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Design and Implementation of a Microcontroller-Based Vehicle Arresting System Using RF Communication

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Abstract: *In modern security systems, preventing unauthorized vehicle entry at check posts is a major challenge. Conventional barricades are weak and can be easily broken by high-speed vehicles. This paper presents the design and implementation of an automated vehicle stopping system using a microcontroller-based approach. The system employs RF communication and a remotely controlled bollard mechanism to stop vehicles attempting to evade checkpoints. The system consists of a main control unit using the AT89C52 microcontroller, RF transmitter and receiver modules, DC motors, and a rack-and-pinion mechanism for vertical movement of bollards. The results demonstrate that the system effectively detects and responds to unauthorized vehicle entry by deploying strong barriers. The proposed system enhances security at check posts, military zones, and restricted areas.*

Keywords: Microcontroller, RF Communication, Bollards, Check Post Security, Embedded Systems, Vehicle Control

I. INTRODUCTION

Security at check posts plays a vital role in preventing illegal activities such as smuggling and unauthorized access. Traditional barricades used at checkpoints are often insufficient to stop vehicles that attempt to forcibly break through. This creates a need for a more robust and automated system capable of preventing such violations. The proposed system introduces an automated vehicle stopping mechanism using vertically rising bollards. These bollards are activated remotely when a vehicle attempts to evade the checkpoint. The system ensures immediate response and effective vehicle interception.

The system is based on microcontroller technology, which allows efficient control of hardware components such as motors, RF modules, and sensors. By integrating embedded systems with mechanical actuators, the project provides a reliable and cost-effective solution for high-security applications.

II. DESIGN AND METHODOLOGY

The system is designed using an embedded microcontroller architecture. The main processing unit is built using the AT89C52 microcontroller, which controls the operation of barricades and bollards. The methodology involves detecting a vehicle that attempts to cross the barricade forcefully. Once detected, the operator activates the remote-control unit, which transmits a command signal using RF communication. The receiver decodes this signal and activates the motor mechanism to raise the bollards.

The system consists of three major modules:

• Remote control unit (AT89C2051 + RF transmitter)
• Main processing unit (AT89C52 + RF receiver)

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• Mechanical unit (DC motor + rack and pinion)

This modular approach ensures efficient control and easy scalability of the system.

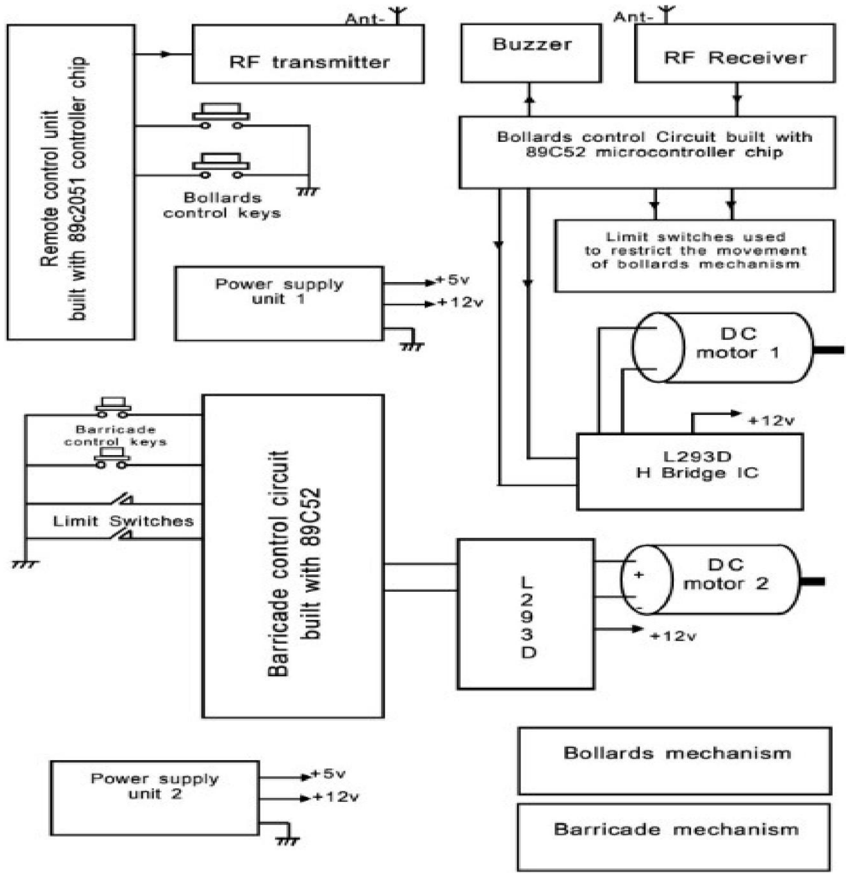

Fig 2.1. Block Diagram

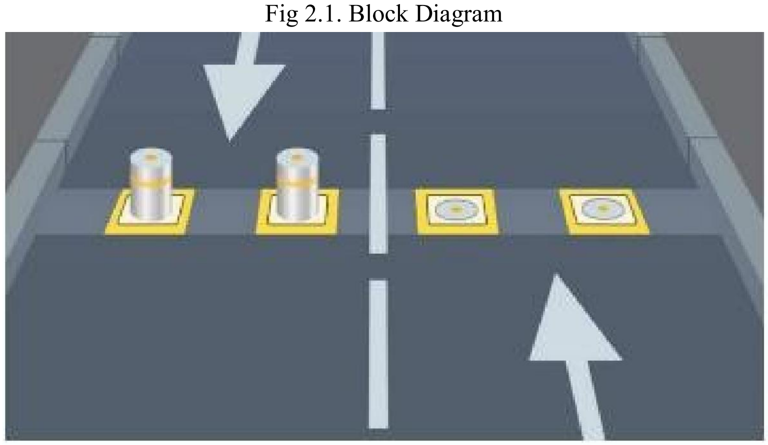

Fig 2. 2. Working Model

The resonant behavior of the cylindrical dielectric resonator is strongly influenced by its physical dimensions and dielectric constant. Proper optimization of these parameters helps achieve efficient mode excitation and stable antenna performance at the desired operating frequency.

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III. SYSTEM CONFIGURATION AND DESIGN

The system consists of a cylindrical arrangement of components including a microcontroller, RF modules, DC motors, and limit switches. The RF transmitter sends digital signals at 433 MHz frequency, which are received and decoded by the RF receiver. The DC motor is driven using an L293D H-Bridge driver circuit, which enables bidirectional movement of the motor. The motor drives a rack-and-pinion mechanism that converts rotational motion into linear motion to raise or lower the bollards.

Limit switches are used to detect the position of the bollards and prevent over-travel. The entire system is mounted on a prototype structure simulating a real road environment. The implementation demonstrates a reliable interaction between electronic and mechanical components, ensuring effective operation of the system.

The system configuration consists of three main units: the remote-control unit, the main processing unit, and the actuator mechanism. The remote-control unit is designed using an AT89C2051 microcontroller interfaced with RF transmitter modules operating at 433 MHz. When a control key is pressed, the microcontroller generates an 8-bit digital code which is transmitted wirelessly to the receiver unit.

The main processing unit is built around the AT89C52 microcontroller, which receives and decodes the transmitted RF signals. Based on the received command, the controller activates the motor driver circuit using the L293D H-Bridge IC. This driver circuit enables bidirectional control of the DC motor, allowing both raising and lowering of the bollards. The use of an H-Bridge is essential because the microcontroller cannot directly drive the motor due to current limitations.

The RF receiver module used in the system operates at the same frequency as the transmitter and demodulates the incoming signal before passing it to the microcontroller. The entire system is powered through a regulated power supply unit that provides stable DC voltage to all components. The integration of electronic control with mechanical actuation ensures reliable and efficient operation of the vehicle stopping system.

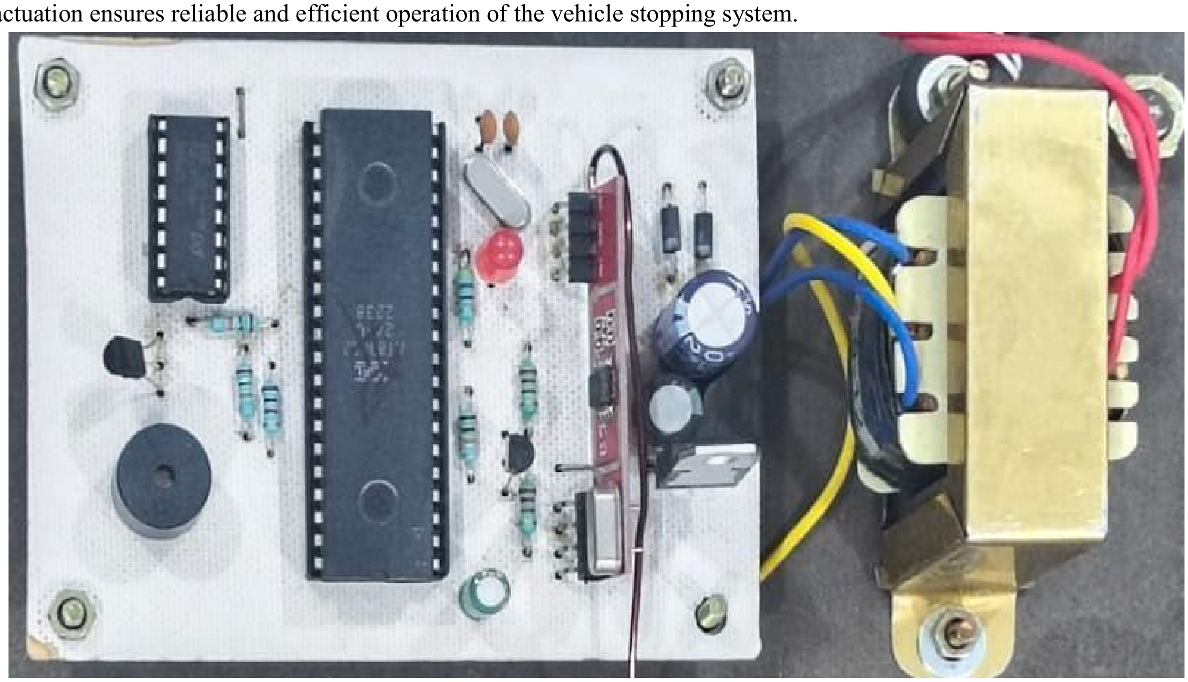

Fig 3.1 Implementation

The actuator mechanism is implemented using a rack-and-pinion system coupled with a geared DC motor. This mechanism converts the rotational motion of the motor into linear motion required to move the bollards vertically. Limit switches are incorporated to detect the extreme positions of the bollards and provide feedback to the microcontroller, ensuring safe operation and preventing mechanical damage.

Key simulation parameters include resonant frequency at 4 GHz, copper ground plane, coaxial feed excitation, and air box enclosure. The resonator dimensions are optimized to achieve minimal return loss and maximum gain.

IV. RESULTS

The prototype model was successfully implemented and tested under various conditions. The system demonstrated reliable performance in detecting and stopping unauthorized vehicles. The RF communication provided stable signal transmission, and the microcontroller accurately controlled the motor operations. The bollards were raised and lowered efficiently using the rack-and-pinion mechanism. The system demonstrated consistent performance in terms of response time and mechanical stability. The integration of the L293D motor driver enabled smooth operation of the DC motor without overloading the microcontroller.

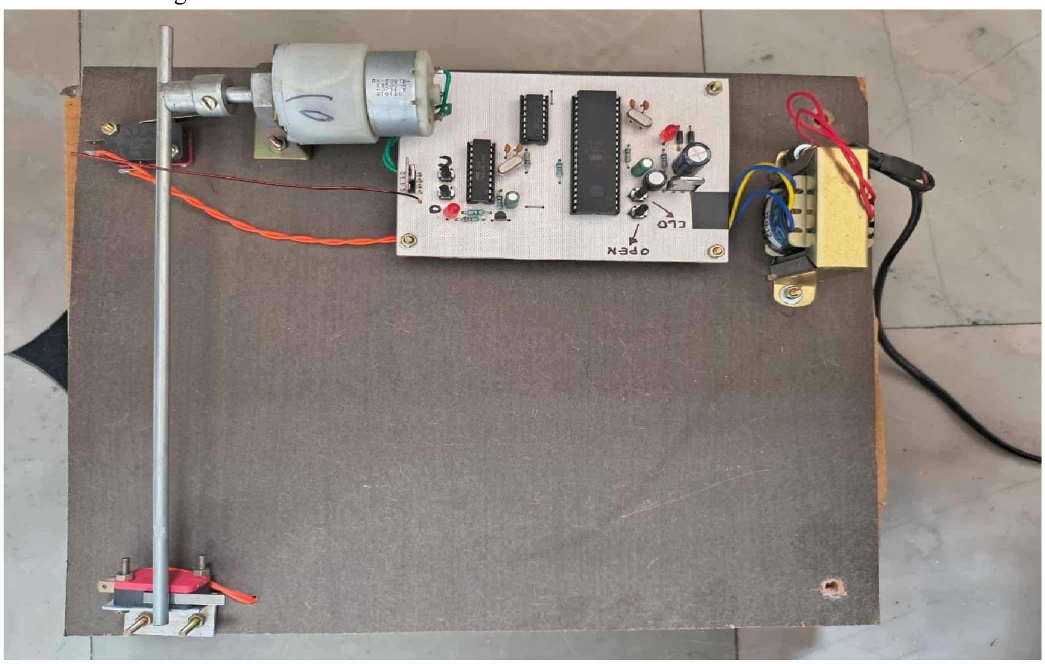

Fig.4.1 Result

The system showed good response time and effective functionality. The results confirm that the proposed system can be used in real-time applications with minor enhancements. The developed prototype was tested under different operating conditions to evaluate the performance of the automated vehicle stopping system. The RF communication between the transmitter and receiver was observed to be stable within a range of approximately 40–80 feet, depending on environmental conditions. The transmitted 8-bit digital command signals were accurately received and decoded by the receiver unit, ensuring reliable control of the system.

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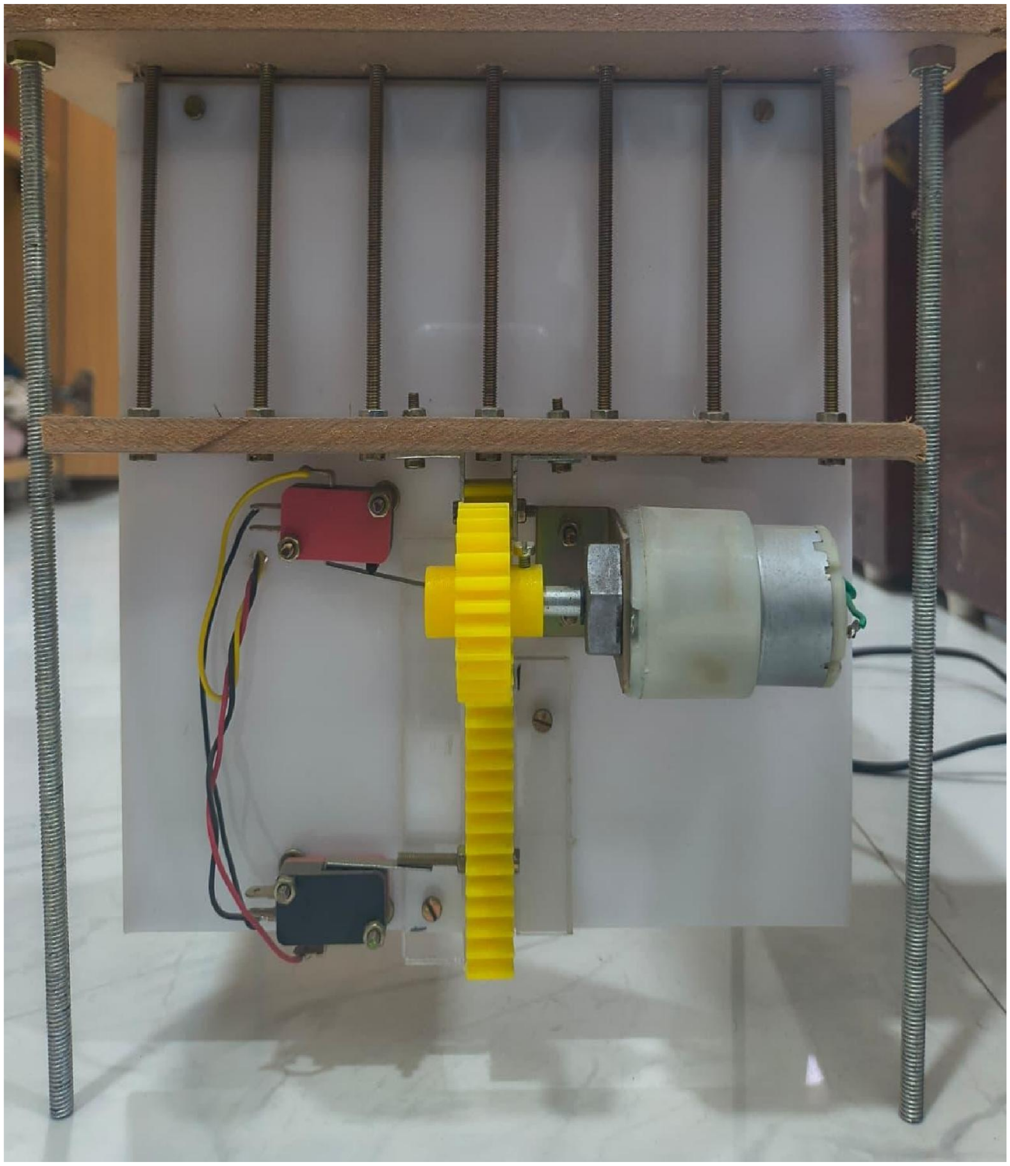

Fig.4. 2 Result

The RF modules successfully maintained synchronization between transmitter and receiver, allowing real-time operation of the system. The results confirm that the system is capable of effectively stopping unauthorized vehicles in a controlled environment.

V. APPLICATIONS

The proposed system can be used in high-security areas such as state border check posts, military zones, and VVIP areas. It is also suitable for toll gates, restricted industrial zones, and airport security systems.

Additionally, the system can be used in smart city infrastructure for traffic control and automated access management. The ability to remotely control and automatically deploy barriers makes it highly useful in modern security systems.

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VI. FUTURE SCOPE

Future improvements can include automation using sensors and artificial intelligence to detect vehicles automatically without human intervention. Integration with RFID systems can allow identification of authorized vehicles.

Advanced microcontrollers or processors can be used to improve system performance and enable real-time data processing. The system can also be integrated with IoT for remote monitoring and control. Further enhancements can include using heavy-duty materials and industrial-grade actuators for real-world deployment.

VII. CONCLUSION

The automated vehicle stopping system was successfully designed and implemented. The system effectively prevents unauthorized vehicle entry using a combination of RF communication, microcontroller control, and mechanical actuation.

The project demonstrates the practical application of embedded systems in security solutions. The proposed system is reliable, efficient, and suitable for real-world applications with further improvements.

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