I-Bottle

ECE 445 Design Document

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Team 58

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Contents

1. Introduction

a. Problem and Solution

Induction kettles are extremely popular, even compared to gas powered stoves. The issue with a kettle is the transfer of hot liquid to a thermally insulated container to steep your tea or make your coffee. We propose an all in one solution that will heat your liquid to the desired temperature and warm on the go.

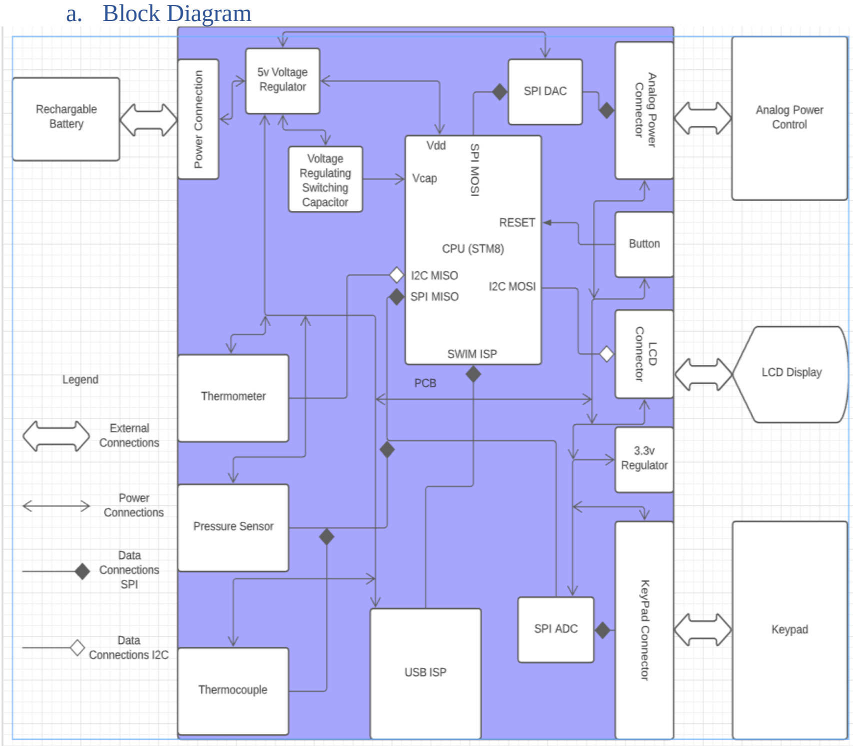
b. Visual Aid

c. High-level requirements list:

1. The induction heating coils will supply 10-20 kW to the base heating plate to boil the liquid inside the container in as little as 5 minutes.
2. Sensors attached to the bottle will measure the temperature of the liquid within 0.5 degrees Celsius.
3. The wireless induction charging pad will transfer 12 V from the wall outlet to the generator via magnetic wireless induction with an optimized efficiency of 50% to 70%.
4. Users will be able to view the current temperature of the liquid and select the desired temperature of their liquid with the press of a button.
5. The control unit will transition seamlessly between low, medium, and high power states based on the computed temperature differential.

2. Design

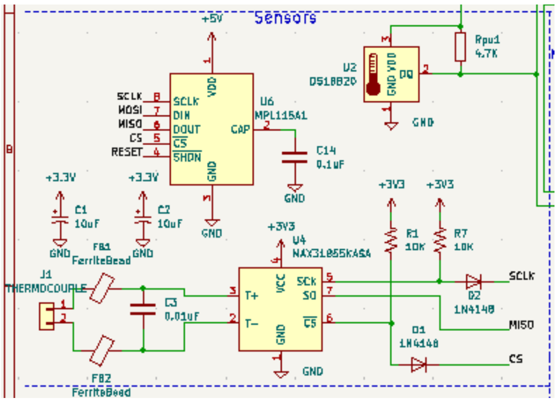
a. Block Diagram



b. Physical Design (if applicable):

c. Sensor Subsystem

The sensor subsystem will measure temperature data from the liquid in our bottle and the heating plate that is heating the liquid. It will also measure pressure data from the bottle cap. When the bottle charger system is plugged in or the bottle is turned on, the sensors will measure data and send this data to the microcontroller. The thermocouple and barometric pressure sensor will use SPI protocol while the DS18B20 liquid temperature sensor will use I2C protocol. The thermocouple requires a digital converter which is the purpose of the MAX31855. The MCU will process the data and send the result to the LCD screen for the user to view.



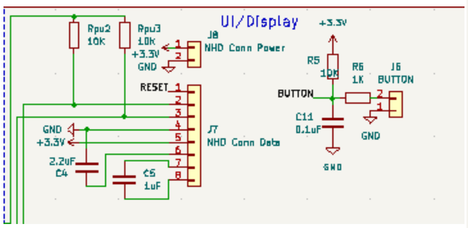
Requirements	Verification
1. The MAX31855 will be supplied a voltage of 3.3 V ± 1% from the voltage regulator. The DS18B20 will be supplied a voltage of 5V ± 1% from the voltage regulator. The MPL115A1 will be supplied a voltage of 5V ± 1% from the voltage regulator. 2. The MAX31855 must supply an output current of 1.6 mA. The DS18B20 must supply an output current of 1 mA. The MPL115A1 will supply an output current of 5 µA. 3. The MAX31855 will measure between -270°C and +700°C with an accuracy of ±2°C. The DS18B20 will measure between -10°C to +85°C with an accuracy of ±0.5°C. The MPL115A1 will measure from 50 to 115 kPa with ±1 kPa accuracy.	1. Measure output voltages from the MAX31855, DS18B20, and MPL115A1 using a voltmeter or oscilloscope, and ensure they maintain a steady voltage of 3.3 V allowing a 1% deviation, 5 V allowing a 1% deviation, and 5 V allowing a 1% deviation, respectively. 2. Measure output currents from the MAX31855, the DS18B20 liquid temperature sensor, and the MPL115A1 barometric pressure sensor using an ammeter, and ensure they maintain a steady current of 1.6 mA, 1 mA, and 5 µA respectively. 3. Measure temperature of water and base plate using a kitchen thermometer to compare to measured temperature from sensors and ensure they are accurate within 2°C and 0.5°C respectively. Measure pressure of room with built in phone barometer to compare to sensor and ensure measurement is accurate within 1 kPa.

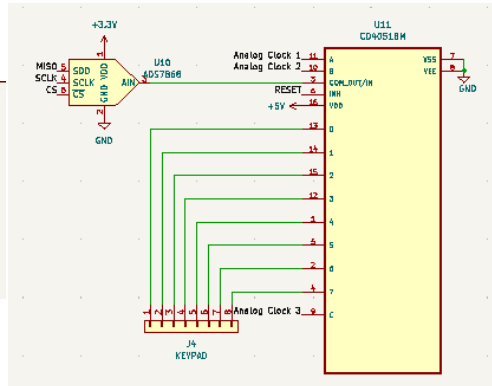
Commented [TMH1]: After power RV, change threshold if necessary

2.4 User Interface Subsystem

The user interface subsystem will allow the user to choose and view the desired temperature of their liquid as well as turn the bottle on and off. The subsystem will consist of a 4x4 Matrix Membrane Keypad with outputs routed through a CD405xB 8 channel Analog Multiplexer/Demultiplexer to allow for manual input of desired temperature, a NHD LCD display to allow the user to view the current and desired temperature of the liquid, and a ______ button to turn the bottle on and off.

Commented [TMH2]: Figure out which button from arduino package we have already and add to components spreadsheet, as well as detail in this section.



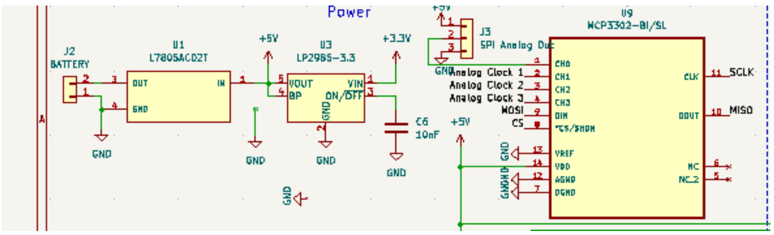


Requirements	Verification
1. Keypad should send correct user input. 2. LCD display should output current and desired temperature of liquid. 3. Button should power on and off the bottle.	1. To verify functionality, we will test the keypad on our PCB board and check that the inputs correspond to the correct outputs using the IDE console. 2. We will watch the LCD display to verify that the outputs on the LCD correspond to the our provided input such as “Hello World” from our IDE console. 3. We will use a multimeter to ensure that no power is being supplied to the bottle when the bottle is powered off, and that _1k_ W are being supplied to the bottle when the power is on.

Commented [TMH3]: After power RV table, fill in

d. Power Subsystem

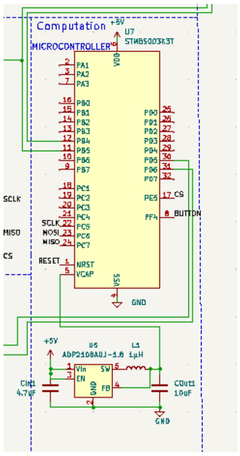
Our power subsystem will supply power internal and externally through two voltage regulators, the L7805 for 5v conversion, and the LP2953-3.3 for 3.3v conversion. These voltages will be used for the internal chips, which vary between needing 5v and 3.3v power. This will be supplied by an external 9v battery. The MCP3302 is used to convert digital output signals from the microcontroller into analog signals, used by the input keypad for an analog clock, and used externally to send data signals to the I-Bottle's induction heating system.



Requirements	Verification
1. Input supply from rechargable battery and use the voltage regulatory systems into +5v and +3.3v 2. Use the Digital to Analog converter to send analog signals externally to control the Induction Coil and internally to create an analog clock	1. Input of 9v with universal ground, converted into 5v with 1% accuracy relative to ground, and 3.3v within 1% accuracy 2. Input MOSI from the Microcontroller and convert into a 3-bit synchronous clock aligned with Microcontroller clock signal 3. Send SPI analog data to an extrenal connection, ensuring a 5v, low frequency (about 60Hz) signal gets sent externally.

e. Control Subsystem

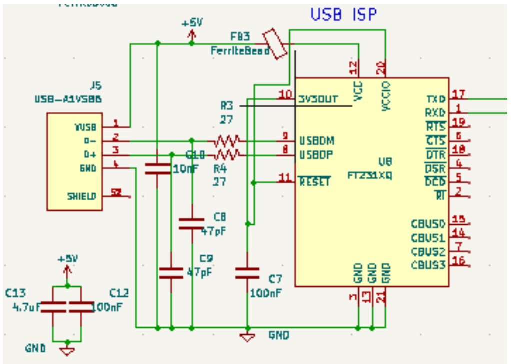
Our control subsystem will consist of a STM8S003K3 microcontroller which will receive data from our peripherals such as our sensors and keypad and transmit data to our LCD display after processing all the received data. The microcontroller requires a regulator capacitor, such as the ADP2108 step down DC-to-DC converter. The microcontroller will receive and send data using SPI and I2C, and be programmed by USB via UART data protocol, the latter which is detailed in the ISP subsystem.



Requirements	Verification
1. Perform calculations with sensor data to send current and desired temperature to LCD display as well as use calculated temperature differential to route necessary power to heating coils.	1. Simulate current and desired temperature situation to test calculation of temperature differential and ensure that sufficient power is supplied to heating coils. 2. Measure temperature of coils to check that power supplied aligns with temperature of coils.

2.6 ISP Subsystem

The In System Programming subsystem will allow the microcontroller to be programmed via USB connection. This requires a FT231X USB to full handshake UART IC to connect with our microcontroller.



Requirements	**Verification**
1. The FT231X will be supplied a voltage of 5V ± 1% from the voltage regulator. 2. The FT231X will handle the data stream from USB to UART to provide communication between a computer that will program the microcontroller while being compliant with USB 2.0 specifications.	- Measure output voltage from the FT231X using a voltmeter or oscilloscope, and ensure it maintains a steady voltage of 5V allowing a 1% deviation. - Configure FT231X with its built-in USB protocol engine to ensure compliant transfer of data from USB to UART.

Tolerance Analysis

Commented [TMH4]: Homero, need to digitize the tolerance analysis from the design doc on google docs, v2

3. Cost and Schedule

a. Cost Analysis

Parts:

Component name or Number	Quantity	Price	TOTAL PRICE
ADDDDD BUTTON	1	0	0
3245 Thermocouple Type-K	1	9.95	9.95
MAX31855 Thermocouple-to-Digital Converter	1	7.76	7.76
DS18B20 Waterproof Thermometer	1	9.95	9.95
MPL115A1 Barometric Pressure Sensor	1	7.95	7.95
NHD-C0220BiZ LCD display 20x2	1	13.49	13.49
27899 Parallax 4x4 Matrix Membrane Keypad	1	9.95	9.95
CD4051BM Single 8 Channel Analog Mux/DeMux	1	1.13	1.13
STM8S003K3 MCU	1	2.13	2.13

Commented [TMH5]: Add component name of button, also find price

ADP2108 Step down DC-to-DC converter	1	2.12	2.12
FT231XQ-T USB to UART IC	1	2.22	2.22
USB-A1VSB6 USB connector	1	0.69	0.69
L7805ACD2T Positive voltage regulator IC	1	0.89	0.89
LP2985-3.3 150 mA, Low-Noise, Low-Dropout Regulator	1	1.06	1.06
MCP3302 Quad Channel SPI Interface	1	5.56	5.56
Lithium Ion Rechargeable Battery (9v)	2	12.5	24.99
MFBW1V2012-801-R Ferrite Bead	2	0.1	0.2
polarized 10 uF cap	2	0.72	1.44
1 uF cap	1	0.18	0.18
2.2 uF cap	1	0.19	0.19
0.01 uF == 10 nF cap	3	2.01	6.03
10 uF	1	0.29	0.29
0.1 uF == 100 nF cap	3	0.29	0.87
47 pF cap	2	0.2	0.4
4.7 uF	2	2.39	4.78
1N4148 diode	2	0.1	0.2
1 uH inductor	1	0.41	0.41
10k resistor	5	0.16	0.8
27 resistor	2	0.26	0.52
1k resistor	1	0.42	0.42
4.7k resistor	1	0.46	0.46
TOTAL			92.04

Commented [TMH6]: Idk what voltage we need for this, so add component name, quantity, and price

Total component price = $92.04

Labor costs:

Cost = $30/hour * 10 weeks * 10 hours/week * 3 people * 2.5 = $22,500.00

Cost / person = $30/hour * 10 weeks * 10 hours/week * 2.5 = $7,500.00

b. Schedule

Week	**Evan**	**Michael**	**Homero**

2/14	Research parts for induction system	Research parts for pcb	Research parts for pcb
2/21	Design power pcb schematic	Design UI and USB pcb schematic	Design sensor pcb schematic
2/28	Finalize PCB Design	Finalize PCB Design and research bottle system design	Finalize PCB Design
3/07	Research Microcontroller Coding and Order Components	Research Microcontroller Coding and Order Components	Research Microcontroller Coding and Order Components
3/14	Spring Break	Spring Break	Spring Break
3/21	Test parts and integrate into project	Write test code for microcontroller	Write test code for microcontroller
3/28	Test parts and integrate write Individual Progress Report	Test parts and integrate write Individual Progress Report	Test parts and integrate write Individual Progress Report
4/4	Test Parts and Prepare for Mock Demo	Test Parts and Prepare for Mock Demo	Test Parts and Prepare for Mock Demo
4/11	Finalize Physical Project for Mock Demo	Finalize Physical Project for Mock Demo	Finalize Physical Project for Mock Demo
4/18	Finalize Any Errors from Mock Demo and Prepare for Final Demo	Finalize Any Errors from Mock Demo and Prepare for Final Demo	Finalize Any Errors from Mock Demo and Prepare for Final Demo
4/25	Demo, Give Presentation and Write Final Report	Demo, Give Presentation and Write Final Report	Demo, Give Presentation and Write Final Report

4. Discussion of Ethics and Safety

Our main concern with the I-Bottle is the heating element. This heating element is a coil that will operate at a low, medium, or high temperature. This coil receives power from the induction generator through the power routing module. This module will be controlled by a state machine ensuring that power is supplied to the coils in an efficient and safe manner to ensure the coil does not overheat. A max temperature threshold will be set so that when our heating plate reaches this temperature, our generator will turn off.

Our secondary concern is the bottle tipping or falling when connected to the base plate. We plan on making our base plate sufficiently heavy to improve sturdiness. We will also place sticky pads on the underside of the base plate to ensure users don’t push the device off their countertop easily. The base plate will be flat, with walls on three or four sides of the plate to make sure the bottle itself doesn’t fall or slip off the device. Finally, we will implement a locking mechanism that ensures the bottle will be heated only when locked into place. We plan on placing the bottle on some raised contact points and then turning the bottle to lock the bottle into place.

Our final concern is the strong magnetic fields our wireless charger will be creating. Magnetic fields can damage other electronics and the bottle's electronics if not isolated correctly. We will use a material that is ferromagnetic to redirect the magnetic field. We plan on building this material into the walls of the base plate to shield the outside environment, as well as around our pcb to shield our electronic components. Proper caution labels will be put on our device components to ensure the safety of public users.

5 Citations

"IEEE Code of Ethics." IEEE, https://www.ieee.org/about/corporate/governance/p7-8.html.