DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Design document for

AlertSense

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ALERTSENSE

Empowering Soundless Safety

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LIST OF ABBREVIATIONS

AAC – Advanced Audio Coding

ADC – Analog-to-Digital Converter

ANSI – American National Standards Institute

DAC – Digital-to-Analog Converter

DHCP – Dynamic Host Configuration Protocol

DNS – Domain Name System

EULA – End User License Agreement

FCC – Federal Communications Commission

FIFO – First-In-First-Out

GPL – General Public License

GUI – Graphical User Interface

I2C – Inter-Integrated Circuit

IC – Integrated Circuit

IP – Internet Protocol

MIPS – Million Instructions Per Second

MSRP – Manufacturer Suggested Retail Price

PCB – Printed Circuit Board

SPI – Serial Peripheral Interface

TCP – Transmission Control Protocol

UDP – User Datagram Protocol

WTA – WIZnet Tester Application

EXECUTIVE SUMMARY

AlertSense addresses a critical challenge faced by individuals with hearing impairments and heavy sleepers during nighttime emergencies. The product offers a unique solution to the lack of effective alarm systems tailored to this specific demographic. Existing alarm systems primarily rely on audible alerts, rendering them ineffective for those with hearing impairments or extremely deep sleepers. AlertSense fills this gap by incorporating a multi-faceted approach, utilizing visual signals, vibrations, and smart technology to ensure individuals are promptly alerted to potential dangers such as fires, gas leaks, or intruders without relying on traditional auditory cues. This innovative design showcased in Figure 1 seeks to enhance the safety and well-being of users who cannot rely on conventional emergency alert systems.

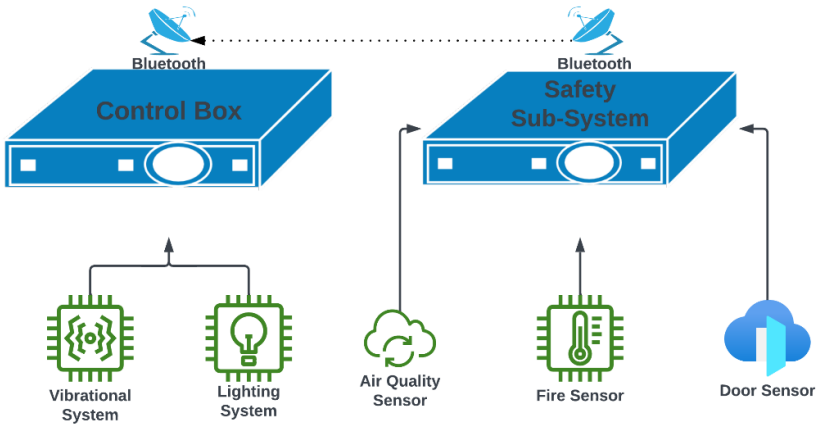

Figure 1: AlertSense High-Level Diagram

AlertSense addresses the core requirements of seamless integration into the user's environment, delivering timely and clear alerts about threats like fires, intruders, and gas leaks while prioritizing comfort. The system meets high-reliability standards and adheres to safety and accessibility norms. Key constraints encompass considerations of size, weight, and cost to maintain practicality and affordability, ensuring alignment with industry standards for assistive devices. Operating in less than one second underscores its commitment to user safety. The product complies with significant standards, such as the National Fire Protection Association's 70 Articles 240 and 300, Bluetooth Core Specification Version 5.2, and the FCC.

The core approach to the AlertSense system centers around a fusion of hardware and software components. At its center is the Arduino Uno WiFi Rev 2 microprocessor, chosen for its processing power, connectivity capabilities, and cost-effectiveness. This central processing unit orchestrates communication and coordination among subsystems, including the Vibrational, Lighting, and Safety systems. The software infrastructure employs HTML, CSS, and JavaScript to craft a user-friendly web application. This interface empowers users to set alarms, configure system parameters, and interact with the AlertSense system effortlessly. The selection of these technologies aligns with AlertSense’s commitment to accessibility and ease of use.

In conclusion, AlertSense pioneers an effective emergency alert solution for individuals with hearing impairments and heavy sleepers. The design integrates vibrational, visual, and auditory cues, laying a strong foundation. Future improvements involve Bluetooth integration and web application improvements. By providing discreet and tailored notifications, AlertSense enhances safety and peace of mind.

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1. PROBLEM STATEMENT

People who are heavy sleepers or have hearing disabilities could potentially face danger during the night due to hearing impairments. AlertSense solves these struggles by appealing to the user's other senses to wake them.

1.1. Need Statement

Every day, many people sleep through their alarms during the night. Many people who struggle to wake up have hearing disabilities, while others are heavy sleepers. It is dangerous for the sleeper to not wake during a fire, intruder, or gas leak. On average, 4000 Americans die each year from house fires [8]. Almost half of the yearly home fire deaths occur between 11 p.m. and 7 a.m. [9]. It is imperative to have an alarm system that can alert those who struggle to wake up via other senses than solely hearing. Another problem for those who cannot wake up is home break-ins. Annually, one million home break-ins occur in the United States, with almost a third occurring during the night [10]. A door alarm that wakes the user would increase the safety factor of the user. Lastly, the threat of a gas leak may threaten the sleeper's safety. It would be helpful to have a gas alarm that could wake the user. A system to wake heavy sleepers and people with hearing impairments during emergencies is needed to ensure their safety.

1.2. Objective

The proposed design solution, AlertSense, is a device meant to ensure reliability and safety for people with hearing impairments during their sleep. There are two main parts of this system. The first part is the control box which houses the battery, processor, and safety system. The safety system features different sensors to detect molecules in the air from a fire and a door sensor to detect intruders. The second main part of AlertSense is the vibrational system. This system has multiple vibrational motors to ensure the user is woken up properly as well as a lighting system to alert more bodily sense. Hence, AlertSense utilizes multiple devices to alert a user during their sleep in case of danger.

1.3. Background and Related Work

AlertSense provides a multi-sensory solution to a common alarm clock for people with hearing impairments or heavy sleepers. Most standard alarm systems for people with a hearing impairment include a light shining in their eyes during the night. Outside of the lighting system, there are no other options for the hearing impaired. Our design would integrate that system with a dimmer light for eye safety, but also with the addition of vibrational movement. [11]

1.3.1. Overview

AlertSense is designed with inclusivity and safety in mind. It incorporates innovative technology to alert individuals who may not hear traditional audible alarms, ensuring they are equally protected in emergencies. Utilizing a combination of visual signals, vibration, and connected smart technology, our system provides comprehensive alerts that can be customized to meet specific needs, allowing individuals with hearing impairments to live confidently and securely in their homes.

2. DESIGN REQUIREMENT SPECIFICATIONS

AlertSense is an alarm system with advanced security and safety features that alert the user if someone is attempting to break into the user's house or if there is a fire present. The device is primarily for people with hearing impairments or sensory impairments but can also be utilized by people who have trouble awakening. AlertSense aims to solve safety risks that could arise during the night.

2.1 Requirements

AlertSense is a system that utilizes carbon monoxide and door sensors to alert a user during the night in cases of danger. With AlertSense being primarily a safety device, a high level of standards is necessary to ensure the safety of its users. Hence, the following section outlines the requirements needed to ensure the best and safest experience for the user.

2.1.1 Marketing Requirements

The marketing requirements for AlertSense are as follows:

1. AlertSense detects an intruder.
2. AlertSense detects a fire.
3. AlertSense shines a light in the user's face to ensure that the user awakens.
4. AlertSense vibrates the user's bed without causing damage to the bed frame.
5. AlertSense connects to the user's smartphone to set alarms.
6. AlertSense allows the user to disable the alarm in cases of a false alarm.
7. AlertSense wakes a user in the case that they are a heavy sleeper.
8. AlertSense has a simple setup for all users.

Figure 2-1 gives a layout of all the marketing requirements for Alert Sense. AlertSense has three main branches which include safety, user-friendliness, and versatility. From these three branches, AlertSense has several measures in place to uphold those three main values.

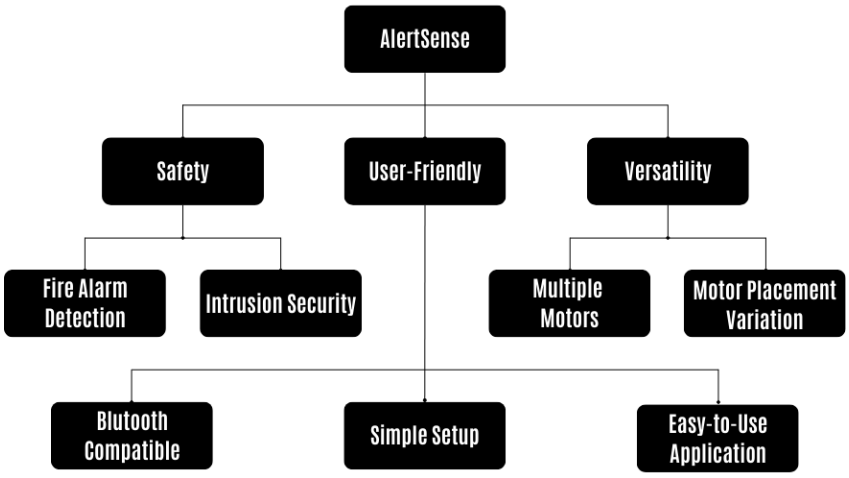


Figure 1-1: Objective Tree for AlertSense

Hence, the objective tree in 2.1 gives a broad overview of the many different marketing requirements stated above. The figure also showcases how AlertSense handles those requirements and upholds the values and standards of safety, user-friendliness, and versatility.

2.1.2 Engineering Requirements

Table 2.1 outlines the major requirements associated with AlertSense. These requirements specify technical details regarding AlertSense's safety and ease-of-use features. AlertSense meets all these requirements to ensure its users are satisfied with usability and safety.

Table 1.1: Engineering Design Requirements

Marketing Requirements	Engineering Requirements	Justification
1	The door sensor can detect changes in the magnetic field in less than 1 second.	Magnetic sensors must send a message to the receiver instantaneously to alert the user of danger [2].
2	Carbon monoxide sensors detect heavy concentrations of carbon monoxide in the air in parts per million in less than 1 second.	Carbon monoxide sensors must instantaneously identify specific particles signaling a fire [3].
3, 5, 8	AlertSense can output from 50 watts up to 100 watts.	This power range displays both the minimum and maximum amount of wattage required to sustain the motors for vibration [1].
3, 4, 5, 8	AlertSense can output a low of 4 volts to a high of 10 volts.	This is the voltage needed to power the dimming light and move the frame at different intensity levels [1].
6, 7, 9	AlertSense consists of 2 processors that are Bluetooth compatible.	Bluetooth allows the user to easily access the AlertSense application [7].

AlertSense detects changes in the magnetic field in less than one second. This guarantees that the door sensor triggers almost instantaneously so that the device can send a signal to the control module to ensure maximum safety.

AlertSense detects carbon monoxide in the air in parts per million in under one second. This is to certify that in the case of a fire in the home, the user is alerted immediately to the safety hazard and can escape the building unharmed.

AlertSense outputs from 50 watts to 100 watts of power. AlertSense can also only output a low of 4 volts to a high of 10 volts. These measurements ensure that the vibration is not too robust that damage is caused to the bed frame or the user, while also certifying that the vibration is not so weak the motors are ineffective.

AlertSense consists of a processor that is Bluetooth-compatible. This guarantees that any user with a smart device can access the AlertSense app and control the alarm system via their device.

2.2 Constraints

Table 2.2 outlines the major constraints associated with AlertSense. AlertSense remains a device that ensures the safety of its users while limiting itself to the listed constraints.

Table 2.2: Constraints

Type	Name	Description
Economic	Cost	AlertSense has a cost constraint of $1000 allotted by the electrical and computer engineering department.
Adaptability	Versatility	The AlertSense system has four motors located on each of the four corners of the bed to ensure versatility regardless of the size of the bed.
Manufacturability	Size	The physical dimensions are 6" high, 9" wide, and 9" deep.
Health and Safety	Reliability	AlertSense has a built-in battery pack to ensure that in the case of a power outage, safety systems are still operational.
Health and Safety	Electrical Safety	AlertSense has an enclosure that protects all the wiring for the system. This enclosure ensures maximum protection of the user from possible hazards [4].
Sustainability	Functionality	The four motors included with the AlertSense system are placed between two fitted sheets. The sheets allow for vibrational absorption to avoid bed frame damage.

2.2.1 Economic Constraints

AlertSense does not exceed a total cost of $1000. This amount is provided by the electrical and computer engineering department. The product is also cost-effective for the user.

2.2.2 Adaptability

The AlertSense system is compatible with multiple bed sizes and types. Due to this constraint, the AlertSense system features four motors on each of the bed's four corners. The location of each motor guarantees versatility and allows for proper vibrational levels for all bed types.

2.2.3 Manufacturability

The dimensions of the control module are 6” high, 9” wide, and 9” deep. These dimensions ensure that it does not take up too much space on the bed while still having adequate space for components.

2.2.4 Health and Safety

Due to AlertSense being used to ensure the safety of people with hearing impairments, the system does not falter in the case of a power outage. To ensure that this constraint is met, AlertSense features a battery pack that activates if the main power source fails.

AlertSense has several motors and wires that could result in hazardous conditions for the user if not kept enclosed. To ensure maximum safety for the user, AlertSense features an enclosure that protects the user from any wire faults or other hazardous materials [4].

2.2.5 Sustainability

AlertSense features several motors that have the potential to damage bed frames. To ensure that AlertSense does not cause any damage, AlertSense features padding around the motors. The motors are also located between two fitted sheets which allows for the system to vibrate the bed while also leaving the frame intact.

2.3 Standards

Table 2.3 outlines the major standards associated with AlertSense. AlertSense complies with all major standards set forth by IEEE, the National Fire Protection Association, Bluetooth, and the FCC.

Table 2.3: Engineering Standards

Specific Standard	Standard Document	Specification/Application
Insulation	The National Fire Protection Association 70 Articles 240 and 300.	The plastic enclosure prevents shock or electrocution of the user [4].
Bluetooth 5.2	Bluetooth Core Specification Version 5.2	Bluetooth ensures easy connectivity with a user's smartphone [7].
Software and System Testing	IEEE Standard for Software and System Test Documentation 829-2008	This practice is standard for testing the hardware and software of products [5].
FCC Section 15.109	Class B Digital Devices	This standard helps to avoid interference from other devices within 10 meters of the system [6].

2.3.1 Testing Standards

AlertSense follows IEEE standards for software and system testing. These standards ensure the system is up to code and runs properly.

2.3.2 Communications Standards

AlertSense uses Bluetooth version 5.2 for communication between a tablet or smartphone to the control module. This version of Bluetooth uses standards from the Bluetooth Core Specification Version 5.2 documentation [7].

2.3.3 Electrical Standards

AlertSense uses standards for overcurrent and wiring from NFPA 70, Articles 240, and 300. By following the standards brought forth in these articles, AlertSense meets all standards for shock absorption and fire hazards [4].

AlertSense use is generally within residential areas, which warrants the need for interference prevention from signals or other digital devices. Hence, AlertSense utilizes standards from FCC Section 15.109 for digital device interference [6].

3. DESIGN APPROACH

In this section, the approach to the project is explored, targeting the development of an innovative alarm system designed to awaken individuals with hearing impairments or deep sleepers during nighttime emergencies. To navigate this phase of the design, AlertSense has organized the content into three primary components: Design Options, System Overview, and Subsystem Descriptions. Within these sections, vital elements are outlined that inform the approach. In line with a commitment to delivering a user-centric solution, AlertSense prioritizes critical requirements, constraints, and standards that include ensuring user safety through timely alerts, complying with accessibility guidelines for individuals with hearing impairments, and delivering non-auditory sensory cues to communicate vital information.

3.1 Design Options

When developing a system that is designed for individuals with hearing impairments, it is imperative to explore various design options to ensure that the final solution is not only effective but also innovative and user-friendly. This section describes design alternatives and choices that were considered during the planning phase. Each design option represents a unique path to achieving AlertSense's project goals, and the selection of the most appropriate approach was driven by the careful evaluation of factors such as technology, materials, user experience, and accessibility. By assessing these design options, AlertSense aims to ensure that the resulting alarm system is not just functional but optimal to meet the specific needs of its target users, providing them with a heightened sense of safety and security during the night.

3.1.1 Design Option 1

The first design option proposed by AlertSense was utilizing multiple vibrational motors strategically integrated into the mattress itself, providing a direct means of alerting the user. These motors were synchronized with a dimming light source located overhead, which was designed to provide a visual component to the alert system. To coordinate these components, a control box was incorporated into the system. This control box housed an array of sensors for detecting potential hazards, a microcontroller for controlling the system, and a backup power source to ensure the system's reliability even in the event of a power outage. This design keeps the motors away from the user and uses fewer materials, keeping the price economical. The

downside of this design was that there was less reliability from the motors. The only solution to this problem would have been to increase the vibrational power, which in turn would have decreased the integrity of the bed frame.

3.1.2 Design Option 2

The second design option, similar in many aspects to the first design, introduced a different method of implementing the vibrational alert system. In this iteration, multiple vibrational motors were placed within a nonconductive sheeting, designed to be both shock and fireproof, ensuring the user's safety during emergencies. This sheeting served as the surface upon which the user sleeps. To enhance the precision and effectiveness of the vibrational alerts, the motors were divided into sections within the sheeting. This sectionalization allowed for specific patterns and locations of vibrations, which were programmed to convey different alerts. Implementing the motors in this design increased the reliability of the motors while simultaneously not affecting the integrity of the bed frame. The downside is that this requires a more direct approach, which poses more risks and increases the budget to maintain safety. AlertSense opted for this choice because it provides a tactile sensation that users can feel without the need to alter or damage the bed frame.

3.2 System Overview

The system overview provides a comprehensive perspective on the design, functionality, and key elements of the alarm system. This section presents the high-level architecture through Level 0 and Level 1 diagrams, along with an in-depth exploration of the core microcontroller that governs the system's operations.

In Figure 3-1, the Control Module serves as the core of the alarm system. This Control Module acts as the control hub for all system functions and interfaces directly with the user. The user is the primary external entity, representing the end users who interact with the system. The Control Module receives input from the Detection Sensors, which include sensors for intruder detection and fire monitoring. The Control Module processes the sensor data and, based on its analysis, triggers the appropriate responses in the User Alert Interface.

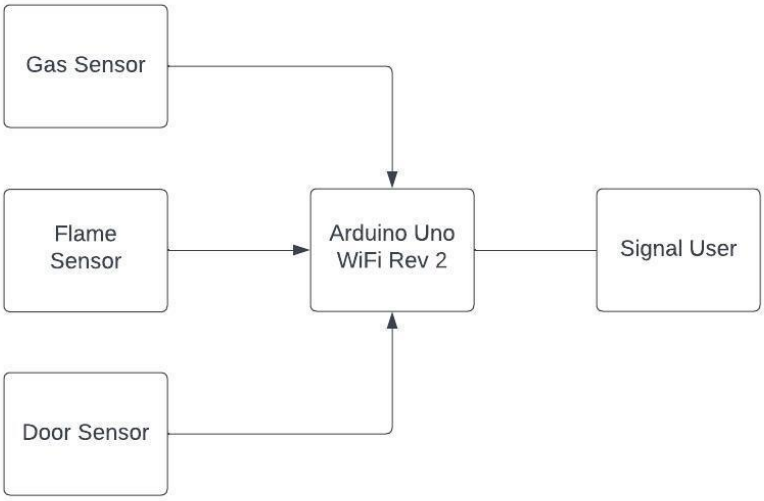


Fig. 3-1: AlertSense at a Glance (Level 0) [15]

In Figure 3-2, the Control Module serves as the central hub, controlling communication with the various subsystems. This diagram highlights the interconnections between the Control Module and each subsystem, including the Safety System, Vibrational System, Lighting System, and Application. It visually conveys how the Control Module is the main component responsible for managing the data flow, commands, and responses between these subsystems, ensuring the effective operation of the entire alarm system.

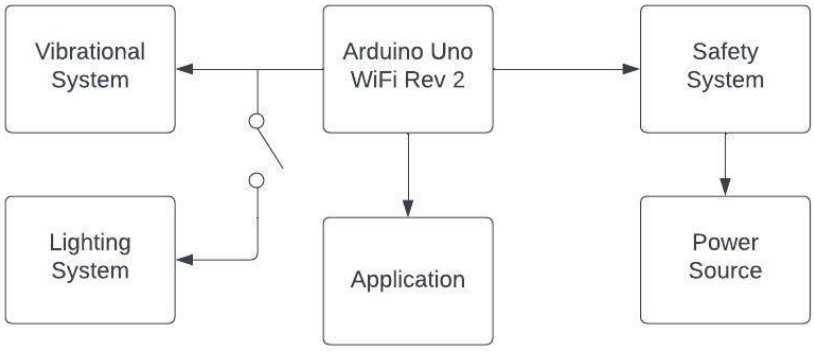


Fig. 0-2: AlertSense Functionality (Level 1) [15]

3.2.1 Microcontroller

The central processing unit for AlertSense is the Arduino Uno Rev 2, responsible for overseeing all subsystem connections and instructions. This microcontroller, showcased in Figure 3-3, was chosen for its robust processing capabilities, extensive connectivity options, and cost-effectiveness. While the ESP32 was considered for its impressive capabilities, it was ruled out due to its lack of embedded libraries and coding complexity. Similarly, the Raspberry Pi, with its substantial processing power and alignment with most criteria, was not chosen because of its steep learning curve in coding and higher cost. Table 3-1 is a comparative table of the microprocessors considered.

Table 3.1 Microcontroller Alternatives

Product Name	Operating Voltage (V)	I/O Pins	Wi-Fi/Blue-tooth	Price ($)
Requirements	>3	>6	YES	<100
Arduino Rev 2 [6]	6-20	20	YES	58
Raspberry Pi [7]	5.1	14	NO	80
ESP32 WROOM-32E [8]	3-3.6	34	YES	59

Fig 3-3: Arduino Uno Rev 2 [6]

In summary, the System Overview section offers a comprehensive insight into the AlertSense alarm system. The Level 0 diagram simplifies the representation of core system elements, underscoring the significance of the Control Module and User Alert Interface. In the Level 1 design, the integration between the Control Module and subsystems, including the Lighting System, Vibrational System, Safety System, and Application, is explored in detail, with a focus on the central role of the microprocessor in system control.

3.3 Subsystem Descriptions

The prototype for AlertSense comprises five subsystems. Subsystem 1 is the Control Module, housing the Arduino unit that orchestrates the operation of all other subsystems, as well as the Bluetooth module for external connectivity. Subsystem 2, the Lighting System, features a dimmable light source that shines directly in the user's face, providing a visual alert in response to a safety system trigger. Subsystem 3, the Vibrational System, employs motors to deliver bed vibrations when the Safety System detects a threat, awakening the user discreetly. Subsystem 4 encompasses the Safety System, equipped with carbon monoxide, air quality, and door sensors, which collectively monitor environmental conditions and potential intrusion or danger. Finally, Subsystem 5, known as the Application and Website system, includes both a user-friendly interface and a website. The application serves as the central control hub, connecting to the Arduino and facilitating user interaction with the alarm system. Simultaneously, the website complements the application by providing users with an online platform where they can access further resources, updates, and support from AlertSense.

3.3.1 Control Module

The control box serves as the secure enclosure for housing sensitive and potentially hazardous equipment within the system. It is designed with dimensions of 6 in L x 9 in W x 9 in H, providing ample space to house critical components, including backup batteries and processors for various subsystems. For safety and early detection, fire and gas sensors are seamlessly integrated into the sides of the control box. Additionally, air vents have been thoughtfully included to ensure proper ventilation and prevent overheating, guaranteeing the reliability and safety of the system even in challenging conditions.

To ensure uninterrupted operation during power outages, an emergency battery plays a vital role in supplying continuous power to the sensors and motors. The control box is designed to accommodate the battery pack while also featuring an automatic charging mechanism. This design allows the system to remain functional without manual intervention. The sensors are required to maintain activity for a minimum of 24 hours, crucial for reliability during emergencies such as fires or intrusions. While in standby mode, the sensors consume a minimal amount of power. Consequently, the battery possesses sufficient capacity to sustain

both the standby mode of the sensors and power the motors [4]. It is essential that the dimensions of the battery align with the constraints of the control box and do not exceed the specified weight limit to ensure seamless integration and optimal performance. Finally, the cost minimum cost is simply decided by how much budget is left. Table 3-2 describes the battery options considered by AlertSense.

Table 3.2 Battery Options

Product	Power Capacity (mAh)	Power (W)	Weight (lb)	Dimensions (in) (LxWxH)	Cost ($)
Requirements	>500	-	< 20	-	<400
ZeroKor Portable Power Bank [10]	24000	65	1.6	6.8 x 3.8 x 1.8	66.98
DenGaWah Portable Power Bank [9]	67500	250	5.1	8.5 x 6.7 x 4.1	139.99
Mormluck Portable Power Bank [5]	24000	127	2.3	6.7 x 3 x 4	119.99

For the backup power source, AlertSense has opted for the Mormluck battery, as depicted in Table 3-2. This battery is selected based on its capacity to provide steady power, sustaining multiple sensors for a minimum of 24 hours. Additionally, it can deliver a substantial voltage boost, sufficient to activate the motors for no more than 1 minute. During standby mode, the combined power consumption of all sensors is calculated to be at least 13mAh. Figure 3-4 shows the method used to determine the minimum current. The Mormluck battery, containing a capacity of 24000mAh, exceeds this requirement, ensuring extended sensor activity for over 24 hours [4]. Importantly, this battery can be connected to a constant power source through an outlet for continuous replenishment. The Mormluck battery emerges as a highly favorable option as it fulfills all specified requirements and budget considerations.

$$\text{Power (Watts)} = \text{Voltage (Volts)} \times \text{Current (Amps)}$$

$$\text{Current (Amps)} = \frac{\text{Power (Watts)}}{\text{Voltage (Volts)}}$$

$$\text{Battery Capacity (Ah)} = \left[\frac{\text{Power (Watts)}}{\text{Voltage (Volts)}}\right] \times \text{Time (Hours)}$$

Fig. 3-4: Calculations and Mormluck Battery [5]

The straightforward formula shown above was employed to calculate the required battery capacity to maintain AlertSense in standby mode for a minimum of 24 hours. The system comprises multiple sensors that draw only minimal current in micro-amps. Consequently, each battery option considered fulfills the requirement to sustain the system's operation for extended periods, ensuring reliable functionality.

3.3.2 Lighting System

The Lighting System collaborates with the Vibrational System to offer an extra means of alerting the user during emergencies. It is seamlessly linked to the control box, enabling immediate activation of the light when a threat is detected. For user convenience, a wall mount with simple installation is included to position the light directly above the user, featuring a low-wattage, eye-friendly light source. The available light options are outlined in Table 3-3 for reference.

Table 3.3: Lighting Options

Product	Wattage (W)	Rated Lifetime (hours)	Cost ($)
Requirements	< 21	-	< 50
Philips LED Bulb (Dimmable) [16]	12.2	15,000	9.99
LAIFUNI Dimmable Under Cabinet Light Bar [17]	15	54,000	46.89
American Lighting LED BRIO 5CCT 6” [18]	12	50,000	27.72

AlertSense incorporates the Philips LED Bulb shown in Figure 3-5 for its lighting needs, primarily selected for its cost-effectiveness and eye-friendly design. The dimmable feature serves to reduce the potential for eye strain. While this bulb may have a slightly shorter rated lifetime compared to alternative options, its affordability and ease of replacement make it a practical choice.

Fig 3-5: Philips LED Bulb (Dimmable) [16]

The light necessitates a wall mount for optimal positioning directly above the user, enhancing its effectiveness in waking the user during emergencies. The provided wall mount is designed for easy installation and extends adequately to ensure precise light placement. Table 3-4 provides an overview of the various wall mounts evaluated by AlertSense.

Table 3.4: Wall Mount Options

Product	Arm Length (in)	Rated Wattage (W)	Material	Cost ($)
Requirements	> 12	> 12	-	< 50
TRLIFE Wall Sconce [19]	22	60	Metal	31.99

VONLUCE Modern Swing Arm Wall Mount Light [20]	14.2	40	Metal	39.99
PULLCU Swing Arm Wall Lamp [21]	18	60	Metal	49.99

The wall mount solution selected for AlertSense is the PULLCU Swing Arm Wall Lamp depicted in Figure 3-6. This choice extends up to 18 inches, guaranteeing that the light is optimally positioned beyond the bed frame and directly above the user. It is also perfectly compatible with the dimmable LED bulb, featuring a wattage rating that comfortably exceeds the bulb's requirements. Additionally, it comes with a lamp shade, which serves to direct the light and reduce the risk of eye strain or damage.

Fig 3-6: PULLCU Swing Arm Wall Lamp [21]

In essence, the Lighting System in AlertSense complements the Vibrational System for user alerting during emergencies. It utilizes the Philips LED Bulb for gentle, dimmable lighting and is efficiently positioned by the PULLCU Swing Arm Wall Lamp. This combination enhances user safety without compromising eye comfort.

3.3.3 Vibrational Subsystem

The Vibrational subsystem plays a vital role in the AlertSense system, consisting of a series of identical motors controlled by the central module. Its primary purpose is to offer an innovative alternative to traditional sound-based wake-up alarms by delivering gentle vibrations to the user's bed. To ensure an even and effective distribution of vibrations, these motors are strategically placed beneath the bed, and a protective cover is used to prevent damage to both the bed and the motors. Table 3-4 provides an overview of the motor options that best align with AlertSense's requirements and overall suitability for the device.

Table 3.5: Motor Options

Product	Operating Voltage (V)	Dimensions (mm)	Material	Cost ($)
Requirements	>= 3	-	-	< 15

Tatoko DC 3V 12000RPM Vibration Motor [22]	3	10 x 3	Stainless Steel	6.99
Tatoko DC Coreless Motor [23]	3	7 x 25	Stainless Steel	9.99
Bojack N20 DC Vibration Motor [24]	3	16 x 12	Metal	8.99

AlertSense opted for the Tatoko DC Coreless Motor shown in Figure 3-7 to serve as the primary mechanism for inducing vibrations in the user's bed. This motor is seamlessly integrated with the control module to streamline its operation. With a voltage range spanning from 1.5 to 3 volts, it offers users the versatility to fine-tune vibration intensity to suit their preferences. Notably, its waterproof design adds an extra layer of durability, ensuring its functionality remains unimpeded even in the presence of moisture. The Tatoko motor emerged as the best choice due to its sturdy build, promising a tactile yet comfortable vibration experience. Furthermore, it presents a cost-effective solution, and when multiple motors are deployed in unison, they collectively possess the strength to effectively rouse a sleeper from slumber.

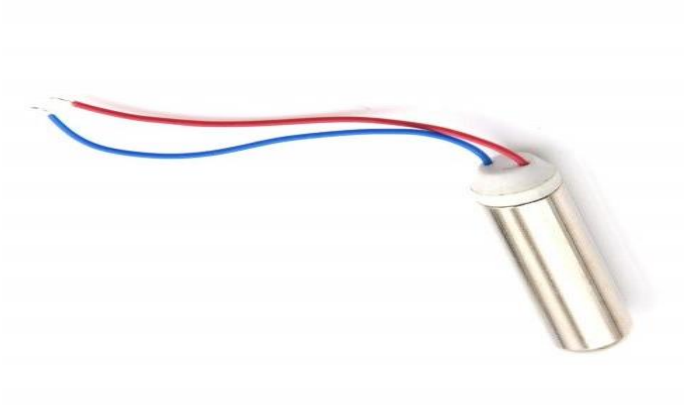


Figure 3-7: Tatoko DC Coreless Motor [23]

Thus, the Vibrational Subsystem is a key component of AlertSense, offering an inventive alternative to sound-based alarms through carefully selected Tatoko DC Coreless Motors. The even motor distribution under the bed, combined with protective coverings, ensures durability and user comfort. This section highlights AlertSense’s commitment to providing a cost-effective, reliable, and user-centric solution.

3.3.4 Safety System

Within the safety subsystem, three distinct functions are incorporated, consisting of a door sensor, a fire alarm, and an air quality alarm. The door sensor employs a magnetometer due to its simplicity and user-friendliness. Positioned on the door frame, a magnet is affixed to the door. When the door is opened, the

magnet shifts away from the sensor, leading to an alteration in the magnetic field, thus activating the sensor. The magnetometer swiftly detects this change and transmits a signal to the processing unit. Table 3-5 outlines the different magnetometer options.

Table 3.6: Magnetometer Options

Product	Operational Voltage (V)	Mount Type	Dimensions (In) (WxH)	Weight (g)	Cost ($)
Requirements	3-9	-	-	-	< 40
HiLetgo GY-271 HMC5883L [1]	3.3	PCB Mount	0.55 x 0.16	13.9	6.69
HiLetgo Mpu9250 GY-9250 [7]	5	PCB Mount	0.59 x 0.98	17.9	14.99
WitMotion WT901 [8]	3.3-5	Surface Mount	2.95 x 0.83	18	33.90

The HiLetgo GY-271 HMC5883L Magnetometer, as depicted in Figure 3-9, was selected for magnetic field detection. This magnetometer provides data representing the strength of the magnetic field, measured in gauss (G) or unit tesla (T). By assessing the magnet's proximity to the magnetometer, the position of the door can be determined, establishing a straightforward door sensor. This magnetometer stands out due to its affordability, compatibility with Arduino systems, and its low operating voltage. These specifications align perfectly with the project's requirements, making it a logical and cost-effective choice for the door sensor application.

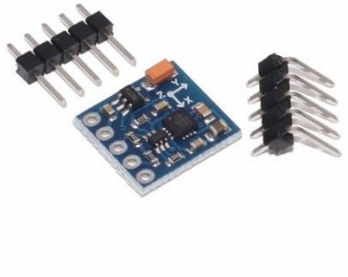


Figure 3-8: HiLetGo GY-271 HMC5883L Magnetometer [1]

As depicted in Figure 3-9, the magnetometer is equipped with extra mounts suitable for PCB usage, facilitating testing with a breadboard setup.

To address fire detection, a specialized fire sensor was selected. This component operates by detecting fire through the assessment of infrared radiation. It achieves this by employing an infrared radiation photodiode to measure levels of infrared radiation, subsequently comparing these levels with a predefined threshold to determine the presence of a fire. Notably, the fire sensor is housed in a separate enclosure, distinct from the primary module, ensuring dedicated functionality and efficient response in fire detection scenarios. Table 3-6 showcases the different flame sensor options.

Table 3.7: Flame Sensor Options

Product	Operational Voltage (V)	Temperature Rating (C)	Dimensions (In)	Weight (g)	Cost ($)
Requirements	3-9	-	-	-	< 30
Oiyagai 5pcs IR Flame Sensor Module [2]	3-5	60	2 L x 0.59 W x 0.59 H	5	10.60
KY-026 3pcs Flame Sensor [11]	0-15	60	1.41 W x 0.63 H	9	7.00
LM393 4 Pin IR Flame Detection Sensor Module [12]	3.3-5	60	3.94 W x 1.18 H	74.6	26.03

The Oiyagai Flame Sensor Module, as featured in Figure 3-10, was integrated for fire detection within the system. The selection of the Oiyagai Flame Sensor Module was due to its price and low operating voltage. While considering alternative options, the KY-026 sensor almost met the specifications; however, it lacked clarity on its operating voltage requirements. In contrast, the LM393 sensor fulfilled the criteria for temperature, voltage, and dimensions but was heavy, making the Oiyagai Flame Sensor Module a more suitable choice for the specific application.

Figure 3-9: Oiyagai IR Flame Sensor Module [2]

In Figure 3-10, the flame sensor shows a slim design that lowers the overall weight and has an extruding IR photodiode that collects IR radiation data.

To address air quality concerns, an air quality sensor was incorporated into the system. This sensor is designed to monitor the air for harmful gases or unfavorable air conditions. It operates by assessing air quality parameters and promptly transmitting a signal to the processing unit if it detects any concerning problems. The air sensor is positioned at the top of the subsystem box, ensuring efficient monitoring of the surrounding air quality.

Table 3.8: Air Quality Sensor Options

Product	Operational Voltage (V)	Operating Humidity (%)	Dimensions (In)	Weight (g)	Cost ($)
Requirements	3-9	-	-	-	< 20
MQ – 5 Methane LPG Natural Gas Propane Sensor Detector Module [3]	5	95	1.25 L x 0.8 W x 1.1 H	7	5.69
Ximimark MQ 135 Air Quality Sensor [13]	5	95	5.71 L x 3.58 W x 1.06 H	17.9	8.99
MS1100 Gas Sensor [14]	2.6-5	90	6.22 L x 4.25 W x 0.83 H	58.9	12.99

For the detection of harmful gases, AlertSense used the MQ-5 Methane LPG Natural Gas Propane Sensor Detector Module, displayed in Figure 3-11. These MQ series air quality sensors incorporate a small heating element and an electrochemical sensor to identify the presence of noxious gases. The heating element warms the electrode's coating, rendering it more reactive. As a result, the resistance measurement fluctuates when gas is present, triggering the sensor and sending a signal to the processing unit. The choice of the MQ-5 sensor is due to its favorable attributes, including price, lightweight construction, and alignment with the AlertSense system's operating voltage requirements.

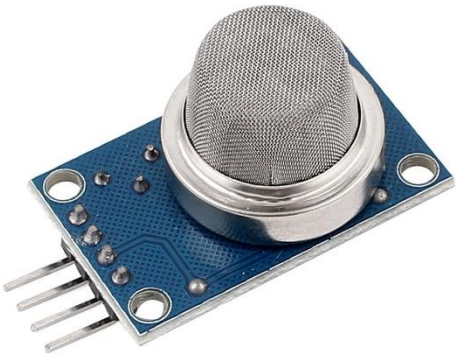


Fig. 3-10: MQ-5 LPG Natural Gas Propane Sensor Detector Module [3]

In Fig. 3-11, the gas detector module is made up of an electrode dome surface which contains a small heater and an electro-chemical sensor inside.

Thus, the safety subsystem section has provided an in-depth understanding of the components that contribute to the security and well-being of its users. The door sensor, fire alarm, and air quality alarm have each been carefully selected and integrated to ensure an efficient safety system. These components, along with the Oiyagai Flame Sensor Module and the MQ-5 Methane LPG Natural Gas Propane Sensor Detector Module, are vital in detecting potential threats such as intruders, fires, and harmful gases.

3.3.5 Application and Website

The Application Subsystem plays a pivotal role in AlertSense, acting as the central control point that facilitates user interaction. To meet its functional requirements, the application is designed for smartphones and tablets, ensuring broad accessibility. It utilizes Bluetooth Low Energy (BLE) for efficient communication with the Arduino control module, providing a reliable and energy-efficient link between the user and the alarm system. To ensure compatibility with both iOS and Android devices, the application is cross-platform, using React. In parallel, the website component is hosted on a dedicated web server, offering users resources, frequently asked questions, and support contact options. The website is constructed using modern web development technologies, including HTML, CSS, and JavaScript, guaranteeing easy updates and maintenance for long-term support. Data exchange with the Arduino relies on the Bluetooth Serial Communication (RFCOMM) protocol. This approach balances efficiency, cross-platform accessibility, and scalability, addressing the diverse needs of AlertSense's users.

HTML, CSS, and JavaScript are the optimal choices for developing a web app that communicates with an Arduino for various compelling reasons. First and foremost, these technologies offer cross-platform compatibility, ensuring that the AlertSense web app can run seamlessly on a wide array of web browsers and operating systems, thus reaching a broad user base. JavaScript, in particular, excels as a scripting language tailored for web applications, allowing AlertSense to create interactive and dynamic web pages that are ideal for real-time communication with external devices like the Arduino Uno via the web.

Moreover, HTML and CSS provide the foundational structure and styling for a web app, while JavaScript adds functionality without introducing significant overhead. This ensures that the web app remains responsive and efficient. The lightweight nature of these technologies is particularly advantageous. Additionally, JavaScript boasts a rich ecosystem of libraries and APIs that simplify web-based communication, making

it easier to establish connections with Arduino devices, and facilitating the exchange of signals and data. Figure 3-12 outlines the overall design of the web application.

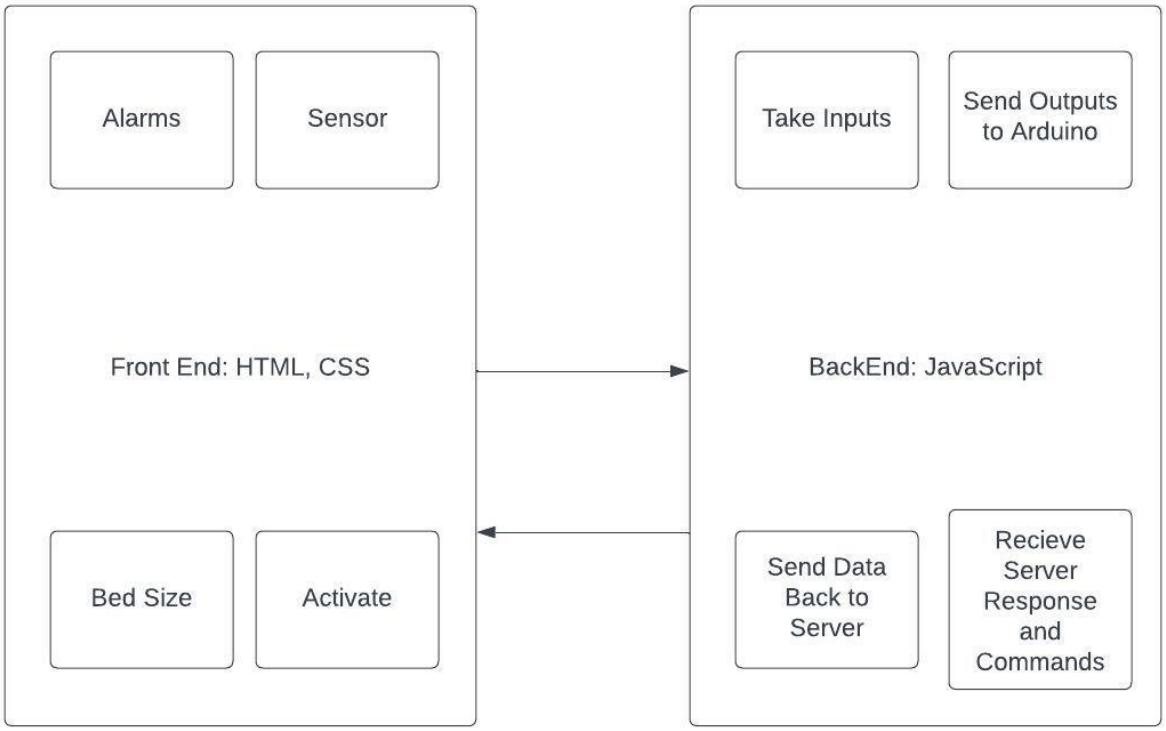


Figure 3-11: AlertSense Application Diagram [15]

On the front-end side in Figure 3-12, the application presents a user-friendly and intuitive interface for users to interact with the alarm system. The primary dashboard offers an at-a-glance view of the system's status, including active sensors and alarms. Within the application, users can fine-tune various settings, including bed size, sensor activation, and timing in which the sensors are activated. It also provides a dedicated section for managing sensor preferences, allowing users to enable or disable specific sensors based on their requirements. This aspect of the application design is written in HTML, CSS, and JavaScript.

The application communicates with the Control Module through Bluetooth technology due to the Arduino Uno having a built-in Bluetooth module. This data exchange facilitates the simplistic transmission of information related to sensor statuses, alarm settings, and user preferences.

Handling simultaneous events is crucial to ensure the application's responsiveness and reliability. The application utilizes event queue management and multitasking mechanisms. These mechanisms ensure that user-initiated commands, such as configuring alarms or adjusting sensor settings, do not disrupt the ongoing processing of sensor data. Effective error handling and asynchronous programming prevent potential problems like deadlock or livelock, guaranteeing that the application's code execution remains accurate and uninterrupted. This aspect of the application is written in JavaScript for data processing and signal transmission.

3.4. Level 2 Prototype Design

As AlertSense ventures into the next phase of its project in Design II, AlertSense's focus shifts towards transforming its comprehensive design specifications into a fully functional prototype. This stage marks a crucial transition from separated subsystems to a complete design. AlertSense intends to build a prototype that not only adheres to the specified design requirements but also exhibits the real-world reliability and user-friendliness that its target audience deserves. The AlertSense System involves precise assembly, thorough testing, and the refinement of user interfaces to ensure that the system not only meets but exceeds the expectations of those who rely on it for their safety. This section outlines strategies for the prototype's physical construction and testing.

3.4.1 Level 2 Diagram

Figure 3-13 shows the prototype with all the subsystems integrated. At the heart of the system, the Arduino Uno assumes the role of the central control unit, orchestrating the functions of the Vibrational System, Lighting System, Safety System, and Application and Website System. The Vibrational System, with its motor components, is directly connected to the Arduino Uno, producing bed vibrations to awaken the user during emergencies. Likewise, the Lighting System, equipped with a dimmable light source, connects to the Arduino Uno and emits visual alerts under the control of the central unit. The Safety System comprises various sensors, including those for carbon monoxide, air quality, and entry detection, all of which feed data into the Arduino Uno. This critical data input triggers alarms and notifications in response to hazardous conditions. The Application, designed as a mobile app and website, establishes a user interface through which individuals can customize alarm settings, deactivate sensors, and receive notifications. This interface is achieved through the Arduino Uno's built-in Bluetooth module, facilitating seamless communication between the user and the system. The close interplay of these low-level components ensures that individuals with hearing impairments are not only alerted to potential dangers but also provided with a user-friendly means of customization, resulting in a comprehensive and accessible alarm system.

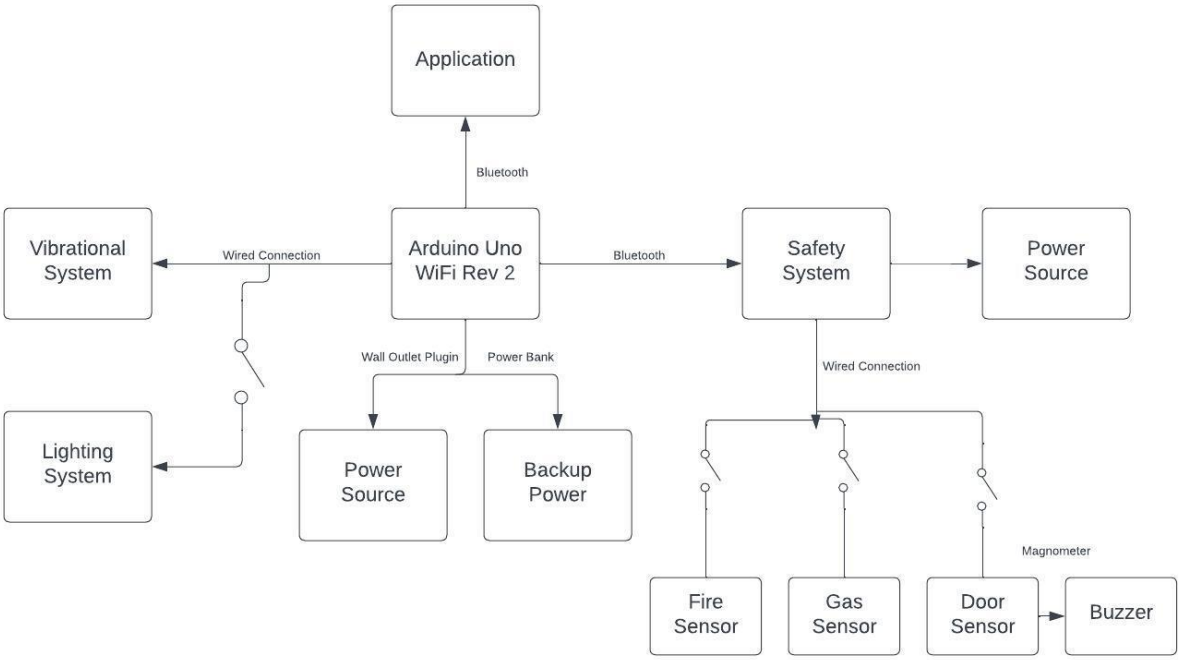


Fig. 3-12: Diagram for AlertSense (Level 2) [15]

AlertSense's commitment to adhering to industry standards, robust testing, and iterative user feedback positions AlertSense to develop a system that is both reliable and empathetic to the unique needs of its users. With the approach phase completed, the focus now shifts toward the testing phase, with the ultimate goal of enhancing the safety and well-being of those it serves.

4 EVALUATION

In this section, we delve into the crucial aspect of testing for AlertSense. As a product designed to provide effective emergency alerts for individuals with hearing impairments and heavy sleepers, testing plays a pivotal role in ensuring the reliability and performance of its key features. AlertSense combines vibrational, visual, and auditory cues to comprehensively address emergency alerts. The following details highlight the testing procedures conducted to validate the functionality and responsiveness of AlertSense, emphasizing its purpose, features, and intended market.

4.1 TESTING CERTIFICATION – SUBSYSTEMS

The AlertSense prototype comprises several major subsystems that synergistically work to address the specific needs of individuals with hearing impairments during emergencies.

The Safety System, equipped with door sensors, carbon monoxide sensors, air quality sensors, and fire sensors, plays a pivotal role in threat detection, triggering appropriate alerts. The Vibrational System, featuring strategically placed motors beneath the bed, introduces a non-intrusive method of waking up the user through gentle vibrations. Complementing this, the Lighting System utilizes a low-wattage LED bulb, specifically the Philips LED Bulb, for visual alerts that prioritize user comfort and cost-effectiveness. The Application Interface, representing the software component, offers a user-friendly platform for interacting with the system. Users can effortlessly set alarms, configure sensor settings, and manage various aspects of AlertSense through this interface. At the heart of the prototype is the Control Module, centered around the Arduino Uno Rev 2 microprocessor. Serving as the central hub, it connects and orchestrates the functionality of all subsystems. This integrated approach ensures a comprehensive and synchronized response to diverse emergency scenarios, making AlertSense a robust and versatile solution.

4.1.1 Control Module/Bluetooth (Subsystem 1)

- The control box serves as the secure enclosure for housing sensitive and potentially hazardous equipment within the system. It is designed with dimensions of 6 in L x 9 in W x 9 in H, providing ample space to house critical components, including backup batteries and processors for various subsystems to fit in tight remote spaces. Additionally, air vents have been thoughtfully included to ensure proper ventilation and prevent overheating, guaranteeing the reliability and safety of the system even in challenging conditions.

- To ensure uninterrupted operation during power outages, an emergency battery plays a vital role in supplying continuous power to the sensors and motors. The control box is designed to accommodate the battery pack while also featuring an automatic charging mechanism. The sensors must

maintain activity for at least 24 hours, crucial for reliability during emergencies such as fires or intrusions. While in standby mode, the sensors consume a minimal amount of power in the micro amps. Consequently, the battery possesses sufficient capacity to sustain both the standby mode of the sensors and power the motors [4]. The control module can transform and output the required voltage of 0 to 5 volts from another source's input. It is essential that the dimensions of the battery align with the constraints of the control box and do not exceed the specified weight limit to ensure seamless integration and optimal performance.

Test Writer: Thach Nguyen						
Test Case Name:		Back Up Power			**Test ID #:**	BU-P-01
Description		Ensures backup power in the case of a power outage.			**Type:**	☐ white box ☑ black box
Tester Information						
Name of Tester:		Thach Nguyen			**Date:**	
Hardware Ver:		Genwah Pack 1.0			**Time:**	
Setup:		The vibrational system will be connected to the back up power source not connected to the wall outlet.				
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	A signal will be sent to activate the motors.	When the arduino receives the signal the motors will run for the required duration time.	☑	☐	☐	
Overall Test Results			**1**	**0**	**0**	

Test Writer: Thach Nguyen						
Test Case Name:		Overheat Prevention			**Test ID #:**	OH-P-01
Description		Maintains normal temperatures during operation.			**Type:**	☐ white box ☑ black box
Tester Information						
Name of Tester:		Thach Nguyen			**Date:**	

Hardware Ver:				**Time:**		
Setup:		Ventilation methods will be in place to adequately keep the control module from overheating while the motors are at full voltage.				
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	5 volts will be supplied to the motors for multiple operation cycles.	The system should remain cool due to air vents and short activation periods.	☑	☐	☐	
Overall Test Results			**1**	**0**	**0**	

Test Writer: Thach Nguyen						
Test Case Name:		Power Regulation			**Test ID #:**	RL-P-01
Description		Ensures that a max of 5 volts is running through the system while fully activated.			**Type:**	☐ white box ☑ black box
Tester Information						
Name of Tester:		Thach Nguyen			**Date:**	
Hardware Ver:					**Time:**	
Setup:		The control module will be connected to a 120 volts ac outlet and brought down to 6 volts using a voltage transformer and regulator.				
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	The inputs of the system will be meaured by a multimeter.	The voltage read by the meter should remain below 6 volts.	☑	☐	☐	
Overall Test Results			**1**	**0**	**0**	

Bluetooth Subsystem Test			
Name of Tester:	Jalen Noles	**Date:**	2/8/2024

Description:		This test will see if the microcontroller will be able to communicate with the other subsystems via Bluetooth within a certain radius.			**Time:**	5:00 PM
Test Case Name		Bluetooth connection Test				
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Have a BLE app send continuous data to Arduino and see when data is interrupted	The data should be constant until around 5 meters	☑	☐	☐	The Arduino was able to receive constant data past leaving the testing area which was about 15 meters

4.1.2. Lighting Subsystem (Subsystem 2)

The lighting subsystem works alongside the vibrational system to provide an additional way to alert the user in the event of an emergency. The lighting system consists of a dimmable LED light and a wall mount, which is used to position the light above the user. It also uses a dimmer and a 5-volt relay. The lighting system is directly connected to the control module, which will power on the light when one of the sensors detects any type of danger. We will test the lighting system by triggering each of the sensors and ensuring that the light powers on. We will also test the brightness of the light to ensure that it will not cause damage to the user's eyes.

Test Writer: Cody McDoniel						
Test Case Name:		Light Relay Attachment			**Test ID #:**	
Description		Checking to see if light accurately works with Bluetooth via the relay.			**Type:**	☐ white box ☑ black box
Tester Information						
Name of Tester:		Cody McDoniel			**Date:**	March 15th
Hardware Ver:					**Time:**	5:00 PM
Setup:		The Bluetooth app is open and the light is attached to the relay.				
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**

1	Test the activation button on the app.	The light should activate when the relay receives the Bluetooth signal.	☑	☐	☐	
Overall Test Results			**1**	**0**	**0**	

4.1.3. Vibrational Subsystem (Subsystem 3)

The vibrational subsystem consists of two different types of motors that will be powered by the control module. These motors provide an alternative to waking up the user by using vibrations instead of sound. The motors would be distributed evenly beneath the bed with a protective covering to prevent damage to both the bed and the motors. We will do testing to decide how much power will be distributed to the motors to see just how much vibration we deem will be necessary.

Vibrational Subsystem Test						
Name of Tester:		Collin Beech			**Date:**	2/8/2024
Description:		This test will see if the motors will run for longer than 20 seconds.			**Time:**	5:35 PM
Test Case Name		Motor Duration Test				
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	A timer is set after we turn the motors on to see if they will run for 20 seconds.	They exceeded the 20 second mark.	☑	☐	☐	

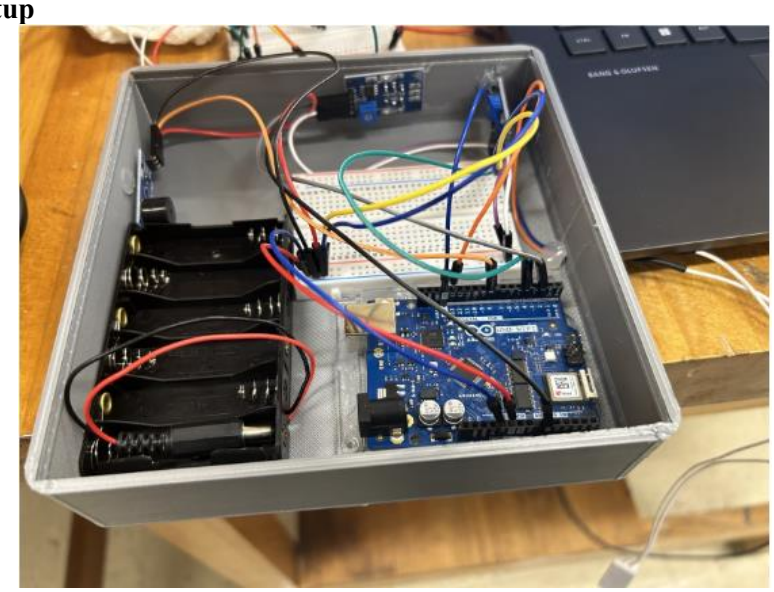
4.1.4 Safety Subsystem (Subsystem 4)

The safety subsystem protects the user from hazardous situations that could result in injury or death. The situations covered by the safety system are intrusion, fire, and gas. An additional feature provided is a battery pack utilized to provide constant power to the system in the event of a power outage. The safety

system is separate from the main module and uses Bluetooth to send alerts. The enclosure for the system is mounted to the wall next to the door.

For the safety subsystem's standards, the system must detect fire, gas, and intruders and send an alert to the main system within a second of detection. To meet the following standards, it is required for the system to contain a fire sensor, gas sensor, and door sensor. For the fire sensor, we are using a fire detection module that focuses on detecting Infared radiation to determine if a fire is present. To detect the presence of a gas, the gas sensor has a special coating which reacts with the electrochemical sensor to check for harmful gases. Finally, for our door sensor, a reed switch is used to detect if the door is ajar.

5.1.4.1 Sensors Setup



5.1.4.2 Test Data

Test Writer: Joshua Edoff			
Test Case Name:	Flame Sensor test #1	**Test ID #:**	Flame-Sen-01
Description	Check relative strength of IR photodiode on flame sensor.	**Type:**	☐ white box ☑ black box
Tester Information			
Name of Tester:	Joshua Edoff	**Date:**	2/4/2024
Hardware Ver:	Flame 1.0	**Time:**	3:59 PM
Setup:	The flame sensor is connected to an Arduino Uno Wi-Fi rev2 and a buzzer. The Arduino is programmed to send output to the buzzer when the flame sensor detects a fire. A light was used to produce the flame for this test.		

Setup	Action	Expected Result	Pass	Fail	N/A	Comments
1	A program is written to send output to the buzzer.	When a fire is placed in front of the flame sensor, the buzzer should begin to ring.	☑	☐	☐	The buzzer successfully rang when a fire was detected from the lighter using the flame sensor.
2	The lighter is placed a foot away from the flame sensor	The flame sensor should detect the presence of the fire and send an alert to the buzzer.	☑	☐	☐	The flame sensor successfully detected the lighter from a foot away and alerted the buzzer
3	The lighter is placed a meter away from the flame sensor	The flame sensor should detect the presence of the fire and send an alert to the buzzer.	☐	☑	☐	The flame sensor did not detect the flame from a meter away. This is due to the small flame not producing enough Infared radiation.
Overall Test Results			**2**	**1**	**0**	The test was a success. The only failure was due the small amount of Infared radiation produced by the lighter but should not be a problem from the system.

Test Writer: Joshua Edoff						
Test Case Name:		Gas Sensor test #1			**Test ID #:**	Gas-Sen-01
Description		Check the relative strength of the chemical sensor in the gas sensor.			**Type:**	☐ white box ☑ black box
Tester Information						
Name of Tester:		Joshua Edoff			**Date:**	2/4/2024
Hardware Ver:		Gas 1.0			**Time:**	4:15 PM
Setup:		The gas sensor is connected to an Arduino and a buzzer. When a gas is detected, the buzzer will ring, alerting its presence. An unlit lighter will be used to produce gas to test the gas sensor.				
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**

1	A program is written to send output to the buzzer.	The gas from the lighter should cause the buzzer to ring.	☑	☐	☐	The buzzer began to ring during the presence of gas.
2	The lighter is placed a foot away from the gas sensor.	The gas sensor should detect the presence of the gas.	☐	☑	☐	The Lighter does not produce enough gas to fill such a distance in a room.
Overall Test Results			**1**	**1**	**0**	The gas sensor is working but for a proper test, a different solution for a gas needs to be used. Safety is a large concern when testing this sensor.

Test Writer: Joshua Edoff						
Test Case Name:		Door Sensor			**Test ID #:**	Door-Sen-01
Description		Check the relative strength of the reed sensor.			**Type:**	☐ white box ☑ black box
Tester Information						
Name of Tester:		Joshua Edoff			**Date:**	2/4/2024
Hardware Ver:		Door 1.0			**Time:**	4:27 PM
Setup:		A reed sensor is connected to an Arduino and buzzer. When the magnet attachment of the reed sensor is taken away from the sensor portion, the buzzer will be set off.				
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	A program is produced to set off the buzzer when the magnet is no longer detected	When the magnet is taken away from the sensor, the buzzer should begin to ring.	☑	☐	☐	The buzzer began to ring when the two parts of the reed sensor were separated.
Overall Test Results			**1**	**0**	**0**	The reed sensor successfully set off the buzzer

				when each portion was separated.

4.1.5 Application and Website (Subsystem 5)

The Application Subsystem serves as the interface through which users interact with the AlertSense system, providing a user-friendly platform to configure settings, set alarms, and manage various functionalities. This subsystem is crucial for ensuring that users, particularly those with hearing impairments, can easily customize the system to meet their specific needs.

The primary components of the Application Subsystem include menus, buttons, and graphical user interfaces (GUIs) designed to facilitate seamless navigation. Users can access features such as setting wake-up alarms, configuring sensor parameters, and managing the overall functionality of AlertSense.

To accommodate user preferences and accessibility requirements, the Application Subsystem incorporates features like adjustable vibration levels and visual indicators with different intensities. The web-based application ensures flexibility, allowing users to control AlertSense remotely from various devices.

Moreover, the subsystem includes a settings menu where users can toggle specific sensors on or off based on their preferences. For instance, users may choose to disable the fire sensor during cooking activities to prevent false alarms. The Application Subsystem thus provides a personalized and adaptable experience, enhancing the overall usability and effectiveness of AlertSense for individuals with hearing impairments.

4.1.6

Test Writer: Cooper Robertson						
Test Case Name:		Application Test #1			**Test ID #:**	Int-Nav-01
Description		Check to verify if users can navigate the application seamlessly.			**Type:**	☐ white box ☑ black box
Tester Information						
Name of Tester:		Cooper Robertson			**Date:**	2/7/2024
Hardware Ver:		Interface Navigation 1.0			**Time:**	4:16 PM
Setup:		The application is open on a web browser and all menu options are available.				
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Test the responsiveness of each header button.	Responded swiftly.	☑	☐	☐	

2	Test the responsiveness of each button within the control panel.	All buttons were responsive with no issues.	☑	☐	☐	

Test Writer: Cooper Robertson						
Test Case Name:	Application Test #2				**Test ID #:**	Alarm-Set-01
Description	Test the functionality of setting alarms.				**Type:**	☐ white box ☑ black box
Tester Information						
Name of Tester:	Cooper Robertson				**Date:**	2/7/2024
Hardware Ver:	Alarm Setting 1.0				**Time:**	4:25 PM
Setup:	The application is open on a web browser and the alarm is ready to be set.					
Setup	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Test to see if the alarm is set via JavaScript.	The alarm was set and the website provided feedback that the operation was a success.	☑	☐	☐	

Test Writer: Cooper Robertson			
Test Case Name:	Application Test #3	**Test ID #:**	Wi-Fi-Func-1
Description	Test to ensure the Wi-Fi connection is successful.	**Type:**	☐ white box ☑ black box
Tester Information			
Name of Tester:	Cooper Robertson	**Date:**	4/3/2024
Hardware Ver:	Wi-Fi 1.0	**Time:**	1:16 PM
Setup:	The application is open and ready to send a signal to the Arduino.		

Setup	Action	Expected Result	Pass	Fail	N/A	Comments
1	Test to ensure the app can send signals via Wi-Fi.	The signal was sent to activate the system from the application and was successful.	☑	☐	☐	

In conclusion, the rigorous testing of the Application Subsystem has been integral to ensuring the optimal performance and user-friendliness of AlertSense. By systematically evaluating interface navigation, alarm setting, and wireless signal emission, AlertSense has verified that the application meets the highest standards of functionality and reliability. The testing process has not only identified and addressed potential issues but has also provided valuable insights for enhancing the overall user experience. The comprehensive testing approach sets the stage for a user centric AlertSense system that effectively caters to the diverse needs of individuals with hearing impairments during emergencies.

4.2. Testing Certification – System Testing

This section marks the commencement of the comprehensive system testing phase, a crucial step in the validation of our full prototype. System testing, a high-level testing practice, is pivotal in ensuring that our integrated system meets the design specifications and requirements. Unlike subsystem testing, which focuses on individual components, system testing evaluates the entire system's functionality, reliability, and interaction with external systems.

Our approach to system testing will encompass a variety of testing methods, including functional testing to verify that each function of the software operates in conformance with the requirement specification; performance testing to ensure the system’s responsiveness and stability under a particular workload; and usability testing to check the user-friendliness and intuitiveness of the interface. Additionally, security testing will be conducted to identify any vulnerabilities and ensure data protection and compliance with relevant standards.

Throughout this phase, we will rigorously document all test cases, outcomes, and any anomalies encountered. This structured approach enables us to identify and address any issues proactively, ensuring the system’s readiness for real-world deployment.

As we conclude the system testing and thereby the Evaluation section of this Design Document, we take a moment to reflect on the journey thus far. This meticulous evaluation process has not only validated the functionality and performance of our design but has also highlighted areas for potential improvement. The insights gained here are invaluable in guiding us towards refining our prototype into a robust, market-ready product.

We now transition towards the final segments of our document, where we will encapsulate the lessons learned, challenges encountered, and the forward path for our project. This closing phase is not just an end, but a gateway to future possibilities and enhancements.

All references cited throughout the Evaluation section, including product specifications, academic papers, and graphical data, are listed below in the IEEE format. This meticulous documentation underscores our commitment to academic integrity and professional excellence.

We also extend our gratitude to all individuals, institutions, and sources of inspiration that have contributed to the development of this project. Their invaluable input and guidance have been instrumental in shaping our design and evaluation process.

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5 SUMMARY AND CONCLUSION

In reviewing the accomplishments of the project, several key aspects stood out. Firstly, the successful development of AlertSense, incorporating features such as gas, fire, and intruder detection, along with seamless integration with smartphones and computers, marked a significant achievement. The implementation of a reliable control module that effectively coordinates alerts and activates corresponding responses also proved to be a notable success.

However, certain challenges were encountered during the project. Fine-tuning the sensitivity and accuracy of the detection sensors, particularly in varied environmental conditions, presented some difficulties. Additionally, ensuring seamless communication between the control module and the AlertSense app required iterative refinement to achieve optimal performance.

Looking ahead, there are several avenues for future extensions and improvements to the project. Enhancements to sensor technology could further enhance the reliability and precision of threat detection, addressing any lingering concerns about false alarms or missed alerts. Moreover, exploring additional integration options with emerging smart home ecosystems, beyond smartphones and computers, could broaden the reach and utility of AlertSense. This could involve compatibility with popular smart hub platforms, enabling users to centralize and manage their home safety alerts more comprehensively.

Furthermore, ongoing user feedback and testing will be essential for identifying areas of improvement and fine-tuning the user experience. This iterative approach will ensure that AlertSense continues to evolve in line with user needs and technological advancements, maintaining its relevance and effectiveness in enhancing home safety.

Overall, while the project has achieved significant milestones, there remains ample opportunity for future growth and development. By addressing challenges and embracing opportunities for enhancement, AlertSense can continue to serve as a vital tool for enhancing safety and peace of mind in the home environment.

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