Independent Study Plan - Microcontrollers

Introduction

This is just a simple draft of what I plan to do next semester. This is all subject to change and serves as a basic guide to keep me on track.

Method

The ideal progression of a week from start to finish will hopefully resemble the following:

1. Conduct a reading of the planned material.

   (a) Take notes on the planned readings.

   (b) Convert notes into Anki Flashcards.

2. Begin lab exercises or open ended project.

3. Refer back to material or online sources for help, if needed.

   (a) Make notes of specific solutions.

   (b) Convert this insight to Anki Flashcards.

4. Finish lab exercises or open ended project.

5. Quick report + document week for website.

Topics

1. Foundational Skills

   (a) Computer Architecture

      i. Review of Computer Architecture

      ii. AVR Assembly

      iii. ARM Assembly?

(b) Advanced C Programming Topics

    i. Pointers

    ii. Memory Management

    iii. Threads, management and synchronization

(c) Optimization

    i. Optimizing programs for low power applications

    ii. Optimizing programs for speed

2. Advanced Peripherals

(a) Motor Controllers

(b) Wi-Fi and RF Controllers

(c) Bluetooth Low Energy (BLE)

(d) USB interfaces

3. Real Time Operating Systems (RTOS)

(a) Scheduling & management

(b) Inner-workings

(c) I honestly know so little about how these work I will have to do more research.

Just reaching even one or two of these topics next semester would be make this a net positive for me.

Books

1. J. L. Hennessy, D.A. Patterson. *Computer Architecture: A Quantitative Approach. 5th Edition.*

2. D.M. Harris, S.L Harris. *Digital Design and Computer Architecture. 2nd Edition.*

3. E. White. *Making Embedded Systems. 1st Edition.*

4. A. Tannebaum. *Modern Operating Systems. 4th Edition.*

5. D. Butenhof. *Programming with POSIX Threads. 1st Edition.*

6. A. Kelley, I. Pohl. *A Book on C. 4th Edition.*

7. E.A. Lee, S.A. Seshia. *Introduction to Embedded Systems: A Cyber-Physical Systems Approach. 2nd Edition.*

8. J. Cooling. *Real-Time Operating Systems: Book 1 - The Theory*

9. J. Cooling. *Real-Time Operating Systems: Book 2 - The Practice*

Links

- AVR Instruction Set Manual

- The Architecture of Open Source Applications

- JPL Institutional Coding Standard for the C Programming Language

- Patterns in C

- AVR Libc Reference Manual

Schedule

Here is a short schedule I came up with for the semester. This is just a rough schedule and I expect that I will veer from it in many different ways. I purposely gave this a good amount of structure in the beginning of the semester so I get in the habit of actually doing the work before making it more open ended.

Week 1, 1/7/19 - 1/13/19:

- Topic: Computer Architecture

- Reading:

    - Hennessy and Patterson, Ch. 2: Instruction Level Parallelism

- – Hennessy and Patterson, Ch. 3: Limits on Instruction Level Parallelism

- – Harris, Ch. 6: Architecture

- – Harris, Ch. 7: Microarchitecture

- Lab Exercises: Assembly Basics: Setup and Blinking LEDs

Week 2, 1/14/19 - 1/20/19:

- Topic: Computer Architecture Cont.

- Reading:

  - – Hennessy and Patterson, Ch. 4: Multiprocessors and Thread-Level Parallelism

  - – Hennessy and Patterson, Ch. 5: Memory Hierarchy Design

  - – Harris, Ch. 8: Memory and I/O Systems

  - – Atmel AVR Instruction Set Manual

  - – Other Misc. Articles

- Lab Exercises: Assembly Basics: Registers and Port Operations

Week 3 (Week 1 of Semester), 1/21/19 - 1/27/19:

- Topic: C Programming Review

- Reading:

  - – Kelley and Pohl, Ch. 1: An Overview of C

  - – Kelley and Pohl, Ch. 2: Lexical Elements, Operators, and the C Systems

  - – Kelley and Pohl, Ch. 3: The Fundamental Data Types

  - – White, Ch. 2: Creating a System Architecture

- Lab Exercises: Recreate ECE 3411 program in assembly

Week 4 (Week 2 of Semester), 1/28/19 - 2/3/19:

- Topic: C Programming Cont.

- Reading:

  - Kelley and Pohl, Ch. 4: Flow of Control

  - Kelley and Pohl, Ch. 5: Functions

  - Kelley and Pohl, Ch. 6: Arrays, Pointers and Strings

  - White, Ch. 3: Getting the Code Working

  - Other Misc. Articles

  - TBD

- Lab Exercises: Make files and using gdb

Week 5 (Week 3 of Semester), 2/4/19 - 2/10/19:

- Topic: C Programming Cont.

- Reading:

  - Kelley and Pohl, Ch. 7: Bitwise Operators and Enumeration Types

  - Kelley and Pohl, Ch. 8: The Preprocessor

  - Kelley and Pohl, Ch. 9: Structures and Unions

  - White, Ch. 5: Task Management

  - TBD

- Lab Exercises: Make files and using gdb continued

Week 6 (Week 4 of Semester), 2/11/19 - 2/17/19:

- Topic: Basic Operating System Principles

- Reading:

  - Tannebaum, Ch. 2: Processes and Threads

  - Tannebaum, Ch. 3: Memory Management

  - Sauermann and Thelen, Ch. 2: Concepts

- Sauermann and Thelen, Ch. 3: Kernel Implementation

- Lab Exercises: Implement basic tasks on Atmega328p with FreeRTOS

Week 7 - Week 10 (Week 5 - 8 of Semester), 2/18/19 - 3/17/19:

- Topic: Real Time Operating Systems

- Reading:

  - Cooling, Book 1

  - Cooling, Book 2

  - TBD

- Lab Exercises: FreeRTOS on AVR and ARM

Week 11 - Week 14 (Week 9 - 12 of Semester), 3/18/19 - 4/17/19:

- Topic: Bluetooth Low Energy (BLE) & Misc. Topics

- Reading: TBD

- Lab Exercises: TBD

At this point in the semester I suspect that I will be busy wrapping up my Senior Design project, working on completing the car for Formula SAE or involved with a side project from previous weeks. It doesn't make much sense to add much more because I probably won't get to it all.