Microcontrollers Lab

Microcontroller Topics

- 1. Build the microcontroller circuit and program the microcontroller with the blink program.
- 2. Add the clock crystal and serial communication to the microcontroller circuit.
- 3. A/D with and without interrupts.
- 4. SPI bus communication and implement D/A converter.
- 5. Motor Control
- 6. Counters, timers, and interrupts (Servo control and PWM motor control)
- 7. Encoder Interfacing
- 8. Xmega Processors
- 9. Closed Loop Digital Motor Control (2 weeks)
- 10. Controller Design for a Hard Drive System (traditional and State Space) includes formal Report. (3 weeks)

Your grade will be based on your weekly assignments, and formal report.

Course Website Location: <u>www.me.pdx.edu/~davet/ME_460_Microcontrollers/Index.htm</u>

Lecture Videos: Type the following address in your browser: https://media.pdx.edu/channel/ME_460_Microcontrollers_Lab/89852392

Reference Books

The C Programming Language, Brian Kernighan and Dennis Ritchie, Prentice Hall (Good C Language reference)

Essential C <u>http://cslibrary.stanford.edu/101/EssentialC.pdf</u> (Good free C introduction)

Embedded C Programming and the Atmel AVR, Barnett, Cox and O'Cull, Thomson (Best AVR programming book, but it is very expensive)

Lab Rules

- DO NOT remove any equipment or materials from the lab
- Get to the Lab Lecture on time Important information concerning your safety, the safety of the equipment and information about the current lab will be discussed. DO NOT attempt to do the lab if you miss the lab lecture.
- Respect the Equipment. Many devices are destroyed if you apply to large a voltage or the incorrect polarity. Before you make any connections to a device make sure all of the power is off and double check your connections before you turn the power on. All of the pertinent information about how equipment should be used is discussed in the lab lecture.
- You will have keycard access to the lab afterhours. Under no circumstances should you ever let anyone into the lab that does not have card key access. Also never prop the door open.
- Work individually. You certainly may discuss the lab with the other people in the class but be certain that you complete each lab individually and completely understand what you did and the reasons for doing it for each lab. Note below that there is a final exam at the end of the term on the lab material. Any work that is handed must be individual work.
- When finished working.
 - Turn off all equipment
 - Completely unhook your breadboard from all equipment and move it out of the way
 - Clean up your area: Remove all loose parts and neatly stow the wires and cables
- When finished using shared equipment or tools return the equipment or tools to the common area.

Lab Tips

- Use red wire for positive voltage (i.e. +15v), use black wire for the ground and use green wire for negative voltage (i.e. -15v)
- Keep the wiring as neat as possible. Run the traces horizontally and vertically whenever possible. A neat wiring job will make it much easier to troubleshoot when things don't work properly. One minute spent laying out the circuit neatly will save 30 minutes troubleshooting. Many students have tested this theory but none have proved it wrong.

Lab Format

Each Monday, during the regular lab time, I will present the lab lecture for the week. Following the lecture you will present your lab demonstrations for the lab from the previous week. For the remaining portion of the Monday lab I will be in the lab to help you get started on the lab. There is no formal lecture on Wednesday during the regular lab time. The time can be used to work on the lab. I will be available in the lab or in my office if you have questions.

Grading

Your grade will be based on your weekly assignments and your formal report.

Microcontrollers Lab Required Prerequisites:

- ME 452/552 Introduction to Controls
- ME 453/553 Advanced Controls and Digital Controls
- ME454/554 Controls Lab (Concurrent Enrolment)

Lab Presentations

The lab presentations each week should be treated as a regular formal presentation not an informal presentation. In other words, have all of your information organized (in one file) and ready to present in an efficient manner. Your presentation should include background information about what you did and why you did and any conclusions or discrepancies you found. It should include all the required plots and comparisons that you were asked to find. If there is a section of the lab that does not require a plot or something to show in the end show screen shots of what you did and summarize the information in a table if applicable.

Lab Presentation Late Policy:

5% deduction per day late (in increments of 5%)

Equipment that needs to be purchased:

For some of the smaller items you could coordinate your orders with other students to save on shipping. I would recommend you get the items that I suggest, and don't make substitutions, to make sure you will have everything you need for the labs. If you do make a substitution make sure what you are getting is equivalent. You will need almost everything for the first lab (Monday March 28), except where noted. So get things ordered soon.

- 1. All of the equipment for the Controls lab (see Controls Lab Equipment). Get a minimum of two of the large breadboards.
- It turns out the programmer we usually use (ATAVRISP2) is no longer made by ATMEL. They currently
 make the ATMEL ATATMEL-ICE-BASIC DEBUGGER / PROGRAMMER but it is quite expensive (\$100).
 Fortunately, I found another company that is selling a compatible original programmer (ATAVRISP2) for a
 good price.
 - (I can loan one of these this term if you don't want to purchase one)

https://www.amazon.com/AVRISP-System-Programmer-Supports-

Studio/dp/B09P499PTC/ref=dp_prsubs_sccl_1/147-6633130-4258925?pd_rd_w=BrUsj&contentid=amzn1.sym.3ad0ccdf-fd9f-4ec9-a400-2b1165fdcd58&pf_rd_p=3ad0ccdf-fd9f-4ec9-a400-2b1165fdcd58&pf_rd_r=7KETZB5QXVPWJPBY8QGG&pd_rd_wg=P0PRb&pd_rd_r=a347300f-83b2-4032-9301-76ec9b13f126&pd_rd_i=B09P499PTC&psc=1

- 3. Breadboard Adaptor for Atmel Programmer <u>https://www.adafruit.com/product/1465</u>
- 4. ATMEL ATMEGA88PA Microcontroller I would get at least 4 of these in case you fry one or two. <u>http://www.digikey.com/product-detail/en/ATMEGA88A-PU/ATMEGA88A-PU-ND/2271010</u>
- 5. Serial to USB adaptor (FTDI TTL-232R-5V)

(I can loan one of these this term if you don't want to purchase one)

https://www.digikey.com/product-detail/en/catalyst-semiconductor-inc-va/TTL-232R-5V/768-1028-ND/2003493

or

https://www.mouser.com/ProductDetail/FTDI/TTL-232R-5V?qs=OMDV80DKjRorBEBwmlJ4Pg%3D%3D

or

https://www.amazon.com/dp/B08BNDLQSZ/ref=sspa_dk_detail_1?pd_rd_i=B08BNDLQSZ&pd_rd_w =2hy4m&content-id=amzn1.sym.08ba9b95-1385-44b0-b652-c46acdff309c&pf_rd_p=08ba9b95-1385-44b0-b652-

c46acdff309c&pf_rd_r=AGV4T01W4E7304PTEQC3&pd_rd_wg=87JKS&pd_rd_r=472390bc-e635-479d-b0f2-

a9757ff313ee&s=industrial&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWxfdGhlbWF0aWM&th=1

AVR ATxmega Development Module with ATxmega128A1U (You will need this about the fourth week of class but it takes a week or so to get it so order it early. The company is in Germany). (These don't seem to be available so I will figure something out)



 $\label{eq:http://www.alvidi.de/shop/product_info.php?info=p18_AVR-ATxmega-Development-Module-with-ATxmega128A1U.html$

7. Digital to Analog Converter (DAC) (get at least 2)

https://www.digikey.com/product-detail/en/microchip-technology/MCP4921-E%2FP/MCP4921-E%2FP-ND/716280?utm_adgroup=Integrated%20Circuits&slid=&gclid=EAIaIQobChMIxvGM4YCQ2wIVB8Rk Ch0UZwsQEAAYASAAEgIljvD_BwE

8. Diode (600V, 5 amp) (get 2)

https://www.digikey.com/product-detail/en/STTH5L06RL/497-5231-1-ND/1121684

9. Crystal Oscillator (16 MHz)

https://www.digikey.com/product-detail/en/ecs-inc/ECS-160-20-4X/X1103-ND/827594

10. LED's (2 of each)

https://www.digikey.com/products/en?mpart=SLR-56VR3F&v=846 https://www.digikey.com/products/en?mpart=SLR-56YY3F&v=846 https://www.digikey.com/products/en?mpart=SLR-56MG3F&v=846

11. Additional (higher capacitance) Capacitors (Get 6 of the 1uf and 2 of the 4.7uf)

(Don't need these this term because the capacitor kit has them)

1uf

https://www.digikey.com/product-detail/en/kemet/C440C105M5U5TA7200/399-4521-1-ND/818378 or

https://www.amazon.com/mxuteuk-Multilayer-Monolithic-Ceramic-Capacitor/dp/B08BF91KY3/ref=sr_1_5?crid=2AO4NXZAKAOV3&dchild=1&keywords=capacitor+1u f&qid=1615836598&sprefix=capacitor+1uf%2Caps%2C229&sr=8-5

4.7uf

https://www.digikey.com/en/products/detail/tdk-corporation/FG26X7R1H475KRT06/5812047 or

https://www.amazon.com/mxuteuk-Multilayer-Monolithic-Capacitor-4-7uf-475/dp/B08BFQ9Z53/ref=sr_1_20?crid=214ANOF42TBRP&dchild=1&keywords=4.7uf+capacitor+50 v&qid=1615844450&sprefix=4.7uf+capacitor%2Caps%2C242&sr=8-20

- 12. Op Amps (get 10-20) Number depends on how many you plan to burn up.
 (I will provide these this term) https://www.digikey.com/product-detail/en/texas-instruments/LM348N/296-12849-5-ND/476163
- H-Bridge (get 2) We only need one but these are easily destroyed so I recommend getting two https://www.digikey.com/product-detail/en/texas-instruments/SN754410NE/296-9911-5-ND/380180

or

https://www.bananarobotics.com/shop/SN754410-Quad-Half-H-Bridge-1A-Motor-Driver-IC?gclid=Cj0KCQjwz7uRBhDRARIsAFqjullmWNrKxk65VgmoDGZBzF7ReYsTrH9Ns8Wweu1ccyw m9111ULjyPwcaArJfEALw_wcB

or

https://www.amazon.com/INSTRUMENTS-SN754410NE-PERIPHERAL-DRIVER-HALF-H/dp/B00DK8A2YS

14. RC - Servo (need 1)

(I can loan one of these this term if you don't want to purchase one)

https://www.amazon.com/Micro-Servos-Helicopter-Airplane-Controls/dp/B07MLR1498/ref=sr_1_4?crid=32NK9A4DHRAW8&dib=eyJ2IjoiMSJ9.qIzKFwPlhRT5n QwQ8qBaoZXUAIoJRoDTVes1qBDXk_AbgAcd5mw62UWYgc47r9NW1JeKxmWmjLao52i74DvkN0V0vqLNYDHTass9pRP4pb0KL_lprKgNX5igM7YugmWp5Wa1UIr6YbKSm5z5-OMwEC0ETIRYaU4S2gSsOnwzNhQLv7DZAixCxssHNoyH_TG0L5YW3ZApqi8Sw3BH-I9SdUYmN6vAeJL1N_br8ANj5HMo8FnUySMSwwvL484P5tlU0ON5xO8WCXKbEHydwVUTkAs2c hwLgGHoaiO4OaNSA.JWkMnLqXzSAx2Lu0aVWODPYVPmSyKDbfh-FEDMWRRG8&dib_tag=se&keywords=remote%2Bcontrol%2Bservo&qid=1710271591&s=toys-andgames&sprefix=remote%2Bcontrol%2Bservo%2Ctoys-and-games%2C136&sr=1-4&th=1

15. Small 12 volt DC motor

(I can loan one of these this term if you don't want to purchase one)

https://www.amazon.com/AUTOTOOLHOME-Torque-Traxxas-Wheels-Electric/dp/B01M58POHF/ref=sr_1_13?dchild=1&keywords=small+motor&qid=1618511536&sr=8-13

A lot of the items are available at Digikey so you might want to coordinate ordering those items from Digikey to save on shipping.