Warren J. Baker Endowment
for Excellence in Project-Based Learning
Robert D. Koob Endowment *for Student Success*

PROPOSAL NARRATIVE.

I. Project Title

Soil-powered wireless soil moisture sensor

II. Abstract

This project proposes a novel wireless soil moisture sensor powered by soil. A pair of specially designed electrodes embedded in the soil will harvest electricity, and the electricity will be conditioned and used to power the soil moisture sensor and the wireless data transmitter. The proposed system will enable battery/solar independent soil moisture sensors to transmit data wirelessly from remote locations for very long periods of time without human interference.

III. Introduction

Soil moisture sensors are common devices used to measure the volumetric water content in soil. Measuring soil moisture content is a very important subject for agricultural applications, it helps farmers understand field water conditions and manage their irrigation systems more efficiently. Crop yields fall drastically if a crop is water stressed, when soil moisture falls below a crop's wilting point, crop losses will be irretrievable. On the other hand, California is experiencing severe drought for years, water resources become very valuable and limited. Applying additional water to fields increases operation costs and puts a strain on local communities. Therefore, knowing the exact soil moisture conditions on farmers' fields will not only help optimize water use, but also will increase crop yields and quality by improved management of soil moisture during critical plant growth stages. Current soil moisture sensors and data acquisition systems typically use batteries or solar power systems as power sources. For regular battery powered soil moisture sensors, sensor and batteries will eventually be depleted and must be replaced on a regular basis (higher labor costs). Unfortunately data can be lost during those times. Compared to battery power, a solar powered soil moisture sensor has the advantage of being able to provide energy for longer time, but the power is weather dependent, collector panels degrade and will eventually have to be replaced, and additional charging control circuits and rechargeable batteries increase device cost.

We propose an innovated system that utilizes specially designed galvanic cells in soil as a reliable, long-life, economic and environmental friendly power source for soil moisture measurement and data transmission. The system will help farmers distribute water optimistically to their fields by constantly monitoring the soil wetness in multiple locations of a field from a single interface. Its concept and design is a blend of chemistry, soil physics, and electronics applied in an agricultural setting. The project's combination of research, design and fabrication aligns with Cal Poly's motto of "learn by doing", and provides the students and faculty an opportunity to develop solutions to agricultural problems.

IV. Objective(s)

The goal of this project is to achieve the following while embracing Cal Poly's ideology of learning by doing:

1. Develop and test a soil powered wireless soil moisture sensor.
2. Determine the practicality and the feasibility of using the proposed device.
3. Attend and give a presentation at the annual ASABE conference for the student paper and poster competition and the BRAE senior project banquet.

V. Methodology

The project will begin in the Renewable Energy Lab by Dr. Schwartz (BRAE), where soil samples collected from around campus will be prepared. Specially designed electrodes shown in Figure 1 are fabricated by an oxidative polymerization process which coats the material with conducting salt to generate a potential. The ceramic center allows determined amount of water to pass through the insulated electrode, this structure will protect the electrode and enables longer chemical reactions (electricity generation). In the laboratory, probes will be inserted into different types of soil, and the corresponding voltage output recorded. A charging circuit will be fabricated and attached to the electrode leads for electricity storage in a rechargeable battery. The electrode serves as a power source for the data acquisition (5TE soil moisture sensor) and wireless data transmission (LoRa). The designed system is shown in Figure 2. The pilot study has started to determine the soil characteristics effect on electricity output of the electrodes, preliminary research results showed that output voltage from the electrodes varied from 0.5V to 1V. Field testing will take place for six weeks between March and May to evaluate the system's performance and lifetime. All significant results recorded during this period will be interpreted for a poster presentation at the BRAE senior project banquet, as well any recommendations for continued research. Given positive results, the project will be sent to the ASABE competition in Orlando for student research.

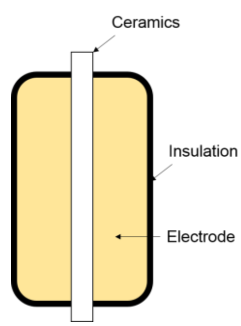


Figure 1. Electrode structure

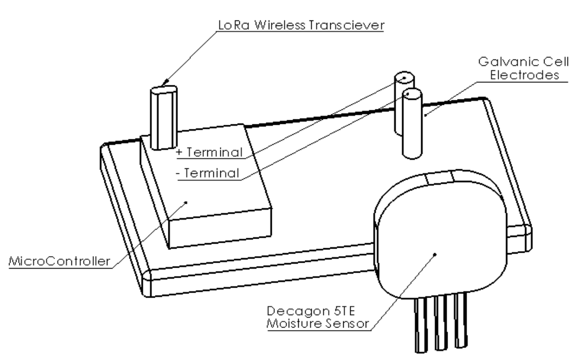
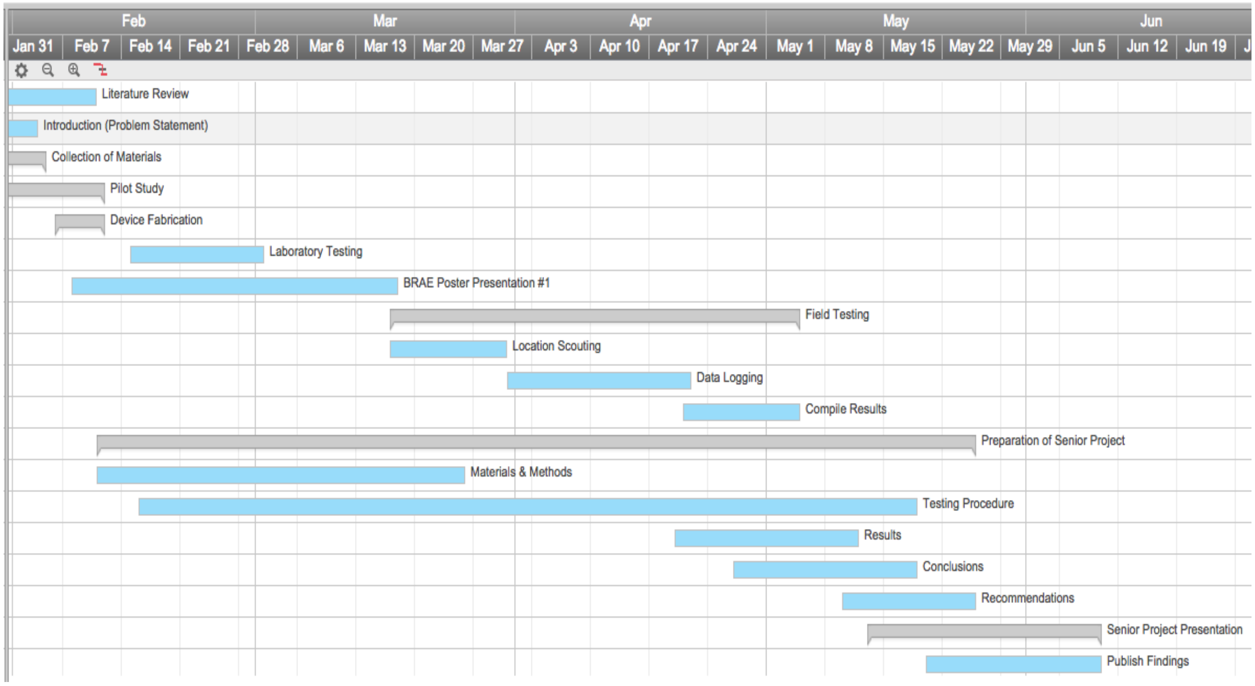


Figure 2. Diagram of Proposed Sensor System

VI. Timeline



VII. Final Products and Dissemination

1. A soil-powered soil moisture sensor will be developed and sent to the 2017 ASABE Conference for the student paper and poster presentation competition.
2. News about this novel device will be sent to school and location newspapers, websites and magazines.
3. The final product, poster, and senior project will be displayed at the Cal Poly BRAE department senior project banquet.

VIII. Budget Justification

Supplies and materials for $1200 (fabrication of specially designed electrodes, experimental supplies, electronics, multi-meter and other necessary tools), circuit design and fabrication for $600, Decagon 5TE soil moistures sensors (5 x $200/unit= $1,000), LoRa wireless transceivers (6 x $100 = $600), gateway and data storage (Microsoft Azure cloud service or a local computer with internet access for $500). 2017 ASABE conference cost (conference registration, traveling and hotel costs will be covered by Dr. Bo Liu's research funds).

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PROPOSAL BUDGET

Student Applicant(s):	
Faculty Advisor:	
Project Title:	**Requested Endowment Funding**
Travel *subtotal*	**$0**
Travel: In-state	**$**
Travel: Out-of-state	**$**
Travel: International	**$**
Operating Expenses *subtotal*	**$ 3300**
Non-computer Supplies & Materials	**$1200**
Computer Supplies & Materials	**$2100**
Software/Software Licenses	**$**
Printing/Duplication	**$**
Postage/Shipping	**$**
Registration	**$**
Membership Dues & Subscriptions	**$**
Multimedia Services	**$**
Advertising	**$**
Journal Publication Costs	**$**
Contractual Services *subtotal*	**$0**
Contracted Services	**$**
Equipment Rental/Lease Agreements	**$**
Service/Maintenance Agreements	**$**
TOTAL	**$3300**