UNICUSANO
ROME

Code: ING-INF/07 **Credits: 9**
Matter: Electrical and electronic measurements
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
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Introduction

1. *Objective of the course :*

Measurement in general, metrological nomenclature and typical conventions used in the field of measurement are covered in the first part of the course. The Electrical and Electronic Measurements course also provides students with a solid knowledge of the main active and passive components of direct current (DC) and alternating current (AC) electrical circuits, as well as the tools required to measure the physical quantities involved. By the end of the course, students should be able to analyze DC and AC circuits using the appropriate tools, describe their characteristics and design and implement circuits that function as high-pass, low-pass and band-pass filters.

Objectives

The course in Electrical and Electronic Measurements has the following educational objectives aligned with the specific goals of the study program:

- *Review the fundamental principles of Metrology.*
- *Explain the main active and passive components of electrical circuits in Direct Current.*
- *Explain the main active and passive components of electrical circuits in Alternating Current.*
- *Describe the operation of key measurement instruments: Ammeter, Multimeter, Oscilloscope.*

Competencies:

[Knowledge and Ability to Understand]

- Understanding technical terminology in the field of metrology.
- Knowledge of the operating principles of key electronic instruments.

- Understanding measurement methodologies in electrical and electronic domains.
- Understanding typical laboratory problems and how to address them.

[Application of knowledge]

- Proficiency in using the oscilloscope as a measurement tool.
- Familiarity with function generators, voltage and current generators, and both bench-top and portable multimeters.

[Ability to draw conclusions]

- Students must develop the ability to integrate knowledge, manage complexity, and form judgments even when provided with limited information.

[Communication skills]

- By the end of the course, students should use clear and correct scientific language and integrate their knowledge with English equivalents. Where possible, Anglo-Saxon terminology for measurement instruments is provided. Students should also be able to write and/or understand a brief laboratory report without ambiguity.

[Ability to learn]

- Students must demonstrate the ability to independently solve original problems related to standard laboratory practice, develop methods to minimize undesired effects during measurement processes, and seek out and adopt new methods and procedures by consulting external sources and international guidelines.

Syllabus

1. *Programme of the course:*

Subject 1 – Basic Tools for Data Analysis and Fundamentals of Electromagnetism

- Space-time invariance postulate, physical quantities, basic concepts of metrology, measurements, measurement systems, scientific notation, and orders of magnitude.
- Definitions of SI standards, an overview of measurement instruments: calibration, sensitivity, accuracy, precision, range, response time, and a brief introduction to measurement errors and histograms.
- Probability, expected value, variance, estimators of E[x]E[x]E[x] and Var[x]Var[x]Var[x], distribution functions, arithmetic mean, and standard deviation, histograms.
- Scientific Method, regression analysis, uncertainty, relative uncertainty, significant figures, absolute and relative error, key electrical quantities: Coulomb's law, current, electric potential, power, resistance, capacitance, and inductance.

- Electric circuit: ideal basic components, active and passive elements.

Subject 2 – DC Circuits, Ammeters, and Multimeters

- Fundamentals of electric circuits: ideal and real current and voltage sources, wire, node, branch, loop, series, and parallel components. Kirchhoff's laws.
- Analysis of resistive circuits: superposition and Δ-Y transformations. Thévenin's and Norton's theorems.
- DC instruments: coil ammeter, fundamentals of magnetism.
- Current measurements, voltage measurements, resistance measurements. Wheatstone bridge and color codes.
- Multimeter operation. Analog-to-digital (AD) converters. Simulation exercises to validate concepts.

Subject 3 – AC Circuits and the Oscilloscope

- Analysis of time-dependent quantities, vector representation of alternating quantities, waveforms, and periodic currents and voltages. Root mean square (RMS) value.
- Introduction to Fourier analysis and synthesis: series, integral representation, and transform for aperiodic functions. Power spectrum.
- Symbolic representation, phasors. Generalized Ohm's and Kirchhoff's laws. Introduction to Laplace transforms. Passive quadripoles.
- Design and analysis of low-pass, high-pass, and band-pass filters (RC, RL, LR, CR, RCL series and parallel circuits). Differentiator and integrator circuits.
- Operation of analog oscilloscopes with an introduction to digital oscilloscopes. Compensated probes.

Subject 4 – Semiconductors and Advanced Topics

- Basics of semiconductors and semiconductor physics. Brief overview of diodes and diode circuits.
- Practical laboratory experiences with examples.

Evaluation system and criteria

Verification of the achievements is carried out through the evaluation of the E-tivity and the Final Examination. The final grade is the sum of the marks obtained from the two E-activities and of the Examination. Each E-tivity is assessed a maximum of 1.5 points, for a maximum total of 3 points.

The exam typically consists of a written test designed to assess the ability to analyze and rework the concepts learned. The content usually includes questions on DC circuits (e.g., a purely resistive circuit, use of the multimeter, etc.), and questions on AC circuits (e.g., analysis of a filter or a resonant circuit, use of the oscilloscope, etc.), as well as a set of theoretical questions requiring brief written answers. The maximum score is 30 points.

Bibliography and resources

2. *Materials to consult:*

The teaching material consists of a series of video lectures/slides and asynchronous tests related to the video lectures. The slides are structured so that all the topics covered in the video lectures are also reported in detail, by points.

3. *Recommended bibliography:*

- Doebelin, Ernest O., and Dhanesh N. Manik. "Measurement systems: application and design." (2007).
- Ferrero, A., Petri D., Carbone P., Catonalani, M., “Modern Measurements, Fondamentals and Applications” 2015