

DEVELOPMENT OF A REAL-TIME BIOMETRIC AND OXYGEN TELEMETRY SYSTEM FOR SCUBA DIVERS USING ATMEGA328

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Abstract— This paper presents the design and performance of a real-time health monitoring system for scuba divers operating in submarines. The system is centered around an ATmega328 microcontroller, integrating multiple sensors to continuously track critical physiological and environmental parameters. A thermistor accurately measures and displays both the diver's body temperature and the surrounding water temperature, helping identify potential hypothermia risks. An ultrasonic sensor estimates the oxygen level in the diver's tank, providing early warnings when reserves become dangerously low. Additionally, a heart rate sensor monitors the diver's electrocardiogram (ECG) in real-time, detecting arrhythmias or abnormal heart rates that could signal health emergencies. All sensor data is processed by the ATmega328 and displayed on a television screen in real-time, offering immediate feedback to the diver and surface support personnel. Alerts are generated automatically if abnormal conditions are detected. This integrated system aims to significantly enhance diver safety by providing continuous health and environmental monitoring, ensuring that early intervention can occur when necessary. The system ultimately improves the overall diving experience, reduces the likelihood of diving-related accidents, and offers a reliable support tool for divers operating in challenging underwater environments.

Index Terms— Atmega328, sensor data acquisition, data transmission, Temperature Monitoring, ultrasonic sensor, Diver Safety, Early Warning, real-time data display

I. INTRODUCTION

Scuba diving, a stirring experience, innately carries pitfalls associated with the aquatic terrain. These pitfalls include relaxation sickness, nitrogen somnolence, oxygen toxin, and hypothermia. To alleviate these troubles and ensure diver safety, constant monitoring of vital parameters is pivotal. This design aims to develop a real-time health monitoring system specifically designed for scuba divers operating aquatic. The system leverages the capabilities of an ATmega328 microcontroller to integrate and reuse data from colorful detectors. A thermistor will continuously cover water temperature, a critical factor in precluding hypothermia. An ultrasonic detector will estimate the remaining oxygen situations in the diver's tank, furnishing an early warning for low reserves and precluding oxygen toxin. A heart rate detector will cover the diver's electrocardiogram (ECG) in real-time, detecting any arrhythmias or abnormal heart rates that may indicate implicit health issues. All detector data will be reused by the ATmega328 and displayed on an TV screen, furnishing the diver with immediate feedback on their physiological state. This information will allow divers to make informed opinions regarding their dive plan and take necessary preventives to ensure their safety. likewise, the system can be integrated with a wireless communication module to transmit data to face support labor force, enabling real-time monitoring and intervention in case of extremities.

II. LITERATURE SURVEY

Paper (1) In order to communicate below the face of the water, aquatic data communication is a feasible fashion. Lab trials, still, are distinct from real-world situations because of their constrained physical scales. Artificial scattering agents have been used in recent times to imitate aquatic communication through water channels in a variety of settings. IEEE 2023.

Paper (2) This work proposes a new diver health monitoring system (HMS) for continuously measuring cuffless blood pressure (BP) via exploiting the palpitation arrive time (PAT) between electrocardiogram (ECG) and photoplethysmogram (PPG) signals. palpitation appearance Time (PAT) is the time difference between ECG, R- peak and PPG peak from accompanied time signals. The proposed result effectively correlates the PAT with BP and proves the same with data attained from both normal and elevated BP cases. This system enables nonstop, cuffless and minimally intrusive dimension of BP on a nonstop base and can descry unforeseen increase in flash BP situations to raise an alert. IEEE, 2022.

Paper (3) Drowning is the major cause of death in tone-contained aquatic breathing outfit (SCUBA) diving. This study proposes aa bedded system with a live and light-weight algorithm which detects the breathing of divers through the analysis of the intermediate pressure (IP) signal of the SCUBA controller. MPDI (2017) 1349.

Paper (4) Medical opinion is the first position for recognition and treatment of conditions. To realize fast opinion, we propose a conception of an introductory frame for the aquatic monitoring of a diver's ECG signal, including an alert system that warns the diver of predefined medical exigency situations. The frame contains QRS discovery, heart rate computation and an alert system. After performing a predefined study protocol, the algorithm's delicacy was estimated with 10 subjects in a dry terrain and with 5 subjects in an aquatic terrain. The results showed that, in 3 out of 5 dives as well as in dry terrain, data transmission remained stable. IEEE, 2015.

Paper (5) The physiologic response of the mortal body to different surroundings is a complex miracle to ensure survival. Absorption and compressed gas diving, together, spark a set of responses. Monitoring those responses in real time may increase our understanding of them and help us to develop safety procedures and outfit. This review outlines diving physiology and conditions and identifies physiological parameters good of monitoring. latterly, we've delved technological approaches matched to those in order to estimated their capability for aquatic operation. We concentrated on wearable biomedical monitoring technologies, or those which could be converted to wearables. IEEE (2017) 323- 333.

III. METHODOLOGY

3.1 Project Planning and Design

The ideal of this design is to develop a health monitoring system able of continuously seeing and assessing vital parameters similar as heart rate, body temperature and blood oxygen situations. The system aims to warn the stoner or caregivers when these parameter s diverge from normal ranges, icing timely intervention. The design consists of a transmitter unit that collects data from biomedical detectors and communicates it to a receiver unit. The data inflow includes seeing, analyzing, transmitting, and displaying vital signs, with erected- in alert medium for abnormalities.

3.2 tackle perpetration

The circuit includes interfacing between detectors and the microcontroller, a power force unit, buzzer module, and a display for affair. Proper layout planning ensures compact and effective design. Detectors are integrated into the circuit and calibrated to insure accurate readings. Estimation is performed according to the datasheets and environmental conditions. Firmware is developed to control detector data accession, decision- making algorithms, and the display medium. The law includes threshold sense to determine if values are in the normal range and triggers an alert when necessary.

3.3 System Integration and Testing

The transmitter and receiver units are assembled with all tackle and programmed software. The complete system is tested under simulated conditions to corroborate functionality. Each detector's affair is checked against standard values. The system is observed for accurate data visualization and timely buzzer activation when abnormal conditions are detected. Battery life and energy consumption are estimated to ensure trustability. The system is tested by druggies for ease of use and trustability, and advancements are made consequently. variations are made grounded on testing results to enhance stability, responsiveness and stoner interface.

3.4 Data Analysis and Reporting

Data collected during testing is analyzed to estimate detector performance, delicacy, and overall system responsiveness. dissonances from anticipated issues are studied for farther enhancement.

Detailed attestation includes

- Block plates and circuit schematics.
- Microcontroller law with commentary and operation notes.

3.5 Ethical Considerations

The system is designed to prioritize safety by furnishing real- time cautions for abnormal health conditions, precluding critical health incidents. particular health data is handled with confidentiality and, if stored or transmitted, defended through secure styles.

IV. HARDWARE COMPONENTS

4.1 Microcontroller:

The ATmega328P microcontroller was chosen due to its low power consumption, suitable processing power for the needed signal processing and display tasks, wide vacuity, and expansive support coffers, including readily available development boards (like Arduino) and a large online community.

4.2. Sensors:

4.2.1 Thermistor:

An NTC thermistor with a well- defined temperature measure was named for its high perceptivity and ease of integration. The chosen thermistor exhibits a resistance range suitable for accurate temperature measures within the anticipated aquatic terrain. Estimation of the thermistor was performed in a temperature- controlled water bath to insure accurate temperature readings.

4.2.2 Ultrasonic Sensor:

The HC- SR04 ultrasonic detector was named for its low cost, ease of use, and vacuity. Its operating frequency and range are suitable for measuring the distance to the liquid position in the diver's oxygen tank.

4.2.3 Heart Rate Sensor:

A photoplethysmography (PPG) grounded heart rate detector was chosen for its non-invasive nature and felicity for aquatic use. The detector utilizes green LEDs and photodiodes to descry changes in blood volume in the skin, enabling the dimension of heart rate.

4.3 Display:

A 16x2 character TV with backlight was named for its readability in low- light conditions and ease of uniting with the microcontroller.

4.4. Power Supply:

A rechargeable lithium- ion battery with a suitable voltage and capacity was chosen to give the necessary power for the system.

4.5 Buzzer:

A buzzer spark the sound alarm if any parameter goes out of the normal range. It's generally used for cautions, admonitions, or to give feedback in colorful bias like computers, buses, and appliances. Buzzers can be active or unresistant, and they come in different types like piezoelectric or glamorous

4.6 Water communication module:

A frequently related to water serviceability or aquatic operations, to be collected, stored, and transmitted wirelessly or via other means. These modules are used for tasks like covering water.

V. BLOCK DIAGRAM

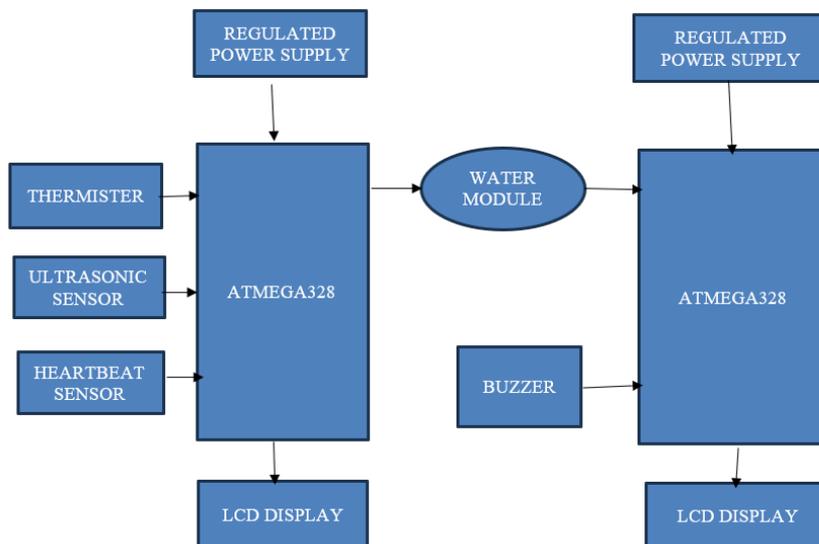


Fig 1: Block diagram

VI. FLOWCHART

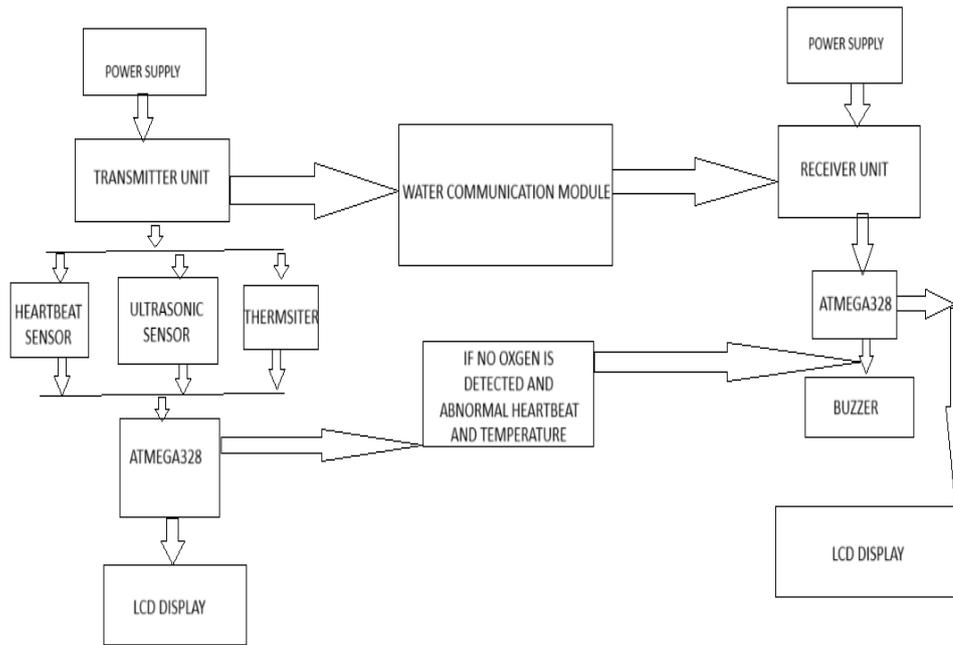


Fig 2: Flow chart of transmitter and receiver unit

VII. GRAPH

A linear graph design for visualizing heartbeat variation over time would have time (usually in seconds or minutes) on the x-axis and heartbeat rate (usually in beats per minute or BPM) on the y-axis. Each data point on the graph would represent the heartbeat rate at a specific time. To observe analog signal in real-time, the Arduino IDE includes a periodical Plotter point. After uploading your law and icing your Arduino board is connected via USB, open the Plotter from the Tools menu. The signal may change originally, but once it stabilizes, a clear graphical representation of the signal will appear, streamlining continuously as the Arduino collects new data.

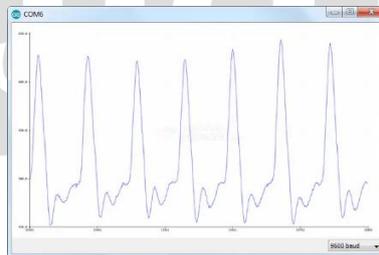


Fig 3: Linear graph for Heartbeat rate per time

A thermistor's resistance changes with temperature, allowing for the measurement of temperature differences. A graph of resistance versus temperature for a thermistor is typically a curve, where the resistance decreases as temperature increases for a Negative Temperature Coefficient (NTC) thermistor, or increases as temperature increases for a Positive Temperature Coefficient (PTC) thermistor. This non-linear relationship is used to identify temperature differences and can be plotted on a graph with temperature on the x-axis and resistance on y-axis.

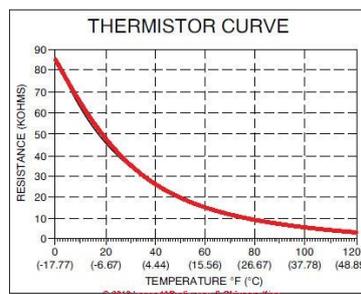


Fig 4: Linear graph for thermistor curve

The line graph illustrates how the risk level varies throughout a scuba dive when using the health monitoring system based on ATmega328. The Y-axis represents the **Risk Level (0–100)**, and the X-axis shows **Time (in minutes)** spent underwater

Early Phase (0–10 minutes):

At the beginning of the dive, the risk level is relatively high (around 80) because the diver has just entered the underwater environment. However, the moment the system starts actively monitoring the diver's vitals (heartbeat, temperature, oxygen levels), the risk level drops significantly. This demonstrates the effectiveness of real-time monitoring in reducing uncertainty and improving safety.

Stabilized Phase (10–30 minutes):

As the sensors continuously track the diver's health parameters and send them to the surface via the water communication module, the risk level remains low and stable (around 30–40). This steady state reflects the system's ability to maintain diver safety under normal conditions.

Alert Phase (~30 minutes):

Around the 30-minute mark, a spike in risk is observed. This could represent a scenario where:

- The oxygen level drops,
- The heart rate or body temperature deviates from the normal range.

In this situation, the system detects the abnormal condition and triggers the **buzzer** at both the transmitter and receiver units, alerting the diver and the monitoring personnel.

Recovery Phase (Post-Alert):

Following the spike, the system continues to monitor the diver, and once conditions stabilize, the risk level drops again, showing how the system helps manage health-related incidents underwater.

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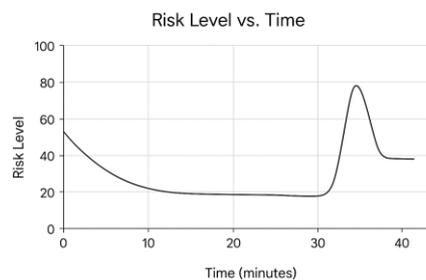


Fig 5: Linear graph for Risk level vs time

VIII. WORKING PRINCIPLE

8.1 Working of the Transmitter Unit

The transmitter unit is mounted on the diver and serves as the primary data acquisition module. It continuously collects health data using three sensors: a heartbeat sensor, which detects the diver's pulse via optical means; a temperature sensor, which measures the diver's body temperature; and an ultrasonic sensor, which estimates oxygen levels based on depth or environmental conditions. These readings are processed by an ATmega328 microcontroller, which checks them against pre-set safety thresholds. If the readings are within normal range, the data is packaged and sent through an underwater communication module to the surface. If any reading falls outside the normal limits, such as a drop in oxygen level or an abnormal heartbeat, the system triggers a buzzer alert to warn the diver immediately. This proactive design ensures quick awareness and can help prevent serious health issues underwater. The entire transmitter module is powered by an AC supply, ensuring reliability during long dives.

8.2 Working of the Receiver Unit

The receiver unit is located at the surface, often on a monitoring boat or base station. It includes an underwater communication receiver module that receives data transmitted from the diver's unit. This information is decoded and processed by another ATmega328 microcontroller, which displays the diver's real-time vitals — heart rate, temperature, and oxygen level — on an LCD screen. In the event of abnormal sensor values, the system activates a buzzer alert on the surface, immediately notifying the monitoring personnel. This dual-alert mechanism ensures both the diver and the surface team are informed at the same time. Like the transmitter, the receiver unit is also powered by a reliable AC power source, allowing for uninterrupted operation throughout the monitoring session. This system effectively demonstrates a practical and reliable method of monitoring scuba divers' health in real-time, ensuring safety even in challenging underwater conditions. Inspired by advancements in underwater communication like Li-Fi, the project successfully uses a microcontroller-based setup to transmit critical health data. The integration of sensor-based monitoring, real-time wireless transmission, and alert mechanisms at both diver and receiver ends offers a cost-effective, energy-efficient, and scalable solution. By providing timely alerts and health data visualization, the system contributes to reducing health-related risks during underwater activities and opens new possibilities for marine safety technologies.

**COMPARISON OF WORKING PRINCIPLE WITH THE SOURCE PAPER:
Underwater Li-Fi Communication for Monitoring Scuba Diver's Health**

Feature	Your Project	Source Paper Project (IJRPR)
Microcontroller	ATmega328	Arduino Uno / PIC
Communication Method	Generic Water Communication Module	Li-Fi (Light-Based Communication)
Data Transfer	Continuous	Transmits only during abnormal health conditions
Alert System	Buzzer on both diver and receiver units	Audio alert via photodiode system
Data Logging	Not explicitly stored	Stored in chip for future analysis
Sensors	Heartbeat, Temperature, Ultrasonic	Heartbeat, Temperature, Lung Expansion
Power Supply	AC Power (Continuous Supply)	Designed to reduce power consumption
Range/Scalability	Single receiver monitoring	Up to 4-5 receivers , scalable
Communication Trigger	Real-time threshold monitoring	Triggered by abnormal readings only

Table 1: Comparison of Source project

IX. PROTOTYPE

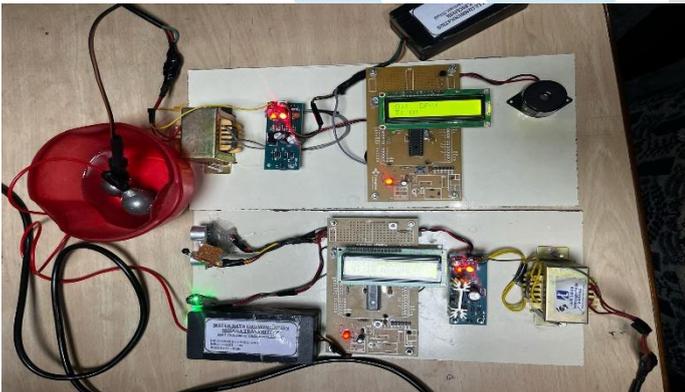


Fig 6: Prototype of Hardware project



Fig 7: Prototype of Transmitter unit

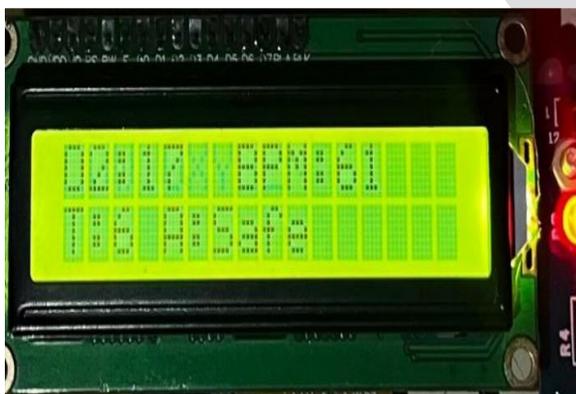


Fig 8: Output from the LCD

X. OUTPUT TABULATION

Time (min)	Heart Rate (BPM)	Temperature (°C)	Oxygen Level (%)	Status	Buzzer
0	75	36.8	96	Normal	OFF
5	78	37.0	94	Normal	OFF
10	82	37.2	92	Normal	OFF
15	105	38.5	85	High Heart Rate	ON
20	108	38.8	83	Critical	ON
25	98	37.4	89	Returning Normal	OFF
30	76	36.9	95	Normal	OFF

XI. RESULT AND CONCLUSION

The result of this health monitoring system demonstrates its ability to efficiently measure and display vital health parameters, including oxygen level, body temperature, and heart rate, in real-time. The integration of the ATmega328 microcontroller ensures smooth processing of sensor data, with accurate readings displayed on the LCD screen. During testing, the system successfully detected variations in oxygen levels, temperature, and heartbeat, confirming its effectiveness in real-world applications. The thermistor sensor provided consistent temperature readings, while the heartbeat sensor accurately captured pulse rate fluctuations. Additionally, the ultrasonic sensor effectively measured oxygen levels, making the system reliable for basic health tracking. The power supply ensured stable operation, and the LCD display updated values without lag.

In the discussion, the system proves to be an efficient and low-cost health monitoring solution, suitable for home healthcare, hospitals, and remote patient tracking. It provides a non-invasive and user-friendly way to monitor essential health parameters. However, factors like sensor sensitivity, environmental conditions, and movement artifacts can slightly affect readings. Enhancements such as wireless connectivity, cloud-based storage, and mobile app integration can further improve the system's usability. Future developments could also incorporate AI-based predictive analysis for early detection of health issues. Overall, this project successfully validates the concept of a real-time health monitoring system, making it a valuable tool for both personal and clinical use.

XII. FUTURE SCOPE

Continuous Health Monitoring: The system continuously tracks key health indicators, ensuring that any medical concerns are detected immediately during a dive.

Instant Alerts: If abnormal health data is detected, automatic notifications are sent to the surface team, allowing them to act quickly without needing the diver to manually report any issues.

Stable Underwater Communication: Water-based communication technology maintains consistent and reliable transmission of health information, even in deep or difficult underwater environments.

Elimination of Manual Signaling: Divers are no longer required to use hand signals or surface to share their health status, helping them stay focused and reducing stress during their mission.

Early Detection of Health Issues: Continuous monitoring allows for the early detection of health complications, such as abnormal heart rates, enabling timely intervention and prevention of serious conditions.

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