205mcd2018

Master Course Description for EE-205 (ABET sheet)

Title: Introduction to Signal Conditioning

Credits: 4

UW Course Catalog Description

Coordinator: Alexander Mamishev, Professor, Electrical and Computer Engineering

Goals: To introduce basic electrical engineering concepts used in the connection of sensors to digital systems, acting as a first course in Electrical Engineering for non-EE majors. To learn the basic elements of circuits, including wires, resistors, capacitors, inductors, independent and dependent voltage and current sources, and operational amplifiers. To prepare students to deal with sensor I/O in digital system courses.

Learning Objectives: At the end of this course, students will be able to:

1. *Describe* the role of signal conditioning in digital systems.
2. *Design* voltage divider circuits to attenuate voltage signals for digital input.
3. *Design* simple op amp circuits to amplify sensor outputs, including saturation and slew rate considerations.
4. *Describe* techniques to deal with noisy sensors.
5. *Design* simple high pass and low pass passive and active filters.
6. *Acquire* and *analyze* analog signals in Matlab.
7. *Analyze* simple circuits using PSpice.
8. *Determine* the sample rates necessary for signals with specific frequency content and *describe* the effects of improper sample rates.
9. *Design* anti-aliasing filters.
10. *Explain* analog transmission line effects on digital signals.
11. *Design* terminations for digital signal lines.
12. *Describe* the importance of isolation.
13. *Design* isolation methods.
14. *Sketch* a simple control system block diagram and *explain* its basic operation.

Textbook: Horowitz and Hill, *The Art of Electronics*, 3rd Ed., Cambridge University Press, 2015, ISBN-13: 978-0521809269.

Reference Texts:

1. Pallas-Areny and Webster, *Sensors and Signal Conditioning*, 2nd Ed., John Wiley & Sons, 2001.
2. Hayes and Horowitz, *Learning the Art of Electronics: A Hands-On Lab Course*, 2016, ISBN-13: 978-0521177238.

3. Nilsson and Riedel, *Electric Circuits*, 11th Ed., Prentice Hall, 2011.

Prerequisites by Topic:

1. Fundamental physics (PHYS 122), including concepts of power, energy, force, electric current, and electric fields
2. Fundamental mathematics (MATH 126), trigonometric and (complex) exponential functions, introductory differential and integral calculus, first and second order linear differential equations

Topics:

1. Sensors, signals, A/D conversion, signal conditioning paradigm, voltage, current.
2. Attenuation, Ohm's Law, resistance, voltage divider, resistor precision, power dissipation.
3. Amplification, ideal op amps, inverting amplifier, non-inverting amplifier, saturation, slew rate, bandwidth, impedance matching.
4. Strain gauges, noise, frequency domain, filtering, FFT, low pass passive filter design, PSpice.
5. High pass passive filters, phase angle, active filters.
6. Aliasing, Nyquist limit, anti-aliasing filters, sample and hold.
7. Digital signals and transmission lines; attenuation, ringing, termination, cross talk.

Course Structure: The classmeets for three 50-minute lectures and one three hour laboratory session per week. The latter is administered by teaching assistants. Homework is assigned weekly. Two exams are given nominally at the ends of the 4th and 8th weeks, and a comprehensive final exam is given at the end of the quarter.

Computer Resources: Experiments require a PC (laptop or desktop) with a sound card, microphone input and headphone output jack.

Laboratory Resources: Students perform laboratories in an undergraduate electronics laboratory using a parts kit provided by the department.

Grading: Homework 20%, Laboratories 20%, Exam-1 15%, Exam-2 15%, Final Exam 30%. The grading scheme in any particular offering is the perogative of the instructor.

ABET Student Outcome Coverage: This course addresses the following outcomes:

H = high relevance, M = medium relevance, L = low relevance to course.

(1) *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics* **(H)** The homework, exams and laboratories require direct application of mathematical, scientific, and engineering knowledge to solve circuit theory problems and analyze, design and test signal conditioning circuits.

(3) *An ability to communicate effectively with a range of audiences* **(M)** Students are required to write and submit a formal laboratory report for each experiment describing the circuits used and the results achieved.

(4) *An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts* **(M)** Several examples in the lectures are based on well known books and movies, based on which different engineering methods are solutions are considered. An ensuing discussion includes comparison of pluses and minuses of different approaches.

(5) *An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives* **(M)** Laboratory work is carried out in teams of typically three students.

(6) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions* **(M)** Students conduct simple signal conditioning experiments using personal multimeters, a breadboard and a parts kit, and a PC-based oscilloscope. The experiments require student to account for differences between measured data and predictions. Some freedom of experiment design is provided.

(7) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies* **(M)** Course materials draw on a mix of books, slides, web entries, live demonstrations, software demonstrations, and recorded lectures. Learning approaches include group and individual discussions, review of materials, verification of validity of web-based information, and estimation of the realism of the solutions.

Prepared By: Alex Mamishev (earlier version by Rich Christie)

Last Revised: March 18, 2019