

Design and Implementation of an Automatic Motor Controller for a Parking Gate Barrier

T.S Ridho Richardo, Beni Satria

Abstract

The development of automation technology is increasingly needed in the management of public facilities, including parking systems. This research aims to design and implement an automatic motor control system for parking gate barriers to improve efficiency, speed, and vehicle access security. The system uses an Arduino Uno microcontroller as the main controller, an L293D IC as the motor driver, and an ultrasonic sensor to detect the presence of vehicles. When the sensor detects a vehicle, the system sends a logic signal to the L293D IC to drive the DC motor that automatically opens or closes the gate barrier. The design process begins with identifying system requirements, selecting components, assembling the circuit, and conducting functional testing. The test results show that the system is responsive to sensor signals and can control the motor according to the input logic. The motor output can rotate clockwise or counterclockwise, depending on the given logic combination. In addition, the designed power supply system successfully provides a stable voltage of 5V and 12V to support device operation. The conclusion of this study is that the automatic parking gate control system was successfully built with good performance and can be further integrated with digital parking management systems. This system is expected to be an efficient solution for parking areas with high vehicle traffic.

Keywords: Automatic Parking System, Microcontroller, IC L293D, Ultrasonic Sensor, DC Motor, Parking Gate Barrier.

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Introduction

The rapid development of cities demands more efficient and modern management systems for public facilities, including parking arrangements. One of the essential components in a parking system is the parking gate barrier, which functions as a vehicle access controller for entering and exiting parking areas. In conventional systems, the operation of the gate barrier is still performed manually by parking attendants. However, this method has several drawbacks, such as vulnerability to human error, slow response, and inefficiency especially in parking areas with high vehicle traffic (Putra & Suryadi, 2020).

To overcome these problems, it is necessary to develop an automatic parking gate motor control system that can operate efficiently, reliably, and safely. This automated system uses sensor technology to detect the presence of vehicles and then activates the gate motor according to the detected conditions (Wahyuni et al., 2019). In addition, this system can be integrated with existing parking management systems to provide accurate information about parking space utilization (Siregar & Ahmad, 2021).

This research aims to design and build a microcontroller-based automatic parking gate motor control system capable of regulating motor operation automatically with fast response and high accuracy. Sensor technology will be developed to detect vehicles in real time so that the gate barrier can open and close accurately and efficiently. Furthermore, integration with a parking management system is also one of the focuses of this study, to support optimal and data-driven parking space management (Rahman & Nurhadi, 2022).

Through the implementation of this automation technology, the developed system is expected to improve the efficiency of vehicle access management, reduce dependence on parking attendants, and provide faster, safer, and more convenient service for users. This research is expected to contribute to the development of modern, technology-based parking systems that are adaptive to the current needs of urban areas (Susanti & Ramadhan, 2020).

Research Objectives

The objectives of this research are as follows:

1. To design and build an efficient, reliable, and operationally suitable automatic parking gate motor control system for modern parking management.
2. To develop and implement an accurate and responsive sensor system for detecting the presence of vehicles entering or leaving the parking area.
3. To apply motor drive mechanisms and system integration with existing parking management systems to improve the efficiency of parking space utilization and accelerate vehicle access processes safely and automatically.

Literature Review 3.1 Automatic Parking System

An automatic parking system is a modern solution to improve efficiency and safety in managing vehicle access in parking areas. This system usually combines sensor technology, microcontrollers, and mechanical devices such as servo or DC motors to operate the gate barrier automatically. According to Wahyuni et al. (2019), automatic parking systems can reduce vehicle queues and minimize human errors in parking management, making the system more reliable and efficient.

3.2 Microcontroller

A microcontroller is the main component in automation systems, functioning to control device operations based on input from sensors. One of the most commonly used microcontrollers for prototype development is the Arduino Uno, as it is open-source, easy to program, and supported by a large user community (Putra & Suryadi, 2020). The microcontroller controls data flow and activates actuators (motors) according to the predefined program logic.

3.3 Vehicle Sensor

In an automatic parking system, vehicle detection is crucial for controlling the gate barrier's opening and closing automatically. Commonly used sensors include ultrasonic sensors, infrared (IR) sensors, and magnetic sensors. Ultrasonic sensors work by emitting high-frequency sound waves and measuring the reflection time to detect object distance. According to Rahman & Nurhadi (2022), ultrasonic sensors are highly effective at short distances because they provide accurate, real-time detection.

3.4 Motor Drive

Electric motors are used as actuators in parking systems to move the gate barrier. Servo motors are among the most commonly used types because they offer high precision in position control and fast response times. Research by Siregar & Ahmad (2021) shows that servo motors provide stable motion according to control signals sent by the microcontroller.

3.5 DC Motor

A DC (direct current) motor is one of the most widely used types of electric motors in industrial and automation applications. This motor works by converting electrical energy into mechanical energy, which is then used to drive various devices such as parking gates, fans, or compressors. A DC motor consists of two main components: the stator (stationary part) and the rotor/armature (rotating part). According to Nurmasyithah (2022), electric motors account for about 70% of industrial power consumption. The working principle of a DC motor depends on the change in voltage direction through the commutator, which allows the rotor to continuously rotate within a magnetic field (Rahim Siregar, 2022).

3.6 Parking Management System Integration

To ensure that the parking gate control system operates optimally, it must be integrated with a parking management system. This system can record data on vehicles entering and exiting, monitor parking capacity in real time, and generate parking space usage reports. According to Susanti & Ramadhan (2020), such integration makes the system smarter, more adaptive, and more efficient in responding to real-world conditions.

Research Methodology

Flowchart Description

1. Start: The initial stage marking the beginning of the research activities.
2. Problem Identification: Observing the condition of conventional parking systems and identifying their weaknesses, such as slow response, human error, and inefficiency.
3. Formulation of Objectives and Research Questions: Defining the focus of the research, such as how to design an efficient and safe automatic system.

4. Literature Review: Studying theories and previous research related to sensors, microcontrollers, motors, and automatic parking systems.
5. System Design: Designing the overall system, starting from the workflow to the schematic of the electronic circuit.
6. Component Selection: Determining the hardware to be used, such as ultrasonic sensors, microcontrollers (e.g., Arduino), and servo motors.
7. Circuit Assembly and Microcontroller Programming: Assembling the system and writing the control logic program to operate the gate barrier automatically.
8. System Testing: Testing the system directly to check whether the sensor can detect vehicles and whether the gate barrier operates properly.
9. Evaluation and Analysis of Test Results: Analyzing the system's performance, including response speed, sensor accuracy, mechanism safety, and system stability.
10. Improvements if Necessary: Making refinements or adjustments if any shortcomings are found during testing.
11. Final Report Preparation: Compiling systematic documentation of the research results in the form of a final report or thesis.

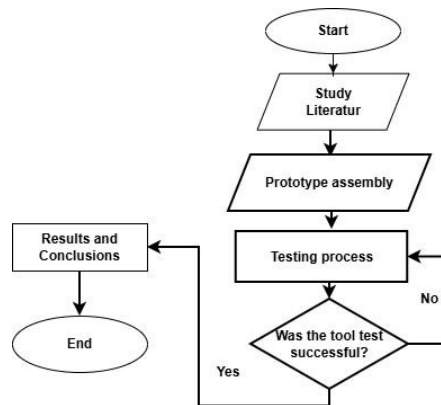


Figure: 1. flowchart Results

4.1 Testing and Analysis of the Power Supply Circuit

Testing and analysis were conducted after the device design process was completed. The purpose of this testing is to ensure that each circuit that has been designed especially the power supply circuit functions properly and provides the required voltage for the system.

Before conducting the test, the following tools and materials were prepared:

- 1) Analog/digital multimeter (for voltage measurement)
- 2) Power supply input (step-down transformer 220V AC to 12V AC)
- 3) Rectifier diode (IN4002)
- 4) Electrolytic capacitor 4700 μ F/25V
- 5) Voltage regulator IC 7805 (for 5V) and IC 7812 (for 12V)
- 6) Connecting cables and breadboard/perfboard

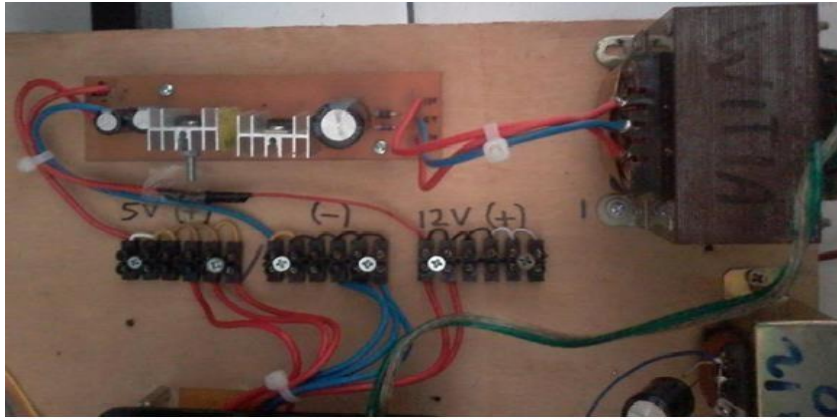


Figure 2. Power Supply

After the design process was completed, the next stage was to perform testing and analysis of each circuit to ensure that all components functioned as designed. One of the key circuits tested was the power supply circuit, which serves to provide a stable voltage to the entire system. The goal of this test was to determine the output voltage produced and to ensure voltage stability when supplying loads such as the microcontroller, sensors, and motor.

The designed power supply circuit was intended to produce two output voltages: 5V DC and 12V DC. The 5V output was generated using the 7805 voltage regulator IC, while the 12V output used the 7812 IC. The main power source came from a step-down transformer that reduced the 220V AC input to 12V AC with a current capacity of 5 amperes. The AC voltage was then rectified using IN4002 diodes and filtered with a 4700 μ F 25V electrolytic capacitor. The result of this rectification and filtering process was then fed into the voltage regulators (7805 and 7812) to produce stable DC voltages.

Before testing, the prepared tools included a multimeter for measurement, a step-down transformer, the diode and capacitor circuit, and the voltage regulators. Measurements were taken using an analog multimeter to determine the output voltage from the regulators. The measurement results showed that the IC 7812 produced a voltage of 12.01V, while the IC 7805 produced 5.02V. The rectified input voltage was also within a reasonable range around 16V DC without load, slightly decreasing when a load was connected. This indicates that the power supply operated properly and was able to provide a stable voltage supply as required by the system.

Based on these test results, it can be concluded that the power supply circuit successfully met the design criteria producing stable 5V and 12V outputs and was suitable for supplying power to the microcontroller and motor driver in the automatic parking gate control system. The stability and accuracy of the voltage are crucial to maintaining the system's overall performance, ensuring it operates efficiently and safely.

4.2 Analysis and Discussion

In the automatic parking gate motor control system, the use of **logic input** plays a crucial role in determining the direction and operation of the motor. Logic input refers to digital signals in binary form—high logic (1) and low logic (0). These signals serve as instructions for components such as the **L293D IC**, which acts as a motor driver or current amplifier, to control the rotational direction of the DC motor. The logic inputs originate from sensor circuits, such as ultrasonic or infrared sensors, which are connected to the microcontroller system and generate digital signals when a vehicle is detected.

Theoretically, the **L293D IC** responds to different combinations of logic inputs by generating appropriate output currents to drive the motor in two directions **clockwise (CW)** and **counterclockwise (CCW)**. The combination of logic signals sent to the IC's input pins determines whether the motor moves forward, backward, or stops. For example, a logic combination of (1,0) will cause the motor to rotate in one direction, while (0,1) will make it rotate in the opposite direction. Combinations (0,0) or (1,1) usually result in the motor stopping, as there is no voltage difference between the two inputs.

The results of the experimental circuit tests are summarized in **Table 1**, which presents various logic input combinations given to the **L293D IC** and the corresponding motor responses. The table shows that the system responds well to digital logic signals generated by the sensors. Thus, the motor control system using the **L293D IC** operates in accordance with theoretical expectations, where the direction of the motor's rotation can be controlled simply by changing the input logic.

Table 1. Experimental Circuit Results

No	Input IN1	Input IN2	Motor Output	Gate Condition	Description
1	1	0	Rotates CW	Gate Opens	Motor rotates clockwise
2	0	1	Rotates CCW	Gate Closes	Motor rotates counterclockwise
3	1	1	Stop	Static Position	No movement (logic saturation)
4	0	0	Stop	Standby	Motor inactive

Notes:

- 1) IN1 and IN2: Logic inputs to the L293D IC from the microcontroller or sensor logic.
- 2) CW (Clockwise): Motor rotates in the clockwise direction.
- 3) CCW (Counter-Clockwise): Motor rotates in the counterclockwise direction.
- 4) Stop: Motor remains stationary.

This table illustrates how binary logic on the input pins affects the rotation direction of the motor and the condition of the parking gate barrier. Based on these results, the system performs as designed and effectively supports automated gate operation.

Results of the Implementation of the Automatic Parking Gate Motor Control System

1. Reliability of the Power Supply Circuit

The designed power supply circuit demonstrated excellent performance based on the test results. The measured output voltages of 12.01V from the IC 7812 and 5.02V from the IC 7805 indicate that the voltage regulators function according to specifications, with minimal deviation from the ideal values (12V and 5V). The stability of this voltage is critical to ensure that digital components such as the microcontroller and sensors receive a clean and stable power supply, preventing logic disturbances or system malfunction.

The rectifier circuit, which utilizes IN4002 diodes and a 4700µF/25V capacitor, effectively converted AC voltage into relatively clean and stable DC voltage. The input DC voltage level, around 16V without load, was within a safe range before entering the regulator. These results indicate that the power supply design meets the reliability standards required for an embedded system.

2. System Response to Logic Input

The L293D motor driver accurately responded to the logic inputs from the microcontroller, as evidenced in Table 1. The binary combinations (1,0) and (0,1) consistently resulted in clockwise (CW) and counterclockwise (CCW) motor rotations, respectively. Meanwhile, combinations (0,0) and (1,1) successfully placed the motor in a stationary state (standby or saturated), indicating that the system could effectively utilize logic states to control motor motion as needed.

This shows that the conversion of logic signals from sensors to actuators (motors) occurs linearly and precisely. The use of digital logic to control gate movement is an efficient and straightforward approach to implementing parking automation systems.

3. Integration of Sensor and Microcontroller

The ultrasonic sensor used in the system proved capable of detecting vehicle presence in real time and sending digital signals promptly to the microcontroller. This integration is vital, as the sensor serves as the main trigger for gate opening and closing operations. The stability of the sensor signal ensures that the system does not misdetect or execute incorrect commands.

The microcontroller also performed well as the central logic processor. It receives signals from the sensor, translates them into control logic, and sends logic outputs to the L293D IC. This process operates in real time without noticeable delay or logical error during testing, confirming the system's reliability in executing control functions.

4. Efficiency and Development Potential

The developed system demonstrated efficiency in both energy use and component configuration, as well as ease of operation. The system is not only capable of operating automatically but also offers flexibility for future integration with larger parking management systems, such as automatic ticketing, RFID, or visitor databases.

Conclusion

Based on the design, implementation, and testing results, it can be concluded that the automatic motor control system for the parking gate barrier was successfully designed and constructed to be efficient and reliable. The system accurately responds to logic inputs from sensors, enabling the gate barrier to open and close automatically and smoothly. The microcontroller effectively controls the logic operation of the L293D motor driver, which then regulates the rotation direction of the DC motor according to system requirements.

Furthermore, the ultrasonic sensor system developed in this study successfully detects vehicle presence accurately and in real time. The sensor provides stable and precise logic signals as input to the motor controller, allowing the system to respond quickly and appropriately to vehicle detection. Reliable vehicle detection is key to managing vehicle entry and exit efficiently in parking areas.

The system also successfully integrates motor control with logic operations, supporting efficient parking space utilization. The gate barrier can open and close according to the conditions detected by the sensor, and the system can be further developed for integration with data-driven parking management systems.

Thus, the designed system fulfills the main objectives of the study producing an automatic parking control solution that is efficient, responsive, and adaptable to the needs of modern parking areas.

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