

**Use MPLAB IDE
to enter and execute
assembly language program**

Part 1 - Enter assembly language program

1. Start MAPLAB IDE (*double click the icon*).
2. Click “File”, “New” and **type** the following code into the file editor window.

```
LIST      P=18F4520          ; directive to define processor
          #include <P18F4520.INC> ; CPU specific variable definitions

Main:      ORG    0x0000 ; code origin, program starts from here
          movlw  0x27    ; load 27H to WREG
          addlw  0x32    ; add 32H to WREG
          addlw  0x7F    ; add 7FH to WREG
          nop          ; do nothing
          nop          ; do nothing
          goto   Main    ; go to the instruction labelled by Main
          nop          ; do nothing

          END
```

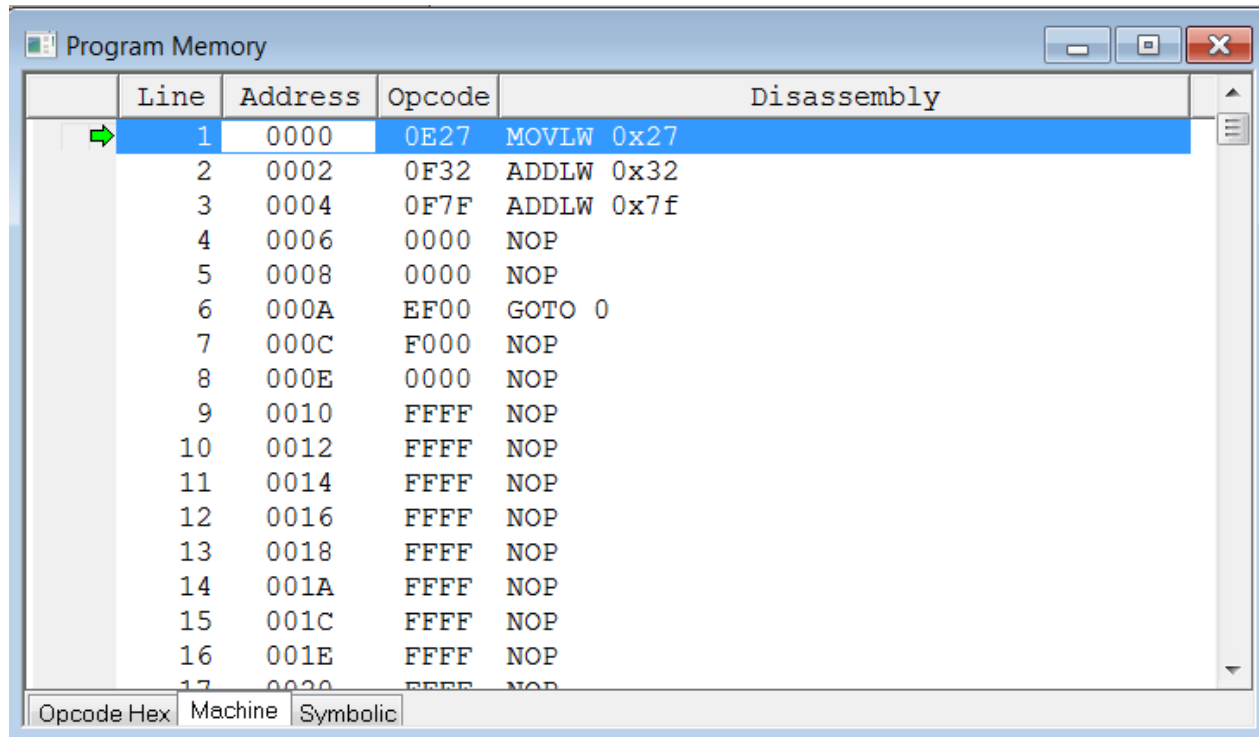
N.B.

If you use “copy and paste” to copy the code from some file to the MPLAB file editor window, in some cases some special characters (*invisible*) may be copied to the editor window. The MPLAB IDE may not be able to handle these special characters.

3. Click “File”, “Save As”.
Create and select the “My Document\Code\Tutorial 2” folder.
Type “tut2-1.asm” as the program file name.
(Make sure you save the file into the “Tutorial 2” folder).
4. Click “Project”, “Project Wizard...”, “Next >”, select device “PIC18F4520”, click “Next >”, select “Microchip MPASM Toolsuite”, click “Next >”
5. Browse into folder “My Document\Code\Tutorial 2” , type “tut2-1” as the Project file name and click “Save”.
6. Click “Next >”, expand the folder tree and locate the file “tut2-1.asm”. Click “Add >>” and “Next >” to put the “tut2-1.asm” file to the Project. Check the project parameters list and click “Finish” to finish the project definition process.

7. Click “Project”, “Build All” and select “Absolute”.
8. “BUILD SUCCEEDED” should appear at the Output window. Should “BUILD FAILED” appear instead, check for the error messages. Fix any errors found and repeat the build process (*step 7*) until success.
9. Click “File”, “Save Workspace” to save your work. It will save all your current project related parameters into the file with extension “mcw”. You can double click the file “tut2-1.mcw” later to continue your development.

10. Click “Debugger”, “Select Tool”, “4 MPLAB SIM” to select MPSIM simulator. The Output window switched to the “MPLAB SIM” tab, i.e. MPSIM takes the control.
11. Click “View”, “Program Memory” (*you will see the contents of program memory*).



The screenshot shows the 'Program Memory' window in the MPLAB IDE. The window has a title bar with standard Windows controls. Below the title bar is a table with four columns: 'Line', 'Address', 'Opcode', and 'Disassembly'. The first row (Line 1) is highlighted in blue and has a green arrow pointing to it. The table lists instructions from Line 1 to Line 17. At the bottom of the window, there are three tabs: 'Opcode Hex', 'Machine', and 'Symbolic', with 'Opcode Hex' currently selected.

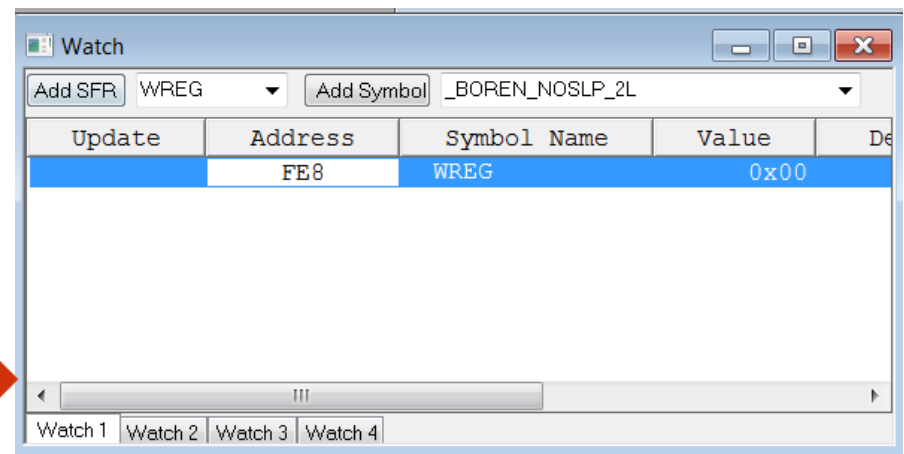
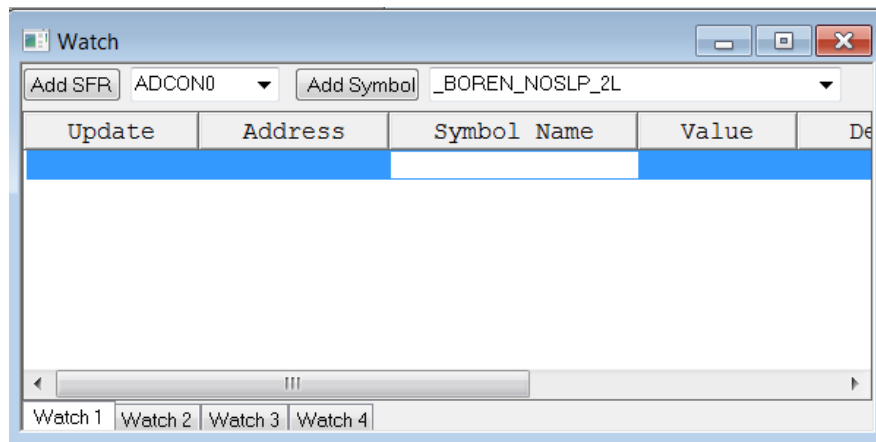
Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP
9	0010	FFFF	NOP
10	0012	FFFF	NOP
11	0014	FFFF	NOP
12	0016	FFFF	NOP
13	0018	FFFF	NOP
14	001A	FFFF	NOP
15	001C	FFFF	NOP
16	001E	FFFF	NOP
17	0020	FFFF	NOP

12. Click “View”, “Watch”.

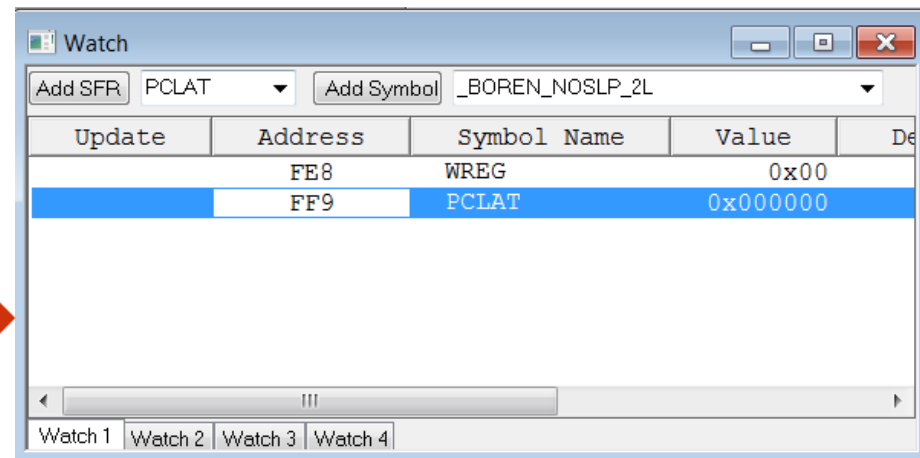
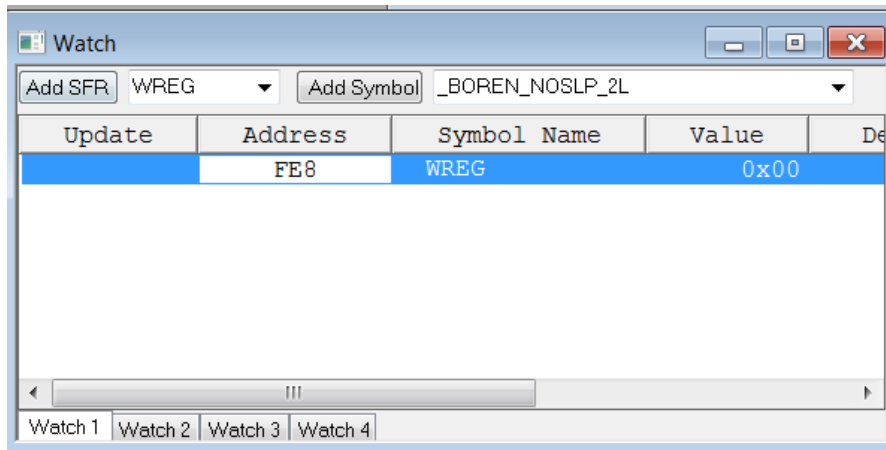
The Watch window is for you to see the contents of some registers.

From the list next to the “Add SFR” button, select “WREG” and then click the “Add SFR” button.

Now you can watch WREG during the simulation.

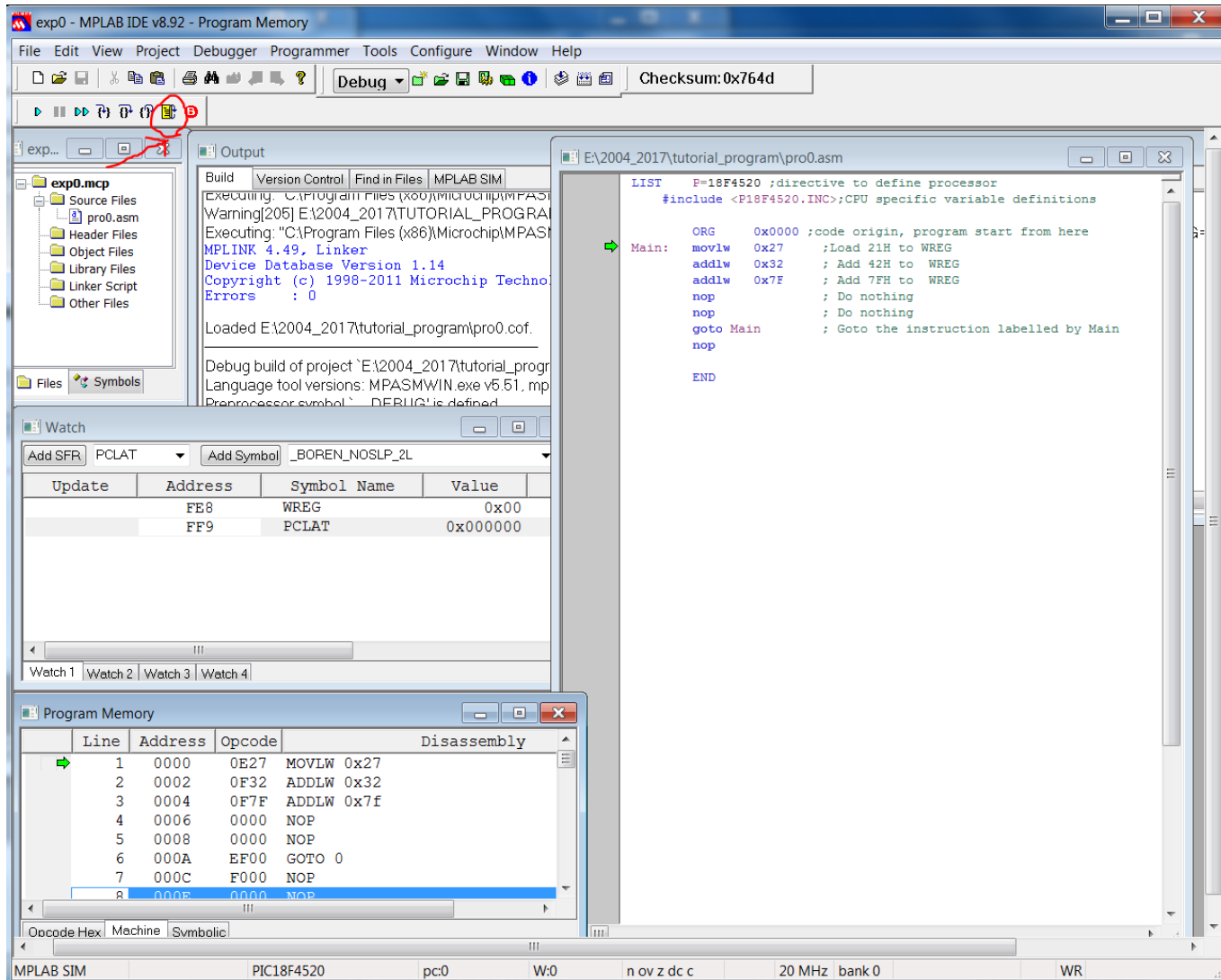


13. Select “PCLAT” and then click the “Add SFR” button. Now you can watch Program Counter (PC) during the simulation.



Part 2 - Simulation

1. Press “Reset” button.



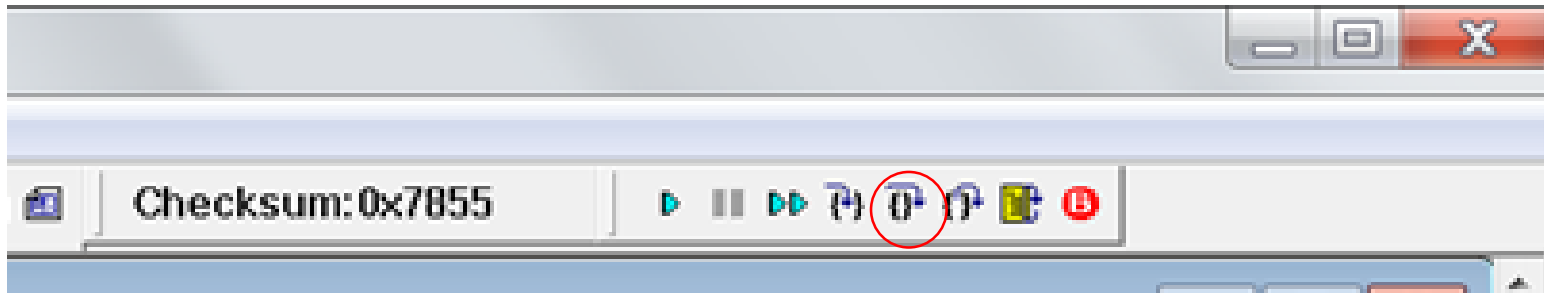
PC = 0

The screenshot displays the MPLAB IDE v8.92 interface with the following components:

- File Explorer:** Shows the project structure for 'exp0.mcp', including Source Files (pro.asm), Header Files, Object Files, Library Files, Linker Script, and Other Files.
- Output Window:** Displays build messages, including 'Executing: C:\Program Files (x86)\Microchip\MPASM\...', 'MPLINK 4.49, Linker', 'Device Database Version 1.14', 'Copyright (c) 1998-2011 Microchip Technology', and 'Errors : 0'. It also shows the loaded configuration file 'E:\2004_2017\tutorial_program\pro0.cof'.
- Watch Window:** Shows the current state of variables. The 'PCLAT' variable is highlighted with a red circle and a red arrow, showing a value of '0x000000'. The 'WREG' variable shows a value of '0x00'.
- Program Memory Window:** Displays the disassembly of the program. The first instruction, 'MOV LW 0x27', is highlighted with a red circle and a green arrow, indicating the current instruction being executed.
- Assembly Code Window:** Shows the source code for 'pro0.asm'. The 'Main:' label is circled in red, and the 'goto Main' instruction is visible.

The status bar at the bottom indicates the simulation is running on a PIC18F4520, with a clock speed of 20 MHz and a bank of 0.

2. Press the “Step Over” button.



See WREG and PC.

The screenshot displays the MPLAB IDE v8.92 interface. The main window shows the assembly code for `pro0.asm`. The code includes a directive to define the processor as PIC18F4520 and a series of instructions: `ORG 0x0000`, `movlw 0x27`, `addlw 0x32`, `addlw 0x7F`, `nop`, `goto Main`, and `END`. The `addlw 0x32` instruction is highlighted in yellow, and a green arrow points to it.

The `Watch` window shows the current state of the WREG and PCLAT registers:

Update	Address	Symbol Name	Value
	FE8	WREG	0x27
	FF9	PCLAT	0x000002

The `Program Memory` window shows the disassembly of the program:

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP

The status bar at the bottom indicates the current configuration: MPLAB SIM, PIC18F4520, pc:0x2, W:0x27, n ov z dc c, 20 MHz, bank 0, and WR.

3. Press the “Step Over” button again.

The screenshot displays the MPLAB IDE v8.92 interface. The main window shows the assembly code for `pro0.asm`. The `addlw 0x7F` instruction is highlighted in yellow, and a green arrow points to it, indicating the current instruction being executed. The `Watch` window shows the values of `WREG` (0x59) and `PCLAT` (0x000004). The `Program Memory` window shows the disassembly of the code, with the `addlw 0x7F` instruction at address 0004 highlighted in blue.

Program Memory Window:

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7F
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP

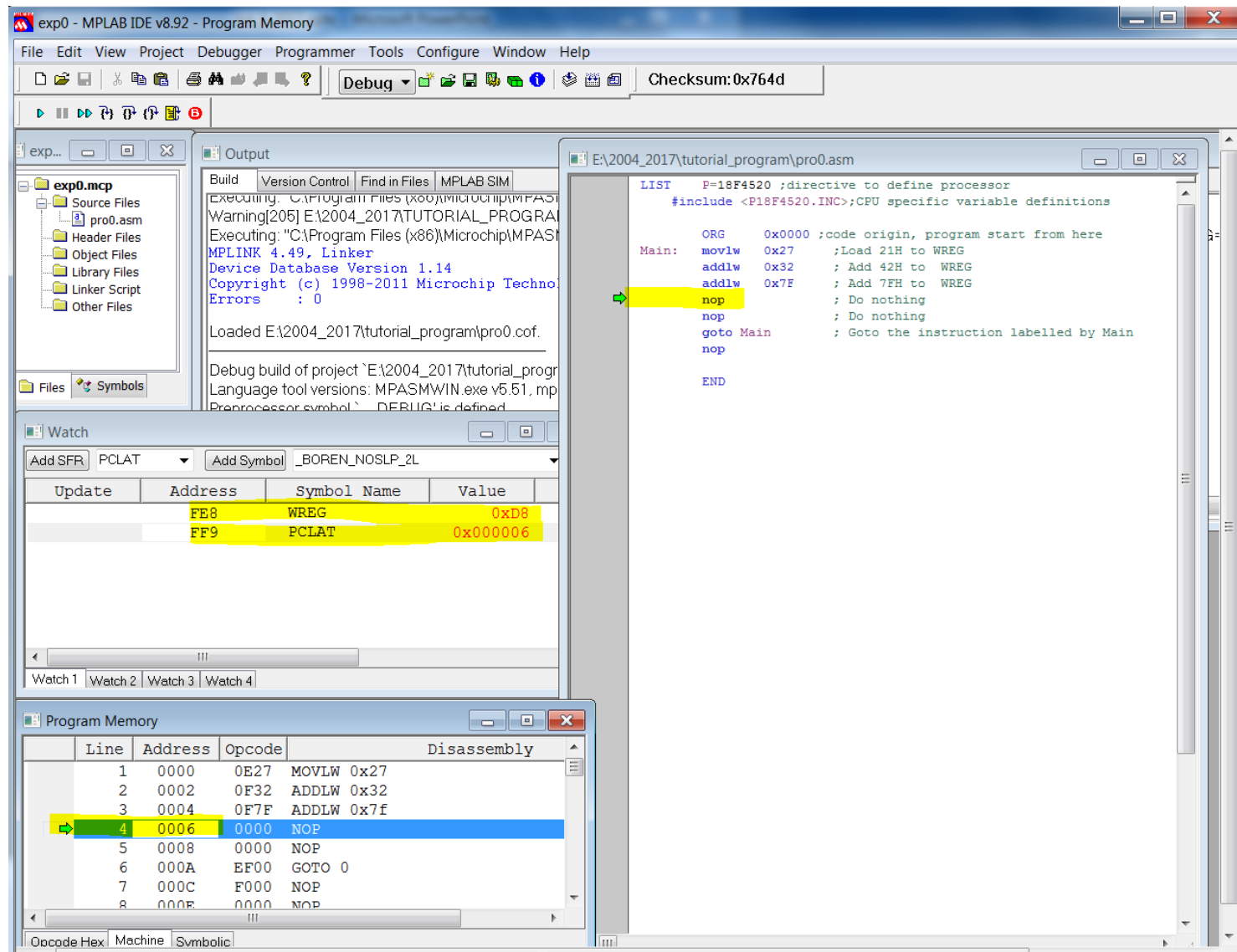
Output Window:

```
LIST P=18F4520 ;directive to define processor
#include <P18F4520.INC>;CPU specific variable definitions

ORG 0x0000 ;code origin, program start from here
Main: movlw 0x27 ;Load 21H to WREG
      addlw 0x32 ; Add 42H to WREG
      addlw 0x7F ; Add 7FH to WREG
      nop ; Do nothing
      nop ; Do nothing
      goto Main ; Goto the instruction labelled by Main

END
```

4 . Press the “Step Over” button again.

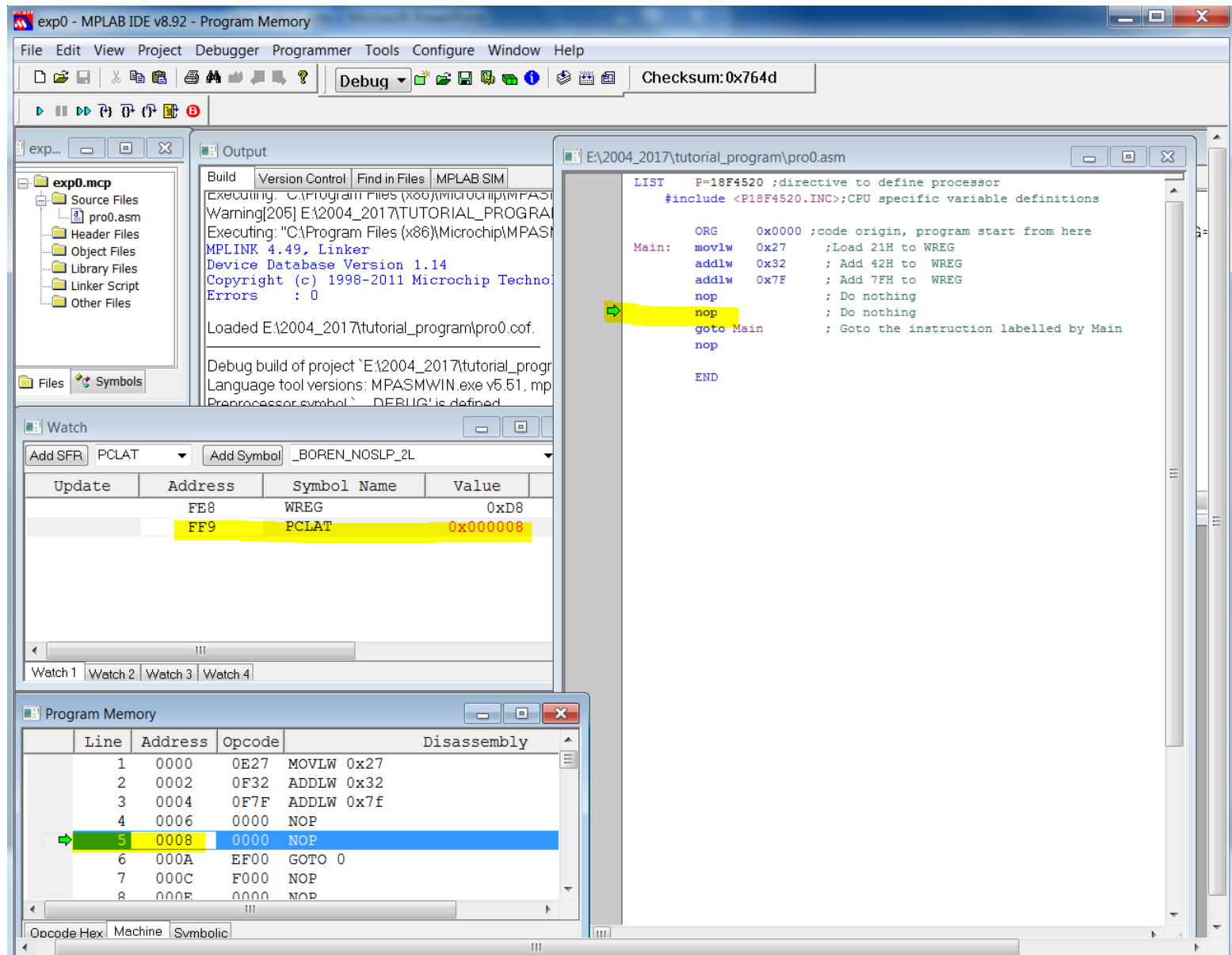


The screenshot shows the MPLAB IDE v8.92 interface during a debugging session. The main window displays the assembly code for `pro0.asm`, with the instruction `nop` at address `0006` highlighted. The Watch window shows the values of `WREG` (`0xD8`) and `PCLAT` (`0x000006`). The Program Memory window shows the disassembly of the code, with the instruction `NOP` at address `0006` highlighted.

Program Memory Disassembly:

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP

5. Press the “Step Over” button again.



The screenshot shows the MPLAB IDE v8.92 interface with the following components:

- File Explorer:** Shows the project structure for `exp0.mcp`, including Source Files, Header Files, Object Files, Library Files, Linker Script, and Other Files.
- Output Window:** Displays the execution progress, including the linker output and the start of the program execution. The output shows the execution of the linker (MPLINK 4.49) and the start of the program execution (Executing: "C:\Program Files (x86)\Microchip\MPASM").
- Watch Window:** Shows the current state of the program's registers. The PCLAT register is highlighted in yellow, showing a value of 0x000008.
- Program Memory Window:** Displays the disassembly of the program. The instruction at address 0008 (NOP) is highlighted in blue, and a green arrow points to it, indicating the current instruction being executed.

The Program Memory window shows the following disassembly:

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP

6 . Press the “Step Over” button again.

The screenshot shows the MPLAB IDE v8.92 interface with the following components:

- exp0 - MPLAB IDE v8.92 - Program Memory** (Title Bar)
- File Edit View Project Debugger Programmer Tools Configure Window Help** (Menu Bar)
- Checksum: 0x764d** (Status Bar)
- exp0.mcp** (Project Explorer):
 - Source Files
 - pro0.asm
 - Header Files
 - Object Files
 - Library Files
 - Linker Script
 - Other Files
- Output** (Debugger Window):
 - Build
 - Executing: C:\Program Files (x86)\Microchip\MPASM\bin\MPASMWIN.exe
 - Warning[205] E:\2004_2017\tutorial_program\pro0.asm
 - Executing: "C:\Program Files (x86)\Microchip\MPASM\bin\MPASMWIN.exe"
 - MPLINK 4.49, Linker
 - Device Database Version 1.14
 - Copyright (c) 1998-2011 Microchip Technology Inc.
 - Errors : 0
 - Loaded E:\2004_2017\tutorial_program\pro0.cof.
 - Debug build of project 'E:\2004_2017\tutorial_program\pro0.asm'
 - Language tool versions: MPASMWIN.exe v5.51, mpasm.exe v5.51, mpasmwin.exe v5.51
 - Preprocessor symbol 'DEBUG' is defined.

- Watch** (Debugger Window):
- Add SFR: PCLAT
- Add Symbol: _BOREN_NOSLP_2L
- Table:

Update	Address	Symbol Name	Value
	FE8	WREG	0xD8
	FF9	PCLAT	0x0000A
- Program Memory** (Debugger Window):

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7F
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP
- E:\2004_2017\tutorial_program\pro0.asm** (Source File):

```
LIST P=18F4520 ;directive to define processor
#include <P18F4520.INC>;CPU specific variable definitions

ORG 0x0000 ;code origin, program start from here
Main: movlw 0x27 ;Load 21H to WREG
      addlw 0x32 ; Add 42H to WREG
      addlw 0x7F ; Add 7FH to WREG
      nop ; Do nothing
      nop ; Do nothing
      goto Main ; Goto the instruction labelled by Main
      nop
END
```


7. Press the “Step Over” button again.

The screenshot displays the MPLAB IDE v8.92 interface during a debug session. The 'Program Memory' window at the bottom shows the instruction at address 0000 (MOVW 0x27) highlighted with a green arrow. The 'Watch' window shows PCLAT at address FF9 with value 0x000000. The 'Output' window shows the linker output. The 'Source' window shows the assembly code for pro0.asm.

Program Memory

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP

Watch

Update	Address	Symbol Name	Value
	FE8	WREG	0xD8
	FF9	PCLAT	0x000000

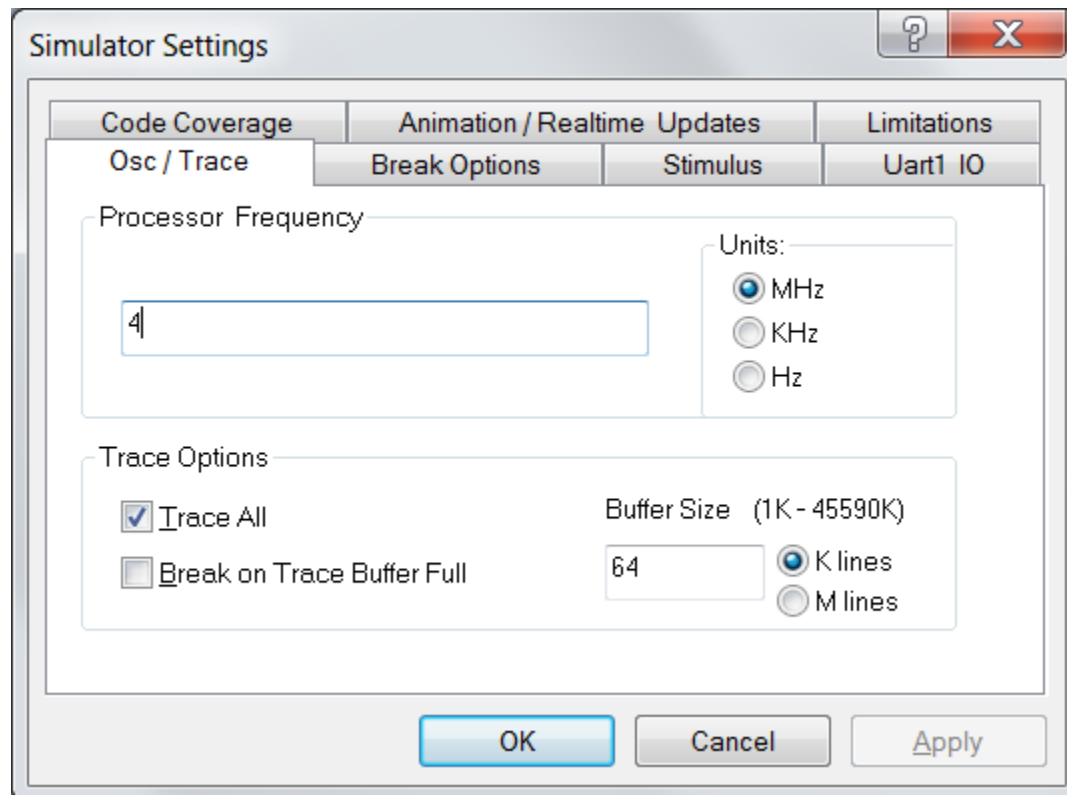
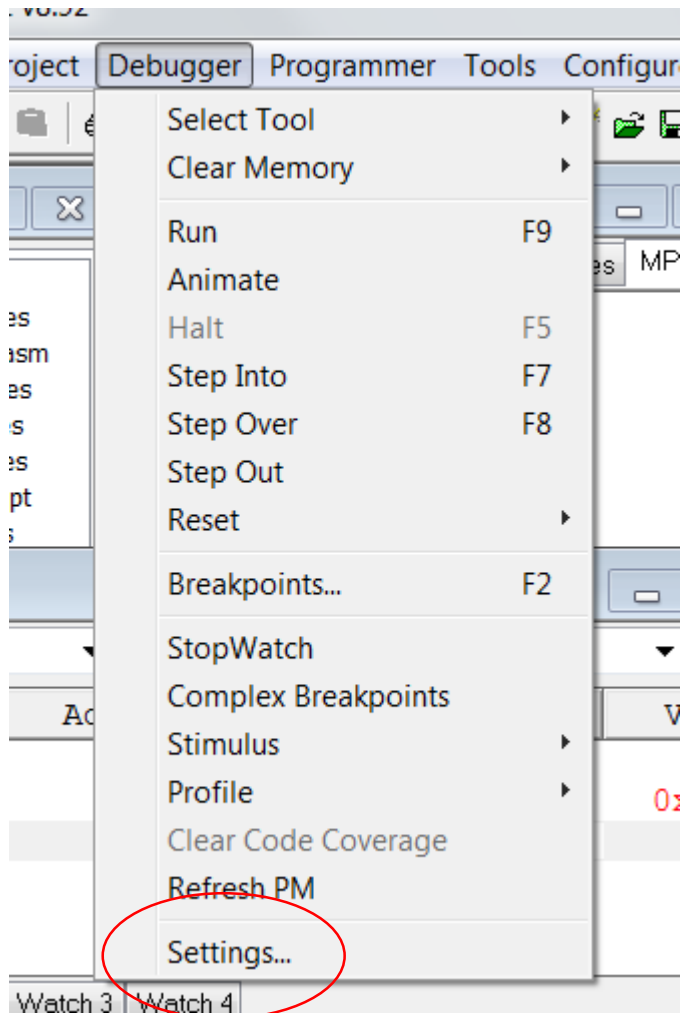
Source

```
LIST P=18F4520 ;directive to define processor
#include <P18F4520.INC>;CPU specific variable definitions

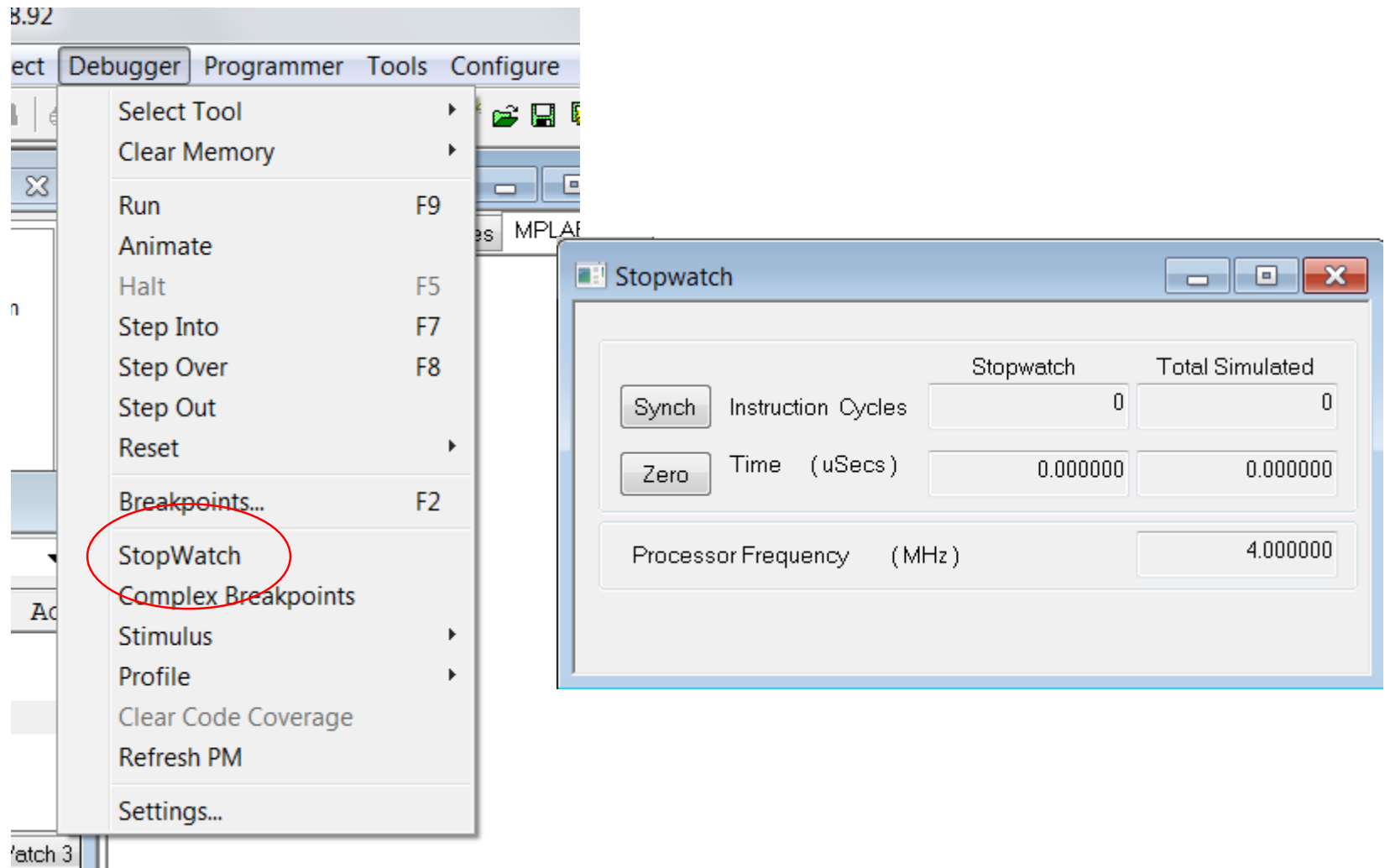
ORG 0x0000 ;code origin, program start from here
Main: movlw 0x27 ;Load 21H to WREG
      addlw 0x32 ; Add 42H to WREG
      addlw 0x7F ; Add 7FH to WREG
      nop ; Do nothing
      nop ; Do nothing
      goto Main ; Goto the instruction labelled by Main
      nop
      END
```

Part 3 - Use Stop Watch

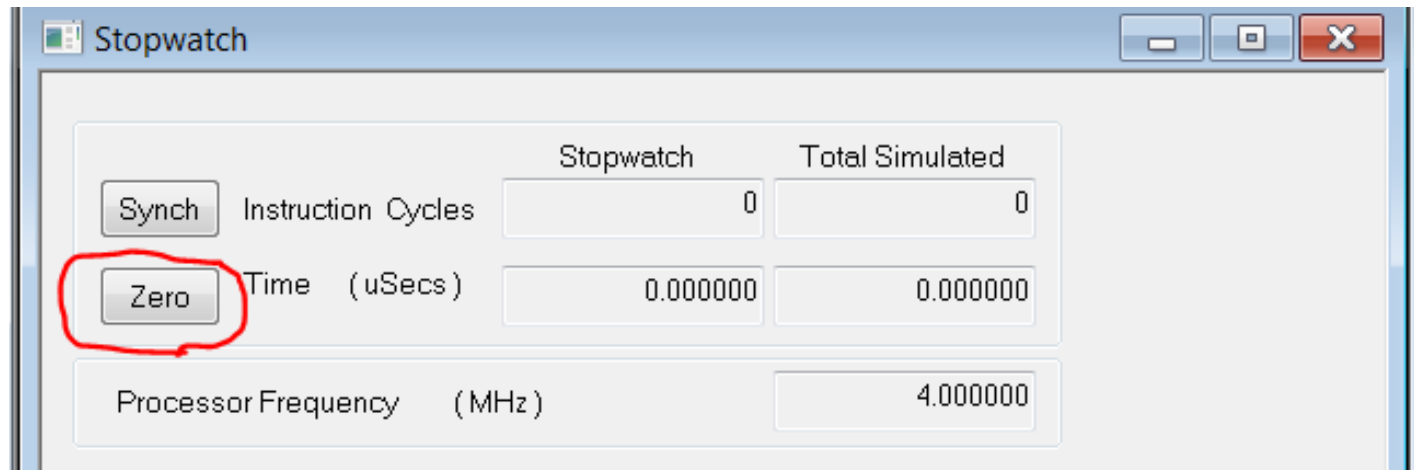
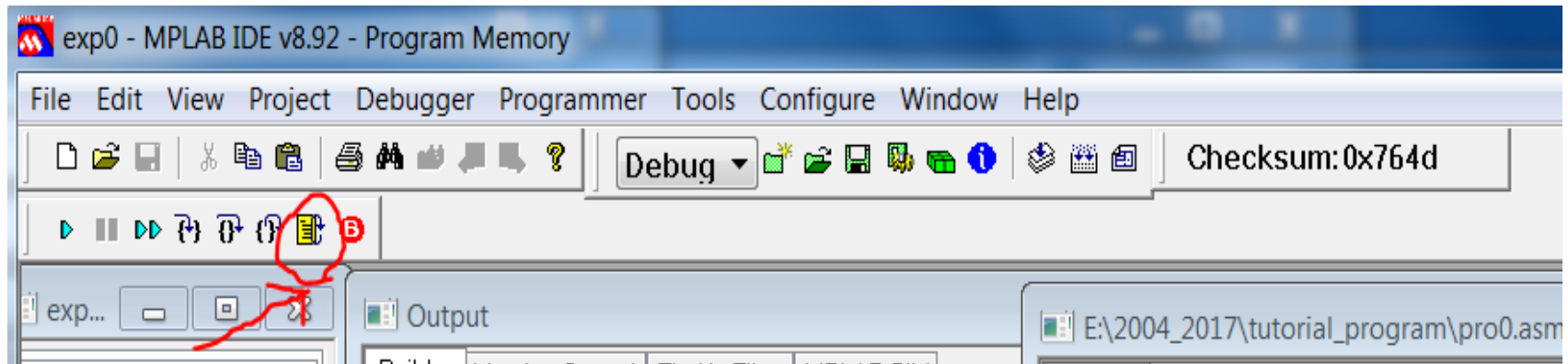
1. Set simulation clock frequency for PIC18 to 4 MHz.



2. Open “Stopwatch” window.



3. To reset the stopwatch, press “Reset” button and “Zero” button (*in Stopwatch window*).



exp0 - MPLAB IDE v8.92 - Stopwatch

File Edit View Project Debugger Programmer Tools Configure Window Help

Debug Checksum: 0x764d

Stopwatch

Synch Instruction Cycles Stopwatch Total Simulated

Zero Time (uSecs) 0.000000 0.000000

Processor Frequency (MHz) 4.000000

E:\2004_2017\tutorial_program\pro0.asm

```
LIST P=18F4520 ;directive to define processor
#include <P18F4520.INC>;CPU specific variable definitions

ORG 0x0000 ;code origin, program start from here
Main: movlw 0x27 ;Load 27H to WREG
      addlw 0x32 ; Add 42H to WREG
      addlw 0x7F ; Add 7FH to WREG
      nop ; Do nothing
      nop ; Do nothing
      goto Main ; Goto the instruction labelled by Main
      nop

END
```

Program Memory

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP
9	0010	FFFF	NOP
10	0012	FFFF	NOP
11	0014	FFFF	NOP
12	0016	FFFF	NOP
13	0018	FFFF	NOP
14	001A	FFFF	NOP
15	001C	FFFF	NOP
16	001E	FFFF	NOP

Watch

Add SFR PCLAT Add Symbol BOREN_NOSLP_2L

Update	Address	Symbol Name	Value	Decim
	FE8	WREG	0xD8	
	FF9	PCLAT	0x000000	

4. Press the “Step Over” button.

The screenshot shows the MPLAB IDE v8.92 interface with the Stopwatch window open. The Stopwatch window displays the following data:

Stopwatch	Total Simulated
1	1

Buttons: Synchronise, Zero

Time (uSecs): 1.000000

Processor Frequency (MHz): 4.000000

The main window displays the assembly code for the program:

```
LIST P=18F4520 ;directive to define processor
#include <P18F4520.INC>;CPU specific variable definitions

ORG 0x0000 ;code origin, program start from here
Main: movlw 0x27 ;Load 21H to WREG
      addlw 0x32 ; Add 42H to WREG
      addlw 0x7F ; Add 7FH to WREG
      nop ; Do nothing
      nop ; Do nothing
      goto Main ; Goto the instruction labelled by Main
      nop
      END
```

The Program Memory window shows the disassembly of the program:

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP
9	0010	FFFF	NOP
10	0012	FFFF	NOP
11	0014	FFFF	NOP
12	0016	FFFF	NOP
13	0018	FFFF	NOP
14	001A	FFFF	NOP
15	001C	FFFF	NOP
16	001E	FFFF	NOP

The Watch window shows the current state of the program variables:

Update	Address	Symbol Name	Value	Decim
	FE8	WREG	0x27	
	FF9	PCLAT	0x000002	

5. Press the “Step Over” button again.

The screenshot displays the MPLAB IDE v8.92 interface with the following components:

- Stopwatch Window:** Shows simulation metrics. The 'Instruction Cycles' and 'Time (uSecs)' are both 2,000,000. The 'Total Simulated' time is also 2,000,000. The 'Processor Frequency' is set to 4,000,000 MHz.
- Program Memory Window:** Displays a list of instructions. Line 3 is highlighted, showing the instruction `ADDLW 0x7f` at address 0004.
- Watch Window:** Shows the current state of variables. The `WREG` register contains the value `0x59` at address `FE8`. The `PCLAT` register contains the value `0x000004` at address `FF9`.

The main editor window shows the assembly code for `pro0.asm`, with the instruction `addlw 0x7f` highlighted, corresponding to the instruction in the Program Memory window.

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP
9	0010	FFFF	NOP
10	0012	FFFF	NOP
11	0014	FFFF	NOP
12	0016	FFFF	NOP
13	0018	FFFF	NOP
14	001A	FFFF	NOP
15	001C	FFFF	NOP
16	001E	FFFF	NOP

Update	Address	Symbol Name	Value	Decim
	FE8	WREG	0x59	
	FF9	PCLAT	0x000004	

6. Press the “Step Over” button again.

The screenshot displays the MPLAB IDE v8.92 interface with the following components:

- Stopwatch Window:** Shows execution statistics. The 'Instruction Cycles' and 'Total Simulated' are both 3. The 'Time (uSecs)' is 3.000000. The 'Processor Frequency (MHz)' is 4.000000.
- Source Window:** Displays the assembly code for 'pro0.asm'. The current instruction is a 'nop' at address 0x0006, highlighted with a green arrow.
- Program Memory Window:** Shows the disassembly of the program memory. The current instruction is 'NOP' at address 0006, highlighted with a green arrow.
- Watch Window:** Shows the values of selected variables. The 'PCLAT' register is highlighted with a yellow background, showing a value of 0x000006.

Program Memory Disassembly:

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP
9	0010	FFFF	NOP
10	0012	FFFF	NOP
11	0014	FFFF	NOP
12	0016	FFFF	NOP
13	0018	FFFF	NOP
14	001A	FFFF	NOP
15	001C	FFFF	NOP
16	001E	FFFF	NOP

Watch Window:

Update	Address	Symbol Name	Value	Decim
	FE8	WREG	0xD8	
	FF9	PCLAT	0x000006	

7. Press the “Step Over” button again.

The screenshot shows the MPLAB IDE v8.92 interface in the Stopwatch mode. The main window displays the assembly code for the program, with the instruction at address 0008 (NOP) highlighted. The Stopwatch window shows the execution progress, with 4 instruction cycles and 4,000,000 uSecs. The Program Memory window shows the instruction at address 0008 (NOP) highlighted. The Watch window shows the current values of WREG (0xD8) and PCLAT (0x000008).

Stopwatch

	Stopwatch	Total Simulated
Instruction Cycles	4	4
Time (uSecs)	4.000000	4.000000
Processor Frequency (MHz)	4.000000	

Program Memory

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP
9	0010	FFFF	NOP
10	0012	FFFF	NOP
11	0014	FFFF	NOP
12	0016	FFFF	NOP
13	0018	FFFF	NOP
14	001A	FFFF	NOP
15	001C	FFFF	NOP
16	001E	FFFF	NOP

Watch

Update	Address	Symbol Name	Value	Decim
	FE8	WREG	0xD8	
	FF9	PCLAT	0x000008	

8. Press the “Step Over” button again.

The screenshot displays the MPLAB IDE v8.92 interface with the following components:

- Stopwatch Window:** Shows execution statistics. The 'Synchronise' button is active. Instruction Cycles: 5 (Stopwatch), 5 (Total Simulated). Time (uSecs): 5.000000 (Stopwatch), 5.000000 (Total Simulated). Processor Frequency (MHz): 4.000000.
- Source Window (E:\2004_2017\tutorial_program\pro0.asm):** Displays assembly code. The instruction at line 6, `goto Main`, is highlighted with a green arrow pointing to it.
- Program Memory Window:** Shows a table of memory contents. Line 6, address 000A, contains the instruction `EF00 GOTO 0`, which is highlighted with a green arrow.
- Watch Window:** Monitors variables. The `PCLAT` register is selected. The current value is `FF9` (highlighted in yellow).

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP
9	0010	FFFF	NOP
10	0012	FFFF	NOP
11	0014	FFFF	NOP
12	0016	FFFF	NOP
13	0018	FFFF	NOP
14	001A	FFFF	NOP
15	001C	FFFF	NOP
16	001E	FFFF	NOP

Update	Address	Symbol Name	Value	Decim
	FE8	WREG	0xD8	
	FF9	PCLAT	0x00000A	

9. Press the “Step Over” button again.

The screenshot displays the MPLAB IDE v8.92 interface with the Stopwatch window open. The Stopwatch window shows the following data:

Stopwatch		Total Simulated
Synch	Instruction Cycles	7
Zero	Time (uSecs)	7.000000
Processor Frequency (MHz)		4.000000

The Program Memory window shows the disassembly of the program:

Line	Address	Opcode	Disassembly
1	0000	0E27	MOVLW 0x27
2	0002	0F32	ADDLW 0x32
3	0004	0F7F	ADDLW 0x7f
4	0006	0000	NOP
5	0008	0000	NOP
6	000A	EF00	GOTO 0
7	000C	F000	NOP
8	000E	0000	NOP
9	0010	FFFF	NOP
10	0012	FFFF	NOP
11	0014	FFFF	NOP
12	0016	FFFF	NOP
13	0018	FFFF	NOP
14	001A	FFFF	NOP
15	001C	FFFF	NOP
16	001E	FFFF	NOP

The Watch window shows the current state of the processor registers:

Update	Address	Symbol Name	Value	Decim
	FE8	WREG	0xD8	
	FF9	PCLAT	0x000000	

The ASM window shows the assembly code for the program:

```
LIST P=18F4520 ;directive to define processor
#include <P18F4520.INC>;CPU specific variable definitions

ORG 0x0000 ;code origin, program start from here
Main: movlw 0x27 ;Load 21H to WREG
      addlw 0x32 ; Add 42H to WREG
      addlw 0x7F ; Add 7FH to WREG
      nop      ; Do nothing
      nop      ; Do nothing
      goto Main ; Goto the instruction labelled by Main
      nop
      END
```