BarT

The Automated Bartender

Design Review

Andrew Doskochynskyy
Matthew Koopmann
Mithun Manivannan
TA: Raj Vinjamuri

ECE445 – Senior Design
Spring 2015
Project #4

Table of Contents

Introduction

Statement of Purpose

As we all probably know, while cocktails are delicious, they can be quite the hassle to concoct. In order to make the perfect drink, not only do you need to know the recipes, but you must also accurately measure the proportions.

As a result, we became interested in developing an automated bartending system that would have the ability to create various cocktails and mixed drinks at the push of a button from the convenience of your mobile phone. To accomplish this, we will implement a user-friendly Android app, which would connect wirelessly via Bluetooth to our automated bartender, allowing users to choose their drinks at their own discretion.

Recently, products similar to our automated bartender have made appearances on popular crowdsourcing websites, such as Kickstarter and Indiegogo. However, these products are expensive and rely on peristaltic pumps in order to dispense liquids. Not only are these pumps expensive and a hassle to clean and maintain, but they also do not possess the ability to serve carbonated beverages. This limits the mixology the user can experience.

Ergo, our primary goal is to design an automated system that won't rely on pumps but rather a pressurized CO_2 system and solenoid valves to dispense the appropriate liquids. This will give our newfangled product the unique ability to serve cocktails as well as carbonated beverages at a fraction of the cost and hassle!

Objectives

Goals & Functions:

- Create a 12V power supply using a Buck converter
- Develop Android App interface for user friendly experience
- Accurately dispense various recipes as quickly and efficiently as possible

Benefits:

- Provides a hassle free, user-friendly experience
- Alcoholic beverages at the push of a button.
- Significantly cheaper than current products on the market.

Features:

- Wireless Android App functionality
- Up to ten different beverages for a plethora of cocktails and mixed drinks
- Optical sensor for automated dispensing
- Carbonated beverages compatibility

Design

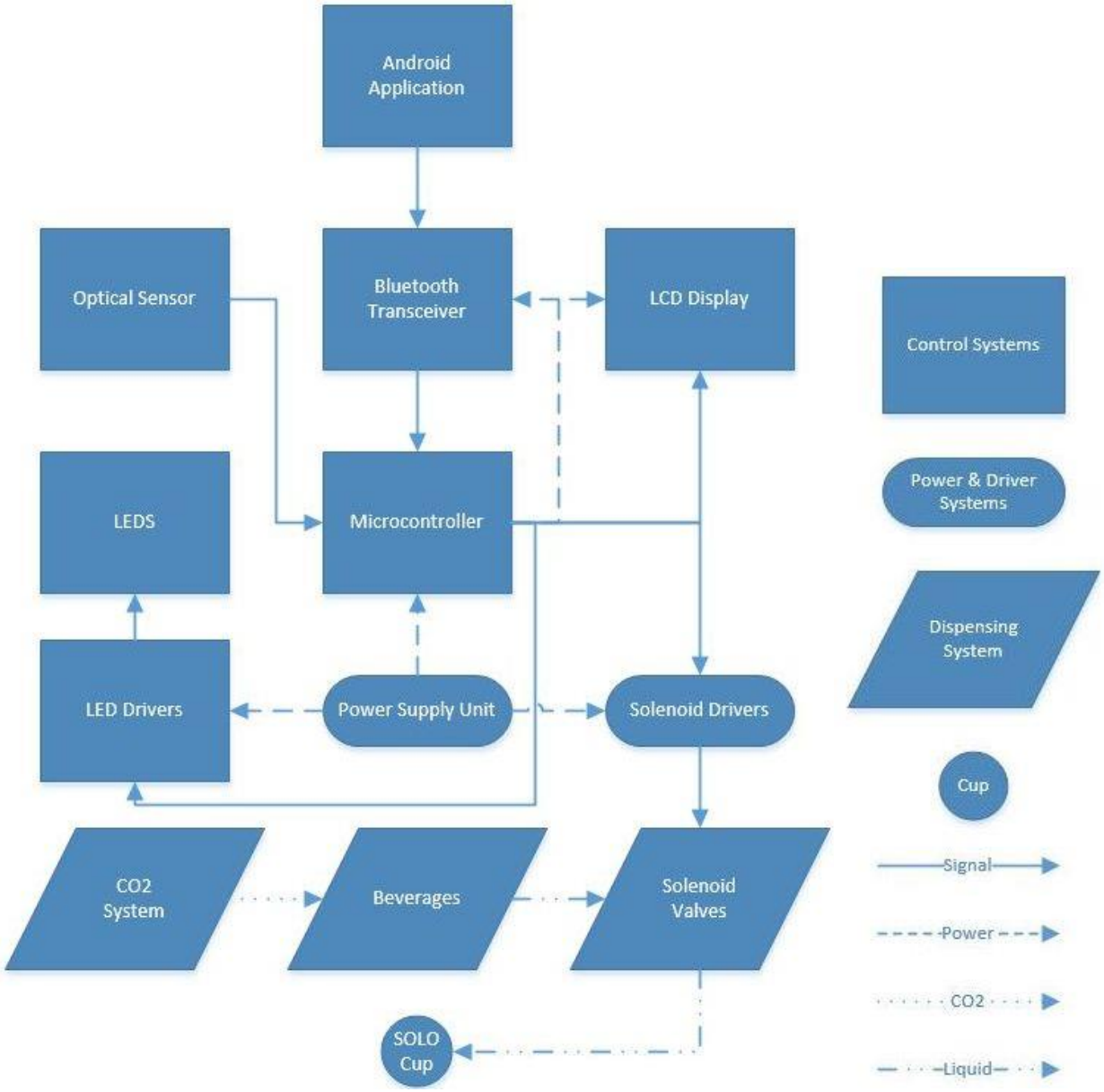


Figure 1: Automated Bartender Block Diagram

Block Descriptions

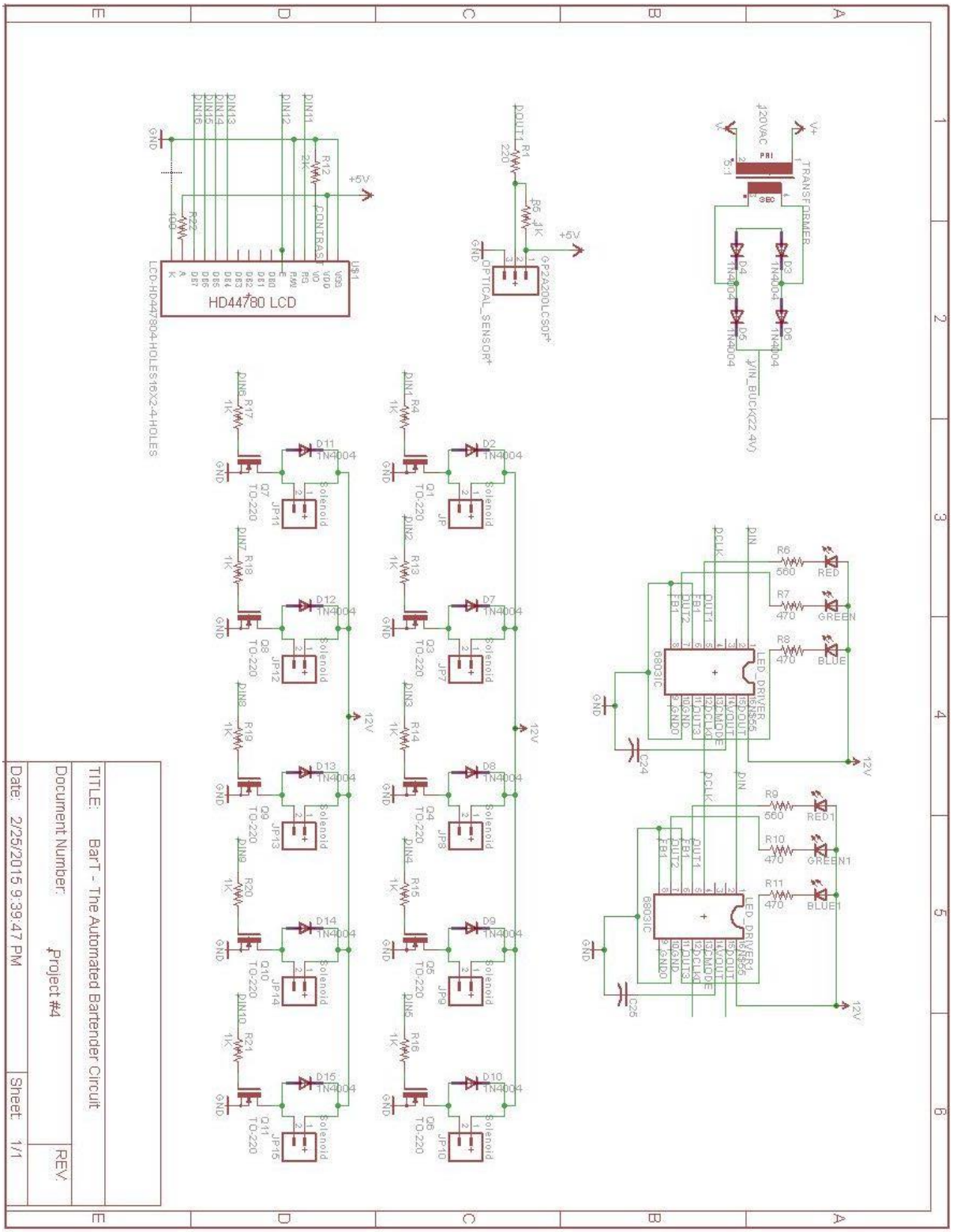


Figure 7: Full Schematic minus Power Supply

From our circuits in figure 7, we have multiple hardware components. Some we a purchasing premade, such as the LCD display, optical sensor and LED drivers and lights. However, we designed and will construct the power supply system as well as the solenoid drivers.

Control Systems

Android Application	
Input	User selects drink
Output	Communicates via Bluetooth transceiver using a keyword system

The android application will allow users to see which drinks are currently available from the Automated Bartender. It provides a photo of the various drinks along with description of ingredients and proportionalities. It will allow the user to order their drink at the touch of a button. Our app will interface with the microcontroller via a Bluetooth transceiver.

Bluetooth Transceiver	
Input	Keywords from Android Application
Output	Keywords to microcontroller

The Bluetooth transceiver we will utilize is the nRF8001 IC, which will couple our Android to our microcontroller, allowing it to interface with the smartphone via Bluetooth. Specifically, we will be a Bluetooth Low Energy (BLE) Shield, which will consume very little power. The BLE Shield is designed to be compatible with many boards, including the Atmega2560. This essential component will differentiate BarT from the competition considering it will provide the capability to control our microcontroller from a mobile device via an Android application.

Figure 2: Bluetooth Low Energy (BLE) Shield

Optical Sensor	
Input	Power: 5V
Output	5V +/- .5V when no cup is present and low output signal <=.5V when a cup is present

We will be utilizing a GP2A200LCS0F reflective optical sensor to detect when a cup has been placed in the dispensing station. This sensor utilizes an emitting and collecting infrared LED, which will provide a hands free control for when to dispense the beverage. There are three PINs on the optical sensor; +5V pin, Vout, and GND. The Vout PIN is the digital sensing output. When no infrared light is being reflected to the collector, Vout will measure 5V. Once the light is reflected off our cup into the collector, the voltage will drop to ~0. This will give our microcontroller the ability to differentiate between the high and low signals thru its digital pin. This is a feature other automated bartenders lack, so we thought it was imperative to incorporate some type of hands free control system.

Figure 3: GP2A200LCS0F Reflective Optical Sensor

SunFounder Microcontroller	
Input	Keywords from Bluetooth Transceiver
Output	Digital controls to the various components

This will be BarT's brains. It will interface with the Bluetooth transmitter to send and receive data from the app. This data will control the various electronic devices of the bartender, such as the solenoids, optical sensor, LCD screen and LED lights.

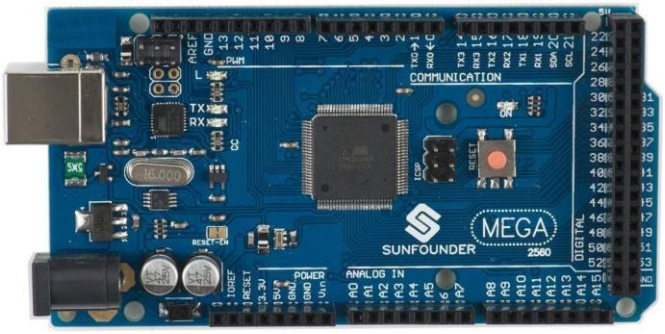


Figure 4: SunFounder Mega 2560 R3

LCD Display	
Input	Username and beverage data from Microcontroller
Output	Display username and drink

The display will be powered and controlled by the microcontroller and will be updated to display the name of the current patron's drink order as well as the next order on the queue.

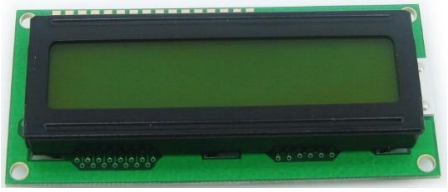


Figure 5: LCD Display QC1602a

Solenoid Valve Drivers	
Input	Digital Signal & 12VDC Power

Considering our solenoid valves will consumer 540mA @ 12Vdc, we need to create a relay system since our microcontroller cannot output such high current. Thus, we will construct an n-type FET transistor network so that our digital signal from the microcontroller can actuate the valves accordingly.

Solenoid Valve	
Input	12VDC/540mA & Pressurized Beverage
Output	Pressurized beverage

These electric valves, which are actuated by our valve drivers, control the volume of liquid dispensed. They will be strategically programmed to dispense an exact amount of liquid using predetermined timing measurements at a specified CO2 pressure.

Figure 6: 1/4" Pneumatic Solenoid Valve

CO2 System	
Input	Pressurized CO2
Output	Regulated CO2 Pressure

This will be BarT's heart and will provide a constant CO2 pressure to our various beverages. Unlike other automated bartenders that rely on peristaltic pumps, our system will function on a constant CO2 pressure. This will both drastically decrease the construction and operation costs as well as provide the luxury to dispense carbonated beverages.

Beverages

There will be the capability to connect up to ten various beverages to our automated bartender, which will provide the users with a plethora of cocktails and mixed drinks.

LED Drivers & Lights

Our LED lights and drivers, which will provide a level of pizazz for the user, will operate at 12VDC and be constructed from a cascade of 6803IC LED Drivers connected to 5050 RGB LEDs. This configuration will be unique considering it will allow us to utilize the fastSPI library which will individually control each LED instead of a constant color like conventional LED setups. These lights coupled to our infinity mirror will provide the user with an experience they'll surely never forget.

Power Supply Unit	
Input	120VAC @ 60Hz from wall socket
Output	12VDC w/ 5A max (60W)

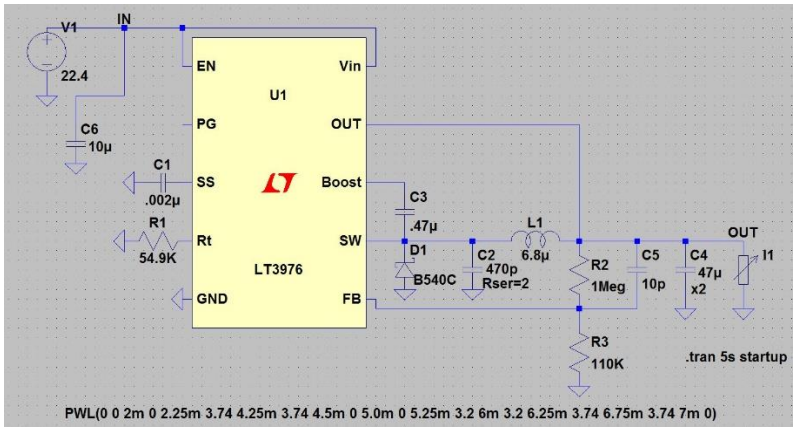


Figure 8: Power Supply Unit Schematic

We designed a power supply that could supply our system with enough current at 12VDC to power our solenoid valves, microcontroller, Bluetooth transceiver, optical sensor, and LED lights. Therefore, the best and most efficient route was to implement a Buck step down converter (figure 8). Since we need a steady output voltage of 12VDC, we will use a 5:1 transformer to step down our voltage from 120VAC to 24VAC. Next, we implemented a full wave bridge rectifier so that our buck converter's input voltage will be a steady 22.6VDC. We made our buck converter's Vin > Vout to account for any shortage or high ripple in voltage.
By calculating our total power consumption in table 1 from the various component's datasheets, our buck converter must be able to supply at least 3.74amps. Thus, to be safe and considering it was the best package available; we chose to implement Linear Technologies' LT3976.

Module	Power Consumption
Solenoid Valve	540mA @ 12VDC = 6.5W
LED Strip [5]	7.6W/meter ~2.4A @ 12VDC = 28.8W
Microcontroller [6]	(40mA/IO pin)*(19pins) = 760mA
Optical Sensor [3]	50mA @ 5VDC = 250mW
Bluetooth Shield [4]	12mA @ Active TX 11mA @ Active RX
LCD Screen [2]	Backlight: 30mA @ 5VDC = 150mW Logic: 1.3mA @ 5VDC = 6.5mW
Total Amperage	**3.74A**

Table 1: BarT's Power Consumption

With some component value calculations below from our Buck Converter's datasheet [1], we were able to bias our output voltage to ~12V with a 1M and 110k resistors, which is confirmed in our simulation in figure 9. We also set our buck converter's switching frequency to 800kHz. This frequency setting was mostly to account for efficiency and should not matter much for our application. Finally, we calculated the necessary inductor and capacitor values to keep out output voltage stable and minimize our ripple voltage. These values were rounded to the closest components available.

$$R_2 = R_3\left(\frac{V_{out}}{1.197} - 1\right); V_{out} = 12V$$
$$\boldsymbol{R_2 = 1M\Omega;\ R_3 = 110k\Omega}$$

$$R_1 = \frac{51.1}{f_{sw}^{1.09}} - 9.27 = \boldsymbol{R_1 = 54.9k\Omega}$$
$$f_{sw}(switching\ frequency) = .8MHz$$

$$L = \frac{V_{out} + V_D}{2f_{sw}} = \mathbf{6.8uH}\ ; V_D \cong .5$$

$$C_{out} = \frac{300}{V_{out} f_{sw}} = \mathbf{47uF}$$

Power Supply Simulations

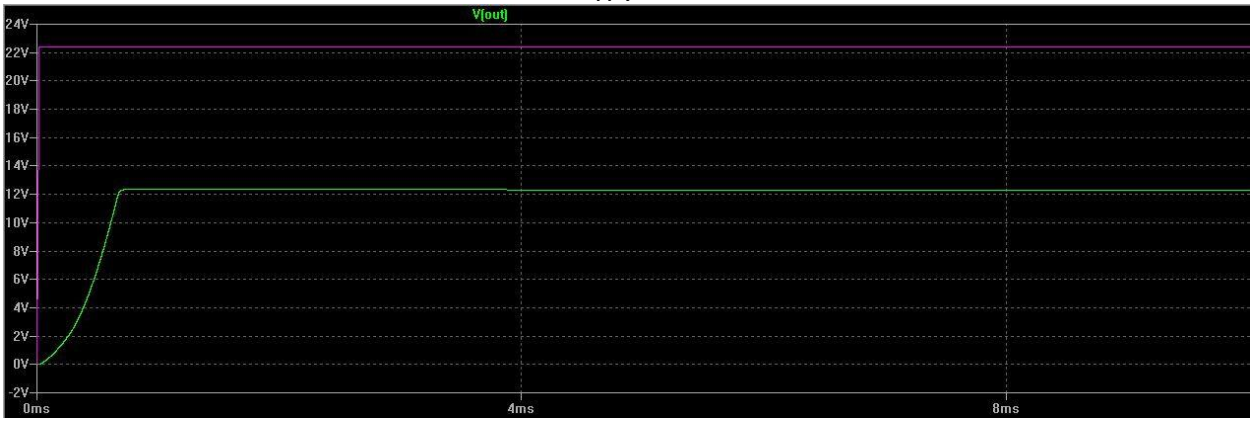


Figure 9: Power Supple No Load Simulation

From figure 9, we simulated our power supply under no load with our input voltage of 22.4V. As a result, we measured our output voltage to confirm a steady 12V. Next, to determine our power supply's ripple voltage, we performed various load simulations in figure 10. Under full load and various load conditions, we simulated a less than 1V ripple voltage, which is less than 10% of our output voltage. So, given this data, we are confident our power supply will suffice for our application.

Figure 10: Power Supply Full Load Simulation

Android Application Flow Chart

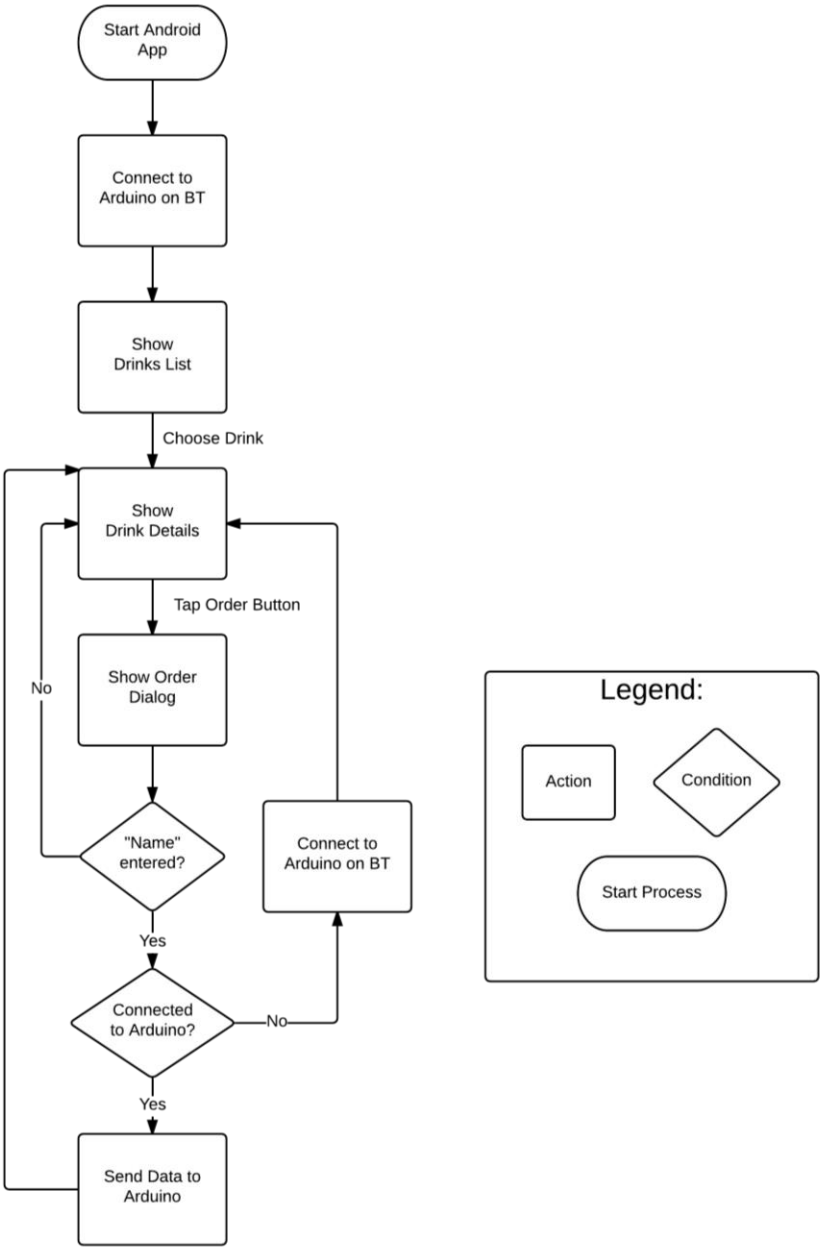


Figure 11: Android Application Flowchart

When the Android application is started, it immediately attempts to **Connect To Arduino on BT**. Afterwards, regardless of success, it shows the user the **Drinks List**, and when the user chooses a drink, shows them the **Drink Details** page. If the user orders the drink, it **Shows the Order Dialog**. If the **Name is Entered** and **Arduino is Connected**, then **Send Data to Arduino**

Arduino Flow Chart

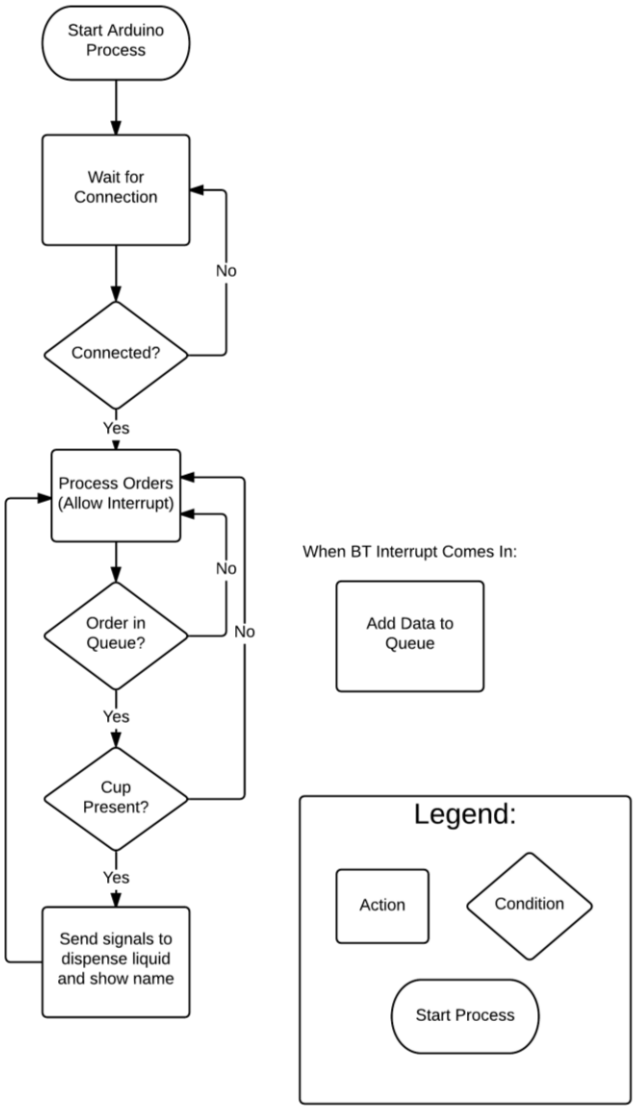
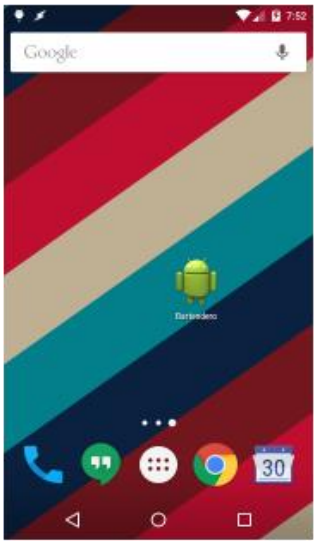


Figure 12: Arduino Flowchart

When the Arduino starts, it **Waits for a Connection** from the Android device. Once connected, the Arduino **Allows Interrupts** and starts to **Process Orders**. If there is an **Order in the Queue,** and there is a **Cup Present**. If both of these exist, the Arduino will start **Sending Signals to dispense the liquid and show name**. While this is happening, the process may be interrupted by the Bluetooth shield to add data to the queue to process after the current order is processed.

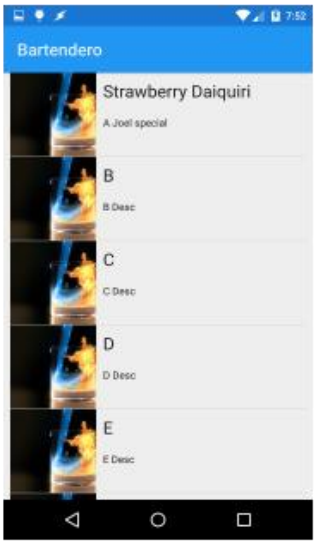
Current Software Screenshots

User launches app



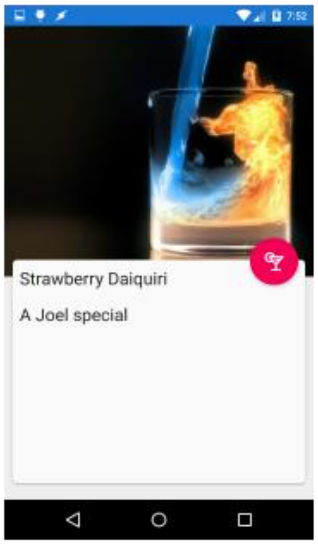
1

The home screen of app will show a list of all available drinks, along with a picture and a short description. (to be added later)



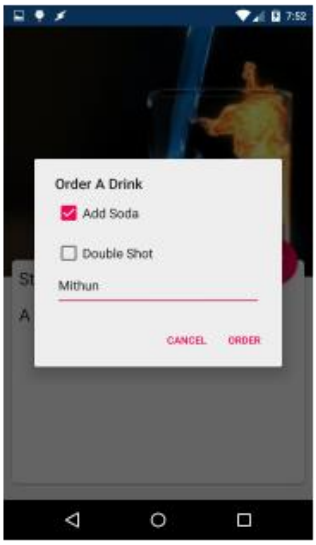
2

Choosing a drink leads to a page that gives more details about the drink and allows the user to order the drink.



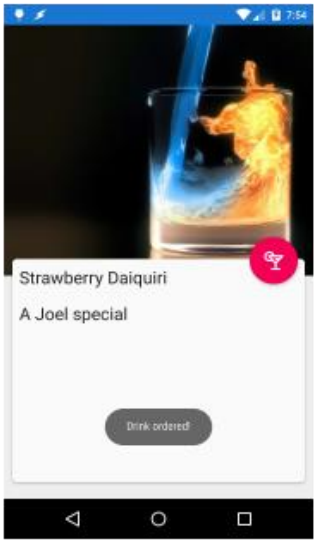
3

Tapping the pink drink icon brings up a dialog where users can add options and their name and submit the drink order



4

You drink order has been sent to Bartendero!



5

Figure 13: Current software screen captures

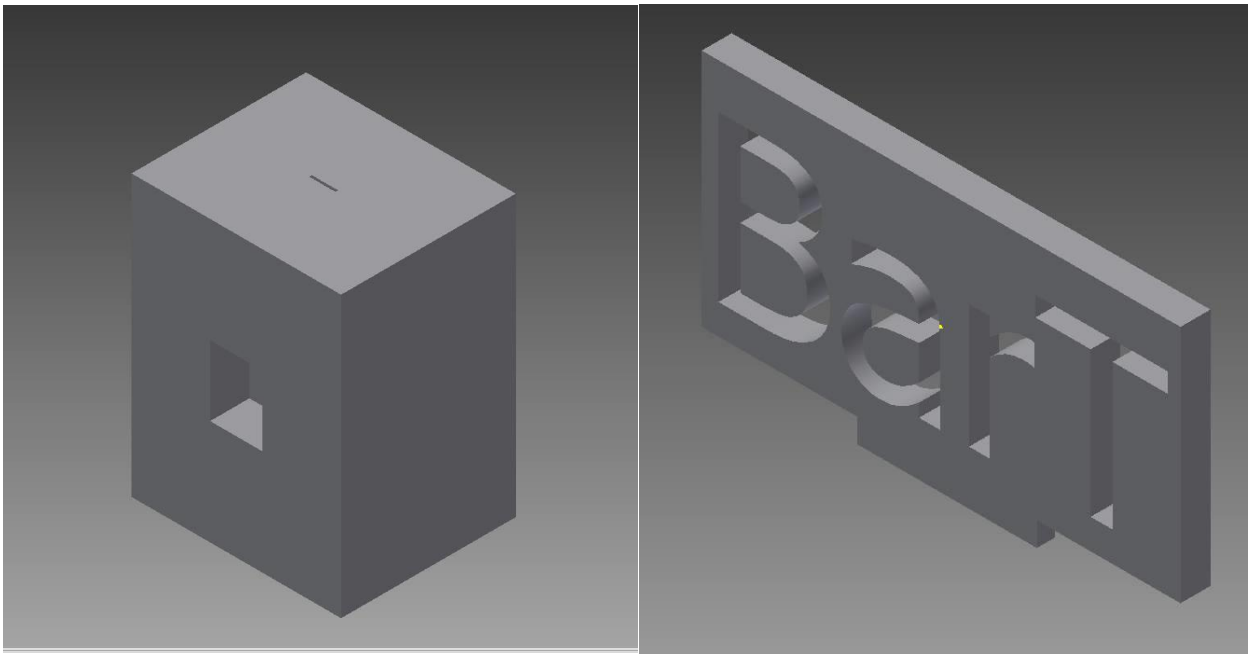


Figure 14: Current Mechanical Designs

BarT will be constructed from ½" Baltic Plywood to the approximate dimensions in figure 14. There will be an infinity mirror as the front with a location to place a cup in the center. This location will have a stainless steel drip tray to account for any liquid dripping from the tubes. The infinity mirror is consists of a one-way tempered glass, a perimeter of LEDs, and a mirror. Also, we will have a piece of glass etched BarT on the top which will be illuminated by some LEDs. Finally, we will have our LCD screen either inside the infinity mirror or near the dispensing station. We plan to make BarT as clean as possible so all the beverages, mechanical and electrical components will be inside the housing.

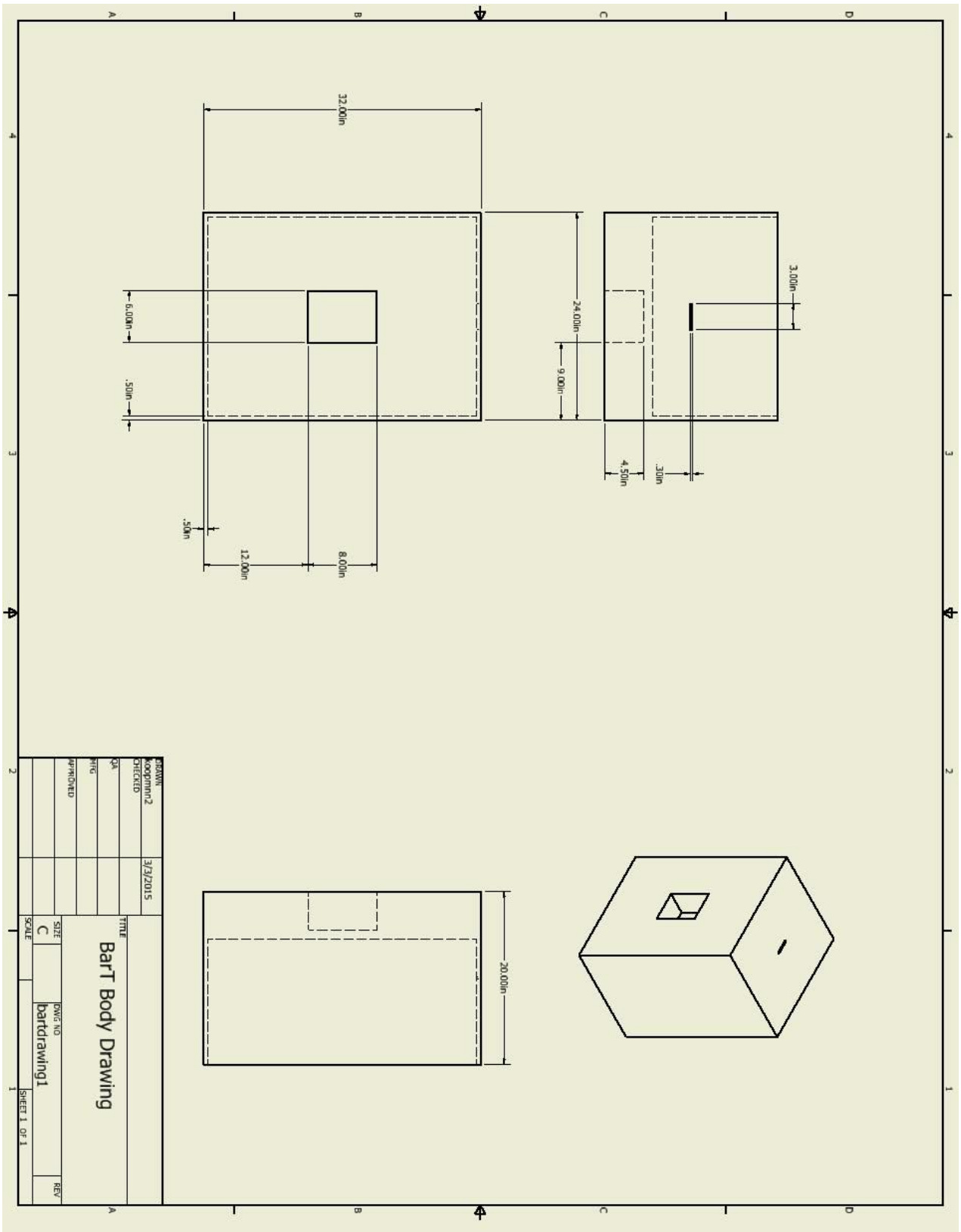


Figure 15: Housing Schematic

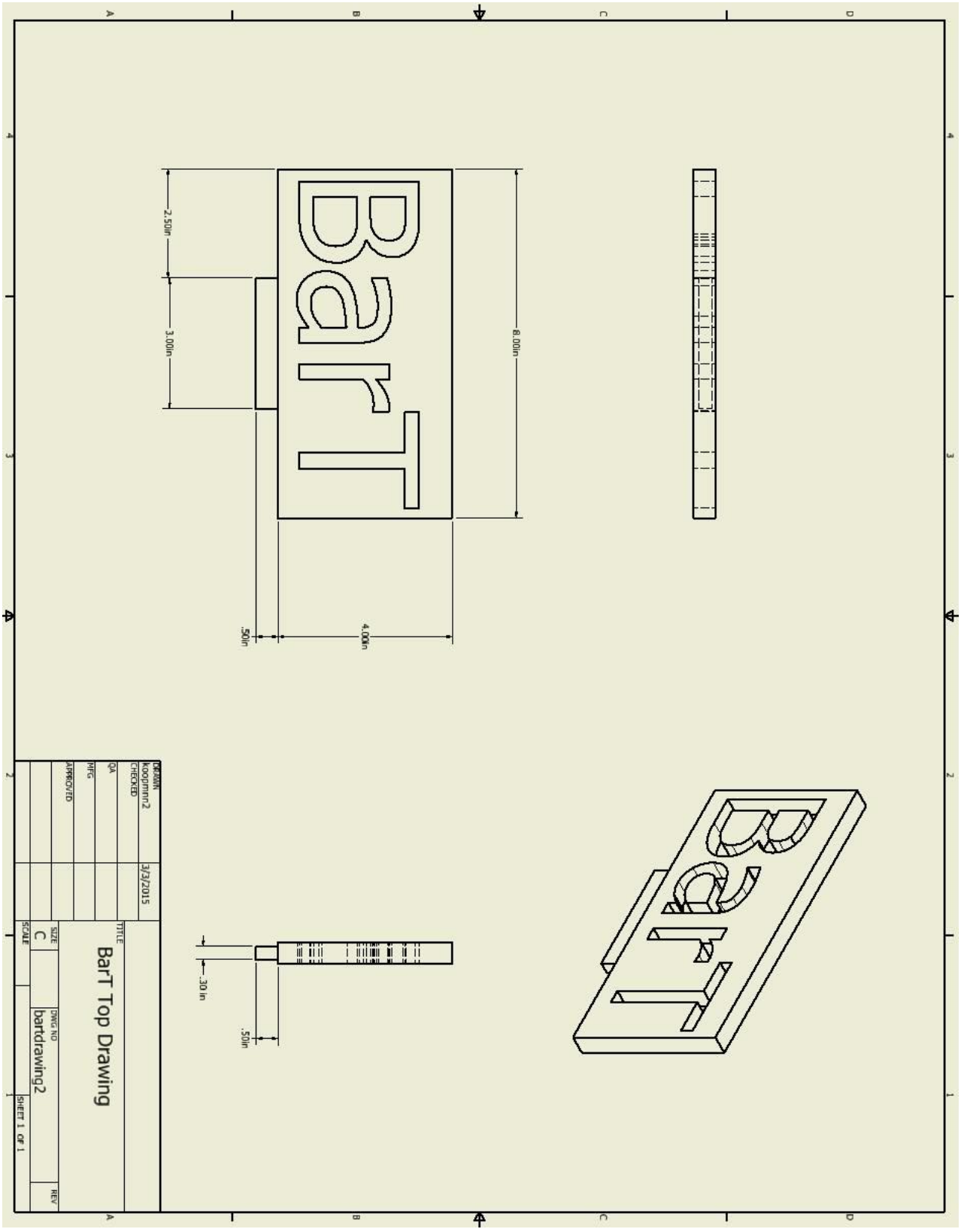

2.50in
3.00in
8.00in
.50in
4.00in
.30 in
.50in
BarT
DRAWN
koopmnn2
CHECKED
3/3/2015
QA
MFG
APPROVED
TITLE
BarT Top Drawing
SIZE
C
DWG NO
bartdrawing2
REV
SCALE
SHEET 1 OF 1

Figure 16: Etched Glass Schematic

Module Requirements and Points

Block	Requirements	Points
Control	1. Microcontroller and Android device should be able to communicate without error through the Bluetooth shield	20
	2. Microcontroller must be able to properly use the input of the optical sensor to dispense liquid only when cup is present	10
	3. Microcontroller must display user's name before, during, and after dispensing, until new cup is placed	10
	4. Microcontroller must properly control solenoid valve opening/closing	10
Power	1. Proper power must be provided to the Microcontroller	5
	2. Proper power must be provided to the Bluetooth shield	5
	3. Proper power must be provided to the solenoid valves drivers for beverage dispensing	10
	4. Solenoid valve drivers must adequately power the solenoid valves	10
Beverage System	1. Beverages must be properly connected to their respective caps	5
	2. Valves must open enough to allow stream of liquid and close tight enough to seal liquid	5
	3. CO2 system must provide adequate pressure to push liquid out through valves	10

Requirements and Verification

Android App

Module	Requirement	Verification
	• Allow users to scroll through drinks and navigate the inner menus to order drinks	1. Add enough drinks for the user to have a large enough selection 2. Scroll up and down and choose a drink at random 3. Verify the drink name and details are correct, then tap the order button 4. Fill out name and choose options if wanted and order 5. If order is placed successfully,
	• Ensure the "Double Shot" and "Add Soda" options work as intended	1. Order a drink with the "Double Shot" option checked 2. Order a drink with the "Add Soda" option checked 3. Order a drink with both options checked 4. Ensure each option works as intended
Android App	• Send and receive data from the Microcontroller to facilitate proper function of the bartender	1. Utilize Bluetooth libraries in the Android SDK 2. Enable Bluetooth on Android device and send test data over Bluetooth to the Microcontroller

		3. Set up Microcontroller to send a message back containing the same data
	• Proper execution on Android device running Lollipop	1. Install app on Android running Lollipop 2. Check all listed functionality to ensure it launches and functions as expected
	• "Admin" mode that allows privileged users with a special password to add/remove drinks based on current availability on Bartendero	1. Open options menu and select "Admin Mode" 2. Enter password that was decided on previously 3.Add a drink to ensure proper function 4. Remove a drink to ensure proper function

Bluetooth Transceiver

Module	Requirement	Verification
Bluetooth Transceiver	• Interface with Microcontroller to send messages to Android	1. Connect BT shield to Microcontroller 2. Write code to send message over BT to Android 3. Verify on Android device, using debugging tools, that the message was received properly
	• Interface with Microcontroller to receive messages from Android	1. Connect BT shield to Microcontroller 2. Write code to receive messages over BT from Android 3. Verify on Microcontroller using debugging tools that the correct messages were received

Microcontroller

Module	Requirement	Verification
Microcontroller	• Interface with the BT shield to send and receive messages from the Android device	1. Connect BT shield to Microcontroller 2. Load proper Bluetooth libraries on Microcontroller 3. Test Bluetooth shield's sending and receiving capabilities using code running on both the Microcontroller and Android
	• Interface with LCD panel to display user information	1. Load proper LCD drivers onto Microcontroller 2. Test sending multiple different messages to LCD screen to verify its integrity
	• Interface with optical sensor to determine when a cup is present	1. Configure optical sensor on microcontroller 2. In debug mode, check incoming digital values from sensor to ensure proper function when a cup is present and when it is not
	• Interface with solenoid relay to open and close valves properly	1. Send "open" signal to one of the 10 relays 2. Ensure that the valve is open 3. Send the "close" signal after a

		predetermined amount of time to close the valve 4. Ensure proper closure of valve 5. Repeat for each of the 10 relays

Beverage Dispensing System

Module	Requirement	Verification
Liquid Dispensing System	• Dispenses accurate quantity of beverage	1. Dispense liquid for a preset volume (shot, double shot, etc) 2. Measure volume of liquid using graduated cylinder 3. Repeat steps 1 and 2 multiple times until confident that system is consistent
	• Dispenses more than two beverages at a time	1. Place an order for a drink on Android, checking the option for "Add Soda" 2. Allow the system to dispense liquid into the cup 3. Taste the liquid to determine if indeed both liquids have been dispensed
	• Successfully halts liquid dispensing	1. Order a drink through app 2. Once order has finished dispensing, check the seal on nozzle for any leaking liquid using a paper towel

Power Supply Unit

Module	Requirement	Verification
	Provides 12V +/- .5V to solenoid drivers	1. Measure voltage @ Vcc and GND output of the power supply when valve is closed 2. Measure voltage drop across valve terminals when initiated.
Power Supply Unit	Provides 3.74A +/- .25A to system	1. Measure current output of power supply during no load 2. Measure current output of power supply during open valve 3. Measure current output of power supply during full system load

Costs & Labor

Name	Hourly Rate	Hours Invested	Total Cost
Andrew	$30.00	225	$6,750
Mithun	$30.00	225	$6,750
Matthew	$30.00	225	$6,750
Total		675	$20,250

Table 2: Labor

Description	Source	Part Number	Quantity	Cost ($)	Total ($)
CO2 Regulator	Ebay	T741HP	1	50.00	50.00
CO2 Canister	Craigslist	-	1	10.00	10.00
CO2 Refill	Depke Gases Supply	-	1	12.00	12.00
Microcontroller	SunFounder	Mega 2560 R3	1	20.00	20.00
Bluetooth Low Energy (BLE) Shield	Maker Shed	-	1	10.00	10.00
Pneumatic Electric Solenoids	Ebay	2V025-1/4-12VDC	10	8.90	89.00
Food Grade Silicone Tubing	Amazon	SCT-02-C	100ft	65.00	65.00
CO2 Bottle Caps	Ebay	-	10	2.50	25.00
Pneumatic Ball Valves	Ebay	-	10	1.80	18.00
CO2 Connector Fittings	Ebay	MTL ¼-N02	4	6.75	27.00
C02 Connector Manifold	Ebay	MTKG 6-6	3	8.00	24.00
5050 RGB Dream Color LED (5m)	Amazon	-	1	29.00	29.00
Reflective Optical Sensor	Digikey	GP2A200LCS0F	1	5.23	5.23
LCD Display	Ebay	QC1602a	1	3.60	3.60
24V Transformer	Ebay	90-T40F3	1	14.26	14.26
42V, 5A Buck Converter	Linear Technology	LT3976	1	5.50	5.50
Bridge Rectifier	Digikey	GBU6G-BPMS-ND	1	0.88	0.88
N-type MOSFET	Digikey	IRLB8721PBF-ND	10	0.732	7.32
Schottky Diode	Digikey	SB540-E3/54GICT-ND	1	0.66	0.66
6.8uH Inductor	Digikey	AIAP-02-6R8K-ND	1	0.56	0.56
5'x5' Baltic Birch	Public Lumber Company	-	2	40.00	80.00
32"x24" Mirror (1/8")	Glass Dimensions Inc.	-	1	30.00	30.00
32"x24" Tempered Glass (1/8")	Glass Dimensions Inc.	-	1	30.00	30.00
6" Drip Tray	Amazon	C608	1	25.00	25.00
Total					

Table 3: Parts

Section	Total ($)
Labor	20,250.00
Parts	407.59
Grand Total	**20657.59**

Table 4: Grand Total

Schedule

Week	Task	Duty
February 6th	Finalize proposal	Andrew
February 16th	Finalize mock design review	Matthew
February 23rd	Finalize design review	Andrew
	Research Bluetooth + Microcontroller interface	Mithun
	Finalize Ethics & Safety	Matthew
March 2nd	Finalize purchasing parts	Andrew
	Create recipes	Matthew
	Set up Bluetooth libraries to interface with Microcontroller	Mithun
March 9th	Reach out to potential sponsorships	Andrew
	Confirm all parts arrival	Matthew
	Set up Bluetooth + Microcontroller interfacing code	Mithun
March 16th	Test power supply circuit & solenoid driver circuit	Andrew
	Assemble two liquid dispensers	Matthew
	Send and process data from Bluetooth to Microcontroller	Mithun
Spring Break	Build BarT	Andrew
March 30th	Expand liquid dispensers	Andrew
	Integrate LCD display with microcontroller	Matthew
	Send and process data from Microcontroller to Bluetooth	Mithun
April 6th	Finalize bartender platform	Andrew
	Determine liquid dispensing standards	Matthew
	Connect Microcontroller to bartending system	Mithun
April 13th	Sign up for demonstration	Andrew
	Purchase beverages	Matthew
	Finalize messages passed to bartender from Microcontroller	Mithun
April 20th	Finalize Assembly	Andrew
	Finalize C02 calibration	Matthew
	Finalize Android & Microcontroller code	Mithun
April 27th	Get majority of final paper complete	Andrew
May 4th	Finalize Paper	Andrew
	Lab Checkout	Matthew
	Finalize Design Documents & Presentation	Mithun

Ethics

In accordance with the IEEE Code of Ethics and our own personal ethical standards, some potential issues must be discussed when considering how our Automated Bartender will be utilized in the real world. The ethical issues we are considering more or less fall under the first code listed in the IEEE Code of Ethics, which states:

> "1. To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment"

Mainly, the biggest concern is the fact that serving alcohol to minors with our automated bartender would not only be unethical, but also illegal. By making the automated bartender user friendly, it could potentially make it easier for minors to acquire alcoholic beverages. Whether the automated bartender is used in a commercial setting, such as a bar or a private setting, or in a consumer, the fact that it may make alcohol more readily available presents an ethical issue.

For example, UIUC Campustown only requires young adults to be nineteen years of age to enter a bar, while requiring patrons to be twenty-one years of age to drink. If a local bar were to purchase our automated bartenders and integrate it into their bar service with our mobile application, the unit would need proper supervision. If not, it could provide an easy means for minors to abuse the bartender's user friendliness, which would present both a legal and ethical issues. Beyond supervising the appliance, one solution to this issue may be to add an ID scanner should the automated bartender ever be taken to the market for commercial use.

In regards to a private, consumer application, the automated bartender could potentially allow children of parents who own a unit to acquire alcoholic beverages. A simple remedy to this would be to implement password protection on our mobile application and a locking mechanism for the containers. Other solutions to this issue could potentially include fingerprint scanners or requiring the parent's device to be within close proximity to the bartender.

Safety

Another issue to be considered is health and safety. Our automated bartender will utilize food grade, silicone tubing, which meets the minimum FDA requirements to ensure that our automated bartender handles liquids in a safe and sanitary manner. In addition, we will implement aluminum solenoid valves to ensure no unwanted toxins leach into our beverages.

In terms of safety, it is important to keep the liquids separate from the electronics that power and drive the unit, such as the power supply unit and controls. We will design BarT so that the liquids will be properly sealed and separate from the electronics so the users with a worry-free experience.

References

[1] Linear Technology, "*LT3976 - 40V, 5A, 2MHz Step-Down Switching Regulator with 3.3μA Quiescent Current",* http://cds.linear.com/docs/en/datasheet/3976f.pdf [Accessed: Feb 24, 2015]

[2] AVR-Developers, "*Specifications for Liquid Crystal Display Module",* http://www.avr-developers.com/icruze/HY-1602F.pdf [Accessed: Feb 22, 2015]

[3] Sharp Corporation, "*GP2A200LCS0F Series",* http://sharp-world.com/products/device/lineup/data/pdf/datasheet/gp2a200lcs_e.pdf [Accessed: Feb 20, 2015]

[4] Nordic Semiconductor, "*nRF8001",* http://www.nordicsemi.com/eng/Products/Bluetooth-R-low-energy/nRF8001 [Accessed: Feb 20, 2015]

[5] Banggood.com, "*5050 RGB Dream Color 6803 IC LED Strip",* http://www.banggood.com/5M-5050-RGB-Dream-Color-6803-IC-LED-Strip-Light-Waterproof-IP67-12V-DC-p-931386.html [Accessed: Feb 20, 2015]

[6] Arduino.cc, "*Arduino Mega 2560",* http://arduino.cc/en/Main/ArduinoBoardMega2560 [Accessed: Feb 20, 2015]