General Gadgets

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March 5, 2009

Patrick Leung
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Re: ENSC 440, *General Gadgets Design Specifications: Kitchen Alert*

Dear Mr. Leung:

The attached document describes the design specifications for General Gadgets Canada's Kitchen Alert. Kitchen Alert is designed to improve kitchen safety and provide convenience for its users. The system will detect and monitor the stovetop situation and take action to alert the user when there are potential problems on the stove. By monitoring the stovetop condition based on temperature, motion, humidity, and smoke from the kitchen's environment, Kitchen Alert will help prevent kitchen fires.

The attached design specifications provide the technical requirements for Kitchen Alert's proof-of-concept prototype. These specifications were chosen specifically to meet our functional requirements. The management and engineering teams at General Gadgets will use this documentation for research and development as well as to ensure that the project stays on course.

General Gadgets Canada is founded by fifth year Engineering Science students: Rasam Hafezi, Alex Kung, Edward Lee, and Eric Matthews. Should you have any questions or concerns regarding our functional specification, please feel free to contact me by phone at (778) 885-0499 or by e-mail at rhafezi@sfu.ca.

Sincerely,

Rasam Hafezi
Chief Executive Officer
General Gadgets Canada

Enclosure: *General Gadgets Design Specifications: Kitchen Alert*

General Gadgets

Design Specs
Kitchen Alert

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Date: March 5, 2009

Revision: 1.0

Abstract

The purpose of this document is to outline the design specifications for prototyping General Gadgets' Kitchen Alert safety device. These specifications are chosen to meet or exceed the proof-of-concept requirements as described in the functional specifications [1].

Kitchen Alert is a kitchen safety device designed to monitor stovetop conditions for gas and electric stoves and alerts the user of the conditions at appropriate times to help prevent cooking disasters, particularly kitchen fires. The system uses inputs from an infrared temperature sensor, a smoke sensor, a humidity sensor, and a motion sensor to assess the risk level around the stove. The system also allows the user to optimize warning thresholds and enable/disable any sensor input at anytime to adapt to different cooking environments.

This document covers the implementation details for software and hardware systems and subsystems, including user interface functionality, as chosen by General Gadgets Canada. Included also is a system test plan which is to be followed by each team member throughout the remaining part of the development phase.

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Glossary

A/D   Analog to Digital. 5

BCD   Binary Coded Decimal. 2, 10

I/O   Input/Output. 2

IP65   Complete protection against dust and protection against low pressured jets of water. 5

Kitchen Alert   A kitchen stove safety device created by General Gadgets. 1, 2, 5–8, 12, 16

MCU   Microcontoller Unit. 2, 10, 11

PWM   Pulse Width Modulation. 10, 11

RoHS   Restriction of Hazardous Substances Directive. 11

SPI   Serial Peripheral Interface. 2, 10

UART   Universal Asynchrounous Reciever-Transmitter. 2, 7

1 Introduction

This document outlines the technical details and design specifications for General Gadgets' innovative kitchen safety device: Kitchen Alert. Kitchen Alert is designed for use with gas and electric stoves found in common household kitchens. Its primary task is to monitor stovetop conditions based on temperature, motion, humidity, and smoke from the cooking environment. When the device senses potential cooking disasters on the rise, it alerts the user with audio and visual feedback so he or she can take appropriate actions to remediate the situation.

Kitchen Alert also includes a clock and a timer as part of the user interface to further assist kitchen users when they cook. The device provides enhanced safety, security, and also convenience to multi-tasking home owners who go in and out of the kitchen to tend to other business.

1.1 Scope

The development of Kitchen Alert will proceed in two phases. Phase I will focus on the proof-of-concept prototype, and Phase II will transform the prototype into the production model. This document solely describes design specifications for Phase I of the development.

1.2 Intended Audience

The design specifications are intended for use by the members of General Gadgets Canada to ensure the functional specifications for Kitchen Alert are met, and that the prototype will stay on budget, as set out in the project proposal document.

Software and Hardware VPs will use the listed specifications to assist them in completing project milestones as the project deadline closes in; the project manager will use them to provide feedback and advice on the team's progress throughout the development phase. All members of General Gadgets Canada will follow the system test plan as depicted in this document to ensure the reliability and robustness of both software and hardware systems of Kitchen Alert.

2 System Overview

Figure 2.1 illustrates the high-level overall system design of Kitchen Alert. At the core of the system is the 40-pin Microchip PIC18F4620 microcontroller, running at a clock speed of 40MHz and powered by a regulated 5 Volt DC power supply. Four sensors used to detect the operating environment conditions are directly coupled to the Input/Output (I/O) pins of the Microcontoller Unit (MCU): an infrared temperature sensor, a motion sensor, a humidity sensor, and a smoke sensor. User inputs are passed to the MCU through a Universal Asynchrounous Reciever-Transmitter (UART) connection using capacitance based touch-sensitive buttons, supported by Quantum Research Group's E1103 Evaluation Kit.

A four digit numerical LED display is driven by the MCU through a 4-bit Binary Coded Decimal (BCD) decoder. The LED display is the primary communication peripheral which shows clock, time, sensor readings, and also displays user configurations. In addition, system modes and status are indicated by up to 16 single LEDs. These LEDs are controlled through the MCU's Serial Peripheral Interface (SPI) bus using a 16-bit I/O Expander. A piezoelectric speaker is directly driven by the integrated circuit to play back alarm warnings and button beeps.
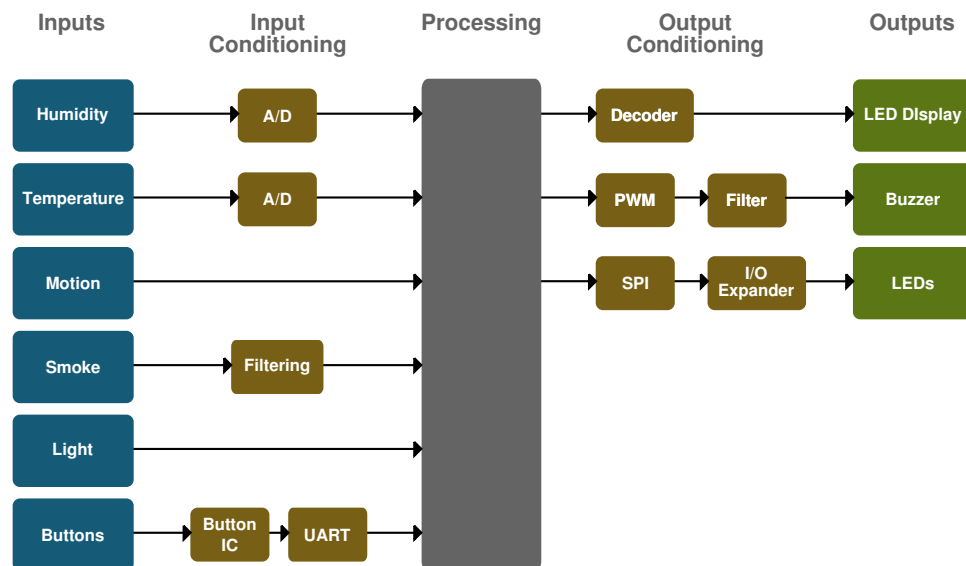

Figure 2.1: System Block Diagram

For the proof-of-concept prototype, the system will be housed behind an 8" by 4" glass panel as shown in Figure 2.2, with the exception of the sensors, which must be strategically placed around the stove for proper detection and operation of the device. The glass panel/user interface, featuring the LED display and LED status indicators, will also serve as the dielectric material for the touch-sensitive buttons, which are shown as cir-

cles, "Clock", and "Configure" in Figure 4.2. Glass is chosen as the user interface material because of its durability, elegant aesthetics, resistance to discoloring, and minimum effort to keep clean. Overall the system will be low-maintenance, intuitive, and easy to use.
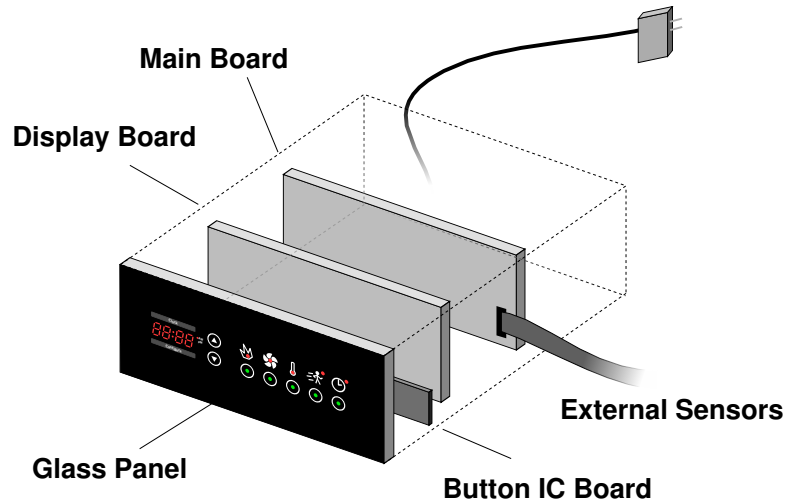

Figure 2.2: Enclosure Exploded View

3 Systems

3.1 Motion

System

To prevent the kitchen from being left unattended the Kitchen Alert needs to monitor the kitchen area. Kitchen Alert will accomplish this by the use of a motion detector. By monitoring the signal from the motion detector the system can determine whether or not there have been movements in the kitchen in a set time interval, which is configurable. If motion has not been detected for the set amount of time and the stove is deemed to be in use the user will be alerted to return to the kitchen by an audible warning.

Hardware

In deciding the type of motion detector many different types were considered including ultrasonic and infrared. The Kitchen Alert system uses an infrared motion detector for the fact that it provides sensitive and high range detection at a low price.

Kitchen Alert uses the DC-SS015 Pyroelectric Infrared PIR Motion Detector Module seen in Figures 3.1, 3.2. This sensor and all its circuitry take up a space of 38mm by 28mm. The motion detector has a range of up to seven meters and 110° sensing angle [3]. The motion detector will be powered by 5V DC power source. The output will be a digital output of 3V high and 0V low. The device will send a high signal in 3 second intervals while motion is being detected. By counting the number of high signals within set intervals the Kitchen Alert System is able to determine if a person is present in the kitchen.
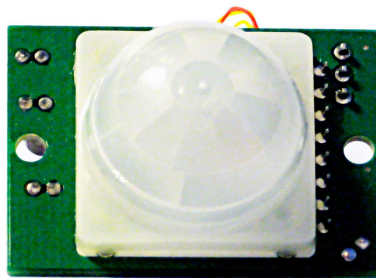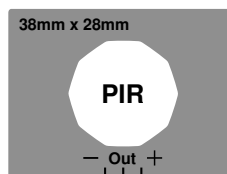

Figure 3.1: Motion Sensor Image

Figure 3.2: Motion Sensor Schematic

3.2 Humidity

Hardware

For the purposes of detecting when extra ventilation is required, the Honeywell HIH-4031 humidity sensor is used. The humidity sensor will be placed over the cooking environment and as such has been chosen to tolerate high temperatures, up to 85°C and moderate condensation [4]. The sensor is powered by a 5V source and outputs a linear voltage response based on the current humidity. The output of the humidity detector is directly connected to one of the Analog to Digital (A/D) inputs of the microcontroller.

Software

The software is responsible for periodically polling the humidity sensor, also sharing A/D capture with the temperature, and translating the input voltage into the percent humidity.

3.3 Infra-red Temperature

To measure the temperature of the cooking area Kitchen Alert will use an infrared temperature sensor. Kitchen Alert will use the Rayomatic 4 by Irtec seen in Figure 3.3. This sensor has the ability measure temperature from 0°C to 500°C. The Sensor is able to withstand up to 90% Relative Humidity and has an Environment Rating of IP65 which means it is completely protected against dust and it is protected against low pressured jets of water. This means that the sensor is able to handle the harsh cooking environment the sensor will be placed in.

Figure 3.3: Rayomatic 4 by Irtec [2]

The Rayomatic 4 temperature sensor has an optical resolution of 4:1 as seen in Figure 3.4. This means that at the normal counter top height the sensor will cover an area approximately equal to the diameter of the cooking pot. The sensor will be powered by a 12V DC source and output an analog signal ranging from 0V to 5V. The signal from the sensor is compensated for the ambient temperature to ensure correct readings. The signal will be send to an analog to digital converter where the corresponding temperature reading is determined.
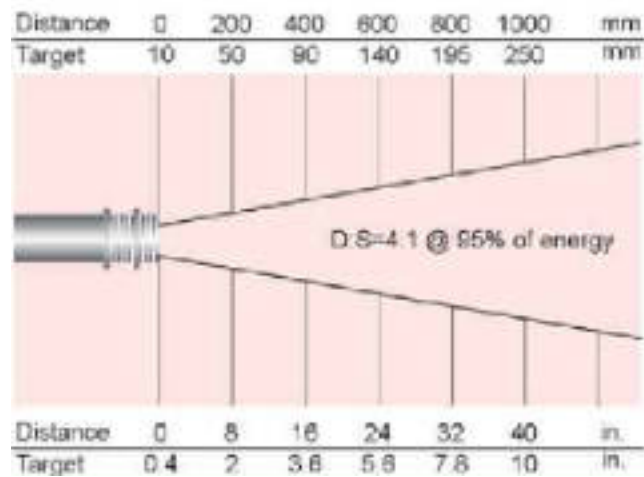
Figure 3.4: Rayomatic 4 Optical Resolution [2]

The Temperature reading will be used in a several ways. Firstly the temperature will be compared to a configurable threshold and if the temperature is deemed excessive, the user is alerted of possible dangerous situations. The temperature will also be monitored for sudden spikes as this could indicate a disaster about to happen. The user is also able to view the cooking temperature at anytime to assist them in their cooking. The temperature sensor plays a key role in kitchen safety.

3.4 Smoke

Kitchen Alert will utilize a smoke detector to assist it in determining if there is a danger of fire in the kitchen area. Kitchen Alert uses a photoelectric smoke detector. A photoelectric smoke detector is sensitive to smoldering fires and visible smoke; this allows it to be in close proximity of the stove without triggering false alarms. When smoke is detected the smoke detector will send out square wave pulses. These pulses will be regulated to 5V due to the higher voltage output of the smoke detector. Kitchen Alert will monitor the number of pulses in a set period of time to determine if there is a risk of fire. Furthermore in conjunction with the temperature sensor Kitchen Alert will try to distinguish between true and false alarms.

4 User Interface

The user interface of Kitchen Alert can be described in two sections: input and system feedback. Input is how users will interact with the system, and system feedback is how the system will show the user the state of the system and the status of their stove area.

4.1 Input Hardware

For user input, a set of capacitive touch buttons is provided. By using capacitive buttons the surface of the device can be smooth, providing an easy to clean and sealed environment for the device. For the purposes of the prototype Quantum Research Group's E1103 kit [5], shown in Figure 4.1, has been used to supply the button interface. The board contains a conroller that senses changes in capacitance for 10 buttons. The board operates off of a 3V power supply while the system operates on 5V. For signal reception by the microcontroller, 3V is above the logic one cut-off [6], however to protect the button IC the logic output of the microcontroller must be down converted from 5V to 3V. This is achieved by a simple diode voltage limiting circuit as shown in Figure A.1. As the buttons supplied with the controller are not of use to us, due to being too small and and not sensitive enough to work through our glass front panel, custom buttons (capacitive plates) have been made to serve this purpose. The status of the buttons is transfered to the microcontroller through a UART interface whenever there is a change in state of the buttons.
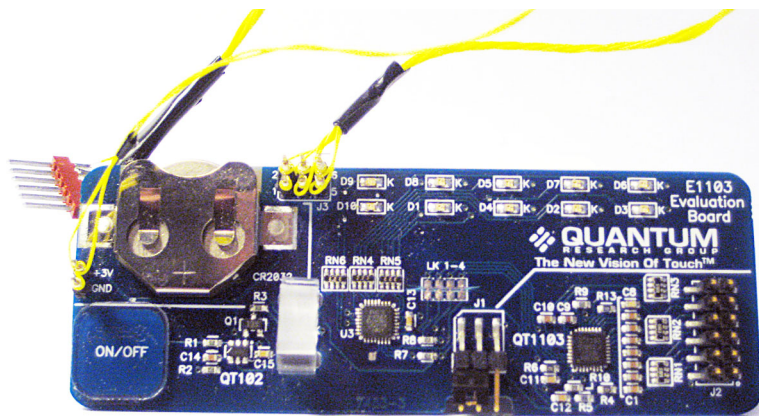

Figure 4.1: E1103 Button Board

4.2 Input Behaviour

The users of Kitchen Alert will provide input into the system via a series of buttons described above. There are nine buttons, and the breakdown of them is six for subsystem select and on/off where applicable, two arrow buttons for configuration adjustments, and one button to enter configuration mode. Whenever a button is pressed, an interrupt is generated and the system will determine which button is pressed. To make it intuitive for users, Kitchen Alert will have a mix of symbols and text labels by each of the input buttons as shown in Figure 4.2.
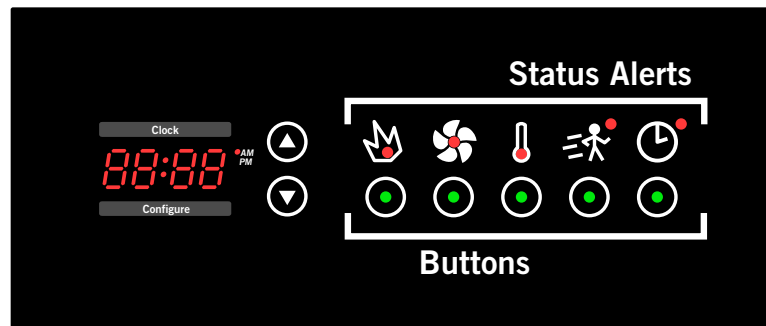

Figure 4.2: User Interface

For the six subsystem select buttons, a press of the button will switch the system into that corresponding subsystem mode. Holding a subsystem button for three seconds can turn off that mode with the exception of the clock. Once a subsystem is turned off, the system will default back to the clock. Holding a subsystem button for three seconds will also turn on a subsystem that is off. After turning a subsystem on, the system will also enter that subsystem mode. For the case when the system generates an alert, the user can turn off the alert for 30 seconds to correct the situation by pressing the corresponding subsystem that the alert is for.

When the configure button is pressed, the system will enter the configuration mode for the subsystem mode that it was just in. While in configuration mode, adjustments to parameter pertaining to the current subsystem can be made via the up and down arrows. When the system recognizes that the user has stopped changing the parameter for 3 seconds, configuration mode will timeout and return to the previous subsystem mode. The following Figure 4.3 and Table 4.1 further explain the procedure.
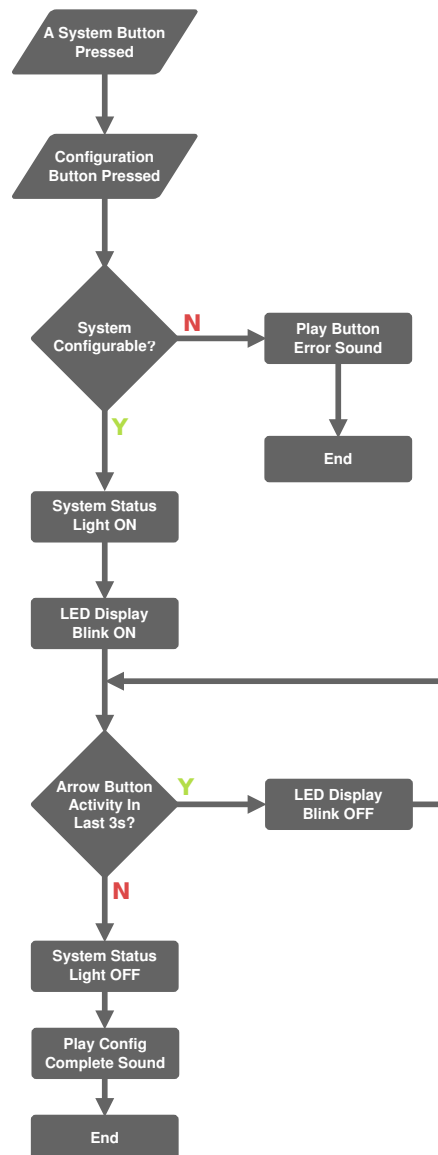
Figure 4.3: Configuration Flow

Table 4.1: Configuration Behaviour

Subsystem	Parameter	Up Arrow	Down Arrow
Clock	Clock	Increases Time	Decreases Time
Humidity	Humidity Threshold	Increases up to 100%	Decreases down to 40%
Temperature	Temperature Threshold	Increases up to 450°C	Decreases down to 50°C
Timer	Time to Countdown	Increases up to 12 hours	Decreases down to 1 min
Motion	Allowable Time for No Motion	Increases up to 12 hours	Decreases down to 1 min

4.3 Feedback Hardware

LED Display

To supply user information such as time, temperature and humidity, a numeric LED display is used as shown in Figure 4.4. The LED display was chosen as its high brightness allows it to be used behind the glass. This particular display is a common cathode display. There is only one set of inputs for the 7 segments and 5 lines for the each of the digits. This means the display must be multiplexed in order to turn on more than one digit at once. In addition a BCD decoder is used both to reduce pin outs from the microcontroller and to decrease the current the microcontroller must supply. The cathode connection for each digit is passed into a pnp-transistor, which is operated as a switch by varying the voltage on the base by the microcontroller. This serves two purposes, first it means the microcontoller does not need to sink the current flowing through the LEDs and it prevents the reverse voltage on the LEDs from exceeding their maximum spec of 5V [7].

Figure 4.4: LED Display Unit

LEDs / IOExpander

A 16-bit I/O Expander with SPI interface is used to drive the green and red LEDs for on/off status and alert status indication. The I/O expander is connected to the microcontroller via four pins: chip select, serial clock, serial in, and serial out. With just those four connections, the I/O expander provides a total of 16 available I/O pins, making it great pin saving piece of hardware to complement the microcontroller. To write to the I/O expander, the microcontroller first enables the chip select. Then, the address of the register that controls the output pin is sent followed by the data of which pin and corresponding LED is high or lit.

Buzzer

The purpose of the buzzer is to play back warning sounds to inform the user when a critical risk level is detected around the stovetop. As a secondary function, it will accompany the button controller by generating short beeps when a button is pressed. This is designed to enhance feedback when working with the touch-sensitive buttons on the user interface. The sounds played through the alarm system will be generated using the microcontroller's onboard Pulse Width Modulation (PWM) and an additional timer (Timer3).

For button beeps, the PWM will use Timer2 on the MCU to generate a square wave at 16 kHz, and Timer3 will modulate the wave's duty cycle to vary the average voltage at the output at 12 data points per desired output period. The output will be filtered using a passive RC circuit to resemble a sine wave. To generate warning sounds, only the

square wave from the PWM will be used as the output. Due to the nature of the square wave output, it is more effective in alarming situations compared to sine waves. Details for buzzer sounds which will be used are listed in Table 4.2.

Table 4.2: Buzzer Modes and Attributes

Buzzer Mode	Waveform	PWM Frequency	Timer 3 Frequency	Output Frequency	Output Characteristic
Critical Alert	Square	2 kHz	-	2 kHz	Intermittent: period of 500ms, 50% on/off duty cycle
Warning	Square	2 kHz	-	2 kHz	Intermittent: period of 1s, 50% on/off duty cycle
Timer Expiry	Sine	16 kHz	12 kHz	1 kHz	Continuous
Button Press	Sine	16 kHz	6 kHz	500 Hz	200ms beep
Successful Configuration	Sine	16 kHz	7.2 kHz	600 Hz	Two 100ms beeps with a 50ms pause in between
Invalid Button Input	Square	100 Hz	-	100 Hz	200ms beep

The alarm hardware we have chosen is the Murata PIEZORINGER®, specificall the PKM44EWH1001C model. PIEZORINGER® is an EU Restriction of Hazardous Substances Directive (RoHS) compliant lightweight piezoelectric speaker, which can be directly driven from ICs with negligible power consumption [8]. The piezoelectric speaker will be connected to the MCU's PWM output pin, as shown in Figure 4.5. The simple RC low-pass filter is designed to filter out the 16kHz PWM base frequency for generating sine waves. The cutoff frequency for the low- pass filter is given by:

$$f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi \; x \; 2.2k\Omega \; x \; 5nF} = 14.5kHz \qquad (4.1)$$
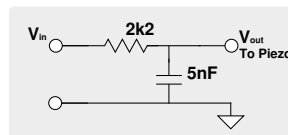

Figure 4.5: Low-pass Filter for Piezoelectric Speaker

4.4 Feedback Behaviour

The Kitchen Alert system has the need to communicate s significant amount of information to the user. The on/off status, the warning or alert status, and the different parameters of the different subsystems all must be indicated in a clear and precise manner.

To indicate the on/off status of each subsystem, green LEDs will be placed behind the buttons of the corresponding subsystem. They will be lit whenever the subsystem is on and unlit when it is off. To indicate an alert for a subsystem, red LEDs will be placed above the subsystem's button by the corresponding symbol. The red LEDs will light whenever there is an alert from that subsystem.

A numeric LED display will be used to display the parameters of the different subsystems. Because there are both normal and configuration modes for all the subsystems, blinking of the LED display will be used to differentiate the too modes. The table below shows what will be displayed from the subsystems in the different modes.

Table 4.3: Config Display

Subsystem	Display Parameter	Configuration Display Parameter (blinking)
Clock	Time	Time
Humidity	Current Humidity	Humidity Threshold
Temperature	Current Temperature	Temperature Threshold
Timer	Countdown Timer	Time to Countdown From
Motion	Time Since Last Motion	Allowable Time for No Motion

5 Test Plan

To ensure that the system works to specification a test plan along with test cases have been created. Whenever the system is changed it must be tested against these test cases. Each sub-system will have its own separate test case.

Test Case: 1
System: Clock/Time
Description: Testing the functionality of setting the clock

Step	Action	Expected Results	Pass / Fail Comments
1	Turn System On.	LED Display will blink to set Time.	
2	Use Arrow Buttons to set current time. When finished, remain inactive for 3 seconds.	The Clock will be set and displays current time.	
3	While in Clock mode press configure button.	The Clock will enter Configuration mode.	
4	Set the clock to a new time using arrow buttons. When finished, remain inactive for 3 seconds.	The Clock will display new time.	

Test Case: 2
System: Humidity Sensor
Description: Testing of turning the humidity sensor on or off and setting the humidity threshold.

Step	Action	Expected Results	Pass / Fail Comments
1	When system is on, press the humidity button. Compare results with external humidity sensor.	LED Display will Display current humidity.	
2	Press configure button.	The Status LED for the Humidity system will blink.	
3	Use the arrow buttons and set the humidity threshold to 50%. When finished, remain inactive for 3 seconds.	The new threshold will be 50%. and Status LED will become steady.	
4	Expose the system to small amount of steam from boiling water.	The Fan/Indicator will turn on once the 50% threshold is reached.	

Step	Action	Expected Results	Pass / Fail Comments
5	Press and hold the humidity button for 3 seconds.	The Humidity system will turn off and the Status LED will turn off.	
6	Press and hold the humidity button for 3 seconds.	The Humidity system will turn on and the Status LED will turn on.	

Test Case: 3

System: Temperature Sensor

Description: Testing of turning the Temperature sensor on or off and setting the Temperature sensor's threshold.

Step	Action	Expected Results	Pass / Fail Comments
1	When system is on, press the Temperature. Compare results with external an external thermometer.	LED Display will Display current temperature.	
2	Press configure button.	The Status LED for the Temperature system will blink.	
3	Use the arrow buttons and set the Temperature threshold to 90°C. When finished, remain inactive for 3 seconds.	The new threshold will be 90°C. Status LED will become steady.	
4	Boil a pot of water on the stove.	The system will set off the alarm and alert the user to come back to the kitchen	
5	Press the Temperature button	The Alarm will turn off for 30 seconds.	
6	Press and hold the Temperature button for 3 seconds.	The Temperature system will turn off and the Status LED will turn off.	
7	Press and hold the Temperature button for 3 seconds.	The Temperature system will turn on and the Status LED will turn on.	

Test Case: 4

System: Timer

Description: This test case will test the functionality of the timer system.

Step	Action	Expected Results	Pass / Fail Comments
1	When system is on. Press the Timer button followed by the Configure button.	The system will enter timer configuration setting. The Status LED for the Timer system will blink.	
2	Use the arrow buttons and set the Timer to 30 seconds. When finished, remain inactive for 3 seconds.	The timer will start counting down from 30 seconds. Status LED will become steady.	
3	Press and hold the timer button.	The status LED for the Timer will turn off. The counter will stop its count down.	
4	Press and hold the timer button.	The status LED for the Timer will turn On. The counter will continue its count down.	
5	Wait until timer expires.	The timer's alarm will turn on.	

Test Case: 5

System: Motion Detector

Description: This test case will test the functionality of the Motion Detector system.

Step	Action	Expected Results	Pass / Fail Comments
1	When system is on. Press the Motion detection button followed by the Configure button.	The system will enter motion configuration setting. The Status LED for the motion system will blink.	
2	Use the arrow buttons and set the threshold to 10 seconds. When finished, remain inactive for 3 seconds.	The motion detector's timer will be set to 10 seconds. Status LED will become steady.	
3	Leave the vicinity of the system for 10 seconds.	The system will alert the user to return to the kitchen.	
4	Return to the system.	The alert will stop.	

6 Conclusion

General Gadgets Canada approves the design specifications contained in this report. By outlining the specific behaviors in the various modes, the Kitchen Alert prototype will be built to operate in the desired manner for the different conditions that it will encounter. To verify the behaviors, the Kitchen Alert system will be put through the comprehensive and systematic test plan described in this report. Members of the General Gadgets Canada will frequently reference these specifications during the development schedule. The prototype for Kitchen Alert is projected for completion in April 2009.

References

[1] General Gadgets Canada, "Functional Specs: Kitchen Alert," February 2009, Version 1.0.

[2] Temperature & Process Instruments, Inc., "IRtec Rayomatic 4 Infrared Fixed Mount Thermometer." [Online]. Available: http://www.tnp-instruments.com/rayomatic4_infrared_thermometer.html

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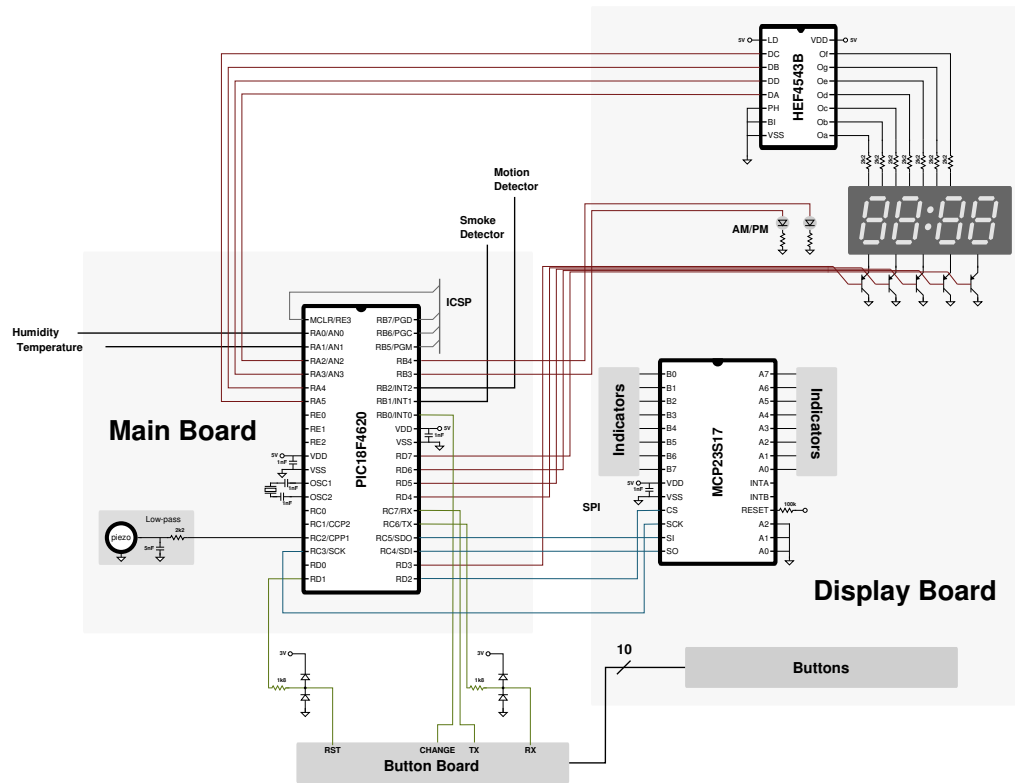[8] Murata Manufacturing Co., Ltd., "Piezoelectric Sound Components." [Online]. Available: http://www.murata.com/catalog/p37e.pdf

A Schematics

Figure A.1: System Schematic