MPLAB Code Coverage User's Guide

Notice to Customers

Important:
All documentation becomes dated and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA," where "XXXXX" is the document number and "A" is the alphabetic revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Help Content to open a list of available online help files.

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1.   MPLAB Code Coverage Overview

MPLAB Code Coverage (SW006026-COV) is an MPLAB® XC C compiler add-on license that provides visibility as to what portions of your code are being executed. In MPLAB X IDE, execute your test cases to completion to see:

- Editor text highlighted by colors representing the coverage.
- A Code Coverage tab with a report displaying percentages of code covered.

The information displayed in the IDE may be written to an HTML Report for later viewing.

Compared to trace, code coverage differs in the following ways:

- Trace indicates when and how many times each line of code was executed.
- Code coverage indicates which portions of code have or have not been executed.

Figure 1-1. Code Coverage in MPLAB X IDE
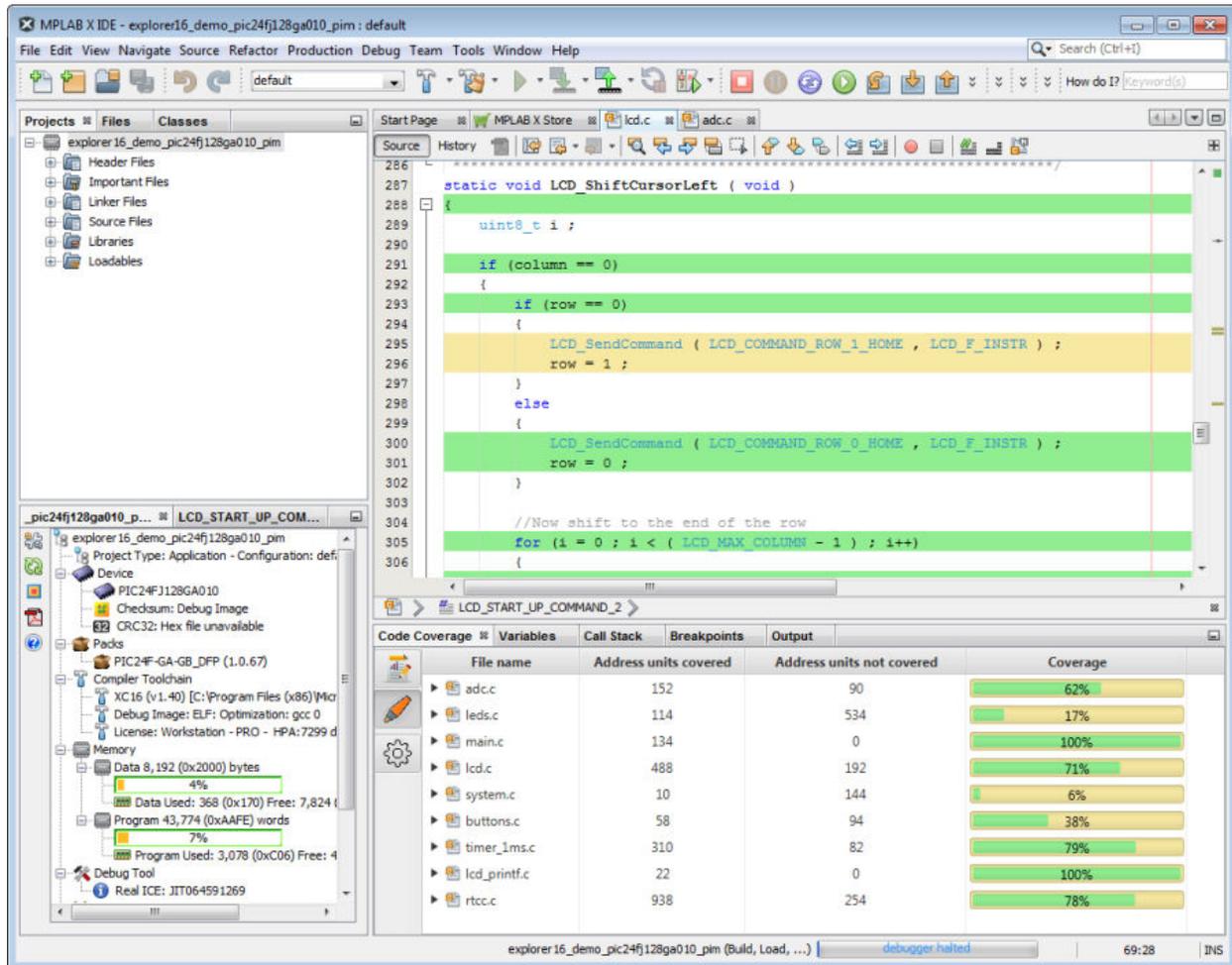
2. MPLAB Code Coverage Details

To view code coverage output, an MPLAB XC C compiler that supports code coverage must be used with MPLAB X IDE.

2.1 Compiler Operation

Code coverage is supported by MPLAB XC C compiler instrumentation. The compiler adds a small amount of code in program memory to update flags in RAM to indicate coverage points.

Note: If your code fills most of program memory, code coverage may not have enough memory to work.

Note: Optimized code can affect how coverage operates. For more information, see section 7. Tips and Tricks.

Compiler Operation - No Add-On License

Without the license, the compilers provide a simple ratio of executed/all coverage points. The compilers don't provide address ranges for the coverage points (bits). So address range overlap, due to multiple paths through the code (e.g., if statements), cannot be used to consider coverage.

Compiler Operation with MPLAB Code Coverage

With a license, each coverage point corresponds to several address ranges. So for multiple code paths, ranges covered in at least one coverage point can be considered covered.

2.2 MPLAB X IDE Operation

MPLAB X IDE Operation - No Add-On License

MPLAB XC C compilers that **do not** have the add-on license will display the compiler simple ratio.

MPLAB X IDE Operation with MPLAB Code Coverage

MPLAB XC C compilers that **do** have the add-on license will display highlighted covered code and percentages of covered code for project files. A report of the coverage may be generated also.

3. Get the Software

To use code coverage, you will need an MPLAB XC C compiler that supports code coverage and an MPLAB X IDE version that supports code coverage display. For full code coverage features, you will need the MPLAB Code Coverage add-on license.

Acquiring MPLAB XC C Compilers

The MPLAB Code Coverage add-on license may be used with MPLAB XC C compilers that support code coverage, beginning with the following versions:

- MPLAB XC8 v2.10
- MPLAB XC16 v1.40
- MPLAB XC32 v2.30

MPLAB XC C compilers may be downloaded for free at https://www.microchip.com/mplab/compilers.

Acquiring MPLAB X IDE

MPLAB X IDE support for viewing code coverage output begins with version 5.25. The IDE may be downloaded for free at https://www.microchip.com/mplab/mplab-x-ide.

Acquiring MPLAB Code Coverage

An MPLAB Code Coverage add-on license may be purchased and activated like other compiler licenses. For more information, see "*Installing and Licensing MPLAB® XC C Compilers*" (DS50002059) for details. This license is for Workstations only (not Networks). This license may be used with FREE or PRO compilers. See also http://www.microchip.com/mplab/codecoverage.

4.   Enable/Disable Code Coverage

To enable or disable code coverage, complete the following steps:

1.   Right click on the name of your project in the Projects window and select "Properties."
2.   Under "Categories," find the project compiler, i.e., XC*nn*, where *nn* is either 8, 16 or 32.
3.   Click on the "Code Coverage" under the compiler (see figure).
4.   Select "Code Coverage Instrumentation." Selections differ for each MPLAB XC compiler. See the table below.

Table 4-1. Enable Code Coverage Options by Compiler

MPLAB XC C Compiler	Enable Options	Description
XC8	Disable	Disable code coverage.
	Enable	Enable code coverage.
XC16	Disable	Disable code coverage.
	Enable Near memory	Use Near RAM space for code coverage instrumentation. This will result in instrumentation code that is less complex and faster. It is recommended that you select Near first, even if you use Far for your program code. If code coverage does not work, then select Far.
	Enable Far memory	Use Far RAM space for code coverage instrumentation. This will result in instrumentation code that is more complex and slower.
XC32	Disable	Disable code coverage.
	Enable	Enable code coverage.

Figure 4-1. Code Coverage Options - MPLAB XC16 Example
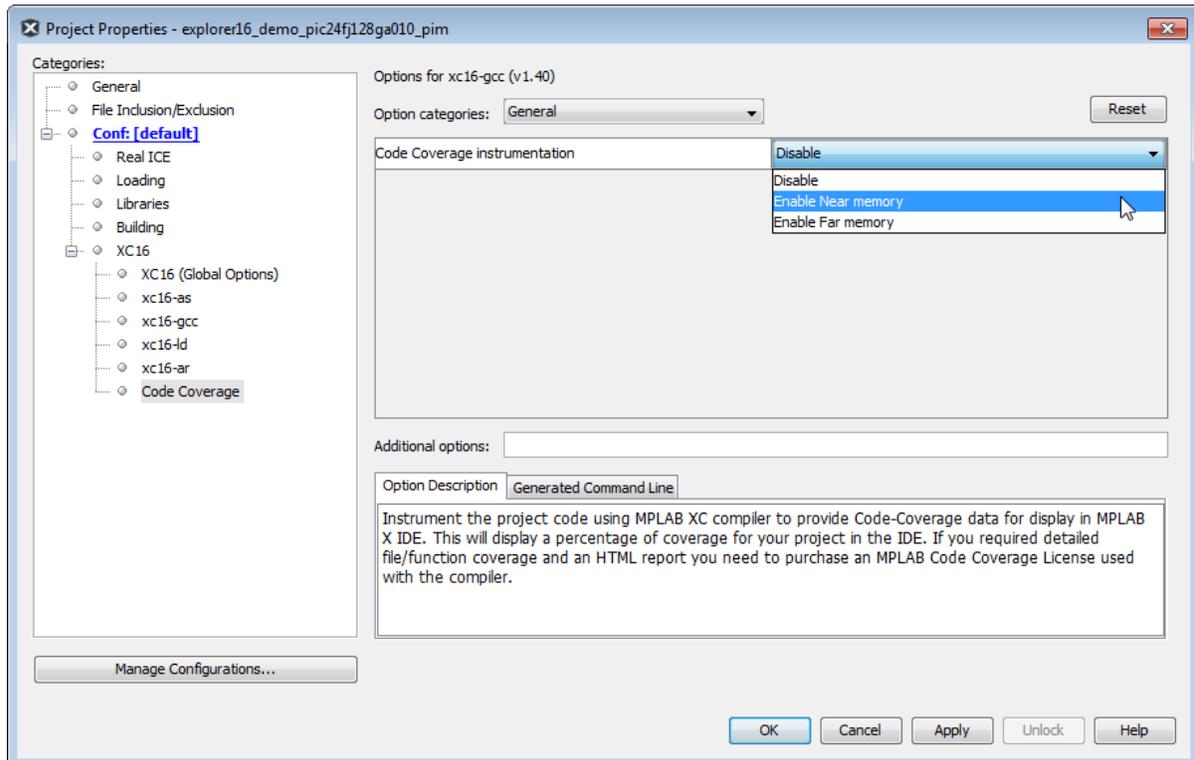
5.   View Code Coverage Output

After you have enabled code coverage, debug your code and execute all test cases to completion, e.g., finish at an empty `while` loop or idle state for a state machine. Then pause/halt execution automatically (`__builtin_software_breakpoint`) or manually.

Note: If the code is still running, you can't be sure if all of the coverage points have been executed.

To view code coverage, select *Window>Debugging>Code Coverage*.

No Add-On License
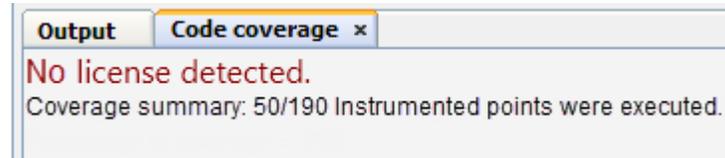
MPLAB Code Coverage Add-On License

- Lines of covered code will be highlighted in the editor.
- A summary report will be shown in the Code Coverage tab.

Summary Report Display	Description
File name	Names of all files in the project.
Address units covered	Address units covered and executed.
Address units not covered	Address units covered but not executed.
Coverage	The Coverage percentage represents x/(x+y) where x = address units covered and executed and y = address units covered but not executed. x vs. y is shown visually in the bar.

For more information on Address Units, see the Address Units section.

Figure 5-1. Code Coverage in MPLAB X IDE
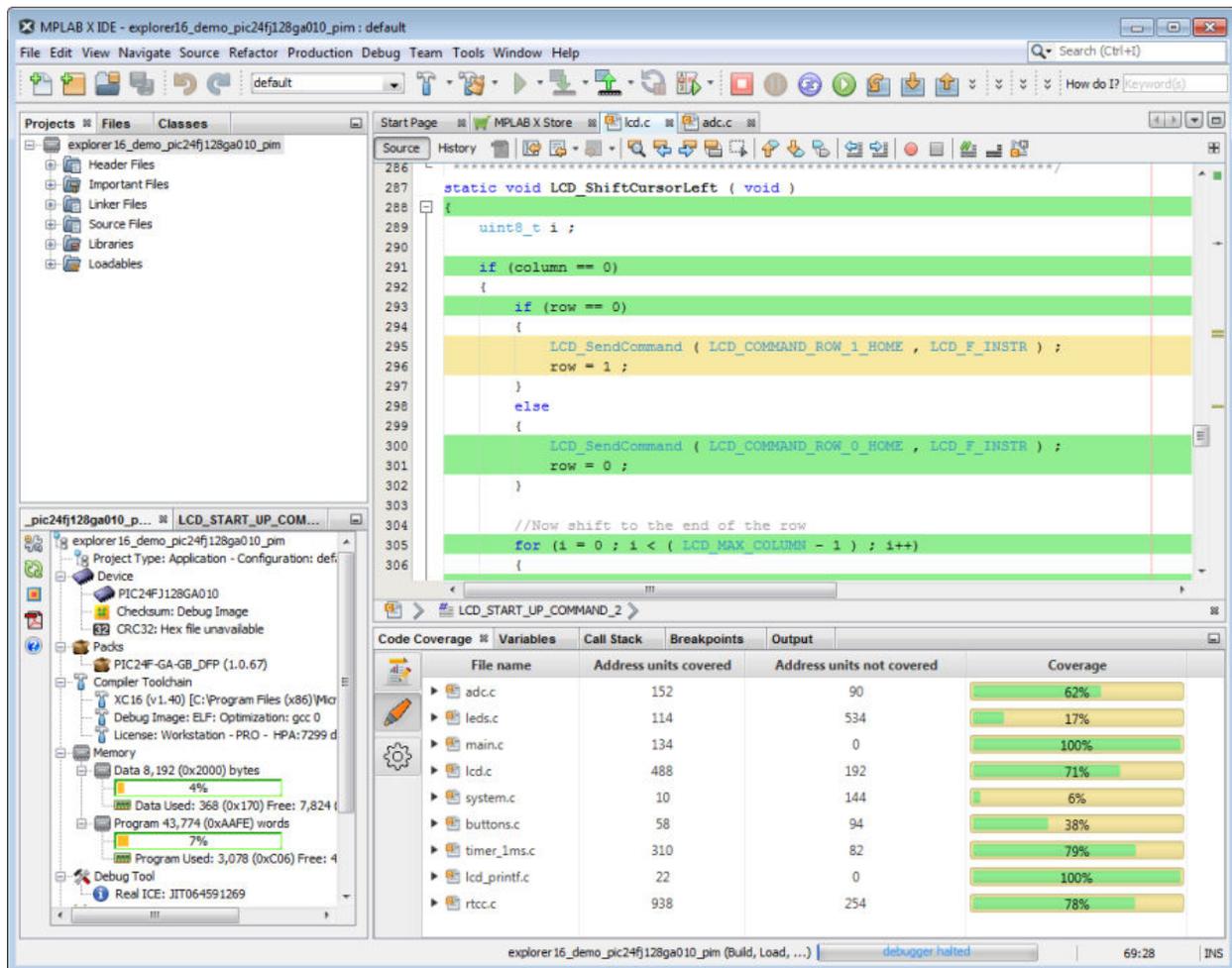
5.1 Color Meanings

The meaning of colors in the Editor and on the Code Coverage tab are shown in the table below.
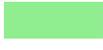
Color	Name	Meaning
	Green	Covered and Executed
	Yellow	Covered but not Executed
	White/None	Not Covered (for lines of code)

5.2 Address Units

An address unit (AU) can represent one or more program memory addresses. An instruction can consume a single AU, multiple AUs or a partial AU. For example, AVR and dsPIC instructions can consume multiple AUs, whereas MIPS and ARM instructions can consume partial AUs.

The AU coverage percentage will be greater than instruction coverage percentage if an instruction can consume multiple AUs. The AU coverage percentage will be less than instruction coverage percentage if an instruction can consume partial AUs.

5.3   Code Coverage Tab Buttons

Click on buttons in the gutter of this tab for the following functions.

	Generate HTML Report. This report will show the same data presented in the Code Coverage window.
	Toggle (enable/disable) color highlighting in editor window.
	Open Project Properties to enable/disable code coverage.

6.   Create a Code Coverage HTML Report

Code coverage information may be saved into a file by clicking on the **Generate HTML Report** button on the **Code Coverage** tab.

For information on the meaning of colors, see section 5. View Code Coverage Output .

Figure 6-1. Report Code Coverage

Source files
All
adc.c
leds.c
main.c
lcd.c
system.c
buttons.c
timer_1ms.c
lcd_printf.c
rtcc.c

All Source files
adc.c *(62%)*
leds.c *(17%)*
main.c *(100%)*
lcd.c *(71%)*
system.c *(6%)*
buttons.c *(38%)*
timer_1ms.c *(79%)*
lcd_printf.c *(100%)*
rtcc.c *(78%)*

Figure 6-2. Report Code Coverage Summary

Coverage Report - All Source files			
Package	**Address units covered**	**Address units not covered**	**Coverage**
Source files	2226	1390	61%
adc.c	152	90	
buttons.c	58	94	
lcd.c	488	192	
lcd_printf.c	22	0	
leds.c	114	534	
main.c	134	0	
rtcc.c	938	254	
system.c	10	144	
timer_1ms.c	310	82	

Functions in these source file(s)	Coverage
ADC_ChannelEnable	66%
ADC_Read10bit	82%
ADC_ReadPercentage	0%
ADC_SetConfiguration	94%
BSP_RTCC_Initialize	0%
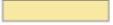
7.   Tips and Tricks

Consider the following tips and tricks to get the code coverage you expect.

Simple Code

When preforming code coverage on a simple program in `main()`, do not let the program simply end. Depending on the device, the code could reset or end up in an undefined state. This may interfere with code coverage calculation.

It is suggested that you place something like a `while(1)` loop at the end of `main()`. Then to see code coverage, either:

*   Place a breakpoint at the last brace of the `while(1)` loop. When you hit the breakpoint, step once to ensure you have completed the loop to see the coverage output.
*   Let the code run for a while before hitting **Pause**. This will ensure that the `while(1)` loop was run (and covered) at least once. View coverage output.

Optimized Code

Different optimizations (`-On`) may result in different coverage of code. Code may be optimized so that is becomes smaller, faster, or more efficient in its operation. Code that is optimized for size with produce different coverage results from code that is optimized for speed.

8.   Increase Code Coverage

Note: Code coverage percentage is determined by Code Covered and Executed/Code Covered (Executed and Not Executed). By increasing the code covered and executed or decreasing total code covered, the code coverage percentage is increased.

The following tips may be useful in helping you increase coverage of your code.

Review Test Cases

Ensure the tests you are running mirror how the code is to be used. Considering all cases can lead to more tests, but also more coverage.

Create tests for each use case, as well as corner cases. Avoid repeated testing of code already tested.

Automate Tests

Use utilities to automate the testing process. Investigate tools that can read your source code, identify inputs & outputs, and program flow to develop relevant tests.

Remove Dead or Redundant Code

Getting rid of code that does not need to be tested will decrease total code and increase coverage.

To find dead code, inspect the sections of code that are not covered after a couple of testing runs and determine if this code is really needed.

To find redundant code, you may need a tool to search for repeating blocks. Then determine if the code blocks can be consolidated.

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