

Design and Implementation of Dot Matrix Display System

Oladimeji Tolulope Tunji* and Idowu OD

Department of Electrical/Electronic Engineering, School of Engineering, The Federal Polytechnic, Ado-Ekiti, Nigeria

Abstract

In today's rapidly advancing technology market, most conventional digital display system is now being implemented using individual logic gates and integrated circuits such as microprocessor and microcontroller chips which contain the circuitry necessary to create logic functions are being used to implement digital systems. The advent of new technologies has made information in form of electronic display in the world of advertisement and promotion. The LED dot matrix display is a display system which is used in information dissemination to larger number of audience within the location which it is situated. It has three sections; power, control and display. This which could be grouped into two main part; the hardware and software. The display system physically conveys set of programmed data on the controller card, the hardware part comprises of numbers of LED module, power supply module, controller card and the casing. The software part is the part on the controller card that stores the received programmed data. It uses a volatile memory which allows reprogramming and memory formatting for maximum of 1000 times. The casing of the display system comprises of rectangular screwed and riveted aluminium rod, ACO Board and transparent plastic which covers it both in the front and back. The system switches on automatically whenever it is plugged to the AC supply and it has a minimum efficient life span of 50,000 hours and a maximum viewing angle and distance of 140 degrees and 25 metres.

Keywords: Display; Dot matrix; Interface; Light emitting diode; Module

Introduction

Information is a fact or proof provided or learned about something or someone, conveying or representing a particular arrangement or sequence of thing. It is also any entity or form that resolves or provides answer to some kind of questions (Thesaurus dictionary). Information can be conveyed by different means; sound (audios) and visual (different displays and videos).

An information display is a means of providing information and/or is used as an object for promotion. Information are displayed by manual and automatic mediums. Manual mediums include the use of billboards, signposts, noticeboards, cardboards, different sizes of paper wall-pinned etc. Automatic mediums include the use of electronic display (displaying videos, static and moving text linked with audios). The birth of signs and display can be said to be as old as the existence of man on the planet earth, from the beginning of the world, different types of displays have been used, each mode to serve the purpose of invention efficiently. Signs are any kind of visual graphics created to display information to a particular audience [1]. In 1389, King Richard II of England compelled landlords to erect signs outside their premises. In ancient Rome, signboards were usually made from stone or terracotta [2]. With advancement in technology, man started carving woods and trees. The use of special dyes on wood as a means of identifying special locations. With discovery of bronze and iron, man started using the materials to display signs thus advent of metal sign boards was born, which are mostly used in developing countries.

Background of the study

Electronic display system is widely used in the advertisement world for promotion of goods and services; it is also used in institutions for displaying information, guiding direction, warnings and aesthetic purposes. The use of electronics is now becoming very important. It is extensively applied in almost our day to day activities [3]. Electronic display system as used in this project refers to a sign that uses an electronic hardware and software to display its copy of messages or images to convey particular information. Also, a fixed light source to provide a message in text, image, pictures and/or symbols that may

appear to move or may appear an on/off messages. This is in contrast to the traditional (manual) or non-electronic signs where the copy displayed is physically applied to the surface by printing, painting or otherwise attaching it onto the sign, the material or substrate to which the copy is applied is typically paper, wood, plastic or wall of building [4].

The advent of new technologies has made information in form of electronic display in the world of advertisement and promotion Light Emitting Diode (LED) is a solid-state light source with several attractive properties for display application. LED is a diode that gives off visible light when it is forward biased. It is chosen as main component of displaying messages because, today LED is the most energy efficiency example and useful system. LED technology is frequently used in signs now instead of neon signs this was introduced in 1910 at Paris motor show [5].

In today's rapidly advancing technology market, most conventional digital display system is now being implemented using individual logic gates and integrated circuits such as microprocessor and microcontroller chips which contain the circuitry necessary to create logic functions are being used to implement digital systems [6]. The operations of the LED'S are automated instead of its being static by it given text shape.

LED displays are increasingly being used, as a replacement of traditional lights. The displays are commonly seen singled coloured or having 2 or 3 colours.

***Corresponding author:** Oladimeji Tolulope Tunji, Department of Electrical/Electronic-Engineering, School of Engineering, The Federal Polytechnic, Ado-Ekiti, Nigeria, Tel: +234-8030896393; E-mail: tululopett@yahoo.com

Received April 04, 2019; **Accepted** April 18, 2019; **Published** April 25, 2019

Citation: Tunji OT, Idowu OD (2019) Design and Implementation of Dot Matrix Display System. J Telecommun Syst Manage 8: 178.

Copyright: © 2019 Tunji OT, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

The ordinary LCD display/Flat panel display is also being widely used and is classified into two namely; the active matrix display and the passive matrix display [7]. The difference between the two is the level of their resolution. The active matrix display has a high resolution while the passive matrix display has a low resolution.

Dot matrix display becomes more widely accepted because of its utilization of the modern technology having abilities of displaying moving and static text and images.

There are two types of the dot matrix display; the LCD dot matrix display and the LED dot matrix display. Due to the reoccurring problem with the LCD and the difficulty with combining different display module, the LED dot matrix display is the most common and most times when the word dot matrix display is mentioned it directly refer to the LED dot matrix display. The dot matrix display is a form of electronic digital display system which as being used in the world of advertisement, in warning signs on roads, railway lines and direction guides and location awareness [8]. They are also made use in public places such as hospitals, airport, bank, stock exchange, bus stand, restaurant, etc.

A LED dot matrix displays consist of LED panel and driving circuit for row and column with simple x-y addressing. The LED matrix is an array of LEDS on a panel in the form of a matrix i.e., having a number LEDS on the row and on the column. There are three scanning method that can be used namely; row scan, column scan and dot by dot scan. These are usually employed in large displays that call for complex controllers processing power. In present day, a Single Chip Microcontroller (SCM), Complex Programmable Logic Devices (CPLD), Field Programmable Gate Array (FPGA) along with other digital Integrated Circuits such as latch, shift registers, etc., are used to simplify data transmission path and control signal path in PCB layout.

When large dot matrix is being designed, the problem of flickering and lower luminous intensity increases. As the sizes becomes larger to reduce the flickering, frame rate and refresh rate need to be increased in both horizontal and vertical directions [9]. Microcontroller is used to control its operations; different types of microcontroller are being used depending on the amount of information to be stored on it and depending on the nature of instructions that will be programmed on it. Experts has confirmed it that the dot matrix display helps in conservation of energy, since it require little energy for its operations and it's cost of maintenance is low. The Federal Polytechnic, Ado-Ekiti, have spent a lot on annually refurbishing and renovating the school. "Name and address" on the wall and board at the administrative block to make it always visible and attractive, but less attention does it invites, and also the amount of electrical power expended in order to ensure lightening at the gate to make the signs obvious at night is no small power. The dot matrix display to be constructed will have the following text displayed on it; "The Federal Polytechnic, Ado-Ekiti" "Training for Skill and Expertise", School of Business Studies, School of Environmental Studies, School of Engineering, School of Science and Computer Studies", and the department in those various school, the school logo, time and date. The implementation of these will proffer a solution to this reoccurring problem in the world of information dissemination [10].

Objective of the project

The objective of the project is to enable student to bring into application the theoretical knowledge and practical experiences learnt in school into solving problems that arise in everyday life as regards visual information dissemination and providing a more effective means

of conveying information which will be cost-effective and energy conserving and with a longer life span. It also involves programming of the desired text and parameter, which will expose student to the field of programming and embedded systems, registers, it's also include a communication medium to enable transmitting of the written program and construction of a frame work [11].

Significance of project

Due to the problem of frequent reoccurring uncirculated mass information dissemination as a result of the manual or analog means of information dissemination. The project will attract larger viewers and enhance circulation of information to almost all expected audience.

It will also serve as a means of digging into the technology of microcontroller and some other basic electronic components such as transistors, resistors and regulators and solid state electronic materials in general because all these will be used in the design and implementation of the dot matrix display and ensure that viewers get the adequate information that is displayed in good and attractive words [12].

Material and Method

Design block diagram

The design block diagram indicates the stages involved and the working operations of the LED dot matrix display, linking both the software and hardware parts. It shows the first stage which is the programming stage from which instructions is being sent and this which is done by dedicated user interface software which states what is to be displayed on the set of modules [13]. It also shows the power supply stage which is the heart of the operations i.e., the power source which energizes the controller card and the led modules (Figure 1).

Expanded block diagram

This block diagram shows the process within the power supply unit and the signal flow from the controller card to the led module (Figure 2).

LED dot matrix module

It is an array of LEDs connected such that the leads of the anode are connected on a row like form and the leads of the cathode are connected on a column like form. The ends of the connection are connected to an IC and power connector such that they are all synchronize together and coordinated as a single device. For the purpose of this project the array is in (16×32) pixels [14].

Below shows the architecture of the led array for an (8×16) pixel led, the same array is used for larger connection such as the (16×32) the difference will be in the number of ICs used and the type used for the major IC (Figure 3).

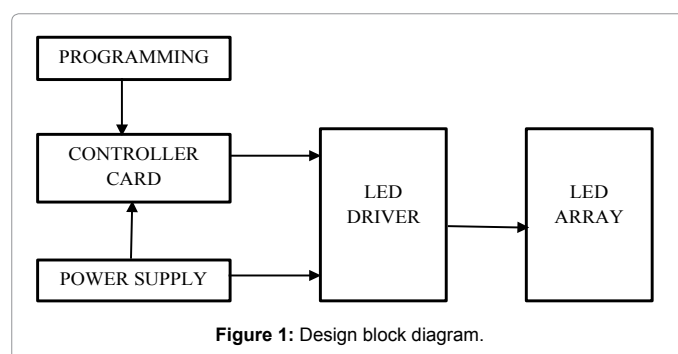


Figure 1: Design block diagram.

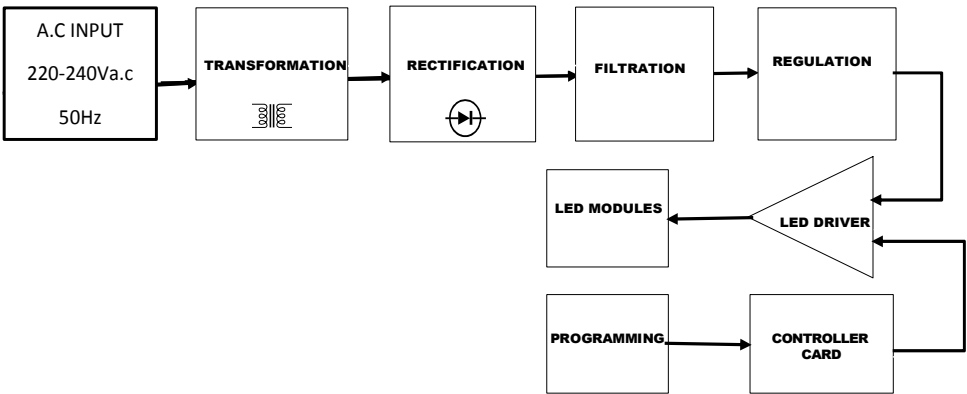


Figure 2: Expanded design block diagram.

http://www.manelsoft.com/projects/pic16f84a_matrix_led_display.aspx

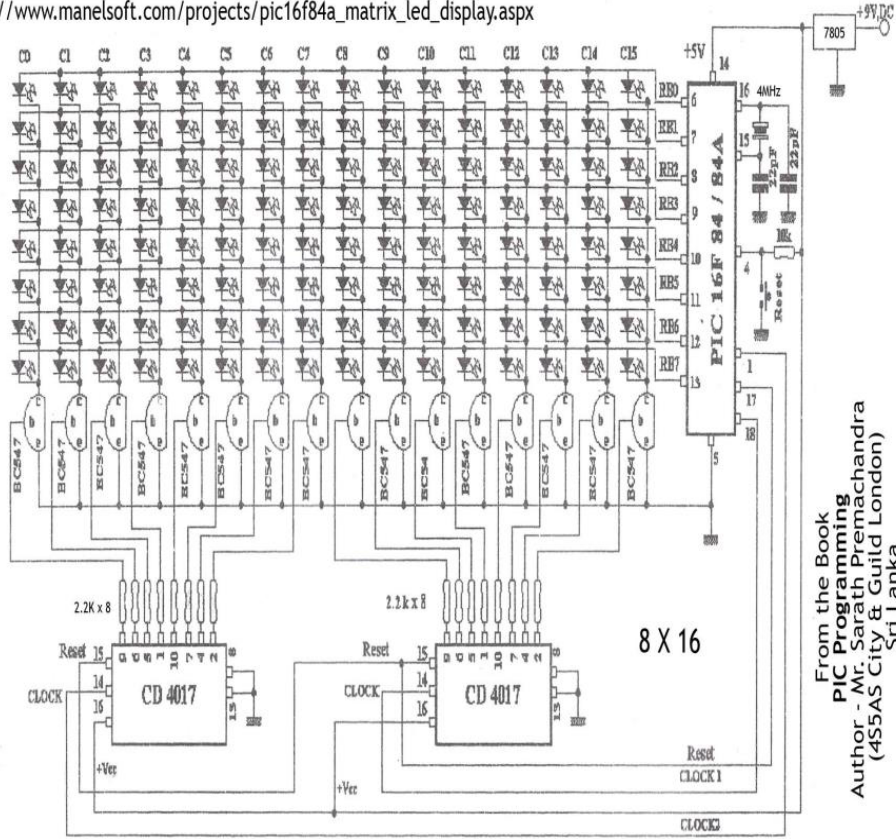


Figure 3: Universal led connection/architecture (8 × 16) as a sample.

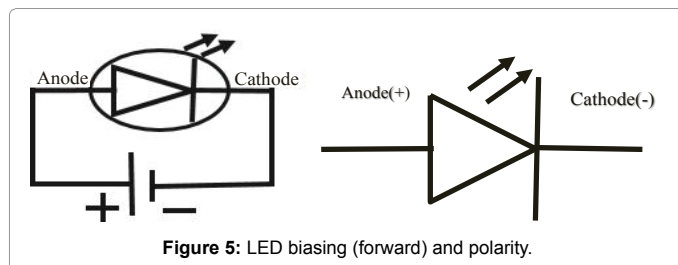
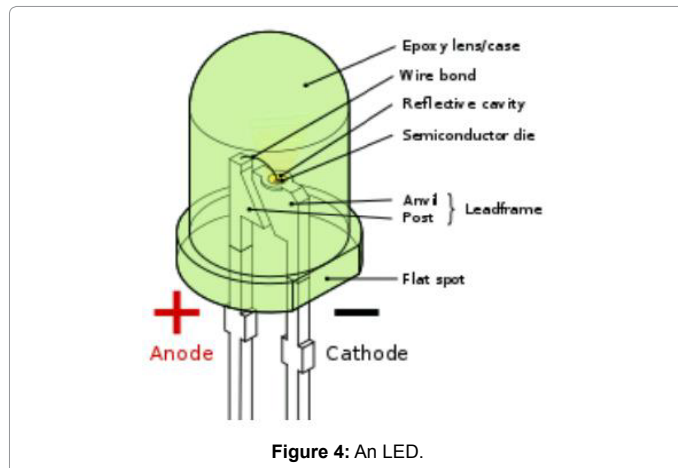
From the Book
PIC Programming
Author - Mr. Sarath Premachandra
(455AS City & Guild London)
Sri Lanka

Light emitting diode (LED): A light emitting diode is a two-lead semi-conductor light source. It is a P-N Junction diode that emits light when activated. When suitable current is applied to the leads, electrons are able to recombine with electron holes within the device releasing energy in form of photons. It emits visible light. For the purpose of these project the LED to be used will emit a red colour visible light. Typically, each led consumes 10-20 mA current and 2.5-5.0 V DC [15]. Each led has the following part making it up; the epoxy lens/case, wire bonds, reflective cavity, semi-conductor die, anvil post, flat spot, anode lead, cathode lead. The image and parts are shown in Figure 4.

LED biasing: Led biasing is the process of connecting the P-N leads of a LED to a DC supply. LED biasing can be divided into two, namely:

1. Forward bias
2. Reverse bias

Forward biasing is a biasing type whereby voltage is applied across the LED in such a way to allow the flow of current and the voltage applied is called the Forward voltage. Reverse biasing is a biasing process whereby voltage is applied across the LED in such a way to



prohibit the flow of current [16]. For the purpose of this project, the biasing method to be used will be the forward bias, since this activates the LED and enable it to emit light. The biasing is illustrated in Figure 5.

LED pixel pitch: The pixel pitch is the center to center distance between two LEDs after it has been arranged and connected on a PCB. The pixel pitch for this project is 10 mm, and this is usually acronym as P10. The pixel pitch determines the quality of image or text to be displayed, the smaller the pixels pitch, and the brighter the display output will be [17]. For text display alone the p10 led module is efficient as it could produce a luminous of 5000 CD/m² which tells the minimum viewing distance of 10 m and best viewing distance of 15 m (Figure 5).

LED scanning mode: Scanning mode describes the working mode of each led in an array of connected LEDs. Not all LED are on at the same time, scanning switches on each LED when needed at succession. The scanning mode of a LED state the number of LEDs working at an instant of time, which means at an instant of time there are some LEDs off while others are on. If each LED are made to turn on and off at the rate of not less than 50 times a second, it won't be noticed by human eye known as perspective of motion. The scanning mode implored in this design will be a ¼ scan mode i.e., at any instant of time one out of every four LEDs is ON [18]. The scanning mode could be row by row, column by column or random.

The following are what is affected by the scan mode

1. Brightness: High scan with more LEDs on at a time, causes higher brightness and lower scan causes lower brightness.
2. Refresh rate: Lower scan produce lower refresh rate than higher scan although the refresh rate could be influenced by the PCB design.
3. Power consumption: The higher the scan mode, the higher the amount of power to be consumed.

4. Reliability: Since not all the LEDs operate at the same time, the life span is then improved.

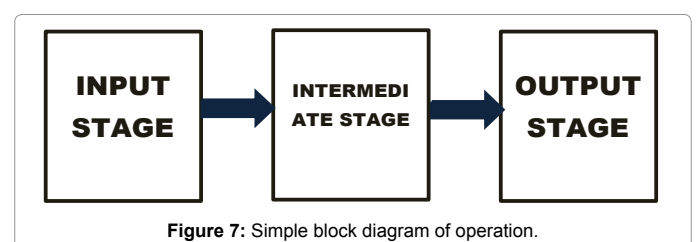
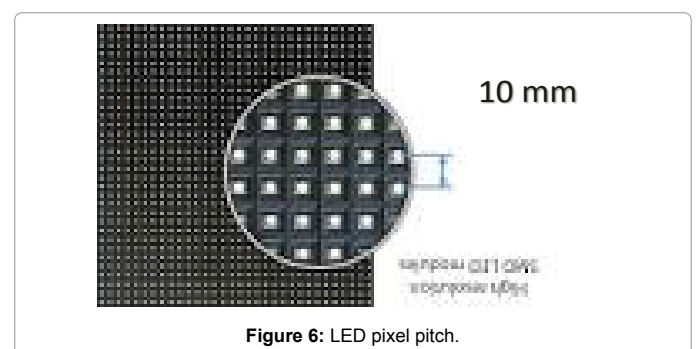
LED drivers: This is an electrical device which regulates the power to an LED or a string of LED. An LED driver responds to the changing needs of the LED or LED circuit by producing a constant quantity of the power to the LED as the electrical properties changes with temperature and some other environment and factors. The type of LED module has an inbuilt LED driver which may not be visible because of the surface mounted technology. The design made use of the ring counter which is connected into the shift register, to enable driving of the LEDs. On the module circuit is found this which is an IC and the following is written on it (TC5020DAP) and (DP4536) [19]. These both drives the column and row arrangement of the LED.

Power supply unit

The electrical energy is not usually consumed the way it is generated and distributed. Most household appliance needs to step down and convert the received alternating current to direct current. For the purpose of this project, the power to be consumed is direct current as we will be dealing majorly with semiconductors. For this to be possible, the project will be making use of a power supply module; Switching Mode Power Supply (SMPS 200 W 5 V) × 3 [20]. There various processes involve in production of a suitable output able to supply the modules and controller card.

SMPS module

The switched mode power is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source to DC loads. Unlike a linear power supply, the pass transistor of a switching mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. Ideally a switch mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time, it has an advantage of higher power conversion efficiency and a Smaller size and lighter weight from elimination of heavy line frequency transformers and comparable heat generation and less standby losses (Figures 6-8).



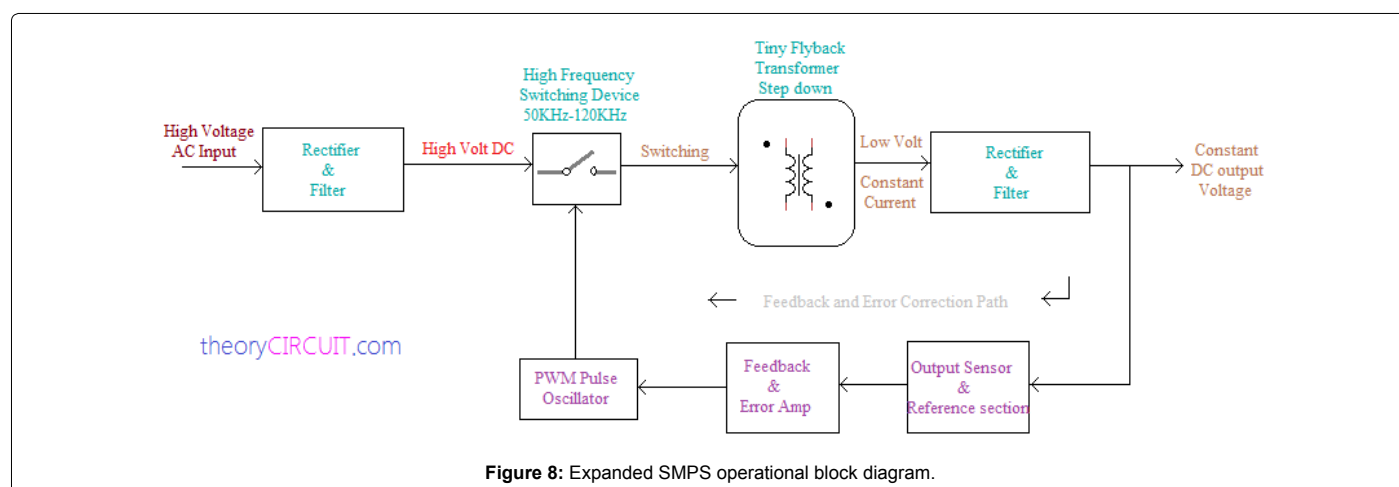


Figure 8: Expanded SMPS operational block diagram.

It has three major stages: input, intermediate and output [21].

1. Input Stage: This is the stage which takes in electrical power from the mains (220-240 V AC) through the live, neutral and Earth terminals and passes through a rectifier and filter and to an high frequency switch and transformer and then to the intermediate stage.
2. Intermediate Stage: This is the stage which involves a feedback system and a pulse width oscillator. It performs error correction and excites the switching system
3. Output Stage: this is the stage where regulated multiple output voltage is produced and then conveyed through connector given four terminals V+, V+, V- and V-.

SMPS circuit: Below shows the circuit diagram and functions of some parts were explained.

1. Rectifier: This is the part of the circuit which does the conversion from the AC voltage to DC voltage, this is achieved by the use of a diode as shown in the circuit
2. Fuse: This also functions to protect the circuit from over voltage.
3. Switching: The switching function of the SMPS is achieved by an IC, i.e., the TNY267 [22].
4. Regulator: The required output is 5 V DC and to achieve this 5 V zener diode is used.
5. Optocoupler: This is the part which connects two separate electrical circuit together by means of a sensitive optical interface, it has an infrared diode which beams an infra-red signal to a photo-transistor on the other circuit.
6. Transformer: The part of the circuit which uses a tiny flyback transformer in stepping down of the input to an approximate of 9 V.
7. Neon lamp: This is a miniature gas discharge lamp used in indicating the presence of current in the circuit (Figure 9).

Controller card

There are lot of controllers and microcontroller that can be used to print on an LED dot matrix display. For the purpose of this project, the controller card to be used is the TF-A6UW (HUB 12). It is a pre-



Figure 9: SMPS power supply module.

designed controller card with a major function of printing information on LED dot matrix display. It comes with a program-Power LED that can be installed on a computer used for reprogramming the controller.

The controller card also comes with features like a USB connector to interface with the system, this enables it communicate with the application for reprogramming the controller. Moreover, it also has a temperature and humidity sensor which can also print their measurement on the display.

The following are the specs of the TF-A6UW controller card:

TF-A6UW: The TF-A6UW is a controller card type which is used for both single and double colour LED modules [23]:

1. Model: TF-A6UW
2. Function introduction: More arbitrary division, dazzle colour border area, WIFI communication
3. Usage: indoor/outdoor
4. Pixel: Single colour 768×32 ; 384×64 ; Double colour 384×32 ; 192×64
5. USB function: USB program update, USB brightness adjustment, USB panel setup. Settings stored as a file format and do not affect the original document in USB. SD card/mini-SD card is Compatible when using USB.
6. Ports: Two 08 ports; four 12 ports
7. Scanning mode: Support 1/16, 1/8, 1/4, 1/2, Scan the monochrome, double colour module
8. Storage: 2 M

9. Program number: Support at most 200 programs, each program supports 16 partitions simultaneous play, each image-text 200 messages. (Quantity in storage space under the premise of memory)
10. Display: Rain, fountain, scroll and much more
11. Border: Support many Colour border, Picture border
12. Flash format: Support GIF, SWF
13. Image format support BMP, JPG, GIF, WMF, ICO
14. Communication way stand-alone, LAN, Internet remote cluster management [24]
15. Brightness level: 16 highlighted, support manual
16. Screen switch: Manual
17. Test buttons: Test buttons on-board, can switch over to test mode
18. Extension function: Temperature sensor/temperature humidity sensor (Diagram for connection), monochrome expand height, through to 75 full-colour interfaces.
19. Electrical parameters: +5 V DC (5.0~6 V), power consumption<3 W
20. Working temperature: -30~76°C
21. Size: 56 mm × 88 mm.

The text to be programmed on the controller card is shown in Figure 10.

“THE FEDERAL POLYTECHNIC ADO EKITI, EKITI STATE, PMB 5351

- SCHOOL OF BUSINESS STUDIES and all departments available
- SCHOOL OF SCIENCE AND TECHNOLOGY and all departments available

- SCHOOL OF ENVIRONMENTAL STUDIES and all departments available
- SCHOOL OF ENGINEERINGS and all departments available
- Date, Day and Time. The text will be animated with several styles.”

Factors considered for material selection

There are several factors put into consideration for material selection, they help in making sound judgment when making decision concerning suitable material for a project, they can be grouped into environmental and electrical factor [25].

Environmental factor: They are environmental conditions of the area where the display is to be mounted they include

1. The ambient temperature
2. Level of exposure to open air
3. Rising or setting of sunshine
4. Rainfall in location during the year
5. Humidity of the area

Electrical factor: There are factors about the energy being supplied:

1. The voltage range being supplied
2. The stability of energy from distribution company
3. Regular power spike or power surge in supplied power
4. Nature of electrical power backup
5. Number of operating hours requires.

Cable and connectors

They are electrical cables used in the electrical signal transmission in a circuit or system and also connectors used in the termination of current or data signal.

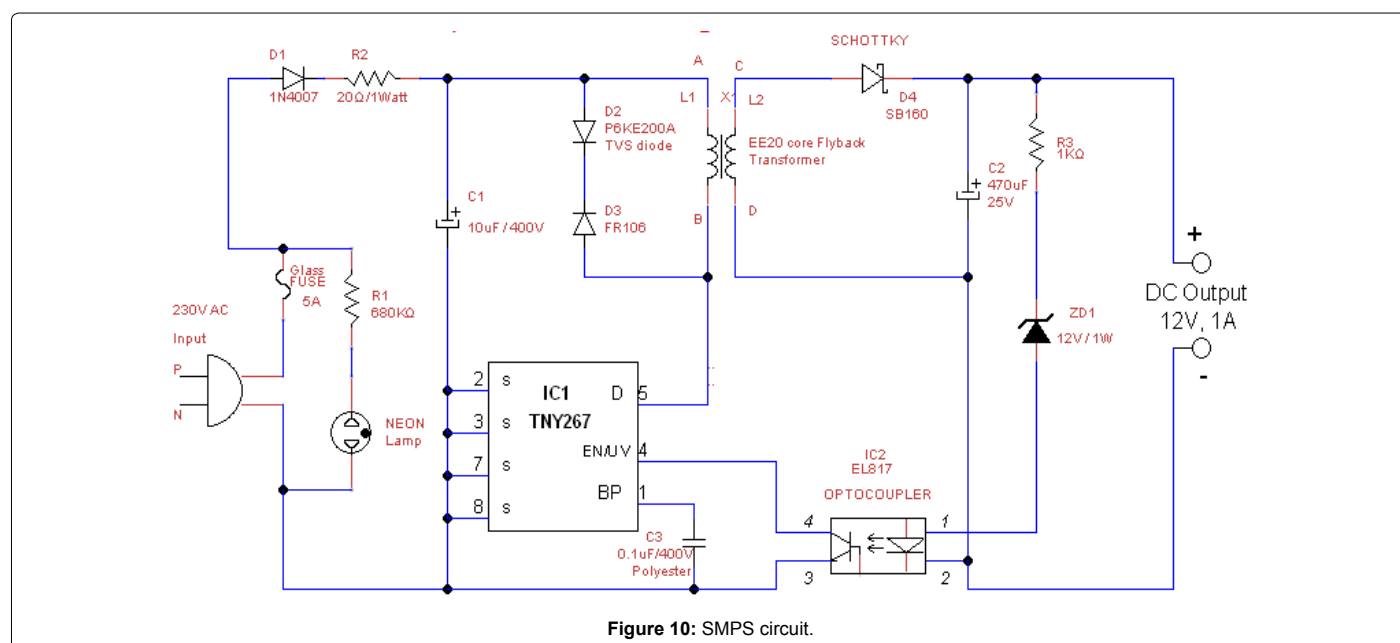


Figure 10: SMPS circuit.

Cable

There are four cable types and can be classified into two groups which will be used for the construction of the project.

1. **Internal Cables:** These are cables that will be inside the construction. They won't be seen except if the casing is opened. They include the flat cable for connecting each module together for the purpose of data transmission to the display and 5 V power cable for supplying power to each of the modules and the controller card [26].
2. **External Cables:** These are cables that appear outside the casing of the project. This is the power supply cable which is used to take power from the socket (220- 240 V AC) It is a three-core cable having the -- Live, Neutral and Earth terminals (Figure 11).

Connectors

There are two main connectors used in termination of signal at modules and controller card:

1. **IDC connector:** Insulation displacement contact is a flexible signal designed to be connected to the conductor of an insulated cable by a connection process which forces a selectively sharpened blade through the insulation thereby eliminating the need to strip the conductors of insulation before connecting.
2. **2 PIN JST connector:** This is the connector attached to the end of the 5 V power supply cable to terminate power to the LED modules, it as a polarized type of connector having a 2 female points (negative & positively) (Figure 12).

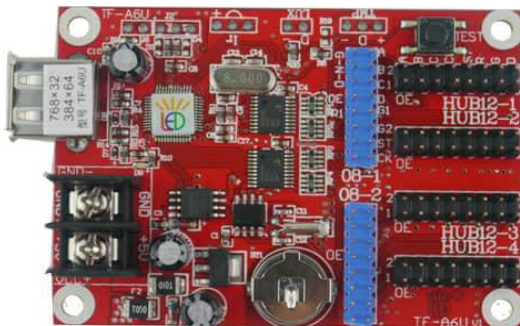


Figure 11: TF-A6UW controller card.

Casing

The casing will comprise of three major parts namely: The framework, the plain plastic covering and the ACO Board. The frame work will have an internal dimension of 6.3 by 2.1 ft [27]. The transparent plastic covers the LED modules, protecting the LEDs from direct exposure to the environmental hazards such as rain, humidity, dust and heats etc., in Figures 13-17.

The casing will be coupled by screws and riveting, and the drilling of holes will be done at a uniform distance.

Programming

The programming of the controller card is the process of writing of instruction to be displayed on the display and this will be done by the (Power LED version 2.88.9) and the parameter needed are the information to be displayed and also the password required to access the controller or establish a communication medium between controller card the computer and to set up the panel on the Power LED software.

The transmission process is done in seconds, with a high-speed using the Wi-Fi.

Design calculation

Electrical power consuming materials are:

1. LED Modules
2. Controller card
3. Power supply module.

LED module consumption: Each Led module has 512 LEDs. A typical LED consumes 10 mA hence if all LED on a module were to be on at the same time total consumption is:

$$512 \times 0.01 = 5.12 \text{ A}$$

The LEDs were connected in parallel to 5 V DC

Power consumed $P = IV$ watts

where $I = 5.12 \text{ A}$

$V = 5 \text{ V}$

$P = 5.12 \times 5 = 25.6 \text{ watts}$ for a single LED module

Using 24 LED modules, the total pixel then becomes

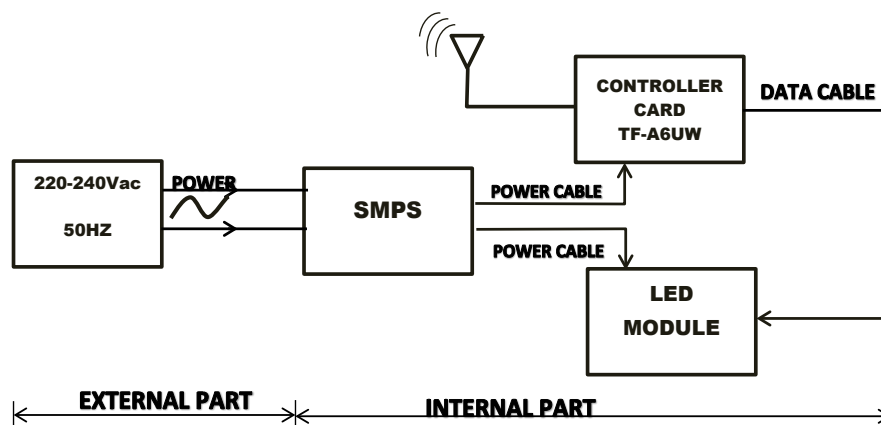


Figure 12: Design block diagram.

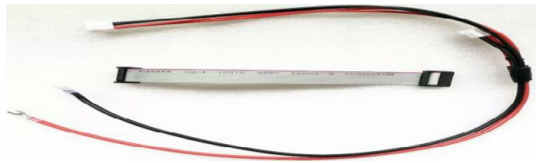


Figure 13: The connecting cables and connectors.



Figure 14: Architecture of ACO board.

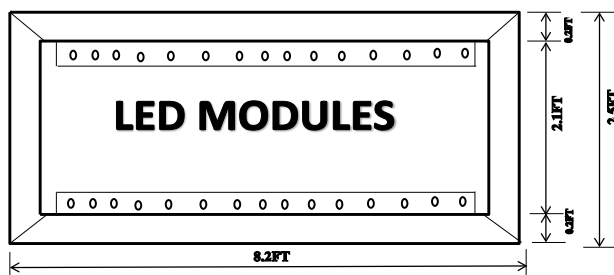


Figure 15: Architecture of framework.

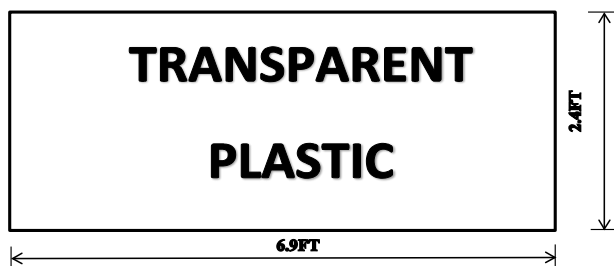


Figure 16: Architecture of transparent plastic.

$(16 \times 32) \times 24$ dimensioned as 4 by 6= (64×192) pixels

Hence total power consumption by the 24 modules then becomes

$25.6 \text{ W} \times 24 = 614.4 \text{ Watts}$

Total Current equals $5.12 \times 24 = 122.88 \text{ A}$

Considering the scan mode which is $\frac{1}{4}$

Hence the new total calculated power= $\frac{1}{4} \times 614.4 \text{ W} = 153.6 \text{ W}$

New total current= $\frac{1}{4} \times 122.8 = 30.72 \text{ A}$.

Controller card power consumption

Voltage=5 V DC

Power=0.5 W

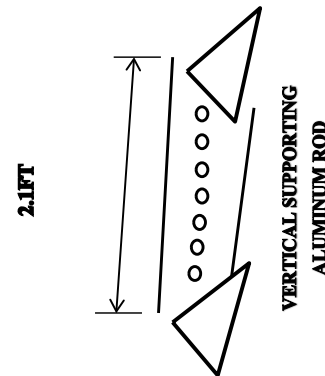


Figure 17: Vertical supporting rod.

Total power=Power \times No of Controller cards= $0.5 \times 1 = 0.5 \text{ W}$

Power consumed in connecting cable and PCB for each module=0.25 W

Hence 24 modules= $24 \times 0.25 = 6 \text{ W}$.

Therefore, total consumed power by the design=LED consumed power with/without scan mode+Controller Card consumed power+connecting cable and PCB.

When scan mode is not applied;

Total power= $614.4 + 0.5 + 6 = 620.9 \text{ W}$

When scan mode is applied;

Total power= $153.6 + 0.5 + 6 = 160.1 \text{ W}$.

Power supply module

Input Voltage=(220-240) V AC

Power output=200 W

Output Voltage=5 V

Output current=40 A

Hence to generate enough power for the design maximum power consumption we then make use of four modules which therefore generates

$200 \text{ W} \times 3 = 600 \text{ W}$.

Specifications

Specification deals with detailed description of the characteristics of the components, device or equipment. The specification is used as stated to help understand the system. The project specification is as follows

1. Input Voltage: Single phase (220-240) V AC
2. Supply Frequency: 50 Hz
3. SMPS Module output voltage: 5 V DC
4. SMPS module power script: $200 \text{ W} \times 3$
5. Controller card input voltage: 5 V DC
6. Controller card power: 0.5 W
7. LED module input voltage: 5 VDC
8. LED module input power: $25.6 \text{ W} \times 24$.

Results, Discussion and Conclusion

The project is the design and construction of an LED dot matrix display dimensioned (6.3 × 2.1 feet) is a gradual process which includes the construction of a frame capable of housing 24 LED modules and the use of a power supply module capable of supplying the LEDs and other circuits involve, the use of a controller card capable of storing and conveying information required to be display and coverings such as the transparent plastic and ACO board which gives physical protection from environmental hazards.

This project has enabled student to put into practice theoretical classroom room-based knowledge in the production of tangible electronic device, thereby bridging the gap between the classroom theory and their practical application.

The execution of the project has broadened student knowledge on the practical application of the following; wireless communication, principle of operation and a common connection and control of the light emitting diode, applications of some computer program and their interaction to the environment, the use of different Integrated Circuit (ICs) [28].

The project will also contribute to technological growth in the aspect of information dissemination involving display boards and add to the beauty of the environment. It will increase the percentage of people getting information due to its attractive, viewing angle and viewing distance.

It is our belief that a highly improved version of this project can be achieved by adding special features to the already produced ones.

Recommendation

Since the project is limited to the construction of a display system to display text only, it is recommended that in such project to be done by student, they should design the project to display different colours and produce an audio output and such it will be capable of displaying pictures with their full colour and also videos, this feature will attract more audience.

The major challenge of this project is finance, as this limits the size of this project, as such it is recommended that if such expensive project is given to student, the department or the school should encourage student by financing part of the projects to encourage execution of standardize project. The school should also try giving out project topics from the first year of study to give enough time for research, design and construction and encourage student to avoid procrastination so has to hasten the project implementation.

References

- Qureshi AI (2014) Let make LED matrix displays. Microtronics, Pakistan, pp: 192-194.
- Augarter S (2009) The most widely used computer on a chip, a photographic history of integrated circuit. Ticknor & Fields, New York, pp: 1-2.
- Bellu R (2006) Automobile. All French cars, History & Collections Nr 78s.
- Rubadou B, Hansen SD (2012) Colour dot matrix proof of concept. Worcester, pp: 1-4.
- Kapoor D, Pandey R, Vaid R, Patil MV (2016) Electronic dice using dot matrix display. Thomson Reuters, India, pp: 1-2.
- Ibrahim D, Louis (2006) 30 projects using pic basic and pic basic pro. Mpg books ltd, Great Britain, pp: 1-3.
- www.wikiwand.com/en/Dot_Matrix
- Fahmy FH, Sadek SM, Ahmed NM, Zahran MB, Nafeh ASA (2010) Microcontroller based moving message display powered by photovoltaic energy. Re & Pad, Egypt, International Conference on Renewable Energies And Power Quality Research, Granada, Spain.
- Kasilingnam G, Ramaligam M, Sekar C (2014) A survey of light emitting diode (LED) display board. Indian Journal of Science and Technology 7: 188-185.
- Pang GKH, Chan CH, Kwan TTO (2004) Tricolour light emitting diode dot matrix display system with audio output. University of Hong Kong Annual Journal, pp: 1-10.
- Steve H (2003) Embedded systems design (2ndedn). Newness, Burlington MA, USA, pp: 11-12.
- https://en.wikipedia.org/wiki/History_of_display_technology
- San HT, New CM, Tun HM (2014) Implementation of pic based LED displays. International Journal of Electronics and Computer Science Engineering 3: 191-198.
- Phillips (2018) LED life expectancy, Phillips, USA.
- Linda L, Chris (2012) Discovering computers. University of Florida archived, Chapter 6, pp: 30-35.
- Silverstein LD, Roosendaal SJ, Jak MJJ (2006) Hybrid spatial temporal colour synthesis and its applications. Journal of Society for Display 14: 3-13.
- Matick RE, Link DT, Gupta S, Dill F (2006) All point addressable raster display memory. Journal of Research and Development 28: 325.
- <https://www.newbiehack.com/MicrocontrollerIntroductionABeginnersGuidetotheAtmelAVRAtmega32.aspx>
- Microchip Technology Inc. (2008) SMPS AC/DC Reference design user guide. DS70320B, pp: 1-10.
- Mazidi MA, Mazidi JG, Mckinlay D (2007) The 8051 microcontroller and embedded systems using assembly and C (2ndedn), Prentice Hall, USA, pp: 2-3.
- Pervez MF, Mortuza AA, Hassan A, Haque MAS, Ghosh HK, et al. (2016) Novel scanning technique for LED dot matrix display to reduce flicker. Institute of Electronics, Atomic Energy Research Journal Bangladesh, pp: 19-24.
- Reddy NJ, Venkareshunaru G (2013) Dot matrix displays. International Journal of Electrical/Electronic and Data, India 1: 50-54.
- Okechukwu OF, David T, Don OVU (2013) Design and construction of a moving text display digital board. Pelegia Research Library, Nigeria, pp: 512-525.
- Saini B, Devi R, Dhankar S, Haque MZ, Kaur J (2014) Smart LED display boards. International Journal of Electronic and Electrical Engineering 7: 1057-1067.
- Simpson A (1978) Testing methods and reliability electronics. The Encyclopaedia Americana (Volume 26), Macmillan Press Ltd, London, pp: 755-756.
- TF-Wi-Fi control cards (TF A6UW) Data sheet, pp 1-6.
- TC5020(S&CIC0996) data sheet.
- Mehta VK, Mehta R (2008) Principle of electronics. Chand S & Company, New Delhi, pp: 125-132.