



ROV Instrumentation and Control



California State University Monterey Bay
ESSP 295/495

4 Units

Professor:

Steven W. Moore, Ph.D.

Course Description:

Students in this introductory electronics/mechatronics course work as a team to design, build, test, and debug instrumentation and controls for a small remotely-operated underwater vehicle (ROV) used to explore kelp forests and other undersea habitats in Monterey Bay. Learning outcomes are based on industry/employer guidelines for marine technology related electronics. May be taken for lower division credit (ESSP 295 recommended for MPC/MATE students) or upper division credit (ESSP 495 recommended for ESSP, CST, and MLML students). Prerequisite: one of the following at college level (or instructor consent): physics, submersible technology, computer programming, electronics. Offered fall semesters. Maximum enrollment = 16 students.

Class Time and Location:

Time: Monday 1:00 - 4:50 pm (with optional lab extension until 6 pm)

Location: Building 13, Room 102 (Physics Lab)

Instructor and Office Hours:

Dr. Steven W. Moore

Associate Professor

Earth Systems Science & Policy Institute

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Office Hours: TBA or by appointment in Building 13, Room 129

Registration Instructions:

You may register for this course in either of two ways:

- Students seeking UPPER DIVISION credit (e.g., most ESSP, CST, and other CSUMB students, as well as MLML students) should enroll in ESSP 495, Section #5 (Course Registration #41194).
- Students seeking LOWER DIVISION credit (e.g, MPC students in the MATE program) should enroll in ESSP 295, Section #1 (Course Registration #41509).

Instructor approval is required for this course.

- Non-CSU students (e.g., MPC, Hartnell, UC) should visit the CSUMB Office of Admissions and Records (Bldg. 21) to request and fill out an "Application for Cross Enrollment." Then drop the form into the "IN" box outside my office door (Bldg 13, room 129) for my signature. Attach a note with your e-mail and/or phone, so I can contact you when I've signed the form.
- CSUMB/MLML students with access to PLANNER/BANNER WEB on-line registration may request approval via PLANNER WEB. Alternatively, you may add the course by placing a completed ADD/DROP form in the "IN" box outside my office door (CSUMB Bldg. 13, Room 129). Attach a note with your e-mail and/or phone, so I can contact you when I've signed the form.

If the course is full:

- Please make sure Admissions & Records puts your name on an official waiting list, and then come to the first class meeting anyway to confirm your interest and reserve a spot in case someone drops the course.

Course Learning Outcomes and Grading:

Your grade in this course will be determined, in large part, by how well you demonstrate mastery of the Electrical/Electronics Knowledge and Skills Guidelines for Marine Technicians compiled by the Marine Advanced Technology Education (MATE) Center. This national center asked marine technicians, marine employers, and other marine technology experts to identify the electronics knowledge and skills they consider most valuable for marine technicians. This course was designed around those recommendations, as they form a good foundation for marine electronics as well as most non-marine applications of electronics.

To facilitate your learning, I have grouped the recommended skills and knowledge into broad Course Learning Outcomes (CLOs). These outcomes specify the things you must DO by the end of the semester to pass the course. They are:

1. Explain the nature of electricity, different ways of generating electricity, electrical properties of materials, and the concept of an electrical circuit.
2. Describe hazards associated with electricity. Describe and explain reasons for standard electrical safety practices and procedures.
3. Describe common varieties, purposes, and principles of operation for the major categories of components used to build electrical circuits for robotic or other mechatronic systems.
4. List major sources for electronic parts and for detailed technical information (called “datasheets”) about those parts.
5. Apply basic circuit theory to analyze/explain/predict/adjust the behavior of very simple sub-circuits commonly used as building blocks in more complex electronic circuits.
6. Draw and interpret simple schematic diagrams of electronic circuits.
7. Describe common circuit construction techniques, and discuss their advantages/disadvantages as methods for building equipment to be used in a marine environment. Discuss special challenges and solutions associated with salt spray, underwater, and deep sea applications.
8. Demonstrate proper use of standard tools for assembling, testing, and repairing electrical circuits and systems.
9. Describe and demonstrate effective use of a systematic approach to “troubleshooting” (diagnosing and correcting problems in) non-working circuits or devices.

IMPORTANT: *All students will need to demonstrate minimum levels of competence in all of these areas to pass the course; however, students enrolled in 495 for upper division credit will need to complete a more advanced set of “sub-outcomes” than those enrolled in 295 to earn an equivalent grade.* Formal statements of the sub-outcomes for lower- and upper-division credit will be provided to you early in the semester, so you’ll know exactly what you’ll need to do for each letter grade.

Warning and Disclaimer:

This one-semester introductory course cannot cover all aspects of electronics and will not substitute for an engineering degree nor for years of on-the-job training and experience. In particular, although basic safety precautions will be stressed, this course alone will NOT prepare you to work safely with high-voltage circuits, including the 110VAC and 220VAC commonly found in household wiring. High-voltage circuits are particularly dangerous in the presence of salt water. Moreover, this course will NOT provide you with enough experience to design, build, test, or repair critical circuits where a malfunction could result in loss of life, serious injury, and/or extensive property damage.

Assessment of course outcomes:

Your mastery of the course outcomes will be assessed in two different ways. First, there will be weekly quizzes covering topics from the readings, lectures, and class discussions. The questions used in these quizzes will be taken primarily from the problems appearing at the end of each chapter in your textbook and are intended to measure your basic electronics knowledge. There will be a comprehensive final exam

covering the quiz material for the semester. Second, there will be projects you must complete to demonstrate that you can use your new electronics knowledge to design, build, test, and debug real circuits. These projects will require a mixture of individual and group work. Simple projects you complete early in the semester will become the building blocks for more complex projects later in the semester, and these more advanced projects will ultimately be combined into a completed class ROV.

Required Materials:

- Textbook: Histan, Michael B. and David G. Alciatore. *Introduction to Mechatronics and Measurement Systems*. © 1999 McGraw-Hill, ISBN 0-07-029089-X
- 3-ring binder: You will need a standard 3-ring binder (1" thick is about right) for organizing your notes and handouts.
- Graph paper: Your binder should be stocked with a supply graph paper (1/4" square grid or similar) to facilitate organized notes and circuit diagrams.
- Electronics Kit: A small locker containing a variety of electronics tools and parts will be assigned to you in lab at the beginning of the semester. You are responsible for returning all tools and parts in good working order at the end of the semester and will be billed for the replacement cost of any damaged or missing items.

Additional Resources:

- Metacognitive Grab-Bag: The Center for Teaching, Learning, and Assessment at CSUMB has funded the purchase of \$1000 in miscellaneous electronic components, which you may check out and use to experiment with different designs for your circuits. We are calling this collection the "Metacognitive Grab Bag", because its purpose is to help you (and us) learn something about your learning process (the term "metacognitive" refers to "thinking about how you think"). Each time you check out a part from the Grab Bag, you'll be asked to answer some quick and simple questions that will reveal something about how you think and learn.
- Course Library: In addition to your electronics kit and the Metacognitive Grab-Bag, you will also have available for reference in the classroom Dr. Moore's personal copies of several helpful books. Please use them as often as you like, but treat them with care and leave them in the classroom. These books will include:
 - Bohm, Harry and Vickie Jensen. *Build Your Own Underwater Robot and Other Wet Projects*. © 1997 Published by Westcoast Words, Vancouver, B.C. ISBN: 0-9681610-0-6
 - Horowitz, Paul and Winfield Hill. *The Art of Electronics*. 2nd Ed. © 1989, Cambridge Univ. Press. ISBN: 0-521-37095-7
 - McComb, Gordon. *The Robot Builder's Bonanza*, 2nd Ed. © 2001, McGraw-Hill. ISBN: 0-07-136296-7
 - BASIC Stamp Programmer's Manual (by Parallax, Inc., makers of the BASIC Stamp microcontroller's we'll be using as the "brains" of our ROV.)
- Computers with Internet Access: Our classroom/lab is equipped with computers, which you may use to access internet information (for example, technical specifications for a part you are using) as needed.
- Course Website: I am creating a course website having links and other additional information for this course. You will be informed of the URL early in the semester. A password may be required.
- Disabilities Accommodations: Students with disabilities who may need accommodations, please visit me during my office hours (XXXX) or phone me (582-3775) or e-mail me (steve_moore@csumb.edu) by Sept 10, which is the last day to add/drop classes. ALSO, please contact Student Disability Resources: Student_Disability_Resources@csumb.edu, Phone 582-3672 (voice), 582-4024 (fax/TTY), <http://www.csumb.edu/students/sdr/>

Course Philosophy and Format:

This is intended to be a **fun but challenging project-based course for people who enjoy learning by diving in and doing**. You and your classmates will work as a team to build the electronic instrumentation and controls for a working remote-controlled vehicle (usually called a "remotely operated vehicle" or ROV) for undersea use. When you finish, you will use the ROV to explore kelp forests or other near-shore marine habitats in Monterey Bay. You will quickly discover that this project provides a fun way to learn a ton of practical electronics in a short period of time!

You will discover that you need at least 250 hours to design and build this ROV at a leisurely pace. The course provides 60 hours of in-class time, which is used for lectures and questions in addition to building/testing of your ROV. You will NOT be allowed to take home oscilloscopes or other in-class equipment, so essentially all construction and testing must be done during these limited class hours. You can do the math to figure out how efficiently you need to use lab time if you want a working ROV by the end of the semester!

Obviously, most of the (very limited) in-class time should be spent building and testing your ROV. I'll give "mini-lectures" in class on an as-needed basis to ensure safety, help clarify confusing points, and keep you moving efficiently in the right direction. However, you will want to do assigned readings and homework, as well as most of your design "brainstorming" and calculations, outside of scheduled class time.

To facilitate a pleasant and productive learning environment, I have found it useful to be explicit about my responsibilities and yours:

My responsibilities as instructor:

- Create and maintain a fun, safe, and supportive learning environment.
- Provide access to tools, parts, and information you will need to complete your project in a safe and effective manner.
- Provide a general schedule of reading assignments, homework problems, or other tasks to help you cover all the required outcomes by the end of the semester.
- Provide hints, "mini-lectures", leading questions, and other information on an as-needed basis to help you solve challenging problems on your own.
- Be your "reality" check in situations where you do not yet have the experience needed to accurately judge the difficulty and/or effectiveness of a particular approach you are considering.
- Assess your mastery of the outcomes periodically throughout the semester for the purpose of giving you feedback and advice, motivating you to keep up with the material, and assigning a grade at the end of the semester.

Your responsibilities as student:

- Be an active learner – I can provide the project and many sources of information. I can also dangle some motivational carrots (like points for completed assignments). But ... I cannot learn for you. YOU must take charge of your own learning by investing the time and energy needed to take advantage of the opportunities, resources, and guidance provided by me and by your classmates. You must be honest with yourself about when you need help and ask for it when you do. I will focus my limited time and energy on helping those who are serious about helping themselves learn.
- Take an active role in project planning and management. This ROV does not come in a kit, and there are no instructions. As a class, you will need to chart your own course, set your own deadlines, evaluate your own progress, and make wise decisions every step of the way. I'll provide guidance, of course, but I usually won't make the decisions for you.
- Be a team player – we'll have more fun and get more done if we work well together and help each other out. Your grade is NOT based on a curve; it's based on how well you meet stated electronics outcomes and on how much you contribute to the learning experience of others. Everyone will get a higher grade if everyone teaches and learns from one another. Avoid wasting time/energy on unproductive conflicts.
- Remember that learning electronics, developing practical problem-solving skills, and learning to work collaboratively are the real goals here. The ROV project is just a fun means to that end.

Why an underwater ROV?

The ROV project was chosen for three reasons. First, an ROV is basically a type of robot, and like any robotic or "mechatronic" project, it provides a fun way to learn about almost every aspect of basic electronics including: analog and digital circuits, sensors, motors, feedback control systems, data

transmission, and microcontroller programming. The fun thing about robotic circuits is that when they work, you can actually see them do something, and when they don't, they often fail in entertaining ways! Second, the end product (your ROV) is one that can be used later by other students and faculty in ESSP for a variety of classes and/or capstone projects. Third, the electronics and problem-solving skills you'll learn are versatile and can be applied directly to a wide range of careers, including those in marine technology, ocean exploration, marine science, underwater archaeology, aquaculture, aquatic resource management, aquarium displays, and interactive educational projects.

More about this semester's ROV project:

The details of the ROV project will vary from semester to semester depending on the availability of resources and opportunities. This semester (Fall 2001) is the first semester the course has been offered, so we'll be focusing on the basic "life support" functions of the ROV, primarily propulsion control (so we can "drive" the ROV through the water) and video camera vision (so we can see where it's going and use it to observe interesting things underwater). If time permits, we may also work on a mechanical arm and/or an automatic depth control ("hovering") mechanism. Mechanical components will be kept as simple as possible, so that you can focus on learning how to design, build, program, and test moderately sophisticated electronics. A rough initial design recommendation and additional details will be provided as the course – and your ROV – progresses. Have fun, and Good Luck!

Tentative Calendar

Note that much of the calendar on the next page is BLANK. That's because YOU and your classmates will be developing the time-line for construction of your ROV during the first or second week of class. I will publish a complete calendar after the class agrees on a proposed work schedule. Also note that if you follow my recommendations for initial test flight date, you have only 7 open class meetings in which to complete your ROV!

Date	Tentative Goals	Reading and homework problems (due following week)
27 Aug	Welcome. Slide show overview of course and ROV project. Go over syllabus. Pretest. Intro to basics of electricity. Intro to circuits. Sign out Lab Kits. Intro to Protoboard, power supply, multimeter. Simple resistor and LED circuits.	Read: Ch 1 – 2.6. Do: 2.2, 2.3, 2.6, 2.8-2.11, 2.13-2.15 (due 10 Sep because of Labor Day)
3 Sep	Labor Day Holiday – no class	Continue with previous assignment if not done yet
10 Sep	ROV project introduction and timeline development. Analog vs. Digital circuits. Intro to BASIC Stamp microcontroller. Start designing ROV.	
17 Sep		
24 Sep		
1		
8	FALL BREAK – no class	
15		
22		
29		
5		
12	Initial test flight of ROV	
19	Adjustments, repairs	
26	ROV test flight #2	
3	Optional improvements to ROV, fine-tuning.	
10	Playing with ROV at sea!!!	none
17	Post-test. Review your pre-test. Complete Course/Instructor Evaluations. ROV party at beach????	none