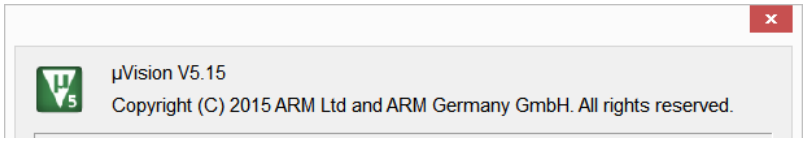
Getting Started in C Programming with Keil MDK-ARM Version 5

Reason for Revision

- This document was revised for Keil MDK-ARM v5.14 on February 18, 2015.
- This document was revised for MSP432 LaunchPad on November 30, 2015.
- This tutorial is based on uVision 5.15.0.0 and Texas Instruments MSP432 LaunchPad, which contains a MSP432P401R microcontroller.
- This tutorial is verified with uVision 5.17 with Texas Instruments MSP432 CMSIS update. On December 29, 2015
- This tutorial is verified with uVision 5.20 with Texas Instruments MSP432 CMSIS update. On July 24, 2016

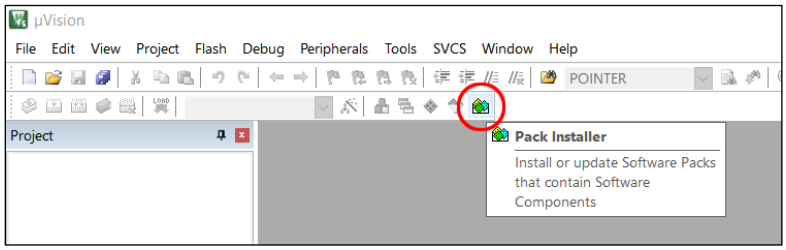


Install MSP432 CMSIS Update

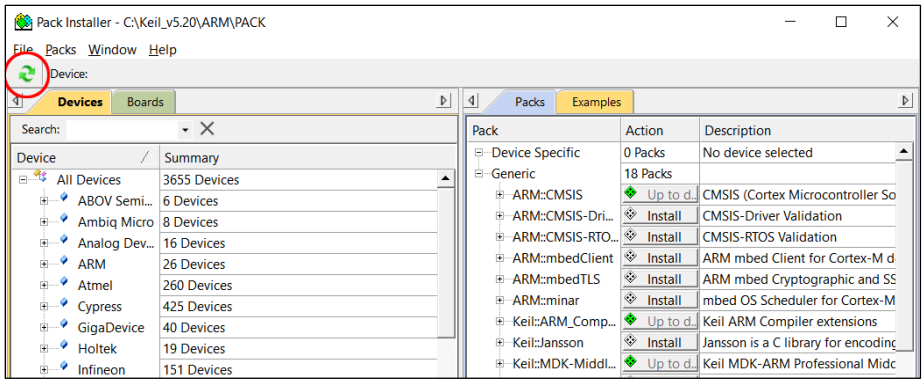
The register naming in the text follows the CMSIS convention. You need to perform MPS432 CMSIS update of the Keil uVision to use the same syntax.

If you already performed MPS432 CMSIS update during the installation of Keil MDK-ARM, you may skip this procedure.

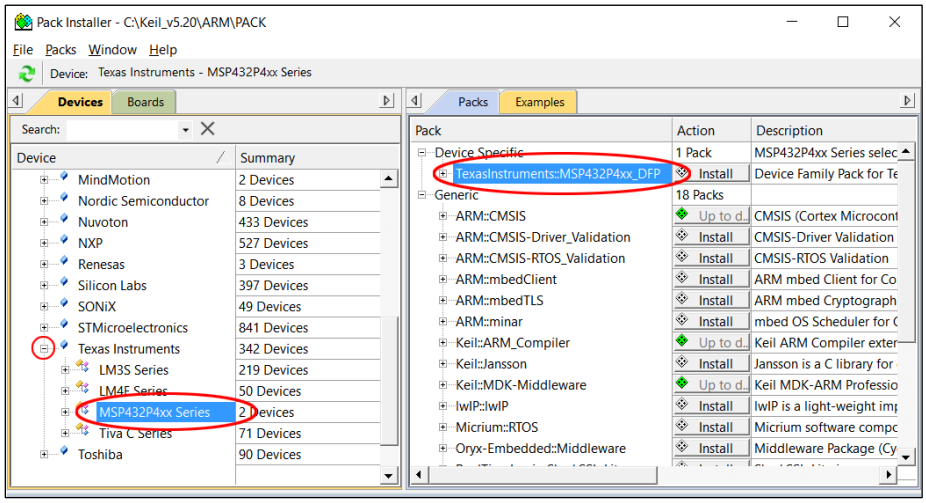
1. Launch Keil uVision.
2. Click Pack Installer button and the Pack installer window will open.



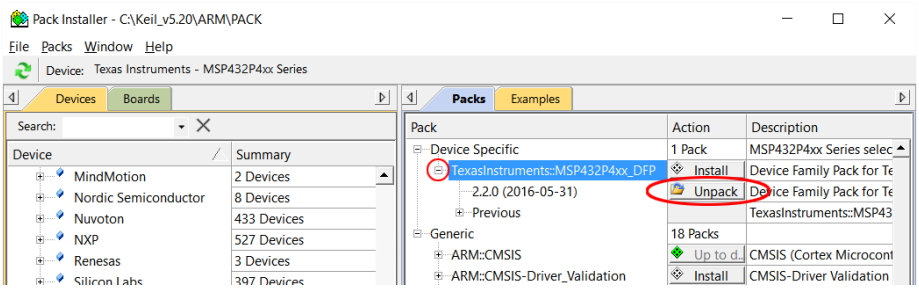
3. Click refresh button to reload the latest catalog of all the device software packs. This may take a few minutes.



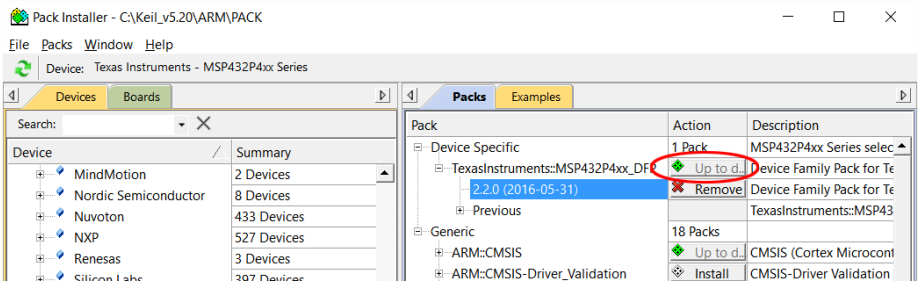
4. After the pack catalog is refreshed, click on the + sign in front of Texas Instruments in Devices tab to open it then click on MSP432P4xx Series. Under the Packs tab in the other half of the window, the TexasInstruments::MSP432P4xx_DFP will be added.



5. Click the + sign before it to expand it and click Unpack button of the latest version. It should be 2.1.0 or later.

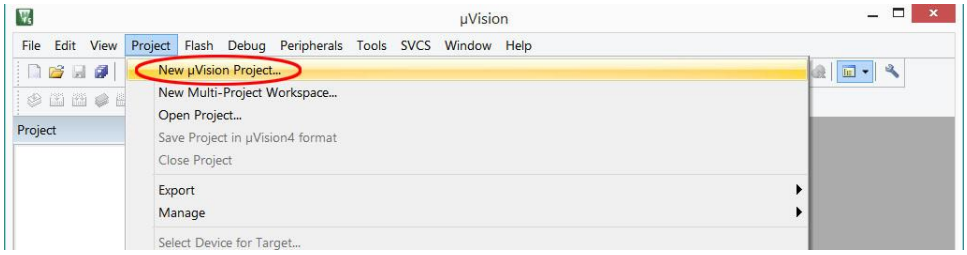


6. When the update is done, the word Unpack will change to Remove and the word Install above also will change to Up to date.

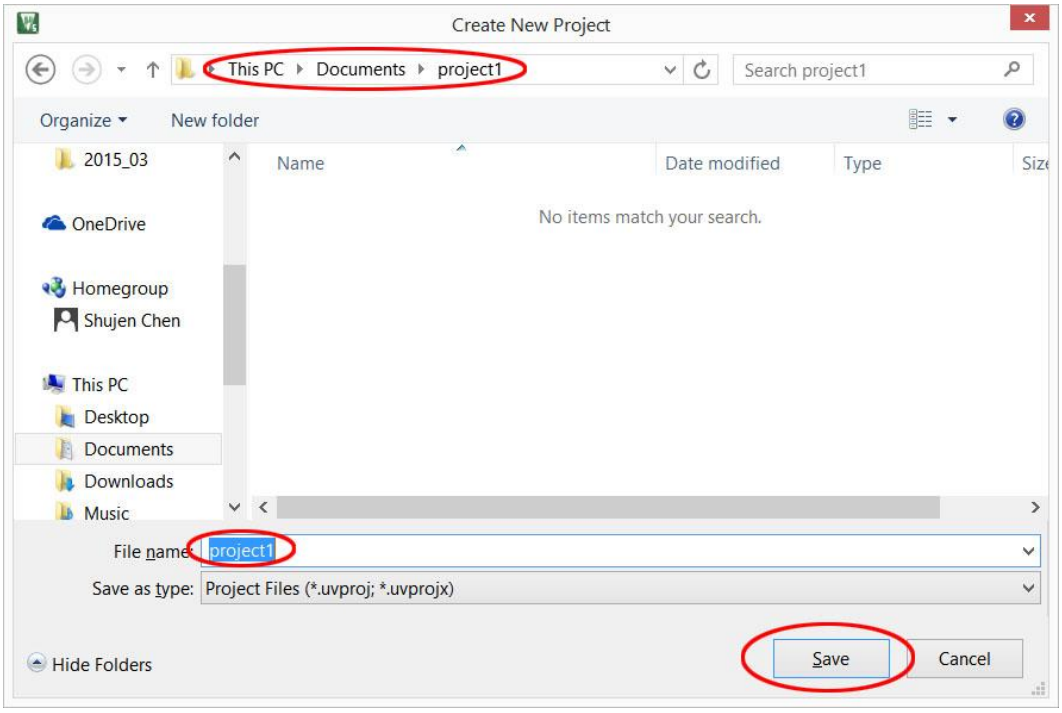


Create a Project with Project Wizard

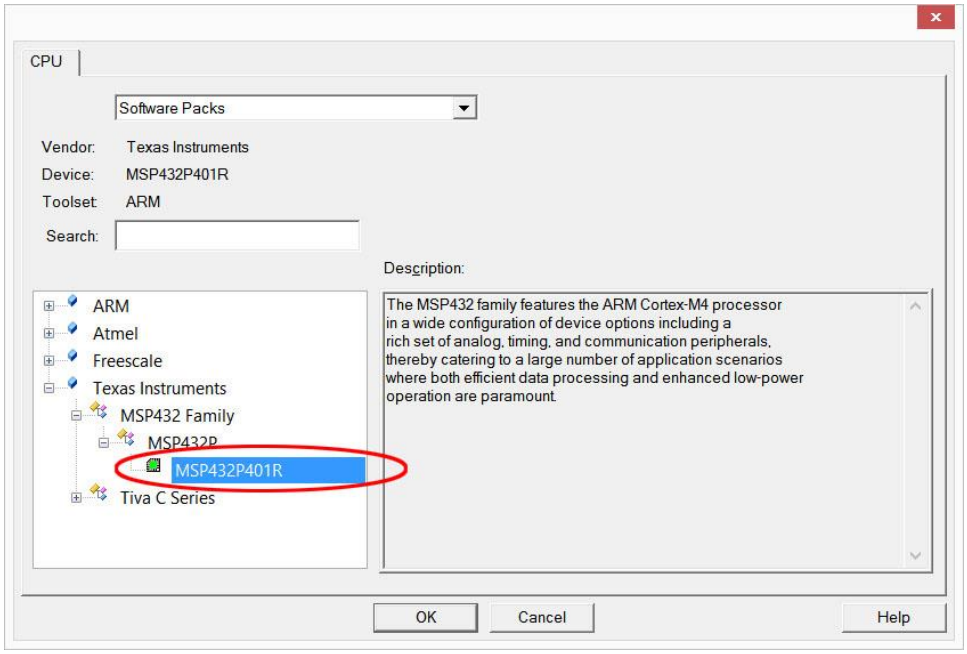
7. Create a new folder named **project1** in **My Documents**. (The folder/file name and the location of the folder are arbitrary. They were selected only for the purpose of this demonstration.)
8. Launch Keil uVision5.
9. From the menu, select Project > New uVision Project…



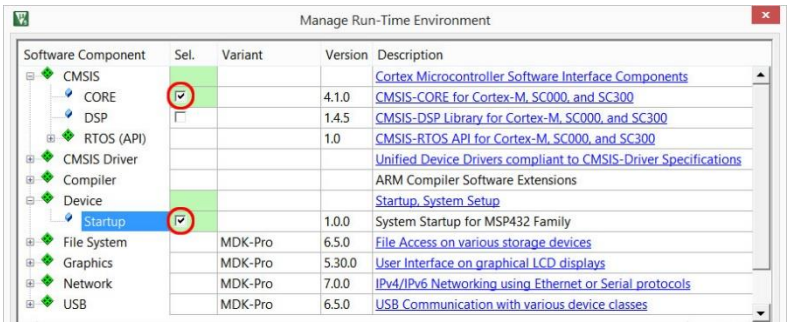
10. In the New uVision Project window, browse to the folder **project1** you just created in **My Documents** folder.
11. If you did not create a folder for the project before launching uVision, you may create a folder using the **New folder** menu item in the **Create New Project** window.
12. Enter a name for the project file. We will call it **project1** and click **Save**.



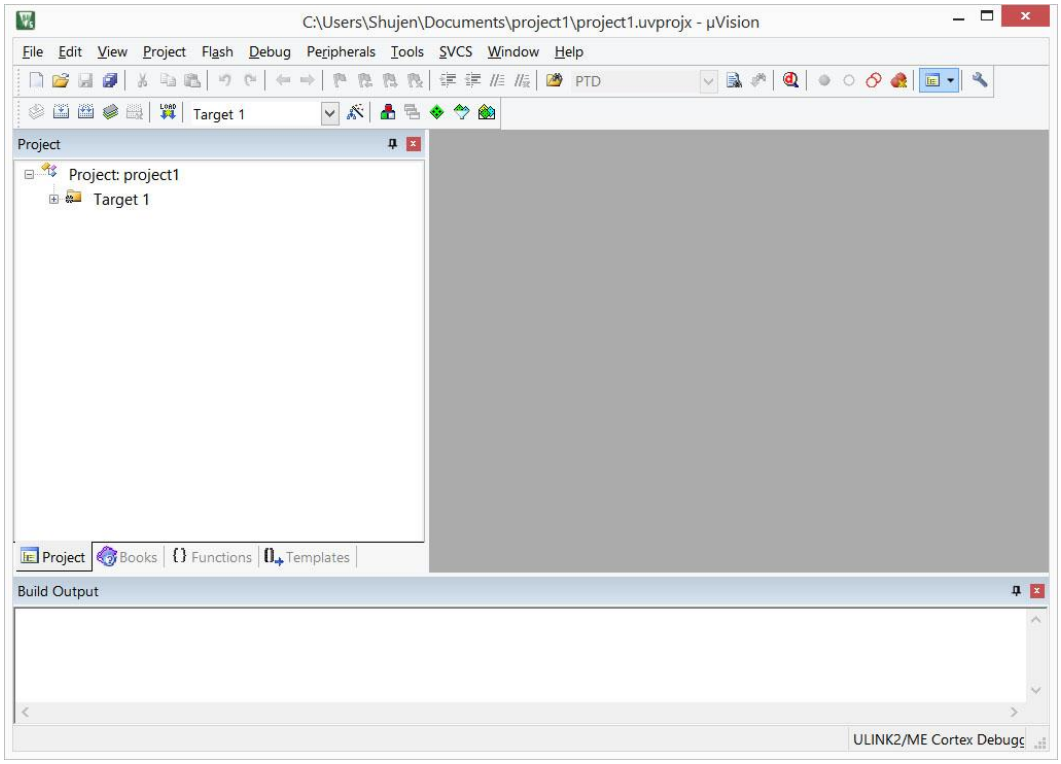
13. A window will pop up for you to select the CPU for this project. The device used on the MSP432 LaunchPad is Texas Instruments MSP432P401R. To select this device, first you need to click on the **+** sign to the left of Texas Instruments to expand the selections than drill down to the expose the exact device. Alternatively, you may start typing in the "Search" field and the possible match will be show below.
14. Click to highlight the device than click OK.



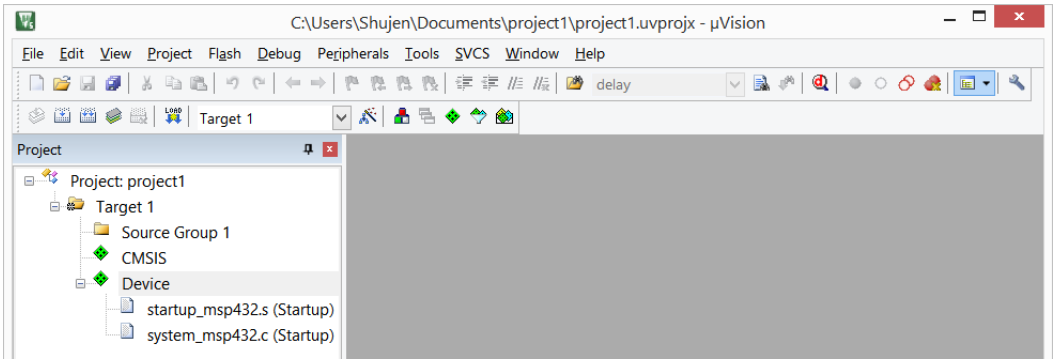
15. The “Manage Run-Time Environment” window will replace the “CPU” window. Expand and click to add the checkmarks for CMSIS->CORE and Device->Startup. Click “OK” button to close the window.



16. In the Project window, a target is created with the default name **Target1**. Click on the **+** sign to the left of Target1 to expand the folder.

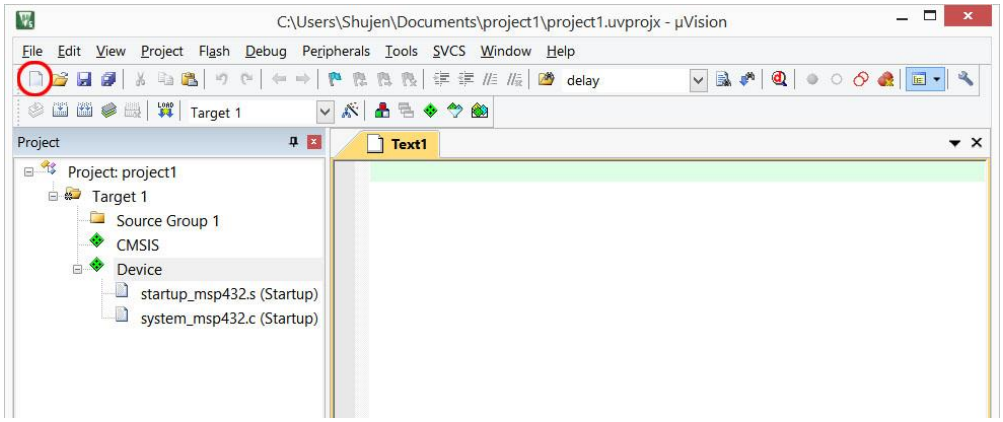


17. A default folder for source code files is created with the name **Source Group 1**. The startup_msp432.s and system_msp432.c files are already in the folder.

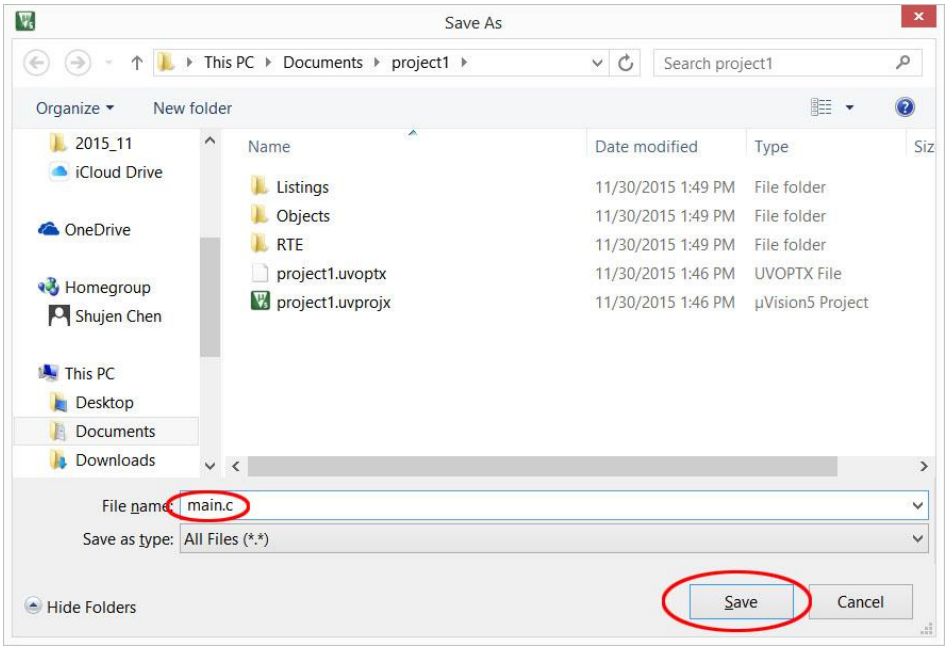


Add a Source File to the Project

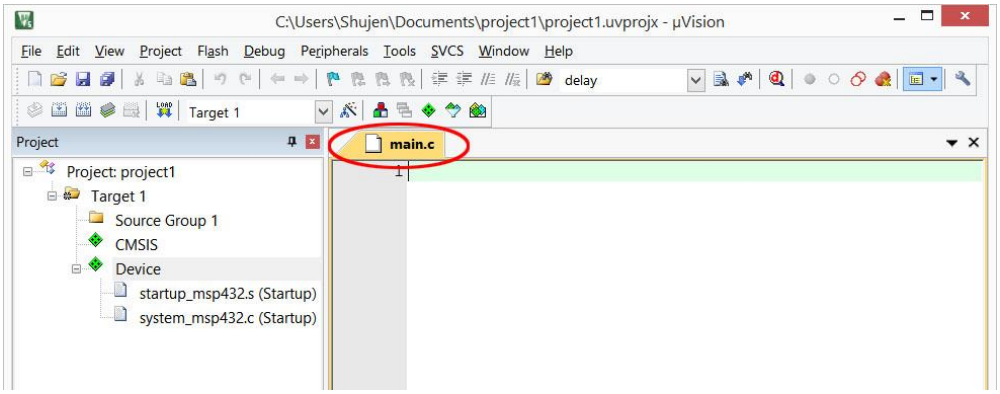
18. Click the **New** button to add a new text file to the display with the default name **Text1**.



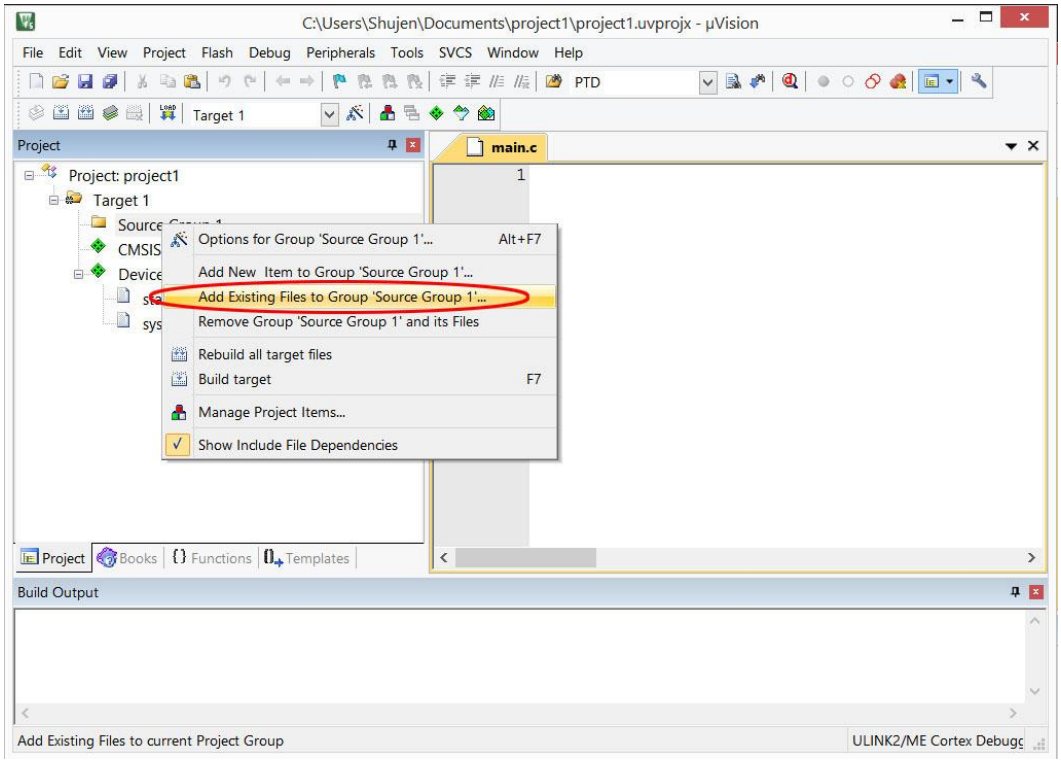
19. From the menu, select **File > Save As…** to open the Save As dialog box. Browse to the project folder if it is not already there. Type in the file name **main.c** and click **Save**.



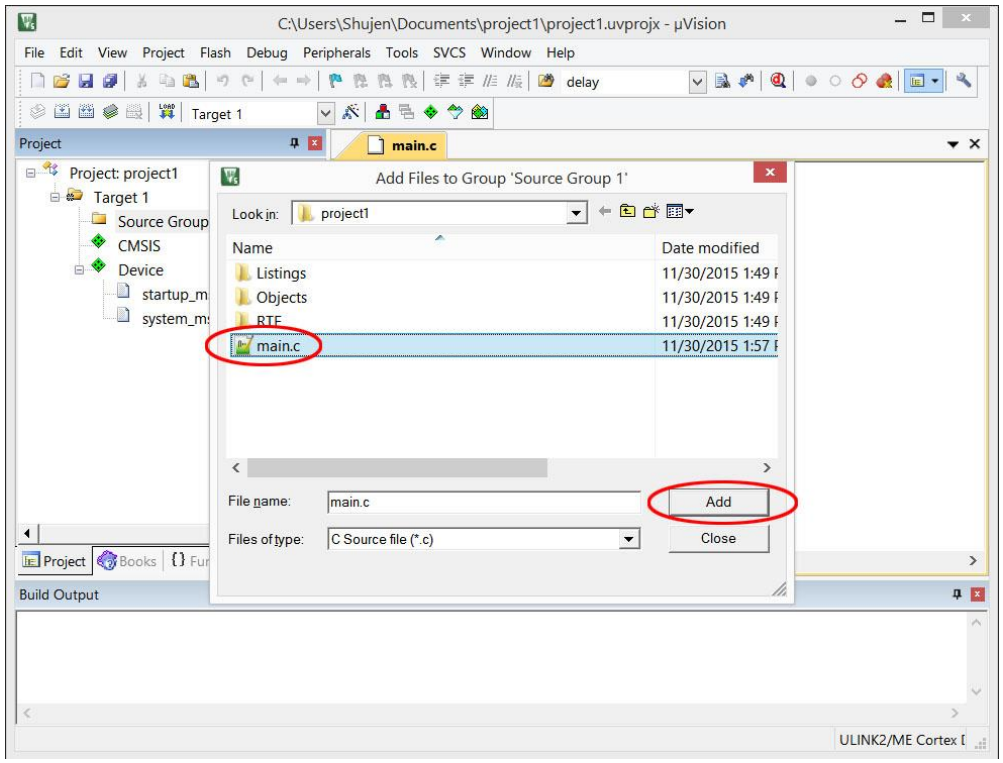
20. You will notice the file name in the tab changed to main.c



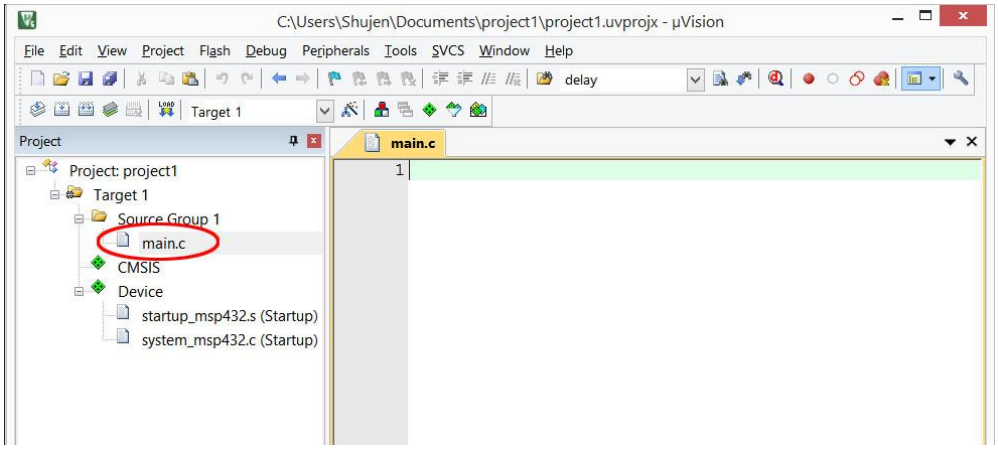
21. The new file needs be added to the project. Right click on the folder **Source Group 1** in the Project window and select **Add Existing Files to Group 'Source Group 1'…**



22. In the dialog box, browse to the project folder if it is not already there. Click select **main.c** then click **Add**.



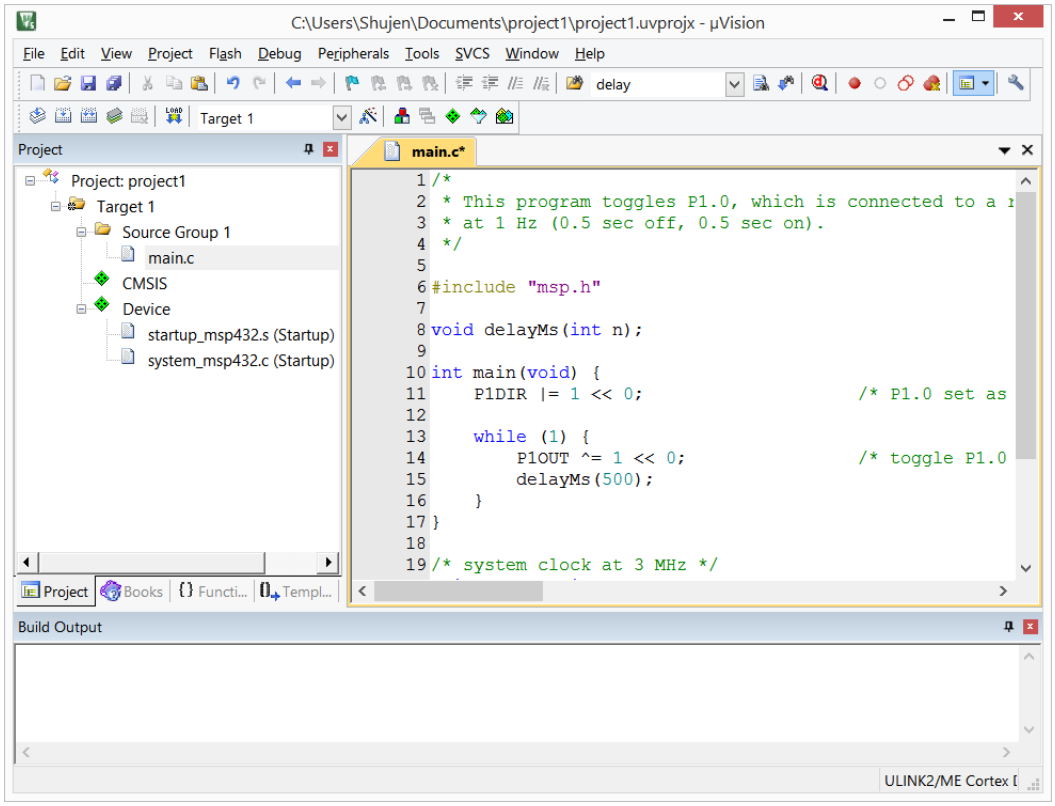
23. Click Close to close the “Add Files” dialog box. The file should appear in the project window under Source Group 1 folder.



24. Copy and paste the following code into the main.c editor window.

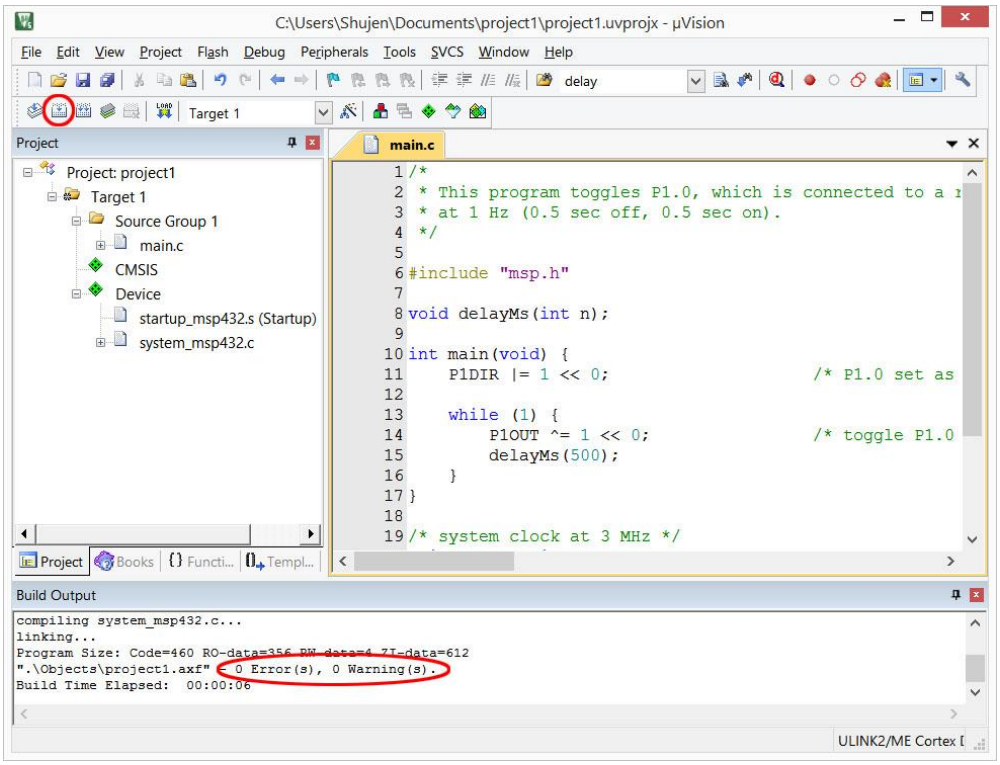
```
/*
 * This program toggles P1.0, which is connected to a red LED,
 * at 1 Hz (0.5 sec off, 0.5 sec on).
 */

#include "msp.h"

void delayMs(int n);

int main(void) {
    P1->DIR |= 1 << 0;                      /* P1.0 set as output */

    while (1) {
        P1->OUT ^= 1 << 0;                  /* toggle P1.0 LED */
        delayMs(500);
    }
}

/* system clock at 3 MHz */
void delayMs(int n) {
    int i, j;

    for (j = 0; j < n; j++)
        for (i = 124; i > 0; i--);      /* Delay */
}
```

25. The file name in the tab will have an ‘*****’ next to it. It symbolizes that the file has been changed without saving. You may click the save button to save the file or proceed to build the project. The file is automatically saved before a build.

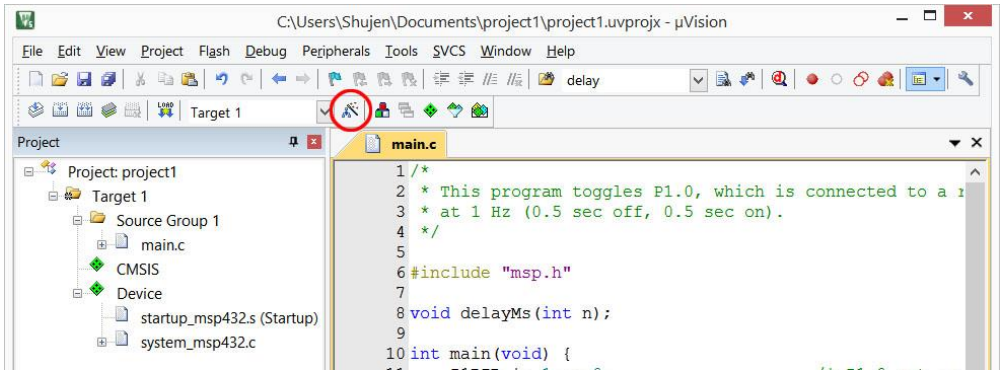


Build the Project and Download to the Target

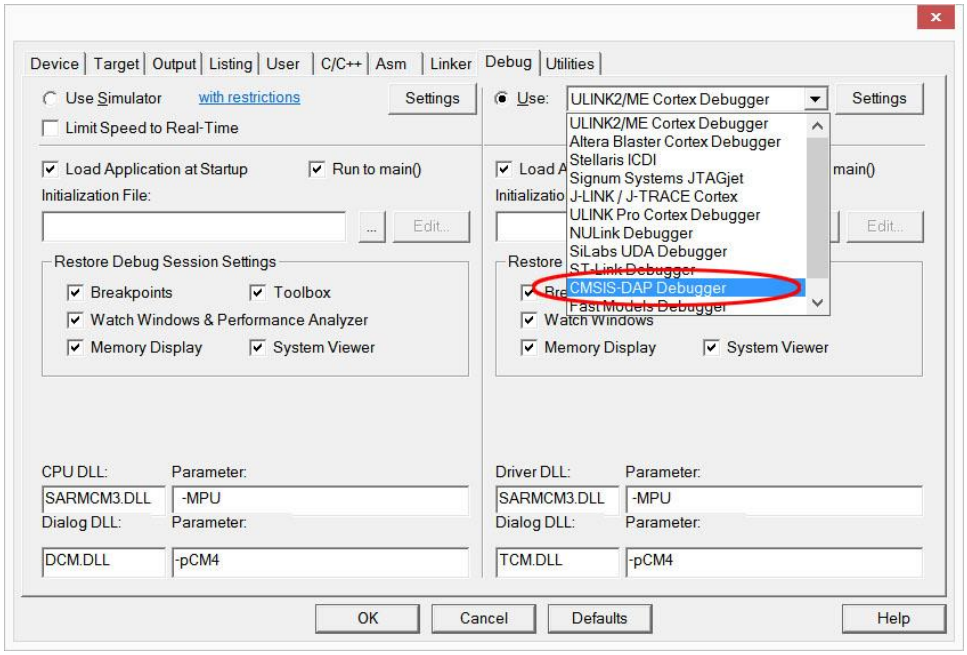
26. Click on the **Build** button and wait for the build to complete. Make sure there are no error messages and review all the warning messages.



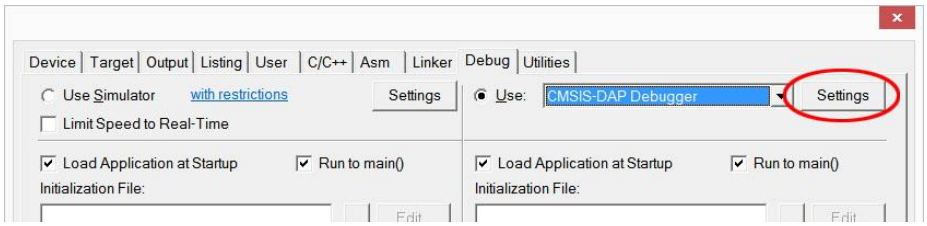
27. Before downloading the program to the target, we need to set up the connection between the uVision IDE and the in-circuit debugger on the target circuit board. Click on the **Target Options** button.



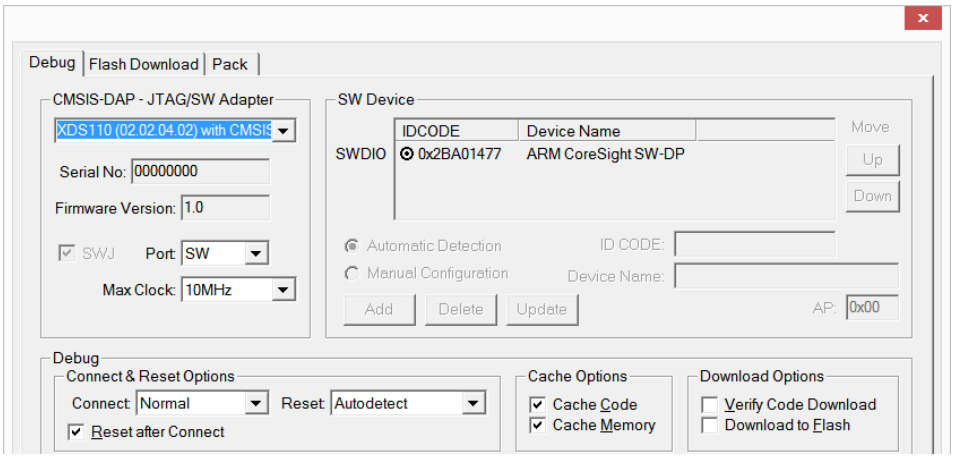
28. Select **Debug** tab and click the radio button on the right and select **CMSIS-DAP Debugger** in the pull-down menu. An additional debug interface was introduced with the newer firmware and Keil MDK-ARM v5.20. It runs much faster than the CMSIS-DAP debugger but has some restrictions. Please check the steps starting at step 39.



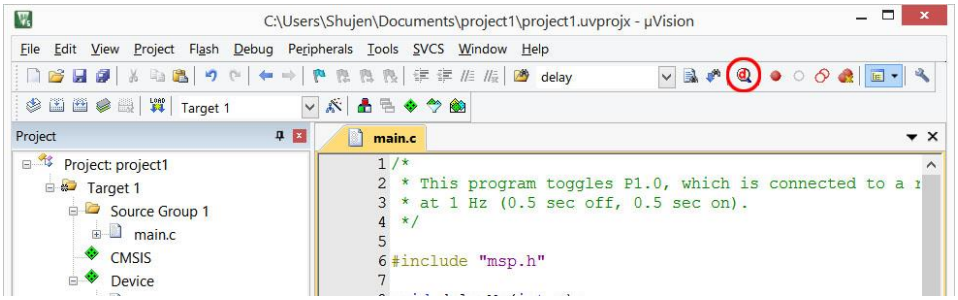
29. You should have the XDS110 device drivers installed in your computer. If you have not done so, download XDS110 device drivers from http://energia.nu/files/xds110_drivers.zip and install them when plug in the board with USB cable.
30. To verify whether the XDS110 driver is properly installed with the board connected, click **Setting** button and a window should pop up showing debug connection.



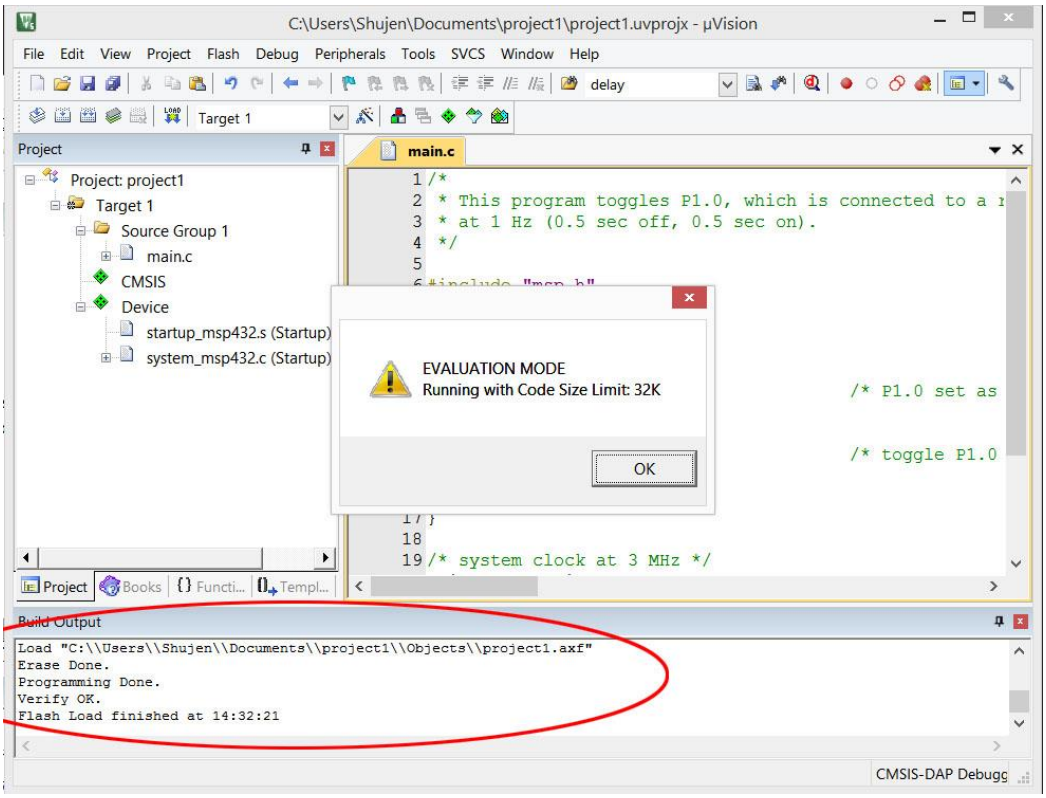
31. Make sure the Port selection has SW and the IDCODE of the debugger should appear in the right panel.



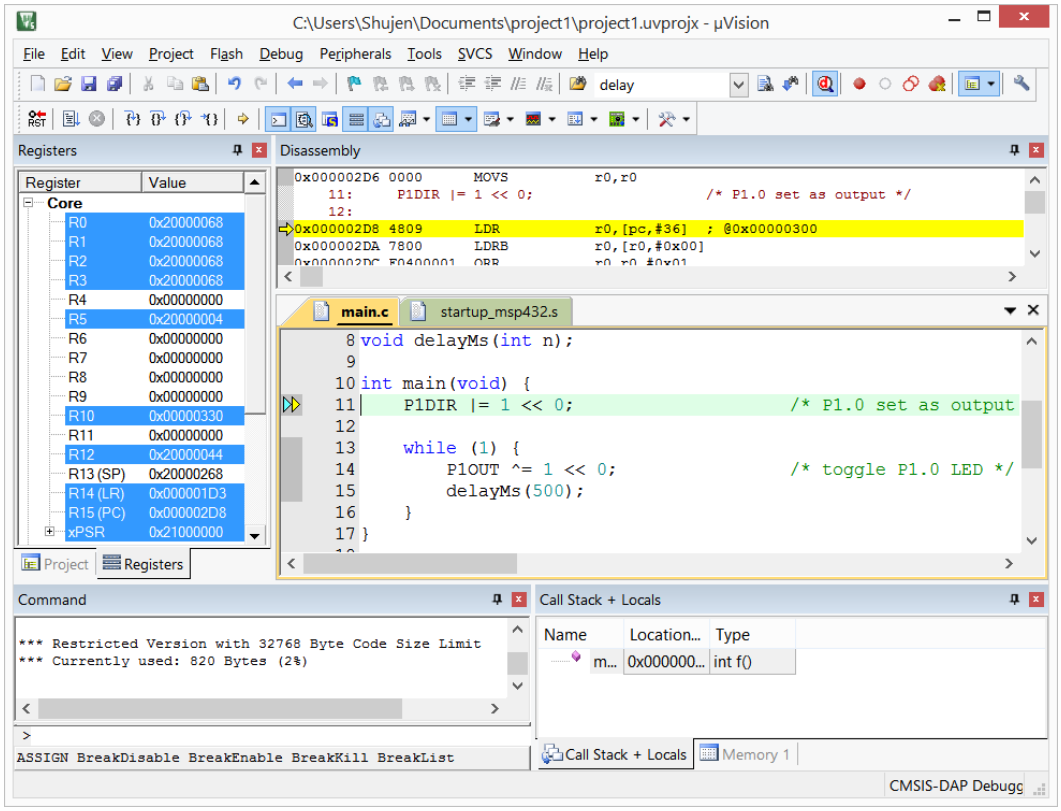
32. To debug the program, click the **Debug** button on the right. The program should automatically download to the target device and the Keil IDE will change the perspective to debug.



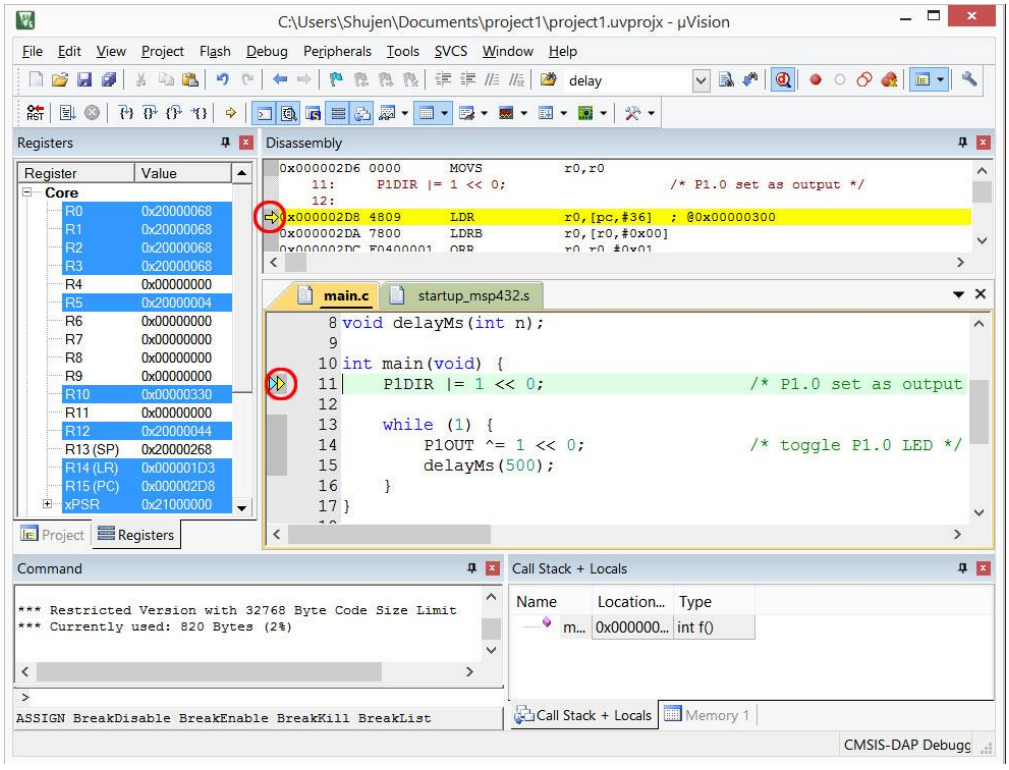
33. It takes a few seconds to download the program. If download goes well, the output window at the bottom will show the messages of “Erase Done”, “Programing Done” and “Verify OK”. If you are running free MDK-ARM Lite Edition, a message window will pop up to warn the code size limitation. Click **OK** to proceed.



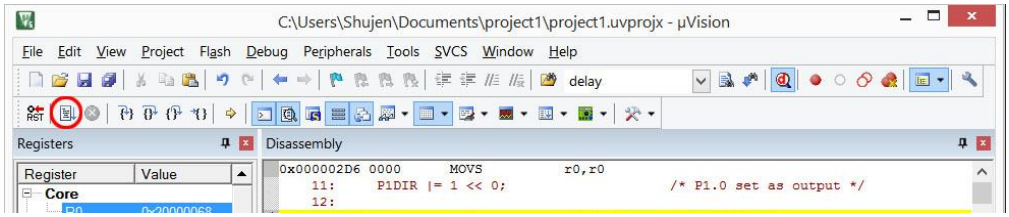
34. When entering the debugger, the IDE changes the perspective to the debug. The source code appears in the middle with the disassembly window above it. To the left, a registers display tab is added. To the lower right, the stack/local variables and memory windows are added.



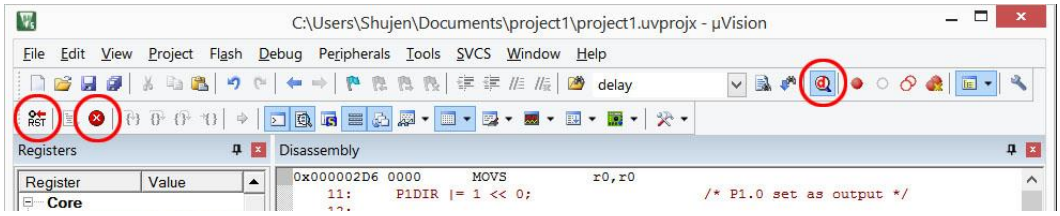
35. The program counter is at the first executable line of the main( ) function as indicated by the yellow arrows in both source file and disassembly window.



36. Click the **Run** button and the program execution should start. If everything has been done properly, the red LED on the LaunchPad should be blinking.



37. On the sides of the **run** button, you will find the **stop** button (red circle with a white cross) and the **reset** button (with RST in it). To stop debug session and return to edit/build perspective, click on the debug button on the right. After you left the debugger, the program in the MSP432 LaunchPad will continue to run. The program will run whenever the power is applied to it.

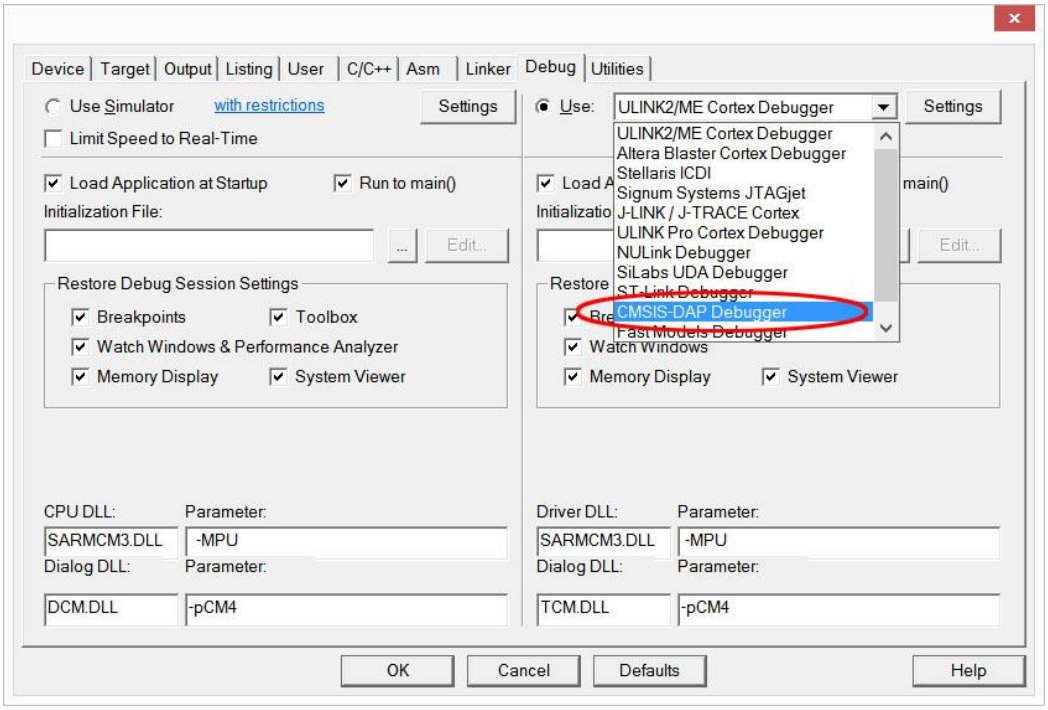


38. Congratulations! You have finished your first Keil uVision programming for the MSP432 LaunchPad.

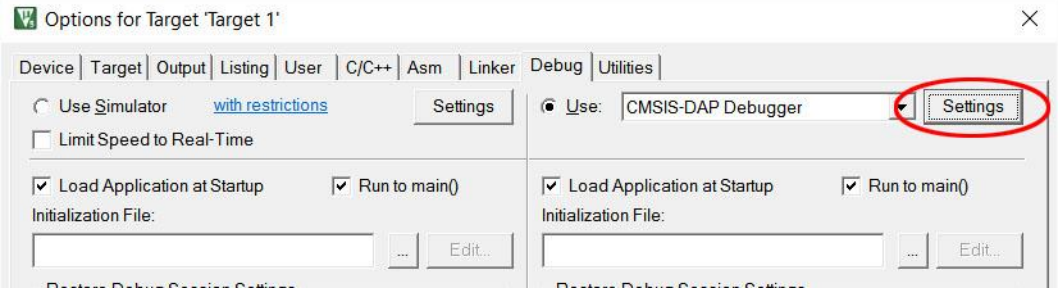
Alternate Debug Interface

Although CMSIS-DAP Debugger works fine, its operations are slow. A new debugger was introduced with Keil-MDK **v5.20** that runs much faster. But it requires the newer version of the firmware on the MSP432 LaunchPad.

39. To verify the firmware version, select **Debug** tab and click the radio button on the right and select **CMSIS-DAP Debugger** in the pull-down menu.

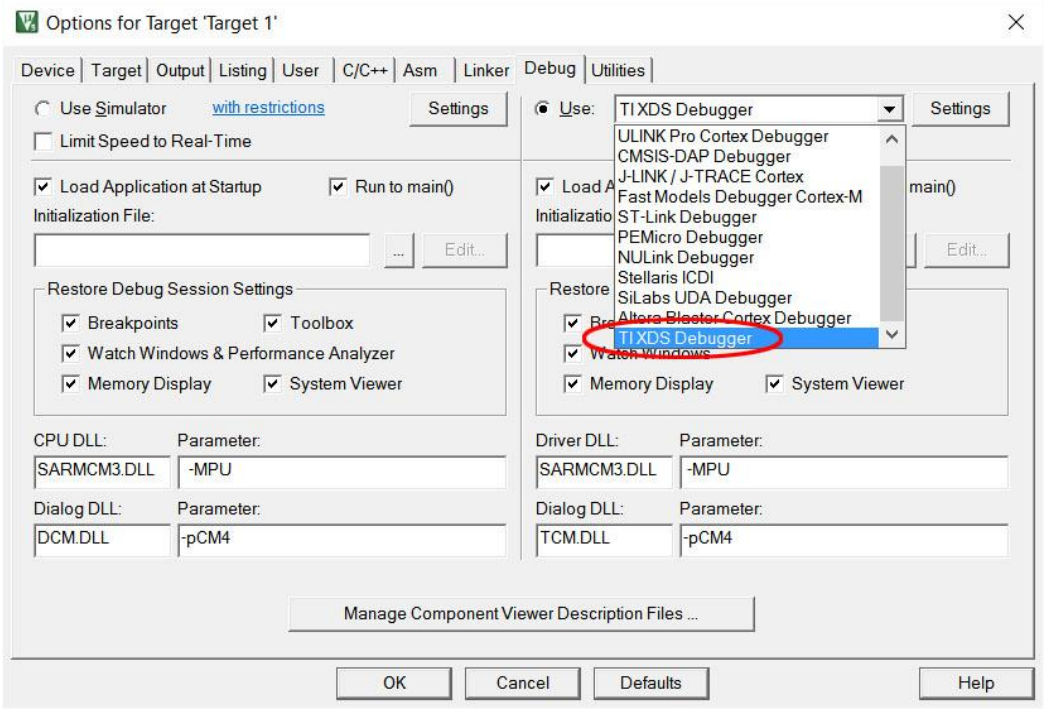


40. With CMSIS-DAP Debugger selected, click on the **Settings** button.

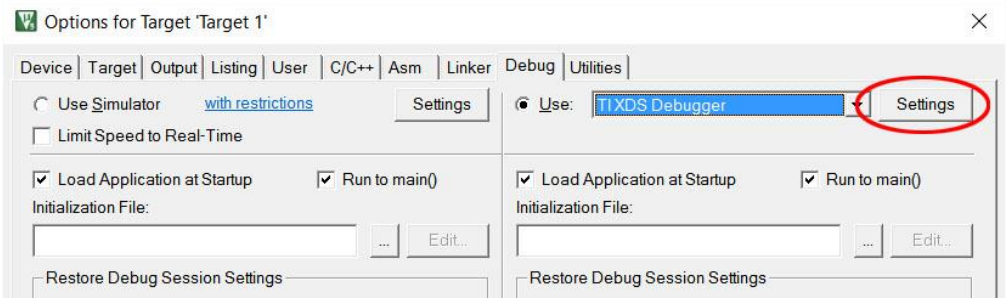


41. Under the CMSIS-DAP-JTAG/SW Adapter, you should see the version number of the XDS110 firmware. If your version number is not 02.03.00.02 or newer, it may not work with the new debug interface. You can always go back to use CMSIS-DAP Debugger even though it runs slower.

42. If you have the new firmware, you may proceed to select the TI XDS Debugger. Close the Cortex-M Target Driver Setup window and return to the Debug tab.



43. You should have the XDS110 device drivers installed in your computer. If you have not done so, download XDS110 device drivers from http://energia.nu/files/xds110_drivers.zip and install them when plug in the board with USB cable.
44. To verify whether the debugger is properly installed with the board connected, click **Setting** button and a window should pop up showing debug connection.



45. There should be an entry in the SW Device panel at the right and the IDCODE of the debugger should appear in the panel. With TI XDS Debugger, you may choose either SW port or JTAG port.