

Embedded Control: Instructors

Section 1, M/Th 10:00am-1:00pm

Dr. Russell Kraft, kraftr2@rpi.edu

Section 2, M/Th 1:00pm-4:00pm

Dr. Kyle Wilt, wiltk2@rpi.edu

Section 3, T/F 10:00am-1:00pm

Dr. Jeff Braunstein, braunj4@rpi.edu

Section 4, T/F 1:00pm-4:00pm

Dr. Kyle Wilt, wiltk2@rpi.edu

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Embedded Control: Lecture 1 Topics

The following are available on LMS
(and/or as handouts):

- 1) *Number Systems Worksheet 1* (by podium)
- 2) *Homework 1* (on LMS)
- 3) *SiLabs/SDCC Installation*
- 4) *Syllabus*

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Outline

- Introduction to Embedded Control course
 - Staff
 - Policies
 - Lab partners & Lab Manuals
- Embedded Control
- Microprocessors and Microcontrollers
 - What are they?
 - How are they different?
- The Embedded Control Development Process
- Number Systems
- Homework Assignment

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Staff

- Professor: Russell Kraft (Course Coordinator, section 1)
 - Email: kraftr2@rpi.edu (use plain text message format)
 - Office: JEC 6028
 - Phone: x2765
- Professor: Jeff Braunstein (section 3)
 - Email: braunj4@rpi.edu
 - Office: JEC 6020
 - Phone: x8708
- Professor: Kyle Wilt (section 2&4)
 - Email: wiltk2@rpi.edu
 - Office: JEC 6034
 - Phone: x8140
- TAs:
 - Administrative TA: ?? ?? (??@rpi.edu)
- If you aren't registered for this course:
 - Do so!
 - If you can't do it today, email Dr. Russell Kraft (kraftr2@rpi.edu) and you will be added to the Blackboard Learning Management System (LMS)

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Manual

- Embedded Control Manual – Available online
 - You will need to print the manual yourself.
 - It will be required for exams and quizzes – no softcopies allowed!
 - The manual has been updated for this Current Semester
 - Previous versions will be missing a fair number of updates
 - *May be possible to print only the first ~100 pages, but we won't be responsible for missing material needed during tests.*
 - There are website that will print/bind PDF files and mail them to you.
 - The manual is needed for quizzes and exams and can't be shared, so you absolutely need your own copy.
 - The manual includes instructions for setting up the software and hardware, and course policies

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Policies

- Course policies: Appendix E of Embedded Control Manual
 - LMS – Course pages – presently may contain some material from last semester (updated as term progresses)
- Grades – BB LMS - Syllabus
 - There are 2 exams.
 - There are 5 quizzes and all count.
 - Homework assignments will be individual efforts on LMS or **individual** programming assignments.
- Attendance is required for all laboratories
 - It is **part** of your lab performance grade (along with preparation and participation).
- **No food or drink allowed in the lab!**
- You need to choose 2 lab partners
 - for the entire semester
 - Choose carefully; avoid someone with same weaknesses (programming ability)

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Roles of the Staff

- Think of us as facilitators!
 - We can give you the material, but you need to learn it
 - Please ask questions
- TAs are responsible for most of the grading
 - Try to resolve issues with them first
 - If the problem can not be easily resolved, come to me or another instructor
- TAs and I are here to help you
 - This is a busy class
 - Check tutorials while you are waiting for help

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Grading

- We bring as much good will to grading as possible
- Be careful when assessing your standing in the course
 - lab report grades are often high
 - exams and quizzes hold more weight
- Laboratory grades (excluding exams) are normalized at the end of the semester to account for differences in grading by TAs.

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Grading

- To distinguish yourself:
 - you need to understand the material so that you can do well on the exams
- You must demonstrate your understanding to the instructor and/or the TA
 - → good lab performance grade (design/debug/troubleshoot)
- Grades are not intended to be punitive
 - hard work & extra hours alone will not guarantee a high grade
 - you need to thoroughly understand the course material

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Information from the Web

- Course uses LMS site as primary web contact.
 - Parts of the Lab and SiLab microprocessor Manual
 - Announcements
 - Course information
 - Grades
 - Tutorials
 - Sample code
 - Syllabus
 - Calendar & Schedules
 - Handouts
 - Lecture slides (archive)
 - Homework assignments
 - Worksheets

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Homework

- Homework is posted on LMS
- Check the website regularly
 - For homework assignments
 - Lecture slides (after lecture) (last semester's slides are up now.)
 - Due dates for your section – check the LITEC Calendar on LMS
- Homeworks:
 - Will **not** be accepted late (NO extensions & 0 points for late submits)
 - It is your responsibility to know what is due when (check LITEC Calendar)
 - HW is due at the beginning of class
 - soft copy submission on BB LMS
 - text file (.c) for programming homework must be submitted on BB LMS before the due date, make sure comments include name and assignment VERSION
 - grading TAs must be able to compile & execute code correctly
 - (pseudocode prelab assignments are submitted as hardcopies, but not HW)
 - All homework assignments are individual efforts. Open Shop TAs will be available for help.

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You'll generally do well if...

- Show up on-time for lecture
- Read the lab manual
- Finish lab work during class
 - Use open shop hours when needed
 - Do your own work and turn it in on-time
 - Refer to and use the tools available to you
- **Take turns writing code and wiring hardware**
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- Ask for help and use the tutorials

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Current Project

- Introduction to embedded control: Interactive game (Simon, Guitar Hero, Whack a Mole, Minesweeper, ...):
 - Goals:
 - To learn LITEC basics
 - Build hardware to interface with microcontroller
 - Write software to make game work
- Final projects: Smart Car and Gondola on Turntable:
 - Implement test hardware on car for code development
 - Software
 - Control car (gondola) direction and speed after obtaining the magnetic heading and ultrasonic ranger value
 - Use accelerometer to measure tilt and drive uphill or downhill
 - Port car code to gondola

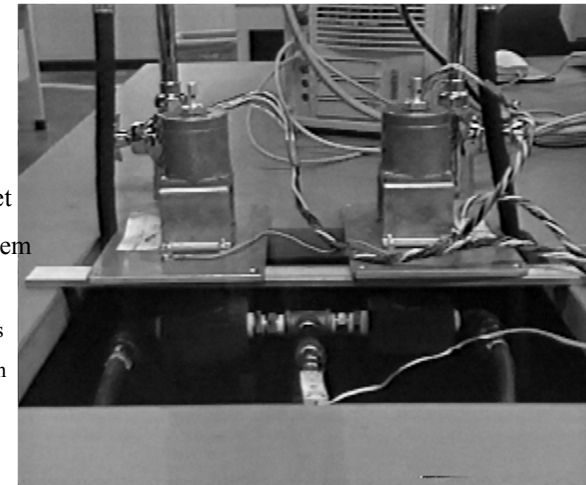
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Intelligent Faucet First Target System

- Simple Game
- Faucet subsystems
- System Integration
- Enhancements

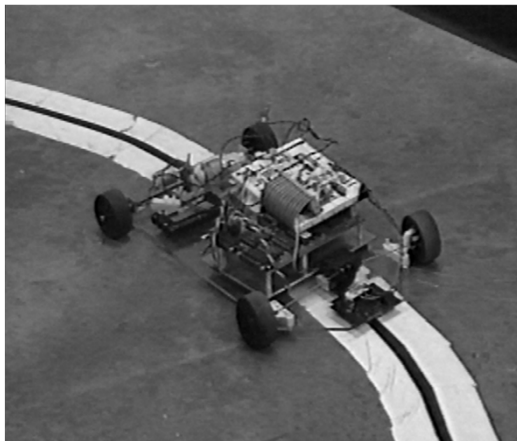


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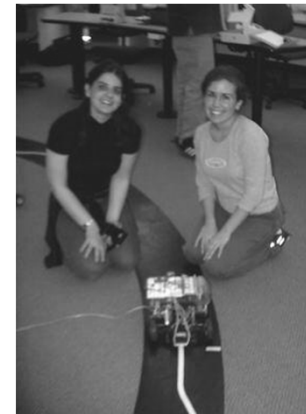
Early Version of Smart Car



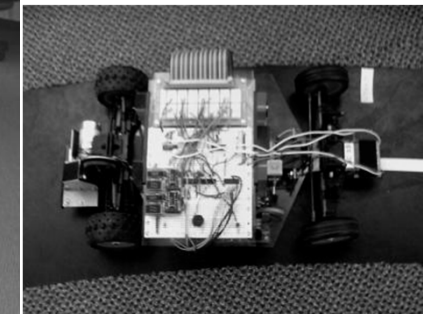
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The Smart Car



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Smart Car Enhancements



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Silicon Labs IDE Software

- Follow the instructions on LMS "Installing SiLabs-SDCC-Drivers" for installing all the software needed for the course
- You will need to install Silicon Laboratories IDE software on your laptop for this course
 - It is not required to install all documentation
 - Install software into the default folder named Silicon Laboratories
- Create folders for projects
 - May be inside a new C:\SiLabs folder
 - No spaces in entire path name (i.e., in "Program Files" may cause issues)
- Save code files in this project folder with a .c extension
 - No spaces or special characters (except '.' and '_') and only one "." in file names
 - A '#' symbol in the file name may cause some very unexpected results
- Refer to Litec manual or Course Resources under LMS for comprehensive instructions on setting up and using the required software

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Installation Summary

- SiLabs IDE – link in Installation document
- SDCC – link in Installation document
- Header files: c8051_SDCC.h, i2c.h – front page of LMS website
- SecureCRT – LMS website section 7 of Course Resources
- Prolific Driver, USB to serial – Windows can auto-find, LMS website section 7 of Course Resources
- RF Driver (by Laboratory 5) – link in Gondola_info document under Lab 5 of Course Resources

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Find 2 partners

- Find partners and change places
 - If you are weak at programming avoid finding other weak programmers as a partners!
- TA will come around with attendance sheet
- Start the software installation
 - Instructions: Main page on LMS
 - If not done today, finish at home
- See you in a bit ...
 - Look at LMS site
 - Sign up for your section under **Sections** (if no change planned)
 - Look at HW #1
 - Think about obtaining a printed Lab Manual

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Syllabus: Manual Appendix D (BB LMS)

- Staff & info
- Objectives
- Required texts
- Grading – see LMS site – Syllabus
 - note percentages
 - lab performance
 - 20% per day late policy on Game & Car/Gondola Reports
 - No late homework (late if 5 minutes after start of class)
- Computers – use your laptop
 - One laptop per team can work in emergency; but set up all 3 machines.
 - Make sure backups of all files are saved
 - Maintain working copies of the code for each laboratory assignment (once a program is completed, leave it untouched and create a new project folder for the next program; copy (don't move) any files to it from the previous folder)

Lab Notebooks

- Your team is required to keep a lab notebook (Teams may be regrouped after students drop class.)
 - One per 3-person team
 - Use one with large pages (larger than 8.5"x11")
 - Quad-ruled notebook with non-removable pages
- Appendix B: Notebook guidelines & requirements BB LMS)
- No 3-ring or spiral binders
- Do not lose your notebook
- Write 3 names, section #, and side (A or B) on the cover

Academic Dishonesty

- I need to remind you that the work that you do for this class must be your own (or your pair's or team's as appropriate). Academic Dishonesty is a serious issue that could have severe consequences.
- The penalty for instances of academic dishonesty can vary, but includes failing the course and being reported to the Dean of Student's Office who will keep the report on your record and may result in expulsion from the institute.
 - Note: The institute will not allow you to drop a course in which there is an academic dishonesty dispute.
- Examples of academic dishonesty include (but are not limited to) copying from another student on an exam or quiz, copying portions of written assignments (homework assignments, lab reports, lab notebooks) from another previous or current student, and having someone else do class work for you and turning it in for credit for you.
- If you use materials (text, graphs, images, etc) that are not of your own creation, it should be referenced using standard formatting procedures.
 - Avoid long quotations from other materials, and reproduce schematics so they represent your own circuit as changes may occur.
- All mobile devices (cell/smart phones, computers, pagers, etc.) must be stored securely away during exams and are not be used unless specifically directed otherwise by the instructor. Use of (or ANY interaction with) a mobile device during an exam without explicit permission of the instructor will be interpreted as the illicit transfer of exam data, will be considered an act of cheating and will be treated as such. [For LMS assessments only the LMS page is allowed to be open.]
- Best advice: If you think something is questionable, then don't do it.

What is Embedded Control?

- System with a "built-in" computer
- Used in all engineering/science disciplines
- Time - Man of the Year article
 - <http://cgi.pathfinder.com/time/moy/daily1.html>
- Bill Gates has predicted that robotics will be the next big thing. <http://www.sciam.com/sciammag/?contents=2007-01>
 - These robots won't look like R2D2 or C-3PO. Most will contain multiple microcontrollers.

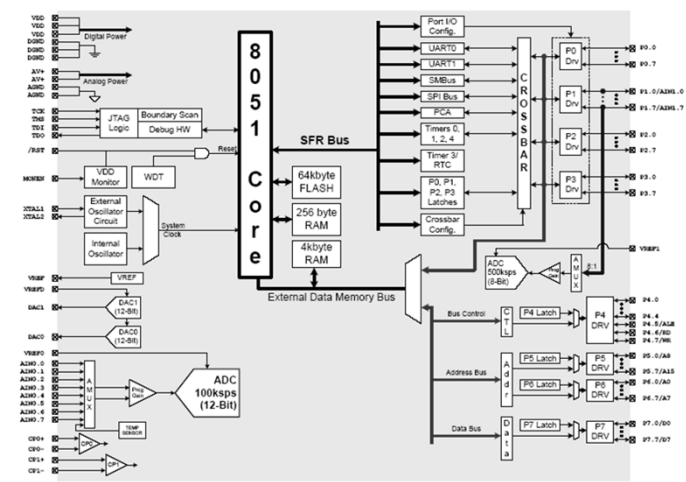
Microprocessor

- A computer processor
 - on a microchip
 - that contains units (CPU, MMU, ...)
 - that handle and process computer instructions
 - Microcontroller: and input and output signals
- Marcian “Ted” Hoff, '58
 - Father of the Microprocessor (earned his BEE at RPI)
 - Developed architecture for single-chip CPU at Intel (1968)

Microcontrollers

- Features:
 - Lots of peripherals integrated in
 - communication
 - I/O (including A/D)
 - timers
 - counters
- Low end arithmetic capabilities
- Low end memory bus interfaces
- Low cost
- A microcontroller is a microprocessor with a lot of stuff integrated into the package
- We will use a SiLabs C8051F020 microcontroller

Microcontrollers (C8051F020 manual pg. 18)



The Development Process

Software	Hardware
Specification Development	
	Selection of Processor
	Hardware Design of Target System
Pseudo Code	
Actual Code	
Compile	
Download	
Test on Evaluation Board	
	Prototype Target System
Port to Target System	
Test Combined System	
Document	

System Development

These recommendation have consistently proved to be the quickest, most efficient way to develop working hardware and software

- Build a simple circuit for a **single** device (LED or buzzer or ...) and manually test device in hardware
- Start with a recommended C code template file
- Modify the code to initialize required 8051 ports for device
- Develop a function to test the single device & call it in the main routine
- Compile, build, correct software errors then download, execute on hardware and troubleshoot
- When everything works properly repeat entire process on a 2nd device
- Keep all test functions for use later if anything stops working

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C Essentials – LMS

- This course requires programming in C
 - "LITEC C"
 - Any existing programming background should be OK
- The manual provides details regarding the specific programming features introduced in this course
 - Relevant to this course
 - Use the reference chapters for help with programming structure, syntax, etc.
 - This material is fair game for quizzes/exams
- C programming texts:
 - May also provide help on more complicated issues
 - LITEC C does not need pointers (you can, if you want to)

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Number Systems

- We will begin the topic of programming skills by introducing *Number Systems*
- *Number Systems we use in LITEC:*
 - decimal (base 10)
 - binary (base 2)
 - hexadecimal (base 16)
- Should be a review of mathematical concepts

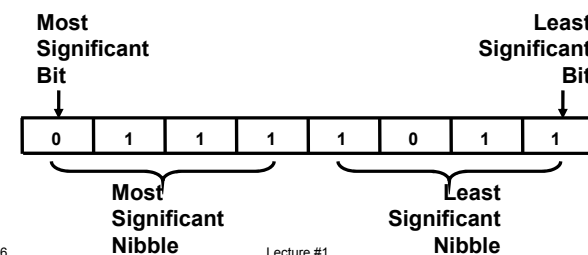
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Number Systems

- Why use different number systems?
 - A number to us: 123
 - This same number to a computer: 01111011
 - Need to convert values between these systems



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Converting: Binary to Decimal

128	64	32	16	8	4	2	1
2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰

0	1	1	1	1	0	1	1
---	---	---	---	---	---	---	---

0(128) + 1(64) + 1(32) + 1(16) + 1(8) + 0(4) + 1(2) + 1(1) = 123

Converting: Decimal to Binary

0	1	1	1	1	0	1	1
---	---	---	---	---	---	---	---

123

÷ 2

61 rem 1

÷ 2

30 rem 1

÷ 2

15 rem 0

÷ 2

7 rem 1

÷ 2

3 rem 1

÷ 2

1 rem 1

÷ 2

0 rem 1

When the answer is '0', fill the rest of the byte with leading zeros

Hexadecimal (“hex”)

- Hexadecimal is more convenient than binary
- Conversion between decimal and hexadecimal:
 - similar to binary: use powers of 16 instead of 2
 - Need 16 different digits
- Hexadecimal digits run 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F
- Example:
 - 123 in hex is 0x7B (the “0x” is used to indicate hex)

Converting: Decimal & Hexadecimal

123

÷ 16

7 rem 11 (use B)

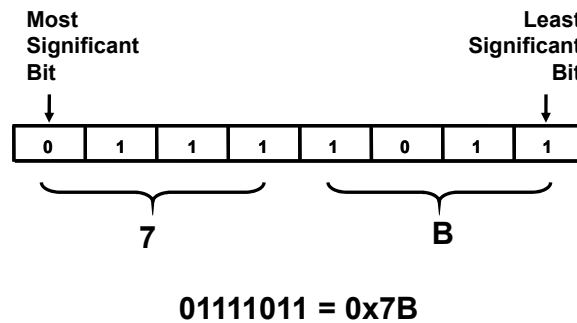
÷ 16

0 rem 7

0x7B

0x7B = 7(16¹) + 11(16⁰)
= 112 + 11 = 123

Converting: Binary to Hexadecimal



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Conversion Table

Binary	Decimal	Hex
0000	0	0x0
0001	1	0x1
0010	2	0x2
0011	3	0x3
0100	4	0x4
0101	5	0x5
0110	6	0x6
0111	7	0x7
1000	8	0x8
1001	9	0x9
1010	10	0xA
1011	11	0xB
1100	12	0xC
1101	13	0xD
1110	14	0xE
1111	15	0xF

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Number System Worksheet

- Use worksheet
 - To test your knowledge of number systems
 - Practice converting between systems
 - Save the worksheet and put it in your lab notebook when you get one.
- Number System Essentials handout
 - Available on LMS: Course Resources>>Tutorials
 - Read it
- Answers will be given at beginning of next class

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Homework

- Homework #1 Due at beginning of next class
 - Create project for code and execute it on EVB
 - Submit electronic copies of modified .c file (optional, to check LMS submission process)
 - Must come to LITEC studio on Wed pm for help
- Assignment:
 - Use SiLabs editor to copy or type in example program
 - Read Chapter 2 of the Lab Manual
 - If you use a word processor – save as text only.

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Remaining Time for Homework

- Use your laptop
- Load SiLabs program if you have not done so
 - Installation instructions in the handout
 - BB LMS under Course Resources
- Run IDE program or any other text editor to type in code
 - Beware of “gremlins” !!!
- To connect, you will also need to download drivers for the serial to USB adapter. If not found automatically, on LMS:
[Course Resources>>Software&Drivers>>PL2303 Prolific DriverInstaller vn.n](#)
 - Windows 7 users: just connect the adapter to your computer, the ***found new hardware*** window will appear. Allow it to search the web. It might take 10 seconds or 5 minutes, but it will find the driver.
 - Windows 8 & up users must use all-black or grey adapters (not 2-piece with blue connectors)