The OUC Solar Sculpture

Denis Aybar, Juan Forero, Simon McGlynn, Daniel Truong

Dept. of Electrical and Computer Engineering
University of Central Florida, Orlando, Florida

***Abstract* — Today, people perceive solar panels to be aesthetically displeasing. They are popping up everywhere with little regard to the aesthetics of the model. This project aims to change that implementation approach. Instead, what if solar panels and the structure they are mounted on shared an aesthetic? This could change attitudes toward solar panels and consequently solar energy. This is precisely what the senior design teams of the Orlando Utilities Commission (OUC) Solar Sculpture project aim to do. By combining the skillsets of mechanical, electrical, and computer engineers with the talents of artists, our aim is to produce a sculpture that provides solar power and beautifies the public domain**

***Index Terms* — Solar power generation, infrared sensors, photovoltaic systems, inverters, microcontroller.**

I. Introduction

Solar energy derived from photovoltaics is a sustainable energy source that has recently become cost-efficient on par with conventional energy sources but without the carbon emissions that contribute to global warming. However, one of the disadvantages of using photovoltaics is the perceived notion that the resulting object will be ugly or lack aesthetic appeal. Photovoltaic panels may be used to express art while advocating for clean technology.

Project OUC Solar Sculpture will be designed with the goal of combining and aesthetic design with solar power to promote more people to the idea of switching to energy-efficient/saving structures as well as feeding green energy into the main grid. The prototype will be designed to be a scaled model of a sculpture and will be put on display in the Orlando City Soccer Club (OCSC) stadium. The prototype should be able to survive the Central Florida environment, be oriented for efficient solar angle/orientation, provide a visual display (via UI or some form) of the estimated solar energy produced, and will abide by the Florida Building and Electric Codes.

The project is sponsored by OUC and will be part of the interdisciplinary senior design program at UCF. This means that the OUC group will work alongside students from the UCF School of Visual Arts and Design and students from the UCF Department of Mechanical and Aerospace Engineering. The students from the visual arts department oversee the aesthetics and overall artistic design of the project, the mechanical and aerospace students oversee the structural integrity and feasibility for real world implementation. The electrical and computer engineers oversee the electric components needed for the system interactivity and converting the solar energy into AC power to send it to the grid. The OUC team will be advised by Dr. Lei Wei, Dr. Samuel Ritchie, Dr. Mark Steiner, Dr. Felix Del Toro and OUC engineers.

The OUC group will work with the art and mechanical students to create a solar structure to replace a generator at the Orlando City Soccer stadium with the requirement of producing a net value of 850 kWh yearly. With the goal to make the system interactive for foot traffic the OUC group will implement motion sensors and sound sensors into the design that once triggered will activate a set of LED patterns provided by the art students to make the solar sculpture light up.

II. System Components

For this system there are two major parts that the team focused on. The first major part of the project focused on the solar energy and sending said energy to the electrical grid as well as displaying the power that is being produced. This portion of the project included the photovoltaic panels, the microinverter, the current sensor, and the voltage divider implemented on the printed circuit board. The second major part of the project focused on the interactivity that the sculpture would have with the foot traffic around it. This portion of the project includes the sound sensor, the IR sensor, the LCD screen, and the LEDs.

A. Microcontroller

The microcontroller acts as the brain of the system that controls other system components by sending and receiving signals to them. The ATmega2560 microcontroller was chosen to control the 1/8 scaled model of the sculpture due to the abundance of available GPIO pins and available memory. This is to allow for scalability for the number of LEDs, sensors, and displays for the actual sculpture.

The solar sculpture utilizes a sound sensor and multiple infrared proximity sensors to provide interactivity with the environment due to the placement being outside of the Orlando City soccer stadium. Both sound and IR sensor require analog pins to output data to which are constantly read by the microcontroller to determine when the sensor has been triggered. The microcontroller would then control the lightning appropriately in regards to the data read.

The LEDs and LCD display can be powered directly from the microcontroller's pins, but are powered directly from an external power supply to avoid crashing the microcontroller due to voltage drops. The microcontroller and other components will all take power directly from the grid rather than a battery due to investors' guidelines.

B. Lighting

To best fit the concepts behind the Solar Sculpture, we decided to use LED lighting as it is bright, energy efficient, and easily programmable. We also considered factors such as how easily can the lighting be placed onto the sculpture, and can whether withstand the high heat, high moisture climate in Florida. To that end, we are recommending the Ribbon Star 50/50, Waterproof LED RGB + WW Strip Light for the sculpture and we are using Adafruit's Neopixel RGBW LEDs for our model because they will offer similar lighting and have software libraries for the Arduino family of microcontrollers that we can take advantage of. The Ribbon Star LEDs we chose are Underwriters Laboratories (UL) listed, which is of great importance in our project as all the electronics used in the sculpture must be UL listed to even be considered for implementation. In addition to a UL listing, we also considered luminous flux, viewing angle, number of colors, weatherproofing/waterproofing, and maximum operating conditions.

The Ribbon Stars have four individual LED die, red, green, and blue in one package and white in another so they may produce any color. From the manufacturers scale of brightness relative to their other products, these LEDs given a 4 out of 6 rating which should give them good visibility. They are rated at 305 lm/ft, but brightness is a subjective term, and how visible they will depend more on contrast with their surroundings, rather than their lumens per foot [3-4]. The LEDs have a viewing angle of 120° so they should allow people who are far from the center line of the LED to still see them.

The Ribbon Stars state that they are water proof and UV/sun proof [4]. They have an ingress protection rating of 68 (IP68), which means they are "dust tight" and protected from "immersion, 1 m or more depth" [5]. These protections suggest that these lights are suitable for the Florida climate. Another concern for operating efficiently in Florida is the LEDs thermal hardiness. They can withstand temperatures up to around 149 °F, far beyond what they should ever experience under normal conditions [4].

These LEDs operate at 12 VDC and are designed to take 6.01 A. Their power usage is 14.4 W per meter. They specify that no more than 20 ft (~6.1 m) should be run in serial, so for the sculpture several parallel strips will likely be necessary [6]. To control the lighting, a digital multiplex 512 (DMX) controller will be used which can set different lighting "scenes" with only push buttons and this controller will be run by a programmable logic controller (PLC). These devices are much more robust than standard microcontrollers and thus more suited to this project.

C. Infrared and Ultrasonic

To give the sculpture a degree of interactivity with passersby at the soccer stadium, we have decided to use proximity sensors. As with the lighting we must use different components for the sculpture and for our model. This is due to the large cost difference for hobbyist parts and UL listed, professional parts. The idea behind using the proximity sensors is that when people approach the sculpture, it will react to them. By using multiple sensors, we can have different lighting patterns and colors based on which sensor/s are triggered.

For our model we chose a Sharp GP2Y0A41SK0F short range proximity sensor and for the sculpture we chose the Bulletin 873P-D30AVP2-3500-D5 ultrasonic sensor. The model sensor is an IR sensor (not a PIR sensor), and the sculpture sensor is an ultrasonic sensor. Originally, we had hoped to have both the model sensor and sculpture sensor be IR sensors, however the requirement for reflectors/ receivers and lack of range of the UL listed IR sensors pushed us towards choosing the ultrasonic sensor [7]. The ultrasonic sensor can sense up to 3.5 m away, but it does have an issue sensing anything within 0.25 m of itself. We do not foresee this being an issue on such a large sculpture, however. See Fig. 1. for more detail.

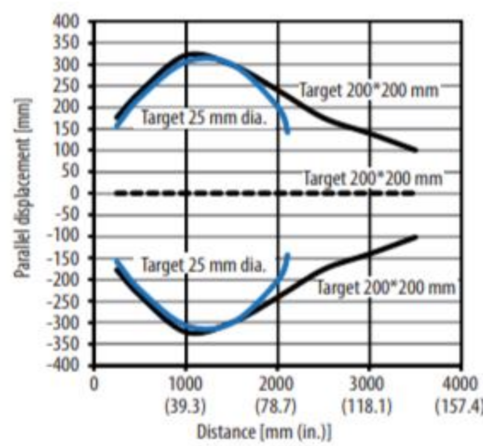

Fig. 1. Rockwell 873P-D30AVP2-3500-D5 ultrasonic sensor limits of detection

As these sensors will be mounted on the outside of the sculpture, they must be hardened against their environment. The Rockwell sensor has an IP67 rating, so it is fully protected against dust and full immersion in water for 30 minutes at a depth of 1 m [3]. The IP67 rating will provide sufficient protection for the sensor in its environment.

The Rockwell sensors must be automated. Since they are programmable, and a PLC will be present in the sculpture, we suggest that the PLC be used for automating the sensors as well as the lights. Having the sensors and lights run through the same PLC should make component integration seamless.

E. Sound Detector

To add a second layer of interactivity, we are proposing the addition of a sound detector. For our model, we have used an open hardware design from Sparkfun to create a sound detector [8]. For the sculpture we are suggesting the use of the GRAS 146AE 1/2" CCP Free-field Rugged Microphone. It should be mounted high on the sculpture, as the idea behind this sound detector is to pick up noise from the stadium and crowds outside of the stadium on game days. The detection of sounds, and their volume, may then trigger changes in the lighting, which should correlate with the excitement of "the ruckus" (Orlando City Soccer fans).

As with all the other exposed electronics on the sculpture, the microphone will need to be hardened against weather. Due to the IP67 rating and ability to operate at temperatures up to 125 °C (~257 °F) of the GRAS microphone, it is suitable for use on the sculpture [9]. The GRAS microphone is not UL listed however, according to [10], a UL listing is not required due to the very low voltages of microphones. This microphone is a free-field microphone meaning that it is intended to be used in places where there is little sound reflected [11]. Given the projected location of the sculpture, an open area outside the stadium, it is unlikely that there will be significant sound reflection.

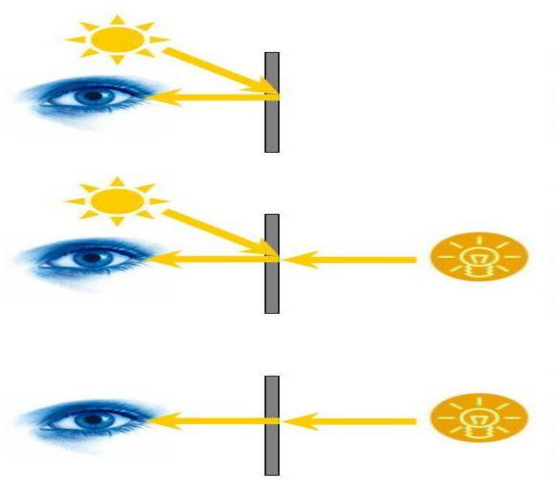

Fig. 2. Reflective (Top), Transflective (Middle), Transmissive (Bottom)

E. LCD

The liquid-crystal display chosen was a 40x4 Parallel Character LCD by CrystalFontz. The LCD uses a 4-bit or 8-bit parallel interface which is easy to install onto the ATmega2560's digital IO pins. This display was chosen in particular due to it being a transflective LCD. Since the Solar Sculpture is planned to be constructed outdoors in Florida environment utilizing transflective (both transmissive and reflective) technology will help readability under direct sunlight and utilizes its backlight for when it's dark outside.

As seen in Fig. 2, a transflective display will allow for a comfortable experience when reading the display at night and daylight. During the night it will be acting as a transmissive display using the backlight. When under bright illumination (direct sunlight) the display will act mainly as a reflective display using the contrast to constant to the brightness.

The reason to choose a character LCD over a higher resolution graphical display is for power and cost efficiency. The overall goal behind the sculpture is to promote energy saving technology to the public. Therefore, for the scaled model, a character LCD is the perfect size and is large enough to display all the information from the system.

Ideally, a larger screen should be used for the actual Solar Sculpture. However, the power consumption of the system will also significantly increase making it harder to achieve an annual net gain of 850 kilowatt-hours per year.

F. PV Panels

For the solar system design, the goal is to have the system output power meet the minimal requirement of 850kWh/year given to us by OUC even with the attached electronics. Although the grid will be powering the structures attached components, the expectation is to have the panels produce more power than the attached components will be consuming as well as meeting the minimal yearly output power. Reason for having the structures electronics components be powered by the grid is so that the electronics do not depend on photovoltaic panels to provide power to them at either night time, cloud shading or rainy days. This gives the project the freedom to concentrate on the power production from the photovoltaic panel side.

When selecting the final panel options to present to the mechanical teams and art teams, several specific traits are to be taken into consideration. The teams' considerations are listed below:

- Photovoltaic panel type
- Efficiency
- Nameplate power output

- Surface area
- Temperature constraints
- Weight
- Voltage/current panel output

Right from the start, thin-film panel technology is discarded. Reasons for this decision is not only because advised to do so by OUCs advisors but also the disadvantages thin-film panel technology usually brings alongside with them. Thin-film technology for the most part needs double to triple the surface area compared to commercial and residential polycrystalline and monocrystalline photovoltaic panels. Structural space constraints presented by OUC limits the amount of surface area space that the photovoltaic panels can cover. That being said, to make the best use of the limited space available and gain the most power per square footage surface coverage, polycrystalline and monocrystalline photovoltaic panels are preferred. While thin-film technology will perform better than polycrystalline and monocrystalline technology under shading, the location of the structure as well as the height of the panel installation makes for these advantages to not make a difference since there will not be any shading issues.

The best photovoltaic panel option from the EE and CE team perspective for the projects demonstration will be the Evergreensolar model ES-A-210-fa2 210W polycrystalline photovoltaic panel. Four of these selected panels with their own selected microinverter on the solar structure at the optimal angle will be more than enough to power the microinverter and meet the minimum annual output required by OUC. Four of the given panels will be producing 1,181 kWh/year. This calculation was made using the following mathematical equation from PVwatts.gov:

$$Size\ (kW) = Arrea\ Area\ (m^2) * 1\frac{kW}{m^2} * Module\ Efficincey\ (\%) \quad (1)$$

The ES-A-210-fa2 photovoltaic panel has a high efficiency rating of 13.35%. The dimensions for this panels are 65 x 37.5 x 1.8 inch which sets it at a bigger than average residential panel. Both the optimum power voltage, V_{mpp} = 18.70v, and current at peak power, I_{mp} = 11.23 A are within the operating range of the selected microinverter. Only limitation to this option would be the weight being 41 pounds which can cause a lot of strain on the solar structure from the mechanical engineering team.

For this projects demonstration purpose we are only using one ES-A-210-fa2 photovoltaic panel due to our project resembling a 1/8th scale model of the solar structure. The output of the project will be measure by a current sensor and voltage divider.

G. Inverter

The qualifications the EE and CE team are looking for to apply to the inverter selection are very simple. Once the optimal solar panel is selected, selecting an inverter is just a matter of matching the photovoltaic panels outputs to the inverters input. Another qualification for final inverter selection is the cost efficiency since the most economical system is desired. The last qualification that is considered is the inverter must be UL listed.

Comparing and contrasting string-inverters and microinverters for the solar sculpture structure has come with ease. The maximum amount of solar panels that are going to be selected to be implemented in the solar sculpture will range between 2 to 4. String-inverters are used to their maximum optimal functionality when a lot of panels are connected together which generally leads up to 6 panels. With only 2 to 4 panels being implemented in the solar sculpture design, a string-inverter would not be used to its maximum capacity. Also, a con for string inverters is they have shading issues. To combat the shading issues, string-inverters use an additional piece of hardware called the power optimizer which is implemented to each individual panel. Purchasing power optimizers adds an additional cost to the total project budget. Since a string-inverter will not be used to its full capacity and will have the highest project budget cost, the string-inverter option is discarded. The EE and CE team will select the necessary amount of microinverters to be implemented into the solar structure.

For the final inverter selection, the EE and CE team researched microinverters from manufactures that are UL listed. In conclusion the ABB MICRO-0.3HV-I-OUTD has been selected to be connected to the photovoltaic panels. The maximum power output from the selected microinverter is 310W while the input power intake is 360W. This input capacity is in range for the selected photovoltaic panels options nameplate output power. Also the absolute maximum input voltage is 79v which also fits the range for the selected photovoltaic panels output voltage. A neat feature that comes along with the ABB microinverter is the communication radio communicator ABB CDD. The free photovoltaic panel monitoring application allows for easy data monitoring of each individual panel. Monitoring the data can be done via web or mobile device wirelessly. The radio communicator can analytically monitor up to 30 different microinverters so monitoring 2 to 4 microinverters will not be an issue. 2 to 4 of the microinverters and the radio communicator combined add up to 8.23 – 11.73 pounds that should be considered in the final system design.

A. Current Sensor

To be able to measure the power that the PV panel is generating, the current is one of two measurements that need to be captured. To get the output current of the photovoltaic panel a current sensor was implemented into our design. The sensor chosen was the ACS711. The current sensor chip is placed on a breakout board with four different connection spots. These connection spots can be utilized to integrate the panel and the voltage divider.

This senor has an input current limit of 15 A and an input voltage limit of 20 V. Both the current and voltage outputs of the PV panel fall within that range, 11 A and 18 V respectively, making this current sensor the best option. Once connected to the PV panel and the printed circuit board the signal sent from the current will be sent to an analog pin on the atmega2560. This measurement will be recorded and multiplied against the voltage recorded from the voltage divider to get the power that is being generated.

B. Voltage Divider

To be able to measure the power that the PV panel is generating, the voltage is one of two measurements that need to be captured. In perfect conditions, the output voltage of the PV panel is around 18 V, connecting this output straight into our printed circuit board would more than likely burn it. To fix this, we introduced a voltage divider to drop down the output voltage and allow us to record this measurement. The resistors chosen for this were 100 kΩ and 25 kΩ. Using the voltage divider formula, this ratio of R1 and R2 would give us an output voltage of ~3.6 V, putting it within the 5 V limit that the atmega2560 has. The output voltage of the voltage divider is put through an op- amp buffer and then sent to the atmega2560.

$$Vout = Vin * R2/(R1 + R2) \quad (2)$$

C. Voltage Buffer

To reduce the effects of impedance and to get a more accurate voltage read, an Op – Amp buffer was placed after the voltage divider. This buffer will take the voltage, pass it through the Op- Amp, and then send a clearer signal to the atmega2560. The reason for this buffer is to get rid of any impedance problems that might arise from the voltage divider circuit. The Op – Amp below has unity gain which will not alter in the voltage in any way, it will just make our calculations more accurate. Fig. 3 shows an Op- Amp circuit with unity gain.

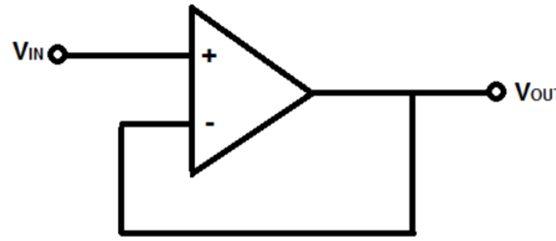

Fig. 3. Op- Amp with unity gain

The Op- Amp we chose was the MAX4200EUK. It allows for an input voltage range from 4V to 5.5 V and draws only a small current of 2.2mA. Both these values allow us to use this Op- Amp without worrying about inaccurate measurements that are being sent to the atmega2560. This measurement will be recorded and multiplied against the current recorded from the current sensor to get the power that is being generated.

III. System Concept

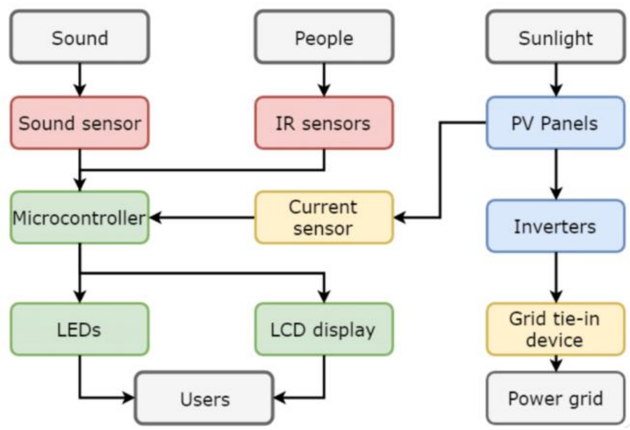

Fig. 4. System Block Diagram

Our project can be broken down into many sub tasks and our concept of how to break it down is shown in the system concept figure, Fig. 4. The system is divided into two large parts. The first part is the functional, energy production part. This part is composed of solar panels, inverters, circuitry to condition the electricity produced, and a device to feed the power produced into the grid. The concept we have for this side of the system is that the sunlight will activate the solar panel, the solar panel will generate DC power, the inverter will convert the DC power to AC power, the circuitry will convert this to power suitable to be injected into the grid, and OUC will handle the actual connection to the grid. Most of the parts of this side of the project are to be purchased and not created by us. The other side of this project is composed of sensors (light and sound), LEDs, a microcontroller, and two screens, one for displaying messages to the public and one to be used by technicians. The power for the LEDs, sensors, and screens will be taken from the grid, we will create the circuitry necessary to output the appropriate power to each device.

V. Software

The ATmega2560 microcontroller is used in the Arduino Mega 2560 microcontroller board. Therefore, we can utilize Arduino open-sourced software available and we can ensure high compatibility with other third-party devices used in the design.

The Arduino integrated development environment, which is available cross platform (Windows, Mac OS X, and Linux), is written in Java, but uses its own variant of C/C++ as its primary language. These libraries are immensely useful as it provides a way to avoid coding directly in assembly and from using instruction sets directly. Instead allows for programming in a higher level language for readability and portability. Since an extensive user-community for Arduino exists, it would be more efficient to utilize these well tested libraries which are more likely to result in a faster processing time due to optimizations in comparison if we were to write our own libraries from scratch with limited time for development.

Relevant libraries that were used for the project are 'LiquidCrystal' for programming and controlling what the LCD displays. 'Adafruit_NeoPixel' library which can be used to individually control specifically NeoPixel variant LED strips. Each pixel's brightness and color can be adjusted quickly with RGBW color codes and a value of 0 to 255 for brightness. 'DistanceGP2Y0A21YK' library is a Sharp IR distance sensor library for variants of the GPY20A21YK family; the library is used as a lookup table in program memory to convert the ADC (Analog to Digital Converter) value to a voltage value which is used to determine the distance in centimeters.

Overall, the idea behind the solar sculpture system was to provide information about the sculpture and the benefit of photovoltaic systems in combination with aesthetics. To provide support for an artistic and aesthetically pleasing sculpture, we implemented LEDs which are supported by various patterns programmed into the microcontroller. These patterns are linked together with each individual sensor having its own unique pattern associated with it. This is a way to provide some interactivity with the sculpture.

Multiple sensors will be placed around the sculpture for maximum coverage and when a person triggers an IR sensor it will turn on the LCD display with information about the sculpture as well as start up the pattern associated with the sensor triggered. The sound sensor is programmed to trigger when the surroundings is very loud because the location of the sculpture is near the Orlando City Soccer Stadium. We will assume the sensor will go off when the crowd is excited or if a major goal has been scored. The sound sensor is independent from the LCD display and will only trigger if there is no pattern currently being processed by an IR sensor. This prevents patterns from being constantly overwritten from multiple sources and allow for patterns to finish before starting a new one.

The LCD display is programmed to display information about the sculpture. The amount of energy generated from the solar panel is calculated by reading an integer value from 0 to 1023 from the analog pins connected to both the voltage divider and current sensor.

$$\frac{Max\ ADC}{System\ Voltage} = \frac{ADC\ Reading}{Analog\ Voltage\ Measured}. \quad (3)$$

This integer value represents a ratio of unit/voltage of upwards to 5 Volts for our system which would represent a max ADC value of 1023. From (1) this will produce a ratio of approximately 4.89 mV/unit.

$$Analog\ Voltage\ Measured = ADC * 4.89\frac{mV}{unit}. \quad (4)$$

We can then convert the ADC value read into a voltage value by multiplying by this ratio to obtain a voltage value in (2). These values from the voltage divider and current sensor taken from the PV panel will be averaged over multiple readings to try to gain a close estimated amount of power generated. We then will convert this value into an understandable unit that regular people can understand which would be money. Multiplying the power generated annually by the standard price of kilowatt-hour in Florida to obtain an approximate amount of money generated annually from the sculpture; we will display this figure as well as the power generated in dollars and kilowatt-hours per year respectively.

VI. PCB Design

For the printed circuit board, we used the Eagle software to make our design. Eagle is very popular software when designing PCB's and a team member already had this software downloaded so it was logical to choose Eagle for our software.

In our system, we have three different circuit boards, our main circuit board, a sound sensor, and one break out board used which is the current sensor. The board file for the sound sensor was found on Sparkfun, was stripped down, and then soldered with the corresponding components.

A. Top Level Schematic

For organizational purposes, all the connections to the microcontroller and between components were given the same names. All the connections are on the circuit board with the sound sensor and current sensor being connected externally through wires.

The signals from the LEDs, LCD, ICSP, and the gate signal from the sound sensor were sent to digital pins on the microcontroller while the signals from the current sensor, voltage divider, envelope signal from the sound sensor, and all the IR sensors were send to analog pins. The fifteen pins that are designed for analog inputs worked perfectly in our favor, using all but one of these pins. The fact that the atmega2560 has enough analog pins for our design allowed us to use all these components with analog output signals without having to design comparator circuits, to turn from analog to digital signal, for all of them.

B. Board Schematic

Fig. 5, shows the board wiring for the two-layer printed circuit board. The USB power input will give a 5 V voltage source for all the components. In case the USB is not enough to power all the components, a DC jack will be used instead to power the components. The LED lights use the most current out of all the components and for this reason they are right next to the power inputs. This prevents any problems that the LED currents will draw. A speaker was put in at the lower end of the board to help the sound sensor filter out any noise. A small potentiometer was used with LCD to be able to adjust the variable voltage needed for contrast between the backlight and the screen. Most of the components used were surface mount components that will allow for easier routing, and more surface area to work with, and better performance of the circuit board.

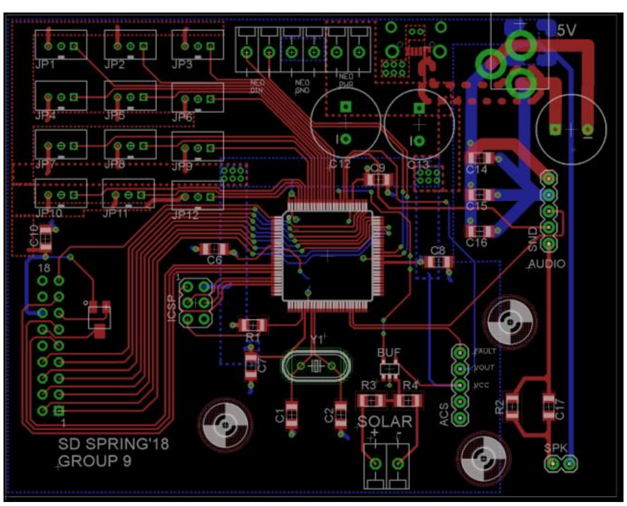

Fig.5. Circuit Board

VII. Conclusion

Through our research and testing, we have confirmed that we can deliver a system that can sense when there are people within 1.5 meters or the sculpture, and can detect a wide range of sound levels. These inputs, coupled with the microcontroller, our code, and the individually addressable RGBW LEDs, can be used to create almost any lighting pattern imaginable. This gives the art students maximum range when creating their concepts. We will also be able to display a live measurement of how much power the PV panel is producing as well as turn that into a monetary value of dollars saved. All our software code can be found at https://github.com/sonicaeon/OUC-Solar-Sculpture.

Our system can give the artists tools to make the sculpture as aesthetically pleasing as possible, but our system must produce the prescribed amount of energy (850 kW/year) too. Our research has led us to conclude that two very large commercial monocrystalline panels would produce the necessary energy, or three standard commercial size panels could also be used. The final panel selection will depend on the final sculpture design. We have concluded though, that microinverters are the best choice for our system. The electricity coming from the microinverters will be conditioned to match the electricity in the grid and will be fed into it by OUC.

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VI. Biography

Denis A. Aybar is graduating with an electrical engineering B.S. degree from UCF. He is very passionate about the power industry within the electrical engineering field. Denis has interned for companies within his field of passion such as TGOOD as a proposal assistant engineer and OUC as a co-op for the GIS department. His interest involves renewable energy and smart grid technology.

Juan Forero is graduating as an Electrical Engineer from UCF. He has interned at OUC as a Planning and Reliability Engineer and Lockheed Martin as a Systems Engineer. Once he graduates, he will start working full time at Lockheed Martin as a Systems Engineer.

Simon McGlynn is a graduating senior of the class of 2018 and will be receiving his B.S. in computer engineering. He has a strong interest in assembly programming, communication protocols, and computer architecture. He has interned with Parseval, LLC as an Audio Automation Engineer and has been funded by IEEE's Orlando ExCom to represent Parseval at IEEE SoutheastCon 2018.

Daniel Truong is currently a senior at the University of Central Florida. His interests include software design and embedded systems. He will be graduating with his Bachelor's in Computer Engineering in the Spring Semester of 2018 and hopes to pursue a career in software development.

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