CS4101 Introduction to Embedded Systems

Lab 1: MSP430 LaunchPad IDE

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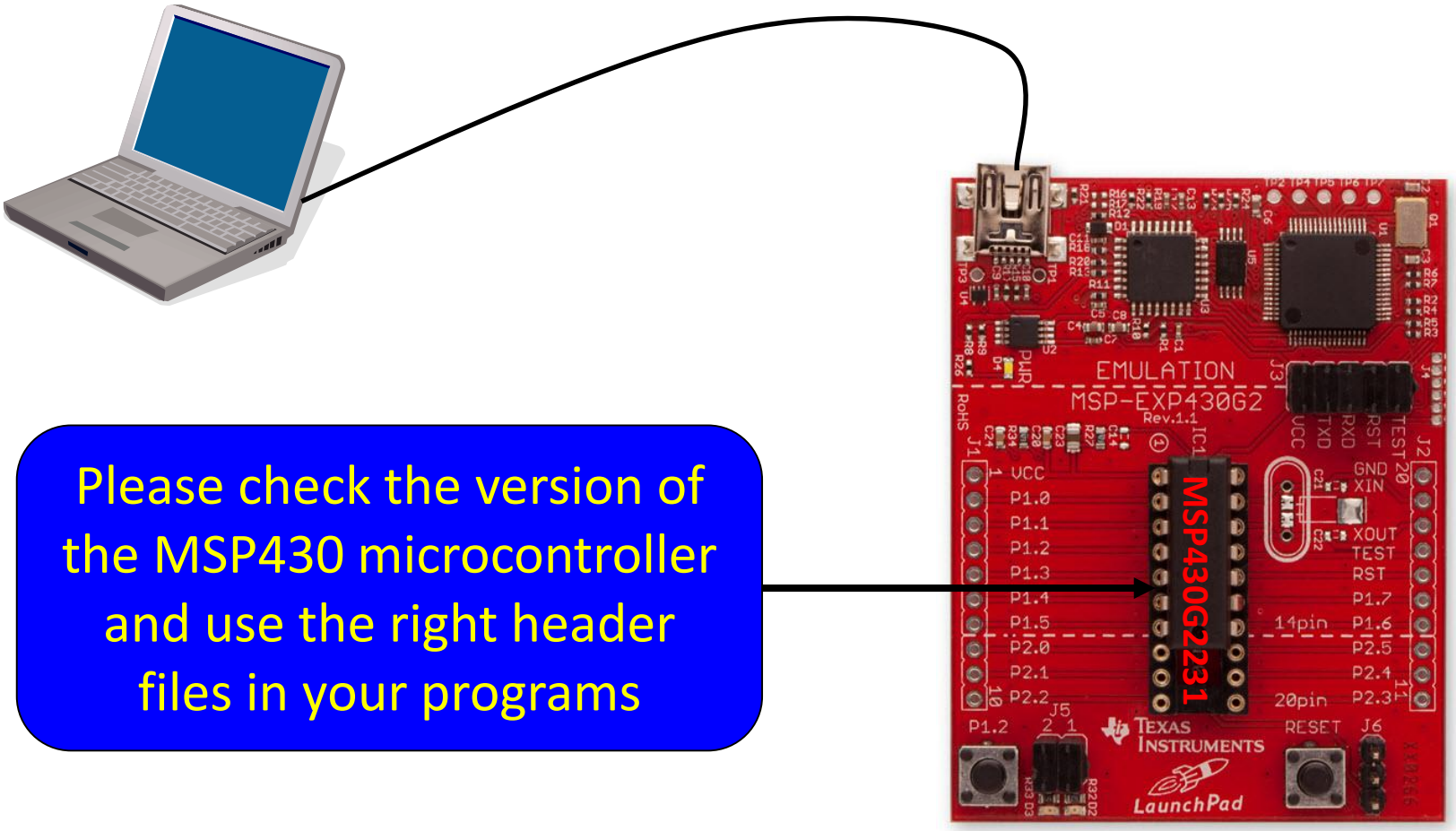
Introduction

- In this lab, we will learn the IDE for MSP430 LanuchPad, Code Composer Studio (CCS)
  - Learn how to set up the LaunchPad development board
  - Learn how to create a new project on CCS
  - Learn how to upload a program to the board
  - Debug a program
  - Run a program
  - Use disassembly window

Hardware Setup

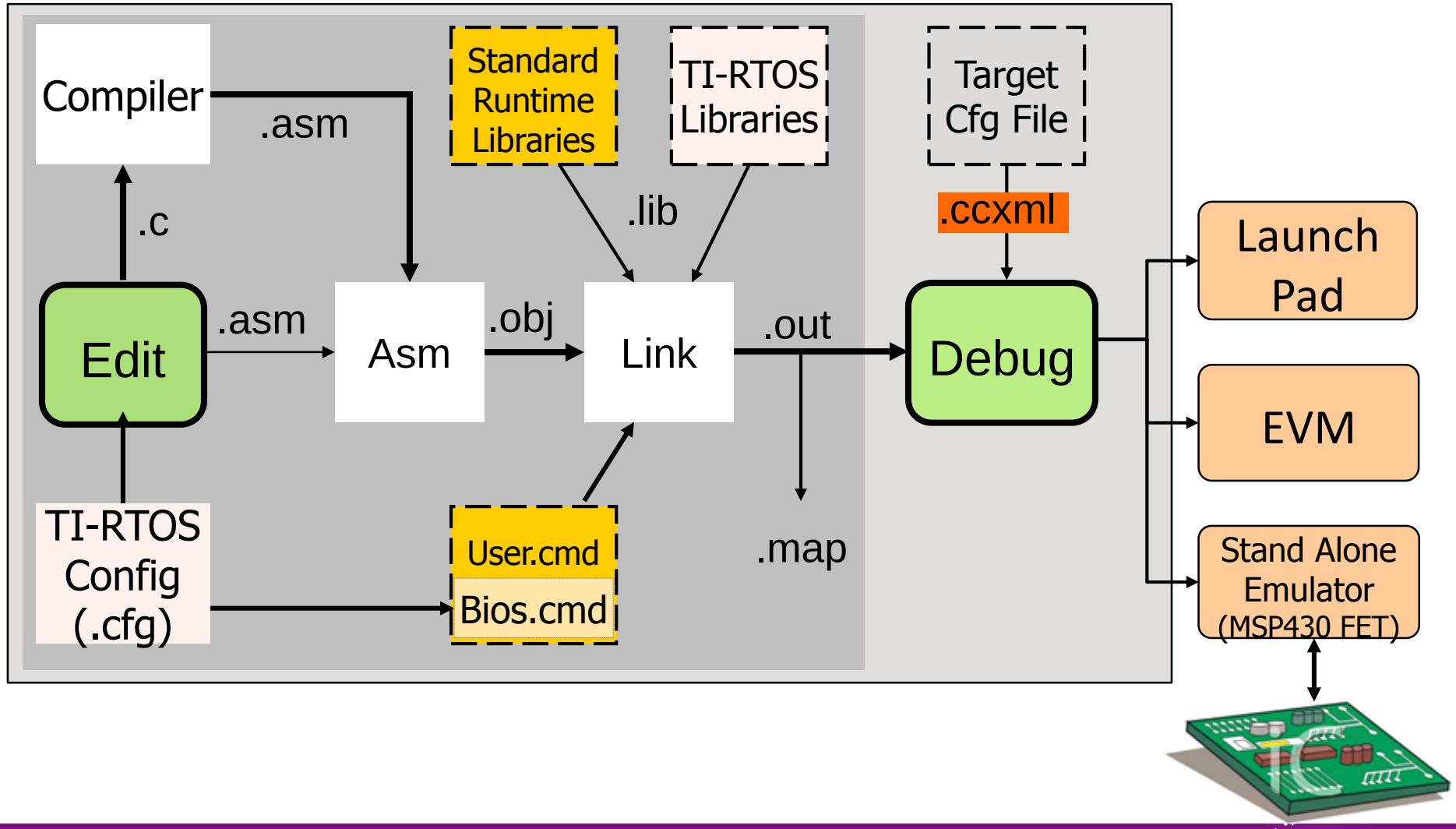


Please check the version of the MSP430 microcontroller and use the right header files in your programs

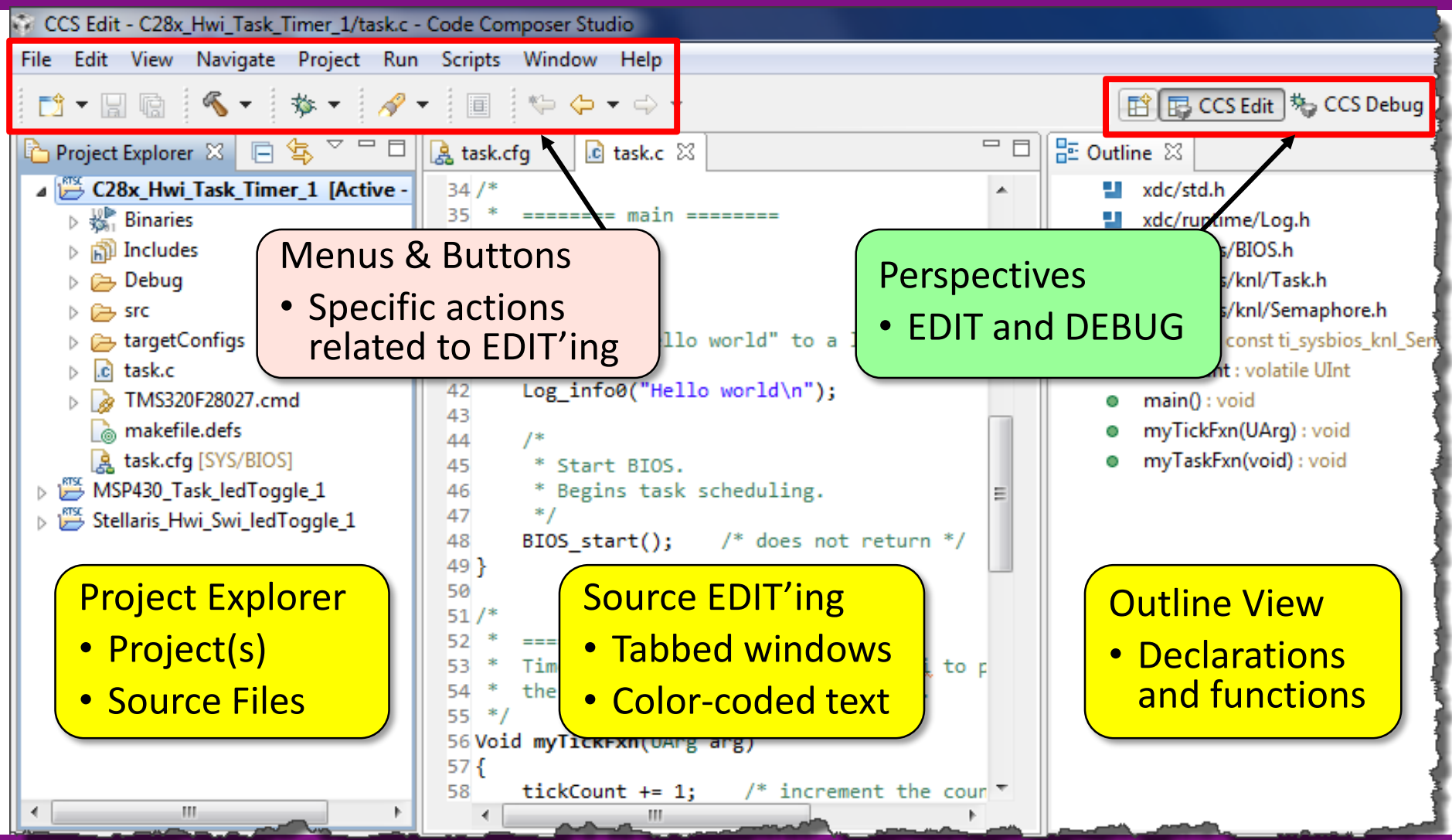
Code Composer Studio (CCS)

- An *Integrated Development Environment* (IDE) based on Eclipse
- Integrated “Debugger” and “Editor” – IDE
  - Edit and Debug have the own “perspectives” (menus, windows)
- Contains all development tools – compilers, TI-RTOS kernel and includes one target – the Simulator

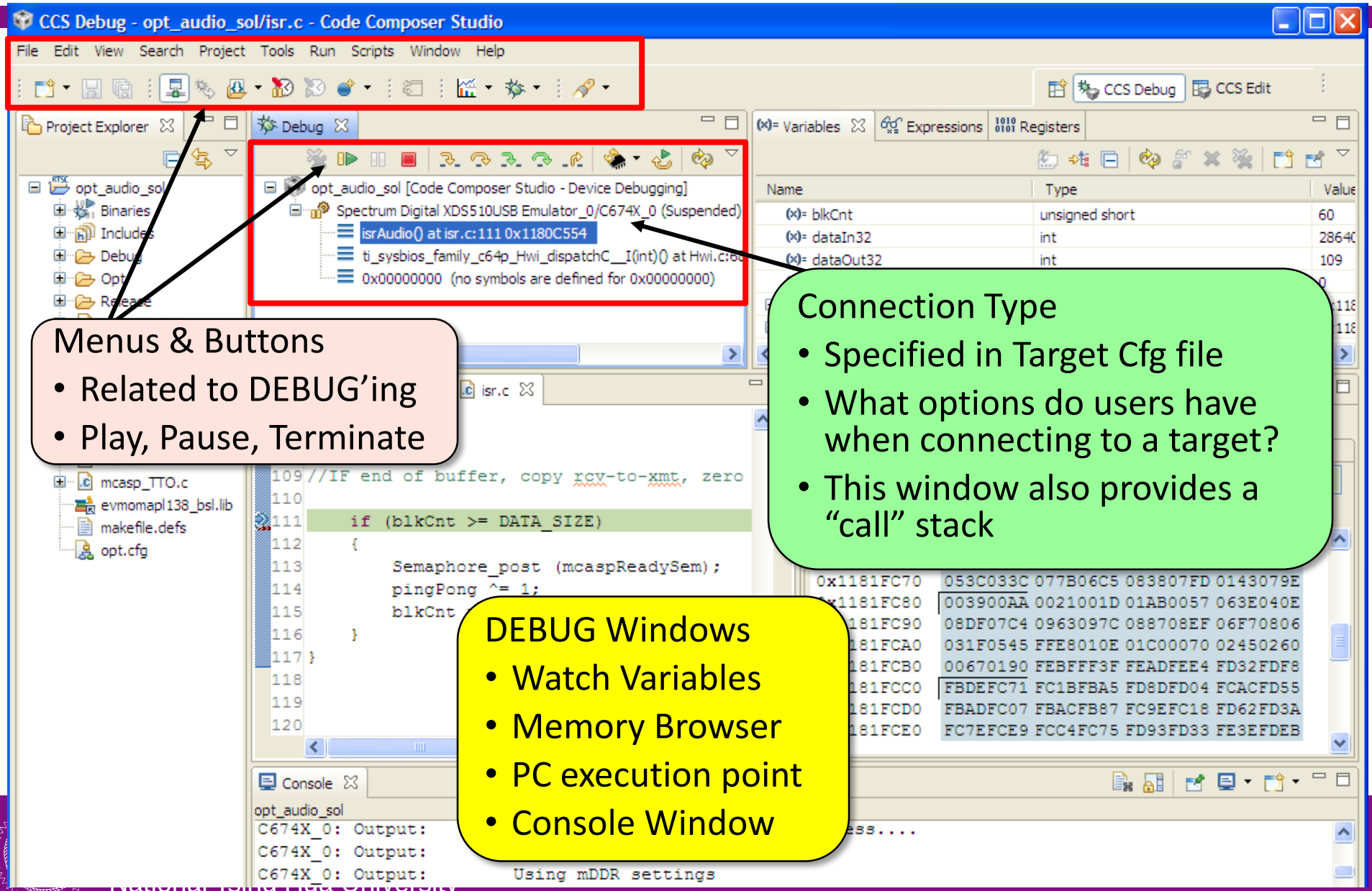
Code Composer Studio (CCS)



CCS GUI – EDIT Perspective



CCS GUI – DEBUG Perspective

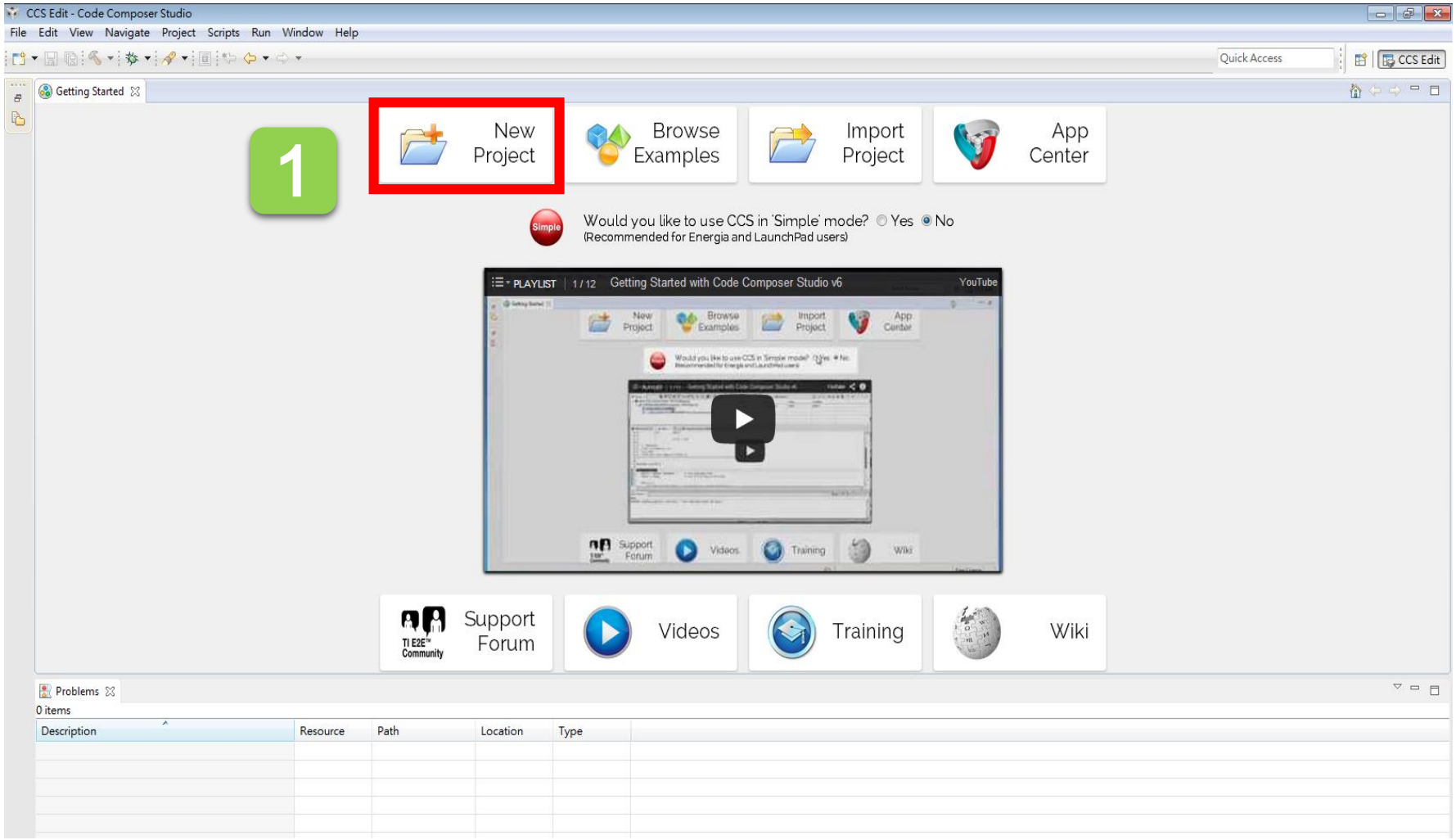


Menus & Buttons
- Related to DEBUG'ing
- Play, Pause, Terminate

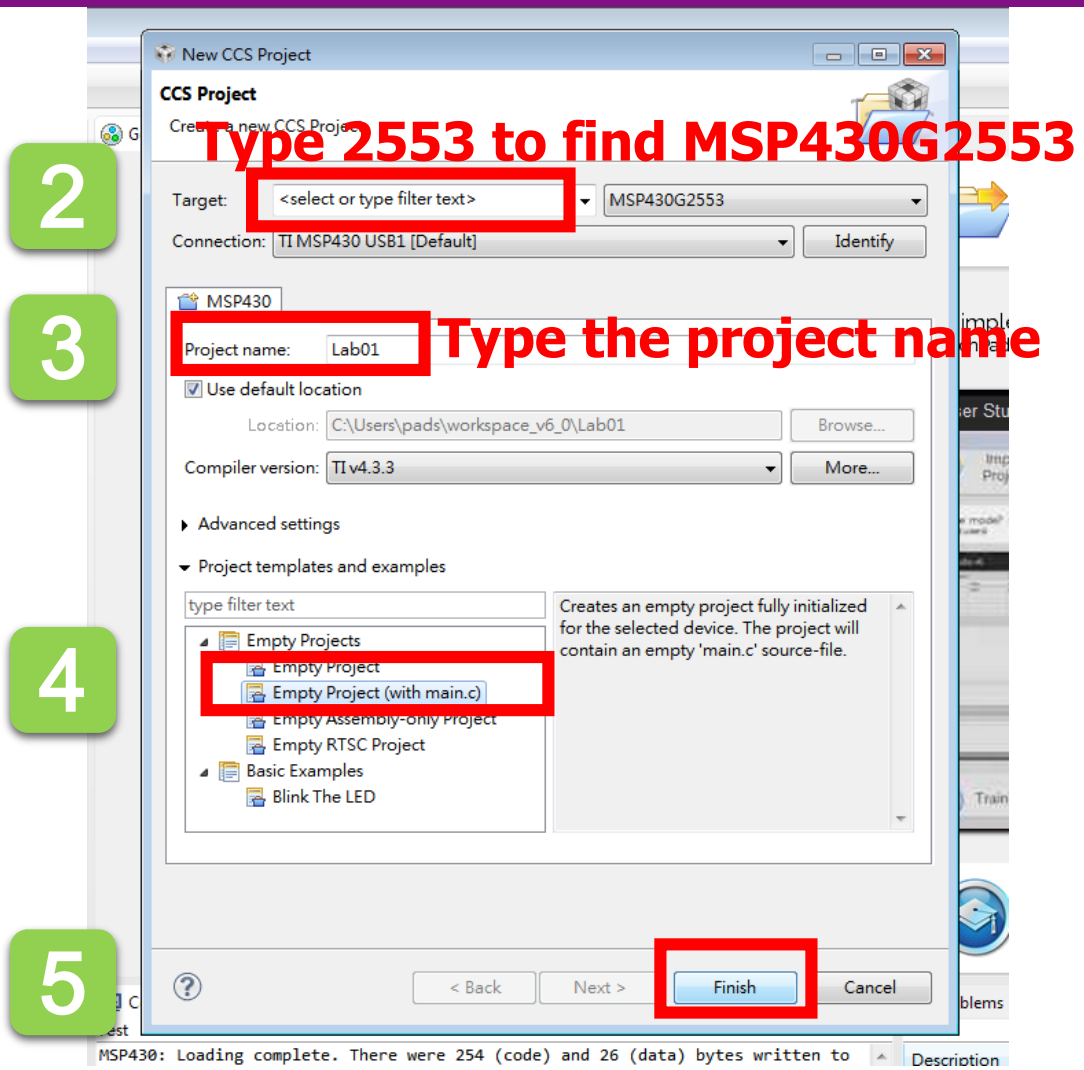
Connection Type
- Specified in Target Cfg file
- What options do users have when connecting to a target?
- This window also provides a "call" stack

DEBUG Windows
- Watch Variables
- Memory Browser
- PC execution point
- Console Window

Create a New CCS Project



Create a New CCS Project



Build and Load the Project

- Three buttons on the horizontal toolbar control code generation. You can move your mouse over each button to read their descriptions.

Button	Name	Description
1	Build	Incremental build and link of only modified source files
2	Rebuild	Full build and link of all source files
3	Debug	Automatically build, link, load and launch debug-session

- Click the **"Build"** button and watch the tools run in the Console window. Check for any errors in the Problems window.

Build and Load the Project

- CCS can automatically save modified source files, build the program, open the debug perspective view for debugging, download the program to the target, and run the program at the beginning of the main() function
  - Click on the **"Debug"** button (green bug) or

    Click **Target** → **Debug Active Project**

Debug Environment

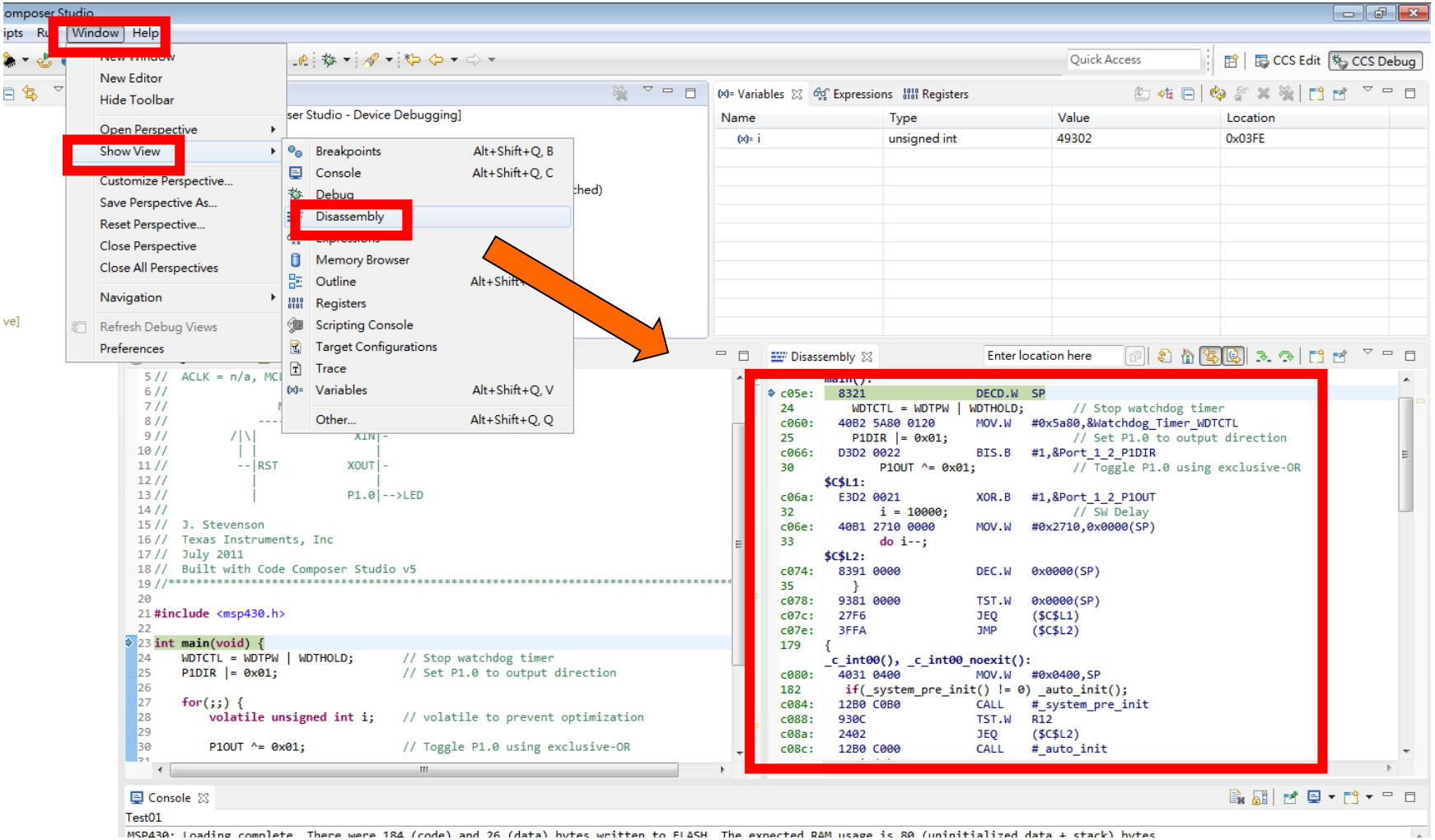
- The basic buttons that control the debug environment are located in the top of CCS:

- At this point you should still be at the beginning of main(). Click the **Run** button to run the code.
  - Notice that the LEDs are toggling, as expected.

End Debug Session and Close Project

- The **Terminate All** button will terminate the active debug session, close the debugger and return CCS to the "C/C++ Perspective" view
  - Click **Target** → **Terminate All** or use the **Terminate All** button
- Next, close the project by right-clicking on project-name in the **C/C++ Projects** window and select **Close Project**.

Use Disassembly Window in Debug



Sample Code: Blinking the Red LED

```
#include <msp430x2231.h>
int main(void) {
   WDTCTL = WDTPW | WDTHOLD;    // Stop watchdog timer
   P1DIR |= 0x01;               // Set P1.0 as output

   for(;;) {
      volatile unsigned int i;  // prevent optimization

      P1OUT ^= 0x01;            // Toggle P1.0 using XOR
      i = 10000;                // SW Delay
      do i--;
      while(i != 0);
   }
   return 0;
}
```

Lab 1

- Upload sample code to the board and run it. The red LED should blink.
- **Basic 1:** Modify the code to blink the green and red LED, which are located at **Port 1 Bit 0** and **Bit 6.**.

```
WDTCTL = WDTPW + WDTHOLD;    // Stop watchdog timer
P1DIR = 0x41;                // P1.0 & 6 outputs (red & green LEDs)
```

0100 0001

- If we want to turn on green LED, we should assign P1OUT to 0x40, which is 01000000 in binary.

0100 0000

```
while(1)    {
    P1OUT = 0x40;            // P1.6 on (green LED)
    _delay_cycles(100);
    P1OUT = 0;               // green LED off
    _delay_cycles(5000);
  }
```

Lab 1

- **Basic 2:**
  - Modify the sample code to remove the **`volatile`** keyword in declaring the variable i. Observe how the LaunchPad behaves.
- **Basic 3:**
  - To explain the behavior of LaunchPad, let us study the assembly code of the two programs.
  - Use the disassembly window to obtain the assembly code of the original sample code and the modified sample code
  - Observe the differences of these two assembly programs and explain the behavior of LaunchPad.

Assembly for Not Using `volatile`

```
24    WDTCTL = WDTPW | WDTHOLD;
      main():
c078:    40B2 5A80 0120    MOV.W   #0x5a80,&Watchdog_Timer_WDTCTL
25    P1DIR |= 0x01;
c07e:    D3D2 0022         BIS.B   #1,&Port_1_2_P1DIR
31    P1OUT ^= 0x01;
       $C$L1:
c082:    E3D2 0021         XOR.B   #1,&Port_1_2_P1OUT
34    do i--;
c086:    3FFD              JMP     ($C$L1)
65     func_epilog_7:       POP     r4
       __mspabi_func_epilog(), __mspabi_func_epilog_7():
c088:    4134              POP.W   R4
66     func_epilog_6:       POP     r5
       __mspabi_func_epilog_6():
c08a:    4135              POP.W   R5
```

Assembly for Using `volatile`

```
23      int main(void) {
        main():
c05e:     8321              DECD.W   SP
24      WDTCTL = WDTPW | WDTHOLD;
c060:     40B2 5A80 0120    MOV.W    #0x5a80,&Watchdog_Timer_WDTCTL
25      P1DIR |= 0x01;
c066:     D3D2 0022         BIS.B    #1,&Port_1_2_P1DIR
31      P1OUT ^= 0x01;
        $C$L1:
c06a:     E3D2 0021         XOR.B    #1,&Port_1_2_P1OUT
33      i = 10000;
c06e:     40B1 2710 0000    MOV.W    #0x2710,0x0000(SP)
34      do i--;
        $C$L2:
c074:     8391 0000         DEC.W    0x0000(SP)
36      }
c078:     9381 0000         TST.W    0x0000(SP)
c07c:     27F6              JEQ      ($C$L1)
c07e:     3FFA              JMP      ($C$L2)
```

Assembly for Using `volatile`

```
179    {
       _c_int00(), _c_int00_noexit():
c080:    4031 0400           MOV.W   #0x0400,SP
182       if(_system_pre_init() != 0) _auto_init();
c084:    12B0 C0B0           CALL    #_system_pre_init
c088:    930C                TST.W   R12
c08a:    2402                JEQ     ($C$L2)
c08c:    12B0 C000           CALL    #_auto_init
183       main(0);
       $C$L2:
c090:    430C                CLR.W   R12
c092:    12B0 C05E           CALL    #main
184       abort();
c096:    12B0 C0B4           CALL    #abort
65     func_epilog_7:        POP     r4
       __mspabi_func_epilog(), __mspabi_func_epilog_7():
c09a:    4134                POP.W   R4
66     func_epilog_6:        POP     r5
       __mspabi_func_epilog_6():
```

Grading Policies

- DEMO in the lab ----------100%
- DEMO within a week (before lab starts) --------80%
- DEMO after a week (before lab starts) ----------60%
- After two weeks (after lab starts)---------- 0%

- TA office hour:
  - Mon 10:00 – 12:00
  - Tue 13:00 – 15:00
  - Wed 10:00 – 12:00