ECE383: Microcomputers – Lab 4
MPLAB Introduction and PIC24 Assembly Language

Goals: The goals of this lab are to introduce students to basic PIC24 assembly language, usage of the MPLAB Integrated Development Environment (IDE) and associated tools.

1. Introduction

This lab introduces the Microchip MPLAB Integrated Design Environment. All files referenced in the lab (available on Blackboard in the **pic24_code_examples_mplab.zip** file, see Blackboard for the installation instructions) are assumed to be in *C:\microchip\chap3.* The tasks in this lab are:

- Use MPLAB to simulate the PIC24 assembly language program in the *C:\microchip\chap3\mptst_word.mcp* project to become familiar with the MPLAB environment.
- Implement some simple programming tasks using PIC24 assembly language.

This lab requires you to capture portions of the screen. For windows computers, you can use the "Snipping Tool" application, though other third party tools are also available.

As always, read through the entire lab and scan the supplied files before starting work. The reporting requirements have you verify computations performed by the assembly language program. In all cases, make it easy for the TA to verify your computations by showing your work. If hand calculations are not presented in a clear and logical format, they will not be graded. While you can work as a group on this Lab, both partners must upload individual deliverables (using their individual name/CWID as required and noted in the instructions).

NOTE: When writing MPLAB assembly language programs, do not use variable names **a** or **b** as these are reserved names.

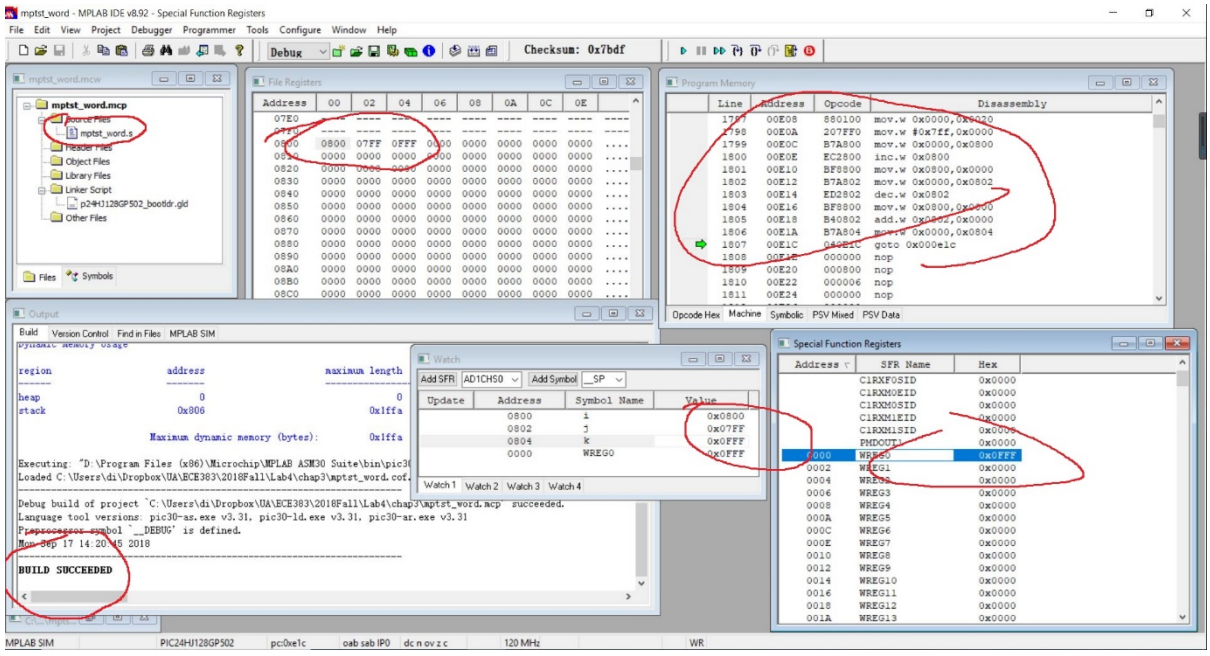
2. TASK 1: MPLAB Introduction

Perform the following steps:

- Copy the files in *C:\microchip\chap3* to a suitable directory on your network drive or hard disk. Make sure the directory you use has no spaces in the directory path. An example of a good directory name to use would be *C:\temp\username* where "username" is your unique login name.
- Start the MPLAB IDE. Use Project->Open and open the *mptst_word.mcp* project located in your directory.
- Use *Configure->Select Device* to select the PIC24HJ128GP502 device for your processor.
- Use *Project->Build All* (Ctrl+F10) to assemble the program. If the source file is not already open, double-click on the *mptst_word.s* source file to open it.
- After the project is assembled, use *View->Program Memory* and open the program memory window. Scroll the window until you find your program in memory. This should start at location 0x204.

- Use *View->File Registers* to view data memory. Scroll to location 0x800, which is where your variables will start.
- Use *View->Special Function Registers* to view the special function registers (W0-W15, etc.).
- Open a watch window *(View->Watch)* and use *Add Symbol* and *Add SFR* to watch variable values and special function register values, respectively, of the **i**, **j**, **k** variables and the **W0** (WREG0) special function register.
- Use *Debugger->Select Tool->MPLAB Sim* to select the MPLAB Simulator.
- Use *Debugger->Step Over* (F8) to single step the program. Watch both the memory locations and watch window locations, and correlate their changing values with the instructions being executed.

Deliverable 1: Upload a screen-capture of the MPLAB IDE environment that clearly shows that complete set of results for TASK 1. The complete set of results shows the **filename** of the program, that the program **built successfully**, and that the special function registers, data memory locations, and program memory have the expected values. Additionally, make sure that your name and CWID are shown as text either as a comment in the program source code or in an external text editor that is open (but do not cover any of the necessary deliverables). A sample of a screenshot highlighting the important features is shown below.



Next: Modify the avalue equate (statement **.equ avalue, 2047**) to be the last four digits of your student ID. Reassemble the program and re-simulate it. Take a screen shot of both the Watch window contents and the memory window contents. In your report, you must show calculations that verify the screen shot values match the expected result (note, avalue is in decimal, as are the **last four digits of your student ID**: the values displayed in the file registers window are in HEX).

Deliverable 2: Upload a screen-capture of the MPLAB IDE environment that clearly shows that complete set of results of program execution for TASK 1 after the avalue equate value. The complete set of results

shows the **filename** of the program, that the program **built successfully**, and that the special function registers, data memory locations, and program memory have the expected values. Additionally, make sure that your name and CWID are shown as text either as a comment in the program source code or in an external text editor that is open (but do not cover any of the necessary deliverables).

Deliverable 3: Upload your assembly language source-code (.s file) for TASK 1 (after modifying the avalue equate) with your name and CWID added as comments.

3. TASK 2: myadd.s

Use *Project->Save Project As* and save the *mptst_word* project as a new project named *myadd*. Save the *mptst_word.s* file as *myadd.s*. Right-click on the *mptst_word.s* file in the left-hand workspace window and use the *Remove* option to remove it from the *myadd* project. Right click on the *Source Files* and use *Add Files* to add the *myadd.s* file to the project. Edit the *myadd.s* file and remove all of the instructions from **`mov #avalue, W0`** through **`mov WREG,k`**. You can now use this file as a start for a new program.

Your CWID student number is an eight digit number $Y_7Y_6Y_5Y_4Y_3Y_2Y_1Y_0$. For this task we will consider this to be an eight digit hexadecimal number.

Write a program to add the four digit hex number formed by $0xY_3Y_2Y_1Y_0$ to the four-digit hex number formed by $0xY_7Y_6Y_5Y_4$. Reserve space for two 16-bit variables in data memory named *lsp* and *msp* to hold the hex values $0xY_3Y_2Y_1Y_0$ and $0xY_7Y_6Y_5Y_4$ respectively. Reserve space for a variable named *sum* to hold the sum of *lsp* and *msp.*

The following C code describes the program. You must translate each line of the C program to corresponding assembly instruction(s).

```
uint8 aa=100, bb=22;
uint16 lsp, msp, sum;

lsp = 0xY3Y2Y1Y0;          // Four digits of CWID treated as hex
msp = 0xY7Y6Y5Y4;          // Four digits of CWID treated as hex
sum = lsp + msp;

sum = sum + aa + bb;
```

Use the watch window to watch variables *aa, bb, lsp*, *msp*, and *sum*. Also, use the data memory window to monitor the memory locations corresponding to these variables.

Deliverable 4: Upload a screen-capture of the MPLAB IDE environment that clearly shows that complete set of results for TASK 2. The complete set of results shows the filename of the program, that the program built successfully, and that the special function registers, data memory locations, and program memory have the expected values. Additionally, make sure that your name and CWID are shown as text either as a comment in the program source code or in an external text editor that is open (but do not cover any of the necessary deliverables).

Deliverable 5: Upload the necessary hand-calculations to determine the variable **sum** that results after the execution of the C-code program you were tasked to convert to assembly (using your CWID).

Deliverable 6: Upload your assembly language source-code (.s file) for TASK 2 with your name and CWID added as comments. Remember also that comments are required for all source code to detail the intent of the program (with at least 1 comment for every 2 lines of code). Source code without comments will be given a zero.

4. TASK 3: mysub.s

Create a project named *mysub,* using the same procedure given in Task 2 (*Project ->Save Project As*, etc.), corresponding to the assembly language file named *mysub.s*. Using digits $Y_5Y_4Y_3Y_2Y_1Y_0$ from your student ID, write an assembly language program that implements the following C program. You must translate each line of the C program to assembly instruction(s).

```
uint16 xx=0xDEAD, yy=0xBEEF;
uint8 i, j, k, l, m;

i = Y1Y0;
j = Y3Y2;
k = Y5Y4;
l = i + k;
m = j - l;
xx=xx-yy-m;
```

Variables *i*, *j*, *k*, *l*, *m* are all 8-bit (byte) variables and xx and yy are 16-bit variables. Y1Y0, Y3Y2 and Y5Y4 are considered as decimal numbers for this task. Use the watch window to watch variables *i*, *j*, *k*, *l*, *m, xx,* and *yy*. Also, use the data memory window to monitor the memory locations corresponding to these variables. Write your program, simulate it, and verify that you calculate the correct results.

Hint: If you experience the error "Link Error: Cannot access symbol (xx) at an odd address", initialize 16-bit variables first and then the 8-bit variables. That is, all variables defined using the *.space 2* directive should appear before variables defined using the *.space 1* directive. This ensures that all 16-bit variables begin at even memory locations.

Deliverable 7: Upload the necessary hand-calculations to determine the values in the variables *l, m,* xx that results after the execution of the C-code program for TASK 3 (using your individual CWID).

Deliverable 8: Upload a screen-capture of the MPLAB IDE environment that clearly shows that complete set of results for TASK 3. The complete set of results shows the filename of the program, that the program built successfully, and that the special function registers, data memory locations, and program memory have the expected values. Additionally, make sure that your name and CWID are shown as text either as a comment in the program source code or in an external text editor that is open (but do not cover any of

the necessary deliverables).

Deliverable 9: Provide the expected values of the flags **C, Z, OV,** and **N** in the STATUS REGISTER after the execution of the instructions in the table below. Assume that **W0 = j and W1 = l**. Upload your values in a hand-drawn table, provide the hand-calculations expected for the results of these instructions, and a write a short/concise description of how you use the results of your hand-calculations to determine the flag values.

Instruction	**Value of flags from STATUS REGISTER**			
	C	**Z**	**OV**	**N**
ADD.B W0,W1,W0				
SUB.B W0,W1,W0				

5. TASK 4: mylogicops.s

Create a project named *mylogicops,* using the same procedure given in Task 2 (*Project ->Save Project As*, etc.) corresponding to the assembly language file named *mylogicops.s*. Write an assembly language program that implements the following C program. You must translate each line of the C program to assembly instruction(s).

```
uint8 u8_a, u8_b, u8_c, u8_d, u8_e, u8_f;
uint16 u16_x=0x0001;

u8_a=0xAF;
u8_b=0x50;

u8_c= u8_a & u8_b;
u8_d= u8_a | u8_b;
u8_e= u8_a ^ u8_b;
u8_f=~u8_a;
u16_x=~u8_d | (u16_x & u8_c);
```

Use the watch window to watch variables *u16_x, u8_a, u8_b, u8_c, u8_d, u8_e,* and *u8_f*. Also, use the data memory window to monitor the memory locations corresponding to these variables. Write your program, simulate it, and verify that you calculate the correct results.

Deliverable 10: Upload the necessary hand-calculations to determine the values in the variables *u8_c, u8_d, u8_e, u8_f, u16_x* that results after the execution of the C-code program for TASK 4 that you converted to assembly.

Deliverable 11: Upload a screen-capture of the MPLAB IDE environment that clearly shows that complete set of results for TASK 4. The complete set of results shows the filename of the program, that the program built successfully, and that the special function registers, data memory locations, and program memory have the expected values. Additionally, make sure that your name and CWID are shown as text either as a comment in the program source code or in an external text editor that is open (but do not cover any of

the necessary deliverables).

In addition to simulating your program within MPLAB, you must download your program to your PIC24 hardware (the Microstick II) and demonstrate the execution of your program on hardware to the TA. Make sure the Microstick II development board is attached to a USB port on your computer and make sure the slider switch on the board is set to position A. With the *mylogicops* project open, use the following steps:

- If not already selected, use *Configure->Select Device* to select the PIC24HJ128GP502 device for your processor.
- Use *Debugger->Select Tool->Starter Kit on Board* to select the Microstick II as the target. You should see messages in the MPLAB Output window indicating a successful connection to the Microstick II board.
- Use *Project->Build All* (Ctrl+F10) to assemble the program. If the source file is not already open, double-click on the *mylogicops.s* source file to open it.
- Use *Debugger->Program* to download your code to the Microstick II. You should see messages in the MPLAB Output window indicating successful programming of the Microstick II board.
- After the project is downloaded, use *View->Program Memory* and open the program memory window.
- Scroll the window until you find your program in memory. This should start at location 0x204.
- Use *View->File Registers* to view data memory. Scroll to location 0x800, which is where your variables will start.
- Use *View->Special Function Registers* to view the special function registers (W0-W15, etc.).
- Open a watch window *(View->Watch)* and use *Add Symbol* and *Add SFR* to watch variable values and special function register values, respectively, of the all of the defined variables and the **W0** (WREG0) special function register.
- Set a breakpoint on the first line of your assembly language program by double clicking on the line in the assembly language program.
- Begin the execution of your program by selecting *Debugger->Run*.
- Use *Debugger->Step Over* (F8) to single step the program. Watch both the memory locations and watch window locations, and correlate their changing values with the instructions being executed.

Deliverable 12: Upload a video that captures your TASK 4 program running on the PIC24 hardware (the Microstick II). This video needs to show all the steps starting from the *Project->Build All* step. During this video, audio must also be captured where you describe each step for the TA to follow. At the end of your video also make sure to include a final shot that shows your ACT card or similar photo ID. Videos without this final detail will be given a grade of zero.