# FINAL REPORT

## I. Project Title
Soil-powered wireless soil moisture sensor

## II. Project Completion Date
4/15/2017

## III. Student(s), Department(s), and Major(s)

(1) Antonio Jimenez, BRAE, BRAE

(2) David Ashton, BRAE, BRAE

(3) Michael Burlingame, EE, EE

## IV. Faculty Advisor and Department
Bo Liu, BRAE

## V. Cooperating Industry, Agency, Non-Profit, or University Organization(s)
**CSU - Fresno**

## VI. Executive Summary
In this project, we designed, built, and tested a specially fabricated device that uses micro-organisms naturally found in soil to generate electricity and power wireless soil moisture sensors. These microbes live throughout all soil and sediment on the earth. Some of the particular microbe species have the unique ability to release electrons outside their bodies as part of their respiration process. The device utilizes these special microbe species in soil to generate electricity. The device is comprised of two electrodes, an anodic (noncorrosive stainless steel mesh) and a cathode (ferricyanide). The anode is placed within the mud where the electrogenic microbes can grow, while the cathode is placed on top exposing it to oxygen in the air. When placed in soil, the electrode pair generates an electrical potential. Multiple cells were fabricated and placed in parallel to increase the power output. The data was compiled into Minitab software and used to analyze the influence of each variable, and if any interaction between the variables. Voltage production observed ranged from 0.12 to 0.33 volts, and the voltage was step up to 5v to charge a capacitor as a sensor power supply. The device is inexpensive and completely passive, requiring no external power input.

## VII. Major Accomplishments

(1) Developed and tested a microbial fuel cell device that can generate electricity using microorganisms naturally found in soil (shown in Figure 1). The anodic (noncorrosive stainless steel mesh) was placed in the mud/soil where the electrogenic microbes can grow, while the cathode was placed on top exposing it to oxygen in the air. Electricity was continuously produced from the electrodes. The voltage varied from 0.12 to 0.33 volts with different soil moisture levels and soil types.

(a) (b)

Figure 1. microbial fuel cell electrodes fabrication (b) electricity generation using electrodes and soil

(2) A circuit was created to step up voltage generated the microbial fuel cell, and to charge a super capacitor. The super capacitor was used as a power supply to power wireless sensors. The sensors nodes were put into sleep mode to save energy and sensor data was sent out once a day. The wireless soil moisture sensor data acquisition board is shown in Figure 2.

Figure 2. Wireless soil moisture sensor data acquisition board

(3) Students attended the BRAE senior project banquet in winter 2017. We are also planning to present the project results during the 2017 annual ASABE conference in Washington State.

## VIII. Expenditure of Funds

| Unit | Price/Unit | Cost |
|---|---|---|
| Materials and supplies | $1,405.23 | $1,405.23 |
| Computer parts | $1,820.98 | $1,820.98 |
| | Total | $3,226.21 |

## IX. Impact on Student Learning

The students worked on this project were able to integrate electricity, electronics, sensors and computer interfacing, and computer programming knowledge into the developed system. Students learned how to use different knowledge sets and integrated them into on complex system to solve real-world problems. After this project, students are aware of these new methods and knowledge used in agricultural applications. The results of this project will also be integrated into several on-going senior projects from the BRAE department at Cal Poly.