Design, Construction and Implementation of a GSM-Based LED Matrix Moving Display System

KALU HENRIETTA CHIAMAKA[1], AKPOILIH ONORIODE EMMANUEL[2], OLATILEWA EYITAYO AIYEDUN[3], OLOGUNAGBA BRIGHT TOLUWALOPE[4]

[1, 2]*Department of Electrical and Electronic Engineering, Petroleum Training Institute, Effurun, Delta State, Nigeria.*

[3, 4]*Afe Babalola University, Ado Ekiti*

Abstract- ***GSM based LED moving Display Board is a system in which there is a moving sign board that helps in updating of new messages easily. The advantage of using LED in place of LCD is the better visibility of LED even from a distance. LED display board can be used for displaying digital information at many places like railway stations, shopping center and educational institutions to many people at a time. But there is a complication in updating the message because the message needs to be entered using a computer and for this purpose, the person needs to be at the venue of the display board. This problem can be solved by using GSM technology. With introduction of GSM based system, the message to be displayed is sent from a mobile phone to the GSM modem connected to the LED display hardware. The modem receives the SMS and sends it to the controller circuit of the LED display. Then the controller circuit filters the message and changes the text in the Led display dynamically. By using this SMS service, it is possible to change the text in the LED display board from anywhere in the country.***

Indexed Terms- ***ATmega328, Display system, SIM800L GSM Module, LED, Matrix.***

I. INTRODUCTION

The LED display system serve as an electronic notice board and displays the important notices instantaneously thus avoiding the latency. Being wireless, the GSM based LED display is easy to expand and allows the user to add more display units at any time and at any location depending on the requirement of the organization. The LED display system is made up 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. Being a GSM-based system, it offers flexibility to display flash news or announcements faster than the programmable system. The LED display system is aimed at the colleges and universities for displaying day-to-day information continuously or at regular intervals during the working hours. LED message scrolling displays are becoming very popular, these displays are seen or used in shopping malls, theatres, public transportation, parks, traffic signs etc. One major drawback with these display is the frequent carriage of the computer or special keyboard for generating and sending messages to the LED moving display boards, this problem can be overcome with the use of a portable GSM based matrix display system. Where a GSM mobile phone is used instead of carrying keyboard or a host computer for generating or sending messages to the LED display board. A text message is typed in the GSM mobile phone and sent through short message service (SMS) of the mobile phone to the LED moving display board. A GSM modem connected to the LED display hardware receives the SMS and sends it to the controller circuit of the LED display. by using this SMS service, it is possible to change the text in the LED display board from anywhere in the country. the idea implemented in this project reduces the total cost that is required in the traditional LED display boards and also makes it easier to send message to the LED display boards. A power supply unit and supporting hardware for microcontroller were also used. This project work eliminates the main problem involved in manually reprogramming the microcontroller, each time a new message is to be displayed on the notice board. GSM technology have been deployed to monitor several

applications such as: cell phone operated robot, SMS based voting system, SMS based security system, GSM based automatic meter reading system using ARM (advanced RISC machines) microcontroller, SMS based teaching and learning system etc. Researches have been done on GSM based e-notice board, where SMS sent from authorized mobile phones via a GSM network were displayed on a digital e-notice board. these works have proven to be efficient and fast. with greater efficiency, messages were displayed with less error and maintenance, though there is need for few modification for better performance.

II. LITERATURE REVIEW

S. Kavitha et.al (2014) carried out a project work titled "GSM Based Sign Board Display". The design was made up of a driver unit, GSM module, LED display and microcontroller. The project was designed to receive SMS and MMS (multimedia messaging service) at the same instant, which can be programmed from an authorized mobile phone. The message to be displayed is sent in the form of SMS from an authorized transmitter. The system receives the SMS, validates the sending mobile identification number (MIN) and displays the desired Information. Thus, the GSM based sign board display helps in sending of circulars in the form of SMS from any place and receiving it with the help of GSM modem, it enhances the mobile way of sending the circulars to the wanted places without the need of human effort. The memory used here helps to display both the past as well as current notices. Therefore, the system works with a simple mechanism and hence both the economy and the complexity of design are reduced. Rahul Kambo and Preeti Abrol (2013) designed and developed "GSM Based Multiple LED Display Boards" using AT89S52 microcontrollers, GSM module, LCD and several moving LED displays. Multiple moving LED displays were connected via different GSM modules at different geographical locations such that the same SMS sent was displayed on all the moving LED displays. The work proved to be cost effective, secure and efficient.

In a research work carried out by Adamu Murtala Zungeru et.al (2014) titled "Design and Implementation of a GSM Based Scrolling Message Display Board" and published in the International Journal of Computational Science Information Technology and Control Engineering (IJCSITCE), two AT89C52 microcontrollers from Atmel were used in the design. The microcontrollers provided all the functionality of the display notices and wireless control. The display was obtained on a 7×96 LED dot matrix display, arranged on a Vero board. The desired text message from a mobile phone was sent via GSM to the GSM module located at the receiving end. The GSM modem was 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. The GSM based scrolling message display eliminated both the unnecessary wired connections and the task of manual reprogramming of the microcontroller whenever a new message had to be displayed. The design also utilized the advantage of microcontrollers to reduce the size of the design and build the entire system into a compact and mobile form and also increased the speed of the processing and message display. The use of inexpensive components like the LEDS, Vero board, microcontrollers, power supply and so on, made the design cost effective.

Nivetha Puritha et.al (2013) designed an "SMS Driven Automatic Display" using ARM-LPC2148 microcontroller to interface multiple graphical display. With this technology, a single notice would be sent to several e-notice boards via ARM-LPC2148.

A project was carried out by Twaha Kabika and Prof Zhang Jian-Min titled "Designing and Implementation of PC Based Moving Message Display Board System with RF Link" in 2014. The aim of the work was to design a system that would allow the user to change message timely, the designed system was a combination of wireless technology with 8×32 matrices LED display boards formalized by designing and integrating the hardware and software with AT89S51 microcontroller, RF module, and 8×32 matrix moving LED display. The system also has a GUI (graphic user interface), the GUI was also linked with the database (MS access 2007) so that only the authorized user would have access to the system, and every single message sent by the user would be stored in the database. Message is entered in the computer

with the use of a keyboard and sent to the display board by the use of RF transmitter (SZ05) which was connected to the computer. Message is received by the RF receiver (SZ05) which is directly connected to the AT89S52RC microcontroller. The microcontroller decodes the received data packet, and the decoded information (message) is transferred to the board for display. This system solved the cost problem in small advertisement sector and assured a real time display of the message.

Gowrishankar Kasilingam et.al (2014) proposed the development of a "GSM Based Digital Notice Board". The complete system would have a dual system in terms of changing message display, dual power supply switchable between solar power system and alternating current (AC) from the utility supply and inbuilt motion detector that would automatically switch OFF the whole system after working hours and would automatically switch ON if any motion is sensed by the motion detector after the programmed working hours. The work would prove higher efficiency in terms of ensuring better communication and continuous power supply.

In this project work titled "Design, Construction and Installation of a GSM Based Matrix Moving Display System", a Digital clock and a temperature sensor will be incorporated into the GSM based LED matrix display system, this would in addition to the display of information and notices, act as a large platform for keeping the masses updated on the current time/date and temperature of the day. This makes the system more efficient and reliable.

BLOCK DIAGRAM OF A GSM BASED LED DISPLAY SYSTEM

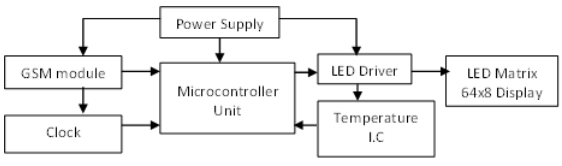


Figure 1: Block diagram of a GSM based LED display system

Components of the Block Diagram

- Power supply

The power supply is an important part of a circuit. it provides required supply to different blocks of the circuit from input. The main blocks include: transformer, rectifier circuit, filter circuit and regulator circuit. Voltage regulator IC LM7805 is used as a voltage regulator.

- LED display

The heart of scrolling display is the dot matrix LED display unit. It is a screen display technology that uses a panel of LEDs as the light source.

- GSM module

It requires a SIM card just like mobile phones, to activate communication with the network.

- Microcontroller unit

The microcontroller unit forms the control unit. It is programmed to carry out the desired function. The microcontroller unit also has a demultiplexer, the demultiplexer section distributes signal to the display unit and allows them light at appropriate times.

- LED driver

The LED driver is an electronic device which regulates the power to the LED and provide an interface between the power supply and the LED load. Digital clock The clock displays the time digitally as opposed to an analogue clock where the time is indicated by the position of rotating hands.

- Temperature sensor

A device which measures the temperature of its environment and converts the input data into electronic data to record or monitor the signal temperature changes.

Components Review

- Transformer

A transformer is a static piece of device by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. The physical basis of a transformer is mutual induction between two circuits linked by a common magnetic flux/. The transformer used in this project is a 240v/12v step down transformer.

- Full Bridge Rectifier

The full bridge rectifier is the most frequently used circuit for electronic D.C power supplies. In the full wave bridge rectifier, the need for a centre tapped

rectifier is eliminated. It consists of 4 diodes D1, D2, D3, D4 connected in a bridge form. The IN4007 Diodes was used from D1 – D4. A total of 1.4volts is used up in the bridge rectifier because each diode uses 0.7volts when conducting.

- Voltage regulator

The importance of voltage regulator is to ensure that a fixed voltage is obtained at the output of the power supply regardless of the variations from the supply input or load connected. The choice of voltage regulator in a circuit should be based on the voltage demand by the microcontroller and the LEDs. Since these components requires a supply of 5volts for operation. The LM7805 voltage regulator IC is mostly used since it meets the requirements.

- Light emitting diodes

LED is a P-N junction semiconductor device which emits visible light when it is forward biased. LEDs are used in various optoelectric display such as pilot lamp, seven segment display, dot matrix display etc. it comes in various colours like red, yellow, green etc. The LEDs used in this project are the green type with a 10mA current consumption

- The Microcontroller

The type of microcontroller used for the purpose of this project work is the IC called ATmega328. The ATmega328 is a single chip microcontroller created by Atmel in the microchip family. It has an 8- core bit RISC (reduced instruction set computing). The ATmega328 is commonly used in many projects and autonomous systems where a simple, low powered, low cost, high performance, advance RISC architecture microcontroller is needed. The most common implementation of this chip is on the popular arduino development platform, namely the Arduino uno and Arduino nano models.

The ATmega 328 provides the following standard features:

- 8 bit AVR (CPU type)
- 32kb flash memory 2kb SRAM
- 1kb EEPROM
- 28 or 32 pin
- 20 MHz operating frequency
- 2 external interrupts
- 1.8 – 5.5 operating voltage
- SIM800L GSM module

This is a miniature GSM modem, which can be integrated into digital communication circuits. It has a SIM socket for inserting a SIM card, this enables the sending and receiving of messages. There is an LED indicator on the right side of the SIM800L cellular module which indicates the status of the cellular network, it blinks at different rates to show what state its in. This module was chosen because it uses a serial communication which is easy to interface with UART (universal asynchronous receiver transmitter) of almost all microcontrollers.

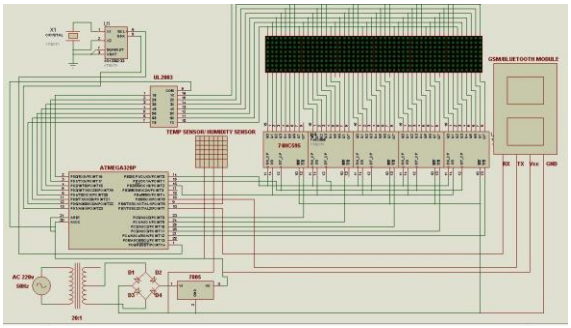


Figure 2: Circuit diagram of the LED matrix based moving display system

III. DESIGN ANALYSIS AND CALCULATION

Design Analysis

This project is micro-controller based; therefore, it has both the hardware and software components. As a result, the design is a combination of the three main units namely; the software, the hardware and the power supply unit. It means, at some point, the design will combine both the hardware and software (i.e. programming)

Design of the Power Supply

The circuit uses standard power supply comprising of a step-down transformer from 240V to 12V and four diodes forming a bridge rectifier that delivers pulsating dc which is then filtered by an electrolytic capacitor of1000µF. The regulated power output is 5v dc. The power supply is made up of the following

1. Transformation
2. Rectification
3. Filtering

4. Regulation

Selection of the Transformer

The transformer chosen for this particular project work is the ordinary two winding step down transformer. It is normally used for the purpose of power supply. The transformer was designed to step down commercial power supply which is normally between 220-240V to 15- 12V, but preferably 12V because of the working requirements of the voltage regulator and subsequently, the microcontroller.

Analysis

By transformation ratio; $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

Where;

V_s = voltage across secondary windings

V_p = voltage across primary windings

N_s = number of turns of secondary windings

N_p = number of turns of primary windings

Calculations for V_s

Given that V_p = 240, $N_s : N_p$ = 20: 1 turns, then;

$$V_s = \frac{V_p}{N_p}$$

$$= \frac{240 \times 1}{20} = 12v$$

Therefore the output voltage of the transformer is 12v.

- Rectification

The output of the transformer, 12Vac cannot be applied to the circuit because it is still A.C in nature. Rectification is therefore the process of converting the A.C output of the transformer (12Vac) into the D.C equivalent either positive or negative pulsating D.C (that is, a D.C output that contains unwanted component.

- The Selection of the Bridge Rectifier

The rectification circuit used in the design is a full-wave bridge rectifier with four diodes. The bridge rectifier was used due to its advantage over the center tapped full wave rectifier. The diodes IN 4007 with maximum current rating of 1A and PIV rating 1000V was used in this project work.

- Choice of Selecting the Diode

The choice of diodes used was based on:

- The Forward Current Rating of Diode

The diode forward current rating is the maximum that the diode can conduct before failing. The diode should be selected in such a way that the current passing through it should be less than the forward current rating.

- The Peak Inverse Voltage

The peak inverse voltage is the maximum reverse voltage that a diode can withstand without destroying the junction. If the reverse voltage across a diode exceeds this value, the reverse current increase sharply and breaks down the junction due to excessive heat. Therefore Peak inverse voltage is extremely important when diode is used as a rectifier. Hence, PIV consideration is generally the deciding factor in diode rectifier circuit. The peak inverse voltage of rectifier diodes lies between 10V and 10kV depending upon the types of diodes.

$$V_{peak} = \sqrt{2}\, V_{rms}$$

Where V_{rms} is the transformer's output voltage (12V ac) we have that:

$$V_{rms} = 12V$$

$$\therefore V_{peak} = \sqrt{2} \times 12 = 16.97V$$

For a bridge rectifier, the peak voltage equals the peak inverse voltage. Therefore the calculated PIV is 16.97V.

- Filtering

The rectified dc output contains a large proportion of ac components known as ripples, thus increasing its ripple factor, thereby reducing efficiency. In the filtering process, a capacitor is used since it possesses infinite resistance to dc thus blocking it while allowing ac to pass through easily. A filtered output contains less distortions than the rectified output. The output from the capacitor is known as the unregulated output.

The filter used in this power supply is a single shunt capacitor. The choice of the filter capacitor depends on:

- The ripple factor allowed
- The capacitor breakdown voltage

The Ripple Factor Allowed

The output of a rectifier consists of a dc component and an ac component (also called ripple). The ripple is undesirable and causes pulsations in the rectified output the effectiveness of a rectifier depends on the amount of ripple in its output, the smaller this is, the more effective is the rectifier. The ripple factor is an indication of the effectiveness of the filter capacitor and is defined as:

$$ripple\ factor = \frac{rms\ value\ of\ AC\ component}{value\ of\ DC\ component}$$

$$\frac{V_{rms}}{V_{dc}} = \frac{I_{ac}}{I_{dc}} =$$

$$\sqrt{(\frac{I_{rms}}{I_{dc}})^2 - 1}$$

The smaller the ripple factor the lesser the amount of ripples and hence more effective is the rectified output signal. The ripple factor for full wave rectifiers is given as:

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

$$I_{dc} = \frac{2I_m}{\pi}$$

$$R = \sqrt{\left(\frac{I_m}{\sqrt{2}} - \frac{\pi}{2_{Im}}\right)^2 - 1} = 0.48$$

The capacitor breakdown voltage

The capacitor breakdown voltage (v_c) can be determined by applying kirchoffs voltage law (KVL) from the bridge rectifier output to capacitor terminal.

$$v_{peak} - v_d - v_c = 0$$

Where v_{peak} = bridge rectifier output

v_c = capacitor terminal voltage

v_d = drop across bridge rectifier diodes

For silicon made diode $V_{d} = 0.7$

For full rectification, on each half section, 0.7 is dropped across each of the two conducting diodes, which gives 1.4 (that is 2 × 0.7

$$V_c = 16.97 - 1.4v = 15.57$$

In practice the rule is to use a capacitor with breakdown voltage double of the terminal voltage. Therefore taking a safety factor of 2, the capacitor voltage V_C becomes $31.14v$ and since this is not a common capacitor voltage a $35v$ capacitor was chosen

For the capacitance value:

Since in practice, a ripple which is 10% of the supply voltage is satisfactory, thus for 10% ripple for full wave rectification we have:

$$V_S = \frac{load\ current}{2FC}$$

Where:

C = smoothing capacitor in farads

I_o= output current from the supply in Amps

V_s= supply in volts

F = frequency

Therefore:

$$c = \frac{1}{2 \times 50 \times 15.57} = 642\mu F$$

A standard value of 1000µF, 35Volts capacitor was selected which is the closest standard value to the calculated capacitance value.

Voltage regulator

The importance of voltage regulator is to ensure that a fixed voltage is obtained at the output of the power supply regardless of the variations from the supply input or load connected. The regulation used is the IC voltage regulator LM7805. The voltage regulator has an input voltage of 5-18v and the output range is 4.8 - 5.2v, an output current of 1.5amps. this regulator was chosen because they are more efficient in providing the much needed constant voltage for the circuit.

Design of the LED Display

The LED display was arranged in an 8*64 matrix form, that is, 8 LEDs in a row and 64 LEDs in a column. The LEDs used are the green type with a 10mA current consumption

Current calculation for LED used:

$$total\ current\ for\ LED\ used = total\ number\ of\ LEDs \times 10mA$$

$$512 \times 10mA = 5120mA$$

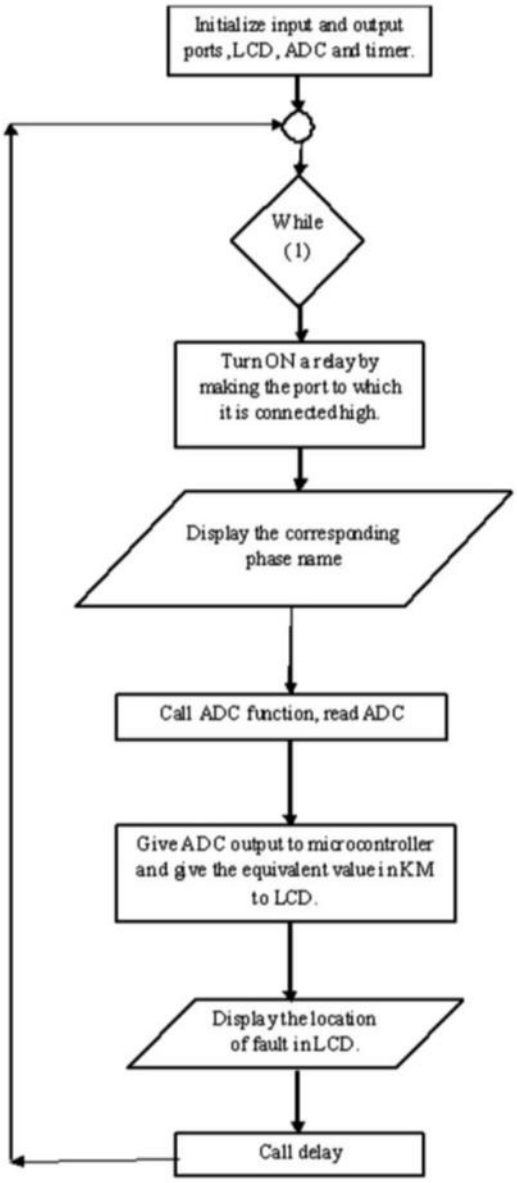
Operational Principle

The project uses the Microcontroller and shift registers to drive the LED Matrix connection in Rows and columns. The LED matrix is connected to have 8 rows and 64 columns, each of the rows is connected through an amplifier to the row shift registers that drives the row 1, while the 64 column LEDs are connected to the 8 shift register serially to each other. Now the microcontroller is the master device that drives all other components using its firmware written in C, the controller uses a technique called persistence of vision in forming each character on the display by driving data through the entire column .The GSM Module (SIM800L) is made up of a SIM card with number. The message transmitted by any number to this number is received and saved in the memory of the SIM card. The module works with the Attention (AT)-commands. The Receiver (RX) and Transmitter (TX) pins of this GSM module are connected to the TX and RX of the ATmega328 respectively so that the information or message is transmitted. The message received by GSM module is retrieved by the ATmega328 using suitable AT commands. The message is transferred to the display board.The matrix system was built around an 8 stage serial shift register 74HC595 and a microcontroller ATmega328.

The Design Statement

This unit is meant to display by running message (LED lighting in sequence) the statement – WELCOME TO ELECTRICAL AND ELECTRONIC DEPARTMENT, PETROLEUM TRAINING INSTITUTE EFFURUN, DELTA STATE.

Flow Chart



IV. CONSTRUCTION

The construction of this project was divided into two parts; the electronics and mechanical (casing) parts. The construction of both units was carefully planned, taking into consideration the operation and utility of the device. The components of the electronics part were tested one after the other to confirm that they exhibit their expected characteristics, thereafter they were connected on a project breadboard so as to test the functionality of the circuit and effect any change

as the case may be. After the pre-connection and testing of components and the circuit, a permanent construction was then made on the Vero matrix board.

To construct the circuit, the following sequential steps were taken

1. Making the layout of the circuit
2. Cleaning the Vero-board surface
3. Insertion of the components to Vero-board
4. Testing of the circuit

MAKING THE LAYOUT OF THE CIRCUIT

To efficiently and correctly build a circuit on Vero-board, making a layout of how the components should be positioned or connected and also cutting tracks is the first step taken. If a layout is not made, the possibility of having a mal-functioning circuit is high. To produce the layout, an edge knife was used to cut tracks and removing them where necessary. This was done prudently to avoid removal of excessive tracks or injury.

CLEANING THE VERO-BOARD

The Vero-board is made up of a number of copper strips or tracks plated on the surface of an insulating material, most often made of fibre. It is proper for one to rid the surface of the copper of any dirt or oxide that might prevent an efficient adhesion. To clean the surface of the copper strips, a sandpaper of every fine texture was used. After filing the surface a hand brush was sunk into a solution of ethanol and was used to flush out the copper particles that have been filed out, by wiping gently across the surface of the Vero-board in an axial direction. It was allowed to dry for couple of minutes.

PLACING THE COMPONENTS ON THE VERO-BOARD

The required components were identified and the layout diagram was followed in the circuit diagram to place each component in its proper position while paying serious attention to the terminals of the components.

SOLDERING OF THE COMPONENTS TO VERO-BOARD

After placing the components in their proper positions and bending their terminals, the other side of the Vero-board was turned to solder the terminals of the components to the copper strips of the Vero- board. To solder, the tip of the soldering iron bit was placed between the terminals of the components and copper strip and allowed to heat up for some few seconds, and then a soldering lead was applied. The soldering leads melted and flowed freely between the terminals of the components and copper strip. Afterwards, the soldering iron was removed allowing the molten lead to cool down and solidify. To ensure good bond, the tip of the soldering iron was regularly clean to free it from dirt.

CASING

After the construction of the electronic unit, the casing was constructed. The project was cased so as to give the device a good finishing, protecting the electronic device from environmental condition like moisture, low and high ambient temperature. To also increase the reliability of the device by offering mechanical strength to it and serving as a protection for humans against contact with dangerous parts of the circuit. The casing here refers to the package that houses the circuit board and all the components mounted on it (although some are attached to the casing itself).

V. TEST AND RESULTS

The aim of testing is to ascertain that after the design and construction of the entire circuit, it will perform the required function optimally as desired. Three basic tests were carried out and they include:

1. Visual inspection test
2. Continuity test
3. Operation test

VISUAL INSPECTION TEST

Visual inspection test was carried out by checking conductor lines, cable termination and components arrangement for faults such as open circuit and short circuit which can be visually detected.

CONTINUITY TEST

Continuity test was carried out with the aid of a digital Multimeter to ensure that specific paths were continuous. The continuity test also verified the result of the visual inspection test.

OPERATION TEST

Operational test was carried out to ensure that the device constructed performed the required function. The operation test was carried out by injecting a known signal using signal generators into the system and the system's output performance was observed.

OBSERVATIONS

i. The display gets jerky when there is an incoming text from the GSM module to interrupt process.
ii. The processor used is a single core processor, hence due to high graphic computation, it cannot perform another task if given.
iii. The transformer used was getting heat up very fast due to the high current demand of the display made of 512 LEDs.
iv. The shift registers are connected serially in a daisy chain.
v. The row driver handles more current than the column driver.

CONCLUSION

The aim and objective of this project was to design and construct a digital moving message display that is GSM based to achieve modern public relation purposes. Nowadays, advert has become a very important part of our daily business as people's attention are easily drawn to things that are animated, this project helps to make that a reality with the aid of its super bright outdoor LEDs that gives animated display of whatsoever you want to write on it using GSM Technology. This aim was achieved and practical understanding on circuit design, construction and programming system techniques was gained.

RECOMMENDATION

Since this study had only focused on simple 8 x 64 LED Matrix Monochrome display, it is recommended that further studies be carried out on variety LED Matrix Technology. The device should be able to display image at low quality not just alphabets and numbers.

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