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An Efficient Solar Powered-Microcontroller Based Digital Led Display System

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Abstract
This paper presents a design of solar powered microcontroller based digital LED display board. The solarpowered microcontroller based solution presented in this work utilizes a non-conventional display technology format HUB 12 driven from a PIC 18F4620 microcontroller through a serial peripheral interface (SPI) communication protocol. Text to be displayed are written or received in their ASCII format and mapped into the display area from the SPI via shift registers. It also integrates the transmission and reception of information through a computer unit with the aid of a radio frequency transceiver module (KYL-500S) to ensure information flexibility. The system is powered by a renewable energy source using 12V/200W solar panel, two 12V/7Ah batteries and a charge controller. The results obtained showed that the system can display any form of text message information provided characters are mapped unto the display area using hexadecimal code from the standard ASCII character.

Keywords: **microcontroller, shift registers, transceiver, solar panel**

1. Introduction

An information display is a way of providing information and/or is used as an object for promotion. It can be seen in a form of cardboard or tarpaulin at stores/shops, streamers and electronic display devices. But the advent of new technologies made the information display in the form of an electronic display most common nowadays especially in the world of advertisements and promotions.

Display technology plays a critical role in how information is conveyed. As a picture is worth a thousand words, display technology simplifies information sharing. Right until late 20^{th} century, Cathode Ray Tube technology (CRT) has been dominating in the display industry. However, new trends such as the desire for mobile electronics have increased demand for displays and surpass CRTs in areas such as picture quality, size, and power consumption. Some of the latest devices likely to replace CRTs are Liquid Crystal Displays (LCD), LEDs, Plasma Displays, Field Emission Displays, and

Electronic Paper. LEDs, being composed of light emitting diodes, can emit their own light to offer thin and power-saving displays. LCD is known for its lightweight, low operating power, and compact design, Plasma Displays generate excellent quality images on very large screens. Field Emission Displays can produce high resolution images like CRTs without the bulky appearance. The makers of Electronic Paper are trying to replace print by developing displays with many paper-like properties. According to Perez. R. (1988), demand for higher quality displays will drive technology evolution; this evolution will require new approaches and innovative ideas in information presentation

An LED display, or light emitting diode display, is a flat panel display that uses light emitting diodes as the display element. An LED display panel can be either a small display or part of a larger display. LEDs used in order to make up LED displays offer several advantages in comparison to other light emitting sources. A light emitting diode is made up of a semiconductor chip which is surrounded by a transparent plastic case. The plastic case allows the light to pass through it. The emission of different colours including ultraviolet and infrared light depends on the semiconductor material which is used in the diode.

According to Brennesholtz (2007), the development of electronic based information display system has covered numerous technologies since its beginning. Cathode ray tube and other significant technologies such as liquid-crystal devices in various forms and light emitting diode (LED) displays have all played an important role in the evolution of electronic display systems.

Tolentino, A.J(2007) designed an “electronic service counter” using LED dot matrix and PIC16F84.This design is limited in the sense that it can only display 2-digit up-counter from numbers “00” to “99”. In another work by Embudo,M. and Tano E. (2007),an “Animated LED Dot Matrix Signboard” was designrd using a 5x7 dot matrix display and the PIC16F84 microcontroller. The signboard outputs a sequential and graphical display. It is designed using shift registers and drivers to latch data and to drive the dot matrix display, correspondingly.

Lewin and Edwards (2002) presented an “8x8 animated LED signboard” commonly used as a Christmas decoration. This project uses a 3mm round LEDs that are closely fitted. It uses octal flip- flops to drive the row and column lines of the display since PIC16F84 does not have enough I/O ports to drive all the LED directly. Also, the memory limitations of PIC16F84 become apparent

with an 8x8 display.

A wireless system was designed wherein the display board need not be reprogrammed to display a new message. This design was aimed to develop a mobile sign board which makes the user to change the scrolling message using SMS service instantaneously. The user can update it even from aremotedistant.Onceread,theSMSisdeletedm akingentryfornextincomingSMS(Guptaetal.2 013).One of the main interesting applications that have led the use of embedded system in communication is the public addressing system. The audio or video systems like public announcement system, programmable sign boards are generally hardwired and hard to enlarge. These limitations can be trounced by the use of wireless interface such as GSM (Ketkar P.U et al. 2013). One limitation of the GSM-SMS design is that an unauthorized user could have access to it and send an unauthorized message to the display board. A LED scrolling message display system using Android application was designed. This system used Bluetooth technology to communicate from Android phone to LED display board (Gorishankar and Mritha.C.S. 2014).

The advancement in the technologies related to wireless communication has led to the emergence of several engineering designs to aid the human requirements. Kamboj and Abrol (2013) presents a combination of wireless technology with LED display boards to overcome the difficulties faced by the existing message display modules using wired connection to computers, keyboards and other less distance remote controls. The message is sent through a cell-phone which is accepted by the GSM module SIM 300 (master). Number authentication is done by AT89S52 microcontroller and the stored numbers in EEPROM is compared with the incoming number. The message will be valid only after the incoming cell phone number is validated. Authentication result is displayed on LCD. Further the same SMS is itself sent by GSM module (master) to multiple LED display boards which are connected via different GSM modules (slaves).

2. Methodology and System Design

In designing a display system, one or more platforms are used in other to build a flexible and reliable system that can easily be operated and new message(s) can be integrated into the system with less difficulty. For this project, choices were made on what type of platform, software component, hardware component and the mode of operation of the display system.

Choices made were based on certain considerations such as low cost, availability, reliability, flexibility and simplicity.Compared to other existing methods of designing this project, the solar power (as a means of power supply) and Radio frequency mode (as a means of communication network) for the microcontroller based LED display is found most appropriate due to low cost, availability, efficiency, reliability andsimplicity when used for thisproject.

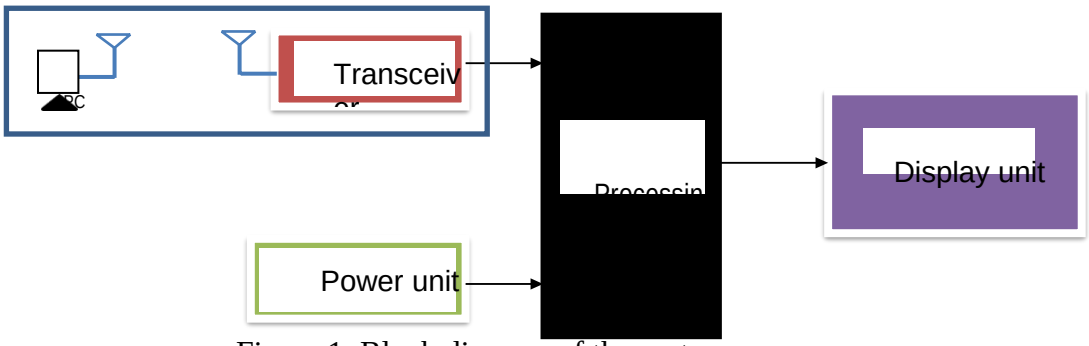


Figure 1: Block diagram of the system

2.1Design Analysis

The System is divided into four sections as shown in figure 1.2 above. Each of these sections forms an integral part of the entire system. Thesections comprises of the communication unit, processing unit, power supply unit and the display unit.

The controller unit which is connected to the display unit has a function to control rows and column drivers of the display system in order to get the desired word/message transmitted by the communication unit.

The display unit comprises of the LED Dot Matrix, Row control, Column control as shown in figure2.

2.1.1 Display Unit

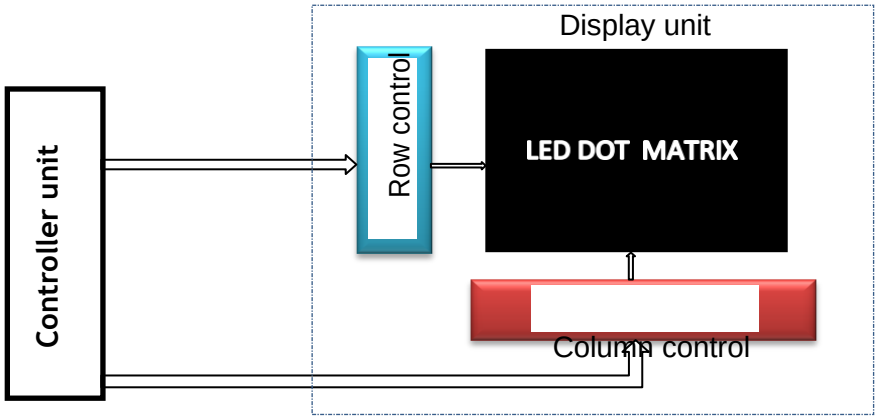


Figure 2: Block Diagram of Display Unit

2.1.2 Led DotMatrix

An illuminated display module usually consists of various resolutions such as the 4 x 8 matrix LED. For this design, the P10 (RG) two-colour 16x32 LED display panel is used. This board has bright 512 LEDs matrix panel with on-board controller circuitry designed. This LED display board, just like many LEDs are connected in serial form. The 16x32 LED display panel with 512 LEDs are arranged in 16 rows and 32 columns structure as shown in figure 1.4. In selecting the LEDs to use for simulation of the design, the 4x8 dot matrix display is used for the sake of compatibility to the simulation software that was used(PROTIUS 8)

Figure 3: 16x32 module configuration

2.1.3 Row control

The row control section is part of the control circuitry of the display unit. It connects the row of the LED matrix to the microcontroller. The MW4953 is used on the row driver which is connected on-board the 16x32 LED display board. There are 8 FET drivers that controls the row of the display board.

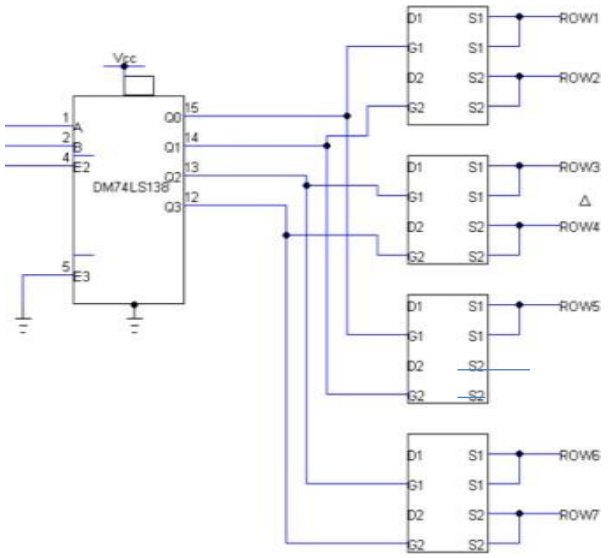


Figure 4: Row driver circuitry

The 74HC595 IC 8-bit shift register can shift 8 bits to the outputs with only 3 wires, which are Data (Ds) and two shift inputs (SH-CP, microcontroller. The 74HC595 IC is a series of serial-in to parallel- out shift register used to convert serial bits to a parallel output port to the LEDs. By shifting the shift registers each shift register is cascaded to form the ST-CP). The LEDs are controlled bymultiplexing the I/O to the

(74HC595) together, the large parallel output port required to address each LED is accomplished. This means the serialoutput of

input of the next shift register

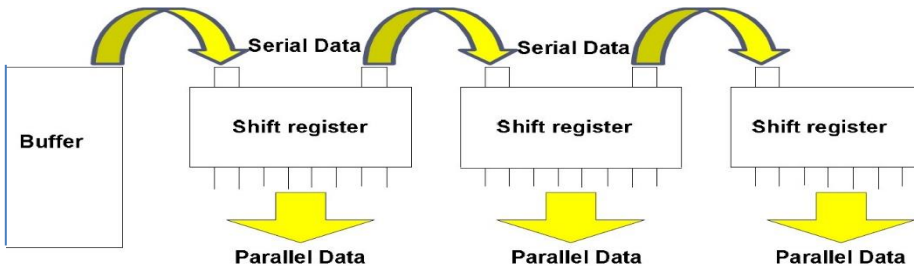


Figure 5: Serial in Parallel Out

The devices have two separate registers within it, a shift register and a storage register; each register is provided with a separate clocking input: SH_CP and ST_CP. In operation, data is fed serially into the register through data source (DS) pin and is shifted on the positive-going transitions of theSH_CP input when connected in this cascading manner. The parallel outputs of the shift registers are not rated to handle enough current to illuminate the LEDs that they control (Htet San et.al 1956).The column control section connects the column of the display unit to the microcontroller. The 74HC595 IC 8-bit shift register is used to drive the column of the display. There are 8 74HC595 shift registers on-board the 16x32 display board. These shift registers are connected to the microcontroller through a buffer (74HC245).

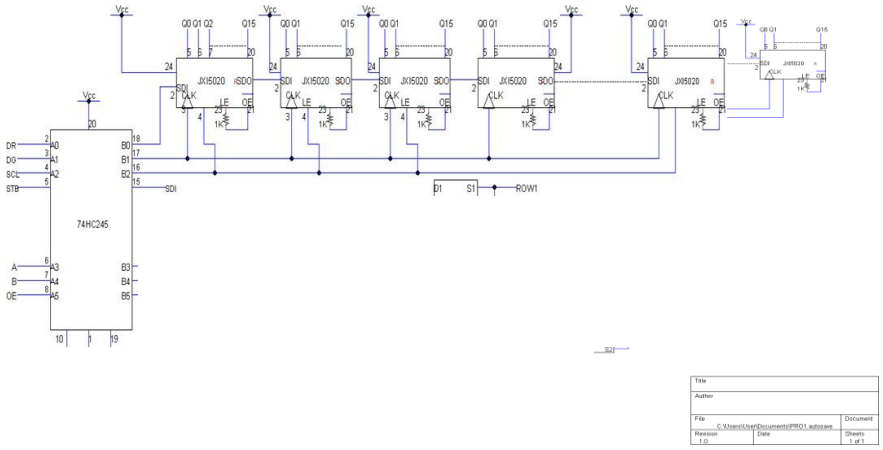


Figure 6: Column control circuitry/row column drivers

2.2ProcessingUnit

The processing unit is the central controller of the operations of the LED Display System. It comprises of a microcontroller which houses the programmed logic;the PIC PIC18F4620 was used, reasons that it possesses some special attributes such as, increased instruction set, internal EEPROM and RAM, as a result, LEDs could be directly connected to microcontroller pins. Also, it has low power consumption which helps to further manage energy consumption rate. Figure1.10 gives the pin configurations of PIC18F4620.PIC 18F4620 microcontroller is used as control unit. PIC 18F4620 microcontroller consists of 40 pins. Pin11 and 32 of the PIC 18F4620 are connected to the Vcc while pin 12 and 31 are connected to the ground. Pin13 and 14 are connected to 22MHz oscillating crystal. In

this system, PORTC and PORTD are used for output pins and PORTB is used for input. PORTC and PORTD are connected to the transceiver. PORTB pin 25 and pin 26 is connected to pin 3 and pin 4 respectively of the KYL 500S RF receiver. PORTC pin 15, 16 and 18 are connected to input A, B and CLK of the 74HC245 while PORT B pin 33 and 34 are connected to input OE and STK of the 74HC245. Enable 1 and 2 are always enabled by connecting them to theVcc.

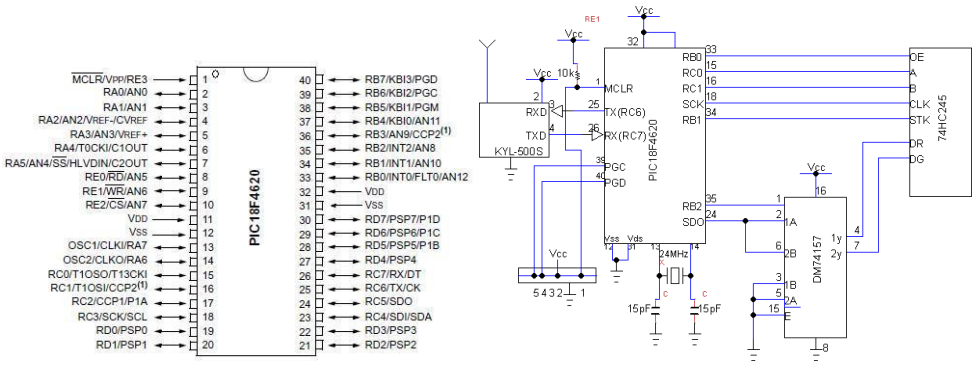


Figure 7: Pin configuration of PIC18F4620

2.3 The Communication Unit

Commonly used communication media include twisted pair of copper (called twisted pair medium), power lines, fiber optic cable, coaxial cable, wireless infrared and radio frequency (RF). Each medium has different strength and weaknesses. The RF technology is used in this design. The block diagram of the communication circuit is shown in figure 9 below.

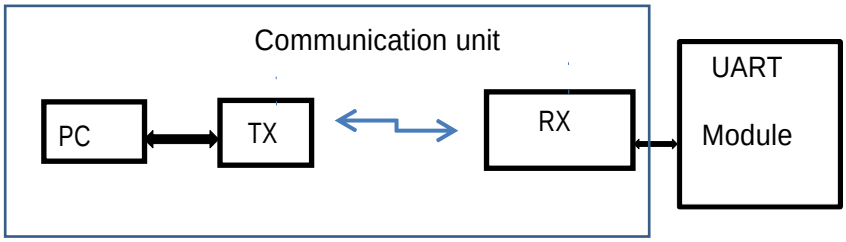


Figure 8: Block diagram of communication unit

2.3.1 PC -End

The PC-End is made up of a PC and a transmitter circuit. A Transmitter is a device that is used to transmit signal to free space at certain frequency.In the transmitter part of the communication unit of the system, a normal PC with standard keyboard or a laptop is required. The PC is connected with the transmitter by using USB to RS232 connector. When message(s) is inputted from the keyboard of the PC, it is transmitted through the transmitter to the receiver by using Air interface. The transmitter used in this design is a 12 channel KYL-500S with a baudrate of 9600 and operates at a frequency of433.92MHz.

2.3.2 **Display Communication End**

The receiver is used to receive signal from free space through the antenna .The Receiver part of the communication unit receives the data sent by the transmitter and are taken to the controller unit which checks the validity of the Data received. If the data (each letter) received is defined in the program inside its ROM then it will process that data for Display. Like the transmitter, the frequency of receiver that used is 433.92MHz.The type of the receiver isKYL-500S.

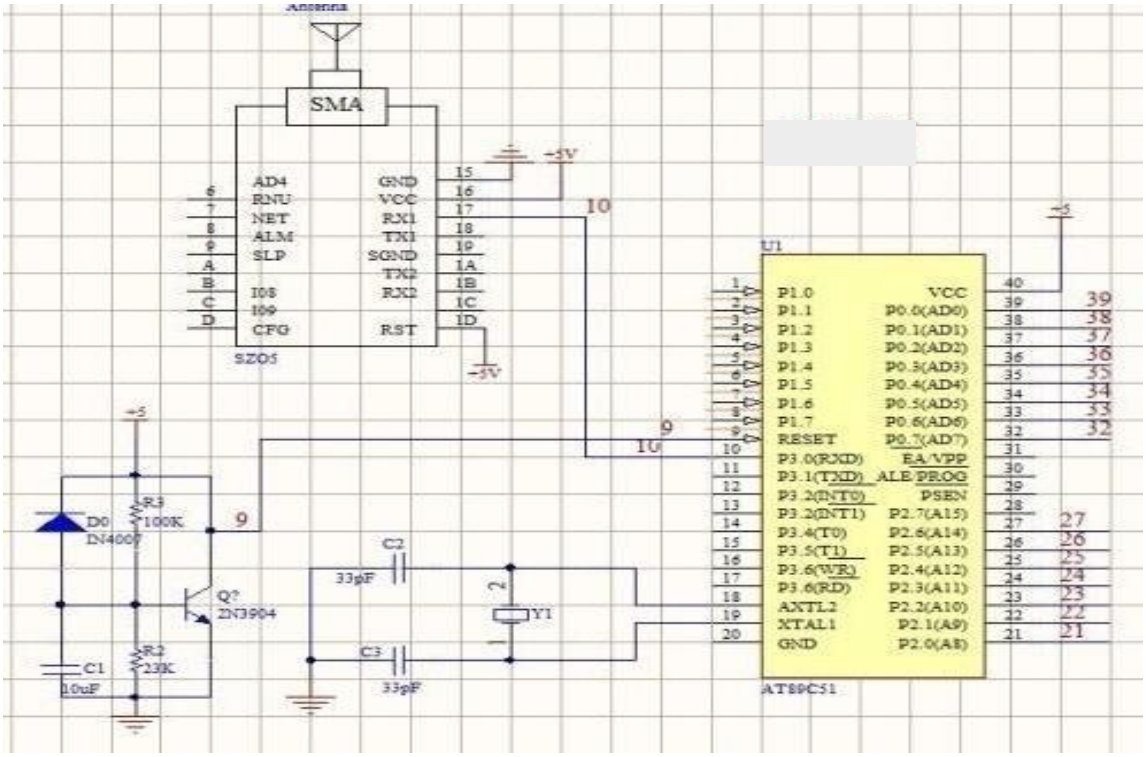


Figure 9: Receiver circuit

2.4 PowerUnit

The power unit is responsible for supplying power to the entire system. Figure 14 shows the block diagram of the powerunit.

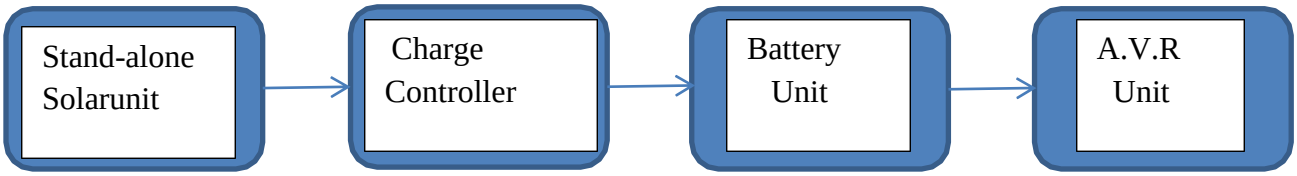


Figure 10: Block diagram of power unit

The stand-alone solar unit consist of amonocrystalline solar panel. Monocrystalline solar panel is used because of its efficiency of 15-20% and it performs better at low sun-light intensity. In order for the excessive voltage not to damage the batteries, a charge controller is used to maintain the proper charging voltage on the batteries. As the input voltage from the solar array rises, the charge controller regulates the charge to the batteries preventing any over-charging. The electricity generated from the PV cells cannot be used directly to power the display system or any other system; instead the electricity is first used to charge a DC battery which would then be used to power the system. There are many types of batteries used for solar systems, a 12V/7Ah lead-acid battery is used as it has the advantage of low maintenance requirement, high tolerance to overcharging, high reliability can deliver very high current and it is cost effective. The output voltage of the power supply unit is regulated by means of a positive IC voltage regulator: 7805 IC.The system requires a 5V supply. However, direct 5V is not readily available in the market which calls for the use of a 12V battery to power the system. The automatic voltage regulator unit regulates the voltage from the 12V supplied by the battery to 5V that is needed by the system.

The battery capacity is calculated thus:

$$Battery\,capacity = \frac{\mathbf{M}axLEDPower \times desired\ operating\ time}{Operating\ voltage}$$

Putting the values we have;

$$Battery\,capacity = \frac{8.05 \times 24}{12} = 16.1Ah$$

For 24 hour operating time = 16.1Ah X DOD

(N/B: DOD (depth of discharge) = 30%)

= 16.1 X 30% = 4.83 Ah

In this design, a 7Ah battery was used. This battery will last for:

Operating hours = $\frac{24 \times 7}{4.83}$ = 35 hours= 1 day, 11 hours

The maximum power requirement of the entire system is 208.005W

2.5 Character MappingDesign

The character map describes or defines the look of each character that will be displayed on the dot matrix. Firstly. The hexadecimal codes of each character (A-Z, 0-9 and some symbols) are generated by making equal square boxes.

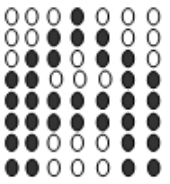
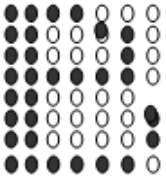
Character	LED Display	Character Map
A		1Fh 3Fh 6Ch 0CCh 3fh 1fh
B		0ffh 0ffh 91h 91h 71h 0eh
C		7eh 81h 81h 42h

Table 1: Control codes written in micro C compiler

2.6 Mode of Operation

The Principle of Operation of the system design mainly depends upon the following four functions.

1. Serial interface between the PC and

KYL-500S using RS-232 communication protocol, and then there is wireless interface between KYL-500S transmitter and KYL-500SReceiver.

2. Row and Column selection of the LED Dot Matrix Board are done by using PIC 18F4620 Microcontroller along with the help of decoders, this is due to the proper received message from the PC.

3. Whatever message is to be displayed is given to the PC through standard PC keyboard. The message to be displayed is only of English letters and numerical from 0 to 9. This message is transferred to the PIC 18F4620 microcontroller from the PC by using KYL-500S which is connected with PC by RS-232 serial communication in the form of ASCII code for the corresponding letter typed in PC. The message typed in the pc with the keyboard is converted to ASCII with the help of designed graphic user interface(GUI).

4. The corresponding ASCII code for the character typed is transferred to micro-controller through the MAX-232. The PIC18F4620 microcontroller reads the corresponding letter typed with the help of RXD pin. The program for selecting the rows and columns is written in C programming language and is stored in the PIC18F4620 microcontrolleritself.

5. The entire system is powered by a 200 W, 12 V monocrystallinesolar panel, alongside a 12 V/7 Ah lead-acidbattery.

3.Results

In the execution of the display unit, the LED module which uses the HUB12 technology houses or contains a row and column driving system for the display already mounted on the module. The module

comes with a length and width of 16x32 LEDs with terminal for interfacing as many as possible port. In order to interface this module, a 5V supply must be connected to all the modules. However, data interface can be plugged from one module to the other.

The PIKIT 2 programmer was used to program the PIC18F4620 microcontroller and the codes were written in the C environment using the micro C compiler. First, the data type was defined to be signed or unsigned. In order to define the various pins of the microcontroller, the protocol drive, which is the master synchronous serial port (MSSP) was first understood to be SPI

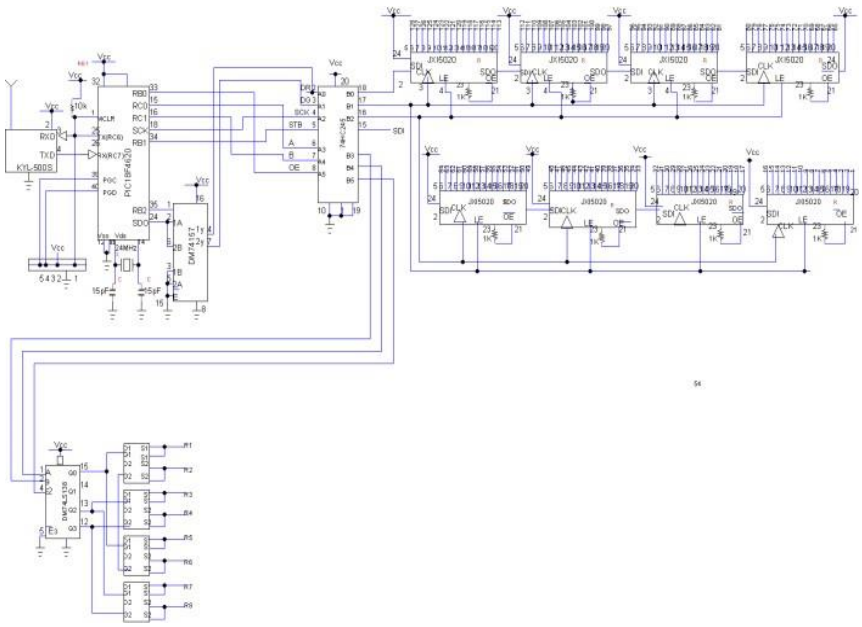


Figure 11: Complete circuit diagram

synchronized. Further, the various pins were defined to be input/output and control pins and the entire lines of codes were written. Refer to appendix to view the entire code. A hexadecimal code was first generated for all the alphabets (A-Z), numbers (0-9) and special characters.

Conclusion

The display consists of a dot matrix of LED arranged in a rectangular configuration such that when powered, characters to be displayed scan through it. This enhanced display system makes our communication more efficient and faster because of the renewable and reliable source of energy or power and also the method in which messages are being changed which is through a radio frequency technology.

Certainly, this model may be able to work under any circumstances with greater efficiency, as it does not need any man power to switch off the system because it is an automated system.

Although the design objectives was achieved and also has an immense economic value and very important to our environment as it can be used in hospitals, railways, bus stations, schools, churches etc.; the design can be improved in its efficiency. Thus the following recommendations;

- Improve on the program to displaygraphics
- A higher battery capacity should be used for durability of thesystem
- Use a three colour LEDmodule.

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