ECE581C2/BIOM581C2 Electronic Circuits for Health and Longevity

Course Description:

The intersection of electronics and healthcare represents one of the most dynamic and impactful areas in modern society. As medical devices become increasingly sophisticated and widespread, there is an increasing need for electrical engineers who understand the unique challenges of designing electronics for biomedical applications for monitoring human health and longevity. This course addresses this need by bringing together topics that meet the specialized requirements of health and longevity applications.

This course is a technical elective for senior undergraduate and graduate students in Electrical and Computer Engineering, particularly those interested in pursuing careers in applying electronics to human health and longevity. It builds on foundational knowledge in electrical engineering while introducing the specific topics in analog and digital circuits and their constraints and considerations unique to healthcare applications.

The timing of this course is particularly relevant given the rapid growth of the digital health industry and the increasing demand for engineers who can design next-generation electronic devices. Furthermore, this course aligns with our department's strategic initiative to strengthen its biomedical engineering focus and responds to consistent feedback from our industry advisory board regarding the need for engineers versed in healthcare technology.

This course allows students to explore cutting-edge electronic systems that revolutionize healthcare through advanced diagnosis and real-time monitoring, this course covers essential components of medical electronics: from biosensors that capture vital health signals to real-time signal conditioning and processing circuits. Students will learn to design simple sensors for capturing human health signals, low-power amplifiers, precision analog-to-digital converters, and efficient digital interfaces.

Prerequisite Courses:

ECE332 and ECE451

Course Grade Mode: Traditional

Course Learning Objectives

Upon successful completion of this course students will be able to

1. Design and analyze biomedical sensors and their interfaces for measuring vital signs and other cellular signals with high sensitivity and repeatability. These signals include: electrocardiogram signal (EKG), blood pressure signal, oxygen signal, and glucose signal.
2. Apply principles from physics and chemistry learn basic principles of how biosensors work. The design principles for biosensors to be applied include mechanical stress, fluid flow rate, optical reflection, etc.

3. Apply principles of low-power circuit design achieving:Sub-1mW total power consumption for monitoring devices with less than 100μA sleep current to achieve one year battery life from CR2032 cell with less than 1nA leakage current in standby mode.
4. Implement high-precision analog signal conditioning circuits with operational amplifiers and instrumentation amplifiers using design parameters sich as CMRR, input impedance, gain accuracy, filter roll-off, power consumption, and THD. Evaluate and select ADC solutions to meet the requirements for resolution, sampling rate, INL/DNL, and power consumption.
5. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions during classroom discussion sessions and final project presentations. For sensor systems, analyzing and interpreting data from experiments means that students can spot trend and associations between data and a set of health and longevity outcomes. These associations can be used to guide design trade-off.
6. Recognize ethical and professional responsibilities in design and implementing electronic systems for human health, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
7. Recognize the ongoing need to acquire new knowledge, to choose appropriate learning strategies, and to apply this knowledge. Electronic systems for human health is a rapidly growing field and new technologies, including AI, to achieve better outcomes.
8. Function effectively as a member or leader of a team that establishes goals, plans tasks, meets deadlines, and creates a collaborative and inclusive environment by demonstrating abilities to meet project/homework deadlines and to be a team player class discussions and presentations.
9. Communicate effectively to convey concepts and trade-offs in designing electronic systems for human health and longevity.

Weekly Scheduled Topics (Tentative):

Week	Topics
1	Physics and chemistry concepts related to electronic sensors
2	Physics and chemistry concepts related to electronic sensors
3	Sensor structures related to monitoring human health and longevity
4	Sensor structures related to monitoring human health and longevity (cont.)
5	Performance, important parameters, and characterization of sensors
6	Student discussions about sensors and their structures and midterm exam
7	Analog circuits interfacing with sensors
8	Analog circuits interfacing with sensors (cont.)

9	Analog circuits interfacing with sensors (cont.)
10	Digital circuits interfacing with computers
11	Digital circuits interfacing with computers (cont.)
12	Digital circuits interfacing with computers (cont.)
13	Students discussions about electronic circuits for health and longevity
14	Examples of electronic systems created for improving human health and longevity
15	Examples of electronic systems created for improving human health and longevity (cont.)

Grading Policy

Assessment Components	**Percentage of Grade**
Final exam	35
Midterm	30
Homework, Reading Assignment, and Lab	25
Student participation in class discussions	10

Textbooks and Course Materials:

A set of slides and reading materials prepared by the instructor will be available from the bookstore.

Office Phone Number, Hours, Contact Email, and Location:

Tuesdays and Thursdays: 12pm – 1:30pm, or by appointment.

Office location: Scott, Room 352

Office Phone Number: 970-491-6574

Contact Email: thomas.chen@colostate.edu