Design and Construction of Integer Calculator by Using Pic

Ohnmar Win[1] and Win Win Thein[2]

Abstract

PIC microcontroller based LCD integer calculator display circuit was constructed with locally available components. It is based on one PIC 16F887 microcontroller, one 16×2 lines LCD display, one 10 MHz XTAL, one 4×4 key pad and other components available. The main objective of the research is to interface an LCD with microcontroller and display the result of calculation. 4×4 key pad was mounted to eight pins of PORTB to control the required numbers. One 10 MHz XTAL was used as timing circuit. The program for this research was written in Mikro C Pro language and down-loaded into the memory of the PIC microcontroller through PIC kit2 programmer board.

Keywords: PIC 16F887, 4×4 Keypad, 16×2 LCD

INTRODUCTION

An electronic calculator is a small, portable electronic device used to perform operations ranging from basic arithmetic to complex mathematics. The first solid state electronic calculator was created in the 1960s, building on the extensive history of tools such as the abacus (developed around 2000 BC), and the mechanical calculator (developed in the 17th century AD). It was developed in parallel with the analog computers of the day. The pocket sized devices became available in the 1970s, especially after the first microprocessor, the Intel 4004, developed by Intel for the Japanese calculator company Busicom.

The whole circuit is powered by 5V DC based on LM7805 power regulator IC. PIC is used for main processing unit in this research. Among many PIC families, PIC 16F887 is widely used for many educational purposes. Display screen of this circuit is 16x2 lines alphanumeric LCD. 4x4 keypad is used for input method of this calculator. PORTD of PIC 16F887is used as LCD port and PORTB as keypad port. Roll and column scanning of keypad are made by built-in keypad library of Mikro C Pro language.

The accuracy and digit handling number of calculator are properties of calculator. This type of research can handle 7 digits, so the maximum number of its handling is 9999999. Accuracy is 100% for its maximum range. C programming can handle the maximum amount of 32 bits. In real software implementation the array means op (op [12]) can stored the any integer to display in LCD and (unsigned long Calc, Op1, and Op2) long integer 32 bits variables for operation. Range 0 to 4294967295 can handle the mathematics application.

The microcontroller based calculator is not only for educational research but also for first step of implementation of artificial intelligence calculation by using of cross compiler PIC method. The block diagram of the whole system is shown in Figure (1).
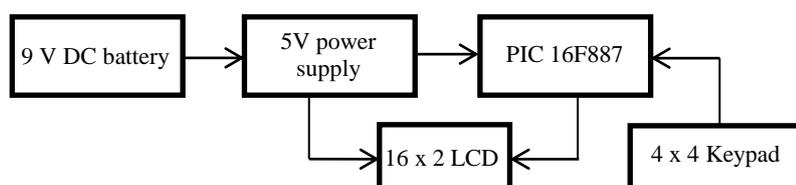
Figure (1). The block diagram of the whole system.

[1] Lecturer, Dr, Department of Physics, Hinthada University
[2] Professor and Head, Dr, Department of Physics, Hinthada University

MATERIALS AND METHODS

PIC 16F887

PIC is microcontroller from Arizona Micro Chip. These PICs are suitable for any Assembly, PICC, CCSC, Hi-tech C, Mikro C, Mikro C Pro, Basic, Basic Pro, JAL, Flow Code languages. PIC 16F887 is mid-range microcontroller with 8 bits SFR, maximum operation frequency is 20MHz , ROM memory is 8k (14 bits word), data memory is 368 bytes, internal EEPROM is 256 bytes. It has 15 interrupts request and PORT A / B / C / D / E as I / O ports. Also it has 3 timers, 2CCP, serial communication for MSSP and UART. 40 pins PDIP of PIC 16F887 is used in this research work. It includes 16 bits capture and 10 bits PWM. Pin diagram and the microcontroller PIC 16F887 (PDIP) from microchip are shown in Figure (2).
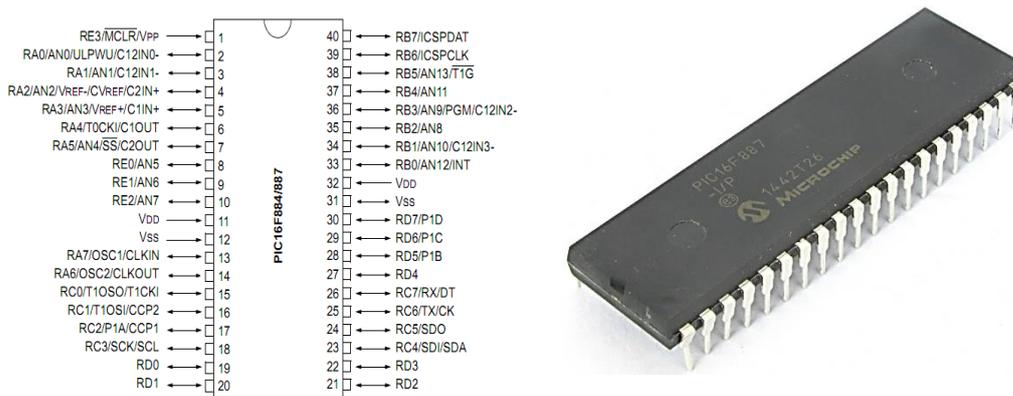
Figure (2). Pin diagram and microcontroller PIC 16F887 from microchip.

Program Memory Organization

The PIC 16F887 has a 13 bits program counter capable of addressing a 8k x14 (0000h-1FFFh) for the program memory space. Accessing a location above these boundaries will cause a wraparound within the first 8kx14 space. The reset vector is at 0000h and the interrupt vector is at 0004h. Figure 3 shows program memory map and stack for the PIC 16F887.
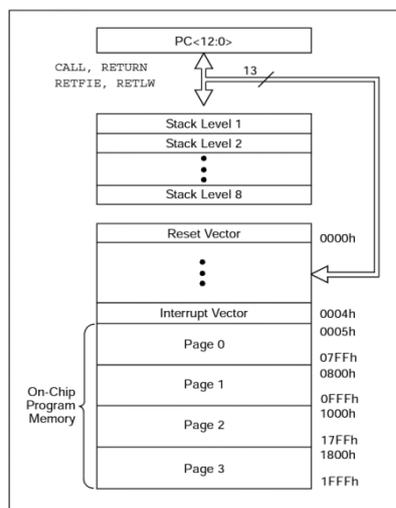
Figure (3). Program memory map and stack for the PIC 16F887

4x4 Keypad

Keypads are basic inputs for a long history of electronics applications. Many of them are found in user interface. Telephone keypads are best examples. 4 x 4 key pad and Mikro C Pro keypad built in library are used for this research, according to C library all pins of keypad are pulling down by 10kresistors. They are arrays of switch and arranged in 4 rows and 4 columns.

Program can be used as switch debounce time for 10ms. The method to detect keypad is row or column scanning. Recommend keypad hardware library from Mikro C Pro, all rows and columns must be pulled down by eight 10kΩ resistors. Actually keypad key do not include minus, plus and other mathematical key. So that programmers use # define directive for their specified key of operation. The real press key of digit1 is stored in variable known as Op1 and digit 2 in Op2. The really scanning of keypad is used keypad (key click) routine.

It is not a customized keypad for calculator but the generalized keypad can be transformed by specified idea of the user. Physical layout and the schematic diagram of 4x4 keypad are shown in Figure 4.

(a)   (b)
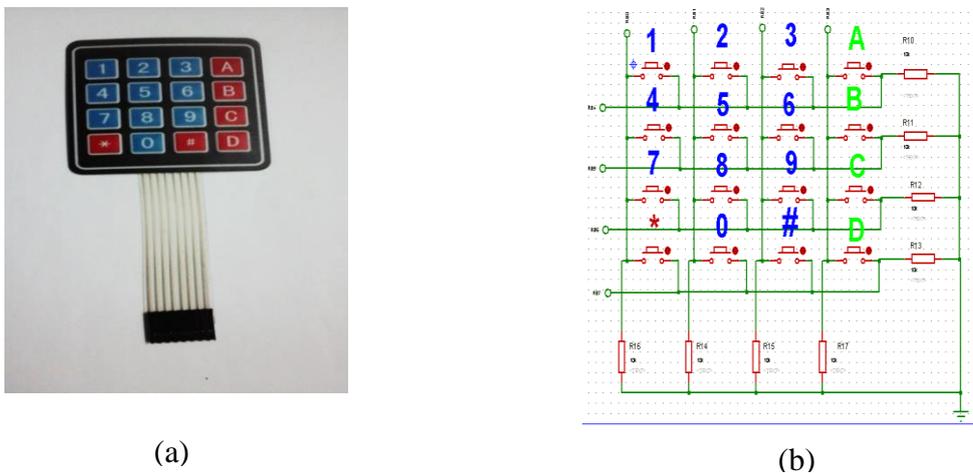
Figure (4). Physical layout and schematic diagram of 4x4 keypad. (a) Physical layout of 4x4 keypad, and (b) The schematic diagram of 4x4 keypad

HD4478016x2 Lines LCD

This component is specifically manufactured to be used with microcontrollers, which means that it cannot be activated by standard IC circuits. It is used for displaying different messages on a miniature liquid crystal display. The model described here is for its low price and great capabilities most frequently used in practice. It is based on the HD44780 microcontroller (Hitachi) and can display messages in two lines with 16 characters each. It can display all the letters of alphabet, Greek letters, punctuation marks, mathematical symbols etc.

LCD can be connected with 4bits or 8bits mode with PIC, in this research 4 bits mode is used. Along one side of the small printed board of the LCD display there are 16 pins that enable it to be connected to the microcontroller. There are in total of 14 pins marked with numbers. Figure (5) shows basic hardware diagram of 16x2 lines LCD.

Display contrast depends on the power supply voltage and whether messages are displayed in one or two lines. For this reason, varying voltage $0-V_{DD}$ is applied to the pin

marked as V_{EE}. A potentiometer is usually used for this purpose. Some of the LCD displays have built-in backlight (blue or green LEDs). When used during operation, a current limiting resistor should serially be connected to one of the pins for backlight power supply (similar to LED diodes).If there are no characters displayed or if all of them are dimmed when the display is switched on, the first thing that should be done is to check the potentiometer for contrast adjustment. Pins and function of LCD is described in Table (1).

Table (1). Pin and functions of 16 x 2 LCD display

Figure (5). Basic hardware diagram of 16x2 lines LCD
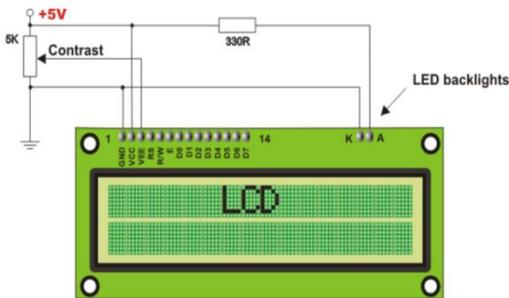
PIN NUMBER	SYMBOL	DESCRIPTION
1	V_{SS}	Ground
2	V_{DD}	VDD (Power supply +5V)
3	V_{EE}	Contrast control
4	RS	0 = instruction input 1 = data input
5	R/W	R/W (read/ write select) 0 = write to LCD 1 = read LCD data
6	E	Enable. Clock signal to initiate data transfer
7	D0	Data bus line 0
8	D1	Data bus line 1
9	D2	Data bus line 2
10	D3	Data bus line 3
11	D4	Data bus line 4
12	D5	Data bus line 5
13	D6	Data bus line 6
14	D7	Data bus line 7

Mikro C Pro Language and IDE (compiler software)

Mikro C Pro IDE is high level programming language for PIC based upon ANSIC language. According to its high level features, it is suitable for both educational and commercial purposes. The file extension for this IDE is ---------- mcppi. It language is easy for beginner and advance programmer. The C language based cross compiler software IDE is running on any computer no matter what the Windows are installed. Therefore it can run any Window 7, 8, 8.1 or 10.

The output and accessories files of this research are expressed as shown in Figure (6). Hex file is final output file for the compiler and this output file transform binary file and burning to PIC by programmer and programmer software for example, PICkit2 and PICkit2 software. The output HEX file extension is ----------- hex and ready for burning to PIC. There are many methods for programming, among them high feature of C cross compiler programming and include file for LCD are used in this research.
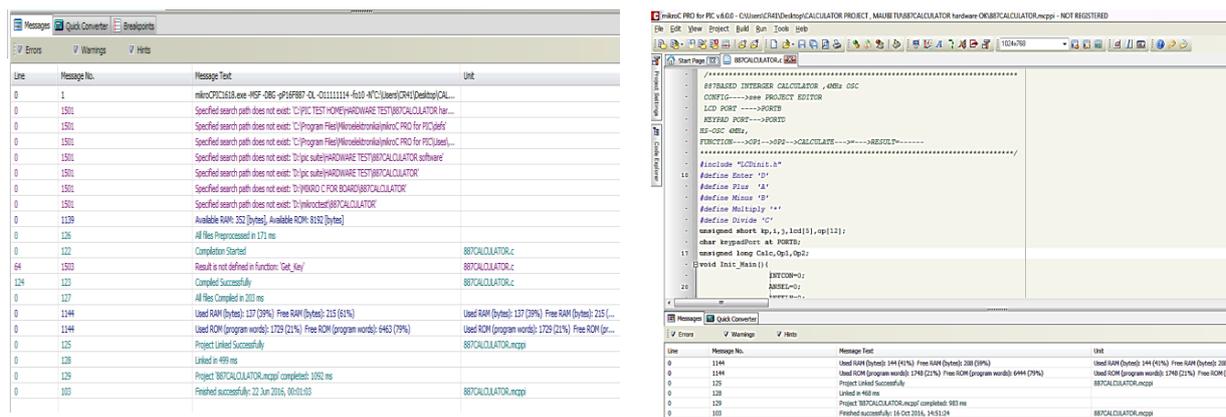
Figure (6). The output and accessories files.

PIC kit2 Programmer and Software

        PIC kit2 is Microchip approval programmer kit. Firstly, programmer software and compiler software is installed into the personal computer. It is changed into the HEX file or machine language (the only under stable language for PIC) automatically using MPASM (Micro C Pro) of the Microchip Inc. Lastly, the program (HEX) file is loaded into the memory of PIC microcontroller via USB port of PC, which is connected to the programmer by using the programmer software. After completing the loading process, PIC can do specific operation by excusing the instructions, which were stored in the program memory. The programmer circuit board is shown in Figure (7).

Figure (7). The photograph of programmer circuit board

Program Description

Program Description of integer calculator in Mikro C Pro is follow ,

```
/********************************************************************/
887BASEDINTERGERCALCULATOR ,10MHzOSC
CONFIG---->see PROJECT EDITOR
 LCD PORT ---->PORTD
 KEYPAD PORT--->PORTB
HS-OSC10MHz,
FUNCTION--->OP1-->0P2-->CALCULATE--->=--->RESULT=------
********************************************************************/
#include "LCDInit.h"
#define Enter 'D'
#define Plus  'A'
#define Minus 'B'
#define Multiply '*'
#define Divide 'C'
unsigned short kp,i,j,lcd[5],op[12];
charkeypadPort at PORTB;
unsigned long Calc,Op1,Op2;
voidInit_Main(){
INTCON=0;
ANSEL=0;
ANSELH=0;
TRISD=0;
```

```
TRISB=0xFF;
PORTB=0;
        }
unsigned char Get_Key(){
kp=0;
do{
kp=Keypad_Key_Click();delay_ms(10);
}while(!kp);
switch(kp){
case1:kp='1';break;
case2:kp='4';break;
case3:kp='7';break;
case4:kp='*';break;
case5:kp='2';break;
case6:kp='5';break;
case7:kp='8';break;
case8:kp='0';break;
case9:kp='3';break;
case10:kp='6';break;
case11:kp='9';break;
case12:kp='#';break;
case13:kp='A';break;
case14:kp='B';break;
case15:kp='C';break;
case16:kp='D';break;
                     }
                 }
void main() {
Init_Main();
Keypad_Init();
Lcd_Init();
Lcd_Cmd(_LCD_CLEAR);
Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Out(1,4,"*********");
Lcd_Out(2,3,"****----****");
delay_ms(2000);
Lcd_Cmd(_LCD_CLEAR);
Lcd_Out(1,5,"INTEGER");
Lcd_Out(2,4,"CALCULATOR");
delay_ms(2000);
Lcd_Cmd(_LCD_CLEAR);
for(;;)
        {
Op1=0;
Op2=0;
Lcd_Out(1,1,"DIGIT1=");
while(1)

 {
Get_Key();
```

```
if(kp==Enter)break;
Lcd_Chr_Cp(kp);
Op1=10*Op1+(kp-'0');
        }
Lcd_Out(2,1,"DIGIT2=");
while(1)
        {
Get_Key();
if(kp==Enter)break;
Lcd_Chr_Cp(kp);
Op2=10*Op2+(kp-'0');
        }
Lcd_Cmd(_LCD_CLEAR);
Lcd_Out(1,1,"ENTER OPERATION");
Get_Key();
switch(kp){
case Plus: Calc =Op1+Op2; break;
case Minus: Calc =Op1-Op2; break;
case Multiply: Calc =Op1*Op2; break;
case Divide: Calc =Op1/Op2; break;
                }
LongToStr(Calc,Op);
                j=0;
for(i=0;i<=11;i++)
                        {
if(op[i]!=' ')
                                {
lcd[j]=op[i];
j++;
                                }
                        }
Lcd_Cmd(_LCD_CLEAR);
Lcd_Out(1,1,"Result=");
Lcd_Out_Cp(lcd);
delay_ms(2000);
Lcd_Cmd(_LCD_CLEAR);
                        }
        }
```

 LCD # include file of main program is described as follow ,

```
//LCD MODULE CONNECTIONS
sbit LCD_RS at RD6_bit;
sbit LCD_EN at RD7_bit;
sbit LCD_D4 at RD3_bit;
sbit LCD_D5 at RD2_bit;
sbit LCD_D6 at RD1_bit;
sbit LCD_D7 at RD0_bit;
sbit LCD_RS_Direction at TRISD6_bit;
sbit LCD_EN_Direction at TRISD7_bit;
```

sbit LCD_D4_Direction at TRISD3_bit;
sbit LCD_D5_Direction at TRISD2_bit;
sbit LCD_D6_Direction at TRISD1_bit;
sbit LCD_D7_Direction at TRISD0_bit;
//END OF LCD MODULES CONNECTION

Hardware Design

This circuit is composed of four main parts - power supply, PIC, display and keypad. $9V_{DC}$ battery is power source. Power supply is linear type 5V positive supply; it's done stabilized 5 V for PIC and HD 44780 LCD. Electrolytic 1000µF is input main filter, 100µF is output main filter. The two 100µF capacitors are by pass capacitors for regulator IC. LM 7805 is voltage regulator for this circuit and its output is stabilized $5V_{DC}$ and source current is 1 A (max). One green LED limiting by 220 Ω resistor is used as power on indicator.

"40 pins 16 F series" 16F887 PIC is used for calculation unit, inputs for 4 x 4 keypad and driver for display unit. Pin 11 and 32 are connected to Vcc. Pin 12 and 31 are connected to V_{ss}. $\overline{MCLR}$ is pin 1 and connected through 10kresistor with 5 V_{DC} for normal operation. Pin 13 (OSC1) and pin 14(OSC2) are connected to 10MHzXTAL and two 22 pF capacitors are used for stabilized purpose of this XTAL.

LCD is connected with RD6 of PIC and enable pin is connected with RD7. MikroC Pro LCD library, keypad library and 4 bit LCD mode are applied in this program. RD0, RD1, RD2 and RD3 are connected with D7, D6, D5 and D4 of the LCD. All inputs of 4x4 keypad are grounded by 10k resistors according to keypad hardware instruction of Mikro C Pro. C1, C2, C3 and C4 are connected to RB0, RB1, RB2 and RB3 and then R1, R2, R3 and R4 are connected to RB4, RB5, RB6 and RB7 respectively (Fig.1).

OPERATION OF THE SYSTEM

PIC and LCD are powered by $5V_{DC}$. C1, C2, C3 and C4 get logic HIGH from RB0, RB1, RB2 and RB3 of PIC respectively. So all columns get logic high and wait for pressing. It's scanning time is about 10 ms.

LCD operation is described as here LCD gets 5V from supply, V_{SS} is grounded, contrast adjust pin V_{EE} get appropriated voltage level from 10k variable resistors, Read/Write control is grounded for writing data from PIC and command inner LCD controller chip by logic 0.

So that operation mode is Write mode. LCD enable pin (EN) is connected with RD7 pin of PIC in this design. According to LCD writing data producer (RD7 of PIC emerge logic 0 and the logic 1 and then logic 0), this performance pulses are creating by associated program routine of LCD library. This action happens in a few micro second order 15µs for logic low and 20µs for high and then low. This means that enable CLK signal for data transfer operation.

At the same time LCD Reset pin (RS) is connected with RD 6 pin of PIC. According to LCD writing data producer (RD6 of PIC emerge logic 0 for data transfer action and the logic 1 for reset condition) this performance pulses are creating by associated program routine of LCD library. This action happens in a few micro seconds order. The data transfer time only needed a few micro seconds.

According to the (long to string) conversion of the program the calculation and display data are produced D4, D5, D6 and D7 from RD3, RD2, RD1 and RD0 pins respectively. The complete circuit diagram of the whole system is as shown in Figure (8). The photograph of PIC 16F887 based integer calculator circuit is shown in Figure (9).
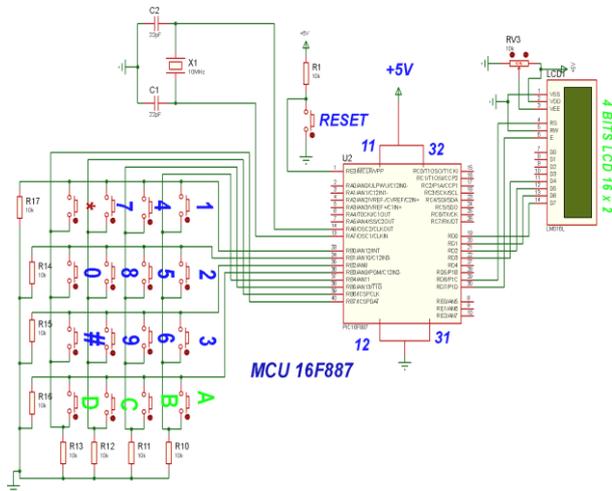
Figure (8). The complete circuit diagram of the whole system

Figure (9). The photograph of PIC 16F887 based integer calculator circuit

RESULTS AND DISCUSSION

The calculation result for this program is 100% right for integer small than 9999999. So the maximum calculation range is available for sample mathematic applications. The calculation number can be stored in op [12] variable of the program. This calculator is not like operation function of commercial calculator. Key A is used for plus, Key B is used for minus, Key C is used for divide, Key D is used for Enter, Key * is used for multiplied in this research.

The calculation procedure of this circuit is as follow: firstly welcome screen is appeared in LCD. Then Digit1=-------------- is appeared on LCD in first line. Anyone can insert integer no more than 9999999 by key pad, if sure digit1, press enter (key D).Now Digit2=-------------- is automatically appeared in second line of LCD. Anyone can also insert integer no more than 9999999 by key pad like digit1. If sure digit2, press enter (key D) again . Now can see "ENTER OPERATION" string in first line of LCD. Anyone can choice desire operation, press A or B or C or *. After press A or B or C or *, then see "RESULT=----------" and see the result. The result is shown after 2 second, new operation cycle is done.

The PIC 16F887 can be replaced any PIC such as 16F877A, 18F452 or other 16 x 2 lines LCD can be replaced by any other 16 X 4 LCD. If the display can be changed GLCD such as Nokia 5110 or other can be used. The programmer needed appropriate graphic LCD routine.

References

Brey B. B., (2003). "The Intel Microprocessors". New York: Prentice-Hall.

Dogan Ibranhim, (2008). "Advanced PIC micro controllers projects in C". London: Elsevier Ltd.

James M., (2001). "Microcontroller Cookbook". Oxford: Butterworth-Heinemann.

Martin Bates, (2000). "PIC microcontroller and introduction to microelectronics". London: Elsevier Ltd.

Martin Bates, (2006). "Interfacing PIC microcontroller embedded design by interactive simulation". London: Newnes.

Myke Preko, (2005). "123 microcontroller experiments for evil genus". New York: McGraw Hill.

Stevens Fred, (1997). "Getting started with PIC microcontrollers". London: Elsevier Ltd.

Thomas L., Floyd T.L., (2006). "Digital Fundamentals". Singapore: Pearson Prentice Hall.

Online Reference

http://www. everycircuit.com

http://www. microchip.com

http://www. socieity.com

http://www. robolab.com

http://www. zulu .com