# Design and Implementation of an SMS-based dynamic matrix LED Display Board

*Habibu, H.[1], Chukwu, E. C.[2], Latifa, Y.[3], Haris, M. Y.[4] & Okosun, O. E.[5]

[1,3,4,5]Electrical and Electronics Engineering Department, Federal University of Technology, PMB 65 Minna Niger State, Nigeria
[2]Electrical and Electronics Engineering Department, Nile University of Nigeria, Plot 681 Abuja, FCT, Nigeria

*Corresponding author email: habufarid@futminna.edu.ng, +2348066544604

**ABSTRACT**

This research work involves the development and implementation of an SMS-based dynamic matrix LED display board. It is a model for displaying messages at strategic positions on campus that requires real-time noticing at various locations such as lecture halls, health care center, Bus-park, cafeteria and so on. The device is developed based on Microcontroller control over GSM technology. The administrator (user) sends a message in the form of SMS via Mobile phone. The GSM/GPRS module in the device receives the sent message and sends it directly to the Master unit (Microcontroller). The Microcontroller performs a password check on the strings it received. If there is a password match, it displays the message on the arrays of the fast switching Light Emitting Diodes (LEDs) else the message is discarded, after which it displays current date time as default message. The SMS is stored in the Module's SIM card after each message has been displayed repeatedly for five times, thereby giving room for the next SMS to be displayed. When the queue is filled, then any new message received would replace the oldest in the memory. This device will eliminate the inconveniences of physically going to the display board to manually input information or messages. This device will find application in our educational institutions.

*Keywords: Global System for Mobile Communication (GSM), Light Emitting Diode (LED), Short Message Service (SMS).*

## 1    INTRODUCTION

The need for information dissemination in our educational institutions cannot be overemphasized due to its importance in conveying important information from an individual to another. The application of Global System for Mobile Communications (GSM) and General Packet Radio Service (GPRS) based designs, has developed an innovative and public utility product used for mass communication (Kenneth, 2007). The visual impact is the most effective mode of influencing human minds, which is the main purpose of advertisements and communication. A display device serves this purpose. A display device is a device used for the presentation of information for visual reception. This device is an SMS (Short Message Service) based dynamic matrix LED (Light Emitting Diode) scrolling (moving) message display. It displays the message received via Short Message Service (SMS) or General Packet Radio Service (GPRS) packets.

The message to be displayed is sent via Short Message Service (SMS) by an authorized user in a unique format containing the appropriate password followed by the message to be displayed. When this message is sent, the Global System for Mobile Communication (GSM) Module incorporated in the device receives the text and

sends the strings to the Master unit (Microcontroller) over UART (Universal Asynchronous Receiver/Transmitter). The Microcontroller then compares the first four characters with a predefined password. If there is a password match with the programmed password, the message will be displayed. This electronic device consists of a matrix of LEDs (Light Emitting Diodes) arranged in a rectangular configuration such that by switching ON or OFF selected lights, texts or graphics can be displayed. This electronic device can be kept in a lecture theatre and can be managed by an administrator. The administrator can also change the password of this device anytime it is compromised. Class representatives', Lecturers', examination officers' and any other authorized user can send flash information from their mobile phones to this device for instant viewing irrespective of their distance from the device, which makes the device completely wireless. As a result of the current advancement in technology, wireless communication has announced its arrival on the big stage since the world is now going mobile (Mazidi and Mazidi, 2016). This device is built with the aid of an embedded system. The use of embedded systems in sharing information has given rise to many interesting applications that ensures comfort and safety to human life (Vijay, 2007).

The purpose of this research work is to design and develop an electronic system that can adequately receive Short Message Service (SMS) and effectively display the sent information on an array of Light Emitting Diodes (LEDs). Due to the versatility of this device, it can be used in banks to show the current value of trading on the stock exchange market, currency exchange rate and interest rate. It can also be used in a shopping mall to notify customers' of the prices of goods and other commercial information. Research works similar to this can be found in (Bollen and Hoppe, 2004), (Kurdthongmee, 2005), (Gaurav et al, 2017), (Ketkar et al, 2013), (Kumar et al, 2018), (Kumar et al, 2012), (Ryan, 2019), (Maha, Bhuiyan, & Masuduzzaman, 2019), and (Singh, et al., 2019). The uniqueness about this work is in the provision of an alternative way of sending a message via the use of a keyboard connected to the display system in a situation of GSM network unavailability.

## 2    MATERIALS AND METHOD

The method adopted in carrying out this work is the principle of serial communication in collaboration with an embedded system. The display device was built by arranging Light Emitting Diodes (LEDs) in the form of a [7x5] matrix in ten (10) places, turning them ON and OFF at a very high speed. The user of this device is expected to send a Short Message Service (SMS) in a unique format containing the appropriate password followed by the message to be displayed. The use of a password was incorporated into the system to eliminate unauthorized access to the device. The Module (SIM 300) in the device receives a text and then sends the strings to the Microcontroller over Universal Asynchronous Receiver and Transmitter (UART). The Microcontroller compares the first four (4) characters with the predefined password, if there is a match, the message received will be scrolled for a programmed time, and else the message is discarded. The device beeps through a buzzer which was interfaced with the Microcontroller for at least three (3) times to alert the audience that a new message is about to be displayed. After the message must have been displayed, it returns back to display the current date and time as the default message. A 230V AC power supply Mains was stepped down, rectified, filtered and regulated to obtain the desired operational output voltage of 5V. An extra battery bank of 6V was also incorporated in the device. It serves as a back-up power supply to the device during a power outage.

The methods used in developing this device consist of two sections viz: the Hardware and the Software section. The use of breadboard was adopted in the hardware section for building and testing of the circuit components. The software section is sub-divided into two parts. The first part involves the writing of the program codes with the aid of software called "Mickro C". The second part of the software section is a circuit simulation. The simulated design of the hardware was tested and analyzed before the actual circuit was built. The software used for the schematic capture and circuit simulation is known as "Proteus Professional".

The idea behind the research was to ease access to information in our educational institutions, putting into extinction the old practice or method of disseminating information. Figure 1 shows the block diagram design of the various stages that makes up the display device.
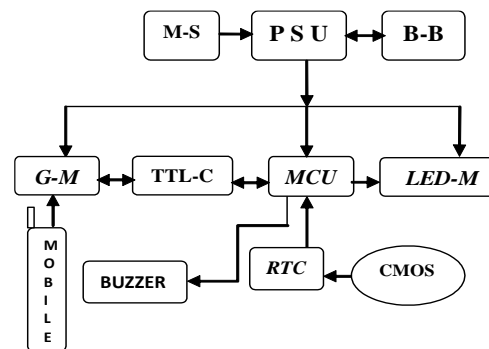


Figure 1. System Block Diagram

The various units (modules) that make up the system are discussed in the following subsections:

### 2.1  POWER SUPPLY UNIT

This unit consists of a 230V/12V, 1.5A transformer which stepped down the 230V AC mains to 12V AC. This voltage was then fed into a full-wave bridge rectifier (KBL406) which was used to convert the oscillating AC voltage into a unidirectional DC voltage. The DC voltage was then fed into the two 1000 µF electrolytic capacitors which filter out the voltage ripples of about ±2V. The filtered DC voltage was then fed into a 7809 voltage regulator which maintains the voltage level at a fixed output of 9V followed by a 7805 regulator which further limits the voltage level to a constant voltage of 5V required to drive the whole circuit. A 10 µF capacitor was placed after each voltage regulator to suppress any possible ripples and also to enhance the stability of the voltage regulators.

The output DC voltage and filter capacitor used is thus calculated using equations (1) and (2) (Gupta, 2009).

$$V_{L(DC)} = \frac{2 \times V_{S\,(max)}}{\pi} \qquad (1)$$

$$= \frac{2 \times \sqrt{2} \times v_{rms}}{\pi}$$

therefore: $\quad V_{L(DC)} = \frac{2 \times \sqrt{2} \times 12V}{\pi} = 10.80V.$

Hence, the output DC voltage is approximately 11V DC. The filter capacitor used was as:

$$C = \frac{1}{(4V\gamma F\sqrt{3})} \qquad (2)$$

Where V is the supply voltage, $\gamma$ =Ripple factor and F is the system frequency. Hence,

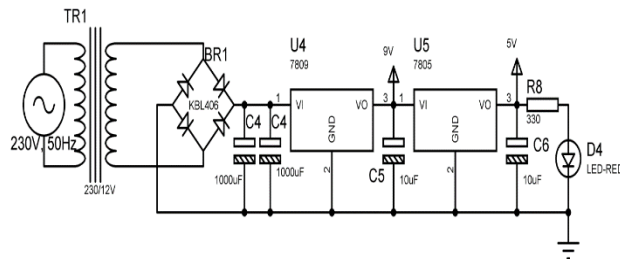$$C = \frac{1}{(4 \times 12 \times 0.12 \times 50 \times \sqrt{3})} = 0.002005F = 2005\mu F.$$



Figure 2. Circuit diagram of the power supply Unit

The 12V AC transformer was used because 12V is the maximum voltage required by the components in this circuit i.e. the buzzer, 1.5A is just sufficient to meet the brightest current requirement of the whole 350 LED's. (KBL406) bridge rectifier was chosen because it can rectify up to 100V. Two $1000\mu F$ capacitors where used because the resultant capacitance of the two capacitors in parallel is the sum of the two capacitors and the voltage handling capacity is just more than required. Two (2) voltage regulators (7809 and 7805) were chosen and used so as to avoid excessive heat loss on a single regulator.

## 2.2 CONTROL UNIT

This unit consists of the Microcontroller and seven 74HC595 shift registers as shown in Figure 3. All the ICs stake 5V from the power supply unit. The DS pin (pin14) of the first shift register was connected to PB0 (pin1) of the Microcontroller while the rest are cascaded by connecting the Q7 pin of the current shift register to the DS pin of the subsequent shift registers. The SH_CP pin (pin11) was connected to PB1 (pin2) of the Microcontroller and the ST_CP (pin12) to PB2 (pin3) of the Microcontroller. Whenever a row is set to logic 1, the corresponding data bits of each character to be displayed

is extracted and arranged serially in the shift registers through the DATA pin. This is done in 50 SH_CP clock cycles after which the ST_CP is pulsed once to latch the arranged data bits. The output is used to trigger the ULN2003A in the display section immediately since the enable pin is always HIGH. The same process is repeated for the other rows.
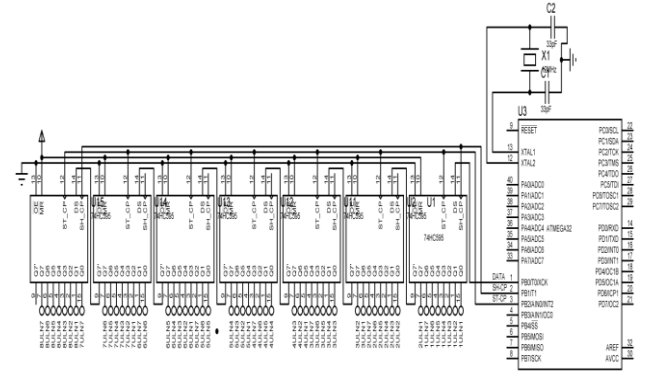


Figure 3. Circuit diagram of the control unit

The AT-mega 32 was used because it has enough memory to manage this data. It has 3 timers and they were used to generate clock pulse at overflow interrupt and many GPIO pins out of which three (3) were used to control the shift register. 74HC595 shift registers were chosen because they are fast, low power consumption and easy to control.

## 2.3 DISPLAY UNIT

This unit is an important part of this research because it displays the message sent to the device. It consists of three hundred and fifty (350) LEDs arranged in matrix form, forming 7 rows and 50 columns as shown in Figure 4. All the anodes were wired together to form the rows, while the cathodes were also joined together to form the columns. This was carried out to minimize the number of pins needed to drive each LED. The rows were connected to PORT A of the ATMega32 Microcontroller. ULN2003A was used to drive the columns, the 16 pin IC contain seven (7) in-built Darlington NPN transistors, having a maximum collector-emitter voltage of 50V. Each channel is capable of sinking 500mA and can withstand peak current of 600mA. Eight (8) ULN2003A were used to achieve this project. Each output pins of the ULN2003A were connected to a column of the LED matrix.

The Microcontroller was used to drive the rows directly because it can source up to 40mA DC current at any

GPIO. ULN2003A was chosen because it is cheap, robust and has a very high gain. Ultra-bright LED's were used because they glow with a sparkling brightness, they can take as low as 1.8V and 25mA.
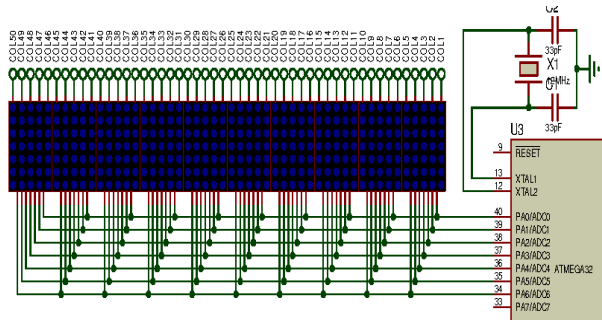


Figure 4.  Circuit diagram of the display unit

## 2.4    COMMUNICATION UNIT

The communication unit comprises of the GSM/GPRS module (SIM300) and a microcontroller as shown in Figure 4. The GSM module communicates with the Microcontroller over UART. The Microcontroller controls the module using the standard AT Commands (Attention Command). The Microcontroller receives the message to be displayed from the GSM module in form of strings at a baud rate of 9600 Bps. It processes the data after which it extracts the message to be displayed or the time/date setting information.
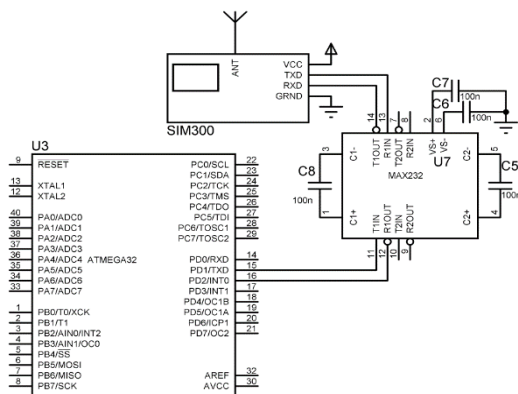


Figure 5. Circuit diagram of the communication unit

The SIM300 was used because it can be programmable via AT command. The Microcontroller was chosen because it has the UART feature which is needed to interface both devices.

## 2.5    REAL-TIME UNIT

The real-time unit comprises of the Microcontroller, DS1307 real-time clock (RTC), and two pull-up resistors as shown in Fig. 6. The serial clock input (SCL) and the serial data input/output (SDA) pins of the DS1307 real-time clock were connected to pins PCO/SCL and PCI/SDA respectively of the Microcontroller. It serves as the communication line between the Microcontroller and the DS1307 clock. A 32.768 kHz crystal oscillator was used to clock the DS1307. The two pull-up resistors as shown in Fig.3.6 were used to pull up the communication line. A 3V CMOS (Complimentary Metallic Oxide Semiconductor) battery was used as a back-up battery to keep the time/date counting during a power outage.

The AT-mega 32 Microcontroller was used because it has $I^2C$ and TWI interface. DS1307 was chosen because it consumes low power and provides seconds, minutes, hours, day, date, month, and year information. The CMOS battery was used because it is resistant to corrosion.
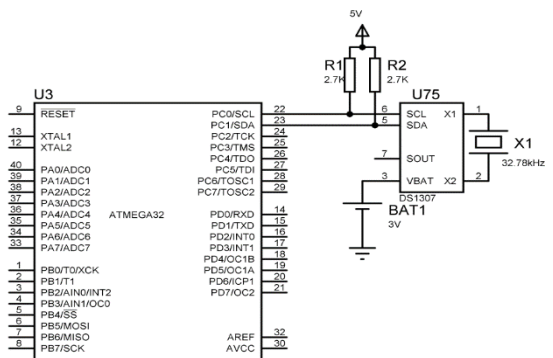


Figure 6. Circuit diagram of the real-time unit

## 3    TESTS CARRIED OUT

It is a common practice that when a project is designed and constructed, it is expedient that the test should be conducted on it so as to ascertain results in comparison to a standard. Tests were conducted on the overall system. The results obtained were compared with the design specification using a test instrument such as Digital multi-meter.

## 3.1    TEST ON POWER SUPPLY UNIT

A digital Multimeter was used in testing the power supply unit at various outputs such as the transformer, rectifier, 7809 and 7805 voltage regulators, shift register and the LED. The results obtained are shown in Table 1.

TABLE 1. TEST ON POWER SUPPLY UNIT

| COMPONENTS | VOLTAGE OUTPUTS (Volts) |
|---|---|
| Transformer | 12.00 |
| Rectifier | 10.80 |
| 7809 Voltage Regulator | 8.95 |
| 7805 Voltage Regulator | 4.96 |
| Microcontroller | 4.85 |
| Shift Register | 4.89 |
| LED Connected in Shunt | 1.93 |

## 3.2 TEST ON LED-MATRIX DISPLAY BOARD

Testing of the LED-Matrix Display board was carried out by sending some Short Message Service (SMS) with the four (4) digit predefined password, using a Mobile-phone to the GSM module incorporated in the device and the results thus obtained are as shown in Table 2.

## 4 RESULTS AND DISCUSSION

The overall system/device was tested to meet the design requirement and functionality specifications of each component that makes up the entire circuit.

From Table 1, a test carried out at various outputs of the components used for this research such as; transformer, rectifier, voltage regulators, shift register, and Microcontroller, showed conformity to standard because the measured values were approximate that of the original manufacturer's value.

From Table 2, tests carried on the LED Matrix display board showed that after sending a message with the appropriate password, the message displayed on the board is exactly that of the originally sent message.

## 5 CONCLUSION

This design work was implemented and found to be functioning in compliance with the model specifications as expected. The device was developed based on Microcontroller control over GSM technology thereby eliminating the inconveniences of physically going to the display board to manually input information or messages.

TABLE 2. LED-MATRIX DISPLAY BOARD RESULTS

| MESSAGE SENT | MESSAGE DISPLAYED ON BOARD |
|---|---|
| 1989DISP Please submit your project work. | Please submit your project work. |
| 1989DISP EEE 522 Lecture holds by 11.00am. | EEE 522 Lecture holds by 11.00am. |
| 1989DISP Happy birthday to Mr. Haruna Ali. | Happy birthday to Mr. Haruna Ali. |
| 1989DISP Submit your course form to Jack. | Submit your course form to Jack. |
| 1989DISP I will be with you In 30minutes time. | I will be with you In 30minutes time. |
| 1989DISP Am on my way to Dubai. Lectures continue when I return. Thank you. | Am on my way to Dubai. Lectures continue when I return. Thank you. |



Figure 7. Result of the Implemented Research Work

This device can be used our educational institutions and other establishments that want to do away with the use of papers for displaying messages. The device is easy to use.

The developed model can be improved upon to display multiple lines of messages at a time.

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