Data Acquisition System for Soil Sensors

Team Dec18-05: Nathan Coonrod, David Severson, Jacob Verheyen, Kyle Kehoe, and Sok Yan Poon
Client/Faculty Adviser: Dr. Halil Ceylan/Shuo Yang

Motivation

The Civil, Construction and Environmental Engineering (CCEE) Department is currently using unreliable sensors for monitoring soil moisture and temperature and those sensors do not come with data acquisition modules. Our project is to design a robust, reliable, inexpensive, and weatherproof data acquisition (DAQ) module for soil temperature and moisture monitoring underground. Our team was originally using MEMS sensors that were provided by the ECpE department. Unfortunately, the MEMS sensors were not durable enough for the application. Therefore, our team also delivered an alternative sensor to interface with our DAQ design.

Design Requirements

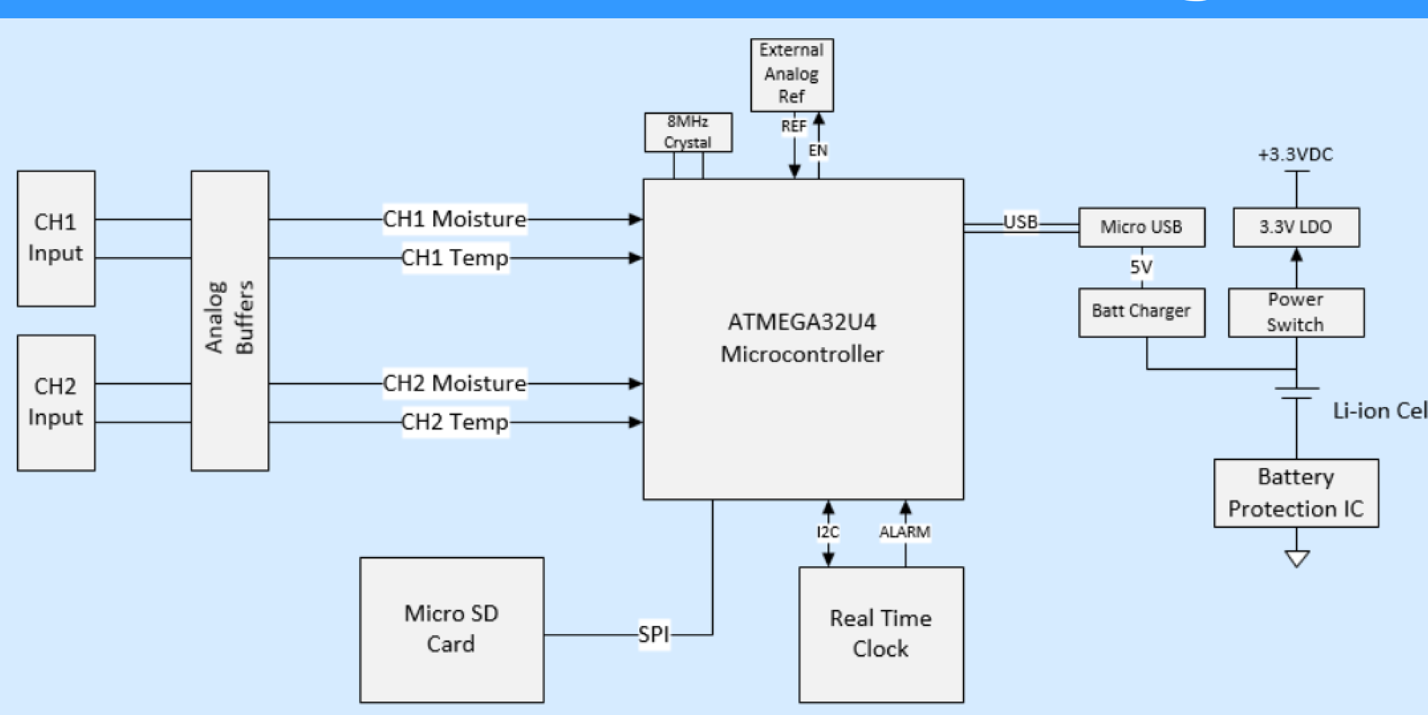
Functional Requirements

- Record 2 Channels of Temperature
- Record 2 Channels of Soil Moisture
- Rechargeable Battery
- Detachable Sensors
- Waterproof
- Battery Charging Indicator
- Status LED
- Onboard Real Time Clock (RTC)

Non-Functional Requirements

- Sample Period of 15 Minutes
- Average Battery Life of 1 Month
- Analog Sensor Interface
- Minimum 6 Feet Sensor Cable Length

Technical Details and Integration



The Arduino IDE and various libraries were used to program the ATMEGA32u4 microcontroller and implement SD card data storage, battery monitoring, RTC timestamping, and waking our microcontroller from deep sleep upon receiving an external interrupt alarm signal from the external RTC.

Operating Environment and Testing

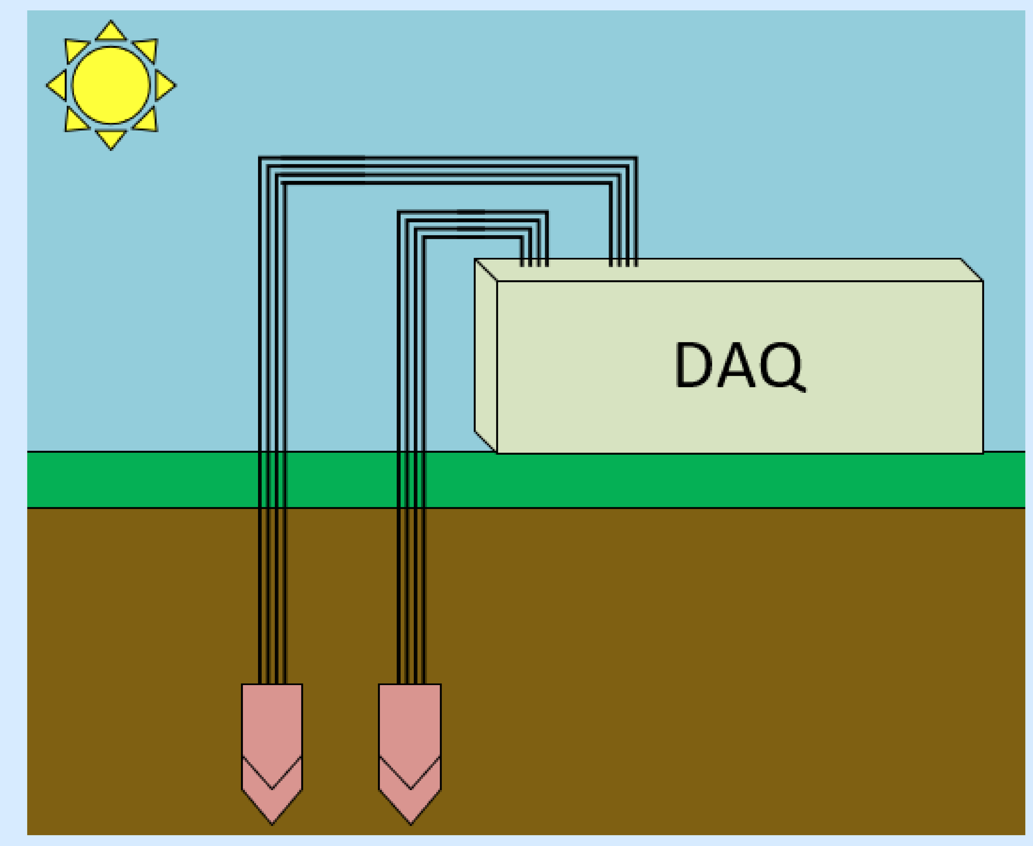
- Our system is designed for Iowa weather conditions including hot summers, cold winters, and heavy precipitation

Key Features	Testing Strategy	Validation
Measurement Reliability	• With the entire system in a temperature chamber, take measurements at various temperatures	• Using a commercial sensor and the readings on the temperature chamber we will validate the system reliability over time
Temperature Accuracy	• Sweep temperature using the temperature chamber to verify our requirements of -30°F to 100°F	• Using a commercial sensor and the readings on the temperature chamber we will validate the system accuracy
Moisture Accuracy	• Mixtures of sand/soil and water used to simulate various moisture conditions	• Using mass, volume, and density relationships, the real moisture content of the sample is compared to measured value

Intended Users and Application

The intended users are graduate students in the CCEE department at Iowa State University to conduct research. The intended application is to directly measure soil moisture and temperature at a fixed soil depth of 4 feet.

Concept Diagram



Budget and Project Resources

Our budget goal was $500.00 for both semesters of senior design for any PCB revisions and the final designed product. The final system is cheaper than existing commercial solutions on the market.

Sensor Cost

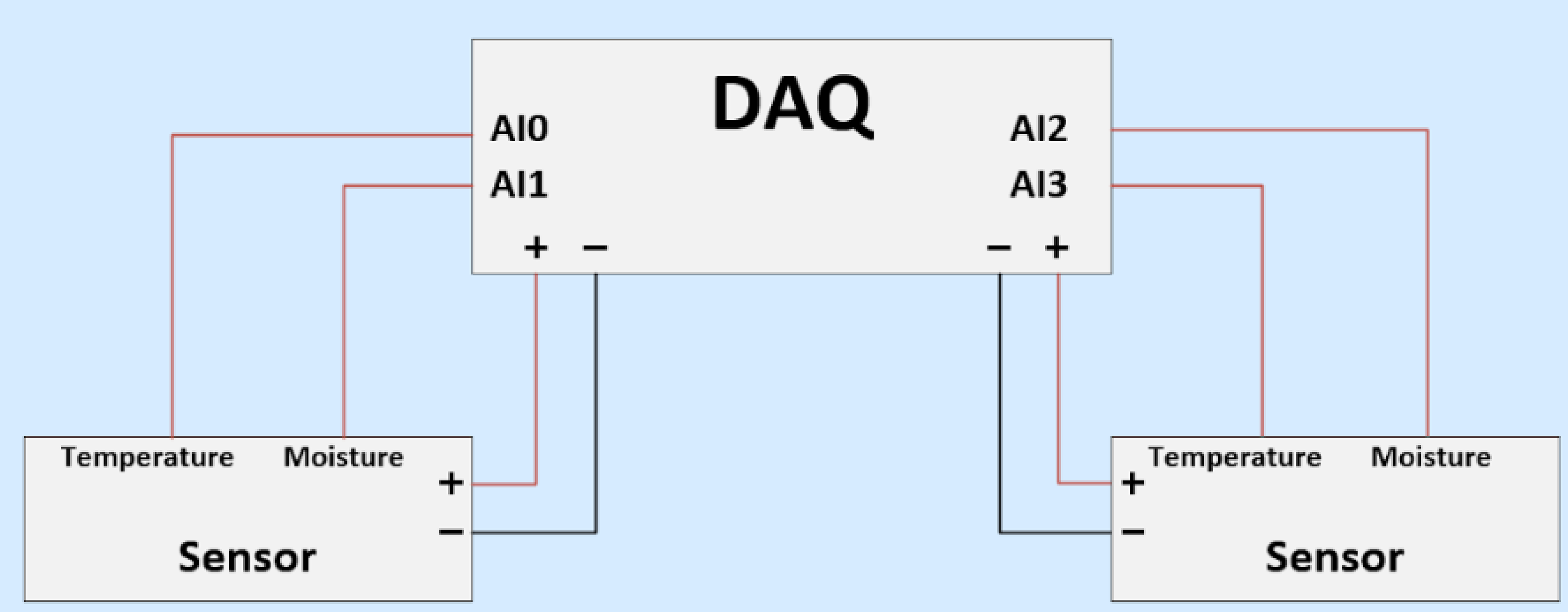
- Cost per Sensor: $18.95

DAQ Cost

- Cost per DAQ: $77.07

Note: Total system cost is $114.97 since two sensor PCBs are needed to interface with our DAQ.

Block Diagram



Applicable Standards

- IEEE Std 1332-2012 - IEEE Standard Reliability Program for the Development and Production of Electronic Products
- IEEE Std 1413-2010 (Revision of IEEE Std 1413-1998) - IEEE Standard Framework for Reliability Prediction of Hardware
- IEEE Std 1241-2010 (Revision of IEEE Std 1241-2000) - IEEE Standard for Terminology and Test Methods for Analog-to-Digital Converters