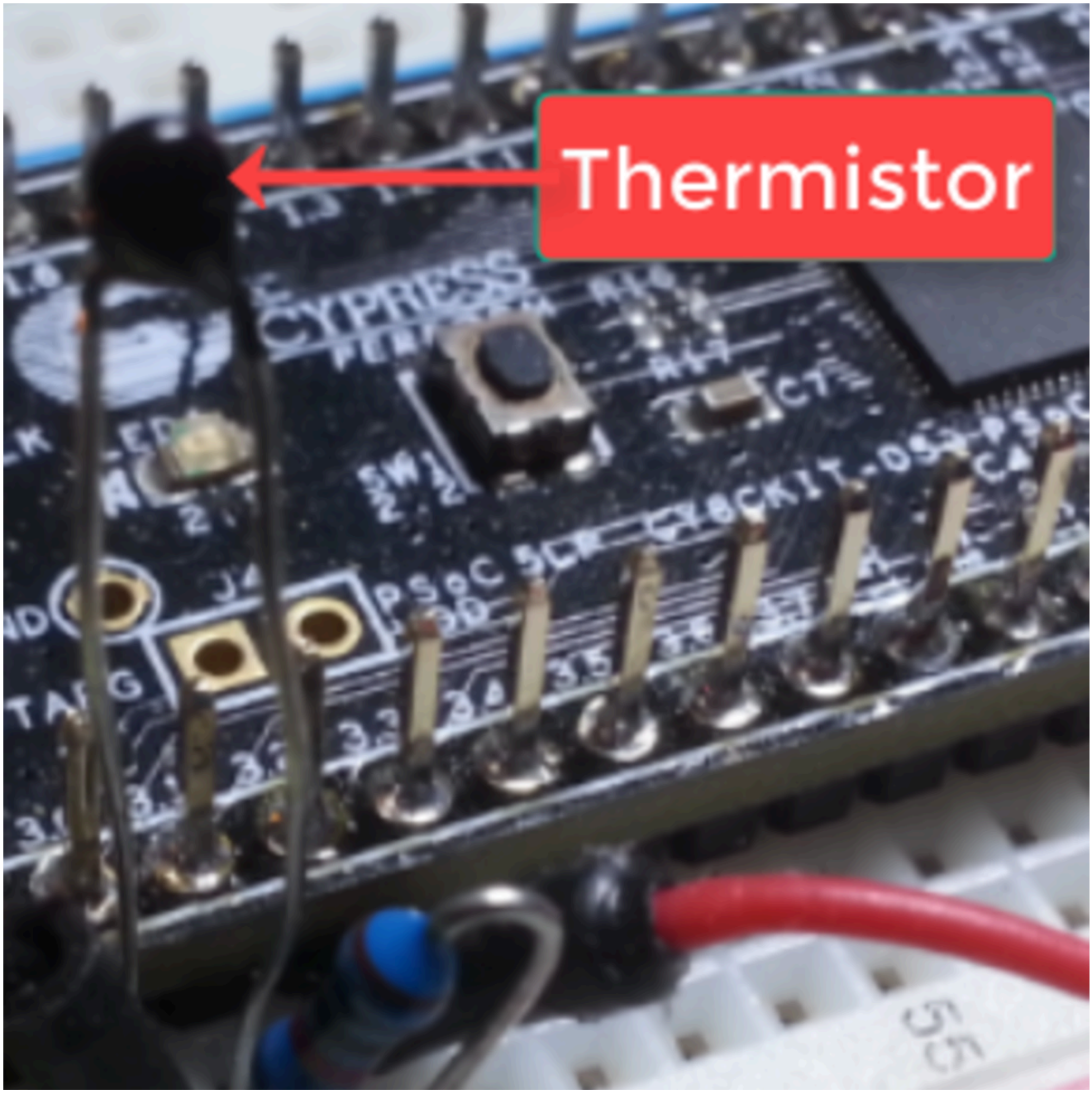
Sensors and Sensor Circuit Design

coursera.org/learn/sensors-circuit-interface/home/info



by University of Colorado Boulder

About this Course
This course can also be taken for academic credit as ECEA 5340, part of CU Boulder's Master of Science in Electrical Engineering degree. After taking this course, you will be able to: ● Understand how to specify the proper thermal, flow, or rotary sensor for taking real-time process data. ● Implement thermal sensors into an embedded system in both hardware and

software. ● Add the sensor and sensor interface into a microprocessor based development kit. ● Create hardware and firmware to process sensor signals and feed data to a microprocessor for further evaluation. ● Study sensor signal noise and apply proper hardware techniques to reduce it to acceptable levels. You will need to buy the following components to do the two course projects based on the videos in this module. Note that if you have already purchased the PSOC 5LP PROTOTYPING KIT, you do not need to buy it again. These parts may be purchased off the Digikey web site, www. Digikey.com. Or, you may obtain the specs from the site, and purchase them elsewhere. These are the part numbers typed out, so you can copy and paste them into the Digikey web site. You will need one of each part. 428-3390-ND NHD-0216BZ-RN-YBW-ND 570-1229-ND A105970CT-ND Additional equipment needed: • Wire - various gauges and lengths • Breadboard • Oscilloscope – suggested models are: o PICOSCOPE 2204A-D2 available on www.digikey.com or o Digilent 410-324 | OpenScope MZ available on www.newark.com Depending on your budget, you can also investigate these models: o Hantek HT6022BE20MHz - https://www.amazon.com/dp/B009H4AYII o SainSmart DSO212 - https://www.amazon.com/dp/B074QBQNB7 o PoScope Mega50 USB - https://www.robotshop.com/en/poscope-mega50-usb-mso-oscilloscope.html o ADALM2000 - https://www.digikey.com/en/products/detail/analog-devices-inc./ADALM2000/7019661

Basic Info	Course 1 of 4 in the Embedding Sensors and Motors Specialization
Level	Advanced
Commitment	4 weeks of study, 6-10 hours/week
Language	English, **Subtitles:** Arabic, French, Bengali, Ukrainian, Chinese (Simplified), Greek, Italian, Portuguese (Brazil), Vietnamese, Dutch, Korean, Oriya, German, Pashto, Urdu, Russian, Thai, Indonesian, Swedish, Turkish, Azerbaijani, Spanish, Dari, Hindi, Japanese, Kazakh, Hungarian, Polish
Hardware Req	Cypress PSoC5 kit CY8CKIT-059, plus more parts defined in reading assignments
How To Pass	Pass all graded assignments to complete the course.
User Ratings	Average User Rating 4.6

Syllabus

Thermal Sensors

In module 1 you will learn how to specify and use temperature sensors in an embedded circuit. First, you will learn about common types of sensors and actuators found in common products such as smart phones and automobiles. Then you will get a high-level overview of analog and digital interfaces, followed by a deep dive into thermistors, RTD's, and thermocouples. For each of these three types of thermal sensors, we define the core theory and formulae, give you examples of how commercial sensors are packaged, and explain what you need to know to purchase them on a web site.

10 videos, 3 readings

1. **Reading:** Non-Credit Students: Welcome and Where to Find Help
2. **Video:** 1: Course Introduction
3. **Video:** 2: Common Types of Sensors and Motors
4. **Video:** 3: Analog and Digital Interfaces
5. **Video:** 4: Temperature Sensors and Applications
6. **Video:** 5: Thermistors: Basic Facts
7. **Video:** 6: Thermistors: How They Work
8. **Video:** 7: RTDs: Basic Facts
9. **Video:** 8: RTDs: How They Work
10. **Video:** 9: Thermocouples: Basic Facts
11. **Video:** 10: Thermocouples: How They Work
12. **Reading:** Week 1 Online Articles
13. **Reading:** Week 1 Videos

Graded: Week 1 Quiz

Sensor Development Kit and Prototyping

In module 2 you will learn how to design a complete temperature sensor system within a development kit environment. We will teach you how to assign internal components to the schematic. This includes pins, amplifiers, MUX's, DAC's, and ADC's. Then you will learn how to wire in external parts: resistors, thermistors in particular, to the kit. Finally, you will take a deep dive into interfacing a thermistor and associated front end components to the development kit. This includes lessons on using the schematic portion of the kit, as well as writing application software in c code.

14 videos, 2 readings

1. **Video:** 1: PSOC Creator, Introduction and Documentation
2. **Reading:** Hardware Needed to do Course Projects
3. **Video:** 2: PSoC Creator 2 Pin Assignment
4. **Video:** 3: Automatically Generated Code
5. **Video:** 4: Adding the LCD display to the Nscope and Developent Kit
6. **Video:** How UART's work

7. **Video:** 6: Debugging with GPIO and DACs
8. **Video:** 7: Documenting Components not in the PSoC Chip
9. **Video:** 8: Pin Types
10. **Video:** 9: Digital to Analog and Back Again
11. **Video:** 10: A Basic Sensor Interface in PSoC
12. **Video:** 11: Thermistor Lab, Part 1
13. **Video:** 12: Thermistor Lab, Part 2
14. **Video:** 13: Thermistor Lab, Part 3
15. **Video:** 14: Thermistor Lab, Part 4
16. **Reading:** Week 2 Online Articles

Graded: Week 2 Quiz

Rotary and Flow Sensors

In module 3 you will learn how rotary sensors work and how to specify them for purchase. In our videos rotary sensors include both optical encoders and resolvers. You will also learn the design intricacies of flow sensors, along with their appropriate applications. The videos will discuss variable area, differential pressure, vortex, ultrasonic, turbine, thermal mass flow, and coriolis flow meters.

15 videos, 3 readings

1. **Video:** 1. Module 3 Introduction
2. **Video:** 2: Summary of Rotary Sensors and Applications
3. **Video:** 3: Optical Encoders: How They Work
4. **Video:** 3a: Measuring Encoder Speed
5. **Video:** 4: Optical Encoders: Applications
6. **Video:** 5: Resolvers: How They Work
7. **Video:** 6: Resolvers: Applications
8. **Reading:** Week 3 Online Articles #1
9. **Video:** 7: Flow Sensors and Applications
10. **Video:** 8: Variable Area Flow Sensors
11. **Video:** 9: Differential Pressure Flow Sensing
12. **Video:** 10: Vortex Flow Meters
13. **Video:** 11: Ultrasonic Flow Meters
14. **Video:** 12: Turbine Flow Meters
15. **Video:** 13: Thermal Mass Flow Meters
16. **Video:** 14: Coriolis Flow Meters
17. **Reading:** Week 3 Online Articles #2
18. **Reading:** Week 3 Videos

Graded: Week 3 Quiz

Amplifiers and Sensor Noise

In module 4 you will learn the theory and practical application of amplifiers and circuit noise. You will review how gain is calculated in inverting, non-inverting, summing, differential, and instrumentation amplifiers. We will then contrast theoretical vs. real-world amplifier performance, and give examples of how commercial chips specs are interpreted. Then we will discuss the causes of noise in sensor circuits, how the noise affects sensor accuracy, and some steps you can take to reduce noise in your sensor circuit designs.

10 videos, 2 readings

1. **Video:** 1: Module 4 Introduction
2. **Video:** 2: Why Study Amplification?
3. **Video:** 3: Basic Amplifiers
4. **Video:** 4: Instrumentation Amplifier
5. **Video:** 5: Amplifier Imperfections
6. **Video:** 6: Amplifier Frequency Response
7. **Reading:** Week 4 Online Articles #1
8. **Video:** 7: Noise in Sensors
9. **Video:** 8: Johnson and 1/f Noise
10. **Video:** 9: Shot and Quantization Noise
11. **Video:** 10: How Noise Affects Sensor Accuracy
12. **Reading:** Week 4 Online Articles

Graded: Week 4 Quiz

Course Project

This module contains the materials you need to complete the thermistor lab assignment.

2 readings

1. **Reading:** Thermistor Data Collection Assignment
2. **Reading:** Thermistor Lab Screen Shots

Graded: Course Project Quiz

General

What do start dates and end dates mean?

Once you enroll, you'll have access to all videos, readings, quizzes, and programming assignments (if applicable). If you choose to explore the content without purchasing, you may not be able to access certain assignments. If you don't finish all graded assignments

before the end of the session, you can reset your deadlines. Your progress will be saved and you'll be able to pick up where you left off.

What are due dates? Is there a penalty for submitting my work after a due date?

Within a course, there are suggested due dates to help you manage your schedule and keep work from piling up. Quizzes and programming assignments can be submitted late without consequence. However, it is possible that you won't receive a grade if you submit your peer-graded assignment too late because classmates usually review assignment within three days of the assignment deadline.

Can I re-attempt an assignment?

Yes. If you want to improve your grade, you can always try again. If you're re-attempting a peer-graded assignment, re-submit your work as soon as you can to make sure there's enough time for your classmates to review your work. In some cases you may need to wait before re-submitting a programming assignment or quiz. We encourage you to review learning material during this delay.

Experience Sensors and Motors in an IoT World

Master sensor and motor theory, and program these devices in a microprocessor system.

Embedding Sensors and Motors

University of Colorado Boulder