Simple Sophisticated Technologies

School of Engineering Science • Burnaby, BC • V5A 1S6

March 5, 2007
Mr. Lakshman One
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440/305 Design Specification for an Automated Cocktail Maker

Dear Mr. One,

The enclosed document specifies detail design aspects of an automated cocktail maker entitled Saaghy™ by Simple Sophisticated Technologies. The Device is currently in the development stage for ENSC 440 course and is expected to be completed by April 2007.

The accompanying document outlines the design specifications of different parts and features of Saaghy™. The document also summarizes testing procedures that the device has to fulfill upon completion. A detailed approach has been conducted in preparing this document and Simple Sophisticated Technologies' team members will follow the stated specifications as their guideline throughout Saaghy™'s design process.

SST's dedicated, talented and motivated team of senior engineering students is comprised of Behzad Behroozan, Mana Hamidi, Sara Hezarkhani, Alireza Nematollahi and Sara Moghaddamjoo. For further information or any concern you may have please do not hesitate to contact me by phone at (778) 883-2424 or by email at project-ensc440@sfu.ca.

Sincerely,

Sara Moghaddamjoo
President and CEO
Simple Sophisticated Technologies Inc.
http://www.sstechnologies.ca

Enclosure: Design Specification for an Automated Cocktail Maker

Simple Sophisticated Technologies™

Saaghy™, The ultimate art of perfect cocktail

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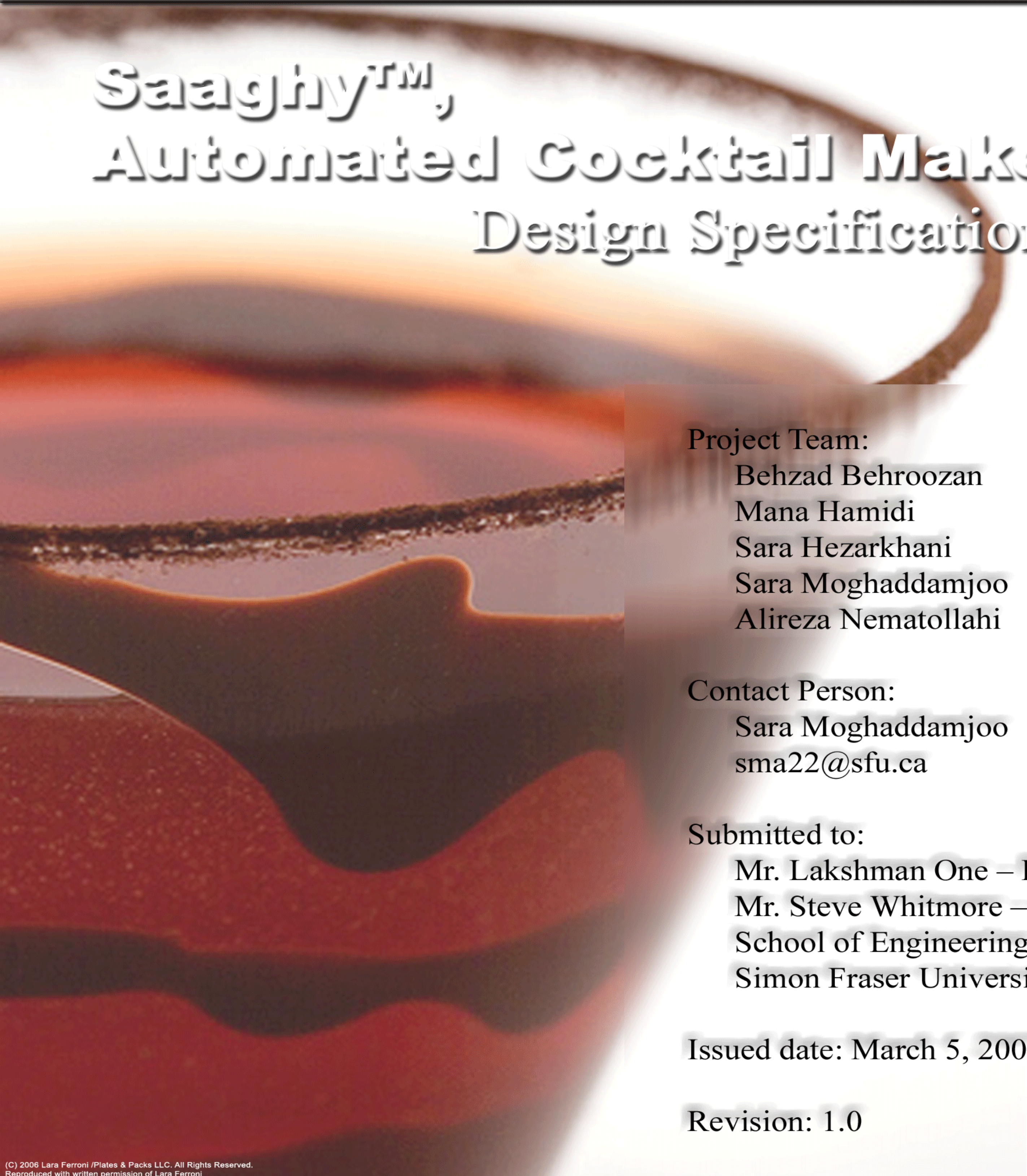

Saaghy™, Automated Cocktail Maker

Design Specifications

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Mr. Steve Whitmore – ENSC 305
School of Engineering Science
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Issued date: March 5, 2007

Revision: 1.0

Simple Sophisticated Technologies

Executive Summery

"Scientists study the world as it is; Engineers create the world that has never been."
-Theodore von Karman

21st century is about technology and speed. Devices are engineered to help peoples' needs in every aspects of everyday life, from a small coffee maker to the complicated computers. Simple Sophisticated Technologies has considered a new idea in designing a device to accommodate cocktail making in any environment. The quality of the drink will be the same no matter how many drinks is made. Also the user can use this device instead of hiring a bartender at a party, even bartenders can use this device to speed up their work.
Simple Sophisticated Technologies has planed to accomplish its goals in two phases. For the first Phase, it is required to accomplish proof of concept which contains the following parts:

1. Controlling fluid flow through a valve.
2. Mixing 2 fluids using valves.
3. Shaking the desired mix.
4. Pouring the drink into a glass.
5. Using the appropriate user interface to choose the desired drinks.

Once the proof of concept is completed, and the system has been fully controlled, it will be possible to add more features to improve the device to be more user-friendly and practical. These improvements include:

1. Adding more choices for drinks.
2. Rotating the disk that contains different fluids.
3. Cleaning features for the whole system.
4. Designing custom made fluid containers.
5. Designing a shaker with an opening for ice.
6. Adding an LCD to the user interface.
7. Making the device user programmable.

The Simple Sophisticated Technologies group has planned to finish the first phase by the beginning of April 2007.

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Revision History

Table 1: Revision History

Version	Date	Description	Member
1.0	Feb 26	Initial Documentation	Sara Moghaddamjoo
1.1	March8	Fluid Mux, Test Plan, Software, Hardware, Flowcharts, MC, Modification	Behzad Behroozan
1.2	March8	UI, MC, Software, Fluid Mux, Pictures, Schematics, Flowcharts, Modification	Mana Hamidi
1.3	March8	Physical Design, UI, Software, Hardware, Schematics, Flowcharts, Modification	Sara Hezarkhani
2.1	March8	Shaker, Test Plan, PSU, Software, MC, Hardware, Schematics, Flowcharts, Modification	Alireza Nematollahi
2.15	March8	Cleaning, Drain, Test plan, Flowchart, Modification, Final Overview	Sara Moghaddamjoo

Note: The table is ordered according to the initial document and the last version that has been prepared by each member.

1. Introduction

Saaghy™ is an automated cocktail maker which uses innovative methods for mixing, shaking and cleaning to make serving drinks easier. In order to prepare the user's desired drink; the device will select the required amount from each ingredient and pours them into the shaker. The shaker will mix the ingredients thoroughly in several vertical movements and the drink will be poured into the glass. The device has three cleaning cycles in order to always keep the environment hygienic for the drink making process.

The development of Saaghy™ happens in two stages. The first stage comprises the completion of a proof-of-concept device aimed to be achieved by the beginning of April 2007. The second stage is the development of the final design for the commercial rationale expected to be finalized by April 2008.

1.1. Scope

The scope of this document covers the design requirements which need to be met mainly for the proof-of-concept version of Saaghy™. Accordingly, some of the design specifications for the production version may change as more product survey feedbacks are collected during the prototype design. The mentioned design requirements represent the current customer's demand from the product. After thorough market studies and testing of the concept, the final modification of the device will be prepared for the production.

1.2. Glossary

AC	Alternating Current
DC	Direct Current
EEPROM	Electrically Erasable/Programmable Read Only Memory
EVB	Evaluation Board
I/O	Input / Output
IC	Integrated Circuit
IDE	Integrated Development Environment
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MC	Microcontroller
NBR	Acrylonitrile Butadiene Rubber
PSU	Power Supply Unit
PVC	Polyvinyl Chloride
PWM	Pulse Width Modulation
RAM	Random Access Memory
RPM	Revolutions Per Minute

SPD	Shaker Position Detector
SST	Simple Sophisticated Technologies
UI	User Interface

1.3. Intended Audience

The main purpose of this document is to act as a guideline to help the engineers in design, integration and quality assurance of Saaghy™. SST's executives and vice presidents can also use the design specification document as a guide to ensure that the development process is inline and to control and to direct the progress toward the end according to the user's expectations from the device. Another intended purpose of this document is to provide a test plan for test engineers and to certify the product specifications for future marketing phase of development.

2. System Overview

A general system overview for Saaghy™ is shown in Figure 1. Once the user selects the desired drink, the system starts by choosing the right ingredients' bottles and pours the specific amount using the fluid multiplexer into the shaking chamber. The shaking chamber then shakes the drinks and after checking for glass placement, pours the mixed drink into the glass.

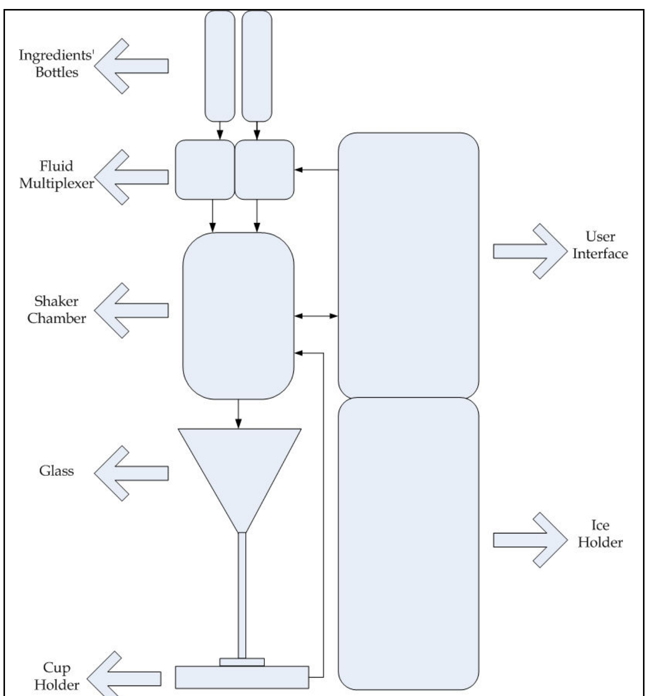


Figure 1: Saaghy™ System Overview

3. System Hardware Design

3.1. Fluid Multiplexer Subsystem Design

Fluid Multiplexer subsystem facilitates the process of dispensing precise amount of ingredients to be poured into the shaker. A two way, normally closed solenoid valve is required for this application. In order to drive the valve, a relay which is controlled by the system's MC, is required.

In general, Fluid multiplexer's progression is dependant on the UI status. The input to the fluid multiplexer subsystem is a signal sent by the UI which initiates the dispensing process. The fluid multiplexer chooses the appropriate ingredients and amounts according to selection of the cocktail requested by the user. Once all the ingredients are poured into the shaker, the fluid multiplexer sends a signal to the shaker to start the shaking process.

Figure 2 shows the block diagram of the Fluid Multiplexer subsystem. The MC block controls the valve states both directly and indirectly through a relay.

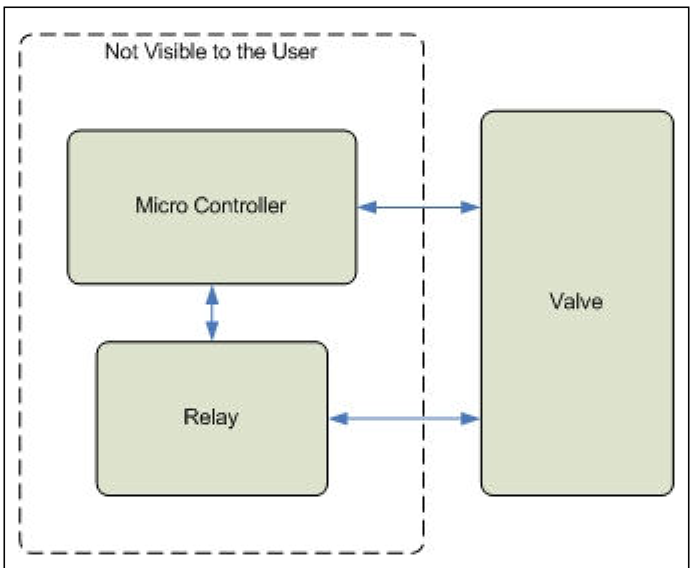


Figure 2: Fluid Multiplexer Block Diagram

An optoisolator relay is used for isolation as well as turning the valve on and off. The relay is composed of an AlGaAs infrared emitting diode which is optically coupled to a power MOSFET. Relay specifications are shown in the Table 2

Table 2: Relay specification

Operating Voltage Range	Load Current	Input-Output Isolation Voltage	Turn-Off Time	Forward Voltage
0-400 VDC	140mA	4000 VRMS	0.5 ms	1.6 VDC

The valve has been selected based on careful considerations of several issues, such as: FDA safety rules, operating voltage range, operating pressure, and flow factor.
Two of the 6 valve configurations, flow multiplication and mixing, are suitable for our application. Figure 3 and Figure 4 indicate these two configurations respectively.

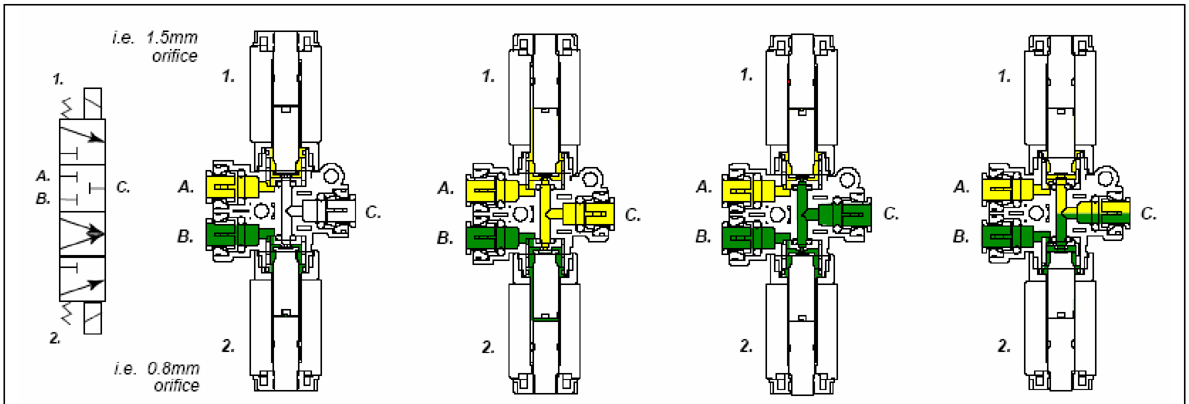


Figure 3: Direct acting, 3-way, Flow Multiplication

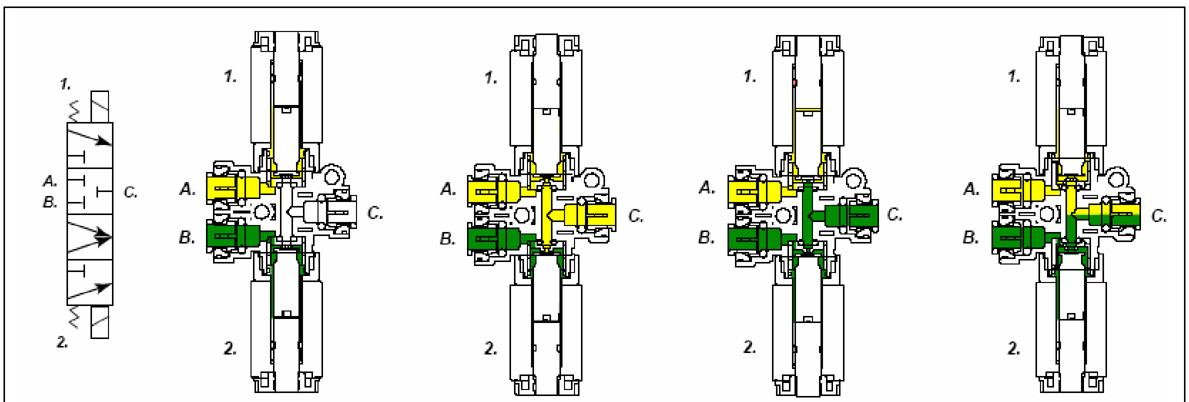


Figure 4: Direct acting, 3-Way, Mixing

The mixing option allows only mixing at the same flow rates, but for this device, it is required that the liquids to be mixed at different flow rates. Therefore a direct acting 3 way flow multiplication valve was chosen (Figure 4).

The chosen valve consists of two direct acting normally closed solenoid valves with the capability of liquid controlling, diverting, and mixing.

In other configuration, two liquids can be mixed in different flow factors from 0.025 to 0.31 both independently or in different amounts.

For the proof-of-concept, a pair of 2-way valves is used, to operate as a 3-way valve, to independently choose between different liquids with flow factor equal to 0.025 to 0.31. This flow factor has been chosen to obtain 30 mL/sec flow rate.

Because as the amount of liquid inside the ingredient containers change after each drink is made, the pressure inside the container changes accordingly. Therefore, the amount of dispensed liquid by the valve must be calibrated through the trial-and-error procedure as the system is configured to work in open-loop configuration.

Also, in order to avoid the possibility of any system crashes when the bottles are empty, the amount of each ingredient left inside the container is tracked by the software.

Other important valve specifications are shown in Table 3.

Table 3: Valve specification

Operating Pressure		**Flow Factor**	**Material**	**Port Size**	**Operating Voltage**	**Description**
Min(psi)	Max (psi)					
0	150	0.025 to 0.31	Stainless and Brass	¼”	12 VDC	Two 2-Way Normally closed Direct acting Solenoid Valve FDA approved Chemical compatibility

The chosen valve is shown in Figure 5.

Figure 5: Spartan 3826 Solenoid valve

Figure 6 shows the cross section of the valve.

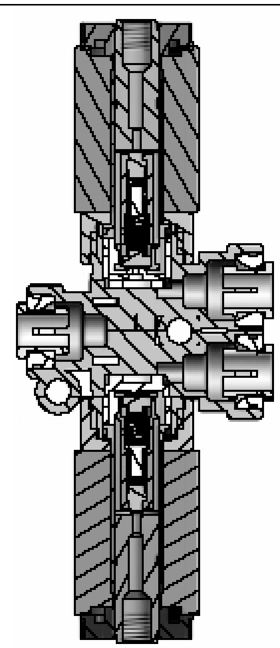
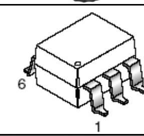
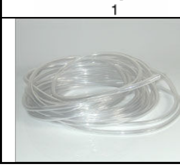


Figure 6: Cross section view of the Spartan solenoid valve

The fluid multiplexer is connected to the shaker through a flexible tube. Chemical stability is an important requirement for the tubing system of Saaghy™. Considering these requirements, Nitrile PVC is chosen for the tubes of the device. Maximum flow capability, because of its smooth surface is another advantageous property of Nitrile PVC for Saaghy™.

Table 4: Components of the Fluid Multiplexer subsystem

Product	Part Number	
Valve	Spartan 3826 series	
Relay	HSR412L	
Tube	1/4" size	

As was mentioned previously, a relay is used to drive the valve. Because of both lower current limit (130 to 220 mA) and current load (120 mA) in series connection than in parallel connection, series topology is chosen for this device. Figure 7 indicates the schematic of the relay series connection. Where DC source is 12 VDC and the LOAD is our chosen valve.

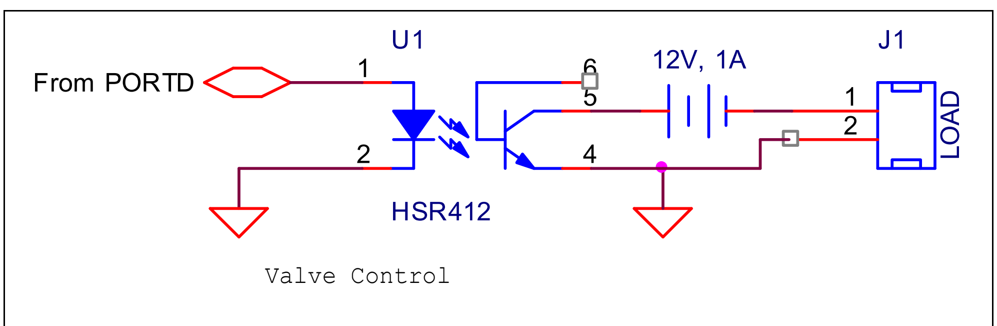


Figure 7: schematic for Fluid Multiplexer circuit

The actual fluid multiplexer circuit is shown in appendix D.

Shaker Subsystem Design

Shaking Chamber is the part of the system which mixes the ingredients and shakes the drink together with ice to make an ice-cold and perfectly mixed drink.

Shaker is a subsystem that is dependent on both the UI and fluid multiplexer. Fluid multiplexer sets a flag in the system which causes the shaker to start its process. While the shaker is busy, the user is allowed to cancel the shaking process by pressing the STOP button. When the process is terminated at any time by the user, the shaker stops and the enclosed ingredients in the shaker will be dumped to drain.

Shaking Chamber with 330ml volume and approximately 330 grams is made of stainless steel container with an ice-filter at the bottom.

In order to shake the drink to a perfect soothing drink, ¾ of the shaking chamber must be filled with ice. Also according to our research and calculations, the shaker must be moved vertically to a height of approximately 7.5 – 10 cm and with a speed of more than 300RPM to mix the ingredients.

The mixed ingredients must be shaken vertically to avoid the inconvenience of dilution and to make the ingredients mix evenly. To do so, the shaking chamber must move vertically approximately 7.5 - 10 cm to cause the liquids move and to mix together.

In order to generate a vertical motion from a circulating motion, several systems have been considered. First system considered was the Cam/Follower system depicted in the Figure 8 below.

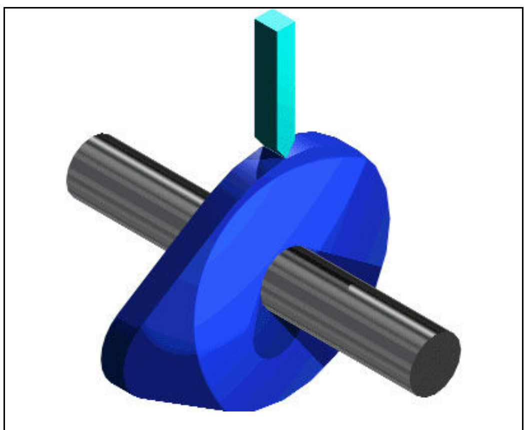


Figure 8: Cam/Followe Mechanism

In this mechanism, the cam causes the shaker attached to the follower to move vertically. The advantage of this system is the simplicity and the lower number of moving parts in the system. However, the amount of noise generated by the moving cam and the follower system is the most notable disadvantage of this system that makes it an inconvenient choice for a home appliance. Using this mechanism, the shaker must move with more than 300 RPM in order to perfectly shake the drink which can be considered a disadvantage. Moreover, using this system, it is practically impossible for the follower to catch up with the moving cam at such high speed and height without getting stuck.

Second mechanism considered was the "The Whitworth quick return mechanism" shown in Figure 9.

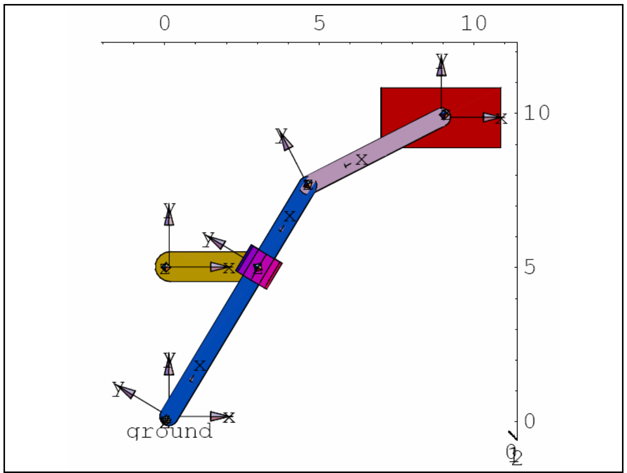


Figure 9: The 'Whitworth' quick return mechanism

The advantage of Whitworth quick return mechanism is the amount of movement of the shaker and the acceleration given to the shaker attached to this system. However, the excessive amount of moving parts makes this mechanism very hard to implement and to maintain. The moving parts of this system need lubrication to avoid excessive friction and failure of the system in the long run. Because Saaghy™ is a home appliance and needs to fit the size of almost every kitchen countertop; the height of the device is a very important parameter that should be considered while designing the system. The size of the moving parts of this mechanism makes this method an inconvenient method to be used.
The third mechanism considered is Crank-Slider mechanism which is illustrated in the figure below.

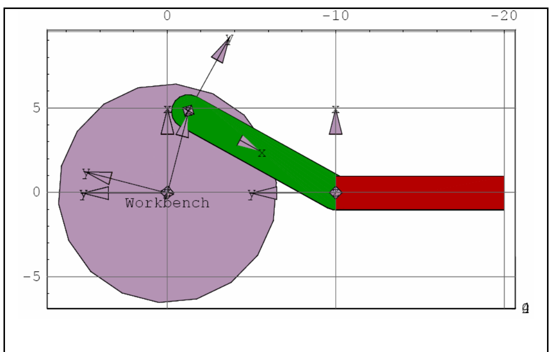


Figure 10: The Crank Slider Mechanism

The crank-slider system is less noisy than the other systems and is very easy to implement and takes up relatively smaller space than does the withworth quick-return mechanism. However, it has more moving parts than does the CAM-Follower system. Also, building such a system is much easier and cheaper than the other methods discussed previously.

Considering the benefits of Crank-Slider system, it is chosen as Saaghy™'s shaker system. In order to implement this structure, a circular disk with radius of 10 cm is required. The motor must be attached to the centre of the disk. Anticipated weight of the mechanics involved in this mechanism is less than 400 grams. Therefore, the chosen motor must be strong enough to drive the entire shaking chamber that weights approximately 800 gram.

The motor specifications are shown in Table 5 below.

Table 5: B16 Motor Characteristics

B16 model		
Voltage	**6V**	**12V**
No load speed	285rpm	675rpm
Amps @ nominal	0.3 A	0.4 A
Stall current	1.0 A	2.1 A
Stall torque	27 oz-in	45 oz-in
Gear ratio	16:1	
Weight	2.29 oz	
Diameter	0.86"	
Length	1.861"	
Shaft diameter	4 mm - with flat	
Shaft length	11 mm	

The picture of the motor is shown in the figure below:

Figure 11: B16 Motor Used To Drive The Shaker

In order to drive this load, the shaker uses 12V DC power supply. In order to prevent losses caused by mechanical systems, we decided to use the motor in direct-drive fashion without using any gears and gearboxes.

In order to guide the movement of the shaker, two rails are used with two springs attached to each rail. These springs both help the movement of the shaker and prevent the shaking chamber to hit the top and bottom of the device.

In order to avoid spillage of the drink while shaking, a rubber cap is used to block the drain of the shaker. This rubber cap is attached on the outside to a mechanism that is controlled by the MC to open and close the drain. The structure of the drain is depicted in Figure 12.

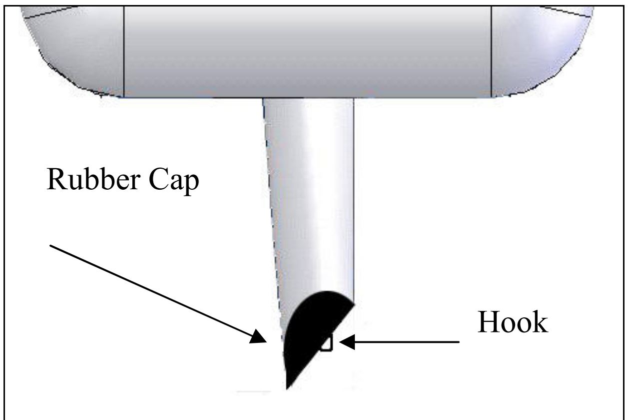


Figure 12: Shaker Drain Mechanism

Another motor is used to open and close the drain cap. This motor is placed inside the shaking chamber and is hidden from the reach of the users. The rubber cap is attached to the motor through a lever arm and a hook attached to the rubber cap. The cap may be safely removed from the mechanism by detaching the lever arm from the hook in order to facilitate the cleaning of the device.

When the shaker is done, the uncertainty in the location that the motor stops may result in possibility of the spillage while the drink is being poured into the Martini glass. In order to avoid this problem, we designed a Shaker Position Detector (SPD) circuit (Figure 13).

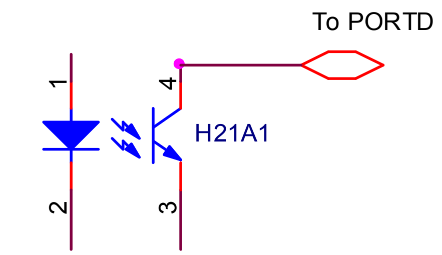


Figure 13: Partial Schematic of SPD

SPD consists of a photointerrupter (Fairchild H21A1) and a rotating wheel that is connected to the main motor (Appendix D)

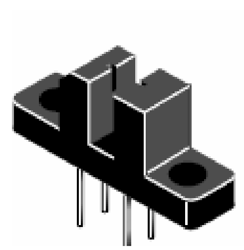


Figure 14: Fairchild H21A1 Photointerrupter

When the motor stops, the photointerrupter output is connected to the microcontroller. If after the motor was stopped the SPD detects that the shaker was stopped at the right position, the shaker will proceed to drain the mixture. However, if the MC detects that the shaker is not at the right position, MC runs the motor slowly until the right position is reached. In this case, the shaker proceeds to drain the mix.

3.2. Cup Holder Subsystem Design

The Cup Holder subsystem is the area of the system which holds the Martini glass. Since the existence of the Martini glass is crucial to the Shaker subsystem, a contact switch is inserted at the bottom of the holding area to recognize the existence of the glass.

The weight of the glass presses down the switch and closes the circuits connected to the I/O pin of MC. Therefore MC can notify the subsystems of the presence of the glass and the procedure will follow accordingly.

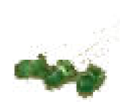
3.3. User Interface Subsystem Design

Saaghy™ provides 20 pre-programmed drink options to the user. For easier navigation, only 4 buttons are considered, each presenting 5 choices of drinks. To achieve optimized design while maximizing the efficiency, only 3 I/O pins of PORTD of the MC are assigned to UI subsystem.

To confirm the drink choice and to terminate drink making process, two specific buttons are considered. An additional I/O pin of PORTD of the MC is designated to fulfill the described purposes, so in total 4 I/O pins of PORTD are used by the UI.

The circuit required for the User Interface consists of Push Buttons, Encoders, Decoders, Flip Flops, and Logical gates which are accompanied by MC.
The above components are chosen with the specification shown in following Table:

Table 6: Components Used in UI Hardware Circuit.

Digital Component	Product	
Encoder	SN74HC148	
Decoder	SN74AHC138	
Inverter	7405Hex	
AND Gate	7421 Dual 4-input AND	
Push Button		
LED		

A typical issue with push buttons is multiple bouncing within a short period of time. This problem usually is taken care of by adding a debouncing circuit.

Different buttons have diverse characteristics due to their physical structure. As we tested our push buttons, we observed jitter but we did not observe the bouncing effect (Figure 15 and Figure 16) consequently no debouncing circuit is required.

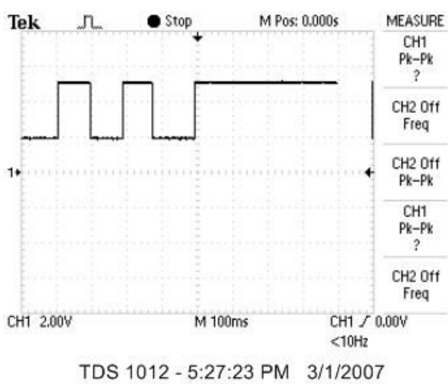


Figure 15: Push Button Bouncing Response.

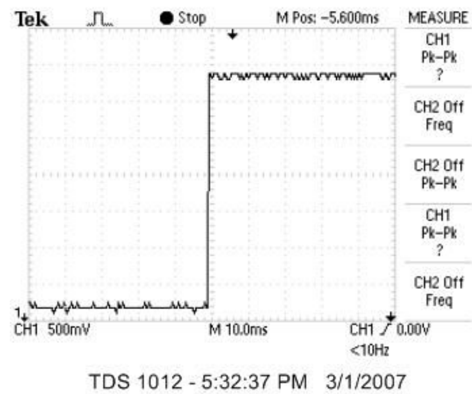


Figure 16: Push Button Bouncing Response Zoomed in.

As a primary requirement of the system, only one button should be active at a time. So a combination of AND gates and inverters are used as "Enable Selector Circuit"
The Block diagrams for this system could be found in Figure 17 and Figure 18.

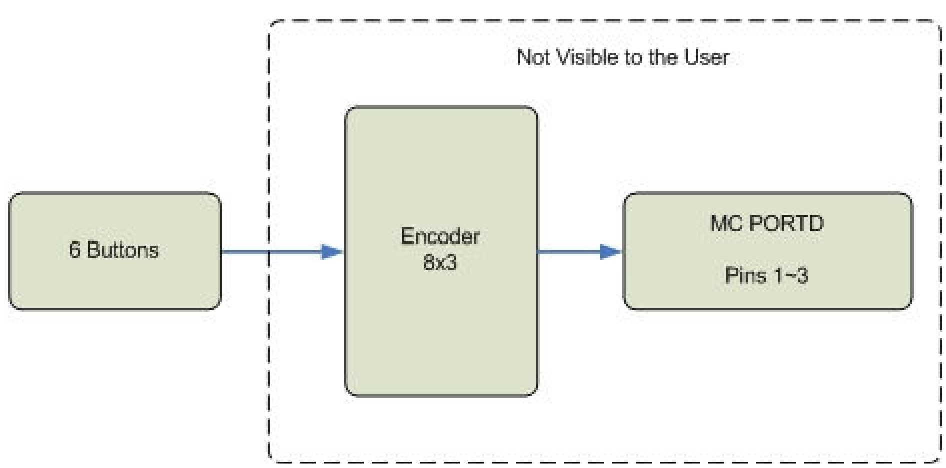


Figure 17: Buttons and Encoder Block diagram.

Once the user makes a selection, the system responds to the user by lighting up the corresponding LED. An overview of this system is shown in Figure 17.

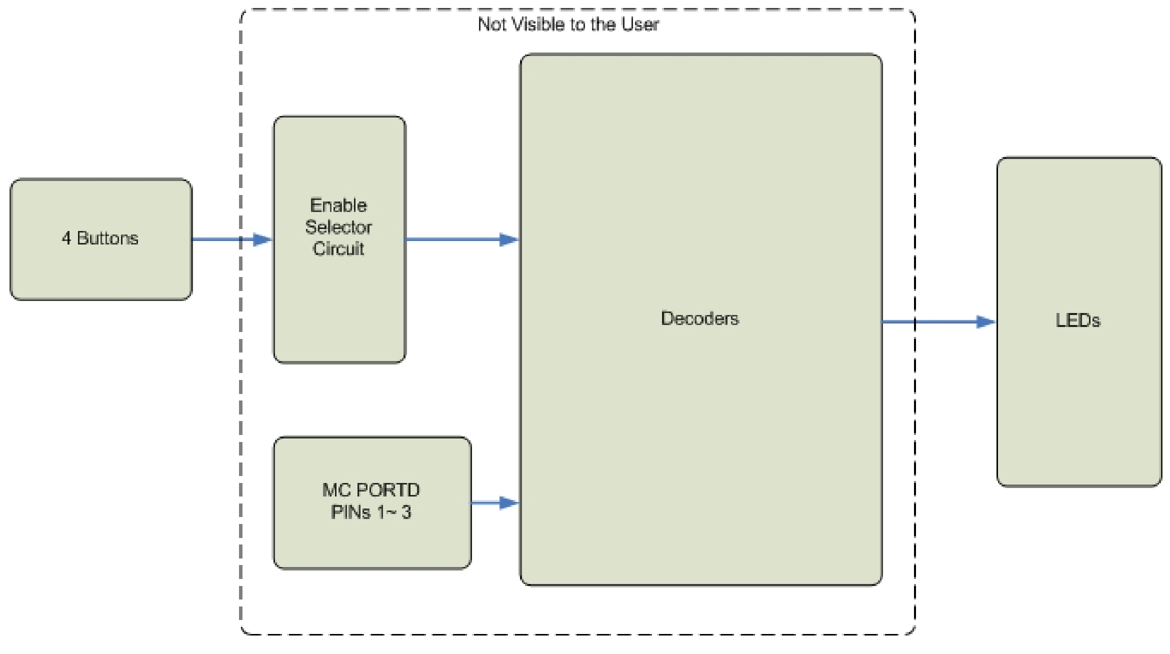


Figure 18: Buttons and LEDs block diagram.

The detailed schematics of these circuits are provided in appendix B.

3.4. Ice Holder Subsystem Design

The ice holder subsystem is a cubic container made of aluminum on the inside and plastic on the outside for the side and the bottom. The top of the container is made of a perforated aluminum sheet in order to serve as glass holder and to keep the glasses cold. The container is not attached to the device and can be moved for the filling and cleaning purposes. A door is located on the front side of the container in order to acquire or insert ice. A pair of tongs will also be provided with the ice container and a hanger will be placed on the side wall of the device in order to hold the tongs. A complete image of the ice container is shown in Figure 19.

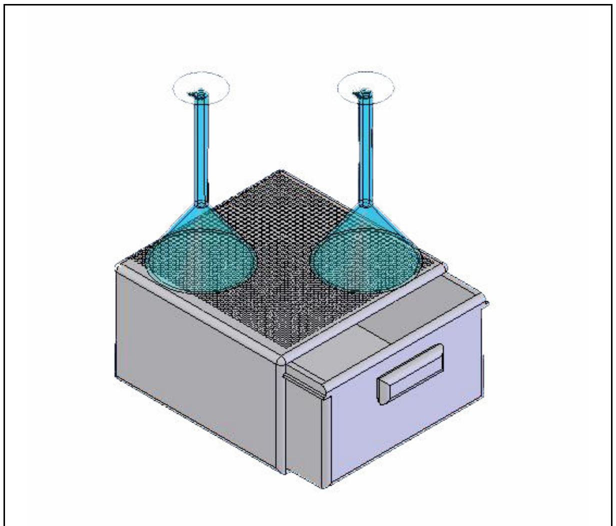


Figure 19: Ice Holder Subsystem Configuration.

4. Firmware Design

4.1. Hardware

The choice of the microcontroller for this project was primarily based on the number of I/O pins available, alternate port functions, low power consumption and simplicity of programming. Based on these criteria, we had the choice of using PICmicro or ATMEL AVR microcontrollers. We chose AVR Butterfly with ATMEL ATMEGA169 8-bit RISC controller because we owned the evaluation board prior to starting the project. This has saved us time spent on purchasing, designing and troubleshooting the board. Figure 20 shows the AVR butterfly evaluation board. A complete internal structure schematic of the microcontroller can be found in the appendix A.

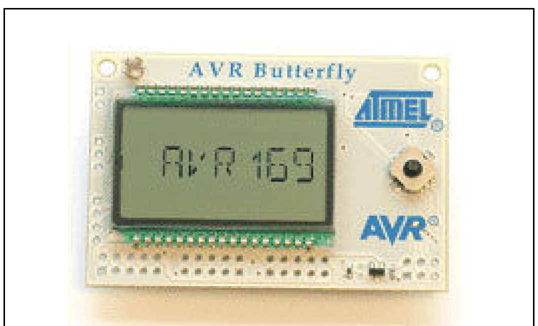


Figure 20: AVR Butterfly Evaluation Board

Table 7 shows the details of the AVR Butterfly.

Table 7: ATMEL ATMEGA169 specifications

Specification	Value
Flash (Kbytes)	16
EEPROM (Kbytes)	0.5
Max I/O Pins	54
Maximum Frequency (MHz)	16
16-bit Timers	1
8-bit Timer	2
PWM (channels)	4
10-bit A/D (channels)	8
Interrupts	23
Self Program Memory	Yes

ATMEGA169 is a programmable microcontroller with 16 KBytes of flash memory. This gives us enough space to add all the drink specifications and other data. In addition, 500 Bytes of EEPROM gives us enough space to program the core.

One of the most important features of the AVR Butterfly is the self-programming feature which allows us to easily program the MC using computer serial port (RS-232) without requiring any extra hardware.

AVR Butterfly runs on a 3.3 V onboard battery and depending on the active components, consumes 20-40 µA of current in active mode and only 0.1 µA of current in standby mode.

Although AVR ATMEGA169 supports an oscillator up to 16 MHz, we use AVR Butterfly's onboard 32 KHz oscillator. This frequency is enough to run our application in real-time fashion.

ATMEGA169 allocates up to 54 bidirectional digital I/O pins, which implicates each port has independent I/O pins to allow the direction of each I/O pin to be set without changing the direction of other pins. This is an especially useful capability of this MC which allows us to allocate each pin of the MC ports to a specific function. Figure 21 shows the equivalent schematic of I/O pins.

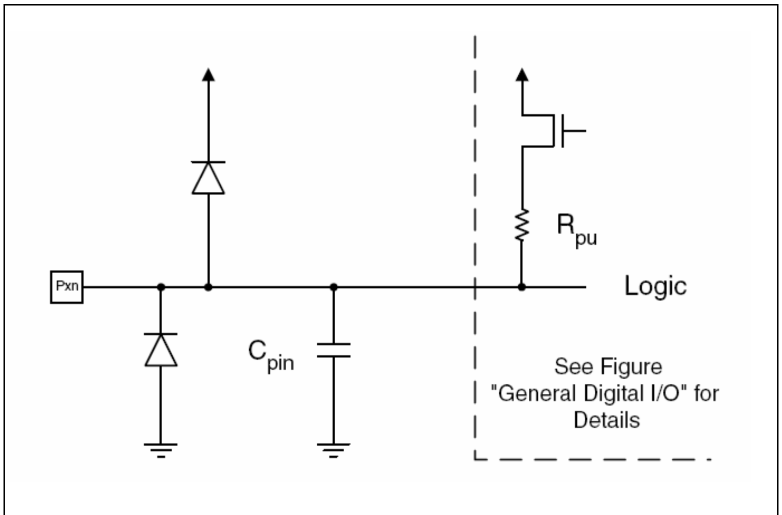


Figure 21: I/O pin equivalent schematic

The above schematic shows that, each pin has a programmable pull-up resistor, and a diode to VCC and one to ground.

Each port of AVR ATMEGA169 has alternate functions in addition to general capabilities. These alternate functions include Pulse Width Modulation (PWM), Interrupts, Analog to Digital Converter (ADC) and Timer Counter (TC).

AVR Butterfly EVB comes with several onboard hardware, such as buzzer, LCD, Joystick and 4 Mbytes of external RAM, and embedded software. Since these hardware require a specific port of the microcontroller to function, we are only restricted to PORTB and PORTD. Even though we will have 16 available I/O pins, it is more than enough pins for our applications.

4.2. *Software and Programming*

The Atmega169 on the AVR butterfly board is programmable through RS232 serial interface.

We use AVR Studio 4.0 IDE as the design software which gives us the choice of using C or Assembly languages. C is the preferred programming language for the project.

5. Power Supply Design

Power supply generates the driving force for the system components and circuits. Power supply for our device should be able to provide a range of currents and voltages to suit the needs for digital/analog and low/high current subsystems. Immobile

Because Saaghy™ is a home appliance and is designed to be stationary, the power supply is designed to use and convert the hydro power system to generate the necessary voltages and currents.
In order to design the power supply system, linear regulated power supplies were chosen over switching regulated power supplies. The basis for this design choice was the need of a simpler design, less components and smaller board area as well as cost issues.

Since the operation of Saaghy™ is not critical, the lower performance and efficiency of the power supply unit is not a major concern.

In order to step down the voltage that is received from the AC outlet, a step down transformer is used. A fuse has been used to make sure the fluctuations of the AC outlet power would not adversely affect the internal circuitry of the device. Also, a switch should be inserted in series with the transformer output to allow on-demand system turn on/off. The output of the transformer is then connected to a bridge rectifier in order to convert the stepped-down AC voltage received from the transformer to equivalent DC. Then, a capacitor is used to smooth out the received DC voltage ripples from the bridge rectifier. An indicating LED should be used to indicate the state of the system. Figure 22 shows the design of the AC-DC converter.

Then the output of this circuit is connected to each of the linear regulators. In order to accommodate the needs of the circuitry used in the device, the power supply unit uses 5V/8V/12V, 1A linear regulators to generate the desired voltage and current as shown in Figure 23. Moreover, the Shaker subsystem including the motor and the motor driver require a maximum of 2.1A and 12V to operate. The Fluid multiplexer uses maximum of 12 V to operate. As a result, a 12V, 3A voltage regulator is used.

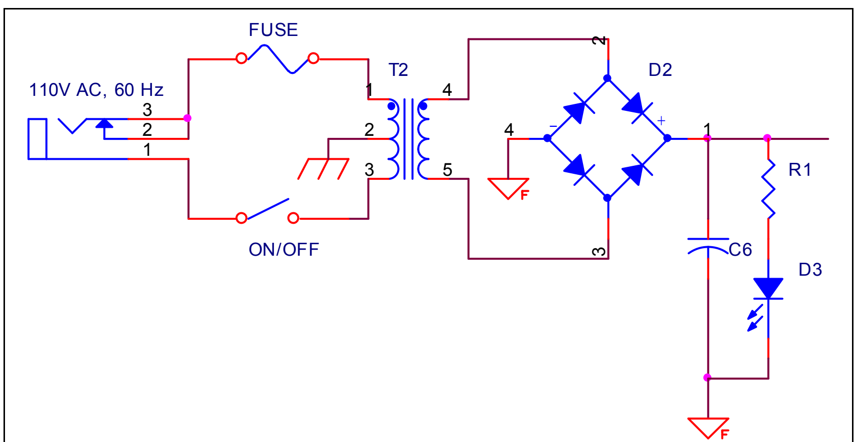


Figure 22: AC-DC Converter Schematic

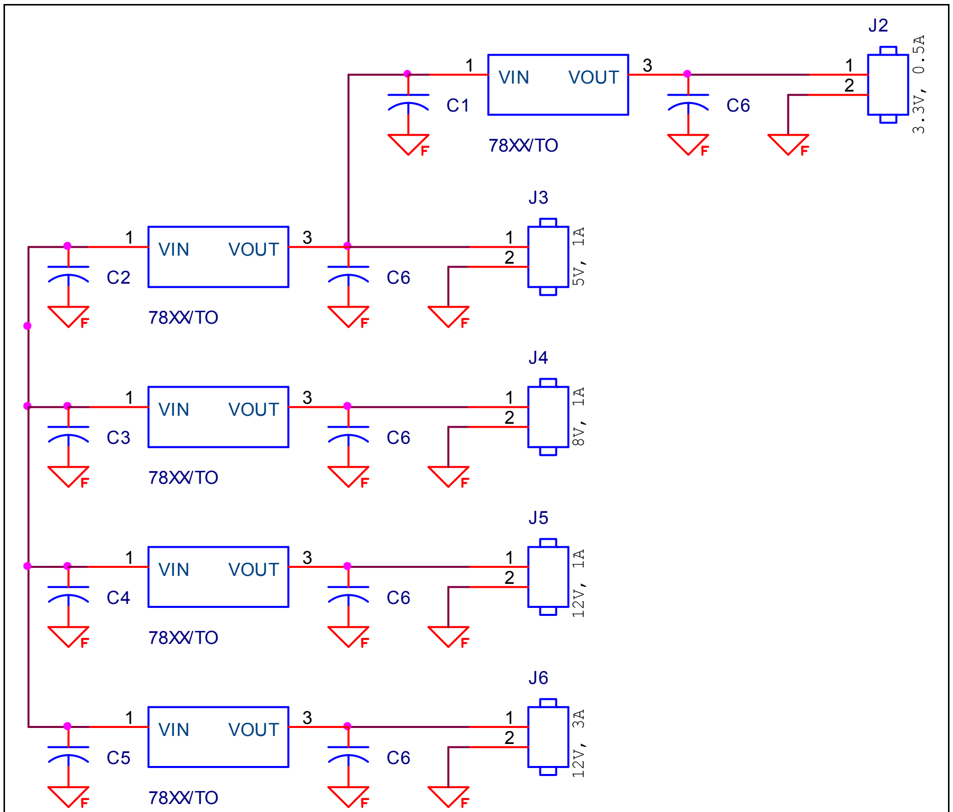


Figure 23: Output Linear Voltage Regulators

It is very important to isolate the power supply unit from the rest of the device, and especially from coming in direct contact with the liquids. This can be done by placing all the high voltage circuitry inside an isolated compartment at the bottom rear of the device.

6. User Interface design

The user interface consists of 6 buttons: 4 buttons each representing 5 different dink options, one button confirming drink selection and one button stopping the process. This design in intended for the proof of concept; however, once the product is modified for the production line, an LCD will be implemented to prompt the user the status of the device.

6.1. Drink Menu

In order to keep the menu easy to follow and eliminated text to the minimum, we have only used 4 buttons to represent the available drink choices to the user. Each button provides 5 different drink choices identified by 5 different pictures. Once the button is pressed for the first time, the first corresponding picture will lit up. If the button is pressed for the second time, the second drink choice assigned to the same button will be highlighted. Therefore, the button can be pressed 5 times in order to scan through all the possible drink options associated with it. The layout of the buttons is shown in the following figure.

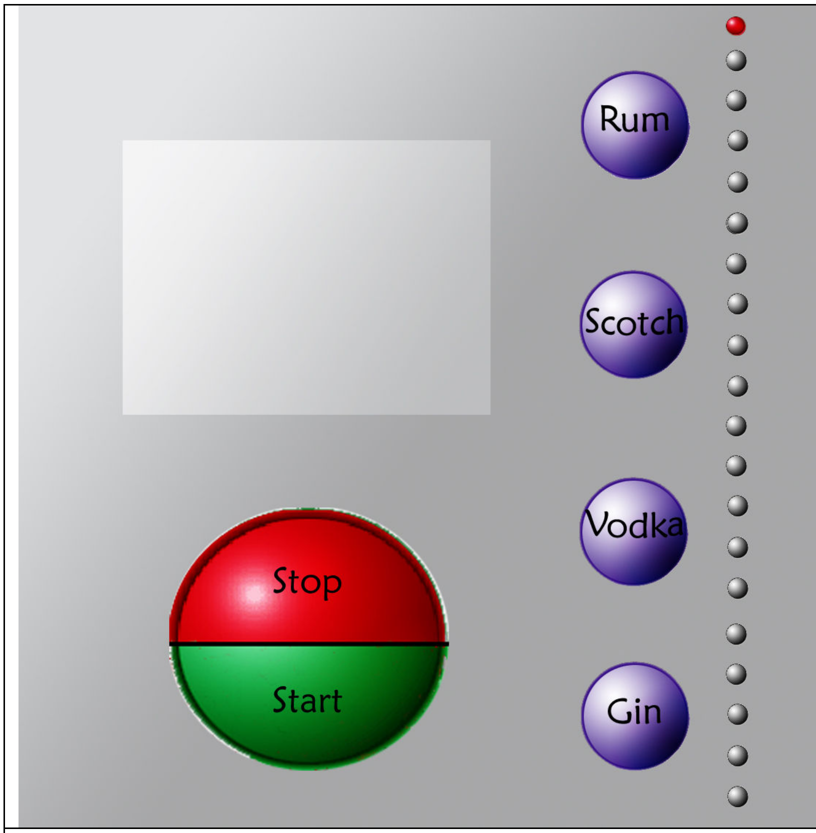


Figure 24: Buttons and LEDs Layout for the User Interface.

The buttons at the right each are associated with different drink choices. To simplify the recognition of the available drink choices, specific symbols indicating the flavor of each drink are implemented at the top of the LEDs. Once the button is pressed by the user, the picture assigned to the selected drink lids up. **Error! Reference source not found.** represents the arrangement of these different symbols.

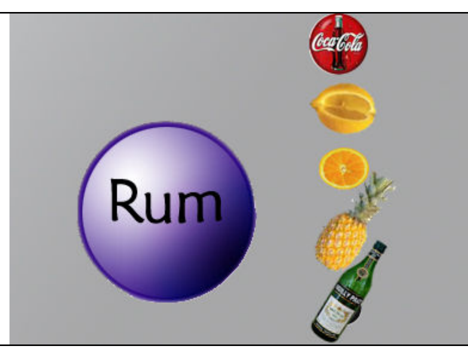


Figure 25: Button and drinks representation.

7. Cleaning System Design

As with any other kitchen appliances, a cleaning system is curtail for Saaghy™. Since internal tubes and valves of the device are in direct contact with various ingredients such as alcohols and juices, Residues left on the internal structure can cause corrosion and possible health problems.

Saaghy™ has three cleaning mechanisms to ensure a clean and non-toxic drink. Also, all the parts are dishwasher-safe.

7.1. Cleaning Mechanisms

The cleaning system of Saaghy™ is only intended for the commercial version of the product and will not be finalized for the proof-of-concept. Three cleaning mechanisms considered in the design of the Saaghy™ are:

1. After-Each-Drink cleaning
2. After-Party cleaning
3. Every 6 months cleaning

7.1.1. After-Each-Drink Cleaning

All the liquid touching surfaces such as internal pipes and shaking chamber need to be cleaned after each drink is made. Removing the residues of previously used ingredients in the internal pipes and shaker helps keeping the quality of the drink the same and avoiding contaminated drinks.

In order to implement this cleaning mechanism, the valves under the rotating disc have access to a source of water for the rinsing purpose. This water source is used for After-Each-Drink cleaning. That is, when the drink is poured into the Martini glass and the Martini glass is taken off the cup-holder area, the cleaning system is activated and 30 ml of water flows through the internal piping and into the shaker and is discarded into the drain.

7.1.2. After-Party Cleaning

After-Each-Drink cleaning system is sufficient for a fast cleaning to remove the leftover residues of previous drink, but the system needs to be cleaned thoroughly after several uses. Because a complete system cleaning takes a very long time and is relatively complicated, Saaghy™ uses another method of cleaning and washing the internal structure to accomplish this.

After-Party cleaning uses the same water source as After-Each-Drink cleaning and is activated through the UI. When activated, system constantly runs the washing liquid through the pipes and valve and finally the shaker shakes the washing liquid and dumps the liquid into the drain. This process takes approximately 10 minutes.

7.1.3. Every-6-MonthsCleaning

Although After-Party cleaning provides the system with a relatively good cleaning option, it is required to disassemble the system every 6 months and rinse the washable parts thoroughly by hand or in the dishwasher.

Disassembly procedure illustration can be found on the device manual as well as on the SST website.

7.2. Drain Mechanism

To facilitate keeping the device clean from spillage of drinks the entire bottom part of the device has been used as a drain tray. The drain has 5 cm height which makes enough space for about 4.5 liters of liquid. The drain is designed such that it can slide open and should be emptied after 4-5 drinks. Also 4 pillars have been allocated in the drain to burry the top components' weight at the pressure points. The spare liquid flows from the following parts to the drain:

1. Fluid Multiplexer: When the liquid is transferred from the fluid multiplexer to the shaker, the possible leakage from the valves may cause liquid overflow. Accordingly, underneath the rotating table will be designed like a cone with a vinyl tube in the middle in order to direct the spare liquid to the drain.

2. Shaking Chamber: When the liquid is transferred from the shaker to the glass any liquid that tips out of the shaker and not to the glass will go to the drain directly from the holes on top of the cup holder (Figure 26). Also to avoid liquid spillage, the shaker has been covered with achromatic polycarbonate sheets and the cup holder is surrounded by the body of the device.

Figure 26: Cup Holder Drain Image

3. Cleaning Mechanism: The water that goes through the tubes and the shaker for the cleaning purposes will end up in the drain through a tube that goes from the back of the shaker to the drain.

Figure 27 shows the drain mechanism.

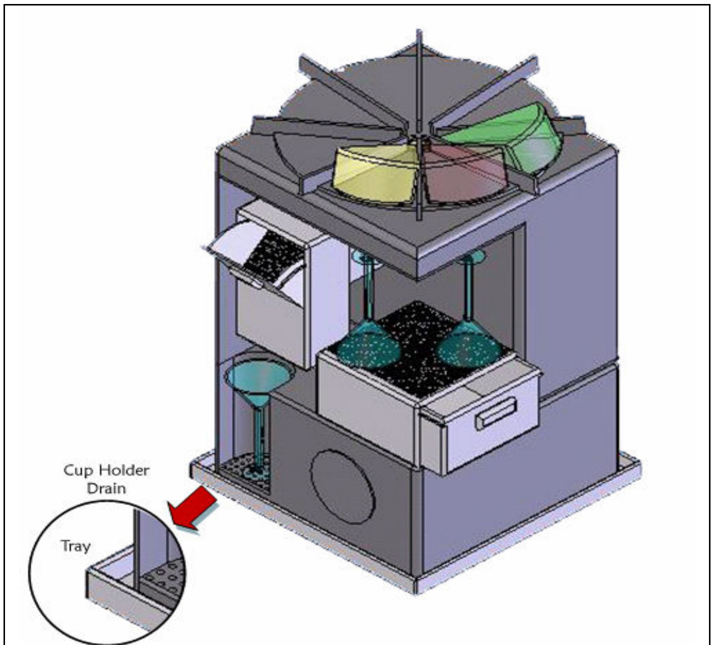


Figure 27: Drain Mechanism.

8. Physical Design

8.1. Casing Material Selection

Considering standard size of the Martini glasses, height of the shaker and shaking distance calculated in section 3.2 the approximate dimensions of Saaghy™ would be 60 centimeters in height, 30 centimeters in length and 30 centimeters in depth.

Placing bottles on the top of the device and having frequent shaking processes, impact strength and deformation could be considered as crucial parameters in the material selection. Also, the weight of the device should be considered so that it is easy to be carried around in addition to the maximum stability. Different plastic polymers could be used building the main body of this device. The cost analysis suggests that using molding methods for individual products is not efficient. Therefore, sheets of plastic and plastic polymers will be used to form the desired shape of the device.
Due to a broad range of outstanding properties, the physical structure of the device will be made of Polycarbonate. This material is transparent engineering thermoplastic which is notable for its extraordinarily good dimensional stability, high impact strength nominal

under load deformation and scratch resistance. Polycarbonate also has a high heat deflection temperature and very low moisture absorption, an essential identity in the presence of liquids. Since most of the ingredients used in the cocktail maker contain alcohol, high chemical stability of this material is an absolute advantage. Polycarbonate also, presents superior electrical insulation properties.

Polycarbonate sheets are available in different colors as shown in Figure 28.

Figure 28: Polycarbonate Sheets

Table 8summarizes different properties of the Polycarbonate.

Table 8: Properties of Polycarbonate

Property		Value
Physical	Water Absorption, 24 hrs	0.12 %
Mechanical	Tensile Strength	9500 psi
	Flexural Strength	15000 psi
	Compressive Strength	12000 psi
	Hardness, Rockwell	M70/R118
Thermal	Max Operating Temp	121 ˚C
	Thermal Conductivity	6.9×10^{-4} cal/cm.sec.°C
Electrical	Dielectric Strength	390 V/mil
	Volume Resistivity at 50% RH	10^{16}

Simple Sophisticated Technologies

8.2. Bottles

As it has been mentioned in the previous documents, custom made bottles entitled TBottle™, are considered for different ingredients storage. To avoid using pumps these bottles are placed on a rotating disk at the top of the device on their heads. Consequently, gravitational force contributes to the liquid flow significantly. Moreover, vent mechanism added to the TBottles™ provides consistent atmospheric pressure balance. Figure 29 represents the arrangement of TBottles™ on the rotating disk.

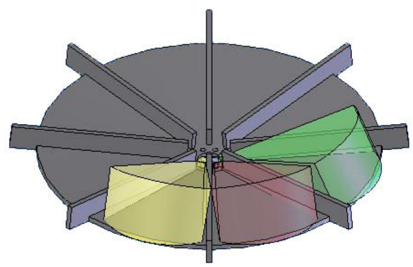


Figure 29. TBottles™ on Rotating Disk

Note that the device fabricated in the proof of concept stage will not include TBottles™.

9. Software Design

9.1. Programming Strategy

9.1.1. Fluid Multiplexer Subsystem Design

The Fluid Multiplexer software controls the flow rate of each liquid by controlling the valve. Fluid Multiplexer uses one I/O pin from PORTD to control the valve.

Fluid Multiplexer software uses the two dimensional arrays to read the ingredients and the amount of each ingredient for the specific drink the user requested through UI.

Because the chosen valve can dispense 27.27ml of liquid every second, the ingredient amounts are stored in multiples of 27.27 ml.

After dispensing is done, the Fluid Multiplexer sets the MUX_DONE variable to inform the shaker subsystem that it can start its function.

The complete flowchart of the subsystem is illustrated in section 9.3.1.

9.1.2. Shaker Subsystem Design

Shaker subsystem software controls the shaking and draining mechanisms by turning on the right motors using PWM.

Because the shaker and Fluid Multiplexer will not work at the same time, these subsystems share ports in order to increase the efficiency of the system.

In order for shaker to start, the global variable MUX_DONE must be set by the Fluid Multiplexer. After shaking is done, the software checks the position of the shaker by checking the status of PORTD. If the shaker is in the right position, then the software checks the existence of the Martini glass in the cup holder by checking the flag set by CHECK_GLASS () function.

If the flag is set, the drain-control motor is turned on and the liquid is poured into the glass. However, if the flag is unset, through the UI, the shaker prompts the user to insert a glass in the cup holder and system halts. After the glass is inserted, the drink is poured into the glass.

After draining the liquid, the shaker software unsets the UI_DONE and MUX_DONE variables and sets the SHAKER_DONE variable, in order to force the system to return to its initial state.

The complete flowchart of the subsystem is illustrated in section 9.3.2.

9.1.3. User Interface Subsystem Design

User interface facilitates communications between outside world and the device. As it has been mentioned previously, Saaghy™ uses 6 different buttons to receive information from the user and uses different LEDs covered by the picture of the drinks to highlight different choices.

In order to keep the user informed continuously and to prompt different messages, it is essential for the UI to have internal communication with other subsystems of the device as well. Different variables have been considered in the software design of the device in order to provide these different communicational stages. For example when the shaking process is done "SHAKER_DONE" variable will be set and passed to the UI.

For maximum efficiency only 4 pins of PORTD of the MC are dedicated to the UI. Initially these 4 pins are set to be at input mode. Upon pressing a button the direction of the same pins will be changed to the output mode, and as a result the corresponding LED will be turned on. Also, this system uses interrupts to detect whether a key is pressed or not.

The complete flowchart of the subsystem is illustrated in section 9.3.3.

9.2. System State Design

The System state design shows how the subsystems in the device are internally related. The passing parameters between the two states are shown above the connection.

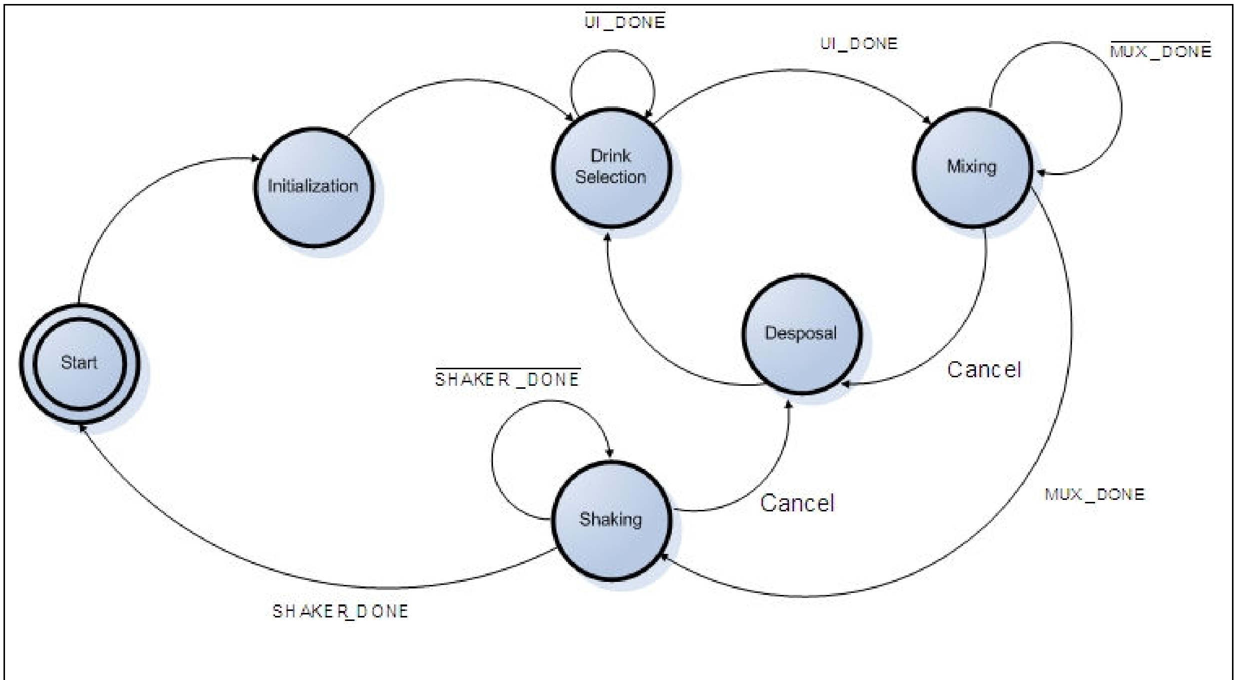


Figure 30: State Diagram

9.3. Algorithms

For a more concise and organized approach, we have implemented separate flowcharts for each subsystem. In addition to the description of the functional procedures, system flowcharts represent the information required to be passed to other subsystems.

9.3.1. Fluid Multiplexer Flowchart

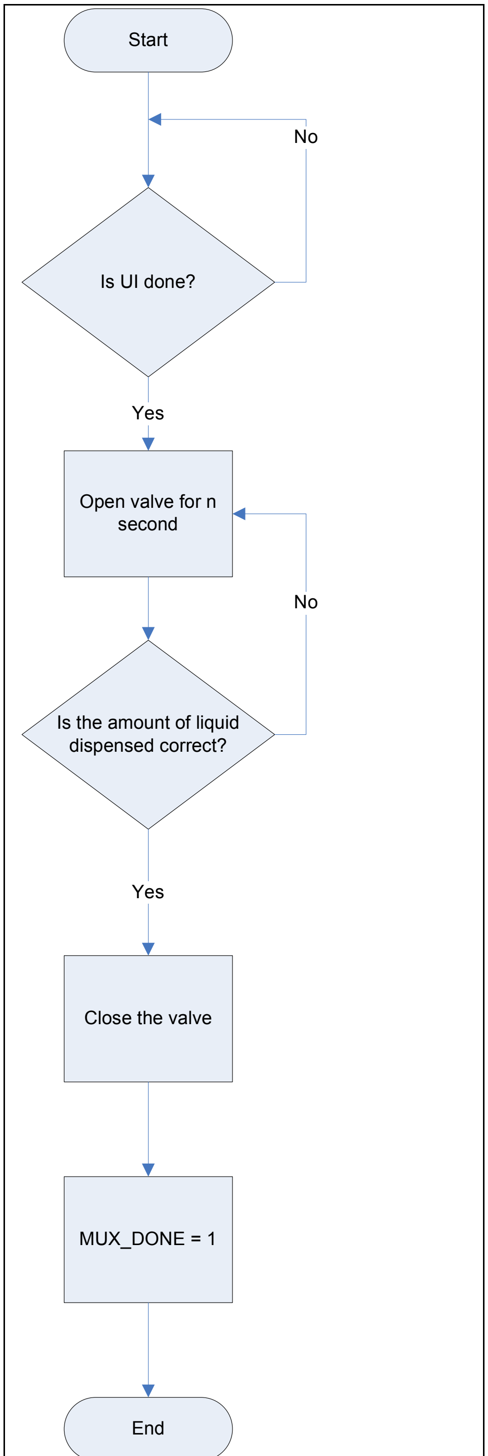


Figure 31: Fluid Multiplexer Flowchart

9.3.2. Shaker Flowchart

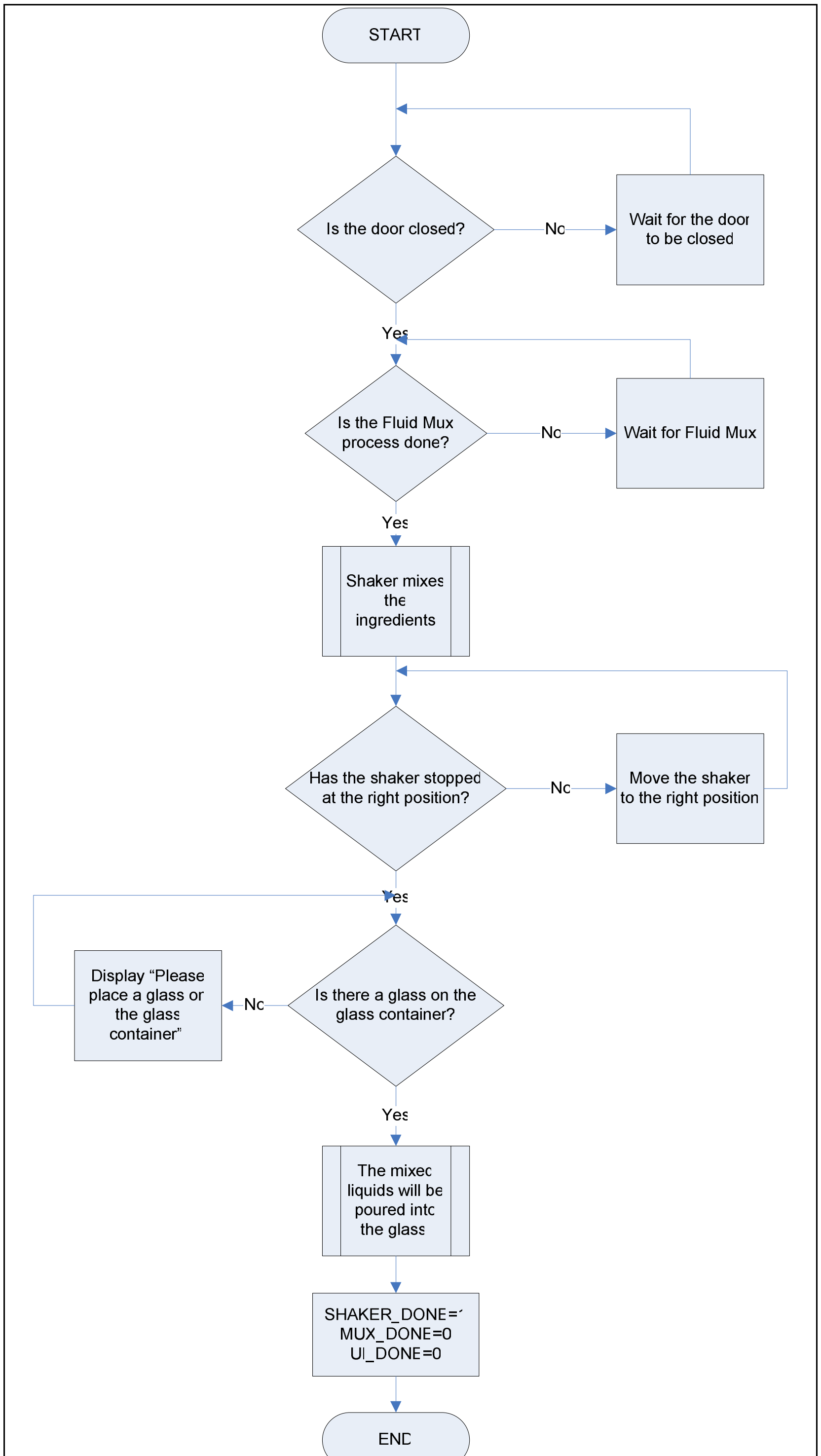


Figure 32: Shaker Flowchart

9.3.3. User Interface Flowchart

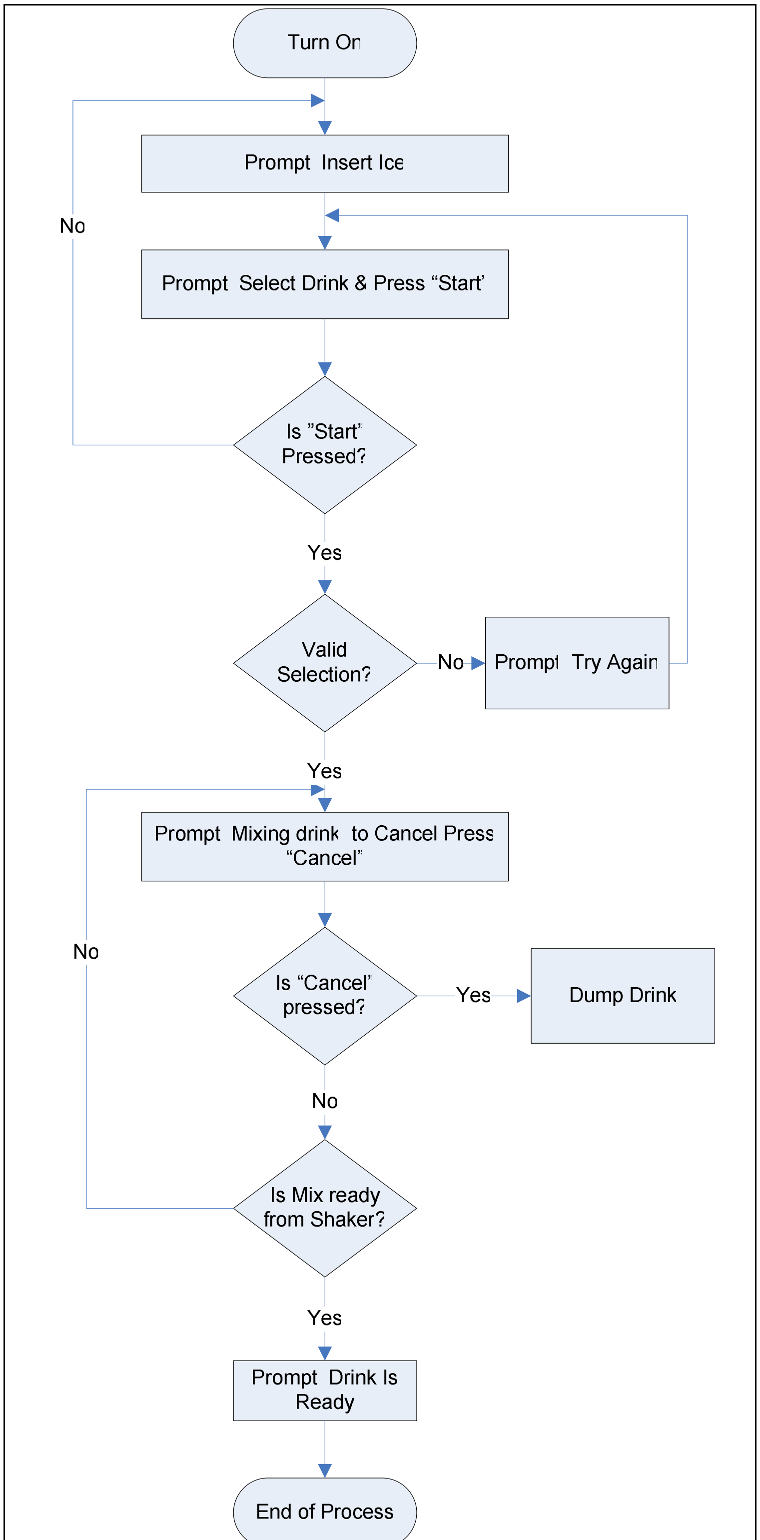


Figure 33: User Interface Flowchart

10. Test Plan

Before assembling and running the system, each subsystem should be tested independently and thoroughly, furthermore its functionality should be confirmed.

10.1. Hardware Test Plan

In order to verify the functionality of each part, 5 levels of independent testing are required.

10.1.1. General system connection Verification

In this testing phase, a thoughtful verification of following tasks should be done:

- Wiring verification of all ICs to the board.
- Wiring verification of all other components to the board.
- Schematic matching verification to make sure all physical connections are identical to the schematics.
- Tolerances checking to verify all of the components are within the specified tolerance range.
- Function verification of the electromechanical parts such as valves and motors

In order to move to the next phase, all above testing options should be completed successfully.

10.1.2. Power supply Verification

In the second phase, a detailed testing is required for the following sections:

- Applying AC voltage to power supply, and verify the desirable DC output voltages.
- Applying correct voltages to all power nodes.
- Checking the physical isolation of PSU from the rest of the device.

It is expected that these tests will verify that all the power nodes have the required voltage. In addition, it is ensured that the output voltages at the output of the voltage regulators will be fixed and there are no noticeable fluctuations.

The power supply functionality must be confirmed before going to the next stage of testing.

10.1.3. Microcontroller Evaluation Board

During this phase, the correct functionality of AVR Butterfly Evaluation Board is verified.

AVR Butterfly EVB is pre-programmed by ATMEL AVR bootloader. Using this bootloader, all the features of the EVB can be thoroughly tested.

Moving to the next testing phase is possible only if the EVB testing and verification is successfully done.

10.1.4. Fluid Multiplexer Subsystem testing

This phase confirms the functionality of Fluid Multiplexer subsystem:

- Testing the relay functionality.
- Testing the basic valve function which is simple opening and closing.
- Testing the flow rate.
- Testing the basic reaction time of the valve.

At the end of this verification process, it is ensured that the valve and relay subsystem is functional and the reaction time and amount of deposited liquid is as expected.

Moving to the next testing phase is possible only if the fluid multiplexer subsystem testing and verification is successfully done.

10.1.5. Shaker Subsystem Verification

This phase confirms the functionality of shaker subsystem:

- Testing the relay functionality.
- Testing the functionalities of the motors.
- Testing the mechanical joints.
- Testing the shaker draining system.
- Testing the shaker position detector (SPD) system.
- Verifying the cup holder functionality.

At the end of this verification phase, the proper functionality of the shaker subsystem including the maximum height that the shaker travels, shaking speed as well as the proper functionality of draining mechanism shall be verified.

Moving to the next testing phase is possible only if the shaker subsystem testing and verification is successfully done.

10.2. Software Test Plan

It is crucial to test the software to ensure that the subsystem codes are functional and are bug free. In order to save time and to ensure that the software code is fully functional, VMLAB software is used to simulate the code for each individual subsystem. After the functionality of each subsystem's software has been tested individually, a separate testbench application will be written to test the entire system.

After the testbench results were verified, the application will be loaded onto the microcontroller, and a set of test cases will ensure that all requirements written in the functional specifications are satisfied.

For testing the software aspect of the system, the test engineer will perform the following high level tasks:

1. Usability and functionality of the user interface.

2. Ensure that after each ingredient is dispensed, the correct volume of the remaining ingredient is stored in the non-volatile memory.

3. The correct mix has been used for each drink.

4. The dispensed amount of ingredients is correct.

10.3. Proof of Concept Experiments

In order to verify the usability and performance quality of Saaghy™ for personal and business use in a quantitative manner, a proof of concept experiment have been conducted. The experiment will also examine the degree to which the device is practical.

The following factors will be satisfied in performing the experiment by the test engineers:

1. Make a survey to identify the potential users.
2. Acquire up to 20 random individuals and at least 5 bartenders for testing.
3. Ask the individuals to try working with different parts of the device while they are sober and after a few drinks.

4. Construct and collect a set of questions from all the contestants in order to get feedback about the device usability.
5. Compare the results received from different individuals and the bartenders to make sure both groups are capable of working with the device without any problems. Modify the device and repeat the test if necessary.

11. Conclusion

The Design Specifications for automated cocktail maker documentation provides initial design standards towards the implementation of the Saaghy™'s proof of concept representation. The design approach for the development of Saaghy™ fulfills all functional requirements described in the *Functional Specifications* and proposal. Our discussion of the product design is primarily divided into hardware, software and firmware design, and subdivided into the subsystems that contribute to making Saaghy™. In the process of developing the proof of concept model for Saaghy™, we execute the hardware, firmware, interface, software and system tests as described in this document. Further, a set of proof of concept experiments verifies our product usability and quantitative manner. By April 2007, we hope that Saaghy™'s proof of concept model is fully developed to be able to serve as a device to help making people's life easier and more enjoyable.

Finally the design of the Saaghy™ with outlined specifications will "create the world that has never been".

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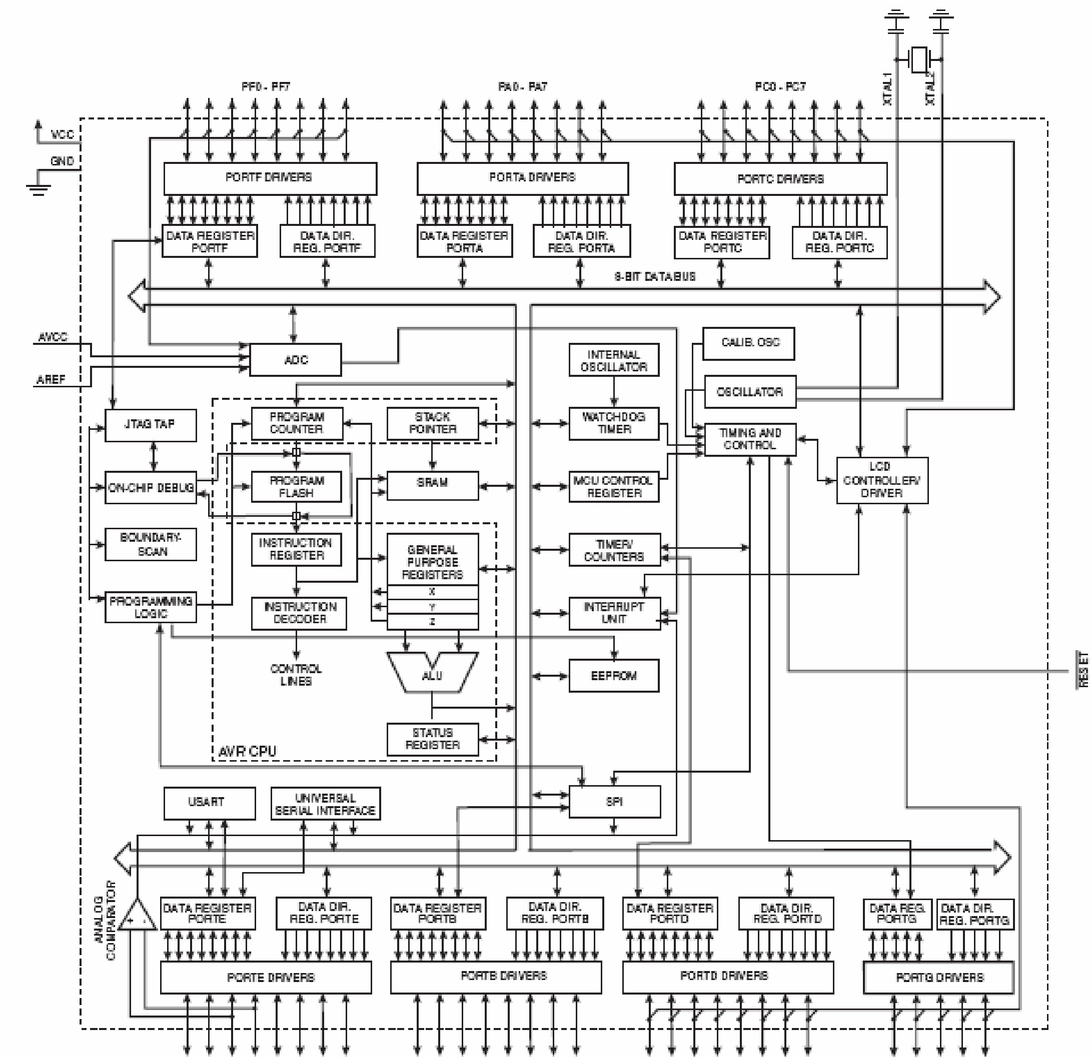
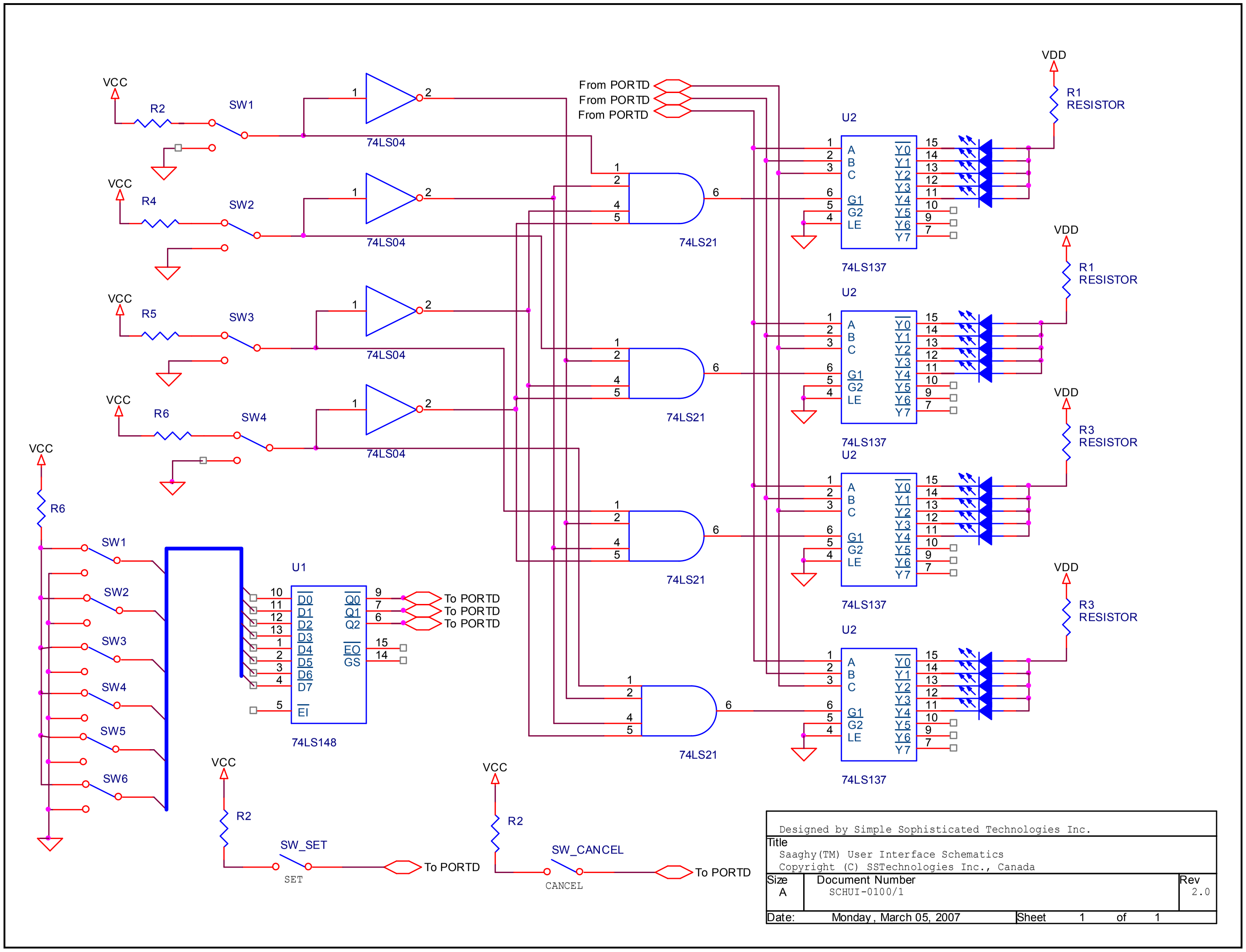
13. Appendix

Appendix A: Microcontroller internal structure and schematic

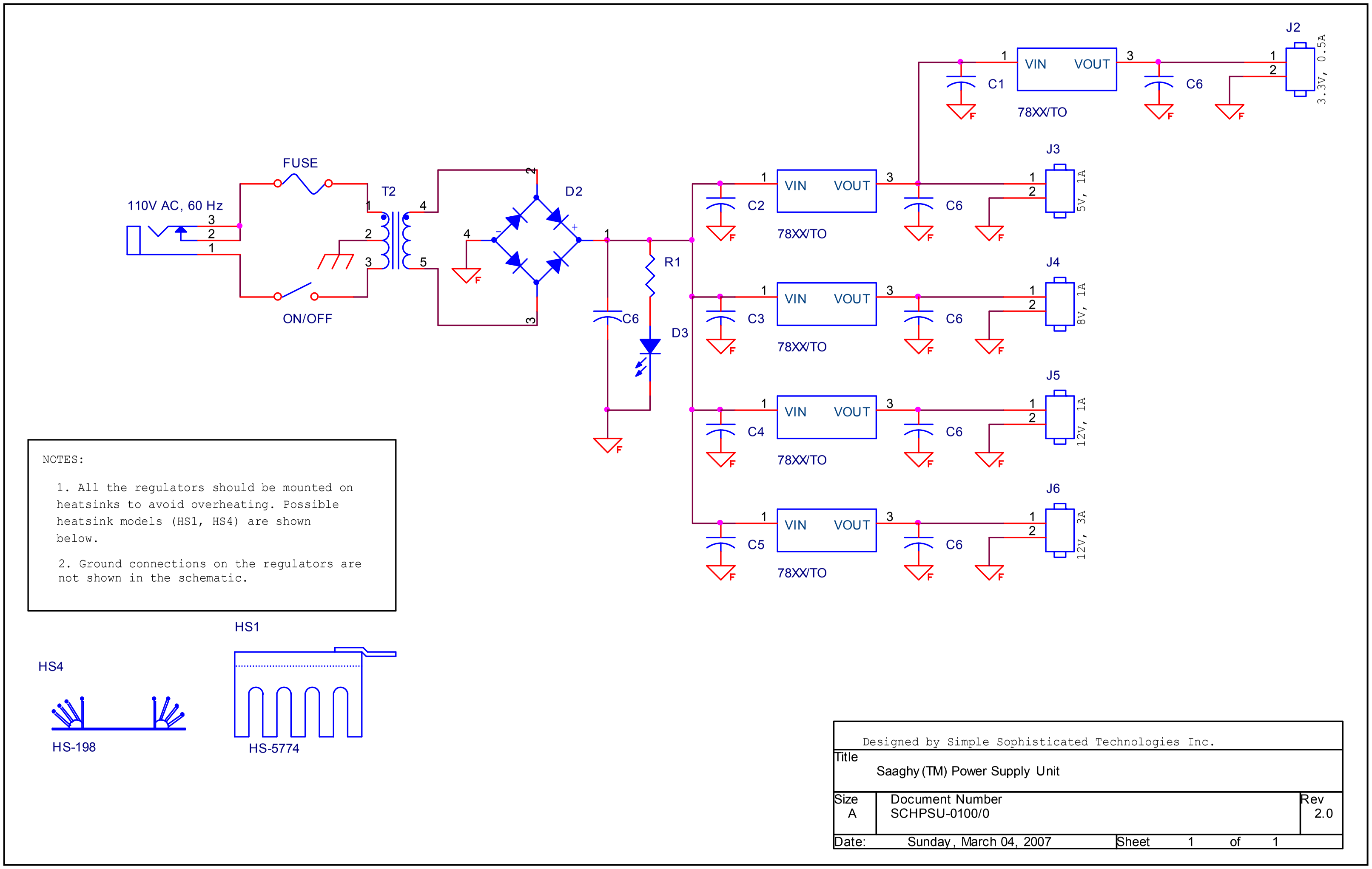
(Courtesy of ATMEL™)



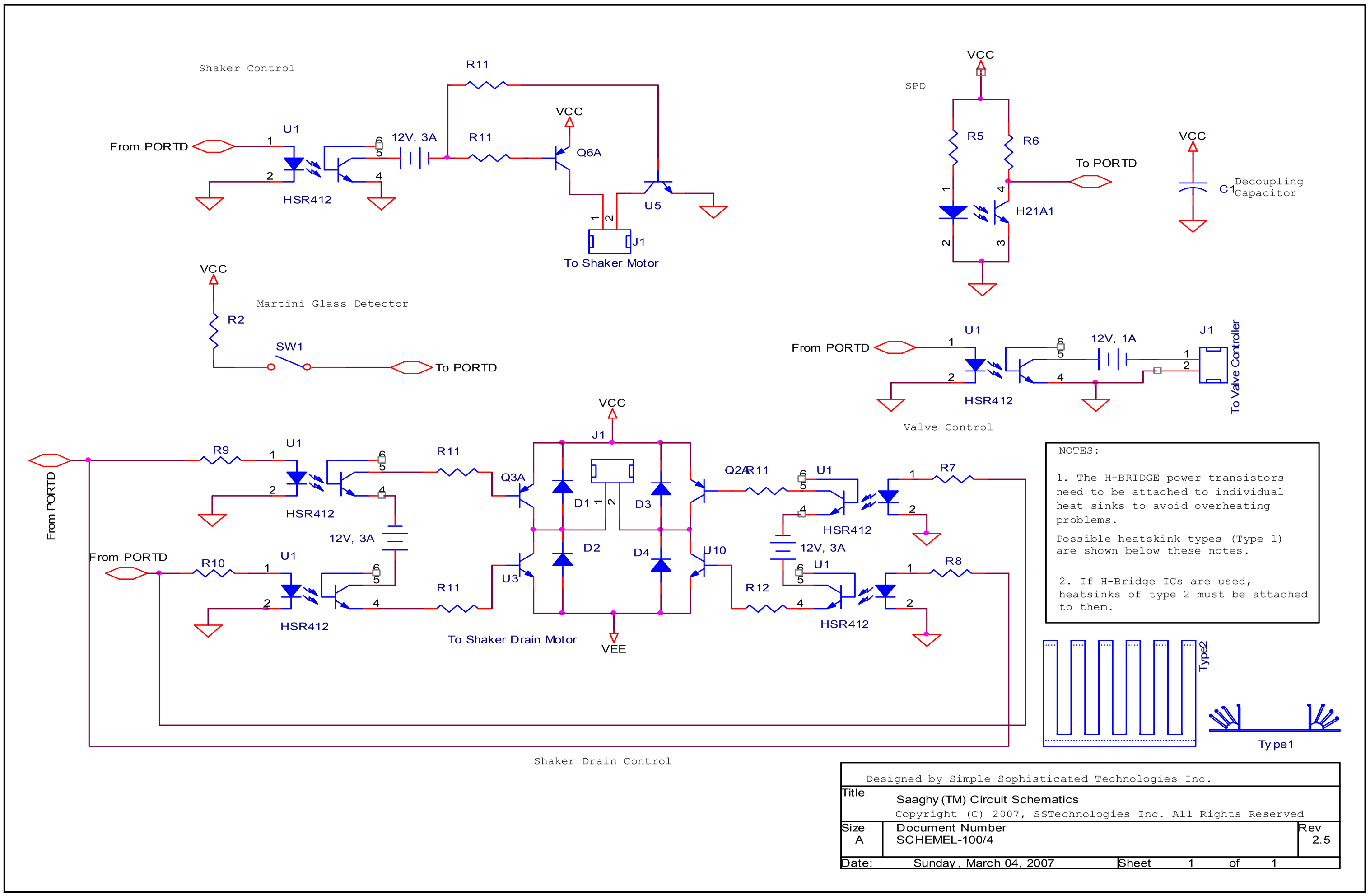
Appendix B: User Interface Schematics



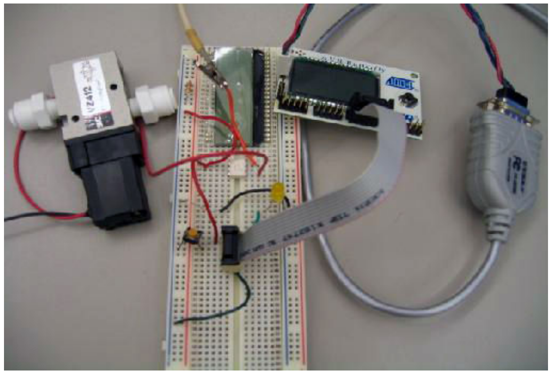
Appendix C: Power Supply Schematics



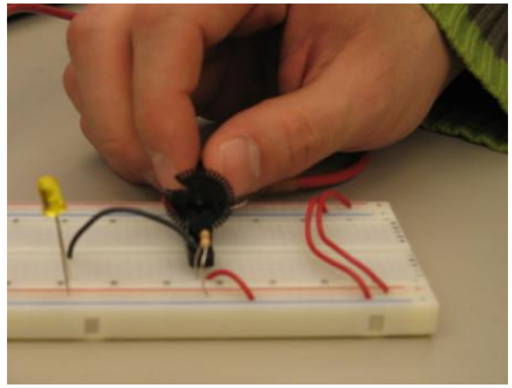
Appendix D: Shaker and Fluid Multiplexer Schematics



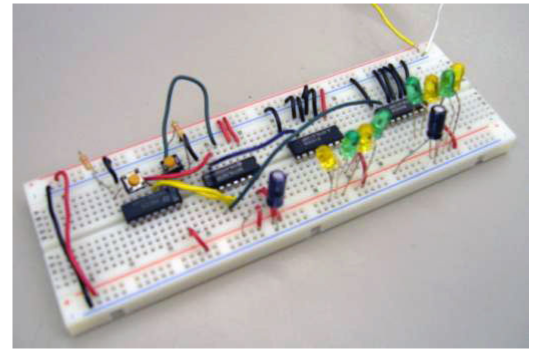
Appendix E: Demo Circuits



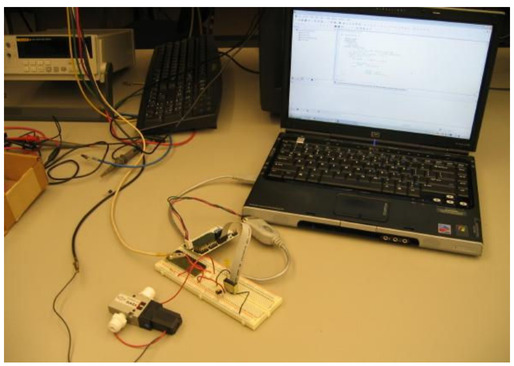
Valve interface to Microcontroller



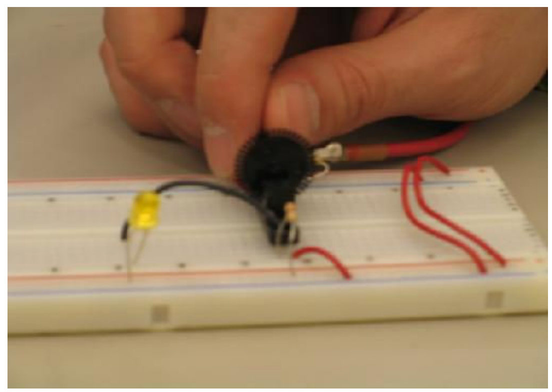
Shaker Position Detector circuit:
When the shaker is at the wrong position



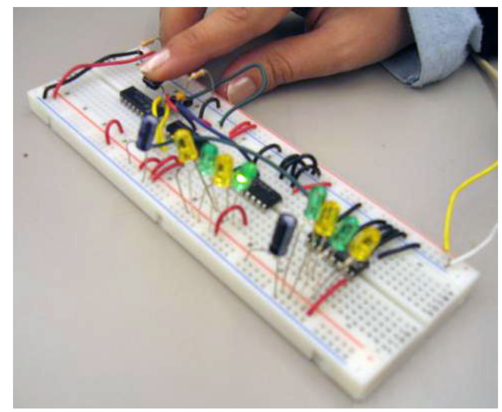
User Interface Circuit



Valve interface to Microcontroller



Shaker Position Detector circuit:
When the shaker is at the right position



User Interface Circuit:
When a button is pressed