MEDTEC SHOOL

Course: Biomedical Electronics and instrumentation

Year: 3rd

Period: 1st semester

Credits: 10

Objectives

The course will allow students to:

- be familiar with the basic components of medical instrumentation
- be familiar with the basic principles of the biomedical sensors
- analyze and understand the basic principles and techniques of biomedical instrumentation
- know the main uses and applications of biomedical instrumentation in the clinical settings
- understand the main limits of validity of biomedical instrumentation
- compare different possible available instruments for clinical measurements
- have a sense of the state of the art in the field of biomedical technology

Prerequisites

Student are required to have acquired the content of the following Courses:

- Fundamentals of Experimental Physics
- Chemistry and Organic Chemistry
- Computer science
- Basics of Circuit theory
- Physiology, Anatomy and Biochemistry

Contents

Basic Concepts of Medical Instrumentation - Classifications of Biomedical Instruments, Static and Dynamic Characteristics, Amplifiers, Comparators, Noise and Active Filters, Frequency Response, Impedance measurements, Design Criteria, Commercial Medical Instrumentation Development Process, Regulation of Medical Devices

Basic Sensors and Principles - Displacement Measurements, Resistive Sensors, Bridge Circuits, Inductive Sensors, Phase-Sensitive, Capacitive Sensors, Piezoelectric Sensors, Accelerometer, Temperature Measurements, Thermocouples, Thermistors, Radiation Thermometry, Optical Measurements, Radiation Sources, Geometrical and Fiber Optics, Optical Filters, Radiation Sensors

Digital electronics and Microcontrollers in Medical Instrumentation - Basics of digital electronics, Microcontrollers, Embedded Medical Systems, Selection of a Microcontroller, IoT-Based Medical Devices, examples.

Biopotential Electrodes - The Electrode–Electrolyte Interface, Polarization, Polarizable and Nonpolarizable Electrodes, Electrode Behavior and Circuit Models, The Electrode–Skin Interface and Motion Artifact, Body-Surface Recording Electrodes. Specific applications: ECG, EMG and EEG.

Biopotential Amplifiers - Basic Requirements, The Electrocardiograph, Problems Frequently Encountered, Transient Protection, Common-Mode and Other Interference-Reduction Circuits, Amplifiers for Other Biopotential Signals, Example of a Biopotential Preamplifier, Other Biopotential Signal Processors, Cardiac Monitors, Biotelemetry

Blood Pressure and Sound - Direct Blood Pressure Measurements. Phonocardiography. Indirect Measurements of Blood Pressure, Tonometry

Measurement of Flow and Volume of Blood - Indicator-Dilution Method Ultrasonic Flowmeters, Thermal-Convection Velocity Sensors, Chamber Plethysmography, Electrical-Impedance Plethysmography, Photoplethysmography

Measurements of the Respiratory System - Measurement of Pressure, Gas Flow, Lung Volume, Respiratory Plethysmography, Gas Concentration

Biosensors - Electrochemical Sensors, Chemical Fibrosensors, Ion-Sensitive Field-Effect Transistor (ISFET), Immunologically Sensitive Field-Effect Transistor (IMFET), Noninvasive Blood-Gas Monitoring, Blood-Glucose Sensors, Electronic Noses, Lab-on-chip, Impedance-based biosensors, Fabrication technology of biochips, Surface functionalization, Antibodies detection, Limit Of Detection (LOD), Point-of-care instrumentation

Clinical Laboratory Instrumentation - Spectrophotometry, Automated Chemical Analyzers, Chromatology, Electrophoresis, Hematology

Medical Imaging Systems - Radiography, Computed Tomography, Magnetic Resonance Imaging, Ultrasonography, Single-Photon Imaging, Single-Photon Emission Computed Tomography, Positron Emission Tomography, Optical Imaging

Therapeutic and Prosthetic Devices - Cardiac Pacemakers and Other Electric Stimulators, Defibrillators and Cardioverters. Ventilators. Infant Incubators. Drug Delivery Devices.

Teaching Methods

The course will be offered through:

- Frontal lectures
- Numerical and circuit exercises
- Class discussion groups on different biomedical measurements
- Watching demonstrations of biomedical instruments (also in collaboration with biomedical companies)
- **Practice- based projects** (students, divided into groups of 4-6 people, will have to develop a project (under the guidance of the Tutors). The groups will have to implement a system composed by a simple circuit for the analog conditioning of a given sensor (e.g. potentiometer, NTC, strain-gauge, pressure sensor, photodiode, etc..), an Arduino-based platform for A/D convertion and communication with a PC and a SW application, developed in Processing, for data acquisition and processing (virtual-instrumentation)

Verification of learning

The final exam is constituted by a written test (max grade 27/30), a final report and demo of the lab's project (max grade 3/30), and a final oral exam.

Texts

John G. Webster (Editor), Amit J. Nimunkar (Editor). Medical Instrumentation: Application and Design, 5th Edition. Wiley