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Development of Solar Powered Electronic Shipping Container Locking System

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Abstract: In recent years, an electronic locking system has developed that utilizes technology that enables the consumer to unlock the locking system via a keyless or smart device in person or remotely, as well as to track the usage of the locking system via notification. However, the usage of the electronic container locking device has been slowed down because the system needs a continuous supply of electricity. The Solar Powered Electronic Locking Device is also one of the options for a continuous power supply to the locking system.

Keywords: Locking System, Electronic Shipping Container, Solar Power

1. Introduction

There has been a lot of development and increased handling performance in ports with the introduction of containers. It helps to lower freight charges, which in turn leads to higher trade flows. Almost all everyday human needs are delivered in containers nowadays. Improved aspects of protection are an essential part of containment. Inside the cargo, the containers are not visible from the outside, minimizing the possibility of robbery. Tank doors are also securely closed and sealed, which may minimize the occurrence of dropping cargo containers.

There are cases, however, where the freight is on wheels and has an attached power unit that can be disconnected [1]. From this issue, security needs to be enhanced by implementing an electronic locking system on the shipping container. Many electronic locks were installed to ensure security for the container and cabin. This is highlighted because the old-fashioned locking system that uses a lock mechanism makes it easy to be forcibly opened by anyone. Examples of electronic keys are by using magnets, solenoids, motors, microcontroller components and power inputs. It is also easier to set up the way this electronic lock works and security is also improved at an optimal level at the same time.

The objective of this research is to study and evaluate an acceptable set for the development of an electronic shipping container locking system designed to provide high protection, easy access, and compatibility with any shipping container design. The basic research targets are to design a regulated power supply for the electronic shipping container locking system using solar photovoltaics. Secondly,

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to develop a user-friendly application for electronic shipping container lock system on Android Smartphone. Lastly, to evaluate a secure system on the electronic shipping container lock system via Bluetooth and smartphone application.

2. Materials and Methods

Throughout the research, simulation using applications accessible on the Internet has been the major tool to study the effectiveness of this system, such as Proteus, Arduino Ide and MIT App Inventor. This study is divided into several sections, such as:

- The configuration of the power supply of the circuit.
- The configuration of the security and locking system in the circuit.
- The configuration of the smartphone application.
- The configuration of the GPS Tracker.

2.1 Materials

Specifications and properties of materials, equipment, and other resources used in the current study. The parts shipping container locking system are as listed in Table 1:

Table 1: Bill of material

No.	Component	Quantity	Price (RM)
a.	GPS Tracker TX02	1	60.00
b.	Sim card local telco	1	38.00
c.	Arduino Nano	1	19.50
d.	Servo Motor sg90 180 degree	1	7.40
e.	Bluetooth Module HC-05	1	14.50
f.	Solar Panel Management Waveshare Module	1	48.83
g.	Solar Panel 6V 1W	1	15.00
h.	JST-PH 2.0 Power Whoop Female Connector Cable	1	3.00
i.	Iron Wire	1	1.20
j.	14500 3.7v 1300mah Li-ion Rechargeable Lithium	2	12.80
k.	AA 14500 Battery Holder	1	1.80
l.	Linear Steel Metal Rod 2mm	2	5.90
m.	Door lock latch tower bolt	1	0.95
n.	Cable connector	1	10.00
o.	MT3608 Step-up DC-DC Boost Converter Module	1	5.00
		Total	231.08

2.2 Flow Chart

A collection of hardware components is assembled in a circuit and soldered together to run the system. In the next step, the code is developed for connection with a phone application, and it is subsequently uploaded to an Arduino Nano via the use of a computer-based program. After that, the system must be tested, and any problems must be identified and rectified as soon as possible. The flow chart shown in Figure 1 explains the entire system's operation in detail.

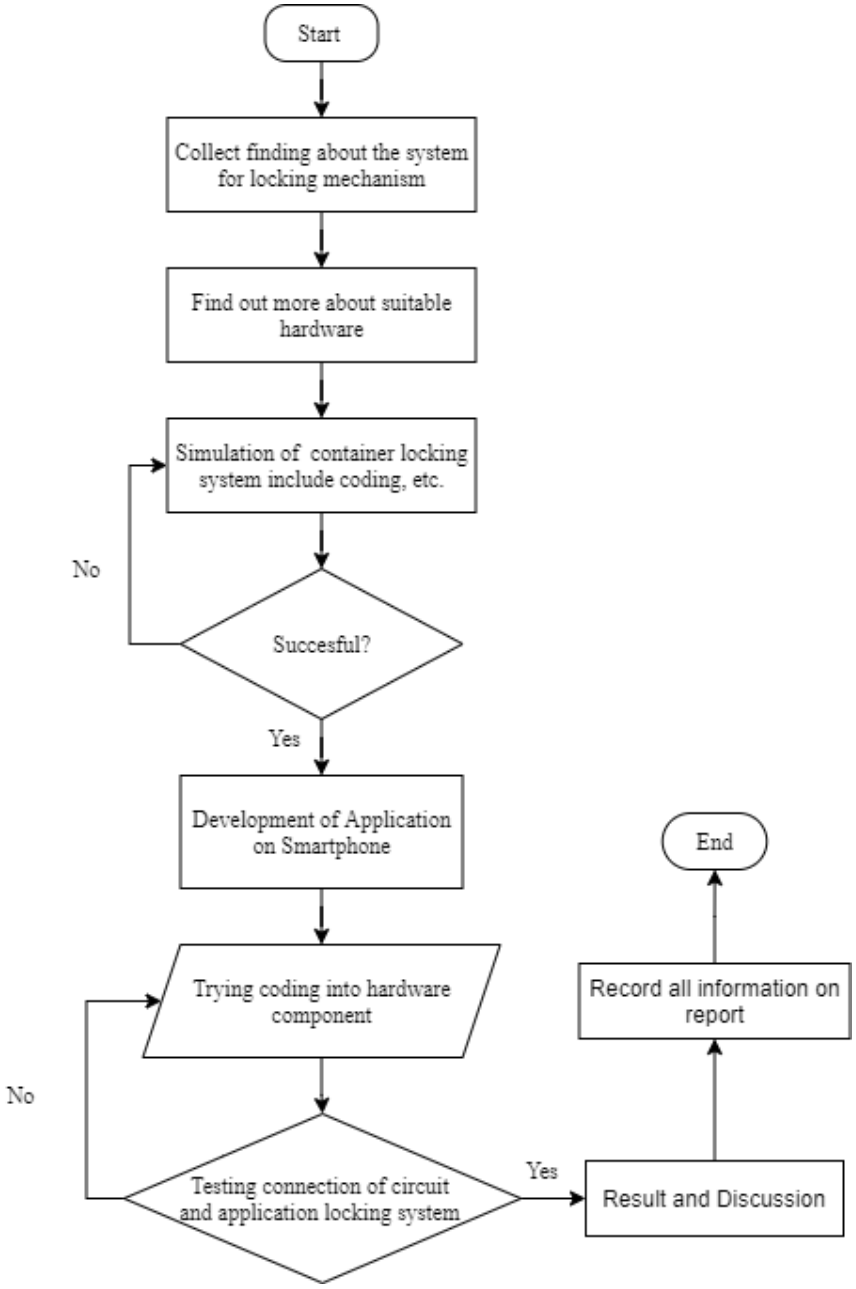

Figure 1: The Flowchart of solar powered electronic shipping container locking system

2.3 The Configuration of Solar Powered Electronic Shipping Container Locking System

Figure 2-5 will display the electronic components of solar powered electronic shipping container locking system. The connection will focus on the Arduino Nano, solar panel management module and GPS Tracker VT02. Figure 6 shows the interface of app on smartphone.

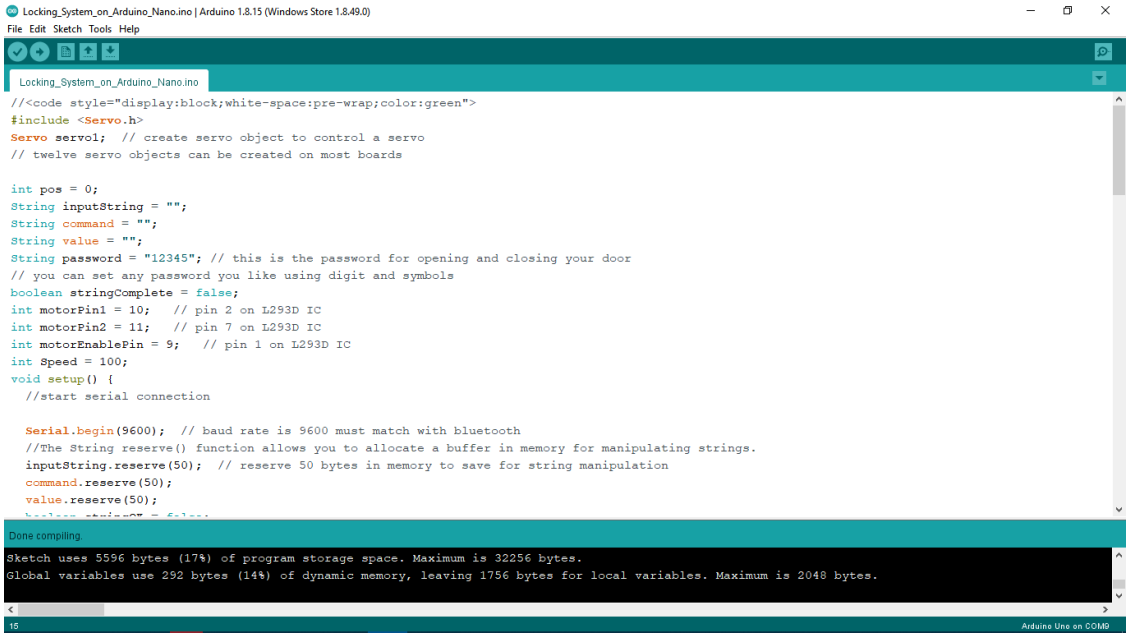

Figure 2: A part of the code that was input into the Arduino Microcontroller was properly compiled

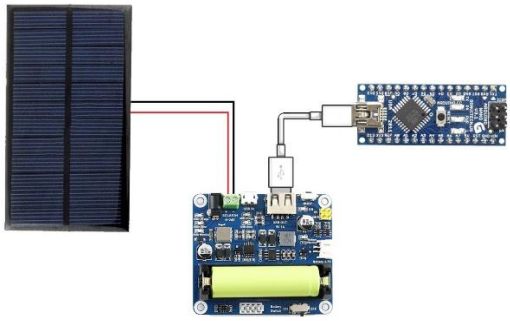

Figure 3: Connection of power supply to the microcontroller

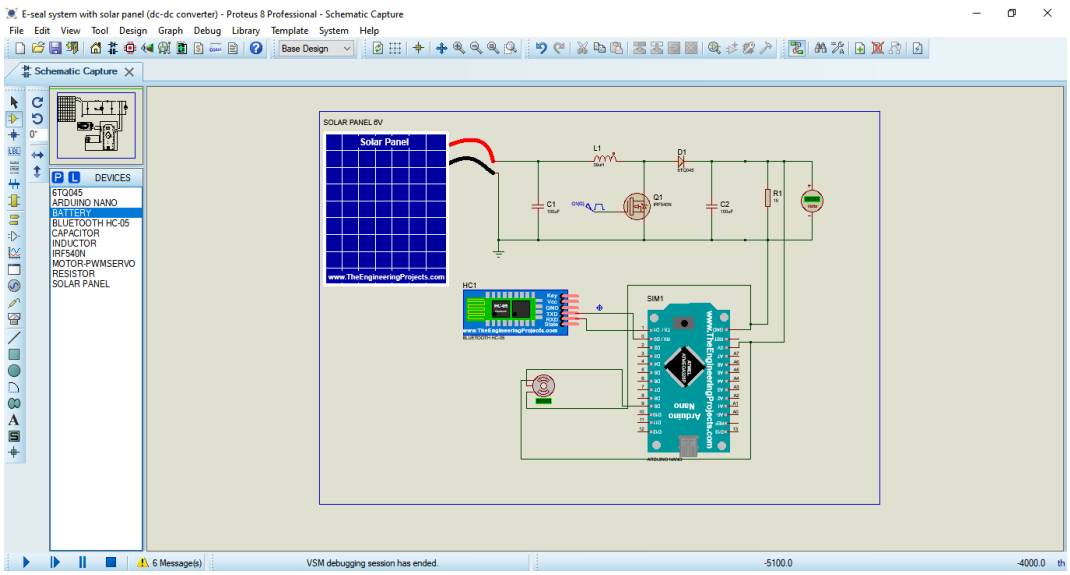

Figure 4: Simulation of locking system

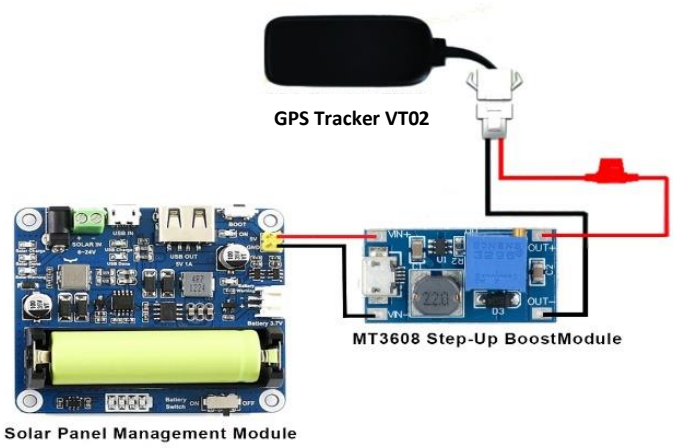

Figure 5: Connection of GPS tracker

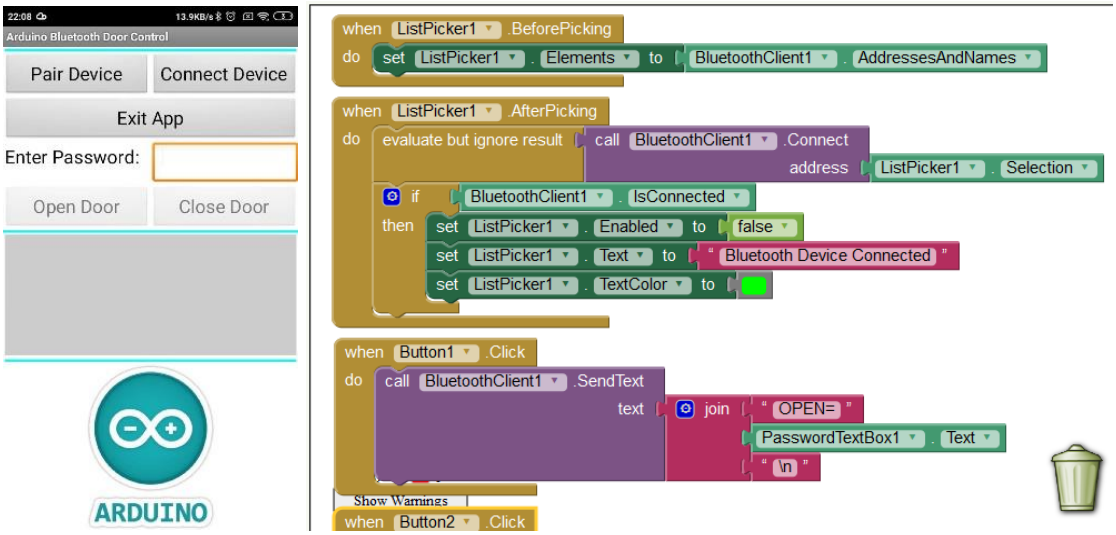

Figure 6: The interface of app on smartphone

3. Results and Discussion

The results and discussion section presents data and analysis of the study. This section can be organized based on the stated objectives, the chronological timeline, different case groupings, different experimental configurations, or any logical order as deemed appropriate.

3.1 Results

Arduino IDE is a piece of software that is used to create, validate, and upload codes to the Arduino Nano microcontroller board. Figure 2 depicts a portion of the code that was used to create this system. When a source is applied to the Arduino Nano after the system code has been uploaded to the board, the system will function properly. A flashing red light from the Arduino Nano and Bluetooth module HC-05 is another indicator that the code was uploaded. The microcontroller's flashing red LED showed that the code had been securely uploaded into the Arduino.

App Inventor is a platform that makes it relatively simple to build applications on smartphones. Although it does not guarantee a more sophisticated GUI design, this research may be used to grasp the idea of security control through a telephone application. The method to build an app in the App Inventor requires a particular button to be placed and labelled to function as intended. After adding a certain

button to the GUI of the app, it needs to define a command block in accordance with its purpose for each button as shown in Figure 6. Once finished, the application must export in an apk. File and install it to the smartphone.

3.2 Hardware Implementation Results

The system's operation is shown in Figure 7. The Arduino Nano microcontroller is linked to other components of the circuit, including the Bluetooth module HC-05, the GPS tracker VT02, and the Solar Panel Management Module. The system is activated by connecting a power source to the Solar Panel Management Module. As soon as the circuit is powered up by a power source, the system will come on and function by referring to the coding that has been uploaded after the user has given a command through an app on their smartphone.

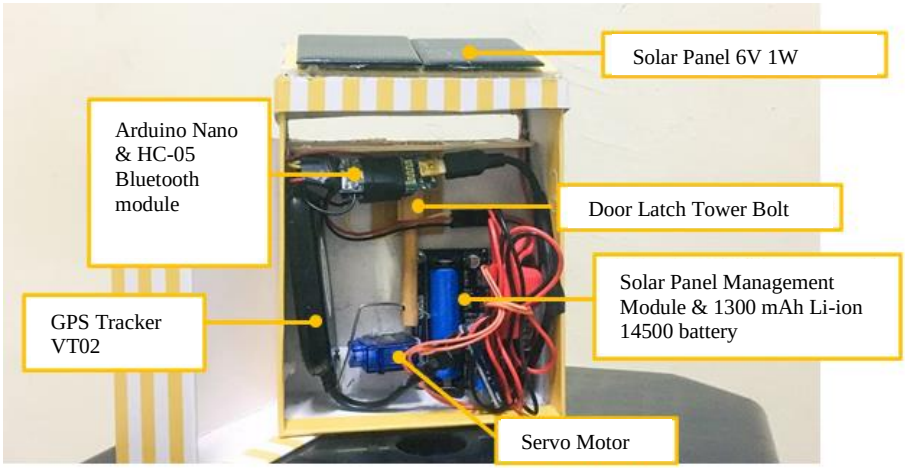

Figure 7: The system was constructed on a hardware model that had been soldered.

According to observations made during the installation of the GPS tracker VT02, a voltage range of 9V-36V is required. While the solar panel management module's output voltage is just 5V. As a result, the output voltage is increased to 9V using the MT3608 Voltage Boost Converter DC-DC Step Up Module as shown in Figure 5. The SIM card utilized in this project is Onex ox. While the SIM card is included in the GPS tracker, customers may add internet plans through the Onex ox black apps to enable tracking. Also, this GPS tracker performs better outside, making it much easier to locate via satellite. The sim card must first subscribe to an internet plan before being included in the GPS tracker, since latitude, longitude, and speed locations are tracked through the internet, as shown in Figure 8.

Figure 8: Messages sent by the GPS tracker.

3.4 Energy Storage from Solar Panel

Figure 9 shows a graph of the amount of energy that can be created from a 6V solar panel in 11 hours based on the LED indicator:

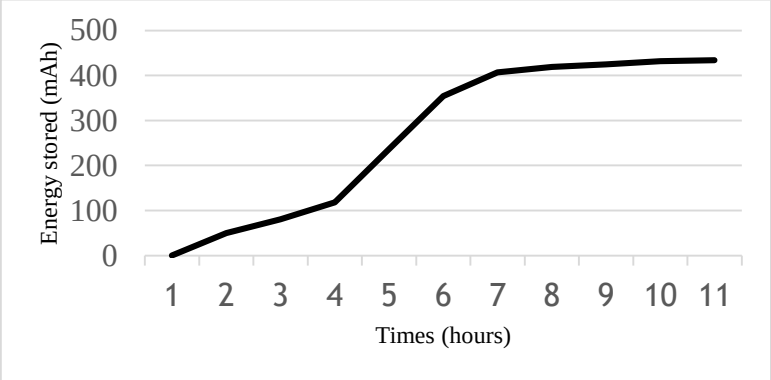

Figure 9: Energy stored by solar panel against time.

The solar panel management module is very important in this development since it allows for the storage, production, and routing of energy to charge depending on observations made by the power supply circuit. This 6V polycrystalline solar panel may provide relatively mild energy due to its low wattage. As illustrated in Figure 4.1, the LED indicators on the solar panel management module allow users to monitor the amount of energy stored in the battery from the solar panel management module.

3.4 Discussion

The battery capacity utilized to store solar panel electricity is 1300mAh, which is high in energy. The stored energy measurements rose during the 11-hour observation period from 7 a.m. to 6 p.m. (11 hours), with the statistically significant difference appearing around noon. This observation is repeated four times in a row for a total of four days, or until the battery indicator indicates that the energy stored has reached its full capacity. For those who are experiencing a significant loss in energy owing to inadequate energy generated by solar panels, it is feasible to overcome this by charging the gadget using a micro-USB cable as an alternate method of charging it. In addition, the locking mechanism is in the locked position as a safety measure if situations involving inadequate energy are encountered. Solar panels are used as the main energy supply to charge the battery so that power can be used continuously. This will overcome the energy capacity constraint problem found in the battery in order to turn the electronic locking system on [2].

Energy storage equipment has been available for decades, but still recent to the industry are solar batteries used in domestic solar-plus-storage systems [3]. Solar only just provides renewable electricity from a clean source, but at night or on gloomy days its utility can be minimal without a battery. The excess energy produced on sunny days may be deposited in a battery for future use by combining solar with a storage system such as lithium batteries. The implementation of solar system storage provides still greater benefits. During times of peak usage, when the grid is most overwhelmed, the devices will store surplus solar generation and then use the electricity [4].

The development phase, which made use of hardware components, was completed after the completion of the implementation phase. The results of the simulation phase on the software show that the Arduino microcontroller program was written in C++ and that it was extracted into an executable format (hex. File) by utilizing the Arduino IDE (Instrumentation and Development Environment).

Afterwards, the hex. File was imported into the Proteus Design Suite program, where the whole circuit design shown in Figure 3 was thoroughly evaluated. Figuratively, the evolution of applications for locking mechanisms on smartphones is shown in Figure 5. It was necessary to conduct many more experiments to determine if the Bluetooth compatibility between the Arduino Uno and the Android Smartphone's keypad could be determined by using the HC-05 Bluetooth module. To access the password, the user must access it via the smartphone's application. The password that was entered had previously been validated, and this was visible in the program. According to the diagram in Figure 7, if the password is correct, a deflection of the motor will occur, and the door will open. Otherwise, it will not respond, indicating that the password is invalid. The job is carried out in a systematic manner.

4. Conclusion

In conclusion, a simulation of the electronic container locking system is provided for in this research paper. The safety and security factors have been considered by the utilization of Bluetooth technology that is implemented in a mobile device. It also offers protection and simplicity for Smartphone users. A free open-source development project focused on Android and Arduino frameworks. The system was responsible for turning the pin to Lock or Unlock the locking system from a specific range by entering a password on the smartphone. By using solar-plus-storage as the main energy for supply on the system, the simulation shows the success in channeling energy for the system to function continuously. Although the simulation could not be fully developed during this study, the locking system was still able to function properly as planned. Therefore, the next study will focus on the initial prototype for each feature placed on this system.

Acknowledgement

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