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Original Article

Design and Implementation of Hybrid Scrolling Message LED Display with Bluetooth Controlled App using Arduino Nano

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Abstract *- Digital display advertisements and noticeboards are essential in the modern, information-driven world. The hybrid message Light Emitting Diode (LED) display is a type of modern display system that presents programmed information and offers a creative solution for real-time information display and engaging graphic designs. This project extends beyond advertising, serving general purposes such as functioning as a real-time clock, date, and message display for both indoor and outdoor project seminars/presentations. The system utilized a Bluetooth mobile app that allows users to send messages to the LED display board wirelessly. Massachusetts Institute of Technology (MIT) App Inventor software was utilized to create the mobile app, and the DS3231 Real Time Clock (RTC) was used to send real-time data to the display. This setup provides a customizable real-time matrix display, enabling users to change the displayed message conveniently. A phone application was developed to control the display, creating a wireless, convenient message board that allows for easy content updates without physical connections. This solution addresses issues with existing systems that display static content. The wireless LED Dot Matrix display successfully operated with minimal errors and maintenance.*

Keywords *- Scrolling, Message, Display, Bluetooth, Arduino-Nano.*

1. Introduction

It has become a challenge that information on paper notice boards cannot be displayed clearly at night for the reader's comprehension without shining light on it, and since paper notices require regular paste for new adverts, as such it is imperative to improve the display method through digital electronic means with the capacity to checkmate these challenges [1]. The digital revolution, driven by advances in solid-state technology, has transformed electronics. Digital electronics involve designing and using circuits to process information in digital form [2]. This shift has also impacted outdoor advertising, moving away from paper-based methods to electronic displays that are more dynamic and less wasteful [3]. Modern information dissemination through electronic digital display systems can replace the traditional methods of giving information to the public, such as signposts and notice boards [4], since information through signposts or paper notice boards is only limited for comprehension in the time and cannot be accessed during the night, as such the introduction of digital electronic display device which information can be clearly read during both day and night [4]. Today, visual information is ubiquitous, and LED matrix displays are among the most common sights in public spaces such as streets, malls, buildings, and parks. These displays have gained popularity due to their cost-effectiveness and reliability compared to traditional means that constantly require changing due to wear and tear and so many factors that affect the durability of an advert [5]. It offers an efficient and cost-effective way to reach a broad audience without direct personal contact [5]. LED Matrix Displays play a crucial role in advertising, communication, presentations, exhibitions, and navigation across various fields. In response to the growing popularity, we have developed a small, home-based, Bluetooth-controlled LED Matrix display for domestic and entertainment purposes [6]. Information displays serve as tools for communication and promotion, traditionally seen in physical forms like cardboard or tarpaulin. However, the advent of electronic displays has revolutionized advertising and promotional activities [7]. LED display boards are particularly effective for displaying messages, making them suitable for both indoor and outdoor usage [8, 9].

1.1. 7 Segment Display

Numerous numeral systems exist, each with its own base for representing numbers. The decimal system, which has a base of 10 and uses the numbers 0 through 9, is what we use

in daily life [10, 11]. However, the binary system with a base of two is used in digital electronics, where the digits 0 and 1 are represented by only two states: Low and High. Based on the term "binary digit," each digit in a binary number is referred to as a "bit" [12].

Prior to the development of Dot-Matrix Displays, a 7-segment LED Display was a common electronic device used to show decimals. This kind of display has seven separate segments that can be illuminated in various ways to create characters with numbers [13, 14]. Table 1 shows how the outputs of the decoder relate to the decimal numbers 0 through 9. A diagram illustrating a display module that combines a 7-Segment LED display and a 7-Segment decoder is also included in Figure 2.

Table 1. 7 Segment decoder truth table

Decoder Outputs							7- Segment Display Output
a	b	c	d	e	f	g	
1	1	1	1	1	1	0	0
0	1	1	0	0	0	0	1
1	1	0	1	1	0	1	2
1	1	1	1	0	0	1	3
0	1	1	0	0	1	1	4
1	0	1	1	0	1	1	5
1	0	1	1	1	1	1	6
1	1	1	0	0	0	0	7
1	1	1	1	1	1	1	8
1	1	1	1	0	1	1	9

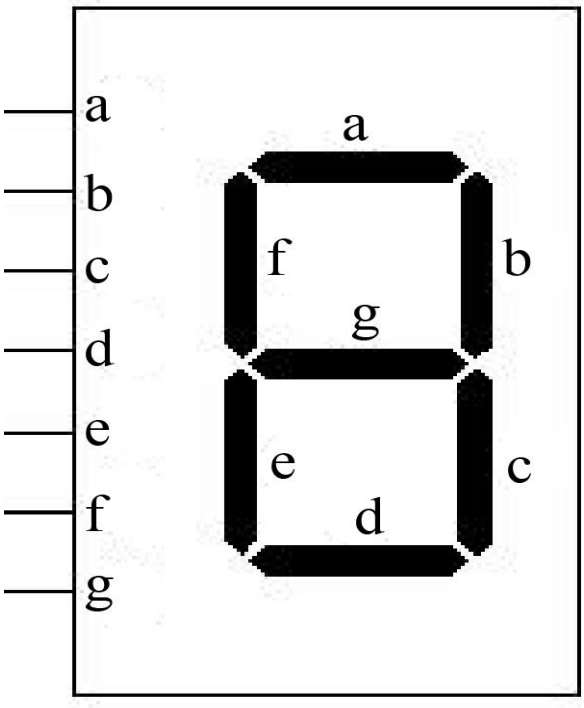

Fig. 1 7 Segment LED display

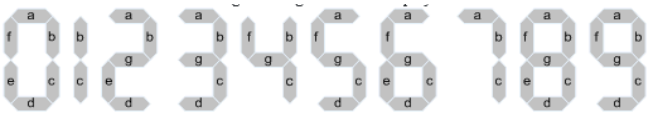

Fig. 2 7-Segment display elements for all numbers

So many researchers have carried out work on this area, some of which are [15], which suggested a design for a Moving Message Crawler Display System that is controlled by a PIC16F876A microcontroller and makes use of a PS2 keyboard for input and serial communication. The keyboard is used as the input device in this system, and user-entered data can be transmitted to the microcontroller for processing in accordance with programmed instructions.

The message was then shown on the display after the processed data had been sent to it via drivers and counters. Due to the wired communication required by this design, the message must be manually typed on the keyboard. However, by enabling wireless input, integrating a Bluetooth module with the microcontroller could remove this restriction. Furthermore, assembly language, which is not very user-friendly, was used to program the system, which limits its accessibility for developers and regular users.

Also, [16] designed and constructed a solar-powered LED matrix display that can be updated wirelessly via Bluetooth board using local materials. The system consists of a display unit: 3 sets of P10 modules were used in one consisting of a 16 x 32 LED linearly connected to form the display unit. An Arduino Nano microcontroller was used to control and manage the whole process with its inbuiltAtmega16uP chip (HC-06). Bluetooth module was used to interface the Android mobile app with the system. When the device is on, it shows a default text: "Welcome to the physics department, Federal University of Technology Owerri. This continues to scroll through with the aid of the embedded shift register until it is being updated remotely with a range of 10m.

The recently updated text starts to display as the defaults disappear temporarily. The complete work was designed and analyzed graphically by determining the charging rate and discharging rate as the solar panel sends 6V 6watt at 1A to charge the 12000mAH internal Li-ion battery, which supplies 5V to the system with the aid of a boost converter at 2.6A. The connection and testing were ascertained to have a long display time when fully charged for 3 hours working satisfactorily. Again, [17] developed an LED dot matrix display using two AT89C52 microcontrollers from Atmel.

The fundamental element that makes wireless control and display notices possible is the microcontroller. Messages were presented by the system using a 7x96 LED matrix display mounted on a Vero board. A GSM module at the recipient's end received text messages sent from a mobile phone over a Global System for Mobile Communication network. An MAX

32 IC connects this module to an AT89C52 microcontroller. The EEPROM component received the messages, which were then shown on the LED matrix panel. Using an LM7805 voltage regulator, the system runs on a regulated 5V, 500mA power supply.

The AC output from a 230/12V step-down transformer can be converted to DC voltage using a bridge-type full-wave rectifier. The system met the design specifications and operated as anticipated during testing. However, none of which had carried any construction work on scrolling message display utilizing RTC for noticeboard, time, and date, involving seminar/presentation purposes; as such, the research on this area serves as an improvement to the already existing literatures.

2. Materials and Methods

The materials used during the design and construction of the project are listed and defined in Table 2.

Table 2. Basic components and software

S/N	Component/Software
1	Arduino Nano
2	Bluetooth Module
3	Buck Converter
4	LED dot Matrix with Max7219
5	2S BMS Module
6	DS3231 RTC Module
7	INR18650-25R Battery
8	12V DC Transformer
9	Connector Wires
10	Android Phone
11	Proteus 8 Professional Software
12	Arduino IDE Software
13	MIT App Inventor Software

2.1. Arduino Nano

This component is a microcontroller that serves as a brain box of the construction. It receives the code, processes and executes it based on the instruction in the codes.

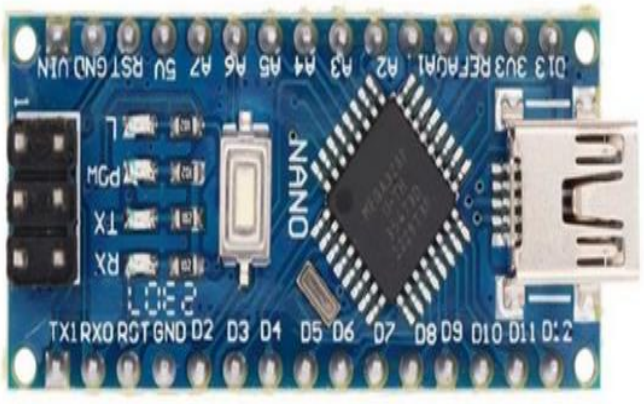

Fig. 3 Arduino nano

2.2. Bluetooth Module

This was utilized for wireless communication between the constructed device and the mobile app.

Fig. 4 HC-06 bluetooth

2.3. Buck Converter

This component was utilized to reduce the voltage level from 230V to about 5V. This was carried out because the brain box Arduino Nano only accepts a maximum of 5V.

Fig. 5 Buck converter

2.4. LED dot Matrix with Max7219

Light Emitting Diode (LED) is a small bulb made with semiconductor materials and can display light when current passes through the terminals. Several LEDs are arranged and connected to form a matrix. Each dot matrix is equivalent to an 8x8 matrix, and different of these dot matrices can be connected to form a display panel.

Fig. 6 LED dot matrix

2.5. 2S BMS Module

The Battery Management System (BMS) component manages and protects the battery connected in series. It enables two of the cells to be charged equally and prevent overcharging or undercharging of the battery.

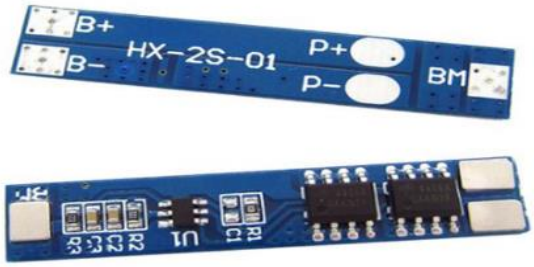

Fig. 7 BMS

2.6. DS3231 RTC Module

RTC means real time clock, and it was used to provide an accurate automatic time, day, and date.

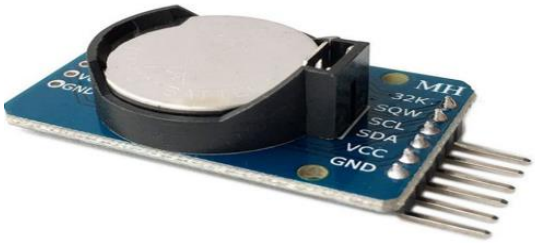

Fig. 8 DS3231 RTC

2.7. INR18650-25R Battery

It is a rechargeable call used as a voltage to supply voltage to the device.

Fig. 9 Battery

2.8. 12V DC Transformer

This is a charger utilized to charge the battery in the constructed device and operates based on direct current by rectifying 230V alternating current to 12V. It was also utilized by setting or regulating output voltage through the bulk converter to 5V.

Fig. 10 12v dc transformer

2.9. Connector Wires

This is an electrical wire used to run connections between components or modules. The pins at both ends can either be male-to-male, male-to-female, or female-to-female connectors.

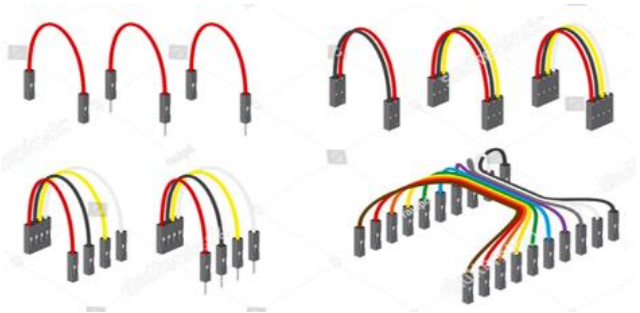

Fig. 11 Connector wires

2.10. Proteus 8 Professional Software

This is software used to design the electronic circuit of the constructed device. The software has advanced tools that can create modern circuits and simulate the design within the environment.

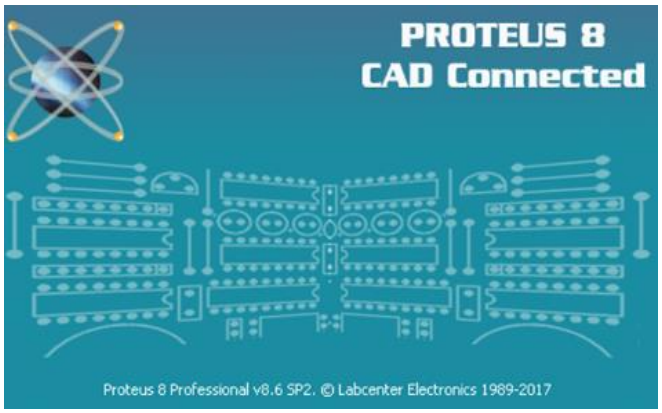

Fig. 12 Proteus

2.11. Arduino IDE Software

This is an Arduino Integrated Development Environment (IDE) with advanced tools to write, compile, and upload code to the constructed device through Arduino Nano.

2.12. MIT App Inventor Software

MIT app is software used to design a mobile app so that information sent from it can be displayed on the constructed device through wireless communication. Arduino Nano was utilized to run the code, and 9 dot matrix modules were also used to display the scrolling message. The library used for the system can only accept the maximum limit of 9 dot matrices modules; as such, it did not work when more than 9 dot matrix LED modules were utilized. Wireless data reception was made possible by an HC06 Bluetooth module, and precise timekeeping was provided by an integrated DS3231 real-time clock.

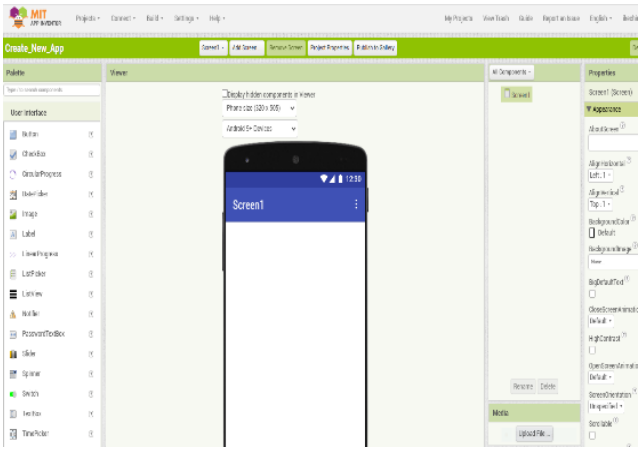

Fig. 13 MIT interface

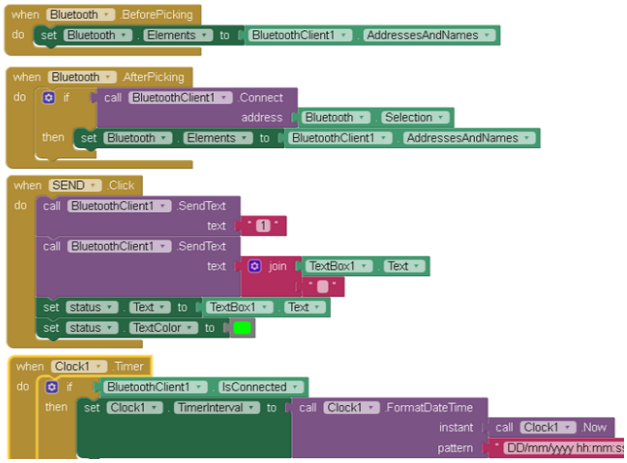

Fig. 14 Block code

Two 18650 batteries were connected to a 2S Battery Management System (BMS) module for power management in order to control voltage and guarantee effective charging. The casing made of plywood was also designed to cover the whole construction. The system was divided into two sections: the reception/display section and the message transmission section, which can be controlled by an Android phone. To send text messages to an LED matrix board, an Android phone application was created using the MIT App Inventor. MIT interface has two main sections: the mobile section, which created the mobile application interface, and the block section. In the mobile section, the buttons and the tools relating to the mobile interface were placed accordingly whereas in the coding section, block codes were interlock for execution, as shown in Figure 14. The Arduino development board was linked to an LED display through a Bluetooth receiver at the receiving end. By using a Bluetooth HC-05 module, the application communicates with the Arduino by sending data. Information about the noticeboard, date, and time are shown in the matrix. After launching the Arduino LED Matrix application, choosing the Bluetooth device that was linked to the LED matrix, entering the necessary data, and clicking the "Send" button, the user can update the text on the LED matrix display board. The program manages the Bluetooth transmission while automatically entering the data entered by the user into its database. The data is sent from the application to the Arduino, which then gets it ready for the LED matrix panel display. The schematic circuit diagram has few connections, as shown in Figure 15.

Before constructing and soldering the components, the circuit was first made on a breadboard and tested to see if it worked. After confirming that it worked effectively on a breadboard, proper construction was then carried out. To charge the batteries, the input voltage entering the BMS board was regulated to give exactly 8.4V using a big bulk converter. Started by setting up a buck converter to output 8.4V and connecting it to the 12V DC transformer jack. The circuits can then be isolated as needed by integrating a sliding switch. Two batteries were connected in series with the BMS module. A second small buck converter was also connected and regulated to an output of 5V after connecting an on/off switch to the BMS module's output. The Arduino Nano and additional modules were then powered by this 5V supply. Despite having a built-in voltage regulator, the Arduino Nano is not powerful enough for this configuration. After which the RTC module was then connected to the Arduino Nano. The Bluetooth module uses the RX and TX pins. So, the code was uploaded to the Arduino Nano before the RX and TX pins were connected to Arduino; otherwise, the code would not upload; as such, nothing was connected to the TX and RX pins when uploading the code.

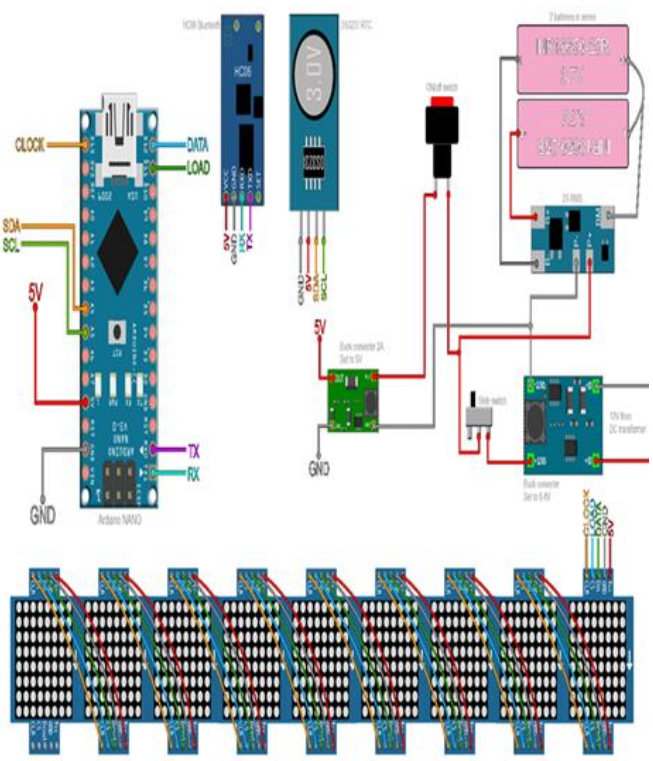

Fig. 15 Schematic circuit diagram

All the dot matrix LED modules were then connected in series. Then hole was opened in the front part of the plywood, and all matrices were placed in the hole and firmly glued to fix them in place. Now, everything was connected together and added inside the plywood case firmly attached to the case with glue. The developed app was downloaded, and the apk file was copied to the Android smartphone as well as the app installed. An unidentified app was then enabled to be installed on the phone, and the device's Bluetooth turned on for connections. From the list, the HC06 module was picked as well as paired with the default password, which could either be "1234" or "0000" Once paired, the preferred mode or send a text were selected by opening th'e app.

3. Results and Discussion

The constructed work offered a real-time matrix display that can be easily customized, allowing users to alter the message that is displayed. Figure 16 shows the internal view of the constructed work, showing all the components utilized for the achievement, whereas Figure 16 shows the external view of the constructed displaying the sent message from the phone app.

The developed phone application, as shown in Figure 18, can be operated through the screen, resulting in a wireless, practical message board that makes it simple to update content without requiring physical connections. This fixes the problems experienced with current systems that show static content. Due to Bluetooth technology, which makes it simple to customize text, including time and date, the wireless LED dot matrix display functions successfully with few errors and maintenance.

Fig. 16 Interior circuit connection

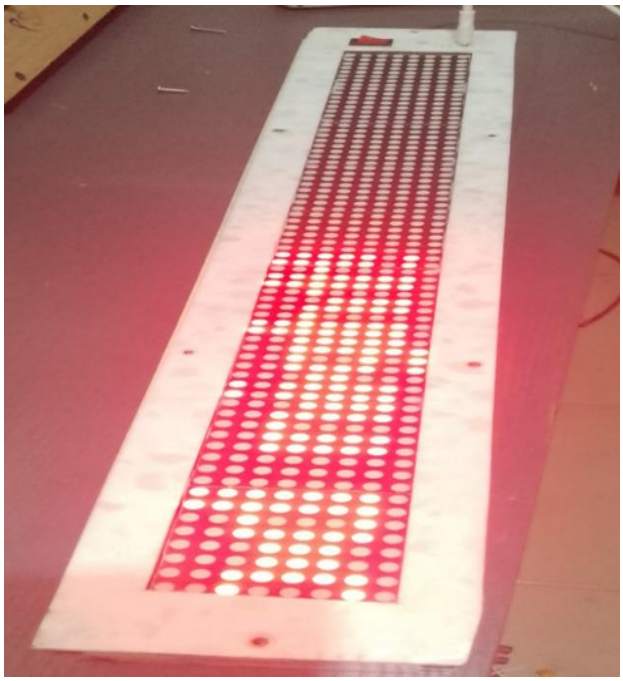

Fig. 17 Scrolling message LED display

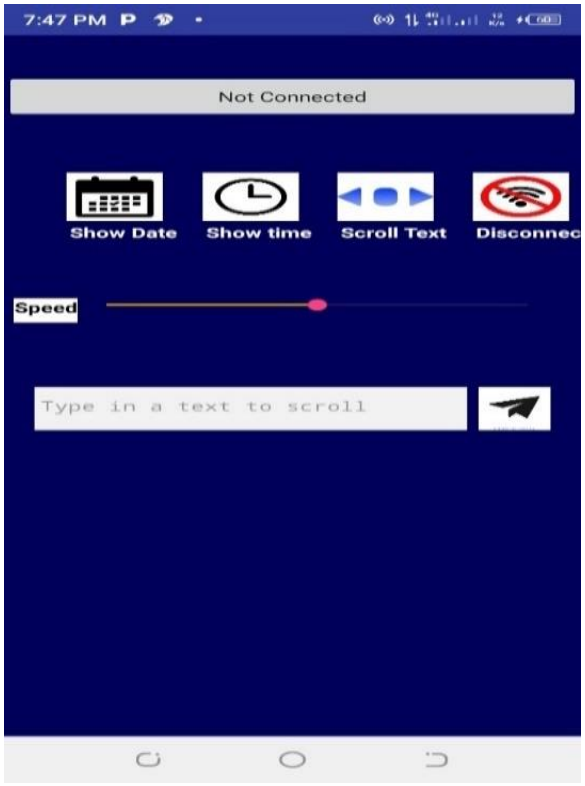

Fig. 18 Designed android app

4. Conclusion

In today's data-driven world, digital notice boards and display advertisements are essential. One cutting-edge example is the LED matrix display, which provides a dynamic platform for real-time information updates and visually

appealing designs while showcasing programmed content. Beyond just being an advertising tool, this system can be used to showcase time, date, and notice board for both indoor and outdoor events, such as seminars or project presentations. An Arduino Nano module can be linked to a Bluetooth-enabled application in the setup, allowing users to wirelessly send data to the LED display. Android app was created with MIT app inventor software, and precise real-time data display can be guaranteed by the DS3231 RTC module.

This setup enables a real-time display that is completely customizable, removing the need for physical connections and enabling users to easily edit messages through a mobile app. This solution allows dynamic content to be updated seamlessly, effectively overcoming the drawbacks of static displays. With Bluetooth technology, the wireless LED dot matrix display runs consistently and requires little upkeep.

Its customizable features, which include notice board functionality, time, and date, make it a flexible and easy-to-use messaging tool. For future work, it can be recommended that more LED dot matrices should be utilized so that information can be transmitted in a broader perception with an advance installed library to accommodate more than 9 LED dot matrices since the installed library for this work could not run more than 9 LED dot matrix.

Acknowledgements

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