UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2020/2021
MASTER'S DEGREE (MSC)	ELECTRICAL ENGINEERING
SUBJECT	MEASUREMENTS SYSTEMS FOR SMART GRIDS AND AUTOMATION
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50363-Ingegneria elettrica
CODE	19847
SCIENTIFIC SECTOR(S)	ING-INF/07
HEAD PROFESSOR(S)	COSENTINO VALENTINA Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**COSENTINO VALENTINA** Monday 10:00 17:00 In presenza / In person: Laboratorio didattico misure elettriche, Edifico 9, piano terra, stanza S09PT062 (ex U030) / Electrical measurement teaching lab, Building 9, ground floor, room S09PT062 (ex U030). A distanza / Remotely: Teams call. RICEVIMENTO PREVIO APPUNTAMENTO VIA EMAIL O CHAT TEAMS / APPOINTMENT IS NEEDED, BY EMAIL OR TEAMS CHAT Tuesday 10:00 17:00 In presenza / In person: Laboratorio didattico misure elettriche, Edifico 9, piano terra, stanza S09PT062 (ex U030) / Electrical measurement teaching lab, Building 9, ground floor, room S09PT062 (ex U030). A distanza / Remotely: Teams call. RICEVIMENTO PREVIO APPUNTAMENTO VIA EMAIL O CHAT TEAMS / APPOINTMENT IS NEEDED, BY EMAIL OR TEAMS CHAT Wednesday 10:00 17:00 In presenza / In person: Laboratorio didattico misure elettriche, Edifico 9, piano terra, stanza S09PT062 (ex U030) / Electrical measurement teaching lab, Building 9, ground floor, room S09PT062 (ex U030). A distanza / Remotely: Teams call. RICEVIMENTO PREVIO APPUNTAMENTO VIA EMAIL O CHAT TEAMS / APPOINTMENT IS NEEDED, BY EMAIL OR TEAMS CHAT Thursday 10:00 17:00 In presenza / In person: Laboratorio didattico misure elettriche, Edifico 9, piano terra, stanza S09PT062 (ex U030) / Electrical measurement teaching lab, Building 9, ground floor, room S09PT062 (ex U030). A distanza / Remotely: Teams call. RICEVIMENTO PREVIO APPUNTAMENTO VIA EMAIL O CHAT TEAMS / APPOINTMENT IS NEEDED, BY EMAIL OR TEAMS CHAT

DOCENTE: Prof.ssa VALENTINA COSENTINO

PREREQUISITES	Electrical measurements knowledge: methods and instruments for measurement of electrical quantities; measurement uncertainty; digital instrumentation
LEARNING OUTCOMES	D.1: KNOWLEDGE AND UNDERSTANDING Students are expected to acquire knowledge and understanding basis concerning automatic measurement systems for diagnosis, characterization and control of electrical systems, machines and processes. In detail a focus is made on main signal acquisition and digital processing issues and main measurement systems, technologies and devices for automation and smart grids management. D.2: APPLYING KNOWLEDGE AND UNDERSTANDING Students are expected to apply their knowledge and understanding skills for the implementation of advanced measurement systems for diagnosis, characterization and control of electrical systems, machines and processes, as well as for smart grids applications. The addressed aspects concern both the employed instrumentation and the measurement signals acquisition and processing. D.3: MAKING JUDGMENTS Students are expected to integrate their knowledge and increase their critical faculties for approaching problems and making judgements concerning the choice of the basic components (hardware/software) of measurement systems for smart grids and automation, , starting from the available information, components technical specifications and requirements of the applications being studied. D.4: COMMUNICATION SKILLS Students are expected to clearly communicate their knowledge, analysis and conclusions concerning design, implementation and management of measurement systems for smart grids and automation. In doing this, students are expected to address both specialist and non-specialist audiences, with correct use of language. D.5: LEARNING SKILLS Students are expected to develop methodological skills and abilities of connection and reworking of knowledge about measurement systems for smart grids and automation and related interdisciplinary contexts. Thanks to this, students will be able to carry out further studies or professional activities with a high degree of autonomy, in those areas where knowledge and skills gained can be helpfully applied.
ASSESSMENT METHODS	EXAMS OUTLINE Practical and oral exam. The oral exam consists of a discussion with essay questions on the whole course programme. Practical part of the exam consist of the execution and discussion of one of the practical exercises developed during the course. Exam duration is at least 45 minutes. The exams looks at: - knowledge and understanding of the course programme and skills in their application for problem solving within the course or related contexts; - mastery of course practical topics and skills in instrumentation use; - correct use of language, clearness and fluency, concepts reinterpretation, critical faculties, and connection skills in disciplinary/interdisciplinary contexts. Marks are out of 30. Minimum mark for passing the exam: 18/30. ASSESSMENT CRITERIA Mark is awarded considering to what extent the student has achieved the learning outcomes. The following scheme can be assumed for reference (see learning outcomes section, descriptors D.1-D.5). Best fit applies when learning outcomes are met at different levels. 29-30 / 30 with distinction D.1/D.2: full contents mastery; no errors; self-corrections/integrations of inaccuracies/omissions; correct and rigorous approach to problems; correct, complete and effective solutions; some originality evidence D.3/D.4/D.5: effective concepts reworking, coherent and autonomous approaches and judgments, disciplinary/interdisciplinary connections; very clear presentation, structured arguments, correct use of language. 24-28 D.1/D.2: good/very good knowledge and understanding of course contents; few minor errors, partially fostered self-corrections or integrations; good approach to

	problems, essentially correct solutions; D.3/D.4/D.5: good coherence in linking concepts and approaching disciplinary or related subjects; good presentation, adequate use of language. 18-23 D.1/D.2: sufficient knowledge of contents; acceptable approach to problems although with limited autonomy, acceptable solutions; errors or omissions not serious; D.3/D.4/D.5: sufficient concepts links within disciplinary contexts, although tentative and guided; basic presentation and use of language. below 18 (mark not awarded) D.1-D.5: learning outcomes are not sufficiently met.
EDUCATIONAL OBJECTIVES	The course aims to give bases on advanced measurement systems for monitoring, control and management of electrical systems, machines and processes, as well as for smart grids applications. For this purpose, the course aims to provide the following knowledge and skills: - knowledge of main types and features of automatic measurement systems employed in the electrical engineering sector, and basic principles for their implementation and management; - knowledge of main types and features of measurement instrumentations and methods for power system and smart grid applications, with particular respect to automatic distributed measurement systems, power quality and energy measurements - know-how to read technical datasheets of main components of automatic measurement systems for smart grids and automation, and know-how to approach issues related to design, development and management of such systems, taking into account technical specifications and requirements for the considered applications.
TEACHING METHODS	Lectures, exercises, projects/case studies development, analysis and classroom discussion. Teaching activities are organized to help the achievement learning outcomes (see learning outcomes section, descriptors D.1-D.5). The course contents are offered through lectures and exercises, emphasizing the applications and the synergy between the different topics (D.1). During the course, the contents are used for problem solving issues and works on projects/ case studies, thus stimulating the development of the ability to apply the acquired knowledge and skills (D.2). During lectures (partly carried out through dialogues and interactions among students and teacher), exercises and activities related to projects/case studies, students are fostered to critically analyze the proposed issues; this helps the development of students analytical abilities and autonomous judgment (D.3). At the same time, the dialogue and interaction opportunities foster students to improve their skills of communication, argumentation and use of language (D.4). Finally, all course activities contribute to the development of learning skills, through knowledge reworking, links to real and interdisciplinary applications and stimulus in facing new problems autonomously (D.5).
SUGGESTED BIBLIOGRAPHY	Dispense del corso fornite dal docente / Lecturer course slides Materiale di consultazione utile / Useful reference material: J. Ekanayake et al, “Smart Grid. Technology And Applications”, John Wiley & Sons Inc., 2012. Qi Huang, et al, “Innovative Testing and Measurement Solutions for Smart Grid”, John Wiley & Sons, 2015 Keithley Instruments handbook “Understanding New Developments in Data Acquisition, Measurement, and Control” (www.keithley.com) Measurement and Computing “Data Acquisition Handbook” (www.mccdaq.com) NI Tutorials, white papers, datasheets and LabVIEW manual (www.ni.com)

SYLLABUS

Hrs	Frontal teaching
15	MEASUREMENT ARCHITECTURES, INSTRUMENTS AND SYSTEMS FOR AUTOMATION. Automatic Measurement Systems (AMS) and applications in the Electrical Engineering sector (smart grids and automation). AMS types and basic architectures. Data acquisition systems. PC-based instruments. Modular measurement systems (PXI, VXI, LXI). SCADA systems. Distributed measurement systems. AMS for measurements of physical quantities, measurement chain, AMS components. Sensors and signal conditioning accessories. Data acquisition boards (DAQ). Types, features, technical specifications. Selection criteria. Use of analog and digital inputs/outputs (AIO-DIO); Signal acquisition and digital processing; metrological issues. Analog-to-digital (A/D) conversion. Signals sampling, quantization and coding. ADC types. Static and dynamic accuracy specifications. Number of bits, quantization error, amplitude resolution (floor). Quantization error mitigation techniques. Shannon's theorem and aliasing. Anti-aliasing methods. Harmonic analysis of digital signals. Frequency resolution. Spectral leakage. Techniques for scallop loss errors and harmonic interference mitigation. Window functions. Virtual instrumentation (VI). G-language (graphical language, LabVIEW). Introduction to VI programming for signal acquisition and digital processing. Measurement instruments remote control through PC.
15	MEASUREMENT ARCHITECTURES, INSTRUMENTS AND SYSTEMS FOR SMART GRIDS. Smart grids and smart metering. Automated Meter Reading (AMR), Advanced Metering Infrastructure (AMI). Distribution management systems (DMS). Building management systems (BMS). Smart meters. Intelligent electronic devices (IEDs). Power quality analyzers. Phasor Measurement Units (PMU). Interface devices for distributed generation. Voltage and current transducers. Voltage and current measurement transformers (VTs and CTs). Current shunts and voltage dividers. Hall effect transducers. Rogowski coils. Power quality fundamentals and related measurement issues. Standards on energy, power quality and harmonics measurements. Power and energy measurements in nonsinusoidal conditions. Metrological characterization of instruments and transducers in nonsinusoidal conditions.

Hrs	Practice
24	PRACTICAL EXAMPLES OF MEASUREMENT SYSTEMS FOR SMART GRIDS AND AUTOMATION. Choice and sizing of measurement chain elements. Case studies development and discussion. datasheets analysis of measurement instrumentation and AMS components. Use of stand-alone instrumentation and PC-based instruments for signal acquisition and time and frequency domain signal analysis. Examples of virtual instruments development in LabVIEW environment.