Faculty of Electrical & Computer Technology and Engineering

DEVELOPMENT OF STOCK MANAGEMENT BY USING IOT FOR THE LABORATORY

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Bachelor of Electronics Engineering Technology with Honours

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A project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology with Honours

Faculty of Electronic & Computer Technology and Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronic Technology with Honours.

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DEDICATION

This final year project is dedicated to all of the people whose continuous support and encouragement have made it possible for it to be completed.

To the Almighty God who is always there for me in times of need. I am grateful for your guidance and strength in my daily existence. I appreciate your unwavering support and concern for me at all times. I appreciate you organizing all of this and seeing it through to a successful conclusion. Lord God, you are loved.

I would want to thank my family for their unending love, support, and tolerance during this academic journey. My motivation has been sustained by your sacrifices and constant support.

I am deeply grateful to my supervisor, Sir Saifullah bin Salam, for his invaluable guidance, knowledge, and ideas that have helped me grow as a thinker. It truly inspires me how dedicated you are to mentoring and educating.

Thanks to my close friends, who not only provided companionship but also moments of happiness and comfort, greatly easing the difficulties encountered on this voyage. Your presence has given me courage and confidence and has also turned a challenging situation into a joyful and shared experience.

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ABSTRACT

The Internet of Things (IoT) technology is being used in a ground-breaking way to optimize inventory control and streamline laboratory operations called "Stock Management" for laboratory environments. This unique system combines IoT sensors, cloud computing, and data analytics to provide real-time monitoring, automatic stock tracking, and intelligent decision-making capabilities. By utilizing IoT devices and connectivity, laboratories can efficiently manage their inventory, reduce stockouts, minimize excess inventory, and improve overall operational efficiency. The system offers benefits such as improved inventory accuracy, cost savings, enhanced traceability, and simplified procurement processes. Moreover, it enables seamless integration with existing laboratory infrastructure and the potential for scalability to accommodate laboratories of varying sizes. This abstract provides an overview of the smart stock management system, its advantages, and its potential impact on laboratory operations.

ABSTRAK

Teknologi Internet of Things (IoT) sedang digunakan dengan cara yang hebat untuk mengoptimumkan kawalan inventori dan menyelaraskan operasi makmal yang dipanggil "Pengurusan Stok Pintar" untuk persekitaran makmal. Sistem unik ini menggabungkan penderia IoT, pengkomputeran awan dan analisis data untuk menyediakan pemantauan masa nyata, penjejakan stok automatik dan keupayaan membuat keputusan yang bijak. Dengan menggunakan peranti dan ketersambungan IoT, makmal boleh mengurus inventori mereka dengan cekap, mengurangkan kehabisan stok, meminimumkan lebihan inventori dan meningkatkan kecekapan operasi keseluruhan. Sistem ini menawarkan faedah seperti ketepatan inventori yang dipertingkatkan, penjimatan kos, kebolehkesanan yang dipertingkatkan dan proses perolehan yang dipermudahkan. Lebih-lebih lagi, ia membolehkan penyepaduan yang lancar dengan infrastruktur makmal sedia ada dan potensi untuk skalabiliti untuk menampung makmal dengan pelbagai saiz. Abstrak ini memberikan gambaran keseluruhan sistem pengurusan stok pintar, kelebihannya, dan potensi kesannya terhadap operasi makmal.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The advent of Internet of Things (IoT) technology has paved the way for transformative innovations across various industries, and the realm of laboratory management is no exception. This report delves into the integration of IoT for stock management in laboratory settings, addressing the challenges associated with traditional inventory tracking methods. Instead of conventional approaches, this initiative explores the potential of IoT devices to revolutionize how laboratories monitor and manage their stock. By providing real-time insights and automated data collection without reliance on sensors or RFID technology, this approach aims to streamline operations, enhance accuracy, and empower laboratory personnel with an efficient and dynamic stock management system. This report will detail the project background, key components, and expected outcomes, shedding light on the potential benefits and advancements brought about by the fusion of IoT and laboratory stock management.

1.2 Background

This project aims to optimize laboratory stock management by implementing an Internet of Things (IoT) based system. Traditional inventory tracking methods can be error-prone and time-consuming. Instead of sensors or RFID, the proposed system will rely on IoT devices for real-time monitoring without physical tracking mechanisms. These IoT devices will facilitate automated data collection, ensuring accurate and current information on inventory levels. The system will provide a user-friendly interface for convenient access to centralized stock data, enabling laboratory staff to manage resources efficiently. The anticipated outcomes include improved operational efficiency, cost savings, enhanced accuracy, and data-driven insights for proactive stock management based on historical trends.

1.3 Global current issue of Stock Management by Using IoT for Laboratory

One global current issue related to Development Of A Stock Management By Using Iot For The Laboratory is the need for efficient inventory tracking and control. It might be difficult to keep track of the numerous parts and pieces of equipment that laboratories frequently use. Manual stock management techniques can waste time, be inaccurate, and result in stockouts or overstocking.

It may be possible to overcome these difficulties by implementing IoT-based solutions for laboratory stock management. IoT devices enable laboratories to track inventory levels, consumption, and location in real time. This makes it possible to manage inventories accurately and quickly, lowering the probability of stockouts and improving resource allocation.

Additionally, IoT-powered stock management systems can offer useful information about usage patterns, expiration dates, and maintenance requirements. With the use of this information, purchase decisions can be made more effectively, waste can be avoided, and the laboratory can run uninterrupted.

1.4 Project Briefing

In the university, many laboratories are used by students and lecturers for learning sessions. Laboratories are usually formed by engineers and assisted by laboratory assistants. On occasion, the lab assistant is required to handle too many types of components at the same time. Every month, the lab assistant is required to count the number of components available in the lab to be updated. Too many components have made it difficult for lab assistants because they must count the types of components first and then calculate the quantity of each type of component whether the count is accurate or not. This project's purpose is to investigate the smart stock management system using IoT. This project also aims to develop smart stock management by using IoT and to test the functionality of smart stock management by using IoT.

In addition, contributing to society the development of better equipment is an important part of minimizing the routine workload of calculating supplies more easily and quickly. In a specific period, this equipment can also save time and effort. . Therefore, to read stock data via IoT, this project uses software (a mobile app for a Blynk) and hardware (a microcontroller).

1.5 Problem Statement

Laboratories frequently struggle with issues like inaccurate inventory counts, ineffective reordering procedures, and trouble monitoring and tracing specific parts. These problems cause inefficiencies, stockouts, and overstock of expired items. Manually counting the stock can be one of the reasons for the issues. Due to inaccurate data recording and human error throughout the counting process, this will occur. Implementing a smart stock component management system in a lab setting would be a workable answer to this problem. Based on these problems, a project is being developed to solve all the issues called Stock Management By Using IoT For The Laboratory.

1.6 Project Objective

The objective of this project is to improve inventory control, optimize stock levels, and enhance operational efficiency. By leveraging IoT technologies, the project seeks to achieve the following specific objectives:

a) To study a system that allows for better management.
b) To develop a system that utilizes IoT technologies to track and manage laboratory stock inventory in real time.
c) To evaluate the functionality of the smart stock management system by using IoT for the laboratory.

1.7 Scope of Project

Implementing a stock management system for laboratories using IoT is the project's main objective. This entails creating and implementing a thorough stock management system designed especially for the laboratory environment. The system will leverage IoT technology, including data collection devices and software components. Additionally, the project will establish a robust IoT network infrastructure to facilitate seamless communication between the data collection devices and a central stock management system. It is important to note that the project scope explicitly excludes the acquisition of IoT hardware and extensive customization of existing laboratory management software. The project will be carried out within a designated laboratory, considering any dependencies on external factors such as the availability of IoT hardware, access to laboratory facilities, and coordination with suppliers.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

To guarantee efficient operations and prevent inventory-related issues, laboratories must manage their stock effectively. Intelligent stock management systems offer promising solutions to optimize stock levels and speed up processes by using modern technologies and a data-driven approach.

The goal of this literature review is to review the f information about smart stock management systems for laboratories. Inventory management is complicated in laboratories since they work with a variety of items and supplies. The difficulties include maintaining correct records, preventing stockouts or overstocks, and timely replenishment.

This review will highlight the best procedures, challenges, and areas for development in the implementation of a smart stock management system for laboratories by looking at the literature. Global current issue of Stock Management by Using IoT for Laboratory

One global current issue related to stock management using IoT for laboratories is the need for efficient inventory tracking and control. Laboratories often deal with a wide range of components, equipment, and keeping track of these items can be challenging. Manual stock management methods are prone to errors, are time-consuming, and may lead to stockouts or overstocking.

Implementing IoT-based solutions in laboratory stock management can help address these challenges. By utilizing IoT devices laboratories can achieve real-time monitoring of inventory levels, location, and usage. This enables accurate and timely inventory management, reducing the chances of stockouts and optimizing resource allocation.

Additionally, IoT-powered stock management systems can provide valuable insights into usage patterns, expiration dates, and maintenance needs. This information can support efficient procurement decisions, prevent wastage, and ensure that the laboratory operates smoothly without interruptions.

2.2 Global current issue of Stock Management by Using IoT for Laboratory

The requirement for effective inventory tracking and control is one ongoing concern with stock management using IoT for laboratories. It might be difficult to keep track of the various parts and equipment that laboratories frequently work with. Manual stock management techniques take a lot of time, are prone to mistakes, and may result in stockouts or overstocking.

These issues can be resolved by implementing IoT-based solutions for laboratory stock management. Laboratories can monitor inventory levels, location, and usage in real-time by using IoT devices. This enables accurate and timely inventory management, reducing the chances of stockouts and optimizing resource allocation.

Additionally, IoT-powered stock management systems can offer useful information into usage patterns, expiration dates, and maintenance requirements. This knowledge can assist in making effective purchasing selections, stop wastage, and guarantee uninterrupted lab operations.

2.3 Types of Laboratories

Laboratories encompass a wide range of types, each serving specific scientific or technological endeavors. Research laboratories are frequently criticized for being antiquated or obsolete, but this perception is unfair. These facilities play a crucial role in numerous companies, offering comprehensive support to various departments rather than focusing solely on a single aspect of the business model. This is evident in contemporary research practices across diverse sectors such as technology and pharmaceuticals. A medical laboratory is a facility where healthcare professionals, including doctors, conduct tests on patient samples to gather essential information about their health. These laboratories are primarily located within hospitals, clinics, or pharmaceutical companies. Clinical laboratories same with medical laboratory that operate within healthcare settings, conducting diagnostic tests on patient samples.[1] Forensic laboratories analyze evidence from crime scenes, supporting law enforcement agencies. Environmental laboratories assess air, water, and soil quality to monitor environmental impact. Quality control laboratories ensure product safety and compliance. Food testing laboratories analyze food samples for safety and nutritional value. Pharmaceutical laboratories contribute to drug development and testing. Educational laboratories provide hands-on training for students. Biotechnology and nanotechnology laboratories specialize in their respective fields. These examples illustrate the diverse nature and critical roles of laboratories in various scientific and technological domains.

2.4 Types of Stock in Electronic Laboratories

Electronic stocks encompass a diverse assortment of materials, gadgets, and machinery employed within laboratories to conduct experiments, research, test, or analyze various subjects. These stocks consist of a wide array of constituents such as integrated circuits (ICs), resistors, capacitors, inductors, transistors, diodes, sensors, microcontrollers, development boards, oscilloscopes, power supplies, breadboards, prototype tools, cables, connectors, and cables.

The fundamental building blocks are integrated circuits, which are semiconductor chips that house numerous coupled circuits. Electric current is regulated by resistors, while electrical energy is stored and released by capacitors. Inductors, in the form of coils, store energy in a magnetic field and are frequently used for energy filtering and management. Signal processing in experiments and devices depends on transistors' ability to switch and amplify signals.

Diodes provide rectifying, demodulation, and voltage control by facilitating one-way current flow. Sensors are essential for experimentation, collection of data, and process control since they detect and quantify physical quantities including temperature, pressure, light, motion, and others.

Compact circuits called microcontrollers that have processors and peripherals make it easier to prototype projects, and development boards provide simple testing grounds for electrical developments. Oscilloscopes allow for the visualization and analysis of electronic waveforms, which is helpful for signal analysis and troubleshooting.

Different types of power supplies, such as switching or linear power supplies, and battery packs, provide electrical energy to laboratory circuits. To speed up experimenting, breadboards make it simple to prototype circuits without soldering. Proper connections between components, devices, and systems are made possible by cables, connectors, and wiring.

2.5 Types of Stock Management in Laboratories

Effective stock management is crucial in laboratory settings to ensure smooth operations, minimize waste, and maintain sufficient supplies for experiments and research activities. Laboratories heavily rely on the availability of materials and supplies to conduct their work efficiently. By implementing effective stock management practices, laboratories can avoid delays and disruptions in experiments or research projects. Proper stock management also helps minimize waste by avoiding overstocking or understocking of materials. This reduces costs, prevents expiration or obsolescence of stock, and minimizes environmental impact. Additionally, efficient stock management allows laboratories to optimize procurement strategies, negotiate favorable terms with suppliers, and allocate resources effectively. It ensures that materials are stored properly, monitored for expiration, and used within specified conditions, thereby maintaining the reliability and accuracy of research outcomes. Overall, effective stock management plays a vital role in supporting laboratory operations, optimizing costs, and ensuring the quality of research activities.

2.5.1 Manual Stock Management

Inventory tracking in the laboratory is part of manual stock management and requires tracking laboratory stock on paper or in an electronic spreadsheet. Important details including item name, amount, and expiration date are entered manually by laboratory staff. They need to check stock quantities and record items that require restocking manually through visual inspection or comparison with minimum stock requirements.

2.5.1.1 Advantages of Manual Stock Management

Manual stock management has several advantages. Firstly, since it doesn't call for specialized software or equipment, it is easy to use and affordable, especially for smaller laboratories with fewer resources. Secondly, manual stock management provides flexibility, enabling laboratories to modify records as needs change and modify their inventory monitoring systems depending on their specific needs. Additionally, it is simpler for laboratory workers to adopt and use this strategy because many of them are familiar with manual data entry techniques like spreadsheets. If choose to track inventory manually without investing in automated software, it can be a cost-effective option, especially when have a limited inventory to manage. This approach helps minimize costs by eliminating the need for additional software expenses.

However, manual stock management also has its limitations. It can be time-consuming, particularly in larger laboratories with a wide range of inventory items, as regular data entry and updates can be labor-intensive and prone to errors. Manual data entry increases the risk of human errors such as typos, miscalculations, or misplacements, potentially leading to inaccurate stock records that can affect inventory control and order fulfilment [2]. Additionally, manual stock management does not provide real-time visibility into inventory levels because changes are only made when personnel manually enters data, which causes delays and a lack of current data. A large number of goods and reliable tracking of numerous stock movements may also become difficult and inefficient with manual stock management as the laboratory's inventory expands or becomes more advanced.

2.5.1.2 Disadvantage of Manual Stock Management

Comparing manual stock management to automated or digital solutions reveals various disadvantages. First of all, manual stock management is subject to human errors including incorrect data entry, calculations, or lost inventory records. Due to a mistake in updating the spreadsheet or a calculation error, incorrect inventory quantities can happen. These mistakes may result in incomplete inventory counts, inconsistent stock levels, and problems satisfying customer orders.

Second, managing stocks manually takes a lot of time and work. Manual inventory counting and tracking can take a lot of time, especially for large quantities or complicated supply lines. Additionally, it can require staff members who are entirely liable for maintaining and updating stock information.

Another disadvantage is the lack of real-time visibility and tracking. Manual stock management systems often rely on periodic or manual checks, which can result in outdated or delayed information about stock levels and availability [3]. This can lead to stockouts, overstocking, or inefficient inventory replenishment decisions.

Additionally, manual stock management solutions might not have the necessary reporting and analytics tools. Without the capacity to produce accurate and timely reports, it might be difficult to analyse inventory data, spot trends, and come to intelligent conclusions. This can make strategic planning and inventory optimisation more difficult..

Last but not least, manual stock management might not be integrated with other platforms or systems. It might be challenging to integrate stock data with sales, purchasing, or accounting systems, which can lead to fragmented operations and potential inconsistencies between several departments or functions.

2.6 Types of Systems for Stock Management

Inventory items are labeled with barcodes in a system that relies on them, and barcode scanners are used to read these codes. An item is scanned using a barcode scanner when it is received or moved, which immediately enters the information in the stock management system. As a result, there is no longer any need for manual data entry, thereby reducing the possibility of record-keeping errors. Barcode scanners offer flexibility and convenience by being portable or integrated into mobile devices.

By utilising radio waves for communication between RFID tags and readers, RFID-based solutions advance inventory tracking. RFID tags can be active (powered by their own power source) or passive (powered by the reader's signal). RFID readers are able to read tags even without a direct line of sight from a distance and can identify numerous tags at once. Compared to barcode systems, this makes it possible to track inventory more quickly and effectively because several goods may be scanned at once and without a human being getting in the way.

Other than that, a centralised solution that automates stock management in laboratories is inventory management software. It controls stock movements, connects with other systems, produces reports, and continuously monitors inventory levels. Visibility is provided by the programme, which also stops stockouts and makes reordering procedures simpler. Additionally, it provides statistics for cost- and inventory-level optimisation. The use of inventory management software in laboratories enhances productivity and stock management decision-making overall.

2.7 What is the Internet of Things (IoT)

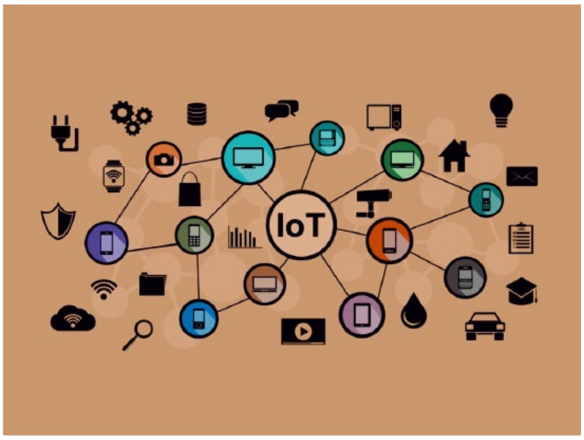


Figure 2.1 Internet of Things

Based on the Figure 2.1, the concept of the Internet of Things (IoT) refers to a network of physical objects, also known as "things," which are equipped with sensors, software, and other technologies to establish connections and exchange data with other devices and systems via the internet. These objects can vary from everyday household items to advanced industrial tools [4].

The Internet of Things (IoT) intends to enable physical and digital items to interact, communicate, and obtain and send information by creating a seamless connection between the physical and digital worlds. IoT devices may collect and transmit information about their surroundings, including temperature, humidity, movement, and location, using sensors. Cellular networks, Wi-Fi, and Bluetooth are frequently utilised in wireless communication technology for IoT communications. This enables devices to send obtained data to connected devices or cloud-based systems for archiving, processing, and analysis. Depending on the circumstances, the data can then be used to gain insights, make wise judgements, automate processes, or start actions.

2.7.1 Advantages of Internet of Things (IoT)

The Internet of Things (IoT) offers a wide range of advantages and benefits in many different fields. First, by automating processes and minimizing manual intervention, IoT increases productivity and efficiency. This results in simplified processes and reduced mistake rates. In addition, IoT provides insights for proactive decision-making and optimized resource allocation through real-time data analytics. Thirdly, IoT can save costs by enhancing maintenance procedures, lowering energy usage, minimizing expensive downtime, and optimizing resource utilisation. Fourthly, IoT improves security and safety by creating a safer environment for people and assets through real-time monitoring and alarm systems.

The personalization of goods and services based on consumer preferences and behaviour further enhances the customer experience offered by IoT. IoT's remote monitoring and control capabilities help sectors like healthcare deliver prompt interventions and lower hospitalisation rates. By reducing waste, maximising resource management, and reducing energy use, IoT also helps to sustain the environment. Last but not least, IoT encourages creativity and creates new business prospects by making it easier to create new goods, services, and solutions that solve particular industry demands and difficulties. IoT benefits include higher productivity, data-driven decision-making, cost savings, improved safety, improved customer experiences, remote monitoring capabilities, environmental sustainability, and chances for innovation.

2.7.2 Disadvantage of Internet of Things (IoT)

The Internet of Things (IoT) has many advantages, but it also has major disadvantages and difficulties. First, as more devices are connected and share sensitive data, security and privacy issues grow. Hackers may take advantage of IoT device vulnerabilities to access personal data improperly or cause data breaches. Second, IoT system complexity and interoperability problems can be problematic. The seamless integration and compatibility of various platforms and devices may be challenging, which obstructs collaboration and communication. Thirdly, IoT devices might overwhelm existing infrastructure and networks with their vast amounts of data, necessitating considerable investments in processing and storage capacity. Additionally, since IoT devices frequently depend on a reliable internet connection, connectivity problems might cause interruptions.

Additionally, because of the IoT's rapid development, device lifecycles may be shortened, increasing the likelihood of failure and the need for frequent upgrades or replacements. Last but not least, in order to protect individual rights and ensure responsible use, the ethical implications of IoT, such as data ownership, consent, and surveillance, need careful consideration and legal frameworks. In general, addressing security concerns, assuring interoperability, controlling data overload, maintaining connectivity, dealing with device depreciation, and addressing ethical considerations are critical variables for reducing the negative aspects connected with adoption of the Internet of Things.

2.8 IoT for Management Stocks in Laboratories

The Internet of Things (IoT) has the ability to improve laboratory stock management and bring about a variety of advantages. By employing IoT sensors to monitor inventory levels in real-time, laboratory staff may obtain up-to-date information and handle supply replenishment efficiently. IoT sensors can also keep an eye on the weather and temperature to protect sensitive items. By collecting data on equipment usage and maintenance needs, IoT-enabled sensors facilitate predictive maintenance, reducing the risk of equipment breakdowns. IoT systems can automate the reordering process, triggering purchase orders or notifications when stock levels reach predefined thresholds. Compliance and safety monitoring can be enhanced through IoT devices, which track hazardous material usage and provide alerts in case of safety breaches. IoT solutions also enable accurate traceability and logging of stock movements, ensuring data integrity and aiding research and regulatory compliance. By leveraging advanced analytics, IoT data can offer insights into stock utilization patterns and optimization opportunities. Though implementing IoT for stock management requires careful planning and consideration of security and privacy, its benefits in terms of real-time monitoring, automation, efficiency, and improved stock control make it a valuable tool for laboratories seeking to optimize their stock management practices.

2.8.1 Cloud

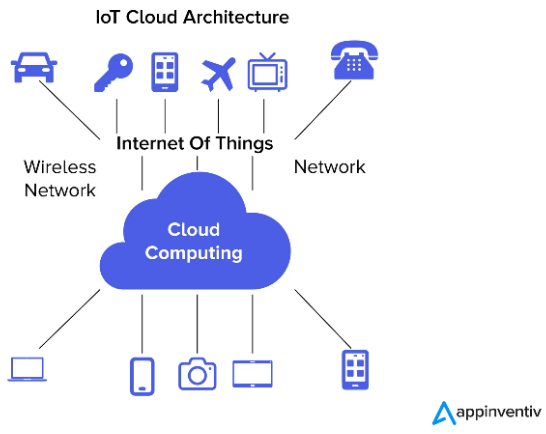


Figure 2.2 Cloud Architecture

Figure 2.2 demonstrates the architecture of cloud computing, where varied services are offered over the Internet. Software, servers, databases, networking, and data storage are some of the components of these tools and programs. Cloud-based storage enables users to save files to a remote database rather than a proprietary hard disc or local storage device. As long as a computing device has internet connectivity, it can access the necessary data and software programs to operate. The benefits of cloud computing, such as cost-effectiveness, enhanced productivity, speed and efficiency, performance, and security, have made it a widely favored option for both individuals and businesses.

2.8.1.1 Telegram Bot

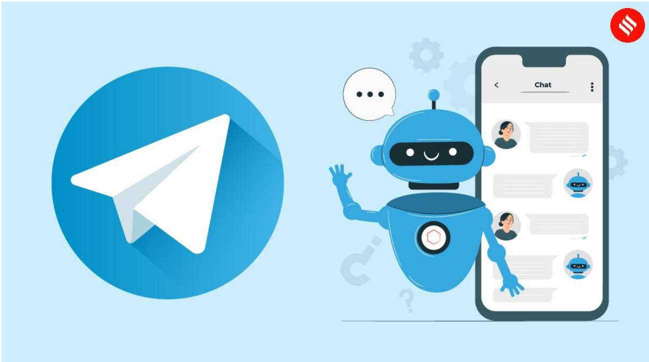


Figure 2.3 Telegram Bot

A Telegram Bot is shown in Figure 2.3 as a software application designed to resemble a standard chat buddy with extra features. It autonomously carries out predetermined tasks without requiring user intervention. The term "bot" is derived from "robot," emphasizing its automated nature [5]. Developers use bots that provide tools and interfaces for creating and maintaining bots to construct the Telegram Bot API. A bot can be used in one-on-one conversations or joined to Telegram groups after being developed and given a unique username.

Information retrieval, work automation, customer assistance, games and entertainment, and language processing for natural conversation are just a few of the many tasks that Telegram bots can perform. To connect with web applications, databases, or IoT devices, bots can integrate with other services and APIs.

2.8.1.2 Blynk

An IoT platform called Blynk allows users of iOS or Android smartphones to remotely operate devices like Arduino, Raspberry Pi, and NodeMCU. This application is used to create a graphical interface or human-machine interface (HMI) by compiling and providing the appropriate address on the available widgets. The Blynk mobile app, available on iOS and Android, allows users to create customized UIs by dragging and dropping widgets such as buttons, sliders, and graphs. It establishes a connection to hardware devices via the internet, enabling command sending and data retrieval. Blynk Cloud acts as a server, relaying messages between the app and hardware devices. It offers features like data logging, email notifications, and push notifications to enhance IoT project functionality. The Blynk Library, installed on the hardware device, simplifies integration with Blynk Cloud through APIs and libraries compatible with various hardware platforms and microcontrollers.

2.8.1.3 ThingSpeak

ThingSpeak is an Internet of Things (IoT) platform made to gather, process, and display data from various sensors and devices. Users can send data to ThingSpeak using a variety of protocols, including MQTT and HTTP and arrange it into channels with many fields for various parameters. The platform makes it easier to create dashboards that are configurable and come with built-in visualization features like maps and charts. Custom analytics are made possible by MATLAB-based scripts that facilitate automation. ThingSpeak is flexible for Internet of Things applications in domains like home automation, agricultural, and industrial monitoring since it interacts easily with hardware platforms like Arduino and Raspberry Pi. It is a well-liked option for people and companies executing IoT projects without requiring significant infrastructure development because of its open API, which enables future modification and interaction with a variety of apps and services.

2.9 Microcontroller

Microcontrollers are extremely small integrated circuits that combine a microprocessor core, memory, and input/output peripherals onto a single chip. It contributes significantly to embedded systems by enabling control and processing in a variety of electronic devices, including consumer electronics, automobiles, industrial machinery, and appliances. Microcontrollers may connect with external components, process data, do computations, handle inputs and outputs, and interface with other devices which enables them to carry out specified instructions. Microcontroller programming requires the use of specialized software and programming languages. Based on the specific requirements of the application, a microcontroller should be selected, taking into account factors like processor speed, memory size, input/output capabilities, and power consumption. Microcontrollers are a wonderful choice for implementing automation and control in a number of electronic systems due to their popularity. The efficiency and cost-effectiveness of microcontrollers are also well known.

2.9.1 Arduino Uno

Figure 2.4 Microcontroller Arduino Uno

The Arduino Uno microcontroller board, which is based on the ATmega328, is shown in Figure 2.4. In Arduino Uno, the term "Uno" is Italian for "one." Arduino Uno is named for marking the upcoming release of the microcontroller board namely Arduino Uno Board 1.0. This board includes digital I/O pins-14, a power jack, analog i/ps-6, ceramic resonator-A16 MHz, a USB connection, an RST button, and an ICSP header. All these can support the microcontroller for further operation by connecting this board to the computer. The power supply of this board can be done with the help of an AC to DC adapter, a USB cable, otherwise a battery. . The board may also work with a range of expansion boards to add additional functionality and allow for project customization. The Arduino community is active and helpful, providing a wealth of resources, guidelines, and code examples to support learning and development. The Arduino Uno microcontroller board's adaptability and ease of use make it a fantastic choice for developing and building a variety of electronics projects.

2.9.2 ESP32

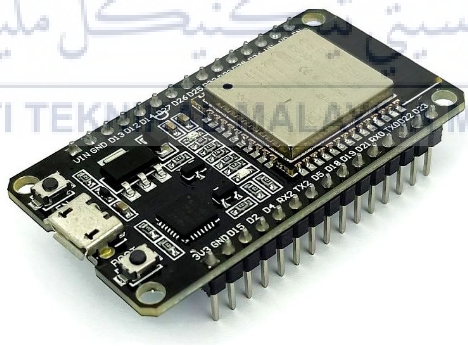


Figure 2.5 ESP32

The ESP32 family of system-on-chip microcontrollers, which is known for its low cost and high energy efficiency, is shown in Figure 2.5. Both dual-mode Bluetooth and integrated WiFi are included with them.Tensilica power management blocks, filters, and noise-receiving amplifiers are included in the ESP32 series. The ESP32 microcontroller, which replaces the ESP8266, is a versatile system-on-chip (SoC) with a range of peripherals, including wireless WiFi and Bluetooth capabilities. It is more powerful and functional than Arduino boards and features dual built-in Wi-Fi and Bluetooth capabilities. In-depth TCP/IP support is offered for reliable full-stack Internet connections. Additionally, the ESP32's Wi-Fi module allows it to operate as both an access point and a Wi-Fi station.

2.10 Comparison between Arduino Uno and ESP32

Table 2.1 Comparison between Arduino Uno and ESP32

TYPES	ARDUINO UNO	ESP32
Processing Power	Operates at 16MHz and has limited processing power	A more powerful dual-core Xtensa LX6 processor, running at up to 240 MHz, offering significantly higher processing capabilities.
Memory	Has 2 KB of SRAM and 32 KB of flash memory, which is sufficient for many simple projects	Provides more memory options with up to 520 KB of SRAM and up to 16 MB of flash memory, allowing for more complex applications and data storage.
Connectivity	Has limited connectivity options, offering only USB and UART for communication.	Built-in Wi-Fi and Bluetooth capabilities, making it suitable for IoT applications. It supports both traditional

		Wi-Fi and BLE (Bluetooth Low Energy), enabling wireless communication and connectivity with other devices.
GPIO Pins	20 GPIO pins, including digital and analog input/output pins.	With up to 36 digital and 18 analog input/output pins, allowing for more extensive interfacing with sensors, actuators, and other external components.
Price	More affordable	More expensive

Table 2.1 gives a side-by-side comparison of the distinctions between Arduino Uno and ESP32 microcontrollers. To help in understanding the differences and similarities of the two devices, this table compares their features, functionalities, and specifications.

2.11 Research by Related Project

The research that led to the proposed project title was conducted in order to compare its advantages and disadvantages. The objective of the project was achieved with the help of this linked research.

2.11.1 Research on Warehouse Inventory Management System Using Iot And Open Source Framework

The RFID reader is shown in Figure 2.6, retrieving data from RFID tags. The project focuses on resolving the challenges associated with inventory management in warehouses, specifically the laborious and inefficient manual search for products. To address this issue, the project proposes the adoption of RFID technology within a warehouse inventory management system [6].

The system stores comprehensive product information and tracks the precise location of each item within the stockrooms. RFID tags are employed to store product details, which are then transmitted wirelessly to a central server, represented by a Raspberry Pi in this case. By utilizing the Internet of Things (IoT) architecture, the system effectively monitors and traces products through the utilization of RFID tags, collecting data and timestamps for verification purposes.

The central server, the Raspberry Pi, functions as a monitoring system for all the accumulated information. To facilitate user convenience, a user-friendly web page interface is developed, allowing users to easily track products within the warehouse. This solution offers a cost-efficient alternative to existing warehouse inventory management systems, operating dynamically to enhance overall efficiency.

In conclusion, the project aims to enhance warehouse inventory management by implementing an RFID-based system that leverages IoT architecture and a central server for monitoring and tracking products. This system provides a cost-effective and efficient solution, streamlines product tracking, and features an intuitive user interface, differentiating it from current systems.

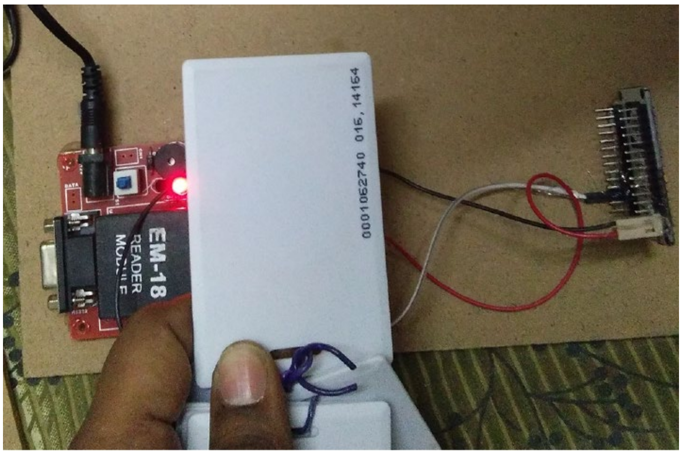


Figure 2.6 The RFID reader reads the data from RFID tags

2.11.2 Research On Review Of RFID And Iot Integration In Supply Chain Management

Supply Chain Management (SCM) is becoming increasingly intricate and dynamic. RFID and IoT play a crucial role in meeting customer demands within the supply chain. The integration of RFID with IoT, also known as RFID-IoT, aims to develop automated sensing systems that are efficient, interoperable, and highly secure by connecting IoT devices via the internet.

The objective is to thoroughly analyze the literature to enhance management system efficiency, increase productivity, and reduce costs [7]. Furthermore, the paper explores the challenges encountered in implementing RFID-IoT in the supply chain based on the findings of the reviewed papers. The conceptual framework model encompasses four essential SCM perspectives: product manufacturing, shipping and distribution, inventory, and retail shops. The insights and recommendations derived from this review are expected to inspire further endeavors in the development of RFID-IoT technologies.

2.11.3 Research On Design of Smart Inventory Management System For Construction Sector Based On Iot And Cloud Computing

Figure 2.7 illustrates the ultimate result of this project. Efficiently monitoring and managing raw materials and goods consumption is crucial for the sustainability and profitability of manufacturing industries. With intense global competition, these industries are constantly seeking inventory management systems that can reduce costs and expedite the supply of materials and goods for efficient production. Therefore, it is essential to continuously improve existing inventory management designs to remain competitive. While barcode-based systems have brought significant benefits to modern inventory management, our research suggests an opportunity to enhance these designs by integrating them with Cloud Computing, Arduino-based wireless station nodes, IoT, and a secure data access channel through a dedicated web portal [8]. In this paper, we propose a novel approach using our model and demonstrate its potential in managing the inventory of essential formwork shuttering products in the construction sector. Although our research background pertains to Indian construction companies, the findings can be extended to other regions as well.

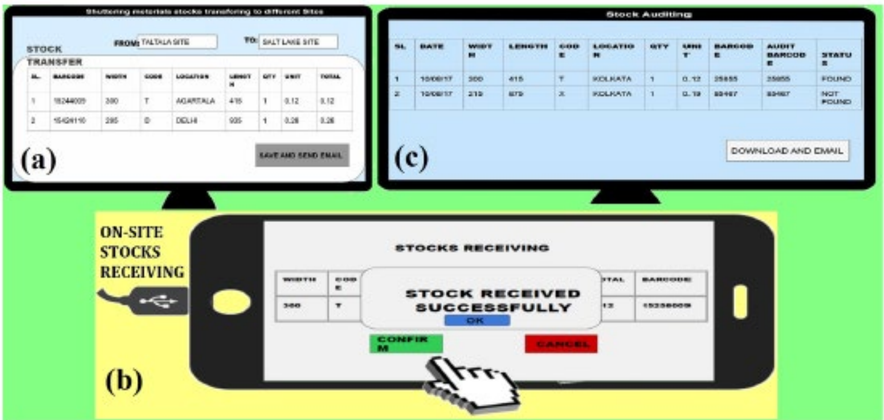


Figure 2.7 The final outcome for this project

2.11.4 Research on Design and Development of IoT Based Inventory Management System for Small Business

This journal informed us that information and communication technology advancements have simplified various aspects of our lives. The widespread use of the internet has contributed to this transformation, as people increasingly rely on portable smart devices such as smartphones for their daily activities. Tracking and monitoring tasks are now preferably carried out using these devices, eliminating the need for manual processes [9].

IoT has revolutionized the field of inventory management, offering both advantages and disadvantages. When using Arduino and RFID technology, some IoT-based inventory management solutions are constrained. This project intends to create an IoT-based inventory management system that uses NodeMCU and Load Cell technologies to overcome these restrictions. In comparison to Arduino, the NodeMCU has a variety of advantages, including an integrated Wi-Fi module, more computing power, and a more compact design. The usage of load cells, in contrast, offers greater simplicity for a variety of inventory management requirements as opposed to RFID, which is better suited for larger-scale organizations with big stock.

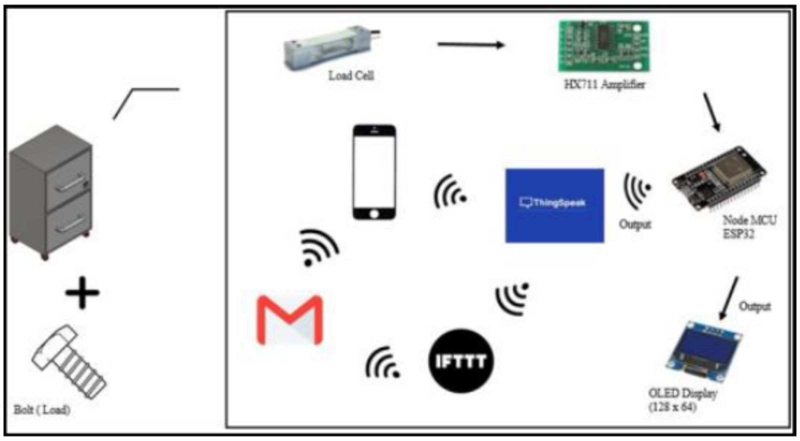


Figure 2.8 Block diagram for this project

Figure 2.8 displays the block diagram representing the structure of this project. The overall goal of this project is to automate inventory management through the application of IoT. The technology will do stock counts automatically and offer internet accessibility. Additionally, it will keep track of past data and status updates, delivering alerts when stock levels are getting low.

2.11.5 Research on Study of Smart Inventory Management System Based On The Internet Of Things (IoT)

This article told that in today's evolving business landscape and the increasing demand for diverse products, traditional inventory management models are unable to meet the requirements efficiently [10]. This paper introduces a new intelligent Inventory Management System based on the Internet of Things (IoT) and describes its principles and structure. This system offers significant advantages over traditional approaches, and its development holds promising prospects. Effective inventory management is crucial for optimizing customer service and minimizing costs in manufacturing operations. As companies expand globally and manage numerous components across multiple warehouses, inventory management becomes a complex task that consumes valuable time and effort. Traditional methods, such as using robotic arms and marking warehouse areas for tracking, have been employed, but they often fall short of addressing the challenges posed by modern inventory management.

2.11.6 Research on Laboratory Management: Digital Laboratory Information System (DLIS) Concept

Laboratories play a crucial role in education and learning, as they contain a wealth of data including information about goods, inventory of laboratory instruments, components and devices, logbooks, lending records, and scheduling. However, many laboratories still rely on conventional methods to manage this data [11]. This paper proposes a concept called Digital Laboratory Information System (DLIS) that leverages computer systems integrated with the Internet of Things (IoT) technology to manage laboratory data digitally. DLIS offers numerous benefits for users and laboratory administrators. It enables data to be more flexible, facilitating easier updates and upgrades. Additionally, DLIS allows remote access to laboratory data through the IoT, eliminating constraints of distance and time for users.

2.11.7 Research on Remote Laboratory Experiment Access via an RFID Interface

Figure 2.9 depicts the arrangement of the smart card reader. This research focuses on utilizing radio frequency identification (RFID) technology for remote access to laboratory experiments. Contactless smart cards, commonly used in applications like travel cards and access control systems, are explored for their potential in enabling access to electronic engineering experiments in a remote laboratory environment [12]. The study presents a case study design that demonstrates this concept by integrating experiment data onto a contactless smart card and accessing it through a card reader and web server setup.

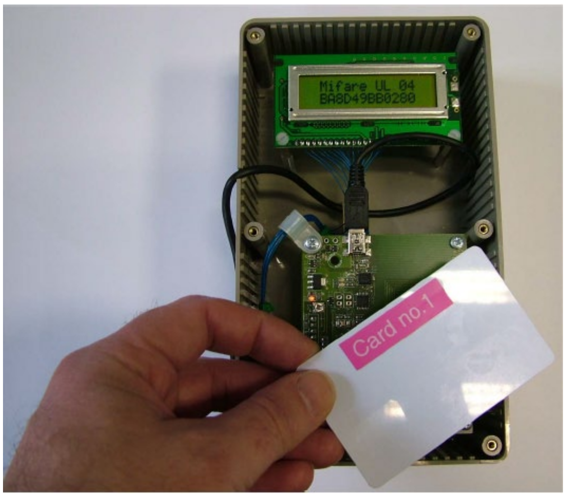


Figure 2.9 Smart card reader set-up

RFID technology enables wireless connectivity between electronic circuits. Its applications range from travel cards and access control to inventory tracking. It facilitates the wireless transfer of data and power. An RFID system typically comprises three components: the RFID tag, the RFID reader (or interrogator) equipped with an antenna, and a computer (PC) running software that interacts with the reader and tag. While there are various types of RFID systems, a basic configuration involves a PC running software that communicates with the RFID reader hardware via a USB serial interface.

2.11.8 Research on Advanced Smart Inventory Management System Using IoT

The Smart Inventory Management System based on the Internet of Things (IoT) is an automated solution designed to streamline inventory management using various components such as Arduino Uno, Nodemcu, three IR sensors, Load cell sensor, Status LED, and Ultrasonic sensor [13]. This system leverages IoT principles to provide real-time inventory data, simplifying the task of inventory management. The IR sensors accurately detect the quantity of goods present in the inventory, while the ultrasonic sensors determine the presence and level of inventory items. To ensure precise measurements, load cell sensors are employed to measure the weight of items, which is then converted into quantity count by dividing the total weight by the weight of a single item. The collected data is wirelessly transmitted to the cloud through the Nodemcu, and the Status LED provides a visual indication of the inventory status, enabling easy monitoring of the system. The system offers a user-friendly interface accessible through a web or mobile platform, ensuring convenient and efficient inventory management. Overall, the IoT-based Smart Inventory Management System proves beneficial for businesses by reducing inventory management costs and enhancing operational efficiency.

2.11.9 Research on Stock Management Using IoT

In this fast-developing business generation, it is important to keep track of everything in small-scale industries it is difficult to keep the track of material although we can check it manually it is not so 100% sure that it is correct so here, we introduce a Stock management system using IoT. With the use of this system, we can check the inventory from anywhere this system is accurate it will give the correct number of quantities of material left in the Inventory. Also, this system will give a message through email. If the material goes below user-defined criteria [14].

Figure 2.10 Stock Management by Using IoT

The application of IoT for stock management is shown in Figure 2.10, underscoring the growing importance of smart systems and the Internet of Things in business and industry. This generation and the upcoming generations are IoT and AI-based so all businesses or industries are heading towards IoT or AI-based Projects, in products nowadays where time is everything, it is important to keep track of materials or products to avoid losses. Finding a specific product in a short period of time is a difficult endeavor. The demand for stock management system using IoT is increasing day by day because of its automatic working. The place or section where westored the material is known as the Warehouse themain aim of the Warehouse is to control the flow of material otherwise it will affect things liketime and cost. Because of the profit, stock management systems employing IoT are important in today's commercial section. Stock management using IoT provides Less effort, it is more efficient and it has got stable result the demand for automatic warehouses is increasing because in human- based Warehouses it is very difficult to avoid errors. In this era of IoT, advanced sensors can manage your stocks very easily.

2.11.10 Research on An IoT Based Inventory System for High Value Laboratory Equipment

An illustration of the current state of testing for new RFID technology can be found in Figure 2.11. In this journal told that Radio Frequency Identification (RFID) technology plays a pivotal role in enabling IoT. By utilizing electromagnetic fields, RFID facilitates the automatic identification and tracking of tags affixed to various objects or assets. Automated monitoring systems employ RFID to streamline processes such as item identification, tracking, monitoring, and enhancing security measures. In environments where numerous items are accessed by multiple users, the risk of loss increases due to inadequate monitoring. To address this challenge, they have developed an RFID-based system for efficiently managing the inventory of high-value laboratory equipment at our RFID lab in KFUPM University, Saudi Arabia [15].

This system employs cost-effective battery-less tags attached to the equipment, along with an Arduino microcontroller connected to a GSM shield. Notably, our system boasts unique features, including authentication of checkout using both smart cards and RFID, as well as the ability to send SMS alarms in the event of equipment theft or unauthorized lending. The proposed system serves as a foundation for innovative research, acting as a bridge between the digital and physical realms to enable the digitization of laboratories.

Figure 2.11 An image of the developing RFID technology being tested

2.11.11 Research on IoT-Based Inventory Tracking in the Pharmaceutical Industry

Inventory visibility has been a longstanding concern for supply chains in various industries, including pharmaceutical companies that have a responsibility to ensure consumer safety. Traditionally, these companies have relied on outdated and complex methods to track and count inventory units, resulting in inaccuracies, mismanagement, product waste, returns, and consumer risk. However, recent technological advancements, specifically in the field of Internet of Things (IoT), offer potential solutions to effectively manage and protect pharmacy inventory while upholding consumer safety and brand reputation [16].

This study examines the economic and practical implications of implementing an IoT-based inventory visibility solution in the sponsor's supply chain, aiming to mitigate consumer risk and minimize financial waste. By conducting extensive research on existing technologies, conducting device experiments, and analyzing the supply chain from multiple perspectives, the team proposes the adoption of a Bluetooth technology IoT network infrastructure and a strategic implementation plan to address the sponsor's inventory visibility requirements.

2.12 Research on Smart Inventory Management System

The Smart Inventory Management System is an online software application designed to meet the needs of stock analysis in a variety of warehouse situations. Its structure is shown in Figure 2.12. It offers a user-friendly graphical interface for managing daily transactions and accessing historical data. The system generates management reports such as monthly inwards, deliveries, and returns.

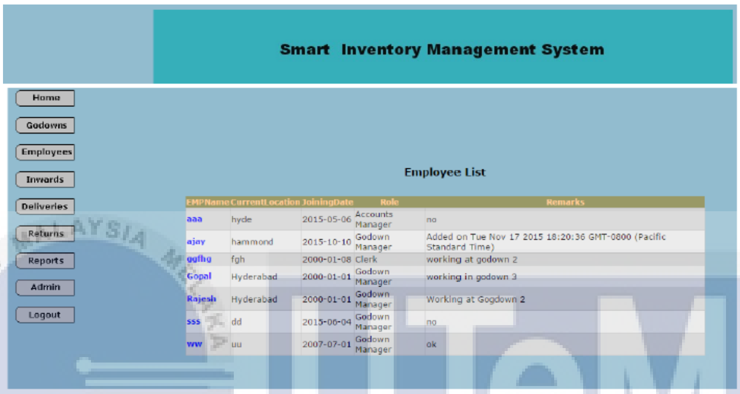


Figure 2.12 System of Smart Inventory Management System

By maintaining a centralized database, any modifications made at one location are immediately reflected across the system. Being an online tool, multiple users can simultaneously log in and utilize the application.

The primary objective of this application is to minimize the manual effort involved in managing transactions and historical data across various warehouses. Additionally, it provides users with an interface to view detailed information such as daily stock statements for all warehouses.

2.12.1 Research on Inventory Management System Using IoT

Figure 2.13 shows the prototype of this project. This Inventory management involves monitoring and calculating the available stocks at different stages of the production process. It is a crucial tool for industries experiencing continuous growth and facing challenges related to product demand and timely delivery. The scope of inventory management extends beyond industries and encompasses fields like healthcare. Our proposed design offers a cost-effective solution that can address both simple and complex stock management issues. For example, it can efficiently manage stocks of cereal manufacturing plants, including wheat and barley, where high efficiency is required. Moreover, our design is applicable to liquid inventory management, such as detergents and soft drinks. In medical applications, it facilitates efficient storage and updating of drug stocks. The underlying technology driving this efficient stock management system is the Internet of Things (IoT). IoT is a network comprising physical components with embedded software, electronic concepts, and components. It enables the sensing and remote maintenance of various components through a network infrastructure, promoting integration between physical and computer-based systems [17].

Figure 2.13 Prototype of this project

2.12.2 Research on IoT Smart Inventory Management System for Kitchen Using Weight Sensor, LDR, LED, Arduino Mega and NodeMCU (ESP8266) WiFi Module with Website and App

The final product, the Smart Kitchen Inventory Management System (SIMS), is shown in Figure 2.14. This Internet of Things (IoT) technology is designed primarily to make inventory management in restaurants, kitchens, and pharmacies more efficient and straightforward.It offers enhanced efficiency and convenience. SIMS provides users with real-time inventory updates and automatically places orders for new items when quantities are low [18]. User can also manually order items through the SIMS app, which will be delivered directly to their doorstep. The system allows users to generate expenditure lists for specific timeframes, providing insights into their spending patterns. Furthermore, users can track the status of their orders and view their order history through the website. With the integration of the Smart Kitchen Inventory (SKI) component, a part of SIMS, users can eliminate the hassle of traditional grocery shopping. They can conveniently operate the system from anywhere, using the website or the Android app, and order any required items whenever needed.

Figure 2.14 Final product

2.12.3 Research On A Smart Warehouse Inventory Management And Monitoring System Using Internet Of Things And Open Source Technology

Figure 2.15 depicts the implemented hardware of the system. In today's industrial landscape, effective inventory management plays a critical role. However, traditional methods often require significant manpower and time investment. This paper introduces a smart inventory management system designed to streamline the process and reduce manual effort. By leveraging IoT technology and open-source tools, the system enhances performance and security. RFID technology is utilized to tag products, which are then scanned by an RFID reader. The Arduino Mega, in conjunction with the ESP8266-01, collects product data and updates it on a web server [19].

The system automatically monitors product quantities in the inventory and initiates orders when supplies run low. Environmental parameters within the inventory are monitored using sensors such as DHT11, MQ2, and fire sensors, enabling appropriate actions to be taken as necessary. The GSM module sends updated messages to users regarding the products. Real-time monitoring of the collected data on the web server is facilitated through an Android app powered by IoT technology.

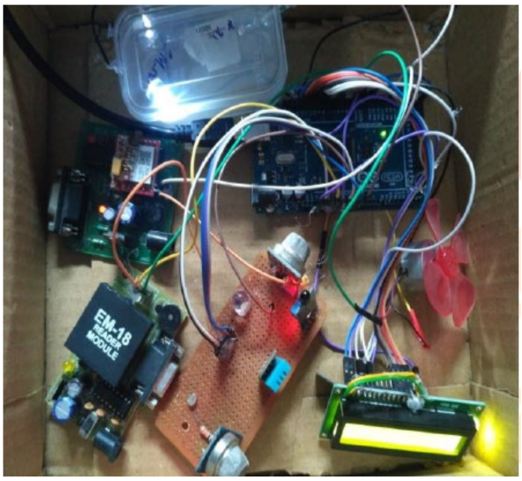


Figure 2.15 Hardware of the System Implemented

2.13 Comparison Selected Related Works

Table 2.2 Comparison Selected Related Works

NO	AUTHOR	TITLE	COMPONENTS	FUNCTIONS
1	B. Sai Subrahmanya Tejesh, S. Neeraja	Warehouse Inventory Management System Using Iot And Open Source Framework	• RFID tags • Raspberry pi 3 • ESP8266	• Real-time Inventory Monitoring • Automated Inventory Management • Predictive Maintenance
2.	Weng Chun Tan, Manjit Singh Sidhu	Review Of Rfid And Iot Integration In Supply Chain Management	• RFID Tags and Readers • Infrared Sensors • NodeMCU	• Inventory Tracking and Visibility • Supply Chain Automation and Efficiency • Demand Forecasting and Inventory Optimization
3.		Design Of Smart Inventory Management System For	• Arduino Uno • RFID tracker	• Real-Time Inventory Tracking • Automated Inventory Monitoring

	Rajesh Bose, Haraprasad Mondal, Indranil Sarkar, Sandip Roy	The Construction Sector Based On Iot And Cloud Computing	• RT203 barcode scanner • GPS tracker • ESP8266	• Inventory Optimization
4.	Shariman Johari, Wan Abdul Aziz	Design And Development Of Iot Based Inventory Management System For Small Business	• Thingspeak • ESP32 • OLED Display	• Real-Time Inventory Tracking • Automated Inventory Monitoring • Stock Replenishment and Order Management:
5.	Souvik Paul, Atrayee Chatterjee, Digbijay Guha	Study Of Smart Inventory Management System Based On The Internet Of Things (Iot)	• RFID reader • RFID antenna • RFID tags	• Real-Time Inventory Monitoring • Automated Data Collection • Inventory Tracking and Traceability
6.	I Fushshilat, A Rahmat, Y Somantri and E Haritman	Laboratory Management : Digital Laboratory Information Sysem (DLIS) Concept	• DLIS	• Sample Tracking and Management • Test Request and Workflow Management (Automated)

				• Test Result Recording and Reporting (Automated)
7.	Ian Grout1, Ciara Murphy1 and Alexandre César Rodrigues da Silva2	Remote Laboratory Experiment Access Via An RFID Interface	• RFID reader • RFID tags	• User Authentication and Access Control • Experiment Selection and Configuration • Real-time Experiment Monitoring and Control
8.	S.Prabakaran,V.Shangamithra ,G.Sowmiya, R.Suruthi	Advanced Smart Inventory Management System Using Iot	• Power supply • Arduino uno • NodeMCU ESP8266 • Ultrasonic sensor • LED • IR sensor	• Real-time Inventory Monitoring • Automated Inventory Tracking • Order Management

9.	Asif Daftarband, Mohsin Shaikh, Prof B. B. Waghmode	Stock Management Using Iot	• ESP8266 • Ultrasonic sensor	• Real-time inventory tracking • Automated stock monitoring • Supply chain visibility
10.	Wasim Raad, María-Victoria Bueno-Delgado, Mohamed Deriche, Wael Suliman	An Iot Based Inventory System For High Value Laboratory Equipment	• Arduino GSM Shield • RFID reader	• Real time asset tracking • Equipment utilization monitoring • Remote monitoring and condition monitoring
11.	Andrew Kerr Anthony Orr	Iot-Based Inventory Tracking In The Pharmaceutical Industry	• Bluetooth • IR sensor	• Real time inventory tracking • Temperature and environmental monitoring • Expiry date management
12.	Ajay Akarapu Chandrakanth Reddy Dasari Nagaraju Deshini Sushmita Mamidi	Smart Inventory Management System	Pentium IV processes architecture 1. 256 MB RAM. 2. 40 GB Hard Disk Space.	• Real-time inventory tracking • Automated stock monitoring and alerts • Demand forecasting and planning

			3. Ethernet card.	
13.	S. Jayanth, M.B. Poorvi and M.P. Sunil	Inventory Management System Using Iot	• Raspberry pi • Wifi module • Ultrasonic sensor • Wifi router	• Real-time inventory tracking • Automated stock monitoring • Remote monitoring and control
14.	Sifat Rezwan, Wasit Ahmed, Mahrin Alam Mahia and Mohammad Rezaul Islam	IoT Based Smart Inventory Management System for Kitchen Using Weight Sensors, LDR, LED, Arduino Mega and NodeMCU (ESP8266) Wi-Fi Module with Website and App	• Weight sensor • LDR • LED • Arduino Mega • NodeMCU ESP8266	• Real-time inventory tracking • Monitor their inventory levels and receive automatic notifications • The system provides features such as generating expenditure lists for a specified period, tracking order status and history through the website, and offering the convenience of online grocery shopping through the Smart

				Kitchen Inventory (SKI) component.
15.	Ch.N.S.Kameswari, B S S Tejesh	Smart Warehouse Inventory Management And Monitoring System Using Internet Of Things And Open Source Technology	• Arduino mega 2560 • RFID • LDR • LED • Gas sensor • ESP826	• Real-time inventory tracking • Automated stock monitoring and alerts • Warehouse layout optimization

A comparative study of a few relevant works is shown in Table 2.2. The purpose of this table is to present a thorough summary and comparison of numerous research or projects that are pertinent to the topic at hand. It enables readers to identify major distinctions, patterns, and takeaways from the chosen research.

2.14 Summary

The literature review concludes that using IoT for stock management in laboratories offers significant benefits. IoT enables real-time monitoring, data collection, and automation, improving inventory control and efficiency. IoT sensors track inventory levels and facilitate timely reordering and reducing waste. Automation and remote monitoring streamline procurement processes and provide flexibility for multi-site laboratories. Integrating IoT with Laboratory Information Management Systems enhances data accuracy and workflow efficiency. However, security and privacy considerations must be addressed. Overall, IoT holds promise for optimizing stock management in laboratories.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Efficient stock management is essential for laboratories to ensure seamless operations and maximize productivity. Traditional stock management techniques, however, frequently experience inefficiencies, errors, and a lack of real-time visibility. The development of the Internet of Things (IoT) has created new opportunities for altering laboratory stock management procedures. This section presents an introduction methodology for implementing a smart stock management system using IoT, enabling laboratories to achieve enhanced control, automation, and optimization of their inventory.

3.2 Selecting and Evaluating Tools for A Sustainable Development

In the context of sustainable development in laboratory stock management, there are specific tools and technologies available that utilize the Internet of Things (IoT). Although there may not be an extensive amount of literature specifically focused on this specific topic, we can explore related tools and concepts within the broader realm of IoT and sustainable stock management.

RFID technology utilizes radio waves to identify and track tagged items. By employing RFID tags on laboratory inventory and storage units, it becomes feasible to monitor stock levels, automate inventory management, and streamline the restocking process. Real-time data provided by RFID enables efficient resource allocation, leading to waste reduction.

The deployment of sensor networks within laboratory environments allows for real-time monitoring of parameters like temperature, humidity, and light levels. These sensors can notify staff of any deviations from optimal conditions that could impact the quality or shelf life of stored materials. By maintaining optimal conditions, unnecessary spoilage or waste can be minimized.

The utilization of data analytics and predictive modeling techniques aids in forecasting demand, optimizing stock levels, and reducing waste. Through the analysis of historical data and consideration of factors such as usage patterns, experiment schedules, and seasonal variations, informed decisions can be made regarding stock management, thereby decreasing the likelihood of excess or obsolete inventory.

Implementing smart shelving and storage systems equipped with IoT sensors provides real-time visibility into stock levels and locations. These systems can automatically trigger reorder requests when stock falls below a specific threshold or offer insights into usage patterns, facilitating more efficient stock rotation and preventing the accumulation of expired or unused materials.

Cloud-based inventory management systems enable centralized monitoring, data storage, and collaboration among laboratory staff. These systems integrate data from various IoT devices, providing a comprehensive overview of stock levels, usage trends, and environmental conditions. They also facilitate remote access and automate workflows, contributing to efficient stock management practices.

While literature specifically addressing IoT-enabled smart stock management in laboratories might be limited, exploring related subjects such as IoT applications in inventory management, IoT-driven supply chain optimization, or IoT-enabled sustainability practices in healthcare or industrial settings can provide valuable insights. Additionally, examining case studies and industry reports on IoT implementations in laboratory or healthcare settings can offer practical knowledge and real-world applications.

3.3 Methodology

The methodology chapter for the project "Stock Management by Using IoT for Laboratory" encompasses several key aspects. Firstly, the research design chosen for this project is described, emphasizing its alignment with the project's objectives. The system architecture design is then outlined, highlighting the components involved, such as protocols, and the cloud platform. The chosen architecture's justification and importance for effective stock management are discussed.

The hardware and software setup necessary for the IoT-based stock management system is examined in terms of implementation, along with the selection criteria for the software tools and frameworks used. It includes information on the categories of data gathered, the mechanisms used for data collecting and storage, and the data gathering techniques used to obtain relevant data from the electronic laboratory.

The steps of the project's development and testing are discussed, along with the exact execution of the smart stock management system and the methods used to assess its performance and functionality. The conclusions of the review are then shown, together with the measurements that were used to evaluate the effectiveness of the system. These outcomes are examined and compared with the project's objectives and expected outcomes.

Finally, the chapter concludes by summarizing the key findings and conclusions derived from the project. It acknowledges any limitations or challenges encountered during the implementation and provides recommendations for future enhancements and improvements to the smart stock management system. The methodology chapter acts as a comprehensive guide to the project's approach, techniques, and processes, laying the foundation for successful implementation and evaluation of the "Stock Management by Using IoT for Laboratory" project.

3.3.1 Block Diagram

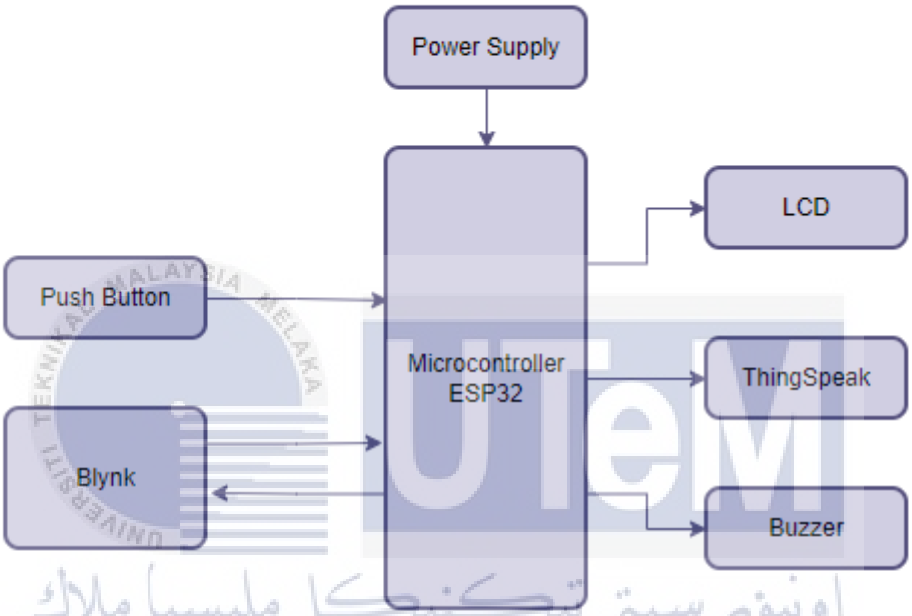


Figure 3.1 Block diagram for this project

The block diagram depicted in Figure 3.1 depicts an overview of the project scheme, explaining the functions of the input, process and output components. The ESP32 microcontroller is used as the central control unit responsible for managing and executing system operations. This microcontroller receives the input signal from Blynk and updates the status on the LCD if there is any addition or subtraction. The button also functions as 'next page' on the LCD to display 'next output'. In addition, a buzzer is used to emit a sound when the button component is used. As a result, the ESP32 requires a 5V power supply to facilitate the efficient operation of the stock management system.

3.3.2 Flowchart of Project Development

During completing this project, a methodology flowchart is illustrated in Figure 3.2 which describes the method that will be implemented in this project.

Basically, this flowchart is about the progression every week for PSM 1 and PSM 2 in order to complete this project.

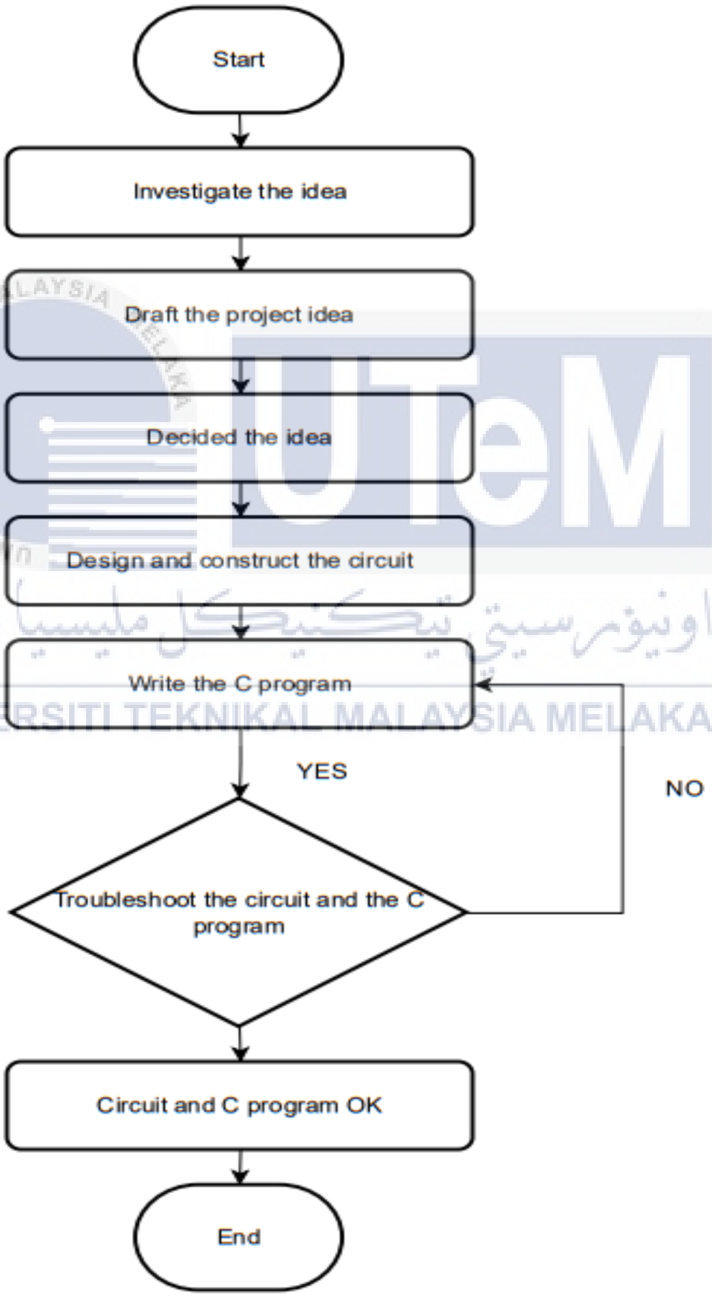


Figure 3.2 Flowchart of project development

3.3.2.1 Flowchart Project

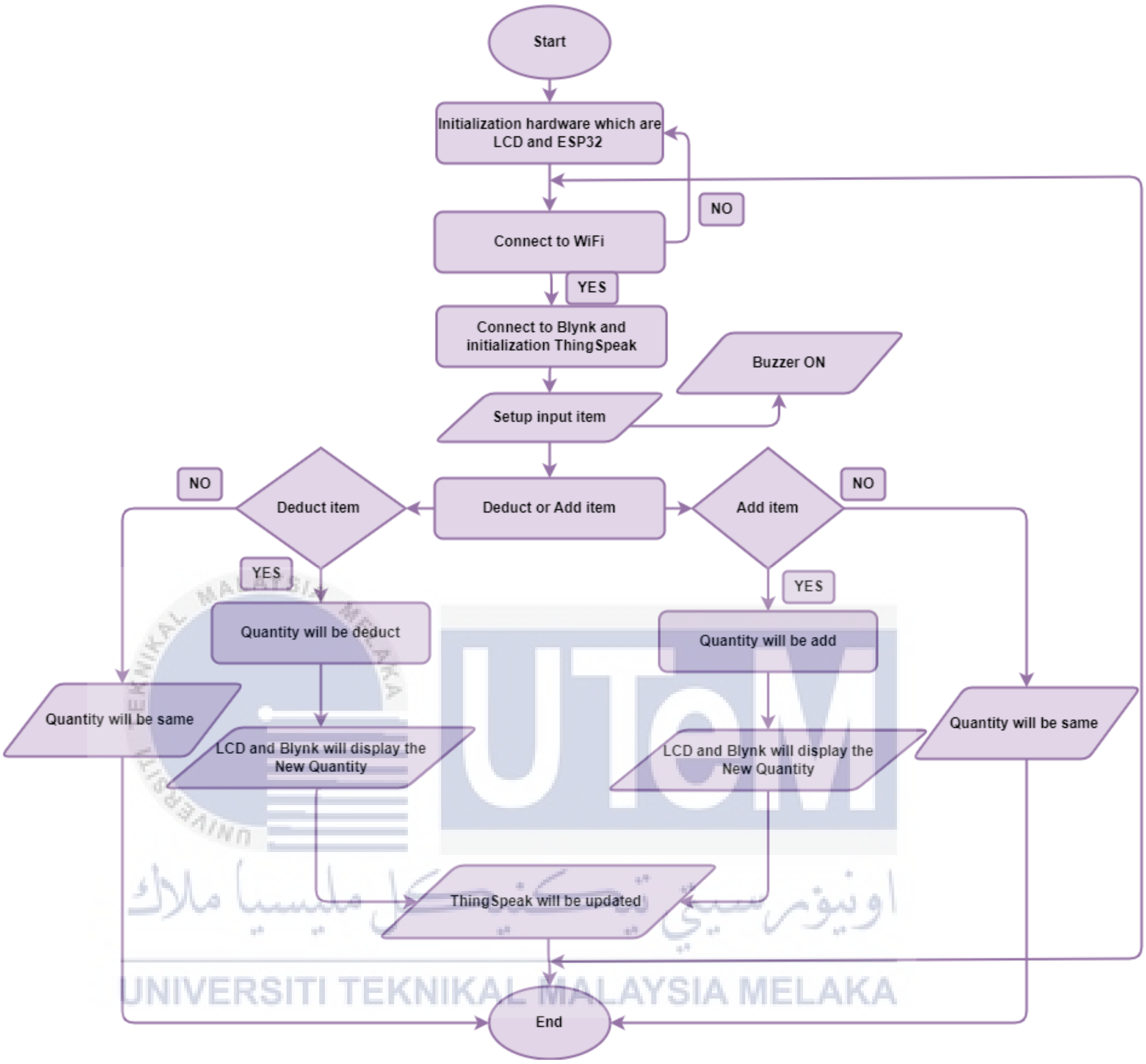


Figure 3.3 Flowchart project

Figure 3.3 shows the system flow chart. It starts by connecting to the LCD and ESP32, which are the startup hardware. After that, the system makes a WiFi connection, connects to Blynk, and begins communicating to ThingSpeak. The Buzzer is then activated when a number of setup settings are configured. When the user chooses to add or deduct, the system chooses the appropriate operation dynamically. The quantity of the chosen item is then updated on the LCD. The quantity shown on the LCD stays the same if no adjustments are thought to be necessary. The current total transactions are recorded in ThingSpeak, as any changes made to the system are automatically reflected there as well. For the purpose of facilitating ongoing operations, this iterative process keeps repeating.

3.4 Software Implementation

This project contains a few software such as Arduino IDE for C program, Blynk, and ThingSpeak. Basically, the components that be used in the hardware part also will be used in the software part. The overview of the softwares that used is shown as below.

3.4.1 Fritzing

Figure 3.4 Fritzing

An open-source hardware project called Fritzing is shown in Figure 3.4. Its goal is to make electronics more useable and accessible to everyone while encouraging a creative culture. The initiative includes a software tool, a community website, and various services that draw inspiration from Processing and Arduino. This fosters a collaborative ecosystem where users can document their prototypes, share them with others, facilitate electronics education in classrooms, and create professional printed circuit boards (PCBs) designs for manufacturing. Because it makes the process of designing and prototyping circuits simpler, Fritzing is particularly well-liked among educators, hobbyists, and newcomers to the field of electronics. It is simple to visualize and experiment with circuit connections with the program, which comes with a variety of parts and modules that can be dragged and dropped onto a virtual breadboard. Additionally, Fritzing provides PCB layout design features, enabling users to design circuit boards for their projects that appear professional. Additionally, Fritzing gives users the opportunity to create documentation, such as schematic diagrams, PCB layouts, and graphics, all of which can be useful for sharing and showcasing electronic projects [20].

3.4.2 Arduino IDE

Figure 3.5 Arduino IDE

The Arduino IDE (Integrated Development Environment), a specialized application tool made specifically for programming Arduino microcontrollers, is shown in Figure 3.5. In a user-friendly setting, developers may write, build, and upload code to Arduino boards. To make coding easier, the IDE includes a code editor with syntax highlighting and simple code completion. A Library Manager is also included, which makes it easier to install and manage libraries by offering pre-written code for different components. Users can choose the suitable board and install the required board support package using the Board Manager.

The IDE's Serial Monitor makes it possible to communicate with the Arduino board via the serial port, which makes it helpful for data sharing and troubleshooting. The development workflow is streamlined by the IDE's handling of compilation and uploading. It provides a wide range of integrated examples and tutorials to aid users in understanding programming principles. A helpful community that offers comprehensive documentation and assistance makes the Arduino IDE possible. The Arduino IDE offers an all-inclusive and user-friendly framework for programming Arduino boards, enabling developers to realise their projects.

3.4.3 Blynk

Figure 3.6 Blynk

An IoT (Internet of Things) platform called Blynk is shown in Figure 3.6. It provides both a local or cloud-based server backend and an intuitive mobile app interface. The creation of linked applications is made easier by this combination. The control interface is provided by the Blynk mobile app, which enables users to design interactive dashboards with custom widgets for managing and controlling Internet of Things (IoT) devices. To connect hardware like Arduino, ESP8266, and Raspberry Pi to the Blynk platform, the Blynk Library provides pre-built code and functionalities.

In order to facilitate communication between the software and hardware, virtual pins serve as replacements for data and actions. Users can build dynamic user interfaces and automate operations depending on conditions or occurrences with a variety of widgets and triggers. Users can distribute energy to various features and widgets using Blynk's energy-based resource management system. Blynk makes IoT development simpler overall by offering a user-friendly platform for building IoT apps with remote control and monitoring features.

3.4.4 ThingSpeak

ThingSpeak

Figure 3.7 ThingSpeak

MathWorks has developed an Internet of Things (IoT) platform called ThingSpeak, which is shown in Figure 3.7. For gathering, processing, and displaying data from different IoT devices and sensors, it offers a reliable solution. It facilitates real-time data collection through various protocols like HTTP and MQTT, storing this information in a cloud-based system to accommodate large datasets. The platform includes built-in analytics tools for data processing, enabling users to derive meaningful insights through statistical analysis and filtering. Users can effortlessly create personalized visualizations using charts and graphs, aiding in the interpretation of data trends. ThingSpeak seamlessly integrates with MATLAB, allowing for advanced data analysis using MATLAB scripts. The platform also supports alerts and notifications based on predefined conditions, which can be communicated through email, SMS, or other channels. With its open API, developers can create custom applications and integrate ThingSpeak with other systems.

Additionally, the platform fosters a community environment, encouraging users to share their projects and data, promoting collaboration and learning. ThingSpeak's versatility makes it suitable for a range of applications, from home automation to industrial monitoring.

3.5 Hardware Development

This project contains a few electronic components that include a microcontroller which is ESP32, a push button, a buzzer, and LCD, and a smartphone for Blynk. These components must be in good condition and ensure the ability of the components to work on the system before being connected with the hardware parts. Basically, the components that be used in the software part also will be used in the hardware part. The overview of the components that used is shown as below.

3.5.1 ESP32

Figure 3.8 ESP32

Figure 3.8 features the ESP32. A microcontroller, also known as an MCU (Microcontroller Unit), is a compact and self-contained computer integrated into a single chip. It is specifically designed to perform dedicated tasks within embedded systems.

Microcontrollers are widely utilized in electronic devices and embedded systems that require real-time control and monitoring.

These programmable devices allow users to define custom functionality and behavior by writing code or firmware. They possess the ability to process data, perform calculations, and establish communication with various sensors, actuators, and external devices. Microcontrollers play a vital role in enabling precise control and automation in a wide range of applications [21].

3.5.2 Push Button

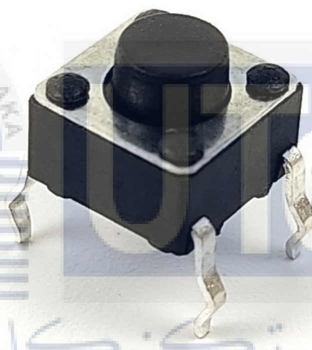


Figure 3.9 Push Button

The push button, a kind of tactile switch that is often in an open state by default, is highlighted in Figure 3.9. They serve the purpose of activating a circuit or establishing a specific connection only when they are physically pressed. In other words, a push button creates a connection within the circuit when it is pressed and breaks that connection when it is released. This functionality allows for momentary control or activation of the circuit. The functionality of a push button depends on the specific requirements of a project. It can serve as an input trigger, initiating actions or events in a circuit or program.

Push buttons can also be used for mode selection, allowing users to cycle through different options or configurations. They can be employed for incrementing or decrementing values, such as in counters or timers. Push buttons are commonly used for menu navigation in user interfaces, allowing users to move through menu options. In microcontroller-based systems, push buttons can generate interrupt signals, triggering immediate actions or handling specific events. When using a push button in a circuit, it is typically connected to a digital input pin and a reference voltage. Debouncing techniques are often implemented to eliminate bouncing or unintended triggering caused by switch contacts. With their versatility and adaptability, push buttons are fundamental components in various electronic projects, enabling user interaction and control [22].

3.5.3 Liquid Crystal Display (LCD)

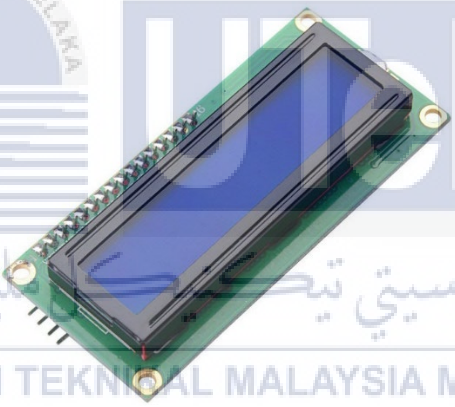


Figure 3.10 Liquid Crystal Display

An LCD, or liquid-crystal display, is seen in Figure 3.10. It is a type of electronic flat-panel display that works by using liquid crystals' ability to modulate light. Unlike other display technologies, liquid crystals themselves do not emit light directly. Instead, they manipulate light passing through them to generate the visual output on the display screen. LCDs operate by regulating the passage of light through the liquid crystal material via electric currents. Their primary objective is to exhibit alphanumeric characters, symbols, graphics, and images in a format that is both clear and easily legible. Moreover, LCDs facilitate user interaction through touch-sensitive panels, allowing for input and providing feedback. With their energy efficiency, customizable features, and widespread adoption, LCDs have become an essential element in modern electronic devices, delivering efficient and adaptable visual information and enhancing user engagement [23].

3.5.4 Buzzer

Figure 3.11 Buzzer

An electrical audio signal is converted into an audible sound by a buzzer, as shown in Figure 3.11. Its primary function is to provide prompts or alarms in various applications. Depending on the specific design and intended use, a buzzer can generate different types of sounds, such as musical tones, flute-like sounds, buzzing tones, alarm sounds, electric bell sounds, and various other types of audible alerts. Buzzers are commonly used to provide audio feedback and alerts in different applications. Buzzer also provides audio feedback to users, indicating successful operations, errors, or task completion.

They are used in timers, reminders, and countdown applications, signaling the completion of specific time intervals. In fault detection systems, buzzer are employed to indicate faults or malfunctions by activating when abnormal conditions are detected. They find applications in games, entertainment systems, and assistive technology devices, providing sound effects, game cues, and auditory assistance for individuals with visual impairments. Buzzer is typically connected to power sources and control signals, such as microcontrollers or digital circuits, to activate and deactivate the sound output. The selection of buzzer types, such as electromagnetic, piezoelectric, or magnetic buzzers, depends on factors like sound level, power consumption, frequency range, and size requirements. Overall, buzzer play a vital role in providing audible alerts, enhancing user experiences, and enabling interactive functionality in a wide range of electronic applications [24].

3.6 Summary

In conclusion, this chapter's methodology offers a thorough overview of the strategy and methods used to accomplish effective inventory control. It illustrates the important elements and technology used while outlining the stages taken throughout the stock management system's installation. The hardware infrastructure, including microcontrollers required for tracking and collecting data on inventory levels, is described in this chapter. It also goes into the IoT platforms and communication protocols used to make data transfer and integration with the inventory management system possible. The chapter also explores software-related topics, such as the programming languages, frameworks, and libraries used to provide functionality for automation, data analytics, and user interfaces. Overall, the methodology chapter provides a comprehensive overview of the strategies and tools utilized in the implementation of the smart stock management system for the laboratory, serving as a guide for the future.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The outcomes and results of Stock Management By Using IoT will be outlined and discussed in this session. Moreover, the implementation and design of the prototype will be illustrated. At the same time, the software configuration using Arduino IDE will be demonstrated as well. The outcome consists of the operation of the stock management system which is how it worked from the beginning until getting the result and to get the desired result. At the same time, the findings from the project will be analyzed. Project results can be viewed through notifications sent to Blynk and will be sent to ThingSpeak displaying the data.

4.2 Development of Stock Management by using IoT for Laboratory

To create fusion device systems that are safe, dependable, and functional, hardware circuit design is an essential component of the development process. In this project, a Blynk device powers a system module that communicates with mobile phones. These systems were supplied by using a power bank. Figure 4.1 shows the hardware system, and Figure 4.2 shows the complete system.

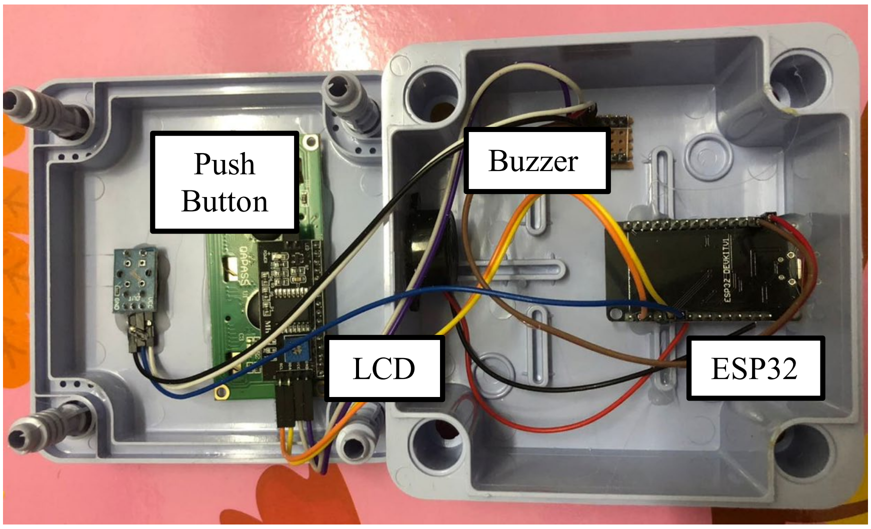


Figure 4.1 Overall system module

An overview of the entire system in this project is given by the figure, which is shown in Figure 4.1. The system consists of an LCD, ESP32, push button, and buzzer. It also combines ThingSpeak for monitoring the current data and uses Blynk for system control.

Figure 4.2 Hardware

About Figure 4.2 shows the hardware of this project. This project is applied in the laboratory area. This project uses a laboratory at the university to demonstrate the application of the project.

4.3 Software Development

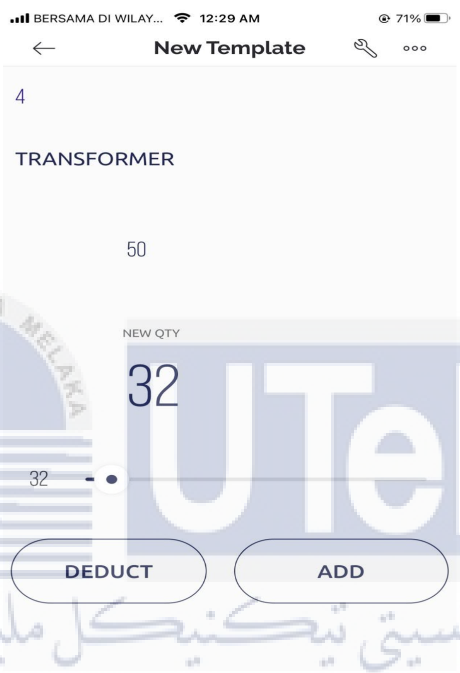


Figure 4.3 Project Dashboard on Mobile Application

Figure 4.3 shows the project dashboard on a Mobile Application using Blynk. Blynk is an application developed to remotely control hardware, show data to store and then visualize it. In this project, Blynk is used to display the value obtained from the input. in addition, Blynk also communicates with what we program in the Arduino IDE. Once Blynk is connected, the values from the input are collected and immediately displayed to the Blynk Application. In addition to displaying the input values currently being used for this project, this dashboard is equipped with three display settings for item number, current quantity and new quantity. The slider is also used to select the quantity that needs to be added or deduct in Blynk. While the button is used for deduct and add selection.

Table 4.1 Widgets use for Blynk Application

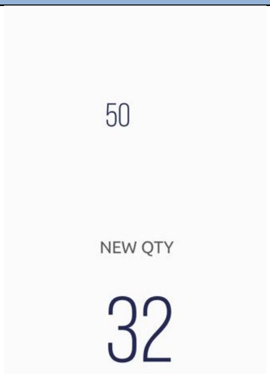
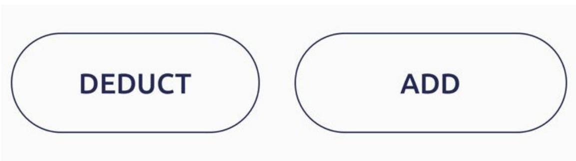
WIDGET	FUNCTION
 1. Current and New Quantity	Display the Current Quantity and New Quantity for user monitor.
 2. Name of component	Display the Name of Component for user monitor.
 3. Slider value	Display the value that need to add or deduct in the Blynk application.
 4. Button Deduct and Add	User can manually press the button to choose either add or deduct the value.

Table 4.1 shows the list of widgets used in developing the software part of this project. Each of the widgets used have their own functions in making this project successfully.

4.4 Project Integration

4.4.1 Connection of NodeMCU ESP32

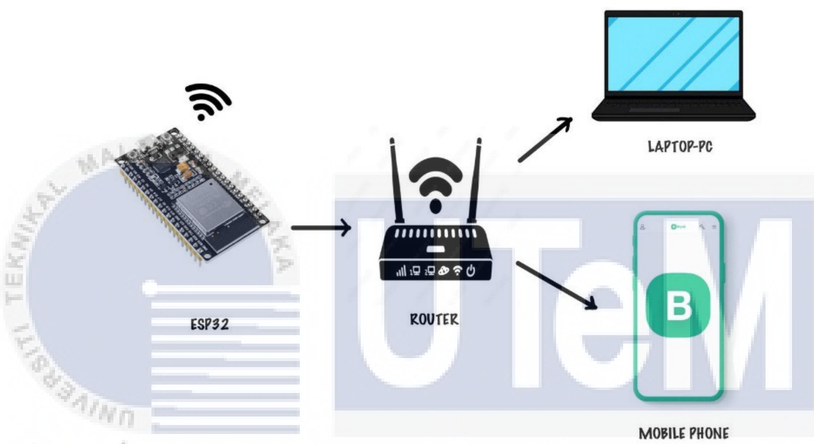


Figure 4.4 Block diagram of Internet connection of ESP32

The Blynk application on the user's mobile device can be accessed through the internet by connecting the NodeMCU ESP32, as illustrated in Figure 4.4. The microcontroller, NodeMCU ESP32, will read all of the data from input and subsequently transmit it to the user across the Internet of Things (IoT).

4.4.2 Login Blynk

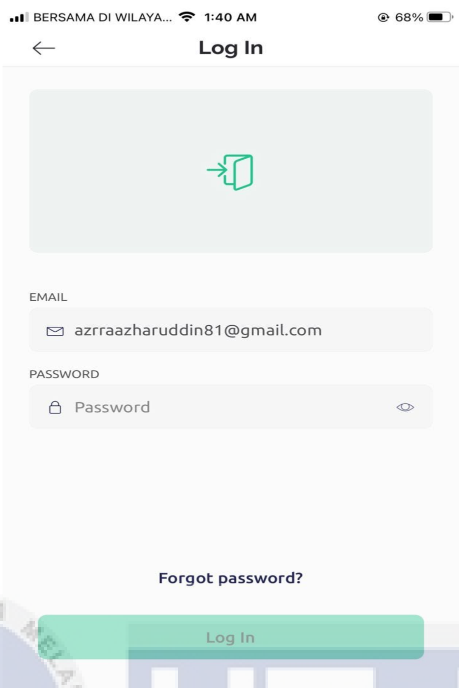


Figure 4.5 Login page on Blynk Application

User will then have to log into their Blynk account with their email and password for security purposes as shown in Figure 4.5. User can get access to their account using multiple devices so they can still monitor their latest quantity of stock even with a different mobile phone.

4.4.3 Add and Deduct Button

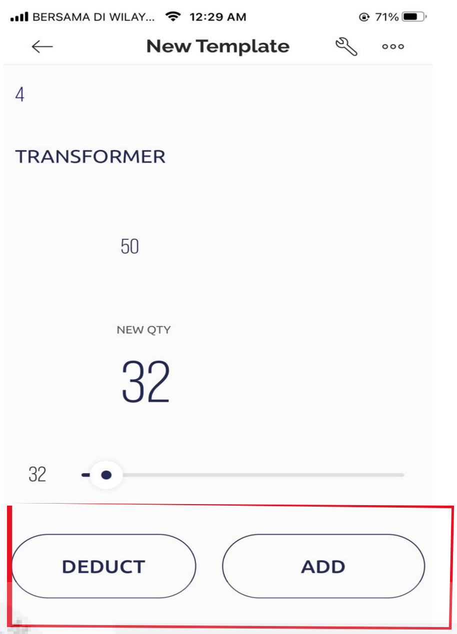


Figure 4.6 Button Add and Deduct

The Blynk Application shows plus and minus buttons in Figure 4.6. The user-selected input can have values added or subtracted using these buttons. Users can also select numerical values via a slider in Figure 4.7, and the Blynk system will process them to perform operations like addition and subtraction. The modified outcome is then displayed on the Blynk application.

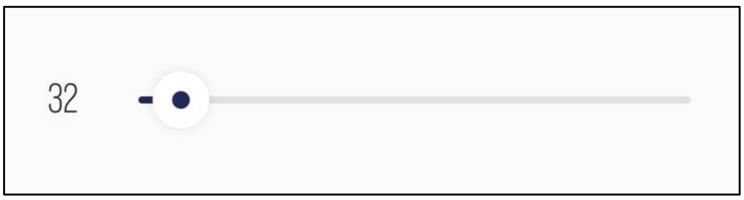


Figure 4.7 Slider widget

4.4.4 LCD Display

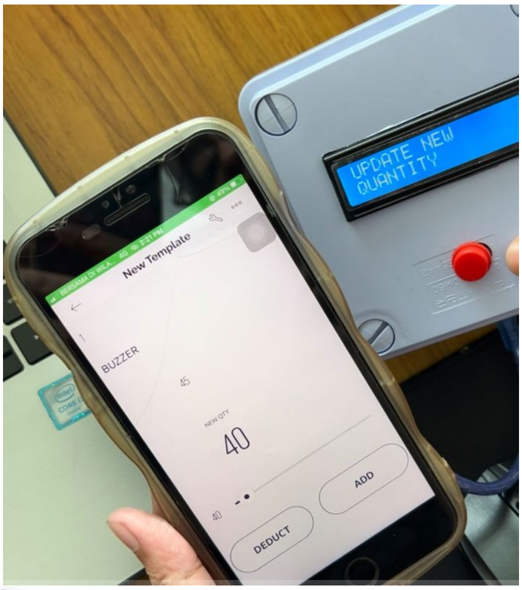


Figure 4.8 LCD Display

The LCD in Figure 4.8 serves two functions in terms of providing stock management-related information. It shows the current stock level at first. Following that, any additions or deduction to the stock are reflected in the revised quantities that are displayed on the LCD screen. Before commencing the process, the LCD will exhibit the most recent stock quantity and showcase the initial label 'STOCK MANAGEMENT.' The LCD screen will also indicate 'wifi connected' and 'success' upon successfully establishing a connection to the wifi network.

4.4.5 ThingSpeak

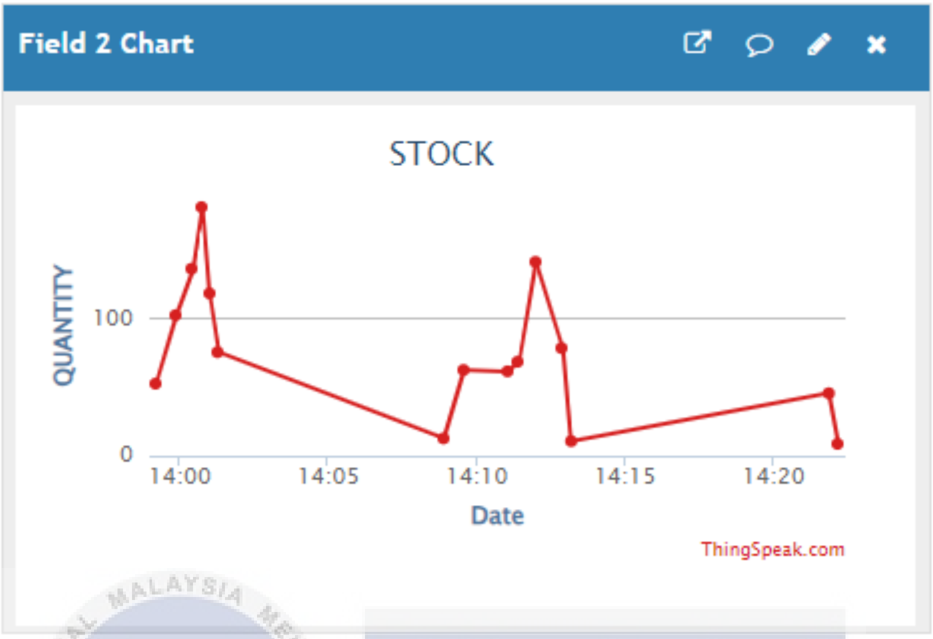


Figure 4.9 Graph in ThingSpeak

ThingSpeak as shown in figure 4.9 shows the chart to display the quantity of stocks for this project. Devices transmit data to channels via the Internet of Things platform ThingSpeak. Based on the data, users can perform analyses, visualizations, and action triggers. It serves as a centralized center for organizing and deciding using data from linked devices. Figure 4.10 shows ThingSpeak has exported the collected data to Microsoft Excel.

	A	B	C	D	
1	created_at	entry_id	field1	field2	la
2	2024-01-05T15:43:35+08:00	1	DC MOTOR	74	
3	2024-01-05T15:44:07+08:00	2	LDR	159	
4	2024-01-05T15:44:40+08:00	3	DIODE	84	
5	2024-01-05T15:45:14+08:00	4	RELAY	39	
6	2024-01-05T15:46:11+08:00	5	RESISTOR 10K	-20	
7	2024-01-05T15:46:30+08:00	6	SWITCH	74	
8	2024-01-05T15:47:27+08:00	7	DC MOTOR	128	
9	2024-01-05T15:48:04+08:00	8	FUSE	100	
10	2024-01-05T15:48:36+08:00	9	BATTERY	147	
11	2024-01-05T15:48:57+08:00	10	RELAY	64	
12	2024-01-05T15:50:54+08:00	11	BUZZER	30	
13	2024-01-06T20:17:02+08:00	12	BUZZER	30	
14	2024-01-06T20:17:28+08:00	13	TRANSFORMER	69	
15	2024-01-06T20:17:43+08:00	14	LDR	23	
16	2024-01-06T20:17:58+08:00	15	BATTERY	93	
17	2024-01-06T20:22:20+08:00	16	BUZZER	48	
18	2024-01-06T20:22:37+08:00	17	SWITCH	90	
19	2024-01-06T20:22:55+08:00	18	DC MOTOR	85	
20	2024-01-06T20:23:16+08:00	19	DIODE	106	
21	2024-01-06T20:23:35+08:00	20	BUZZER	66	
22	2024-01-06T20:23:54+08:00	21	TRANSFORMER	132	

feeds

Figure 4.10 Export data for Microsoft Excel from ThingSpeak

4.4.6 Website LabStockIoT.Com

Figure 4.11 Website for monitor data for other users

Figure 4.11 displays a website created for monitoring stocks. The website provides information and explanations related to the project. Users can conveniently check the latest stock updates on the website, saving them the need to inquire elsewhere or consult with others, thus optimizing time. The displayed stock information is sourced directly from the regularly updated Excel sheet. Additionally, high-ranking users have the privilege to log into ThingSpeak, where they can access graphical representations of the data concerning stock outflows and inventory levels within the laboratory.

4.5 Analysis Data

In the laboratory, a stock management system has been implemented, using IoT technology to improve efficiency. The system has collected real-time data at the inventory level, ensuring accurate monitoring and control. Through the integration of IoT devices, laboratories can automatically track stock levels, providing a seamless and efficient solution for inventory management. The system's predictive analytics capabilities allow labs to forecast demand, facilitating strategic planning and resource allocation. This IoT-driven stock management solution improves data accuracy, reduces manual errors and enables data-driven decision making to optimize stock levels. Continuous monitoring and analysis of stock-related data captured by IoT devices increases operational efficiency, reduces costs and improves overall inventory management in the laboratory.

4.5.1 Data from Stock Management using IoT for Laboratory for one day

The data that has been obtained from Stock Management system has been will be released by day to be analyzed in the form of table to make it easier for users to analyze an item and the amount of items. this can make it easier for users to track the daily use of each item.

Table 4.2 Data for Day 1

DATE	ITEM	QUANTITY
01/01/2024	Buzzer	176
01/01/2024	Resistor 10K	142
01/01/2024	Switch	146
01/01/2024	Transformer	110
01/01/2024	DC Motor	112
01/01/2024	LDR	127
01/01/2024	Fuse	88
01/01/2024	Diode	43
01/01/2024	Battery	121
01/01/2024	Relay	106

In Table 4.2, the data illustrates the stock quantity for a day in the laboratory, using an IoT-based stock management system. The information displays the quantity for each item as of January 1, 2024.

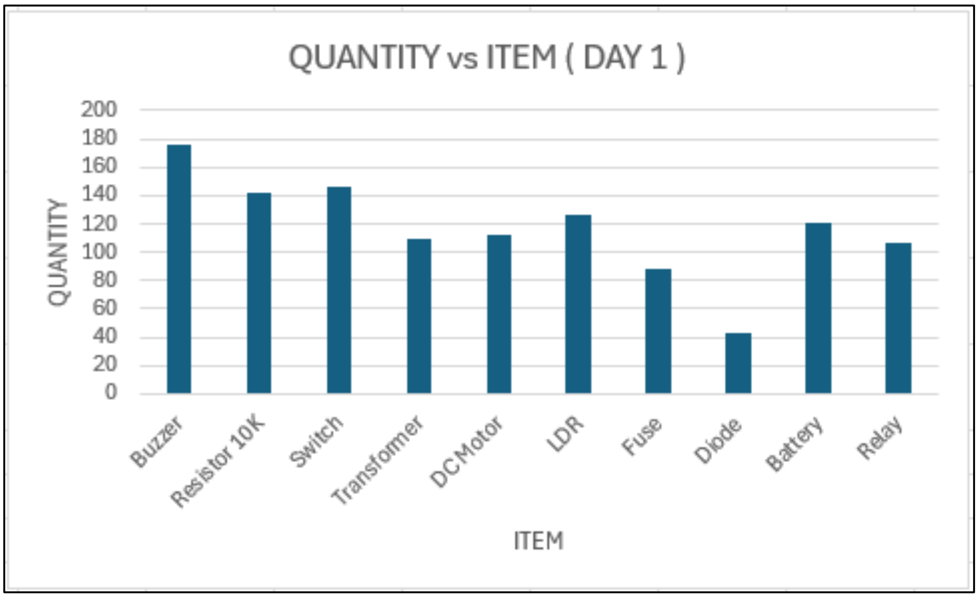


Figure 4.12 Result of Day 1

The results for one day regarding the stock quantity are shown in Figure 4.12, which includes details such as items and quantities. A bar chart showing the current stock level of each item for the day is included in the accompanying graph. These results make it easy for users to track how many items are used in a day for each item.

4.5.2 Data from Stock Management using IoT for Laboratory for seven days

The table has been created by organizing and combining the data collected from the Stock Management system into categories based on Day 1 to Day 7. The data table format makes it easy for users to monitor the weekly consumption trends. This simplifies the monitoring procedure and provides a clear picture of how each item is used daily. Users can effectively track and analyze item usage trends over a set seven-day period with the help of this handy table.

Table 4.3 The total amount of Data for 7 days

ITEM	Sum of QUANTITY
Battery	371
Buzzer	602
DC Motor	277
Diode	349
Fuse	438
LDR	486
Relay	465
Resistor 10K	759
Switch	759
Transformer	357

In Table 4.3, the data illustrates the total of stock quantity for a week in the laboratory, using an IoT-based stock management system. The information displays the items and the total quantity from Day 1 until Day 7.

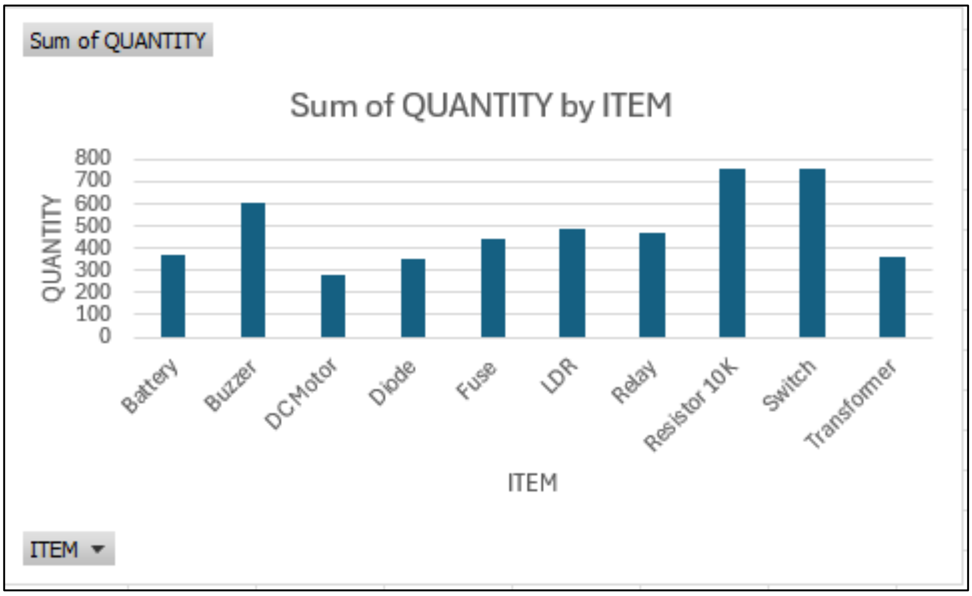


Figure 4.13 The total amount quantity of items in a week

The results for seven days regarding the stock quantity are shown in Figure 4.13, which includes details such as items and quantities. A bar chart showing the total amount of items for the day is included in the accompanying graph. These results make it easy for users to track how many items are used in 7 days. This is particularly beneficial for users as it simplifies the process of monitoring and understanding the usage patterns of items over the seven days. By visually representing the data, users can easily track and analyze the variations in item consumption, facilitating a more informed and efficient approach to managing laboratory stock over the specified timeframe.

4.6 Summary

The chapter on results and discussion in the report on stock management using IoT for a laboratory presents the findings and analysis derived from the implementation of the system. It begins by providing an overview of the collected data, including inventory levels, usage patterns, and stock replenishment activities. The chapter discusses the effectiveness of the IoT-enabled stock management system in improving inventory control and reducing manual intervention. The report discusses the integration of real-time data into the inventory management system, enabling proactive decision-making and enhanced forecasting capabilities. It also addresses any challenges or limitations encountered during the implementation, such as connectivity issues or data synchronization delays. The findings are compared and discussed in relation to the objectives and expectations outlined in the earlier chapters, providing insights into the system's performance, benefits, and potential areas for improvement.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In summary, the development of smart stock management systems using IoT technology presents significant opportunities for laboratory environments. The implementation of an IoT-based stock management system has yielded positive outcomes in terms of inventory accuracy, stock visibility, and operational efficiency within laboratory settings. By leveraging IoT technology, laboratories can automate stock monitoring, facilitate instantaneous data collection, and streamline stock replenishment procedures. The research findings emphasize the importance of ensuring data security, maintaining device functionality, and integrating the system with existing laboratory infrastructure. It is recommended that laboratories consider adopting IoT-based stock management systems while taking into account their specific operational needs and requirements. Embracing IoT technology will enable laboratories to enhance stock management practices, optimize resource utilization, and ultimately enhance overall productivity and efficiency in laboratory processes.

5.2 Potential for Commercialization

A Stock Management System Using IoT For The Laboratory has significant potential for commercialization. It offers benefits such as improved efficiency, cost savings, and better decision-making. By using IoT technology, the system provides real-time inventory monitoring, automated stock replenishment, and accurate data. It can be easily scaled and adapted to different laboratory sizes and needs. Integration with existing infrastructure is seamless, and it gives laboratories a competitive advantage in the market. The demand for efficient inventory control solutions in laboratories creates a favorable environment for commercial success.

5.3 Future Works

Future works or improvements of Stock Management by Using IoT For The Laboratory could be enhanced such as:

i) Incorporate a 'Text Input' feature in Blynk to facilitate the quick and convenient addition of a 'New Item' or the ability to search for a component by name.

ii) Utilize Google Sheets to keep tabs on both outgoing and incoming inventory movements.

iii) Leverage Google Sheets for seamless integration into Google Sites, enabling others to easily access the website and monitor stock movements, as well as stay informed about the current stock quantities.

iv) Employ IoT and RFID sensors for real-time inventory tracking, where each item is equipped with a unique identifier, ensuring automatic updates to stock levels.

v) Enforce robust security measures and access controls to safeguard data, ensuring that system access is restricted to authorized personnel only.

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APPENDICES

Appendix A Gantt Chart PSM 1

ACTIVITY	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Confirmation project's title														
Introduction (Chapter 1)														
Project progress														
Update Logbook														
Research journals (Literature review)	PSM Briefing and The Registration					Mid Term Break								
Methodology (Chapter 3)														
Survey components and price														
Preliminary result analysis														
Full report progress														
Presentation PSM 1														

Appendix B Gantt Chart PSM 2

ACTIVITY	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Details calculation and theory concept														
Project design finalization														
Hardware and sensor finalization														
Assemble hardware part														
Collecting the data														
Final documentation and report writing														
PSM 2 draft submission														
Preparation and Presentation														
Submission of final report														