Design and Construction of Message Display System Using PIC Microcontroller

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Abstract

This paper is intended to design and display message on Liquid Crystal Display (LCD) using PIC microcontroller. PIC (Peripheral Interface Controller), a special type of microprocessor is used to control the LCD (Liquid Crystal Display) and the related circuit. The proposed message displayed system is based on microcontroller, digital logic circuitry, programming, as well as the LCD display and other necessary power delivery. In this paper, the message display system which is based on PIC microcontroller is intended to use for advertising on a billboard. The design of the system is simple but it used efficient technology for cost effectiveness. The message can also be displayed occasionally for special purpose via personal computer. By storing the desired characters message inside the storage of PIC, i.e. EEPROM, ROM, and other external flash memories, the stored message can be displayed. The control program for displaying message is written by Assembly Language and the code is changed into Hex format by using MPLAB 7.20 software and then Hex codes are placed into PIC with the help of EPIC Win software. The proposed microcontroller-based control system can give accuracy, efficient time response and flexibility. The main contribution of this paper is to implement a PIC based displayed system for desired short message as an information system in Myanmar.

Keywords: PIC 16F84A, LCD Display, Power Electronic Devices.

1. Introduction

A microcontroller is similar to a microprocessor but it additionally contains its own program command code, memory, data storage memory, bi-directional I/O (input/output) ports and a clock oscillator. Many microprocessors require the use of additional chips to provide these requirements. PICs are self-contained. The general advantage of PICs is that they can be programmed to perform many functions for which many other chips would normally be required. The PIC 16F84A is the device which is used throughout this circuit. It has been chosen because of the case of reprogramming. It is an EEPROM (electrically erasable programmable read only memory) device. This means that it can be rapidly reprogrammed without needing for ultra-violet erasing.

In this system, the low cost and a simple design of LCD GDM 1602A is used messages display system. The assembly programming language is used to build the design and display any messages.

The paper is organized as follows. In the first section, the introduction of message display system is described. In the second section, microcontrollers are described. The third section consists of electronic components and operation of message display system. The fourth section consists of design and implementation of message display system. The fifth section explains of programming and software for message display system. In the last section, conclusions and limitations are described.

2. Microcontrollers

A microcontroller is an inexpensive single-chip computer. A single-chip computer means that the entire computer system lies within the confines of the integrated circuit chip. The microcontroller on the encapsulated silver of silicon has features similar to those of the standard personal computer. The microcontroller is capable of storing and running a program.

Microcontrollers are typically used where processing power is not so important. What is more important are generally compact construction, small size, low power consumption and low price for chips. There are countless numbers of small electronic devices, which are nowadays based on microcontrollers. A modern home can have tens or hundreds of microcontrollers. Every modern device, which has electronics, has a microcontroller. The microcontroller's ability to perform math and logic functions allows it to mimic sophisticated logic and electronic circuits. Special applications of microcontrollers are well suited for data logging.

Microcontrollers are frequently found in home appliances (microwave oven, refrigerators, television and VCRs, stereos), computers and computer equipments (laser printer, modems, disk drive), cars (engine control, diagnostics) climate control, environmental control (green-house, factory, home), instrumentation, aerospace, and thousands of other uses. In many items, more than one processor can be found. The following block diagram states a typical microcontroller unit (MCU) Figure 1.

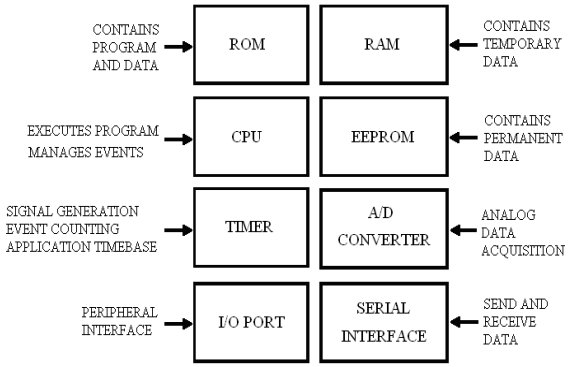

Figure 1: Block Diagram of a Typical MCU

The microcontroller Unit (MCU) contains a CPU (Central processing Unit), RAM (Random Access Memory), ROM (Read Only Memory), I/O (Input/Output) lines, serial and parallel ports, timers, and sometimes other built-in peripherals such as A/D (Analog-to-Digital) and D/A (Digital-to-Analog) converters [5].

3. Electronic Components and Operation of Message Display System

3.1 General Features of PIC 16F84A

PIC 16F84A has a total of 18 pins. It is most frequently found in a DIP 18 type of case but can also be found in SMD case which is smaller from a DIP. DIP is an abbreviation for Dual in Package. SMD is an abbreviation for Surface Mount Devices suggesting that holes for pin to go through when mounting are not necessary in soldering this type of a component. The pin diagram of PIC 16F84A is shown in Figure 2.

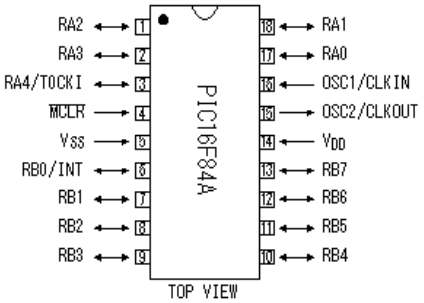

Figure 2: Pin Diagram of PIC 16F84A

3.1.1 Description of PIC 16F84A Microcontroller

The PIC 16F84A belongs to the mid-range family of the PIC microcontroller devices. The program memory contains 1K words, which translates to 1024 instructions, since each 14-bit program memory word is the same width as each device instruction. The data memory (RAM) contains 68 bytes. Data EEPROM is 64 bytes [3].

There are also 13 I/O pins that are user-configured on a pin-to-pin basis. Some pins are multiplexed with other device functions.

These functions include:

- External interrupt
- Change on PORTB interrupt
- Timer 0 clock input

There are two types of memory inside the PIC, Programmable Read Only Memory (PROM) and Random Access Memory (RAM). The PROM holds the instructions or codes for the program and the RAM is the area of memory where instructions are executed. Two areas of memory are not connected and have separate buses for communication. This type of construction is known as Harvard Architecture. The general advantage of PIC is that they can program many functions for which many other chips would normally be required. This not only makes for simplicity in electronics designs, but also allows some functions to be performed which could not be done using normal digital logic chips. The block diagram of a PIC microcontroller is shown in Figure 3.

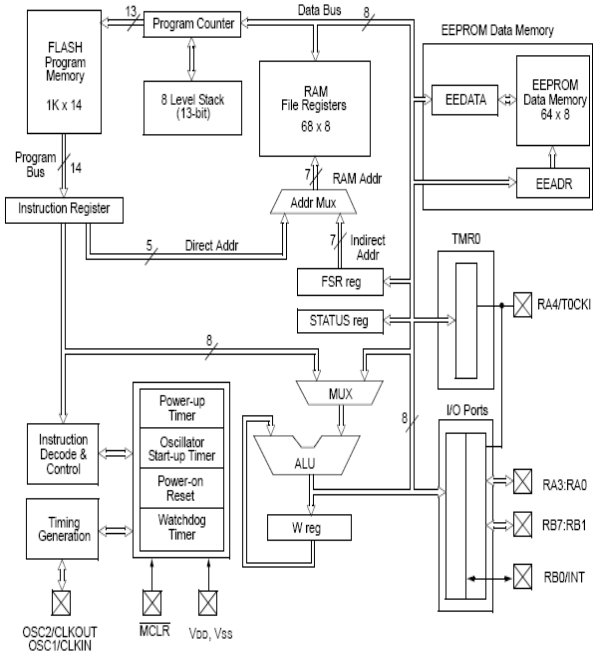

Figure 3: Block Diagram of PIC 16F84A

3.2 The Input-Output Ports of PIC 16F84A

The input/output ports are used for the PIC to do the operation which cooperates with the circuits outside. The PIC 16F84A has the 13input/output pins. Those are classified into five sets and eight sets and five sets are called A port and eight sets are called B port. The A port corresponds to the PORTA register and the B port corresponds to the PORTB register. Each register is composed of 8 bits and the input/output pin corresponds to every bit. As for PORTA, 5 bits from bit 0 to bit 4 are used and 3 bits from bit 5 to bit 7 are not used. As for PORTB, all of the 8 bits correspond to the input/output pins respectively.

The mode (the input or the output) of each pin is specified by the TRISA register (for PORTA) and the TRISB register (for PORTB). The setting "0" of TRISx means for the output and "1" means for the input. These modes setting can be set every pin. The control of the A port and the B port is done with the PORTA register and the PORTB register. That is, as for the A port, 5 pins are controlled at the same time and as for the B port, 8 pins are controlled at the same time. The control of the output operation is done by setting the contents output to the W register (8 bits) and writing it in the PORTA register or the PORTB register by the MOVWF instruction. Data setting is done to the bit(s) which was set for the input. However, the actual output is done only by the pin which was set for the output and does not have an influence on the pin which is set for the input [2].

The control of the input operation is done by taking in the contents of PORTA or the PORTB register to the W register by the MOVF instruction. In this case, the data of the pin(s) which was set for the output becomes data by the writing operation immediately before reading. This is because the output data latch register keeps an output state. It is necessary to consider using only the data of the input pins when making software. The A port and the B port are rather different in the circuit and the function. Also, in the A port, the RA4 pin can be used as the clock input of the TMR0. In case of the B port, from RB4 to RB7 have the function to watch over the change of the input signal. Moreover, RB0 has an external interrupt function. The input-output ports of PIC 16F84A is shown in Figure 4.

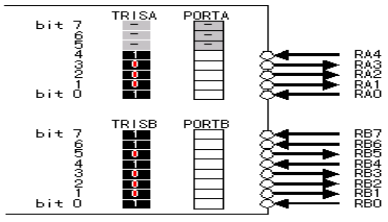

Figure 4: The Input-Output Ports of PIC 16F84A

4. Design and Implementation of Message Display System

The digital electronic displays are very important in industry, home and public applications. There are several kinds of display systems controlled by microcontrollers. Display unit such as Light Emitting Diode (LED), Liquid Crystal Display (LCD) and Cathode Ray Tube (CRT) can be used as a basic element of a display unit.

Display medium was analyzed under a variety of different criteria. The main criteria consisted of cost, size, weights, ease of use, technological reference and support. LED technology provides a very light weight, long life weight, long life expectation and coming in under the maximum mass. The greatest disadvantage of LED is the high power consumption. Cathode ray tubes fail to satisfy either the viewable distance of the display or the maximum mass. The disadvantages of CRT technology are the mass and volume. LCDs are very clear display, high resolution, high brightness, light weight and the cheapest cost among the three major display mediums. Super bright (high resolution) LCDs are available to see from a long distance.

4.1 Description of Liquid Crystal Display (LCD)

Alphanumeric dot matrix liquid crystal displays are used for displaying visual information, symbols, alphanumeric and icons in an impressive fashion. These modules have built-in controllers, driver, character generator RAM/ROM, and associated circuitry for easy implementation of the logic for refreshing, multiplexing and updating the display. LCDs are usually controlled by microcontrollers.

LCDs come in many shapes and sizes but the most common is the 16 character× 2 lines display. This article deals with the characters-based LCD modules which use the GDM 1602A controller chip.

The GDM 1602A is an LCD dot matrix display module that consists of an LCD panel and controller/driver circuits. It is capable of displaying two lines of 16-characters. The GDM 1602A module incorporates the control circuits, data RAM and characters generator RAM required for display. This module provides both 8 bit and 4 bit parallel interfaces and allows the controlling microcontroller to read and write data directly [4].

Most LCD modules conform to standard interface specification. A 14 pin access is provided having eight data lines, three control lines and three power lines. The connections are laid out in one of two common configurations, either two rows of seven pins, or a single row of 14 pins.

General Specifications:

(1) Drive method: 1/16 duty, 1/5 bias.
(2) Display size: 16 characters.
(3) Character structure: 5×7 dots + cursor.
(4) Display data RAM: 192 characters.
(5) Character generator RAM: 8 characters (64×8 bits).

Pin 1 and 2 are the power supply lines, V_{SS} and V_{DD}. The V_{DD} pin should be connected to the supply and V_{SS} to the 0V supply or ground. The supply voltage is 4.5V to 6V.

Vee or V0 used to alter the contrast of the display. Ideally this pin should be connected to a variable power supply. A preset variable resistor connected between the power supply lines, with its wiper connected to the contrast pin is suitable in many cases, but be aware that some module may require a negative voltage, as low as 7V in some cases.

Alphanumeric LCD type displays alphabetical, numerical and symbolic characters from the standard ASCII character set. This type can also display low-resolution graphics. The display is a standard GDM 1602A which displays 2 lines of 16 characters (16×2). Each character is 5×8 pixels, making it 80×16 pixels overall. In the demo program, a fixed message is displayed on line1, showing all the numerical digits. The second line finishes with a character that counts up from 0 to 9 and repeats, to demonstrate a variable display. The display receives ASCII codes for each character at the data inputs (D0-D7).

The data is presented to the display inputs by the MCU, and latched in by pulsing (minimum 1ms) the E (Enable) input.

The RW (Read/Write) line can be tied low (write mode), as the LCD is receiving data only.

The RS (Resister Select) input allows commands to be sent to the display, RS=0 selects commands mode. RS=1 data mode.

The display itself contains a microcontroller, the standard chip in this type of display is the GDM 1602A. It must be initialized according to the data and display options required. Pin layout diagram of an LCD is shown in Figure 4.1.

4.1.1 LCD GDM 1602A Display

In this thesis, the GDM 1602A LCD display is used to show the alphanumeric characters. The GDM 1602A LCD displays inexpensive, easy to use, and they are even possible to produce a readout using the 8×80 pixels of the display. Each of the 640 pixels of the display must be accessed individually and this is done with a number of surface-mount driver controller chips mounted on the back of the display. This saves an enormous amount of wiring and controlling so that only a few lines are required to access the display to the outside word. It can communicate to the display via an 8-bit data bus. For an 8-bit data bus, the display requires a +5V supply plus 10 I/O lines. The LCD GDM 1602A display is shown in Figure 5.

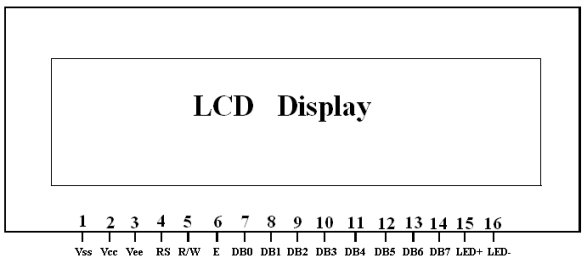

Figure 5: Pin Layout Diagram of an LCD GDM 1602A

4.2 Power Supply Circuit

Almost all electronic circuits required a DC power source. Electronic equipments are energized by power supply, a piece of equipments, which converts the alternation voltage. A power supply consists of a transformer, a rectifier and a filter. A much better DC power can be constructed using a common and inexpensive three terminal regulator. These regulators are integrated circuits consisting of several solid state devices and designed to provide the attributes of temperature stability, output current limiting and thermal overload protection. The most popular unit can provide up to 1A of output current is designed 79xx or LM 320xx for negative voltages and 78xx or LM 340xx for positive voltages. The xx designates for limited to the values 05, 06, 10, 12. and 24. This circuit 7805 IC is used for regulated 5V power supply [8].

The values of C1 vary with application. In the least demanding case when V_{in} is a normally constant voltage, C1 should be about 1000µF. Since the frequency response of the regulator is limited, the capacitor C1 is used to remove "induces frequency signals" from V_{in}. For proper functioning of PIC16F84A microcontroller, it is necessary to provide power and oscillator circuit. The circuit diagram of LCD power supply unit is shown in Figure 6.

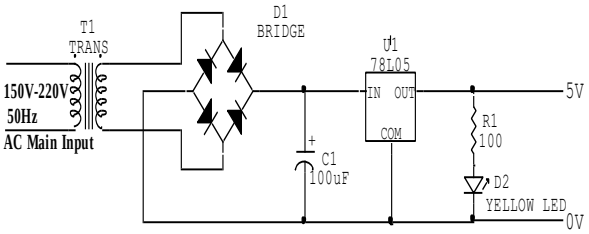

Figure 6: Power Supply Circuit

4.3 The Circuit Operation of the Message Display System

This display configuration shows 10 outputs from the microcontroller, two control lines and eight data lines are connecting to the display. R/W is the read/write control lines, RS is the register select and E is the chip enable. The R/W line tells the display to expect data to be written to it or to have data read from it, the data that is written to it is the address of the character, the code for the character or the type of command. The R/S line selects either a command to perform (R/S = 0), i.e. clear display turn cursor on or off, selects a data transfer (R/S = 1). The E line enables (E = 0) and disables, (E = 1) the display.

The 10 lines are used to drive the display that would only leave two lines for the rest of control with the PIC 16F84A. This circuit use 33pF capacitors and 4MHz crystal. Also the R/W line is used to write commands to the micro and read the busy line which indicates when the relatively slow display has processed the data. This circuit allows the micro enough time to complete its task then do not have to read the busy line, and can just write to the display. The R/W line can be connected to 0V in a permanent write mode and do not require a read/write line from the PIC16F84A microcontroller. The circuit diagram of display circuit is shown in Figure 7 and the photo of the LCD display circuit is shown in Figure 8.

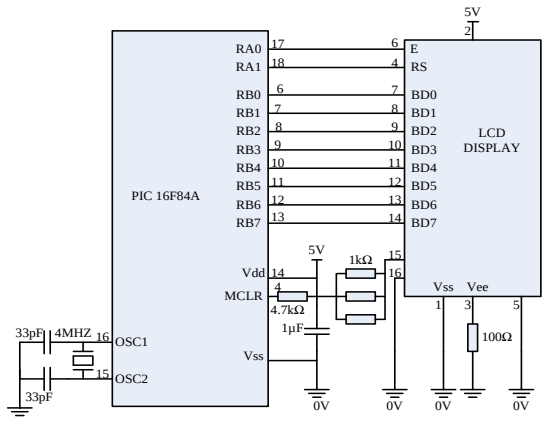

Figure 7: The Circuit Diagram of Display Circuit

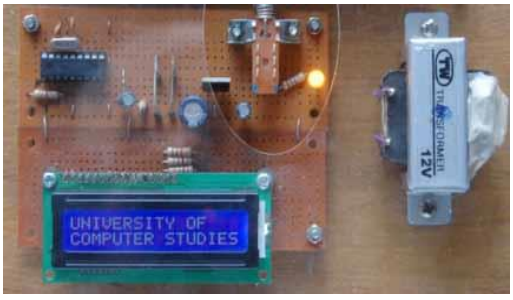

Figure 8: The Photo of the LCD Display Circuit

5. Programming and Software for Message Display System

5.1 PIC Programming Language

PIC microcontroller can do various operations by executing the instructions, which were stored in the program memory. When designing a system based on PIC microcontroller, a program is needed to control that system.

Programming can be done in several language such as ASSEMBLY, C and BASIC which are most commonly used languages. ASSEMBLY belongs to low level language but it takes up the least amount of space in memory and gives the best result where the speed of program execution is concerned. It is the most common used language in programming microcontrollers. Programs in C language are easier to be written and easier to be understood, but they are slower in executing from ASSEMBLY programs. BASIC language is the easiest one to be learned, but like C programming it is also slower than ASSEMBLY. This system is implemented by using assembly programming language.

The assembly programming language is focused particularly to programming microcontrollers. Program consists of a sequence of commands written in programming language. MPLAB 7.20 Compiler is a program that runs on computer and its task is to translate the original Assembly code into language of zeros and ones which are fed to microcontroller. The process of translation of Assembly program into HEX code, the program written in notepad, and saved as file assembly code (Program.asm), and the generated assembly code is further translated into executive HEX code which can be written to microcontroller memory. Programmer is a device which is used to transfer HEX files from computer to microcontroller memory. Assembly allows faster and much easier development of application for PIC Microchip's assembly language MPASM.

5.2 System Implementation

This system can accept alphanumeric and ASCII characters to show the form of message. Write an assembly program in MPLAB software and save as filename.asm. The convert asm file to Hex codes by using MPLAB 7.20 software. Check the resulting Hex codes in MPLAB software. Write a Hex codes to PIC 16F84A using EPIC Win programmer software connected by parallel port. Construct the complete circuit with PIC 16F84A and display LCD. The LCD display messages "UNIVERSITY OF COMPUTER STUDIES".

5.3 System Flow

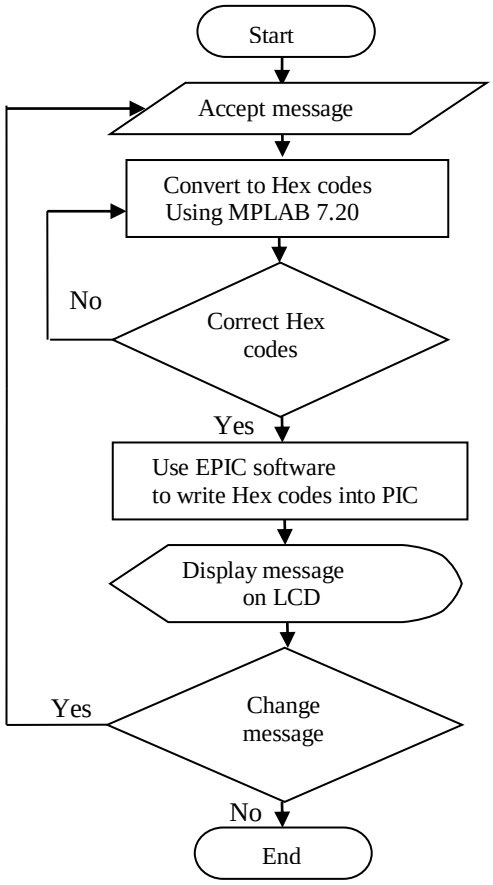

Figure 9: System Flow Diagram of Message Display System

6. Conclusions and Limitations

6.1 Conclusions

In this paper, design and construction of microcontroller-based message display system has been presented. They are flash devices that can be electrically erased and reprogrammed. Message display system is applied with the latest technology PIC microcontrollers. PIC selection is considered based on the cost and availability in the local market. They can be used up to an oscillator frequency of 4MHz and come in a standard 18 pin plastic package. The LCD GDM 1602A is also easily bought in electronic market.

In this paper a few problems were also encountered in the fabrication of Printed Circuit Board (PCB). Leakage of currents and short circuits are possible in the fabrication PCB. In this message display system high quantity lighting medium LCD GDM 1602A is used. In advertising, the message display system can promote marketing. The significant advantages of the system are simply design, high performance and cost-effectiveness.

In this circuit a PIC 16F84A microcontroller IC is used to drive the LCD GDM 1602A. This circuit is used to display message on LCD display. Desired messages are programmed in the memory of PIC using assembly language and then this message can be displayed. This circuit can be used in the football stadium to display the information. This can also be used to display advertisements to be used as a billboard.

6.2 Limitations

The message display can be displayed (16 characters× 2 lines) simultaneously from left to right. Graphic display is not available without changing hardware components. It is more suitable for indoor applications because water clear normal bright LCD is used. It is not easy to extend more than (2 rows and 16 columns) without changing hardware components. It can store data memory (RAM) 68 bytes and data (EEPROM) 64 bytes.

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