ECE411L – Embedded System for design – Lab Exercises

|  |  |  |
| --- | --- | --- |
| **S.No** | **Experiments** | **Tools used / Remarks** |
| 1. | Toggle Port pin using software delay - Assembly |  |
| 2. | Addition of two 8 bit numbers - Assembly | MPLAB X IDE, PIC-AS, simulator |
| 3. | Subtraction of 8 bit numbers - Assembly |
| 4. | UART – Transmission -PIC Assembly |
| 5. | Timer Interrupt – PIC Assembly |
| 6. | ADC Interfacing – PIC Assembly |
|  | **C Programming** |
| 7. | LED Blinking – Port Programming | MPLAB X IDE, XC8 compiler, simulator |
| 8. | Analog to Digital Converter |
| 9. | Timer Interrupt |

**Exercise 1**: Write an assembly program to toggle the 0th Pin of PORTB of PIC18 Microcontroller.

**Objective**: To write an assembly language program to toggle the logical level of 0th pin of PORTB of PIC18 microcontroller.

**Algorithm:**

1. Clear the TRISB register to make the PORTB pins as output pins.
2. Write 0 to PORTB.0
3. Call delay routine
4. Write 1 to PORTB.0
5. Call delay routine
6. Go to step 2

**Assembly Program:**

**#include <xc.inc>**

**COUNT1 equ 20h ; These two values relate to the delay between flashes**

**COUNT2 equ 21h ;**

**PSECT res\_vect, class=CODE, reloc=2**

**res\_vect:**

**goto main**

**ORG 0x100**

**main:**

**BCF TRISB,0,a**

**Loop:**

**BCF PORTB, 0,a**

**MOVLW 0x4**

**MOVWF COUNT2, a**

**CALL DELAY**

**BSF PORTB, 0,a**

**MOVLW 0x4**

**MOVWF COUNT2, a**

**CALL DELAY**

**GOTO Loop**

**DELAY:**

**DECFSZ COUNT1,1**

**GOTO DELAY**

**DECFSZ COUNT2,1**

**GOTO DELAY**

**RETURN**

**end res\_vect**

**Output:**

Graphical user interface, text, application, chat or text message

Description automatically generated

Figure 1. Watch window showing PORTB value as 0x01

Graphical user interface, application

Description automatically generated

Figure 2. Watch window showing PORTB value as 0x00

**Note: The configuration bits are not included which has to come after the inclusion of header files**

**Conclusion:** Thus, an assembly program is written to toggle the 0th pin of PORTB in MPLAB X IDE using PIC-AS assembler and simulated using MPLAB X simulator and the snaps of the output watch window are given.

Project: Blink

**Exercise 2**: Write an assembly program to add two 8 bit numbers and show the sum and carry in the file registers for an PIC18 microcontroller with MPLAB X simulator.

**Objective**: To write an assembly language program to add two 8 bit numbers and show the sum and carry in the file registers for an PIC18 microcontroller with MPLAB X simulator.

**Algorithm:**

1. Take the number in the W (working ) register.
2. Add another number with the content of W Register
3. The SUM contained in W Register can be moved to General purpose File Register
4. Check the carry flag on the STATUS register.
5. If it is 1, then set memory location for Carry as 1
6. Go to step 6 (infinite loop)

**Assembly Program:**

**#include <xc.inc>**

**SUM set 10H**

**CAR set 11H**

**PSECT res\_vect, class=CODE, reloc=2**

**res\_vect:**

**goto main**

**PSECT code**

**main:**

**movlw 0x00**

**movwf CAR,a**

**MOVLW 95H ; WREG = 25H**

**;ADDLW 0x15 ; Add 34H to WREG**

**;ADDLW 21**

**ADDLW 10010101B**

**MOVWF SUM,a ; Save the added sum in W reg to loc 10H**

**BNC HERE**

**movlw 0x01**

**movwf CAR, a**

**HERE: GOTO HERE ; Infinite loop here**

**END res\_vect**

**Output:**

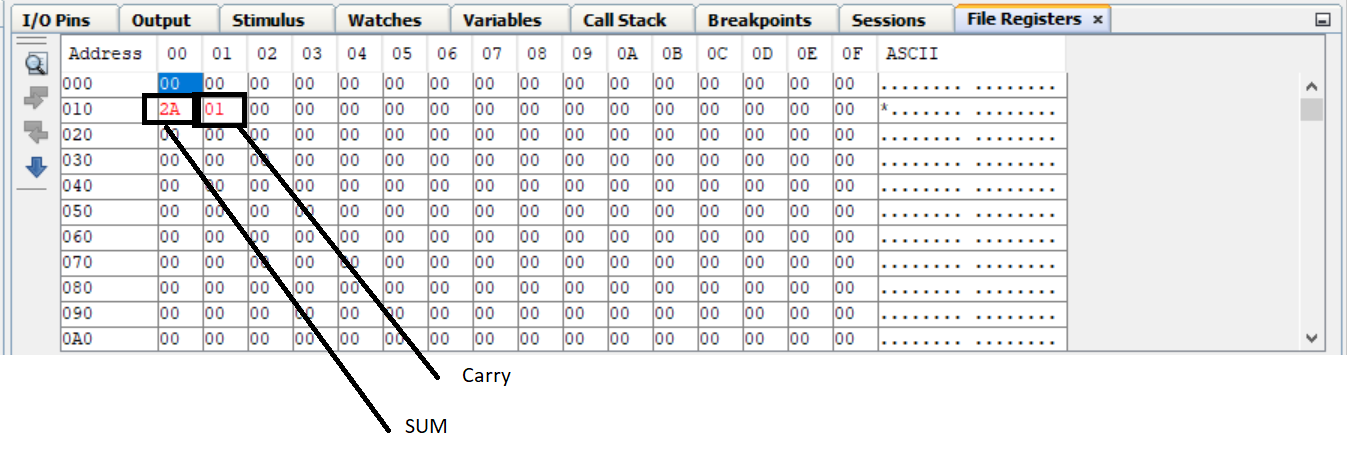


Figure 1. File Register window showing SUM and Carry

**Note: The configuration bits are not included which has to come after the inclusion of header files**

**Conclusion:** Thus, an assembly program is written to add two numbers and store the sum and carry at the file registers. And the same has been simulated using MPLAB X simulator and the snaps of the output File Register window are given.

Project: addition\_with\_carry

**Exercise 3**: Write an assembly program to subtract two 8 bit numbers and show the subtraction result and borrow in the file registers for an PIC18 microcontroller with MPLAB X simulator.

**Objective**: To write an assembly language program to subtract two 8 bit numbers and show the subtraction result and borrow in the file registers for an PIC18 microcontroller with MPLAB X simulator.

**Algorithm:**

1. Take the number in the W (working ) register.
2. Subtract the content of W Register from another number
3. The difference will be stored in W Register can be moved to General purpose File Register
4. Check the borrow flag on the STATUS register.
5. If it is 1, then set memory location for borrow as 1
6. Go to step 6 (infinite loop)

**Assembly Program:**

**#include <xc.inc>**

**RESLT set 10H**

**BORW set 11H**

**PSECT res\_vect, class=CODE, reloc=2**

**res\_vect:**

**goto main**

**PSECT code**

**main:**

**movlw 0x56**

**sublw 0x89**

**;BANKSEL SUM ; need to work on this**

**MOVWF RESLT,a ; Save the added sum in W reg to loc 10H**

**movlw 0x01**

**btfss STATUS,0**

**movwf BORW,a**

**HERE: GOTO HERE ; Infinite loop here**

**END res\_vect**

**Output:**

Graphical user interface, application, table, Excel

Description automatically generated

Figure 1. File Register window showing difference and Borrow

**Note: The configuration bits are not included which has to come after the inclusion of header files**

**Conclusion:** Thus, an assembly program is written to subtract two numbers and store the difference and borrow at the file registers. And the same has been simulated using MPLAB X simulator and the snaps of the output File Register window are given.

Project: Subtraction

**Exercise 4**: Write an assembly program to transmit a character from UART continuously and show that received characters at UART window of MPLAB X Simulator. Set the baud rate as 9600. Assume that the PIC18 has FOSC as 16MHz

**Objective**: To write an assembly language program to to transmit a character from UART continuously and show the characters at UART window of MPLAB X Simulator.

**Algorithm:**

1. Calculate the SPBRG for the baud rate of 9600. [ FOSC/(64\*(SPBRG+1)) ]
2. Load the calculated value (25) to SPBRG.
3. Configure TXSTA register. Make TXEN bit and BRGH bit as 1.
4. Enable UART reception on RCSTA.
5. Transmit 0x41 (ASCII value for A) and check whether the transmission is completed (Polling TRMT bit)
6. Go to step 5

**Assembly Program:**

**#include <xc.inc>**

**COUNT1 equ 21h ; These two values relate to the delay between flashes**

**COUNT2 equ 22h ;**

**PSECT res\_vect, class=CODE, reloc=2**

**res\_vect:**

**goto main**

**PSECT code**

**main:**

**;---CONFIGURE SPBRG FOR DESIRED BAUD RATE**

**movlw 25 ;baud rate = 9600bps**

**movwf SPBRG,a ;at 4MHZ**

**;---CONFIGURE TXSTA**

**movlw 00100100B**

**movwf TXSTA,a**

**;Configures TXSTA as 8 bit transmission, transmit enabled, async mode, high speed baud rate**

**movlw 10000000B**

**movwf RCSTA,a ;enable serial port receive**

**lp: movlw 0x41**

**movwf TXREG,a ;place the A character to TXREG**

**wthere:**

**btfss TRMT ;check if TRMT is empty**

**goto wthere ;if not, check again**

**goto lp**

**end res\_vect**

**Output:**

Text

Description automatically generated with low confidence

Figure 1. UART window showing the received characters

**Note: The configuration bits are not included which has to come after the inclusion of header files**

**Conclusion:** Thus, an assembly program is written to transmit a character continuously. And the same has been simulated using MPLAB X simulator and the snaps of the output File Register window are given.

Project: UART\_Tx

**Exercise 5**: Write a PIC assembly program to use the timer interrupt-based delay to change the bit pattern on PORTC

**Objective**: To write an assembly language program to change the bit pattern on PORTC. The delay between the change of bit pattern is done by using the timer interrupt.

**Algorithm:**

1. Set Global Interrupt Enable (GIE) and Peripheral Interrupt Enable (PIE) bits.
2. Set Timer1 Interrupt Enable bit.
3. Configure the Timer 1 prescaler.
4. Load appropriate value on Timer1 such that timer1 overflows after 50ms.
5. Start the Timer1.
6. Go to step 6.

**Timer1 ISR:**

1. Clear the Timer 1 Interrupt flag
2. At Timer1 ISR, decrement the counter (A2) which is initialized with the value of 100.
3. When the counter reaches 0, check the LSB of A4 and selects the bit pattern either 0xAA or 0xCC based on A4.0 bit value. If the count becomes 0, reload the counter with value 100.
4. Reload the Timer1 registers with the appropriate value for getting overflow after 50ms
5. Return from ISR

**Assembly Program:**

**#include <xc.inc>**

**A1 equ 0x20**

**PSECT res\_vect, class=code, reloc=2**

**res\_vect:**

**goto main**

**PSECT code**

**main:**

**CLRF STATUS,a**

**CLRW ; w =0**

**CLRF TMR1L,a ; TMR1L = 0**

**CLRF TMR1H,a ; TMR1H = 0**

**CLRF INTCON,a ; INTCON = 0**

**CLRF PORTC,a ; PORTC =0**

**MOVLW 0X64 ; w = 100**

**MOVWF A1,a ; A1 = 100**

**CLRF TRISC,a ; TRIC = 0 All PORTC pins as output**

**BSF INTCON,7,a ;SET GLOBAL INTERRUPTS ENABLE BIT**

**BSF INTCON,6,a ;SET PERIPHERAL INTERRUPT ENABLE BIT**

**BSF PIE1,0,a ;TIMER1 INTERRUPT ENABLE BIT**

**MOVLW 0X10 ; w = 0x10**

**MOVWF T1CON,a ;1:2 PRESCALE VALUE, TIMER1 OSC ENABLED**

**MOVLW 0X57 ;TIMER1 IS LOADED WITH A VALUE**

**MOVWF TMR1L,a ;EQUIVALENT TO 50ms DELAY**

**MOVLW 0X9E**

**MOVWF TMR1H,a**

**BSF T1CON,0,a ; Turn on timer**

**LOOP: GOTO LOOP**

**PSECT isr\_vect, class=code, reloc=2**

**goto isr**

**ORG 0x200**

**isr:**

**BCF PIR1,0,a ; CLEAR THE INTERRUPT FLAG**

**DECFSZ A1,1**

**GOTO EXIT**

**BTG PORTC, 4, a**

**MOVLW 0x64**

**MOVWF A1,a**

**EXIT: MOVLW 0X57**

**MOVWF TMR1L,a ;RELOAD THE TIMER**

**MOVLW 0X9E**

**MOVWF TMR1H,a**

**RETFIE**

**END res\_vect**

**Output:**

Graphical user interface, application

Description automatically generated

Figure 1. Watch window showing the PORTC with a value of 0xCC

Graphical user interface, application

Description automatically generated

Figure 2. Watch window showing the PORTC with a value of 0xAA

**Note: The configuration bits are not included which has to come after the inclusion of header files**

**Conclusion:** Thus, an assembly program is written to use timer interrupt-based delay for alternating between two bit patterns on PORTC has been done. And the same has been simulated using MPLAB X simulator and the snaps of the output File Register window are given.

Project: timer

**Exercise 6**: Write an assembly program to convert the given analog voltage as digital value and give those values to PORTB and PORTC using MPLAB X simulator.

**Objective**: To write an assembly language program to convert the given analog voltage as digital value and give that values to PORTB and PORTC using MPLAB X simulator.

**Algorithm:**

1. Configure RA0 as input. Configure AN0 as Analog input, ADC result as right justified and conversion clock as FOSC/32
2. Start the ADC Conversion.
3. Check for the end of conversion.
4. Transfer the ADC result high byte (ADRESH) to PORTB and Low byte (ADRESL) to PORTC.
5. Go to step 6 (Infinite loop)

**Assembly Program:**

**#include <xc.inc>**

**PSECT res\_vect, class=CODE, reloc=2**

**res\_vect:**

**goto main**

**PSECT code**

**main:**

**clrw**

**CLRF TRISC, a ;PORTC IS CONFIGURED AS OUTPUT**

**CLRF TRISB, a ;PORTB IS CONFIGURED AS OUTPUT**

**MOVLW 0X01**

**MOVWF TRISA, a ;RAO/AN0 IS CONFIGURED AS INPUT**

**MOVLW 0x8E ;AN0 CONFIGURED AS ANALOG INPUT**

**MOVWF ADCON1,a ;RESULT OF ADC IS RIGHT JUSTIFIED**

**MOVLW 0X01**

**MOVWF ADCON0,a ;CONVERSION CLK RATE Fosc/32 CHANNEL0**

**BSF ADCON0,1,a ;START THE CONVERSION**

**LOOP: BTFSC ADCON0,1,a ;CHECK FOR END OF CONVERSION**

**GOTO LOOP**

**MOVF ADRESH,W, a**

**MOVWF PORTB, a**

**MOVF ADRESL,W, a**

**MOVWF PORTC, a**

**GOTO main**

**END res\_vect**

**Input:**

Graphical user interface, application

Description automatically generated

Figure 1. Add the voltage for AN0, VDD and VSS in the stimulus and fire it.

**Output:**

Graphical user interface, table

Description automatically generated

Figure 2. Watch window showing the PORTB and PORTC having the digital value (0xFFC0) corresponding to 5V.

**Note: The configuration bits are not included which has to come after the inclusion of header files**

**Conclusion:** Thus, an assembly program is written to get the digital equivalent of analog value using ADC.

Project: adc

C Programming

**Exercise 7:** Write a C program to toggle all the pins of PORTA of PIC18 Microcontroller.

**Objective**: To write a C language program to toggle the logical level of all the pins of PORTA of PIC18 microcontroller.

**Algorithm:**

1. Clear the TRISA register to make the PORTA pins as output pins.
2. Write 0 to PORTA
3. Call in built delay function for 1 sec delay
4. Write 0x7F to PORTA
5. Call in built delay function for 1 sec delay
6. Go to step 2

C Program:

#include "pic18f2550.h"

#include "conbits.h"

void main(void) {

TRISA = 0x00; //POrtb as output

while(1)

{

PORTA = 0x00;

\_\_delay\_ms(1000);

PORTA = 0x7F;

\_\_delay\_ms(1000);

}

return;

}

Output:

Graphical user interface, text, application, chat or text message

Description automatically generated

**Note: The configuration bits are not included which has to come after the inclusion of header files**

**Conclusion:** Thus, a C program is written to blink the LEDs connected to PORTA.

Project folder: C\blink\_led.X

**Exercise 8:** Write a C program to do analog to digital conversion using in built ADC and show the digital equivalent at PORTB and PORTC.

**Objective**: To write a C program to do analog to digital conversion using in built ADC and show the digital equivalent at PORTB and PORTC.

**Algorithm:**

1. Configure RA0 as input. Configure AN0 as Analog input, ADC result as right justified and conversion clock as FOSC/32
2. Start the ADC Conversion.
3. Check for the end of conversion.
4. Transfer the ADC result high byte (ADRESL) to PORTB and Low byte (ADRESH) to PORTC.
5. Go to step 2

**C Program:**

#include <xc.h>

#include <stdio.h>

#include <pic18f2550.h>

#include "conbits.h"

unsigned int count = 0;

void main(void) {

unsigned int AdcResult = 0;

TRISB = 0x00; //PORTB pins are made as output

TRISC = 0x00; //PORTC pins are made as output

TRISA &= 0xEF;

TRISA |= 0x01;

ADCON2 = 0xBE; //

ADCON1 = 0x0E; // AN0 as analog pin

ADCON0 = 0x01; //ADC Module ON

while(1)

{

ADCON0 |=0x02; //Start the ADC conversion

while((ADCON0&0x02)== 0);

PORTB = ADRESL;

PORTC = ADRESH;

AdcResult = ADRESL + (ADRESH << 8);

if(AdcResult < 5)

{

PORTA |= 0x10;

\_\_delay\_ms(1000);

PORTA &= 0xEF;

\_\_delay\_ms(1000);

}

}

}

**Input:**

Graphical user interface, application

Description automatically generated

Figure 1. Add the voltage for AN0, VDD and VSS in the stimulus and fire it.

**Output:**

Graphical user interface

Description automatically generated

Figure 2. Watch window showing the PORTC and PORTB having the digital value (0x03FF) corresponding to 5V.

**Note: The configuration bits are not included which has to come after the inclusion of header files**

**Conclusion:** Thus, an assembly program is written to get the digital equivalent of analog value using ADC.

Project folder : C\adc1.X

**Exercise 9**: Write a PIC C program to use the timer interrupt-based delay to toggle pin PORTA.4.

**Objective**: To Write a PIC C program to use the timer interrupt-based delay to toggle pin PORTA.4.

**Algorithm:**

1. Set Global Interrupt Enable (GIE) and Peripheral Interrupt Enable (PIE) bits.
2. Set Timer1 Interrupt Enable bit.
3. Configure the Timer 1 prescaler.
4. Load appropriate value on Timer1 such that timer1 overflows after 50ms.
5. Start the Timer1.
6. Go to step 6 (Infinite loop).

**Timer1 ISR:**

1. Clear the Timer 1 Interrupt flag
2. At Timer1 ISR, decrement the counter (A1) which is initialized with the value of 100.
3. When the counter reaches 0, toggle PORTA.4 pin. If the count becomes 0, reload the counter with value 100.
4. Reload the Timer1 registers with the appropriate value for getting overflow after 50ms
5. Return from ISR

C Program:

#include <xc.h>

#include <pic18f2550.h>

#include "conbits.h"

unsigned int count = 0;

void \_\_interrupt() high\_isr(void){

INTCONbits.GIE = 0;

if(PIR1bits.TMR1IF){

if (++count == 100)

{

PORTA ^= 0x10; //4th pin of PORTA is toggled

count =0;

}

PIR1bits.TMR1IF = 0;

}

TMR1 = 0x9E57;

INTCONbits.GIE = 1;

}

void main(void) {

TRISA &= 0xEF; //PORTA.4 pin is made as output

// PORTB &= 0xEF; // logical level at portb pins are made as 0

T1CONbits.T1CKPS0 = 1; //Select the prescaler as 1:2

TMR1 = 0x9E57; // To make the timer overflow after 50ms @ fosc = 4MHz

//RCONbits.IPEN = 1;

PIE1bits.TMR1IE = 1;

INTCONbits.PEIE = 1;

INTCONbits.GIE = 1;

T1CONbits.TMR1ON = 1; //Start the timer

while(1){

}

}

Output:

Graphical user interface, application

Description automatically generated

**Note: The configuration bits are not included which has to come after the inclusion of header files**

**Conclusion:** Thus, an C program is written to use timer interrupt-based delay for toggling PORTA.4 pin, has been done. And the same has been simulated using MPLAB X simulator and the snaps of the output File Register window are given.

Project: C\interrupt