EE375: COMPUTER ARCHITECTURE WITH MICROCONTROLLERS

PROJECT 5: Arduino (Microcontroller-based Platform) GPS project

Research Questions Due **Lesson 32** for 15 Points
Part A Due **Lesson 35** for 35 Points
Part B Due **Lesson 39** for 50 Points

Learning Objective: Design, build, and test an Arduino-based GPS.

Write the code required to integrate an Arduino Uno Microcontroller, an ITEAD Studio GPS Shield v1.1, and a DFRobot LCD/keypad shield v1.0 to create your own GPS navigation device. You have three submissions which include two in-class demonstrations.

You are provided the hardware, links to selected reference documents, and a shell software solution. The shell solution contains code that provides a menu structure for the project and some initialization functions. Your complete solution will need to add code and functions to the shell to:

1. Initialize components,
2. Sample the GPS device, and
3. Perform data conversion to/from the display format (strings).

You will need to install the DFR_Key_v2 and TinyGPS12 libraries available in the project 5 resources folder (see Appx B for the URL). You may wish to verify degree headings between points on the http://www.movable-type.co.uk/scripts/latlong.html website.

Return (Paper copies must be submitted to your instructor and electronic copies must be saved to your electronic turn-in folder in at least one partner's P5 subfolder NLT the start of your class period or the designated time as listed above):

- Design Document *(for parts A and B)*
- Test Plan *(part B only)*
- User Manual *(part B only)*
- *Electronic submission* of your **P5*_LastName1LastName2*.ino** file *(for parts A and B)*
- *Demonstration* of your GPS device as per the Part A and Part B specifications.
- Documentation as per course policy; ***annotate number of hours worked and overall percent contribution for each partner individually next to his/her name on your joint cover sheet.***

Submission Requirements:

1. **Research Questions (15 points):** Due Lesson 32 at the start of your class hour.
   a. Using the provided references and other reputable sources, research and answer the questions in Appendix B. Your goal is not to simply get answers, but to understand and exercise the process of building a device with a microcontroller and peripherals. **This work is limited to your formal group.** You are only authorized to seek outside assistance for help in locating/identifying a source, not the information from that source. You may **NOT** reference other students for answers to the questions.
   b. Submit a document that contains the answers to the questions. For each answer, indicate the source from which you determined the answer (your sources cannot be other students, see above). Because of the nature of the assignment, **you do not need**

to use footnotes but you do need to follow CSE citation-name style documentation as per course policy. If you are unclear on how to document, you may use http://writing.wisc.edu/Handbook/DocCSE_CitationSystems.html as a reference.

2. **Part A (35 points):** Due Lesson 35 at the start of your class hour.
   a. During Lesson 35, your team will demonstrate a working system for receiving and displaying a GPS location. This requires initialization, sampling, and conversion to a display string. **Do this within the provided shell via the first screen of the Navigate menu option.** Do not change the shell; add your code to the sections highlighted by the ALL CAPS comments. The GPS provides decimal degree floats for latitude and longitude. Change these to display arrays in the form ***±ddd°mm'ss.s*** where ***d*** is integer degrees, ***m*** is integer minutes, and ***s*** is decimal seconds.
   b. Submit a flowchart or pseudocode design document that illustrates the desired operation of your conversion function. Include enough detail for this design to be implementable without further refinement of procedurally abstracted steps. It should be clear to the reader of the document how the software operates.
   c. Submit your solution code both in hardcopy and electronically.

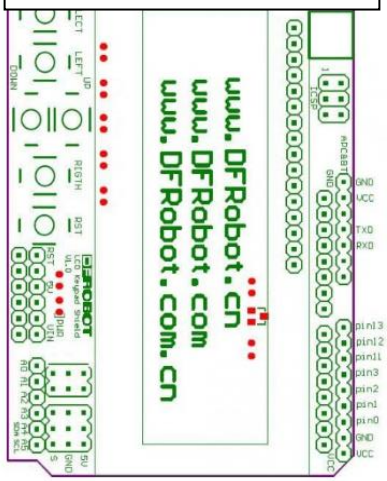
3. **Part B (50 points):** Due Lesson 39 at the start of your class hour.
   a. During Lesson 39, demonstrate that your device can successfully load target coordinates and provide accurate feedback to the user for navigating to a target location. Your instructor will give you coordinates (e.g. 41° 23' 30.0", -73° 57' 22.4") and verify your device provides feedback for navigating to the specified location. Points will be awarded for successfully loading destination coordinates via the LCD shield, demonstrating that the device displays direction and distance to a destination location, and for successfully locating destination locations. You will not be allowed to have any other navigation devices on your person during the project demo.
   b. Submit a revised and updated version of your design document. Include your second conversion function and discuss any major design changes that occurred during the course of your work. In other words, what did you modify in your design in response to a problem you encountered and why? You must discuss at least one item that changed.
   c. Submit a test plan with specified test cases, the conditions of each test, and expected and actual results with analysis of your results. Pictures are a great way to capture your test setup. However, pictures are not required. Your goal is to enable a reader to replicate your test setup and duplicate your test results. Include enough detail to achieve that goal.
   d. Submit a User Manual that provides a detailed explanation of how to use your GPS device and **may be understood by non-engineering majors**.

Appendix A: Overview of Hardware Schematics for EE375 Project 5

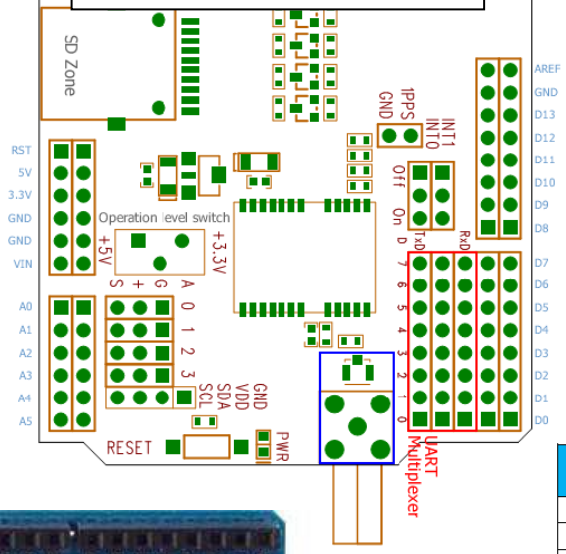
Appendix B: Research Questions for EE375 Project 5

Appendix A – Overview of Hardware Schematics for EE375 Project 5

DFRobot LCD/Keypad Pinout



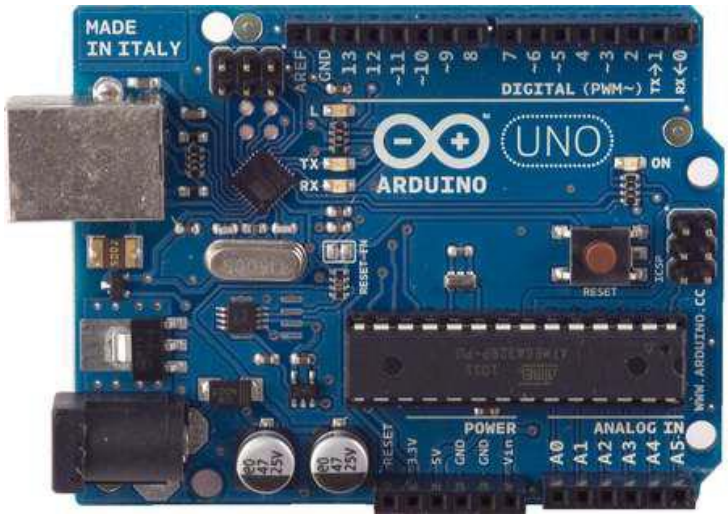
DFRobot LCD/Keypad Schematic



DFRobot LCD/Keypad Pinout

Analog 0	Button (select, up, right, down and left)
Digital 4	DB4
Digital 5	DB5
Digital 6	DB6
Digital 7	DB7
Digital 8	RS (Data or Signal Display Selection)
Digital 9	Enable
Digital 10	Backlit Control

http://arduiniana.org



Arduino PIN	Description
D0	Data
D1	Din
D2	-
D3	-
D4	-
D5	-
D6	-
D7	-
D8	-
D9	-
D10	CSN
D11	MOSI
D12	MISO
D13	SCK
A0	Breakout
A1	Breakout
A2	Breakout
A3	Breakout
A4	IIC_SDA
A5	IIC_SCL

ITEAD Studio GPS Shield Pinout

Appendix B – Research Questions for EE375 Project 5

References: This is not an all inclusive list. You may need to find some answers in sources not listed below.

a. **Cadet project reference folder (\\usmasvddeecs\eecs\Cadet\Courses\EE\EE375\152_Files\P5_Resources) *Many documents***
b. http://www.dfrobot.com/wiki/index.php/Arduino_LCD_KeyPad_Shield_(SKU:_DFR0009)
c. Arduino forum (http://forum.arduino.cc/index.php)
d. IsteadStudio webpage (http://imall.iteadstudio.com/im120417017.html)

Questions:

1. How much Flash memory does the Arduino Uno R3 have on chip? How much can the programmer use?
2. What is the operating voltage of the Arduino Uno? What is the input voltage range for proper operation?
3. What is the clock frequency of the Arduino Uno? What is the clock period?
4. Which pins are designated for Arduino USART RX/TX?
5. What is the DC output current rating of the Arduino Uno R3 I/O pins?
6. How does the DFRobot LCD/Keypad shield communicate which button is pressed? In other words, how would the Arduino Uno interpret the shield's output to determine the button pressed?
7. How many control lines does the DFRobot LCD/Keypad shield use to control the LCD display? To which Arduino Uno pins do these correlate?
8. How many characters are displayable at a time on the LCD?
9. What function from the *LiquidCrystal* library writes to the LCD display? What is the data type of the argument provided to the function?
10. In the *LiquidCrystal* library, how do you control the position of the cursor on the LCD?
11. How can you control the sampling rate of the buttons on the keypad shield? *(Thought question)* With what frequency should you sample the buttons?
12. What BAUD rate does the GPS shield use when communicating with other devices using RS232? (*Hint:* the SIRF III datasheet isn't the value to use & most references in forums use an incorrect value as well; the default BAUD rate for situations where speed is not critical works well). Assuming an 80 Byte message is delivered to your Arduino at this BAUD rate, how much time will it take to receive the entire message?
13. What is the maximum output frequency (for location messages) of the GPS shield? *(Thought question)* How often do you need to sample the GPS shield for your application?
14. How do you configure the USART (RS232) pins on the GPS shield (in the UART Multiplexor section) to interface with the Arduino? Discuss/diagram how your jumpers need to be configured.
15. For what voltage should you configure the GPS shield board selector switch?
16. Using the *TinyGPS* library, what is the format of the data the the function *f_get_position( )* returns? (i.e., how is that return value interpreted to determine your location?)
17. *(Thought Question)* Assume that it takes 8 ms to update your LCD display, 300 ns to read and interpret a key press, the time to receive a GPS location message is 90 ms, and your code execution overhead requires 100 us. If each of these processes run in a loop sequentially, what is the maximum frequency of this loop? Would this frequency cause any issues with the frequency needed by the overall system? (i.e., will your system work correctly at this rate?)