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Research Article

Design and Construction of Multi-Coloured Led Scrolling Display Using Pic Microcontrollers

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Abstract: This paper develops an easily programmable Light Emitting Diode (LED) based scrolling display. Unlike existing systems, it is designed to display multiple colours writings and alter the characteristics of the message by varying speeds and other properties. Led message scrolling display of multi-colour using microcontroller seeks to develop an information board which could be used everywhere to disseminate information in a more robust and acceptable manner. This work makes use of assembly language as programming language in conjunction with microcontrollers. The circuit was first simulated before carried out actual construction. PIC microcontroller 16F877 was used for this work which has just enough memory space and power for the system is maintained at 12 V which is readily available and hence the whole system can be battery powered so as to cater for power interruption. Testing of the whole design was done using PS2 keyboard port interface in the programming of the display board. The developed system displays 32 letters which can be increased by use of external memory, operates with a 5 v power supply, and has 784 LEDS which are ganged for father viewing distance. This makes a total board size of 0.3 m^2.

Keywords: Light Emitting Diode, Programmable, LED, scrolling display, multi-colour, microcontroller.

INTRODUCTION

The information board is made by the use of a microcontroller unit to produce display pattern that would be displayed on a Light Emitting Diodes (LEDs) board at a very fast rate, taking advantage of the persistence of vision of the human eye, so as to create visual pattern that would look like real life alphanumeric characters from the eye. LED unlike Liquid Crystal Display (LCD) is used in this work; although LCDs are easier to implement or interface with microcontrollers, they are much more expensive, fragile and of a shorter lifespan when compared to LEDs, apart from this, it implements multiple colours on the LED. The system is interfaced with a keyboard, by implementing the Universal Asynchronous Transmitter Receiver (UART) peripheral on the chip, to ensure it is well controlled by the user and the Electrically Erasable Programmable Read Only Memory (EEPROM) memory in the microcontroller is interfaced with it to store a series of binary digits (bits) which in the proper succession, will represent alphabets, numbers, or even symbols and hence display intelligible messages. The term microcomputer is used to describe a system that includes at minimum a microprocessor, program memory, data memory, and an input-output (I/O) device. Some microcomputer systems include additional components such as timers, counters, and analogue-to-digital converters. In this work, the unit is used to set up the information board.

LED scrolling displays have the following benefits over other conventional technologies

- Greater visibility
- Improved Colour
- Less Maintenance
- Low Power Requirement
- Lighter weight
- Smaller size

SCOPE OF PAPER

- Design of a 12V easily powered micro controller LED based scrolling display.
- Implement UART peripheral by interfacing keyboard with the microcontroller.
- To design a system that can be programmed and easily re-programmable.
- To design a multi-coloured LED scrolling display system.

OBJECTIVES

The objectives of this work are to:

- Make use of digital electronics to display information in a unique manner.
- Build a user friendly, keyboard interfaced message board system.

KEYBOARD COMMUNICATION

The keyboard connects to the computer via a five pin male plug or a PS/2 plug. Keyboards and computers work together in a bi-directional format. This means that they can each send information to one another. These bi-directional lines are the clock line coming from the keyboard and the data line coming from the computer.

Both lines must be idle, or high in order for the keyboard to send data. The computer will send a signal to the keyboard through the clock line letting it know that the line is clear to send. If the line is not clear, the keyboard will hold the information until the line opens meaning the communication mode is half duplex.

Scan Codes: Inputs can be sent through a keyboard to the MCU via scan codes. The diagram below shows the Scan Code in Hex assigned to the individual keys. The Scan code is shown, in **Fig. 1** below, on the bottom of the key. E.g. The Scan Code for ESC is 76.

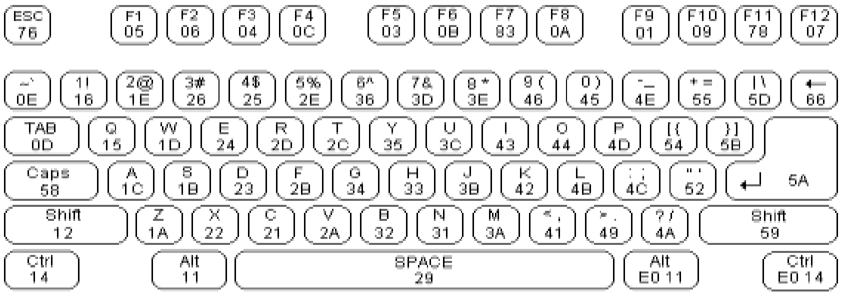


Fig. 1: Keyboard scan codes.

As well shown in the figure, the scan code assignments are quite random. In many cases the easiest way to convert the scan code to ASCII would be to use a look up table.

The Keyboard's Connector: The PC's AT Keyboard is connected to external equipment using four wires. These wires are shown in **Fig. 2** below for the 5 Pin DIN Male Plug and PS/2 Plug.

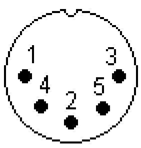
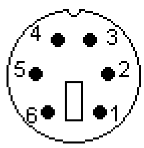
 **5 Pin DIN**	1. KBD Clock 2. KBD Data 3. N/C 4. GND 5. +5V (VCC)	 **PS/2**	1. KBD Clock 2.GND 3.KBD Data 4.N/C 5. +5V (VCC) 6. N/C

Fig 2: Keyboard connector.

HARDWARE DEVELOPMENT

The general overview of how the system is expected to function is shown in **Figure 3** below:

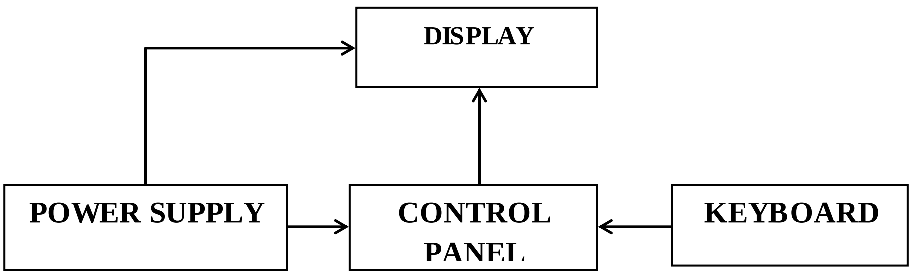


Fig. 3: Block Diagram of scrolling light display system.

The process of the design actually involves setting up individual parts of the figure shown above then linking them up together. First is the setting up of a power supply unit in hardware, next is the design and construction of the display board and then the design of the control panel in which is done first in software, simulated and then implemented in hardware. The software design involves developing a program code, testing it on an emulator software; then, when it functions as required, deploying the code into the microcontroller via the control panel. The control panel then feeds the display board to send out bytes of data through one of its ports to the display section.

HARDWARE DESIGN

The Hardware design first considers the selection of a suitable microcontroller and then the design of the LED display system[1]. This selection process involved gathering the relevant components for the project. These components consist of the power unit, oscillator component, shift register, LEDs, electronic switches (4066IC), optocouplers, current limiting resistors, some capacitors and then some transistor ICs.

Voltage Regulator: Voltage regulators are linear integrated circuits used to convert a voltage applied to their input into a fixed or variable (usually lower) voltage. They come in various forms depending on the voltage needed for example LM7812 regulates to +12 V, LM7815 regulates to +15 V and the LM79xx series to regulate to negative voltages. In this application, 5 V voltage regulators LM7805 is used which gives an output of 5volts which powers the PIC microcontroller and the ICs since they are all CMOS ICs. The regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current.

Shift Register: The HEF4017B is a 5-stage Johnson decade counter with ten spike-free decoded active HIGH outputs (O0 to O9), an active LOW output from the most significant flip-flop (O5-9), active HIGH and active LOW clock inputs (CP0, CP1) and an overriding asynchronous master reset input (MR) as shown in **Fig 3.5** below. The counter is advanced by either a LOW to HIGH transition at CP0 while CP1 is LOW or a HIGH to LOW transition at CP1 while CP0 is HIGH. IC you can shift 8 bits to the outputs with only 3 wires, that are Data (Ds) and two shift inputs. In order to obtain control over the 4017 LEDs in a 27-module display, multiplexing of the I/O to the microcontroller is required. To do this, a series of serial-in to parallel-out shift registers are used to convert a stream of serial bits from the Atmel to a parallel output port to the LEDs. This process effectively extends the I/O of the microcontroller by converting a serial port to a parallel one. To accomplish the large parallel output port required to address each LED, the shift registers (HEF4017B) are daisy chained together. This means the serial output of one stage of the shift register sequence is cascaded to form the input to the next shift register[2].

Voltage Levels: Optical isolators (commonly called opto-couplers) are designed to electrically isolate one circuit from another while allowing one circuit to control the other. The usual purpose of isolation is to provide protection from high-voltage transients, surge voltages and low-level electrical noise that could possibly result in an erroneous output or damage to the device. Such isolators allow interfacing of circuits with different voltage levels and different grounds etc.

TRANSISTOR IC

This was actually used to meet the need of a sequential grounding for the project. These ICs (ULN 2003 in particular) are high-voltage high-current Darlington transistor arrays. Each consists of seven NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads[3].

MULTICOLOUR STRATEGY

For the purpose of switching, we had a number of options. Either we use a switching IC or a multiplexer. But for the project, after a number of considerations, a switching IC 4066 was used for the switching. The IC receives input from one of the ports of the microcontroller and this is used to govern the type of colour that is displayed on the screen. Each IC has 4 electronically controlled switches. And for each colour, seven of these ICs were needed. So that it will be equal to the rows on the screen. This IC is what is used to mix the colours. For instance, we have three colours on the LED. These colours were mixed to form a total of eight (2^3) colours as shown in **Table 1** below

Bits D 0 –Red

D 1 –Blue

D 2 –Green

Table-1: Colour Mixing Code.

S/N	PORT D	Resulting colour
1	00000100	green
2	00000010	blue
3	00000001	red
4	00000110	cyan
5	00000101	yellow
6	00000011	magenta
7	00000111	white
8	00000000	black (off and not shown)

SOFTWARE DEVELOPMENT

Software for the PIC microcontroller can be developed using a variety of languages ranging from Assembly language to Basic, C, Pascal, as long as there is a compiler to convert the code to its machine equivalent usually in hex format which is very close to the binary format. For the purpose of this project, assembly language is used since it is very close to the machine language[4].

Generation of Data: The basic function of the program was to output data codes via a single microcontroller port (PORT B). The development of this program was done in two stages. First was generating the LETTER DATA, and then from the letter data we generated a column control data.

The Letter Data: The message to be displayed was first code generated. The code is done for a standard 5 × 7 display. The LEDs that make up the 5 × 7 display switches on or off rhythmically that represents each alphabet to be displayed.

A typical example is the letter H shown below[5]:

xxxx**x**
xxxx**x**
xxxx**x**
xxxxx
xxxx**x**
xxxx**x**
xxxx**x**

Then from the letter data, the binary code for each column is drawn. For the letter H example it is gotten as

- First column: 11111110
- Second column: 00010000
- Third column: 00010000
- Forth column: 00010000
- Fifth column: 11111110

This data is then stored in the code as a table. Then the UART of the MCU is interfaced with the keyboard for asynchronous transmission. When the keyboard sends a string of data, the MCU receives it into its memory then once the communication is over, the MCU fetches the ASCII from its memory and then feed it to its RAM which in turn jumps to a point on stack based on the value of the ASCII and then writes out the bytes in the stack to PORTB as shown for the letter H above. Hence this pattern is displayed on the screen. It is shifted and displayed at a relatively fast speed to beat the human eye contrast frequency detection threshold which is about[1] 15-30Hz. The text effects such as scrolling and flashing, is implemented within the software of the display, to enhance its ability to attract attention as well as displaying messages longer than the screen length. Single color LEDs are primarily used when the exhibited information is principally simple text i.e., where no emphasis or highlighting is required[6]. Single color LEDs were selected to be used in this work. The creation of the LED display for this paper clearly is not pioneering a new technology or product line, as many examples of similar devices can be found in the market today. But the main purpose of our paper is to implement multi-coloured display which can be used in new 8 coloured displays[7].

Technical Specifications

The individual LED on the scrolling panel acts as a load to the general circuit. From the result, we conclude that for nominal operation, the current through the LEDs must be less than 20 mA and greater[6] than 2 mA. As seen in the **Table 3.2 be**low after this range, the diode current rapidly increases as this could be a source of failure to the system if the diodes start burning out. Operating current for the diodes n this project was approximately 10 mA. Hence total average current drawn by each port B, pin line is:

TOTAL CURRENT I = Current per line x number of lines ... (1)

I = 28 × 10 =280 mA per line.

The voltage drop across each diode ranges from 1.6 v to 2.2 v. Hence the total voltage drop is:

Total Voltage Drop = Voltage Drop across a component x Number of components ... (2)

V= 1.6 × 7 to 2.2 × 7 = 11.2 to15.4 V

Hence for optimum brightness, the diodes operate at 10 mA, 2 V and hence the power dissipated at each LED is averaged at 20 mW which is well in the operating range of the diode and ensures long life of the diode.

Total illumination of the system is given by:

Total Illumination I = Illumination per LED × Number of LEDs ... (3)

Luminous intensity of 1led= 100 mcd

For the whole system, I = 100 × 784=78.4 cd

This range is below the brightness of most lamps but it is just perfect for the scrolling display as it enhances readability and reduces glare.

Type	Colour	I_F max.	V_F typ.	V_F max.	V_R max.	Luminous intensity	Viewing angle	Wavelength
Standard	Red	30mA	1.7V	2.1V	5V	5mcd @ 10mA	60°	660nm
Standard	Bright red	30mA	2.0V	2.5V	5V	80mcd @ 10mA	60°	625nm
Standard	Yellow	30mA	2.1V	2.5V	5V	32mcd @ 10mA	60°	590nm
Standard	Green	25mA	2.2V	2.5V	5V	32mcd @ 10mA	60°	565nm
High intensity	Blue	30mA	4.5V	5.5V	5V	60mcd @ 20mA	50°	430nm
Super bright	Red	30mA	1.85V	2.5V	5V	500mcd @ 20Ma	60°	660nm
Low current	Red	30mA	1.7V	2.0V	5V	5mcd @ 2mA	60°	625nm

Start up: According to datasheets, to smoothen the curve of the start-up voltage into the microcontroller, a capacitor of range (1-10 µF) was used. And to sustain the pulse in the MCLR (master reset pin) a capacitance of 1 µF was used as

Time constant, T, $= \frac{1}{RC} = \frac{1}{10000 \times 0.000001} = 10s.$ ... (4)

Hence the capacitor is used to ensure stability on start up.

CONSTRUCTION

This section of the project report considers the step by step process involved in constructing the system. It considers the development process from the start to the finish.

The Particle Board: The processes involved in the construction of the display unit started with the cutting of the particle board to a dimension of 1150 mm for the length and 240 mm for the breadth using a sharp knife. Followed by this was the spraying of the particle board with black paint which was initially brown. The essence of the selection of black colour for the paint is for total absorption of any stray light that incident on it for proper visibility. Holes were then drilled on the board using a drilling bit of 3 mm so that the LEDs can be properly rested on the board without falling through since it has a size of 4 mm. In the drilling of the holes, an allowance of 25 mm was left for both edges of the length and 3 mm for both edges of the breadth so as enable the board to be attached to the casing without blocking any of the LEDs. A measurement of 20 mm was left between two (2) for the length and 18mm for the breadth so as to make the LEDs compact to increase its brightness. **Figure 4** shows the drilled particle board and **Figure 5** shows the board when connected.

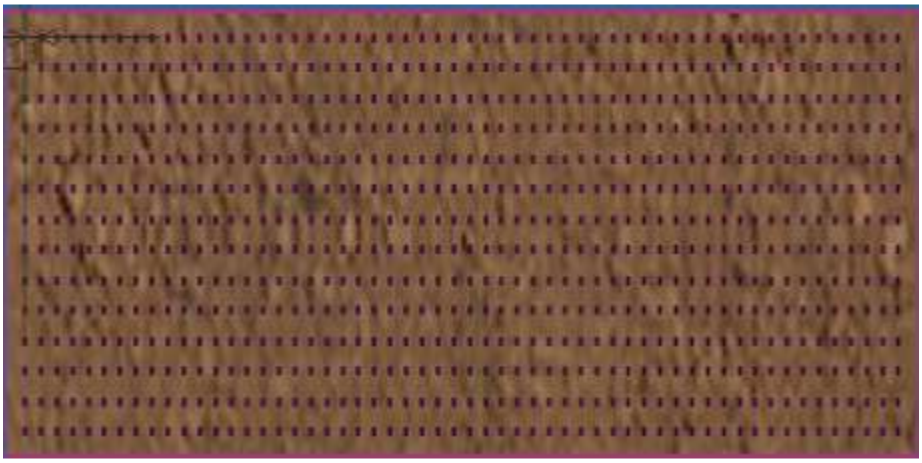


Fig. 4: Picture of a drilled particle board.

This dimension was based on the following calculations:

- LENGTH:

No of LEDs = 56

Distance between LEDs = 20 mm.

Required Length = No of LEDs x (Dist. between LEDs – 1) ... (5)

Required length for LEDs = 55 × 20 = 1100mm

Clearance =25 × 2 = 50 mm

Total Required Length =1150 mm

- BREADTH

No of LEDs =14

Distance between LEDs =18 mm

Required breadth = No of LEDs × (Dist. between LEDs – 1)

Required Breadth distance =18 × 13 =234 mm

Clearance = 3 x 2 = 6 mm

Total Required Breadth = 240 mm

Fig. 5: Showing the internal connections of the matrix display.

MOUNTING THE COMPONENTS

Next, components were mounted on the Vero board, the major ones being the opto-couplers, the capacitors, the resistors and for safety, none of the ICs were mounted on the board directly as the temperature of the solder may over-heat and in turn damage the component. Hence IC base was mounted on the Vero board before ICs are then mounted on the board. The full developed Vero board is shown in **Figure 6** below.

Fig. 6: The mounting of components on the panel back of the project.

RESULTS

After all the simulations and coding were verified to work correctly, the program was deployed to the microcontroller chip and the mounted on the Vero-board then all other connections were made. The figures below shows the working scrolling display with all seven colours for the word ‘this’.

Fig. 7: ‘THIS” in colour green.

Fig. 8: ‘THIS” in colour blue.

Fig. 9: 'THIS" in colour Red.

Fig. 10: 'THIS" in colour Green and Blue.

Fig. 11: 'THIS" in colour Green and Red.

Fig. 12: 'THIS" in colour Blue and Red.

Fig. 13: 'THIS" in colour Green and Blue and Red.

CONCLUSION

The making of a dot matrix scrolling light display is a challenging and painstaking task but, it is worth the while. It reveals the secrets of microelectronics and facilitates a better understanding of electronics in general. This work successfully implemented a multicolored LED scrolling display for only 8 colours now which can be improved upon in order to achieve a full range of 256 colours. It also shows the implementation of keyboard interfacing using the UART peripheral on board the microcontroller.

REFERENCES

1. B. Martins. Interfacing PIC Microcontroller. Published by Elseviey.2006.
2. Byte Craft Limited. First Steps with Embedded systems". Byte craft limited, Canada.2002.
3. Dogan Ibrahim. Advanced PIC microcontroller projects in C", Newness-Elsevier.2008.
4 Ken Arnold. Embedded Control Hardware Design". LLH Technology Publishing. United States of America.2001.
5 Amer Iqbal. Teach Yourself PIC Microcontrollers". Microtronics, Pakistan. 2006.
6 John Iovine. PIC Microcontroller Project Book" Mc Graw Hill, Newyork.2000.

7 F. H. Fahmy, S.M. Sadek, N.M. Ahamed, M.B. Zahran, and Abd El-Shafy A. Nafeh. 'Microcontroller-Based Moving Message Display Powered by PhotovoltaicEnergy' Granada (Spain).2010.

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