Antarctica Ross Ice-Shelf Antenna Neutrino Array (ARIANNA)

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Overview

The ARIANNA experiment involves a triangular formation of ultra high energy neutrino detectors at the Ross Ice Shelf in Antarctica. The study of these neutrinos helps to identify the origins of cosmic rays in galactic and extragalactic magnetic fields [1].

The University of California--Irvine has developed its own detectors for the experiment using both spectroscopy and radio frequency technology. In order to study neutrinos with sufficient statistics, these detectors need to be produced at high quantities, calling for an improved and more affordable design [2].

Background

The ARIANNA hardware allows for 256 input samples that are read into an FPGA and then into an Mbed microprocessor [2]. The Mbed calculates a second trigger state as well as manages data storage [3]. The Mbed microprocessor, must now be replaced with the Raspberry Pi Compute Module 4 due to its floating point calculations and deep learning capabilities. With the transition from the arm Mbed microprocessor to the Raspberry Pi, improvements in budget utilization could be observed through the mass production of neutrino detectors [3]. Updating the circuit board will significantly reduce dead time seen by the Mbed, and improve productivity.

Goals and Outcomes

Quarter 1:

Analyze and rework current schematics of the ARIANNA base motherboard. This includes, but not limited to, working directly with the team and finding newer components to the base receiver of the satellite.

Becoming familiar with current tools and software that the ARIANNA project utilizes. This includes, Easy EDA, PCB Editor, and mBed Studio. As for hardware, we will be learning about the Raspberry Pi, and how it could potentially give better performance, over the mBed, to the receiver.

Overall Goal:

Become familiar with integrating new components onto an existing project, all while learning industry best practices.

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Methodology

Fig. 1 - ARRIANA printed circuit board with an integrated Mbed 1768

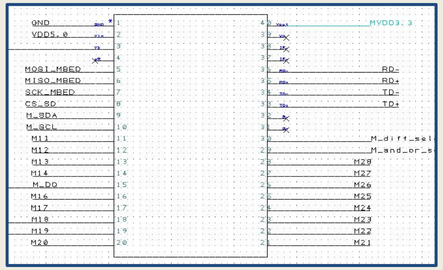

Fig. 2 - Mbed 1768 Microcontroller schematic

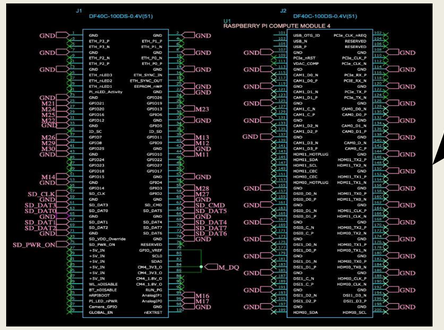

Fig. 3 - Raspberry Pi Compute Module 4 schematic with inputs and outputs compatible with the ARIANNA PCB

- The schematics for the PCB and Mbed controller are analyzed.
- Inputs and Outputs for the Mbed will be examined to determine their respective components on the Raspberry Pi CM4.

- All new components such as the Micro SD Card reader (Fig. 4) and USB hub (Fig. 5) are designed to be compatible with the Raspberry Pi.
- The schematics are integrated into the existing ARIANNA design and implemented in the new PCB.

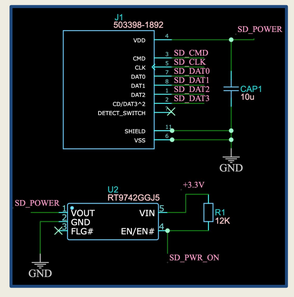

Fig. 4 - MicroSD Card Reader schematic

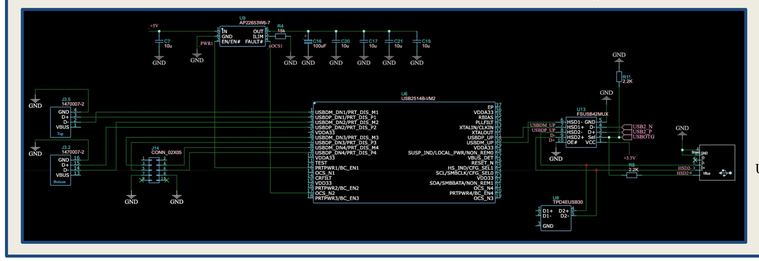

Fig. 5 - RPCM4 compatible USB 2.0 Hub

Quarter Accomplishments

- Gained experience in : EasyEDA, PCB Artist, C, Python, and schematic analytical skills.

- Reworked the schematics and PCB design, that the ARIANNA team had originally created for their Mbed, into the Raspberry Pi Compute Module 4.
- Learnt deeply about standardized components that were not deployed through academic careers such as: Thermistors, USB/SD slots, Ethernet connections, HDMI, and the concept of decoupling capacitors.

Future Work

- Design the mounting and support circuits of the Iridium satellite data module into a PCB using CAD software.
- Acquire an Iridium module and support board, along with an antenna specialized for satellite use.

Fig. 6 - Iridium module to be integrated onto the PCB

References

[1] S. Barwick, E. Berg, et al., “Design and Performance of the ARIANNA HRA-3 Neutrino Detector Systems,” *IEEE TRANSACTIONS ON NUCLEAR SCIENCE*, vol. 62, 5, pp. 2202 - 2215.

[2] A. Anker et. al, “White Paper: ARIANNA-200 high energy neutrino telescope,” University of California--Irvine, Irvine, CA, White Paper, 2020

[3] A. Anker et. al, “Targeting ultra-high energy neutrinos with the ARIANNA experiment,” *Advances in Space Research*, vol. 64, pp. 2595-2609.