EECE.3170: Microprocessor Systems Design I

Summer 2016

Lecture 12: Key Questions

June 16, 2016

1. Describe the assembler directives that can be used in the MPLAB IDE.

2. Explain the operation of the following assembly program, which lights a single LED:

```
Start:
     banksel        TRISC      ;select bank1
     bcf            TRISC,0    ;make C0 an output
     banksel        LATC       ;select bank2
     clrf           LATC       ;initialize the
                               ; LATCH by
                               ; turning off
                               ; everything
     bsf            LATC,0     ;turn on LED C0 (DS1)
     goto           $          ;sit here forever!

    end
```

3. Explain the equivalent program in C, shown below:

```
void main(void) {
     TRISCbits.TRISC0 = 0;    // Pin 0 = output
     LATC = 0; //clear all pins to 0
     LATCbits.LATC0 = 1; // turn ON LED
     while(1) continue;
}
```

4. Describe how to compile and run code in MPLAB. Explain the differences between running code in the simulator and on the development board. Also, discuss how to use the in-circuit debugger to access code on the chip as it runs.

5. Describe the following assembly program, which blinks a single LED:

```
cblock 0x70    ;shared memory accessible from all banks
Delay1          ;Two registers for delay loop in shared mem
Delay2
     endc

    ORG 0
Start:
     banksel        OSCCON         ;bank1
     movlw          b'00111000'    ;set cpu speed of 500KHz
     movwf          OSCCON         ;OSCCON configures
                                   ;  internal clock
     bcf            TRISC,0        ;Pin C0 = output for DS1
     banksel        LATC           ;bank2
     clrf           LATC           ;Turn off all of the LEDs
MainLoop:
    bsf             LATC, 0        ;turn on DS1

OndelayLoop:
     decfsz         Delay1,f       ;Waste time.
     bra            OndelayLoop    ;Inner loop takes 3 inst
                              ; per loop * 256 loops =
                                   ; 768 instructions
     decfsz         Delay2,f       ;The outer loop takes an
                                   ; additional 3
                                   ; instructions per loop
                                   ; * 256 loops
     bra            OndelayLoop    ;(768+3) * 256 = 197376
                                   ; instructions /
                                   ; 125K instructions per
                                   ; second = 1.579 sec
     bcf            LATC,0         ;Turn off LED C0
OffDelayLoop:
     decfsz         Delay1,f  ;same delay as above
     bra            OffDelayLoop
     decfsz         Delay2,f
     bra            OffDelayLoop
     bra            MainLoop      ;Do it again...
     end
```

1. Extra space to describe first program.

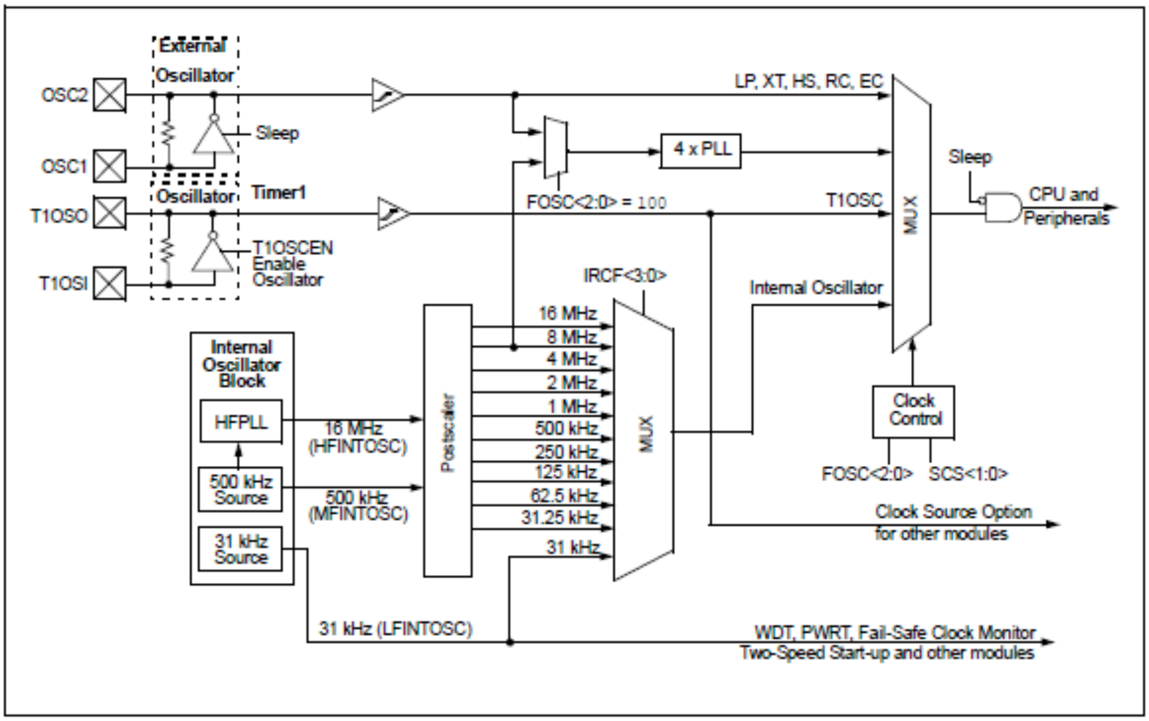
6. Describe the equivalent program in C, shown below:

```
void main(void) {
    unsigned int delay;  // 16 bit variable

    OSCCON = 0b00111000; //500KHz clock speed
    TRISCbits.TRISC0 = 0;     //using pin as output
    delay = 11250;
    while (1) {
     //each instruction is 8us  (1/(500KHz/4))
     while(delay-- != 0)continue;

     LATCbits.LATC0 ^= 1;     //toggle LED
     delay = 11250;      //reset delay counter
    }
}
```

7. Describe the basic functionality of the PIC16F1829 clock generation module below:



8. Explain the operation of the programs used to rotate the LEDs using an instruction count-based delay loop (rotate.asm and rotate.c).

9. Explain the features of a typical microcontroller timer module.

10. Explain the operation of the programs used to rotate the LEDs using a timer-based delay loop (timer0.asm and timer0.c).

```
; *******************************************************************
; Lesson 3 - "Rotate"
;
; This lesson will introduce shifting instructions as well as bit-oriented skip operations to
; move the LED display.
;
; LEDs rotate from right to left at a rate of 1.5s
;
;
; PIC: 16F1829
; Assembler: MPASM v5.43
; IDE: MPLABX v1.10
;
; Board: PICkit 3 Low Pin Count Demo Board
; Date: 6.1.2012
;
; *******************************************************************
; * See Low Pin Count Demo Board User's Guide for Lesson Information*
; *******************************************************************

#include <p16F1829.inc>
     __CONFIG _CONFIG1, (_FOSC_INTOSC & _WDTE_OFF & _PWRTE_OFF & _MCLRE_OFF & _CP_OFF & _CPD_OFF &       ↙
    _BOREN_ON & _CLKOUTEN_OFF & _IESO_OFF & _FCMEN_OFF);
     __CONFIG _CONFIG2, (_WRT_OFF & _PLLEN_OFF & _STVREN_OFF & _LVP_OFF);

    errorlevel -302                     ;supress the 'not in bank0' warning
    cblock 0x70                         ;shared memory location that is accessible from all banks
Delay1                                  ;define two file registers for the delay loop in shared memory
Delay2
     endc

    ; -------------------LATC-----------------
    ; Bit#:  -7---6---5---4---3---2---1---0---
    ; LED:   ---------------|DS4|DS3|DS2|DS1|-
    ; -----------------------------------------

    ORG 0                               ;start of code
Start:
     banksel        OSCCON              ;bank1
     movlw          b'00111000'         ;set cpu clock speed of 500KHz
     movwf          OSCCON              ;move contents of the working register into OSCCON
     clrf           TRISC               ;make all of PORTC an output
     banksel        LATC                ;select the bank where LATC is (bank2)
     movlw          b'00001000'         ;start the rotation by setting DS4 ON
     movwf          LATC                ;write contents of the working register to the latch
MainLoop:
OndelayLoop:
     decfsz         Delay1,f            ;Waste time.
     goto           OndelayLoop         ;The Inner loop takes 3 instructions per loop * 256 loopss = 768    ↙
    instructions
     decfsz         Delay2,f            ;The outer loop takes an additional 3 instructions per lap * 256    ↙
    loops
     goto           OndelayLoop         ;(768+3) * 256 = 197376 instructions / 125K instructions per second ↙
     = 1.579 sec.

Rotate:
    lsrf            LATC,F              ;shift the LEDs and turn on the next LED to the right
    btfsc           STATUS,C            ;did the bit rotate into the carry (i.e. was DS1 just lit?)
    bsf             LATC, 3             ;yes, it did and now start the sequence over again by turning on    ↙
    DS4
    goto            MainLoop            ;repeat this program forever

    end                                 ;end code section
```

```
/**
 *******************************************************************
 * Lesson 3 - "Rotate"
 *
 * This lesson will introduce shifting instructions as well as bit-oriented skip operations to
 * move the LED display.
 *
 * LEDs rotate from right to left at a rate of 1.5s
 *
 * PIC: 16F1829
 * Compiler: XC8 v1.00
 * IDE: MPLABX v1.10
 *
 * Board: PICkit 3 Low Pin Count Demo Board
 * Date: 6.1.2012
 *
 * *******************************************************************
 * See Low Pin Count Demo Board User's Guide for Lesson Information*
 * ******************************************************************
 */

#include <htc.h>                                        //PIC hardware mapping
#define _XTAL_FREQ 500000                               //Used by the XC8 delay_ms(x) macro

//config bits that are part-specific for the PIC16F1829
__CONFIG(FOSC_INTOSC & WDTE_OFF & PWRTE_OFF & MCLRE_OFF & CP_OFF & CPD_OFF & BOREN_ON & CLKOUTEN_OFF &      ↙
    IESO_OFF & FCMEN_OFF);
__CONFIG(WRT_OFF & PLLEN_OFF & STVREN_OFF & LVP_OFF);

    /* -------------------LATC-----------------
     * Bit#:  -7---6---5---4---3---2---1---0---
     * LED:   ---------------|DS4|DS3|DS2|DS1|-
     *-----------------------------------------
     */

void main(void) {
    TRISC = 0;                                          //all pins are outputs
    OSCCON = 0b00111000;                                //500KHz clock speed
    LATC = 0b0001000;                                   //start the rotation by setting DS4 ON - rotate     ↙
    from the right to left

    while (1) {
            __delay_ms(500);                            //delay 500ms
            LATC >> = 1;                                //shift to the right by 1
            if(STATUSbits.C)                            //when the last LED is lit, restart the pattern
                LATCbits.LATC3 = 1;
    }

}
```

```
; *******************************************************************
; Lesson 9 - Timer0
;
; Timer0 is a counter implemented in the processor. It may be used to count instruction
; cycles or external events, that occur at or below the instruction cycle rate.
; In the PIC18, Timer0 can be used as either an 8-bit or 16-bit counter, or timer. The
; enhanced mid-range core implements only an 8-bit counter.
; This lesson configures Timer0 to count instruction cycles and to set a flag when it rolls
; over. This frees up the processor to do meaningful work rather than wasting instruction
; cycles in a timing loop.
; Using a counter provides a convenient method of measuring time or delay loops as it
; allows the processor to work on other tasks rather than counting instruction cycles.
;
;
; LEDs rotate from right to left, similar to Lesson 3, at a rate of ~.5 seconds.
;
; PIC: 16F1829
; Assembler: MPASM v5.43
; IDE: MPLABX v1.10
;
; Board: PICkit 3 Low Pin Count Demo Board
; Date: 6.1.2012
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; *******************************************************************
; * See Low Pin Count Demo Board User's Guide for Lesson Information*
; *******************************************************************

#include <p16F1829.inc>
     __CONFIG _CONFIG1, (_FOSC_INTOSC & _WDTE_OFF & _PWRTE_OFF & _MCLRE_OFF & _CP_OFF & _CPD_OFF &  ↙
    _BOREN_ON & _CLKOUTEN_OFF & _IESO_OFF & _FCMEN_OFF);
     __CONFIG _CONFIG2, (_WRT_OFF & _PLLEN_OFF & _STVREN_OFF & _LVP_OFF);

     errorlevel -302                    ;surpress the 'not in bank0' warning

    ; -------------------LATC-----------------
    ; Bit#:  -7---6---5---4---3---2---1---0---
    ; LED:   ---------------|DS4|DS3|DS2|DS1|-
    ; -----------------------------------------

     Org 0
Start:
                                        ;Setup main init
     banksel        OSCCON              ;bank1
     movlw          b'00111000'         ;set cpu clock speed to 500KHz
     movwf          OSCCON              ;move contents of the working register into OSCCON

                                        ;Configure the LEDs
     banksel        TRISC               ;bank1
     clrf           TRISC               ;make all of PORTC an output
     banksel        LATC                ;bank2
     movlw          b'00001000'         ;start with DS4 lit
     movwf          LATC

                                        ;Setup Timer0
     banksel        OPTION_REG          ;bank1
     movlw          b'00000111'         ;1:256 prescaler for a delay of: (insruction-cycle * 256-counts)*  ↙
    prescaler = ((8uS * 256)*256) =~ 524mS
     movwf          OPTION_REG

MainLoop:
    btfss           INTCON, TMR0IF      ;did TMR0 roll over yet?
    bra             $-1                 ;wait until TMR0 overflows and sets TMR0IF
    bcf             INTCON, TMR0IF      ;must clear flag in software

                                        ;rotate the LEDs
    banksel         LATC                ;bank2
    lsrf            LATC, f
    btfsc           STATUS,C            ;did the bit rotate into the carry?
    bsf             LATC,3              ;yes, put light DS4 back up

    bra             MainLoop            ;continue forever

    end
```

```
/**
 *******************************************************************
 *  Lesson 9 - "Timer0"
 *
 *  Timer0 is a counter implemented in the processor. It may be used to count instruction
 *  cycles or external events, that occur at or below the instruction cycle rate.
 *  In the PIC18, Timer0 can be used as either an 8-bit or 16-bit counter, or timer. The
 *  enhanced mid-range core implements only an 8-bit counter.
 *  This lesson configures Timer0 to count instruction cycles and to set a flag when it rolls
 *  over. This frees up the processor to do meaningful work rather than wasting instruction
 *  cycles in a timing loop.
 *  Using a counter provides a convenient method of measuring time or delay loops as it
 *  allows the processor to work on other tasks rather than counting instruction cycles.
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 *
 *  LEDs rotate from right to left, similar to Lesson 3, at a rate of ~.5 seconds.
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 *  PIC: 16F1829
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 * *******************************************************************
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 */

#include <htc.h>                                     //PIC hardware mapping
#define _XTAL_FREQ 500000                            //Used by the XC8 delay_ms(x) macro

//config bits that are part-specific for the PIC16F1829
__CONFIG(FOSC_INTOSC & WDTE_OFF & PWRTE_OFF & MCLRE_OFF & CP_OFF & CPD_OFF & BOREN_ON & CLKOUTEN_OFF &   ↙
    IESO_OFF & FCMEN_OFF);
__CONFIG(WRT_OFF & PLLEN_OFF & STVREN_OFF & LVP_OFF);

    /* -------------------LATC-----------------
     * Bit#:  -7---6---5---4---3---2---1---0---
     * LED:   ---------------|DS4|DS3|DS2|DS1|-
     *-----------------------------------------
     */

void main(void) {
    OSCCON = 0b00111000;                            //500KHz clock speed
    TRISC = 0;                                      //all LED pins are outputs
    LATC = 0;
    OPTION_REG = 0b00000111;                        //1:256 prescaler for a delay of: (insruction-cycle *  ↙
    256-counts)*prescaler = ((8uS * 256)*256) =~ 524mS
    LATCbits.LATC4 = 1;                             //start with DS4 lit


    while (1) {
        while (!INTCONbits.TMR0IF) continue;        //you can let the PIC do work here, but for now we will↙
     wait for the flag
        INTCONbits.T0IF = 0;                        //flag MUST be cleared in software
        LATC >> = 1;                                //rotate the LEDs
        if (STATUSbits.C)                           //when the last LED is lit, restart the pattern
            LATCbits.LATC3 = 1;

    }


}
```