Program of ELECTRONICS LABORATORY FOR AUTOMATION course

Theoretical part

Sensors and actuators concepts

Basic concepts concerning transducers, sensors and actuators. Diagram of the measurement and regulation chain. Sensor classification. Active and passive sensors. Absolute sensors and relative sensors. Sensor characteristics. Functional characteristics of a sensor/transducer and transfer function. Difference between ideal and real sensor characteristic. Concepts of: hysteresis, precision, accuracy, sensitivity, resolution, saturation, dead band, dependence on environmental variables, reliability, dynamic characteristics, frequency and time response, mechanical and physical parameters and economic parameters.

Physical Principles of Sensing

Physical concepts of the sensors. Electrical charges, fields and potentials. Capacitance: capacitors and dielectric constant. Magnetism: Faraday's law, solenoid, toroid and permanent magnets. Inductors. Resistances: specific resistivity, sensitivity to temperature, traction and humidity. Piezoelectric effect, piezoelectric ceramic materials and piezoelectric polymer films. Pyroelectric effect. Hall effect. Thermoelectric effect, Seebeck effect, Peltier effect. Sound waves. Thermal properties of materials, temperature scales, thermal expansion, thermal capacity. Thermal transfer, thermal conduction, thermal convection, thermal radiation. Light, polarization of light, scattering of light.

Sensors

Sensors for level, misalignment and position measurement: potentiometric, capacitive, magnetic, optical and ultrasonic sensors, level and thickness sensors. Sensors for speed and acceleration measurement: accelerometer characteristics, piezoresistive and piezoelectric capacitive accelerometer, gyroscope. Sensors for strength, strain and tactile measurements: strain gauge, tactile sensor (piezoelectric, piezoresistive and MEMS), piezoelectric force sensor, optical fiber sensor. Pressure measurement sensors: pressure concept, mercury pressure sensor, piezoelectric and capacitive pressure sensor. Indirect pressure sensors. Vacuum sensors. Acoustic sensors: resistive microphone, condenser, piezoelectric, solid state. Humidity sensors: humidity concept, capacitive humidity sensors, optical hygrometer. Light detectors: photodiodes, phototransistors, photoresistors, image sensors. Radiation sensors: detector based on scintillating materials, ionization detector.

Optical fiber sensor

Optical fiber. Advantages of optical fibers. Extrinsic and intrinsic optical fiber sensors. Fiber Bragg Gratings (Fiber Bragg Grating, FBG). FBGs manufacturing processes. FBGs as temperature and strain sensors. FBGs as multi-functional sensors, FBG arrays for multi-parameter measurements. FBGs in the field of railway safety. FBGs as hydrophones. FBGs as temperature and humidity sensors in high energies (CERN). FBGs as a sensor for mechanical deformation of aircraft wings. Methods to make the Bragg reticulum a chemical sensor.

Micro and Nano fabrication methods

Integrated circuits. MicroElectroMechanicalSystem (MEMS). Manufacturing techniques. Oxidation. Deposition: CVD Process, PECVD Process, PVD Process and E-Beam evaporation. Photolithography: Lithography in proximity and projection contact. X-ray lithography. Lithium and ionic beam lithography. Micro-Nano imprint lithography. Etching: Dry and wet etching, Reactive ion etching. Inspection techniques. Optical microscope. Atomic Force Microscope (AFM).

Arduino

Arduino as a platform to automate a sensor-actuator system. Microcontroller operating principle: operation voltage, input-pin and output-pin, connection of sensors and actuators. Arduino programming: open-source software, IDE programming, language syntax. Concepts of LED diode and LCD display. Basic concepts for Arduino use: sensor-actuator system based on the flashing of an LED controlled by a Pulse Width Modulation (PWM) impulsive signal with relative LED switch on and off messages reproduced on the LCD.

Practical part

Laboratory exercise on conventional sensors

Laboratory exercises concern the experimental thermocouple characterization, experimental setup, temperature-voltage characteristic curve, sensitivity, hysteresis and repeatability.

- Thermocouple

http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercises concern the experimental load cell characterization: experimental setup, weight-tension characteristic curve, sensitivity, hysteresis and repeatability.

- Load cell

http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercises concern the experimental photodiode characterization: experimental setup, characteristic curve optical power-voltage, sensitivity, hysteresis and repeatability.

- Photodiode

http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercises concern the experimental capacitive humidity sensor characterization: experimental setup, humidity-voltage characteristic curve, sensitivity, hysteresis and repeatability.

- Humidity sensor

http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercise on fiber-optic sensors

Laboratory exercises concern the characterization of a fiber optic cantilever vibrational sensor: experimental setup and characterization of the fiber optic vibration sensor, acquisition of induced vibrations, characterization curve in terms of responsivity and performance calculation in terms of band and resolution.

- Otpical fiber vibrational sensor
http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercises concerning the characterization of an optical fiber thermohygrometer based on a Bragg coated grating: experimental setup and characterization of a fiber optic thermo-hygrometer through controlled water supply and comparison with a conventional reference sensor, relative humidity calibration curve- wavelength and amount of water-wavelength.

- Optical fiber thermohygrometer
http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercises concern the characterization of radio-chromic films by means of absorbance measurements: experimental setup concerning an optical fiber system for absorbance measurements, detection of the absorbed dose from pre-irradiated radio-chromic films through the study of the absorbance spectrum.

- Absorbance measurements of radio-chromic films
http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercises concern the fabrication and experimental characterization of long period optical fiber grating: experimental setup for the optical characterization of the device during the realization phase, characteristic curve of refractive index of the external-shift mean of the resonance wavelength and calculation of the sensitivity of the device realized.

- Long period optical fiber grating characterization
http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Electronic systems of industrial automation
Laboratory exercises: digital scale. Prototype system development of digital scale based on load cell and managed by the Arduino hardware platform that allows the display of the weight applied on an LCD display and enables different LED actuators according to the measured weight range.

- Project sheet: digital scale
http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercises: thermometer. Prototype system development able to monitor the temperature based on the thermocouple and managed by the Arduino hardware platform designed to enable different LED actuators according to the measured temperature range.

- Project sheet: thermometer
http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercises: liquid optical fiber sensor. Prototype system development of a liquid detector based on an optical fiber sensor (cut fiber) and managed by the Arduino hardware platform that allows the display of the liquid name inside which the sensor is immersed and enables different LED actuators to depending on the liquid in which the sensor is immersed.

- Project sheet: liquid optical fiber sensor
http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101

Laboratory exercises: optical power meter. Development of a prototype system of an optical power detector based on the optoelectronic laser source - photodiode chain and managed by the Arduino hardware platform that allows visualization of the optical power delivered by the laser on an LCD diplay and enables different LED actuators according to the intensity of the optical power emitted.

- Project sheet: optical power meter
http://www.optoelectronics.ing.unisannio.it/index.php?option=com_content&view=article&layout=edit&id=101