UniverSOL: Solar Powered Cell Phone Charging Station

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***Abstract* — The UniverSOL Charge Station is an integrated electrical and computer system that employs off-grid technology to provide charging services for cellular devices. A photovoltaic system using Maximum Power Point Tracking (MPPT) addresses the foremost goal of this project: to furnish sustainable, renewable energy in order to address the ever-growing energy supply and demand crisis. Additionally, this system was implemented as a secure environment at no cost to the consumer. The secure system includes locking compartments that are pin accessible through a user-friendly touch screen interface. A detailed overview of the design processes and applications undertaken to develop the station follows.**

***Index Terms* — Current measurement, energy efficiency, energy harvesting, maximum power point trackers, microcontroller, shift registers, solar power generation.**

I. Introduction

This station was conceptualized by the team during one of the initial project development meetings. As each member joined the group, the primary focus was powering tablets, laptops, and cellular phones. One member in particular was awaiting an important call and required high priority to charge his cellular phone. The team considered how mobile phones have become a necessity to function efficiently in society. The conversation grew into the convenience it would be to have cellular phone charging stations available in high traffic areas. These areas include such locations as amusement parks, malls, sporting and concert venues, and local parks. Specifically, these locations are environments where individuals require long-term use throughout the day of cameras, GPS, and the ability to contact others. However, many of these locations rarely have sufficient or secure power options. Furthermore, individuals are required to have a power cord on hand. In the event that a consumer does find an open power outlet, the phone has to be safeguarded against theft, leading to an inconvenient interruption while waiting for the phone to charge.

While the aforementioned dependency of cellular devices is apparent, these advancements in technology draw attention to a greater concern regarding the environment. Energy consumption and demand has increased exponentially and continues to climb each day. In the same respect, this high demand begs for cleaner, alternative and sustainable solutions to grid power.

The overall solution to meet energy demands responsibly, remain respectful to the environment, and provide a useful service to the public was to develop a secure station to charge phones using alternative energy. And through these concepts, the UniverSOL Charge Station was born.

II. Operational Objectives

To address sustainable energy purposes through the power system, an off-grid photovoltaic (PV) system was designed. PV systems are generally made up of silicon that undergoes the photovoltaic effect through semiconductor physics converting light into electricity. A solar panel is used to accomplish this goal. A battery is typically used in these systems as the energy storage device that makes up for intermittency during the evening or bad weather. To complete the system, a charge controller had to be implemented to regulate the power input from the solar panel to the battery.

In order to ensure a secure environment to charge the phones, locking compartments were implemented. The touch screen interface allows for an individual pin to be entered upon use of a compartment. Solenoid locks perform through the execution of a microcontroller unit and touch screen interface activating the function of the compartments.

Because this system provides a public service, an easily operable and understandable station was designed. The touch screen prompts the user through the process. Light emitting diodes (LEDs) signify whether the phone is charging or fully charged. Through the use of current sensors, amperage consumption of the phone is realized. The microcontroller unit receives these values and sends signals based on the current status of the phone.

III. System Components

Following a generalized system functionality overview, a detailed description of the system components is inherent to present the project. Each of these components were designed and selected according to specifications and system compatibility.

A. Solar Panel

As previously acknowledged, the solar panel is the collector, converter, and distributor of natural sunlight to electrical energy. Several variables had to be considered when choosing the correct panel such as the types of panels available on the market, power requirements and operating specifications.

Types of panels are categorized based on the material make-up of the solar cells. The three types consist of monocrystalline, polycrystalline, and thin film materials. Energy conversion efficiency and cost balances were weighed in the selection. Upon obtaining a solar panel that was generously provided by UCF, the polycrystalline panel matched sufficient energy efficiency requirements.

TABLE I displays the established typical efficiency ranges and relative expense associated with each of these technologies.

TABLE I
SUMMARY OF SOLAR CELL TECHNOLOGY FOR SOLAR PANEL

TYPE	EFFICIENCY	EXPENSE
Monocrystalline	17%	High
Polycrystalline	11%-14%	None
Thin Film	4%-7%	Low

A detailed explanation of the power requirements and operating specifications design regarding the solar panel are highlighted in the hardware design section of this document.

B. Battery

One of the fundamental requirements of the station was continuous operation without interruption of power. Because the core source of power generation is dependent upon solar power, that power will not always be readily available. Consequently, the solar energy accumulated in periods of heightened energy consumption had to be stored and then distributed utilizing a rechargeable battery.

Certain battery bank characteristics maintain viability of the PV system. The battery energy storage capacity is based on Amp-Hour (Ah) rating. The amount of Amp-hours is how many amps are drawn from the battery in a number of hours.

Beyond having an adequate power supply to the system, the Depth Of Discharge (DOD) rating is inherent. The DOD is the maximum amount of energy the battery is capable of discharging in one cycle (one discharge and recharge period) and is rated in percentage of battery capacity. Because the PV system endures long durations of battery discharge, the DOD rating had to be high enough to qualify as a deep cycle.

C. Charge Controller

The main purpose of using a charge controller was to protect the PV system by preventing reverse current flow and inhibiting overcharge to the battery. The solar panel draws a small amount of current when the panel voltage drops below the battery voltage during the periods of intermittency. Additionally, overcharge of the battery had to be prevented because the solar panel continues to supply energy when the battery is fully charged. The charge controller selected features MPPT technology that is explained in detail following this section.

D. Microcontroller

The UniverSOL Charge Station uses an ATmega 328p microcontroller for the embedded system software. All of the components of the user interface, which includes the touch screen and State of Charge (SOC) status indicators, are designed and processed through the 328p as are the hardware components.

The 328p is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture running at 20MHz with 32KB of flash memory. The 28 pin chip houses 14 digital Input/Output (I/O) pins, as well as 6 analog I/O pins. Operating voltage of the 328p is 5 Volts, while the active current is 0.2 mA. Because the system is solar powered it was important to utilize a microcontroller that was not expensive to power, and had a low current rating.

Due to our system requiring more than 14 digital I/O pins in order to function, a 74HC595 shift register was programmed through the microcontroller to increase the pin count of the 328p chip. By inputting 3 digital I/O pins and programming accordingly, the shift register was able to output 8 usable digital pins, increasing our total pin count by 5. Each of the 4 lockers require 3 digital pins, leaving 7 of the digital I/O pins to be used by the touch screen. However the touch screen only utilizes 6 pins, which leaves only 1 of the digital pins unused.

Of the 6 analog I/O pins on the 328p chip, the system requires only 4, one per locker, to read in the current values from the charging cell phones. The 328p analog pins read in values of Voltage but the system needs to monitor the current. To solve this issue all of the current readings from the cell phones are connected into a current sensor, and that is then connected to the analog I/O pins. Once the 328p receives the voltage from the current sensor, it converts it from a voltage number ranging from 0-1024 to indicate 0-5V, to the correct voltage from the cell phone. After the actual numerical voltage is calculated, it is compared to the current sensors rating volts per ampere, to calculate the actual current being fed into the chip. From here the current sensor range is calculated to determine which SOC the cell phone is in.

E. State of Charge (SOC) Status Indicators

The State of Charge status indicators consist of two color sets of LEDs per locker cabinet. One set is red and the other is green. The indicators are used to inform the user of the SOC of the phone from up to 50 ft away. This arrangement eliminates the need for the user to constantly approach the charging station and open the locker in order to verify SOC.

The UniverSOL Charge Station differentiates between three States of Charge for each locker, depending on the current level output from the cell phone. When a locker is unused and there is no phone connected to the charging cables inside, the locker does not illuminate. In this case, both indicators will be off to inform the user of an open locker currently available for use. The second state occurs when a phone is plugged into the locker charging cable and draws a full or near full current value, thus charging. This state is indicated by the red LED inside the locker lighting up. The third case results when there is a phone plugged into the locker charging cable, but that phone inside has a fully charged battery. This state is indicated by only the green LED being lit up.

In order to determine the different SOCs, various phones were tested against their current draw at different charging levels. From this data, the current ranges were determined to properly indicate the states of charge in the lockers.

F. Solenoid Locking System

The Electro-Mechanical 12V DC solenoid locks from Adafruit are mounted to each locker door and are used as the system's security locking mechanisms. The locks complement the motivation of the UniverSOL Charge Station with its energy efficient design. When the solenoid lock is in the OFF state, the metal bolt is fully extended out and the door is in the locked position. While in the OFF state, the lock is not drawing any power from the 12V battery. When a signal is sent from the microcontroller, the coil energizes and pulls the metal bolt to the center of the coil. This activates the solenoid lock and releases the spring loaded locker door. These highly efficient solenoid locks draw only 650mA when operating under 12V.

G. Touch Screen

The user interface of the UniverSOL Charge Station is powered by a 4.3 inch color touch screen display. The touch screen is located within the Bay2 locker in order to decrease any glare from the sun, improve the quality of the picture, and prevent any rain damage. Although it is located inside the locker, the locker door has a clear front surface, which makes the touch screen visible even when the locker door is closed.

The user reserves a locker through the touch screen by navigating through a series of menus. Once a locker is chosen to be reserved, the user will be required to create a personal identification number (PIN) to store so only they will have access to the locker. Since these lockers are storing valuable items, it is important to use levels of security to prevent theft.

The touch screen is connected to the 328p microcontroller through 6 digital I/O pins, as well as the 5V power supply and the 328p's ground pin. Having the touch screen powered by the microcontroller reduces the amount of total energy used, making our system more efficient and sustainable.

Fig. 1. Pinout diagram connecting the touchscreen to the ATmega328p microcontroller through the highlighted pins.

IV. MAXIMUM POWER POINT TRACKING

One of the main objectives in the design of this renewable, sustainable system was to ensure this system was functioning as energy efficiently as possible. However, energy harvesting proves to be a challenge in the development of PV systems. As illustrated in TABLE I, the solar panel already loses a substantial amount of the energy received in the conversion process from natural energy to electrical energy. In addition, solar panels do not receive the same amount of power throughout the day, making it impossible to provide a continuous nominal supply of power to the battery.

A further problem arises from matching the voltage ratings of a solar panel to a battery. The panel supply voltage rating is required to be higher than the voltage rating of the battery and is manufactured as so. This is because the charging voltage for the battery is higher than the actual voltage rating specification. As consequences, the system loses additional power when a greater voltage is supplied or the battery will not be charged under low voltage supply conditions.

Finally, certain characteristics of solar panels affect the overall power output of the panel. In particular, a solar panel voltage output decreases as the current drawn from the panel increases. When the current drawn exceeds a threshold, the voltage will collapse and power drawn from the panel will drop significantly, becoming very low.

To maximize energy efficiency and enhance the amount of power delivered from the solar panel to the battery, a maximum power point tracking system was implemented. MPPT is an electrical system that tracks the voltage and current values of the power input using an algorithm to deliver maximum available power when the battery is in a discharged state. It operates to allow the PV system module to produce all of the power that it is capable of [1].

V. Hardware Design

While this project consisted of some mechanical engineering along with electrical and computer engineering, this section primarily focuses on the project design of the electrical and computer systems. Each component was designed and selected in accordance with form, fit, and function purposes.

A. PV System with MPPT

Fundamental determinations formed the framework of the PV system. As a stand-alone system, one day of autonomy was determined a sufficient period of time to operate successfully throughout the prototype demonstration and showcase. Power requirements of total possible maximum consumption by the system were evaluated to be 490.8 Wh/day through an electrical load schedule illustrated in TABLE 2.

TABLE 2
SUMMARY OF ELECTRICAL LOAD

LOADS	QUANT.	WATTS	HRS/ DAY	W-HRS/ DAY
Phones	4	5	24	480
Touch Screen	1	.25	24	6
MCU	1	.2	24	4.8

Sizing the parts properly for the PV system was imperative not only to the system functioning properly, but also for maximizing efficiency.

1) For the rechargeable battery, the industry recommendations qualified for a nominal 12 V for small off-grid PV systems. The battery energy storage capacity was established through the Amp-Hour (Ah) rating and the DOD. The DOD parameter was designed to deplete no less than 60% of the energy when undergoing discharge, another common industry factor. The battery amp-hour capacity rating was calculated using (1).

$$Ah = \frac{Wh/day * Days\ Autonomy}{.85 * Max.DOD * Battery\ (V)} \quad (1)$$

The minimal required Amp Hour Capacity rating was found to be 80.2 Ah. The team elected to use a lead acid battery in the system because it was determined that these batteries were the most in practice with PV Systems and performance delivery dependable. In addition, they were the most eco-conscious and of moderate expense in comparison to lead acid gel and lithium ion batteries. Therefore, the battery for the PV system is the Trojan 12V 89Ah AGM Lead Acid deep cycle battery.

2) For the solar panel, calculations were made using (2) to determine the minimum rating value of the required maximum operating current (Imp). The average amount of sun hours/day received in Central Florida was determined 5.76 through a solar insolation map.

In addition, the solar panel open-circuit voltage (Voc) rating of the panel had to be compatible with the charge controller. In this system, the charge controller specifications called for a maximum Voc of 40 V.

$$Min.Imp = \frac{Wh/day}{Battery\ (V\ )} * \frac{1}{5.76(\frac{h}{day})} \quad (2)$$

A 235W Suntech polycrystalline solar panel was used for the system. The panel Imp rating of 7.79 A exceeded the minimum calculated requirement of 7.10 A. The Voc rating fell below the maximum requirement at 37.0 V.

3) As the component connected in-line between the solar panel and battery, the charge controller had to be rated based on the amperage capacity it can handle at maximum power delivered from the solar panel and voltage levels it will be supplying to the battery. The amperage capacity was calculated using (3). Because the solar panel power can actually exceed the amount of rated power supplied on the highest of irradiation days, a 1.25 NEC power buffer factor was applied for this case. Additionally, the battery charging voltage level maxes out at 14.4 V when a battery is highly discharged, so that maximum voltage parameter was used when rating for the battery.

$$Amp\ Cap. = \frac{Solar\ Panel\ (W)}{Battery\ (V\ )} + (.25 * \text{Amp Cap.}) \quad (3)$$

Selecting a charge controller extended beyond system compatibility between components. Many charge controller products offered on the market provided for built-in MPPT technology. The incorporated MPPT technology increased the expense for the component compared to a basic charge controller. As an alternative route, research was conducted between a few MPPT IC chips from some of the largest semiconductor device manufacturers, like Texas Instrument and Linear Technologies. However, considering the power requirements for the PV system, there were not many High Power MPPT IC Chips available without modifying the circuit which would have been even more costly. Further expenses would have included expanding space on the PCB or the purchase of an additional PCB to house that system. So, a charge controller with a built-in algorithm based MPPT system and DC-DC converter was selected for a more reasonable cost.

The component selected was the 30A/15V Blue Sky Solar Boost 3000i. Beyond the MPPT system, this device features a built-in heat sink and digital display to monitor the operation of the PV system status.

The fully integrated system was tested in the lab and on a cool, intermittent low/high irradiation day (partly cloudy) with the battery discharged below 70%. Because the battery determines the amount of current that flows into it, the PV system had to be in this state, known as Bulk charge mode, in order to achieve MPP gains. If the system had been designed using a basic charge controller that regulates through Pulse Width Modulation (PWM), the current output would not exceed the panel Imp rating of 7.79 A. TABLE 3 illustrates the data collected during testing and the expected PWM output calculated using (4).

$$PWM = Vout * Imp \tag{4}$$

TABLE 3
SUMMARY OF PV SYSTEM ACTIVITY

SETTING	Pin W	Vout	Iout	PV Pout W	PWM Pout W
Lab	150	13.3	10.3	137	67
Low	46	12.9	3.4	43.8	43.8
High	228	13.6	14.4	195.8	105.9

In the lab setting, using a simulated PV power supply, the system achieved a 48% gain. Under low irradiation conditions outside, the charge controller acted as a PWM controller because the current output did not exceed the Imp. Under high irradiation conditions, the system performed exceedingly well with a 54% gain. Normally, gains in excess of 40% can be expected in cooler temperatures with highly discharged batteries. In addition, actual charge current increases can be amplified based on the greater difference between PV Vmp and battery voltage [2]. In this system's case, the Vmp is 37 V, while the battery voltage is 12 V, justifying these high gains.

B. Power Distribution Management System

The station's battery has a 12 V DC while the cell phone batteries charge at 5 V. The team had to overcome the stepping down voltage problem as well as distribution of voltage among the four lockers.

The solution was the implementation of the WAGAN Quad Power USB hub. The WAGAN hub has a single 12 V DC input and four 5 V USB output ports. The device is rated at 6.8 A, with two ports rated at 2.4 A, and the other two rated at 1 A. The maximum current a cell phone can draw while charging is 1A. The WAGAN is equipped with internal overvoltage protection, short circuit protection, and overheating protection for each port, shutting down the port to prevent accidental overload.

The four output lines from this device are fed through a 6-inch Male to Female USB cable, into an in-line current/volt meter. Each port has its own current/volt meter for visual inspection and demonstration purposes, to verify the SOC of each phone. Out of each current/volt meter, a modified USB cable carries the power to the circuit board. The USB male end connects to the in-line current/volt meter port and the other end's flying leads are soldered into the circuit board.

Traces on the circuit board are connected to four linear current sensors. Output traces from the sensors are connected the power cables leading to each locker. When a user plugs in a cell phone to be charged, the circuit is complete from the UniverSOL station's battery to the cell phone battery.

The 12 V battery power is also being fed into the circuit board. This 12 V is being used to control the power to the solenoid locks on each of the four lockers. The 12 V is also being fed to the LM7805 voltage regulator. The output of the voltage regulator is 5 V, and is being distributed to various devices on the circuit board, including the ATmega328p processor and the current sensors.

C. Current Sensors

The UniverSOL Charge station utilizes current sensors to monitor the charging activity of the cell phones. The microcontroller relies on these current readings in order to control the charge status indicators. The current readings are measured by the Atmega328p through the Allegro ACS712 Hall Effect Current Sensors. The current delivered to the phones runs in-line with the ACS712 by connecting into pins 1 and 2 and coming out of pins 3 and

4 as depicted in Fig. 2. The Atmega328p is then able to read a voltage related to the input current from pin 7 of the ACS712.

When the current from the phone is applied through the conductors of the ACS712, a magnetic field is generated that is sensed through the built in Hall Element. The magnetic field and current magnitude are proportional to each other and a linear relationship is created between the output Hall voltage and input phone current. The output Hall voltage is then measured by one of the microcontroller's ADC channels normally in the form of millivolts. The microcontroller interprets the voltage reading in millivolts and sends a signal to activate the SOC charge status indicators.

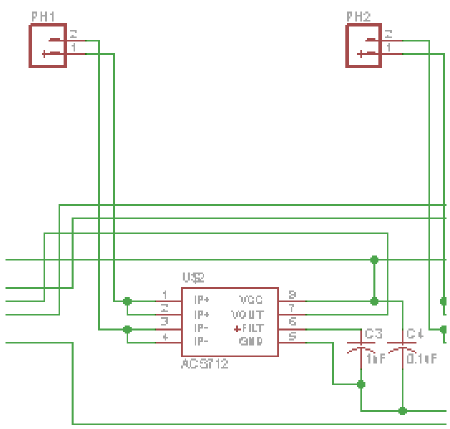

Fig. 2. ACS712 Circuit Schematic.

D. Solenoid Security Locking System

The UniverSOL Charge Station's security system is designed to allow users to feel comfortable about leaving their expensive smartphones locked away in a charging compartment. One of the major deciding factors for using solenoid locks to accomplish this goal was because of the robust and durable design. All of the electro-mechanical components are housed in a thick metal box-frame with pre-drilled holes for mounting.

Once user access has been granted by entering a pin on the touchscreen, a signal is sent from the microcontroller and through an NPN transistor that acts as a switch for the solenoid lock circuit. Once activated, the solenoid locks are programmed to remain in the unlocked position for a total of 4 seconds. As depicted in Fig. 3, a protection diode is placed in parallel with the solenoid locks to dissipate the inductive voltage spikes that can possibly damage other system components.

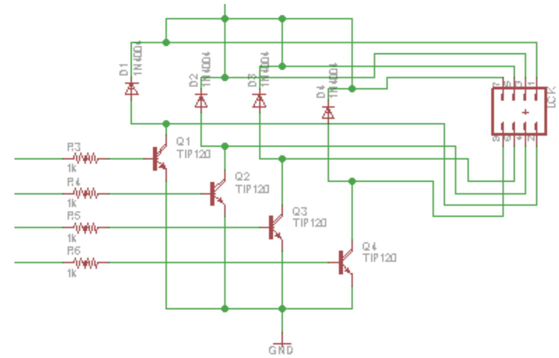

Fig. 1. Solenoid Lock Circuit Schematic.

Alignment of the locks and locking brackets was achieved by mounting the solenoid locks onto a spacing block before mounting them onto the locker door. A block was precisely measured and cut to allow the solenoid locks to be positioned so that the doors can lock and unlock without any complication. A small excess of wire from the solenoid lock to the PCB board is looped around the door hinges which prevents the doors from interacting with the wires.

E. Cabinet Illumination

In order to allow the user to see the charging condition of the phone up to fifty feet away, LED indicator lights are strategically placed to be viewed through the window in the locker door. To account for visibility, this is accomplished by the use of three LEDs wired in parallel.

The LED indicator system is mounted using a perfboard located in each charging locker. When the LED components are soldered into the board, the solder joints merely keep the components in place and do not create a circuit. All electrical connections are made externally on the back side of the board. Documentation found on the ATmega328p processor website suggests the use of 220ohm resistors. One end of the resistor is tied to signal in, the other end is tied to the anode of the LED. The cathode of the LED is then connected to the ground.

The team decided to use super bright 5 mm LEDs with 3.2-3.8v forward voltage at 20milliamps. Maximum continuous current is 30 milliamps with 8000 millicandelas typical brightness.

Three wires come into the board: the red relates to the red positive, the clear relates to the green positive, and the black is the common ground for both. The cathodes of all the diodes are tied together and fed to ground terminal header to reduce extra wires coming into the perfboard. The red positive connects all three resistors in the red LED circuit. Similarly, the clear positive connects to all three resistors in the green LED circuit. So, each circuit is wired to receive one positive signal to illuminate the three LEDs. When the positive signal is removed, the LEDs will no longer illuminate.

All connections on the back side of the board are made with non-insulated buss wire. Four boards were manufactured and tested, and the LEDs were adjusted to allow for the best view angle to the user. Each unit was mounted on 1.5 inch stand-offs. Not only do the stand-offs prevent the possibility of shorts, but also brings the LEDs closer to the viewing window. For best viewing, each board is mounted to the rear wall inside of each charging locker.

V. Software Design

Since the UniverSOL Charge Station is constantly reading input voltages, and converting those into current levels, the program is run under a continuous loop with function calls to respond to events in the system. Events in the system can be triggered by different current levels and user inputs on the touch screen. Each of these events then relates to a specific function call to execute the desired response.

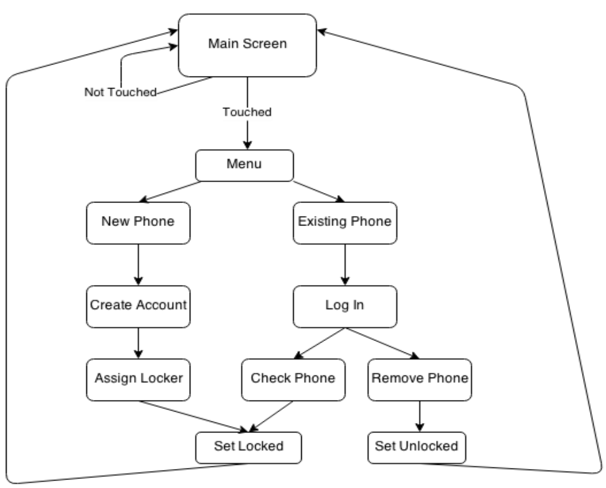

Fig. 4. Flowchart for the user interface of the touchscreen.

Fig. 4 above shows the flowchart for the user interface through the touch screen display. Each node in the user interface will be a difference graphical menu displayed on the touch screen requiring a user input. The menu state will be saved at each point so the touch screen will know which screen to display on the next loop iteration. The screen will have a time out that after 20 seconds of no input touches will return to the main menu, and then the power-saving mode. This is to decrease the overall power used by the whole system, and to make sure the complete system is as efficient as possible.

User data will only be stored in the system while the locker is used, and then will be erased to prevent any kind of theft of devices, or of valuable user information. Reserving a locker through the touchscreen will require a PIN to access the locker and unlock or lock the door. In order to prevent the mistyping of data, or forgotten PINs we are requiring the user to input the matching PIN twice to ensure matching numbers, and prevent accidental number presses.

The ATmega 328p chip will control the LEDs in each locker through a 74HC595 shift register. Through synchronous serial communication, and an array of bytes, we can control 8 digital pins powering an LED using only 3 pins from the microcontroller. Diagram of the shift register expanding 3 pins to 8 is shown in Fig. 5.

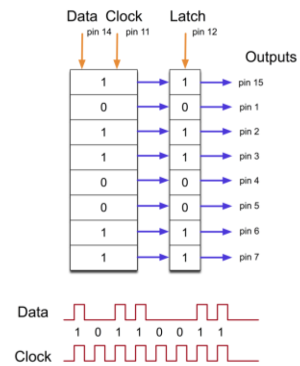

Fig. 5. Diagram for outputting lighting indicators through a shift register. Maps 3 digital pins to 8 digital pins. [3]

VI. Board Design

All of the designed circuitry for the UniverSOL Charge Station was designed using CadSoft's Eagle PCB Design Software and placed onto a Printed Circuit Board (PCB). Electrical components were uploaded from various libraries into Eagle to precisely match the specific requirements of the specific components of the system. A schematic of the system's designed circuit topology was first created and then converted into a PCB design.

The board components and traces were meticulously laid out by hand onto the PCB board as shown in Fig.6. It is a two layer board with a combination of surface mounted and DIP hole-through packaged electrical components. The Atmega328p is seated in a 28-pin DIP hole-through socket for easy transferability between the PCB board and the Atmega328p development board. All other electrical components are directly soldered onto the PCB board. Having a majority of the DIP electrical components on the PCB board allowed the UniverSOL Charge Station team to mount the components ourselves, essentially giving us the freedom to troubleshoot any issues directly. The traces are laid out across the top, bottom, and a combination of both to complete the circuit.

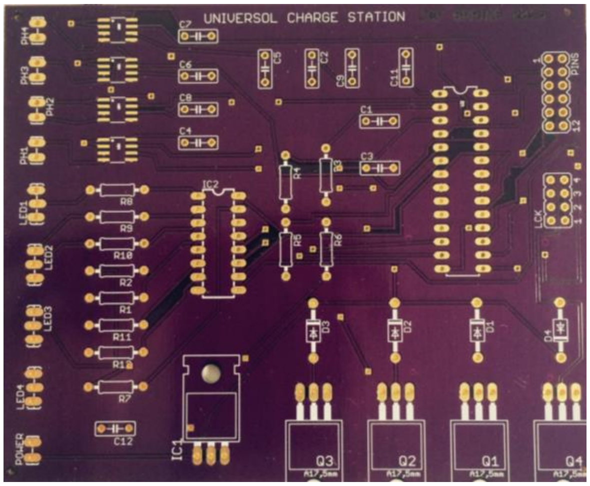

Fig. 6. Designed PCB Board.

VII. Conclusion

The UniverSOL Charge Station project was a valuable experience in the research, design and development phases. Group 17 engineers acquired new knowledge in embedded system, user interface software, power system, and renewable energy design. Above and beyond technical experience, an understanding and appreciation of the interdisciplinary field of engineering was achieved through project planning and management, analysis, demonstration, reporting, and presentation.

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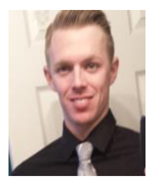
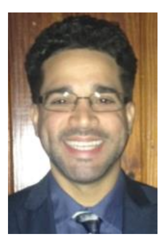
GROUP 17 ENGINEER BIOGRAPHIES

Amy Parkinson is currently participating in the University of Central Florida CWEP Co-op program at Lockheed Martin as an Electrical Engineer intern. She has earned an Associate of Science in Architectural Engineering Technology from The Pennsylvania State University. Upon graduating with a Bachelor of Science in Electrical Engineering, she will be joining the Lockheed Martin team as an Electrical Engineer at the Mission Systems and Training facility in Orlando, Fl.

John Curristan is currently a senior at the University of Central Florida and will receive the degree of Bachelor of Science in Electrical Engineering in May of 2015. He earned an Associate of Science in Electronics and Robotics from Henry Ford Community College, Dearborn, Michigan, and had a career in the automotive electronics industry before pursuing his BSEE. His plans are to establish a new career in electrical engineering in central Florida.



Brock Stoops is currently a senior at the University of Central Florida and will graduate with honors in May of 2015 and receive a Bachelor of Science degree in Computer Engineering with a Minor in Mathematics. After graduation he will be relocating to St. Petersburg, FL to begin his career as a Software Developer at American Express



Jonathan German is currently working as a Transmission Line and Substation Engineering Intern at Lazen Power Engineering. He will be earning a Bachelor of Science degree in Electrical Engineering in May of 2015. After graduation, Jonathan plans to become a licensed Professional Engineer (P.E.) and pursue a rewarding career in the Power and Energy industry.