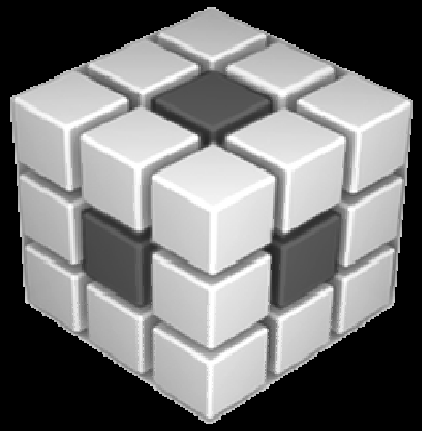
# Code Composer Studio™

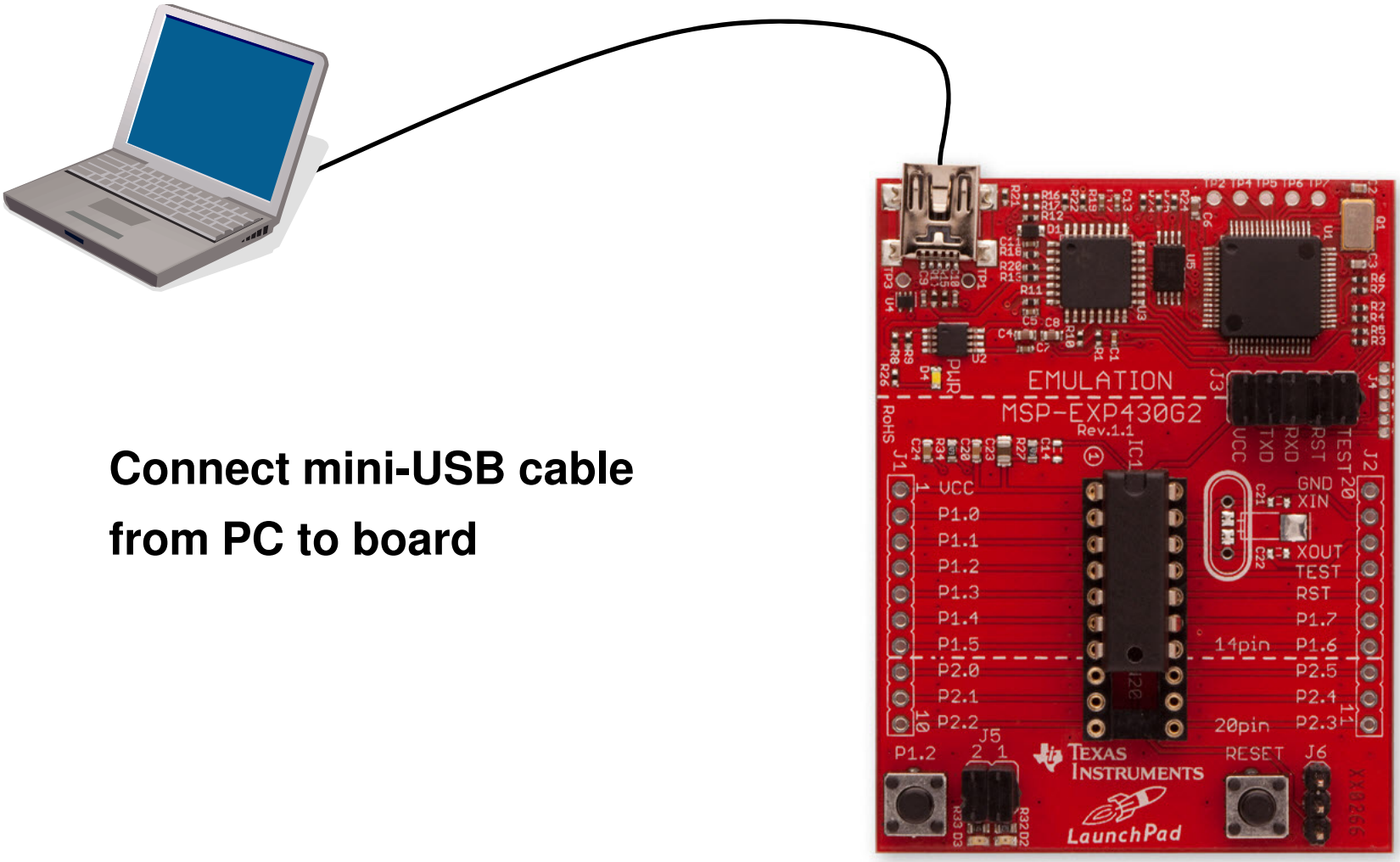


Texas Instruments

## Fundamentals Workshop with the MSP430

## Lab Material

# LaunchPad: Hardware Setup




**Connect mini-USB cable from PC to board**

# LAB conventions

- Lab steps are numbered for easier reference

  1. ...
  2. ...

- Explanations, notes, warnings are written in blue
  - Warnings are shown with
  - Information is marked with
  - Tips and answers are marked with
  - Questions are marked with

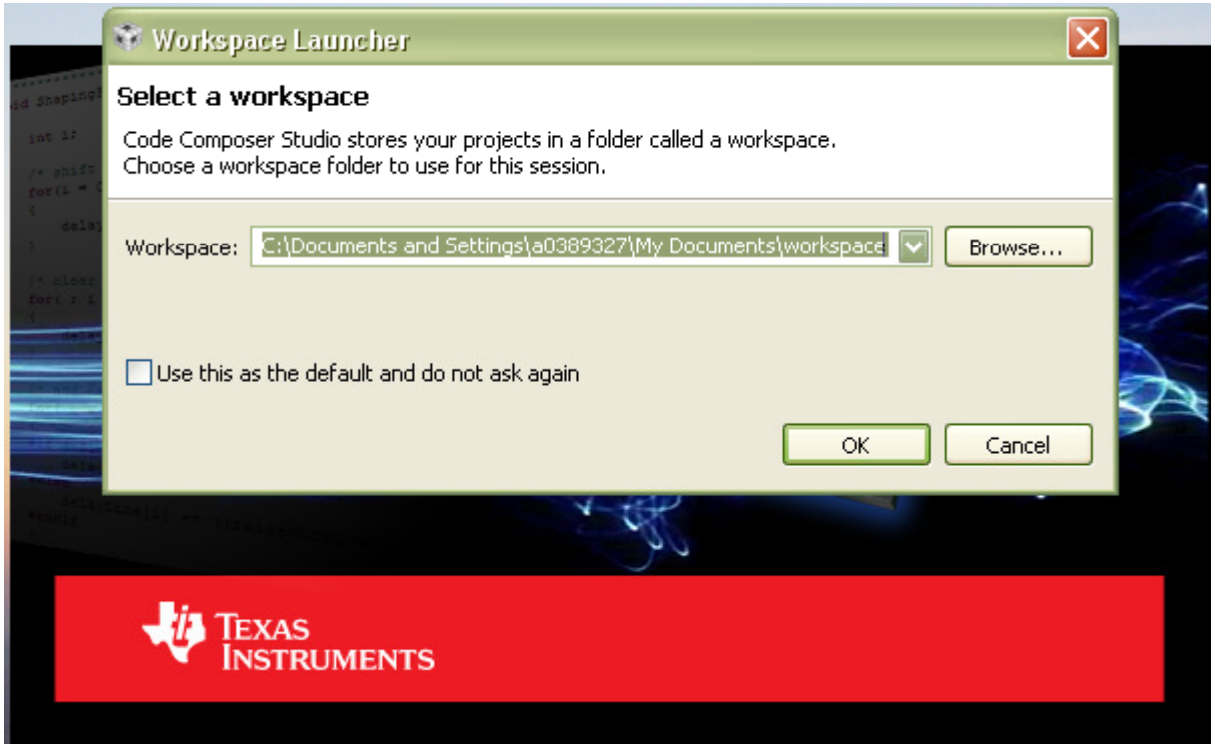
# LAB 1: BLINK LED

# Blink LED Example: Exercise Summary

- Key Objectives
  - Create and build a simple program to blink LED1
  - Start a debug session and load/flash the program on the Launchpad
  - Run the program to blink LED1
- Tools and Concepts Covered
  - Workspaces
  - Welcome screen / Resource Explorer
  - Project concepts
  - Basics of working with views
  - Debug launch
  - Debug control
  - Profile Clock
  - Local History
  - Build Properties
  - Changing compiler versions

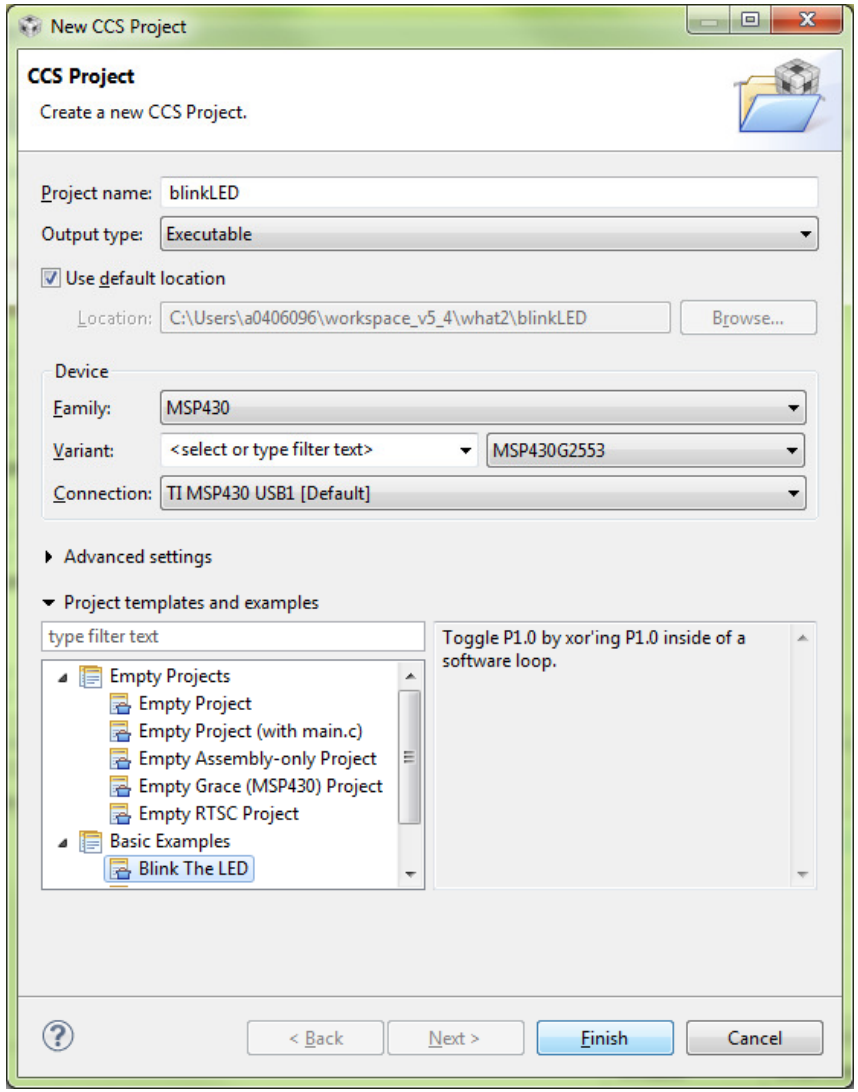
# Workspace

- Launch CCS and select a workspace folder
  - Defaults to your user folder



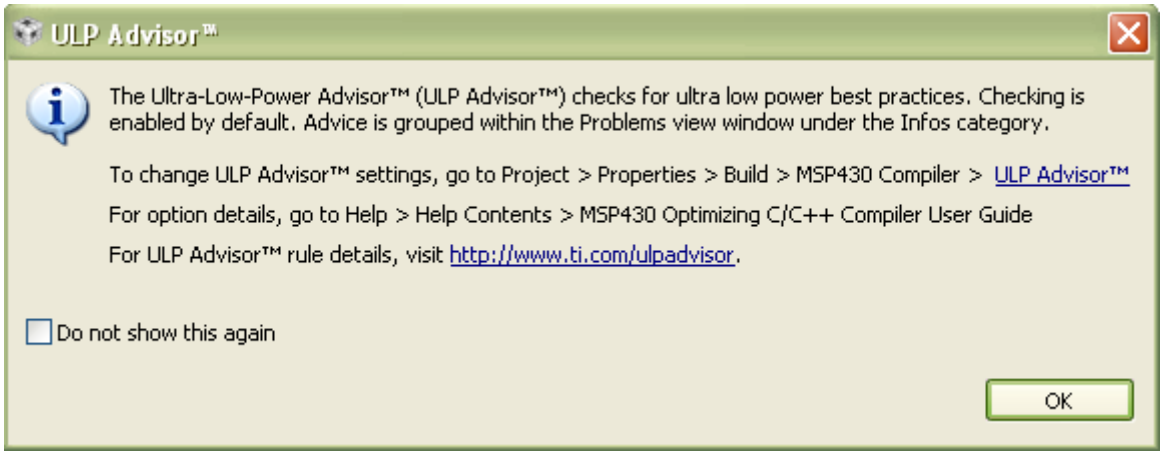
# Create the Project

1. Create a new project in the CCS Workspace by going to menu *File → New → CCS Project*
2. Fill in the boxes as shown in the image. Select the Blink LED template and double check the exact device variant with that in the launchpad socket
3. Click *Finish*



# ULP Advisor Message

- A message highlighting the ULP Advisor may appear on project creation
- This message can be ignored for now as ULP will be covered later in this workshop
- Use the “Do not show this again” checkbox if you do not wish to see this message again

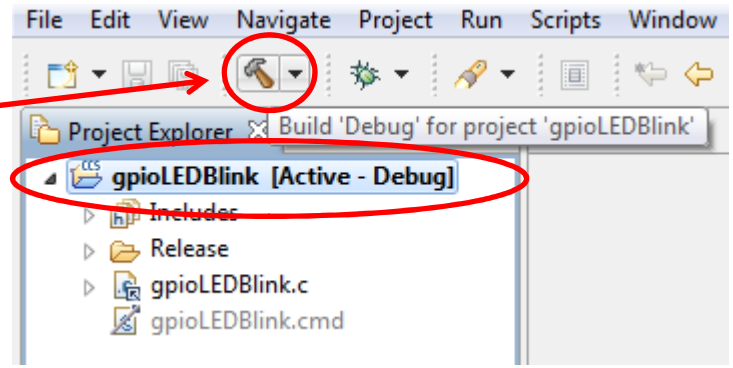


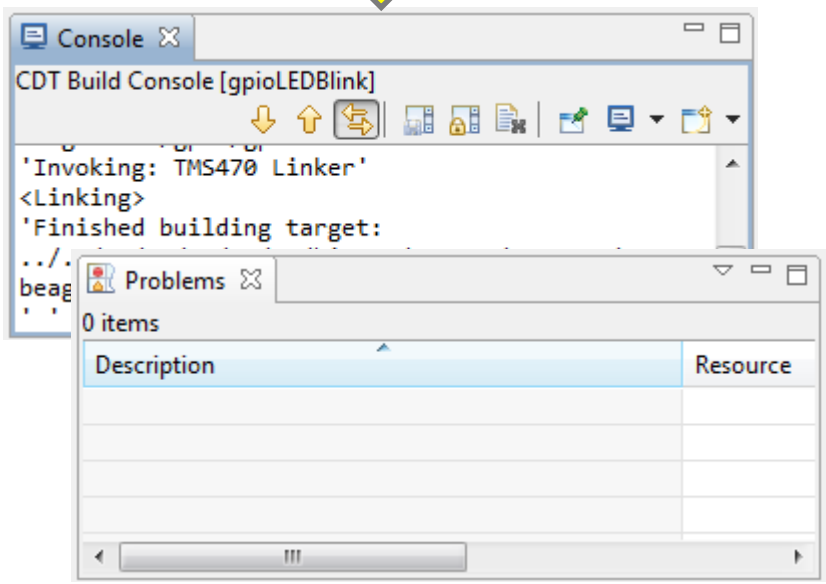
# Build 'BlinkLED' Project

1. In the *Project Explorer* view, select the BlinkLED project (it should appear [Active – Debug]) to make it active
2. Click on the Build icon in the toolbar. The project will start the building process.

   When using a newly installed CCS, the tool will take extra time to build the Runtime Support Library (RTS) at this time. This is normal and will only happen once.
3. The *Console* view will appear at the bottom with build messages (information, warnings, errors) as the project builds
4. The *Problems* view will also appear at the bottom to highlight any possible build errors.

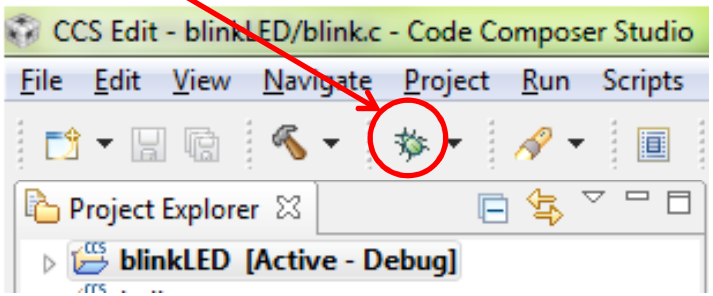
   When building the RTS, some warning messages will appear in the problems view and can be ignored.
5. If the build is successful, the *Problems* view will contain no errors (warnings can still be seen)



# Debug ‘BlinkLED’ Project

1. Click on the “green bug” button – make sure the project is selected!




When pressing the debug button, several actions are done automatically

- Prompt to save source files
- Build the project (incrementally)
- Start the debugger (CCS will switch to the *CCS Debug* perspective)
- Connect CCS to the target
- Load the program on the target
- Run to **main()**

# Build, Load/Flash the Program

CCS Debug - blinkLED/main.c - Code Composer Studio

File Edit View Search Run Project Tools Scripts Window Help

Debug

blinkLED [Code Composer Studio - Device Debugging]
TI MSP430 USB1/MSP430 (Suspended)
main() at main.c:26 0xF800
c_int00_noinit_noexit() at 0xF83C

Variables | Expressions | Registers

| Name | Type | Value | Location |
|---|---|---|---|
| i | unsigned int | 63548 | 0x027C |

TI Resource Explorer | main.c

```
15 //  J. Stevenson
16 //  Texas Instruments, Inc
17 //  October 2008
18 //  Built with Code Composer Studio v4
19 //*****************************************************************************
20
21 #include <msp430.h>
22
23
24
25 int main(void)
26 {
27   WDTCTL = WDTPW + WDTHOLD;          // Stop watchdog timer
28   P1DIR |= 0x01;                     // Set P1.0 to output direction
29
30   for (;;)
31   {
```

Console

blinkLED

```
MSP430: Program loaded. Code Size - Text: 74 bytes  Data: 2 bytes
```

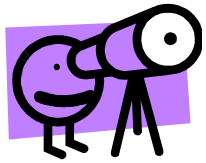
Licensed | Writable | Smart Insert | 26 : 1

**Switched to 'CCS Debug' perspective**

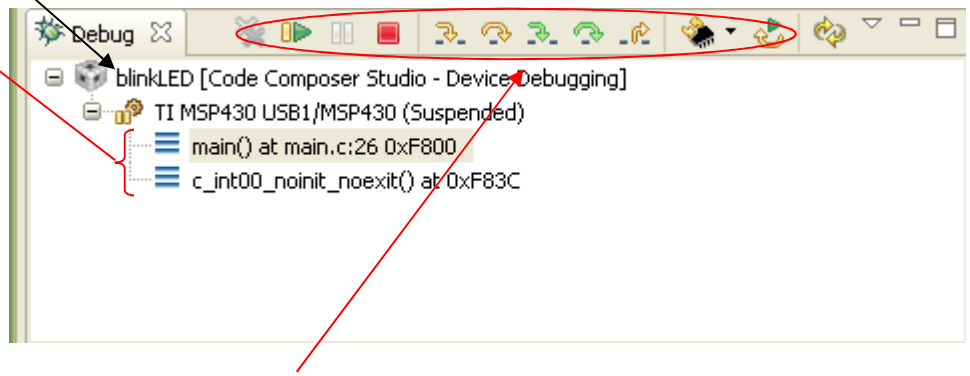
**Program counter at 'main'**

**Code size information displayed in console view**

# View: Debug



- The Debug view displays:
  - Target configuration or project
  - Call stack

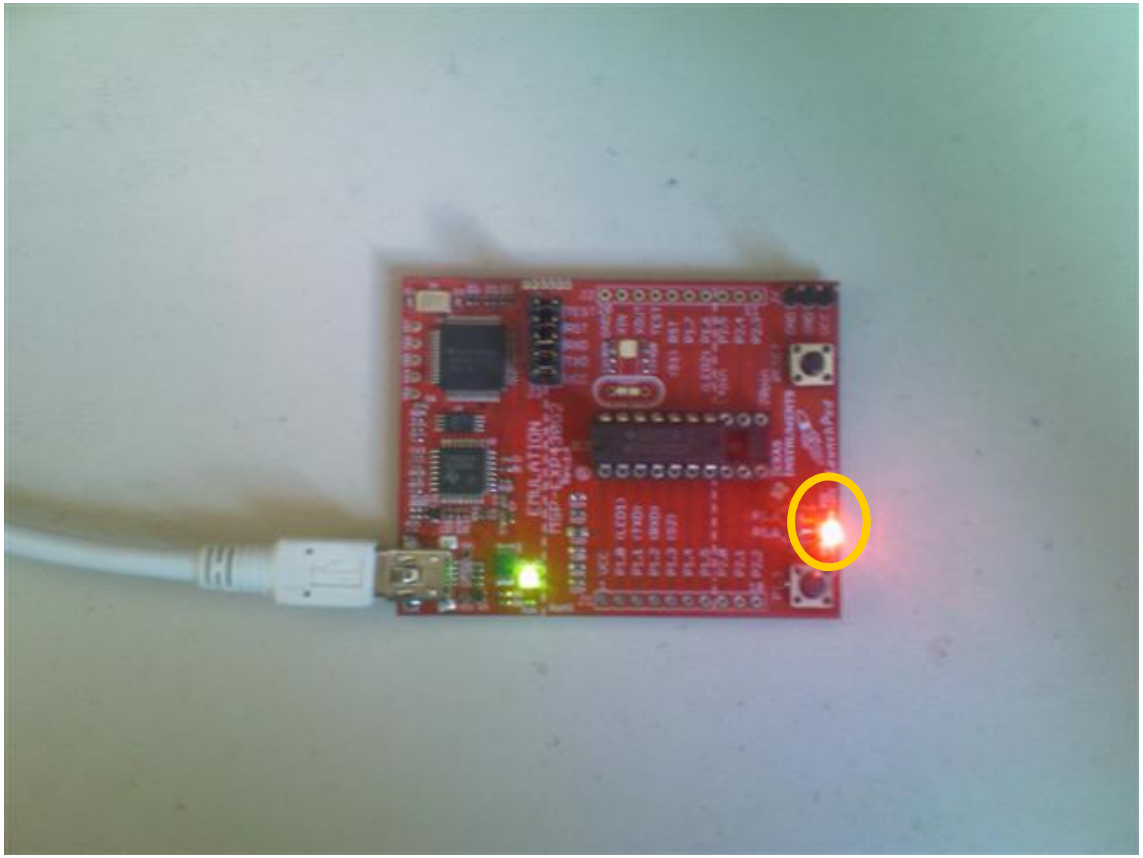



- Buttons to ‘run, halt, terminate (debug session), source and asm stepping, reset CPU, restart program

# Blink LED1

1. Press the *Run* button to run the program

LED1 on the Launchpad should now be blinking

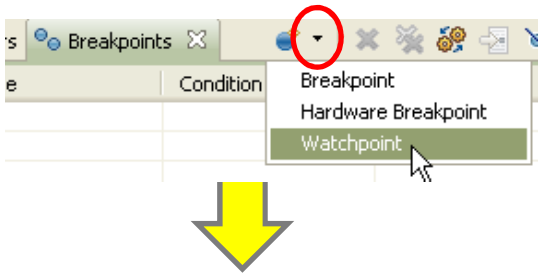


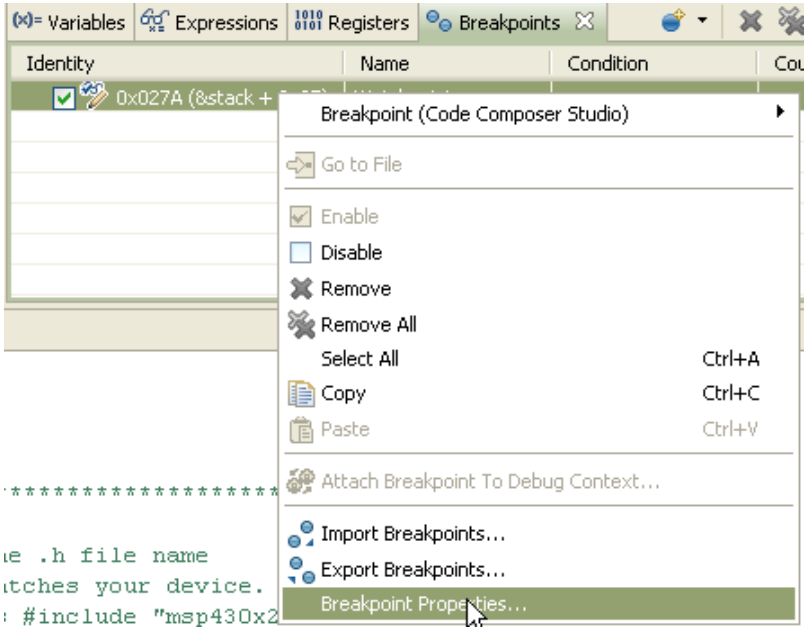
# Debugging: Using Watchpoints

A Watchpoint is a type of breakpoint that monitors activity on a memory address

In this step we will set a watchpoint to halt the CPU anytime the LED will toggle

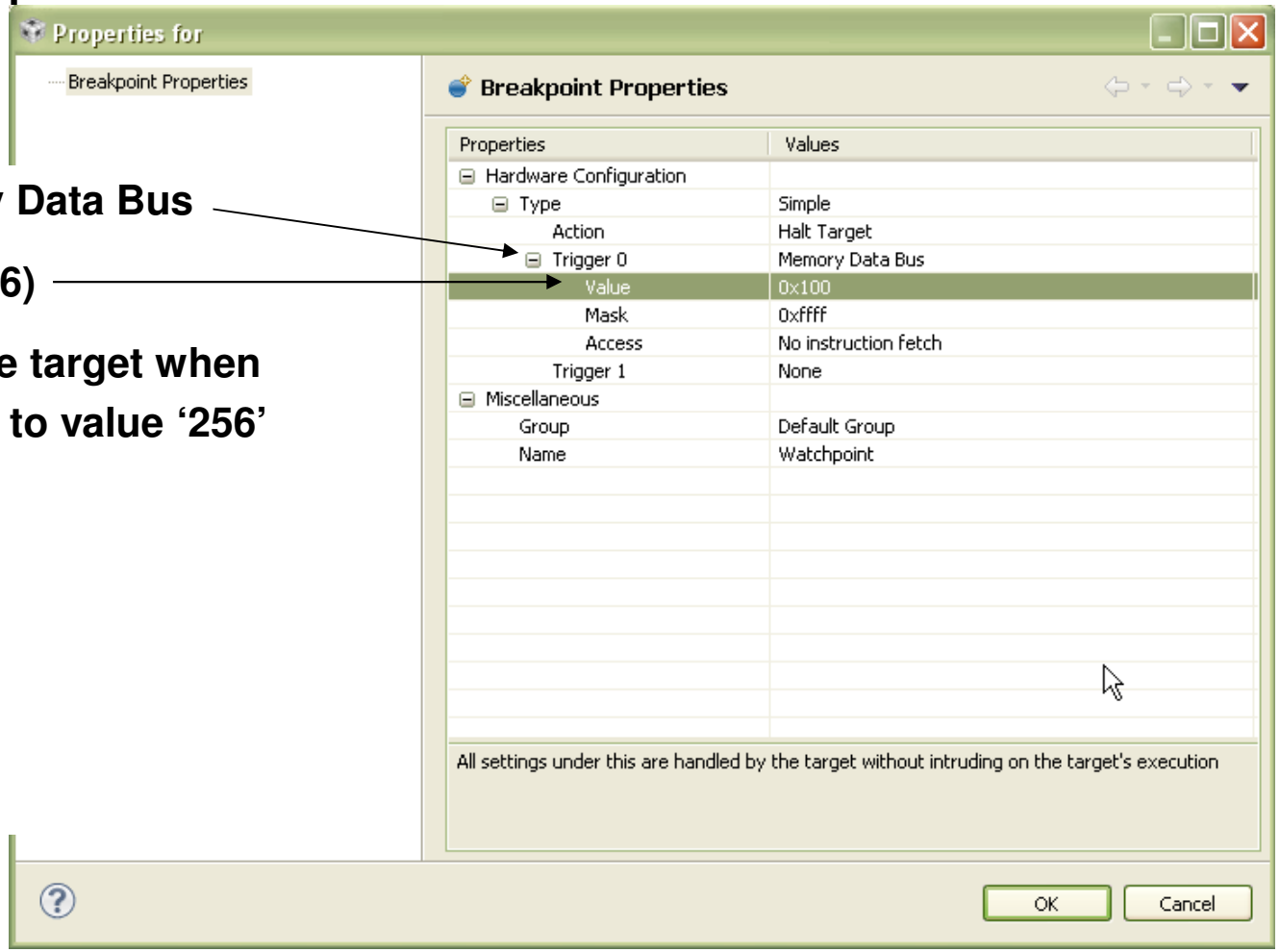
1. Press the *halt/suspend* button to halt the running program
   - The code should stop somewhere in the **for** loop
2. Open the *Breakpoints* view
   - *View → Breakpoints*
3. Create a new *Watchpoint*
   - *Location*: set it to "i"
4. Right-click on the watchpoint and select
   - *"Breakpoint Properties"*



# Debugging: Using Watchpoints

- Set the Properties as shown below:




- **Trigger: Memory Data Bus**
- **Value: 0x100 (256)**
- **Basically halt the target when variable 'i' is set to value '256'**
- **Click OK**

# Debugging: Using Watchpoints

1. Run the target again. Execution will automatically halt when i is 256

CCS Debug - blinkLED/main.c - Code Composer Studio

File Edit View Search Run Project Tools Scripts Window Help

Debug

blinkLED [Code Composer Studio - Device Debugging]
TI MSP430 USB1/MSP430 (Suspended)
main() at main.c:39 0xF81A
c_int00_noinit_noexit() at 0xF83C

Variables | Expressions | Registers | Breakpoints

| Name | Type | Value | Location |
|---|---|---|---|
| i | unsigned int | 256 | 0x027A |

TI Resource Explorer | main.c

```
25 int main(void)
26 {
27   WDTCTL = WDTPW + WDTHOLD;          // Stop watchdog timer
28   P1DIR |= 0x01;                     // Set P1.0 to output direction
29
30   for (;;)
31   {
32     volatile unsigned int i;         // volatile to prevent optimization
33
34     P1OUT ^= 0x01;                   // Toggle P1.0 using exclusive-OR
35
36     i = 10000;                       // SW Delay
37     do i--;
38     while (i != 0);
39   }
40 }
```

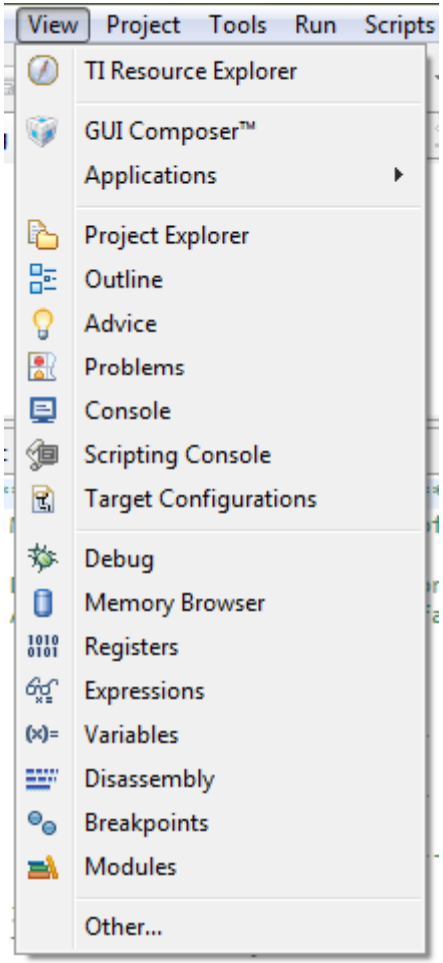
You may need to bring the variables tab into focus

Variables | Expressions | Registers | Breakpoints

| Name | Type | Value | Location |
|---|---|---|---|
| i | unsigned int | 6636 | 0x027A |

# More Debugging

- Investigate other debugging views (Open via *View* menu)
  - Memory Browser
  - Registers
  - Disassembly (see next slide)
- Set breakpoints
  - Double click on a source line to set/clear
  - See list of breakpoints with the *Breakpoints* view
- Use the buttons in the *Debug* view to:
  - Restart the program
  - Source stepping
  - Assembly stepping

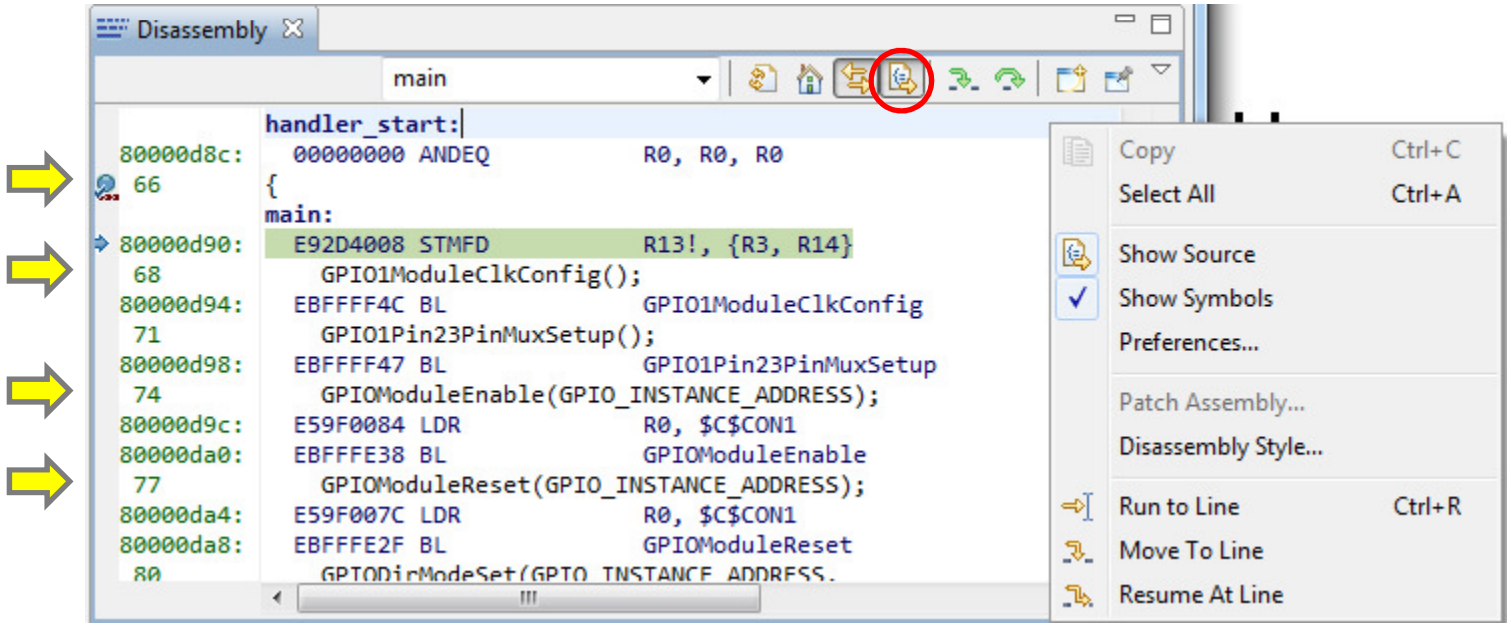


# View: Disassembly

1. Go to the main() symbol in the Disassembly view by typing “main” in the address field and hit <ENTER>

   You can see the current location of the PC (small blue arrow) and any breakpoints (small blue circles)

2. Toggle the *Show Source* button. Note the toggling of interleaved source with the disassembly



# Remove the Watchpoint

1. Go to the Breakpoints view
   - Select *Remove all Breatpoints*
   - Select “Yes” when prompted

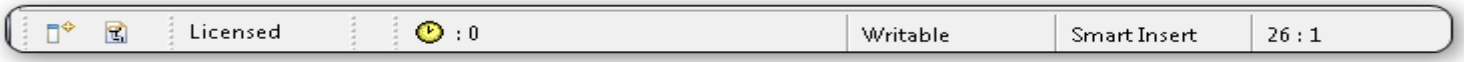
2. Restart execution
   - Go to the Debug View
   - Click on the Restart button 
   - The program counter should be back at main

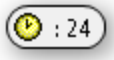
# Debugging: Using Profile Clock

The profile clock

- Available on most devices and can be used to count cycles
- On some targets it can be used to count other events like cache hits/misses, bus stalls, etc.

1. Enable the Clock
   - Menu *Run* → *Clock* → *Enable*
   - The clock will now be displayed on the status bar




2. Add a breakpoint on line 35 "}" of the for loop by double clicking
3. Click the *Run* button
   - Clock should now show 24 cycles 


Tip: Double-clicking on the clock icon will reset the count to '0'

# Remove the Watchpoint

1. Go to the Breakpoints view
   - Select *Remove all Breatpoints*
   - Select “Yes” when prompted

2. Restart execution
   - Go to the Debug View
   - Click on the Restart button 
   - The program counter should be back at main

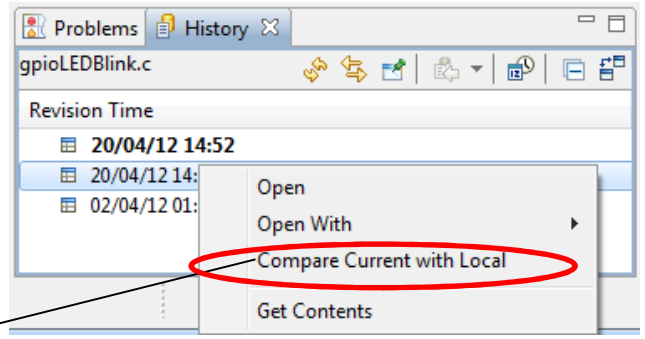
# View: Local History

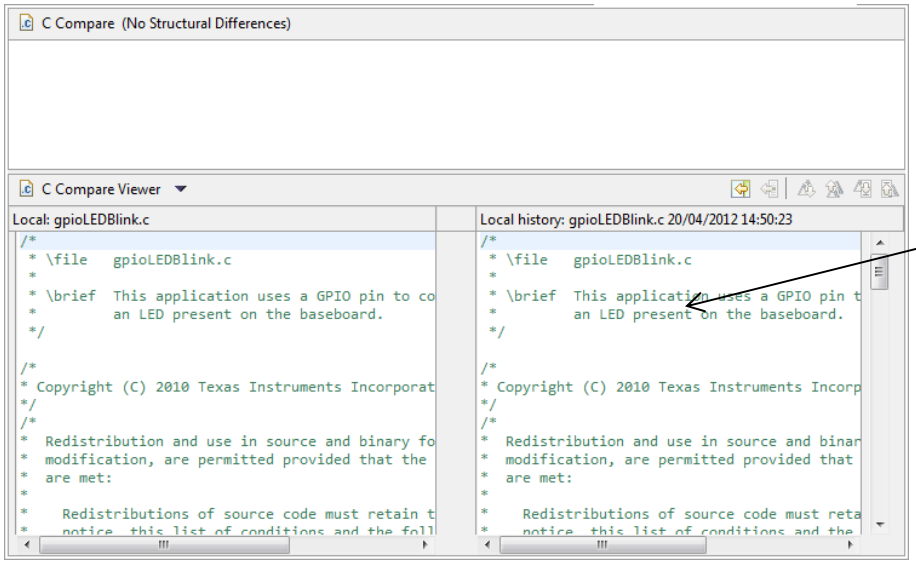
## CCS keeps a local history of source changes

1. Switch to the *CCS Edit* perspective
2. Right-click on a file in the editor and select *Team* → *Show Local History*

## You can compare your current source file against any previous version or replace it with any previous version

1. Double-click on a revision to open it in the editor
2. Right-click on a revision to compare that revision to the current version




## CCS also keeps project history

1. Recover files deleted from the project
2. Right-click on the project and select *Recover from Local History* in the context menu

# Terminate the Debug Session

1. Go to the Debug View
2. Click on the terminate button
3. This will kill the debugger and return you to the Edit perspective

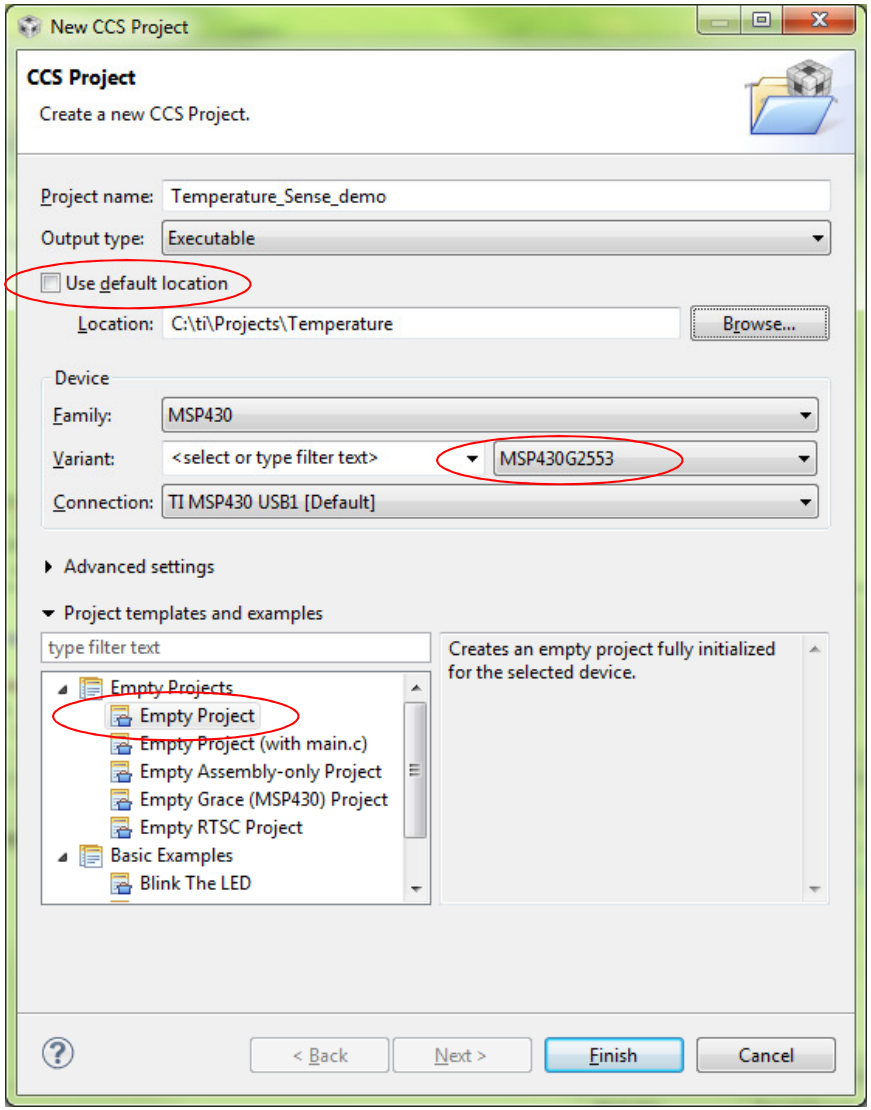
# LAB 2 : TEMPERATURE SENSE DEMO

# Temperature Sense Demo: Briefing

- Key Objectives
  - Create and build the Temperature Sense Demo
  - Start a debug session and load/flash the program on the LaunchPad
  - Run the program to start Temperature Sense Demo
- Tools and Concepts Covered
  - Adding source files
  - “Focus” concept
  - Loading Symbols
  - Changing Build Options
  - Changing Compiler Version

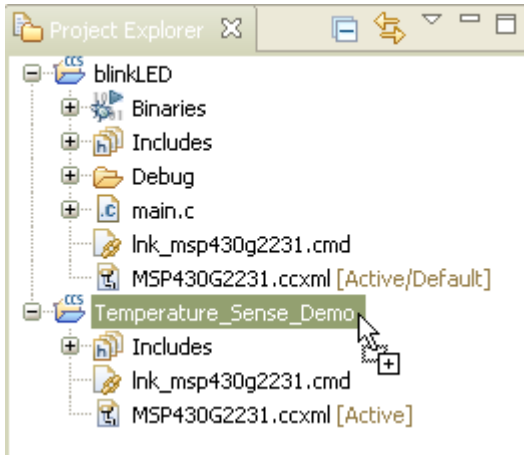
# Create the Project

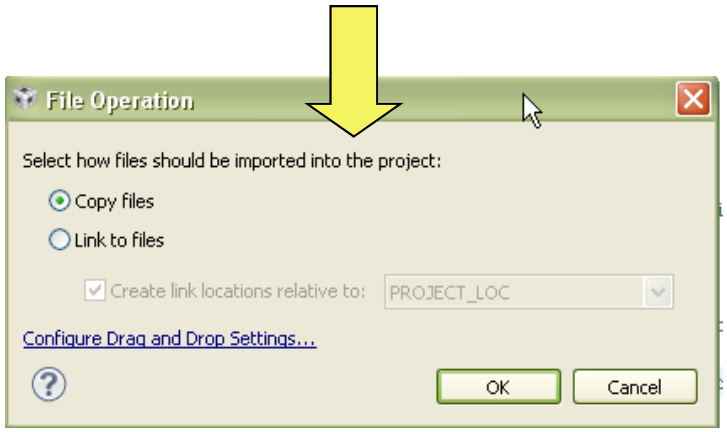
1. Create a new project in the CCS Workspace by going to menu *File → New → CCS Project*
2. Fill in the boxes as shown in the image. This time the project will be created outside the workspace
   - Uncheck the box to use default location
   - Specify **C:\ti\Projects\Temperature**
3. Click *Finish*



# Add Temperature Sensor Source Code

1. Open Windows explorer and browse to
   - C:\TI\LaunchPad\temperature_sensor
2. Drag and drop 'Temperature_Sense_Demo_G2xxx.txt' to the 'Temperature_Sense_Demo' project. Use the file that matches the MSP430 device being used (G2231 or G2553) Make sure the file is dragged to the 'Temperature_Sense_Demo' project
3. In the dialog popup, select the option to 'Copy Files' and hit 'OK'



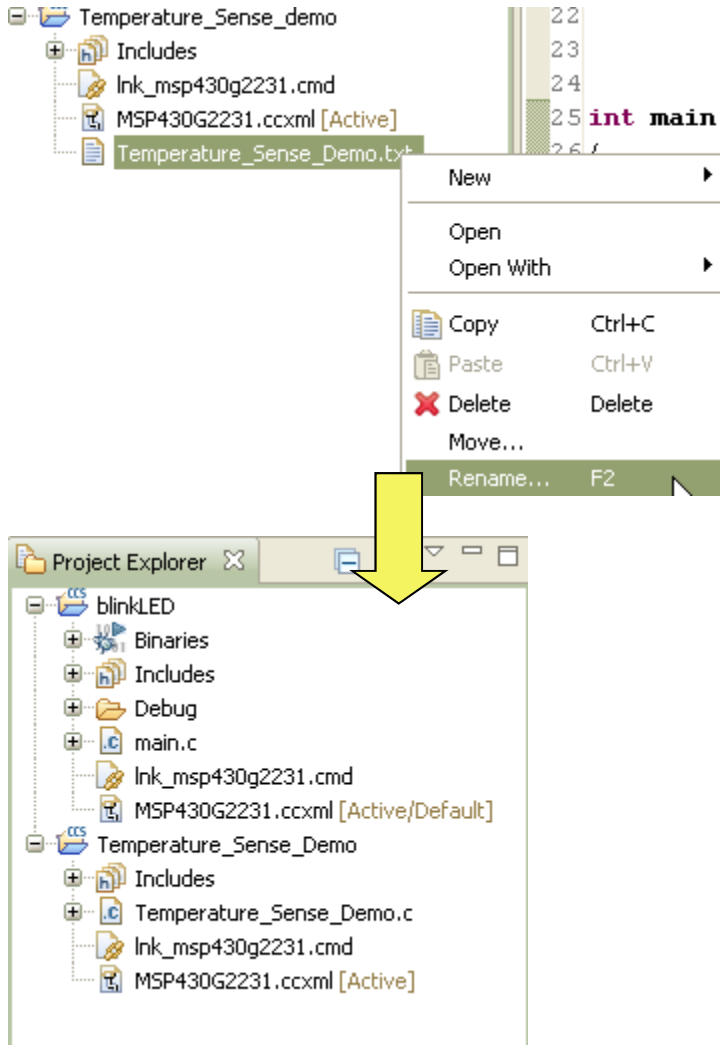



# Add Temperature Sensor Source Code

1. Right-click on the ‘Temperature_Sense_Demo_G2xxx.txt ’ file in the Project Explorer and select the option to ‘Rename..’ the file

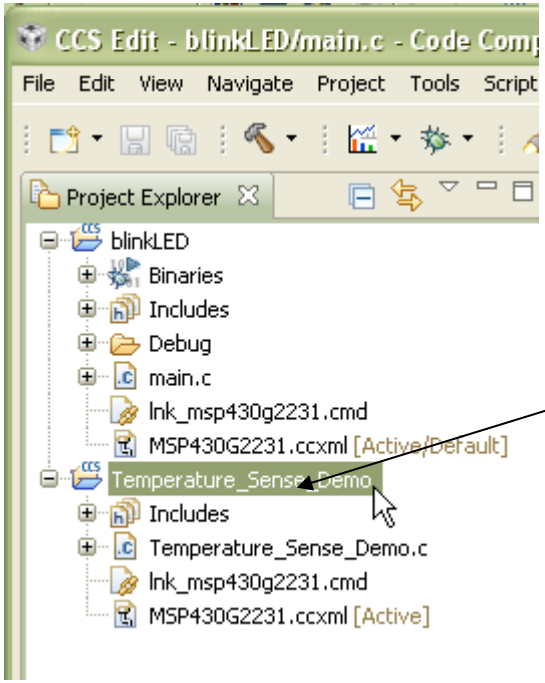
   -Rename the file so that the ‘.txt’ extension is renamed to ‘.c’

2. Project is ready to build



# Eclipse Concept: Focus

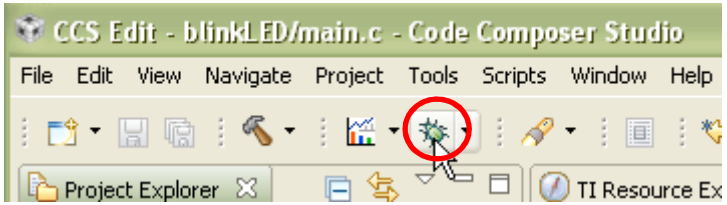
- Focus refers to the highlighted portion of the workbench
  - Can be an editor, a view, a project, etc.
- This concept is important since several operations inside Eclipse are tied to the element in focus
  - Project build errors, console, menu and toolbar options, etc.




**'Temperature_Sense_Demo' project is in 'Focus' since it has been selected. So pressing the 'Debug' button will build the project and start the debugger for the 'Temperatrue_Sense_Demo' project**

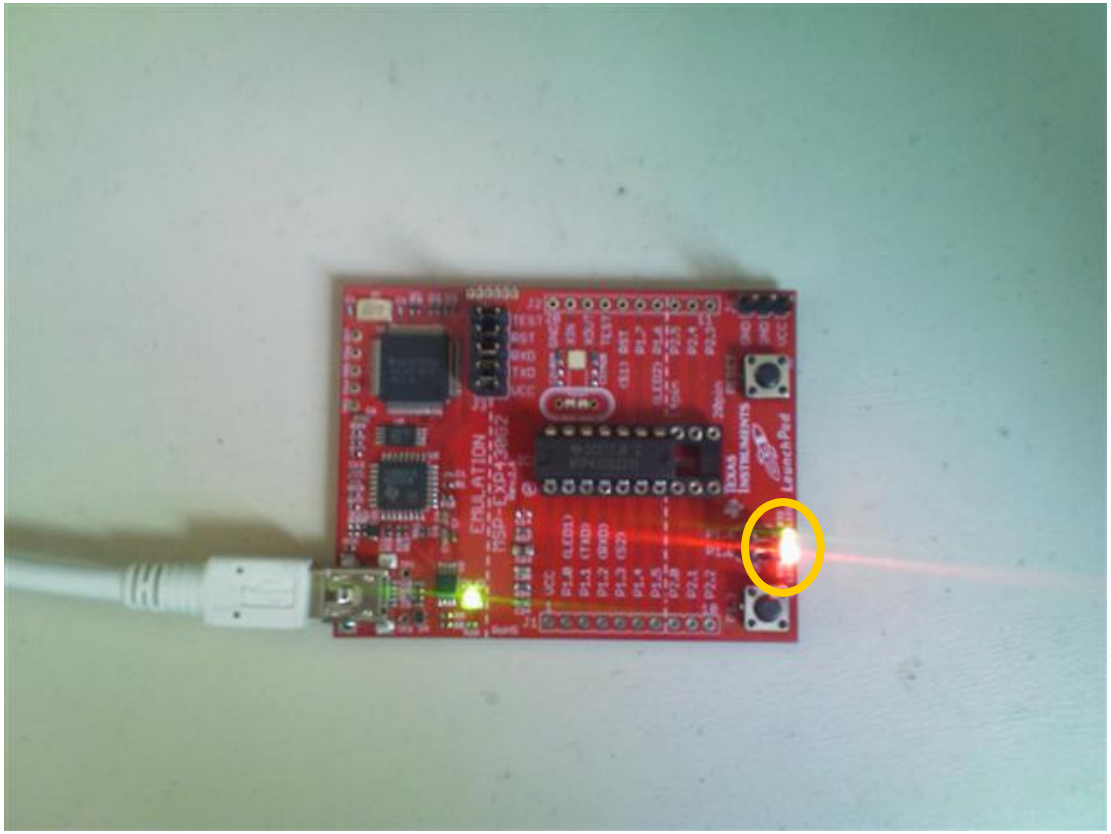
# Build and Load/Flash the Program

1. Make sure the ‘Temperature_Sense_Demo’ project is in ‘Focus’. Then use the ‘Debug’ button



# Temperature Sense Demo

1. Press the ‘run’ button to run the program
   - LED1 (red) and LED2 (green) on the LaunchPad should now alternate blinking

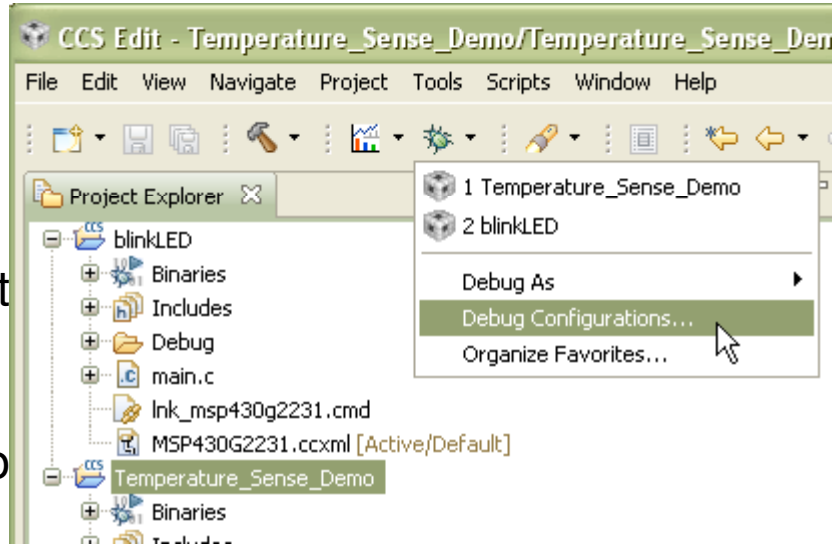


# Temperature Sense Demo: Debugging

1. Press the halt\suspend button to halt the running program
   1. The code should stop in the PreApplicationMode() function.
2. Step-into the code once and it will enter the timer ISR for toggling the LEDs (ta1_isr)
3. Step-over a few more times and notice that the red and green LEDs alternate on and off
4. When you are done, terminate the debug session

# Loading Symbols for Flashed Program

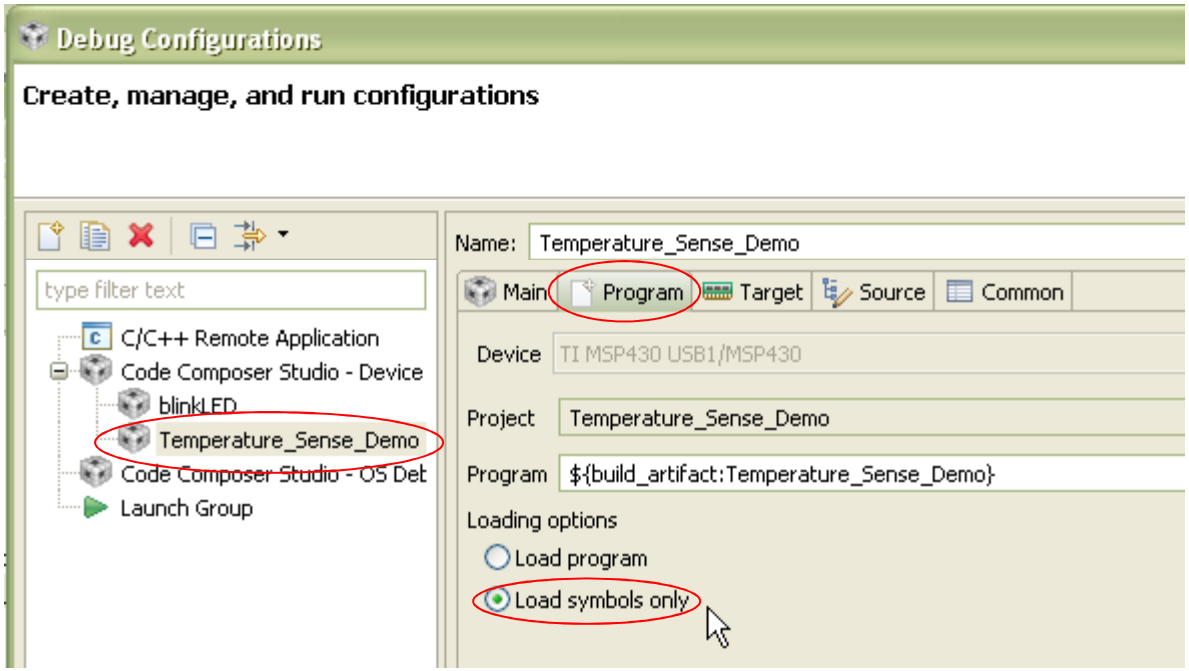
1. If the program is already flashed in CCS and just wish to debug the existing code flashed on the target, you can configure CCS to debug the project by loading symbols only
2. Select the drop-down menu next to the 'bug' button and select 'Debug Configurations..'




Eclipse Concept: Debug Configurations - Cached information created when a debug session is first launched for a project or target configuration. Information cached includes which target configuration to use, debug settings…

# Loading Symbols for Flashed Program

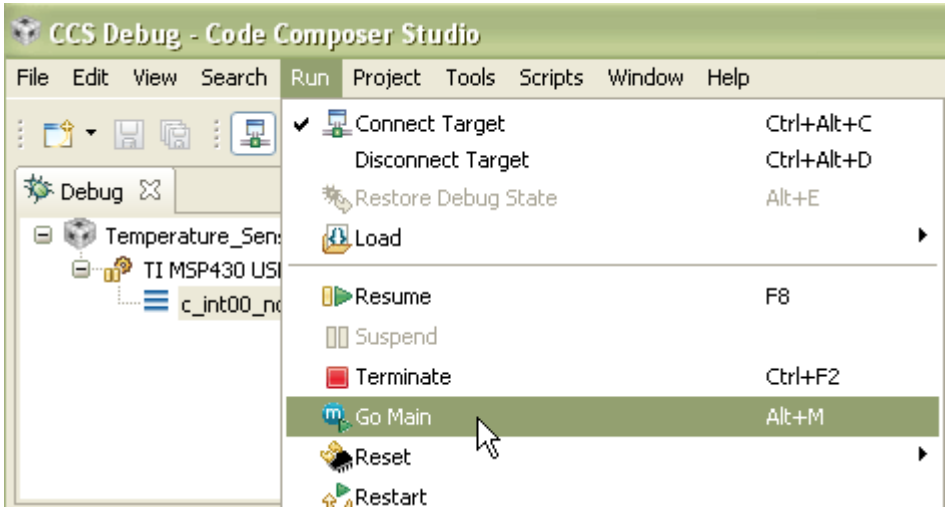
1. Select ‘Temperature_Sense_Demo’ in the left panel and the ‘Program’ tab in the right panel
2. Under ‘Loading options’, select ‘Load symbols only’




3. Then select ‘Apply’ and then ‘Debug’

# Loading Symbols for Flashed Program

1. The debugger will start up, connect to the target, and load only the symbols for the program for the debugger (no code is loaded/flashed on the target)
2. The program counter will be set to the entry point of the code and not at 'main'
   - 'Run->Go Main' will run the target to 'main'



# Loading Symbols for Flashed Program

CCS Debug - Temperature_Sense_demo/Temperature_Sense_Demo.c - Code Composer Studio

File Edit View Search Run Project Tools Scripts Window Help

Debug

Temperature_Sense_demo [Code Composer Studio - Device Debugging]
TI MSP430 USB1/MSP430 (Suspended)
main() at Temperature_Sense_Demo.c:88 0xF800
c_int00_noexit() at 0xFC90

**Callstack displayed**

Variables | Expressions | Registers | Breakpoints

| Identity | Name | Condition | Count | Action |
|---|---|---|---|---|

TI Resource Explorer | main.c | Temperature_Sense_Demo.c | c_int00_noexit() at 0xfc6e

```
82 void ConfigureTimerPwm(void);
83 void ConfigureTimerUart(void);
84 void Transmit(void);
85 void InitializeClocks(void);
86
87 void main(void)
88 {
89   unsigned int uartUpdateTimer = UART_UPDATE_INTERVAL;
90   unsigned char
91   WDTCTL = WDTPW
92
93   InitializeClocks();
94   InitializeButton();
95   InitializeLeds();
96   PreApplicationMode();                    // Blinks LEDs, waits for button press
97
98   /* Application Mode begins */
99   applicationMode = APP_APPLICATION_MODE;
100  ConfigureAdcTempSensor();
```

**Source code is found automatically**

Disassembly

main

```
.text, _text, main:
f800:  120A                PUSH
 89    unsigned int uartUpdateTimer
f802:  403A 03E8           MOV.W
 91    WDTCTL = WDTPW + WDTHOLD;
f806:  40B2 5A80 0120      MOV.W
 93    InitializeClocks();
f80c:  12B0 FD2A           CALL
 94    InitializeButton();
f810:  12B0 FCF6           CALL
 95    InitializeLeds();
f814:  12B0 FD74           CALL
 96    PreApplicationMode();
```

Console

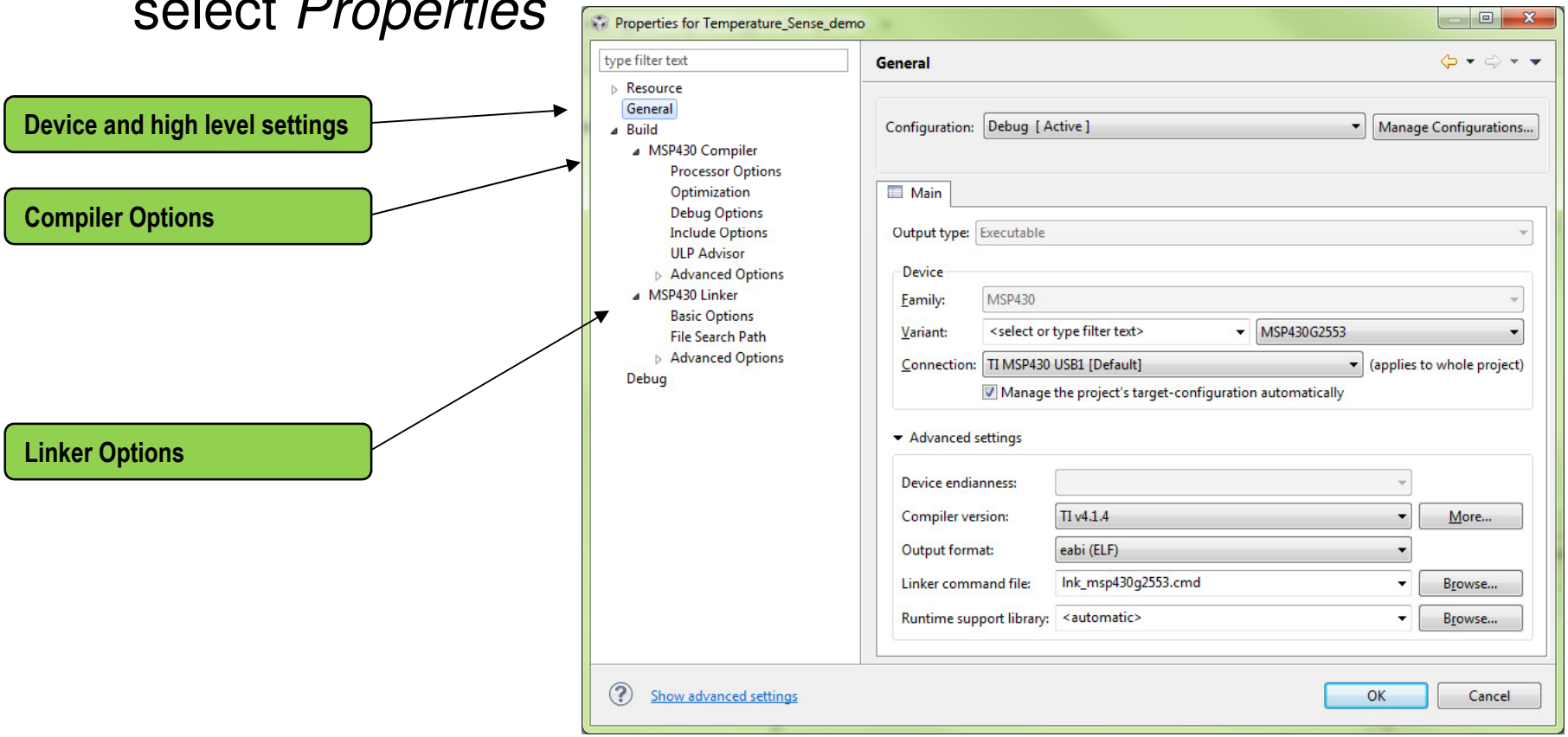
CDT Build Console [Temperature_Sense_demo]

```
**** Build of configuration Debug for project Temperature_Sense_demo ****

C:\Development Tools\Programs\Code Composer Studio v5.1 M6_3\ccsv5\utils\bin\gmake -k all
gmake: Nothing to be done for `all'.

**** Build Finished ****
```

Licensed | Writable | Smart Insert | 88 : 1

# Changing Project Properties

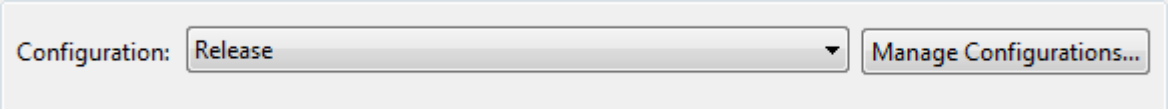
1. Make sure you are in the *CCS Edit* perspective
2. Right click on the Temperature_Sense_demo project and select *Properties*



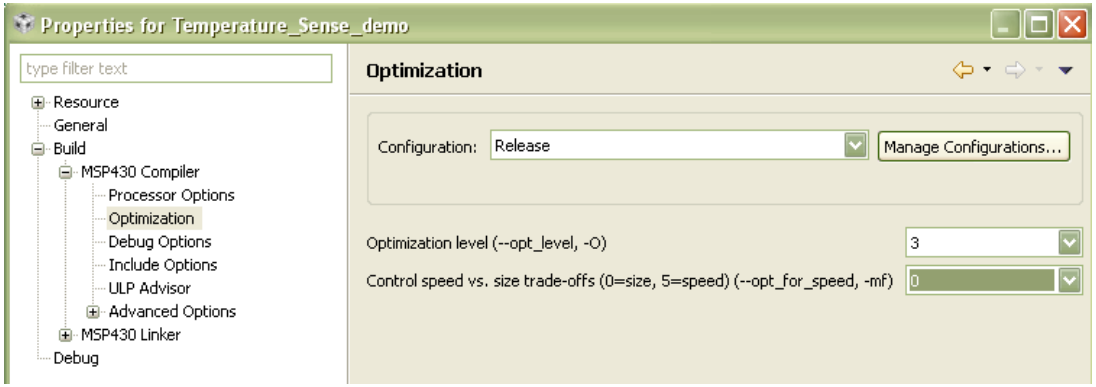
# Changing Build Options

Build options are set per build configuration

1. Change your Configuration to *Release*




2. Change the optimization settings
   - Go to the *Build* → *MSP430 Compiler* → *Optimization*
   - Change the optimization level to 3
   - Change the speed vs size to 0



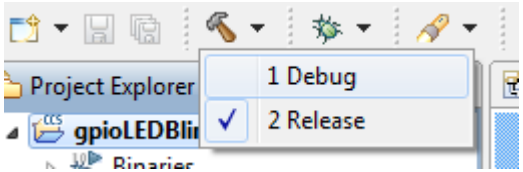

3. Click OK

# Changing Build Options

1. Change the active configuration to *Release*
   - Right click on the Project
   - Select *Build Configurations* → *Set Active* → *Release*
2. Build the project by clicking the build button
   - In the console view you will see that the *Release* configuration has been built

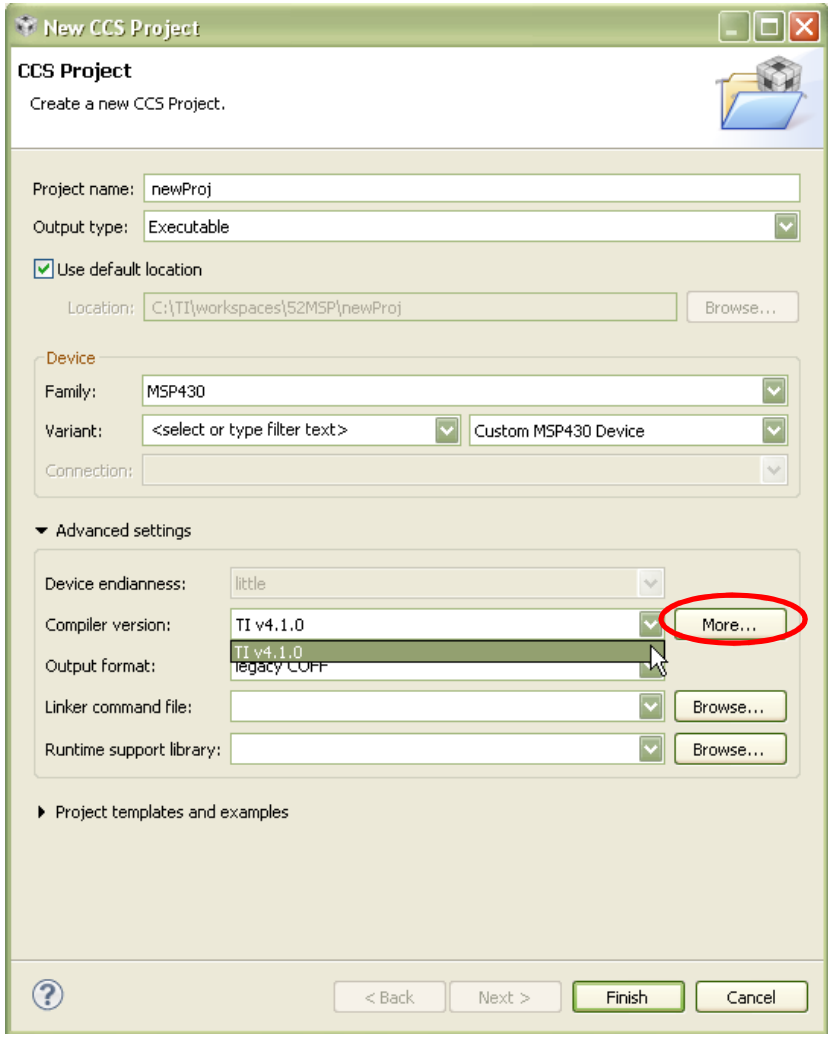
ⓘ You can also change the configuration and build it by clicking on the arrow beside the build button and selecting the configuration you want to build

- Select *Release* and it will build this configuration
- The active configuration is indicated by the Checkmark



# Compiler Versions

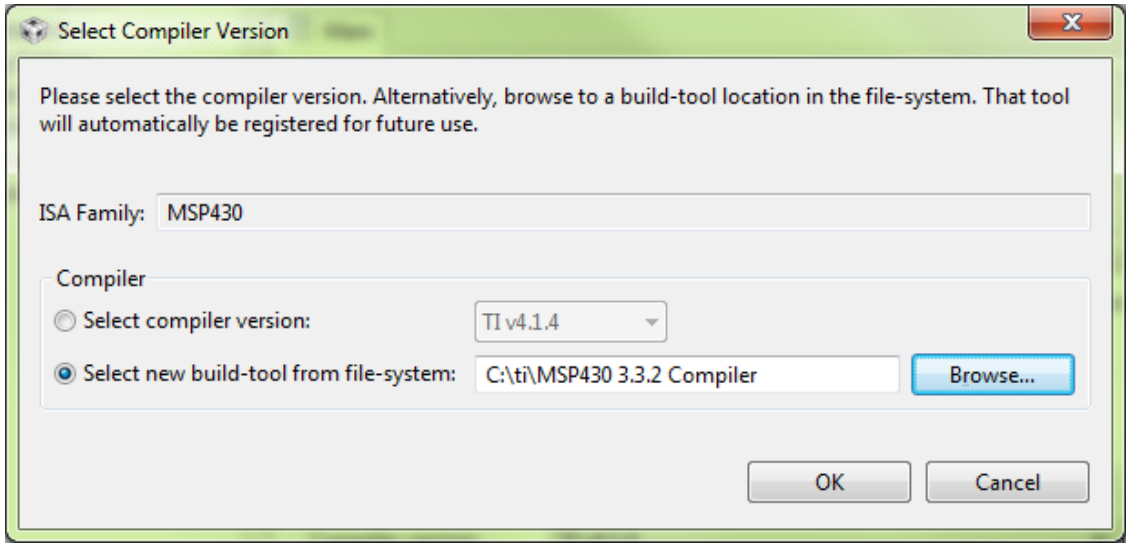
1. Launch ‘New CCS Project’ Wizard -- - In ‘CCS Edit’ perspective, Project -> ‘New CCS Project’
2. Fill in the fields as shown on the right
3. Expand the ‘Advanced Settings’ and check the ‘Compiler version:’ dropdown menu
   - Note there is only one option (v4.1.x)
   - Select ‘More…’ button next to the ‘Compiler version:’ field



# Changing the Compiler Version

1. Click on *General*
2. Click on the *More…* button beside the Compiler version *TI v4.1.x*
3. Check the option *Select new build-tool from file-system*
4. Browse to the location of the new compiler tools and click OK

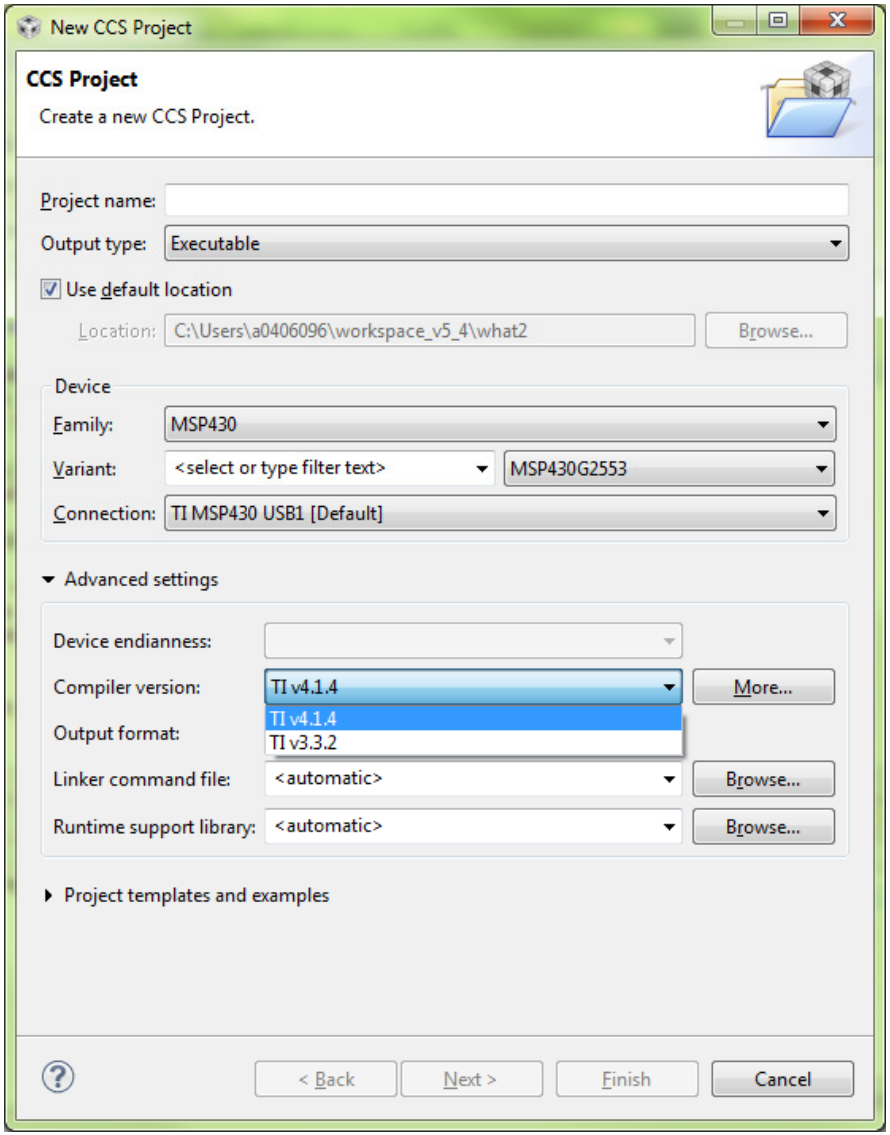
   `C:\TI\MSP430 3.3.2 Compiler`




CCS will determine what compiler is located there and select it for your active configuration.

# Compiler Versions

- The 'Compiler version:' field will be updated to use version 3.3.2 of the TI MSP430 compiler
- Note how both v3.3.2 and v4.1.x (default version that ships with CCSv5.4) now appear in the dropdown list
- The location of v3.3.2 is now known to CCS and will be available as an option for all projects using the same workspace
- Note that compiler versions can be changed for existing projects via
  - Right click on your project and select 'Properties'
  - Click on 'General'



# Blink LED Example: Exercise Summary

- At this point you experimented the following concepts:
  - Workspaces
  - Welcome screen / Resource Explorer
  - Project concepts
  - Basics of working with views
  - Debug launch
  - Debug control
  - Profile Clock
  - Local History
  - Build Properties
  - Changing compiler versions
  - Debug symbols
  - Profile

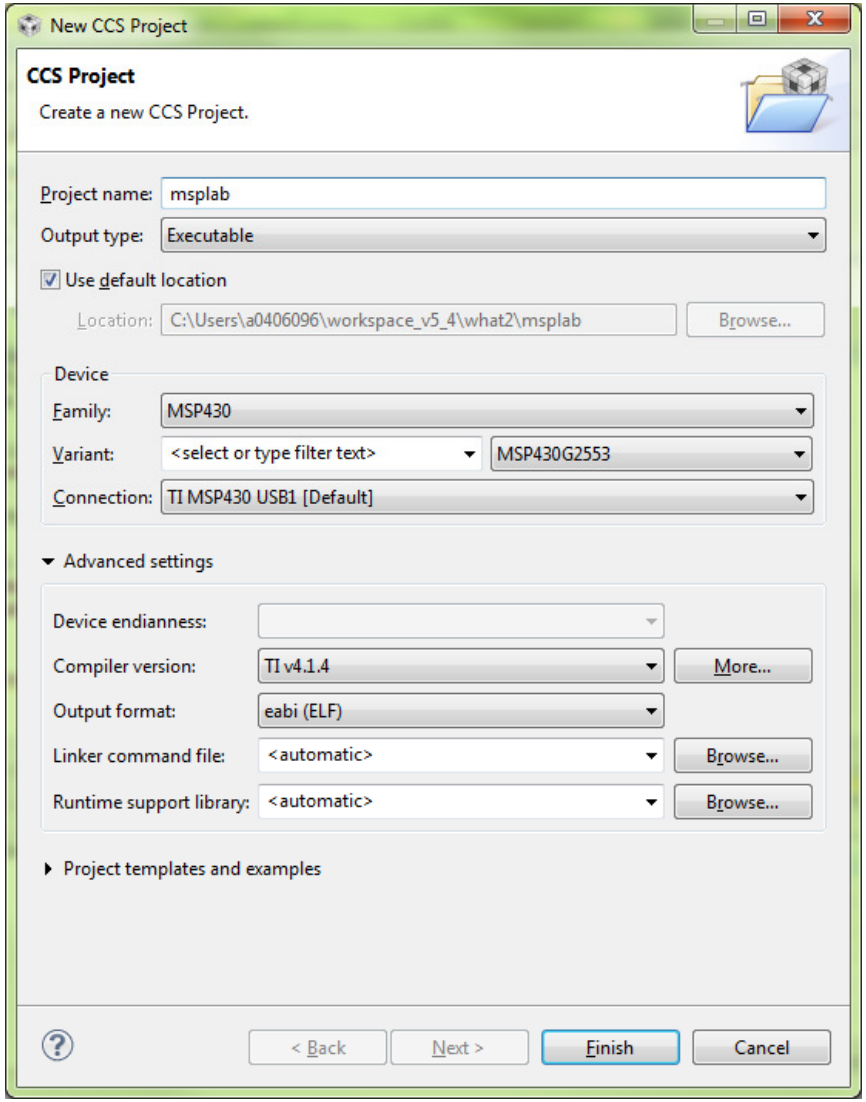
# LAB 3 : SHARING PROJECTS

# Portable Projects: Briefing

- Key Objectives
  - Create a project that uses a linked source file
  - Make the project portable
- Tools and Concepts Covered
  - Linked Resources
  - Linked Resource Path Variables
  - Build Variables

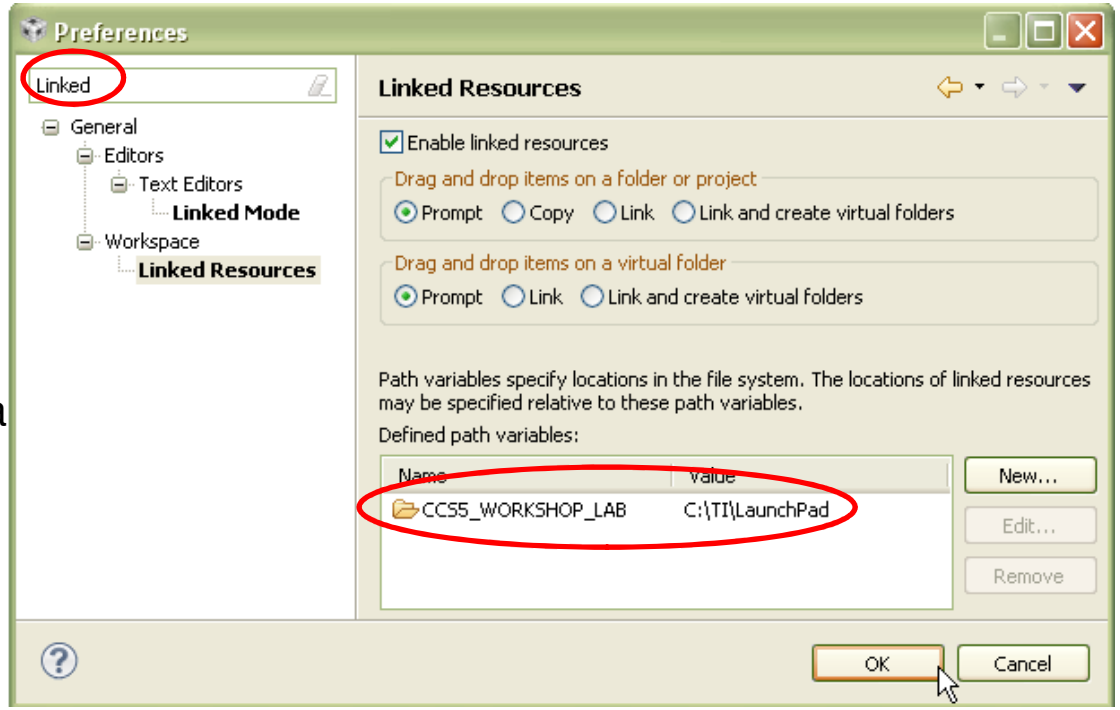
# Create a New Project

1. Launch ‘New CCS Project’ Wizard
   - Select ‘*New Project*’ from the Welcome page
2. Fill in the fields as shown in the right
   - Use compiler version **4.1.x (not 3.2)**
3. Select ‘*Finish*’ when done
4. Generated project will appear in the Project Explorer view
5. Remove the generated ‘main.c’ file from the project



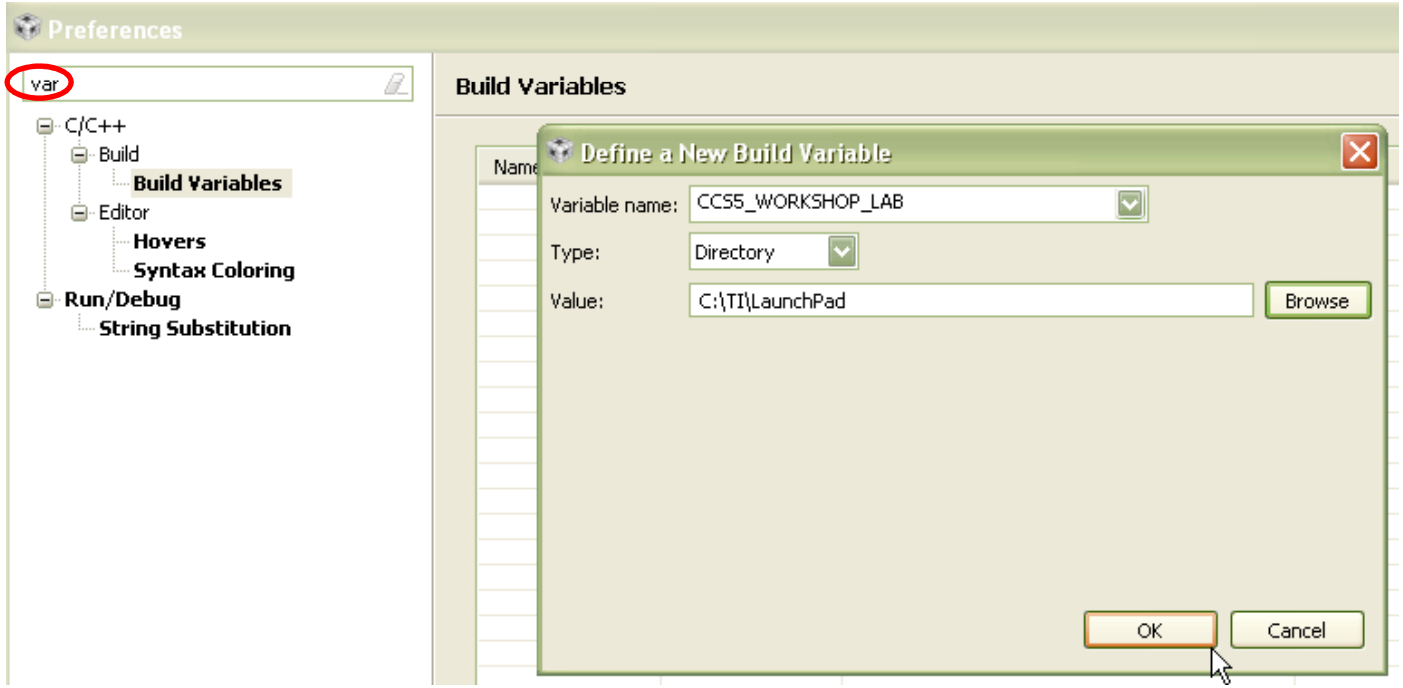
# Create a Linked Resource Path Variable

1. Open the workspace preferences
   - *Window -> Preferences*
2. Go to the 'Linked Resources' preferences
   - Type 'Linked' in the filter field to make it easier to find
3. Use the 'New' button to create a 'Linked Resource Variable' that points to the root location of the workshop LaunchPad labs
4. Hit 'OK' when finished



# Create a Build Variable

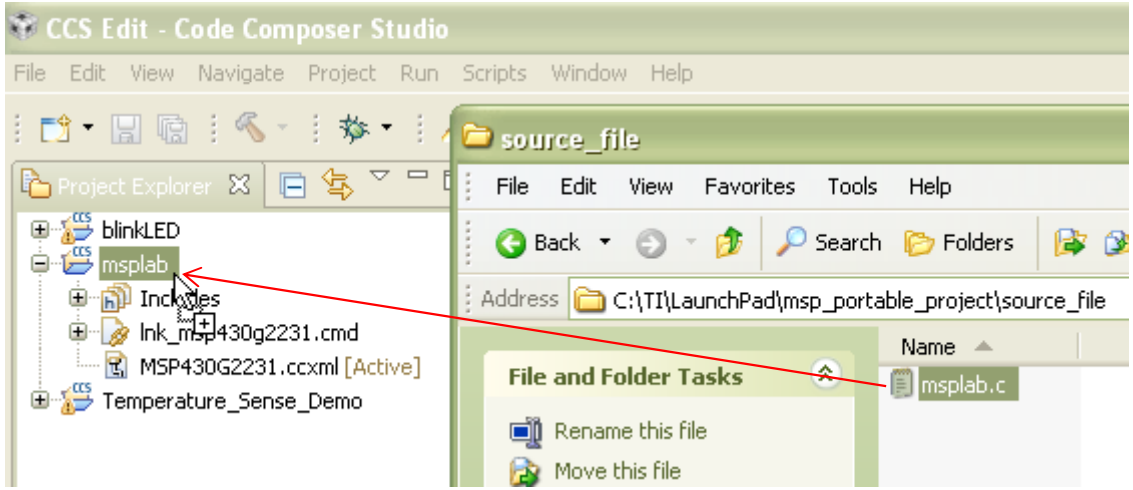
1. Go to the 'Build Variables' preferences
   - Type 'Variables' in the filter field to make it easier to find
2. Build Variables allow you to use variables in the project properties
   - Linked Resource variables are only used for linked files
3. Use the 'Add' button to create a 'Build Variable' that points to the root location of the workshop LaunchPad labs
   - Set the 'Type:' to 'Directory' to browse to a directory
4. Hit 'OK' when done



# Link Source Files to Project

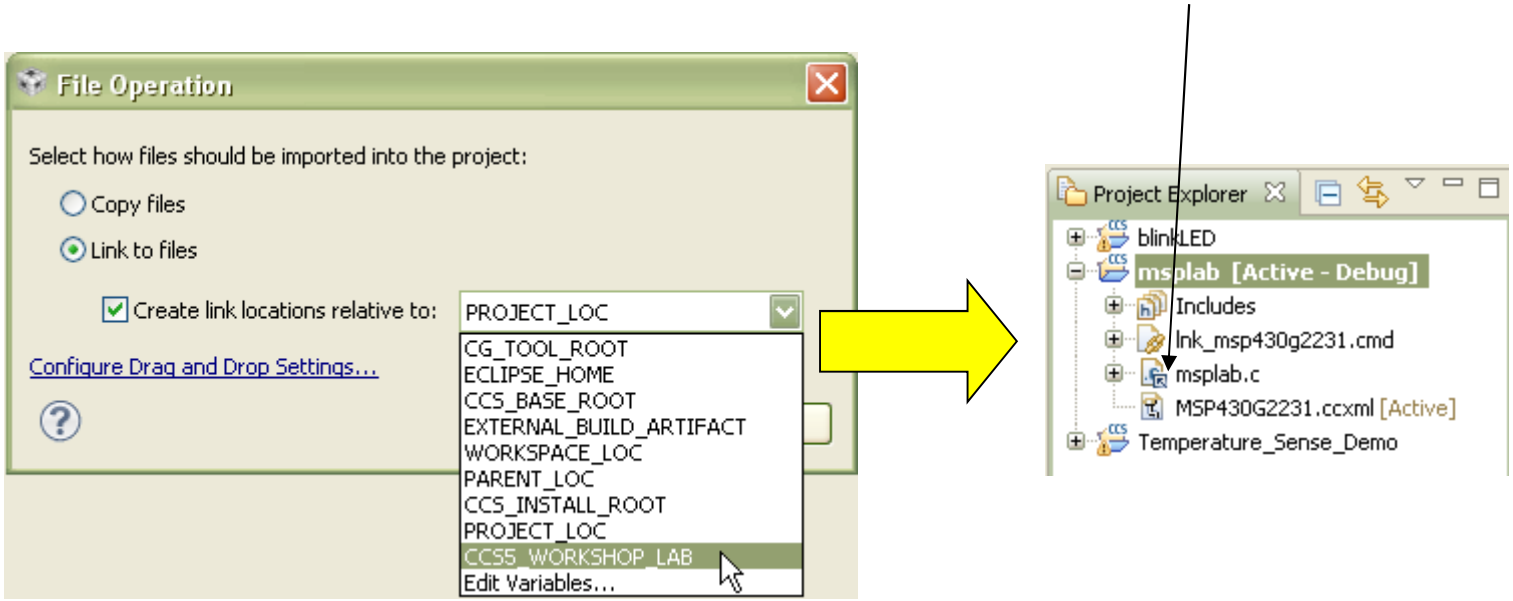
1. Open Windows Explorer and browse to
   C:\TI\LaunchPad\msp_portable_project\source_file

   Drag and drop the ‘msplab.c’ file in to the ‘msplab’ project



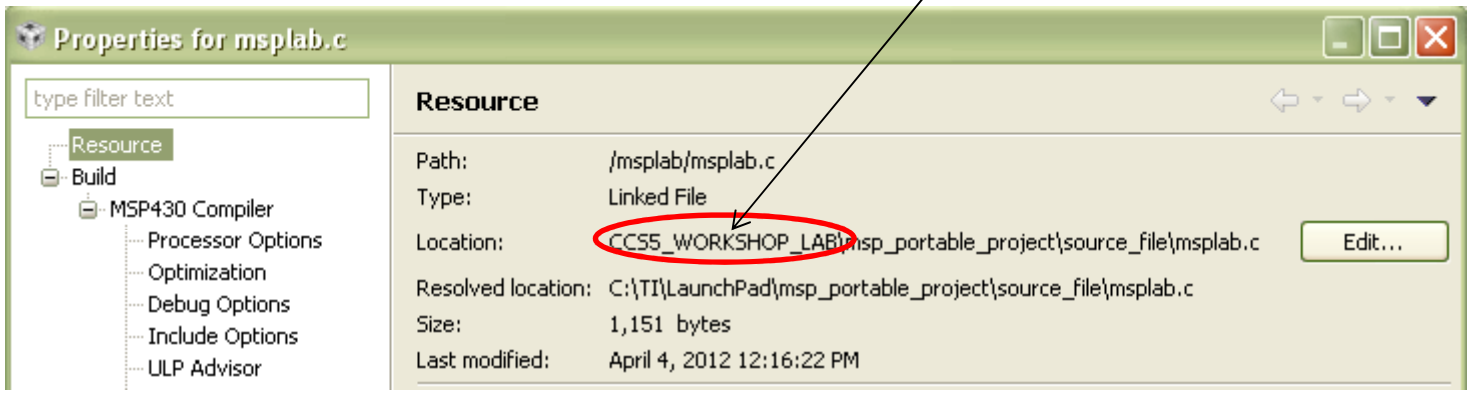
# Link Source Files to Project

1. A dialog will appear asking if you wish to Copy or Link the files:
   - Select 'Link to files'
   - Select 'Create link locations relative to:'
     - Use the new Linked Resource variable we created (CCS5_WORKSHOP_LAB)
   - Hit 'OK'
2. Files will now appear in the Project Explorer with the 'link' icon



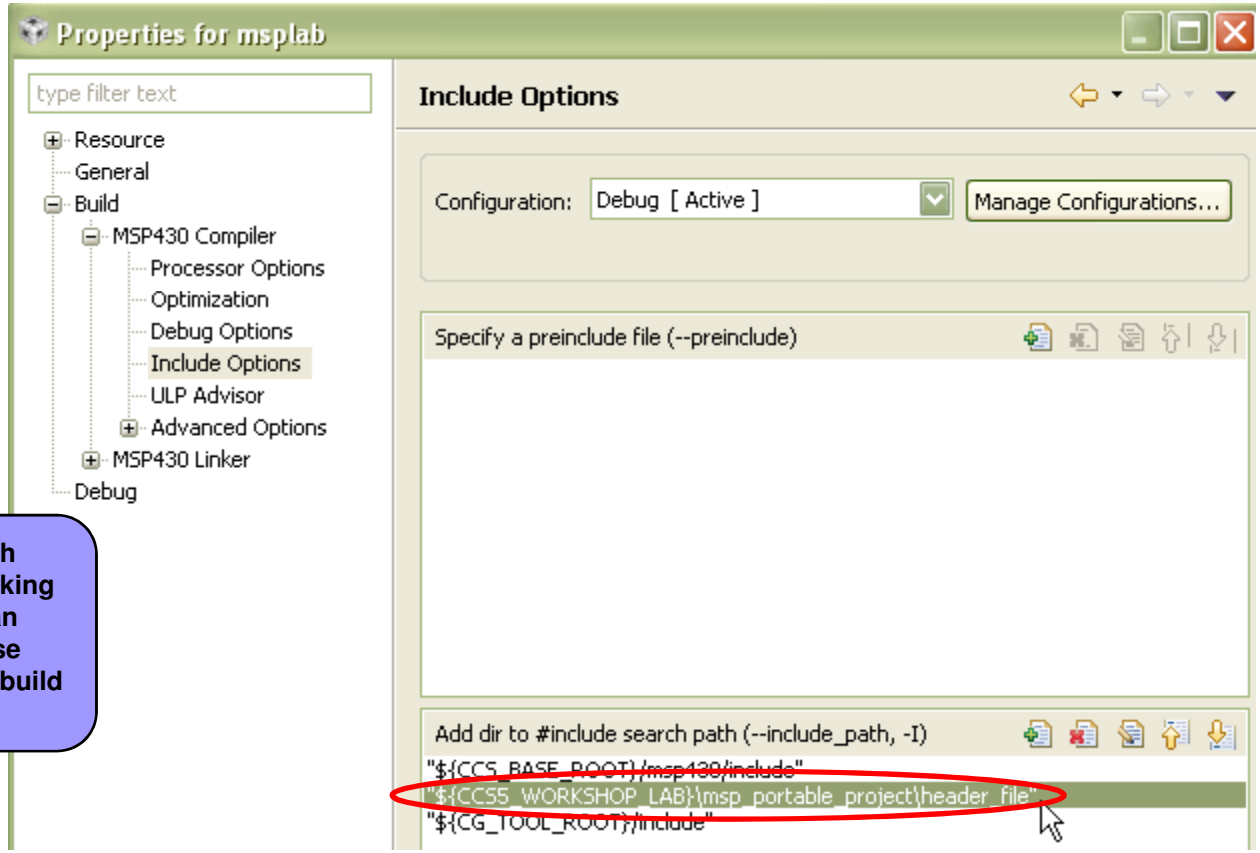
# Link Files to Project

1. Right-click on ‘msplab.c’ file and check the ‘Properties’
   – See how the ‘Location’ parameter references the Linked Resource Variable



# Modifying Project Properties

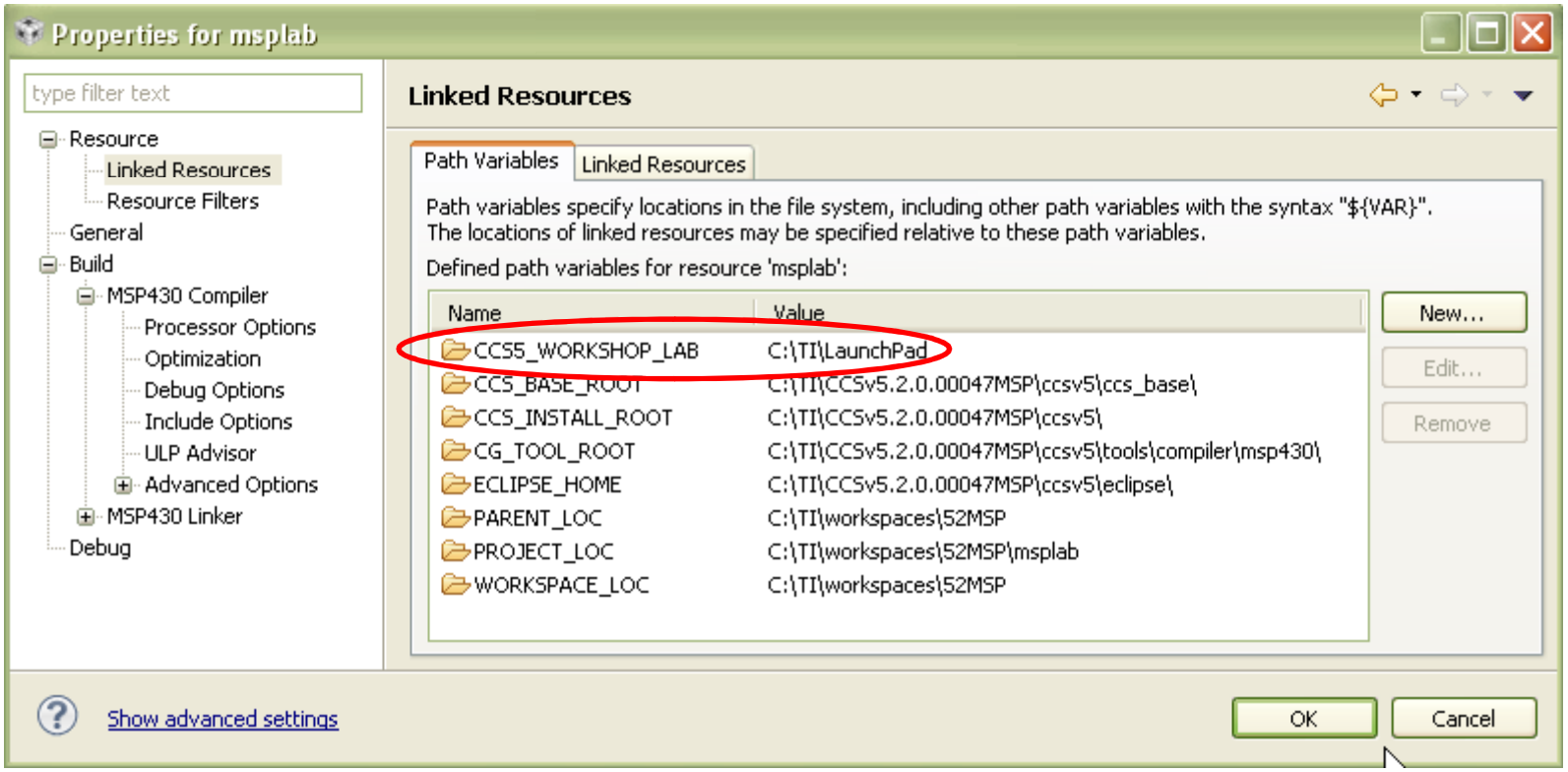
1. Right-click on the project and select 'Properties'
2. In the compiler 'Include Options', add the following entries to the list of include search paths:
   - **${CCS5_WORKSHOP_LAB}\msp_portable_project\header_file**
3. '${<BUILD VARIABLE>}' is the syntax to use a Build Variable in the project properties




**WARNING: Linked Resource Path Variables are only used when linking source files to a project. They can not be used for build options. Use Build Variables when modifying build options**

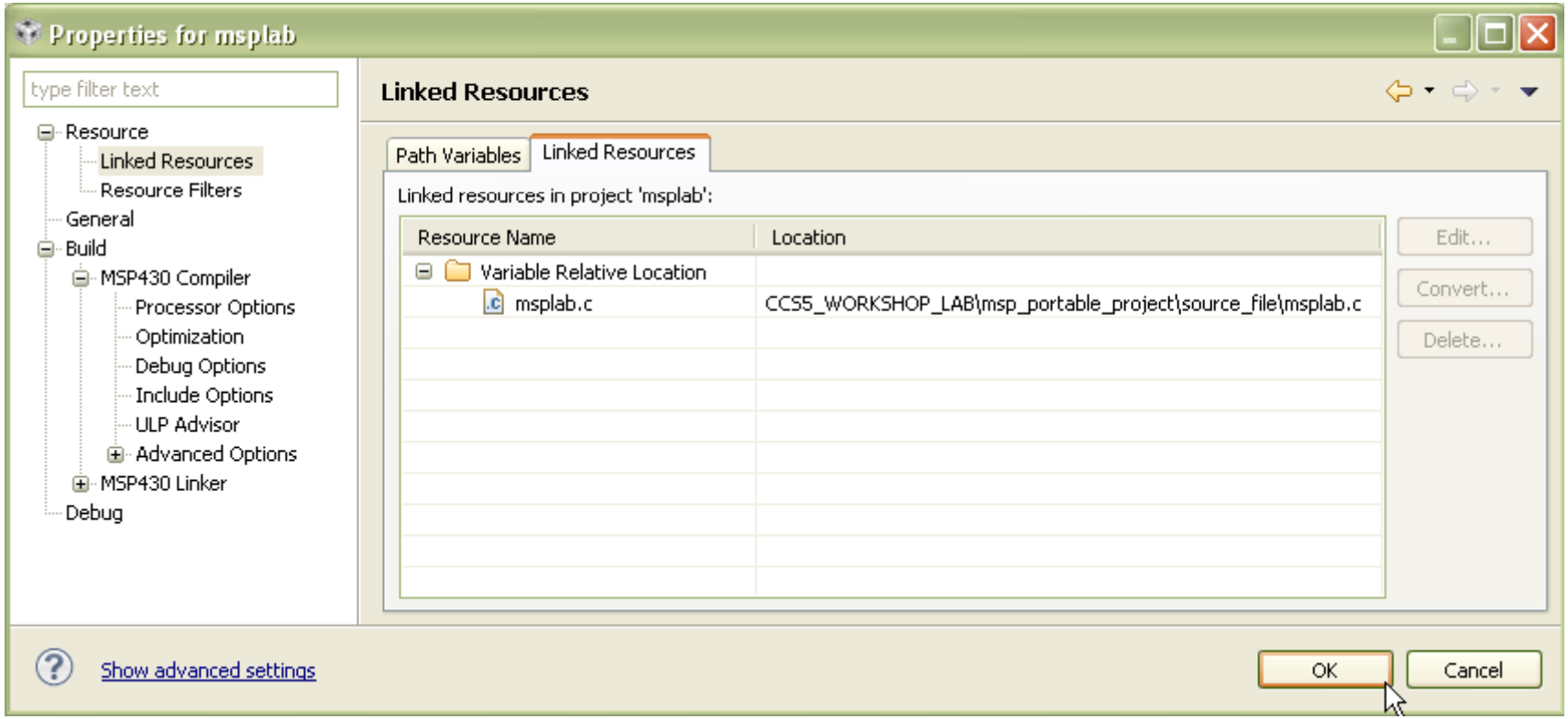
# Project Properties

1. Go to ‘Resource -> Linked Resources’ to see all the Linked Resource Path Variables that is available to the project
   - This will show all variables created at the project level and workspace level
2. See the workspace level Linked Resource Path Variable that was created appears in the list
3. Variables may be edited here but changes will only be recorded at the project level (stored in the project files)



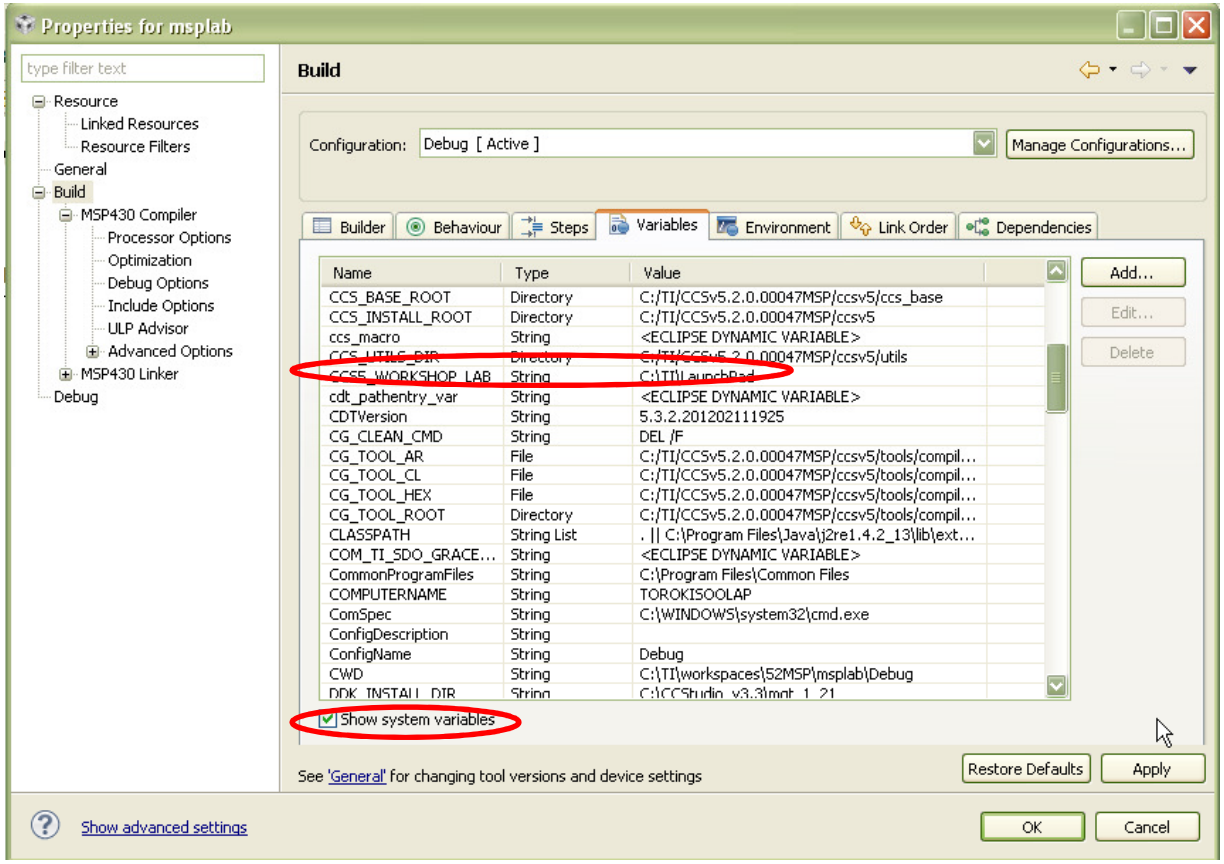
# Project Properties

1. The 'Linked Resources' tab will show all the files that have been linked to the project
   - It will sort them by files linked with a variable and files linked with an absolute path
2. Links can be modified here with the 'Edit…' button
3. Links can be converted to use an absolute path with the 'Convert…' button



# Project Properties

1. Go to ‘Build’ to see all the Build Variables that is available to the project
   - Only project level variables will be listed by default
   - Enable the “Show system variables” checkbox to see variables set at the workspace and system level
2. See how the workspace level Build Variable that was created appears in the list



# LAB 4: Ultra Low Power Advisor

# Import and Build ULP Demo Project

1. Import ULP Demo project into the workspace
   - Import -> Existing CCS Eclipse Project
   - Project is located in:
     - C:\ti\LaunchPad\ulp_demo
2. Explore the one source file ‘ulp_demo.c’
3. Build it

# ULP Diagnostics

- ULP Diagnostics appear in problems view

1. Maximize ‘Problems’ view
2. Click on link to open advice window for that diagnostic

- Experiment with the links
- Can position Advice window anywhere

Problems

0 errors, 18 warnings, 4 others

| Description | Resource | Path | Locatio |
|---|---|---|---|
| Warnings (18 items) | | | |
| Infos (4 items) | | | |
| #10371-D (ULP 1.1) Detected no uses of low power mode state changes using LPMx or _bis_SR_register() or __low_po | ulp_demo | | |
| #1535-D (ULP 8.1) variable "const_local" is used as a constant. Recommend declaring variable as either 'static const' or ' | ulp_demo.c | /ulp_demo | line 47 |
| #1539-D (ULP 11.1) Loop program control flow variable "flags_var" compared against higher bits. Recommend compare | ulp_demo.c | /ulp_demo | line 72 |
| #1544-D (ULP 13.1) Detected loop counting up. Recommend loops count down as detecting zeros is easier | ulp_demo.c | /ulp_demo | line 88 |

Click here!

Advice

# ULP Advisor > Rule 8.1 Use 'static' & 'const' modifiers for local variables

## What it means

In an MSP430 C function, local variables without any modifiers are dynamically allocated upon each function call. This requires additional code & RAM space and the impact increases depending on the function call frequency. On the other hand, when declared as 'static', the variables are only generated once and remain available throughout the lifetime of the application. This minimizes the amount of code needed to re-allocate/re-initialize the variables every time the function is invoked. Alternatively, when the const modifier is used, the variable is stored as data in flash as part of the function, hence requiring no further re-allocation for each function entry.

## Risks, Severity

Using local variables without 'static' or 'const' modifier requires additional code execution to reallocate & reinitialize the variables each time the function is invoked.

## Why it is happening

The project code contains a function with local variables that are not but can be declared with the 'static' and/or 'const' modifiers.

## Remedy

ULP Advisor | MSP430™ Ultra-Low Power MCUs

## ULP Advisor - Rule Table

ULP 1.1 Ensure LPM usage
ULP 2.1 Leverage timer module for delay loops
ULP 3.1 Use ISRs instead of flag polling
ULP 4.1 Terminate unused GPIOs
ULP 5.1 Avoid processing-intensive operations: modulo, divide.
ULP 5.2 Avoid processing-intensive operations: floating point
ULP 5.3 Avoid processing-intensive operations: (s)printf()
ULP 6.1 Avoid multiplication on devices without hardware multiplier

ULP 7.1 Use local instead of global variables where possible
**ULP 8.1 Use 'static' & 'const' modifiers for local variables**
ULP 9.1 Use pass by reference for large variables
ULP 10.1 Minimize function calls from within ISRs
ULP 11.1 Use lower bits for loop program control flow

# Fix Rule 8.1

- For function ulp_demo_rule_8_1
- Static and const variables are preferred over plain local variables
  - Add `static const` before `const_local`
- Make change directly
- Or cheat …
  - Change `#define BREAK_RULE_8_1` to 0
- Build
- Diagnostic about rule 8.1 no longer in problems view

# Rule 8.1 – After Fix

```
39
40 //-----------------------------------------------------------------------------
41 // Demonstrate rule 8.1 - Use 'static' and 'const' modifiers for local
42 // variables
43 //-----------------------------------------------------------------------------
44 int ulp_demo_rule_8_1()
45 {
46     static const int const_local = 10;
47     return const_local;
48 }
49
```

Problems

0 errors, 18 warnings, 3 others

Description

- Warnings (18 items)
- Infos (3 items)
  - #10371-D (ULP 1.1) Detected no uses of low power mode state changes using LPMx or _
  - #1539-D (ULP 11.1) Loop program control flow variable "flags_var" compared against hi
  - #1544-D (ULP 13.1) Detected loop counting up. Recommend loops count down as detect

# Fix Rule 11.1

- For function ulp_demo_rule_11_1
- Change #define F1 … F4 to 1, 2, 4, 8
  - MSP430 can use those constant values cheaply
- Make change directly
- Or cheat …
  - Change `#define BREAK_RULE_11_1` to 0
- Build
- Diagnostic about rule 11.1 no longer in problems view

# Rule 11.1 – After Fix

```
50 //-----------------------------------------------------------------------------
51 // Demonstrate rule 11.1 - Use lower bits for loop program control flow
52 //-----------------------------------------------------------------------------
53 #define F1 0x01
54 #define F2 0x02
55 #define F3 0x04
56 #define F4 0x08
57
58 unsigned flags_var = 0;
59 void ulp_demo_rule_11_1()
60 {
61    while (flags_var & (F2 | F3))
62       do_some_processing();
63 }
```

Problems

0 errors, 18 warnings, 2 others

Description

- Warnings (18 items)
- Infos (2 items)
  - #10371-D (ULP 1.1) Detected no uses of low power mode state changes using LPMx
  - #1544-D (ULP 13.1) Detected loop counting up. Recommend loops count down as d

# Fix Rule 13.1

- For function ulp_demo_rule_13_1
- Change to loop that counts from N-1 to 0
  - Comparisons against 0 are cheaper
- Make change directly
- Or cheat …
  - Change `#define BREAK_RULE_13_1` to 0
- Build
- Diagnostic about rule 13.1 no longer in problems view

# Rule 13.1 – After Fix

```
69 //-----------------------------------------------------------------------------
70 // Demonstrate rule 13.1 - Count down in loops
71 //-----------------------------------------------------------------------------
72 void ulp_demo_rule_13_1(int input)
73 {
74    int i;
75    for (i = input-1; i >= 0; i--)
76        do_some_processing();
77 }
78
```

Problems

0 errors, 18 warnings, 1 other

Description

- Warnings (18 items)
- Infos (1 item)
  - #10371-D (ULP 1.1) Detected no uses of low power mode state changes using LPMx or

- Rule 1.1 problem remains
- Click the link to see related advice

# Importance of Rule 1.1

Advice

## ULP Advisor > Rule 1.1 Ensure LPM Usage

### What it means

Low power mode (LPM) usage is highly recommended. One of the necessary steps to achieve low power consumption in an MSP430 application is to minimize the time spent active mode and maximize the time in low power modes. Peripherals can be configured to operate without CPU intervention and the CPU only needs to wake up to perform critical tasks and quickly return to low power mode.

### Risks, Severity

An application that always stays in active mode is not energy efficient and could significantly reduce lifetime for battery-powered applications.

### Why it is happening

This remark is issued when no LPM-entering instruction can be found in any code file in the project.

### Remedy

- Use low power modes in your application when applicable, i.e. while waiting for certain peripheral tasks to complete,

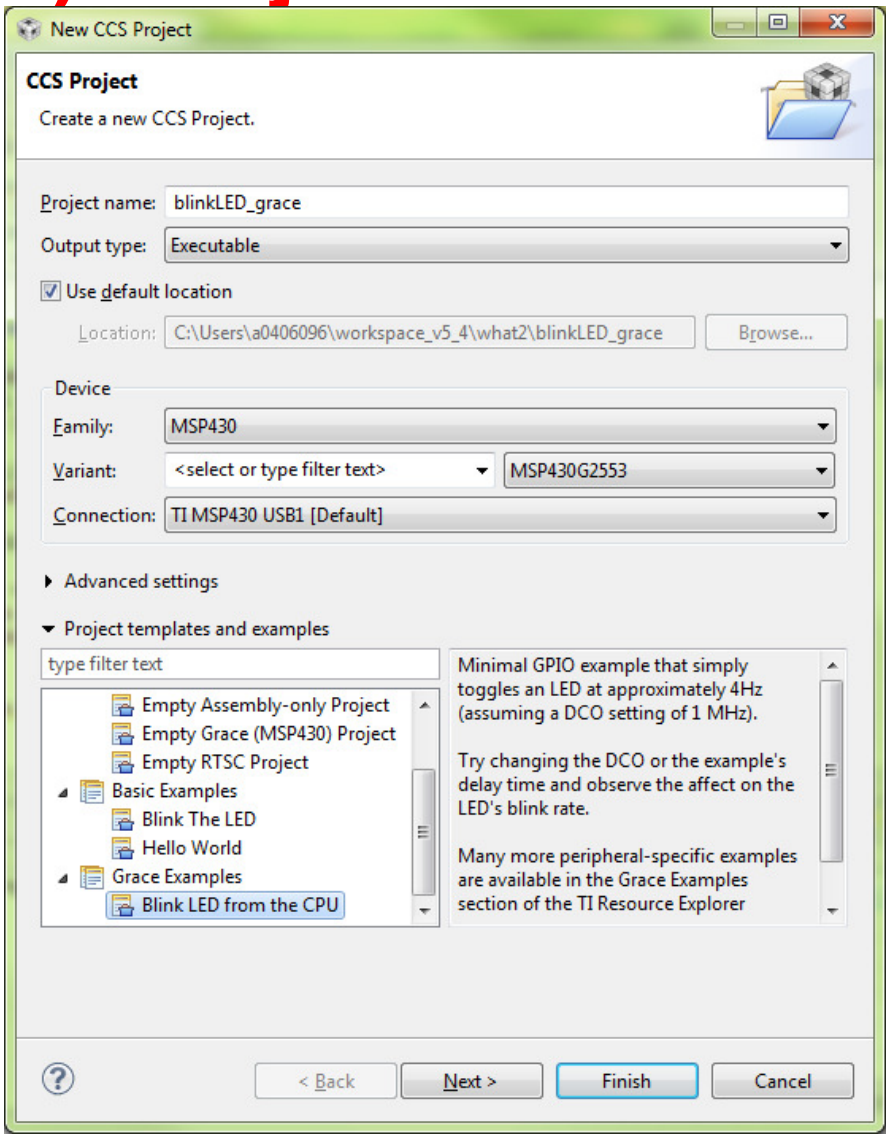
# Importance of Rule 1.1

- Remain in low power mode (LPM) as long as possible
- Cannot run any code while in LPM
- Come out of LPM with an interrupt
- Primary technique for conserving power
- More details beyond scope of this demo

# LAB 5 : GRACE

# Create a New (Grace) Project

1. Start the Project Wizard
   - Select 'New Project' on the Welcome page
2. Fill in the fields as shown on the right
   - Select the '**Blink LED from the CPU**' template under '**Grace Examples**'
3. Select 'Finish' when done



# Grace – Configuration File

CCS Edit - blinkLED_grace/led.cfg - Code Composer Studio

File Edit View Navigate Project Run Scripts Window Help

CCS Debug

Project Explorer

- blinkLED
- blinkLED_grace [Active - Debug]
  - Includes
  - targetConfigs
  - led.c
  - lnk_msp430g2553.cmd
  - led.cfg [Grace]
  - makefile.defs
- hello
- Temperature_Sense_demo

Available Products

type filter text

- Grace (MSP430)
  - CSL
  - Peripherals
- MSP430 DriverLib
  - DriverLib
- XDCtools
  - Diagnostics
  - Memory Management
  - Synchronization
  - System
- Other Products
  - ccsv5/ccs_base

led.cfg

## Grace (MSP430) - Welcome

Welcome Device Overview

### Introduction

The Grace tool is a plug-in to Code Composer Studio that allows you as a MSP430 developer to generate peripheral set up code within minutes. Along with each peripheral module, typical application use cases are provided. Each of these consist of easy-to-follow steps for initial set up of the peripherals as well as ready-to-use code snippets for peripheral runtime control that can be copied straight into your application.

### Getting Started

1. Click on the Device Overview link to see the peripheral modules available for configuration (depicted in blue)
2. Click on the peripheral module you want to configure
3. Follow the use case instructions or freely configure your device
   **Note:** For F2xx/G2xx devices, you can use the Grace Snippet feature (via **Window->Show View->Other->Grace->Grace Snippets** ) to place various use case example codes directly into your application. Or, you can copy the example code from any use case by selecting the text and using the right-click context menu and paste directly into your application
4. Select **Project->Build All** to build your project or press the **Debug** icon to build and load your project onto your connected target device

### More Information

- An overview of how to use Grace can be found here
- Additional information on how to use Grace can be found on the Grace Wiki
- In-depth peripheral specific information is available in the MSP430x2xx Family User's Guide
- Grace Product Release Notes
- Please post your questions and feedback to the MSP430 E2E Forum

Grace

Outline

type filter text

- BCSplus
- CSL
- GPIO
- InterruptVectors
- Program
- System
- WDTplus

Console

blinkLED

```
MSP430: Loading complete. Code Size - Text: 178 bytes Data: 2 bytes.
```

Problems Advice

0 items

| Description | Resource | Path |
|---|---|---|

Licensed blinkLED_grace

# Grace – Building/Running the Example

1. Build and load the Grace example using the 'Debug' button
   - HINT: Make sure the new grace example project is in focus
2. Run the example
3. LED1 should be blinking
   - Note the blink rate
4. Terminate the debug session and return to the 'CCS Edit' perspective

# Grace – Modifying the Example

- Let's change the blink rate. How?
  - Modify the source code… or..
  - Tweak register values… or..
  - **Use Grace to change the clock value!**

- In the 'led.cfg' file, select the 'Device Overview' button to see the peripheral modules available for configuration

# Grace – Modifying the Configuration

CCS Edit - blinkLED_grace/led.cfg - Code Composer Studio

File Edit View Navigate Project Run Scripts Window Help

CCS Debug

**Project Explorer**

- blinkLED
- blinkLED_grace [Active - Debug]
  - Binaries
  - Includes
  - Debug
  - src
  - targetConfigs
  - led.c
  - lnk_msp430g2553.cmd
  - blinkLED_grace.launch
  - led.cfg [Grace]
  - makefile.defs
- hello
- Temperature_Sense_demo

**Available Products**

type filter text

- Grace (MSP430)
  - CSL
  - Peripherals
- MSP430 DriverLib
  - DriverLib
- XDCtools
  - Diagnostics
  - Memory Management
  - Synchronization
  - System
- Other Products
  - ccsv5/ccs_base

**led.cfg**

**Grace (MSP430) - Welcome**

Welcome Device Overview

**Introduction**

The Grace tool is a plug-in to Code Composer Studio that allows you as a MSP430 developer to generate peripheral set up code within minutes. Along with each peripheral module, typical application use cases are provided. Each of these consist of easy-to-follow steps for initial set up of the peripherals as well as ready-to-use code snippets for peripheral runtime control that can be copied straight into your application.

**Getting Started**

1. Click on the Device Overview link to see the peripheral modules available for configuration (depicted in blue)
2. Click on the peripheral module you want to configure
3. Follow the use case instructions or freely configure your device
   **Note:** For F2xx/G2xx devices, you can use the Grace Snippet feature (via **Window->Show View->Other->Grace->Grace Snippets** ) to place various use case example codes directly into your application. Or, you can copy the example code from any use case by selecting the text and using the right-click context menu and paste directly into your application
4. Select **Project->Build All** to build your project or press the **Debug** icon to build and load your project onto your connected target device

**More Information**

- An overview of how to use Grace can be found here
- Additional information on how to use Grace can be found on the Grace Wiki
- In-depth peripheral specific information is available in the MSP430x2xx Family User's Guide
- Grace Product Release Notes
- Please post your questions and feedback to the MSP430 E2E Forum

Grace

**Outline**

type filter text

- BCSplus
- CSL
- GPIO
- InterruptVectors
- Program
- System
- WDTplus

**Console**

blinkLED_grace

```
MSP430: Loading complete. Code Size - Text: 314 bytes Data: 2 bytes.
```

**Problems** | **Advice**

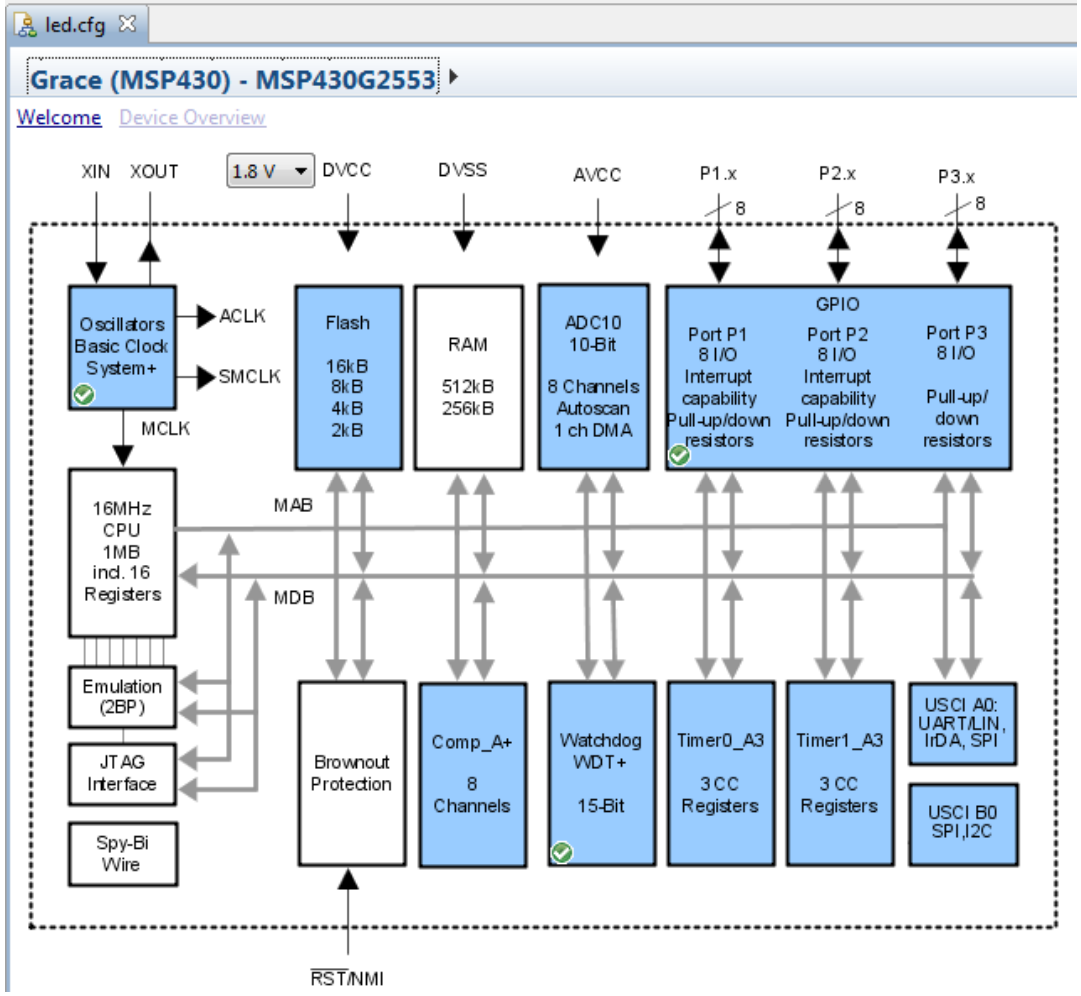
0 errors, 12 warnings, 0 others

| Description | Resource | Path |
|---|---|---|
| Warnings (12 items) | | |

Licensed

# Grace – Device Overview

- Interactive block diagram of the peripheral modules available for configuration
- Select the 'Basic Clock System+' (BCS+) peripheral to configure it
  - NOTE: The name of the peripheral can vary depending on the device
    - **G2553**: 'Oscillators Basic Clock System+'



# Grace – BCS+ Overview

CCS Edit - blinkLED_grace/led.cfg - Code Composer Studio

File Edit View Navigate Project Run Scripts Window Help

CCS Debug

led.cfg

Grace (MSP430) ▸ Clock - Overview

Overview Basic User Power User Registers

Enable Clock in my configuration

**Overview -** This view describes the peripheral and shows you the most important use cases for it

**Select the 'Basic User' mode to configure the clock frequency**

Introduction

The basic clock m umption. Using three internal clock signals, the user can select the best balance of performance and low power consumption. The BCS+ can be configured to ope ith one or two external crystals, or with resonators, under full software control.

The BCS+ incorporates an oscillator-fault fail-safe feature which detects an oscillator fault for LFXT1 and XT2. The crystal oscillator fault bits, LFXT1OF and XT2OF, are set if the corresponding crystal oscillator is turned on and not operating properly. The fault bits remain set as long as the fault condition exists and are automatically cleared if the enabled oscillators function normally.

The OFIFG oscillator-fault flag is set when an oscillator fault (LFXT1OF or XT2OF) is detected. If OFIE is set, the OFIFG requests an NMI interrupt. When the interrupt is granted, the OFIE is reset automatically. The OFIFG flag must be cleared by software. The source of the fault can be identified by checking the individual fault bits.

If a fault is detected for the crystal oscillator sourcing the MCLK, the MCLK is automatically switched to the DCO for its clock source.

Use Case: Oscillator Fault Handling

**Grace Configuration:**

1. Enable BCS+ and select the Power User View
2. Configure low speed external clock source 1 with 32.768kHz external crystal and external high speed external clock source 2 appropriately
3. Select XT2CLK for both MCLK and SMCLK clock sources
4. Enable the Oscillator Fault Interrupt and specify the name of the Interrupt handler, e.g. NMIISRHandler

**User Code:**

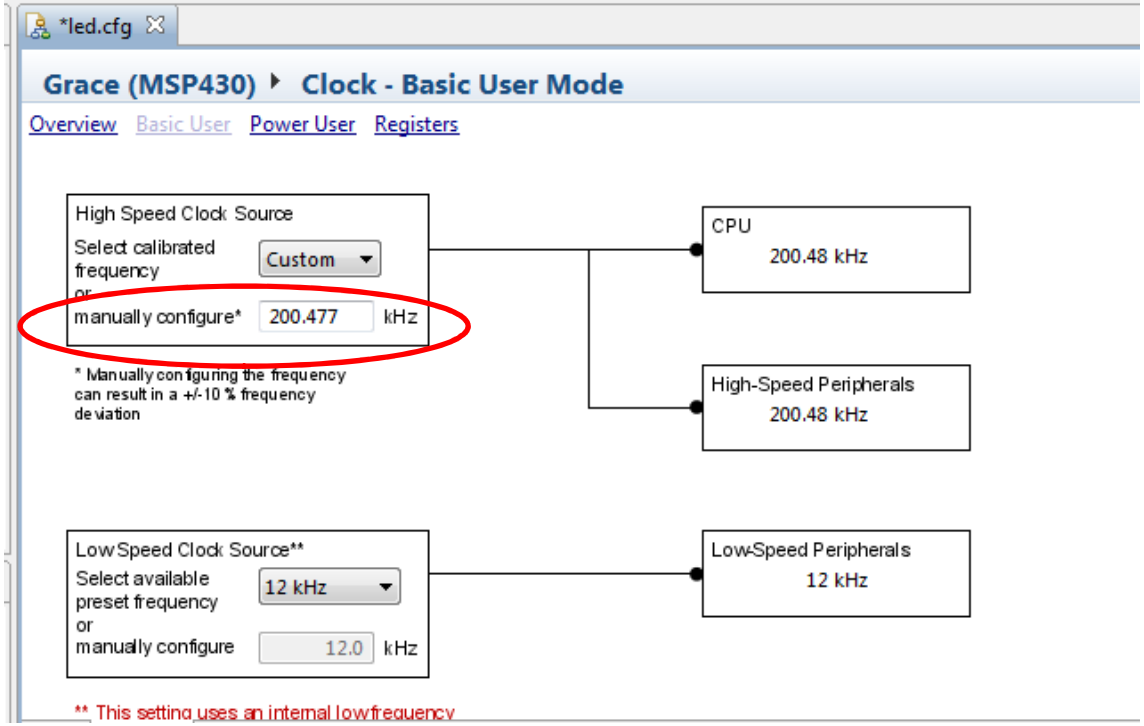
```
// NMI (OSC Fault) Interrupt Handler
void NMIISRHandler(void)
{
    // XT1/XT2 Failure Detected
    do {
        IFG1 &= ~OFIFG;             // Clear OSC Fault flag
        __delay_cycles(50000);      // Time for flag to set again
    } while (IFG1 & OFIFG);         // Loop while OSC Fault flag is set
    IE1 |= OFIE;                    // re-enable osc fault interrupt
}
```

Grace BCS+

Licensed

# Grace – BCS+ Basic User Mode

- This view includes most of the configuration settings that most users will need
- Change the frequency of the 'High Speed Clock Source' from 1 MHz to 200 kHz
- Save the led.cfg file



# Grace – BCS+ Power User Mode

*led.cfg

Grace (MSP430) ▸ Clock - Power User M blinkLED_grace/led.cfg

Overview Basic User Power User Registers

**Power User Mode.** This view includes all the configuration settings of the peripheral

## Configure Clock Source

Internal High Speed Clock Source

Internal DCO[2] 200.477 kHz

Pre-calibrated DCO Values Custom

Disable DCO

Low Speed External Clock Source 1

Select Clock Source** 12 kHz

## Select Clock Source

Clock Source DCOCLK → Divider Divide by 1 → Main System Clock (MCLK) 200.48 kHz

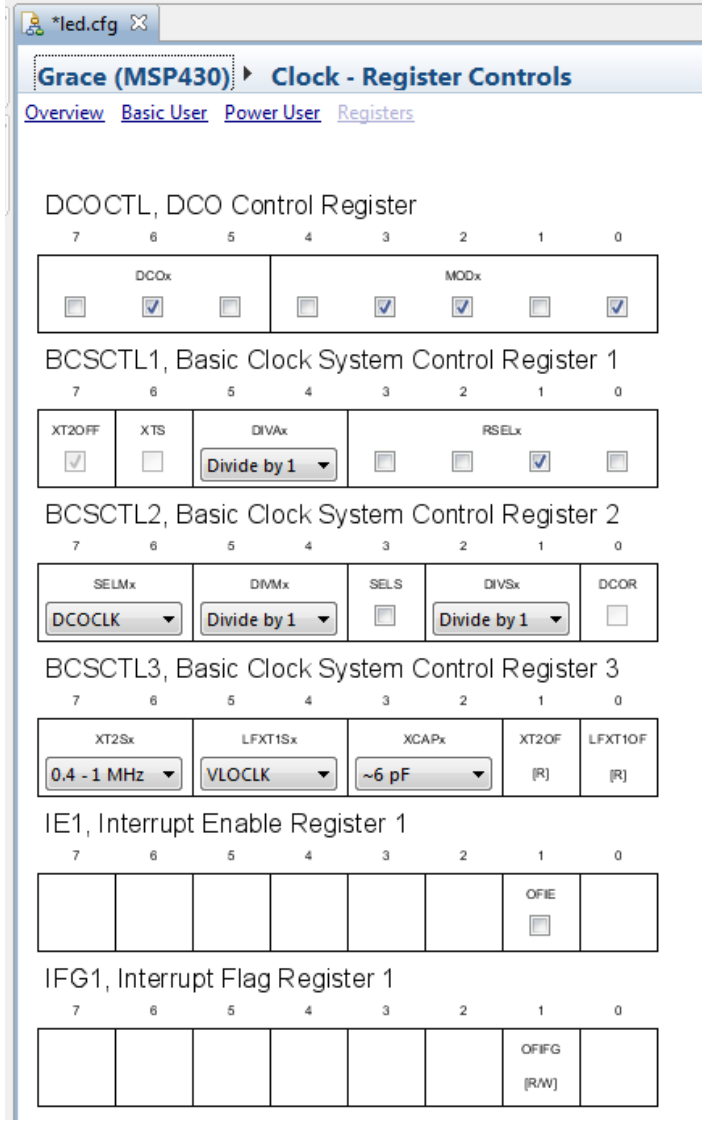
Output MCLK — No MCLK Pins

Clock Source DCOCLK → Divider Divide by 1 → Sub System Clock (SMCLK) 200.48 kHz

Output SMCLK — SMCLK Output OFF

Clock Source from Low Speed External Clock Source 1 → Divider Divide by 1 → Auxiliary Clock (ACLK) 12 kHz

# Grace – BCS+ Register Controls




**Register Controls.** This view depicts the peripheral's control registers and individual bit settings.

# Grace

- Rebuild and reload the Grace example using the ‘Debug’ button
  - HINT: Make sure the new Grace example project is in focus
- Run the example
- LED1 should be blinking
  - Note that new blink rate is 5x slower