

## **ACCESS CONTROL AND SECURITY SYSTEM VIA BLUETOOTH APPLICATION ON ANDROID SMARTPHONE**

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### **ABSTRACT**

*Smartphone technology can be applied not only to establish communication needs but also to support other purposes. One of them is related to personal safety and security functions. It is undeniable that criminal acts can occur anytime and anywhere. Even in a private or residential area, theft could happen. Smartphone and sensor technology can be used as a solution to encounter this problem. In this case, it can be utilized to improve the security control system of the gate or garage door at home. This research presents a prototype of a gate and garage door control and security system that operates through an application on an android smartphone. The application of HC-05 Bluetooth is used to send signals from the smartphone to the Arduino Uno microcontroller, while the micro servo acts as a locking mechanism on the gate itself. The buzzer function is presented to notify homeowners when the gate or garage door is open for more than 15 seconds. This prototype can control gates and garage doors with an average connection time of only about 5 seconds. Thus, this prototype is feasible to use as an alternative to control and improve housing security systems.*

**Keywords:** Access control, Android smartphone, Buzzer alarm, Locking mechanism, Security system.

### **ABSTRAK**

*Teknologi smartphone dapat diterapkan tidak hanya untuk memenuhi kebutuhan komunikasi tetapi juga untuk mendukung keperluan lainnya. Salah satunya adalah yang terkait dengan fungsi keselamatan dan keamanan pribadi. Tidak dapat dipungkiri bahwa tindak pidana dapat terjadi kapan saja dan dimana saja. Bahkan di wilayah pribadi atau di perumahan pun, pencurian bisa saja terjadi. Teknologi smartphone dan sensor dapat digunakan sebagai solusi untuk menghadapi permasalahan ini. Dalam hal ini, penggunaannya dapat dimanfaatkan untuk meningkatkan sistem kontrol keamanan gerbang atau pintu garasi rumah. Penelitian ini menyajikan prototipe sistem kontrol dan keamanan gerbang dan pintu garasi yang beroperasi melalui aplikasi smartphone android. Aplikasi Bluetooth HC-05 digunakan untuk mengirimkan sinyal dari smartphone ke mikrokontroler Arduino Uno, sedangkan micro servo berfungsi sebagai mekanisme penguncian pada gerbang itu sendiri. Fungsi buzzer dihadirkan untuk memberi tahu pemilik rumah saat pintu gerbang atau garasi terbuka lebih dari 15 detik. Prototipe ini dapat mengendalikan gerbang dan pintu garasi dengan rata-rata waktu koneksi hanya sekitar 5 detik. Dengan demikian, prototipe ini layak digunakan sebagai alternatif untuk mengontrol dan meningkatkan sistem keamanan perumahan.*

**Kata Kunci:** Alarm buzzer, Kendali masuk, Mekanisme penguncian, Sistem keamanan, Smartphone android.

## **I. INTRODUCTION**

**A**DVANCES in science and technology brought conveniences to human life. In this modern era, smartphone has become indispensable as a basic need for people and it is considered as a very important device because of its significant function in many areas of our lives [1]-[10]. A smartphone is a mobile device that has many features in purpose to replace the personal computer. Although only occasionally, smartphones can also be used to increase the monitoring security system of a gate or garage door [11]- [14]. Some technologies have been applied to improve the security system of a gate because a conventional gate is considered not safe enough. On a conventional gate, the opening and closing of the gate are still by pulling it with human power from close range and using a padlock

TABLE 1  
 COMPARISON WITH THE RELATED WORKS

Parameters	Prajati [16]	Romadhon [17]	Hulqiarin [18]	This work
Access to control the gate/garage	RFID and Matrix key-board	Ultrasonic sensors	GSM modem	Installed application and HC-05 Bluetooth module
Motor driver	N/A	Not implemented	N/A	L298N motor driver module implementation
Limit switch	N/A	Not implemented	N/A	Limit switch implementation
Locking mechanism	N/A	N/A	Solenoid	Micro-servo
Time needed of the process	N/A	N/A	Slower	Faster
Alarm	Not implemented	Not implemented	Not implemented	Implemented

system. This will be troublesome if there is for example bad weather such as heavy rain while homeowners have to go down first from their vehicle to open the gate and unlock the padlock. Furthermore, this can trigger a crime such as theft or robbery when the homeowners leave their houses or vehicles [15], [16]. In those cases, the existence of smartphone function is needed as a critical and helpful tool. Therefore, we conduct research that aims to create a security system that is operated through an application of an android smartphone connected to the Bluetooth module (network) which can be used from a certain distance. Through the application, apart from its function to increase the security system, homeowners also easily can open and close the gate and garage door as one integrated system. Alarms (buzzers) are activated to notify the homeowner if the gate and the garage door have been left open for more than the desired interval.

Many technologies have been implemented to improve the security system of a gate, as well as the garage door. To improve the performance and uniqueness of this research, the authors have learned three journal articles with a similar concept for comparison. The first paper of Prajapati is about RFID based gate access control system by college ID card [16]. In this research, there the processes to open the gate is based on the card. If the card is valid, the LCD will display the information and the gate will be opened automatically. But in our research, we used an application installed in Android smartphone and HC-05 Bluetooth module to send the command to Arduino Uno which is expected to simplify the process to open and close both the gate and garage door. In [17], the system uses an Arduino Mega as the main controller of the system, a DC motor to drive the gate for opening automatically, three ultrasonic sensors to detect if there is a car in front of the gate, and an LCD which displays the response received by the sensor. There is no use of motor driver and limit switch in this system. But, in our work, we implemented an L298N module driver and four limit switches placed on each end of travel of both gate and garage door. The prototype of the third work [18] consists of input, controller, and output. In the implementation, the prototype is using a solenoid as the locking mechanism. But, in our work, we replaced the solenoid with a micro servo and implemented it on the gate. It is because solenoids only can be moved in a specific position. After all, it is driven by an electromagnetic field, while the micro servo is probably more accurate in positioning because the user can control the degree of movement.

All the researches as mentioned above did their experiment in separation of gate or garage door security system. The novel contribution of our research is that we decided to create the prototype of the gate and garage security system as one integrated system which works simultaneously. Meanwhile, to increase the security system, alarms are implemented and will be stopped when the gate and garage door are closed. The alarms are buzzers that function to notify the homeowner if the gate or the garage door has been left open for more than the desired interval. Based on the previous research shown and this research, some difference that can be declared as our complete contribution as mentioned in Table 1.

## II. RESEARCH METHODS

### A. Overall System Design

Block diagram of the overall system design is shown in Figure 1. Arduino Uno will send the output signals to micro servo, DC motors, and buzzer. HC-05 Bluetooth module should be connected to the application on the android smartphone. When the Bluetooth module is connected, the process will be divided into two parts. The first one is to control the gate, and the second one is to control the garage door.

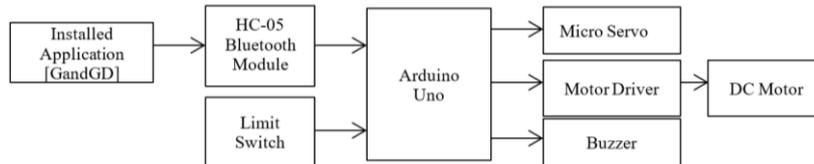


Figure 1. Block diagram prototype of gate and garage door security system controlled by smartphone

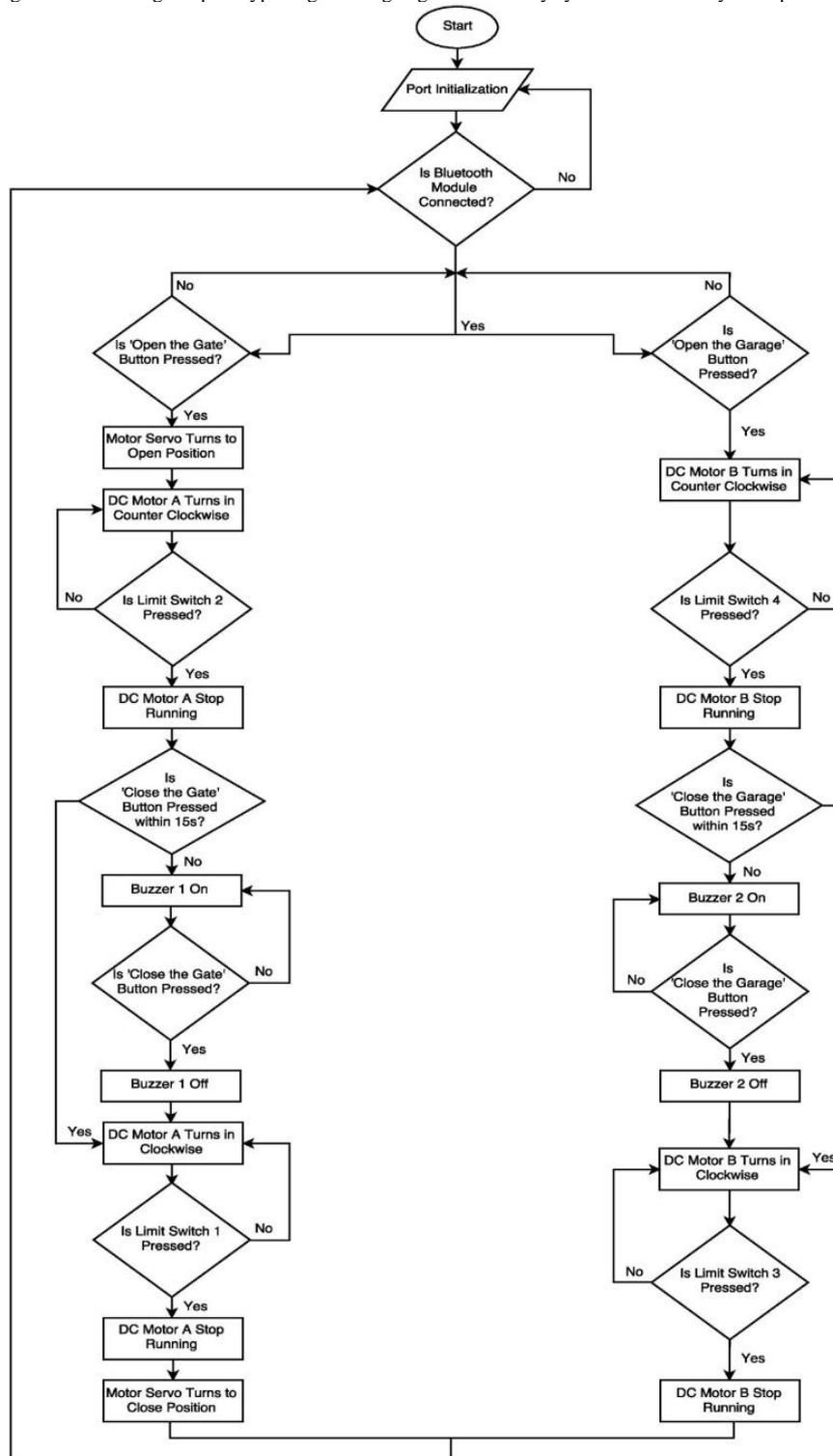


Figure 2. Flow chart of gate and garage door security system prototype controlled by android smartphone.

The overall flow chart of the system is representing in Figure 2 below. HC-05 Bluetooth module should be connected to the application on the android smartphone. When the Bluetooth module is

TABLE 2  
LIST OF CHARACTERS AND COMMANDS

Button	Character Transmitted	Command
Choose device to connect to	N/A	Pairing the Bluetooth module to the application
Open the Gate	'A'	Unlocking micro servo and opening the gate
Close the Gate	'B'	Closing the gate and locking micro servo
Open the Garage	'C'	Opening the garage door
Close the Garage	'D'	Closing the garage door

TABLE 3  
THE LIST OF CHARACTERS AND COMMANDS WHEN THE BUZZER IS ACTIVATED

Button	Character Transmitted	Commands
Close the Gate	'B'	Turning the buzzer off, closing the gate, and locking micro servo
Close the Garage	'D'	Turning the buzzer off and closing the gate

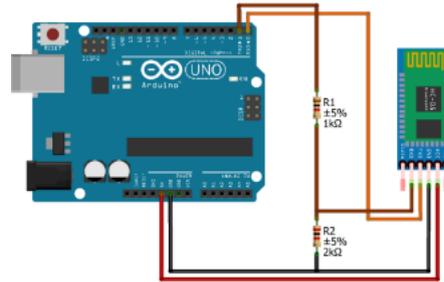


Figure 3. Pin configurations of HC-05 Bluetooth module

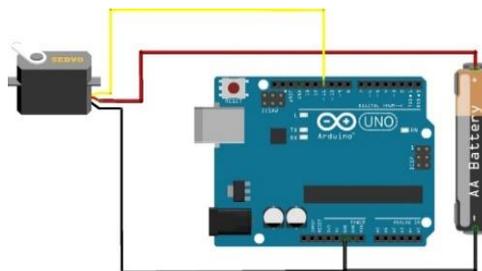


Figure 4. Pin configurations of micro-servo

connected, the process will be divided into two parts. The first one is to control the gate, and the second one is to control the garage door.

The system will control the gate when the 'Open the Gate' or 'Closed the Gate' button is pressed. On the other hand, the homeowner has to click the 'Open the Garage' or 'Closed the Garage' button to control the garage door. There is an alarm system implemented in the system to increase the security system level. The application will send a character as a command to Arduino UNO when the button is clicked. The list of the characters is shown in Table 2.

When the gate or garage door is left open more than the interval, which is fifteen seconds, the buzzer will be activated to notify the homeowner. To stop the buzzer, 'Close the Gate' or 'Closed the Garage' button has to be clicked. After the buzzer stops, the gate or garage door will be closed automatically. The list of characters and commands when the buzzer is activated, are explained in Table 3.

### B. HC-05 Bluetooth Module Implementation

In this research, the HC-05 Bluetooth module is used as the communicator between the application on an android smartphone and Arduino Uno. There are 4 pins that are connected to the Arduino Uno and the pin configurations are shown in Figure 3. The HC-05 Bluetooth module is a 3.3 V device, but it contains a voltage regulator which allows an input voltage from 3.6 to 6 volts. However, the logic voltage level of the TX and RX pins is 3.3V. Therefore, the line between the RX pin of the Bluetooth module and the TX pin of Arduino Uno needs to be connected through a voltage divider in order not to burn the Bluetooth module.

### C. Micro-Servo Implementation

Micro-servo is used as the locking mechanism of the gate. All of its wires are connected to Arduino

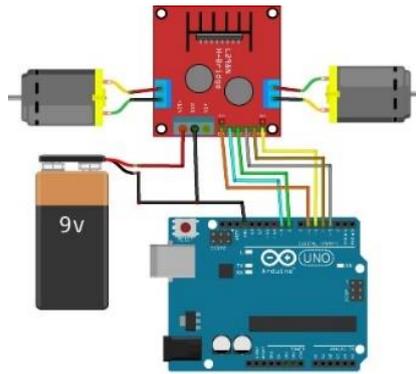


Figure 5. Pin configurations of DC motors and L298N motor driver module

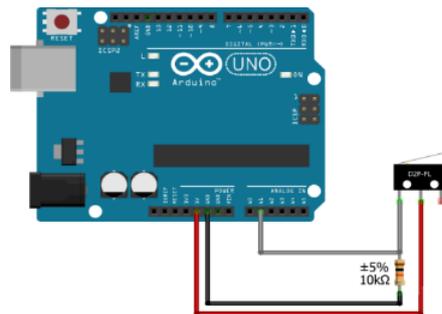


Figure 6. Pin configurations of limit switch

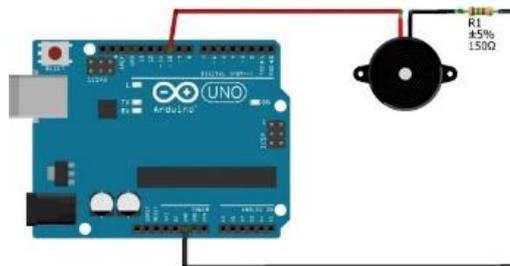


Figure 7. Pin configurations of buzzer

Uno. The orange wire or a signal wire is connected into digital pin 11, the red wire is connected into + wire of 6V battery as the power supply, and the brown wire is connected into Gnd pin. The pin configurations of micro-servo as shown in Figure 4.

#### *D. DC Motors and L298N Motor Driver Module*

One of the DC motors is used to operate the movement for the gate and the other DC motor for the garage door. The overall pin configuration of DC motors and the L298N motor driver module are shown in Figure 5.

#### *E. Limit Switch Implementation*

A Limit switch is used to stop the motion of the DC motor when it is pressed. It has 3 pins which are common (COM) pin, normally open (NO) pin, and normally closed (NC) pin. However, in this research, there are only 2 pins connected to Arduino Uno as shown in Figure 6.

NO pin is connected to the 5 V pin of Arduino Uno. COM pin is connected into analog pin 1 and a pull-down resistor on the ground. The pull-down resistor is a 10 k $\Omega$  and is used to ensure a well-defined logical level under all conditions [19].

#### *F. Buzzer Implementation*

In this research, buzzers are used as alarms to notify the homeowner if the gate or garage door has been left open more than the desired interval. It has two wires which are red and black wire. Both of the wires are connected to Arduino Uno as shown in Figure 7. The red-wire is connected to digital pin 8 and the black wire is connected to appropriate ground through a 150  $\Omega$  resistor.

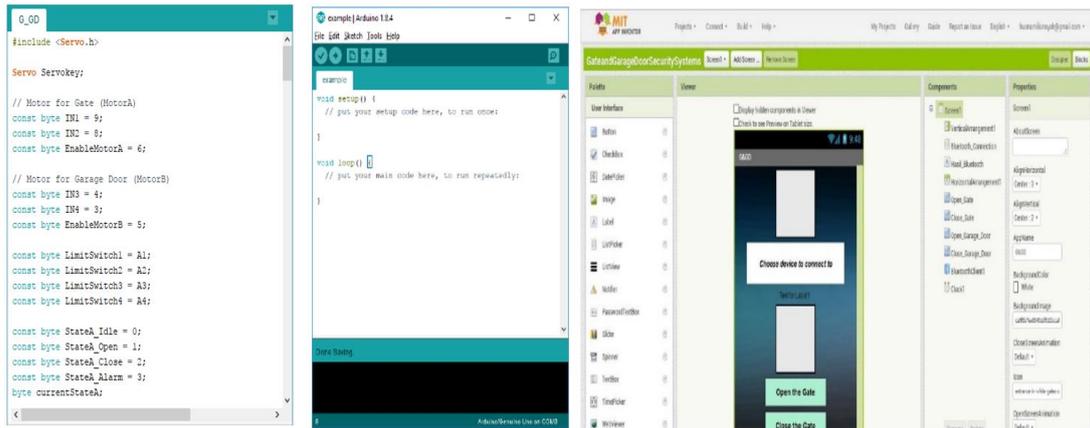


Figure 8. (a) The user interface of Arduino IDE [19], (b) App Inventor 2 [20]

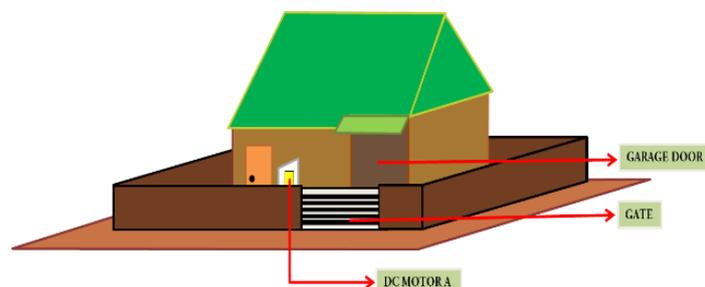


Figure 9. The design of gate and garage door security system prototype

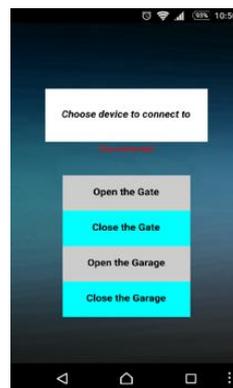


Figure 10. The user interface of the application

**G. Arduino IDE and App Inventor 2 Software**

This prototype used two software which is Arduino IDE and App Inventor 2. The Arduino IDE shown is the program used to write, open, and edit the source code and upload it into the Arduino board. Arduino IDE was created from JAVA programming language, but the software uses its programming language similar to C and C++ which is called sketch shown in Figure 8.a. App Inventor 2 is an open-source Android application development tool and browser-based software, and it is based on drag and drop method and visual blocks programming in the process of developing the application. The drag and drop method will simplify the design process of the user interface which is done in the designer window shown in Figure 8.b. The required components are located in the palette panel and have to be dragged and dropped into the viewer panel. The user interface can be organized through the properties panel.

**H. Design of Physical Prototype**

This prototype is made of plywood, except for the gate part that is comprised of acrylic. The prototype has two DC motors, 4 four limit switches, a micro servo, two buzzers, a motor driver, a Bluetooth module, and an Arduino Uno. As seen in Figure 9, one of the DC motors is located outside of the house to move the gate. The other one is located inside to move the garage door.

TABLE 4  
 THE FUNCTION OF EACH LIMIT SWITCH

Limit Switch	Function
Limit Switch 1	Stopping DC motor A when the gate is fully closed.
Limit Switch 2	Stopping DC motor A when the gate is fully opened.
Limit Switch 3	Stopping DC motor B when the garage door is fully closed.
Limit Switch 4	Stopping DC motor B when the garage door is fully opened.

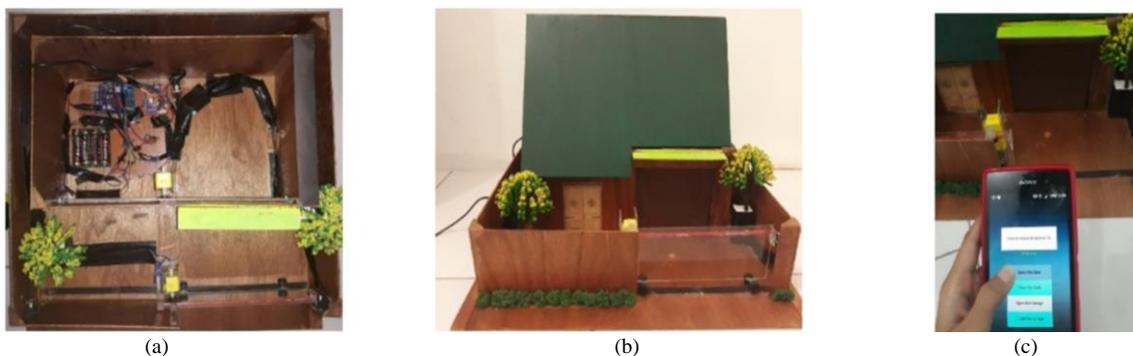


Figure 11. (a) Top-view and (b) Front-view of the final prototype (c) Monitoring status in smartphone

### I. Design of Software Prototype

There are two software used for this research which are Arduino IDE 1.8.4 and App Inventor 2. In order to make and implement the program to Arduino Uno, the authors use Arduino IDE 1.8.4. The user interface of the application can be seen in Figure 10.

The overall program contains HC-05 Bluetooth module control, direction control of micro servo, direction and speed control of both DC motors, limit switches control, and buzzer control. For the mobile application, it has 5 buttons which are Choose device to connect to, Open the Gate, Close the Gate, Open the Garage, and Close the Garage.

## III. RESULTS AND DISCUSSION

The prototype is designed according to Figure 9 to increase the security system of gate and garage door where their operations can be controlled with application on an android smartphone through Bluetooth connection (Fig.11.(a) and (b)). In this research, the first experiments have been done to determine the maximum distance that could be covered by the HC-05 Bluetooth module. The coverage area data is tested from a radius of 1 meter until 10 meters from the gate (the experiment figure was not shown for simplicity), and the result shows that all tests are working properly. From 10 times of testing, it shows that the average time required for the initial connection is 5.02 seconds.

Second experiments have been conducted regarding the function of the limit switch. There are four limit switches implemented in this prototype and each of the switch has a different function as shown in Table 4. When the system controls the gate and the 'Open the Gate' button is pressed, the micro servo will turn in an open position to unlock the gate and DC motor A rotates counter-clockwise. If the gate hits limit switch 2 as it is explained in Table 4, DC motor A will stop which indicated that the gate has been fully opened as shown in Figure 11.(c). In order to close the gate, the homeowner has to click the 'Close the Gate' button and DC motor A will rotate clockwise. When the gate has been fully closed and limit switch 1 is pressed, DC motor A will be stopped.

The 'Open the Garage' button is clicked and DC motor B turns in counter-clockwise. When limit switch 4 is pressed, it will trigger DC motor B to stop. On the other hand, to close the garage door, the homeowner has to click the 'Close the Garage' button. Consequently, DC motor B will turn in clockwise and will be stopped when the garage door hits limit switch 3. However, there is no locking mechanism implemented on the garage door. Subsequently, micro-switch turns in a close position automatically to lock the gate.

Third experiments would be related to buzzer (alarms) activations. There are alarms implemented in this system which are two buzzers. The buzzers are set to have different frequencies which are 2,3 KHz for the gate and 5,5 KHz for the garage door to produce different sounds, so that the homeowner can detect which one is opened. If the alarm of the gate is activated, it will be stopped when the 'Close the

TABLE 5  
EXAMINATION ON THE APPLICATION, GATE AND GARAGE DOOR, AND ALARMS SYSTEMS

Motor	Pressed Button	Command	Buzzer Activation		Status
			Buzzer 1	Buzzer 2	
N/A	Choose device to connect to	Connecting to HC-05 Bluetooth module	Off	Off	[ √ ] Accepted [ X ] Rejected
Motor A	Open the Gate	Unlocking micro servo and moving the gate to open position	On	Off	[ √ ] Accepted [ X ] Rejected
	Close the Gate	Moving the gate to close position and locking micro servo	Off	Off	[ √ ] Accepted [ X ] Rejected
Motor B	Open the Garage	Moving the garage door to open position	Off	On	[ √ ] Accepted [ X ] Rejected
	Close the Garage	Moving the garage door to close position	Off	Off	[ √ ] Accepted [ X ] Rejected
Motor A & Motor B	Open the Gate	Unlocking micro servo and moving the gate to open position	On	On	[ √ ] Accepted [ X ] Rejected
	Open the Garage	Moving the garage door to open position	On	On	[ √ ] Accepted [ X ] Rejected
Motor A & Motor B	Close the Gate	Moving the gate to close position and locking micro servo	Off	Off	[ √ ] Accepted [ X ] Rejected
	Close the Garage	Moving the garage door to close position	Off	Off	[ √ ] Accepted [ X ] Rejected

Gate' button is clicked, and the gate is closing automatically. Similarly, the alarm of the garage door will be stopped if the 'Close the Garage' button is pressed. From the experiment, the five buttons on the application have been working properly and the system can control both gate and garage door at the same time. Experimental data of the application, gate and garage door, and the alarms are summarized in Table 5.

#### IV. CONCLUSIONS

Based on the results of the experiments, some conclusions can be drawn. Firstly, the gate and garage door security system controlled by an application on the android smartphone was successfully implemented. It means that both the gate and garage door cannot be opened or closed without the commands sent from the application in the smartphone. Secondly, the prototype can be connected to the HC-05 Bluetooth module easily with an average time of 5.02 seconds. Therefore, opening or closing the gate and garage door is faster than the conventional ones. Alarms (buzzers) are activated automatically when the gate or garage door is opened for more than the desired interval. This device prototype can be a solution to overcome the problem of life-safety and security of the user by controlling the gate and/or garage door system automatically in real-time. However, to obtain better performance improvements in the future, some advancements might be recommended. The first improvement related to system security, by applying ultrasonic sensors as a safety barrier on gates and garage doors. The second is for android applications, which can be made in java-based software so that the program can be more flexible as what the researcher wants.

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