Design and Implementation of A Led Dot Matrix Display

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Abstract

Information passage and sharing is very vital in the world of communication. In recent years there have been a call to modernize the information passage processes and going by the human aesthetics taste for colorful and beautiful things and environments, there is a need, therefore, to introduce aesthetics into the way information are displayed on billboard especially in a dark environment which characterizes Sub-Saharan Africa. In this paper, therefore, the design and implementation of moving message display based on microcontroller was carried out. The display units which comprise transformers, ATMEGA microcontroller, Filtration unit, uses Light Emitting Diodes LED in a 7×60 arrangement to form the predetermined characters, which lights up progressively as an effect. Once the message is completely displayed, it latches for a proposed time and abruptly disappears and the process is repeated over again with the scrolling of characters.

Keywords: Display, Information, LED, Microcontroller, Signal.

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I. INTRODUCTION

The act of creating awareness to the public is as old as human, right from the first day of creation. The beauty of the world as we know it today was made glaring with the creation of light. The important of light can be traced back to the accolades according to Thomas Alva Edison when he successfully invented the incandescent lamp after nearly hundreds of experiments. He was popularly known as the person whose experiment was believed to have light up the world. To this end, the advent of board display was invented as a veritable tool in the advertisement world and this was achieved by inscribing letters on the board for members of the public for the purpose of information. But with the advent of the dot matrix which uses Light Emitting Diode LED displays, this made advertisement easier and also improves on the aesthetic nature especially during the night. The uniqueness of the LED is that it consumes only a small amount of power [1][2], and has an estimated lifetime of 10,000hrs and produces an aesthetic visual display[3][4]. The attractive nature of the matrix display makes it more persuasive to both present and potential customers out there in the marketing sector; therefore it should be embraced in the military, universities, banking hall, filling stations etc. for information passage. The display lights up progressively as an effect. Once the message is completely displayed, it latches ON for a proposed time and abruptly disappears; the circuit then resets itself to begin a line scrolling of the character.

2. PRINCIPLE OF OPERATION OF LED DOT MATRIX DISPLAY

Generally, the LED DOT matrix display uses some very smart techniques of digital switching and micro-computing [5][6]. The circuit mostly comprises of power supply unit, signal generation, and control unit, port expansion unit, buffer and driver unit, clock input unit, and display unit. For the purpose of this study, a microcontroller chip atmega16 was used. This chip and its associated hardware periphery comprise of the signal generation and control unit. U1 through U8 are serial in parallel out shift registers (SIPO) with part number 74HC595. These were used to route the control signal coming from a few pins of Microcontroller Unit (MCU) to the output display drivers. This is essential since the MCU has a limited number of physical pins, hence few connections for serial communication resulting in multiple parallel output signals. U10 through U16 are buffer and driver chips used to sink high current through the huge

number of row light emitting diodes (LEDs). These integrated circuits can as well be easily replaced with transistor switches in very high power applications. Clock input unit can be any simple clock generation circuit e.g. a 555 timer astable multi-vibrator with variable frequency control.

3. DIGITAL SWITCHING TECHNIQUE

The method employed in creating characters on the screen is called multiplexing [7]. The screen used in this study was made with individual LEDs connected in matrix form of rows and columns and sectionalized. Each unit is a five by seven arrangement of LEDs. A unit can display a digit or alphabet or character at a time with its 5X7 matrix arrangement. For instance, to display an 'A' on the screen, the equivalent of 'A' is stored as a 5X7 multidimensional array in memory. The storage is in digital form with 1 representing a lighted point and 0 representing a dark point. All possible characters to be written to the screen must be stored in this format so that their binary representations in memory are used to create their shape on the screen in the multiplexing operation.

4. MULTIPLEXING OPERATION

Multiplexing is simply the act of selecting one of many points. It is worth noting that there is apparently no standard way of performing the sequence of switching of the rows and columns. Some implementation may put data on the row and select which column it belongs to while others may do the converse i.e put data on the column and select which row it belongs. The later was used for our design. In both options, the concept is known as multiplexing. To display a 5x7 character on the screen, the control algorithm fetches the digital stored array value of the bottommost row of the character from memory, spits it out through the SIPO shift registers then selects the lowest row called B1 in the schematic diagram. This displays the content of row B1 of the character, some delay is issued to allow the viewer to see it then the data is cleared. Subsequently, the content of row B2 is fetched into SIPO register, some delay given, and the registers are cleared. These steps are repeated through B7. The multiplexing operation results in the entire shape of the 5X7 character we are trying to display. This is due to the phenomenon known as persistence of vision in which a light beam incident to the eye is retained for a while before it is discarded. The

switching action is so fast that the eyes do not detect any flicker from the on-off switching.

5. METHODOLOGY

The method adopted in this study was based on the dot matrix arrangement of which LEDs are arranged in rows and column to display the information "*WELCOME TO THE DEPARTMENT OF ELECTRICAL ELECTRONICS ENGINEERING NIGERIAN DEFENCE ACADEMY KADUNA*". The minimum allowable character size suitable for the dot matrix arrangement is the 5 x 7, although higher numbers of rows and columns arrangement exist. For the sake of this study, the 7 x 60 arrangement was used.

DESIGN SPECIFICATION

The proposed LED display consists of 60 columns x 7 rows of LEDs. It has a total of 60 input lines to show a message. The rows inputs and the column inputs are used for different tasks from each other; either for input data or to enable a row or a column. Atmega16 microcontroller needs a few external circuits (oscillation and reset). Also, once the control of ports on the Atmega16 was established, through simple test programs, the connection of the serial to parallel shift register chain was attempted. A microcontroller provides both dot matrix display elements and driver circuit substantially on the same circuit board.

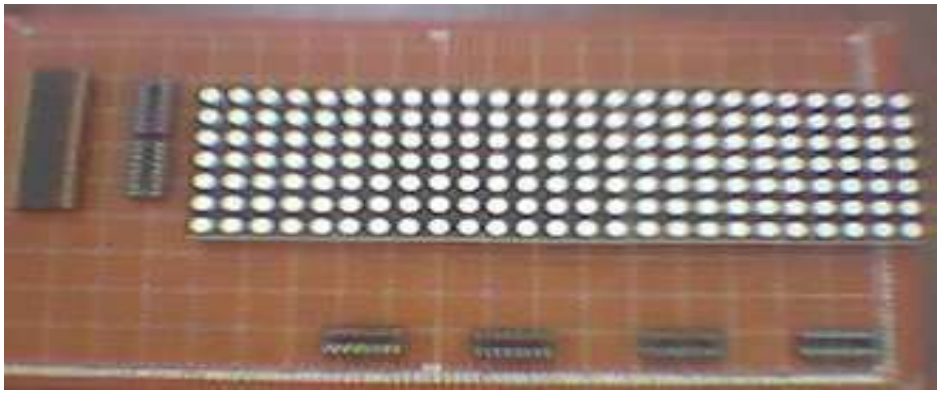

Figure 1. (LED Dot Matrix on Strip Board)

It is mainly composed of an 8 pieces of 74HC595 shift register, one piece of ULN 2004darlington sink driver and one piece of 74HC 259 buffers. Display control signals are serially transmitted to the dot matrix display element driver circuit as indicated in Fig. 1. Firstly a single shift register was wired to the microcontroller, and then two shift

registers were cascaded on the breadboard to trial the cascading process. As each new section of the system was developed it was integrated with the existing circuit. Characters were checked on a breadboard before building them on a stripboard.

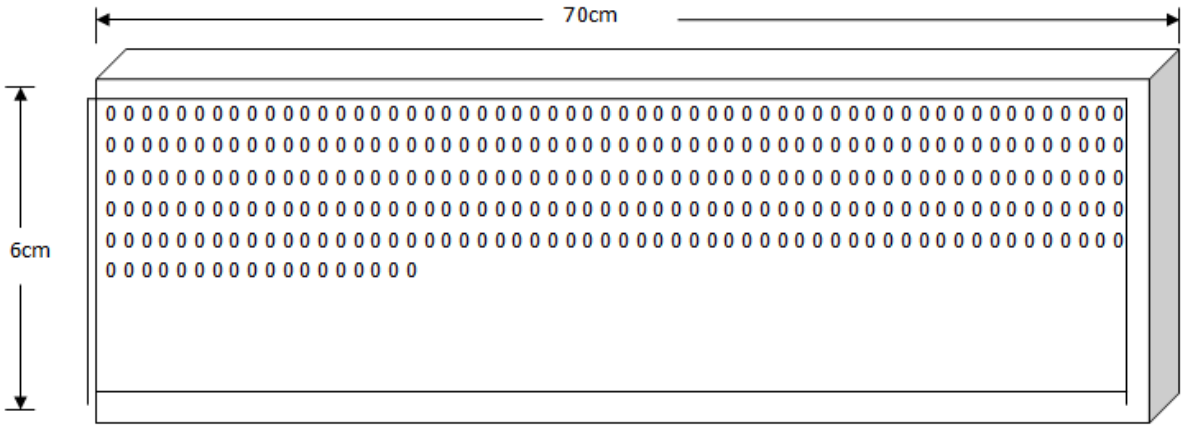

Figure 2. The framed circuit

DESIGN CONSIDERATION

The major consideration in the design of the dot matrix display is the type of light emitting diodes (LED's). In this design, the out-door type is used because it gives a good and better usual display of whatever kind of information of any time of the day with good clarity, As a result of the technology used.

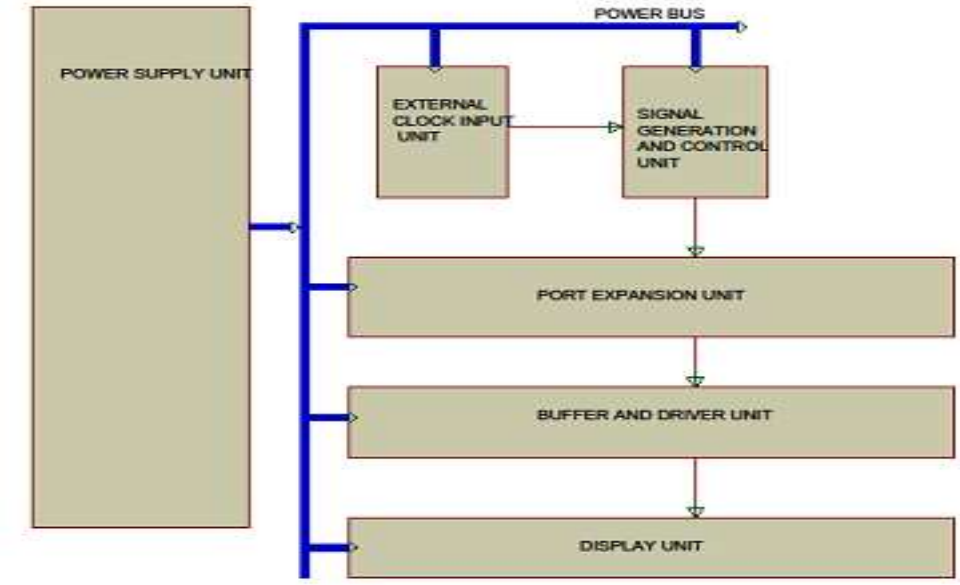

Figure 3. Block diagram of the Led dot matrix display

SIZING OF TRANSFORMER

$$TUF = \frac{Pdc}{Pac} = \frac{V_L}{Pac} \quad (1)$$

Where TUF =0.693 for full wave and bridge and $I_L = 1.5A$ Maximum current

Therefore $Pac = \frac{V_L}{TUF} = 10.82V$ **(2)**

Since the value of 10.82v, was gotten, A transformer size of 12V was used.

ELECTRIC LOAD

N.B the output voltage$V_L = 5V$

Electrical load energy demand one day (EL) can be calculated as follows.

$$Voltage = 5V$$

$$Maximum\ current = 1.5A$$

$$Time\ of\ operation = 24h$$

$$Given\ that\ power = voltage\ x\ current$$

$$Therefore\ for\ 24h\ display, we\ have$$

$El = Pac \times Time = 180W$ **(3)**

N.B From our previous calculations of the power was in respect to the transformer, we will now proceed with our calculations

$$r = 0.1\ TUF = 0.693\ 5mA\ /5v$$

$V = IR$ (4)

$$5/5 \times 10{-}^{3} = 1K\Omega$$

Current supplying LED's=$5mA$ Each I(.E $35mA\ for\ 7\ LED's\ on\ the\ row$)

FILTRATION

$$V_L/I_L = 5/5mA = 1K\Omega$$

$r = 1/\sqrt[4]{3} \times RL \times F \times C$ (5)

$$C = 1/\sqrt[4]{3} \times 1000 \times 0.1$$

$$C = 1/4 \times 1.74 \times 1000 \times 50 \times 0.1$$

$$C = 1/6.96 \times 1000 \times 50 \times 0.1$$

$$C = 1/34800$$

$$C = 28.7\mu F$$

PIV= $Vmax - 0.7$ **(6)**

$$PIV = 11.3V$$

20.18 is not a standard valve so the below capacitor was used.

Capacitor=$22\mu F$ $16V$

$28.7\mu F$ is not a standard value so we now used $22\mu F$

For Regulation of the filtered dc voltage we use, a 7805 regulator IC

$Irms = output\ voltage/\sqrt{2}$ (7)

$$Irms = \frac{5mV}{1.74} = 0.0029A$$

Power $= IV = 0.7W$ (8)

$I(led) = \frac{V - Vd}{R}$ (9)

$$R = \frac{5 - 2.8}{5mA} = 440\Omega$$

$$R(T) = 440\Omega(7\ LED's)$$

$\frac{440}{7} = 62.9 \approx 63\Omega$ is connected to each LED's on the row.

EXTERNAL CLOCK INPUT (SIGNAL GENERATING & CONTROL)

This unit consist of 555 timer (IC), astable multi-vibrator which generates clock pulse signal, it also consist of a resistor and capacitor which together are used to control rate pulse generation. 555 Timer was used to generate the pulse signal in term of the frequency and period of the message displayed.

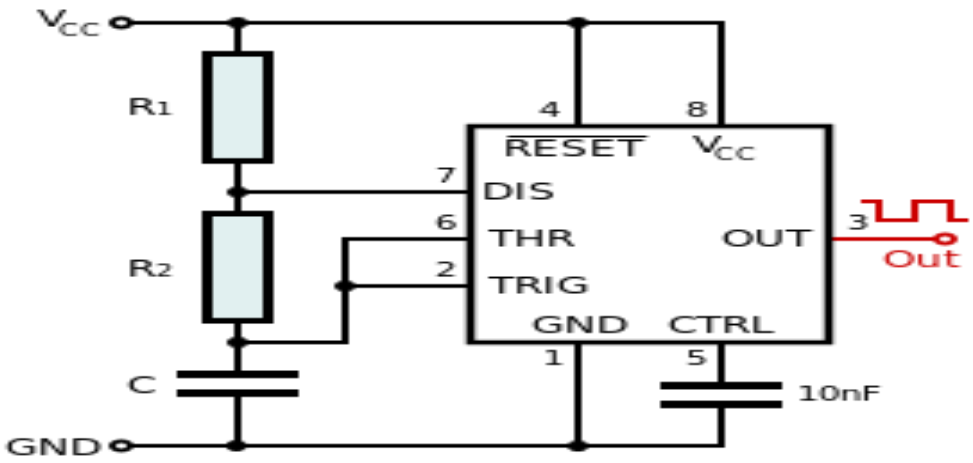

Figure 4. Astable Multivibrator

$$F = \frac{1}{T} \quad \textbf{(10)}$$

To calculate the frequency of the 555timer used is as follows

$$F = \frac{1.44}{(R1 + R2)C}$$

$$R1 = 1K\Omega$$

$$R2 = 1K\Omega \rightarrow 11K\Omega$$

$$C = 22\mu F$$

$$F = 1.44/(1000 + 8000) \times 22 \times 10^{-6}$$

$$F = \frac{1.44}{0.2} = 7.2Hz$$

$$T = \frac{1}{F} \quad \textbf{(11)}$$

$$T = \frac{1}{7.2} = 0.14Secs$$

PORT EXPANSION

As a result of the micro-controller chip ATmega16 with limited number of physical pins, the need for port expansion was introduced which consist of a serial in parallel out shift register (SIPO) with part number 74HC595 resulting in multiple parallel output signal. This is T8-bit serial-in, serial or parallel-out shift register with output latches; 3-state.

6. RESULTS AND DISCUSSION

The AC supply to power the dot matrix display (LDMD) is stepped down by a step-down transformer. The AC 12v output from the transformer is rectified to DC output which is locked down by a regulator transistor (7805) to give out a constant 5v DC which is the required output to power the LED dot matrix display. The device (LDMD) which is a display device that converts electrical Signal transmitted from electronic device into optical signal transmitted using Light Emitting Diodes (LEDs). The modular test was carried out in the laboratory to determine the variation between the ideal value and measured value of the parameters this is shown in Table 1.

MODULAR TEST

A software oscilloscope interface was used to measure the pulse signal generated from the oscillating unit as well as current and voltage of each unit of the system, multimeter was used to measure the input voltage, output voltage and current as compare with ideals voltage.

Table 1. Table of Experimental Results

QUANTITY (IEs)	IDEAL VALUE	MEASURED VALUE
INPUT VOLTAGE	240V (ac)	208.5V(ac)
OUTPUT VOLTAGE	5V (dc)	4.72(dc)
INPUT CURRENT	2A (ac)	1.4A(ac)
OUTPUT CURRENT	4.3mA (dc)	5mA(dc)

7. CONCLUSION

Controlling a 420-LED's moving message display present severe real-time challenge to any Microcontroller in term of it command codes and programming. The prototype used for this study was said to have been extremely developed economically using several strip boards on which the components were mounted. The project was tested in the laboratory and performed according to specification hence; the goal of this study was achieved. Also, the design was done in such a way to accommodate extra features whenever the need arises. The complete system is such that it can be mounted in remote areas (i.e. if powered by a standalone photovoltaic system) as an addressable guide panel or other areas where alternating current voltage are available.

REFERENCES

[1] Anyasi, I.F and Ofili, C. (2004). "Design Analysis of a Light Emitting Diode "Curtain" Display of the Characters (Elect/Elect Eng. Dept). Journal of Engineering Science and Applications 3(2); 65-76

[2] Boylestad, R.I and Nashelsky, L. (2002). "Electronic Devices and Circuit Theory. Eight Edition. Published by Asoke K. Ghosh, Prentice-Hall of India Private Limited.

[3] Cesar T., Jasper O. Molly N. and Eric P. (2017). "Illumination Aesthetics: Light as a Creative Material within Computational Design" Explorative Engineering pp.6111-6122

[4] Daniel, R. Erika, H. Aaron, K. Krisanne, S. Stefanie, A. Shraddha, D. and James, S. (2015). "Light-**Emitting Diodes** A Brief Review and Clinical Experience" The Journal of Clinical and Aesthetic Dermatology. 8(6); 36-44.

[5] Theraja, B.L and Theraja, A.K. (1994). "A Textbook of Electrical Technology. First Edition. Published by Nirja Construction.

[6] Grantham, P. Chi-Ho, C. and Thomas, K. "tricolor light emitting diode dot matrix display system with audio output" The University of Hong Kong, Pokfulam Road, URL:http://www.eee.hku.hk/~gpang

[7] Rob, P. (1983) "The Blit: A Multiplexed Graphics Terminal" Bell Laboratories Murray Hill, New Jersey 07974. Pp.1-16