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Design and Build a Vending Machine Prototype Using RFID Based on IoT

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Abstract

This research discusses the design and build of an Internet of Things (IoT)-based vending machine prototype with a payment method using Radio Frequency Identification (RFID). The system is designed using the ESP32 microcontroller connected to an RFID reader, DC motor, photointerrupter sensor, and RTC as the main controller. The Blynk application is used as a medium for monitoring drink stock and real-time notifications. Test results show that the prototype can perform cashless transactions with RFID automatically, dispense products according to user selection, and display stock data through the Blynk application. The application of RFID and IoT technology in vending machines has proven to improve operational efficiency, reduce cash transaction usage, and provide a more practical transaction experience. This research is expected to be a modern solution for digitally based automatic sales systems in the future.

Keywords: *Vending Machine, RFID, IoT, ESP32, Blynk.*

1. Background

Vending machines sold in Indonesia generally only sell snacks and soft drinks. The lack of vending machines in Indonesia and the high costs required to bring vending machines released in the market mean that most payments are made using manual systems, such as coins and usage. Drinks and food fall from their places when consumed (Pamungkas, 2021).
A vending machine is a solution to the lack of services for transactions involving food, drinks, and daily necessities, sold 24 hours a day. As work activities have increased in recent years, there is a growing need for machines that can sell instantly and require no social contact. However, unfortunately, there is still an unresolved issue with vending machines. The issue is that this transaction still relies on direct transactions (cash) (Suprapto, 2022).
A vending machine is a device that can carry out transactions automatically by inserting a certain amount of money into the machine, which will then respond by dispensing a specific item or product. This device can be used in the automatic sale system of snacks, soft drinks, newspapers, tickets, or instant food. Vending machines can be found in public areas such as airports, department stores, bus stops, and office centers, allowing customers to purchase drinks without interacting with a person. The benefits include speed, convenience, cleanliness, and not requiring a large space. In office centers, there are several facilities typically provided by the company that can be used by employees, whether in the form of amenities to support employees' work or facilities for their daily activities within the office center. One of the facilities that is usually available in offices is a place for (Sakti, 2021).

2. Literatur Review

2.1. Vending Machine

A vending machine is a machine that can dispense items such as snacks, canned drinks, and other consumer products automatically for customers. Like a traditional vendor, this machine will release the desired item after we insert a number of coins/bills. The vending machine requires money to operate. There is a slot for inserting money into the machine for a specified amount. After the money is inserted, the user can select the drink they wish to purchase. Once the drink is selected, the machine will automatically drop the corresponding drink, and finally, the user can retrieve the drink from the small door provided (Maulana, 2019).

2.2. ESP32

Espressif systems ESP32 is a microcontroller device created by a company located in Shanghai, China, namely Espressif Systems. This device provides a solution for Wireless Fidelity (WiFi) internet networking independently as a connector from existing microcontroller devices to the WiFi internet network. The ESP32 currently uses a dual-core processor that operates on Xtensa LX16.1 instructions (Wiesesha, 2023).

2.3. Internet of Things

IoT is a concept aimed at expanding the benefits of continuous internet connectivity. Essentially, IoT refers to objects that can be uniquely identified as virtual representatives in an internet-based structure. The way IoT works is through the interaction between machines connected to each other, regardless of distance. To achieve the aforementioned operation of IoT, the internet serves as the link between the two machine interactions, while the user's role is merely to manage and supervise the operation of these devices directly (Nurul Hidayati, 2019).

2.4. RFID

Radio Frequency Identification (RFID) is a technology that uses auto-ID or Automatic Identification methods. Auto-ID is a method of data capture through the automatic identification of objects without human involvement. Auto-ID works automatically, thereby enhancing efficiency in reducing errors in data entry. RFID is a data capture technology that can be used electronically to identify, track, and store information that was previously stored in an ID tag using radio waves. RFID is an automatic identification method using a device called an RFID tag or transponder. The transmitted data can be in the form of codes intended to identify a specific object.

2.5. L298N

The L298N motor driver is a DC motor driver module used to control the speed and direction of rotation of DC motors. This module is widely used in the electronics world and is often connected to Arduino microcontrollers. The L298N IC is an H-bridge type IC that can control inductive loads on coils such as solenoids, relays, DC motors, and stepper motors. Electric motors consist of coil windings, resulting in a very large inductive load. The L298N IC contains transistor logic (TTL) with NAND gates that function to change the rotation direction of either DC motors or stepper motors.

2.6. Photo Interrupter

The photointerrupter is an electronic sensor that uses light. The photointerrupter sensor has an optical source paired with a receiver. Essentially, the photointerrupter has two separate circuits, namely the input and output circuits. In the input circuit, there is a radiation source. The radiation emitted will be received by a detector that is part of the output circuit known as the receiver. The photointerrupter sensor used in this design is the standard photointerrupter sensor type GP1S53VJ000F. GP1S53VJ000F is a sensor formed from an infrared circuit and a phototransistor. This sensor was chosen because in the drive motor, a movement limit is needed to determine the forward and reverse limits of the motor (Gunawan, 2016).

2.7. Push Button

A push button switch is a simple device/switch that serves to connect or disconnect the flow of electric current with an operation system that is press to unlock (not locking). As the name suggests, the function of the push button switch is to disconnect or connect the electric flow by pressing its button. This switch is included in the type of toggle contacts that operate according to its use. Normally Open (NO), the switch functions as normally open and serves to connect the current to a load. Normally Closed (NC), the switch functions as normally closed and serves to disconnect the current to the load (Salim, 2020).

3. Design and Analysis

3.1. Research Methodology

The method used in this research is the design method (prototyping). This method includes several main stages, namely:

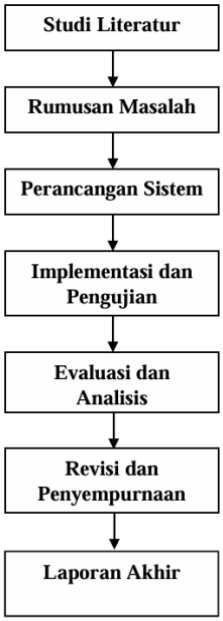

Figure 1: Research Methodology

3.2. Control System Flowchart

The design of this tool begins with the creation of a flowchart to facilitate the planning and development of the program on the microcontroller. The creation of a flowchart is useful for simplifying the understanding of the working process of the tool. The program flowchart from this research includes the control system of the tool's operation, which can be seen in Figure III.2:

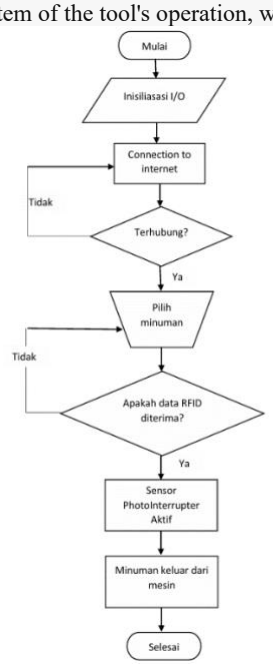

Figure 2: Control System Flowchart

The following is an explanation of the Flowchart for the automatic bell control system as follows:
1. Start by activating the system or device.
2. Initialize Input/Output by waiting until the initialization time or the device is active.
3. Connect the hardware to the internet such as wifi, etc., as a connection to Blynk.
4. If not connected, return to the initial connection; if connected, select the drink through the push button.
5. The next process is to scan the RFID. If yes, the selected drink will be dispensed automatically. If not, re-select. 6. Finished.

3.3. Block Diagram Series

The design of the block diagram circuit is the design of electronic components in such a way that it has the desired function. Generally, the planning of the tool design is as follows:

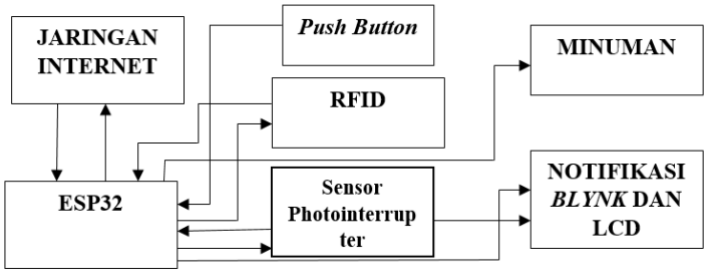

Figure 3: Blok Diagram Series

The block diagram series in figure III.2 shows that the first process involves connecting the hardware being used, such as a smartphone or computer, to Wi-Fi. In the next process, the push button is manually pressed and then a transaction is made through RFID. Then, the data from the RFID is sent to the ESP32, which will instruct the vending machine to dispense a drink. Furthermore, if the stock decreases, a notification is sent to Blynk.

3.4. Electronic Circuit Scheme

The schematic of the electronic circuit uses the ESP32 as a microcontroller that receives data from RFID. The ESP32 is designed to serve as the connection between the hardware and the internet. The output of the ESP32 will be connected to the Vending Machine to dispense the selected beverage.

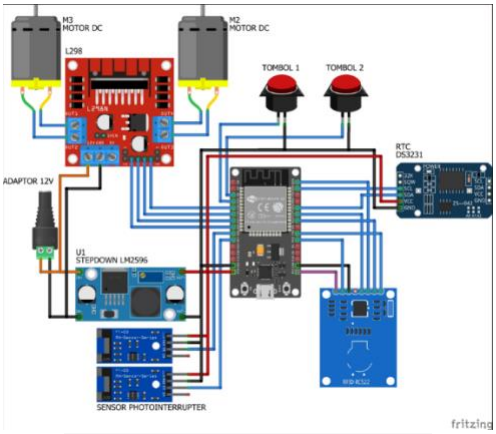

Figure 4: Electronic Circuit Scheme

4. Results and Discussion

In this chapter, the author outlines and explains the research results by conducting tests. The tests to be conducted are software and hardware tests. Here is the explanation:

4.1 Software Testing

To conduct the program test, the initial steps in this experiment are as follows:

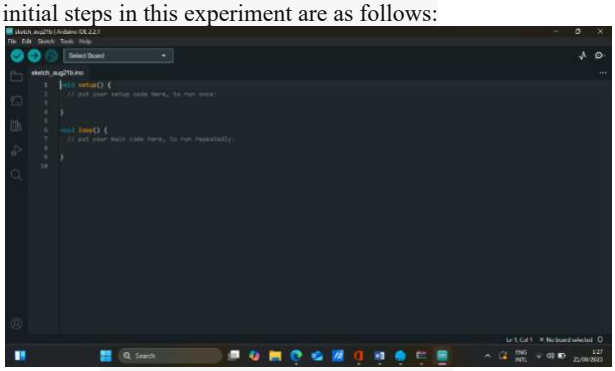

Figure 5: Initial Display of Arduino IDE

4.2 Hardware Testing

After all the programs are typed, design the hardware as shown in Figure IV.2.

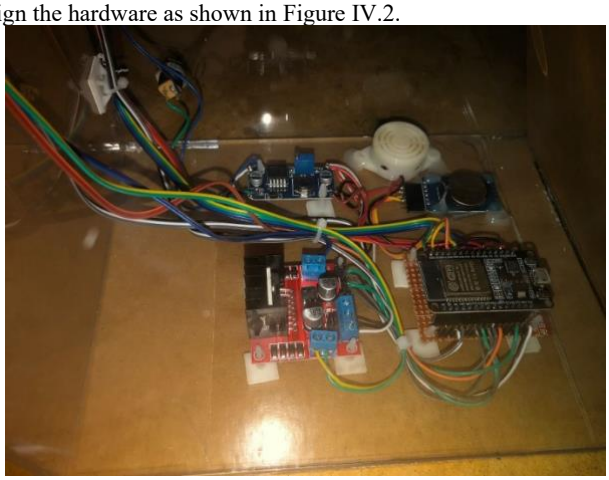

Figure 6: ESP32 Hardware Design and Other Components

Next, the test for the device's activity, based on the indicators in the active/on circuit:

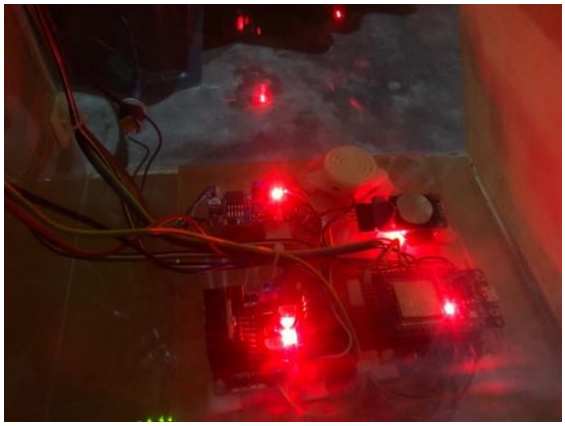

Figure 7: Position of the tool when active

4.3 Blynk Testing

In this Blynk testing, we create a new template with widgets as shown in the image below:

Figure 8: Blynk Display

After the program has been fully typed, the next step is to input the program code into the circuit by clicking the Bar menu on the Arduino IDE and then clicking upload, with the note that the Board and Port in the Arduino IDE Bar menu are already set. Next, wait a moment until the upload process is complete, then the program that has been uploaded will automatically be saved to the microcontroller.

4.4 Implementation of Overall Testing Using PhotoInterrupter Sensors to Count Stock and RFID Connected with Blynk

This experiment was conducted by attaching the RFID to the RFID reader. As a trial, the next step was to select the available drinks, as well as testing on out-of-stock items. After all the components were successfully designed in the "Design and Build of Vending Machine Prototype Using IoT-Based RFID", here is the image of the successful testing of the vending machine using IoT-Based RFID in Figure IV.5 :

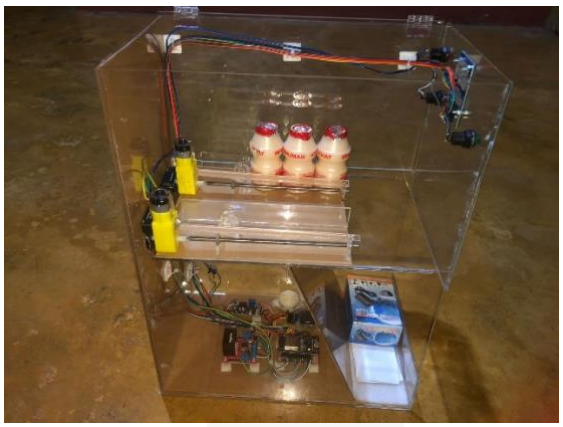

Figure 9: Overall Circuit Results

5. Conclusion

Based on the results of the research above, there are several conclusions:

1. This study successfully designed and built an IoT-based vending machine prototype with RFID payment method using ESP32 microcontroller.
2. The system is capable of detecting and sending stock notifications in real-time to the Blynk application.

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