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Design and Implementation of a Multi Sensor Based Vehicle Safety System Using RFID and Microcontroller for Accident Prevention

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Abstract

Vehicle safety is a crucial aspect of driving safety, especially given the growing number of drivers whose abilities may increase the risk of traffic accidents. This study aims to design and build a microcontroller-based safety system capable of providing early warnings and taking automatic actions to prevent accidents. The developed system utilizes an ATMega8535 microcontroller integrated with several types of sensors, including an SRF04 ultrasonic sensor for distance detection, a phototransistor for speed measurement, and an LM35 sensor for monitoring engine temperature, and is equipped with a security system using RFID. The research method employed involves the design and implementation of an embedded system using a prototype approach. Data from the sensors is processed by the microcontroller to determine whether conditions are safe or hazardous based on specific threshold values. If the distance to an object is less than 11 cm, the engine temperature exceeds 80°C, or the vehicle speed exceeds the specified limit, the system will issue a warning via a buzzer and automatically activate the braking system. Vehicle status information is displayed in real-time on an LCD. Test results show that the system performs very well in terms of detecting conditions and responding quickly, with an average response time of approximately 1–1.4 seconds under various sensor test conditions. The system is also capable of efficiently integrating security (RFID) and safety (multi-sensor) functions into a single device. The conclusion of this study is that the designed system can improve driving safety by providing early warnings and taking actions to minimize the occurrence of accidents.

Keywords: Vehicle Safety, ATMega8535 Microcontroller, Multi-Sensor, RFID, Embedded System.

1. Introduction

Safety is a crucial aspect that must be prioritized in community life, including in the use of vehicles. As community activities continue to increase, so do the associated needs, making transportation a vital component in supporting these activities. Cars, particularly in urban areas, are one of the most widely used modes of transportation. Therefore, driving safety, especially as it relates to safety technology is a critical consideration. [1]Generally, vehicle safety systems are classified into two categories: active safety systems and passive safety systems. Active safety systems function to prevent accidents through various detection and control mechanisms.

Meanwhile, passive safety systems play a role in minimizing the impact of accidents when they cannot be avoided. Thus, passive safety systems will activate when active safety systems are no longer able to prevent an accident from occurring. As the number of vehicle users increases, the number of traffic accidents also tends to rise, particularly during the annual exodus period, which often results in fatalities and injuries. Therefore, a vehicle safety system is needed that can provide protection and reduce the occurrence of accidents. [2]

The system developed in this study uses an ATMega8535 microcontroller connected to software as the main controller. Additionally, the system is equipped with several sensors, namely the SRF04 ultrasonic sensor, a phototransistor, and an LM35 temperature sensor, which collect vehicle-related data. This data is then processed by the microcontroller to facilitate decision-making within the system. Furthermore, the safety system incorporates RFID (Radio Frequency Identification) technology, which serves as a vehicle security mechanism.[3]

2. Research Methods

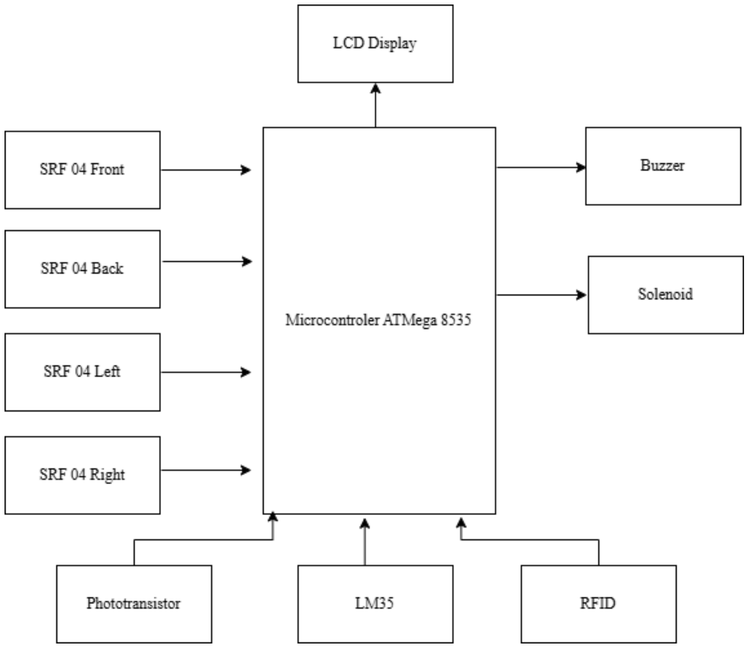

Figure 1. Block Diagram System

Based on the block diagram above, the system uses an SRF04 ultrasonic sensor, a phototransistor, an LM35, and an RFID as inputs. This design uses four SRF04 sensors, which are placed on the front, rear, left, and right sides of the vehicle. The vehicle locking security system uses RFID [4]In this system, the SRF04 functions as a distance sensor, the phototransistor measures speed, and the LM35 measures the vehicle's engine temperature. The outputs of this system are a buzzer (alarm) and the brakes; a solenoid is used in this design. When the vehicle's speed, distance, or engine temperature exceeds the threshold values, the buzzer sounds as a warning of potential danger. The LCD displays whether the security system is locked or not, and also shows the measured distance, speed, and engine temperature [5]. The SRF04 sensors located at the front and rear of the vehicle will automatically stop the vehicle because the SRF04 sensors at the front and rear send a stop command to the microcontroller. Therefore, when the distance and speed exceed the preset normal thresholds, after the buzzer (alarm) sounds, the vehicle will automatically stop[6].

The circuit design consists of a microcontroller, sensors, an LCD display, and other components. These components serve different functions. In this design, the operating principles of each component can be described as follows:

2.1 Ultrasonic SRF04

Sensors are input components in a system that convert physical quantities into electrical signals so they can be processed by a microcontroller. In this study, the SRF04 ultrasonic sensor was used to detect the distance to or presence of obstacles around the vehicle[7]. The system was designed using four SRF04 sensors mounted on the front, rear, left side, and right side of the vehicle to support comprehensive distance monitoring.

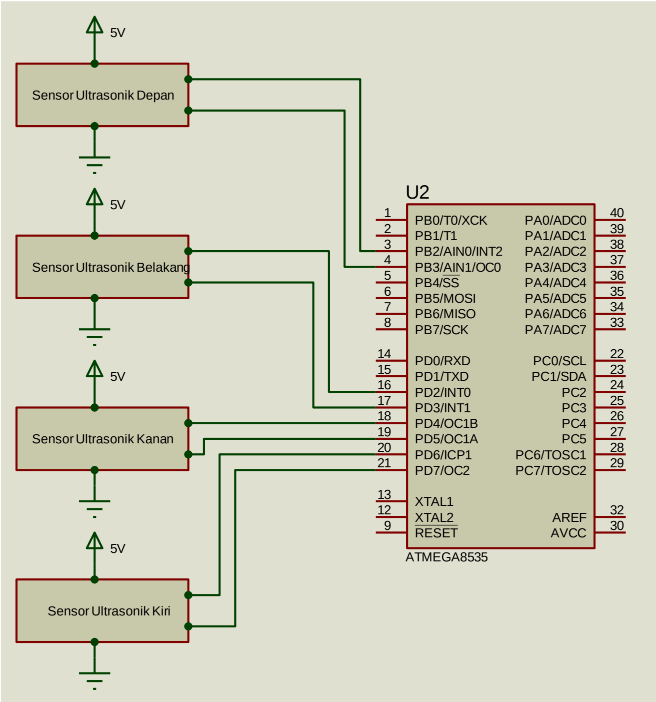

Figure 2. SRF 04 Circuit

2.2 LM 35

The LM 35 is used to measure the engine temperature in a vehicle. This sensor is powered by a +5 V DC supply. It is controlled by the microcontroller via Port A.

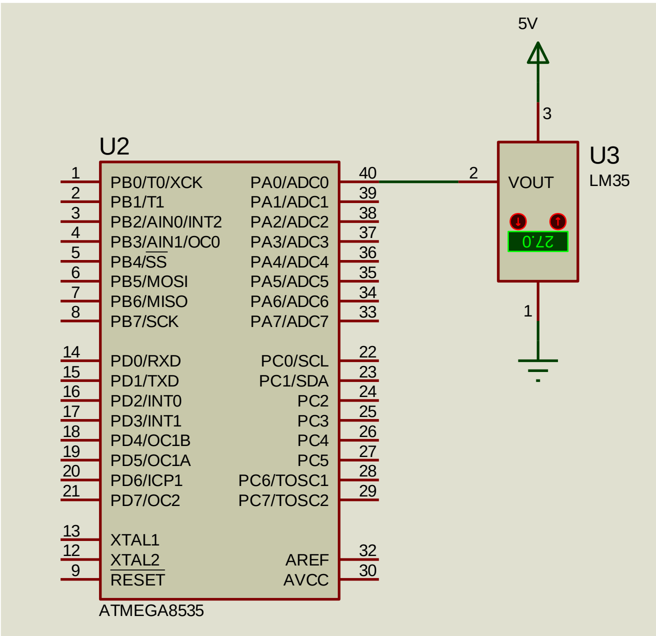

Figure 3. LM 35 Circuit

2.3 LCD Display

The LCD is a component that displays the vehicle's distance, speed, and engine temperature. The LCD is controlled by a microcontroller via PORT C. The LCD display used in this system is the M1632, a 2x16-character display.

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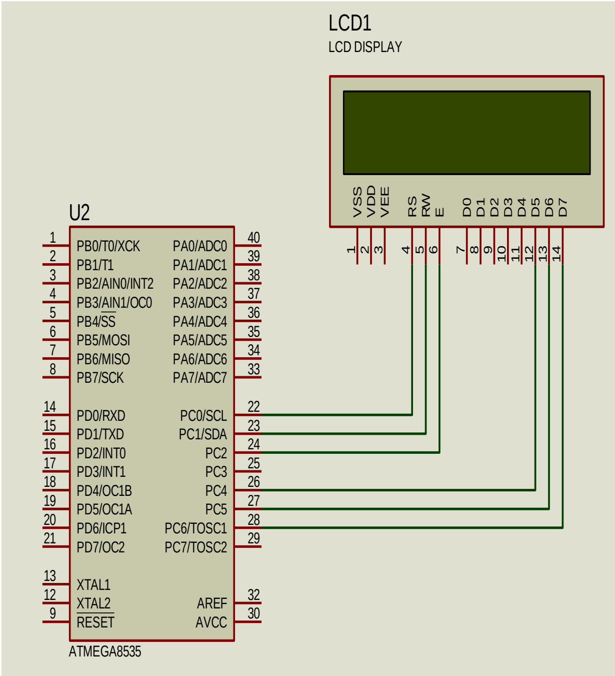

Figure 4. LCD Display Circuit

3. Results and Discussions

The overall system design operates as follows: when the system is powered on, the ATmega8535 microcontroller performs a reset and sets the initial values for all components. Once the initialization process is complete, the system reads data from the ultrasonic sensors mounted on the right and left sides of the vehicle [8]. If the distance to a detected object is less than 11 cm, the microcontroller activates a buzzer as a warning signal. Additionally, ultrasonic sensors mounted on the front and rear of the vehicle are used to detect obstacles in those areas. If the distance to a detected object is less than 11 cm, the microcontroller will activate the buzzer and send a command to the solenoid (braking system) so that the vehicle can stop automatically.

The system also monitors the vehicle's engine temperature using an LM35 sensor. If the engine temperature exceeds the predetermined threshold that is, more than 80°C, the microcontroller will activate the buzzer to indicate a hazardous condition. The measured distance and engine temperature values will be displayed on the LCD in real-time. Next, a phototransistor sensor is used to measure the vehicle's speed. When the vehicle's speed exceeds the preset maximum limit, the microcontroller activates the buzzer as a warning, displays a warning message on the LCD, and issues a command to stop the vehicle in order to reduce the risk of an accident [9].

RFID Output Data

Table 1. RFID Output Data

Voltage Value When The Safety System Is Locked (V)	Voltage Value When The System Is Inactive (V)
0	4.98

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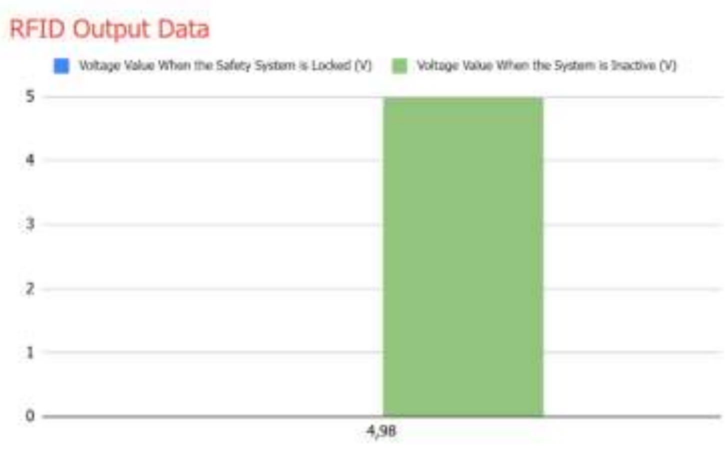

Figure 5. RFID Output Data

Based on the test results, the RFID system demonstrated good performance in controlling the vehicle security system. When the security system is locked, the voltage is 0 V, whereas when the system is deactivated, the voltage rises to 4.98 V. This difference in voltage indicates that the RFID system is capable of effectively activating and deactivating the vehicle security system [10]. Furthermore, the test result graph shows a clear voltage difference between the two states, indicating that the system operates stably and provides a good response.

Table 2. Front SRF 04 Output Data

No	Speed	Distance	Solenoid Time Response (Second)	Voltage (V)
1	30 Km / Hour	3 cm	1	4.94
2	40 Km / Hour	5 cm	1	4.90
3	50 Km / Hour	7 cm	1.2	4.92
4	80 Km / Hour	10 cm	1.3	4.94

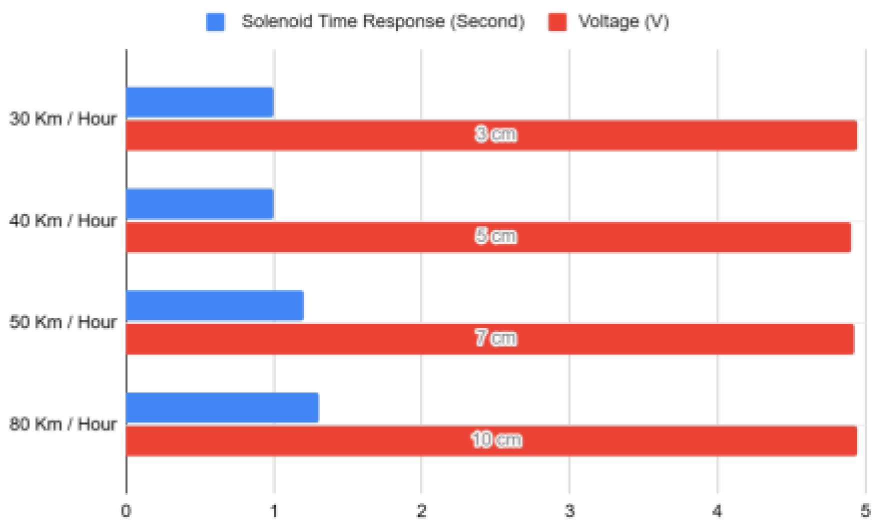

Figure 6. Front SRF 04 Output Data

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Test results for the SRF04 sensor mounted on the front of the vehicle show that increases in vehicle speed and object distance affect the solenoid's response time. The response time increased from 1 second to 1.3 seconds. However, the sensor's output voltage remained stable within the range of 4.90–4.94 V. Based on the test graph, the sensor was able to provide a good response under various test conditions, so it can be concluded that the front SRF04 sensor works effectively in detecting the presence of objects in front of the vehicle [11].

Table 3. Back SRF 04 Ouput Data

No	Speed	Distance	Solenoid Time Response (Second)	Voltage (V)
1	30 Km / Hour	3 cm	1.1	4.94
2	40 Km / Hour	5 cm	1.3	4.90
3	50 Km / Hour	7 cm	1.4	4.92
4	80 Km / Hour	10 cm	1.4	4.94

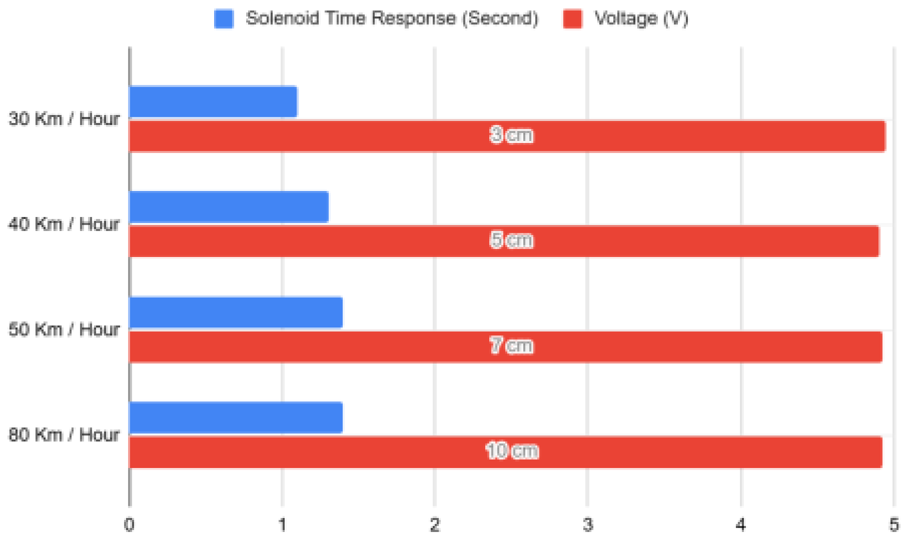

Figure 7. Back SRF 04 Output Data

Based on the test data, the rear SRF04 sensor has a solenoid response time ranging from 1.1 to 1.4 seconds, with an output voltage that remains relatively stable between 4.90 and 4.94 V. An increase in vehicle speed and object distance causes the system's response time to increase slightly [12]. The test graph shows that the rear sensor is able to detect objects consistently and continues to function well under various test conditions.

Table 4. Right Side SRF 04 Output Data

No	Speed	Distance	Buzzer Response Time (Second)	Voltage (V)
1	30 Km / Hour	3 cm	1	4.94
2	40 Km / Hour	5 cm	1.1	4.90
3	50 Km / Hour	7 cm	1.3	4.92
4	80 Km / Hour	10 cm	1.3	4.94

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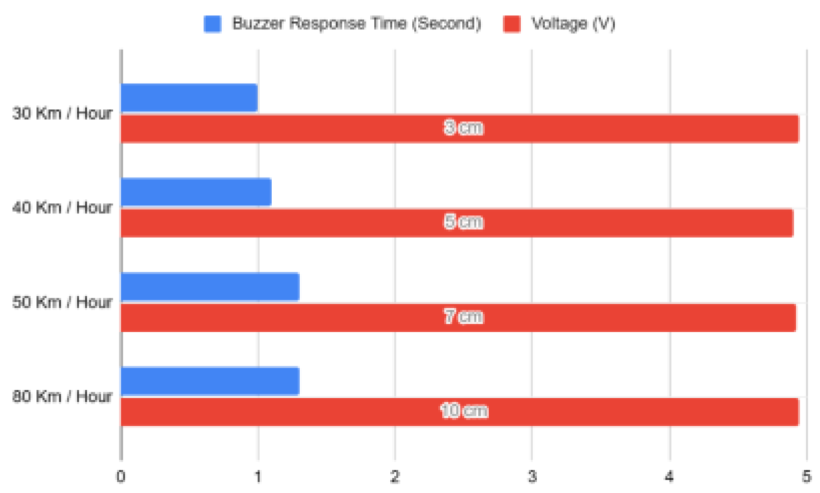

Figure 8. Right Side SRF 04 Output Data

Test results for the right-side sensor indicate that the buzzer response time increases as vehicle speed and object distance increase, specifically from 1 second to 1.3 seconds. The output voltage remains stable within the range of 4.90–4.94 V. The test graph indicates that the warning system on the right side of the vehicle operates quickly and reliably, thereby supporting the vehicle's safety system optimally and efficiently.

Table 5. Left Side SRF 04 Output Data

No	Speed	Distance	Buzzer Time Response (Second)	Voltage (V)
1	30 Km / Hour	3 cm	1	4.95
2	40 Km / Hour	5 cm	1	4.94
3	50 Km / Hour	7 cm	1.2	4.92
4	80 Km / Hour	10 cm	1.3	4.94

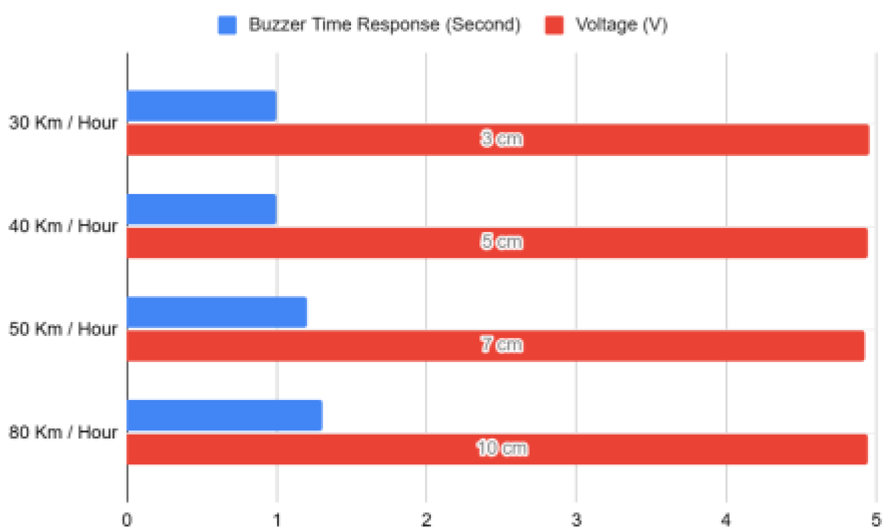

Figure 9. Left Side SRF 04 Output Data

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Testing of the SRF04 sensor on the left side of the vehicle yielded results nearly identical to those of the right-side sensor. The buzzer response time is in the range of 1–1.3 seconds, while the output voltage remains stable at 4.92–4.95 V. Based on the test graph, the sensor is capable of detecting objects effectively under various vehicle speeds, ensuring that the left-side warning system functions effectively and reliably.

Table 6. Output Data Engine temperature On vehicle using the LM 35 sensor

Temperature	Buzzer Time Response (Second)	Voltage (V)
81^0C	1.2	4.94
82^0C	1.2	4.95
83^0C	1.3	4.95

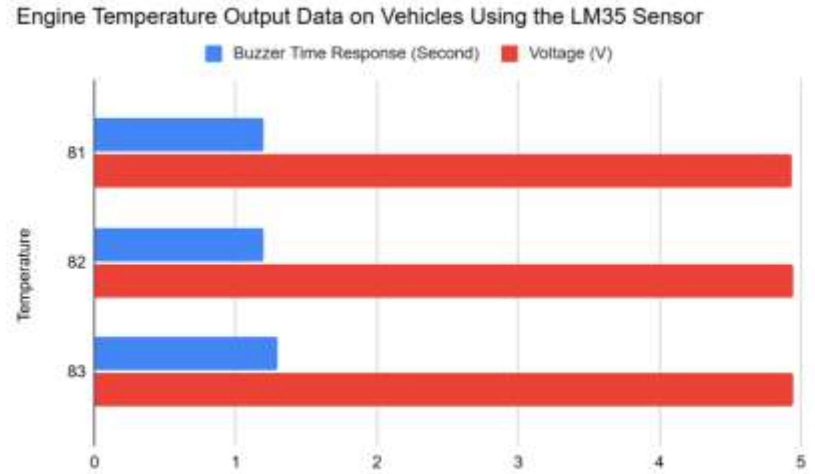

Figure 10. Output Data On Vehicles Using The LM 35 Sensor

Based on the results of the LM35 sensor test, an increase in the vehicle’s engine temperature from 81°C to 83°C caused the buzzer’s response time to increase from 1.2 seconds to 1.3 seconds. The sensor’s output voltage remained stable within the range of 4.94–4.95 V. The test results graph shows that the LM35 sensor is capable of detecting changes in engine temperature effectively and providing a rapid warning response. Thus, the vehicle temperature monitoring system can function effectively and reliably in detecting the vehicle’s engine temperature conditions [13].

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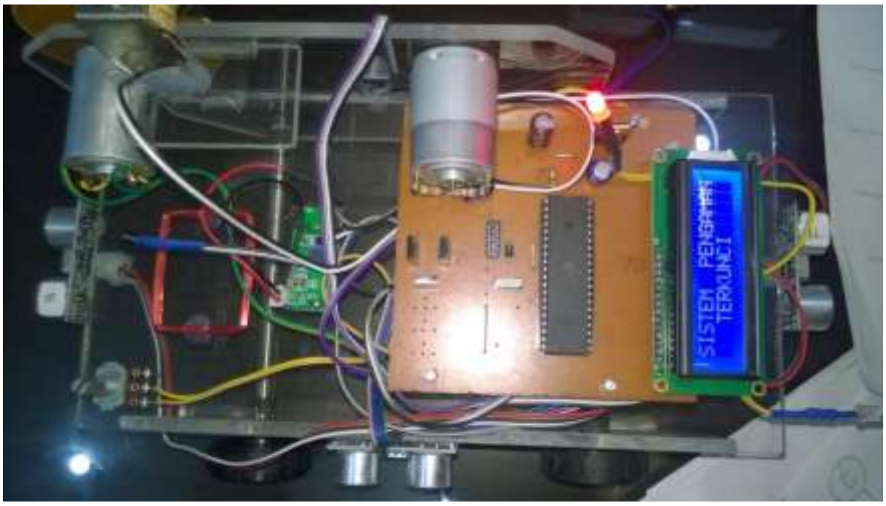

Figure 11. The security system is in a locked state (inactive)

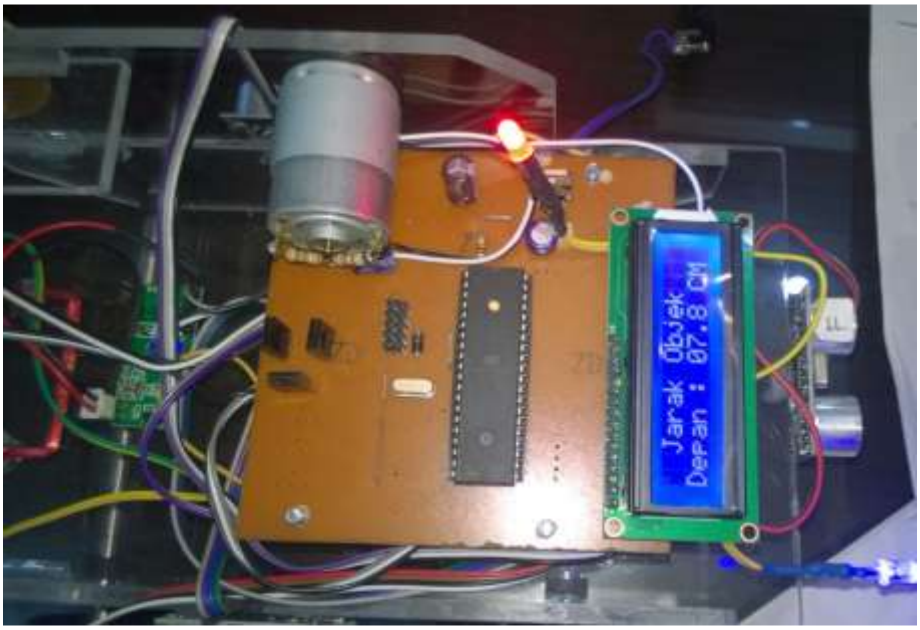

Figure 12. Distance measured on the Front Ultrasonic sensor

4. Conclusion

Based on the test results conducted on the RFID-based vehicle security and monitoring system, the SRF04 ultrasonic sensor, and the LM35 temperature sensor, it was found that all system components functioned properly in accordance with their designed functions. The RFID system successfully controlled the operation of the vehicle's security system by detecting a significant voltage difference between the locked and unlocked states, thereby enabling the user identification process and security system activation to proceed effectively and efficiently. Test results for the SRF04 sensors on the front, rear, right side, and left side show that the sensors are capable of detecting the presence of objects at various distances and vehicle speeds with a relatively fast response time, ranging from 1 to 1.4 seconds. Additionally, the output voltage generated by all sensors remains stable within the range of 4.90–4.95 V. This indicates that the object detection system can operate consistently in issuing warnings and activating the vehicle's safety actuators [14]. Testing of the LM35 sensor also showed that the sensor is capable of accurately detecting changes in vehicle engine temperature within the range of 81°C to 83°C. The system can trigger a buzzer response quickly, with a response time of approximately 1.2–1.3 seconds and a stable output voltage [15]. These results demonstrate that the vehicle temperature monitoring system can be effectively

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used to detect potential engine overheating conditions. Overall, the designed system performs well, is stable, and responds effectively in supporting vehicle safety and real-time condition monitoring. Therefore, this system has the potential to be developed and implemented as a sensor- and microcontroller-based solution to support vehicle safety and security.

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