Keur-Keg: A 5 Gallon Automated Home Beer Brewer

Jason Carlisle, Laura Hoshino, Kyle Rits, and Kevin Ruzich

Dept. of Electrical Engineering and Computer Science, University of Central Florida, Orlando, Florida, 32816-2450

Abstract **— This paper presents the design methodology utilized to realize the software and circuitry of the automated beer brewer. The process of brewing beer can be tedious and long which allows room for error and inconsistency of the product. A perfect brew of a certain recipe can be difficult to achieve because the timing, temperature, and processes need to be precise. In this system the user inputs a recipe and then loads all of the ingredients into the correct dispensing units, the system will complete most of the brewing and fermentation process with the push of a button and minimal user interaction saving hours of time and making it so the user can achieve a consistent product every time they brew beer.**

Index Terms **— Automation, circuit testing, software testing, temperature control .**

I. Introduction

Home brewing has become significantly more popular as craft brewers have introduced people to the different flavors that can be achieved with beer brewing. Although this has allowed the consumer to narrow down and understand what specific flavors they may enjoy from their beer, the beer may not be easily repeatable at home. By having an automated beer brewing system, the user would then be able to make more of their favorite batches to keep it readily available for themselves and loved ones. The automation of the brewing processes also allows the user to still enjoy the brewing process but spend that time on something else. Currently there are similar products on the market for small scale personal brewing systems that can achieve proper consistency and temperature throughout the entirety of the process for the steps previously described that we would like to replicate and improve upon. In addition, the scale of the automated beer brewer that we have produced is a larger than most of the products currently available on the market. This product can produce five gallons of beer for the fermentation process while most of other products available for home brewing produce two gallons or less.

II. Project Objectives

The objectives for this project include having the total output current as minimal as possible, all parts to work in sequence with the MCU, to obtain a successful product output of 5 gallons using multiple different recipes, a battery backup for the MCU, the ability to save recipes, and having a consistent final product every time. The desire is to be able to plug the system in to any 120V, 20A outlet and have the system operate at full capacity. The reasoning behind limiting the system to a 120V, 20A outlet is because this is typically available in most homes. Some of the home brewing kits that are available for an output of five gallons use a 240V outlet which although can be easily installed in homes, it becomes more work for the user. This objective was completed by performing careful research on the parts needed and then selecting the proper parts to build the system. In order to stay within the bounds of a typical 20A circuit, the MCU controls the loads that will be on at the same time. To achieve the optimal output and proper consistency, the MCU had to be coded properly allowing it to communicate between the timers, sensors, motors, and pumps. Consistent products every time relies mostly on proper coding of the MCU to ensure precise timing, temperature, and mechanical operations. A battery backup for the MCU is an important objective because if a power loss occurs at any time the timer on the MCU still continues.

III. System overview

This section will provide an overview of the major subsystems that are necessary in order to automate the beer brewing process.

A. User Interface

For the system to be automated, the user must initialize the process by choosing certain aspects of brewing process, such as the steeping time, boiling time, the number of hops and at what times, etc. The user interface occurs via a touch screen.

B. Communication

The communication occurs between the MCU and the user input, the sensors and components that have to be turned on or off such as the heater, mixer, and pumps. The sensors and the user input provide the MCU with the feed back necessary to determine when they should be turned on or off. There is also communication that occurs between the microcontroller and the internet via a WiFi module in order to let the user know at what stage the automated brewer is at that may need the user's attention.

C. Data Acquisition

During the entire brew process that system receives data about how much fluid is in the pots, ensuring that the heaters are surrounded by fluid, and constant temperature readings from thermistors as the brewing process moves into each stage. The main sensors in the system are a flow meter, float switches and thermistors. The sensors' data is relayed back to the MCU and the temperature is displayed on the interface board for the user to see.

D. Power Distribution

This system deals with both AC and DC power. 120VAC was used for the heaters, pumps, and the refrigerator. From the 120VAC, a switching 12VDC power supply was used to step down the voltage for the solenoids, float switch, flow meter, actuator, fan, actuator, and mixing motor. Then we designed a circuit with to step down the voltage from 12VDC to 5VDC using Texas Instrument's TPS563231DRLR voltage regulator. Texas Instrument's TPS560430YDBVR voltage regulator was used to step down the voltage from 12VDC to 3.3VDC.

E. High Power and Low Power Switching

This system makes use of 120VAC power for the heaters, pumps, refrigerators. The system needed to be able to control those high voltage components. The microcontroller was only capable of outputting at most a 5VDC so relays were used that could receive signals from the MCU to allow 120VAC power to flow through them. The system also controlled the lower voltage components via relays such as the solenoids and mixing motor.

IV. Automated Process Control

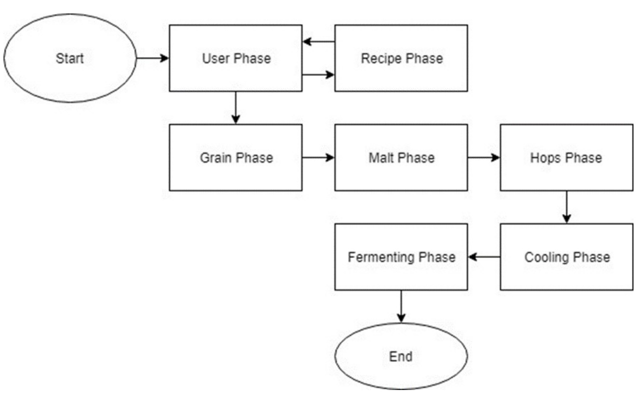

Fig. 1. Overview of the software flow diagram for the brewing process.

A. User and Recipe Phase

As seen in Fig. 1, the software starts with the user interface, where the user can manage recipes, select which recipe to use, manage WiFi settings, and start the brewing process. The software saves all of the WiFi settings and recipes into the microcontroller's EEPROM. To prevent errors in the brewing process, all recipe values are checked for bad or empty data, and the user is not allowed to save the recipe until it is valid. Once the user selects a valid, non-empty recipe, they are allowed to start the brewing process.

B. Grain Phase

In the grain phase, the system starts by filling the first pot with the initial amount of water designated by the user. Next, it heats up the water to the user designated temperature and starts a timer for a period of time input by the user. During this time, the system controls the temperature between ±5° Fahrenheit. After the timer has finished, the system transfers the liquid to the second pot and starts the next phase.

C. Malt, Hops, and Cooling Phase

Once all the water has been added to the second pot, the system turns on a heater and mixing motor and waits until the water reaches a boil. It then starts a timer and checks if the recipe requires liquid malt, due to the physical properties of malt, designing an automated dispenser proved to be beyond the scope of this project, therefore the user is notified via email when it is time to add malt if malt is part of their recipe. As the timer progresses, the systems checks if it is time for any hops to be added, if it is, then the system activates a linear actuator which drops the hops into the second pot. Once the timer finishes, the system turns off the heater and starts cooling the liquid by pumping it through a hose that is in ice. Once the liquid is cooled, it is transferred to the fermentation pot inside of the refrigerator and the fermentation phase starts.

C. Fermentation Phase

In the fermentation phase, the microcontroller monitors the temperature to be within ±5° Fahrenheit of the recipe's required temperature by turning on and off the refrigerator as needed. The system also starts a timer, and checks if and when extra ingredients needed to be added, due to the unknown nature of what types of ingredients the recipe might call for, there was not enough information to design an automated dispenser, therefore, once again, the user will receive a notification via email when it is time to add the fermentation ingredient. Finally, when the timer for fermentation finishes, the user is informed via email, and the system continues to monitor the temperature until the user presses a "continue" button on the user interface, at which point the system goes back to the User Phase.

V. System Components

A. Microcontroller

The system makes use of one microcontroller, the ATmega2560. This microcontroller was chosen because it had an ICSP header, which makes sending code to the microcontroller much easier. In addition to this the ATmega2560 has 27 digital I/O pins, 8 PWM digital I/O pins, 16 ADC pins, 3 TX/RX communication sets, a 3.3V voltage regulator, a reset button, a protection circuit for VCC and GND, and an output to the sub PCB containing SPI communication (MOSI, MISO, SCK, and CC), 1 set of TX/RX, a 3.3V connection, 2 digital I/O pins, and 3 PWM digital I/O pins. This microcontroller is capable of outputting 5VDC and 3.3VDC signals for controls. It requires a 5VDC power input as with several components throughout the system. The microcontroller controller operates the following components directly: relays, temperature sensors, float switches, flow meter, and WiFi module. Through the relays, the microcontroller is also able to operate the filling/transfer pump, cooling pump, heating elements, refrigerator, solenoids, actuators, and the mixing motor.

B. Power Supply

The system has 120VAC, 12VDC, 5VDC, and 3.3VDC power requirements. The voltages required for the different electrical components in the system are shown below in Table 1. The main power for the power distributions system will be coming from a single standard 120V, 20A outlet.

TABLE I
Summary of Voltage Requirements

Voltage	Use
120VAC	Filling/transfer pump, cooling pump, heating elements, refrigerator
12VDC	Temperature sensors, solenoids, float switch, flow meter, actuators, fan, and mixing motor
5VDC	Relays, microcontroller
3.3VDC	WiFi Module

The power distribution system consists of the 120VAC outlet, a terminal block, a 12VDC power supply, three 5VDC regulators, a 3.3VDC regulator, and a 9V battery. Figure 2 shows the basic layout of the power distribution system. The whole system will connect to a 120V, 20 A outlet which is protected by a GFCI plug. That 120VAC power will first feed a terminal block that will then feed the relays that switch the power for heating elements, filling/transfer pump, cooling pump, refrigerator, and finally a 12VDC power supply. The LEDMO Switching 12VDC, 10 A, 120 W power supply was chosen to step down the voltage from 120VAC to 12VDC. This power supply was bought instead of designed in order to reduce the overall cost of the power supply system. This power supply was chosen due it being able to produce the minimum of 8A that was needed to keep the whole system running. The 12VDC provided by the LEDMO switching converter was then connected to a single PCB with two circuits designed using Texas Instrument's Power Architect that would convert the 12VDC to 5VDC and 3.3VDC.

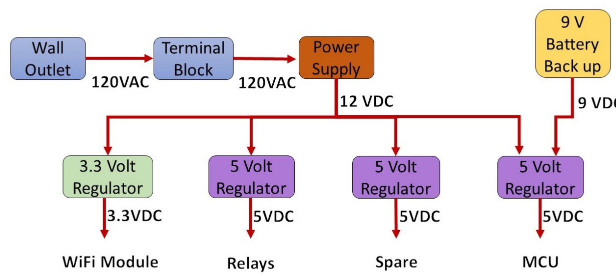

Fig. 2. Overview of the power distribution system.

The power distribution system was connected as shown in Fig. 2. For the 5VDC power, Texas Instrument's TPS563231DRLR synchronous step-down voltage regulator was used. For the 3.3VDC power, Texas Instrument's TPS564201DDCR synchronous step down voltage regulator was used. Through the different iterations of the design of the power supply, it was decided to separate the 5VDC power into 3 separate circuits to reduce the current going though each 5VDC circuit. By doing this, it simplified the circuit so it made the circuit easier to troubleshoot and allowed spares to be available. In addition, by separating the 5VDC loads to separate circuits, the MCU could be isolated to its own power supply circuit. By separating the MCU to its own circuit, a back up battery system was easily integrated by using 2 Schottky diodes to allow the flow of electricity in the intended direction of only towards the MCU. In the event of a power loss, the 9V battery automatically supplies power to the MCU .

Fig. 3, shows the schematic for the 5VDC power supply. The Schottky diodes allow current to flow through the voltage regulator without back feeding the other power supply and possibly causing issue. The Schottky diodes chosen were the PMEG40T10ER by Nexperia. This diode was specifically chosen for its low forward voltage at a maximum of 460mV and very low leakage current. Choosing a diode with a minimum leakage current was important because the 9V battery back up is not meant to be charged and therefore needed this protection. The 9V battery is meant to maintain power to the MCU in cases of temporary power loss.

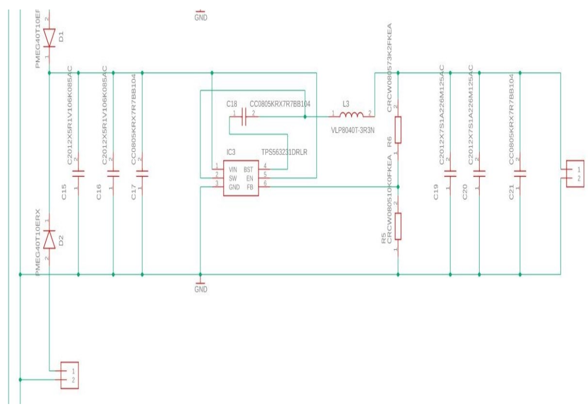

Fig. 3. Partial power supply schematic focuses on the MCU power supply circuit.

The power supply PCB was kept separate from the MCU PCB in order to make it easier to troubleshoot. In addition, we could then easily layout everything in the control cabinet. Figure 4 below shows the layout of the power supply PCB.

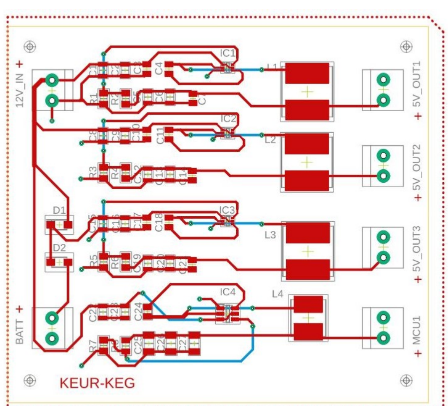

Fig. 4. Power supply PCB board layout.

D. Relays

In order to control the power in the entire system, the system used two different relay boards. The first were two 16-channel 12VDC relay boards manufactured by Wal Front that supported a high/low level trigger of 5VDC and had a rating of up to 250VAC at 10A and 30VDC at 10A. This board was originally bought for testing and then a similar board was designed with this relay board in mind for the system. This board was used to control components in the system that did not have large current draws and any voltage. This includes the solenoids, the mixing motor, the linear actuators, the fluid transfer pump, the cooling pump, and the refrigerator. The relay board is user friendly and can be used with most MCUs. Since the ATmega2560 is able to provide 5VDC signals it was able to properly control the relay boards. Having this many relays allowed the system to have spares, should a relay burn out, and it allowed for flexibility of scalability of the system as elements of the system were being tested.

Another relay had to be used for the two heating elements due to their large current draws at 13.75A. The 16-channel relays previously discussed were only rated for at most 10A loads. The relay board used for the heating elements was a 2-channel, 30A board manufactured by Electronics-Salon. This relay was chosen because it could accommodate the current draw, it had a 5VDC coil voltage, and had 2 channels for the two heaters in the system. Since this relay could be controlled by a 5VDC signal it was compatible with the abilities of the MCU to provide a 5VDC on and off signal to the heaters. Because this relay board was mean for higher current, reproducing the board was cost prohibitive, so the board that was bought was the board that was used.

E. Touch Screen Display

The touch screen display used for the user interface was the 7” ER-TFTM050-5 screen with the capacitive touch panel manufactured by East Rising Technology Company, Limited. This display was used in conjunction with the RA8875 40-pin driver board produced by adafruit. Compared to other forms of user interface this was chosen because it was more appealing to the consumer, since most products are moving towards touch screens, and it was more intuitive for the user. The cost of the screen was also very low, considering this interface allows for both input and output in one device. For the functionality of this project, using the driver allowed for less pin connections that directly connected to the MCU, making it much easier to trouble shoot any problems with connections or pins not working properly. The touch screen also allowed flexibility in what could be displayed to the user and the type of interaction to be asked of the user. With the screen, the user was provided with only the potential input characters needed, which eliminated unknown results of invalid character inputs. The user is able to see the information they input for recipes as well as see what stage of the brewing phase the automated system is currently in. Fig. 5 shows the options available for the user to input for every time they set up a new brew.

Th user is able to input the initial amount of water to be used up to 3 gallons, the steeping temperature, the steeping time, the boil time, the number of hops dispensed up to 4, the times at which hops should be dispensed, the fermenting temperature, the fermenting time, the number of ingredients to be added during fermenting, the times at which the extra ingredients should be added during the fermenting phase, and finally if malt will be used.

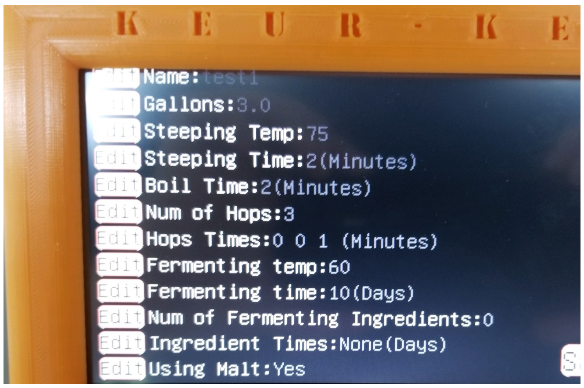

Fig. 5. User interface display for brew recipe options.

F. WiFi Module

The system relies on the display to show notifications and the WiFi in order to send notifications via email to the user when liquid malt should be added, the brewing cycle is finished, and to add hops during the fermentation process. The WiFi module that was used is the ESP8266 manufactured by Espressif Systems. This module was chosen because of its low cost, large community support, and compatibility with the MCU that had already chosen.

G. Motors and Pumps

For the automated brew system, it required two fluid pumps and one mixing motor. One fluid pump was to transfer water and the various brewing fluids throughout the fluid transfer system. The other fluid pump was used to pump cold water through the cooling system. Both of these pumps were Pentair’s Shurflo 2088 series pumps. They were both rate for 115V, self-priming, and had the ability to pump water up to 12 vertical feet. This was important to prevent backflow of any liquid so that the brew fluids do not accidentally flow back into the clean water reservoirs. The pump is able to transfer liquid at about 3.3 gallons per minute. It was important that the pump be self-priming so that it could run dry at first without harming itself, since when the pumps initially start any brew cycle or sanitizing cycle there will not be any fluids in the fluid systems. The pumps also have an automatic turning on and off feature to maintain the pressure in the hose line at 45-psi. Although both pumps are from the same series, the filling/transfer pump was specifically chosen to be able to withstand the heat from the fluid that comes from the mash and boil stages of the brew process and was therefore a little more expensive. For the cooling pump the upper temperature range limit did not matter since it was running icy water, which helps to keep itself cool.

The mixing motor is used in the boil pot with a stainless-steel mixing paddle. The motor is a 50-rpm synchronous motor. The mixing motor was chosen for its low cost and low current draw. During testing, it was determined that in the boil pot, once the liquid or dry malt had been properly mixed in then, then the mixing had to stop in order for the brew to be able to reach a boil. Once the boil begins, the MCU receives a signal from the thermistor that the target temperature has been achieved and the mixing can start again.

H. Sensors

The three main sensors that were used to provide feedback data of the system to the MCU are a flow meter, thermistor, and float switch. The flow meter sends data to the MCU with how much water, in gallons, to intially fill the steeping pot. The flow meter use was the 1/2” Water Flow Sensor manufactured by Gredia. The flow meter has a working voltage of 5-24VDC and has an accuracy of within ±2%. Another important factor in this flow meter was that it was food-grade, since the product of the automated home beer brewer is a product that will be consumed by the user.

The next sensor that provided important feedback during the automated brew process was the thermistor. This was crucial for the consistency of the beer brew, since temperature and times sustained at certain temperatures greatly affect the taste and alcohol levels in the final fermented product. A thermistor operates by having extremely high resistance when the temperature is low and as the temperature increases the resistance quickly drops off. The thermistor used in our system was a Type 2, 10kOhm resistance thermistor manufactured by Mamac Systems.

The last sensor used in the automated beer brew system, is a float switch. The float switch serves two purpose in the system. If the float switch is not activated in the steeping and boil pots then the heating element will not turn on since the float switch has not sent a signal to the MCU. It serves as a safety feature to prevent the heating elements from turning on before they are fully submerged in water, which could seriously damage them. The float switch in the fermenter serves the purpose of providing a stop signal to the MCU of when to stop filling the fermenter with water to the 5 gallon mark. Since at the fermenting stage it is difficult to gauge how much water has boiled out of the system, the flow meter could not be used and instead the float switch is at the physical location of the five gallon fill mark in the fermenting container. The float switch used in the system was the DerBlue stainless steel float switch. This sensor was chosen because it was able to handle the boiling temperatures that occur during a brew and it was made of stainless steel. The stainless steel was an important aspect of the float switch since it is better able to hold up to the acids encountered during the brew process. Stainless steel also does not produce or retain any flavors like other metals may.

I. Solenoids and Linear Actuators

A big part of the automation for the beer brewing process were the solenoids and the linear actuators. These two components were what directed the movement of the physical elements of this system such as water, grains, malt, hops, and brew. The solenoids were an integral part of the fluid filling/transfer systems since the system only uses a single pump. Each solenoid was connected to a relay on one of the 16-channel relay boards, which connected back to a digital I/O pin on the MCU. When the MCU would give the 5VDC signal to open or close, the solenoids were then powered by 12VDC power to open or close. The system uses the DIGITEN ½" 12V electric solenoid due to its low cost and ability to withstand boiling water temperatures. During individual component testing, the solenoids drew 0.6A to open or close. Once all systems were combined, the solenoids were retested and it was determined that the opening of the solenoids were resetting the MCU. When the solenoids were opening after having been closed, it was creating a spike in voltage and current was backflowing into the MCU and causing it to reset until the solenoid coil ran out of magnetic energy. In order to fix this problem, a diode was placed at the terminals for each solenoid. The cathode of the diode was place on the hot terminal and the anode was paced on the neutral terminal of the solenoid. This resolved the issue of the solenoids resetting the MCU.

In order to dispense hops and powdered malt, linear actuators were used to open and close the storage containers that the user can prefill with ingredients to be dropped into the boil pot. The linear actuators are controlled by the MCU by way of a 5VDC signal to 2 relays on the 16-channel relay boards. One relay extends the linear actuator, so the container is sealed and the other relay retracts the linear actuator so that the ingredients are dispensed. The linear actuators used were the NEW Jia Qun 2" stroke heavy duty linear actuator. The maximum force provided by the linear actuator was 225lbs which was more than necessary to the gate valves that sealed the ingredient dispensers. When individually tested this component drew 0.7 A at 12VDC and operated with no problems. After combining all the components into one system, this component also caused the MCU to reset when it was being tested as one system. After some troubleshooting, it was discovered that the actuator motor was producing noise that interfered with the MCU. In order to resolve this issue, a 200pF capacitor was added to each linear actuator to filter out any noise it produced. After the capacitors were implemented the MCU worked properly.

J. Heating Elements

The automated brew system uses two heating elements, one in the steeping pot and the other in the boil pot. A low watt density heating element that could be fully submerged was chosen because it was the most efficient way of heating up the water in a safe way. The reason for going with a low watt density heating element was it would minimize the amount of minerals from collecting on the heating element. The heating element was limited to 1650W in order to be able to run the system on a typical 120V, 20A circuit. The heating element specifically used for this system was the DERNFORD 120V, 1650W foldback water heater element. The heating element was made of stainless steel, like most other parts of the system in order to withstand the caustic nature the brewing process.

VI. User Communication

The system has two methods of communication with the user, a touch screen and email. The touch screen is controlled through the RA8875 driver board. This allows for the microcontroller to control the 40-pin touch screen through just 8 pins. The microcontroller communicates with the internet through the ESP8266 WiFi module via serial communication.

During the user phase, the touch screen is used to control the WiFi settings, display existing recipes, allow the user to input new recipes, manage old recipes, and select a recipe for use, and then allow the user to start the selected recipe. During the brew cycle, the user interface is used to show what cycle the process is in, how far along the cycle is, as well as information about the cycle, such as the amount of water added, and the current temperature.

In order to send emails to the user, the microcontroller has to access a secondary server due to the security protocols of most email servers. The microcontroller sends a signal to IFTTT.com, which has the desired email commands, and sends the corresponding email depending on which signal was sent.

VII. Physical Design

The following will give an overview of the physical design of the automated brew system design as shown in Fig. 6.

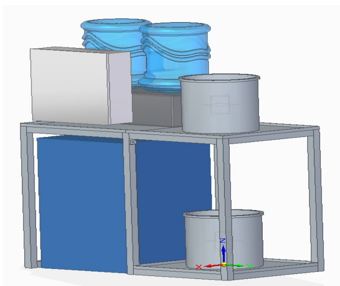

Fig. 6. Physical design layout of system.

A. Stand

The aluminum stand was custom built for the purposes of housing the automated home beer brew system. The aluminum stand has a place to hold a 7 gallon water reservoir and two 5 gallon jugs. In addition, it holds the control cabinet which houses all the electronics and power distribution systems in one convenient location. The steeping pot sits on the top right part of the stand and the boiling pot sits on the bottom right part of the stand. This was done so that the fluid transfer system could be contained on mostly the right side of the system.

B. Fluid Containers

The water reservoir and water jugs are plastic and combined can hold a total of 17 gallons of water. This is enough to not only brew but to then be able to do a sanitizing cycle prior to brewing and a flush cycle immediately after brewing. The steeping pot, boil pot, and sealed fermenting pot are all stainless steel and are capable of holding at least 5 gallons of fluid.

C. Control Cabinet

The control cabinet houses all the electronics and power distribution system of the of the automated home beer brew system. This was done for convenience and to protect the electrical components from water intrusion. Fig. 7 shows the layout of the control cabinet. The blue PCB is the PCB with the WIFI module. The green PCB contains the MCU. The red PCB is the power supply system. The 12VDC power supply is located at the very top right of the control cabinet. The red board with the blue relays is the 2-channel relay board. The two white boards are the 16-channel relay boards. Finally, the bottom of the control cabinet has a din rail with terminal blocks mounted to it. All the PCBs are mounted with standoffs so that they were easily removable to be able to work on them or easily swap them out. In addition, most of the cables are run through the cable trays in order to keep a neat and orderly look to the control cabinet.

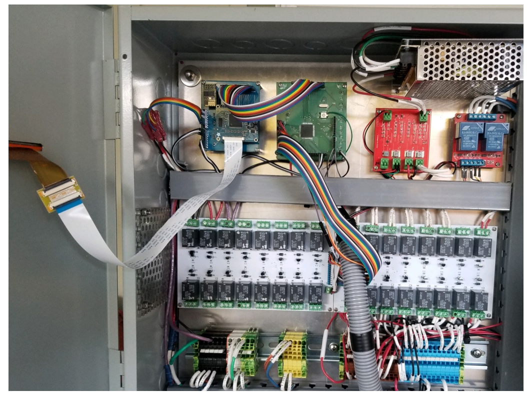

Fig. 7. Control cabinet layout.

D. Mini-Fridge

The mini-fridge is important for the fermenting process because it contains the fermenting pot in it. It will maintain the temperature of the fermentation process at the user defined temperature. This can be anywhere from 30 to 70 degrees Fahrenheit. The mini-fridge temperature is controlled by the MCU turning it on and off via a relay.

VIII. MCU and Sub PCB design

This section will discuss the PCB design for the main and sub PCB the worked in conjunction with it. Several PCBs were designed and ordered for this project. The main and sub PCB were the brains of the project, providing connection between all sensors process that needed to occur.

A. Main PCB

The main PCB was designed in Eagle starting with a blank ATmega 2560 chip. An excel document was created to verify and map all 100 of the pins on this MCU. The pinout of the MCU consists of 27 digital I/O pins, 8 PWM digital I/O pins, 16 ADC pins, 3 TX/RX communication sets, a 3.3V voltage regulator, a reset button, a protection circuit for VCC and GND, and an output to the sub PCB containing SPI communication (MOSI, MISO, SCK, and CC), 1 set of TX/RX, a 3.3V connection, 2 digital I/O pins, and 3 PWM digital I/O pins. The power consumption was then tested for all components needed to run the entire project. These components consisted of all the inputs which are the temperature sensors, flow meter, float switches, WIFI module, and LCD display. The outputs were also tested for switching relays on and off, turning LEDs on, and having loads on the 5V and 3.3V circuits. This was done to test and verify the ATmega 2560 could handle all the components needed to operate the project under a worst-case scenario. The schematic was then created and checked for any errors and warnings before the board layout was created. After creating the board layout, the traces were carefully routed, and the correct sizes were taken into careful consideration before finalizing. Bigger traces were needed for circuits that operated under heavier loads. The final board layout is shown in Fig. 8.

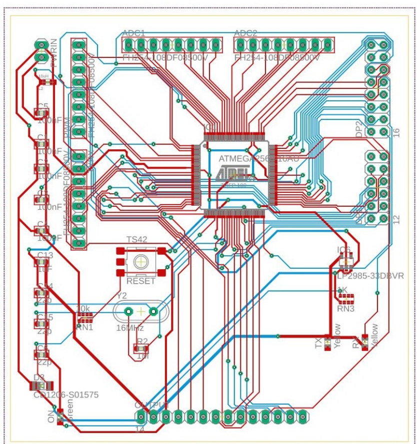

Fig. 8. Main PCB board layout.

B. Sub PCB

A sub PCB was created in this case and was used specifically for the voltage divider circuit for the temperature circuits, the communication board RA8875 for the LCD display, and the WIFI module. This was needed in order to complete the testing on these components without having to alter the MCU and also to complete the testing on the MCU. This board consists of the same 14 pin input from the MCU, extra 5V and GND connections, 4 ADC connections, 4 10K Ω resistors for the temperature voltage divider circuit, and extra 3.3V pins. The components on this board are all easy to solder components so if changes are needed later in the project, it would be easy to re-design, create, and install. The layout for the sub PCB is shown in Fig. 9.

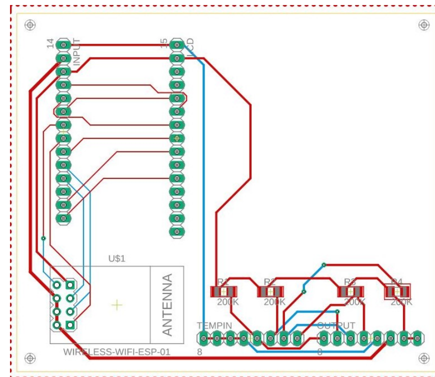

Fig. 9. Sub PCB board layout.

IX. CONCLUSION

This project has provided valuable engineering design experience, both electrically and mechanically. The project began with the design process, then moved on to professional documentation and testing of individual parts, then all the parts and systems were combined, and finally testing of the final product. This project has also provided the team members with experience in managing a project from concept to finish. From coming up with an idea, to providing a budget, researching existing and new technologies, and all the way up to building the product. The team had to figure out how to automate the mechanical processes that occur during the beer brewing process, such as the transferring of fluids and boiling water to certain temperatures. This involved providing controls loops with sensors to provide feedback and an MCU to send out controls signals to various relays that operated solenoids, pumps, and heating elements. In addition, one of the main design constraints was maintaining the whole system to work on a standard 120V, 20A circuit, which the team has managed to accomplish. Many challenges were encountered that typically occur, such as redesigns and processes not working, but the team took these challenges head on to overcome the obstacles. The system has met the original goal of automating the beer brew process through the transference of the beer brew into the fermenter and allowing the user to decide the final process of the beer brewing experience, bottling or kegging the brew.

BIOGRAPHY

Jason Carlisle is currently a senior student of the electrical engineering department at the University of Central Florida and will receive his Bachelor's of Science in Electrical Engineering in December of 2019. He started his career in the electrical field in 1997 moving on to obtain a masters license in the electrical field. After many years traveling the world installing and maintaining laboratories for his current employer, Germfree, he moved into his current position of electrical engineer. He plans on continuing his education and ultimately obtain his PE.

Laura Hoshino is currently a senior student of the electrical engineering department at the University of Central Florida and will receive her Bachelor's of Science in Electrical Engineering in December of 2019. Laura is currently working at The Walt Disney Company as an Associate Electrical Specialist with their Architecture and Facilities Engineering division. Upon graduation she will be promoted to Associate Electrical Engineer with the same division. Laura plans on continuing to expand upon her knowledge of MEP (Mechanical Electrical, and Plumbing) engineering and eventually obtain her P.E. license.

Kyle Rits is currently a senior student of the computer engineering department at the University of Central Florida and will receive his Bachelor's of Science in Computer Engineering in December of 2019. He will commission into the United State Air Force as a 2^{nd} Lieutenant and pursue a career as a Cyber Operations Officer.

Kevin Ruzich is currently a senior student of the electrical engineering department at the University of Central Florida and will receive his Bachelor's of Science in Electrical Engineering in December of 2019. Kevin spent seven years in the United States Navy, worked on the installation, commissioning, and the troubleshooting of wind turbine generators across the US and Canada, and worked for Mitsubishi on machinist equipment. Kevin decided to quit his job and enroll full time in school to complete a lifelong goal of obtaining his Electrical Engineering degree. Upon graduation he plans to take a month or so to travel the United States once again, search for the perfect job, and work hard at becoming a great engineer. He also plans on obtaining his P.E. license as soon as he finds out what state he will be living in.

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