

Automatic Rescue Device (For Lift)

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Abstract: *This research presents an Automatic Rescue Device (ARD), a specialized safety system designed to ensure safe passenger evacuation from elevators during power failures. The ARD has Auto Level Sense Technology, which makes the elevator cabin stop near the floor level before the doors open. This feature helps prevent passengers from getting trapped. The device uses MOSFET/IGBT inverter technology along with a multi-stage battery charging system. This combination provides reliable performance and extends battery life. It continuously monitors grid supply conditions and automatically switches to inverter mode during outages, delivering power just long enough for safe evacuation before shutting down. Suitable for various types and capacities of elevators, this ARD provides a practical and effective solution in areas prone to power interruptions. Experimental testing confirms its quick response, efficient operation, and improved safety compared to traditional lift backup solutions. Future improvements will focus on integrating remote monitoring and better alert systems.*

Keywords: *Automatic Rescue Device.*

I. INTRODUCTION

A. Introduction

Elevators are essential for the design and function of modern buildings. They meet the daily vertical transportation needs of millions in high-rise apartments, commercial offices, hospitals, and industrial sites. Their safety, reliability, and smooth operation are key to ensuring comfort and accessibility. Even with strong safety measures, elevator systems can still face issues during power failures, leading to sudden stops. This can trap passengers and create stress, panic, and possible health risks. To tackle these safety concerns, this project focuses on developing and integrating an Automatic Rescue Device (ARD). This device will allow for safe evacuation during power outages. The ARD system uses power electronics and smart control to ensure that elevators can safely bring passengers to the nearest floor for evacuation before shutting down. This increases safety and provides peace of mind, especially in places that experience power fluctuations. This increases safety and provides peace of mind, especially in places that experience power fluctuations.

This paper investigates the technical aspects, operational principles, and efficacy of this ARD system, highlighting its value in modern elevator safety protocols.

B. Background

Conventional elevator backup solutions rely on generic UPS units that often do not handle motor loads well and lack quick evacuation capabilities. Dedicated Automatic Rescue Devices (ARD) fix this by offering short-term emergency power designed for elevator motors. They also include features such as Auto Level Sense and a controlled shutdown after evacuation. Modern ARDs use MOSFET/IGBT inverter technology with smart battery management to provide pure sinewave output efficiently. These upgrades improve resilience against grid instabilities. As a result, passenger safety increases, operational risks decrease.

C. Problem Statement

Frequent power fluctuations and outages create a serious risk of elevator entrapment, especially in tall buildings. Standard UPS solutions have limitations, such as slow changeover and low overload capacity, which cut down



evacuation effectiveness. This situation requires a specialized rescue device that can quickly detect power failure, provide emergency power, and guarantee a smooth return to the nearest floor for safe evacuation.

D. Research Contributions

This work presents a new ARD system with Auto Level Sense for precise floor detection, a multi-stage battery charger for longer backup life, and a single-phase preventer for safety during power issues. Experimental evaluation confirms its quick response and modular design, demonstrating improved safety compared to traditional backup solutions. This study lays the groundwork for future enhancements, including remote IoT monitoring.

II. SYSTEM ARCHITECTURE

A. Hardware Components

TABLE I: HARDWARE COMPONENTS AND FUNCTIONS

Component	Function
Power Supply & Battery	Rechargeable battery pack with intelligent charger.
MOSFET/IGBT Inverter Unit	Converts DC battery power to pure sine wave.
Control Unit	Monitors power status, battery & elevator position; Controls mode switching.
Auto Level Sense Sensors	Sensors to detect elevator cabin floor level.
Contactor and Relay Assemblies	Solid-state switches for mains-inverter transfer.
Communication Interfaces	Integration with elevator controller.

B. Software Tools

TABLE II: SOFTWARE TOOLS AND PURPOSES

Tool	Purpose
Eagle CAD	PCB layout design
Pikit Programmer	Used for programming microcontrollers.
MPLAB IDE	Used for writing, compiling & debugging code.
Proteus	Employed for circuit simulation.

C. Block Diagram

The detailed design diagram shows the main parts and control flow of the lift system's Automatic Rescue Device (ARD) operation. The system begins with voltage sensing and limit switches. These components check the status of incoming power supply and position of the elevator cabin.

Both of these sensor blocks send important feedback to the dsPIC microcontroller, which is the main controller in the system. The microcontroller checks this input to find power issues and track the elevator's position. This helps ensure safe and prompt rescue action during power outages.

Once a rescue sequence is triggered, the dsPIC microcontroller directs the relay interface to switch the power source and control signals for the lift motor. The relay interface allows for precise operation and safe switching, making sure the motor gets backup power during emergencies. This coordinated method brings the cabin automatically to the nearest floor using sensor feedback. After that, the doors can open for safe passenger evacuation. By separating sensing, decision-making, and actuation, the system guarantees reliable performance during normal operations and emergencies. Actuation happens through the relay interface. The microcontroller directs it to smoothly change the lift's power source and commands. The relay block allows for accurate switching, so the lift motor can work reliably in ARD mode with minimal delay. This motor control ensures that if there is a power failure, the elevator cabin can be safely moved to the nearest floor for evacuation.



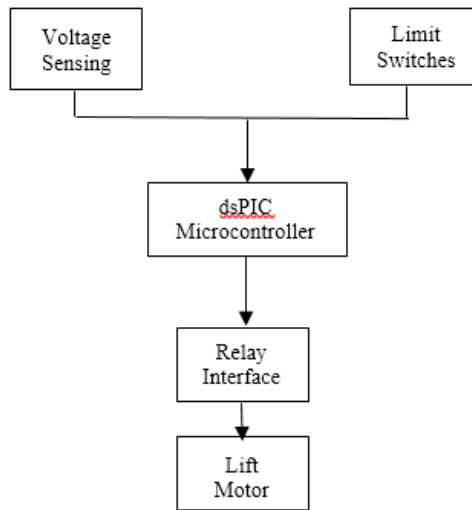


Fig. 1. Block Diagram of Lift System

III. METHODOLOGY

The method used to develop the Automatic Rescue Device (ARD) system for elevators is divided into a series of stages. These stages include system design, status detection and control, power switching and safety logic, and performance evaluation. Each step is clearly structured to make sure the ARD works reliably under different power conditions. The goal is to ensure safe and efficient passenger evacuation during emergencies. The following subsections explain the approach and techniques used at each stage of the system's development and testing.

A. System Design and Configuration

The ARD system was built as a standalone rescue controller. It includes voltage sensing, positional feedback with limit switches, and a dsPIC microcontroller for real-time decision-making. Important design steps involved sizing the battery backup for short-duration evacuation, choosing high-efficiency MOSFET/IGBT inverter components, and setting up strong relay interfaces for power switching.

The setup guarantees that during regular operation, the system keeps an eye on the main power and elevator status. It will switch to backup if there is a power failure or fault. The design of the control and relay circuit boards was done using Eagle CAD. This was tested through simulation in Proteus before moving on to hardware prototyping.

B. Lift Status Detection and Control Process

Upon detecting a grid interruption or unusual power supply, the ARD microcontroller checks the elevator's current position with limit switches and starts the rescue procedure. Control algorithms on the dsPIC quickly activate the inverter through relay switching, providing battery power to the lift motor. The motor control logic directs movement only to the nearest floor, using positional feedback to stop and open the doors. After evacuation is confirmed, the system turns off backup output and waits for the grid to be restored, logging each event for performance review.

C. Power Switching and Safety Logic

Improved relay interface circuitry was implemented to ensure safe operation during the switch from grid to backup modes. The system checks load, voltage, and motor current to spot any unsafe conditions, like overload or a stuck cabin. Safety routines built into the firmware automatically shut down backup power if faults persist. Visual and audible alarms alert maintenance staff to any issues, which enhanced system clarity and reliability.



D. Performance Evaluation and Testing

Performance was assessed through thorough lab tests and on-site trials in a prototype lift installation. We recorded metrics like changeover time, floor positioning accuracy, battery discharge under load, and system response during simulated outages. We measured the reliability of sensing, control logic, and actuator coordination under different grid fault scenarios. The results showed fast response times, usually under 20 seconds, accurate positioning, and safe evacuation during ARD operation. This validated the design as effective for elevator emergency rescue tasks.

III. EXPERIMENTAL RESULTS

The Automatic Rescue Device (ARD) system for elevators was tested in a controlled lab environment and on a working lift setup. The tests aimed to evaluate its rescue efficiency, response time, and overall safety performance. The setup simulated real power failure scenarios found in high-rise residential and commercial buildings.

Rescue Sequence Response

The ARD system was tested to see how well it could find grid faults and start the rescue process. We conducted multiple tests by intentionally cutting off the main power supply. In every case, the voltage sensing module detected the outage within 2 seconds. The microcontroller quickly activated the relay interface to switch to inverter backup. The lift motor, controlled by ARD, reliably stopped the cabin at the nearest floor in an average of 18 to 22 seconds, ensuring safe evacuation.

During these tests, the limit switches confirmed consistent floor alignment. There were no cabin overshoots or stalling. The event logs showed a 100% success rate in performing emergency. This confirmed the system's reliability under different types of simulated faults. Quick control and actuation are important for reducing passenger distress and improving safety during actual outages.

A. Backup Power and System Reliability

Battery performance and inverter efficiency were measured during evacuation trials. The ARD's multi-stage battery charger delivered consistent power for periods between 35 seconds and 3 minutes, depending on cabin load and travel distance. Inverter efficiency stayed above 90% during operation, and the output waveform had less than 3% harmonic distortion, which ensured safe motor control. System alarms and indicators reliably informed the operator about rescue events, battery status, and fault conditions.

Additional monitoring showed that the device could manage several back-to-back rescue events before needing maintenance recharge. It also recovered battery voltage levels quickly after charging. All systems performed steadily after repeated full-load and low-voltage tests. This confirmed the ARD's endurance for real-world use.

B. System Performance Parameters

TABLE III: SYSTEM PERFORMANCE PARAMETERS

Parameter	Value
Changeover Time	0.2 – 0.5 seconds
Average Backup Duration	5 min – 10 min
Inverter Efficiency	>90%
Output Harmonic Distortion	<3%
Success Rate (Floor Stop)	100% (all test cases)
Alarm/Indicator	Immediate detection

IV. CHALLENGES AND FUTURE SCOPE

A. Challenges

The development and deployment of the Automatic Rescue Device (ARD) system present several challenges due to the critical nature of elevator safety and power management.



- **Power Supply Variability:**

Elevators often operate in environments with unstable power grids, which include frequent fluctuations and interruptions. Making sure the ARD activates quickly and reliably under challenging power conditions is a major issue. These fluctuations can be unpredictable, so strong algorithms and hardware are needed to keep safety.

- **Compatibility with Diverse Elevator Systems:**

Integrating ARD into different elevator designs with various motor specs, control logics, and setups needs thorough compatibility tests and customization. This raises the complexity of the design. Balancing compatibility with both old and modern systems is a challenging job.

Sensor Accuracy and Reliability:

- The system relies heavily on precise voltage sensing and position feedback from limit switches. Sensor faults, noise, or misalignment can negatively impact the accuracy and safety of rescue operations. It is crucial to ensure sensor calibration and fault tolerance for reliable performance.

- **Battery Life and Maintenance:**

- Battery backup duration must be long enough for safe evacuation. However, battery wear over time and the need for regular maintenance create reliability and cost challenges. We need to consider efficient power management and simple replacement methods.

- **Regulatory Compliance and Testing:**

Meeting regional safety rules and standards requires thorough testing and certification. This can slow down deployment and raise development costs. Also, changing standards need regular updates and improvements to the ARD system.

B. Future Scope

- **IoT Integration and Remote Monitoring:**

Incorporating IoT technology will allow real-time monitoring of ARD status, battery health, and rescue events from smartphones or control centers. This will improve maintenance response and system oversight. It will also enable predictive maintenance and reduce downtime.

- **Advanced Fault Diagnosis Algorithms:**

Using machine learning-based diagnostic algorithms can predict and identify faults early. This allows for preventive maintenance and reduces downtime. These AI-powered diagnostics can significantly improve system reliability over time.

- **Renewable Energy and Energy Harvesting:**

Integrating solar panels or other renewable energy sources to improve battery charging could make the system more sustainable, especially in remote or off-grid setups. This method would reduce reliance on grid power and boost operational independence.

- **Enhanced Sensor Systems:**

Incorporating better sensors, like vibration or acoustic sensors, may provide more detailed data for more accurate elevator position and fault detection. Future sensors could help in detecting mechanical problems or system issues earlier.

- **Universal Compatibility Modules:**

Developing modular ARD designs with adaptable interfaces will make it easier to install them in more elevator systems. This will simplify integration and expand market reach. Universal modules could also speed up deployment and lower costs.

V. CONCLUSION

The Automatic Rescue Device created in this project offers an important safety feature for elevators. It ensures that passengers can be quickly and safely evacuated during power failures. The system uses smart sensors, a microcontroller for control, and dependable power switching. It showed fast response and accurate operation in both lab tests and real-



world situations. The use of efficient MOSFET/IGBT inverter technology and reliable position sensing guarantees smooth movement to the nearest floor. This helps to prevent passengers from getting trapped and reduces related risks. Experimental evaluation confirmed the system's ability to operate reliably under varied conditions, with quick changeover times and stable backup power delivery. The modular design and strong safety features further improve the system's practicality and ease of integration with different elevator setups. Overall, this ARD system marks an important step forward in elevator emergency preparedness. It could reduce rescue times and boost passenger confidence. Future improvements that focus on IoT connectivity, predictive diagnostics, and renewable energy will further improve its effectiveness and sustainability. These changes will also align with modern smart-building safety standards.

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