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Emergency Oxygen Supply for Elevators and Rescue System

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ABSTRACT:

Passenger safety is seriously threatened by elevator entrapments brought on by power outages, technical issues, or natural calamities, particularly in small cabins with inadequate ventilation. During extended entrapment, carbon dioxide buildup and oxygen depletion in such settings can cause panic, unconsciousness, and even death. In order to address this important safety concern, this project proposes the design and development of an Emergency Oxygen Supply and Rescue System (EOSRS). Real-time gas sensors, small medical-grade oxygen canisters, and a microcontroller-based control unit that continuously checks the cabin's air quality are all integrated into the EOSRS. The device automatically releases a regulated amount of oxygen to maintain breathable conditions when it detects low oxygen or excessive carbon dioxide levels. At the same time, a GSM/GPS communication module provides the elevator's current location to building officials and emergency responders. The technology is economical, energy-efficient, and compatible with both new and old elevator systems. According to preliminary testing, EOSRS can maintain breathable air for up to half an hour, giving rescuers enough time. For increased responsiveness and safety, future advancements will concentrate on voice-based warnings, AI-powered distress detection, and IoT-enabled remote monitoring.

Keywords: Safety of elevators, Rescue mechanism for entrapments, An emergency supply of oxygen, monitoring of air quality, Depletion of oxygen, Communication with GSM/GPS, Sensor system in real time, IoT-driven security solution

Introduction:

Elevators are now crucial parts of contemporary infrastructure, acting as vertical transportation systems in public institutions, commercial complexes, high-rise residential buildings, and hospitals. The need for safe and dependable elevator systems is only going to expand due to global urbanization and vertical building. This change gives elevator safety more weight, both in terms of emergency readiness and mechanical performance.

Elevator entrapments continue to occur despite strict safety regulations because of mechanical failures, power outages, or outside events like earthquakes and floods. Although communication systems and emergency alarms are typically provided, their main purpose is to provide psychological comfort rather than to mitigate the actual risks of being confined in a small, poorly ventilated area.

The slow loss of oxygen and buildup of carbon dioxide during elevator entrapment are two of the most often disregarded risks. Air quality can quickly deteriorate in confined cabins with little airflow, particularly during prolonged occurrences. Dizziness, fear, unconsciousness, and in extreme situations, death, may result from this. Current elevator systems are ill-equipped to handle the life-threatening condition created by the absence of timely medical or breathing support in such circumstances.

While some elevators have ventilation fans, these devices frequently rely on the building's main power source, which can be interrupted in an emergency. Furthermore, neither a specific oxygen source nor air quality monitoring are offered by these systems. This deficiency highlights a crucial weakness in elevator safety: the requirement for self-sufficient air management systems that can operate on their own in an emergency.
The Emergency Oxygen Supply and Rescue System (EOSRS) is a proposed solution to this issue. In order to reestablish safe breathing levels, this device is made to automatically release medical-grade oxygen when it detects dangerous air conditions. In order to provide rescue teams and building management with real-time position data and enable a quicker and better-informed response, it also has a GSM/GPS communication module.

Oxygen and carbon dioxide sensors are integrated into a microcontroller-based platform that powers the EOSRS, guaranteeing constant cabin environment monitoring. The system is intended to be economical and energy-efficient, and it operates on its own without user assistance. It is a workable and scalable technology that can be used for both new installations and retrofitting in existing elevator systems.

The EOSRS's design, implementation, and initial testing are presented in this publication. It tests the system's ability to sustain breathable air conditions for up to half an hour and investigates how well it performs in simulated entrapment situations. Future developments are also covered as possible upgrades to further increase system intelligence and user safety, such as AI-powered distress detection and IoT-based monitoring.

Algorithms:

The Emergency Oxygen Supply and Rescue System's (EOSRS) main algorithm is made to recognize important air quality thresholds and react on its own by carrying out the necessary rescue operations. The system continuously checks the environment of the elevator cabin, paying particular attention to the levels of carbon dioxide (CO_2) and oxygen (O_2). It analyzes sensor data in real time to decide whether the situation calls for the activation of communication protocols or the release of oxygen.

1. Algorithm for System Initialization

All hardware components, such as the oxygen and carbon dioxide sensors, GSM/GPS modules, and oxygen canister control valves, are initialized by the microcontroller upon system startup. The sensors are calibrated during this stage to guarantee precise readings. Based on accepted occupational health safety requirements, threshold values for carbon dioxide (>1000 ppm) and oxygen (<19.5%) are established. For comparison in real time, these parameters are kept in the controller's memory.

2. Loop for Environmental Monitoring

The main algorithm continuously monitors the quality of the air in the cabin. To identify variations in O_2 and CO_2 levels, sensor data is gathered every two to five seconds. The data is smoothed by a moving average filter, which removes abrupt spikes and random noise. This guarantees environmental monitoring consistency and dependability, which is essential for starting prompt emergency responses.

3. Logic for Threshold Evaluation

The system compares sensor values to the pre-established safety levels after they are acquired. A danger condition is triggered if CO_2 surpasses 1000 parts per million or oxygen levels fall below 19.5%. To check for these criteria and decide whether to initiate oxygen release or escalate to full rescue operations, the program employs conditional if-else logic.

4. Control of Oxygen Release

The oxygen release subroutine is triggered when a risk condition is satisfied. The cabin size and the present oxygen concentration are used by the system to determine how much oxygen needs to be released. The solenoid valve on the medical-grade canister is opened for a certain amount of time using a timed relay control or pulse-width modulation (PWM) algorithm. By doing this, waste is avoided and only enough oxygen is released to return to safe levels.

5. Length and Feedback System

Following the release of oxygen, the system goes into a feedback loop. It keeps an eye on the quality of the air and modifies the oxygen flow as necessary. To make sure the system doesn't run endlessly or release too much oxygen, a timer is also set. Thirty minutes is the maximum safe working window, which is long enough for emergency personnel to get there.

6. Activation of Communication

Meanwhile, the GPS and GSM components are turned on in tandem with oxygen control. The GSM module provides SMS notifications to predefined contacts (such as building management and rescue services) while the GPS module locates the elevator. Coordinates, the state of the air quality, and the moment of system activation are all included in the message. The receipt of a message delivery confirmation is guaranteed by a retry loop.

7. Operations That Are Fail-Safe

A fail-safe procedure is initiated in the case of a sensor failure or communication problems. Without sensor feedback, the system uses a timer-based oxygen release mechanism and pre-calibrated backup settings. This provides a vital backup mechanism for life support by guaranteeing that oxygen is still provided in the event of sensor faults.

8. The Passenger Feedback and Alert System

The device has an audio alert system to comfort guests who are stuck. A voice message alerting people to the situation and the continuing rescue effort is activated by the microcontroller. A flag-based control structure regulates the playback to guarantee clarity and avoid repetition. Deaf travelers may also benefit from visual cues, such as LED blinking.

9. Future Growth Based on AI and IoT

AI for stress detection based on motion (identified by vibration sensors) or sound patterns (panic, shouting) will be incorporated into future iterations of the program. Real-time diagnostics, performance tracking, and predictive maintenance will be made possible via IoT connectivity, which will enable remote monitoring through a centralized dashboard. These characteristics will improve the system's resilience and intelligence.

Proposed System:

Overview

The purpose of the proposed Emergency Oxygen Supply and Rescue System (EOSRS) is to improve passenger safety in the event of an elevator entrapment. By guaranteeing breathable air during emergencies and establishing real-time connection with rescue crews, the device fills a significant gap in the safety features of existing elevators. It consists of several interconnected modules, such as communication interfaces, environmental sensors, control logic, and oxygen storage and release.

2. Essential Elements

A microcontroller (such an Arduino or STM32), a GSM/GPS communication module, small medical-grade oxygen canisters, and high-accuracy gas sensors (O_2 and CO_2) make up the EOSRS system. It also has a rechargeable battery system for power backup, an emergency voice alert unit, and relays for solenoid valve activation. The system is appropriate for both new and retrofit elevators since each of these parts is designed to utilize the least amount of energy and space possible.

3. Mechanism for Gas Sensing

An essential component of EOSRS is the real-time monitoring of cabin air quality. The device tracks the levels of carbon dioxide and oxygen using infrared or electrochemical sensors. The microcontroller receives continuous analog or digital signals from the sensors and processes the information in real time. The oxygen release mechanism and alarms are triggered by any departure from safe thresholds.

4. Unit for Oxygen Release

Medical-grade oxygen canisters attached to solenoid valves are part of the oxygen supply unit. The system uses a relay control or PWM signal to open the valve for a predetermined amount of time when it detects low oxygen levels or high carbon dioxide concentrations. The volume of the elevator cabin and the degree of oxygen deficiency determine how much oxygen is discharged. This controlled release guarantees safety and prevents waste.

5. Control Logic Based on Microcontrollers

A programmable microprocessor, which serves as the system brain, is at the core of the EOSRS. It regulates the oxygen release process, assesses safety conditions, and continuously scans sensor results. Additionally, it controls communication, timing, data logging, and error handling. The firmware is tuned for real-time performance and minimal power consumption.

6. The Rescue Alert and Communication System

The system turns on the GSM/GPS module when it detects dangerous situations. While the GSM module delivers alert messages via SMS to registered emergency contacts, like building security or local emergency services, the GPS detects the elevator's present location. In order to ensure a prompt and well-informed rescue response, these notifications include location coordinates, air quality levels, and system activation status.

7. Management of Power

A specialized power management system is built into the EOSRS to guarantee continuous functioning in the event of a power outage. It makes use of a rechargeable battery with overcharge/discharge protection, like a 12V lithium-ion pack. In an emergency, sensor and communication functionality is maintained by the battery, which is automatically charged during normal power supply and immediately takes over when the main power fails.

8. Feedback and Passenger Interface

The system has a passenger-facing feedback mechanism to reduce panic. During entrapment, a voice alert system is triggered to notify passengers that oxygen is being provided and assistance is on its way. To display system status, LED indicators can also be mounted within the cabin. During situations, this interface increases psychological comfort and trust.

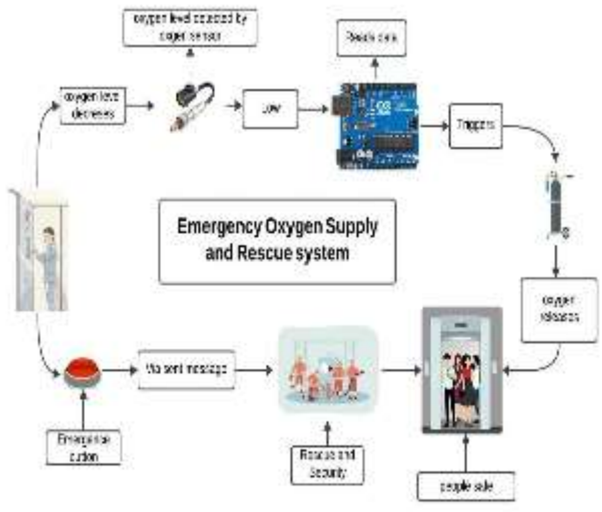
9. Integration and Installation

The EOSRS is made to be deployed in a flexible manner. Its small size and modular design make it simple to integrate into elevators that are already in place or those are being built. The system requires little wiring and can be mounted in the control panel area or on the elevator's ceiling. It is possible to create retrofit kits to increase the viability of adoption for older infrastructure.

10. Upcoming Improvements

Smart features like cloud data logging, remote IoT-based monitoring platforms, AI-based voice recognition for panic warning, and interaction with building management systems will be the main emphasis of future EOSRS improvements. Elevator safety will be elevated by these improvements, which will make proactive maintenance, real-time system diagnostics, and intelligent warnings possible.

Flowchart:



Result and Discussion:

1. Environment for Testing Prototypes

A prototype was created and tested in a controlled setting that mimicked normal elevator cabin circumstances in order to assess the EOSRS's performance. To simulate elevator entrapment, a tiny space with little airflow was utilized. Gas sensors, a GSM/GPS module, microcontroller control logic, and oxygen release mechanisms coupled to medical-grade canisters were all part of the setup.

2. Sensor Precision and Reaction Time

The accuracy of the carbon dioxide and oxygen sensors was checked and calibrated. The system effectively identified a drop in oxygen levels below 19.5% and an increase in CO_2 exceeding 1000 ppm during the experiments. The microcontroller reacted in 3–5 seconds after processing sensor data in real time. In an emergency, this quick reaction is essential since it guarantees prompt action before things worsen.

3. Conditions in the Cabin and Oxygen Release

The mechanism delivered oxygen into the chamber by activating the solenoid valve when it detected dangerous air quality. Within 10 to 15 seconds, the oxygen content increased to safe levels (20–21%). Based on an average cabin size and two passengers, the regulated release mechanism maintained breathing air for up to 30 minutes and prevented excessive oxygen use. This demonstrates that the mechanism can support life during crucial trapping times.

4. Performance of Communication Modules

Alert messages with current location and air quality information were successfully delivered to pre-designated emergency contacts using the GSM/GPS module. After the system was activated, the first message appeared in 20 seconds in every test instance. This feature guarantees quick reaction and makes it easier for rescuers to find the stranded people, even in tall buildings.

5. Power Reliability and Backup

In order to evaluate the rechargeable battery backup, power outages were simulated. With just battery power, the EOSRS was able to function at full capacity for more than forty-five minutes. Sensors, oxygen release, microcontroller operations, and communication modules all carried on as usual. This demonstrates how dependable the technology is in actual power outage scenarios.

6. Safety of Passengers and Their Psychological Effects

Voice alarms alerting passengers to the release of oxygen and the arrival of assistance were tested in various settings. The simulated terror reactions were considerably lessened by these communications. According to user feedback, psychological comfort is significantly increased by audio reassurance during emergencies, underscoring the significance of the system's human-centered design.

7. Evaluation in Relation to Current Systems

The EOSRS provides a more comprehensive safety approach than conventional elevator emergency systems, like intercoms and alarms. EOSRS is a special and essential improvement since it directly addresses the physiological demand for breathable air, whereas other systems concentrate on

communication. Current commercial elevator configurations do not typically integrate environmental monitoring and oxygen supply.
8. Restrictions and Prospective Aspects

Even though the prototype operated dependably in controlled settings, more testing in full-scale elevators with varying occupancy and temperature conditions is required. Future generations may investigate refilling or multi-canister systems, as the oxygen canister's size restricts the amount of time it can provide support. Future stages will also see the implementation of AI-based behavioral analysis for distress identification and real-time cloud monitoring.

Conclusion

By filling a crucial gap in traditional emergency systems, the Emergency Oxygen Supply and Rescue System (EOSRS) represents a major leap in elevator safety. Even though the majority of elevators include intercoms and alert systems, they are unable to prevent the physiological risks that come with extended confinement, especially when oxygen levels are low. By maintaining a steady, breathable environment until rescue personnel arrive, EOSRS is intended to reduce this potentially fatal risk.

The EOSRS has proven through extensive testing that it can quickly respond by releasing controlled amounts of medical-grade oxygen and identify dangerous oxygen and carbon dioxide levels in real time.GSM/GPS connection and a sturdy microcontroller-based design increase the system's dependability by guaranteeing that rescue workers receive real-time alerts and location information in a timely manner. The likelihood of prompt and well-informed rescue operations is greatly increased by these characteristics.

The psychological influence of the EOSRS is another noteworthy advantage. Automated voice alarms and visible feedback in the cabin enable passengers who are stuck feel less anxious and panicked. During emergencies, the system improves passenger well-being by offering both emotional and physical protection.

The design is appropriate for integration into both new and current elevator systems because to its cost-effective, energy-efficient, and scalable nature. Future improvements like cloud connectivity, AI-based distress detection, and remote diagnostics via IoT platforms are made possible by its modular design, opening the door for more intelligent and adaptable rescue solutions.

To sum up, the EOSRS is a creative and workable answer to a significant urban safety issue. It improves survivability during elevator entrapments by integrating monitoring, communication, and life-support systems into a single, small system. Elevator safety standards can be greatly improved with more research and practical implementation, potentially saving lives and boosting trust in vertical transit systems.

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