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April 20, 2009

Patrick Leung
School of Engineering Science
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Burnaby, B.C. V5A 1S6

**Re: ENSC 440, *General Gadgets Post-Mortem for Kitchen Alert***

Dear Mr. Leung:

The attached document describes the outcome of General Gadgets Canada's Kitchen Alert after nearly four months of development. Kitchen Alert detects and monitors the stovetop situation and takes action to alert the user when there are potential problems in the kitchen area. By monitoring the stovetop condition based on temperature, motion, humidity, smoke, and light from the kitchen's environment, Kitchen Alert helps prevent kitchen fires and creates a more enjoyable cooking experience for its users.

The attached post-mortem summarizes the current state of the prototype, design deviations from original specifications, time and budget, future developments, team dynamics, and individual reflections on the project by each of the team members.

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 Post-Mortem, please feel free to contact me by phone at (778) 885-0499 or by e-mail at rhafezi@sfu.ca.

Sincerely,

Rasam Hafezi

Rasam Hafezi
Chief Executive Officer
General Gadgets Canada

Enclosure: *Enclosure: General Gadgets Post-Mortem for Kitchen Alert*

# Post-Mortem
## Kitchen Alert

**Prepared for:**

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Chief Executive Officer

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# Glossary

**BJT** Bipolar Junction Transistor. 4

**Kitchen Alert** A kitchen stove safety device created by General Gadgets. 1

**PCB** Printed Circuit Board. 5, 7

# 1 Introduction

For the past four months, General Gadgets Canada has been developing a proof-of-concept prototype for Kitchen Alert. Kitchen Alert is a product 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, it alerts the user with audio and visual feedback so they can take appropriate actions to remediate the situation. Kitchen Alert also includes a clock/timer as part of the user interface to further assist kitchen users when they cook. The device provides enhanced safety, security, and convenience to multi-tasking home owners who go in and out of the kitchen to tend to other business.

This document describes Kitchen Alert's prototype which was completed on April 5, 2009. It discusses the state of the system and the deviations from the original specifications, budget and timeline, as well as general issues regarding the development phases as a team and individually.

# 2 Current System State

As the prototype currently stands, nearly all of the features and functionality of the systems are operational. General Gadgets' goal of creating a device which improves the safety and convenience of kitchens has been met. The schematic for our prototype is included in Appendix A. A summary of the overall system, unique features and functions for the prototype is outlined below.

## 2.1 Overall System

Kitchen Alert is composed of five sensors to detect the following kitchen environmental conditions: smoke, humidity, temperature, motion, and burner status. These environmental parameters are processed by counter-top unit shown in Figure 2.1, which is also the user interface of the system.


**Figure 2.1:** Kitchen Alert Prototype

The user interface is visible behind the smooth glass finish that is the front panel of the unit. A 4-digit, 7-segment numeric display is used to show clock/timer, sensor readings, as well as configuration parameters for each of the individual subsystems represented by the intuitive symbols, which indicate the following system modes: burn detection, humidity detection, temperature sensor, motion sensor, and timer. Individual LED indicators are also used to denote system status and AM/PM for the clock.

User inputs are passed to the unit by way of capacitance-based touch-sensitive buttons on the panel. The nine buttons used are: Clock, Configure, two arrow buttons, and five on/off buttons which associated to the five system modes. Each system can be turned on (lit blue LED indicator) or off by holding its corresponding on/off button for 2 seconds. A quick tap of an on/off button will switch the LED display to show information from the corresponding system mode. Furthermore, a tap of the Configure button allows the user to adjust the current mode's settings using the arrow buttons. While in configuration mode, a quick tap of an arrow button will perform a single adjustment of the displayed setting, and holding down an arrow button will speed through the setting until the button is released.

A built-in speaker housed inside the counter-top unit is used to provide audio feedback to the user. For example, a short beep indicates a button has been pressed, three quick beeps in succession indicate a successful configuration, and a constant beeping noise indicates either an alarm or timer has gone off. Different audio frequencies are used for the various situations to create a range of dynamic sounds.

## 2.2 Burn Detection

When a non-adjustable temperature threshold of 240°C or smoke has been detected, an alarm will go off while the burn detection's red LED indicator flashes until the user acknowledges the situation by holding down its on/off button. There are three sensitivity settings for the smoke sensor under this mode: 1, 2, and 3, with 1 being the most sensitive and 3 the least sensitive.

## 2.3 Humidity Detection

When a preset relative humidity threshold is detected, the red LED indicator for the fan indicator will be turned on to indicate that a range-hood fan should be turned on. The threshold for the relative humidity can be set between 10-100% inclusive on 2% increments.

## 2.4 Temperature Sensor

When a preset temperature threshold is detected, an alarm will go off while the red LED indicator flashes until the user acknowledges the situation by holding down its on/off button. The temperature threshold can be set between 50-500°C inclusive on 2°C increments.

## 2.5 Motion Sensor

The motion sensor, which has a 120 degree detection angle, is used to detect movement in the kitchen. The motion detection is activated when the light sensor senses a stove burner is turned on by monitoring the burner's LED indicator. When a preset amount of time with no motion is detected while a burner is on, an alarm will go off to notify the user to return to the kitchen. The timeout for the motion sensor can be set between 30 seconds to 5 minutes inclusive on 1 second increments.

## 2.6 Clock/Timer

The time of day is indicated by the LED display and is configured on a 12-hour basis, with AM/PM indicators. The timer can be set to expire from 1 minute to 23 hours 59 minutes inclusive on 1 minute increments. An alarm goes off with the red LED flashing when the timer expires.

# 3 Design Deviations

Due to challenges encountered in our software and hardware developments and specification oversights, we had to make a few adjustments to our design specifications in attempt to meet all of the functional requirements as previously set out. The functional requirements which General Gadgets had laid out have been met with a few exceptions. The most notable changes made to our design are listed below.

## 3.1 Infrared Temperature Sensor

The IR sensor we had chosen as per our design specifications was the IRtec Rayomatic 4. Because of a manufacturer's delay, the sensor would not arrive until mid-April, which would be too late for us to complete the project on time. Luckily we were able to purchase a different sensor, Raytek's Thermalert CI, with very similar performance characteristics.

## 3.2 Alarm

Originally the alarm hardware was chosen to be the Murata PKM44EWH1001C for its lightweight ability to be driven directly from ICs with negligible power consumption [1]. However the sound output of this piezoelectric speaker turned out to be much lower than we had expected, and the low frequency response could've been improved on. Instead, we used a 6-Ohm speaker taken from a Sony TCM-200DV cassette player/recorder to give us a better sound output.

On the software side, we had originally planned to generate sine waves to drive the speaker for some alarm tones by varying the duty cycle of the pulse-width modulator and filtering the output. We had made many attempts using different op-amps and Bipolar Junction Transistor (BJT) circuits in active filters and in conjunction with passive filters, but none gave us a clean enough signal to hear the difference. In the end we used square waves for all tones and used a BJT to source the speaker current, so as to not source to much current from the micro-controller.

## 3.3 Functional Specifications

A couple of short comings for the functional deviations are:

1. Detection spot size of the temperature sensor was smaller than planned. Four inches instead of 6 inches and the accuracy of the sensor was slightly less 3-5 degrees instead of 2 degrees.
2. Shut-off of stove burner/electric coil is not controlled by the system. We had decided that this feature would be best to implement in the production model, since the proof-of-concept and usefulness of the product had been successfully demonstrated through all other features.

# 4 Future Development

General Gadgets' future plans for Kitchen Alert, should we choose to pursue further development, would include automatic fan activation when the humidity threshold has been reached, automatic stove burner/power shut-down when motion detection times out, and a standalone sound module for generating audio feedback with higher sound quality. In addition, to improve visual feedback, we would go with a custom display, allowing proper display of special symbols like the degree symbol, or percent symbol. A custom display would also make it possible to easily show that user which system is currently being displayed. Other parameters to consider include reducing the heat dissipation of the system by using a unified voltage (currently the system uses 12V, 5V, and 3V supplies) to eliminate the need for several voltage regulators and eliminating voltage conversion circuits, designing a Printed Circuit Board (PCB) for improved reliability and compactness, and possibly a feature to alert the user on his/her mobile phone through text messaging when the system detects a potential hazard.

# 5 Timeline

Throughout the development phases, the team's continuous effort ensured that our progress stayed mostly on schedule as originally proposed. The most notable difference between actual and projected schedule is on the research phase, which was found to be more of an on-going process than we previously anticipated. 5.1 below shows the comparison of the two schedules.

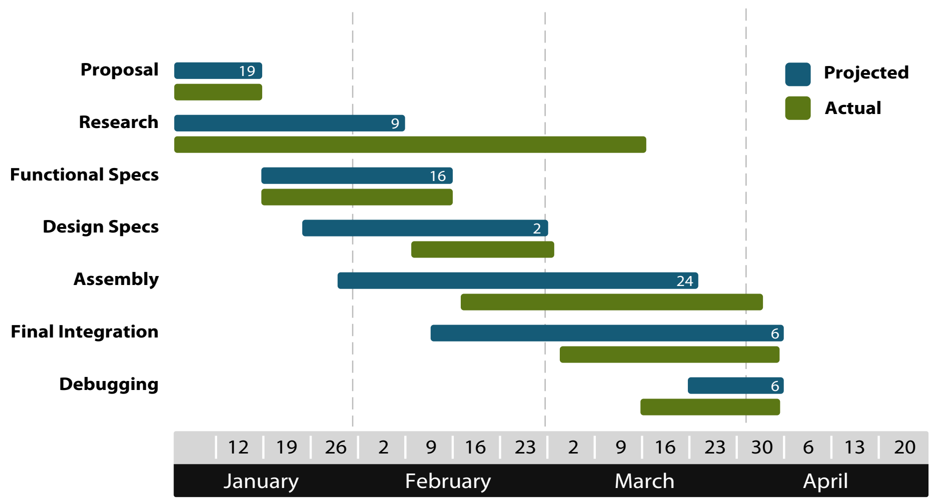


**Figure 5.1:** Project Timeline

# 6 Budget

General Gadgets' spending for this project is shown in Figure 6.1 and Table 6.1 below. The most expensive item purchased was an industrial grade, infrared temperature sensor, which takes contactless passive measurements and is able to withstand the high humidity and high temperatures found in a stove-top environment.

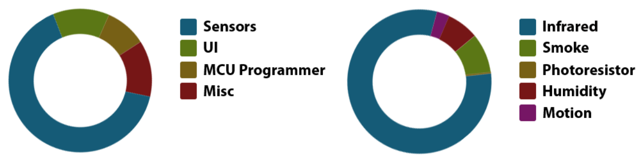


**Figure 6.1:** Budget Proportions

**Table 6.1:** Budget Main Components

| Component | Cost |
|---|---|
| Infrared Sensor | $300 |
| MCU Programmer | $50 |
| Cap Touch Buttons | $50 |
| Smoke Sensor | $30 |
| Humidity Sensor | $20 |
| MPU | $14 |
| Motion Sensor | $10 |

# 7 Team Dynamics

Having worked with each other in group settings numerous times throughout our undergraduate years, our team members were comfortable working together from start to finish on this project. Each team member recognized other members' areas of strength from day one, and combining the wide spread of expertise within the team, the project roles and share of work was distributed properly and fairly. This led to increased work efficiency throughout each of the development phases.

At the early phases of the project, the team held bi-weekly meetings regularly to keep each other updated on the latest research and ideas. Once the majority of the parts had been gathered, almost all work put into development was done in all members' presence, with the exception of software programming. Working in this manner allowed each member to be familiar with all aspects of the project and not just the assumed roles for each person. Because of this, the bi-weekly meetings solely for discussion were deemed unnecessary since we were working together 4 or 5 days a week.

On the other hand, there were times when there was not enough work to be shared among the group, particularly during the phase when we transferred our components from the bread boards to the prototype board, because the board was too small for more than two people to work on it at once. This was a period of time where the progress slowed down since we could not conduct further software testing without the components intact. However things picked up again once all the hardware transfer had been successfully completed.

We were very pleased with the performance of each member's contributions to the team work. We were grateful that our thorough hardware and software planning had paid off such that each development phase had a smooth transition into the next. Even though a few problems still arose, no irreversible disasters occurred during the course of the project.

# 8 What we would have done differently

If we were to undertake a similar project again, we would go with a PCB instead of a prototype board. Even though we have vastly improved our soldering skills after this project, piecing together all the components on a prototype board is still very time consuming and more prone to connection problems and reliability issues. In this particular project, there were no major design changes once the components were on the prototype board, thanks to our thorough planning and testing when we were still developing our circuits on bread boards. Because of this, we are confident that a PCB would've been ideal since it could've saved us much of our valuable time.

# 9 Individual Reflections

## 9.1 Rasam Hafezi

I really enjoyed working on this project, as it gave me a new understanding of the development cycle. At the beginning of the semester we were heavily warned about the work load of this project. These warnings led us to adopt a system where our group met almost every day of the week.

This semester I was at school at about 7:30 am every day, this allowed me to prepare myself for the work ahead of us that day. Our group meetings were usually from the morning to about 4 or 5 in the afternoon. I believe these were good because it allowed us to meet every day without getting too burned out.

In our group, for the most part all tasks were done as a group. Although, some people were more focused on a certain area than others. My focus was on procurement of parts, hardware design and finances. In my duties in parts procurement the main problem that I ran into was with our infra-red temperature sensor. The vendor had promised us that the product will be ready and shipped in a month, and had given us the latest date it would be shipped at. We had calculated that one month plus a week for shipping and a few contingency days would still give us enough time to integrate the sensor.

On the day the product was to be shipped out, I phoned the vendor to remind them to not forget our shipment. They then informed me that the manufacture had delayed the production by a month and it would take them at least a month longer to ship the item. This was one of the most stressful days of this project for me. This phone call took place at about 8:00 am. I quickly started a search online and called anyone who might have anything comparable. After spending hours calling any number that my search would reveal I was able to track down a vendor that had a product almost identical to what we had previously ordered. A week later with a short drive to Point Robert's we had our sensor in hand. This experience thought me to expect the best but anticipate the worst and be ready to act if necessary.

Besides the technical skills I acquired while working on this project I learned a lot about developing a product and all the little things that go along with it. This whole experience taught me that if you work smart and continuously you will achieve your goal. Even when it seems impossible, it usually works out with a bit of hard work.

This project was a very positive experience for me and I have decided to continue working on this after the semester is finished. I will be spending the next few months developing a business plan to analyse the potential of this product.

## 9.2 Eric Matthews

I've been waiting for a course such as ENSC 440 for my entire time in engineering at SFU. Prior to this course only ENSC 151, in first year, gave any significant opportunity for independent work. Having an open course like this allows you to to create whatever experience you choose.

From all the horror stories we were told about the course, we got an early start and before the semester began we had chosen a company name and I had prepared the general appearance of our future documents. It wasn't until the end of the first week of the semester that our idea for the course began to form. From there we did a significant amount of early planning. I spent a great deal of time at the beginning of the course planning out the design of our project, figuring out what we needed to get started and then getting our initial code base written so we had a platform to work with.

From there, throughout the course I focused on planning and keeping us on track, software development, getting our initial components working, then at the end, finishing the desired software functionality of our system. Throughout the course I was working as the integrator for our documents as well as creating all necessary schematics and diagrams.

One of the surprising things I found in this course was at first it seemed that what we had learned in previous courses was of no help. At the beginning of the course we were completely lost, not knowing even the basic setup needed to get a working system with a microcontroller up and running. We learned a tremendous amount in those first weeks and it stayed that way throughout the course. And as we progressed I found that my original thoughts were wrong as I found myself drawing more and more upon all that I had previously learned in engineering in order to make our project a success.

## 9.3 Alex Kung

Though every so often I questioned the amount of time spent on the project, at the end I found it to be worth all of it. To come be able to work with the group members that I had was a privilege. There were never any major arguments, and we combined our ideas very well. When we got Kitchen Alert to work, it was hard not to be proud.

In the end, our product was able to function correctly and pass the test conditions we put it through, but there were times when it was not very certain that it was going to. At one point, we did not know if we could actually do a good demo, and it was quite a troubling feeling. We did not stop working, though, and when we got back at it, we managed not to worry so much and found a way to make it happen.

The project itself gave so many opportunities for me to learn. I got a chance to work on hardware, software, design, and testing. I was fortunate enough not to have to do any soldering, so thanks to Eddie and Rasam for breathing in more than their share of solder. Still, being part of the decision-making in terms of components and placement of them was very interesting. When I began work to write code for the behaviour of the system at first, it was quite a challenge. Thinking through how the system has to act and translating it to code was something that I am glad I got to do because I got a great understanding of that process.

When it came time to put together the final prototype and transfer over from the breadboard, we had no idea what we were getting into. It was one thing to transfer and connect components, but it was another thing to get it to work. Problems just seem to find its way in. But, when the prototype was finally ready for testing and demo, it was a great moment of relief and satisfaction. Filming our video demo and presenting our project went relatively easy compared to the rest of the things we had to do.

Now that we are done with the project in terms of courses, it will be interesting to see if there holds opportunities for us elsewhere with Kitchen Alert.

## 9.4 Edward Lee

ENSC 305/440 was an unique experience for me. The amount of time and effort required was immense and sometimes a little overwhelming, but the end result was priceless. It was rewarding to see our project progress day by day from a simple idea to a fully functional device in a period of time as short as 13 weeks. Our group had made the right decision to maintain a minimal course load for the semester, allowing our schedule to be more flexible, which I believe played a large role in our team's success. My most notable contributions to the project were focused on hardware assembly and debugging, as well as writing the code for our system's alarm/button sounds. I have always enjoyed hands-on work and this course has provided me with the opportunity to refine my mechanical and soldering skills while refreshing my software skills.

Unlike most other Engineering Sciences courses offered at SFU, this course provided us with total freedom to exercise our technical knowledge and skills which we have obtained since our first year. Through this course, I have further developed not only my technical background and experience, but also improved my teamwork and time-management skills, which will be invaluable assets for pursuing a career in engineering. I have learned that the saying "measure twice, cut once" is one of the best advice for any engineering task. Having learned that some other groups experienced great difficulties on their projects due to serious oversights, I was pleased that our group had put in the extra time in the beginning of the semester to research and plan out the technical aspects of our project, which resulted in minimal problems in meeting our project goals and deadlines.

# 10 Conclusion

Four months have gone by and what started as a passing anecdote about a pot boiling over on the stove has turned into a complete prototype. Our product, Kitchen Alert has met and exceeded our expectations, and only now after having used the system in real situations have we begun to appreciate the benefits that this product could bring. It has been an incredible experience for all of us, and one of the most worthwhile of our undergrad experience. We leave this course with a much improved skill set, both on the technical side and in terms of soft skills. We look forward to whatever future Kitchen Alert may have and even if it ends with this course we are still proud of the work we put in and what we accomplished.

# References

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

# A Schematics

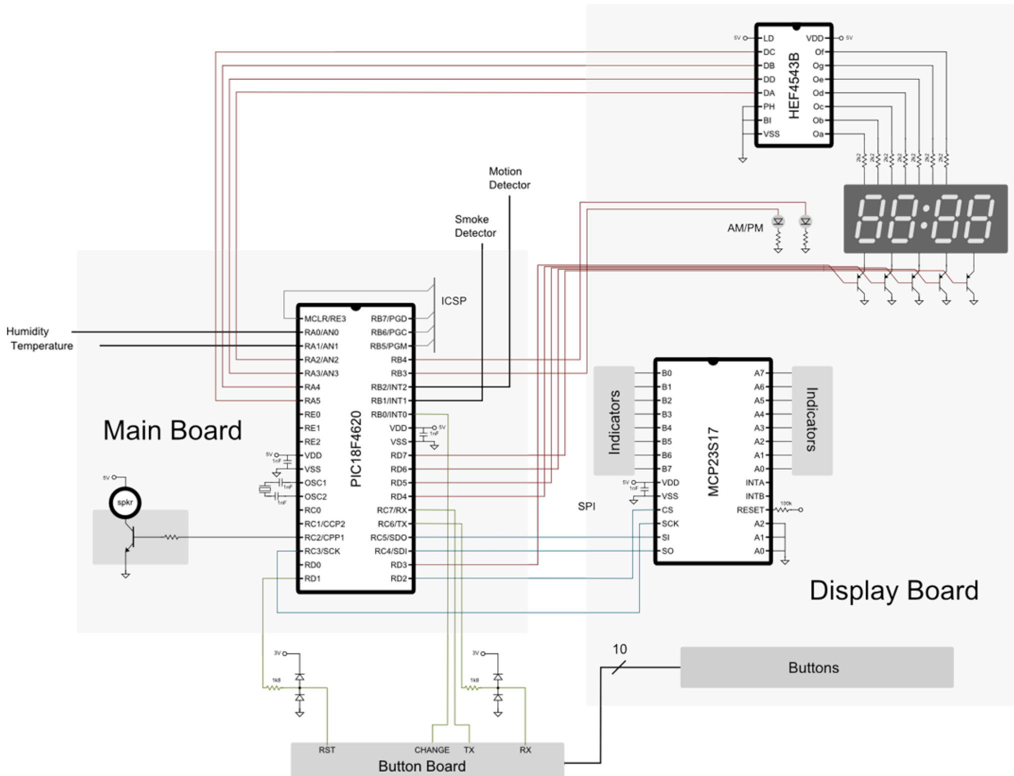


**Figure A.1:** System Schematic