March 16th, 2011

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, BC
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Re: ENSC 440 Functional Specification for the Safety Add-on for Electric Stoves

Dear Dr. Rawicz,
Attached is a document describing from our company **Universal Safety Solutions Inc.** providing technical guidelines for design of our product ShutSmart. The ShutSmart will facilitate the safe usage of electric stoves throughout North America. It works as an emergency response to unattended stoves that are a major cause of fires in houses. It would nullify the human errors due to common user negligence by alerting the users of unattended stoves, or by disconnecting the power supply to the stove thereby preventing any major mishaps. ShutSmart will be stove independent, in the sense that it can be installed by the user for any electric stove without making any major changes in the stove design.

The design specification provides a set of high-level requirements for the development of functioning prototype. Design improvements for future iterations have been discussed as well.

Universal Safety Solutions Inc. is a team of three hard-working and committed engineering students – Abhishek Dubey, Sibghat Ullah and Vikas Yadav – who bring to the table a wide spectrum of knowledge from various fields of engineering. If you have any questions or concerns regarding our project proposal, please feel free to contact me by email at vya3@sfu.ca.

Sincerely,

Vikas Yadav
Project Manager
Universal Safety Solutions Inc.

Enclosure: Design Specification for the Safety Add-on for Electric Stoves

Design Specification for

ShutSmart – The Safety Add-on for Stoves

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ENSC 440

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ENSC 305

Issued Date:

Mar 16, 2011

EXECUTIVE SUMMARY

ShutSmart is a product proposed by Universal Safety Solutions Inc. It is essentially a safety add-on feature for electric stoves throughout North America. ShutSmart will act as a complete safety system for open top stoves by offering the user with audio/visual feedback in case of any emergency situations. The user will be presented with a few options which can be taken to prevent any mishaps from occurring. The product will also have the capability to override the whole stove system and turn off the stove in case the user is unavailable to take necessary actions. This particular unique feature is bound to set a new standard for stove safety throughout North America.

The design specification for ShutSmart contains a detailed description of the design and development of our proof-of-concept model. The main focus of the document will be to provide an in-depth analysis of the design of a working prototype for ShutSmart, which is being developed by USS. The document will also present ideas for the improvement of the working prototype design. While these ideas will not be implemented in the proof-of-concept model, they might be fulfilled in future iterations.

USS will be developing the following key components for ShutSmart:

- **Main Unit**
  It contains a microcontroller board which will be receiving signals (receiver end of the wireless signal system) based on the stove top situation, and will take appropriate actions. The actions include alerting the user about any untoward situations through alarms and alerts, and switching off the stove in the absence of the user through an in-built relay system.
- **Wireless Control Unit**
  This unit will be placed underneath the stove plate, and will contain the transmitter end of the wireless signal system. It will continuously send the appropriate voltage-driven signal to the receiver end in the main unit prompting it to take action. This unit contains a small microcontroller board along with a batter holder. Owing to its close proximity to the stove, the unit will be enclosed a durable and heat resistant casing.
- **Sensor Unit**
  This component will be implemented in future iterations and includes the smoke alarm and motion sensor system. The smoke alarm system will provide audio and visual alert in the event of smoke thereby preventing any fires. The motion sensor system will detect the presence of the user near the stove and prompt the main unit to act accordingly.

The document provides a detailed description of the selection of resources and the associated functional and design requirements. A system test plan has been added to the document which will provide an idea about the thorough testing procedures that will be followed for quality assurance of all the major components of the product. A system flowchart has been included to give a clear idea about the integrating process that will take place. The document also includes a plan for testing the system as a whole to ensure that the final product is fully functional and ready to be deployed.

TABLE OF CONTENTS

Executive Summary ii
List of Figures v
List of Tables v
Glossary vi

1. Introduction 1
- **1.1. Scope** 1
- **1.2. Intended Audience** 1

2. System Overview 2

3. Design Specifications 4
- **3.1. Main Unit** 4
  - 3.1.1. **Choice of Microcontroller** 4
  - 3.1.2. **Design Implementation** 5
    - A. DC Power Supply 6
    - B. Voltage Regulator 6
    - C. Capacitor 7
    - D. Crystal Oscillator 7
    - E. Reference Pin 7
    - F. Wireless Receiver 7
    - G. Speaker 8
    - H. Push Button 8
    - I. Voltage to operate Relay 8
- **3.2. Wireless Control Unit** 9
  - A. MSP430-G2211 Microcontroller 10
  - B. MSP430 Development board 11
  - C. Honeywell NTC Thermistor 11
  - D. 5KΩ resistor 12
  - E. 2 AA batteries 13
  - F. Battery holder for 2 AA cells 13
  - G. 25 AWG wires for connections 13
  - H. QAM-TX1-433-ND Transmitter 13
  - I. Chassis box 14
  - J. Push pins 14

3.3. Sensor Unit 15
A. Smoke Alarm System 16
B. Motion Sensor System 16
C. Transmitter Circuit 16

4. System Test Plan 17
4.1. Component Testing 17
4.1.1. Digital FM transmitter and receiver 18
4.1.2. Thermistor circuit placed in the wireless control unit 18
4.1.3. Relay gates located in the main unit 19
4.1.4. ATMEGA168 microcontroller board in the main unit 19
4.1.5. External casing for the wireless control unit 19
4.2 Unit Testing 20
4.2.1. Main Unit 20
4.2.2. Wireless Control Unit 20
4.2.3. Sensor Unit 21
4.3 Complete System Testing 21

5. Conclusion 22
6. References 23
7. **APPENDIX A** 24

LIST OF FIGURES

Figure 1: External overlay of ShutSmart safety system 2
Figure 2: Detailed system overlay for ShutSmart safety system 3
Figure 3: PIN definition for ATMEGA168 – 20PU 4
Figure 4: Flowchart depicting the functioning of microcontroller 5
Figure 5: Microcontroller circuitry for the main unit 6
Figure 6: Oscilloscope screenshot showing that no signal is being detected 7
Figure 7: Oscilloscope screenshot showing that a signal is being received 7
Figure 8: Constructive interference on three consecutive pins to increase volume intensity 8
Figure 9: Schematic of the wireless control unit 9
Figure 10: MSP430-G2211 MCU Schematic 10
Figure 11: Output wave produced at port 2.. 11
Figure 12: MSP430 development board along with the microcontroller 11
Figure 13: Resistance v/s Temperature graph of Honeywell NTC thermistor 12
Figure 14: Battery holder 090381-10 13
Figure 15: QAM-TX1-433-ND transmitter 13
Figure 16: Chassis for wireless control unit 14
Figure 17: General dimensions of the push pins 15
Figure 18: USS team's conception of the front overlay for the sensor unit 16
Figure 19: USS team's conception of the inner schematic of the sensor unit as seen from top 17
Figure 20: Physical schematic of QAM-TX1-433-ND transmitter 24

LIST OF TABLES

Table 1: Pin descriptions for QAM-TX1-433-ND transmitter 24
Table 2: Electrical characteristics of QAM-TX1-433-ND transmitter................................24

GLOSSARY

A/D	Analog to Digital
AC	Alternating Current
ADC	AC to DC
AM	Amplitude Modulation
ASK	Amplitude Shifting Keying
AVR	Alf and Vegard's Risc Processor
CCFMFC	Council of Canadian Fire Marshals and Fire Commissioners
CMOS	Complementary Metal-Oxide-Semiconductor
DAC	DC to AC
DC	Direct Current
FM	Frequency Modulation
GHz	Giga Hertz
LED	Light Emitting Diode
MCU	Microcontroller Unit
MHz	Mega Hertz
NTC	Negative Temperature Coefficient
PTC	Positive Temperature Coefficient
RF	Radio Frequency
RISC	Reduced Instruction Set Computer
USS	Universal Safety Solutions Inc.
Vcc	Common Collector Voltage

1. INTRODUCTION

ShutSmart is a safety add-on for open top electric stoves that are widely used across North America. The final product will have three units in it – the main unit, the wireless control unit and the sensor unit. The main unit will be plugged into the wall socket on one end and the stove on the other, thereby providing buffer connectivity between the stove and the electric line running in the household. There will be a wireless control unit clamped beneath each of the stove plates and they will interact with the main unit relaying the stop top conditions for appropriate action to be taken. These units will be easy to install and will not require any technical skills. The sensor unit concept is still in the developmental stages – it will be a common sensor unit comprising of a smoke detector and a motion detector that will be mounted above the stove. The procedure for setting up the product is going to stove-independent and extremely user-friendly ensuring its market viability.

1.1. SCOPE

This document gives detailed information about the design specifications chosen for ShutSmart. The document deals largely with the design of the proof-of-concept model for the product. Hence, the main focus is on the design specifications required to satisfy the functional requirements marked as priority I and II in the *Functional Specifications* for the product [1]. The functional requirements marked as priority III have been discussed and the ideas for their implementation in future iterations and in the final product have been presented as well. The document also covers a thorough test plan for the product and its components, detailed theoretical calculations and the availability of alternatives.

1.2. INTENDED AUDIENCE

The design specification is a set of designing rules for ShutSmart that have been agreed upon by the members of USS Inc. They will act as a strict guideline for the team when developing the product. It will be an extremely handy tool for the integration engineers since a detailed understating of the design of each and every component of the product is critical for the final development of the product. The test engineers will be able to use the design specifications and the detailed test plans included to carry out the quality testing of the product and its components in an organized manner.

2. SYSTEM OVERVIEW

The external system overview of ShutSmart safety system can be seen in Figure 1. As we can see, the overlay of the product consists of three units which would be integrated together to complete the final product. ShutSmart will deal with unattended stoves, along with a joint system for smoke detection and motion detection. The three units are as follows:

A. Main Unit
B. Wireless Control Unit
C. Sensor Unit
    a. Smoke Detection System
    b. Motion Detection System

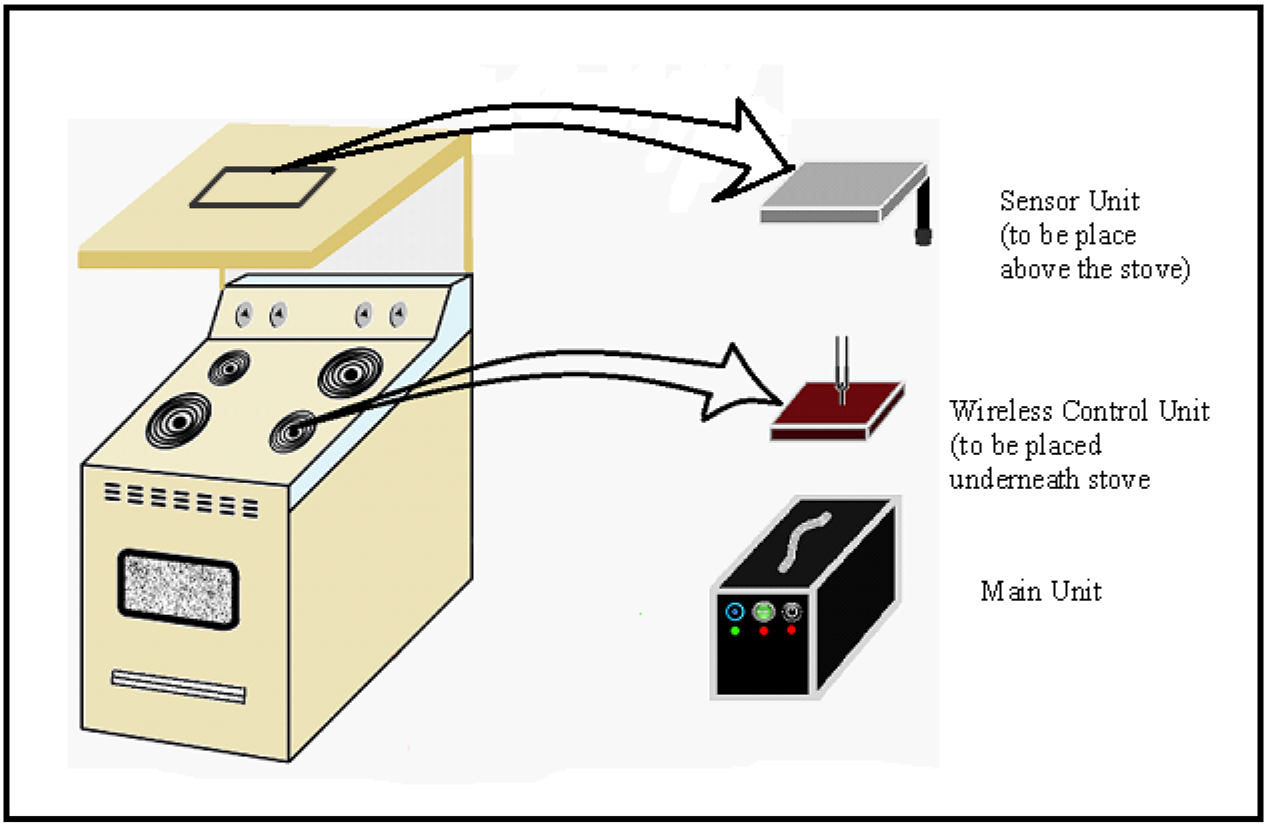

Figure1: External overlay of ShutSmart safety system

A detailed system overlay can be seen in Figure 2.

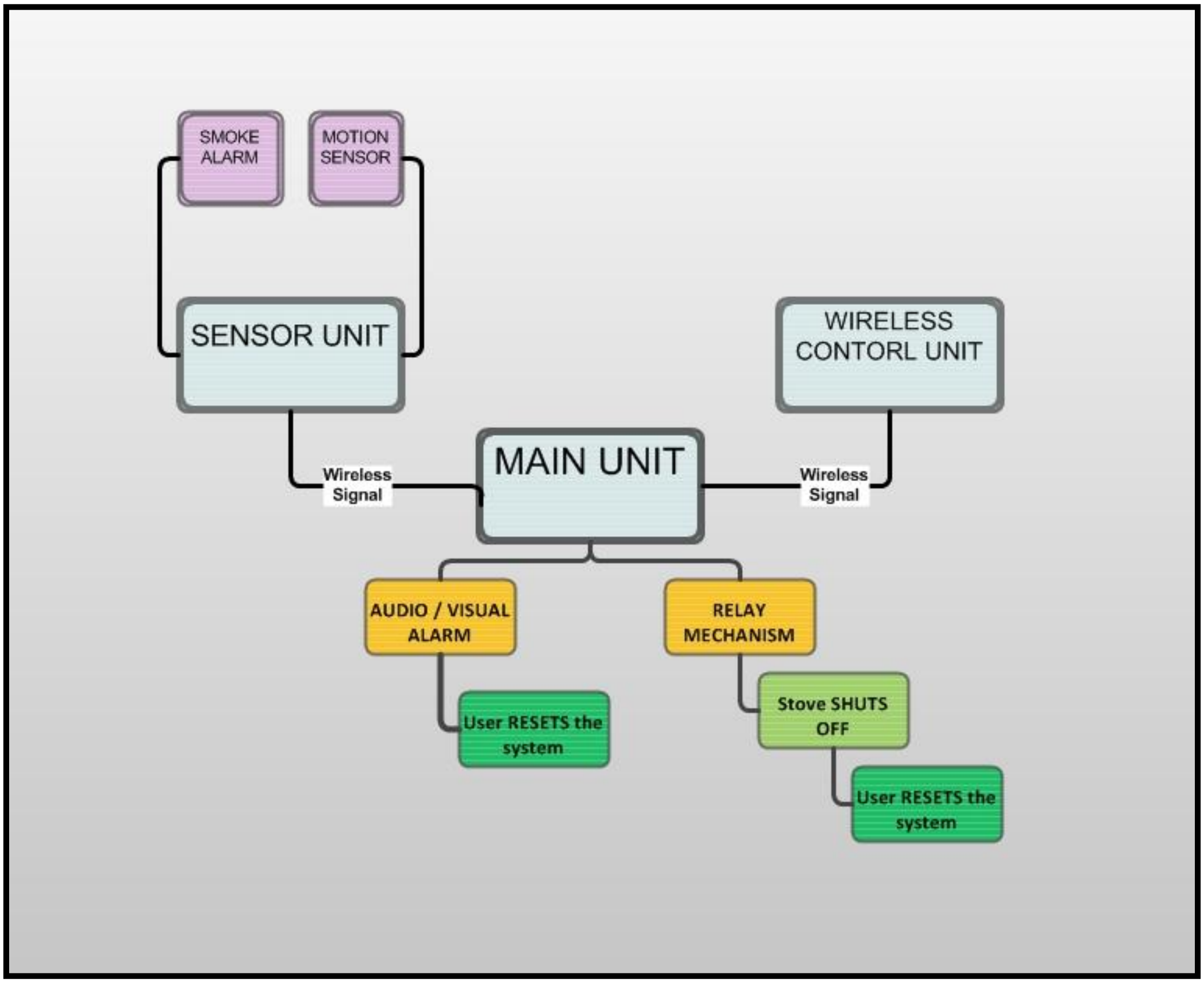

Figure 2: Detailed system overlay for ShutSmart Safety System

3. DESIGN SPECIFICATIONS

3.1. MAIN UNIT

The Main control unit encompasses the most essential part of our project. The digital signal which is transmitted by the wireless control unit on detection of heat is received by the main control unit and all the decision making is done by the Main control unit. Main control unit is a box depicted in Figure1 in which we will plug in our stove and the other end will go to the wall outlet. The major functions of the main unit include the following:

- Playing the buzzer alarm if heat is being continuously detected on an unattended stove.
- If a user responds to the buzzer, reset timers and avoid switching off the stove
- If a user doesn't respond, activate the relay mechanism and shut off the stove

3.1.1. Choice of Microcontroller

ATMEGA168-20PU was chosen for the main control unit, which is a low power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. This microcontroller belongs to the AVR family, which has a unique characteristic of storing programs in the on chip flash memory. The program may be written in assembly language code or in C before loading it on the chip; our team had proficiency in C language, so we chose to write our code in C. Microcontroller included two 8-bit timers and a 16-bit timer with a separate prescaler and a compare mode, which fulfilled our need for this project. Our project also demanded management of multiple inputs and produce multiple outputs simultaneously and this microcontroller allowed us to have that parallel processing. Below is a figure (Figure 3) taken from the datasheet of the microcontroller depicting various pins on the microcontroller:

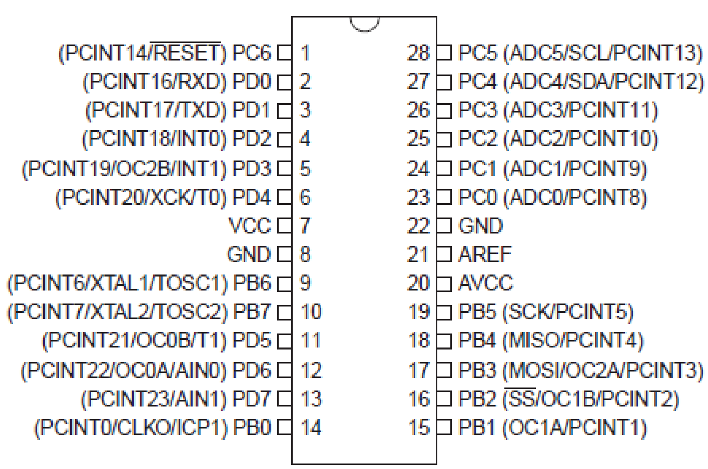

Figure 3: PIN Definition for ATMEGA168-20PU [2]

3.1.2. Design Implementation

Our main unit has the following components in it:

- Main circuit on a PCB
- Wires running from one end to another carrying high amounts of currents
- A fan at the back to avoid heating of the unit
- LEDs and Buttons in the front to control the unit

The overall functioning and the process for functioning of the microcontroller are summarized in the flowchart below (Figure 4):

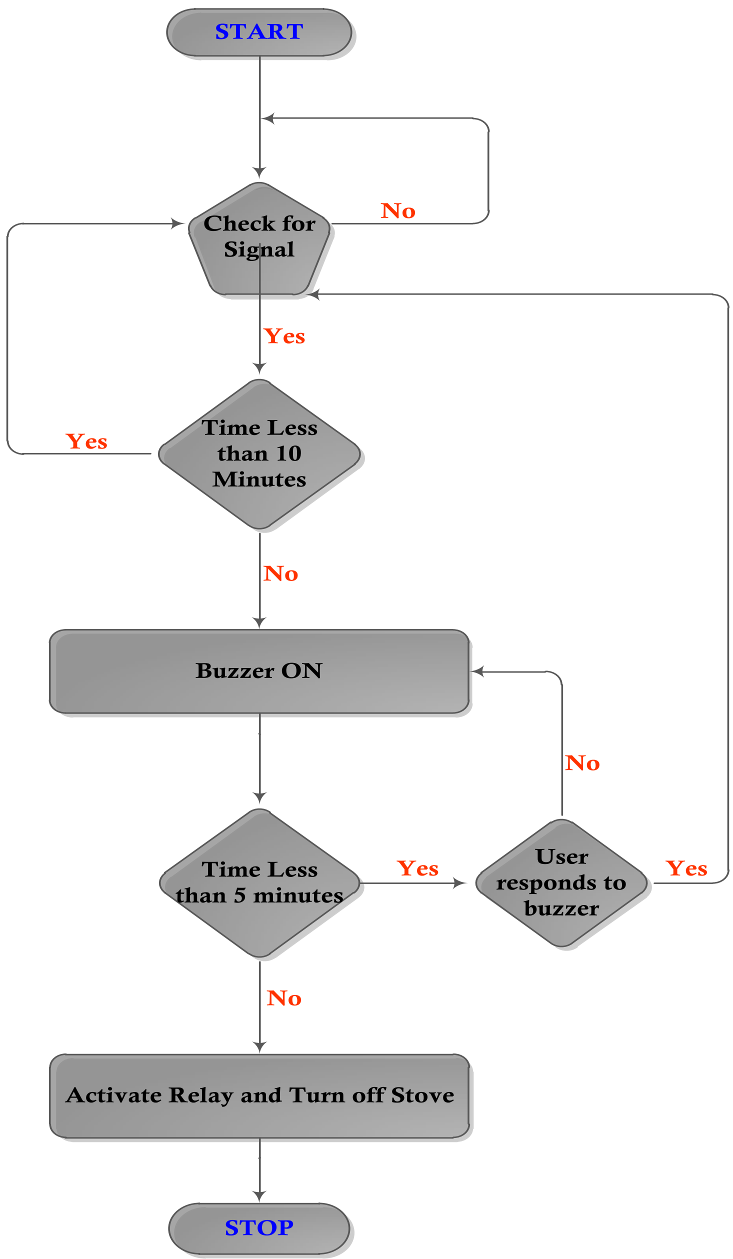

Figure 4: Flowchart depicting the functioning of microcontroller

Next, the most critical part of designing the main unit includes programming of the microcontroller and interfacing various components to it. First of all microcontroller must be able to successfully detect the digital signal that is being received as all further decisions are based on that. Secondly we must be able to produce 3-6 volts from the chip for the buzzer to be loud enough given that the input is 5 volts to the chip. Thirdly we must allocate a pin, which constantly checks for the user interrupt while the buzzer is on and terminates the buzzer once user pushes a button. Last but not least, we should have a pin dedicated for the relay, which provides DC 2-3 volts to activate a relay. All of these features were successfully implemented and tested and following is the circuit diagram for the microcontroller:

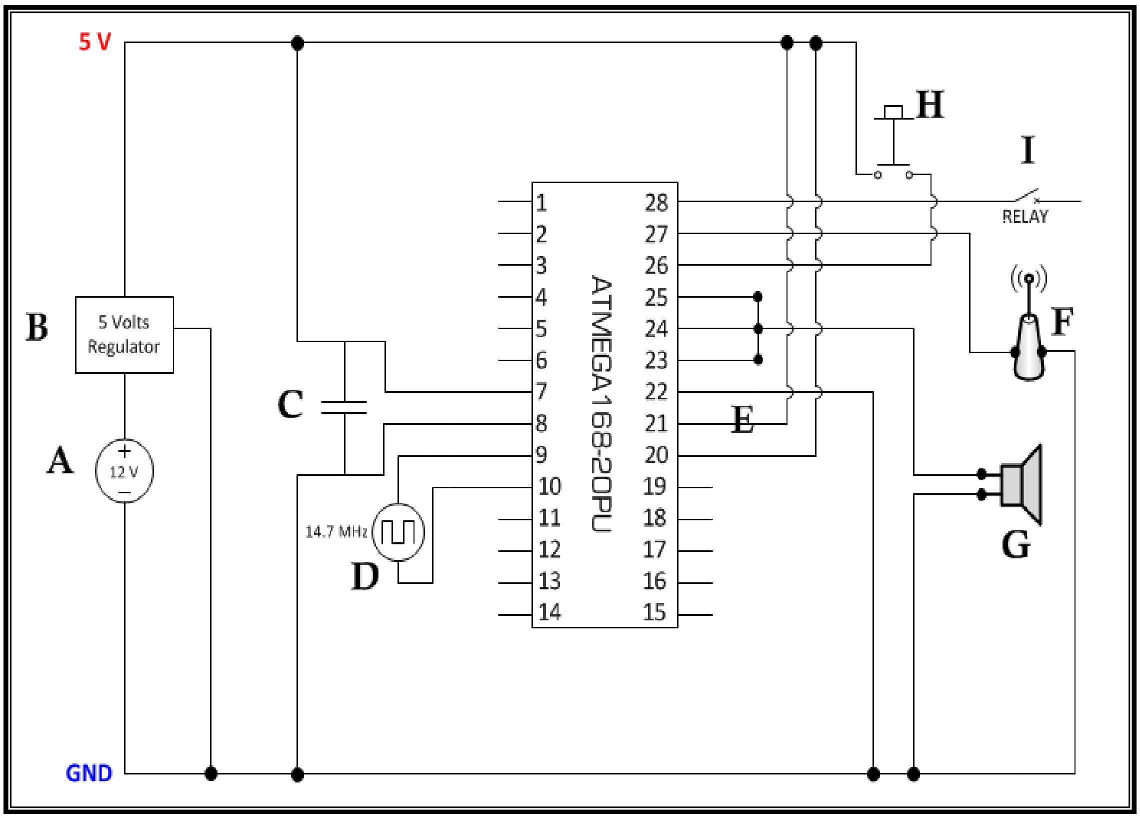

Figure 5: Microcontroller Circuitry for the main unit

There are various elements to the circuit above, which are labelled from A to I and explained in details next:

A: DC power supply (12 Volts) – A 12 volts DC power supply was essential because our main relay (triggered by small relay, I, shown above) requires 12 volts for operation. This will also power the fan and the main unit LED.

B: Voltage Regulator (5 Volts output) – This is a voltage regulator (7805) which takes the 12 volts coming for the main unit and cuts it down to 5 volts to be used by the microcontroller. It provides a steady 5 volts signal to the V_{CC} pin of the microcontroller.

C: Capacitor (0.1 µF) – we are using it here as a bypass capacitor, i.e. it helps smooth out the power supply to the microcontroller. It stores energy and maintains a voltage across it, so if the microcontroller pins have a sudden demand for power at the beginning of a clock cycle consuming the power at the V_{CC} pin, capacitor ensures proper operation by compensating for the spikes in voltage consumption.

D: Crystal Oscillator (14.7456 MHz) – Just like every computer has a clock (e.g. 1.7 GHz or 2.2 GHz), our microcontroller required a clock too. We chose this specific crystal because it was readily available and sufficient for our needs. 14.7456 MHz crystal means that it has the ability to execute 14745600 instructions every second. Thus, it provides a very reliable and efficient clock signal for the microcontroller to execute instructions.

E: Reference pin – it is an analog reference pin for the A/D convertor. 5 volts dc is supplied to it, basically what that does is any voltage above 2.5 V (2.42V in practice) makes the microcontroller pin HIGH and any voltage below 2.5 V or 2.42 V makes the pin LOW.

F: Wireless receiver – this part of the circuit receives a signal which has been transmitted by the wireless control unit. This is directly connected to the input pin of the microcontroller. There pin will have two of the following states: (1) when there is a signal (2) when there is no signal (noise could be there). Figure below depicts both cases:

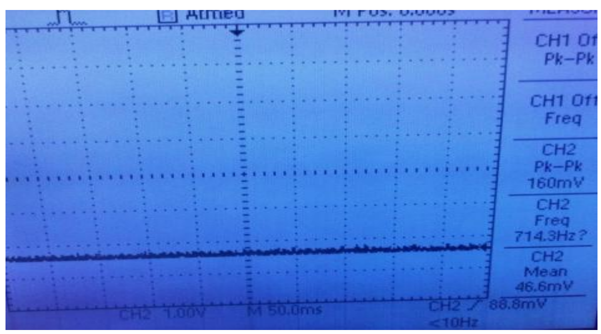

Figure 6: Oscilloscope screenshot showing that no signal is being detected, only noise

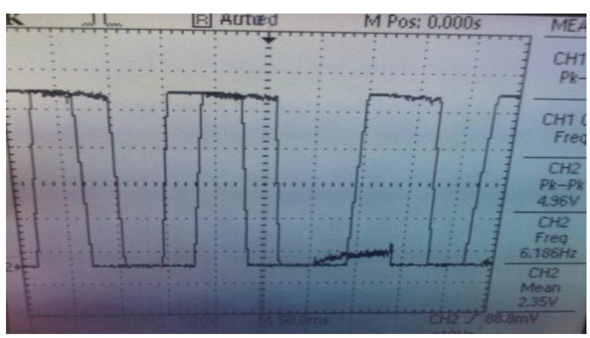

Figure 7: Oscilloscope screenshot showing that a signal is being received

Figure 7 depicts a dc signal that is going to the input pin. More accurate calculations were taken later and the following was found about the signal:

- Voltage fluctuates between 2.7 volts (logic 1) and 120 millivolts (logic 0)
- Frequency of the square wave = **6.186 Hz**
- Time period = 1/f ≈ **161 milliseconds**

Finally, when we checked to see if a pin was high or not, we took 10 readings over an interval of 20 milliseconds i.e. total of 200 milliseconds, which includes one full cycle of the wave. Therefore, if any of the sample readings was logic 1, we considered the pin to be high and low otherwise.

G: Speaker – any speaker needs an alternating voltage to produce a buzzing sound. We used frequency oscillator provided in Lab1 to find the frequency which provides the loudest bearable sound. Frequency came out to be 851Hz. We generated this frequency though our code for the chip and combined voltages from 3 pins into one to make the sound louder. We used the phenomenon of constructive interference for the three digital signals to add up as shown below:

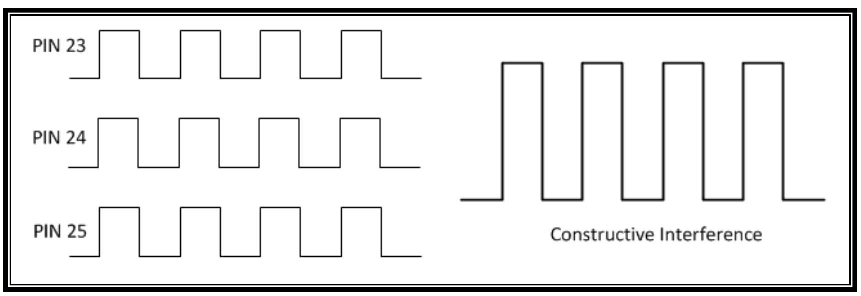

Figure 8: Constructive interference on three consecutive pins to increase the volume intensity

H: Push button – this button is interfaced to pin 26 of the microcontroller, which is another input pin. One of end of push button is connected to 5 volts and the other end to the microcontroller. Basically, when the button is pushed in, it makes the PIN high, i.e. logic 1 for the time the button is pushed in. We implemented a code such that it checks for an interrupt (i.e. button being pushed in) every 1.702 milliseconds. Average reaction time for humans is 215 milliseconds [6] i.e. time it takes to push a button and then push it again right after. Best way to test this is to start and stop a stopwatch as fast as you can. Therefore, it gives us ample time to detect a pushed button.

I: Voltage to operate relay – This pin gets high only when the buzzer has gone off 5 minutes continuously and user hasn't responded to it. At this stage, PIN 28 becomes high (i.e. provides 3 volts) for 2 seconds, which gives sufficient time for the relay switch to be thrown over, which further activates a circuit with bigger relay used for turning the stove off. The relays were selected for the purpose of turning off the stove. We selected a relay that would be able to handle high currents. It had a maximum rating of 30Amperes and 250Volts, and total wattage of 7.5KWatts.

3.2. WIRELESS CONTROL UNIT

The wireless control unit is meant for judging whether the stove is attended or not. The following schematic represents the overall design of this device

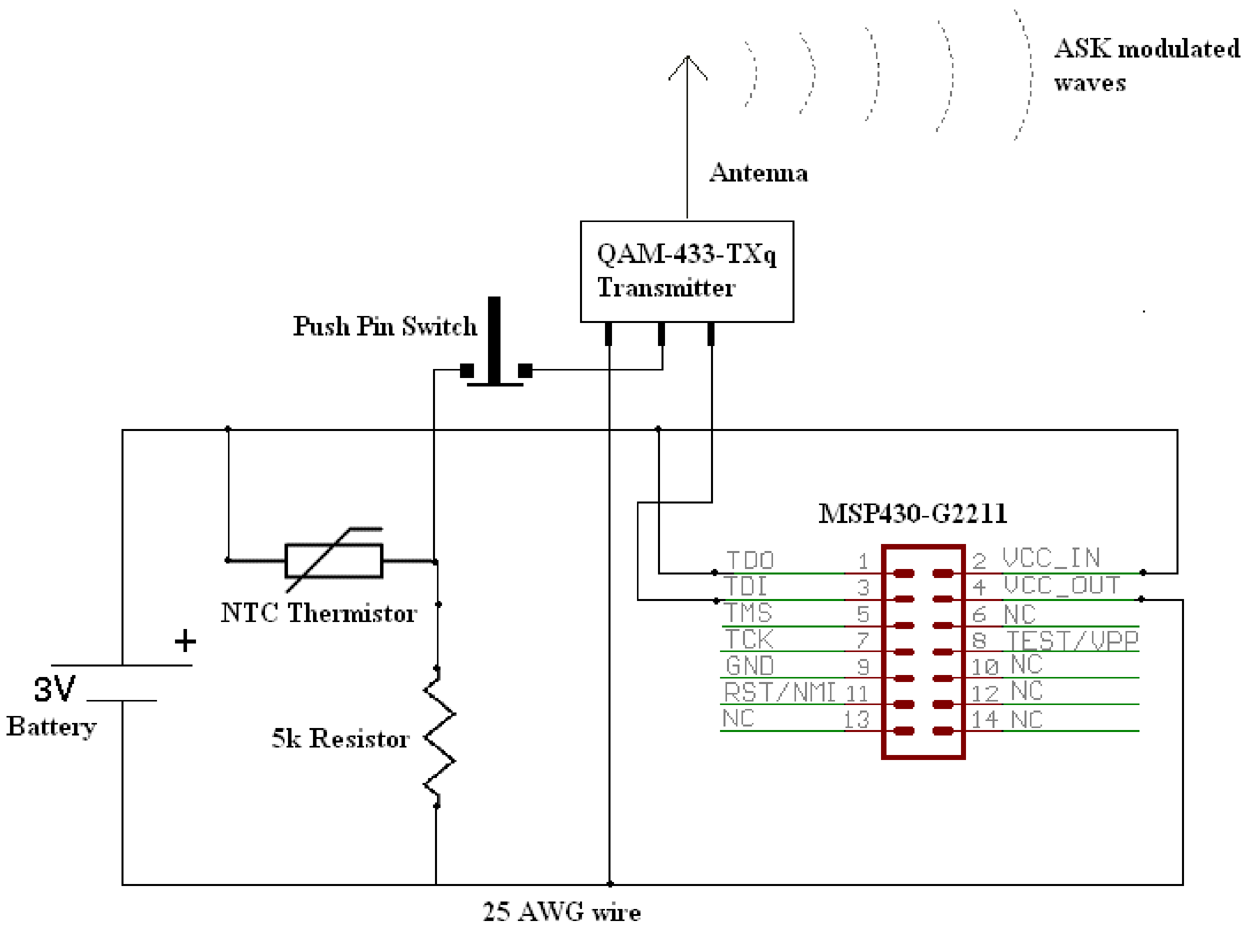

Figure 9: Schematic of wireless control unit

When the push pins are pressed due to an object on the coil of the stove, the pins transmit the force downwards and disconnect the circuit. This means that something is being cooked and there is no need to send any warning signal. When the push pins are released and the circuit completes, the NTC thermistor gets heated up and its resistance decreases. The 5k resistor is in series to it and acts as a voltage division. This divider brings the voltage up for the QAM transmitter which means that now we are ready to transmit the signal. The MSP430G2211 chip is already functioning and generating a wave of digital signals. These signals now automatically start getting generated via the transmitter because our requirement for sending them has been met as the thermistor and resistor combined together acts as a control for sending these signals.

The wireless control unit is designed to send wireless signals to the main control unit once it is known that the stove has been left on for a long period of time. The design of wireless control system consists of the following parts.

A. MSP430-G2211 Microcontroller
B. MSP430 Development board.
C. Honeywell NTC Thermistor
D. 5KΩ resistor
E. 2 AA batteries
F. Battery holder for 2 AA cells
G. 25 AWG wires for connections
H. QAM-TX1-433-ND Transmitter
I. Chassis box
J. Push pins
K. Relay System

A. MSP430 Microcontroller - The MSP430-G2211 chip from Texas Instruments was found to be the best solution for transmitting a good quality signal while consuming less power. The chip is capable of going into power save mode which can save even more power. The chip contains of a built-in clock crystal, ADC, DAC, timers and registers which can serve our purpose very well. Figure 10 shows the internal schematic view of the microcontroller chip.

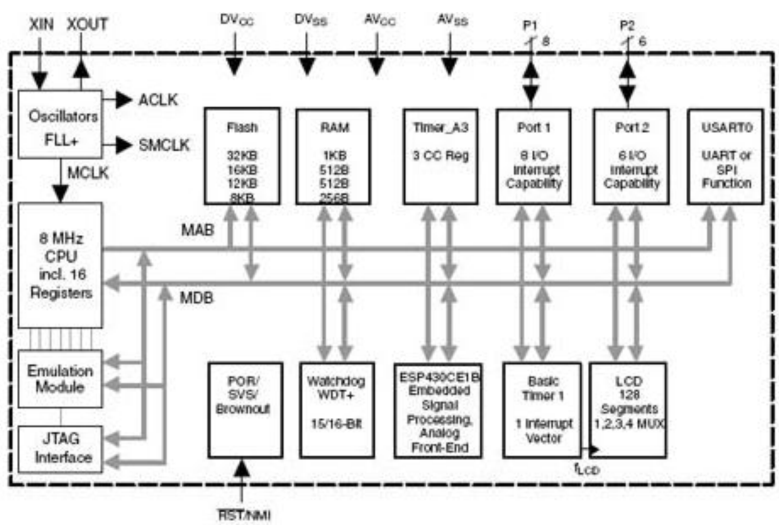

Figure 10: MSP430-G2211 MCU Schematic

There were other alternatives available that meant to perform the same but not only there cost was high, their inbuilt design was not meeting our requirements in the most efficient way.

MSP430-G2211 takes 3V input and runs in a loop. It produces two values at port 1 that is 1 and 0 at the delay of about 0.5 sec. This causes a digital signal to be produced at the output pint called port 2. The output signal can be seen in Figure 11.

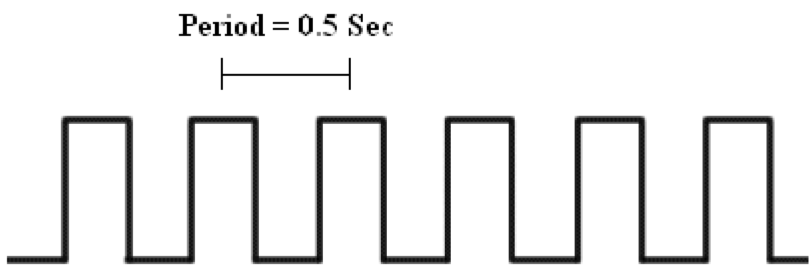

Figure 11: Output wave produced at port 2

B. MSP430 Development board - The MSP430 Development board is the platform used to program the MSP430 chip. Being small in size and extremely compatible, we used this kit in our design along with the microcontroller. The purpose being is to program the chip any time required. This way depending on the change in designs of stoves, we can well manage to change the programming code of the microcontroller while keeping it intact with the rest of circuit. The following diagram shows the development board along with installed MSP430 MCU.

Figure 12: MSP430 Development board along with microcontroller

C. Honeywell NTC Thermistor - Honeywell is a very famous company for manufacturing sensors and detectors. That’s why we trusted their NTC thermistor which is not only having a wide range of temperature operation but also has small size (which is needed in our case), linear resistance-temperature relation and strong formation. The NTC thermistor we used in our design has a value of 10KΩ at room temperature. The term NTC means negative temperature constant. Thermistors respond to temperature by either increasing or decreasing their resistance. The following expression tells us how they change their resistance based on change in temperature:

$$\Delta R = k\Delta T$$

Where

ΔR = change in resistance
ΔT = change in temperature
k = first-order temperature coefficient of resistance

Thermistors can be classified into two types, depending on the sign of *k*. If *k* is positive, the resistance increases with increasing temperature, and the device is called a positive temperature coefficient (**PTC**) thermistor. If *k* is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature coefficient (**NTC**) thermistor. The following curve shows the resistance v/s temperature curve for the Honeywell NTC thermistor of our design.

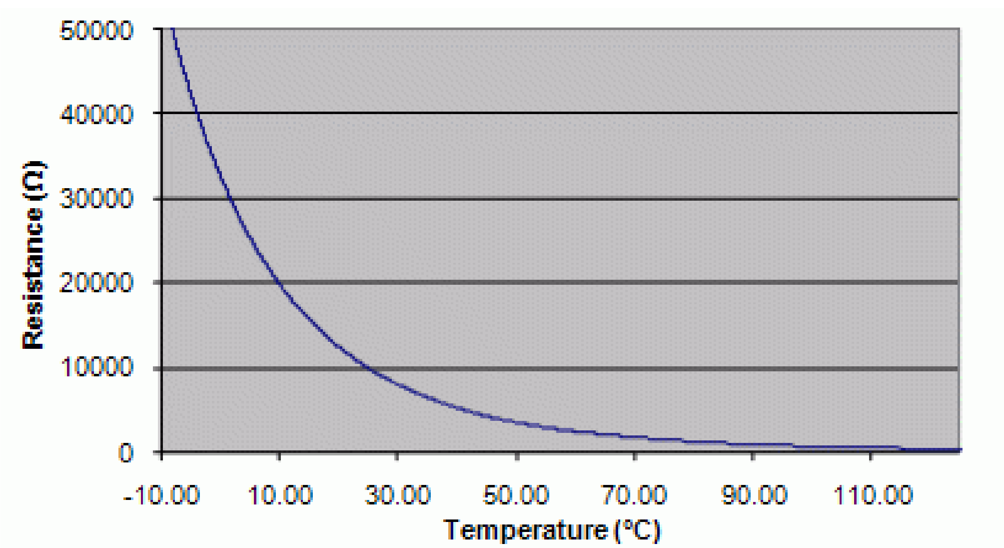

Figure 13: Resistance v/s Temperature Graph of Honeywell NTC thermistor

D. **Resistor (5kΩ) -** The resistance used for voltage division purpose is 5KΩ. It is because the value of resistance of thermistor decreases along with increase in temperature and our voltage divider brings the voltage up for the transmitter. This makes it capable of transmitting the signal properly. At 80°C, the resistance of thermistor is going to be 2kΩ (from the above figure) and hence the voltage division brings the input to the transmitter well above 1.7V which then starts operating.

E. **2 AA batteries -** In our design, we require the total power to the wireless control unit to be 3V. Therefore installing two AA size batteries in series with each other can solve the purpose better. The MSP430-G2211 chip requires 3V to operate and the transmitter also requires its supplied power to be no more than 3V.

F. **Battery holder for 2 AA cells -** The batteries have to be installed in a battery holder so that they can be easily replaced if they run out. The battery holder used in our case is called 090381-10 - Sealed battery holder. The batteries stay protected inside and there is a manual on-off switch that can shut down the entire wireless control unit if required. The following figure shows the battery holder we used in our design.

Figure 14: Battery holder 090381-10

G. **25 AWG wires for connections -** 25AWG wire size is capable to serve our purpose best as we are dealing with our power limits to be 0.03 Watts. We know that the wire thickness is related to the amount of current flowing through it. In our case since our current limit is 10mA maximum, 25AWG connector wires can work best here. Their light weight not only make the overall device less heavy, but also they cause less resistance as the area of cross section is small.

H. **QAM-TX1-433-ND Transmitter -** In our design, we used an ASK (Amplitude Shift Keying) modulation since the signals we want to send to the main control unit has to be digital. QAM-TX1-433-ND Transmitter is best meant for ASK signal transmission with 50M operating range and less power consumption. The small size and less cost make it a perfect pick for our design. Refer to APPENDIX A or the general technical representation and pin specifications of the transmitter. The following figure shows the general technical representation of this transmitter.

Figure 15: QAM-TX1-433-ND Transmitter

The following features are associated with this transmitter:

- Complete RF transmitter
- Transmit range of up to 50meters
- CMOS/TTL Input
- No adjustable components
- Very stable operating frequency
- Low current consumption (typ 11ma)
- Wide operating voltage (1.5-5Volts)
- ASK Modulation
- Available as 315 or 433 MHz

I. **Chassis box** – the dimension of the chassis used for enclosing the wireless control unit is 5in x 3.5in x 1in.The top surface has a hole of radius 0.5cm for the push pin connection. The following figure represents the general dimensions of this box:

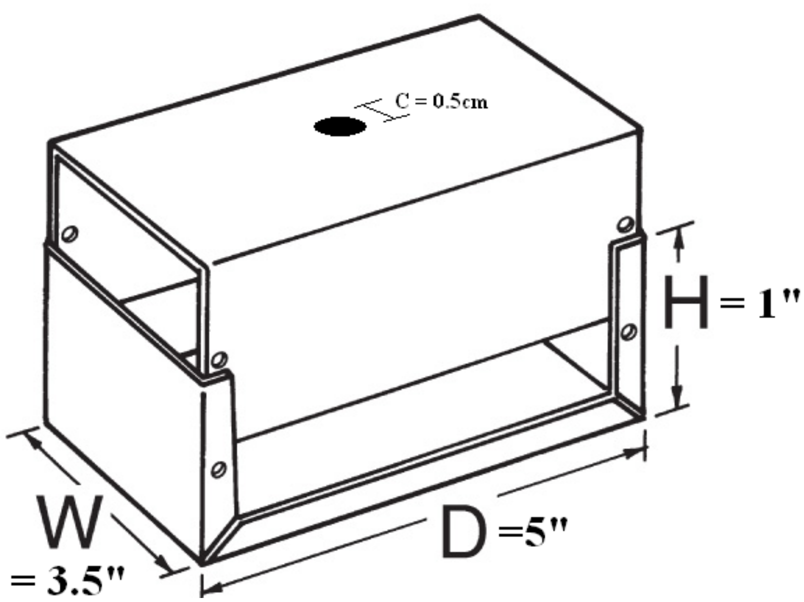

Figure 16: Chassis for wireless control unit

J. **Push Pins -** The push pins are used for transferring the weight down to the switch that determines whether something is being cooked on the stove or not. The push pins is a Y-shaped structure that bears an equal amount of weight of the object on its prongs and transferred that down to the switch. The switch is controlled via spring that connects the circuit again once the object is removed and the push pins restore back to their normal position. The following figure describes the general dimensions of the push pins.

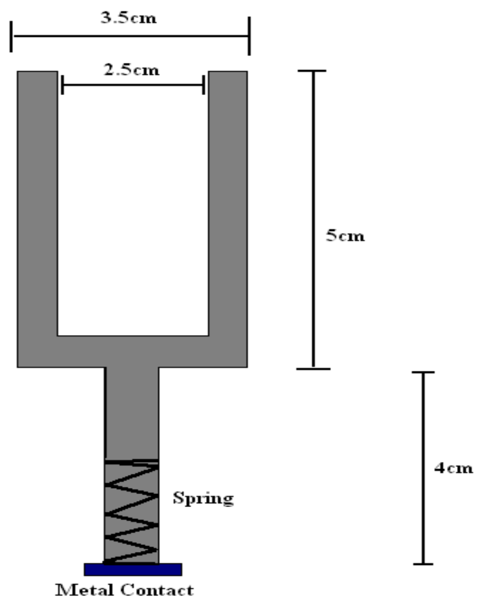

Figure 17: General dimensions of the push pins

3.3 SENSOR UNIT

Owing to time constraints, the sensor unit design plan will not be included in the first working prototype of ShutSmart and intead will be implemented in future iterations. The smoke detector and the motion sensor in this unit will act as an important supplement for our product. They will combine with the main unit and the wireless control unit to provide a foolproof safety system for households throughout North America.

The sensor unit will consist of a smoke alarm, a motion sensor and a digital transmitter circuit enclosed in a 6in x 4in x 3in ABS plastic box. The unit will be require approximately 7.5V and will be powered by a 9V battery which will be included within the box. It will be placed directly above the center of the foure stove plates (as seen in Figure 1). The unit will have the option of either being mounted near the exhaust or being stuck using a strong adhesive.

Figure 18 depicts the USS team's conception of the sensor unit as seen from the front, while Figure 19 shows the USS team's conception of the inner layout of the sensor unit circuit*. We will not discuss the three main components of the Sensor Unit:

A. Smoke Alarm System

The smoke detector will be an ionization smoke detector and will act as a localised smoke alarm system for the stove. It will detect any smoke from sources like burning food and immediately trigger off an audio/visual alarm to alert the user of the occurrence. When the alarm is triggered, a shrill, loud and continuous beeping sound will greet the user and the led light visible through the sensor unit will turn from steady green state to flashing red.

B. Motion Sensor System

The motion sensor system will aid the other units by detecting the presence of the user near the stove. This feature will prove extremely useful in cases where the user purposely leaves the stove unattended for various reasons. For instance, in cold cities people tend to use the heat from the stove to keep their rooms warm. Some dishes take a long time to cook and require being taken off the stove for some time period. We would not want the alarm in the main unit to sound if the user has indulged in this practice knowingly. This feature will make our product a lot more user-friendly by taking into consideration the situation the user is in.

C. Transmitter Circuit

This transmitter circuit will be a lot similar to the transmitter circuit shown in the wireless control unit. It will consider the signals from the smoke alarm and the motion sensor, and provide continuous feedback to the main unit. The main unit will incorporate this feedback along with the signals provided by the wireless control unit to take appropriate action.

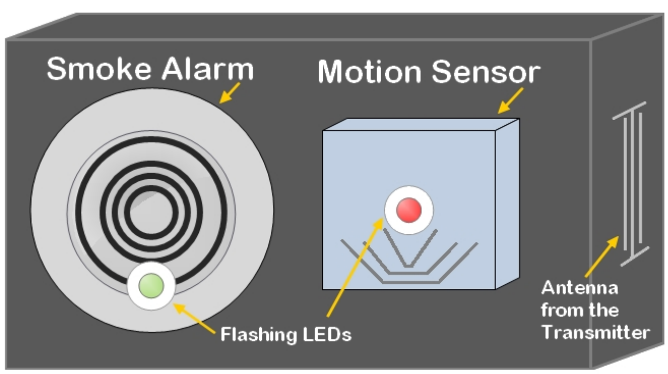

Figure 18: USS team's conception of the front overlay for the sensor unit

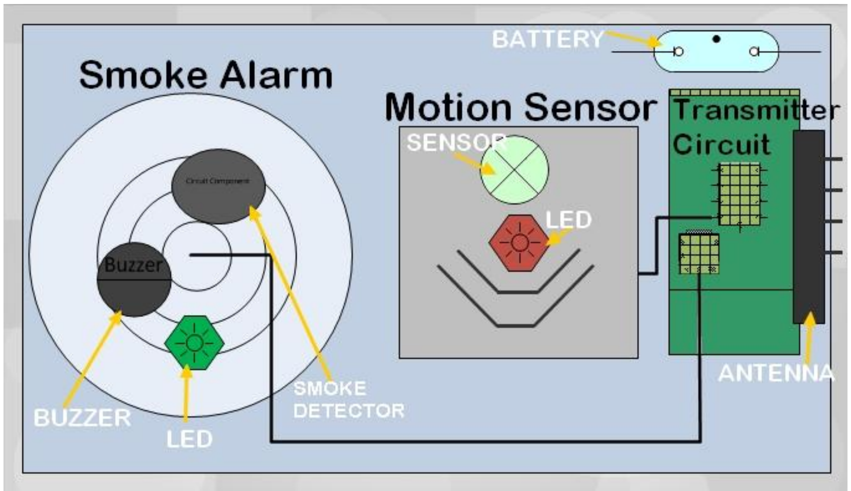

Figure 19: Artist's conception of the inner schematic of the sensor unit as seen from the top

4. SYSTEM TEST PLAN

The testing of the product will be done in three steps:

- Testing of the individual components while they are being developed – it will involve the testing of the circuits, external enclosures, etc.
- Testing of the three basic units – main unit, wireless control unit and sensor unit – before integration of the complete product.
- Testing of the complete product system – this will be done once the process of integration if complete to check for the quality and safety of the product once deployed.

4.1. COMPONENT TESTING

The following section of the document discusses the detailed test plans for the individual components of ShutSmart:

4.1.1. Digital FM transmitter and receiver

Procedure for testing:

- We will test the effectiveness of the transmitter-receiver system based on the distance. The total range for the system can be anywhere from 1 meter to 3 meters. We will be testing it over a range of 0.75 meters to 5 meters. This will test the signal clarity over the distance giving us the optimal distance range that would give us a continuous and clear uninhibited signal.

- A major concern with wireless transmission of this sort is the change in the quality of the signal when it encounters any obstructions. We will place some common obstructions to simulate the stove environment and test the signal quality in the presence of these obstructions.

Precautions to be taken:

- Most microcontrollers are voltage/current sensitive and a sudden spurt in the supply voltage or current can destroy the microcontroller. We will need to ensure that the supply voltage does not exceed the rating of the microcontroller which is around 3.6 Volts.
- Since we are using a self-made coiled wire as antenna for the transmitter and receiver system, it will be important to ensure that the coils are wound uniformly for the antenna to function well.
- The two microcontroller circuits will need to be handled with diligence as excessive pressure or other mishandling can damage the circuit.

4.1.2. Thermistor Circuit placed in the wireless control unit

Procedure for testing:

- The thermistor circuit is one of the most critical parts of our product. As it will be located beneath the stove plates, we will need to test its activity in conditions of high temperature. We will test the sensitivity of the thermistor over a range of 40 ^{O}C to 80 ^{O}C for establishing its sensitivity over high temperatures.
- The thermistor circuit will also be tested at low temperatures to ensure its functionality in the event of drop in the room temperature.

Precautions to be taken:

- A fire extinguisher should be kept handy at all times when testing over high temperatures.
- Appropriate footwear (rubber slippers) should be used when to prevent electric shocks from the high currents.
- Oven gloves must be used when handling the stove rings to prevent burns.

4.1.3. Relay gates located in the main unit

Procedure for testing:

- The relay mechanism will first be tested independent of the microcontroller circuit in the main unit. We will provide an input signal with a high peerage and test the functionality of the relay circuit. The current running through the stove will be a maximum of 50 amperes. So the input amperage will be in the range of 10 amperes to 65 amperes.

- The relay gates will then be incorporated with the microcontroller board and tested by giving the required input signal through the microcontroller.
- Proper insulation will be needed on the components surrounding the relay, so that the arc produced by the relays will not have any adverse effect on them.

Precautions to be taken:

- Insulated footwear and gloves are necessary because we will be dealing with high currents and high intensity of heat.
- Safety goggles should be worn at all times to shield the eyes from any damage that may be caused by relay arcing.

4.1.4. ATMEGA168 microcontroller board in the main unit

Procedure for testing:

- The microcontroller board in the main unit will be tested extensively over a range of realistic conditions. To being with we will test the microcontroller over a temperature range of 10 ^{O}C to 40 ^{O}C. The presence of an exhaust fan in the main unit will ensure that extreme temperatures are not reached.

Precautions to be taken:

- Safety goggles are a necessity throughout the testing.
- Full sleeves clothing and insulated footwear must be worn at all times.
- The input voltage to the microcontroller should not exceed the recommended voltage rating given in the microcontroller datasheet.

4.1.5. External casing for the wireless control unit

Procedure for testing:

- The wireless control unit will be enclosed within a heat-resistant and durable casing as it will be within close proximity of the heat produced by the stove coils. Therefore, the casing will be separately tested over high temperatures within a range of 10 ^{O}C to 80 ^{O}C.
- The external casing will also be tested for liquid-proofing as it chances of liquid spills (water, oil, etc.) would be possible owing to its location beneath the stove plates.

Precautions to be taken:

- A fire extinguisher will be kept handy throughout the testing to deal with any fires that might be caused due to high temperature.
- Protective gloves and eyewear will be used to prevent any damage from excessive liquid spills.

4.2. UNIT TESTING

The following section will discuss the testing procedures for the three units of the product separately before integration:

4.2.1. Main Unit

- After being assembled the main unit will be tested over high input voltages and currents to test the functionality of the fuse. In case of excessive current supply, the fuse should break the circuit without causing any damage to the main unit or its components.
- The external casing of the main unit will be tested for durability by trying its functionality under high pressure conditions and testing its endurance towards liquid spills.
- The effectiveness of the exhaust fan will be tested by pushing the circuit to its maximum usage limit and checking if the exhaust fan is successful in normalizing the temperature around the circuit for proper functionality of the unit.
- The push buttons and the buzzer will be tested repeatedly under different circuit conditions to ensure their durability over repeated usage.

4.2.2. Wireless Control Unit

- The iron clamps on top of the unit will be tested to ensure that they can handle the weight of heavy objects. They will be tested by putting objects of various weights on it ranging from 50 grams to 5 kilograms.
- The weight testing will also help in establishing the effectiveness of the spring system which would break the circuit when an object is placed on the clamps, and reform the circuit when the weight is removed.
- The clarity of the signal coming from the transmitter end in the unit will be tested to ensure that it is not being affected by the high heat or other obstructions in the way. A clear signal will be expected at the receiver end in the main unit throughout which will be observed using an oscilloscope.
- The unit will be tested for heat endurance by being subjected to high heat – temperature range of 10 ^{O}C to 80 ^{O}C.
- The unit will also be tested for resistance to liquid spills – water, oil, etc.

4.2.3. Sensor Unit

- The sensor unit will be tested for resistance towards high temperature and smoke produced from cooking.
- The transmitter circuit will be tested for signal clarity following similar procedures as with wireless control unit.

4.3. COMPLETE SYSTEM TESTING

This last section of test plans will deal with the testing procedure for the product system as a single unit:

- We will finally test the overall product in real-time by incorporating all the three units in a test stove to establish the functionality and feasibility of the product.
- The alarm system and the relay mechanism will be tested by leaving the stove unattended for the required time period.
- In the next step, a standard dish will be selected and will be burnt on purpose to test the smoke alarm system. This will once again test the automatic stove shutoff system with regards to the smoke alarm and motion sensor.
- The system will be left on for long periods of time to test its functionality over time.
- The testing procedure will be recorded on video tape and time stamped as proof of successful testing.
- A fire extinguisher will be kept handy at all times in the event of a fire.
- One of the team members will be assigned to main MCB of the house to turn off the main power in case of any unwanted occurrence.

5. CONCLUSION

These proposed design specifications provide detailed information about the product design that will fully satisfy the functions requirements of the ShutSmart safety system (as seen in Functional Specifications document [1]). These specifications will be the foundation for the development of our product and provide support to the integration and test engineers. The sensor unit design will be subject to change on further discussions and revisions with the USS Inc. team. The product development is on track. Our company is expected to furbish a working and deployable prototype by April 5th, 2011.

6. REFERENCES

[1] Universal Safety Solution Inc., “Functional Specifications for ShutSmart – the safety add-on for stoves”, Feb 2011.

[2] ATMEL, “Microcontroller with 4/8/16K byter in-system programmable flash”, Internet: http://www.atmel.com/dyn/resources/prod_documents/doc2545.pdf , September 2007* [March 05, 2011].

[3] Quasar UK, “AM Super Regen receiver”, Internet: http://media.digikey.com/pdf/Data%20Sheets/RF%20Solutions%20PDFs/QAM-RX2.pdf, November 2005* [March 05, 2011].

[4] Digikey, Product search: Chassis, Internet: http://search.digikey.com/scripts/DkSearch/dksus.dll?Cat=2163622&k=L204-ND, March 2011* [March 10, 2011].

[5] Panasonic, “DQ Relays (ADQ), Internet: http://pewa.panasonic.com/assets/pcsd/catalog/adq-catalog.pdf, July 2004* [March 10,2011].

[6] Human Benchmark, “Reaction time statistics”. Internet: http://www.humanbenchmark.com/tests/reactiontime/stats.php, 2006* [March 10,2011]

APPENDIX A

QAM-TX1-433-ND Transmitter

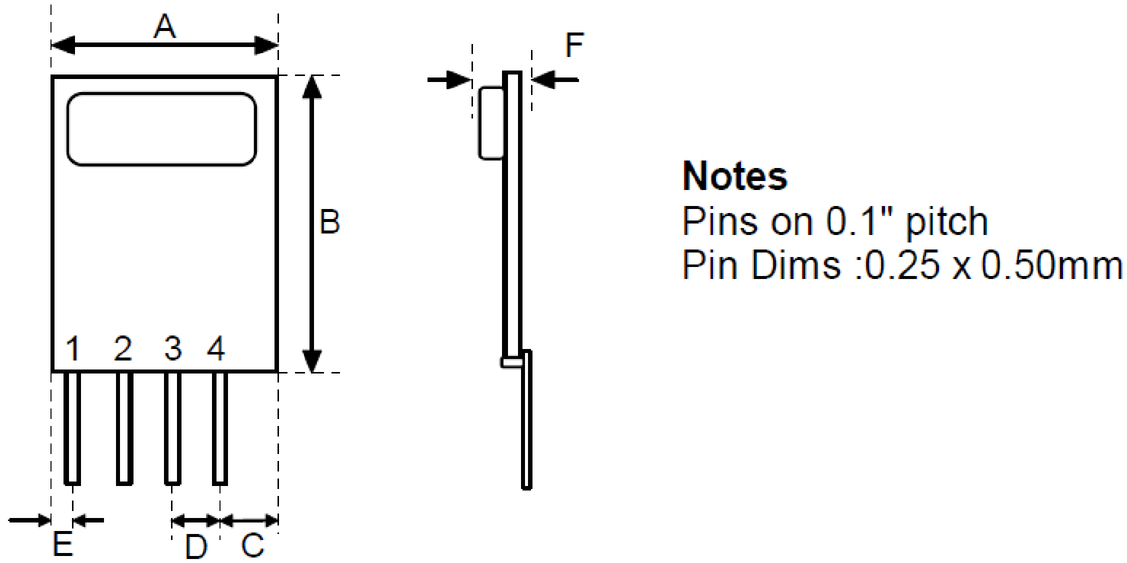

Figure 20: Physical schematic of QAM-TX1-433-ND transmitter

Table 1: Pin descriptions for QAM-TX1-433-ND transmitter

Pin	Name	Description
1	GND	Ground
2	IN	Data input
3	Vcc	Supply Voltage
4	ANT	External Antenna

Table 2: Electrical characteristics of QAM-TX1-433-ND transmitter

Ambient temp = 25°C unless otherwise stated.

Characteristic	Min.	Typ.	Max.	Dimensions
Supply Voltage	1.5	3	5	Vdc
Supply Current (Vcc=5V IN=1kHz)	2.9	11	22	mA
Working Frequency		315 / 433.92		MHz
Time from Power on to data transmission		20		Ms
Data Rate	200		3,000	Hz
Operating Temperature	-20		+60	°C