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Revolutionizing Fire Safety: Integrating Auto Shutdown Technologies, Built-In Sprinkler in Modern Fire Alarm Panel

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Abstract**:** *The integration of modern fire alarm systems with smart sprinkler technology and automatic shutdown capabilities represents a significant advancement in fire safety measures. This research assesses the feasibility and effectiveness of implementing such systems among residents in Cebu City, Philippines, addressing demographic profiles, technical requirements, and user perspectives. A descriptive-correlational research approach involving 53 respondents in fire safety systems was employed. Results indicate high acceptance and effectiveness of the integrated system, with stakeholders rating features like advanced detection systems and integration with sprinklers as highly acceptable. Additionally, stakeholders perceive the system as reliable, effective, and safe, highlighting its potential to enhance fire safety standards in residential and commercial settings. Recommendations include collaboration between fire departments, technology developers, and local authorities to facilitate adoption, incentivization by insurance companies, and ongoing innovation in smart fire safety technology. Implementation of these recommendations can contribute to widespread adoption and effectiveness, ultimately saving lives and minimizing property damage in fire emergencies.*

Key words: *Fire Safety, Technology, Smart Sprinkler Systems, Automatic Shutdown, Integrated Fire Alarm.*

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Introduction

The rapid progress in electrical technology has brought forth a new era of innovation, namely in the field of fire safety systems. Firefighting operations in the Philippines take an extended period to finish due to the lack of resources and low upgrades in technologies in the Bureau of Fire Protection (BFP); the poor performance results in increased damage, making it nearly impossible to reduce damage and save all of the lives affected by the fire incident (Zadeh et al., 2021). The fire department's delay in arriving at the fire location is due to obstacles encountered, such as delays in receiving information about the fire from the community (Kahanji et al., 2019).

Currently, fire alarm systems integrate smoke and heat detectors with alarm systems, which alert building occupants and typically send a signal to a staffed monitoring station, either on or off site (Schroll, 2007). This system may be preventative; however, it lacks protective measures. Researchers have enhanced a modern fire alarm system with smart sprinkler integration and automatic shutdown technologies. The heat and smoke detectors, with a built-in sprinkler, can signal the system, which will automatically enable the sprinklers and shut down the power source.

Modern fire alarm systems equipped with smart sprinkler integration and automatic shutdown technologies have the potential to improve fire safety measures. Such a system would combine early detection and notification of a fire with an automated response to suppress the fire and shut down the power source, which can significantly reduce the risk of property damage and save lives (Cheng et al., 2017). In the following sections, we will delve into the intricacies of this innovative system, its components, benefits, and potential to revolutionize fire safety standards.

The researchers undertook the study of modern fire alarm systems enhanced with smart sprinkler integration and automatic shutdown technologies in response to the growing demand for more effective and responsive fire prevention and mitigation measures. The integration of an innovative fire alarm system with automatic sprinkler technology has emerged as a promising solution (Lv et al., 2022). In order to enhance the protection of lives and property during fire emergencies, this study explores the convergence of cutting-edge electrical engineering and fire safety technology.

Smart sprinkler integration and automatic shutdown technologies enhance modern fire alarm systems, aiming to improve overall fire safety (Okoro & Omokaro, 2017). The incorporation of these characteristics provides a faster response to potential threats. The fire alarm quickly detects incidents, activating the sprinkler system for immediate fire suppression, minimizing damage, and saving lives. This comprehensive method seeks to provide a complete and timely response to fire situations (Walter & Wilson, 2008).

Statement of the Problem

This study aims to assess the feasibility and effectiveness of implementing modern fire alarm system integrated with sprinkler and power supply shutdown capabilities among residents in Cebu City. The study aims to address the following objectives.

Specifically, it will seek to answer the following objectives:

1. Determine the demographic profile of the respondents:

1.1. Civil Status;

1.2. Gender

1.3. Educational Background & Economic Status

2. Identify the technical requirements necessary for the development of the smart fire alarm system as to;

2.1. Special Feature;

2.2. Design;

2.3. Bill of materials?

3. Evaluate the perspectives of respondents regarding the smart fire alarm system with built-in sprinkler and auto shutdown of power supply in terms of;

3.1. Functions;

3.2. Usefulness and;

3.3. Safety

4. Is there a significant difference between the perceptions of the respondent groups on the level of acceptability of the Smart Fire Alarm System with Built-in Sprinklers and Auto Shutdown Technologies?

5. Propose recommendations on potential technological advancements based on the study findings?

Literature Review

This chapter covers the fundamental components of contemporary fire alarm systems enhanced by automatic shutdown and smart sprinkler integration. This further provides more information on fire alarm control units, components of detection and alarm systems, signal types, alarm-initiating devices, and notification appliances. This chapter also emphasizes the procedures that staff members, including fire inspectors, should follow when testing and examining these systems. It also addresses the importance of creating and upholding accurate documentation for the installation, testing, calibration, and upkeep of fire detection and alarm systems.

In enclosed spaces, fires can be prevented, put out, contained, or blocked with the help of firefighting systems (James, 2016). Automatic fire suppression systems equip rooms and buildings where there is a significant risk of fire. We distinguish between systems that automatically activate and follow a preset program and those that require operator activation; we refer to the former as automatic fire protection systems and the latter as fire protection units. A sensor that can detect combustion, alarm signaling devices, fire-extinguishing equipment, starting and stopping devices, and feeders for the fire-extinguishing substance are all parts of an automatic fire-fighting system. Atomizers, foam generators, and pipe nozzles form and direct the fire-extinguishing material, which can be a liquid, foam, powder, or gas. Fire-extinguishing materials are fed into the system through independent or integrated feeders or from a centralized source like a water supply. The most popular systems use aerosols, powders, carbon dioxide, water (sprinkler and drencher systems), or both. Threaded connections fasten sprinkler heads to the pipes, and a sprinkler system consists of a grid of pipelines mounted on the room's ceiling. A thermal lock secures the sprinkler's disk, keeping the opening closed. When the room temperature reaches a certain point, the disk opens and the lock brakes (Hamden & Alzubaidi, 2014).

A thorough examination of 5,613 published articles ultimately determined 30 to meet the inclusion criteria. We divided the study's conclusions into two major categories: risk factors and preventive measures for home building fires and the injuries they cause. In terms of preventive actions, the factors to lower the risk of injuries from fires mentioned in the reviewed studies included raising awareness, improving emergency medical services, changing regulations, altering the environment, and changing behavior, such as fleeing the scene of a fire. Numerous studies also revealed that low-income families, single-family homes, elderly residents, those with physical or mental disabilities, smokers, and areas with a high concentration of young children were particularly vulnerable to fire-related injuries and fatalities (Shokouhi et al., 2019).

Fire hazards in buildings: review, assessment, and strategies for improving fire safety. Current fire protection measures do not measure the fire safety of buildings, offer limited strategies to reduce fire risk, and fail to consider modern fire hazards. The key to reducing the risk of fire in buildings is to put important measures in place, such as dependable fire protection systems, appropriate regulation and enforcement of building code requirements, raising public awareness, and making appropriate use of resources and technology. To increase building fire safety, a significant amount of research and training are needed. This includes creating sensible fire design strategies and affordable fire suppression systems, evaluating novel materials, and creating performance-based codes (Kodur et al., 2019).

The Power of Water: An In-Depth Look at its Cost-Effective and Efficient Role as a Firefighting Agent. Water is the most widely used firefighting agent because it is affordable and readily available. Additionally, it has favorable fire-extinguishing properties like a high latent heat of vaporization and a high specific heat. Water can absorb 9280 Btus (2586.5 kJ) of heat when it is heated from a room temperature of 70 °F (21 °C) to 212 °F (100 °C) (Du et al., 2018).

Advancements in Fire Protection. According to Alqourabah et al. (2021), house combustion is one of the biggest concerns for property owners, designers, and builders. For a very long time, single sensors were utilized to detect fires; however, these sensors were unable to gauge the fire's intensity in order to notify emergency response teams. One of the most dangerous situations that a building may encounter during its lifetime is fire. In recent decades, building design has placed a high priority on creating workable protection strategies and concepts against possible fire disasters. The demand for new and creative fire prevention systems has risen as a result of rapid technological breakthroughs, in contrast to conventional and traditional techniques. Whenever it comes to existing buildings, this demand for new technologies is especially pressing. When it comes to fire safety, retrofitting an existing building presents more of a challenge than designing a new structure with materials and components that have better fire ratings from the start. Moreover, approaches to designing a new structure with cutting-edge fire safety features differ from those that might be better suited for retrofitting an existing structure (Wang et al., 2012).

The Escalating Challenge of Fires in the Philippines. Fire can cause unpredictable damage. It is undesirable and detrimental. Since the dawn of human civilization, fire has aided in its evolution. It serves to warm, cook, and ward off predators. Fires that spread are uncontrollably wild. It may ruin people's lives and means of subsistence. Every year, fires in the Philippines claim lives and cause property damage. According to Kurata et al., 2023), that in the Bureau of Fire Protection the number of fires in the Philippines increased by 13% in the first two months of 2022 compared to the same period the previous year. January and February saw 2,103 fire reports, up 12.9% from 1,863 in 2021. In spite of preventative measures and quarterly fire drills, fire incidents continue to rise, necessitating more effective solutions (Espinosa et al., 2022).

The National Fire Protection Association-Fire Safety Evaluation System. As stated by Chow (2002), Hong Kong created the EB-FSRS system to evaluate the fire safety of high-rise nonresidential buildings. Its goals are to ascertain whether current fire safety procedures differ from the new codes and to suggest suitable handling throughout the transition. The system divides into three categories, similar to the National Fire Protection Association's Fire Safety Evaluation System: key risk parameters, active fire protection systems, and passive building construction.

IoT-Enhanced Fire Safety: A Smart Solution for Industrial Areas. For the most part, safety precautions can be developed in a way that benefits society, thanks to the Internet of Things. The majority of fire incidents occur in industrial areas, where they seriously harm both human life and natural resources. The author of this paper suggests an IoT-based smart water sprinkler system for fire detection that will be beneficial to the fire-crackery sector. This paper examines the primary cause of fire incidents' harm and explores strategies for future prevention through the implementation of firefighting apparatuses. This suggested system accomplishes the necessary tasks and adds features like a call feature and an SMS alert that includes GPS coordinates and simultaneously activates the water system. This system has the potential to save many lives and prevent numerous dangerous fire incidents (Ranjith & Naveen, 2022).

Design of an integrated motor/controller drive for an automotive water pump application. We present a cost-based trade-off study that includes five distinct brushless machine types, and the results indicate that an interior PM synchronous machine is the optimal prime mover for this application. We created the physical arrangements of the motor and controller to maximize cooling efficiency while minimizing weight and volume. We discuss some of the major concerns related to the controller design, including the physical arrangement of important components, the creation of an EMI filter to satisfy automotive standards, and the use of finite-element thermal analysis to analyze worst-case component temperature rises (Harris et al., 2022).

Alqourabah et al. (2021) state that one of the biggest worries for property owners, designers, and builders is house combustion. For a considerable amount of time, emergency response teams relied on single sensors to detect fires, but these sensors were unable to accurately assess the fire's intensity. The goal of this study is to develop a smart fire detection system that will simultaneously protect valuable assets and lives by not only using integrated sensors to detect fires, but also notifying local police stations, emergency services, and property owners. This model uses various integrated detectors, including flame, smoke, and heat. The system algorithm processes the signals from those detectors to determine the likelihood of a fire, and then uses a connected GSM modem to transmit the anticipated outcome to multiple parties (Liu et al., 2010). We have utilized Internet of Things technology to provide the fire department with the necessary real-time data without compromising human safety.

Failsafe Motor Control Design to Prevent Runaway Motors. As stated by Ducote et al. (2022), it is good to examine motor control designs to safeguard against runaway motors, particularly those powered by motors, and against closed valves that could catch fire. The demand for new and creative fire prevention systems has risen as a result of rapid technological breakthroughs, in contrast to conventional and traditional techniques. After identifying the primary obstacles, we conduct a survey of the pipeline sector to ascertain the prevalence of each obstacle in similar operations and identify any unpublished best practices.

The Essential Role of Automatic Fire Alarm Systems in Modern Architecture. Modern architecture is still prone to fires, resulting in significant losses of life and property. The building required the installation of automatic fire alarm equipment to reduce the risk of fire (Liu et al., 2010). Fire hazards are common, according to Shah et al. (2019), that in high-security areas, it is right to install smoke detectors to prevent injuries from fire accidents. Because the fire break connected to the smoke detector sets off an early alarm, it can detect smoke. This allows for the evacuation of people and prompt action to extinguish the fire before it extends to other areas of the building. Aside from emitting an alarm, the smoke detector designed for this project also activates a fan, facilitating prompt and effective smoke extraction.

Enhancing Safety: A Low-Cost Fire Alarm System with Sprinkler for Timely Response and Damage Prevention. Rajput et al. (2017) state that fire mishaps are concerning incidents that cause severe losses in terms of lives and property. Depending on the needs and circumstances, fire detectors come in a variety of types with different features. Numerous temperature detectors are in close proximity to the system's timely installation. Upon activation, the alarm surveys its surroundings before initiating the response. We install an alarm to safeguard the area, uphold security, and foster a feeling of safety. It not only stops significant losses from catastrophic fires, but it can also save lives on occasion. It not only stops significant losses from catastrophic fires, but it can also save lives on occasion. This paper presents the development of a low-cost sprinkler-equipped fire alarm system that aims to provide early fire extinguishment and public awareness of the fire.

Smart fire-warning materials and sensors: design principles, performances, and applications. Benson & Elsmore (2022), assert that although preventing combustible materials and fires is crucial in today's world, it has proven to be an international challenge. Recurrent fire disasters have a detrimental effect on the environment worldwide, resulting in significant casualties and irreversible property losses. The development of intelligent fire warning materials and sensors that integrate active fire alarm responses with conventional passive flame retardant techniques has become a growing concern in recent times. An insightful and comparative review of these fire warning systems is still lacking, though. This review comprehensively discusses not only the flammability of combustible materials, but also provides detailed information on passive flame-retardant materials, conventional active fire warning sensors, and advanced smart fire warning materials and sensors. The synthesis, fabrication techniques, characterizations, and conceptual design of smart warning materials

Understanding the Interactions and Effectiveness of Life Safety and Property Protection. According to Frank et al. (2013), buildings frequently have systems installed to reduce the risk to life safety, property destruction, etc. at a reasonable cost. Understanding how each system contributes to and interacts with the others to achieve the goals is crucial. This calls for historical data that directly addresses effectiveness, or historical data on efficacy—the impact of a properly operating system on each of the goals it is meant to address—and reliability—the likelihood that the system will function as needed at any given time. Certain systems may be detrimental to certain goals, even though they may be beneficial to others.

Efficiency of Fire Sprinklers: Ensuring Digital Telecommunications Equipment Safety. In support of Bell Canada's proposed program to outfit major central offices with automatic fire sprinkler systems, the fire extinguishment tests validated a number of design parameters pertaining to the fire sprinkler protection of digital telecommunications equipment. From an extinguishment standpoint, fire sprinklers have successfully halted the spread of flames outside the original fire frame (Edgar, 1989).

Curtain Wall Sprinklers and Strategic Enclosures for Smoke Control. As stated by Wood (2018), the horizontal fire shutters, glass enclosure at the top of the communicating stair, and 2-hour-rated curtain wall sprinklers all work together to prevent the growth of a significant smoke plume in the main lobby and do away with the need for mechanical smoke control. Combination smoke/fire dampers, magnetic closing doors, and elevator hoist way protection facilitate building compartmentalization and reduce smoke spread during a fire incident. Duct smoke detectors, installed in both air handlers, detect the presence of smoke in the building's HVAC system and alert the fire alarm system to turn off the HVAC system in the event of an alarm.

Smart Fire Detection and Suppression. According to Mohani et al. (2021), a smoke detector in the suggested system detects smoke and sets off an alarm, which sends a low-voltage signal to microcontrollers. The microcontroller will speak and flash lights to notify the occupants that one of the smoke detectors has detected smoke. Other components connect to the relays. It will communicate simultaneously with the water pump, air suckers, and valves. The solenoid valve will control the water pump, which uses pipes installed inside the building to deliver water to the room in an attempt to put out the fire. In the meantime, the air sucker will remove smoke from the space to keep people from suffocating. The proposed design's main goals are the system's cost-effectiveness, compactness, ease of expansion, ease of installation, and replaceable parts are the main goals of the suggested design.

A Comprehensive Display System for Efficient Alarm Management. Jin & Wu (2020) findings led to the design of a sequential fire alarm display system, which connects to various fire controllers manufactured by the factory to display detailed alarm data. This display system's software integrates database, multimedia, and communication features to enable features like data storage, information retrieval, fire inspection, and alarm display, among others. With the accompanying drawing software, users can easily add, remove, move, and alter fire detection and firefighting equipment on building floor maps.

Environments like storage depots, aircraft cargo bays, and ships, where frequent visual inspection is impractical, are designing advanced fire alarm systems. To improve fire detection, these systems use multiple sensors that measure different parameters. Their goal is to enhance traditional smoke detectors, which, although accurate in identifying fires, frequently produce false alarms because of impurities such as dust and water droplets that interfere with the smoke particle detection system. Like older smoke detector systems, these advanced systems greatly reduce false alarms while maintaining reliable fire detection by taking into account multiple fire-associated parameters, such as smoke obscurity and concentrations of various combustion-related chemicals.

A fire alarm system is an interconnected system of devices and components designed to trigger a response from building occupants. The control panel, the notification appliance, and the initiating device are its three main parts. Initiators can operate manually, such as fire alarm boxes, or automatically, like smoke detectors. An initiating device alerts building occupants to evacuate by turning on one or more notification appliances, such as bells, horns, or strobe lights. Apart from alerting occupants, fire alarm systems have the ability to send signals to locations either on or off-site, where qualified staff can respond appropriately by notifying building, property, or fire department personnel, among other actions. Additionally, these systems have the ability to start a variety of life safety features, including pressurizing elevator shafts and stair towers, disengaging magnetic door hold-open devices to divide building areas, locking and unlocking exit doors, activating fans, and closing smoke dampers. Additionally, fire alarm systems interact with other fire safety systems, monitor their status, and respond to any changes in the system's typical state of readiness, system activation, or electrical or electronic issues related to the fire safety system. Most systems provide vital information, such as the type of alarm and the location of the alarm, to first responders upon their arrival.

There are undoubtedly advantages to using smart technologies, and they may support continued technological advancement (Bughin et al., 2010). A study was conducted on an IoT-based smart fire detection system equipped with an automated water sprinkler. The aim was to develop a fire detection system that not only detects fires using integrated sensors but also notifies property owners, emergency services, and local police stations. This system aims to safeguard lives and valuable assets simultaneously. This system's design improves fire detection's efficacy and efficiency. The study's proposed fire detection systems focused solely on putting out fires without regard for responsiveness.

The Role of Automatic Fire Extinguishers and Fire-Spreading Algorithms. According to Kozlowski (2000), forest fires are a widespread problem that affects human, plant, and animal life negatively in many ways in every nation. Numerous developing nations are continuously searching for a solution to this issue. India, among others, lacks the modern technology required to tackle this issue. While there are a few issues with the current approach, they are easily fixable. It'll be too late, and the fire will spread swiftly until the military forces or fire engines arrive to put it out. Because it is fully automatic and doesn't require human energy, the automatic fire extinguisher will be very helpful in this situation. Not only do forest fires and other types of fires severely harm the nation's ecosystem, but they also result in significant financial losses. Thanks to the fire-spreading algorithm, we can better understand and predict how forest and urban fires will spread. To accomplish the primary goal of drowsing fire, firefighters and controllers are trained through virtual simulations of virtual scenarios.

Fire Sprinkler Systems in Different Single-Family Housing Types. We compare the advantages and disadvantages of installing and using a fire sprinkler system in three common types of single-family homes: colonial, townhouse, and ranch. The colonial style of home has the highest installation costs, while the ranch style has the lowest. According to this report, homeowners who live in single-family homes equipped with sprinkler systems benefit from lower risks of civilian fatalities and injuries, homeowner insurance premiums, uninsured direct property losses, and uninsured indirect costs. We primarily focus on the initial purchase and installation of the sprinkler system. We do not consider maintenance and repair expenses because they are relatively small (Butry et al., 2007).

Challenges and Guidance in Smoke Management. Modern commercial buildings in India can accommodate hundreds of thousands of people, yet smoke inhalation frequently causes fire incidents. To reduce the risk of fire, it is critical to manage smoke properly. Buildings must adhere to modern building codes and internationally recognized performance-based fire safety designs. Providing efficient smoke management solutions presents a challenge for HVAC engineers and contractors operating in India. This document offers guidelines regarding code requirements, the function of engineered smoke management systems, smoke management principles, and challenges associated with the installation, use, and upkeep of smoke management systems (Gabhane, 2018).

A Comprehensive Overview of Fire Alarm Systems and Components. The Fire Alarm Control Unit, Heat and Smoke Detectors, Water Flow Devices, Sprinkler Control Valve Tamper Switches, Projected Beam Smoke Detectors, and Air-Sampling Type Smoke Detectors are some of the parts that make up the fire alarm system. There is also a description of notification appliances such as bells, speakers, strobes, and horns. Wiring diagrams help to explain system integration and interconnection (Low, 2015).

Indigenous Development of Affordable Smoke Sensors. Industrial and nuclear facilities must have a fire alarm system in place to safeguard the environment, plant workers, and public safety from fires. These systems install thousands of fire sensors and electronics in accordance with standards. However, the lack of a reputable, approved manufacturer in India necessitates the development of these detectors domestically. In order to create inexpensive smoke sensors, electronics, and communication protocols, ISS/EIG is testing feasibility prototypes (Wu et al., 2018).

Exploring fire detection and alarm systems. A fire detection and alarm system's study, analysis, and design were the primary objectives of the thesis project. This topic was appropriate since it dealt with a crucial and important aspect of modern life. Through studying and working on the project, the author acquired invaluable knowledge in the field of fire detection and alarm systems. The project aimed to illustrate the similarities and differences between the fire alarm systems in Finland and Vietnam by presenting data on the two systems. Second, the practical section's aim was to build a demonstration system to demonstrate how a basic fire alarm system functions was the aim of the practical section. In order to achieve the goals of this thesis, the author investigated the primary fire detection and alarm system standards in Finland and Vietnam. Together with the other necessary components, an Arduino Uno served as the control device for the practical portion. Upon finishing the project, the author showcased the functioning of a fire detection and alarm system and examined the system prerequisites in the listed countries (Luong, 2019).

House combustion is considered as one of the main concerns for builders, architects, and property owners. Single sensors were used for fire detection for a long time, but they couldn't tell how big a fire was to alert the emergency response teams. The goal of this project is to implement a smart fire detection system that will simultaneously protect assets and lives by notifying local police stations, emergency services, and property owners of a fire, in addition to detecting it using integrated sensors. This study proposes a model that makes use of multiple integrated detectors, such as heat, smoke, and flame detectors. The system's algorithm analyzes the signals from those detectors to estimate the chance of a fire. The system then links a GSM modem to send the predicted result to various parties. Thanks to the application of Internet of Things technology, which permits the gathering of real-world data without putting human lives in danger, the fire service now has access to crucial data. Ultimately, the main feature of the proposed method that increases its dependability is the reduction of false alarms. The system's utilization of the Unidos platform facilitates faster and more dependable data transmission. The trial results further illustrated the superiority of our concept with respect to affordability, efficacy, and responsiveness.

Research Methodology

This study employs a descriptive-correlational research approach, focusing on the qualitative nature of understanding the relationship between the utilization of an automated fire alarm system and the practices of Electrical Engineering students during the design process. It aims to establish a foundation for a university-wide program related to fire alarms. The research will be conducted within households in Cebu City, ensuring a diverse rural environment and familiar settings for participants. The study involves 53 individuals from local households, some were categorized belonging to self-employed and skilled workers and experts yet professionals in conventional fire alarm systems, including electrical and electronic engineers, teachers and students from the college of technology department, selected to provide varied perspectives. Data collection involves a structured questionnaire divided into demographic information and Likert scale responses regarding the effectiveness of modern fire alarm systems. The survey instrument was validated by experts before administration. The researcher personally administered the questionnaire, ensuring clarity and understanding among respondents. Statistical treatment includes percentage calculation, weighted mean determination, average weighted mean calculation, mean calculation, and T-test analysis to assess the acceptability of the smart fire alarm system. Ethical considerations involve obtaining consent from relevant authorities and informants, ensuring autonomy, privacy, and confidentiality. The scoring procedures follow a parametric scale to determine the effectiveness of the smart fire alarm system. Finally, the study will present the profile of respondents in terms of civil status and gender, providing demographic insights crucial for understanding the effectiveness of modern fire alarm systems in households.

Results and Discussion

The analysis of the Modern Fire Alarm Panel with integrated Sprinkler and Automatic Shutdown Technologies indicates high effectiveness and widespread acceptance across diverse demographics and professional groups. Special features like advanced detection systems and integration with sprinklers are particularly well-received, with stakeholders consistently rating the system as highly acceptable. This consensus underscores its suitability and importance in enhancing fire safety measures and safeguarding lives and property from fire hazards in various settings.

Basically, in this portion, it is proper to present first the profile of the respondents in terms of civil status, gender, educational background and economic status, providing valuable demographic information.

Table 1. Demographic Profile of the Respondents

Indicators	Category	Frequency	Percentage
Civil Status	Married	28	52.8
	Single	20	37.7
	Widow	5	9.43
Gender	Male	38	71.6
	Female	15	28.3
Educational Background & Economic Status	Professional (Teacher, Doctor, Electrical and Electronic Engineers)	13	24.53
	Skilled Worker (Foreman, Lead man, wage laborer)	5	9.43
	Self-employed	3	5.66
	Students in College of Technology	32	60.37

The table 1 reveals the demographic characteristics of the 53 participants who were part of the study investigating the efficacy of the Modern Fire Alarm Panel with built-in Sprinkler and Automatic Shutdown Technologies.

In terms of civil status, the respondents are primarily married, constituting 52.8% of the total, followed by single individuals at 37.7%. A smaller percentage, 9.43%, are widowed.

Regarding gender distribution, the majority of respondents are male, accounting for 71.6% of the total sample, while females comprise 28.3%.

For educational background and economic status, the respondents exhibit diversity. A significant portion, 60.37%, are students in the College of Technology. Professionals, including teachers, doctors, electrical, and electronic engineers, make up 24.53% of the sample. Skilled workers, such as foremen, lead men, and wage laborers, represent 9.43%, while self-employed individuals account for 5.66%.

Overall, the profile of the 53 respondents reflects a mix of marital statuses, gender, educational backgrounds, and economic statuses. This diverse representation provides valuable demographic information for the study, allowing for a comprehensive analysis of the effectiveness of the modern fire alarm panel across different demographic groups.

Table 2. Level of Acceptability of the Modern Fire Alarm Panel with Built in Sprinkler and Auto Shutdown Technologies in terms of Special Features

Indicators	*VHA*	*HA*	*A*	*LA*	*NA*	Mean	Verbal Description
	5	4	3	2	1		
Advanced Detection Systems	*4.98*	*4.40*	*4.45*	*4.43*	*4.48*	*4.55*	*A*
Intelligent Alarm Notification	*4.86*	*4.49*	*4.50*	*4.48*	*4.40*	*4.54*	*VHA*
Integration with Sprinkler Systems	*4.89*	*4.50*	*4.45*	*4.46*	*4.42*	*4.54*	*VHA*
Overall Average:	*4.54*						
Interpretation:	*Very Highly Acceptable*						

Legend:

		X	SUM	1.50	2.49	LA	Less Acceptable
		%	Percentage	1.00	1.49	NA	Not Acceptable
		VD	Verbal Description				
4.50	5.00	VHA	Very Highly Acceptable				
3.50	4.49	HA	Highly Acceptable				
2.50	3.49	A	Acceptable				

The table provides an assessment of the level of acceptability of the modern fire alarm panel with built-in sprinkler and auto shutdown technologies based on its special features. The indicators evaluated include advanced detection systems, intelligent alarm notification, and integration with sprinkler systems.

Across all indicators, the ratings consistently fall within the range of "Very Highly Acceptable" (VHA) or "Highly Acceptable" (HA). For advanced detection systems, intelligent alarm notification, and integration with sprinkler systems, the mean scores are 4.55, 4.54, and 4.54 respectively. These scores indicate a strong consensus that the special features of the modern fire alarm panel, such as advanced detection capabilities, intelligent alarm notifications, and seamless integration with sprinkler systems, are highly desirable and effective.

The overall average score of 4.54 reinforces the interpretation that the modern fire alarm panel with built-in sprinkler and auto shutdown technologies is "Very Highly Acceptable."

Table 3. On the Level of Acceptability of the Modern Fire Alarm Panel with Built in Sprinkler and Auto Shutdown Technologies to Design

Indicators	VHA	HA	A	LA	NA	X	VD
	5	4	3	2	1		
Reliability	*4.52*	*4.54*	*4.44*	*4.20*	*4.20*	*4.38*	*HA*
Effectiveness	*4.55*	*4.52*	*4.38*	*4.22*	*4.22*	*4.38*	*HA*
Integration and Compatibility	*4.50*	*4.52*	*4.38*	*4.18*	*4.18*	*4.35*	*HA*

Ease of Installation and Maintenance	*4.55*	*4.50*	*4.40*	*4.16*	*4.16*	*3.52*	*HA*
Total:	*4.53*	*4.52*	*4.4*	*4.19*	*4.19*		
Interpretation:	***HIGHLY ACCEPTABLE***						

Legend:

		X	SUM	1.50	2.49	LA	Less Acceptable
		%	Percentage	1.00	1.49	NA	Not Acceptable
		VD	Verbal Description				
4.50	5.00	VHA	Very Highly Acceptable				
3.50	4.49	HA	Highly Acceptable				
2.50	3.49	A	Acceptable				

The data presented in the table provides an evaluation of the acceptability of a modern fire alarm panel with built-in sprinkler and auto shutdown technologies based on various indicators. The indicators include reliability, effectiveness, integration and compatibility, and ease of installation and maintenance, each rated on a scale from 1 to 5. The table also provides a summary of the total ratings for each indicator.

Across all indicators, the ratings fall within the range of 4.19 to 4.53, indicating a consistently high level of acceptability. Specifically, the average ratings range from 4.19 to 4.53, placing them within the "Highly Acceptable" category according to the legend provided. This suggests that the modern fire alarm panel with built-in sprinkler and auto shutdown technologies is highly acceptable in terms of reliability, effectiveness, integration and compatibility, as well as ease of installation and maintenance.

Overall, the data suggests that the design incorporating these technologies is highly favoured and would likely be well-received by users. This level of acceptability signifies that the system meets or exceeds expectations across key criteria, indicating its suitability for deployment in various contexts where fire safety is a priority.

Table 4. On the Level of Acceptability of Modern Fire Alarm Panel with Built In Sprinkler and Auto Shutdown Technologies to Bill of Materials

FIRE ALARM PANEL COMPONENTS				
COMPONENTS	DESCRIPTION	QUANTITY	UNIT	AMOUNT
POWER SUPPLY	Electrical power source for the system	1	pc	950
14 PINS RELAY	For shutdown Technology for the system	1	set	250
Circuit Breaker	For Electrical control of house wiring	1	pc	400
Terminal Blocks	For connection 10x2	2	pcs	200
Labels and signage	For light indicators	5	pcs	500

NC push button	For reset button	1	pc	100
Back up Battery	For emergency back-up power	1	pc	1500
TOTAL				3900

FDAS COMPONENTS				
Smoke detector	Sensors to detect smoke particles in the air	2	pcs	1200
Heat Detector	Sensors to detect abnormal temperatures	2	pcs	1200
Alarm Bell	Signal For Smoke or Heat Detection	1	pc	400
Manual Call Point	Manual operation for malfunction of heat and smoke detector	1	pc	500
TOTAL				3300

INSTALLATION COMPONENTS Depending on Actual visit and Estimate				
Sprinkler System	System of water sprinklers for fire suppression	1	set	10000
Testing and commissioning tools	Tools for system testing and commissioning	5	pcs	5000
Wiring	Electrical cables for connecting components	1	roll	2000
TOTAL				17000

ESTIMATED COST	
FIRE ALARM PANEL COMPONENTS	3900
FDAS COMPONENTS	3300
INSTALLATION COMPONENTS Depending on Actual visit and Estimate	17000
TOTAL	24000

The data in the table above presents a breakdown of the materials required for a modern fire alarm panel with built-in sprinkler and auto shutdown technologies. The fire alarm panel components include a power supply unit, relay for shutdown technology, circuit breaker, terminal blocks, labels and signage, NC push button, and a backup battery, totaling to 3900. The FDAS (Fire Detection and Alarm System) components consist of smoke detectors, heat detectors, an alarm bell, and a manual call point, amounting to 3300. Additionally, installation components such as a sprinkler system, testing and commissioning tools, and wiring, which may vary depending on actual visit and estimation, sum up to 17000.

Considering the estimated costs, the total amount for the fire alarm panel components and FDAS components comes to 7200. When factoring in the installation components, the total cost amounts to 24000.

In terms of acceptability, the total cost appears substantial, primarily due to the installation components, particularly the sprinkler system, which comprises a significant portion of the total cost. However, considering the critical role of fire alarm systems in safeguarding lives and property, especially with built-in sprinkler and auto shutdown technologies, the investment seems justifiable for ensuring safety and compliance with regulatory requirements. While the initial cost might be high, the long-term benefits of a reliable and efficient fire alarm system with advanced features outweigh the expenses, making it a prudent investment for residential or commercial properties.

Table 5. On the Level of Acceptability of the Modern Fire Alarm Panel with Built in Sprinkler and Auto Shutdown Technologies to Functions

Indicators	*Students*		*Professional/Experts*		*Faculty*		*X*	*VD*
	X	*VD*	*X*	*VD*	*X*	*VD*		
Fire Detection	*4.52*	*VHA*	*4.55*	*VHA*	*4.52*	*VHA*	*4.53*	*VHA*
Alarm Notification	*4.54*	*VHA*	*4.52*	*VHA*	*4.52*	*VHA*	*4.53*	*VHA*
Sprinkler System Control	*4.54*	*VHA*	*4.54*	*VHA*	*4.52*	*VHA*	*4.53*	*VHA*
Remote Monitoring and Control	*4.52*	*VHA*	*4.62*	*VHA*	*4.52*	*VHA*	*4.55*	*VHA*
Total:	*4.53*		*4.56*		*4.52*			
Interpretation:	*Very Highly Acceptable*							

Legend:

		X	SUM	1.50	2.49	LA	Less Acceptable
		%	Percentage	1.00	1.49	NA	Not Acceptable
		VD	Verbal Description				
4.50	5.00	VHA	Very Highly Acceptable				
3.50	4.49	HA	Highly Acceptable				
2.50	3.49	A	Acceptable				

The data presented in the table indicates a very high level of acceptability for the modern fire alarm panel with built-in sprinkler and auto shutdown technologies across various stakeholders, including students, professional/experts, and faculty. Across all indicators, including fire detection, alarm notification, sprinkler system control, and remote monitoring and control, the average scores range between 4.52 and 4.56. These scores fall within the range of “Very Highly Acceptable” according to the provided legend.

For fire detection, alarm notification, and sprinkler system control, the average ratings consistently fall within the “Very Highly Acceptable” category, ranging from 4.52 to 4.54 across all stakeholders. This suggests a high level of satisfaction and confidence in these features among students, professional/experts, and faculty members.

Furthermore, the ratings for remote monitoring and control also demonstrate a high level of acceptability, albeit slightly higher variability with an average score of 4.55 among professional/experts, while students and faculty rated it slightly lower at 4.52. However, these scores still indicate a very high level of acceptance across all stakeholders.

Overall, the data suggests that the modern fire alarm panel with built-in sprinkler and auto shutdown technologies is very well-received and highly acceptable among the targeted groups, providing a robust and reliable safety solution for various environments.

Table 6. On the Level of Acceptability of Modern Fire Alarm Panel with Built in Sprinkler and Auto Shutdown Technologies to Usefulness

Indicators	**Electrical and Electronic Engineers**						
	VHU	*HU*	*U*	*LU*	*NU*	X	VD
	5	4	3	2	1		
Performance	*4.78*	*4.68*	*4.53*	*4.13*	*4.10*	*4.44*	*HU*
Quality	*4.88*	*4.48*	*4.43*	*4.23*	*4.12*	*4.43*	*HU*
Capabilities	*4.78*	*4.68*	*4.53*	*4.13*	*4.10*	*4.44*	*HU*
Facilitating Conditions	*4.88*	*4.48*	*4.43*	*4.23*	*4.12*	*4.43*	
Total	*19.32*	*18.32*	*17.92*	*16.72*	*17.44*		
Interpretation:	*Highly Useful*						

Legend:

4.50	*5.00*	*5*	*VHU*	*Very Highly Useful*	*VD*	*Verbal Description*
3.50	*4.49*	*4*	*HU*	*Highly Useful*	*x*	*sum*
2.50	*3.49*	*3*	*U*	*Useful*		
1.50	*2.49*	*2*	*LU*	*Less Useful*		
1:00	*1.49*	*1*	*NU*	*Not Useful*		

The table provides a comprehensive assessment of the acceptability of a modern fire alarm panel with built-in sprinkler and auto shutdown technologies in terms of its usefulness across various indicators as perceived by electrical and electronic engineers.

Across all indicators—performance, quality, capabilities, and facilitating conditions—the ratings consistently fall within the range of “Highly Useful” (HU). The average scores for the indicators range from 4.10 to 4.88, with the highest average being for quality (4.88). This indicates a strong consensus among electrical and electronic engineers that the modern fire alarm panel with integrated sprinkler and auto shutdown technologies is highly effective, reliable, and capable.

The total scores across all indicators further confirm the high level of acceptability, with the majority falling within the “Highly Useful” category. Specifically, the total scores range from 16.72 to 19.32, reinforcing the notion that the system is perceived as “Highly Useful” by the engineers.

In summary, based on the ratings provided by electrical and electronic engineers, the modern fire alarm panel with built-in sprinkler and auto shutdown technologies is deemed highly acceptable and useful. Its strong performance, quality, capabilities, and facilitating conditions contribute to its overall effectiveness in fulfilling its intended functions, making it a valuable asset for fire safety and protection in various settings.

Table 7. On the Level of Acceptability of the Modern Fire Alarm Panel with Built in Sprinkler and Auto Shutdown Technologies to Safety

Indicators	**Acceptability of the Safety of the Modern Fire Alarm Panel with Built in Sprinkler and Auto Shutdown Technologies**			
	Faculty		**Students**	
	X	VD	X	VD
Safety habits is being applied	4.90	VHA	4.36	HA
Preparations of tools, machines, materials and accessories	4.80	VHA	4.82	VHA
Construction time frame is enough	4.50	VHA	4.82	VHA
Adequate ventilation of the working area	4.60	VHA	4.68	VHA
Quality of the finished Device	4.60	VHA	4.45	HA
Steps of operations are feasible	4.60	VHA	4.50	VHA
Machine Scheduling	4.70	VHA	4.55	VHA
Proper housekeeping of the working area	4.80	VHA	4.64	VHA
Average weighted mean	**4.69**		**4.62**	
Interpretation	**Very Highly Acceptable**		**Very Highly Acceptable**	

Legend:

4.50	*5.00*	*5*	*VHA*	*Very Highly Acceptable*	*VD*	*Verbal Description*
3.50	*4.49*	*4*	*HA*	*Highly Acceptable*	*x*	*Sum*
2.50	*3.49*	*3*	*MA*	*Moderately Acceptable*		
1.50	*2.49*	*2*	*A*	*Acceptable*		
1.00	*1.49*	*1*	*NA*	*Not Acceptable*		

The table revealed an assessment of the level of acceptability of the Modern Fire Alarm Panel with Built-in Sprinkler and Auto Shutdown Technologies to safety, as perceived by faculty and students. The indicators evaluated include safety habits application, preparation of tools, machines, materials, and accessories, construction time frame adequacy, ventilation of the working area, quality of the finished device, feasibility of operation steps, machine scheduling, and proper housekeeping of the working area.

For both faculty and students, the ratings consistently fall within the range of “Very Highly Acceptable” (VHA) for most indicators. This indicates a strong consensus among both groups that the safety features of the modern fire alarm panel, including aspects like safety habits application, preparation of tools and materials, construction time frame, ventilation, feasibility of operation steps, machine scheduling, and housekeeping, are highly desirable and effective.

The average weighted mean for faculty and students is 4.69 and 4.62 respectively, reinforcing the interpretation that the modern fire alarm panel with built-in sprinkler and auto shutdown technologies is "Very Highly Acceptable" in terms of safety.

In summary, based on the ratings provided by both faculty and students, the modern fire alarm panel with built-in sprinkler and auto shutdown technologies is perceived as very highly acceptable in terms of safety. Its safety features are deemed effective and essential in ensuring a safe working environment, indicating its value in enhancing safety measures and protecting individuals and property from fire hazards.

SIGNIFICANT DIFFERENCE ON THE LEVEL OF ACCEPTABILITY OF THE DESIGN SYSTEM BY THE RESPONDENTS

The test of significant mean difference between the respondents on the level of acceptability of the Smart Fire Alarm System with Built-in Sprinklers and Auto Shutdown Technologies presented in table 8.

Table 8. SIGNIFICANT DIFFERENCE

N=53

Group	n	df	$\dot{x}$	S	Computed t-value	Tabulated t-value	Decision
College of Technology Students/Skilled Workers/Self-employed	50	51	2.42	0.78	1.0766<2.0054		Accept H0
Professors / Instructors / Experts	3		2.94	1.48	Computed t is < than the table value of t		
Tested @ 5% level of Significant							

The table shows that the computed value of t at 1.0766 is lesser than the tabulated t-value of the same test statistics at 2.0054. This accepts the null hypothesis of no significant difference between the perceptions of the respondents as to the extent of the level of acceptability of the design system of the Smart Fire Alarm System with Built-in Sprinklers and Auto Shutdown Technologies. The indicated difference means that the two groups perceived the items on the design system as similar. The stated difference in means was not enough to mean a real difference. This further entails that the respondents of this study used the device for electronics exercises as part of the required competencies.

Summary of Findings

The study on the effectiveness of Modern Fire Alarm Panel with built-in Sprinkler and Automatic Shutdown Technologies provides valuable insights into various aspects of the system's performance and acceptability. Firstly, the demographic profile of the respondents reflects a diverse range of marital statuses, genders, educational backgrounds, and economic statuses, offering comprehensive insights into the potential user base.

The assessment of the system's special features reveals a high level of acceptability, with indicators like advanced detection systems, intelligent alarm notification, and integration with sprinkler systems consistently rated as “Very Highly Acceptable” or “Highly Acceptable.”

This suggests a strong consensus among respondents regarding the effectiveness and desirability of these features. The result of this finding was corroborated with the previous study conducted by Evans et al (2013) that sustainable use of sprinkler system will improve water management and could clearly acquire the potential to positively impact crop water productivity, water and energy conservation, and the environment.

Similarly, the evaluation of the sprinkler system based on reliability, effectiveness, integration, compatibility, ease of installation, and maintenance indicates consistently high levels of acceptability across all indicators. The results are also compatible with previous research findings that suggest that the implication or evaluation of this system is always in accord with the efforts on developing and promoting practices that are deemed most feasible and effective (Ndamani & Watanabe, 2017). These findings suggest that the system meets or exceeds expectations in key areas, making it suitable for deployment in various contexts.

The breakdown of materials and estimated costs highlights the substantial investment required, primarily due to installation components such as the sprinkler system. However, considering the critical role of fire alarm systems in safeguarding lives and property, the investment is deemed justifiable for ensuring safety and regulatory compliance. Similarly, according to Hossain (2021), the fire alarm system, which utilizes sprinklers as initiating devices, provides comprehensive coverage for the safety of the structure, safeguarding both the property and stored goods.

The acceptability of the system is further confirmed by various stakeholders, including students, professionals, faculty, and electrical and electronic engineers, who perceive it as highly effective, reliable, and useful. The system's safety features are also highly rated, with indicators such as safety habits application, preparation of tools and materials, and proper housekeeping being deemed very highly acceptable.

Overall, the study's findings suggest that the Modern Fire Alarm Panel with built-in Sprinkler and Automatic Shutdown Technologies is highly effective, reliable, and acceptable across various dimensions, making it a valuable asset for enhancing fire safety measures in residential and commercial settings.

Conclusion

In conclusion, the integration of modern fire alarm systems with sprinkler technology and automatic shutdown capabilities presents a significant advancement in fire safety measures. The study has emphasized the pressing requirement for innovative ways to tackle the difficulties encountered by firefighting operations, especially in regions such as the Philippines where limited resources and obsolete equipment impede efficient response to fire situations. By combining early detection mechanisms with automated response systems, such as built-in sprinklers and power shutdown features, the proposed system offers a comprehensive approach to fire prevention and mitigation. The research findings highlight the feasibility and effectiveness of implementing such integrated systems among residents in Cebu City, providing valuable insights into technical requirements, user perspectives, and potential advancements. Moreover, the study emphasizes the broader implications of this technological innovation, benefiting various stakeholders including fire departments, building owners, insurance companies, regulatory agencies, technology manufacturers, academia, and homeowners. Moving forward, the incorporation of intelligent fire safety systems signifies a substantial advancement in improving comprehensive fire safety regulations and safeguarding lives and property from the destructive consequences of fire crises.

Recommendation

According to the research study's findings on modern fire alarm systems enhanced with smart sprinkler integration and automatic shutdown technologies, several recommendations emerge to optimize the implementation and effectiveness of such systems.

First, we recommend close collaboration between fire departments and emergency services, technology developers, and local authorities to facilitate the adoption of these innovative fire safety solutions. This collaboration can include training programs for firefighters and emergency responders to familiarize them with the operation and maintenance of integrated smart fire alarm systems. Additionally, building owners and facility managers must give priority to installing advanced fire protection systems in commercial, residential, and industrial buildings. This will improve the safety of occupants and reduce property damage. In addition, insurance companies and risk assessors should consider incentivizing the adoption of integrated smart fire safety systems through adjusted underwriting guidelines and premium discounts, thereby promoting widespread adoption among property owners.

Regulatory bodies and standards organizations are essential in ensuring that these systems are functional and compliant. They achieve this by either revising existing rules or creating new standards specifically designed to integrate smart fire safety technology. In addition, technology makers and providers should persist in developing and improving their products to cater to the important demands and ardent desires of clients looking for all-encompassing fire safety solutions.

Finally, ongoing research and development efforts in academia and research institutions should focus on optimizing integrated smart fire safety solutions for specific applications and environments, further advancing the field of fire safety engineering and technology. By implementing these recommendations, stakeholders can collectively contribute to the widespread adoption and effectiveness of modern fire alarm systems enhanced with smart sprinkler integration and automatic shutdown technologies, ultimately improving overall fire safety standards and saving lives.

OUTPUT OF THE STUDY

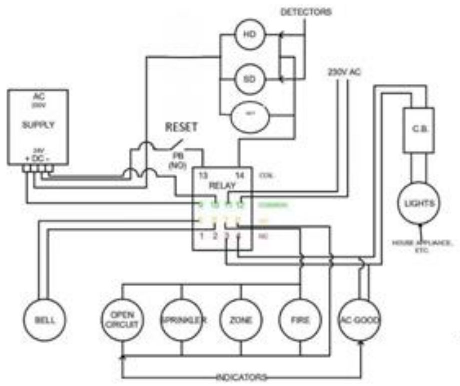
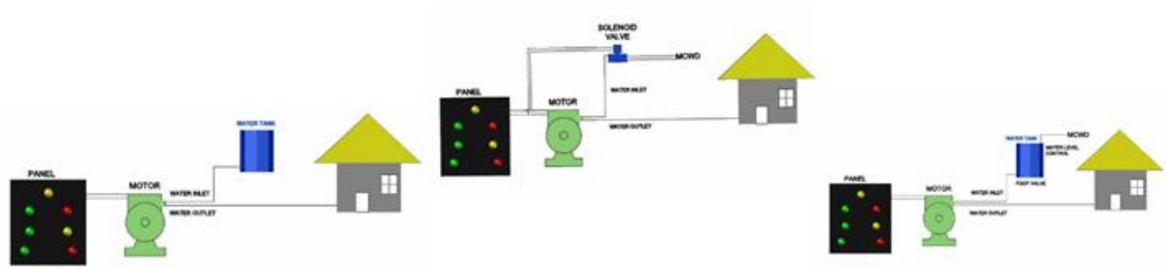


Diagram of modern fire alarm panel

Actual prototype of modern fire alarm panel


C

Inside wiring of modern fire alarm panel



3 types of installation process

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