UNIVERSITÀ DI PAVIA

Anno Accademico 2020/2021

ELECTRO-OPTICAL INSTRUMENTATION	
Enrollment year	2019/2020
Academic year	2020/2021
Regulations	DM270
Academic discipline	ING-INF/01 (ELECTRONICS)
Department	DEPARTMENT OF ELECTRICAL,COMPUTER AND BIOMEDICAL ENGINEERING
Course	ELECTRONIC ENGINEERING
Curriculum	Photonics
Year of study	2°
Period	1st semester (28/09/2020 - 22/01/2021)
ECTS	6
Lesson hours	52 lesson hours
Language	English
Activity type	WRITTEN TEST
Teacher	GIULIANI GUIDO (titolare) - 6 ECTS
Prerequisites	Knowledge of the advanced concepts in Physics and Optics, and in Electronics.
Learning outcomes	Students will learn the basic principles of operation, the block scheme, the realization details, the performance, the applications, of instruments and sensors based on electro-optic and photonic technologies. By the end of the Course, students are expected to develop skills in the design and realization of electro-optical instruments and sensors.
Course contents	* Introduction: optical sensors and optical instruments * Overview of milestones, market and revenues for opto-electronic instrumentation * Diffraction-based instrumentation o overview o collimation of a Gaussian beam for alignment

o the laser level and applications
o wire diameter sensor
o particle-size measurement
* Telemeters
o Introduction and classification and ranges of operation
o time-of-flight telemeters: cooperative and non-cooperative targets, Power balance equation, system equation and range evaluation vs noise contributions and transmitted power,
o sine-wave modulated telemeter: accuracy and equivalence with the ToF, ambiguity problem and the swept-frequency approach.
o 3D telemeters
o LIDAR
* Optical fiber sensors (OFS)
o Introduction and paradigm;
o sources (LED, laser, SLED) and fibers (multi- and mono-mode)
o readouts: Intrinsic and extrinsic OFS; direct and indirect effects;
o OFS for mechanical, temperature, electrical and chemical measurands
o readouts: intensity, polarization state, optical phase
o the case study of OFS strain gauge: by intrinsic coupling loss, by grating-assisted extrinsic coupling loss, by scrambing mode loss, by polarization readout, by interferometric readout.
o temperature OFS by fluorescence, by differential absorption, by blackbody emission
o Polarizaion-based OFS: linear and circular birefringence
o Current sensor and Verdet constant
o Inteferometric OFS: types of interferometers and their properties
* Interferometry
o Principle; Interferometric configurations; Applications
o Basic configurations: Mach-Zehnder, Sagnac, Michelson, Twyman-Green, Dual beam, Dual frequency
o Extension to mechanical/geometrical measurements
o Performance limits: Noise Equivalent Displacement and Quantum Noise; Cosine error; Limited coherence length of the laser source (temporal coherence limit); Spatial coherence and polarization effects; Dispersion of the propagation medium; Thermodinamic phase noise; Speckle-Pattern errors
o Self-Mixing Interferometry: Principla; S-M interferometry with Zeeman He-Ne laser; S-M interferometry with Semiconductor Laser
o Laser vibrometers: motivation for vibration measurements; principle; traditional LDV; Closed-loop and open-loop Self-mixing Vibrometer; Scanning laser vibrometer; applications
* Optical Gyroscopes
o Introduction: gyrosope applications and technologies
o Principle: Sagnac effect
o RLG - Ring Laser Gyroscope: structure; output signal; lock-in of modes and solutions; Dithered-RLG; Zeeman-RLG; performance
o FOG - Fiber Optic Gyroscope: structure; output signal; Open loop; Closed loop; performance
o NER (Noise Equivalent Rotation) for RLG and FOG
* Interferometers for the detection of gravitational waves
o Principle and theoretical background: quadrupolar interaction; Strain
o Antennas for Gravitational Waves: VIRGO experiment; LIGO

	experiment o Antennas for Gravitational Waves - technologies and solution: high-power laser + recycling mirrors; suppression of mechanical and seismic vibrations; Fabry-Perot filters as interferometer mirrors; NED vs. frequency o Successful detection of gravitational waves: black holes merger; neutron stars merger * Laser triangulation sensors o Principle o Sensor: Linear CCD/CMOS sensor vs. PSD; o Performance o Applications o 2D Laser Triangulation
Teaching methods	The Course is based on lectures that illustrate the principles and the measuring schemes adopted in sensors and instruments, with reference to practical examples and numerical analysis of performance and specifications. Tutorial laboratory sessions provide a "hands-on" experience where students are requested to implement experimentally a Michelson Interferometer, and to operate a laser vibrometer and a laser triangulation distance sensor.
Reccomended or required readings	S. Donati, " Electro-Optical Instrumentation: Sensing and Measuring with Lasers", Prentice Hall, 2004. Slides of the Course
Assessment methods	Written or oral test, with questions aiming at understanding which are the concepts acquired by the student and his/her ability to explain how the functional blocks of an optoelectronic device/instrument work. The minimum score to pass the exam is 18, the top one is 30 cum laude.
Further information	
Sustainable development goals - Agenda 2030	$lbl_legenda_sviluppo_sostenibile