Automated Real Time Light Emitting Diode (LED) Display Board for the University of Jos, Nigeria

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Abstract: **LED dot matrix displays Systems are cost-effective method and convenient way to display message. An electronic cascaded RGB 32*32 LED dot matrix display board for the display of Computer Science departmental and examination time table was developed. The LED dot matrix display board enables features with user interactions which enable users to select the day of the week to view its periods which are displayed as static messages, courses which are displayed as scrolling messages and a timer is use to set the color of the current day of the week, ongoing lectures, and venues to green. This system will help in proper and accurate information dissemination in the department and help in solving the problem of student missing lectures and examination.**

Keywords: **Matrix, Semiconductor, LED, Computer Hardware, Micro programming**

I. INTRODUCTION

Light Emitting Diodes (LED) have been around us for over 30 years, this simple semiconductor junction emits continuous light when the current pass through the junction at low voltage, and has proved useful for saving energy. It has a fairly wide angle vision, and can be arranged in matrices to display text, numbers, and even images (Mateur, Elgouri, Dahou, & Hlou, 2014). LED dot – matrix display has been widely used in advertisement, traffic light and in many display applications because of its brightness to be compared to LCD, low cost and low power consumption. It has a common size of 5*7 (Darshil, & Vishal, 2013). Different patterns like scrolling message, fixed message can be generated in dot-matrix and the display can be in different languages.

Htet, Chaw, & Hla, (2013) stated that LED display is a way of visual information where large LCD and other display become too expensive, the displays are commonly seen in single colored or having two or three colors and is popular for displaying information because it allows both static and animated images. According to Mateur, et al, (2014), LED like other semiconductor has a PN junction and a directly DC voltage need to be applied to emitting light photons, in principle, the change of the intensity of current pass through the junction results in a variation of the brightness of LED, It is relatively simple to drive more LEDs individually. However, as the number of LEDs increases, the amount of resources needed to operate these LEDs are growing at an unsustainable level. As such, LEDs are often organized in matrices to make effective use of resources.

II. LITERATURE REVIEW

LED display board is a cost-effective solution for displaying messages with different changing effects, the provide long life, low cost, efficiency, brightness, full range of colors .Because of these properties, they are widely used for simple displays in electronic devices and can be found in shopping malls, theaters, restaurants, public transportation, traffic signs, highways signs, banks, pharmacies, churches and schools. These boards can be large LED panels or LED dot matrix displays which could be in mono, bi, and multicolor (Gowrishankar, Mritha, & Chandra, 2014), can display static and dynamic messages. Joy et al (2014) stated that "LEDs are more energy efficient than the incandescent bulbs, halogen bulbs and even compact fluorescent light bulbs" this shows that many number of applications using them will increase further in near future. The automated Real-time LED Display board is aimed at the department of computer science university of Jos for displaying academic announcement such as lecture attendance(semester timetable), and exams timetable continuously during working hours. This research is based on a message display system using two cascaded 32*32 dot-matrix LED which displays the departmental semester timetable and incorporates the following features: user interaction by enabling users to change from one view to another of the display by selecting which day of the week to view its periods, courses and venues using a 4*5 matrix keypad, Arduino microcontroller for generating the output signal to the dot-matrix LED to display the output using C programming language, Ethernet shield which is for web-based configuration of the LED dot matrix display board and saving the periods, courses and venues on the onboard SD card of the Ethernet shield , and it will be implemented using C programing language to drive the Arduino microcontroller to scan through the individual row of the LED with the needed data to produce the desired message and Setting the color of the current day to green using a real time clock timer.

2.1. Review of related existing system

Bakare et al., (2015) implemented a Light Emitting Diodes (LEDs) dot matrix moving message display system which shows a text containing 23 characters (i.e., GREAT DEPT. OF ELECT. ENGRG) which was achieved using a PIC16F648A Microcontroller, The microcontroller was programmed using Assembly language, with MPLAB software and a PIC Programmer .The LEDs are controlled by

signals from the microcontroller and decade counters in a sequential manner which results in the moving message. A 49*8 dot matrix display made up of 392 low power Light Emitting Diodes (LEDs) was used. The connection was done in such a way that the cathodes of all the LEDs on a particular column are connected together while the anodes of all the LEDs on a particular row are also connected together. This gives each row and column a separate line and allows the LEDs on each of these rows or columns to be powered by the same line. A limiting resistor for the eight (8) output lines of the microcontroller to the LEDs on the dot matrix was used; a dynamic display scheme which helped to improve the brightness of the display and also save energy consumed by the hardware was also employed.

Gowrishankar et al., (2014) proposes an idea to develop a sign board in which the messages are continuously running, where it empowers the user to change the messages using SMS instantaneously and also desk bound device such as PC or laptop. Has a dual system in terms of changing message display and uses dual power supply such as solar power and Alternative Current (AC) power which creates the ability to work at any situation. The new design includes a motion detector which switches off the system automatically after working hours and will switch on automatically if any motion is sensed by the motion detector after the programmed working hours.

Adamu et al., (2014) developed a research work with two AT89C52 microcontrollers from Atmel. The microcontrollers provided all the functionality of the display notices and wireless control. The Display was obtained on a 7X96 Light Emitting Diode (LED) dot matrix display, arranged on a Vero board. A desired text message from a mobile phone is sent via a Global System for Mobile Communication (GSM) to the GSM module located at the receiving end. The GSM modem is connected, through MAX 232 Integrated Circuit (MAX 32 IC), to the AT89C52 microcontroller. The message that was stored in the Electrically Erasable Programmable Read

Only Memory (EEPROM) was then displayed on the LED dot matrix display. This hardware uses regulated 5V, 500mA power supply. A three-terminal LM7805 was employed for regulation of the voltage. A bridge type full-wave rectifier was used to rectify the AC output of the secondary 230/12V step down transformer. The system was tested to work according to specification.

Bhawna et al., (2014) explained the development of GSM based Smart LED Display Boards Using Short Message Service (SMS) which can replace the currently used programmable electronic. The proposed GSM-based display system can be used in public places like schools, hospitals, railway stations, gardens. The SMS based display board incorporates the widely used GSM to facilitate the communication of displaying message on display board via user's mobile phone from any part of the world. The project was built around AT89S51 microcontroller from Atmel which provides all the functionality of the display a wireless control. The LED display system mainly consists of a GSM receiver and a display toolkit which can be programmed from an authorized mobile phone. It receives the SMS, validates the sending Mobile Identification Number (MIN) and displays the desired information after necessary code conversion and the display was simulated using Proteus software.

Prachee et al., (2013) describes a GSM based LED display, which uses a GSM modem which was connected to the LED display hardware to receive the SMS and send it to the AT89C51 controller circuit of the LED display. Then the controller circuit of the LED display filters the message content in SMS and changes the display text in LED display. This paper present a reduction in the total cost that is required in the traditional LED display boards and also makes it easier to send message to the LED. The AT89C51 microcontroller was used to drive the LED display board with a buzzer connected to it to produce sound on arrival of an SMS.

Jagan et al., (2013) proposed a wireless electronic display board which is synchronized using the GSM technology. The areas of application of this proposed technology is public places, malls or big buildings to enhance the security system and also make awareness of the emergency situations and avoid many dangers. Various AT commands were used to display the message onto the display board. GSM technology was used to control the display board and for conveying the information through a message sent from authenticated user.

Rahul et al., (2013) presents a combination of wireless technology with LED Display Boards formalized by designing and integrating the hardware and software with AT89S52 microcontroller, GSM module, LCD, moving LED display. The proposed design overcame the difficulties faced by previous moving text message display modules using wired entry via computer, keyboard or remote control entry (small distance). The message was sent through a cell-phone which is accepted by the GSM module SIM 300 (master). Number authentication is done by AT89S52 microcontroller and the stored numbers in EEPROM is compared with the incoming number. The message validation is done only after the incoming cell phone number is validated. Authentication result is displayed on LCD whether the number is matched or not matched and the message is finally displayed on moving LED (Light emitting diode) display.

Obiechine et al., (2013) designed a working Dot Matrix Information Display with the following components 8051 processor, AT89C52 microcontroller, LM 7805 regulator, light emitted diode (LED), latch 74374 IC. The project was carefully designed such that the Dot Matrix Information Display operates with electrical power from any source-alternate or direct current. The Program use was Assembly language and it was burned into the EPROM (Erasable

Programmable Read Only Memory). The display has a feature of multiple color makes it unique from other single color display. It was thereafter installed at the vice chancellor's office free from mechanical shock and vibration.

Fahmy et al., (2010) designed a textual display system with a moving message display panel which displays a text containing 22 characters (i.e., PHOTOVOLTAIC DEPARTMENT), based on a light emitting diode (LED) dot matrix array powered by solar energy. The research involves taking the device from an initial concept, through a design phase, to constructing a prototype of the product. The system consists of the display unit, which is powered from a photovoltaic (PV) module and a solar sealed lead acid battery. The main purpose of this research was to utilize the solar energy and a rechargeable battery to power a universal self-contained characters display unit. This display unit was useful for creating attention-getting messages, location identifiers such as maps and address identification display modules. The control of the panel was based on an Atmega 8515 a Microcontroller which was programmed using Assembly language, through the use of AVR studio software and STK500 kit.

Bajpai et al., (2015) presented a project on display of different information using a special purpose LED display that is propeller display. The entire project was based on the mechanism of persistence of vision (illusion effect of human eye i.e. if anything appears in the same spot constantly, the human eye will perceive all of the display at once and viewer can read the data associated with it. The construction was done using ATMEL AT89C51 which is a 40 pin microcontroller with a display of 16 bright LEDs to display the message VIT STC ETC.ENGG. All the synchronizing part was implemented C language and Keil Compiler.

2.2. Research methodology

The research methodology is carried out based on the following:

1. Data gathering: The data for this research is gathered through review of existing documents on different display technology, uses and kinds of LED dot matrix display and the economy importance of LED dot matrix display through searching of books, articles, journals and manufacturer web sites and also domain expert were interviewed to find out how things are currently done.
2. Data analysis: Data analysis is done through feasibility study in order to determine if this project work is worth doing and how to carry out this project at a reasonable cost. This helped in the analysis for the selection of the various hardware components used in this project based on cost, reliability, compatibility and availability criteria. Technical, economical and operational feasibility questions were addressed.
3. Coding: The Arduino board would be coded using the Arduino IDE which is based on C programming to drive the Arduino microcontroller and scan through the individual row of the LED's with the data needed to produce a message.
4. Testing**:** Both unit and system testing would be performed to ensure proper functioning of the hardware components and software of the system.

III. SOLUTION DESIGN

This section explains the methodology adopted in analyzing and modelling the display system in order to capture the requirements of the system using diagrams such as the sequence diagram, use case diagram and functional decomposition diagram.

3.1 Analysis of the proposed system

The proposed display system which is an embedded system, is a combination of software and hardware components is analyzed in ordered to decide whether if it's worth going ahead with this project whose design has been chosen. In the analysis phase of this proposed system fact finding was done in order to investigate how things are currently done in order to gather data. Below is the method use in analyzing the proposed display System.

3.1.1 Requirement analysis and definition

Requirement analysis and definition involves stating the services provided by the system, constraints, and goals which serve as a system specification. The requirements of the system can be divided into functional and nonfunctional requirements.

I. Functional system requirements

1. Communication interface:
   - i. RS232
   - ii. Ethernet
   - iii. USB: Universal serial bus
   - iv. SPI: Serial peripheral interface
2. Power supply: Regulated 5v.
   - i. The content of the display shall be stored on an SD card.
   - ii. The content of the repository (SD card) shall be read by the Arduino microcontroller and displayed on the LED dot matrix display.
   - iii. The Arduino mega microcontroller shall be used in interfacing the various hardware components.

II. Non functional system requirements

- i. Operational: The system should be able to work on any web browser.

ii. Security: The content of the display should only be changed by the administrator user.
iii. Availability and reliability: The system should be available 24 hours in a day, with exception of scheduled maintenance.
iv. The periods, courses, and current day of the display should be green in color.

3.1.2 Functional decomposition diagram: The constituent parts involved in the process are:

i. Web-based
ii. SD card
iii. Arduino Ethernet shield
iv. Arduino mega 2560 Microcontroller
v. Matrix keypad
vi. LED Display

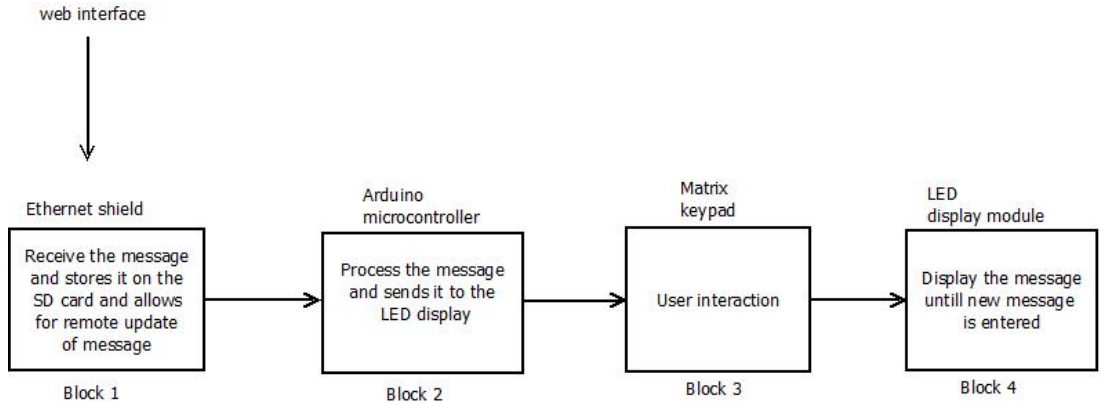

Figure 1: Functional decomposition diagram

The figure 1 shows the functional decomposition diagram, block 1 contain the Ethernet shield in which the SD card is mounted, receives the verified message from the web interface which can be configured remotely through the Ethernet shield and forwards the message to the Arduino Microcontroller. Block 2 contains the Arduino microcontroller which processes the message and sends the message to the LED Display. Block 3 is the DS1302 Timer which interrupts the LED display. Block 4 is the LED display that displays the message until it is interrupted by the Arduino microcontroller.

IV. DESIGN IMPLEMENTATION

This section describes the design and implementation of the display system. After the functional and nonfunctional requirements of the display system has been stated in section three, the next task is to design the structure of the overall system.

4.1 Design of the display system

The design constitute of the architectural diagram of the system showing the various components that make up the system. Different design choices exist for the development of LED dot matrix display. In this project, design choices and their justification was made on the type of platforms, hardware components, how the content of the display can be updated dynamically through a web interface and enabling user interaction.

4.1.1 Architecture of the display system

Architecture of the system consists of Arduino mega 2560 Microcontroller which involves in the operation of processing and validation. Regulated 5v per supply is to power up the whole circuit components. The onboard micro-SD card is used to store files for serving over the network and the Ethernet shield and Arduino mega is used to create web server which enables remote configuration of the message. Microcontroller forwards the message to the LED dot matrix display. The 32*32 LED dot matrix display receives the message and can display only characters at a time as shown in figure 2.

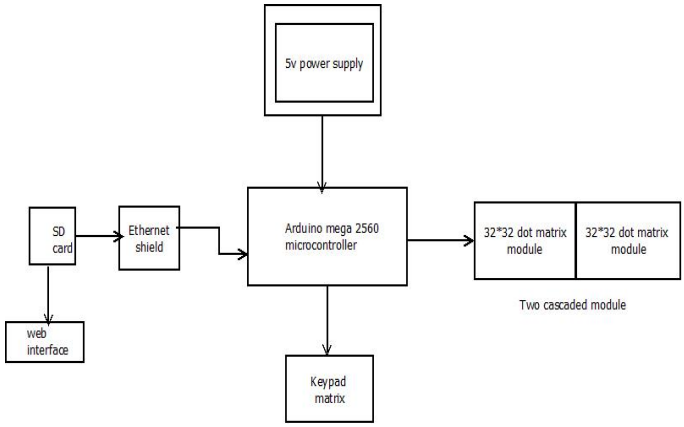

Figure 2: Architectural diagram of the system.

4.1.2 Interfacing the display with arduino mega

This display is made up of 2048 bright RGB (Red Green Blue) LEDs arranged in a 32x32 grid on the front with 4mm grid spacing**.** At the back there is a PCB (Printed Circuit Board) with two sets of dual connectors (two inputs, two outputs), the two displays is networked by connecting one

output of one display to the next input of the other display. These panels require 13 digital pins (6 bit data, 7 bit control).

4.1.3 Interfacing the Arduino mega with the real time clock DS1302

The Real Time Clock / Calendar provides Seconds, Minutes, Hours, Day, Date, Month, and Year information, it communicates with the microcontroller through a simple serial interface Only three wires are required to communicate with the Real Time Clock / RAM: CE/RST (Reset) on 30, I/O (data line) on 31, and SCLK (serial clock) on 32 of Arduino mega digital pins respectively

4.1.4 Main design choices

The various design choices below were made in order to capture the requirements of the system.

1 Mode of configuration of the display board

A web-based controller is used to receive and validate the desired message to be displayed on the 32*32 dot matrix display. Display messages on academic announcements such as the departmental timetable, exams table and are entered through the web controller. Only authorized user can change the content of the display which makes the display system a secured one.

2 Method of storage of the message

An on board mounted SD card on the Ethernet shield is used to store the message to be displayed. It offers flexibility to display messages faster than the programmable system. Communication is centralized around the Ethernet shield module designed for direct access to the internet. The Arduino mega 2560 and Ethernet shield is set up as a web server. The web server is used to serve up web pages that can be accessed from a web browser running on any computer connected to the same network as the Arduino.

3 Display technology used

Two cascaded 32*32 dot matrix LED display prototype is used in displaying the intended message. This display board is used to display dynamic messages; both static and scrolling messages are displayed by the board. The period is displayed as static messages while the courses are scrolling messages. The two boards were cascaded by joining the output of the first board to the input of the second board. The display contents and scrolling speed can be adjusted according to user requirements and it is designed in such a way that the LED module, displays daily the timetable for the department of computer science.

4 Choice of microcontroller

The microcontroller used is Arduino mega 2560 because of its large number of input and output pins and memory space. Atmel chip has serial capability whereby PIC does not have this feature. Serial capability allows coding to be programmed into the Atmel chip using Serial to USB converter connects to the Arduino Software where sketch uploads can be done.

5 User interaction

The display allows user interaction by using a matrix keypad which enables users to select the day to view on the timetable. This also helps in reducing the time a user will use in accessing information from the LED dot matrix board as shown in figure 3.

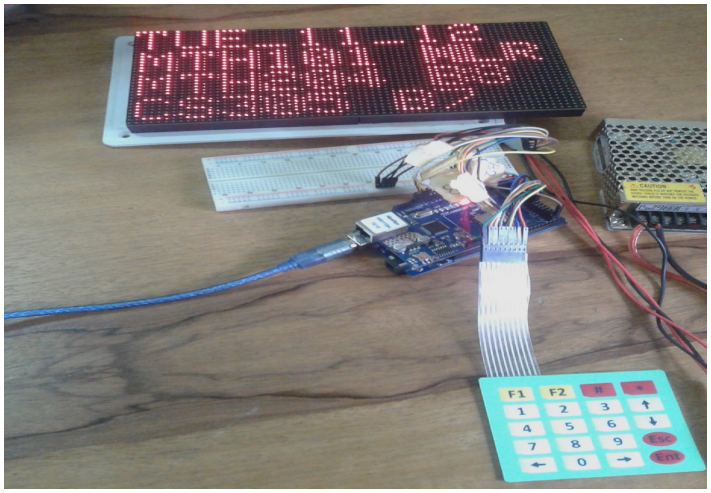

Figure 3: Proposed System

V. EVALUATION/TESTING

This section explains the evaluation and testing of the developed display system in order to ensure that the display system has captured all the requirements that are stated in the analysis phase. Evaluation is done by testing the individual components in order to validate the efficiency of the design and a good design is one where test results prove that it meets the requirements. Evaluation and testing is an unavoidable part of any software and information technology project.

The test approach used for this system is bottom up approach in which different modules that make up the subsystem were tested to obtain their workability before incorporating them in the design, after that the subsystems that make up the system are tested to make sure that there is accurate interfacing between them, then the whole system is tested together as a whole, to ensure that it meets its requirement. The control program is also tested before integrating it with the hardware. Testing Phase which is also known as verification and validation is a process for checking that software meets the original requirements and specifications and that it accomplishes its intended purpose. Verification is the process of evaluating software to determine whether the products of a given development phase satisfy the conditions imposed at the start of that phase; while, validation is the process of evaluating software during or at the end of the development process to determine whether it satisfies specified requirements.

VI. CONCLUSION AND RECOMMENDATION

In conclusion, an electronic LED dot matrix display board displaying semester timetable and examination timetable has been successful developed and has meet its objectives. The storage and retrieval of information is done by the Arduino mega microcontroller. This display board incorporates features such as user interaction, allowing users to select which view of the display to view its periods and courses.

6.1 Recommendation

The new system operation is consistent, reliable and friendly to its users. It also incorporates unique features such as user interaction and enables real time activities. There is a need for future researchers to add more features to the display system. More features like, adding a web-based controller, through which the content of the display can be dynamically changed, using a PIR (Passive Infrared sensor) which will be used to switch the display board on and off to minimize power consumption and the size of the display can be increased by adding more display module.

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