[1]Developing Software for Microcontrollers

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Abstract

This project is the development of a data acquisition device, based on the XMOS startKIT microcontroller, capable of reading and saving analog values at a high rate. The project development consisted of two phases; for use by the Carthage College RockSat-C team in an experiment which is looking at the effect of electromagnetic radiation emitted from lightning on the atmosphere, and a means for large bodies of data created during a test to be observable during the test. The project is based on code developed by; M. Hernandez, T. Shannon as part of 2015 – 2016 Carthage College RockSat-X team.

Introduction

RockSat mission. The objective of the RockSat-C experiment was to observe very low frequency (VLF) electromagnetic (EM) waves that come from natural lightning discharges as a function of altitude. The experiment, shown in (Fig. 1), was designed to receive and store electric and magnetic field data from antennas as well as data from a magnetometer/compass. The Carthage College RockSat-C team expected to see 60Hz interference, mostly from power lines, as well as various structures corresponding to lightning discharges.

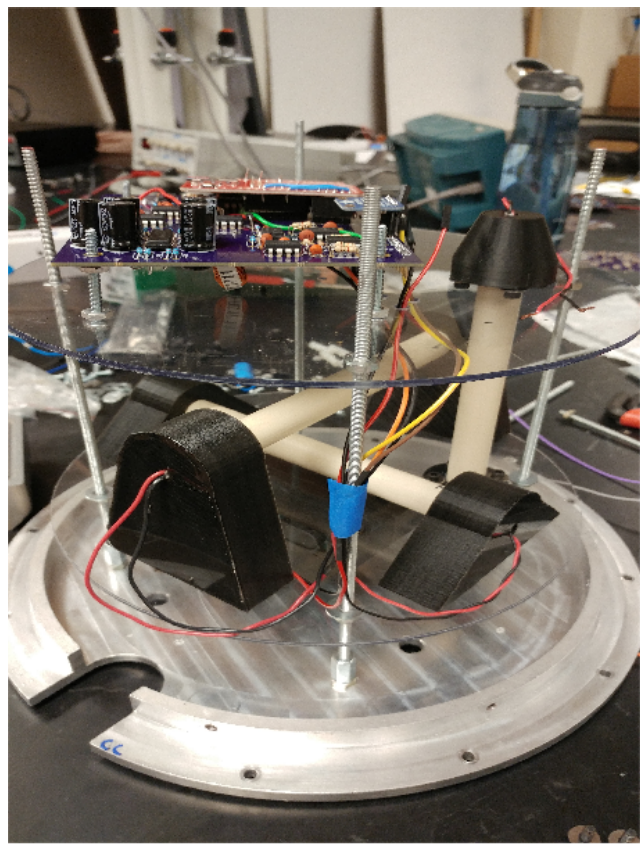

Figure 1, This is a picture of the assembled experiment without the outer metal casing.

The comprehensive success criteria were to take measurements of the magnetic and electrical fields produced from lightning discharges and carried by electromagnetic waves in the very low frequency, or VLF, spectrum (3-30kHz). For data to be useful the antenna had to be sampled at a rate of around 100kHz. This meant that the digital electronics had to be able to read an analog to digital converter, then store the resulting value in a long-term storage device at least 10^5 times a second.

[1]I would like to thank the Wisconsin Space Grant Consortium for funding my research.

Observable test data. The objective of this portion of the project was to make testing programs with the XMOS startKIT, shown in (Fig. 2), easier. To do this I wanted the large quantities of data created as part of texts to be visible during the test. Without this any data created during tests of the RockSat code would require data to be saved to a micro-SD which would have to be transferred to a computer and run through external programs to become visible. In order to ensure the microcontroller was handling the data correctly, every set of tests on the program used for the RockSat mission had to be examined. The goal was then to shorten the time necessary to examine data by having it visible during testing.

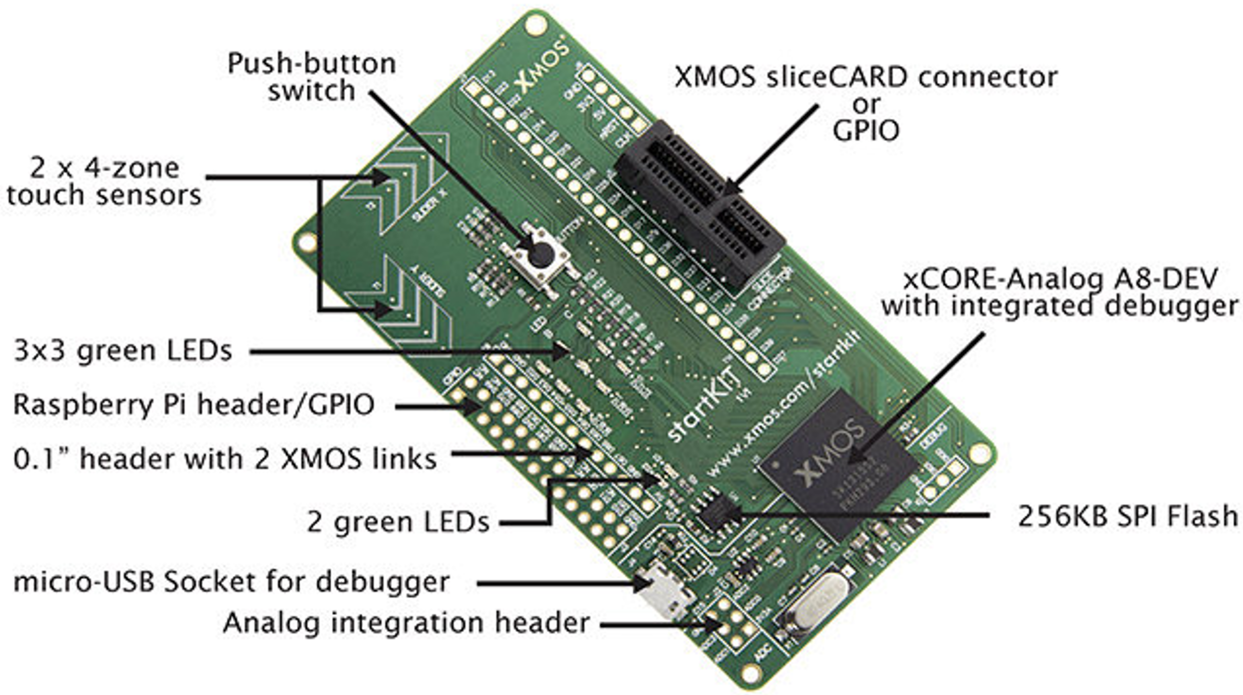

Figure 2. XMOS startKIT (Toeh, 2015).

Materials and Methods

Development for both the RockSat mission and observable test data followed mostly the same format. I began by searching for any preexisting material that could add me in my development. This would include things like preexisting program libraries I could import and use to fulfill some part of the design or examples of similar programs I could reference to see what my program should do. From there, I would attempt to get one part of my program working at a time. When using libraries, I would create a separate test program to learn how to use the library before attempting to integrate it into my main program. As I worked on my program I often encountered errors which I would have to address before moving on. These errors were often the result of my own inexperience with the XC programing language. The language was created specifically for use with devices, like the startKIT, that use XMOS XCore processor architecture. I continued building one part of the program after the other until I reached a near finished piece

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at which point I had to put all the parts of the program together and see if it worked. When I got errors, I had to modify the program to get rid of them.

Key Results

RockSat mission. The final program developed for the RockSat team was able to sample collect data at the desired rate from four built in ADCs and save the data to a micro-SD card. The program did this while also communicating with a magnetometer, shown in (Fig. 3), over I^2C. I^2C is a two-wire communication protocol used to transfer information between devices. The magnetometer provided the direction of the earth's magnetic field relative to the device, an example of this is shown in (Fig. 4), which helped to provide the experiments orientation at a given point in time. This information was collected at a rate of around 75hz and saved in the same files the ADC values were in. This was done in a way that did not slow data collection down. As such, the program was able to collect ADC values from antennas as well as directional information and save both to a micro-SD card.

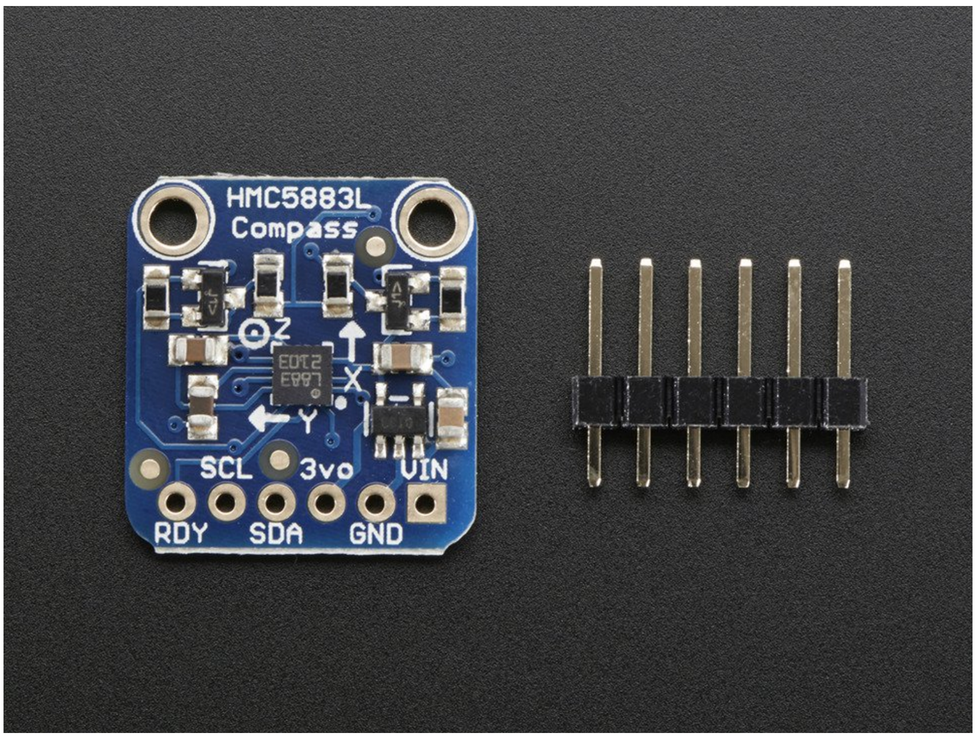

Figure 3. Magnetometer. (www.adafruit.com/product//1733).

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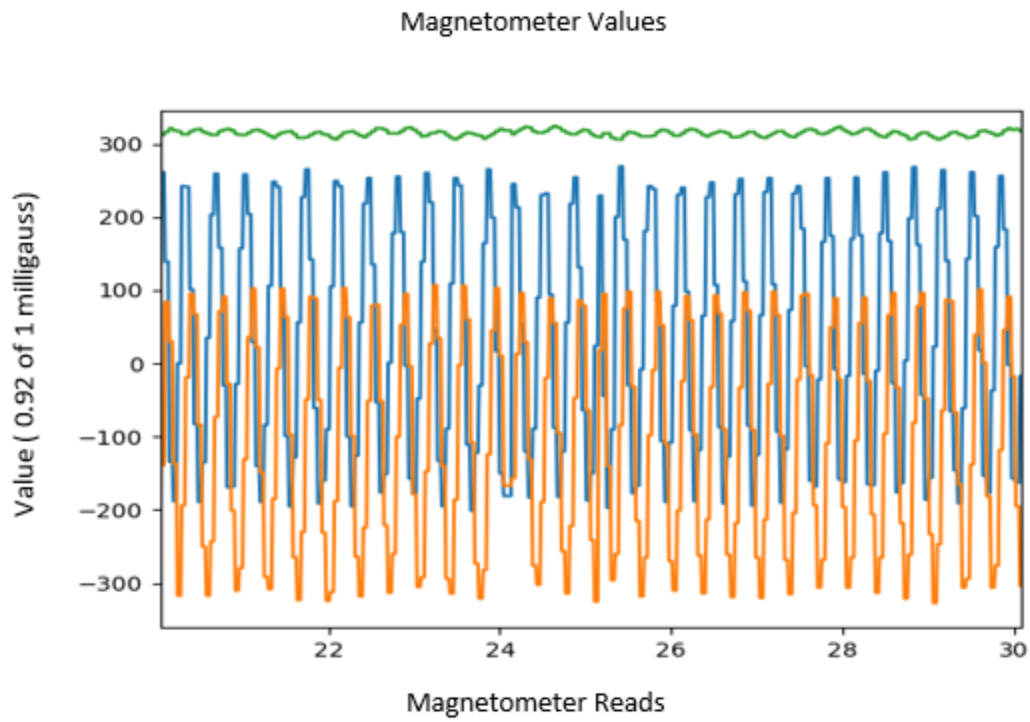

Figure 4, The orange line represents values from the x axis, the blue from the y, and green the z.

Observable test data. The effort to allow data from the program to be visible while the program was running ultimately failed. While I was able to display information during operations by connecting the startKIT microcontroller to a raspberry pi vis an SPI interface, the data was inaccurate due to errors in the transfer process. Specifically, when trying to have the two devices tell each other when to start sending multiple values over while the startKIT was running other tasks on the same core, a high error rate would occur. When the two devices were set up to only communicate without any other tasks communication was possible at high rate, exceeding 10khz.

Discussion

RockSat mission. The ability of the startKIT to sample ADCs and save the resulting data at such a high rate makes it usable for experiments involving electrical input. Devices that use SPI or I^2C for communication can be connected to the startKIT. The startKIT is also a very cheap device costing under $20. This makes the microcontroller a low-cost data acquisition system that can be used for a variety of experiments.

Observable test data. Since errors became common after trying to get the startKIT to run multiple tasks on the same core, it may be possible for the program to work if a different microcontroller is used. Specifically, one with more cores than the four core startKIT. This would allow the communication task to run uninterrupted and, would hopefully, fix the high error rate. This would have however require redeveloping the program to work on a different system.

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Acknowledgments

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Previous work. I would like to recognize the work of M. Hernandez and T. Shannon on the software tis project was based on.

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