sw=0.45SO+0.55OzK where SO is the average grade obtained for report preparation, preparation to the laboratory, and engagement in the laboratory, and OzK is the grade from the test. Scale for the final grade: Sw>4.75 - 5.0 (bdb); 4.25=4.75 - 4.5 (db+); 3.75=4.25 - 4.0 (db); 3.25=3.75 - 3.5 (dst+); 2.75=3.25 - 3.0 (dst); Sw<=2.75 - 2.0 (ndst).

Programme content

Lecture
Introduction: measurable quantity, measurement unit, International System of Units, definitions of selected basic units, SI derived units, measurement standard (etalon), primary and secondary standards, traceability chain for measurements, custodian of national measurement standards, classification of measurement methods, international standard for circuit symbols, voltage and current arrows, sign convention, Kirchhoff ’s laws, closed loop, serial and parallel connection of resistors, voltage divider, serial and parallel connection of capacitors.
Selected issues of measurement theory: measured quantity value, measurement result, true quantity value, reference quantity value, absolute measurement error, relative measurement error, measurement accuracy and measurement precision, number of significant figures, systematic measurement error, random measurement error, excessive error, population and sample, point and interval estimation, estimators of the standard deviation, variance and expected value, instrument error and accuracy class, determination of the instrument error, definition of the measurement uncertainty, standard uncertainty, combined standard uncertainty, the law of propagation of uncertainty in indirect measurements, expanded uncertainty, algorithm for determining the expanded uncertainty, determination of the expanded uncertainty in the laboratory practice, the correct way to write a measurement result.
Analog (analogue) oscilloscope: types of oscilloscopes, cathode ray tube – CRT, oscilloscope bandwidth,

block diagram of the analog oscilloscope, oscilloscope modes, analog oscilloscope trigger parameters, time base coefficient, time base generator, how the waveform is drawn on the oscilloscope screen?, stable display of waveforms, signal amplitude measurement, measurement of DC component, period and frequency measurement, phase shift measurement, block diagram for X-Y mode of the two-channel oscilloscope, phase shift measurement using the Lissajous figure.
Measurements of the electric signal and electronic devices parameters: basic parameters of voltage and current signals, measurement of mean, root mean square value, instantaneous value, peak factor, form factor, rise time, fall time, duty cycle, frequency, basic parameters of electronic circuits, measurement of resistance, capacitance, inductance, impedance triangle, impedance measurement.
Selected methods of measurement: rules for drawing block diagrams, symbols of electronic components, schematic diagram, systematic error of the method, correction for systematic error, voltmeter-ammeter method of measuring resistance, measuring the period using the digital method, measuring frequency using the digital method, counting error and gating error, measurement input and output impedance, impulse reflectometry, measurement of signal propagation speed, detection of damages in transmission lines, characteristic impedance, measurement of signal attenuation in a coaxial cable.
Introduction to analog-to-digital conversion: continuous analog signal, discrete analog signal, digital signal, signal sampling and quantization, codes of digital signals in ADC, operational amplifier, inverting and non-inverting amplifier, analog voltage comparator, voltage follower, Miller integrator, basic parameters of ADC, basic conversion errors.
Analog-to-digital converters: flash (parallel) converter, dual ramp (slope) integrating converter, R-2R digital-to-analog converter, digital ramp analog-to-digital converter, successive approximation method.
Digital oscilloscope: block diagram of the digital oscilloscope, trigger modes, digital oscilloscope cycle, trigger parameters, sample and hold circuit, flash analog-to-digital converter, acquisition memory, digital oscilloscope cycle, pre-trigger viewing, peak detect mode, automatic time and voltage parameters measurement, pre-trigger viewing, peak detect mode, models of measuring probes, compensation of the passive measuring probe.

Laboratory
Measurements of the electric signal and electronic devices parameters: basic parameters of voltage and current signals, measurement of mean, root mean square value, instantaneous value, peak factor, shape factor, rise time, fall time, duty cycle, resistance measurement, measurement of the current-voltage characteristic of semiconductor devices, inverting and non-inverting voltage amplifiers, measurement of the frequency characteristic, analog voltage comparator, measurement of the input and output signal, measurement of the transient characteristic.
Analog oscilloscope: oscilloscope modes, trigger parameters, signal image stabilization, time base generator, deflection coefficient, time base coefficient, division of the oscilloscope, amplitude, frequency, and DC component measurement procedures for periodic signals, phase shift measurement, X-Y mode, measurement of the phase shift by the Lissajous figure method.
Selected measurement methods: rules for drawing block diagrams, symbols of electronic components, a block diagram of a measurement system, a schematic diagram, systematic error of a measurement method, correction of a systematic error by introducing a correction, direct and indirect measurement, voltmeter-ammeter method of measuring resistance, determination of standard complex uncertainty in indirect measurements, pulse reflectometry, characteristic impedance of the cable, determination of the speed of signal propagation in the cable, measurement of the relative permittivity of the cable material, determination of the propagation constant, measurements of cable attenuation.
The correct way to write a measurement result: number of significant figures, systematic measurement error, random measurement error, excessive error, instrument error and accuracy class, determination of the instrument error, standard uncertainty, combined standard uncertainty, the law of propagation of uncertainty in indirect measurements, coverage factor, expanded uncertainty, determination of the expanded uncertainty in the laboratory practice, rectangles of uncertainty, rules for plotting characteristics.

Course topics

none

Teaching methods

Lecture: traditional multimedia presentation with examples 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	116	5,00
Classes requiring direct contact with the teacher	60	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	56	2,00