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Anti-Drowning Inflatable System

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Abstract: This project proposes the development of a wearable device designed to automatically inflate a flotation mechanism in emergency situations, providing a life-saving buoyancy aid.Thedevicecanalso bemanuallyactivatedby the user. It continuously monitors for distress signals and, upon detection, inflates a compact, integrated flotation bladder, ensuring mmediate supportandmakingsurethattheuser does not drown. This innovative wearable technology has the potential to save count lesslivesbyofferingarapid,reliable,and user-friendly solutiontohelppreventdrowning.Designedtobe compact, lightweight, and comfortable, the manual activation feature empowers users to take control in emergencies. By providingavitalsafetynet, thisdevice aim store duce drowning- related fatalitiesandenhancetheoverall safety of individualsat risk of drowning.
Keywords: Anti-drowning, Inflatable Device, Drowning, Automatic Inflation

I. INTRODUCTION

Urban In today's world, water-based activities such as swimming, diving, and boating are popular recreational and professional pursuits, but they come with inherent risks, particularly the danger of drowning. While life vests and otherflotationdeviceshavebeendevelopedtomitigatethese risks, they are often bulky, cumbersome, and not always practical for all types of water activities. There is a growing need for a more compact, intelligent, and responsive safety system that can assist individuals in water-related emergencieswithouthinderingtheirmovementorcomfort.In response to this need, we propose the development of a wearable, automaticdrowningpreventionsystemdesignedto offer real-time monitoring and immediate assistance in life- threatening situations.

This system centers around the use of an ESP32 microcontroller, which serves as the core processor responsible for managing the device's various sensors and triggering mechanisms. The ESP32's advanced capabilities, includingWi-FiandBluetoothconnectivity, makeitanideal choice for this application, as it provides potential for future enhancements,suchasremotemonitoringorintegrationwith other devices for alert systems. However, the main focus of theESP32inthisdesignisitsroleinprocessingdatafromthe pressure sensor and water presence sensor, ensuring that the system remains vigilant to any signs of danger. efficiency One of the key components of this system is the pressuresensor(LPS33HW), whichmonitorswaterdepthby detecting the surroundingpressure. This sensor iscritical for determining whether a person is submerged at a dangerous depth. For example, the system can be configured to trigger inflation when the sensor detects that the user is submerged beyond a threshold, such as 1.5 meters. This ensures that the system is sensitive enough to detect a genuine drowning situation while minimizing the risk of false positives. Working in conjunction with the pressure sensor is a water presence sensor, which acts as a secondary confirmation mechanism to ensure that thedevice only activates when the user is truly in contact with water. This prevents accidental activation of the airbag in dry conditions or when the device is simply exposed to moisture.

When the system determines that the user is in distress— submerged beyond a safe depth for a prolonged time—it automatically triggers the airbag inflation system. The inflation isfacilitated throughapin-actuatedcompressedgas mechanism, whichrapidlyinflatesanair bagdesignedtobring the person to the surface of the water. The system also featuresamanual inflationoption, allowingtheusertotrigger the airbag manually via a waterproof push button in case the automatic system fails or in situations where immediate inflation is necessary.

To enhance the user experience and provide real-time feedback, an OLED display (SSD1306) is incorporated into the device. This display provides vital information such as waterdepth,sensorstatus,systemalerts,andbatteryhealth.It can also display important messages like "Safe,""Drowning Detected,"or"ManualInflationTriggered,"ensuringthatthe user is always aware of the system's operational status. The displayfurtheraddstothedevice'sfunctionalitybyofferinga clear interfaceformonitoringand troubleshooting, making it an essential component for both usability and safety.

The physical design of the device is another crucial consideration. Thewearablenatureofthedeviceensuresthat it can be comfortably worn without restricting movement, whether attached to a vest, wristband, or other body-worn gear.

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Theairbagitselfisdesignedtobesmallandcompactin its folded state, ensuring it does not impede the user's activities, butitisalsocapableofinflatingtoasizesufficient to provide buoyancy and assist in flotation in an emergency. The system'scasing iswaterproofanddurable,ensuring that it can with stand the challenging environments associated with water-based activities.

This project aims to address the critical need for a responsive,unobtrusivedrowningpreventiondevicethatcan be worn comfortably during various water activities. By utilizing advanced microcontroller technology, precise sensor systems, and a carefully designed inflation mechanism, this wearable solution offers a new level of safety for individuals at risk of drowning. Through ongoing monitoring and automatic intervention, the device can significantly reduce the risk of drowning and provide peace of mind for both users and their loved ones.

II. BENEFITS

The Anti-Drowning Inflatable System is a wearable safety devicedesignedtoprovideanautomaticresponseindrowning situations. Itintegratesawaterpresencesensorandapressure sensor to detect potential drowning and activates an airbag inflationmechanism whennecessary.Thisensuresaquickand reliable response without requiring manual intervention, making it ideal for swimmers, boaters, and individuals in aquatic environments.

Built for efficiency and durability, the system uses an ESP32 microcontroller for precise control and low power consumption. The mini linear actuator and TB6612FNG motor driver enable smooth airbag deployment. An LED indicatorprovidesvisual feedback when thesystem isactive, enhancing usability.

With versatile applications, the system can be used in pools, lakes, and open waters, offering added security for both recreational users and professionals. It can also assist individuals with limited swimming ability. The compact, energy-efficient,andcost-effectivedesignmakesitascalable solution for drowning prevention, contributing to enhanced water safety and personal security.

III. OBJECTIVES

1) Develop an Automated System: Create a device that autonomouslydetectsdrowningscenariosusingpressure and water presence sensors.
2) ImplementRapidActivation:Ensurethesystemtriggers airbag inflation within seconds of detecting potential drowning.
3) DesignforWearability:Produceacompact,lightweight device that can be comfortably worn during aquatic activities.
4) Enhance User Interaction: Incorporate both automatic and manual inflation capabilities for user control in emergencies.
5) BroadenSafetyApplications:Makethedeviceeffective for a wide range of users, including swimmers, non- swimmers, and water sports participants

IV. PROPOSED SYSTEM

The Anti-Drowning Inflatable System is an innovative, wearablesafetydevicedesignedtodetectdrowningscenarios andautomatically deployan airbagtoassisttheuserinstaying afloat. The system integrates pressure and water presence sensors to continuously monitor the user's environment.

When the system detects prolonged water submersion anda critical pressure threshold, it automatically activates an inflation mechanism, deploying a compact airbag within seconds to provide buoyancy and prevent drowning.

Thedeviceisdesignedforwearability,ensuringitiscompact, lightweight, and comfortable for swimmers, non-swimmers, and water sports participants. Its user-friendly operation includesboth automatic and manualactivation, allowing users to manually trigger inflation if needed. The system iscontrolled byanESP32microcontroller,whichprocessessensordatain real time and activates a mini linear actuator to release compressed gas, inflating the airbag.

To enhance safety and reliability, thesystem incorporates an LED indicator to signal its operational status, ensuring users areawareofitsactivation.The systemisalsoenergy-efficient, using DC-to-DC buck converters to optimize power consumption for extended use.

With its broad safety applications, the Anti-Drowning Inflatable System is ideal for individuals engaging in swimming, boating, fishing, and other water activities. Its ability to function autonomously withoutexternalintervention makesitareliablelife-savingdevice,providingascalableand cost-effective solution to reduce drowning incidents.

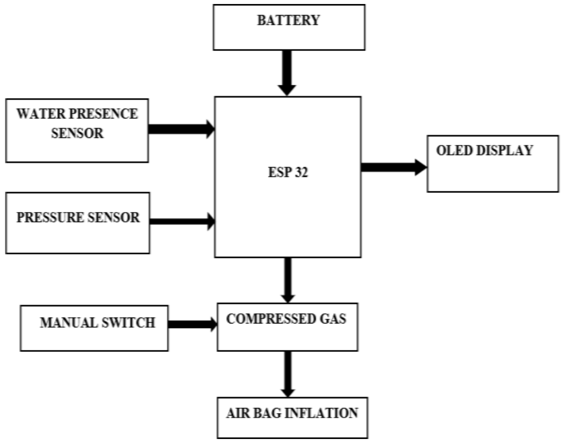

Fig1.Block Diagram

The above is the block diagram of the proposed system.The system has mainly the following components:

1) ESP32 Microcontroller: This is the central processing unit of the system, responsible for collecting data from the sensors, processing it, and deciding when to trigger the inflation mechanism. It manages communication between all components and handles the logic for both automatic and manual inflation control.
2) Water PresenceSensor:Thissensor detectsifthedevice is in contact with water. It serves as an initial trigger to confirm that the user is submerged, ensuring that the system only activates in actual water-related emergencies.
3) Pressure Sensor: The pressure sensor monitors water depth by measuring external pressure. When the user is submerged beyond a pre-set depth, it signals the ESP32 to initiate the inflation mechanism if the depth is sustained for a certain period.
4) Airbag Inflation System : When triggered, this system releases compressed gas to rapidly inflate the airbag, helping the user float to the surface. It can be activated either automatically (based on sensor data) or manually using a switch.
5) Manual Switch: A backup mechanism that allows the user to manually inflate the airbag by pressing a waterproof button. This ensures user control in case of emergenciesoriftheautomaticsystemfailstoactivate.
6) OLED Display: The OLED display provides real-time feedback on system status, including water depth, battery life, and alerts like "Drowning Detected." It helps the user stay informed about the device’s operation at all times.
7) Li-ion Battery: A rechargeable lithium-ion battery powers the entire system. It supplies energy to the ESP32,sensors,OLEDdisplay,andtheairbaginflation system, ensuring the device functions reliably during water activities.

V. SYSTEM ARCHITECTURE

The Anti-Drowning Inflatable System follows a structured architecture that integrates multiple components to ensure real-time drowning detection and automatic airbag inflation.

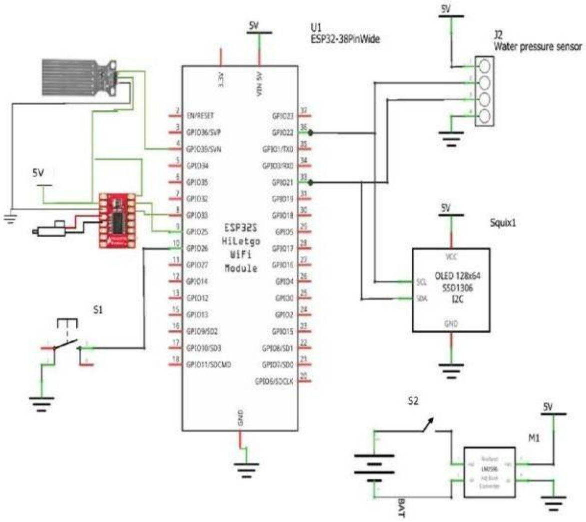

Fig2Circuitdiagram

1) *Sensor Module*
- Water Presence Sensor (SEN 18): Detects the presence of water to determine if the user is submerged.
- Pressure Sensor (LPS33HW): Monitors pressure changes to confirm depth and detect drowning scenarios.

2) *Processing Unit ESP32Microcontroller:*
- Continuouslycollectsandprocessesdatafromthe sensors.
- Implementslogictodeterminewhentotriggerthe airbag inflation mechanism.
- Controlstheactuatorfortheinflationprocess.

3) *Actuation System*
- Mini Linear Actuator (10mm, 15mm/s, 64N, 12V): Releases the compressed gas mechanism when activated.
- Motor Driver (TB6612FNG): Controls the actuator's movement to ensure smooth operation.

4) *Power Management*
- 7.4V LiPo Battery: Provides the main power source for the system.
- DC-to-DCBuckConverters:Regulatesvoltage levels to efficiently power components.

5) *User Interface & Indicators*
- LEDIndicator:Provides visualfeedbackwhenthe system is activated.
- ManualInflationButton:Allowstheusertomanually trigger airbag inflation in case of emergencies.

6) *Airbag Deployment System*
- CompressedGasCanister:Storesthegasrequiredfor inflation.
- InflatableAirbag:Expandsrapidlyuponactivationto provide buoyancy.

VI. METHODOLOGY

1) *System Designand Architecture*
- The anti-drowning inflatable system detects drowning in real time and triggers an automatic rescue response.
- Drowning detection is achieved using an SEN18 water presence sensor and an LPS33HW pressure sensor.Ifwaterpresenceisdetectedandthepressure exceeds 1160 hPa, the system confirms a drowning scenario.
- Theactuationmechanismincludesa10mm,15mm/s, 64N, 12V mini linear actuator controlled by a TB6612FNG motor driver. Upon detection, it releases compressed gas to inflate an airbag.
- System feedback is provided through an LED indicator, which confirms activation and ensures immediate user awareness.

2) *Hardware Implementation*
- The ESP32 microcontroller serves as the core processing unit, handling sensor data, executing drowning detection logic, and controlling the actuator.
- The power system consists of a 7.4V LiPo battery with DC-to-DC buck converters, ensuring efficient power distribution.
- Sensors include the LPS33HW pressure sensor for depth measurement and the SEN18 water presence sensor for detecting submersion.
- Theactuatorsystem,controlledviatheTB6612FNG motor driver, enables precise and timely airbag deployment.
- A user alert system with an LED indicator signals system activation for enhanced safety.

3) *Software and Algorithm Implementation*
- TheESP32firmware,developedusingArduinoIDE, processes sensor inputs and applies drowning detection logic.
- The drowning detection algorithm continuously reads sensor data, compares the pressure with the 1160 hPa threshold, and triggers the actuator upon detecting a drowning situation.
- The actuator control system powers the TB6612FNG motor driver to activate the linear actuator and inflatethe airbag. A manual activation option is also included.

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4) Performance Evaluation and Testing

- Sensor accuracy was validated against standard measurement devices to ensure reliable detection.
- The pressure threshold of 1160 hPa was optimized through empirical testing for effective drowning detection.
- The actuatorresponsetime wasmeasured to ensure rapid airbag inflation for timely rescue.
- User feedback helped refine sensor placement, optimize power consumption, and enhance system usability.
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VII. RESULTS AND DISCUSION

The anti-drowning inflatable system effectively detected drowningconditionsusingtheSEN18waterpresencesensor andLPS33HW pressuresensor.Whenthepressure exceeded 1160 hPa and water presence was detected, the system promptly activated the actuator, inflating the airbag within seconds. The LED indicator provided immediate visual confirmation of activation, ensuring that the system responded accurately to potential drowning situations.

The accuracy of the LPS33HW pressure sensor was validatedagainststandardmeasurementdevices,confirming reliable submersion depth detection. Similarly, the SEN18 water presence sensor consistently detected water contact, reducing the chances of false triggers and improving the system's overall reliability. The combination of these sensors ensured that drowning detection was precise and responsive.

Fig3Proposedsystem

The actuator system performed efficiently, with the 10mm, 15mm/s, 64N, 12V mini linear actuator demonstrating a rapid response upon activation.

The time taken from drowning detection to full airbag inflation was within an acceptable range, ensuring timely deploymentto assistthe user.The system'sability torapidly inflate the airbag enhances its effectiveness in emergency situations.

The power management system, consisting of a 7.4V LiPo battery and DC-to-DC buck converters, provided stable power distribution, allowing the system to function efficiently. Low power consumption ensured extended operation without frequentrecharging, making it suitable for continuous monitoring and real-world application.

Although the system performed well under controlled conditions, further real-world testing in different aquatic environments is necessary to validate its effectiveness in various scenarios. Future improvements could include integrating wireless communication for remote monitoring andrefiningpoweroptimizationstrategiestoenhanceoverall efficiency and usability.

VIII. CONCLUSION

The anti-drowning inflatable system demonstrated reliable performanceindetectingdrowning conditionsandproviding a swift rescue response.

By utilizing a combination of water presence and pressure sensors, the system accurately identifiedsubmersionand triggeredtheinflationofanairbag within seconds, ensuring timely assistance in emergency situations. The actuator responded efficiently, allowing for rapid deployment, while the power management system, consisting of a 7.4V LiPo battery and DC-to-DC buck converters, ensured stable and prolonged operation without frequent recharging.

The inclusion of an LED indicator providedreal-timefeedback,enhancingsystemreliabilityand user awareness. Testing under controlled conditions confirmedtheaccuracyandresponsivenessofthesensorsand actuator; however, further real-world testing is necessary to validateitseffectivenessacrossdiverseaquatic environments. Future improvements, such as integrating wireless communicationforremotemonitoringandoptimizingpower consumption, could further enhance its practicality and usability. With continued refinement, this system has the potential to serve as an effective life-saving device for swimmers, non-swimmers, and water sports participants, offering an added layer of safety in aquatic activities.

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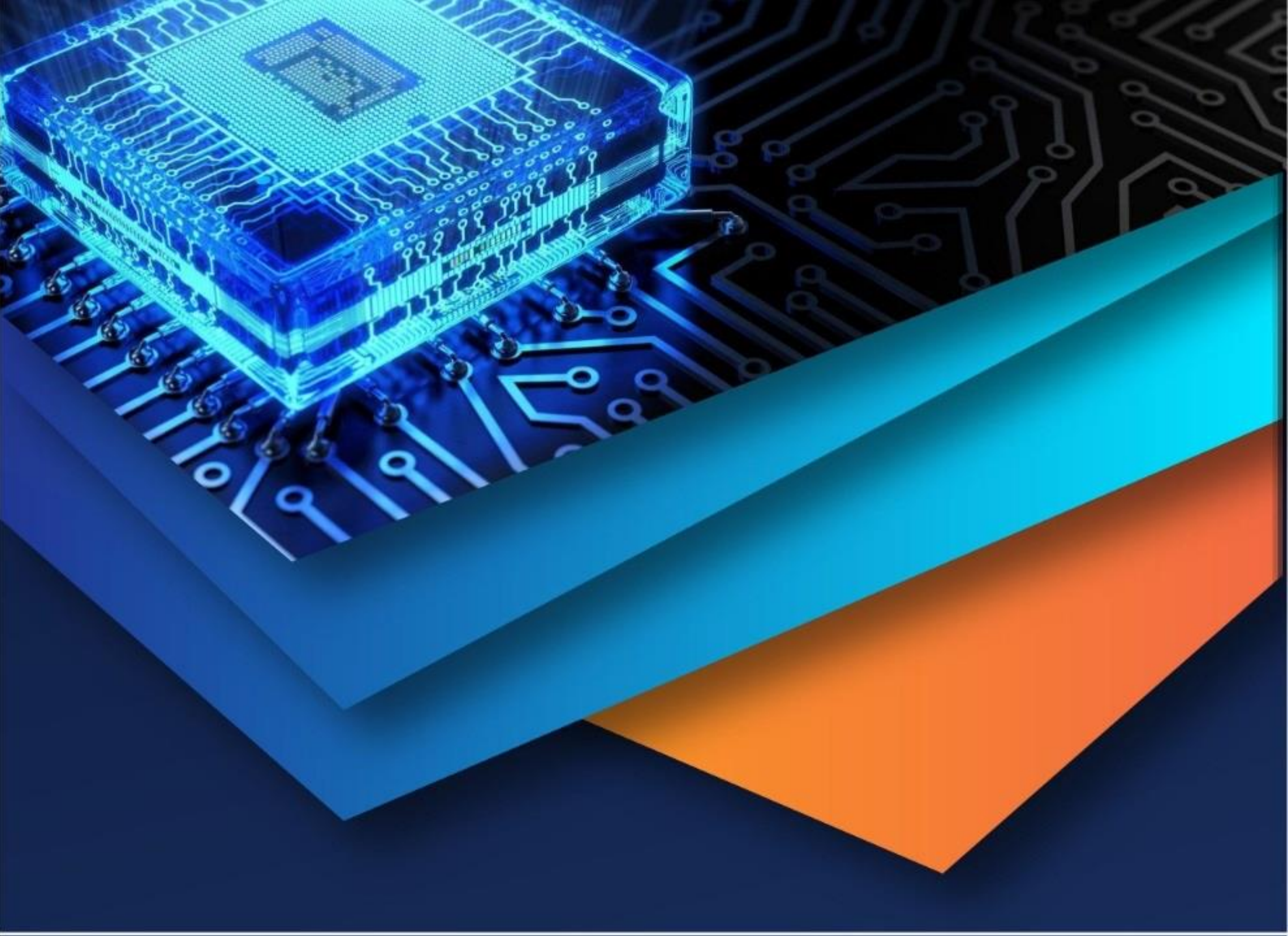

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