University of Nevada, Reno

Interactive Fire Prevention System

A thesis submitted in partial fulfillment
of the requirements for the degree of

Bachelor of Science in Electrical Engineering,

by

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ABSTRACT

The numbers of structural fires are not significantly decreasing over the last decades. 49% of residential fires are caused by cooking accidents having several casualties and costs from $800 to 35,000 to repair. The proposed Interactive Fire Prevention System is designed to help prevent the spread of residential kitchen fires due to unattended equipment. The Fire prevention system have two compatibility models depending on the type of stove the customer have. A gas stove model that will be operated by a solenoid gas valve and an electrical stove model that will be operated by an AC relay. This paper includes both designs with technical details about how to implement this tiered alarm and alert system, as well a business plan for the product.

ACKNOWLEDEMENTS

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INTRODUCTION

Background

Currently, there are fire alarm systems in almost every residential, commercial, and industrial structures. In residential buildings, fire alarm systems usually consist of smoke sensors that trigger an alarm to notify residents of the hazard. In commercial and industrial buildings, more specifically their kitchens, fire alarm systems include a fire suppression system of sprinklers and fire retardants that will automatically activate on the emergency. Every year the National Fire Protection Association (NFPA) conducts a survey on fire loss. This survey accounted for nearly 12,000 civilian injuries, as well as almost 3,000 deaths in 2014 alone [16]. Moreover, home structure fires found that 45% of residential fires and 42% of civilian injuries were caused by cooking equipment [17]. These trends indicate that residential buildings need more attention and improvement.

Work Objective Statements

Doutech Systems will develop a product focused on safety for kitchen fires at a residential level. Doutech Fire Prevention System (DFPS) gives the user more peace of mind and safety while cooking on the stove. DFPS is designed to provide the residents with alarm codes and safety precautions (such as turning off the gas/electricity to the burner) to help prevent the occurrence and severity of kitchen fires. This unique system of alarms helps residents to quickly determine the type of emergency and what they should do. By quickly informing residents about the intensity of a fire or a potential fire in their households, they can easily avoid injuries either by preventing the fire (if it is a starting fire) or evacuating the building.

The main objective of DFPS is to reduce the amount of residential fire incidents caused by unattended stoves.

Methods

DFPS design will use infrared, smoke, and LPG sensors to determine the current state of the emergency. Based on the amount of smoke, DFPS can determine how hazardous the environment is for the residents. Also, to obtain a more accurate conclusion, the infrared sensor will determine if there are flames on the area of the stove and if it is necessary to activate the suppression system (Actuators). The readings provided by the sensors are continuously sent to a microcontroller (Arduino) to be analyzed and to activate the proper alarm. In the case of false alarms, a push button is going to be installed to turn off the alarms and sensors for a specific amount of time.

Conclusions & Significance

The Doutech Fire Prevention System is a product designed with the sole purpose of reducing the number of residential fire outbreaks originating in the kitchen. This is achieved through preventative measures such as disabling gas flow to the stovetop and a tiered alarm warning. Using IR flame, smoke, and LPG sensors the user is given a range of alerts that can potentially save their life. Overall, the system will be designed to integrate all sensors in a compact, efficient, and reliable form. Doutech Fire Prevention System is a significant improvement in fire safety and prevention. In the future, when additional resources are available, the team plans to develop the product even further to ensure the user is getting the most reliable and proactive system possible.

BACKGROUND

Every year the National Fire Protection Association (NFPA) conducts a survey on fire loss. This survey revealed that 74% of 494,000 structural fires occurred in residential structures. Residential fires also accounted for nearly 12,000 civilian injuries, as well as almost 3,000 deaths in 2014 alone [16]. An additional survey conducted by the NFPA on home structure fires found that 45% of residential fires and 42% of civilian injuries were caused by cooking equipment [17]. The occurrences of residential fires are not decreasing at any noticeably constant or drastic rate as seen in Figure 0.

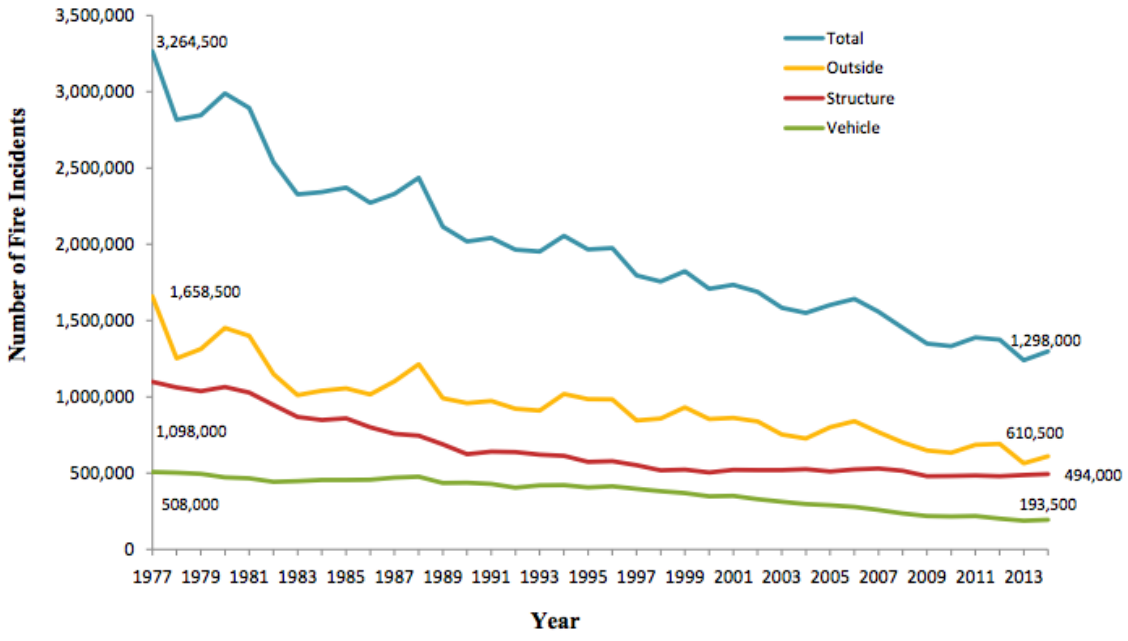

Figure 0: Number of fire incidents per year from 1977-2014 [16].

It is evident that the numbers of structural fires are not decreasing, and therefore civilians are still in danger of injury or death due to these types of fires. Doutech Systems undertakes the

dangers and risks associated with home cooking accidents by creating a fire prevention system specifically for the kitchen, where nearly half of all home fires originate.

The Doutech Fire Prevention System (DFPS) gives the user more peace of mind and safety while cooking on the stove. The system is designed to provide the user with a series of warning alarms and safety precautions (such as turning off the gas to the burner) to help prevent the occurrence and severity of kitchen fires. Infrared, smoke, and natural gas sensors are implemented through use of an Arduino which constantly sense kitchen cooking environment. The IR sensor is designed to detect if a flame has formed on the stovetop. In addition, the smoke sensors detect the accumulation of smoke working in the same capacity as a traditional smoke alarm. The smoke and IR sensors are also integrated with a natural gas sensor which detects if gas stoves are left on without a flame for an extended period of time. If any of the warning or danger thresholds are exceeded the system will emit an alarm to warn the user of potential fires on the kitchen stove, if the status of the system does not change or escalates, the Doutech Fire Prevention System will emit an evacuation alarm to tell the user that there is nothing they can do to aid the situation and keep them out of harm's way.

In order to solve the problem of residential fires originating on the stove, various companies have introduced products including automatic fire extinguishers and fire detection systems that alert the fire department in the event of a fire. The StoveTop FireStop is a set of small magnetic canisters containing a fire retardant. This device is mounted underneath the rangehood and sprays out the retardant if it detects large flames on the stovetop [18]. The second product, the ADT Alarm System, is just a fire alarm integrated with their home security system. This alarm system alerts the ADT with a signal if the alarm is tripped, and

then they alert the proper authorities to relinquish the fire [19]. Both of these technologies take action after a fire has already started, and do not attempt to stop the source of the fire.

The Doutech Fire Prevention System (DFPS) takes action before a fire has a chance to spread and grow. By utilizing a combination of smoke, natural gas, and IR (flame) sensors integrated using a microcontroller, the DFPS will attempt to put out the flames using a fire retardant system and cut of the stove's fuel source.The system will also give the user ample warning and time to attempt alleviate the issue with a tiered alarm system in order to lower the risk of the fire spreading to the rest of the home or kitchen. The Doutech Fire Prevention System helps at multiple stages to help prevent the origination of a fire when possible and takes action when necessary to put out or stop the spread of stovetop fires to prevent stovetop fires from spreading, therefore reducing the occurrence of residential fires.

REVIEW OF LITERATURE

Doutech Fire Prevention System integrates products and designs that have been patented decades ago. The following list shows patents of similar designs, their year of publication, and a brief list of their main features.

- Fire Extinguishing System for Stoves and Ranges (Apr. 4, 1972) by Walter E Dockery[1]:
    - Automatically operated fire extinguishing system.
    - Targets fire due to burning fat or grease.
    - Feedback based on thermostats.
    - Removable/rechargeable fire extinguisher.
    - It uses solenoid operated valves to open the power or fuel line energizing the burners of the stove.
    - Includes an audible alarm, which can be turned off manually if alarm was not desired.
    - Emergency switch to apply power to solenoid and operate the system.
- Automatic Fire Prevention System (Jun 23, 1987) by Henry T. Peters and Harry Kalayjian[2]:
    - Fire alarm circuit and a timer circuit which automatically shut down energy supplies.
    - Targets fires that have origin when equipment is unattended.
    - Provides a visual and audible indicator that an alarm condition has been detected.
- Fire Extinguishing Systems and Methods (Feb 16, 1999) by Henry J. Stehling, et al[3].:

- It uses fire suppressants to extinguish fires on cook stoves, fryers or other heating devices.
- Detection circuit using heat sensors.
- It provides acoustic sensors that trigger the suppression system when the fire alarm is activated.

ARGUMENT

The most common reason of kitchen fires are due to unattended equipment, Doutech Fire Prevention System (DFPS) targets this issue by constantly monitoring the smoke, gas and heat radiation (flames) levels using sensors. DFPS notifies the residents if there is any potential fire and prevents it goes out of control.

Doutech Fire Prevention System will be a product that can installed in the kitchen of any domestic residence. Using smoke sensors, temperature sensors, and natural gas sensors, our system is capable of determining different emergency situations that are going to be assigned to different alarm patterns and volumes. Based on the emergency situation, our system will also automatically trigger a preventive or suppressive action.

METHODOLOGY

CHAPTER 1: BUSSINESS PLAN

Section 1.1: Executive Summary

Background

Doutech Systems is a brand new company who aims to provide property owners and families peace of mind around safety precautions used against fires, and natural gas leakages in residential building. As a company, our mission is to design a system that will reduce the current trends of domestic fires, property losses, and casualties caused by cooking accidents.

Management Team

The founders of Doutech will fulfill four executive positions: chief executive officer, chief of operations, chief financial officer, and chief marketing officer. With the founders combined skills, the product prototype will have a strong technical foundation. Once Doutech Systems has developed a commercial design for the product, the company plans to expand into other key areas which will require engineers, lab technicians and subsequently, a human resource employee.

Product and Technologies

The initial Doutech Systems product is the Doutech Fire Prevention System (DFPS). DFPS consists in the integration of most effective fire suppression systems invented during the last decades that would be operated and controlled by a microcontroller. Using multiple sensors, DFPS would be capable of determining a variety of fire emergency situations, and accordingly, applying the most convenient suppressive method. The creation of an alarm

code is going to be implemented to help the residents quickly determine the emergency situation and the proper action to take.

Market and Competitive Analysis

The target market for the DFPS is wide and easily expandable throughout the nation. Market trends in housing and data resourced from the National Fire Protection Association (NFPA) provides positive insight in the market acceptance of the DFPS.

Critical Risks

Even though there exists a growing market for Doutech product, Doutech Systems is a new company and it will be exposed to multiple risks on the market. These risk factors include the competitiveness of the market, market entry strategy, and risks associated with the development and implementation of the system's technology. Being aware of these risks, a plan to reduce these risks has been designed and included in Doutech business plan.

Operating Strategies

Doutech is prepared to introduce their product to national retailers such as Home Depot and Lowe's in an effort to create partnerships with them. This will help to put our product in front of more customers outside of the realm of the internet.

Cashflow and Income Statements

A deep study for the cash flow of Doutech System projects that the company will experience a minimal cash flow for the first two years as the DFPS is in the development stages, and will have limited manufacturing capabilities. Doutech expects to have a positive cash flow

from the end of year two. Once positive cash flow is established and partnerships with manufacturers and retailers secured, Doutech Systems will be able to repay their initial investors, and maintain the manufacturing, distribution, and partnership fees by itself.

Section 1.2: Company Overview

History and Current Status

The founders of Doutech Systems are Electrical Engineering students of program the University of Nevada, Reno. The company members were randomly selected for a capstone class senior project. We decided to apply our varied knowledge in engineering to start a brand new company named Doutech. The name of Doutech refers to the obsolete word "douter" (or a candle extinguisher) and the abbreviation of the word technology. The current status of our company is assembling design modules and resources.

Vision

Doutech's vision is to give every family and property owner more peace of mind regarding the safety precautions used against fires, and natural gas leakages in residential building.

Mission

Our mission is to reduce the statistics of fires and casualties at a residential level caused by cooking accidents, with the residents' safety as our utmost concern.

Objectives and Goals

Our main objective is to develop an efficient, convenient, and reliable method to communicate an emergency situation to residents, and to prevent fires originated in the kitchen from spreading to the rest of the domestic building.

Strategy

The strategy of our company is to improve the current fire alarm protection system by integrating it with automated technologies that will prevent a potential accidental fires from spreading. Our company intend to design a product based on NFPA standards. This way, our product can be certified/recognized by NFPA (National Fire Protection Association). Once our product is certified, we plan to create a partnership with bigger companies dedicated to home improvements like Home Depot and Lowe's to distribute and market our product.

Section 1.3: Products and Technology

Proprietary Position

Doutech Fire Prevention System includes a complementary system of sensors, alarms, and fire suppression devices. The main feature of DFPS is an alarm code that will be activated accordingly to the emergency status. Each of these status will include a suppressive method as shown in Figure 1.1.

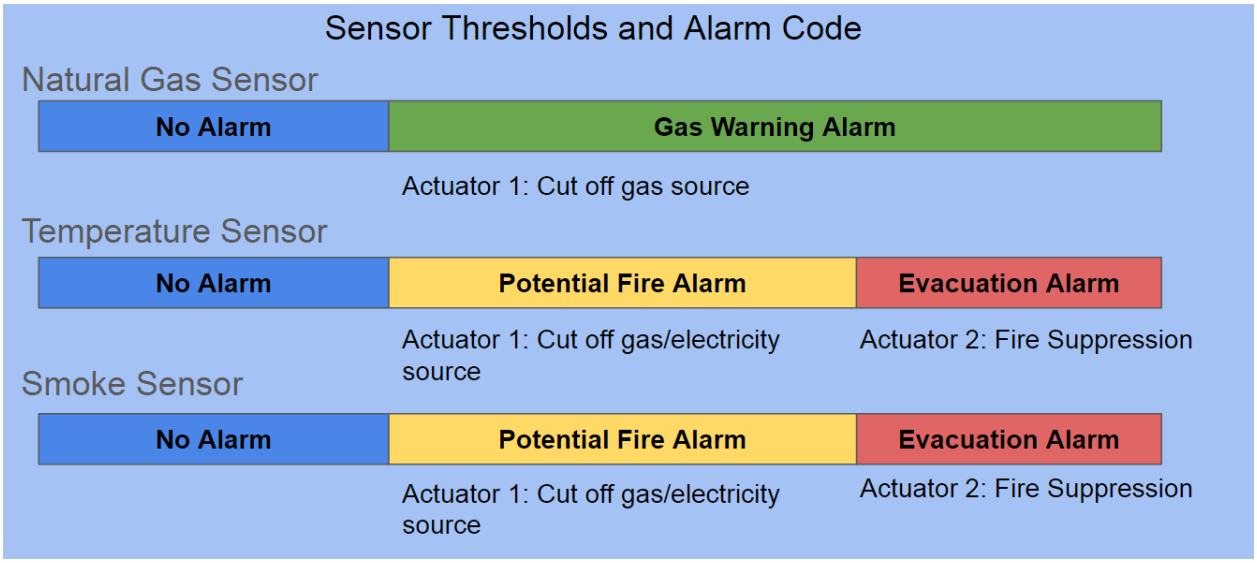

Figure 1.1: Relationship among sensor readings and alarm code

Figure 1.1 describes 4 different states of the system. The first alarm state is “No Alarm”. This is when all sensors are reading normal values and there is no fire danger. The second alarm state is “Potential Fire Alarm”, which is going to indicate something on the stove may be burning and it is a potential fire danger. The objective of this alarm is to make notify residents to attend the kitchen and to prevent something to lit on fire. When the “Potential Fire Alarm” is activated, actuator 1 will cut-off the fuel or electricity that is feeding the stove burners. The second alarm state could fail to prevent the fire if nobody attended the stove and the fire reached the food. If after a period of time the second state alarm is activated, sensors indicates the fire is not gone, the system will activate actuator 2, and suppress the fire on the stove. As a final stage, if the fire is not turned-off after all preventive methods, the “Evacuation Alarm” is going to be activated and all residents must evacuate the residence. As an alternate feature, DFPS has a “Gas Alarm Warning” that will be triggered by the natural gas sensor only. This feature will be used only on gas fueled stoves and actuator 1 will cut off the fuel source. Each

alarm state will activate an unique pattern of sounds at different volumes, with the exception of the “No Alarm” state.

Competitive advantages

Similar products and services includes fire suppression systems used in commercial and industrial kitchens. Our product is mainly targeting residential kitchens, making it affordable for the average consumer. Even when the competition uses the same suppression system, DFPS includes an alarm code with four different stages. Each of these stages has a different sound pattern at different volumes to help the residents identify the emergency. The objective of these set of alarm is to avoid using the suppression system as much as possible.

In domestic residences and complexes, the amount of false alarms is significant, and the volume of the traditional alarm is significantly high (set by NFPA). The inability to turn of the alarm manually makes these false alarms extremely uncomfortable for the residents. DFPS offers a warning alarm (at lower volume) that will be triggered before the standard alarm is triggered (set by NFPA) in order to notify the residents a potential thread. DFPS includes in its design a push button to turn off the alarm in case of false alarm. DFPS relies mostly on the residents to be completely functional and avoid using the suppression system unnecessarily. In the case, the residents do not support the prevention system, then, DFPS will activate its suppression system.

In case of customers with hearing impairments, our alarm code with be adapted to use light patterns instead of sounds, this will give DFPS an extra advantage against our competitors.

Section 1.4: Competitive Analysis

The target market for the Doutech Fire Prevention System (DFPS) is wide and easily expandable throughout the nation. Market trends in housing and data resourced from the National Fire Protection Association (NFPA) provides positive insight in the market acceptance of the DFPS.

Target Customers

The Doutech product is targeted towards customers who are either homeowners or multi-unit proprietors. In 2015, 1 million households were accounted for in Nevada [4]; 59.1% of those Nevada households were owner-occupied with an average income of $52,800. According to a survey by the New York Times completed in 2012, 78% of low- and middle-income families cook at home at least five times a week [5]. In addition to private homeowners, proprietors of multi-family housing units will also be targeted; 30.1% of total housing units in Nevada are multi-unit structure (i.e. apartment complexes) [6]. In order to better facilitate the state fire safety codes in Nevada, residents in the Reno-Tahoe area will be focused on.

Based on these facts, the market for the Doutech Fire Prevention System (DFPS) is large and despite Doutech's initial focus on the Reno-Tahoe area it will have the ability to be applied to the remaining States.

Table 1.1: Nevada Household Demographics - A majority of Nevada homes are owned by their residents and a significant amount of residences are multi-unit.

% of Owner occupied households	59.1
% of Multi-unit structures	30.1
Avg. Income of Household	$52,800

Psychographics

The private and multi-unit proprietor will value the safety of their families and occupants, respectively. These customers also have financial investments in their properties, whether those investments be remodeled rooms, furniture, and/or personal belongings. The private owner will feel a more emotional need to protect their family, since they have more of an emotional investment in their home. The emotional need is also based off of their instinct to protect their family. Multi-unit proprietors (i.e. landlords) will have a more practical need to protect their properties since they are the center of their business.

Target Market

The market for fire protection systems is expansive: in 2013 it was valued at $33.6 billion and is projected to grow to $79.18 billion by 2020, with a compound annual growth rate of 11.53% [7]. This will prove to be a moderate challenge for Doutech Systems to enter if the product fails to differentiate itself in the marketing strategy (see Section 1.6 for more details). Another important factor for fire protection systems is the housing market growth. While the single unit home market is not expected to grow significantly in 2016, multi-family

units are expected to increase, Figures 1.2 and 1.3 . Lastly, the amount of fire incidents have not decreased significantly within the last 5 years, Figure 1.4. This provides some insight in the quality of fire prevention that the competition provides for its customers. According to the National Fire Protection Association, 45% of home fires involving cooking equipment, 17% of which resulted in fatalities, Figure 1.5. Of those cooking equipment caused fires, a majority of them were due to ranges. The target market is spread among 91 businesses in total, therefore DFPS will face competition. Currently there are systems that protect and/or prevent fires but they are limited to industrial kitchens and not residential kitchens. Detailed information about competitive risks can be seen in Section 1.6.

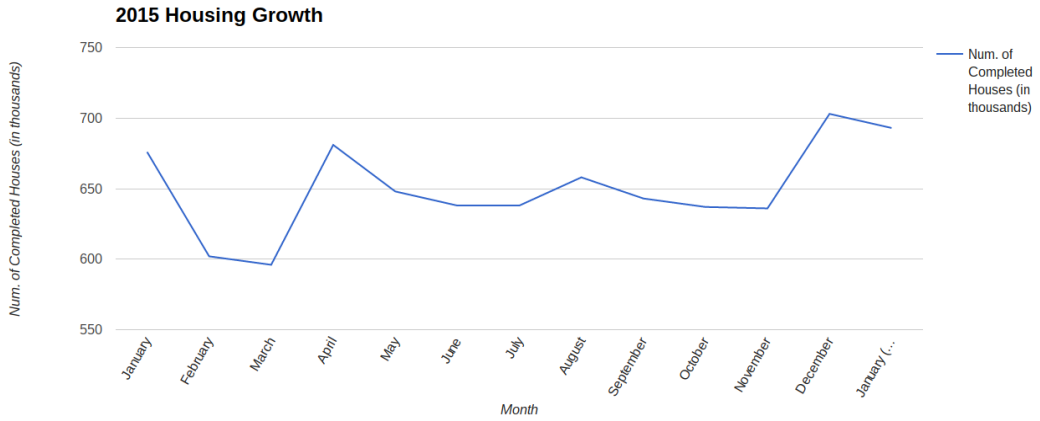

Figure 1.2: 2015 Housing Growth [8]- The projected growth rate has been positive in the last year but is expected to slow in the upcoming year**.**

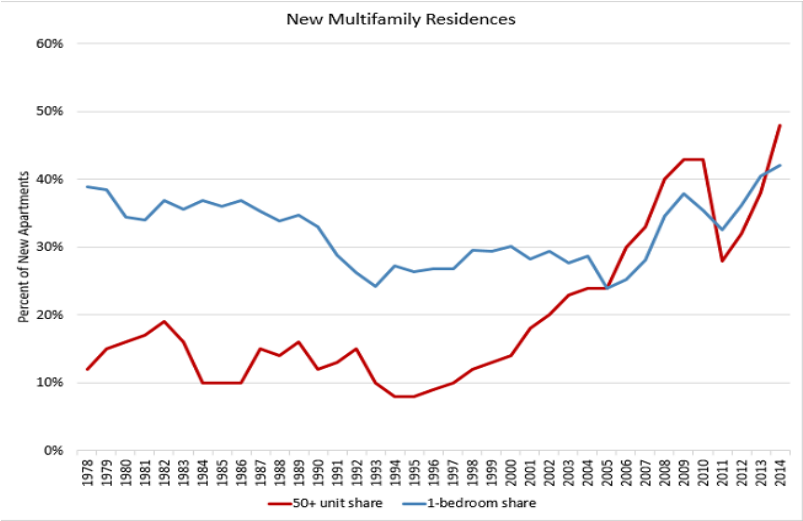

Figure 1.3: Apartment complex market growth [9]- Multi-unit complex construction has increased over the last 10 years**.**

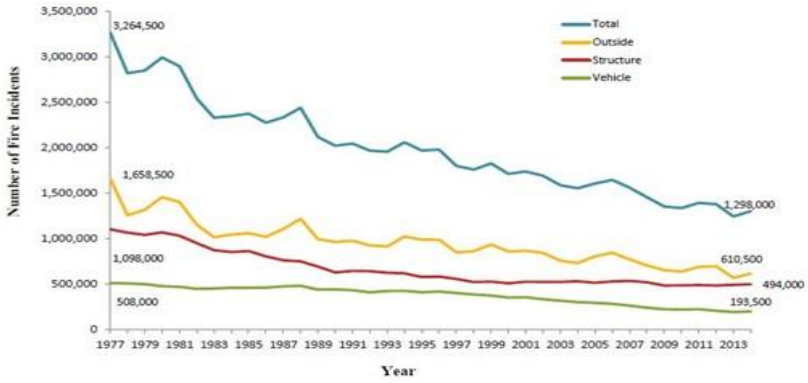

Figure 1. Fire Incidents by Type in the United States by Year (1977-2014)

Figure 1.4: Fire incidents per year [11]- The amount of structural fire incidents have not decreased significantly, reflecting poor fire prevention technologies that exist in the market**.**

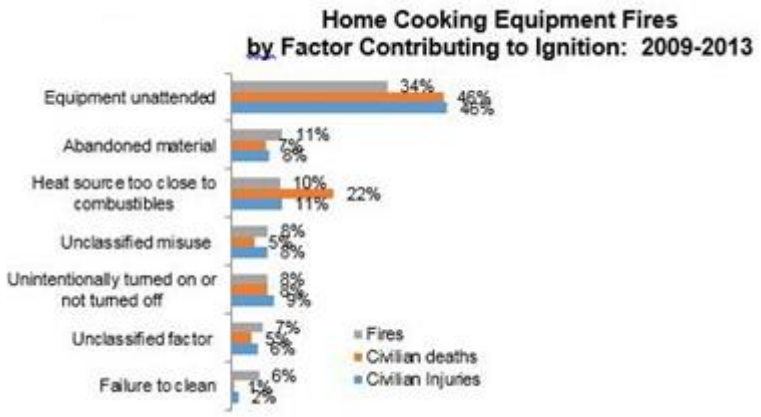

Figure 1.5: Breakdown of what causes cooking equipment fires [10]- The leading cause of cooking equipment-related fires was being left unattended which resulted in 46% civilian deaths**.**

Competitive Environment

The competitive environment is dependent on the type of services that other companies in the same market provide. A majority of automated fire extinguishing systems only appeals to industrial customers and they are considered passive because they only alert the customer of a potential fire hazard, whereas the DFPS will actively alert and shut off the stove. Based on these criteria, there is one company (Company B) that is a potential competitor. Their targeted market includes residential customers, which coincides with Doutech's targeted customers. A disadvantage to Doutech is that Company B has been functioning longer than Doutech; it also targets residential, commercial and industrial markets; and it is recognized by the NFPA, National Association of Fire Equipment Distributors, and other business related organizations. While the last disadvantage can be fixed in the near future, Doutech can apply for recognition from similar organizations as soon as the first product is developed (1-3 years). Company B is currently located in Los Angeles and only serves customers in

that area, whereas Doutech will be located in Reno and plans on expanding within 5 years. Doutech is striving to achieve that goal within 5 years so that it can create a strong customer base, and avoid losing potential customers to Company B. Another advantage that Doutech has is its focus on one product. This will allow the research and development resources to be centralized, subsequently allowing the personnel skills to be focused on one technology. Although there is competition in the market, there is only one company that is direct competition to Doutech and the advantages of said company are also achievable by Doutech.

Section 1.5: Operating Strategies

Doutech System's strategies have been designed to successfully implement the company mission, values, and goals. Projected deadlines will assist Doutech in executing these strategies, but certainly does not limit the company to these accomplishments.

Marketing Strategies

Doutech Systems will focus on developing contacts with major retail stores, advertising through social media services, and demonstrating the product at technology conventions and through the internet.

The DFPS will sell to customers based on its ease of installation and low cost; additionally, it will provide a more safe alternative to customers current alarm system. In order to avoid financial and legality risks, Doutech Systems will partner with major retail stores that target homeowners, i.e. Lowe's and Home Depot. This will allow Doutech to pass the personnel and resource costs to aforementioned retailers, who already have licensed contractors to hire

for home installation work. Additionally, Doutech will avoid having to open its own stores since the partnership will include selling the product in the major retail stores.

In the case that contracts are not developed with major retailers, then Doutech will distribute sales through the internet to avoid overhead costs with storefronts. Advertising will be modified to better target customers directly, since the sales strategy will be directly from Doutech Systems to the customer. The installation process will be managed by hiring contractors with relative experience.

In the first phase, Doutech will focus on the Reno-Tahoe area in order to have a close presence to customer feedback. In the second phase, Doutech will expand to the western United States and in the third phase the product will be available to the whole United States.

Table 1.2: Marketing Strategy Schedule- Each phase will represent expanding targeted customers geographically, which be based on

Phase	**Goal**
I	Target customers in Reno-Tahoe area.
II	Expand to Western US
III	Expand to the entire US

Advertising for the product will be applied in web-based services and product demonstrations. Social media resources, such as Facebook, Twitter, and Reddit, will allow the company to reach many customers without high financial costs. It will also serve as a means to provide a positive company-to-customer relationship by allowing customers to

contact the company directly and efficiently. Customers who do not regularly use the internet will be targeted through physical ads (i.e. newspapers, magazines, etc) although a limited amount of resources will be provided for this area since the company is targeting internet users.

Product demonstrations will occur at technology conferences and through YouTube videos. The technology conference demonstrations will not begin until the product is in its second phase of production to ensure a successful demonstration. The purpose of these technology conference demonstrations will be to appeal to retail companies. YouTube videos will begin as soon as the first prototype is developed and will be filmed by the company in order to avoid high media costs. This type of advertising will appeal to customers who are researching fire protection, similarly to the social media approach.

Research and Development

Research and development for the Doutech Fire Protection System (DFPS) will begin in the first quarter of 2016. The research in this phase will include, but not be limited to: current technologies, competitive patents, and theoretical design. Information from this research will be used in the development stage, which will involve a draft design utilizing sensors, actuators, and a portable gas stove. The initial prototype will be assembled during the second quarter of 2016, with a projected deadline for the second Monday of April. The CFO will authorize the parts purchased for the initial prototype with funding originating from the Electrical Engineering Department. Laboratory testing, which will guide the research and development department, will commence immediately. The prototype will be tested under various conditions (i.e. smokey, gaseous, high heat, etc.) to find areas of improvement. All

research, development and prototype assembly mentioned previously will be conducted at the University of Nevada, Reno.

Production

The 2016 fourth quarter will focus on the first phase of manufacturing, with the goal of producing ten fully functional and assembled products. The CFO will need to authorize the bulk-parts order (e.g. sensors, solder, etc) by the end of the second quarter in order for manufacturing to commence immediately on the projected date. In contrast with the initial prototype, these products will have a pre-planned layout to streamline the assembly process. The first phase of manufacturing will be conducted in-house to prevent exhausting financial resources. Quality assurance (QA), one of Doutech's utmost valued goals, will be combined with the Manufacturing Phase 1. Each assembled product will be tested with rigorous criteria. The product will not be allowed to continue onto the next phase unless it has been approved by the Chief board. Future production goals include renting or purchasing a manufacturing facility in the surrounding Reno-Tahoe area, purchasing manufacturing equipment, and increasing the personnel size of manufacturing technicians.

Table 1.3: Company Strategy Calendar- Doutech Systems plans on reaching the first manufacturing phase by the third quarter of 2016.

Quarter (2016)	Item
I	Patent research and theoretical design
II	Prototype development
III	Manufacturing Phase 1

Financial Strategies

Doutech System's financial strategy is designed for the first five years of the company. For the first two years, Doutech anticipates negative cash flow due to the costs associated with research, development, and production. The small amount of revenue that will be generated in this timeframe will be re-invested into the company. Detailed financial statements can be seen in Section 9 and 10. In order to alleviate these financial costs, Doutech will pursue funding from angel investors and/or venture capitalists; salaries will not be provided for the Chief positions; and personnel expansion will only occur under extreme conditions. Alternative funding will be granted by the United States government through their grant program. The initial funding amount will be $2000 to cover the production costs, but the company will also be seeking other services from the investors. A contract exchanging funding for shares in the company will be drafted and become official once both parties reach an agreement.

By 2018, Doutech will begin generating revenue through sales and plans on returning the initial invested amount to the donors. The original contract will have expired intentionally by this year, therefore allowing Doutech to purchase back some, but not all, of the shares. With the positive cash flow, additional personnel will be hired but only when absolutely necessary (one level below extreme conditions). Chief positions will continue to work without salaries until 2020 when the personnel budget will be reviewed.

Doutech Systems will be financially stable by 2020 based on sales revenue and low costs. As mentioned in the strategies section, the company will avoid costs in sales and product implementation by passing those costs to the major retailers.

Section 1.6: Critical Risks

There are three key risk factors that could potentially threaten the success of Doutech Systems and the viability of the Fire Prevention System. These risk factors include the competitiveness of the market, market entry strategy, and risks associated with the development and implementation of the system's technology. Doutech is fully prepared to meet and reduce all risks associated with producing this product and growing the company.

Competitive Risk

Currently, there are numerous companies in the market of fire and smoke monitoring and warning, such as ADT, which the Doutech Fire Prevention System will have to compete with. The main market competitor for the Doutech Fire Prevention System will be the standard fire and smoke alarm systems that nearly all residential homes already have installed. Doutech

will have to gain the attention and trust of the average homeowner in order to be successful in such a competitive market. In order to address this issue Doutech Systems is ready to implement marketing strategies which include promoting the fire *prevention* capabilities of system, a feature that no other current system on the market implements. This will bring the system's potential for added fire protection to the attention of consumers. Demonstrations at retail sites like Lowe's and Home Depot will also give them the opportunity to bring the system into their place of residence after seeing first hand the capabilities of the system.

Market Entry Strategy Risk

The second key risk factor for this product is the strategy by which it will be introduced into the market. The current plan for entering the market is focused on internet sales and promoting the product through social media platforms. Also, depending on the success and demand of the market for the product there may be issues in terms of distribution and manufacturing capabilities of the company. In an effort to alleviate the risk associated with market entry Doutech is prepared to introduce the product to national retailers such as Home Depot and Lowe's in an effort to create partnerships with them. This will help to put our product in front of more customers outside of the realm of the internet. Working with various retailers will also reduce the demand on the company in terms of shipping products directly to the customer as well as costs associated with installing the system. The manufacturing of these products can then be done by hired technicians to allow Doutech to meet or exceed the amount of systems sold.

Technology Risk

Finally, the acceptance cycle for the Doutech Fire Prevention System will likely be long since it is a new technology for residential buildings. Further, manufacturing issues may arise during the early stages of the company. Doutech has considered the possibilities of the technology risk associated with the product and its development and is confident that partnering with retailers such as Lowe's and Home Depot will help to demonstrate the dependability and usefulness of the Doutech Fire Prevention System as well as reducing the risk of manufacturing issues. By putting our product in front of more customers there will be a subsequent reduction in the acceptance cycle of the system as more and more people will purchase the system for their homes.

Section 1.7: Cash Flow Statement

Figure 1.6 shows the expected cash flow for Doutech Systems for the first five years of operations.

Doutech Systems
Cash Flow Statement

For the Year Ending	12/31/2016	12/31/2017	12/31/2018	12/31/2019	12/31/2020
Cash at Beginning of Year	500	(4,500)	(17,800)	(300)	85,700
Operations					
Cash receipts from customers	1,000	3,500	55,000	153,000	657,000
Cash paid for					
Inventory purchases	(900)	(800)	(2,500)	(5,000)	(23,000)
General operating and administrative expenses	(100)	(6,000)	(15,000)	(15,000)	(28,000)
Wage expenses	-	-	-	-	(300,000)
Net Cash Flow from Operations	**-**	**(3,300)**	**37,500**	**133,000**	**306,000**
Financing Activities					
Cash paid for					
Repayment of loans	-	(5,000)	(5,000)	(12,000)	(34,000)
Advertising	(5,000)	(5,000)	(15,000)	(35,000)	(75,000)
Net Cash Flow from Financing Activities	**(5,000)**	**(10,000)**	**(20,000)**	**(47,000)**	**(109,000)**
Net Increase in Cash	**(5,000)**	**(13,300)**	**17,500**	**86,000**	**197,000**
Cash at End of Year	(4,500)	(17,800)	(300)	85,700	282,700

Figure 1.6: Cash flow statement highlighting net cash flow for the first five years of operation.

Doutech Systems will not start making money until the fourth year of its operation. This is

due to loan repayment, start of business expenses, and a smaller amount of profits due to partnerships with retail chains and/or insurance companies. By the end of the fifth year, Doutech expects to have around $282,700 in cash. This amount will be achieved by the original workers and founders agreeing to take in no salary until the final fifth year of operation. Given the price of each unit selling at $, Doutech finds these projections to be financially viable and stable.

Section 1.8: Funds Required

The required amount for funding of DFPS is $2000. This is broken down into the categories of prototype construction, marketing and advertising, continued construction costs, and miscellaneous fees/expenses. Table 11.1 shows a pie chart of this cost breakdown. An initial amount of $500 will be used to construct a prototype device. It is anticipated that $500 will be spent on advertising and marketing fees. Should a buyer be found, additional manufacturing costs will be $1000 . Overall, Doutech is requesting $2000 for a full funding of the DFPS.

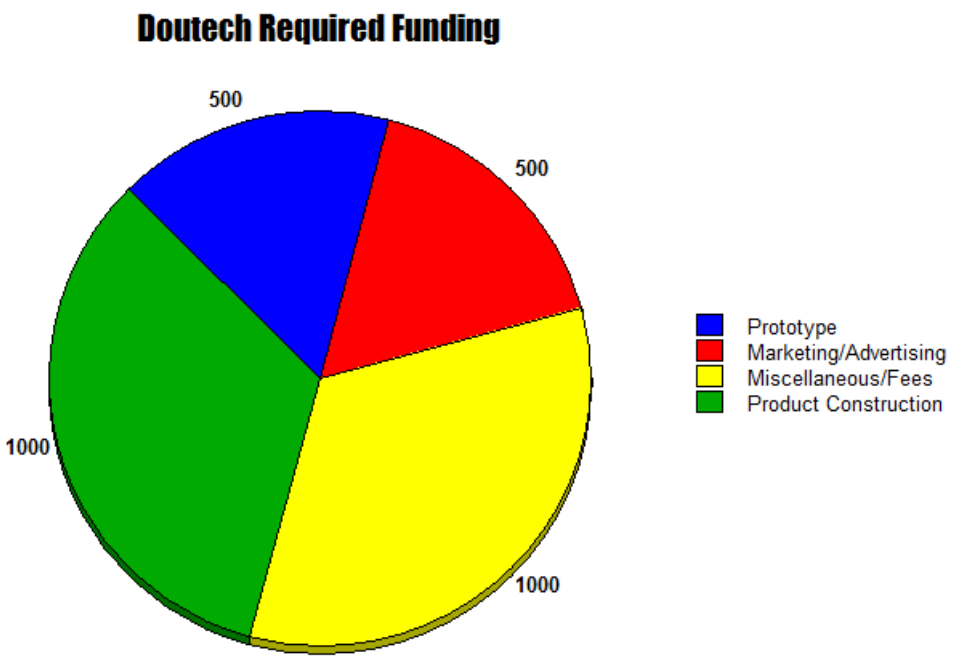

Figure 1.7: Required Funding [15] - This pie chart highlights the total funding requested to begin operations at Doutech. Amounts are in ($) dollars.

CHAPTER 2: PLAN DESCRIPTION

Section 2.1: General Structure

Figure 2.1 shows a general diagram of the main elements of DFPS and the feedback flow of the information.

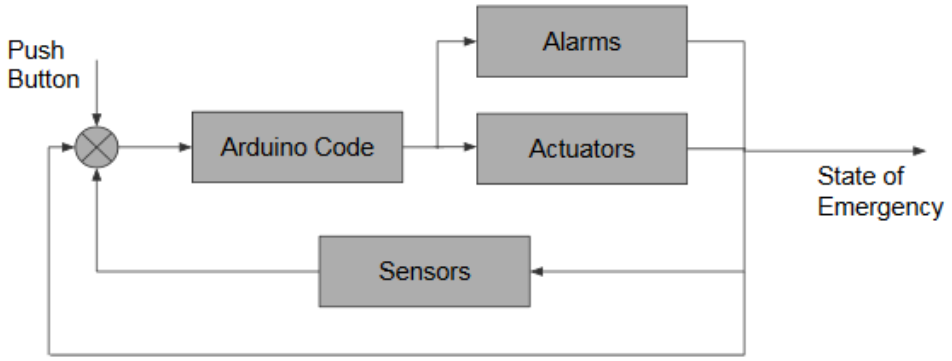

Figure 2.1: Feedback System Diagram

The general structure of DFPS consists in a control system with a microcontroller, several sensors, and actuators. Figure 2.2 describes an approximated location of all its elements, this design is going to vary depending on the kitchen size and shape, location of the stove, and other elements.

Figure 2 shows that the smoke and gas sensors are above the stove. The exact location of these sensors will be determined by NFPA 72 code and the customer kitchen. The flame sensor is going to be located near the stove to perceive flames that go out of the desired range

and intensity. All sensors readings are going to be connected to the microcontroller. As the sensor readings are processed by the microcontroller, it will send the signal to activate the alarms, solenoid valves, and relays for the suppression system. All sensors provide a continuous feedback to determine the status of the emergency.

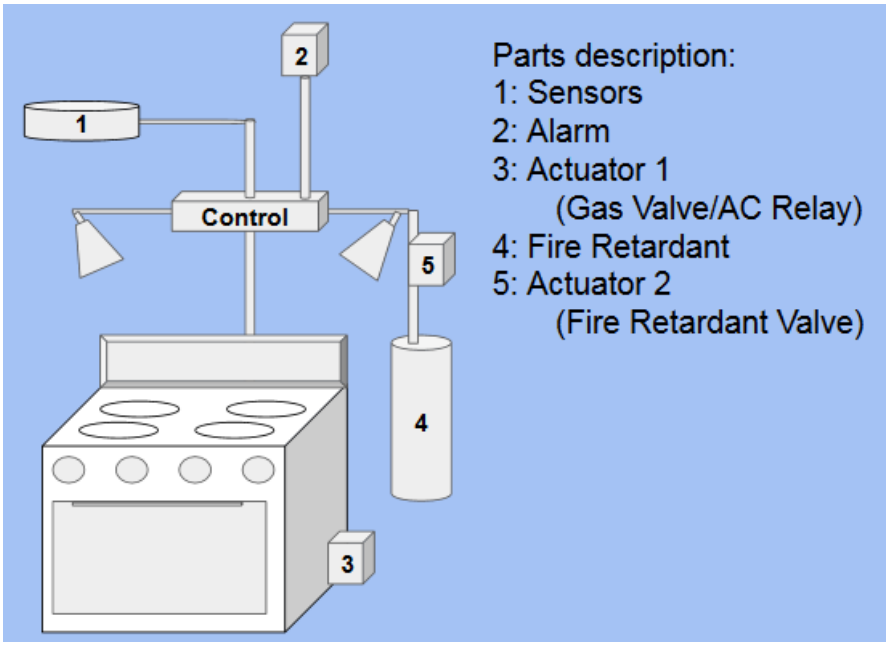

Figure 2.2: General Diagram for DFPS

In the case of a conventional propane/butane stove, Doutech Systems is going to attach a solenoid gas valve in the hose to control the gas flow. In the case of electrical stoves, Doutech Systems is going to use an 110/220v AC relay in the main electrical power source of the stove. This variation is going to give more adaptability to the customers' stove. The alarm will be configured (using the microcontroller) to reproduce at least 3 different sound patterns at different volumes in order to determine the state of the emergency.

Section 2.2: Assembling and Materials Description

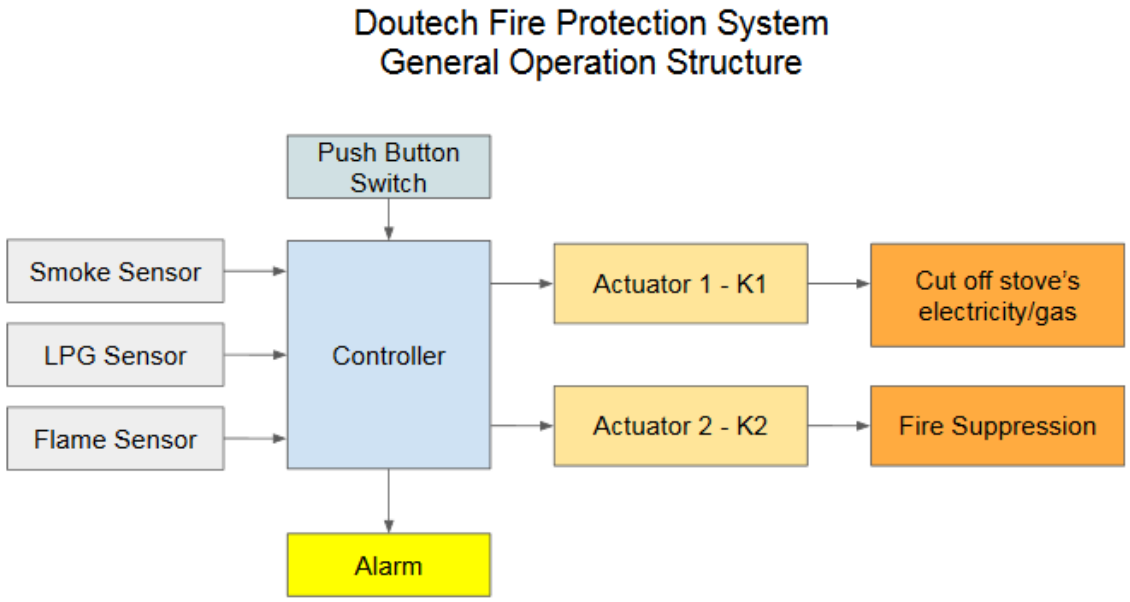

Figure 2.3: General Operation Structure

Building an environment (Prototype Only)

In order to present and to test a prototype of the Doutech Fire Prevention System, it is necessary to build an appropriate environment. The prototype design will include the small scale construction of a kitchen, mostly focused on the stove. Customers usually have a stove, a propane tank or main line providing propane. In order to recreate that environment, our prototype will need a liquefied propane tank, a gas pressure regulator, a 1/4"gas hose and a single stove burner.

Actuator 1 Source Cut-off Installation

Having a stove already installed we proceed to install Actuator 1 shown in Figure 2.3. Actuator 2 consists in the use of a solenoid gas valve that will be powered by a 12V battery and controlled by a 5V relay. The 12 V solenoid gas valve be installed as shown in Figure 2.4.

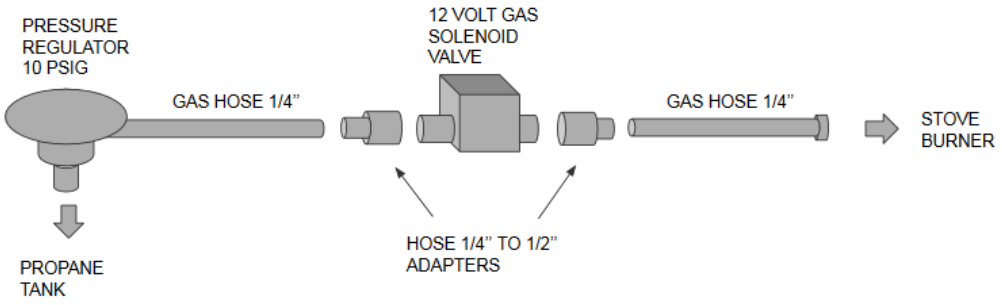

Figure 2.4: Assembling Diagram 1 - Solenoid Valve Installation

Actuator 2 - Suppression System Installation

Due to time issues, this document is not explaining in detail the parts and assembling plan for actuator 2. In general, actuator 2 is going to operate in a similar way actuator 1 operates. Proper piping above the stove and a fire retardant tank will be installed as shown in Figure 2.2. Actuator 2 system will be operated and controlled by a second relay and a secondary solenoid valve. For this prototype, the fire suppression system using actuator 2 will not be implemented. Instead, a LED is going to indicate the time when the fire retardant must be released.

Controller Installation

For the implementation of the DFPS a microcontroller Arduino Mega 2560 will be used as the controller shown in Figure 2.3. Figure 2.5 shows the Arduino connections labeling its inputs and outputs connections.

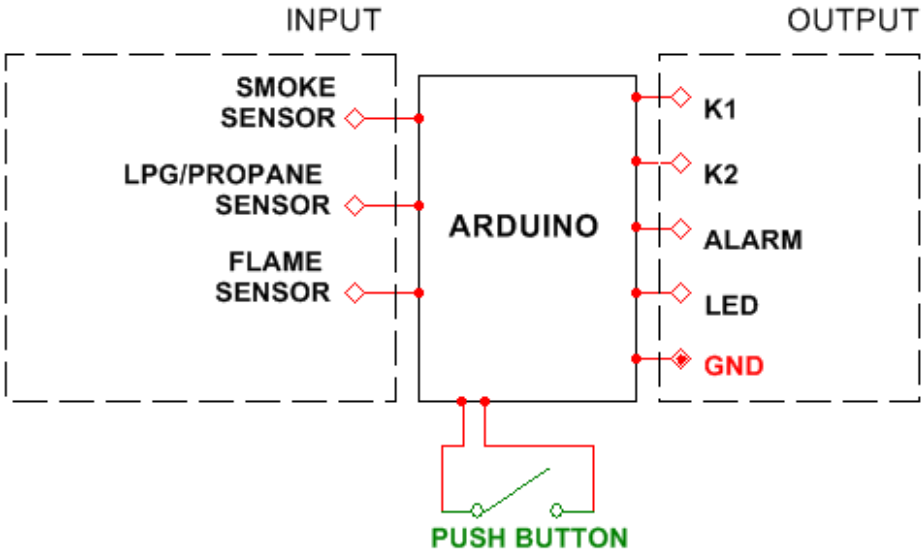

Figure 2.5: Arduino General Connections

The sensors used are the MQ-6 (LPG Sensor) and MQ-2 (Smoke Sensor) and a flame sensor (IR Sensor 760nm-1100 nm). See datasheets in *Appendixes C*. A push button is going to be installed to allow the user to stop any false alarms. Also, K1 and K2 are signals that will activate the relays shown in Figure 2.6.

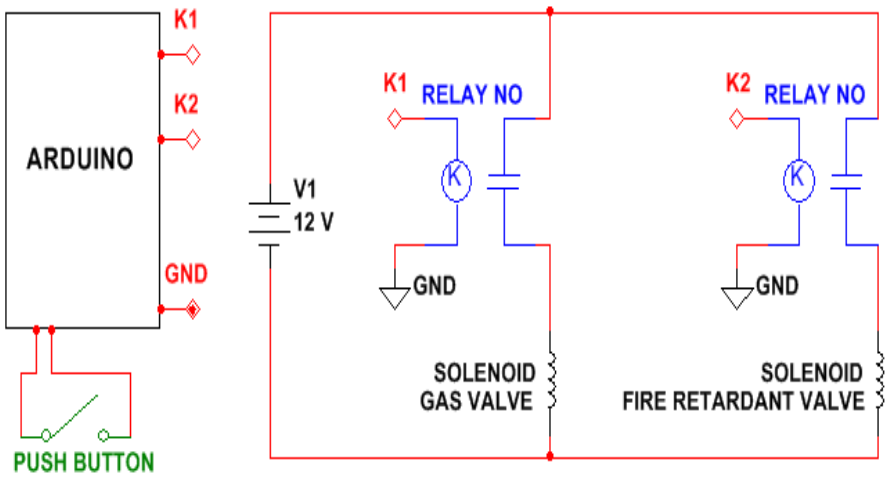

Figure 2.6: Solenoids Schematics - Propane fueled stove design.

For the electrical installations in Figure 2.6 electrical wires and a 12V battery are going to be required. In the case the customer's stove is electrically powered, instead of a solenoid gas valve, the design will use an AC relay as shown in Figure 2.7.

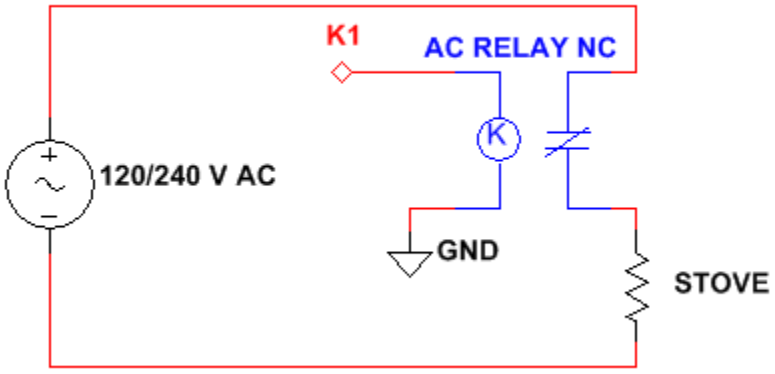

Figure 2.7**:** AC Relay Schematic - Electrically powered stove design

Section 2.3: Operation Process

The operation process of DFPS will be completely controlled by the microcontroller (Arduino), which will use threshold values in order to compare the sensor readings for smoke, LPG (Propane), and flame luminosity.

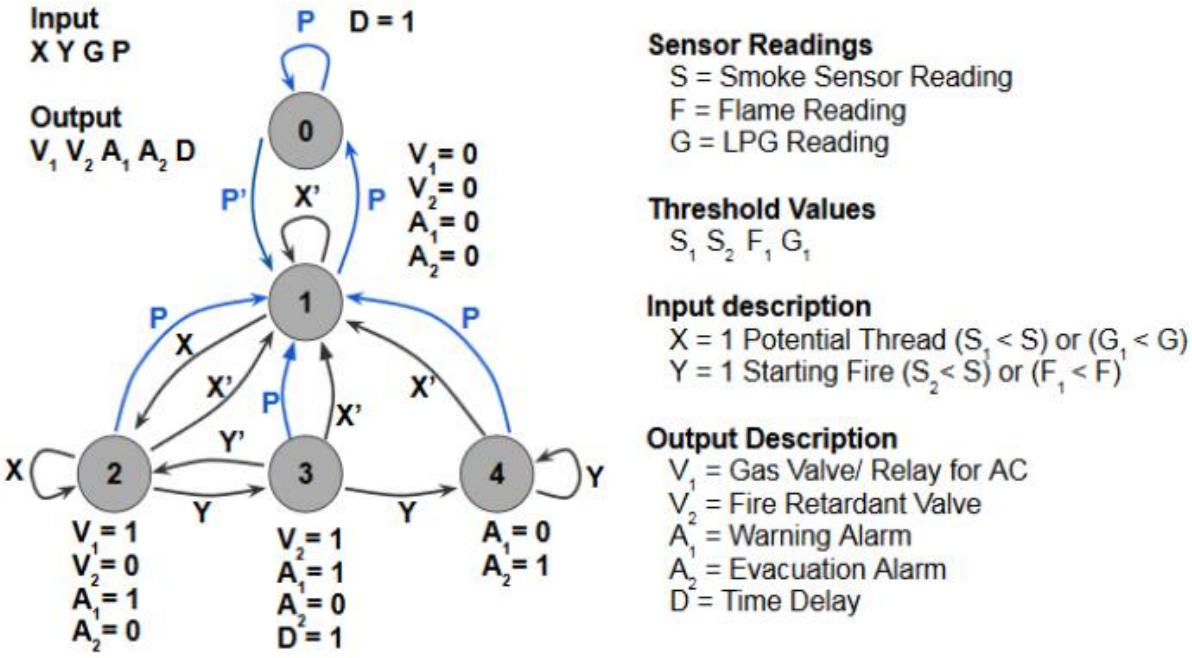

Figure 2.8: State Diagram for the Arduino Operation.

The operation of the system shown in Figure 2.8 will always be at one state at the time. The set of actions the system will take is going to be determined by the current state and the incoming reading from the sensors. A detailed description of each state is shown in Table 1.

Table 2.1: State Description of System Operation

State 1: Standby	The system is on a "Standby" position when all sensors readings are under the threshold values (X=0). When on this state, all alarms and actuators are turned off. This means the system will be just waiting for changes in the sensor readings. The system will remain almost all the time in this state.
State 2: Warning	X=1: The system moves to a "Warning" state when either the gas sensor reading is greater than the defined threshold value for LPG ($G_1 < G$) or the smoke sensor reading surpassed the first threshold value for smoke ($S_1 < S < S_2$). When any of these conditions happen, the system will consider that as a potential thread. V_1=1 (Cut off the fuel/source): As soon as the system move to state 2, the Arduino signal K1 is set to 5 V. This controls the solenoid gas valve and electricity that feeds the stove. A_1=1 (Activate warning alarm): Whenever the system is on State 2, the warning alarm will be activated. The warning alarm has two different modes and each one of the is activated depending on what sensor (propane or smoke) made the system go to state 2. The system is not expected to activate both alarms at the same time. Each mode has a different pattern in the sound that will be easily identified by the residents.
State 3: Suppression	Y=1: The "Suppression" state is the state when the fire is going to be extinguished. This state is going to be reached if and only if state 2 failed to prevent the fire from growing. The sensors will detect state 2 has failed if the smoke readings keep increasing ($S_2 < S$) or if there is still a visible flame ($F_1 < F$) in the range of the stove. V_2=1: When the system reach this state, the fire retardant valve will be instantly activated, releasing all the content of the fire retardant tank. D=1: This state is going to have a delay when the sensors readings are going to be ignored. This delay is critical to obtain an accurate reading after the fire retardant has been released. After the delay, the sensors will start reading again to determine the current situation. If the sensor readings are in the warning range ($S_1 < S < S_2$) or below ($S < S_1$), The system will come back to state 2 (Y=0), and later to state 1 (X=0). In the case the fire was not extinguished, sensors readings are still in a hazardous ranges (Y=1), then the system will move to State 4.

Table 2.1 (Continued): State Description of Doutech Fire Prevention System Operation

State 4: Danger	The "Danger" state is going to be reached only after passing through the "Suppression" state. The meaning of reaching this state is that the fire is out of the control of DFPS. A_2=1 (activate evacuation alarm): The system will turn off the warning alarm and is going to activate the evacuation alarm. Residents are requested to leave the building and to notify firefighters about the emergency.
State 0: False Alarm	In the case of a false alarm, a push button switch will be installed to allow residents to turn off all alarms and actuators. This feature will work at any state, making the system pass through state 1(to turn off everything), and then move to state 0, where the sensors are going to be off and no alarms will be triggered. Once in state 0, a delay will be activated before returning to state 1. This delay will be customizable by the users.

Figure 2.9 illustrates the operation process described in Table 2.1 with its detailed description shown in Table 2.1. The process that describes states 1, 2 and 4 are encircled by their respective closed loops in Figure 2.9. State 3 is a transition state to activate the fire retardant, so the system does not remain on this state for more than the delay assigned to it.

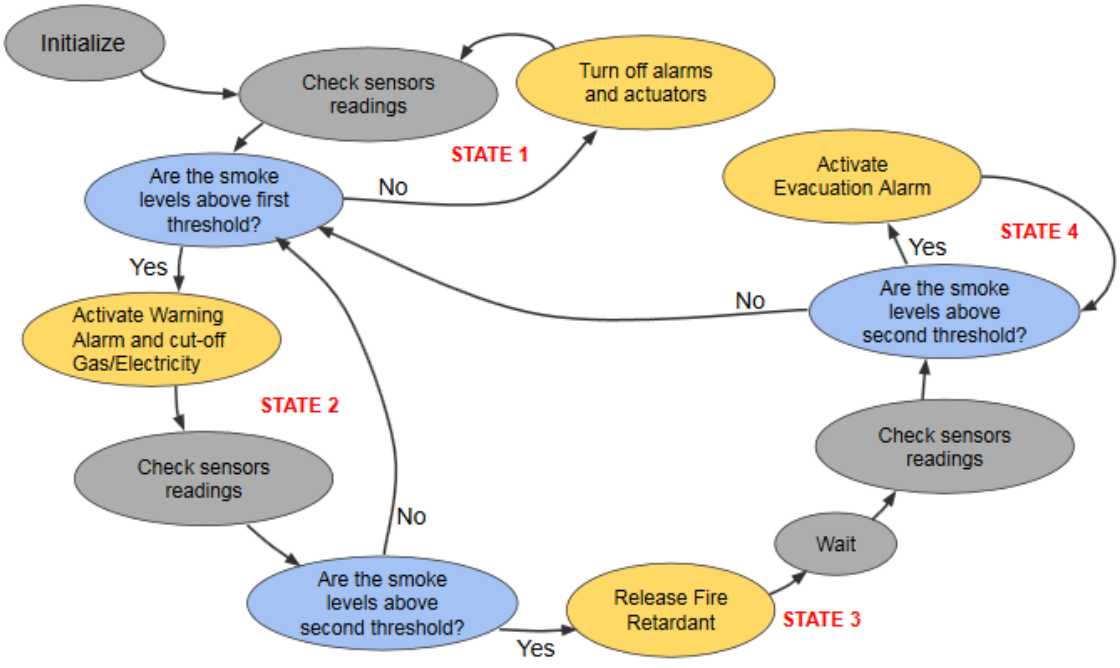

Figure 2.9: Operation Process Detailed Flowchart

Section 2.4: Expected Results & Prototypes

The Doutech Protection System product will be easily integratable into a residential kitchen, and provide reliable services by alerting the user of potential fire hazards. The prototype's objective is to either warn or alert the user, depending on the level of intensity the sensors process. It will consist of an alarm, fire retardant system indication, an automatic shut off valve, and disarming button. The alarm will contain the sensors, the Arduino, and the sound device to alert the user. All sensors and sound devices will be in accordance with the NFPA standards. The prototype's wiring--between the alarm container, the valve and button--will be contained in discreet metal tubing to be aesthetically pleasing. The alarm will be attached to a wooden backdrop with the testing equipment secured to the flooring of the testing chamber.

Section 2.5: Limitations and Alternatives

There are several limitations to the Doutech capstone project which include areas in financial, time, and expertise. The financial limitations depend on the functionality success of specific parts being used in the prototype fabrication, i.e. solenoid gas valve. The current model that is planned on being used is made of plastic material, and if this material proves to be too delicate for the Doutech applications then a more expensive brass gas valve will be ordered. This will put financial strain on the project, as additional unforeseen costs will most likely incur. Additionally, a fire retardant system was calculated to be too costly for the Doutech

budget, thus it was replaced by a more cost efficient RGB LED indication system. Secondly, the Chief board made a unanimous decision that the amount of time for the fabrication stage would be insufficient for including a fire retardant system (e.g. assembling the physical parts and control system design). Testing and evaluation time for the Doutech product will be constrained, as well, since the team is limited to a few weeks for project completion. Lastly, the team as a whole lack experience installing gas valves. External expertise will be required so that this portion of the project is safely fabricated, but any additional changes that could improve the system will be difficult to formulate, due to the lack of expertise.

Since this project is using LEDs to indicate when the fire retardant system should be activated, an effective alternative would to fabricate a fire retardant system for demonstrations. The fire retardant system can use special fluids or water. A brass gas valve would be a reliable alternative to the plastic solenoid gas valve. The alarm system could be expanded so that its sound alert reach could be available in rooms other than the kitchen. Another strategic alternative would be to add mobile communication capabilities so that the product could be connected to the user's smartphone and/or tablet. The goal of this alternative would be to integrate it into a smart home control system, instead of limiting the product's capabilities.

CHAPTER 3: RESULTS AND DISCUSSION

Section 3.1: Evaluation & Assessment Plan

The Doutech Fire Prevention System will be evaluated and assessed with high standards to deliver a reliable and convenient product to residential kitchens. Please refer to *Section 2.2 and Appendix C* for equipment details.

For the smoke and gas sensor (SAG), several variables will be tested: the distance between the SAG sensors and the stove, time response of SAG sensors, the different smoke intensities, and whether they can handle harsh environmental conditions. The distance between the SAG sensors and the stove will also be based on the NFPA standard 72. In addition to the distance variable, the time response of the sensors to the three thresholds will be tested and analyzed. The three thresholds will determine the smoke intensity, which the sensor will then communicate what level of danger the fire is at to the system. This variable is very important because it ensures that the customer receives their warning and danger alarms in a reasonable proper amount of time. These smoke intensities will be assessed through previous research, due to the limited amount of resources in the Doutech research and development phase.

The nature of the Doutech product requires extensive research in the National Fire Protection Association code book to ensure that it follows all Nevada and United States standards. This includes, but is not limited to, the NFPA 92 and 92B codes which outline the requirements for smoke-control systems. A group of sensors have been selected during the research and development phase based on specifications, and selections will be refined once the candidate

has passed all state and federal regulations. An Arduino was selected based on its cost effectiveness, ease of programming and wide range of functionality. It will not require any individual testing, but will be used to test the other parts used in the product. Other items, such as the relays and automatic shut off valves, have been selected to match electrical and mechanical requirements from the system (i.e. power, pressure limits, etc).

Section 3.2: Sensors, Control Devices and Alarms Illustrations

Figure 3.1: Smoke, gas and flame sensors

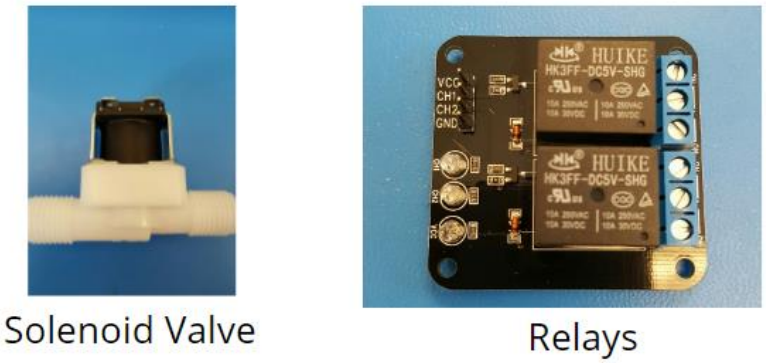

Figure 3.2: Solenoid Valve and Relays

Figure 3.3: Alarms. (Visible and sonic)

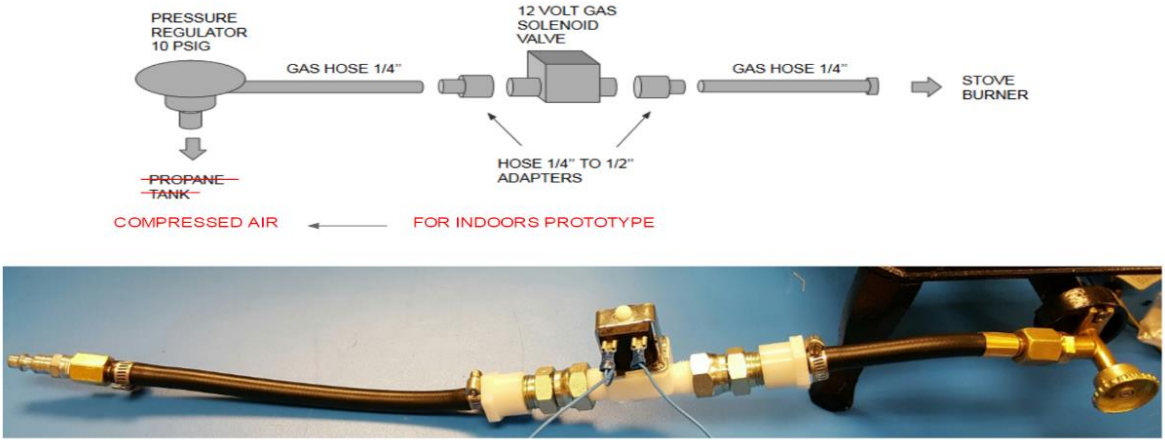

Figure 3.4: Solenoid Assembly

The gas flow will be controlled with a shut off valve that will undergo testing to determine its time response and effectiveness. The main gas pressure valve will be controlled manually at the source, so that the automatic shut-off valve (ASOV) will be able to withstand the amount of pressure. Testing will involve using the Arduino to trigger the ASOV and recording its time response.

Section 3.3: Operation Results

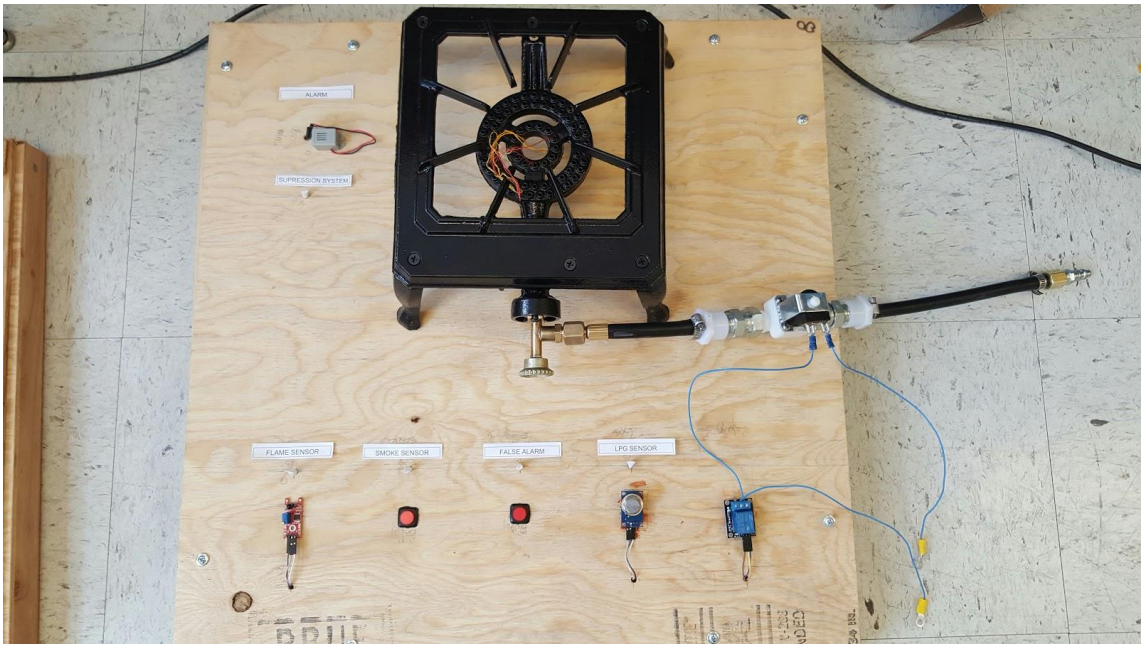

Figure 3.5: Propane Stove Model Prototype

In order to safely test the several different fire conditions, Doutech will build a non-flammable structure to place the prototype and stove in. The Arduino will be situated outside of this structure to prevent overheating. In the case that the structure doesn't meet standards, a local fire station has a kitchen for fire demonstrations. Doutech will reach out to this department and conduct tests there to avoid external damage. As mentioned previously, the Arduino will be used to run the tests and gather data.

System operation is stable and it is always in a specific state. When nothing is happening, system is always in a stand-by position. This allows the system to be operating in a low-cost energy consumption. The system, and the sensors provide a quick response at the exposure of different situations. The false alarm push button has priority over all actions and states of the system providing an option for the user to interrupt any alarm and actuator.

Section 3.4: Future Work

For the development of the project, more testing is recommended for more accurate sensor readings and a better evaluation of the danger. Also, the logic of the code based on sensor readings can be improved by adjusting the threshold according to the environment (humidity, air, etc). After the project is over, we recommend some potential improvements to work on. Implementing the fire prevention system in a real environment will provide a new world of challenges that will improve each feature of the design. Moreover, the implementation actual fire retardant system is highly recommended. The idea of creating all-in-one unit will allow the users to get easy access and installation to this product without requiring further knowledge.

CONCLUSIONS

The Doutech Fire Prevention System is a product designed with the sole purpose of reducing the number of residential fire outbreaks originating in the kitchen. This is achieved through preventative measures such as disabling gas flow to the stovetop and a tiered alarm warning system which helps give the user time to alleviate the issue, or evacuate the home if the situation is too severe. Doutech Systems has designed a product that will increase the amount of time a resident has to try respond and react to a potential fire while also reducing the number and severity of such occurrences.

There are various products on the market that either alert the consumer or fire department of fires, or attempt to extinguish fires automatically. None of the currently available technologies or products take a preventative step or give the consumer any time to extinguish the flames before they have grown substantially larger and more dangerous. Using IR flame, smoke, and natural gas sensors the user is given a range of alerts that can potentially save their life. In building the prototype, the selected sensors will be tested in order to establish reliability as well as set the thresholds of sensitivity for the system. Overall, the system will be designed to integrate all sensors in a compact, efficient, and reliable form. All states of the microprocessor will be tested in order to establish this reliability and repeatability of the system.

In the future, when additional funding and time are available, the team plans to develop the product even further to ensure the user is getting the most reliable and proactive system possible. The Doutech Fire Prevention System is a significant improvement in fire safety and prevention that will help to improve the safety in one's home, saving consumers the hassle of fire damages and repair as well as keeping them safe from fire related injury and death.

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Appendix A

Smoke Sensor (MQ-2) and LPG Sensor (MQ-6)
Datasheets

TECHNICAL DATA MQ-2 GAS SENSOR

FEATURES

Wide detecting scope — Fast response and High sensitivity
Stable and long life — Simple drive circuit

APPLICATION

They are used in gas leakage detecting equipments in family and industry, are suitable for detecting of LPG, i-butane, propane, methane ,alcohol, Hydrogen, smoke.

SPECIFICATIONS

A. Standard work condition

Symbol	Parameter name	Technical condition	Remarks
Vc	Circuit voltage	5V±0.1	AC OR DC
V_H	Heating voltage	5V±0.1	ACOR DC
R_L	Load resistance	can adjust	
R_H	Heater resistance	33 Ω ±5%	Room Tem
P_H	Heating consumption	less than 800mw	

B. Environment condition

Symbol	Parameter name	Technical condition	Remarks
Tao	Using Tem	-20℃-50℃	
Tas	Storage Tem	-20℃-70℃	
R_H	Related humidity	less than 95%Rh	
O_2	Oxygen concentration	21%(standard condition)Oxygen concentration can affect sensitivity	minimum value is over 2%

C. Sensitivity characteristic

Symbol	Parameter name	Technical parameter	Remarks
Rs	Sensing Resistance	3K Ω -30K Ω (1000ppm iso-butane)	Detecting concentration scope: 200ppm-5000ppm LPG and propane 300ppm-5000ppm butane 5000ppm-20000ppm methane 300ppm-5000ppm H_2 100ppm-2000ppm Alcohol
α (3000/1000) isobutane	Concentration Slope rate	≤0.6	
Standard Detecting Condition	Temp: 20℃ ±2℃ Humidity: 65%±5%	Vc:5V±0.1 Vh: 5V±0.1	
Preheat time	Over 24 hour		

D. Structure and configuration, basic measuring circuit

	Parts	Materials
1	Gas sensing layer	SnO_2
2	Electrode	Au
3	Electrode line	Pt
4	Heater coil	Ni-Cr alloy
5	Tubular ceramic	Al_2O_3
6	Anti-explosion network	Stainless steel gauze (SUS316 100-mesh)
7	Clamp ring	Copper plating Ni
8	Resin base	Bakelite
9	Tube Pin	Copper plating Ni

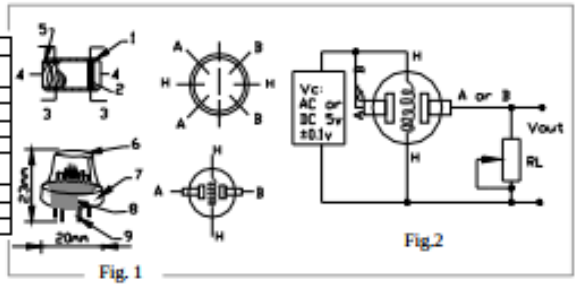
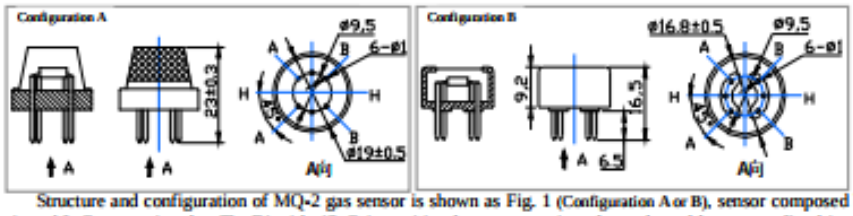


Fig.2

Fig. 1



Structure and configuration of MQ-2 gas sensor is shown as Fig. 1 (Configuration A or B), sensor composed by micro AL_2O_3 ceramic tube, Tin Dioxide (SnO_2) sensitive layer, measuring electrode and heater are fixed into a

TECHNICAL DATA MQ-6 GAS SENSOR

FEATURES

- High sensitivity to LPG, iso-butane, propane
- Small sensitivity to alcohol, smoke.
- Fast response . • Stable and long life • Simple drive circuit

APPLICATION

They are used in gas leakage detecting equipments in family and industry, are suitable for detecting of LPG, iso-butane, propane, LNG, avoid the noise of alcohol and cooking fumes and cigarette smoke.

SPECIFICATIONS

A. Standard work condition

Symbol	Parameter name	Technical condition	Remarks
Vc	Circuit voltage	5V±0.1	AC OR DC
V_H	Heating voltage	5V±0.1	ACOR DC
P_L	Load resistance	20K Ω	
R_H	Heater resistance	33Ω ±5%	Room Tem
P_H	Heating consumption	less than 750mw	

B. Environment condition

Symbol	Parameter name	Technical condition	Remarks
Tao	Using Tem	-10℃-50℃	
Tas	Storage Tem	-20℃-70℃	
R_H	Related humidity	less than 95%Rh	
O_2	Oxygen concentration	21%(standard condition)Oxygen concentration can affect sensitivity	minimum value is over 2%

C. Sensitivity characteristic

Symbol	Parameter name	Technical parameter	Remarks
Rs	Sensing Resistance	10K Ω - 60K Ω (1000ppm LPG)	Detecting concentration scope: 200-10000ppm LPG , iso-butane, propane, LNG
α (1000ppm/ 4000ppm LPG)	Concentration slope rate	≤0.6	
Standard detecting condition	Temp: 20℃±2℃ Humidity: 65%±5%	Vc:5V±0.1 Vh: 5V±0.1	
Preheat time	Over 24 hour		

D. Strucyure and configuration, basic measuring circuit

	Parts	Materials
1	Gas sensing layer	SnO_2
2	Electrode	Au
3	Electrode line	Pt
4	Heater coil	Ni-Cr alloy
5	Tubular ceramic	Al_2O_3
6	Anti-explosion network	Stainless steel gauze (SUS316 100-mesh)
7	Clamp ring	Copper plating Ni
8	Resin base	Bakelite
9	Tube Pin	Copper plating Ni

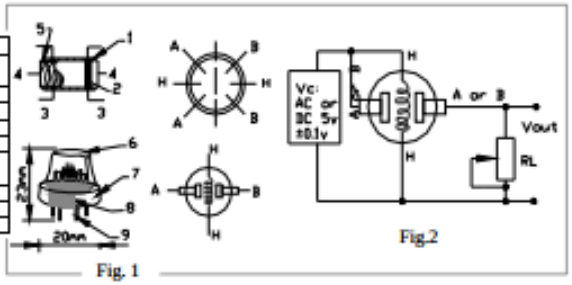
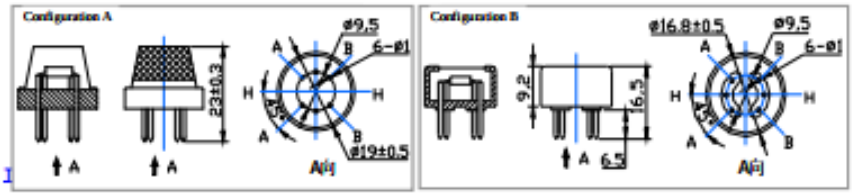


Fig.2

Fig. 1

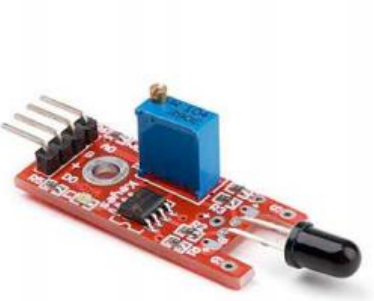


Appendix B

Flame Sensor Module - KY026 Datasheet

Future electronics

Flame Sensor Module

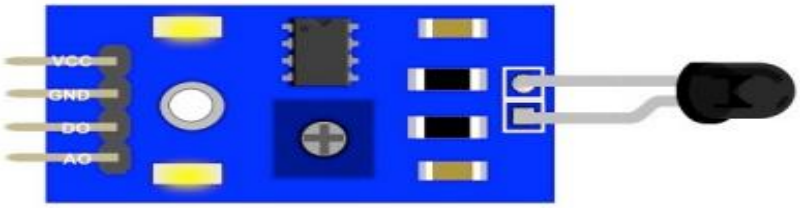


Description

- Detects a flame or a light source of a wavelength in the range of 760nm-1100 nm
- Detection distance: 20cm (4.8V) ~ 100cm (1V)
- Detection angle about 60 degrees, it is sensitive to the flame spectrum.
- Comparator chip LM393 makes module readings stable.
- Adjustable detection range.
- Operating voltage 3.3V-5V
- Digital and Analog Output
  - DO digital switch outputs (0 and 1)
  - AO analog voltage output
- Power indicator and digital switch output indicator

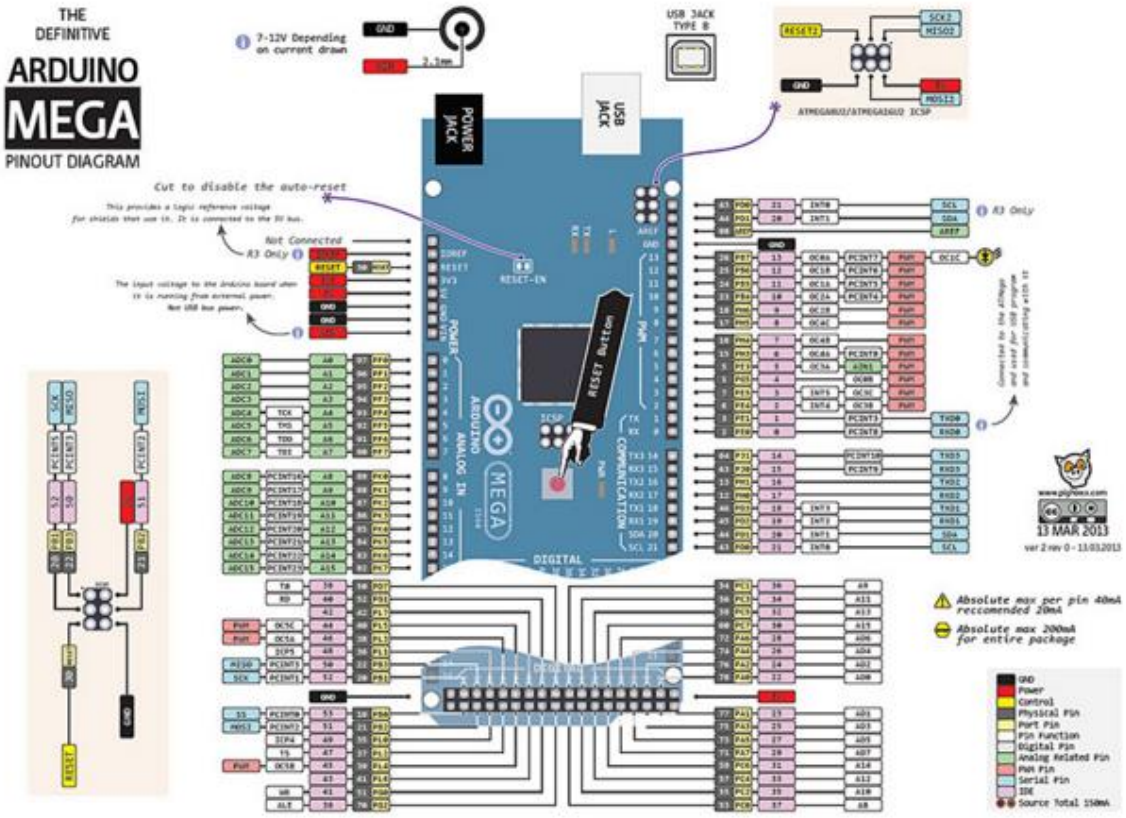
Interface Description (4-wire)

1) VCC -- 3.3V-5V voltage
2) GND -- GND
3) DO -- board digital output interface (0 and 1)
4) AO -- board analog output interface



Appendix C

Arduino Atmega2560 Pinout



Appendix D

Solenoid Valve Datasheet

Figure D.1: ¼” Plastic Solenoid Gas Valve with terminals

Model# APLO-1/2

Specifications:	
Port Size	1/2" NPSM
Voltage	12V DC Coil (6 Watts)
Build Material	Plastic (POM)
Working Medium	Water – Air – Oil
Operation Mode	Normally Open
Fluid Viscosity	Low Viscosity Fluids (below 20 cst)
Pressure Limits	3 - 115 psi (8bar)
Temperature	32 to 125° F | 0 to 50°C
Seal Material	EPDM Seal
Response Time	Fast Acting (Less than one second)

Figure D.2: Specification data for the solenoid gas valve.