Farming Assistant & Solar Tracker | F.A.S.T.

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***Abstract* — The role of the Farming Assistant & Solar Tracker is to provide extensive climate data over a nuanced region allowing the user to have easily accessible and accurate data. The F.A.S.T. is independently powered, can constantly gather data from an extensive sensor system, send the data between F.A.S.T. units such that the end user can receive data from all units just by accessing a single main unit through a star network. The F.A.S.T. also has a solar tracking features so ensure the power systems runs efficiently and independently. Ultimately the F.A.S.T. is a low maintenance, reliable, and scalable way to monitor and collect climate data for any region.**

***Index Terms* — LoRa, solar tracking, star network, solar powered, self-powered, mobile application, sensor system, agriculture, field monitoring, long distance**

I. Introduction

Modern citizens that use agriculture not only as their main source of monetary income such as, large landowners, farmers, or cattle ranchers find it pertinent to gather information about the weather. It is required to help predict the outcome of their financial future. In modern times people are busy and want this information from multiple sources as fast as possible with minimal hassle, whether that be on their phones, tablets, or PC. Contemporary farming and ranching require large yields for the ever-expanding population and to help their businesses grow for themselves and their employees. It is essential that people fully utilize existing relevant technologies so that we can advance the growth of plants, provide local area view of weather, or anything that can help reduce agricultural lost due to weather. With modern weather stations, it is possible to send real time weather data anywhere we want to in the blink of an eye.

One of the main disadvantages of modern weather stations is they only have one device gathering data from the environment. Meaning a large landowner would need to purchase multiple weather stations at a very high cost to place multiple weather stations throughout their properties. An important asset of the Farming Assistance & Solar Tracking (F.A.S.T.) device will be the star networking capabilities that provide data from a large distance but is all viewable within one single android application. This data will all be provided to the application when connected to Bluetooth via the master device. Another disadvantage of modern weather station is they need prolonged external charging. The F.A.S.T. device will be self-charging with a rotational solar panel. The main device will have the ability track where the most energy is being provided from, and in turn, rotate the solar panel to charge the battery as quickly and efficiently as possible.

The F.A.S.T. device is an alternative to other types of weather stations, especially if intended to be used across a large area of land. The device will contain a plethora of sensors each providing a useful parameter for the user in their goal of maximizing their understand of their field as well as minimizing time spent on gathering data. The F.A.S.T. devices will allow the user to have access to historical data as well a live data to make choices that are founded on previously recorded information about future crop yields. The F.A.S.T. device will allow a farmer to easily monitor their fields at a moment's notice with minimal cost.

II. Project Overview

The Farming Assistant & Solar Tracker project, or F.A.S.T., aims to help farmers by providing them a significant amount of information about their entire field. The project can be used for non-agricultural purposes as well due multi-use nature of the measurements that can be taken. The F.A.S.T. may be used by a private golf course to monitor the status of all the fields in the golf course in an easy and efficient manner. The project implements several different systems in a cohesive manner in order to facilitate the overall function. The F.A.S.T. implements a star-shaped network through the use of LoRa in order to transmit measurements from auxiliary units to the main unit which will the provide all of the measurements from all of the units to the user's Android device via Bluetooth and a custom Android application.

The F.A.S.T. is split up into two kinds of units. A main unit which is referred to as the "master" unit and an auxiliary unit which is referred to as the "child" unit. The reason for having two different types of units is to save costs. The main unit is equipped with solar tracking capabilities and a solar power system. The main unit also features an anemometer to measure wind speed. The child units lack the anemometer, the solar tracking, and the solar power system. This was done purely to save costs considering this is a self-funded student project. Ideally, all units would be identical to the master unit with solar tracking, the solar power system, and an anemometer. Using a single master unit and several child units the F.A.S.T. project is successfully implemented and serves as a very promising proof-of-concept for future projects which aim to use only master units in their implementation.

One of the main benefits of the F.A.S.T. is the solar tracking and solar charging capability. Ideally, all units would track the sun to maximize solar capture and be completely self-sufficient in terms of power. This is a major benefit for the user because it means they do not have to consider cost of powering the unit since it will be powered using solar panels and the solar power system.

III. SYSTEM OVERVIEW

The F.A.S.T. project is made up of several systems that each implement an important part of the overall F.A.S.T. project. These systems all work together to implement the overall function of the F.A.S.T. project. All of the systems are going to be discussed in-depth in this section.

A. Communication System

The F.A.S.T. project has two communication systems which are vital to the overall function of the project. One of the communication systems is used to allow communication between all the F.A.S.T. units. The communication between the units is called the F.A.S.T. network. The F.A.S.T. network is a star network in which all the child units connect to the master unit and transmit their measurements to the master unit. A graph representing the F.A.S.T. network is shown in Figure 1 below.

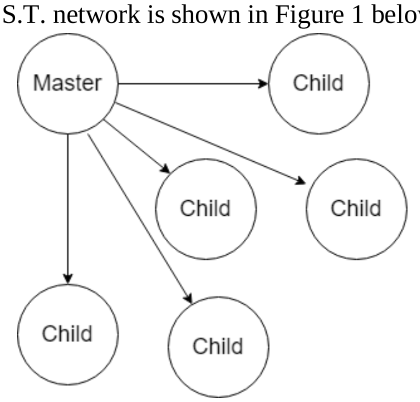


Figure 1. F.A.S.T. Star Network graph

The overall F.A.S.T. network supports child units sending their messages to the master unit across vast distances. Farms or fields in general can cover a very large area so, the F.A.S.T. network is able to send transmissions consistently across large distances as well as receive them. The F.A.S.T. network is able to handle these necessary long-distance communications consistently without errors.

The secondary communication system that is present in the F.A.S.T. project is used to implement communication between the F.A.S.T. network and the mobile application. This secondary communication system is implemented through the use of Bluetooth and is only present in the main unit. Bluetooth is used for the secondary communication system because this system does not require long range support and Android devices can implement Bluetooth based applications relatively easily.

B. Power System

The F.A.S.T. power system needs to work independently and reliably without any aid from the grid such that farmers can set and forget about the unit. A battery system in conjunction with photovoltaic cells will allow the F.A.S.T. to sustainably power itself with little to no maintenance. The solar panels can charge the batteries and power the unit if excess current allows through a charging module. The output of this charging module leads to two different buck boost converters to provide multiple voltage lines.

C. Solar Tracking System

The solar tracking system's main purpose is to point panels toward the sun for maximum light intensity throughout the day. One of the goals for F.A.S.T is to achieve a more accurate tracker as well as maximum energy output. To achieve this goal, we decided to make F.A.S.T capable of dual-axis rotation. By moving on two axes, the system can have a wide range of position options. A dual axis tracker can optimize the collection of solar energy when seasons and sun paths change. To implement dual axis rotation, we use 4 lux sensors to measure light intensity and a dual axis servo motor system combined with dual gears to provide freedom to follow the light intensity.

D. Sensor System

The sensor system on a F.A.S.T. unit is in charge of taking and recording measurements that are of interest to the user. In the selected farming application, the sensors measure values that are relevant to farming. Values such as air humidity, wind speed, UV intensity, and others are all measured by the F.A.S.T.'s sensor system. These are all measurements that are directly relevant to a farmer and would provide them with as much information as necessary in order to make decisions about their field. All F.A.S.T. units have their own sensor system which allows the user to have measurements from different areas of their fields to better understand how the different sections of their land are doing.

IV. HARDWARE DESIGN DETAILS

The hardware that supports all the individual systems of the F.A.S.T. project is extremely important to the function of this project. The specific hardware design details will be discussed in this section and how each system works will be described in detail. The parts of each of the main systems will be discussed as well as their implementation and their designed use.

A. LoRa Communication System

The F.A.S.T. network is implemented using the LoRa network protocol. LoRa, which stands for Long Range, offers very low power and extremely long-range transmissions in the sub 1-GHz band. According to the official LoRa documentation [1], a single LoRa station can cover an entire city or an area of around 100 square kilometers. In rural environments, range can be upwards of 10 kilometers [2]. Under ideal conditions, a range of over 800 kilometers has been observed and verified [3]. An agricultural field offers ideal condition for the LoRa technology and therefore LoRa was the perfect choice to implement the F.A.S.T. network.

The RFM95W LoRa module was selected as the LoRa transceiver for the F.A.S.T. project. This module functions using SPI which greatly simplifies the software necessary to run this transceiver. This specific transceiver operates in the 915MHz [4] frequency which is not ideal for dealing with obstacles or penetrating obstructions, but in an agricultural field this would not be an issue and will suffice for our use. The RFM95W consumes very low power while on standby and receiving messages, and it consumes slightly more when it sends a transmission [4]. An external 915MHz omni-directional antenna is used in the LoRa communication system to greatly increase the range. All F.A.S.T. units are equipped with their own antenna to maximize the range of the overall F.A.S.T. network.

When deployed, the F.A.S.T. network will allow for a theoretical range of several kilometers, under ideal conditions, between the master unit and any single child unit. This extensive coverage will easily cover a field and allow for measurements to be sent across vast distances to a central location. Under non-ideal conditions, the F.A.S.T. network will still be able to support a range in the hundreds of meters which is more than enough for its intended use case. Due to the manner in which LoRa functions, additional F.A.S.T. units can easily be added to the network with no hardware modifications required. This allows our F.A.S.T. network to be extremely scalable.

B. Power System

The power system uses TP4056 charging modules to charge two 18650 3000mAH Lithium Ion batteries. Each battery requires its own charging module to ensure there is not any rapid charge or discharge from the batteries into each other. The TP4056 charging module does utilize charge protection to ensure that if the current draw of the load is too high or if the input of the load is too high the module will act as an open circuit stopping the battery from interacting with the load or input. This charge protection has led to placing the photovoltaic cells in groups of two to charge the batteries as if they were in groups of four the current output could potentially be too high to safely charge the batteries.

The values for both the photovoltaic modules and the battery capacity were extrapolated after an accurate power draw from the unit was determined. After putting the unit in its most power intensive mode the current the load was drawling was measured to be on average .12 Amps with a max peak of .23 Amps. Equation 1 below shows how the minimum battery capacity to power the unit for 24 hours. After applying the equation, the total battery capacity needed to last the unit for 24 hours in its most intensive mode is 2.880 Ah. Because one for the prioritized features of the F.A.S.T is low maintenance reliability the chosen battery capacity was double this amount by choosing two 3 Ah 3.7 Volt 18650 lithium Ion batteries for a total capacity of 6 Ah.

$$Battery\ capacity = hours * current \qquad (1)$$

To allow the batteries to be powered by photovoltaic cells, charge protection, and a reliable output the TP4056 charging module was chosen as it was specifically designed for 3.7 Volt 18650 lithium Ion batteries and had the proper specification to protect them from overcharging or rapid discharging which could be a safety hazard. The TP4056 can only safely supply a single battery so each battery had their own charging module. The TP4056 also has a 1A restriction on the amount of current that can safely pass through [5].

The photovoltaic cells were chosen instead of an integrate solar panel system such that the power could be easily scaled if tests deviated from expected consumption. To understand the current needed to be supplied by the solar panel system we used Equation 2. A single cell produces 2.25 Ah. To ensure the batteries can be charge entirely on an average day four photovoltaic cells were used in the solar panel system. Groups of two were connected in parallel instead of the entire system in parallel because the solar panels would exceed the maximum input current for the TP4056 module.

$$\frac{Solar\ Panel\ Watts*Hours*0.75}{Solar\ Panel\ Voltage} = Amp\ Hours \quad (2)$$

After the power and battery capacity requirements were estimated, using two variable buck boost converters allowed a stable 5 Volt and 9 Volts line to be established from the systems. The outputs of the TP4056 modules were placed in parallel and fed the input to the 5 Volt buck boost converter which then in turn feeds as the input to the 9 Volt [6].

C. Solar Tracking System

To implement a dual axis solar tracking system, the team need a combination of four VEM7700 lux sensors and two servos responsible for vertical and horizontal axis which will be interfaced to the PCB. This section will discuss the servo placement and interfaces as well as the housing for the servos, solar panel, and the lux sensors.

I. Servos

Figure 2 is a block diagram showing how the servos are related to the lux sensors, microcontroller, and the panel. The microcontroller will receive values from the sensors and the sensors are constantly feeding data to the MCU. Calculations are made based on the sensor values and these calculations determine which way the servos must turn. These calculations are based on the tracking algorithm which will later be discussed in detail. The microcontroller will then send signals to the servo motors. The vertical or tilt servo will rotate the panel up and down and the horizontal or rotation servo will rotate the servo left and right covering both axes for higher energy output.

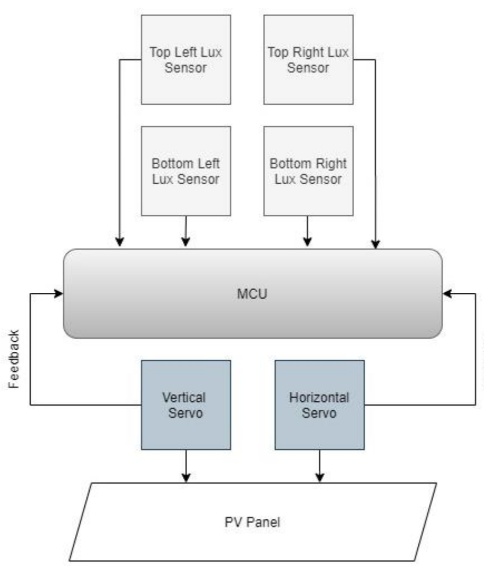


Figure 2. Servo Block Diagram

Figure 3 shows where the servos are placed in relation to the housing. The tilt servo will be placed closest to the photovoltaic mount and will be responsible for tilting the photovoltaic modules up and down. The rotation servo will be placed at the bottom of the housing and will be responsible for rotating the whole system. The servo motors are properly mounted in place and all the wires from the tilt rotation servo are properly tucked so that they will not be in the way of anything. It is also ensured that the wires do not get stuck on any crevices to avoid breaking.

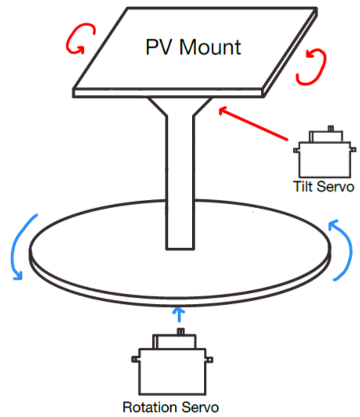


Figure 3. Servo Placement

The team selected a tilt and rotation servo strong enough to hold the photovoltaic module and each component that will be attached to the servo. Every component that the motor is responsible for moving will contribute to the total load inertia. Ensuring the limitation of the load of the servos to prevent issues such as vibration and in extreme cases breaking of the servo. Another important factor considered was speed or velocity. Ensuring that the servo could go as far and as fast as needed it while carrying its load.

The team found that the SG90 Micro Servo with a stall torque of 1.8 kg/cm at 4.8V would suffice for the horizontal movement. The load for the vertical servo is greater as it is responsible for rotating the solar panels up and down. The SG90 servo was not strong enough and thus decided on the AGFrc Sub-Micro Servo with a stall torque of 3.0kg/cm at 4.8V.

II. Housing

Choosing the right material to build the housing is crucial as the material chosen would meet the device's performance requirements. After comparing metal, wood and plastic based on physical labor involved, cost, and time, plastic was decided to be the best option.

The housing is built with plastic by means of a 3D printer. Table 1 compares PLA, ABS and PETG based on strength, stiffness, durability, cost, water resistance, impact resistance, and UV resistance. This information was gathered from a website called Simplify 3D. [7] PETG was chosen because of its strength, durability, and water-resistant capabilities.

	PLA	ABS	PETG
Strength (MPa)	65	40	53
Stiffness	7.5/10	5/10	5/10
Durability	4/10	8/10	8/10
Cost (per kg)	$10 - $40	$10 -$40	$20 - $60
Impact Resistant	No	Yes	No
UV Resistant	No	No	No
Water Resistant	No	No	Yes

Table 1 : Material comparison for 3D printing

To accelerate development time, it was decided to use a predesigned 3D model. The model used was found on a website called Thing Verse which provides primarily free open-source hardware designs. The design chosen is capable of dual axis rotation, however, to fit four of the photovoltaic panels, the mount had to be modified. The four VEML7700 lux sensors are mounted in the middle of the four panels and are shielded for directionality.

V. SENSOR SYSTEM DESIGN DETAILS

The sensor system is perhaps the most fundamentally important part of the F.A.S.T. project. It is the system that generates the information that is of value to the user. This section will go into all of the individual sensors that make up the F.A.S.T. sensor system. All of these sensors were selected because value was seen from an agriculture perspective in the measurements they could take. The F.A.S.T. sensor system can be retrofitted with different sensors if a different application is desired with minor hardware changes. Most of the sensors selected operate through the use of the I2C protocol which greatly simplifies the overall complexity of the sensor system since most of the sensors share the protocol. However, there are several sensors that are purely analog, and these sensors require a bit more processing on the software side of this project.

A. Wind speed sensor

A wind speed sensor is part of the F.A.S.T. sensor system. The windspeed is a variable of interest to a farmer because it has been observed that wind speed can have an effect on plant growth [8]. The effect depends highly on the crop as well as the speed. Therefore, having an accurate wind speed measurement provides the user with valuable data with regards to their field. An anemometer is an instrument that measures windspeed so one of these sensors was used in the F.A.S.T. project. An analog anemometer was used which generates an output voltage which is then converted to a wind speed. The selected anemometer requires an input voltage of 9V which is provided by the F.A.S.T. power system.

B. Ambient pressure, temperature, and humidity sensor

Plant growth can be affected by the pressure, temperature and humidity experienced by the plant [9][10][11]. For this reason, sensors were selected to measure these values. Specifically, the Bosch BME280 was selected to measure air pressure, air humidity and air temperature. The BME280 is able to function through the use of SPI or I2C. This sensor is extremely small and is commonly used in smart watches. The sensor is also very low power and accurate. The soil temperature and soil moisture are also variables of interest and sensor is used to measure these as well. The STEMMA soil sensor can measure soil moisture by measuring the capacitance seen from the sensor and by using its own temperature sensor. Both of these sensors together provide all of the humidity, temperature, and pressure measurements that are of value to the user.

C. Soil Moisture and Soil Temperature

Each unit, including the master have the ability to detect soil moisture and soil temperature as discussed previously. Using the Adafruit Stemma I2C soil sensor as the selected sensor, it provides each unit with accurate data for soil moisture and soil temperature. Soil moisture is read with a unit called capacity that ranges from 200 (very dry) to 2000 (very wet) [12]. Soil temperature is read in degrees Celsius with an accuracy of ±2°C. These readings can depend on how packed the soil is. If the soil is more packed the readings can be more accurate. These measurements are important for farmers or other agricultural industries to keep track of the conditions of their soil as specific plants often prefer a distinct soil with certain temperature and moisture requirements. For proper output reading and function the sensor is provided a 5V input.

D. Lux Sensor

Lux is an important measurement used within the designed system. Using the lux sensor VEML7700 which is an accurate sensor with an I2C interface. The VEML7700 can read lux values that range from 0 to 120,000 lux with an ambient light resolution of 0.0036 lux [13]. Each child unit is provided a single lux sensor. While the master unit contains five of these VEML7700 lux sensors. One lux sensor to provide an accurate reading of the surrounding area around the unit, and four others for solar tracking system described previously in the paper. The more accurate the lux reading the more accurate the solar tracking system can be. Lux is an important measurement to provide to farmers because often different types of plants require specific amounts of light throughout the day to grow to their full potential.

D. UV (Ultraviolet) sensor

Using the GUVA-S12SD each unit can read ultraviolet (UV) light and output a UV index. The GUVA-S12SD ultraviolet light sensor is an analog read device that when provided 5V of input will output a voltage that is converted to a read analog read value within the software. This analog read value represents a UV index. The output voltages from this device range from 0.5V to 1.2V and values within the range provide the device with a sensor value that is converted to this UV index.[14] Ultra violet light is important to the projects users because too much UV can damage plants, hurt animals, and destroy other agricultural products.

VI. SOFTWARE DESIGN DETAILS

Different software is used throughout the F.A.S.T. devices. Arduino C is used to control the ATMEGA328P. Which controls the entire sensor system, LoRa transmission, and solar tracking, within each of the F.A.S.T. devices. Java is used to create the android application with the help of android studio to create the XML display as well as connect the master device to the application's Bluetooth capabilities.

A. Sensor System Software

Each sensor has code to provide each of the units with its specified field data. Sensors including VEML7700, BME280, and Adafruit STEMMA soil sensor all use an I2C interface to read and receive data. The ATMEGA328P sends the device a read signal to the sensor address, the data is read, and a stop signal is sent back to the device. Adafruit provides individual .h files that make coding these devices simple. The devices must first be initialized, and then within the devices continuous loop, the data is read from the I2C devices as described.

The Anemometer and GUVA-S12SD are both analog devices. Therefore, they output an analog voltage that is converted to its corresponding wind speed and ultraviolet intensity index.

$$Wind\ Speed\ = 18.811(Vout) + 7.0158 \tag{3}$$

Equation 3 is the linear regression equation found via calibration of the Anemometer. The calibration of this anemometer involved us purchasing an already working anemometer to test the wind speed of multiple fans. Using the working anemometer and the sensor in sync with each other to the equation for proper windspeed output was able to be determined. The output voltage from the anemometer could then be read by simply plugging the output voltage into the linear regression equation and receiving the current windspeed in meters per second. The GUVA-S12SD similarly outputs a voltage that is converted to a readable form that represents a UV index.

All data from the sensors is sent with serial output within the Arduino code in a string to later be delimited by the android code. After the master unit receives all the data it will serially output the data via Bluetooth UART to the android application.

B. Solar Tracking Software

Each of the VEML7700 devices all have the same I2C address, therefore a creative solution was needed to solve the reading of multiple lux sensors. Using the TCA9548A I2C multiplexer the device can read from four individual VEML7700 lux sensors that are required for the master unit's solar tracking ability.

The four lux sensors are named top left, top right, bottom left, and bottom right and are placed on the mount accordingly. After getting values from the lux sensors, the averages of the top, bottom, left and right sensors are calculated. Next, the differences between the top and bottom as well as left and right are calculated. The average of the top sensors will then be checked in order to determine if it is greater than the average of the bottom sensors. If the average of the top sensors is greater, rotate the vertical servos up. If not, check to see if the average of the bottom sensors is greater than the average of the top sensors. Rotate the vertical servos down if the average of the bottom sensors is greater. If not, the vertical servo remains in the same position. The same logic is used for the horizontal servo.

C. LoRa Transmission Software

The software that enables the LoRa transmissions is broken up into two sections. The payload packaging and the LoRa transmission/receiving section. The payload packaging section simply takes all the measurements and places them in the payload that will be sent. This payload packaging section is present in all the child units because these units are the only ones that transmit. In the payload packaging section, all the measurements taken in the sensor system software section of the program are loaded into the payload. The payload itself is a float array whose indices each contains a different measurement. The 0^{th} index of the payload array contains the machine identification number which identifies which machine the received transmission comes from. The 1^{st} index contains the air temperature in

Celsius. The 2nd index through to the 8th index each contains different measurements. The measurements are identified by their location in the array which stays constant between transmissions. The last index in the array is a constant -1.00 which is used to mark the end of the end of the message and as an error checking method. A transmission is known to be complete and uncorrupted if it has the expected number of measurements and the last index contains a -1. Once the float array is prepared, it is converted to a byte array using a conversion function and a union between floats and bytes. Once the byte array is converted, then the packaging section of the LoRa software section is completed.

The actual transmission section of the LoRa software is simply to call the transmit function that is present in the RH_RF95.h library which takes in the byte array and the number of bytes to be sent as its arguments. Afterwards, the entire process is repeated for the next set of measurements. The main unit does not send any transmissions, but instead it receives all the transmissions from the child units. After the master units performs its own measurements, it listens for a transmission and if a transmission is present, then it verifies the receives byte array to ensure it is proper. Once the byte array is verified, then it is converted to a float array which will now be identical to the float array that was packaged on the child side of this transmission. The information is then sent to the mobile application through the use of a serial Bluetooth connection.

D. Mobile Application Software

Using android studio, the application for the F.A.S.T. network has been developed with java and XML. Using a worker thread, each byte transmitted from the master unit is read and fed to a data string. This string will contain all the values sent via between each unit via LoRa. The data is then delimited and sent to its corresponding device tab for easy viewing for the F.A.S.T. user, depending on which device they intend to see data from. The application includes Bluetooth open, close, and listen buttons that provide the app different Bluetooth functionalities. A connection must be previously established for the data to appear in the tab as well as the listen button clicked. Once pressed, all the intended data will appear on screen in an organized, delimited manner.

VII. PCB DESIGN

This project required several different PCBs to expedite the design process and to minimize costs. A child PCB and a master PCB were both designed concurrently to save costs. The child PCB would implement less sensors than a master PCB to minimize the budget of the project. However, in a commercial application all units will simply use a single PCB with the master PCB and the power PCB combined into one. The following subsections will provide in-depth discussions on each PCB design.

A. F.A.S.T. "Child" Unit Logic PCB

The child logic PCB was designed as a cost saving measure. To complete this project, a minimum of four units to properly showcase the F.A.S.T. network in action is needed. However, fabricating six master units would have been substantially more expensive than fabricating three master units and three child units. The child unit logic PCB contains headers for sensors which cannot be placed directly on the PCB to function properly such as the lux sensor, UV sensor, and the soil sensor. The sensor that could be solder onto the board and still retain their function was the BME280 which recorded the air pressure, humidity, and air temperature. The logic PCB also contains two 5V to 3.3V logic converters for use with the RFM95W transmitter and the BME280. There is also a 5V to 3.3V voltage converter to power the RFM95W and the BME280. The child unit board also uses a 7805 linear voltage regulator coupled with a 9V battery connector to provide a 5V line. This is purely a cost-saving measure that allowed for reduced budget and rapid development. At the center of the PCB, the MCU is located which is an ATMEGA328P. Header pins for debugging were also provided on the board for all the pins on the MCU.

B. F.A.S.T. "Master" Unit Logic PCB

The Master unit logic board is simply an expanded child unit PCB. This PCB contains everything the child does and more. It contains header pins to connect to the power PCB to power the master unit. A separate power PCB is needed for the master unit because the master unit requires a 9V line as well as a 5V to power itself. On top of what the child unit board contains, the master unit also has a connection to the analog anemometer. The solar tracking mechanism is present in the master PCB. This PCB uses a dual MCU design. One of the MCUs is responsible for receiving the transmissions and performing the measurements. The second MCU is responsible for the solar tracking mechanism. The master PCB also has additional header for the solar tracking MCU to provide a connection to the four lux sensors required as well as the servos used to do the actual movement required for the solar tracking.

C. F.A.S.T. Power System PCB

The F.A.S.T. Power System PCB contains the TP4056 modules to the buck boost converters to provide a steady 5 Volt and 9 Volt line to the Master Unit. The power PCB has an on and off switch for both the 9 Volt and 5 Volt line. The logic behind the Power PCB is the output from the TP4056 modules are placed in parallel and are the inputs for a buck boost converter which converts the output supplied from the batteries to a steady 5 Volts. The output of this converter is then fed to another buck boost converter to boost the converter to 9 Volts. The outputs are placed on the header pins and there are two outputs for each voltage type and a single common ground. The power PCB was designed after the master unit and was printed separately to accommodate time and monetary constraints.

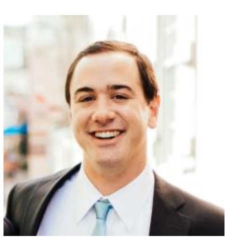
VII. Conclusion

The F.AS.T. project was successfully developed, implemented, and tested as described in this paper by integrating all the systems described previously. Throughout this project several difficulties arose due to the COVID-19 pandemic such as slow shipping of critical parts, usage restrictions of on-campus facilities, having to take precautionary measures to protect the team, among others. Through teamwork and perseverance, all mentioned difficulties were overcome to result in a successfully developed a fully functioning project.

The F.A.S.T. project was implemented by designing two different units each with their own PCB design and power system. All aspects of the project were successfully implemented and verified using thorough testing. All of the systems in the F.A.S.T. project worked together and communicated with each other in order to implement the overall function. This project can be deployed almost immediately to any farmers or interested parties that would like to get as much information about their land with as little hassle as possible.

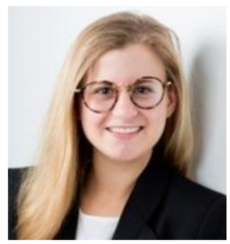
Designers

Nicole Andrade is a senior computer engineering student at UCF. She is interested in embedded and software development. Nicole will be joining Northrop Grumman in Melbourne, Fl as an Electrical Engineer after graduation.



Christopher Badolato is a senior computer engineering student at UCF. He is interested in Software engineering, and embedded software development. Chris will be joining Northrup Grumman as a reliability engineer after graduation.

Jan Iglesias Morales is a senior computer engineering student at UCF. He is interested in embedded development and software engineering. He has a passion for learning and ECE. He is the current president of the IEEE HKN – Zeta Chi chapter at UCF and will be graduating with Magna Cum Laude honors in December of 2020. Jan will be joining Texas Instruments in Dallas, Texas as an Applications Engineer after graduation.



Savannah Irvin is a senior electrical engineering student at UCF. She is interested in technical sales and solutions engineering. She is the current Professional Development Chair of the UCF Society of Sales Engineers. Savannah will be joining VMware in Austin, Texas as an Academy Solution Engineer after graduation.

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