IAR Embedded Workbench

C-SPY® Debugging Guide

for the Renesas

RL78 Microcontroller Family

UCSRL78_I-4

IAR SYSTEMS

EDITION NOTICE

Fourth edition: November 2019

Part number: UCSRL78_I-4

This guide applies to version 4.x of IAR Embedded Workbench® for the Renesas RL78 microcontroller family.

Internal reference: BB5, Mym8.4, IJOA.

Brief contents

Contents

Tables

Preface

Welcome to the *C-SPY® Debugging Guide for RL78*. The purpose of this guide is to help you fully use the features in the IAR C-SPY® Debugger for debugging your application based on the RL78 microcontroller.

Who should read this guide

Read this guide if you plan to develop an application using IAR Embedded Workbench and want to get the most out of the features available in C-SPY.

REQUIRED KNOWLEDGE

To use the tools in IAR Embedded Workbench, you should have working knowledge of:

- The architecture and instruction set of the RL78 microcontroller family (refer to the chip manufacturer's documentation)
- The C or C++ programming language
- Application development for embedded systems
- The operating system of your host computer.

For more information about the other development tools incorporated in the IDE, refer to their respective documentation, see *Other documentation*, page 23.

What this guide contains

Below is a brief outline and summary of the chapters in this guide.

Note: Some of the screenshots in this guide are taken from a similar product and not from IAR Embedded Workbench for RL78.

PART 1. BASIC DEBUGGING

- *The IAR C-SPY Debugger* introduces you to the C-SPY debugger and to the concepts that are related to debugging in general and to C-SPY in particular. The chapter also introduces the various C-SPY drivers. The chapter briefly shows the difference in functionality that the various C-SPY drivers provide.
- *Getting started using C-SPY* helps you get started using C-SPY, which includes setting up, starting, and adapting C-SPY for target hardware.

- *Executing your application* describes the conceptual differences between source and disassembly mode debugging, the facilities for executing your application, and finally, how you can handle terminal input and output.
- *Variables and expressions* describes the syntax of the expressions and variables used in C-SPY, as well as the limitations on variable information. The chapter also demonstrates the various methods for monitoring variables and expressions.
- *Breakpoints* describes the breakpoint system and the various ways to set breakpoints.
- *Memory and registers* shows how you can examine memory and registers.

PART 2. ANALYZING YOUR APPLICATION

- *Trace* describes how you can inspect the program flow up to a specific state using trace data.
- *The application timeline* describes the **Timeline** window, and how to use the information in it to analyze your application's behavior.
- *Profiling* describes how the profiler can help you find the functions in your application source code where the most time is spent during execution.
- *Code coverage* describes how the code coverage functionality can help you verify whether all parts of your code have been executed, thus identifying parts which have not been executed.
- *Power debugging* describes techniques for power debugging and how you can use C-SPY to find source code constructions that result in unexpected power consumption.

PART 3. ADVANCED DEBUGGING

- *Interrupts* contains detailed information about the C-SPY interrupt simulation system and how to configure the simulated interrupts to make them reflect the interrupts of your target hardware.
- *C-SPY macros* describes the C-SPY macro system, its features, the purposes of these features, and how to use them.
- *The C-SPY command line utility—cspybat* describes how to use C-SPY in batch mode.

PART 4. ADDITIONAL REFERENCE INFORMATION

- *Debugger options* describes the options you must set before you start the C-SPY debugger.
- *Additional information on C-SPY drivers* describes menus and features provided by the C-SPY drivers not described in any dedicated topics.

- *OCD emulators reserved resources* contains important information about using some of the hardware debuggers with the RL78 microcontroller.

Other documentation

User documentation is available as hypertext PDFs and as a context-sensitive online help system in HTML format. You can access the documentation from the Information Center or from the **Help** menu in the IAR Embedded Workbench IDE. The online help system is also available via the F1 key.

USER AND REFERENCE GUIDES

The complete set of IAR Systems development tools is described in a series of guides. Information about:

- System requirements and information about how to install and register the IAR Systems products are available in the *Installation and Licensing Quick Reference Guide* and the *Licensing Guide*.
- Using the IDE for project management and building, is available in the *IDE Project Management and Building Guide for RL78.*
- Using the IAR C-SPY® Debugger, is available in the *C-SPY® Debugging Guide for RL78.*
- Programming for the IAR C/C++ Compiler for RL78 and linking using the IAR ILINK Linker, is available in the *IAR C/C++ Development Guide for RL78.*
- Programming for the IAR Assembler for RL78, is available in the *IAR Assembler Reference Guide for RL78.*
- Performing a static analysis using C-STAT and the required checks, is available in the *C-STAT® Static Analysis Guide*.
- Developing safety-critical applications using the MISRA C guidelines, is available in the *IAR Embedded Workbench® MISRA C:2004 Reference Guide* or the *IAR Embedded Workbench® MISRA C:1998 Reference Guide*.
- Migrating from an older UBROF-based product version to a newer version that uses the ELF/DWARF object format, is available in the guide *IAR Embedded Workbench® Migrating from UBROF to ELF/DWARF*.

Note: Additional documentation might be available depending on your product installation.

THE ONLINE HELP SYSTEM

The context-sensitive online help contains information about:

- IDE project management and building

- Debugging using the IAR C-SPY® Debugger
- The IAR C/C++ Compiler
- The IAR Assembler
- Keyword reference information for the DLIB library functions. To obtain reference information for a function, select the function name in the editor window and press F1.
- C-STAT
- MISRA C

WEB SITES

Recommended web sites:

- The Renesas web site, **www.renesas.com**, that contains information and news about the RL78 microcontrollers.
- The IAR Systems web site, **www.iar.com**, that holds application notes and other product information.
- The web site of the C standardization working group, **www.open-std.org/jtc1/sc22/wg14**.
- The web site of the C++ Standards Committee, **www.open-std.org/jtc1/sc22/wg21**.
- The C++ programming language web site, **isocpp.org**. This web site also has a list of recommended books about C++ programming.
- The C and C++ reference web site, **en.cppreference.com**.

Document conventions

When, in the IAR Systems documentation, we refer to the programming language C, the text also applies to C++, unless otherwise stated.

When referring to a directory in your product installation, for example `rl78\doc`, the full path to the location is assumed, for example `c:\Program Files\IAR Systems\Embedded Workbench` *`N.n`*`\rl78\doc`, where the initial digit of the version number reflects the initial digit of the version number of the IAR Embedded Workbench shared components.

TYPOGRAPHIC CONVENTIONS

The IAR Systems documentation set uses the following typographic conventions:

Style	Used for
`computer`	• Source code examples and file paths. • Text on the command line. • Binary, hexadecimal, and octal numbers.
`parameter`	A placeholder for an actual value used as a parameter, for example *`filename`*`.h` where *`filename`* represents the name of the file.
[`option`**]**	An optional part of a linker or stack usage control directive, where **[** and **]** are not part of the actual directive, but any `[`, `]`, `{`, or `}` are part of the directive syntax.
{`option`**}**	A mandatory part of a linker or stack usage control directive, where **{** and **}** are not part of the actual directive, but any `[`, `]`, `{`, or `}` are part of the directive syntax.
`[option]`	An optional part of a command line option, pragma directive, or library filename.
`[a|b|c]`	An optional part of a command line option, pragma directive, or library filename with alternatives.
`{a|b|c}`	A mandatory part of a command line option, pragma directive, or library filename with alternatives.
bold	Names of menus, menu commands, buttons, and dialog boxes that appear on the screen.
italic	• A cross-reference within this guide or to another guide. • Emphasis.
`...`	An ellipsis indicates that the previous item can be repeated an arbitrary number of times.
▥	Identifies instructions specific to the IAR Embedded Workbench® IDE interface.
▣	Identifies instructions specific to the command line interface.
💡	Identifies helpful tips and programming hints.
⚠	Identifies warnings.

Table 1: Typographic conventions used in this guide

NAMING CONVENTIONS

The following naming conventions are used for the products and tools from IAR Systems®, when referred to in the documentation:

Brand name	Generic term
IAR Embedded Workbench® for RL78	IAR Embedded Workbench®
IAR Embedded Workbench® IDE for RL78	the IDE
IAR C-SPY® Debugger for RL78	C-SPY, the debugger
IAR C-SPY® Simulator	the simulator
IAR C/C++ Compiler™ for RL78	the compiler
IAR Assembler™ for RL78	the assembler
IAR ILINK Linker™	ILINK, the linker
IAR DLIB Runtime Environment™	the DLIB runtime environment

Table 2: Naming conventions used in this guide

Part 1. Basic debugging

This part of the *C-SPY® Debugging Guide for RL78* includes these chapters:

- The IAR C-SPY Debugger
- Getting started using C-SPY
- Executing your application
- Variables and expressions
- Breakpoints
- Memory and registers

The IAR C-SPY Debugger

- Introduction to C-SPY
- Debugger concepts
- C-SPY drivers overview
- The IAR C-SPY Simulator
- The C-SPY hardware debugger drivers

Introduction to C-SPY

These topics are covered:

- An integrated environment
- General C-SPY debugger features
- RTOS awareness

AN INTEGRATED ENVIRONMENT

C-SPY is a high-level-language debugger for embedded applications. It is designed for use with the IAR Systems compilers and assemblers, and is completely integrated in the IDE, providing development and debugging within the same application. This will give you possibilities such as:

- *Editing while debugging*

  During a debug session, you can make corrections directly in the same source code window that is used for controlling the debugging. Changes will be included in the next project rebuild.
- *Setting breakpoints at any point during the development cycle*

  You can inspect and modify breakpoint definitions also when the debugger is not running, and breakpoint definitions flow with the text as you edit. Your debug settings, such as watch properties, window layouts, and register groups will be preserved between your debug sessions.

All windows that are open in the IAR Embedded Workbench workspace will stay open when you start the C-SPY Debugger. In addition, a set of C-SPY-specific windows are opened.

GENERAL C-SPY DEBUGGER FEATURES

Because IAR Systems provides an entire toolchain, the output from the compiler and linker can include extensive debug information for the debugger, resulting in good debugging possibilities for you.

C-SPY offers these general features:

- *Source and disassembly level debugging*

  C-SPY allows you to switch between source and disassembly debugging as required, for both C or C++ and assembler source code.

- *Single-stepping on a function call level*

  Compared to traditional debuggers, where the finest granularity for source level stepping is line by line, C-SPY provides a finer level of control by identifying every statement and function call as a step point. This means that each function call—inside expressions, and function calls that are part of parameter lists to other functions—can be single-stepped. The latter is especially useful when debugging C++ code, where numerous extra function calls are made, for example to object constructors.

- *Code and data breakpoints*

  The C-SPY breakpoint system lets you set breakpoints of various kinds in the application being debugged, allowing you to stop at locations of particular interest. For example, you set breakpoints to investigate whether your program logic is correct or to investigate how and when the data changes.

- *Monitoring variables and expressions*

  For variables and expressions there is a wide choice of facilities. You can easily monitor values of a specified set of variables and expressions, continuously or on demand. You can also choose to monitor only local variables, static variables, etc.

- *Container awareness*

  When you run your application in C-SPY, you can view the elements of library data types such as STL lists and vectors. This gives you a very good overview and debugging opportunities when you work with C++ STL containers.

- *Call stack information*

  The compiler generates extensive call stack information. This allows the debugger to show, without any runtime penalty, the complete stack of function calls wherever the program counter is. You can select any function in the call stack, and for each function you get valid information for local variables and available registers.

- *Powerful macro system*

  C-SPY includes a powerful internal macro system, to allow you to define complex sets of actions to be performed. C-SPY macros can be used on their own or in conjunction with complex breakpoints and—if you are using the simulator—the interrupt simulation system to perform a wide variety of tasks.

Additional general C-SPY debugger features

This list shows some additional features:

- Threaded execution keeps the IDE responsive while running the target application
- Automatic stepping
- The source browser provides easy navigation to functions, types, and variables
- Extensive type recognition of variables
- Configurable registers (CPU and peripherals) and memory windows
- Graphical stack view with overflow detection
- Support for code coverage and function level profiling
- The target application can access files on the host PC using file I/O
- Optional terminal I/O emulation.

RTOS AWARENESS

C-SPY supports RTOS-aware debugging.

These operating systems are currently supported:

- FreeRTOS, OpenRTOS, and SafeRTOS
- Micrium uC/OS
- OSEK Run Time Interface (ORTI)
- Segger embOS

RTOS plugin modules can be provided by IAR Systems, and by third-party suppliers. Contact your software distributor or IAR Systems representative, alternatively visit the IAR Systems web site, for information about supported RTOS modules.

A C-SPY RTOS awareness plugin module gives you a high level of control and visibility over an application built on top of an RTOS. It displays RTOS-specific items like task lists, queues, semaphores, mailboxes, and various RTOS system variables. Task-specific breakpoints and task-specific stepping make it easier to debug tasks.

A loaded plugin will add its own menu, set of windows, and buttons when a debug session is started (provided that the RTOS is linked with the application). For information about other RTOS awareness plugin modules, refer to the manufacturer of the plugin module.

Debugger concepts

This section introduces some of the concepts and terms that are related to debugging in general and to C-SPY in particular. This section does not contain specific information related to C-SPY features. Instead, you will find such information in the other chapters of this documentation. The IAR Systems user documentation uses the terms described in this section when referring to these concepts.

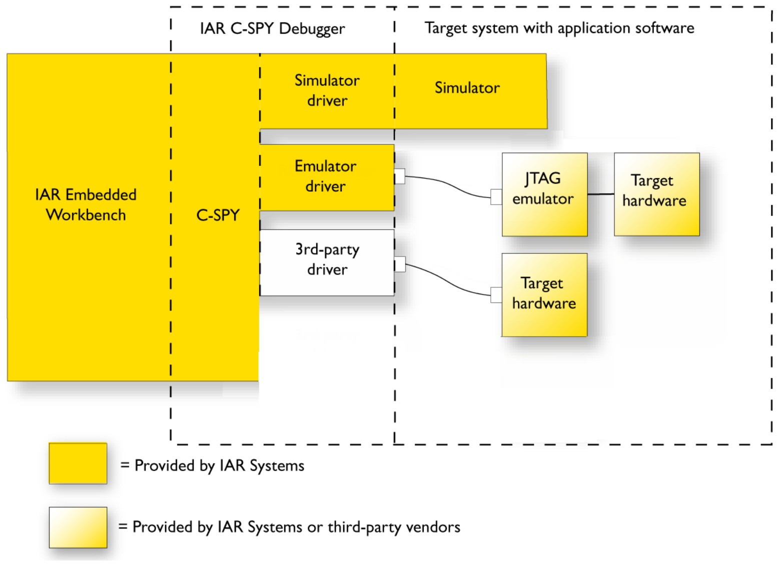
These topics are covered:

- C-SPY and target systems
- The debugger
- The target system
- The application
- C-SPY debugger systems
- The ROM-monitor program
- Third-party debuggers
- C-SPY plugin modules

C-SPY AND TARGET SYSTEMS

You can use C-SPY to debug either a software target system or a hardware target system.

This figure gives an overview of C-SPY and possible target systems:



THE DEBUGGER

The debugger, for instance C-SPY, is the program that you use for debugging your applications on a target system.

THE TARGET SYSTEM

The target system is the system on which you execute your application when you are debugging it. The target system can consist of hardware, either an evaluation board or your own hardware design. It can also be completely or partially simulated by software. Each type of target system needs a dedicated C-SPY driver.

THE APPLICATION

A user application is the software you have developed and which you want to debug using C-SPY.

C-SPY DEBUGGER SYSTEMS

C-SPY consists of both a general part which provides a basic set of debugger features, and a target-specific back end. The back end consists of two components: a processor module—one for every microcontroller, which defines the properties of the microcontroller, and a *C-SPY driver*. The C-SPY driver is the part that provides communication with and control of the target system. The driver also provides the user interface—menus, windows, and dialog boxes—to the functions provided by the target system, for instance, special breakpoints.

Typically, there are three main types of C-SPY drivers:

- Simulator driver
- ROM-monitor driver
- Emulator driver.

C-SPY is available with a simulator driver, and depending on your product package, optional drivers for hardware debugger systems. For an overview of the available C-SPY drivers and the functionality provided by each driver, see *C-SPY drivers overview*, page 35.

THE ROM-MONITOR PROGRAM

The ROM-monitor program is a piece of firmware that is loaded to non-volatile memory on your target hardware; it runs in parallel with your application. The ROM-monitor communicates with the debugger and provides services needed for debugging the application, for instance stepping and breakpoints.

THIRD-PARTY DEBUGGERS

You can use a third-party debugger together with the IAR Systems toolchain as long as the third-party debugger can read ELF/DWARF, Intel-extended, or Motorola. For information about which format to use with a third-party debugger, see the user documentation supplied with that tool.

C-SPY PLUGIN MODULES

C-SPY is designed as a modular architecture with an open SDK that can be used for implementing additional functionality to the debugger in the form of plugin modules. These modules can be seamlessly integrated in the IDE.

Plugin modules are provided by IAR Systems, or can be supplied by third-party vendors. Examples of such modules are:

- The various C-SPY drivers for debugging using certain debug systems.
- RTOS plugin modules for support for real-time OS aware debugging.
- C-SPYLink that bridges IAR Visual State and IAR Embedded Workbench to make true high-level state machine debugging possible directly in C-SPY, in addition to the normal C level symbolic debugging. For more information, see the documentation provided with IAR Visual State.

For more information about the C-SPY SDK, contact IAR Systems.

C-SPY drivers overview

These topics are covered:

- Differences between the C-SPY drivers

At the time of writing this guide, the IAR C-SPY Debugger for the RL78 microcontrollers is available with drivers for these target systems and evaluation boards:

- Simulator
- E1
- E2
- E2 Lite (including E2 On-Board)
- E20
- EZ-CUBE
- EZ-CUBE2
- IECUBE
- TK.

Note: The E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, and TK emulators use the same C-SPY driver, the OCD driver.

DIFFERENCES BETWEEN THE C-SPY DRIVERS

This table summarizes the key differences between the C-SPY drivers:

Feature	Simulator	IECUBE	E1, E2, E2 Lite, E2 On-Board, EZ-CUBE2	E20, EZ-CUBE, TK
Code breakpoints[1]	Unlimited	Yes	Yes[2]	Yes[2]
Data breakpoints	Yes	Yes	Yes[2]	Yes[2]
Event breakpoints	—	Yes	Yes[2]	Yes[2]
Execution in real time	—	Yes	Yes	Yes
Zero memory footprint	Yes	Yes	—	—
Simulated interrupts	Yes	—	—	—
Real interrupts	—	Yes	Yes	Yes
Interrupt logging	Yes	—	—	—
Data logging	Yes	—	—	—
Smart Analog data collection	—	—	Yes	Only E20
Live watch	Yes	Yes	Yes	Yes

Table 3: Driver differences

Feature	Simulator	IECUBE	E1, E2, E2 Lite, E2 On-Board, EZ-CUBE2	E20, EZ-CUBE, TK
Cycle counter	Yes	—	—	—
Execution timer	—	Yes	Yes[2]	Yes[2]
Code coverage	Yes	Yes	—	—
Data coverage	Yes	Yes	—	—
Function/instruction profiling	Yes	—	—	—
Trace[1]	Yes	Yes	Yes	—
Timer	—	Yes	—	—
Flash self programming emulation	—	Yes	—	—
Pseudo emulation	—	Yes	—	—
Direct Memory Modification	—	Yes	—	—
Power debugging [1]	—	—	Limited (E2 only)	—
Data flash emulation	—	Yes	—	—

Table 3: Driver differences (Continued)

1. With specific requirements or restrictions, see the respective chapter in this guide.

2. Breakpoints are ignored in some circumstances, see *Breakpoints when single stepping using the OCD driver*, page 65. See also *Breakpoints in the C-SPY hardware debugger drivers*, page 129.

The IAR C-SPY Simulator

The C-SPY Simulator simulates the functions of the target processor entirely in software, which means that you can debug the program logic long before any hardware is available. Because no hardware is required, it is also the most cost-effective solution for many applications.

The C-SPY Simulator supports:

- Instruction-level simulation
- Memory configuration and validation
- Interrupt simulation
- Peripheral simulation (using the C-SPY macro system in conjunction with immediate breakpoints).

Simulating hardware instead of using a hardware debugging system means that some limitations do not apply, but that there are other limitations instead. For example:

- You can set an unlimited number of breakpoints in the simulator.

- When you stop executing your application, time actually stops in the simulator. When you stop application execution on a hardware debugging system, there might still be activities in the system. For example, peripheral units might still be active and reading from or writing to SFR ports.
- Application execution is significantly much slower in a simulator compared to when using a hardware debugging system. However, during a debug session, this might not necessarily be a problem.
- The simulator is not cycle accurate.
- Peripheral simulation is limited in the C-SPY Simulator and therefore the simulator is suitable mostly for debugging code that does not interact too much with peripheral units.

The C-SPY hardware debugger drivers

C-SPY can connect to a hardware debugger using a C-SPY hardware debugger driver as an interface. The C-SPY hardware debugger drivers are automatically installed during the installation of IAR Embedded Workbench.

IAR Embedded Workbench for RL78 comes with several C-SPY hardware debugger drivers and you use the driver that matches the hardware debugger you are using.

FEATURES

In addition to the features described in *Differences between the C-SPY drivers*, page 35, the emulator drivers also provide:

Feature	IECUBE	E1, E2, E2 Lite/On-board, E20, EZ-CUBE, EZ-CUBE2, TK
Security	No	10-byte ID code authentication
Application download	Yes	Yes
Hardware breakpoints	Device-specific	Device-specific
Software breakpoints	Unlimited	Unlimited
RAM monitoring	Yes	Pseudo real-time monitoring
Pin masking	For internal and external reset pins	For internal and external reset pins

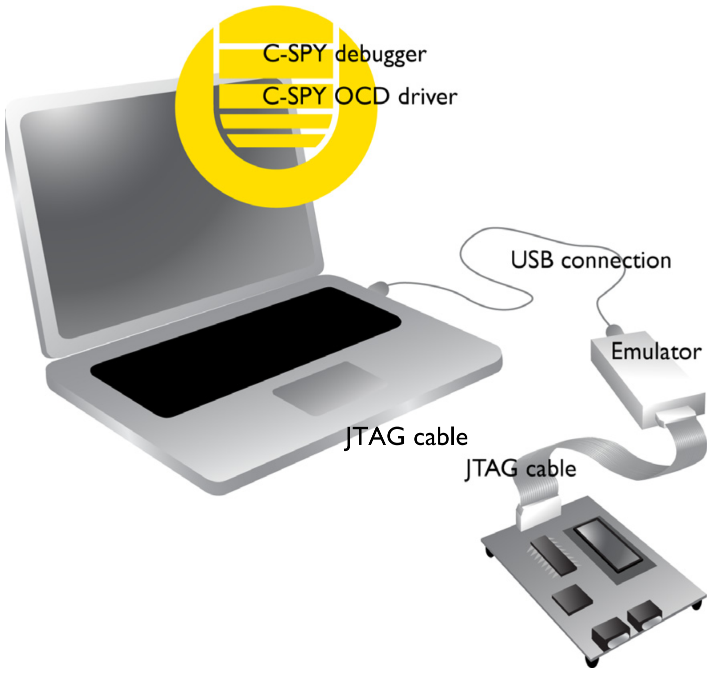
Table 4: Emulator debug features

Feature	IECUBE	E1, E2, E2 Lite/On-board, E20, EZ-CUBE, EZ-CUBE2, TK
Time measurement (from execution start to break)	Resolution: 16.667 ns, Max. time: ~10 min	Resolution: 100 µs, Max. time: ~100 hours
Built-in flash loader	Yes	No (monitor)

Table 4: Emulator debug features (Continued)

THE E1, E2, E2 LITE/ON-BOARD, E20, EZ-CUBE, EZ-CUBE2, AND TK EMULATORS

The C-SPY hardware debugger driver uses USB to communicate with the hardware debugger. The hardware debugger communicates with the JTAG interface on the microcontroller.



For further information, refer to the documentation supplied with the hardware debugger.

When a debugging session is started, your application is automatically downloaded and programmed into flash memory. You can disable this feature, if necessary.

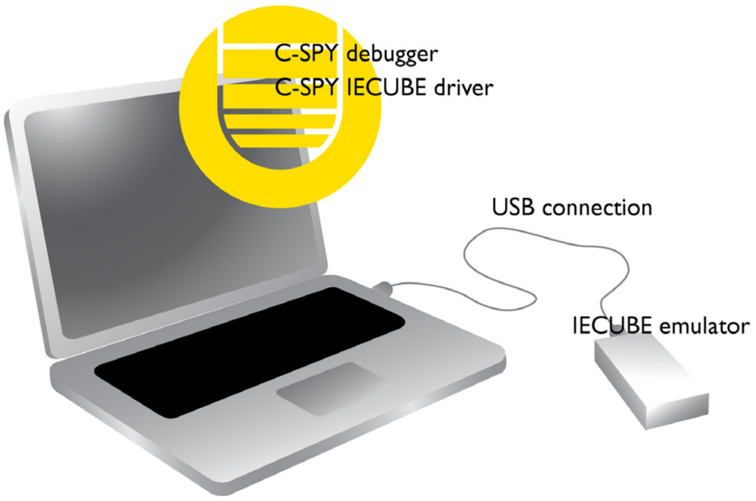
Hardware installation

For information about the hardware installation, see the documentation supplied with the hardware debugger from Renesas. A Renesas USB driver that is needed for communicating with the emulator is optionally installed during the IAR Embedded Workbench installation.The following power-up sequence is recommended to ensure proper communication between the target board, hardware debugger, and C-SPY:

1. Connect the emulator to the host computer.
2. Start the C-SPY debugging session.

THE IECUBE EMULATOR

The C-SPY hardware debugger driver uses USB to communicate with the hardware debugger.



For further information, refer to the documentation supplied with the hardware debugger.

When a debugging session is started, your application is automatically downloaded and programmed into flash memory. You can disable this feature, if necessary.

Hardware installation

For information about the hardware installation, see the documentation supplied with the hardware debugger from Renesas. A Renesas USB driver that is needed for communicating with the emulator is optionally installed during the IAR Embedded

Workbench installation.The following power-up sequence is recommended to ensure proper communication between the target board, hardware debugger, and C-SPY:

1. Power up the IECUBE emulator.
2. Start the C-SPY debugging session.

Getting started using C-SPY

- Setting up C-SPY
- Starting C-SPY
- Adapting for target hardware
- Reference information on starting C-SPY

Setting up C-SPY

These tasks are covered:

- Setting up for debugging
- Executing from reset
- Using a setup macro file
- Selecting a device description file
- Loading plugin modules

SETTING UP FOR DEBUGGING

1. Before you start C-SPY, choose **Project>Options>Debugger>Setup** and select the C-SPY driver that matches your debugger system: simulator or a hardware debugger system.
2. In the **Category** list, select the appropriate C-SPY driver and make your settings. For information about these options, see *Debugger options*, page 399.
3. Click **OK**.
4. Choose **Tools>Options** to open the **IDE Options** dialog box:
   - Select **Debugger** to configure the debugger behavior
   - Select **Stack** to configure the debugger's tracking of stack usage.

For more information about these options, see the *IDE Project Management and Building Guide for RL78*.

See also *Adapting for target hardware*, page 47.

EXECUTING FROM RESET

The **Run to** option—available on the **Debugger>Setup** page—specifies a location you want C-SPY to run to when you start a debug session as well as after each reset. C-SPY will place a temporary breakpoint at this location and all code up to this point is executed before stopping at the location. Note that this temporary breakpoint is removed when the debugger stops, regardless of how. If you stop the execution before the **Run to** location has been reached, the execution will not stop at that location when you start the execution again.

The default location to run to is the `main` function. Type the name of the location if you want C-SPY to run to a different location. You can specify assembler labels or whatever can be evaluated to such, for instance function names.

If you leave the check box empty, the program counter will contain the regular hardware reset address at each reset. The reset address is set by C-SPY.

USING A SETUP MACRO FILE

A setup macro file is a macro file that you choose to load automatically when C-SPY starts. You can define the setup macro file to perform actions according to your needs, using setup macro functions and system macros. Thus, if you load a setup macro file you can initialize C-SPY to perform actions automatically.

For more information about setup macro files and functions, see *Introduction to C-SPY macros*, page 321.

For an example of how to use a setup macro file, see *Initializing target hardware before C-SPY starts*, page 47.

To register a setup macro file:

1 Before you start C-SPY, choose **Project>Options>Debugger>Setup**.

2 Select **Use macro file** and type the path and name of your setup macro file, for example `Setup.mac`. If you do not type a filename extension, the extension `mac` is assumed.

SELECTING A DEVICE DESCRIPTION FILE

C-SPY uses device description files to handle device-specific information.

A default device description file is automatically used based on your project settings. If you want to override the default file, you must select your device description file. Device description files from IAR Systems are provided in the `rl78\config` directory and they have the filename extension `ddf`.

For more information about device description files, see *Adapting for target hardware*, page 47.

To override the default device description file:

1 Before you start C-SPY, choose **Project>Options>Debugger>Setup**.

2 Enable the use of a device description file and select a file using the **Device description file** browse button.

Note: You can easily view your device description files that are used for your project. Choose **Project>Open Device Description File** and select the file you want to view.

LOADING PLUGIN MODULES

On the **Plugins** page you can specify C-SPY plugin modules to load and make available during debug sessions. Plugin modules can be provided by IAR Systems, and by third-party suppliers. Contact your software distributor or IAR Systems representative, or visit the IAR Systems web site, for information about available modules.

For more information, see *Plugins*, page 403.

Starting C-SPY

When you have set up the debugger, you are ready to start a debug session.

These tasks are covered:

- Starting a debug session
- Loading executable files built outside of the IDE
- Starting a debug session with source files missing
- Loading multiple debug images
- Editing in C-SPY windows
- Hardware configuration when starting for the first time

STARTING A DEBUG SESSION

You can choose to start a debug session with or without loading the current executable file.

To start C-SPY and download the current executable file, click the **Download and Debug** button. Alternatively, choose **Project>Download and Debug**.

To start C-SPY without downloading the current executable file, click the **Debug without Downloading** button. Alternatively, choose **Project>Debug without Downloading**.

LOADING EXECUTABLE FILES BUILT OUTSIDE OF THE IDE

You can also load C-SPY with an application that was built outside the IDE, for example applications built on the command line. To load an externally built executable file and to set build options you must first create a project for it in your workspace.

To create a project for an externally built file:

1 Choose **Project>Create New Project**, and specify a project name.

2 To add the executable file to the project, choose **Project>Add Files** and make sure to choose **All Files** in the **Files of type** drop-down list. Locate the executable file.

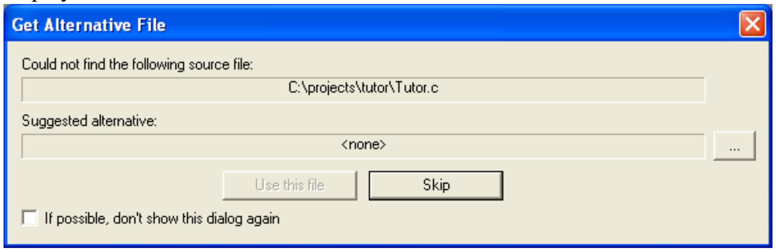
3 To start the executable file, click the **Download and Debug** button. The project can be reused whenever you rebuild your executable file.

The only project options that are meaningful to set for this kind of project are options in the **General Options** and **Debugger** categories. Make sure to set up the general project options in the same way as when the executable file was built.

STARTING A DEBUG SESSION WITH SOURCE FILES MISSING

Normally, when you use the IAR Embedded Workbench IDE to edit source files, build your project, and start the debug session, all required files are available and the process works as expected.

However, if C-SPY cannot automatically find the source files, for example if the application was built on another computer, the **Get Alternative File** dialog box is displayed:


Get Alternative File

Could not find the following source file:

C:\projects\tutor\Tutor.c

Suggested alternative:

<none>

Typically, you can use the dialog box like this:

- The source files are not available: Click **If possible, don't show this dialog again** and then click **Skip**. C-SPY will assume that there is no source file available. The dialog box will not appear again, and the debug session will not try to display the source code.
- Alternative source files are available at another location: Specify an alternative source code file, click **If possible, don't show this dialog again**, and then click **Use this file**. C-SPY will assume that the alternative file should be used. The dialog box

will not appear again, unless a file is needed for which there is no alternative file specified and which cannot be located automatically.

If you restart the IAR Embedded Workbench IDE, the **Get Alternative File** dialog box will be displayed again once even if you have clicked **If possible, don't show this dialog again**. This gives you an opportunity to modify your previous settings.

For more information, see *Get Alternative File dialog box*, page 54.

LOADING MULTIPLE DEBUG IMAGES

Normally, a debuggable application consists of a single file that you debug. However, you can also load additional debug files (debug images). This means that the complete program consists of several debug images.

Typically, this is useful if you want to debug your application in combination with a prebuilt ROM image that contains an additional library for some platform-provided features. The ROM image and the application are built using separate projects in the IAR Embedded Workbench IDE and generate separate output files.

If more than one debug image has been loaded, you will have access to the combined debug information for all the loaded debug images. In the **Images** window you can choose whether you want to have access to debug information for a single debug image or for all images.

To load additional debug images at C-SPY startup:

1. Choose **Project>Options>Debugger>Images** and specify up to three additional debug images to be loaded. For more information, see *Images*, page 401.
2. Start the debug session.

To load additional debug images at a specific moment:

Use the `__loadImage` system macro and execute it using either one of the methods described in *Using C-SPY macros*, page 323.

To display a list of loaded debug images:

Choose **Images** from the **View** menu. The **Images** window is displayed, see *Images window*, page 53.

EDITING IN C-SPY WINDOWS

You can edit the contents of the **Memory**, **Symbolic Memory**, **Registers**, **Register User Groups Setup**, **Auto**, **Watch**, **Locals**, **Statics**, **Live Watch**, and **Quick Watch** windows.

Use these keyboard keys to edit the contents of these windows:

Enter	Makes an item editable and saves the new value.
Esc	Cancels a new value.

In windows where you can edit the **Expression** field and in the **Quick Watch** window, you can specify the number of elements to be displayed in the field by adding a semicolon followed by an integer. For example, to display only the three first elements of an array named `myArray`, or three elements in sequence starting with the element pointed to by a pointer, write:

```
myArray;3
```

To display three elements pointed to by `myPtr`, `myPtr+1`, and `myPtr+2`, write:

```
myPtr;3
```

Optionally, add a comma and another integer that specifies which element to start with. For example, to display elements 10–14, write:

```
myArray;5,10
```

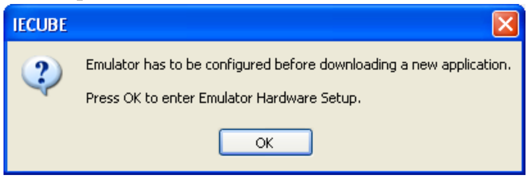
To display `myPtr+10`, `myPtr+11`, `myPtr+12`, `myPtr+13`, and `myPtr+14`, write:

```
myPtr;5,10
```

Note: For pointers, there are no built-in limits on displayed element count, and no validation of the pointer value.

HARDWARE CONFIGURATION WHEN STARTING FOR THE FIRST TIME

When a C-SPY emulator is started for the first time in a new project, the hardware must be set up.


IECUBE

Emulator has to be configured before downloading a new application.

Press OK to enter Emulator Hardware Setup.

Click **OK** to enter the **Hardware Setup** dialog box. See *Hardware Setup*, page 56.

When the hardware setup is done and you click **OK**, the download of the debug file is started.

If the debug file contains a memory area that is not defined in the hardware setup, several warnings will be displayed in the **Debug Log** window.

The hardware setup is saved for each project and does not have to be set more than once. If you want to change the setup for a project, choose **Hardware Setup** from the **Emulator** menu.

Adapting for target hardware

These tasks are covered:

- Modifying a device description file
- Initializing target hardware before C-SPY starts

MODIFYING A DEVICE DESCRIPTION FILE

C-SPY uses device description files provided with the product to handle several of the target-specific adaptations, see *Selecting a device description file*, page 42. Device description files contain device-specific information such as:

- Memory information for device-specific memory zones, see *C-SPY memory zones*, page 154.
- Definitions of memory-mapped peripheral units, device-specific CPU registers, and groups of these.
- Definitions for device-specific interrupts, which makes it possible to simulate these interrupts in the C-SPY simulator, see *Interrupts*, page 297.
- Definitions of Renesas device files.
- Definitions of emulator memory information and number of flash blocks.

Normally, you do not need to modify the device description file. However, if the predefinitions are not sufficient for some reason, you can edit the file. Note, however, that the format of these descriptions might be updated in future upgrades of the product.

Make a copy of the device description file that best suits your needs, and modify it according to the description in the file. Reload the project to make the changes take effect.

For information about how to load a device description file, see *Selecting a device description file*, page 42.

INITIALIZING TARGET HARDWARE BEFORE C-SPY STARTS

You can use C-SPY macros to initialize target hardware before C-SPY starts. For example, if your hardware uses external memory that must be enabled before code can be downloaded to it, C-SPY needs a macro to perform this action before your application can be downloaded.

1 Create a new text file and define your macro function.

By using the built-in `execUserPreload` setup macro function, your macro function will be executed directly after the communication with the target system is established but before C-SPY downloads your application.

For example, a macro that enables external SDRAM could look like this:

```
/* Your macro function. */
enableExternalSDRAM()
{
  __message "Enabling external SDRAM\n";
  __writeMemory32(...);
}

/* Setup macro determines time of execution. */
execUserPreload()
{
  enableExternalSDRAM();
}
```

2 Save the file with the filename extension `mac`.

3 Before you start C-SPY, choose **Project>Options>Debugger** and click the **Setup** tab.

4 Select the option **Use Setup file** and choose the macro file you just created.

Your setup macro will now be loaded during the C-SPY startup sequence.

Reference information on starting C-SPY

Reference information about:

- *C-SPY Debugger main window*, page 49
- *Images window*, page 53
- *Get Alternative File dialog box*, page 54
- *Operating Frequency dialog box*, page 55
- *Hardware Setup*, page 56

See also:

- Tools options for the debugger in the *IDE Project Management and Building Guide for RL78*.

C-SPY Debugger main window

When you start a debug session, these debugger-specific items appear in the main IAR Embedded Workbench IDE window:

- A dedicated **Debug** menu with commands for executing and debugging your application
- Depending on the C-SPY driver you are using, a driver-specific menu, often referred to as the *Driver menu* in this documentation. Typically, this menu contains menu commands for opening driver-specific windows and dialog boxes.
- A special debug toolbar
- A special hardware debugger toolbar
- Several windows and dialog boxes specific to C-SPY.

The C-SPY main window might look different depending on which components of the product installation you are using.

Menu bar

These menus are available during a debug session:

Debug

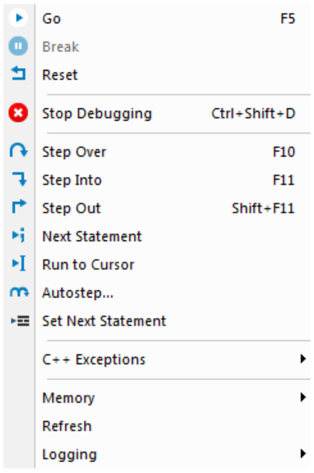
Provides commands for executing and debugging the source application. Most of the commands are also available as icon buttons on the debug toolbar.

C-SPY driver menu

Provides commands specific to a C-SPY driver. The driver-specific menu is only available when the driver is used. For information about the driver-specific menu commands, see *Reference information on C-SPY driver menus*, page 407.

Debug menu

The **Debug** menu is available during a debug session. The **Debug** menu provides commands for executing and debugging the source application. Most commands are also available as icon buttons on the debug toolbar.



These commands are available:

Go (F5)

Executes from the current statement or instruction until a breakpoint or program exit is reached.

Break

Stops the application execution.

Reset

Resets the target processor. Click the drop-down button to access a menu with additional commands.

Enable Run to '`label`', where `label` typically is `main`. Enables and disables the project option **Run to** without exiting the debug session. This menu command is only available if you have selected **Run to** in the **Options** dialog box.

Reset strategies, which contains a list of reset strategies supported by the C-SPY driver you are using. This means that you can choose a different reset strategy than the one used initially without exiting the debug session. Reset strategies are only available if the C-SPY driver you are using supports alternate reset strategies.

Stop Debugging (Ctrl+Shift+D)

Stops the debugging session and returns you to the project manager.

Step Over (F10)

Executes the next statement, function call, or instruction, without entering C or C++ functions or assembler subroutines.

Step Into (F11)

Executes the next statement or instruction, or function call, entering C or C++ functions or assembler subroutines.

Step Out (Shift+F11)

Executes from the current statement up to the statement after the call to the current function.

Next Statement

Executes directly to the next statement without stopping at individual function calls.

Run to Cursor

Executes from the current statement or instruction up to a selected statement or instruction.

Autostep

Displays a dialog box where you can customize and perform autostepping, see *Autostep settings dialog box*, page 87.

Set Next Statement

Moves the program counter directly to where the cursor is, without executing any source code. Note, however, that this creates an anomaly in the program flow and might have unexpected effects.

C++ Exceptions>Break on Throw

Specifies that the execution shall break when the target application executes a `throw` statement.

To use this feature, your application must be built with the option **Library low-level interface implementation** selected and the language option **C++ With exceptions**.

This menu command is not supported by your product package.

C++ Exceptions>Break on Uncaught Exception

Specifies that the execution shall break when the target application throws an exception that is not caught by any matching `catch` statement.

To use this feature, your application must be built with the option **Library low-level interface implementation** selected and the language option **C++ With exceptions**.

This menu command is not supported by your product package.

Memory>Save

Displays a dialog box where you can save the contents of a specified memory area to a file, see *Memory Save dialog box*, page 168.

Memory>Restore

Displays a dialog box where you can load the contents of a file in, for example Intel-extended or Motorola s-record format to a specified memory zone, see *Memory Restore dialog box*, page 169.

Refresh

Refreshes the contents of all debugger windows. Because window updates are automatic, this is needed only in unusual situations, such as when target memory is modified in ways C-SPY cannot detect. It is also useful if code that is displayed in the **Disassembly** window is changed.

Logging>Set Log file

Displays a dialog box where you can choose to log the contents of the **Debug Log** window to a file. You can select the type and the location of the log file. You can choose what you want to log: errors, warnings, system information, user messages, or all of these. See *Log File dialog box*, page 82.

Logging>Set Terminal I/O Log file

Displays a dialog box where you can choose to log simulated target access communication to a file. You can select the destination of the log file. See *Terminal I/O Log File dialog box*, page 80

C-SPY windows

Depending on the C-SPY driver you are using, these windows specific to C-SPY are available during a debug session:

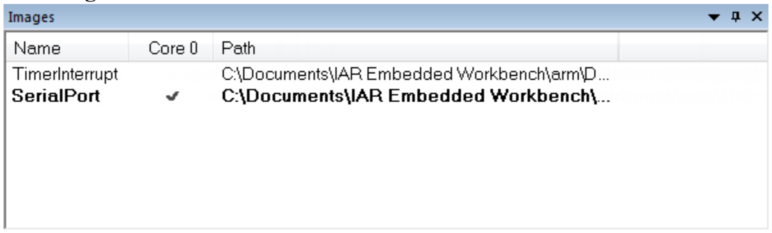
- C-SPY Debugger main window
- Disassembly window
- Memory window
- Symbolic Memory window
- Registers window
- Watch window
- Locals window

- Auto window
- Live Watch window
- Quick Watch window
- Statics window
- Call Stack window
- Trace window
- Function Trace window
- Timeline window, see *Reference information on application timeline*, page 229
- Terminal I/O window
- Code Coverage window
- Function Profiler window
- Images window
- Stack window
- Symbols window.

Additional windows are available depending on which C-SPY driver you are using.

Images window

The **Images** window is available from the **View** menu.



Name	Core 0	Path
TimerInterrupt		C:\Documents\IAR Embedded Workbench\arm\D...
SerialPort	✓	**C:\Documents\IAR Embedded Workbench\...**

This window lists all currently loaded debug images (debug files).

Normally, a source application consists of a single debug image that you debug. However, you can also load additional images. This means that the complete debuggable unit consists of several debug images. See also *Loading multiple debug images*, page 45.

Requirements

None; this window is always available.

Display area

C-SPY can use debug information from one or more of the loaded debug images simultaneously. Double-click on a row to make C-SPY use debug information from that debug image. The current choices are highlighted.

This area lists the loaded debug images in these columns:

Name

The name of the loaded debug image.

Core *N*

Double-click in this column to toggle using debug information from the debug image when that core is in focus.

Path

The path to the loaded debug image.

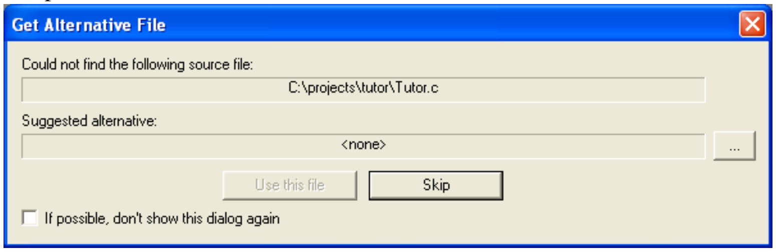
Related information

For related information, see:

- *Loading multiple debug images*, page 45
- *Images*, page 401
- *__loadImage*, page 347

Get Alternative File dialog box

The **Get Alternative File** dialog box is displayed if C-SPY cannot automatically find the source files to be loaded, for example if the application was built on another computer.


Get Alternative File
Could not find the following source file:
C:\projects\tutor\Tutor.c
Suggested alternative:
<none>
...
Use this file
Skip
If possible, don't show this dialog again

See also *Starting a debug session with source files missing*, page 44.

Could not find the following source file

The missing source file.

Suggested alternative

Specify an alternative file.

Use this file

After you have specified an alternative file, **Use this file** establishes that file as the alias for the requested file. Note that after you have chosen this action, C-SPY will automatically locate other source files if these files reside in a directory structure similar to the first selected alternative file.

The next time you start a debug session, the selected alternative file will be preloaded automatically.

Skip

C-SPY will assume that the source file is not available for this debug session.

If possible, don't show this dialog again

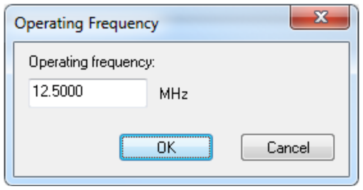
Instead of displaying the dialog box again for a missing source file, C-SPY will use the previously supplied response.

Related information

For related information, see *Starting a debug session with source files missing*, page 44.

Operating Frequency dialog box

The **Operating Frequency** dialog box is available from the *C-SPY driver* menu during a debug session.



Operating frequency: 12.5000 MHz

Use this dialog box to inform the emulator of the operating frequency that the MCU is running at. This information is used by the **Timeline** window and by the interrupt and power logging.

Requirements

A C-SPY hardware debugger driver.

Operating frequency

Specifies the operating frequency that the MCU is running at. This value is used by the interrupt and power logging to convert cycles to time and by the **Timeline** window to estimate the number of elapsed cycles.

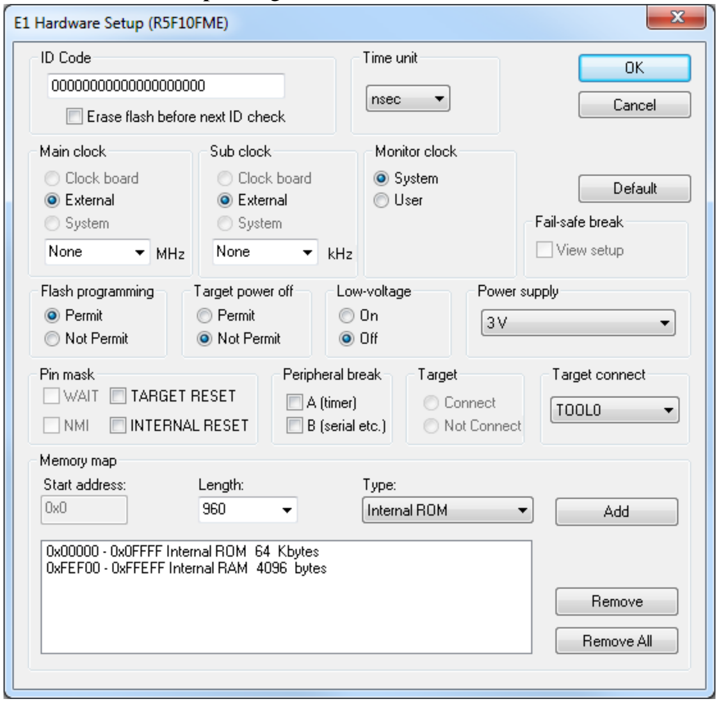
Related information

For related information, see:

- *Requirements for interrupt logging*, page 301
- *Power debugging using C-SPY*, page 278
- *The application timeline*, page 221.

Hardware Setup

The **Hardware Setup** dialog box is available from the **Emulator** menu.



E1 Hardware Setup (R5F10FME)

ID Code: 00000000000000000000
[ ] Erase flash before next ID check
Time unit: nsec

Main clock: ( ) Clock board [● External] ( ) System — None MHz
Sub clock: ( ) Clock board [● External] ( ) System — None kHz
Monitor clock: [● System] ( ) User
Fail-safe break: [ ] View setup

Flash programming: [● Permit] ( ) Not Permit
Target power off: ( ) Permit [● Not Permit]
Low-voltage: ( ) On [● Off]
Power supply: 3 V

Pin mask: [ ] WAIT [ ] TARGET RESET [ ] NMI [ ] INTERNAL RESET
Peripheral break: [ ] A (timer) [ ] B (serial etc.)
Target: ( ) Connect ( ) Not Connect
Target connect: TOOL0

Memory map
Start address: 0x0 Length: 960 Type: Internal ROM

```
0x00000 - 0x0FFFF Internal ROM  64  Kbytes
0xFEF00 - 0xFFEFF Internal RAM  4096  bytes
```

Use this dialog box to configure the emulator. All options are not available for all emulators.

ID Code

Use this option for devices that are read-protected with an ID Code. Type a hexadecimal number of 20 digits (10 bytes) as the ID Code. By default, all digits are `F`.

For examples about how to define the ID Code, see *Security ID and option bytes*, page 426.

IECUBE: This option is not used.

Erase flash before next ID check

Clears the flash memory before downloading your application.

IECUBE: This option is not used.

Time unit

Selects the time unit to be used in the **Trace View** window, the **Function Profiler** window, and by the `TIME` registers in the **Registers** window.

Main clock

Selects the main clock source input to the CPU. If a main clock board with an oscillator or resonator is connected, the setting is automatically set to **Clock board** and cannot be changed. If no clock board is connected, the setting is **System**.

E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, TK: The main clock is always set to **External**.

Sub clock

Selects the sub clock source input to the CPU. Choose between:

External	The target power supply (TVDD) detection result is `ON`.
System	The target power supply (TVDD) detection result is `OFF`.

E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, TK: The sub clock is always set to **External**.

Monitor clock

Controls the operation clock of the monitor program. **System** configures the monitor program to be executed using the main clock. **User** configures the monitor program to be executed using the clock selected by the user application.

IECUBE: This option is not used.

Fail-safe break

IECUBE: Select the **View Setup** option to make the **Fail-safe break** options available.

Choose between:

Flash illegal	Illegal flash access.
Fetch from protect	Fetch from fetch-prohibited area.
Write to protect	Write to write-prohibited area.
Read protect SFR	Read of read-prohibited SFR.
Write protect SFR	Write to write-prohibited SFR.
Odd word access	Word access on odd address.
Stack overflow	User-specified stack limit exceeded (upper limit).
Stack underflow	User-specified stack limit not reached (lower limit).
Read uninit. RAM	Failure to perform RAM initialization.
Unmapped area	Access to non-mapped area.
Uninit. stack pointer	Failure to perform stack pointer initialization.
Fail-safe peripheral	Fail-safe from peripheral.

Note: See the in-circuit emulator and the emulation board documentation for detailed information about the options.

Deselect the **View setup** option to hide the options.

E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, TK: This option is not used.

Flash programming

Controls flash programming. Choose between:

Permit	Allows downloading to flash memory.
Not permit	Prohibits downloading to flash memory.

IECUBE: This option is not used.

Target Power Off

Together with the Pin mask option **Target reset**, this option controls the Power Off emulation of the target board. A reset operation will result in the following:

Target power off	Target reset	Result of reset operation
Permit	Selected	No reset operation performed
Permit	Deselected	Executes the application immediately after a reset operation
Not permit	Selected	No reset operation performed
Not permit	Deselected	Generates a break after a reset operation

Table 5: Target Power Off options

IECUBE: This option is not used.

Low-voltage

Enables low-voltage flash programming down to 1.8 V.

IECUBE: This option is not used.

Target connect

Selects the communication port between the emulator and the target board. The only available option is TOOL0.

IECUBE: This option is not used.

Pin mask

Select the non-connected pod pins.

Peripheral break

Controls peripheral emulation.

IECUBE: Choose between:

Disabled	Stops emulation on break.
Enabled	Does not stop emulation on break.

E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, TK: Choose between:

A (timer)	Stops timer-related peripheral emulation on break.
B (serial etc.)	Stops peripheral emulation related to serial communication on break.

Target

IECUBE: Select whether the target board is to be connected to the IECUBE in-circuit emulator or not.

E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, TK: This option is not used.

Power supply

E1, E2, E2 Lite/E2 On-Board, EZ-CUBE2: Specifies the target board power. Choose between:

3V low voltage adapter	The emulator provides 3 V power. This option must be used for the S1 core with a low voltage adapter board.
3V	The emulator provides 3 V power.
5V	The emulator provides 5 V power. (Not available for the E2 Lite emulator.)
Target	The board has its own power supply.

E20, EZ-CUBE, TK: The power supply is always set to **Target**.

IECUBE: This option is not used.

Memory map

Use the **Memory map** options to change the predefined memory areas.

Unallocated memory areas, except the SFR area, are always set as guarded, which means that they are read- and write-protected. If an application reads or writes in guarded memory or writes in ROM, the execution is stopped.

Start address	The starting address of the memory area.
Length	The length in bytes of the memory area.

Type	**Internal ROM –** The internal ROM area, 8–960 Kbytes. By default, the maximum available area is defined. **Internal RAM –** The internal RAM area, 512–63,232 bytes. By default, the maximum available area is defined. **External Target area –** The target memory area. **Internal Stack Area –** The assumed stack area. The internal high-speed RAM area can be used for the stack. Any stack operations performed outside this area will result in stack overflow.
Add	Adds a new memory area with the properties of the current settings of the **Start address**, **Length**, and **Type** options.
Remove	Removes the memory area selected in the display list from the memory map.
Remove all	Removes all memory areas in the display list from the memory map.
Display list	Displays the memory map.

Executing your application

- Introduction to application execution
- Analyzing execution
- Reference information on application execution

Introduction to application execution

These topics are covered:

- Briefly about application execution
- Source and disassembly mode debugging
- Single stepping
- Troubleshooting slow stepping speed
- Running the application
- Highlighting
- Viewing the call stack
- Terminal input and output
- Debug logging

BRIEFLY ABOUT APPLICATION EXECUTION

C-SPY allows you to monitor and control the execution of your application. By single-stepping through it, and setting breakpoints, you can examine details about the application execution, for example the values of variables and registers. You can also use the call stack to step back and forth in the function call chain.

The terminal I/O and debug log features let you interact with your application.

You can find commands for execution on the **Debug** menu and on the toolbar.

SOURCE AND DISASSEMBLY MODE DEBUGGING

C-SPY allows you to switch between source mode and disassembly mode debugging as needed.

Source debugging provides the fastest and easiest way of developing your application, without having to worry about how the compiler or assembler has implemented the code. In the editor windows you can execute the application one statement at a time while monitoring the values of variables and data structures.

Disassembly mode debugging lets you focus on the critical sections of your application, and provides you with precise control of the application code. You can open a disassembly window which displays a mnemonic assembler listing of your application based on actual memory contents rather than source code, and lets you execute the application exactly one machine instruction at a time.

Regardless of which mode you are debugging in, you can display registers and memory, and change their contents.

SINGLE STEPPING

C-SPY allows more stepping precision than most other debuggers because it is not line-oriented but statement-oriented. The compiler generates detailed stepping information in the form of *step points* at each statement, and at each function call. That is, source code locations where you might consider whether to execute a step into or a step over command. Because the step points are located not only at each statement but also at each function call, the step functionality allows a finer granularity than just stepping on statements.

There are several factors that can slow down the stepping speed. If you find it too slow, see *Troubleshooting slow stepping speed*, page 67 for some tips.

The step commands

There are four step commands:

- **Step Into**
- **Step Over**
- **Next Statement**
- **Step Out**.

Using the **Autostep settings** dialog box, you can automate the single stepping. For more information, see *Autostep settings dialog box*, page 87.

If your application contains an exception that is caught outside the code which would normally be executed as part of a step, C-SPY terminates the step at the `catch` statement.

Consider this example and assume that the previous step has taken you to the `f(i)` function call (highlighted):

```
extern int g(int);
int f(int n)
{
 value = g(n-1) + g(n-2) + g(n-3);
 return value;
}
int main()
{
  ...
  f(i);
  value ++;
}
```

Breakpoints when single stepping using the OCD driver

If you are using one of the OCD emulators—E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, TK—breakpoints are ignored in code during single stepping, and also when the **Run to Cursor** command is used. Among other things, this means that terminal I/O does not work when single stepping using an OCD emulator.

Step Into

While stepping, you typically consider whether to step into a function and continue stepping inside the function or subroutine. The **Step Into** command takes you to the first step point within the subroutine `g(n-1)`:

```
extern int g(int);
int f(int n)
{
 value = g(n-1) + g(n-2) + g(n-3);
 return value;
}
```

The **Step Into** command executes to the next step point in the normal flow of control, regardless of whether it is in the same or another function.

Step Over

The **Step Over** command executes to the next step point in the same function, without stopping inside called functions. The command would take you to the `g(n-2)` function call, which is not a statement on its own but part of the same statement as `g(n-1)`. Thus, you can skip uninteresting calls which are parts of statements and instead focus on critical parts:

```
extern int g(int);
int f(int n)
{
 value = g(n-1) + g(n-2) + g(n-3);
 return value;
}
```

Next Statement

The **Next Statement** command executes directly to the next statement, in this case `return value`, allowing faster stepping:

```
extern int g(int);
int f(int n)
{
 value = g(n-1) + g(n-2) + g(n-3);
 return value;
}
```

Step Out

When inside the function, you can—if you wish—use the **Step Out** command to step out of it before it reaches the exit. This will take you directly to the statement immediately after the function call:

```
extern int g(int);
int f(int n)
{
 value = g(n-1) + g(n-2) g(n-3);
 return value;
}
int main()
{
  ...
  f(i);
  value ++;
}
```

The possibility of stepping into an individual function that is part of a more complex statement is particularly useful when you use C code containing many nested function calls. It is also very useful for C++, which tends to have many implicit function calls, such as constructors, destructors, assignment operators, and other user-defined operators.

This detailed stepping can in some circumstances be either invaluable or unnecessarily slow. For this reason, you can also step only on statements, which means faster stepping.

TROUBLESHOOTING SLOW STEPPING SPEED

If you find that stepping speed is slow, these troubleshooting tips might speed up stepping:

- If you are using a hardware debugger system, keep track of how many hardware breakpoints that are used and make sure some of them are left for stepping.

  Stepping in C-SPY is normally performed using breakpoints. When C-SPY performs a step command, a breakpoint is set on the next statement and the application executes until it reaches this breakpoint. If you are using a hardware debugger system, the number of hardware breakpoints—typically used for setting a stepping breakpoint in code that is located in flash/ROM memory—is limited. If you, for example, step into a C `switch` statement, breakpoints are set on each branch; this might consume several hardware breakpoints. If the number of available hardware breakpoints is exceeded, C-SPY switches into single stepping on assembly level, which can be very slow.

  For more information, see *Breakpoints in the C-SPY hardware debugger drivers*, page 129 and *Breakpoint consumers*, page 129.
- Disable trace data collection, using the **Enable/Disable** button in both the **Trace** and the **Function Profiling** windows. Trace data collection might slow down stepping because the collected trace data is processed after each step. Note that it is not sufficient to just close the corresponding windows to disable trace data collection.
- Choose to view only a limited selection of SFR registers. You can choose between two alternatives. Either type `#`*`SFR_name`* (where *`SFR_name`* reflects the name of the SFR you want to monitor) in the **Watch** window, or create your own filter for displaying a limited group of SFRs in the **Registers** window. Displaying many SFR registers might slow down stepping because all registers must be read from the hardware after each step. See *Defining application-specific register groups*, page 156.
- Close the **Memory** and **Symbolic Memory** windows if they are open, because the visible memory must be read after each step and that might slow down stepping.
- Close any window that displays expressions such as **Watch**, **Live Watch**, **Locals**, **Statics** if it is open, because all these windows read memory after each step and that might slow down stepping.
- Close the **Stack** window if it is open. Choose **Tools>Options>Stack** and disable the **Enable graphical stack display and stack usage tracking** option if it is enabled.
- If possible, increase the communication speed between C-SPY and the target board/emulator.

RUNNING THE APPLICATION

Go

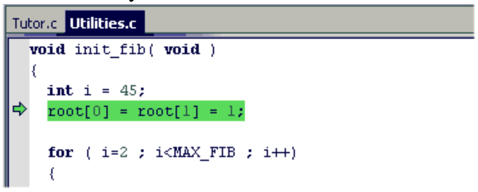
The **Go** command continues execution from the current position until a breakpoint or program exit is reached.

Run to Cursor

The **Run to Cursor** command executes to the position in the source code where you have placed the cursor. The **Run to Cursor** command also works in the **Disassembly** window and in the **Call Stack** window.

HIGHLIGHTING

At each stop, C-SPY highlights the corresponding C or C++ source or instruction with a green color, in the editor and the **Disassembly** window respectively. In addition, a green arrow appears in the editor window when you step on C or C++ source level, and in the **Disassembly** window when you step on disassembly level. This is determined by which of the windows is the active window. If none of the windows are active, it is determined by which of the windows was last active.



```
void init_fib( void )
{
  int i = 45;
  root[0] = root[1] = 1;

  for ( i=2 ; i<MAX_FIB ; i++)
  {
```

For simple statements without function calls, the whole statement is typically highlighted. When stopping at a statement with function calls, C-SPY highlights the first call because this illustrates more clearly what **Step Into** and **Step Over** would mean at that time.

Occasionally, you will notice that a statement in the source window is highlighted using a pale variant of the normal highlight color. This happens when the program counter is at an assembler instruction which is part of a source statement but not exactly at a step point. This is often the case when stepping in the **Disassembly** window. Only when the program counter is at the first instruction of the source statement, the ordinary highlight color is used.

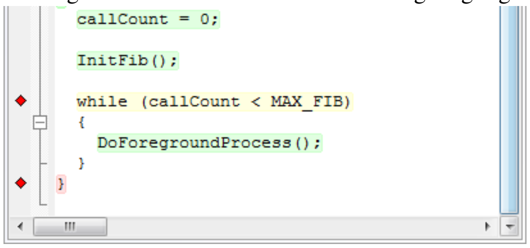
Code coverage

From the context menu in the **Code Coverage** window, you can toggle highlight colors and icons in the editor window that show code coverage analysis for the source code, see *Code Coverage window*, page 273.

These are the colors and icons that are used:

- Red highlight color and a red diamond: the code range has not been executed.
- Green highlight color: 100% of the code range has been executed.
- Yellow highlight color and a red diamond: parts of the code range have been executed.

This figure illustrates all three code coverage highlight colors:



```
callCount = 0;

InitFib();

while (callCount < MAX_FIB)
{
  DoForegroundProcess();
}
}
```

VIEWING THE CALL STACK

The compiler generates extensive call frame information. This allows C-SPY to show, without any runtime penalty, the complete function call chain at any time.

Typically, this is useful for two purposes:

- Determining in what context the current function has been called
- Tracing the origin of incorrect values in variables and in parameters, thus locating the function in the call chain where the problem occurred.

The **Call Stack** window shows a list of function calls, with the current function at the top. When you inspect a function in the call chain, the contents of all affected windows are updated to display the state of that particular call frame. This includes the editor, **Locals**, **Register**, **Watch**, and **Disassembly** windows. A function would normally not make use of all registers, so these registers might have undefined states and be displayed as dashes (---).

In the editor and **Disassembly** windows, a green highlight indicates the topmost, or current, call frame; a yellow highlight is used when inspecting other frames.

For your convenience, it is possible to select a function in the call stack and click the **Run to Cursor** command to execute to that function.

Assembler source code does not automatically contain any call frame information. To see the call chain also for your assembler modules, you can add the appropriate `CFI` assembler directives to the assembler source code. For more information, see the *IAR Assembler Reference Guide for RL78*.

TERMINAL INPUT AND OUTPUT

Sometimes you might have to debug constructions in your application that use `stdin` and `stdout` without an actual hardware device for input and output. The **Terminal I/O** window lets you enter input to your application, and display output from it. You can also direct terminal I/O to a file, using the **Terminal I/O Log Files** dialog box.

This facility is useful in two different contexts:

- If your application uses `stdin` and `stdout`
- For producing debug trace printouts.

For more information, see *Terminal I/O window*, page 79 and *Terminal I/O Log File dialog box*, page 80.

Note: If you are using one of the OCD emulators, terminal I/O might not work. See *Breakpoints when single stepping using the OCD driver*, page 65.

DEBUG LOGGING

The **Debug Log** window displays debugger output, such as diagnostic messages, macro-generated output, and information about trace.

It can sometimes be convenient to log the information to a file where you can easily inspect it, see *Log File dialog box*, page 82. The two main advantages are:

- The file can be opened in another tool, for instance an editor, so you can navigate and search within the file for particularly interesting parts
- The file provides history about how you have controlled the execution, for instance, which breakpoints that have been triggered etc.

Analyzing execution

MEASURING THE EXECUTION TIME (IECUBE)

To measure the execution time between two points:

1. Choose **Emulator>Edit Events** to open the **Edit Events** dialog box.
2. Define two OP fetch events at two addresses (select **Access type: OP fetch**). For more information, see *Edit Events dialog box*, page 90.
3. Click **OK** to close the dialog box.
4. Choose **Emulator>Timer Setup** to open the **Timer Settings** dialog box.
5. Select **Enable conditional measurement**, and in the **Start timer** and **Stop timer** lists, select the two events that you defined earlier.

6 Click **OK** to close the dialog box.

7 Make sure to disable any code breakpoints before running, except a final breakpoint—the timer results are only shown after execution stops.

8 Choose **Debug>Go**.

After the execution has stopped, the measurement result can be seen in the **Debug Log** window.

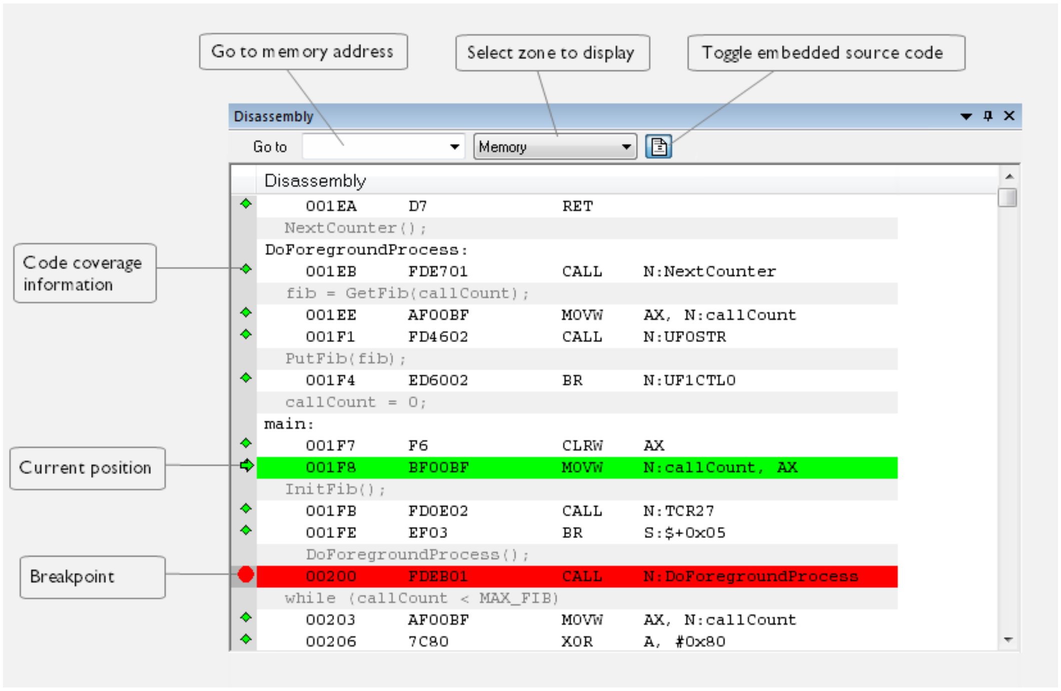
Reference information on application execution

Reference information about:

See also Terminal I/O options in the *IDE Project Management and Building Guide for RL78*.

Disassembly window

The C-SPY **Disassembly** window is available from the **View** menu.



```
Disassembly
    001EA      D7              RET
  NextCounter();
DoForegroundProcess:
    001EB      FDE701          CALL    N:NextCounter
  fib = GetFib(callCount);
    001EE      AF00BF          MOVW    AX, N:callCount
    001F1      FD4602          CALL    N:UF0STR
  PutFib(fib);
    001F4      ED6002          BR      N:UF1CTL0
  callCount = 0;
main:
    001F7      F6              CLRW    AX
    001F8      BF00BF          MOVW    N:callCount, AX
  InitFib();
    001FB      FD0E02          CALL    N:TCR27
    001FE      EF03            BR      S:$+0x05
    DoForegroundProcess();
    00200      FDEB01          CALL    N:DoForegroundProcess
  while (callCount < MAX_FIB)
    00203      AF00BF          MOVW    AX, N:callCount
    00206      7C80            XOR     A, #0x80
```

This window shows the application being debugged as disassembled application code.

To change the default color of the source code in the Disassembly window:

1. Choose **Tools>Options>Debugger**.
2. Set the default color using the **Source code coloring in disassembly window** option.

To view the corresponding assembler code for a function, you can select it in the editor window and drag it to the **Disassembly** window.

See also *Source and disassembly mode debugging*, page 63.

Requirements

None; this window is always available.

Toolbar

The toolbar contains:

Go to

The memory location or symbol you want to view.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

Toggle Mixed-Mode

Toggles between displaying only disassembled code or disassembled code together with the corresponding source code. Source code requires that the corresponding source file has been compiled with debug information

Display area

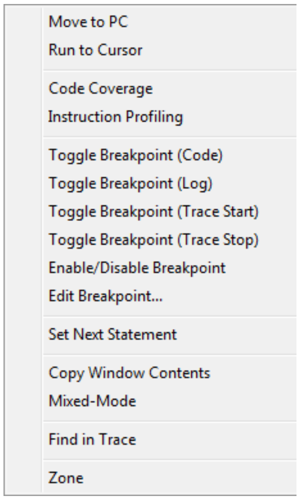
The display area shows the disassembled application code. This area contains these graphic elements:

Green highlight color	Indicates the current position, that is the next assembler instruction to be executed. To move the cursor to any line in the **Disassembly** window, click the line. Alternatively, move the cursor using the navigation keys.
Yellow highlight color	Indicates a position other than the current position, such as when navigating between frames in the **Call Stack** window or between items in the **Trace** window.
Red dot	Indicates a breakpoint. Double-click in the gray left-side margin of the window to set a breakpoint. For more information, see *Breakpoints*, page 125.
Green diamond	Code coverage icon—indicates code that has been executed.
Red diamond	Code coverage icon—indicates code that has *not* been executed.
Red/yellow diamond (red top/yellow bottom)	Code coverage icon—indicates a branch that is *never* taken.
Red/yellow diamond (red left side/yellow right side)	Code coverage icon—indicates a branch that is *always* taken.

If instruction profiling has been enabled from the context menu, an extra column in the left-side margin appears with information about how many times each instruction has been executed.

Context menu

This context menu is available:



Note: The contents of this menu are dynamic, which means that the commands on the menu might depend on your product package.

These commands are available:

Move to PC

Displays code at the current program counter location.

Run to Cursor

Executes the application from the current position up to the line containing the cursor.

Code Coverage

Displays a submenu that provides commands for controlling code coverage. This command is only enabled if the driver you are using supports it.

Enable	Toggles code coverage on or off.
Show	Toggles the display of code coverage on or off. Code coverage is indicated by a red, green, and red/yellow diamonds in the left margin.
Clear	Clears all code coverage information.

Next Different Coverage >	Moves the insertion point to the next line in the window with a different code coverage status than the selected line.
Previous Different Coverage <	Moves the insertion point to the closest preceding line in the window with a different code coverage status than the selected line.

Instruction Profiling

Displays a submenu that provides commands for controlling instruction profiling. This command is only enabled if the driver you are using supports it.

Enable	Toggles instruction profiling on or off.
Show	Toggles the display of instruction profiling on or off. For each instruction, the left-side margin displays how many times the instruction has been executed.
Clear	Clears all instruction profiling information.

Toggle Breakpoint (Code)

Toggles a code breakpoint. Assembler instructions and any corresponding label at which code breakpoints have been set are highlighted in red. For more information, see *Code breakpoints dialog box*, page 140.

Toggle Breakpoint (Log)

Toggles a log breakpoint for trace printouts. Assembler instructions at which log breakpoints have been set are highlighted in red. For more information, see *Log breakpoints dialog box*, page 143.

Toggle Breakpoint (Trace Start)

Toggles a Trace Start breakpoint. When the breakpoint is triggered, the trace data collection starts. Note that this menu command is only available if the C-SPY driver you are using supports trace. For more information, see *Trace Start breakpoints dialog box*, page 212.

Toggle Breakpoint (Trace Stop)

Toggles a Trace Stop breakpoint. When the breakpoint is triggered, the trace data collection stops. Note that this menu command is only available if the C-SPY driver you are using supports trace. For more information, see *Trace Stop breakpoints dialog box*, page 213.

Toggle Breakpoint (Code HW)

Toggles a code hardware breakpoint. Assembler instructions and any corresponding label at which code hardware breakpoints have been set are highlighted in red. See *Code HW breakpoints dialog box*, page 141.

Enable/Disable Breakpoint

Enables and Disables a breakpoint. If there is more than one breakpoint at a specific line, all those breakpoints are affected by the **Enable/Disable** command.

Edit Breakpoint

Displays the breakpoint dialog box to let you edit the currently selected breakpoint. If there is more than one breakpoint on the selected line, a submenu is displayed that lists all available breakpoints on that line.

Set Next Statement

Sets the program counter to the address of the instruction at the insertion point.

Copy Window Contents

Copies the selected contents of the **Disassembly** window to the clipboard.

Mixed-Mode

Toggles between showing only disassembled code or disassembled code together with the corresponding source code. Source code requires that the corresponding source file has been compiled with debug information.

Find in Trace

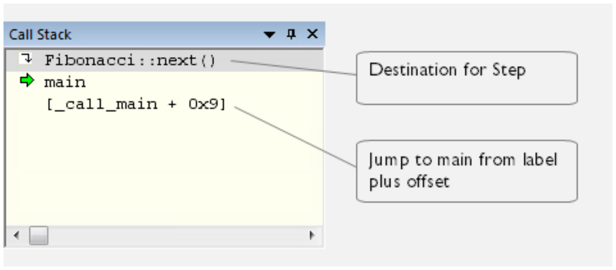
Searches the contents of the **Trace** window for occurrences of the given location—the position of the insertion point in the source code—and reports the result in the **Find in Trace** window. This menu command requires support for Trace in the C-SPY driver you are using, see *Differences between the C-SPY drivers*, page 35.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

Call Stack window

The **Call Stack** window is available from the **View** menu.



```
Fibonacci::next()
main
[_call_main + 0x9]
```

This window displays the C function call stack with the current function at the top. To inspect a function call, double-click it. C-SPY now focuses on that call frame instead.

If the next **Step Into** command would step to a function call, the name of the function is displayed in the gray bar at the top of the window. This is especially useful for implicit function calls, such as C++ constructors, destructors, and operators.

See also *Viewing the call stack*, page 69.

Requirements

None; this window is always available.

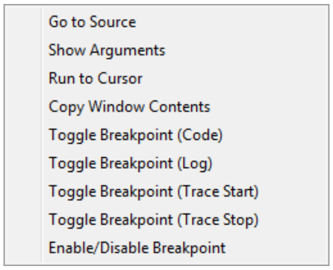
Display area

Each entry in the display area is formatted in one of these ways:

`function(values)***`	A C/C++ function with debug information. Provided that **Show Arguments** is enabled, `values` is a list of the current values of the parameters, or empty if the function does not take any parameters. `***`, if present, indicates that the function has been inlined by the compiler. For information about function inlining, see the *IAR C/C++ Development Guide for RL78*.
`[label + offset]`	An assembler function, or a C/C++ function without debug information.
`<exception_frame>`	An interrupt.

Context menu

This context menu is available:



These commands are available:

Go to Source

Displays the selected function in the **Disassembly** or editor windows.

Show Arguments

Shows function arguments.

Run to Cursor

Executes until return to the function selected in the call stack.

Copy Window Contents

Copies the contents of the **Call Stack** window and stores them on the clipboard.

Toggle Breakpoint (Code)

Toggles a code breakpoint.

Toggle Breakpoint (Log)

Toggles a log breakpoint.

Toggle Breakpoint (Trace Start)

Toggles a Trace Start breakpoint. When the breakpoint is triggered, trace data collection starts. Note that this menu command is only available if the C-SPY driver you are using supports it.

Toggle Breakpoint (Trace Stop)

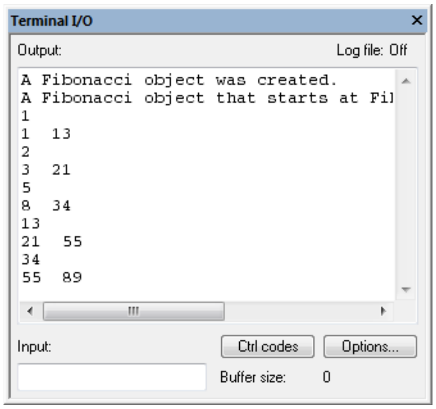
Toggles a Trace Stop breakpoint. When the breakpoint is triggered, trace data collection stops. Note that this menu command is only available if the C-SPY driver you are using supports it.

Enable/Disable Breakpoint

Enables or disables the selected breakpoint

Terminal I/O window

The **Terminal I/O** window is available from the **View** menu.



```
A Fibonacci object was created.
A Fibonacci object that starts at Fil
1
1  13
2
3  21
5
8  34
13
21  55
34
55  89
```

Use this window to enter input to your application, and display output from it.

To use this window, you must:

1 Link your application with the option **Include C-SPY debugging support**.

C-SPY will then direct `stdin`, `stdout` and `stderr` to this window. If the **Terminal I/O** window is closed, C-SPY will open it automatically when input is required, but not for output.

See also *Terminal input and output*, page 70.

Requirements

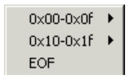
None; this window is always available.

Input

Type the text that you want to input to your application.

Ctrl codes

Opens a menu for input of special characters, such as `EOF` (end of file) and `NUL`.

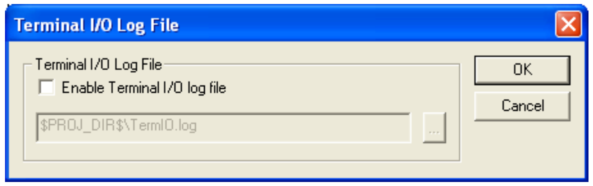


Options

Opens the **IDE Options** dialog box where you can set options for terminal I/O. For information about the options available in this dialog box, see *Terminal I/O options* in *IDE Project Management and Building Guide for RL78*.

Terminal I/O Log File dialog box

The **Terminal I/O Log File** dialog box is available by choosing **Debug>Logging>Set Terminal I/O Log File**.



$PROJ_DIR$\TermIO.log

Use this dialog box to select a destination log file for terminal I/O from C-SPY.

See also *Terminal input and output*, page 70.

Requirements

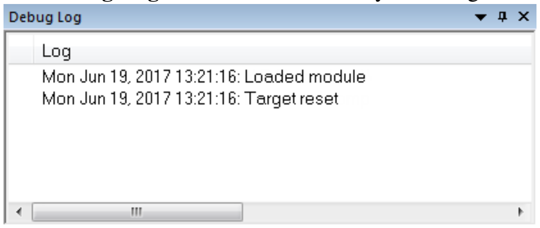
None; this dialog box is always available.

Terminal IO Log Files

Controls the logging of terminal I/O. To enable logging of terminal I/O to a file, select **Enable Terminal IO log file** and specify a filename. The default filename extension is `log`. A browse button is available for your convenience.

Debug Log window

The **Debug Log** window is available by choosing **View>Messages**.



```
Log
Mon Jun 19, 2017 13:21:16: Loaded module
Mon Jun 19, 2017 13:21:16: Target reset
```

This window displays debugger output, such as diagnostic messages, macro-generated output, and information about trace. This output is only available during a debug session. When opened, this window is, by default, grouped together with the other message windows, see *IDE Project Management and Building Guide for RL78*.

Double-click any rows in one of the following formats to display the corresponding source code in the editor window:

```
<path> (<row>):<message>
<path> (<row>,<column>):<message>
```

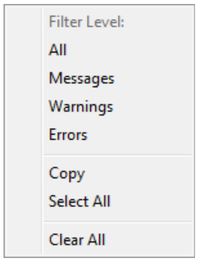
See also *Debug logging*, page 70 and *Log File dialog box*, page 82.

Requirements

None; this window is always available.

Context menu

This context menu is available:



These commands are available:

All

Shows all messages sent by the debugging tools and drivers.

Messages

Shows all C-SPY messages.

Warnings

Shows warnings and errors.

Errors

Shows errors only.

Copy

Copies the contents of the window.

Select All

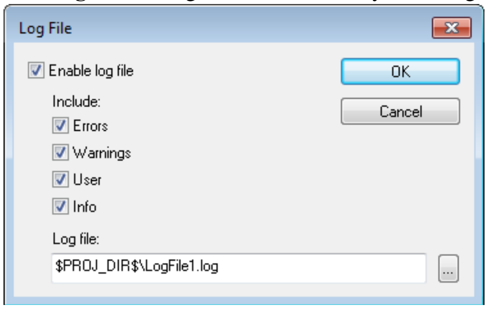
Selects the contents of the window.

Clear All

Clears the contents of the window.

Log File dialog box

The **Log File** dialog box is available by choosing **Debug>Logging>Set Log File**.



[✓] Enable log file

Include:

[✓] Errors

[✓] Warnings

[✓] User

[✓] Info

Log file:

$PROJ_DIR$\LogFile1.log

Use this dialog box to log output from C-SPY to a file.

Requirements

None; this dialog box is always available.

Enable log file

Enables or disables logging to the file.

Include

The information printed in the file is, by default, the same as the information listed in the **Debug Log** window. Use the browse button, to override the default file and location of the log file (the default filename extension is `log`). To change the information logged, choose between:

Errors

C-SPY has failed to perform an operation.

Warnings

An error or omission of concern.

User

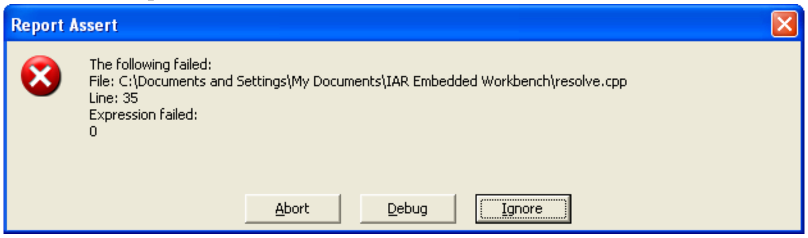
Messages from C-SPY macros, that is, your messages using the `__message` statement.

Info

Progress information about actions C-SPY has performed.

Report Assert dialog box

The **Report Assert dialog box** appears if you have a call to the `assert` function in your application source code, and the assert condition is false. In this dialog box you can choose how to proceed.



```
The following failed:
File: C:\Documents and Settings\My Documents\IAR Embedded Workbench\resolve.cpp
Line: 35
Expression failed:
0
```

Abort

The application stops executing and the runtime library function `abort`, which is part of your application on the target system, will be called. This means that the application itself terminates its execution.

Debug

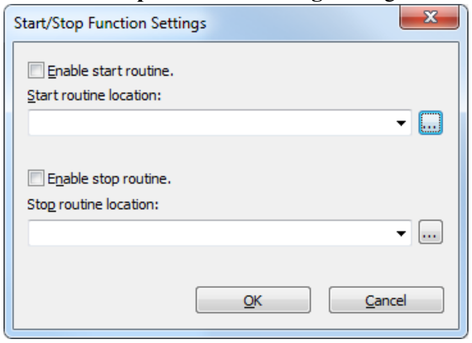
C-SPY stops the execution of the application and returns control to you.

Ignore

The assertion is ignored and the application continues to execute.

Start/Stop Function Settings dialog box

The **Start/Stop Function Settings** dialog box is available from the C-SPY *Driver* menu.



Use this dialog box to configure the emulator to execute specific routines of your application immediately before the execution starts and/or after it halts. This is useful if you want to control your system in synchronization with starting and stopping the execution of your application.

Requirements

One of these alternatives:

- The C-SPY E2 driver
- The C-SPY E2 Lite driver.
- The C-SPY E2 On-Board driver.
- The C-SPY EZ-CUBE2 driver.

Restrictions on using start/stop routines

Some restrictions apply:

- If the start/stop routines write to the CPU registers, the registers are restored when the routines finish executing.
- The execution of the start/stop routines cannot be single-stepped.
- Breakpoints cannot be used in start/stop routines.

  Note! This means that library functions that use an internal breakpoint in the default debugging support implementation cannot be used, for instance `printf` and `scanf` (see *Breakpoint consumers*, page 129). Such functions can only be used with a custom debugging support implementation.
- When your application starts executing from an address where a software breakpoint has been set, the instruction at the breakpoint is single-stepped, then the start routine is executed.

- If you have specified and enabled a start routine and your application starts executing from an address where you have set an event breakpoint, the breakpoint is triggered if the condition is satisfied and the start routine will be executed. If the start routine is disabled, the event breakpoint will not be triggered. To trigger the event breakpoint without executing the start routine, you must single-step the instruction in the **Disassembly** window before you execute the rest of your application, or disable the start routine.
- If you intend to use a stop routine, specify one that returns normally. If the routine does not return normally, the emulator debugger cannot control execution. To restore control, reset the debugger.
- Hot plug-in is disabled when the start/stop feature is enabled.

Enable start routine

Enables the execution of a routine immediately before your application starts executing.

Start routine location

Specifies the routine to be executed immediately before your application starts executing. Type a label or an address, or click the browse button to open the **Select Label** dialog box; see *Select Label dialog box*, page 86.

Enable stop routine

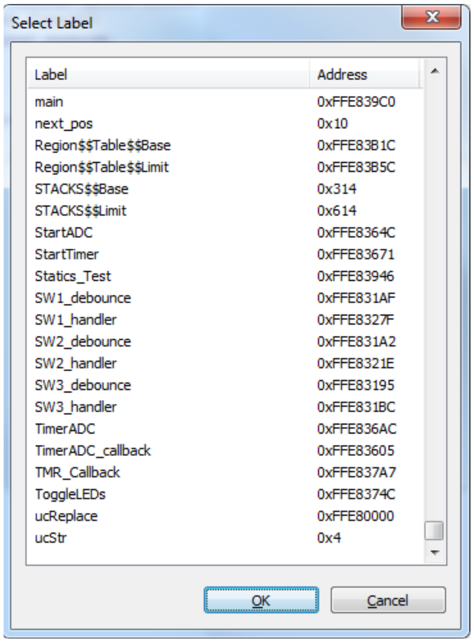
Enables the execution of a routine immediately after your application stops executing.

Stop routine location

Specifies the routine to be executed immediately after your application stops executing. Type a label or an address, or click the browse button to open the **Select Label** dialog box; see *Select Label dialog box*, page 86.

Select Label dialog box

The **Select Label** dialog box is available from the **Start/Stop Function Settings** dialog box.



Label	Address
main	0xFFE839C0
next_pos	0x10
Region$$Table$$Base	0xFFE83B1C
Region$$Table$$Limit	0xFFE83B5C
STACKS$$Base	0x314
STACKS$$Limit	0x614
StartADC	0xFFE8364C
StartTimer	0xFFE83671
Statics_Test	0xFFE83946
SW1_debounce	0xFFE831AF
SW1_handler	0xFFE8327F
SW2_debounce	0xFFE831A2
SW2_handler	0xFFE8321E
SW3_debounce	0xFFE83195
SW3_handler	0xFFE831BC
TimerADC	0xFFE836AC
TimerADC_callback	0xFFE83605
TMR_Callback	0xFFE837A7
ToggleLEDs	0xFFE8374C
ucReplace	0xFFE80000
ucStr	0x4

Select the routine you want to be executed and click **OK**.

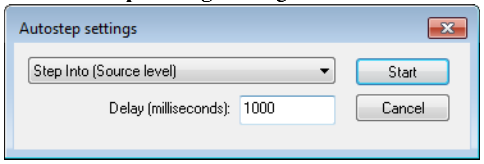
Requirements

One of these alternatives:

- The C-SPY E2 driver
- The C-SPY E2 Lite driver.
- The C-SPY E2 On-Board driver.
- The C-SPY EZ-CUBE2 driver.

Autostep settings dialog box

The **Autostep settings** dialog box is available from the **Debug** menu.



Step Into (Source level)

Delay (milliseconds): 1000

Use this dialog box to customize autostepping.

The drop-down menu lists the available step commands, see *Single stepping*, page 64.

Requirements

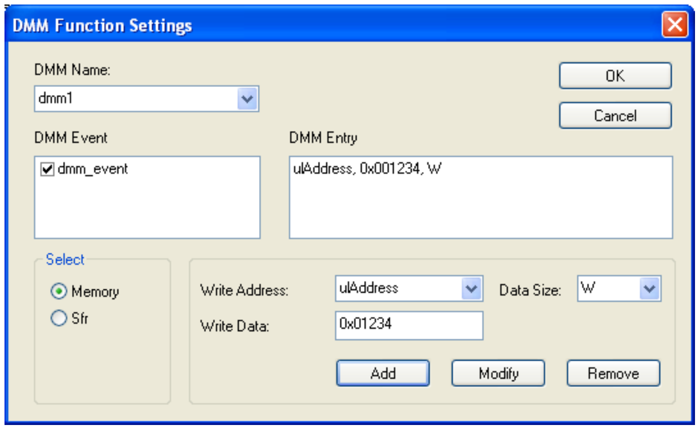
None; this dialog box is always available.

Delay (milliseconds)

Specify the delay between each step in milliseconds.

DMM Function Settings dialog box

The **DMM Function Settings** dialog box is available by choosing **DMM Setup** from the **Emulator** menu.



DMM Name: dmm1

DMM Event: [✓] dmm_event

DMM Entry: ulAddress, 0x001234, W

Select: [✓ Memory] Sfr

Write Address: ulAddress

Data Size: W

Write Data: 0x01234

Use this dialog box to specify which events that will trigger a memory modification and the characteristics of the modification. The supported events are data accesses and execution events. Events that occur before execution cannot define a DMM.

The Direct Memory Modification (DMM) function provides the possibility to modify memory addresses or SFRs if an event occurs.

Requirements

The IECUBE emulator.

DMM Name

To define a new DMM event, enter the name in the **DMM Name** drop-down list. Choose the appropriate characteristics and click **OK**.

To modify an existing DMM event, choose the event from the **DMM Name** list, enter the new characteristics and click **OK**.

DMM Event

Displays the events that will trigger the memory modification.

DMM Entry

Displays the memory addresses and SFRs to be modified, together with their new values.

Select

Select what to modify:

Memory	Modifies a memory address.
Sfr	Modifies an SFR.

Depending on your choice, different sets of options appear to the right.

Write Address

Specifies the memory address to modify. Symbol names can be used instead of absolute addresses to define an address area.

Write Data

Specifies the new value of the memory address or the SFR.

Data Size

Specifies the size of the new data. Choose between **B** for byte and **W** for word.

Sfr Name

Displays all available SFRs. Choose the SFR that you want to modify.

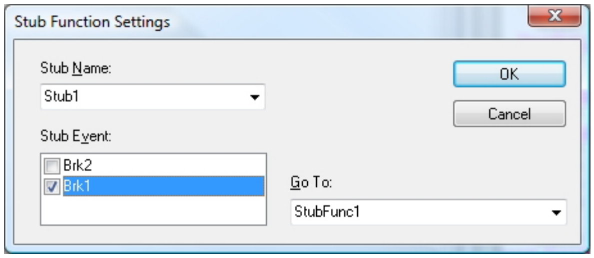
Buttons

These buttons are available:

Add	Displays the new DMM entry in the **DMM Entry** box.
Modify	Changes a selected item in the **DMM Entry** box.
Remove	Deletes a selected item in the **DMM Entry** box.

Stub Function Settings dialog box

The **Stub Function Settings** dialog box is available from the **Emulator** menu.



Use this dialog box to execute a stub function of the application on the occurrence of an event. The supported events are data accesses and execution events. Events that occur before execution cannot define a stub function call.

Requirements

The IECUBE emulator.

Stub Name

To define a new stub event, enter the name in the **Stub Name** drop-down list. Choose the appropriate characteristics and click **OK**.

To modify an existing stub event, choose the event from the **Stub Name** list, enter the new characteristics and click **OK**.

Stub Event

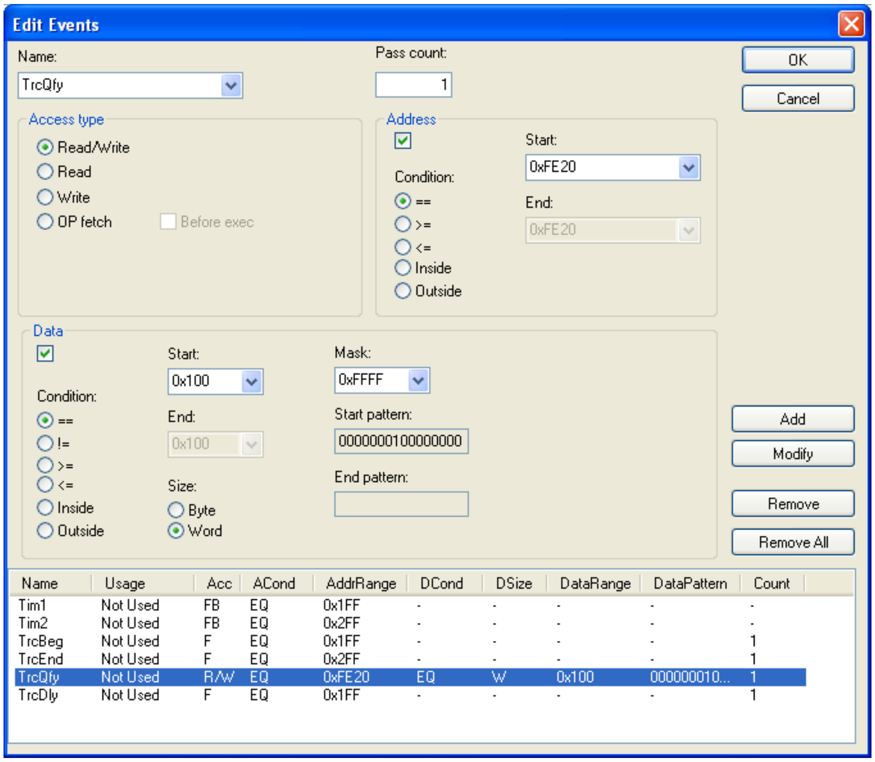
Displays the events that will trigger the execution of the stub function.

Go To

Specify the function to be executed when the event occurs. Instead of a function name, an absolute address can be specified.

Edit Events dialog box

The **Edit Events** dialog box is available from the **Emulator** menu.



Name: TrcQfy

Pass count: 1

Access type: [✓ Read/Write] Read Write OP fetch Before exec

Address: ✓

Condition: [✓ ==] >= <= Inside Outside

Start: 0xFE20

End: 0xFE20

Data: ✓

Condition: [✓ ==] != >= <= Inside Outside

Start: 0x100

End: 0x100

Size: Byte [✓ Word]

Mask: 0xFFFF

Start pattern: 0000000100000000

End pattern:

Name	Usage	Acc	ACond	AddrRange	DCond	DSize	DataRange	DataPattern	Count
Tim1	Not Used	FB	EQ	0x1FF	-	-	-	-	-
Tim2	Not Used	FB	EQ	0x2FF	-	-	-	-	-
TrcBeg	Not Used	F	EQ	0x1FF	-	-	-	-	1
TrcEnd	Not Used	F	EQ	0x2FF	-	-	-	-	1
TrcQfy	Not Used	R/W	EQ	0xFE20	EQ	W	0x100	000000010...	1
TrcDly	Not Used	F	EQ	0x1FF	-	-	-	-	1

Use this dialog box to define the events used by the emulator as breakpoint, trace, timer and sequencer events.

In real-time, the emulator compares the address, data, access type, and probe signals with the events that you have defined. When all defined conditions are true, the event is raised.

Each event is uniquely named and listed with its settings at the bottom of the **Edit Events** dialog box. In the list, the **Usage** column shows how the event is used, that is, as breakpoint, trace, timer, or sequencer event.

Requirements

Any supported hardware debugger system, but requires a device that supports events.

Name

To define a new event, enter the event name in the **Name** list box and choose the appropriate characteristics. Click **Add**.

To modify an existing event, choose the event from the **Name** list box, enter the new characteristics and click on one of the **Modify**, **Remove**, or **Remove All** buttons.

For each event you can specify the access type, address, data, and external probe.

Pass count

Specify the number of times the event must be repeated before the event is triggered. The valid range of values is 1–255.

Access type

Selects the access type that should trigger the event:

Read/write	A read/write access.
Read	A read access.
Write	A write access.
OP fetch	An operation fetch access. An OP fetch event will by default break after execution, but you can modify it to break before execution by selecting the option **Before exec** (IECUBE only).

Address

Specify an address or an address range. Any access to the specified address or address range with the specified condition, causes the event to be triggered.

To define a single address, select a single condition option and enter the value in the **Start** field. For the IECUBE emulator, the condition can be ==, >=, or <=. For all other emulators, only the equal (==) condition is available.

To define an address range, select the **Inside** or **Outside** condition option and enter the start and end values in the **Start** and **End** fields, respectively. This is only possible for the IECUBE emulator. For all other emulators, only a single address can be specified.

Note: You can enter a label instead of an address value.

Data

Specify a condition, access size, and a data value or data range. An access with data or data range with the specified condition, access size and mask, causes the event to be triggered.

To define a single data value, select a single condition option (`==`, `!=`, `>=`, or `<=`), access size (**Byte** or **Word**) and enter the data value in the **Start** field. You can choose to enter a mask in the **Mask** field. The bit pattern for the value with the mask applied is displayed in the **Start Pattern** text box.

To define a data range, select the **Inside** or **Outside** condition option, access size (**Byte** or **Word**) and enter the start and end values in the **Start** and **End** fields, respectively. You can choose to enter a mask in the **Mask** field. The bit pattern for the value range with the mask applied is displayed in the **Start Pattern** and **End Pattern** text boxes.

Only the IECUBE emulator supports all these options. For all other emulators, these restrictions apply:

- Only the equal (`==`) condition is available
- Only byte accesses are available
- Only a single address can be entered.

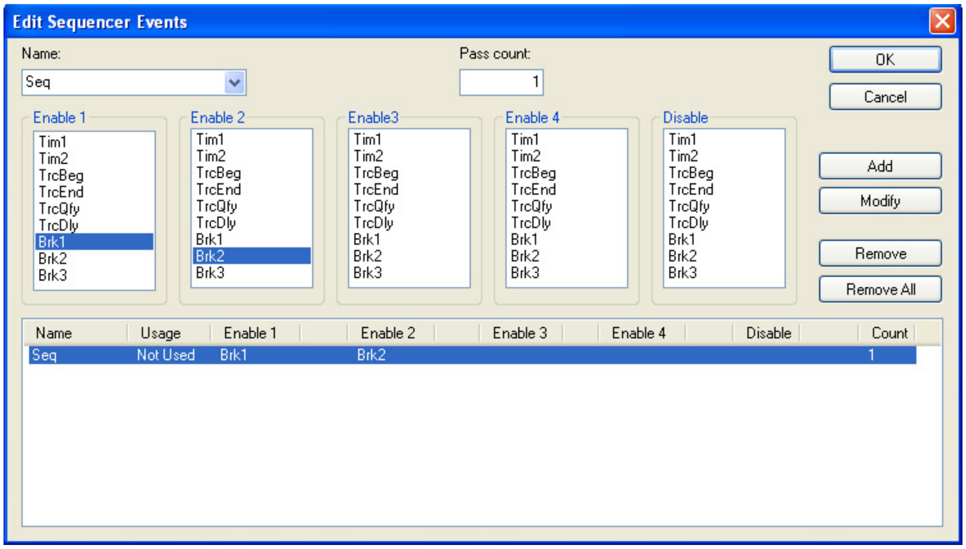
Buttons

These buttons are available:

Add	Adds the selected event in the **Name** list box.
Modify	Modifies the selected event in the **Name** list box using the current settings in the dialog box.
Remove	Removes the selected event from the **Name** list box.
Remove All	Removes all events from the **Name** list box.

Edit Sequencer Events dialog box

The **Edit Sequencer Events** dialog box is available from the **Emulator** menu.



Name: Seq

Pass count: 1

Enable 1: Tim1, Tim2, TrcBeg, TrcEnd, TrcQfy, TrcDly, Brk1, Brk2, Brk3 (Brk1 selected)

Enable 2: Tim1, Tim2, TrcBeg, TrcEnd, TrcQfy, TrcDly, Brk1, Brk2, Brk3 (Brk2 selected)

Enable3: Tim1, Tim2, TrcBeg, TrcEnd, TrcQfy, TrcDly, Brk1, Brk2, Brk3

Enable 4: Tim1, Tim2, TrcBeg, TrcEnd, TrcQfy, TrcDly, Brk1, Brk2, Brk3

Disable: Tim1, Tim2, TrcBeg, TrcEnd, TrcQfy, TrcDly, Brk1, Brk2, Brk3

Name	Usage	Enable 1	Enable 2	Enable 3	Enable 4	Disable	Count
Seq	Not Used	Brk1	Brk2				1

Use this dialog box to set a sequence of events that must occur before a sequencer event is triggered.

Requirements

Any supported hardware debugger system, but requires a device that supports events.

Name

To define a new event, enter the event name in the **Name** list box and choose the appropriate characteristics. Click **Add**.

To modify an existing event, choose the event from the **Name** list box, enter the new characteristics and click on one of the **Modify**, **Remove**, or **Remove All** buttons.

Pass count

Specify the number of times the event must be repeated before the event is triggered. The valid range of values is 1–255.

Enable/Disable

Select up to four **Enable** events that must be triggered in a sequence to create a sequencer event. You can only select one event in each **Enable** list. You do not have to use all **Enable** lists.

If the **Disable** event occurs, the sequence starts over with the first **Enable** event again.

Display area

This area displays all created events and their settings. The **Usage** column shows how the event is used: as a breakpoint, a trace, a timer, or a sequencer event.

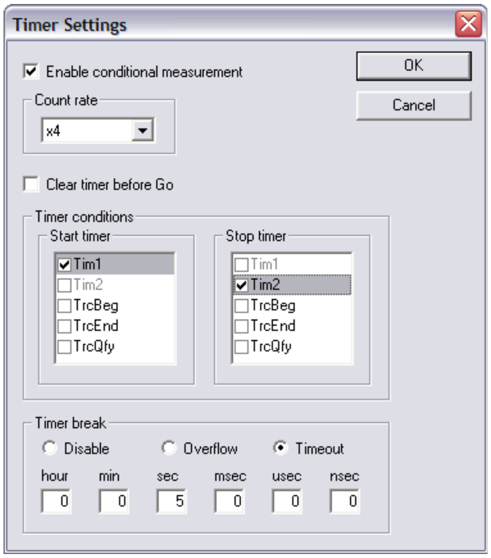
Buttons

These buttons are available:

Add	Adds the selected event in the **Name** list box.
Modify	Modifies the selected event in the **Name** list box using the current settings in the dialog box.
Remove	Removes the selected event from the **Name** list box.
Remove All	Removes all events from the **Name** list box.

Timer Settings dialog box

The **Timer Settings** dialog box is available from the **Emulator** menu.



[✓] Enable conditional measurement

Count rate: x4

[ ] Clear timer before Go

Timer conditions

Start timer: [✓] Tim1, [ ] Tim2, [ ] TrcBeg, [ ] TrcEnd, [ ] TrcQfy

Stop timer: [ ] Tim1, [✓] Tim2, [ ] TrcBeg, [ ] TrcEnd, [ ] TrcQfy

Timer break: Disable, Overflow, [✓ Timeout]

hour	min	sec	msec	usec	nsec
0	0	5	0	0	0

Use this dialog box to define the timer behavior. The timer measures the time between events that you select with the **Timer conditions** options. The result is displayed in the C-SPY **Debug Log** window.

Requirements

The IECUBE emulator.

Enable conditional measurement

Enables the timer.

Count rate

Sets the timer rate value for execution time measurement. The count rate can be set to between 1 and 2048 times the current clock frequency.

Clear timer before Go

Select to clear the timer every time before any **Go** or step command is performed.

Timer conditions

Select the timer events that should start and stop the time measuring. If more than one event is selected in the same list, the timer condition is true when *one* of the events has occurred.

You define the events that appear in the **Timer conditions** lists either in the **Edit Events** dialog box or in the **Edit Sequencer Events** dialog box.

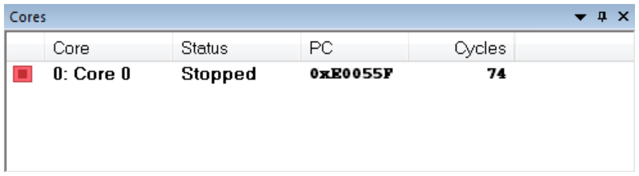
Timer break

Specify when the timer should stop measuring the time. Choose between:

Disable	No timer breaks will occur.
Overflow	A break will occur when the timer exceeds the highest possible measurable value.
Timeout	A break will occur after the amount of time you specify using the boxes below.

Cores window

The **Cores** window is available from the **View** menu.


Cores

	Core	Status	PC	Cycles
🟥	0: Core 0	Stopped	0xE0055F	74

This window displays information about the executing core, such as its execution state. This information is primarily useful for IAR Embedded Workbench products that support multicore debugging.

Requirements

None; this window is always available.

Display area

A row in this area shows information about a core, in these columns:

Execution state

Displays one of these icons to indicate the execution state of the core.

🟥	in focus, not executing

🟥	not in focus, not executing
➡	in focus, executing
⇨	not in focus, executing
➡	in focus, in sleep mode
⇨	not in focus, in sleep mode
☒	in focus, unknown status
☒	not in focus, unknown status

Core

The name of the core.

Status

The status of the execution, which can be one of **Stopped**, **Running**, **Sleeping**, or **Unknown**.

PC

The value of the program counter.

Cycles | Time

The value of the cycle counter or the execution time since the start of the execution, depending on the debugger driver you are using.

Variables and expressions

- Introduction to working with variables and expressions
- Working with variables and expressions
- Reference information on working with variables and expressions

Introduction to working with variables and expressions

This section introduces different methods for looking at variables and introduces some related concepts.

These topics are covered:

- Briefly about working with variables and expressions
- C-SPY expressions
- Limitations on variable information

BRIEFLY ABOUT WORKING WITH VARIABLES AND EXPRESSIONS

There are several methods for looking at variables and calculating their values. These methods are suitable for basic debugging:

- Tooltip watch—in the editor window—provides the simplest way of viewing the value of a variable or more complex expressions. Just point at the variable with the mouse pointer. The value is displayed next to the variable.
- The **Auto** window displays a useful selection of variables and expressions in, or near, the current statement. The window is automatically updated when execution stops.
- The **Locals** window displays the local variables, that is, auto variables and function parameters for the active function. The window is automatically updated when execution stops.
- The **Watch** window allows you to monitor the values of C-SPY expressions and variables. The window is automatically updated when execution stops.
- The **Live Watch** window repeatedly samples and displays the values of expressions while your application is executing. Variables in the expressions must be statically located, such as global variables.
- The **Statics** window displays the values of variables with static storage duration. The window is automatically updated when execution stops.

- The **Macro Quicklaunch** window and the **Quick Watch** window give you precise control over when to evaluate an expression.
- The **Symbols** window displays all symbols with a static location, that is, C/C++ functions, assembler labels, and variables with static storage duration, including symbols from the runtime library.

These additional methods for looking at variables are suitable for more advanced analysis:

- The **Data Log** window and the **Data Log Summary** window display logs of accesses to up to four different memory locations you choose by setting data log breakpoints. Data logging can help you locate frequently accessed data. You can then consider whether you should place that data in more efficient memory.
- The **Data Sample** window displays samples for up to four different variables. You can also display the data samples as graphs in the **Sampled Graphs** window. By using data sampling, you will get an indication of the data value over a length of time. Because it is a sampled value, data sampling is best suited for slow-changing data.
- The **Event Log** window and the **Event Log Summary** window display *event logs* from collected Smart Analog data. The **Timeline** window graphically displays these event logs correlated to a common time-axis. Event logging requires a device that supports Smart Analog data collection and an E1, E2, E20, E2 Lite/E2 On-Board, or EZ-CUBE2 emulator.

For more information about these windows, see *The application timeline*, page 221.

C-SPY EXPRESSIONS

C-SPY expressions can include any type of C expression, except for calls to functions. The following types of symbols can be used in expressions:

- C/C++ symbols
- Assembler symbols (register names and assembler labels)
- C-SPY macro functions
- C-SPY macro variables.

Expressions that are built with these types of symbols are called C-SPY expressions and there are several methods for monitoring these in C-SPY. Examples of valid C-SPY expressions are:

```
i + j
i = 42
myVar = cVar
cVar = myVar + 2
#asm_label
#R2
#PC
my_macro_func(19)
```

If you have a static variable with the same name declared in several different functions, use the notation `function::variable` to specify which variable to monitor.

C/C++ symbols

C symbols are symbols that you have defined in the C source code of your application, for instance variables, constants, and functions (functions can be used as symbols but cannot be executed). C symbols can be referenced by their names. Note that C++ symbols might implicitly contain function calls which are not allowed in C-SPY symbols and expressions.

Note: Some attributes available in C/C++, like `volatile`, are not fully supported by C-SPY. For example, this line will not be accepted by C-SPY:

```
sizeof(unsigned char volatile __memattr *)
```

However, this line will be accepted:

```
sizeof(unsigned char __memattr *)
```

Assembler symbols

Assembler symbols can be assembler labels or registers, for example the program counter, the stack pointer, or other CPU registers. If a device description file is used, all memory-mapped peripheral units, such as I/O ports, can also be used as assembler symbols in the same way as the CPU registers. See *Modifying a device description file*, page 47.

Assembler symbols can be used in C-SPY expressions if they are prefixed by `#`.

Example	What it does
`#PC++`	Increments the value of the program counter.
`myVar = #SP`	Assigns the current value of the stack pointer register to your C-SPY variable.

Table 6: C-SPY assembler symbols expressions

Example	What it does
`myVar = #label`	Sets `myVar` to the value of an integer at the address of `label`.
`myptr = &#label7`	Sets `myptr` to an `int *` pointer pointing at `label7`.

Table 6: C-SPY assembler symbols expressions (Continued)

In case of a name conflict between a hardware register and an assembler label, hardware registers have a higher precedence. To refer to an assembler label in such a case, you must enclose the label in back quotes ` (ASCII character 0x60). For example:

Example	What it does
`#PC`	Refers to the program counter.
``#`PC` ``	Refers to the assembler label `PC`.

Table 7: Handling name conflicts between hardware registers and assembler labels

Which processor-specific symbols are available by default can be seen in the **Registers** window, using the `CPU Registers` register group. See *Registers window*, page 178.

C-SPY macro functions

Macro functions consist of C-SPY macro variable definitions and macro statements which are executed when the macro is called.

For information about C-SPY macro functions and how to use them, see *Briefly about the macro language*, page 322.

C-SPY macro variables

Macro variables are defined and allocated outside your application, and can be used in a C-SPY expression. In case of a name conflict between a C symbol and a C-SPY macro variable, the C-SPY macro variable will have a higher precedence than the C variable. Assignments to a macro variable assign both its value and type.

For information about C-SPY macro variables and how to use them, see *Reference information on the macro language*, page 328.

Using sizeof

According to standard C, there are two syntactical forms of `sizeof`:

```
sizeof(type)
sizeof expr
```

The former is for types and the latter for expressions.

Note: In C-SPY, do not use parentheses around an expression when you use the `sizeof` operator. For example, use `sizeof x+2` instead of `sizeof (x+2)`.

LIMITATIONS ON VARIABLE INFORMATION

The value of a C variable is valid only on step points, that is, the first instruction of a statement and on function calls. This is indicated in the editor window with a bright green highlight color. In practice, the value of the variable is accessible and correct more often than that.

When the program counter is inside a statement, but not at a step point, the statement or part of the statement is highlighted with a pale variant of the ordinary highlight color.

Effects of optimizations

The compiler is free to optimize the application software as much as possible, as long as the expected behavior remains. The optimization can affect the code so that debugging might be more difficult because it will be less clear how the generated code relates to the source code. Typically, using a high optimization level can affect the code in a way that will not allow you to view a value of a variable as expected.

Consider this example:

```
myFunction()
{
 int i = 42;
 ...
 x = computer(i); /* Here, the value of i is known to C-SPY */
 ...
}
```

From the point where the variable `i` is declared until it is actually used, the compiler does not need to waste stack or register space on it. The compiler can optimize the code, which means that C-SPY will not be able to display the value until it is actually used. If you try to view the value of a variable that is temporarily unavailable, C-SPY will display the text:

```
Unavailable
```

If you need full information about values of variables during your debugging session, you should make sure to use the lowest optimization level during compilation, that is, **None**.

Working with variables and expressions

These tasks are covered:

- Using the windows related to variables and expressions
- Viewing assembler variables

See also *Analyzing your application's timeline*, page 223

USING THE WINDOWS RELATED TO VARIABLES AND EXPRESSIONS

Where applicable, you can add, modify, and remove expressions, and change the display format in the windows related to variables and expressions.

To add a value you can also click in the dotted rectangle and type the expression you want to examine. To modify the value of an expression, click the **Value** field and modify its content. To remove an expression, select it and press the Delete key.

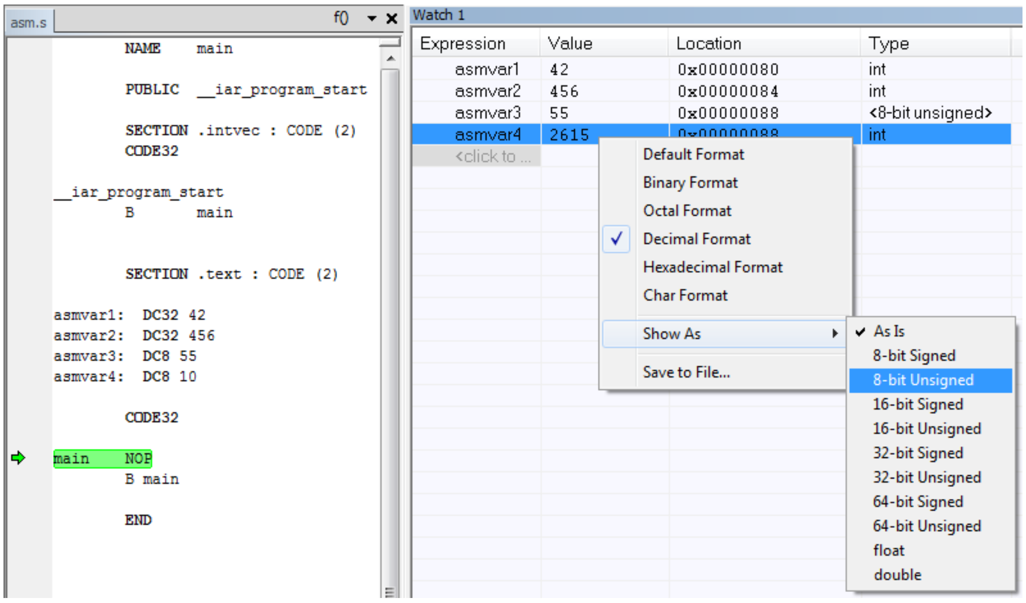
For text that is too wide to fit in a column—in any of these windows, except the **Trace** window—and thus is truncated, just point at the text with the mouse pointer and tooltip information is displayed.

Right-click in any of the windows to access the context menu which contains additional commands. Convenient drag-and-drop between windows is supported, except for in the **Locals** window, Data logging windows, and the **Quick Watch** window where it is not relevant.

VIEWING ASSEMBLER VARIABLES

An assembler label does not convey any type information at all, which means C-SPY cannot easily display data located at that label without getting extra information. To view data conveniently, C-SPY by default treats all data located at assembler labels as variables of type `int`. However, in the **Watch**, **Live Watch**, and **Quick Watch** windows, you can select a different interpretation to better suit the declaration of the variables.

In this figure, you can see four variables in the **Watch** window and their corresponding declarations in the assembler source file to the left:



```
        NAME    main

        PUBLIC  __iar_program_start

        SECTION .intvec : CODE (2)
        CODE32

__iar_program_start
        B       main


        SECTION .text : CODE (2)

asmvar1:  DC32 42
asmvar2:  DC32 456
asmvar3:  DC8 55
asmvar4:  DC8 10

        CODE32

main    NOP
        B main

        END
```

Expression	Value	Location	Type
asmvar1	42	0x00000080	int
asmvar2	456	0x00000084	int
asmvar3	55	0x00000088	<8-bit unsigned>
asmvar4	2615	0x00000088	int
<click to ...			

Note that `asmvar4` is displayed as an `int`, although the original assembler declaration probably intended for it to be a single byte quantity. From the context menu you can make C-SPY display the variable as, for example, an 8-bit unsigned variable. This has already been specified for the `asmvar3` variable.

Reference information on working with variables and expressions

Reference information about:

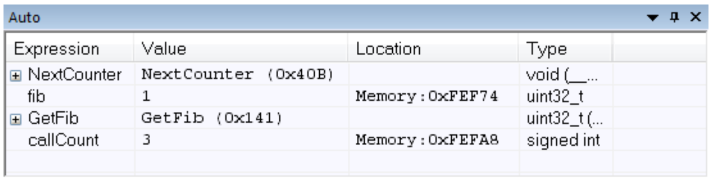
- *Auto window*, page 106
- *Locals window*, page 108
- *Watch window*, page 110
- *Live Watch window*, page 112
- *Statics window*, page 115
- *Quick Watch window*, page 118
- *Symbols window*, page 121
- *Resolve Symbol Ambiguity dialog box*, page 123

See also:

- *Reference information on trace*, page 199 for trace-related reference information
- *Macro Quicklaunch window*, page 376

Auto window

The **Auto** window is available from the **View** menu.



Expression	Value	Location	Type
⊞ NextCounter	NextCounter (0x40B)		void (__...
fib	1	Memory:0xFEF74	uint32_t
⊞ GetFib	GetFib (0x141)		uint32_t (...
callCount	3	Memory:0xFEFA8	signed int

This window displays a useful selection of variables and expressions in, or near, the current statement. Every time execution in C-SPY stops, the values in the **Auto** window are recalculated. Values that have changed since the last stop are highlighted in red.

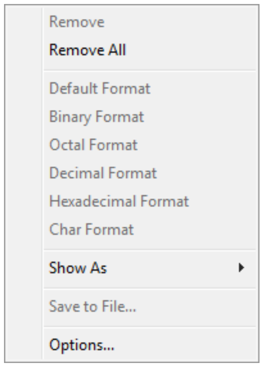
See also *Editing in C-SPY windows*, page 45.

Requirements

None; this window is always available.

Context menu

This context menu is available:



Note: The contents of this menu are dynamic and depend on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Remove

Removes the selected expression from the window.

Remove All

Removes all expressions listed in the window.

Default Format
Binary Format
Octal Format
Decimal Format
Hexadecimal Format
Char Format

Changes the display format of expressions. The display format setting affects different types of expressions in different ways. Your selection of display format is saved between debug sessions. These commands are available if a selected line in the window contains a variable.

The display format setting affects different types of expressions in these ways:

Variables	The display setting affects only the selected variable, not other variables.
Array elements	The display setting affects the complete array, that is, the same display format is used for each array element.
Structure fields	All elements with the same definition—the same field name and C declaration type—are affected by the display setting.

Show As

Displays a submenu that provides commands for changing the default type interpretation of variables. The commands on this submenu are mainly useful for assembler variables—data at assembler labels—because these are, by default, displayed as integers. For more information, see *Viewing assembler variables*, page 104.

Save to File

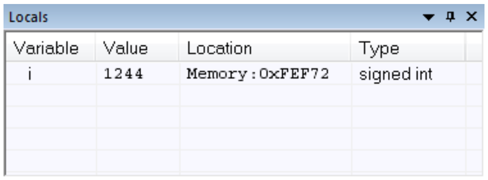
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options for C-SPY windows.

Locals window

The **Locals** window is available from the **View** menu.



Variable	Value	Location	Type
i	1244	Memory:0xFEF72	signed int

This window displays the local variables and parameters for the current function. Every time execution in C-SPY stops, the values in the window are recalculated. Values that have changed since the last stop are highlighted in red.

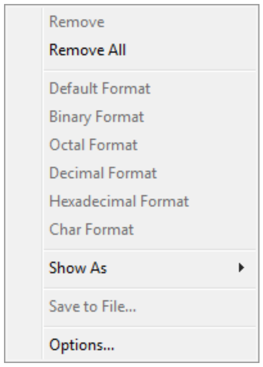
See also *Editing in C-SPY windows*, page 45.

Requirements

None; this window is always available.

Context menu

This context menu is available:



Note: The contents of this menu are dynamic and depend on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Remove

Removes the selected expression from the window.

Remove All

Removes all expressions listed in the window.

Default Format
Binary Format
Octal Format
Decimal Format
Hexadecimal Format
Char Format

Changes the display format of expressions. The display format setting affects different types of expressions in different ways. Your selection of display format is saved between debug sessions. These commands are available if a selected line in the window contains a variable.

The display format setting affects different types of expressions in these ways:

Variables	The display setting affects only the selected variable, not other variables.
Array elements	The display setting affects the complete array, that is, the same display format is used for each array element.
Structure fields	All elements with the same definition—the same field name and C declaration type—are affected by the display setting.

Show As

Displays a submenu that provides commands for changing the default type interpretation of variables. The commands on this submenu are mainly useful for assembler variables—data at assembler labels—because these are, by default, displayed as integers. For more information, see *Viewing assembler variables*, page 104.

Save to File

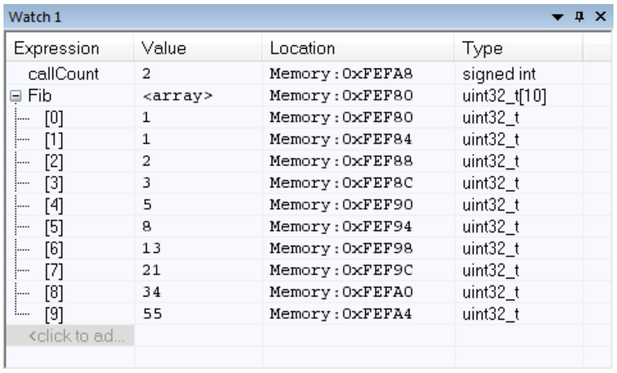
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options for C-SPY windows.

Watch window

The **Watch** window is available from the **View** menu.



Expression	Value	Location	Type
callCount	2	Memory:0xFEFA8	signed int
Fib	<array>	Memory:0xFEF80	uint32_t[10]
[0]	1	Memory:0xFEF80	uint32_t
[1]	1	Memory:0xFEF84	uint32_t
[2]	2	Memory:0xFEF88	uint32_t
[3]	3	Memory:0xFEF8C	uint32_t
[4]	5	Memory:0xFEF90	uint32_t
[5]	8	Memory:0xFEF94	uint32_t
[6]	13	Memory:0xFEF98	uint32_t
[7]	21	Memory:0xFEF9C	uint32_t
[8]	34	Memory:0xFEFA0	uint32_t
[9]	55	Memory:0xFEFA4	uint32_t
<click to ad...			

Use this window to monitor the values of C-SPY expressions or variables. You can open up to four instances of this window, where you can view, add, modify, and remove expressions. Tree structures of arrays, structs, and unions are expandable, which means that you can study each item of these.

Every time execution in C-SPY stops, the values in the **Watch** window are recalculated. Values that have changed since the last stop are highlighted in red.

Be aware that expanding very large arrays can cause an out-of-memory crash. To avoid this, expansion is automatically performed in steps of 5000 elements.

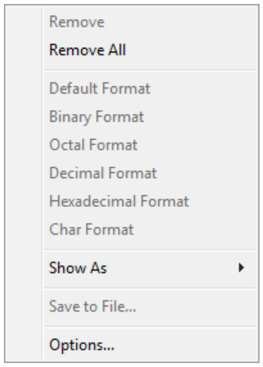
See also *Editing in C-SPY windows*, page 45.

Requirements

None; this window is always available.

Context menu

This context menu is available:



Note: The contents of this menu are dynamic and depend on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Remove

Removes the selected expression from the window.

Remove All

Removes all expressions listed in the window.

Default Format
Binary Format
Octal Format
Decimal Format
Hexadecimal Format
Char Format

Changes the display format of expressions. The display format setting affects different types of expressions in different ways. Your selection of display format is saved between debug sessions. These commands are available if a selected line in the window contains a variable.

The display format setting affects different types of expressions in these ways:

Variables	The display setting affects only the selected variable, not other variables.
Array elements	The display setting affects the complete array, that is, the same display format is used for each array element.

Structure fields	All elements with the same definition—the same field name and C declaration type—are affected by the display setting.

Show As

Displays a submenu that provides commands for changing the default type interpretation of variables. The commands on this submenu are mainly useful for assembler variables—data at assembler labels—because these are, by default, displayed as integers. For more information, see *Viewing assembler variables*, page 104.

Save to File

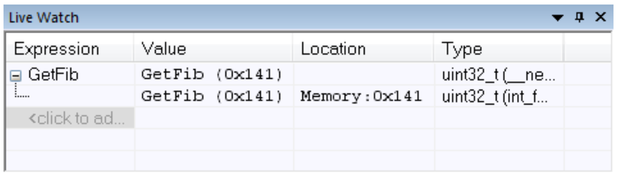
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options for C-SPY windows.

Live Watch window

The **Live Watch** window is available from the **View** menu.



Expression	Value	Location	Type
⊟ GetFib	GetFib (0x141)		uint32_t (__ne...
	GetFib (0x141)	Memory:0x141	uint32_t (int_f...
<click to ad...			

This window repeatedly samples and displays the value of expressions while your application is executing. Variables in the expressions must be statically located, such as global variables.

See also *Editing in C-SPY windows*, page 45.

Requirements

None; this window is always available.

Display area

This area contains these columns:

Expression

The name of the variable. The base name of the variable is followed by the full name, which includes module, class, or function scope. This column is not editable.

Value

The value of the variable. Values that have changed are highlighted in red.

Dragging text or a variable from another window and dropping it on the **Value** column will assign a new value to the variable in that row.

This column is editable.

Location

The location in memory where this variable is stored.

Type

The data type of the variable.

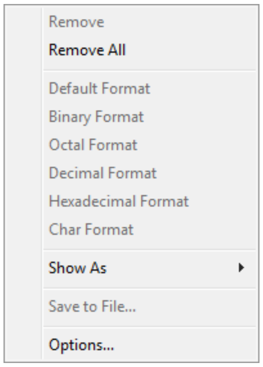
Note: There are restrictions to what this window can display:

For the OCD debugger driver, a maximum of 8 variables with a maximum total size of 16 bytes can be displayed.

For all debugger drivers, only 8 or 16-bit values can be guaranteed to be displayed correctly, and the data must be located at an even address.

Context menu

This context menu is available:



Note: The contents of this menu are dynamic and depend on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Remove

Removes the selected expression from the window.

Remove All

Removes all expressions listed in the window.

Default Format
Binary Format
Octal Format
Decimal Format
Hexadecimal Format
Char Format

Changes the display format of expressions. The display format setting affects different types of expressions in different ways. Your selection of display format is saved between debug sessions. These commands are available if a selected line in the window contains a variable.

The display format setting affects different types of expressions in these ways:

Variables	The display setting affects only the selected variable, not other variables.
Array elements	The display setting affects the complete array, that is, the same display format is used for each array element.
Structure fields	All elements with the same definition—the same field name and C declaration type—are affected by the display setting.

Show As

Displays a submenu that provides commands for changing the default type interpretation of variables. The commands on this submenu are mainly useful for assembler variables—data at assembler labels—because these are, by default, displayed as integers. For more information, see *Viewing assembler variables*, page 104.

Save to File

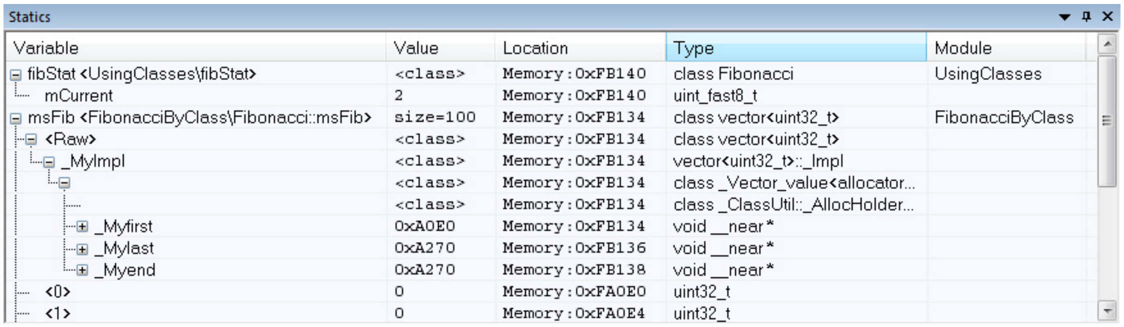
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options for C-SPY windows.

Statics window

The **Statics** window is available from the **View** menu.



Statics

Variable	Value	Location	Type	Module
⊟ fibStat <UsingClasses\fibStat>	<class>	Memory:0xFB140	class Fibonacci	UsingClasses
mCurrent	2	Memory:0xFB140	uint_fast8_t	
⊟ msFib <FibonacciByClass\Fibonacci::msFib>	size=100	Memory:0xFB134	class vector<uint32_t>	FibonacciByClass
⊟ <Raw>	<class>	Memory:0xFB134	class vector<uint32_t>	
⊟ _MyImpl	<class>	Memory:0xFB134	vector<uint32_t>::_Impl	
⊟	<class>	Memory:0xFB134	class _Vector_value<allocator...	
	<class>	Memory:0xFB134	class _ClassUtil::_AllocHolder...	
⊞ _Myfirst	0xA0E0	Memory:0xFB134	void __near*	
⊞ _Mylast	0xA270	Memory:0xFB136	void __near*	
⊞ _Myend	0xA270	Memory:0xFB138	void __near*	
<0>	0	Memory:0xFA0E0	uint32_t	
<1>	0	Memory:0xFA0E4	uint32_t	

This window displays the values of variables with static storage duration that you have selected. Typically, that is variables with file scope but it can also be static variables in functions and classes. Note that `volatile` declared variables with static storage duration will not be displayed.

Every time execution in C-SPY stops, the values in the **Statics** window are recalculated. Values that have changed since the last stop are highlighted in red.

Click any column header (except for **Value**) to sort on that column.

See also *Editing in C-SPY windows*, page 45.

To select variables to monitor:

1. In the window, right-click and choose **Select statics** from the context menu. The window now lists all variables with static storage duration.
2. Either individually select the variables you want to display, or choose one of the **Select** commands from the context menu.
3. When you have made your selections, choose **Select statics** from the context menu to toggle back to normal display mode.

Requirements

None; this window is always available.

Display area

This area contains these columns:

Variable

The name of the variable. The base name of the variable is followed by the full name, which includes module, class, or function scope. This column is not editable.

Value

The value of the variable. Values that have changed are highlighted in red.

Dragging text or a variable from another window and dropping it on the **Value** column will assign a new value to the variable in that row.

This column is editable.

Location

The location in memory where this variable is stored.

Type

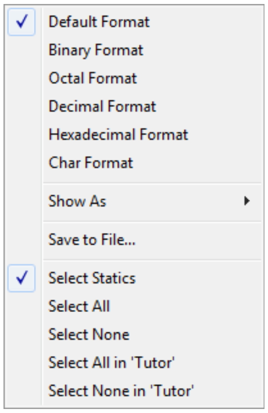
The data type of the variable.

Module

The module of the variable.

Context menu

This context menu is available:



These commands are available:

Default Format
Binary Format
Octal Format
Decimal Format
Hexadecimal Format
Char Format

Changes the display format of expressions. The display format setting affects different types of expressions in different ways. Your selection of display format is saved between debug sessions. These commands are available if a selected line in the window contains a variable.

The display format setting affects different types of expressions in these ways:

Variables	The display setting affects only the selected variable, not other variables.
Array elements	The display setting affects the complete array, that is, the same display format is used for each array element.
Structure fields	All elements with the same definition—the same field name and C declaration type—are affected by the display setting.

Show As

Displays a submenu that provides commands for changing the default type interpretation of variables. The commands on this submenu are mainly useful for assembler variables—data at assembler labels—because these are, by default, displayed as integers. For more information, see *Viewing assembler variables*, page 104.

Save to File

Saves the content of the **Statics** window to a log file.

Select Statics

Selects all variables with static storage duration; this command also enables all **Select** commands below. Select the variables you want to monitor. When you have made your selections, select this menu command again to toggle back to normal display mode.

Select All

Selects all variables.

Select None

Deselects all variables.

Select All in *module*

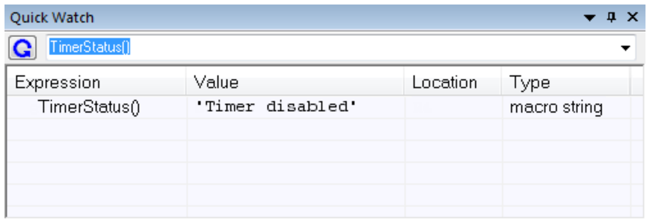
Selects all variables in the selected module.

Select None in *module*

Deselects all variables in the selected module.

Quick Watch window

The **Quick Watch** window is available from the **View** menu and from the context menu in the editor window.



Expression	Value	Location	Type
TimerStatus()	'Timer disabled'		macro string

Use this window to watch the value of a variable or expression and evaluate expressions at a specific point in time.

In contrast to the **Watch** window, the **Quick Watch** window gives you precise control over when to evaluate the expression. For single variables this might not be necessary, but for expressions with possible side effects, such as assignments and C-SPY macro functions, it allows you to perform evaluations under controlled conditions.

See also *Editing in C-SPY windows*, page 45.

To evaluate an expression:

1. In the editor window, right-click on the expression you want to examine and choose **Quick Watch** from the context menu that appears.
2. The expression will automatically appear in the **Quick Watch** window.

Alternatively:

3. In the **Quick Watch** window, type the expression you want to examine in the **Expressions** text box.
4. Click the **Recalculate** button to calculate the value of the expression.

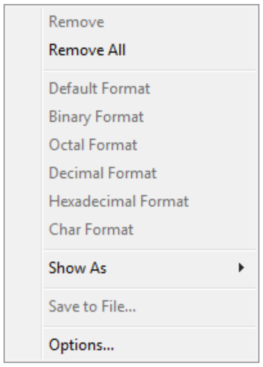
For an example, see *Using C-SPY macros*, page 323.

Requirements

None; this window is always available.

Context menu

This context menu is available:



Note: The contents of this menu are dynamic and depend on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Remove

Removes the selected expression from the window.

Remove All

Removes all expressions listed in the window.

Default Format
Binary Format
Octal Format
Decimal Format
Hexadecimal Format
Char Format

Changes the display format of expressions. The display format setting affects different types of expressions in different ways. Your selection of display format is saved between debug sessions. These commands are available if a selected line in the window contains a variable.

The display format setting affects different types of expressions in these ways:

Variables	The display setting affects only the selected variable, not other variables.
Array elements	The display setting affects the complete array, that is, the same display format is used for each array element.
Structure fields	All elements with the same definition—the same field name and C declaration type—are affected by the display setting.

Show As

Displays a submenu that provides commands for changing the default type interpretation of variables. The commands on this submenu are mainly useful for assembler variables—data at assembler labels—because these are, by default, displayed as integers. For more information, see *Viewing assembler variables*, page 104.

Save to File

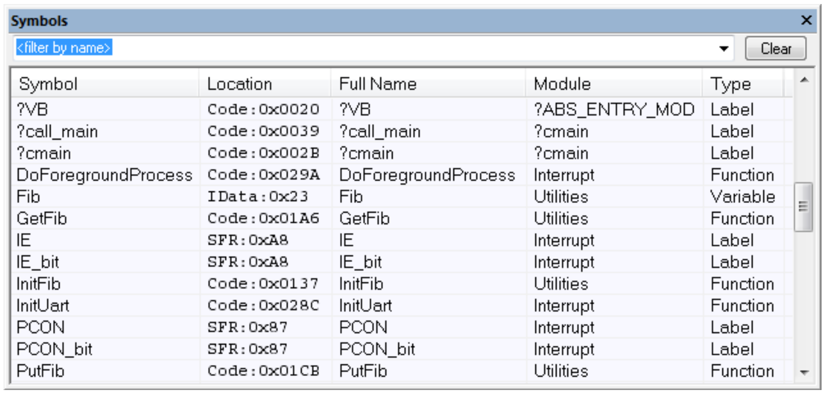
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options for C-SPY windows.

Symbols window

The **Symbols** window is available from the **View** menu.



Symbol	Location	Full Name	Module	Type
?VB	Code:0x0020	?VB	?ABS_ENTRY_MOD	Label
?call_main	Code:0x0039	?call_main	?cmain	Label
?cmain	Code:0x002B	?cmain	?cmain	Label
DoForegroundProcess	Code:0x029A	DoForegroundProcess	Interrupt	Function
Fib	IData:0x23	Fib	Utilities	Variable
GetFib	Code:0x01A6	GetFib	Utilities	Function
IE	SFR:0xA8	IE	Interrupt	Label
IE_bit	SFR:0xA8	IE_bit	Interrupt	Label
InitFib	Code:0x0137	InitFib	Utilities	Function
InitUart	Code:0x028C	InitUart	Interrupt	Function
PCON	SFR:0x87	PCON	Interrupt	Label
PCON_bit	SFR:0x87	PCON_bit	Interrupt	Label
PutFib	Code:0x01CB	PutFib	Utilities	Function

This window displays all symbols with a static location, that is, C/C++ functions, assembler labels, and variables with static storage duration, including symbols from the runtime library.

You can drag the contents of cells in the **Symbol**, **Location**, and **Full Name** columns and drop in some other windows in the IDE.

Requirements

None; this window is always available.

Toolbar

The toolbar contains:

<filter by name>

Type the first characters of the symbol names that you want to find, and press Enter. All symbols (of the types you have selected on the context menu) whose name starts with these characters will be displayed. If you have chosen not to display some types of symbols, the window will list how many of those that were found but are not displayed.

Use the drop-down list to use old search strings. The search box has a history depth of 8 search entries.

Clear

Cancels the effects of the search filter and restores all symbols in the window.

Display area

This area contains these columns:

Symbol

The symbol name.

Location

The memory address.

Full name

The symbol name; often the same as the contents of the **Symbol** column but differs for example for C++ member functions.

Module

The program module where the symbol is defined.

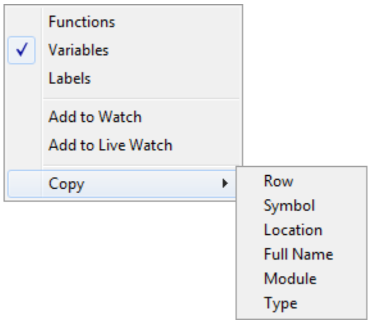
Type

The symbol type, whether it is a function, label, or variable.

Click the column headers to sort the list by symbol name, location, full name, module, or type.

Context menu

This context menu is available:



These commands are available:

Functions

Toggles the display of function symbols on or off in the list.

Variables

Toggles the display of variables on or off in the list.

Labels

Toggles the display of labels on or off in the list.

Add to Watch

Adds the selected symbol to the **Watch** window.

Add to Live Watch

Adds the selected symbol to the **Live Watch** window.

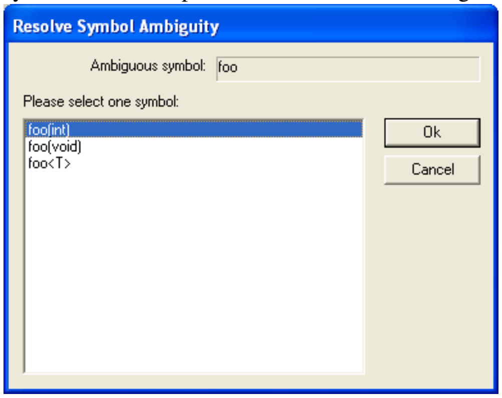
Copy

Copies the contents of the cells on the selected line.

Row	Copies all contents of the selected line
Symbol	Copies the contents of the **Symbol** cell on the selected line
Location	Copies the contents of the **Location** cell on the selected line
Full Name	Copies the contents of the **Full Name** cell on the selected line
Module	Copies the contents of the **Module** cell on the selected line
Type	Copies the contents of the **Type** cell on the selected line

Resolve Symbol Ambiguity dialog box

The **Resolve Symbol Ambiguity** dialog box appears, for example, when you specify a symbol in the **Disassembly** window to go to, and there are several instances of the same symbol due to templates or function overloading.



Ambiguous symbol: foo

foo(int)
foo(void)
foo<T>

Requirements

None; this window is always available.

Ambiguous symbol

Indicates which symbol that is ambiguous.

Please select one symbol

A list of possible matches for the ambiguous symbol. Select the one you want to use.

Breakpoints

- Introduction to setting and using breakpoints
- Setting breakpoints
- Reference information on breakpoints

Introduction to setting and using breakpoints

These topics are covered:

- Reasons for using breakpoints
- Briefly about setting breakpoints
- Breakpoint types
- Breakpoint icons
- Breakpoints in the C-SPY simulator
- Breakpoints in the C-SPY hardware debugger drivers
- Breakpoint consumers

REASONS FOR USING BREAKPOINTS

C-SPY® lets you set various types of breakpoints in the application you are debugging, allowing you to stop at locations of particular interest. You can set a breakpoint at a *code* location to investigate whether your program logic is correct, or to get trace printouts. In addition to code breakpoints, and depending on what C-SPY driver you are using, additional breakpoint types might be available. For example, you might be able to set a *data* breakpoint, to investigate how and when the data changes.

You can let the execution stop under certain *conditions*, which you specify. You can also let the breakpoint trigger a *side effect*, for instance executing a C-SPY macro function, by transparently stopping the execution and then resuming. The macro function can be defined to perform a wide variety of actions, for instance, simulating hardware behavior.

All these possibilities provide you with a flexible tool for investigating the status of your application.

BRIEFLY ABOUT SETTING BREAKPOINTS

You can set breakpoints in many various ways, allowing for different levels of interaction, precision, timing, and automation. All the breakpoints you define will appear in the **Breakpoints** window. From this window you can conveniently view all breakpoints, enable and disable breakpoints, and open a dialog box for defining new breakpoints. The **Breakpoint Usage** window also lists all internally used breakpoints, see *Breakpoint consumers*, page 129.

Breakpoints are set with a higher precision than single lines, using the same mechanism as when stepping. For more information about the precision, see *Single stepping*, page 64.

You can set breakpoints while you edit your code even if no debug session is active. The breakpoints will then be validated when the debug session starts. Breakpoints are preserved between debug sessions.

Note: For most hardware debugger systems it is only possible to set breakpoints when the application is not executing.

BREAKPOINT TYPES

Depending on the C-SPY driver you are using, C-SPY supports different types of breakpoints.

Code breakpoints

Code breakpoints are used for code locations to investigate whether your program logic is correct or to get trace printouts. Code breakpoints are triggered when an instruction is fetched from the specified location. If you have set the breakpoint on a specific machine instruction, the breakpoint will be triggered and the execution will stop, before the instruction is executed.

If you are using the C-SPY OCD driver, code breakpoints (implemented as software breakpoints) are only available when a device based on the S2 or S3 core has been selected. When a device based on the S1 core has been selected, you must instead use Code hardware breakpoints.

Code hardware breakpoints

Code hardware breakpoints are triggered when an instruction is fetched from the specified location. If you have set the breakpoint on a specific machine instruction, the breakpoint will be triggered and the execution will stop.

For emulators supporting **Fetch break before execution**, the breakpoint type Code hardware is implemented as an *event fetch* breakpoint.

For the OCD emulators, the breakpoint type Code hardware is implemented as a *break after execution* hardware event; see the description under *Event breakpoints*, page 127.

Event breakpoints

The hardware debugger systems can define one or more hardware events, such as various types of fetch conditions and various data access conditions, and sequences of events. You can make use of these events by setting *Event breakpoints*. You can make these event breakpoints to be either code or data breakpoints.

For the OCD emulators, fetch condition hardware events are of the type *break after execution*. When a hardware event is used as a code breakpoint, execution always slips a number of cycles from the address the breakpoint has been set on. This slip occurs also when you use debug commands like **Step Over**, **Run to cursor**, etc. Because of this, terminal I/O is not supported and the application will not stop at the exit label. To be able to use all available events (normally two) as breakpoints, you must also deselect the **Stack** options in the **IDE Options** dialog box.

Log breakpoints

Log breakpoints provide a convenient way to add trace printouts without having to add any code to your application source code. Log breakpoints are triggered when an instruction is fetched from the specified location. If you have set the breakpoint on a specific machine instruction, the breakpoint will be triggered and the execution will temporarily stop and print the specified message in the C-SPY **Debug Log** window.

Trace Start and Stop breakpoints

Trace Start and Stop breakpoints start and stop trace data collection—a convenient way to analyze instructions between two execution points.

Data breakpoints

Data breakpoints are primarily useful for variables that have a fixed address in memory. If you set a breakpoint on an accessible local variable, the breakpoint is set on the corresponding memory location. The validity of this location is only guaranteed for small parts of the code. Data breakpoints are triggered when data is accessed at the specified location. The execution will usually stop directly after the instruction that accessed the data has been executed.

Data Log breakpoints

Data log breakpoints are triggered when a specified memory address is accessed. A log entry is written in the **Data Log** window for each access. Data logs can also be displayed on the Data Log graph in the **Timeline** window, if that window is enabled.

You can set data log breakpoints using the **Breakpoints** window, the **Memory** window, and the editor window.

Using a single instruction, the microcontroller can only access values that are two bytes or less. If you specify a data log breakpoint on a memory location that cannot be accessed by one instruction, for example a `double` or a too large area in the **Memory** window, the result might not be what you intended.

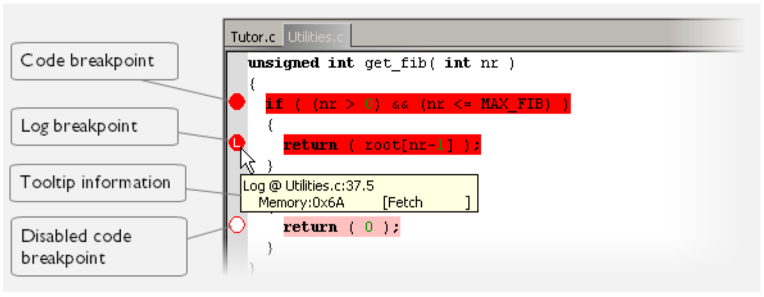
Immediate breakpoints

The C-SPY Simulator lets you set *immediate* breakpoints, which will halt instruction execution only temporarily. This allows a C-SPY macro function to be called when the simulated processor is about to read data from a location or immediately after it has written data. Instruction execution will resume after the action.

This type of breakpoint is useful for simulating memory-mapped devices of various kinds (for instance serial ports and timers). When the simulated processor reads from a memory-mapped location, a C-SPY macro function can intervene and supply appropriate data. Conversely, when the simulated processor writes to a memory-mapped location, a C-SPY macro function can act on the value that was written.

BREAKPOINT ICONS

A breakpoint is marked with an icon in the left margin of the editor window, and the icon varies with the type of breakpoint:



```
unsigned int get_fib( int nr )
{
  if ( (nr > 0) && (nr <= MAX_FIB) )
  {
    return ( root[nr-1] );
  }
```

```
Log @ Utilities.c:37.5
  Memory:0x6A        [Fetch        ]
```

```
    return ( 0 );
  }
}
```

If the breakpoint icon does not appear, make sure the option **Show bookmarks** is selected, see Editor options in the *IDE Project Management and Building Guide for RL78*.

Just point at the breakpoint icon with the mouse pointer to get detailed tooltip information about all breakpoints set on the same location. The first row gives user breakpoint information, the following rows describe the physical breakpoints used for implementing the user breakpoint. The latter information can also be seen in the **Breakpoint Usage** window.

Note: The breakpoint icons might look different for the C-SPY driver you are using.

BREAKPOINTS IN THE C-SPY SIMULATOR

The C-SPY simulator supports all breakpoint types and you can set an unlimited amount of breakpoints.

BREAKPOINTS IN THE C-SPY HARDWARE DEBUGGER DRIVERS

Using the C-SPY drivers for hardware debugger systems you can set various breakpoint types. If possible, the debugger will use software breakpoints for the breakpoints you set, unless you explicitly set a code hardware breakpoint. However, software breakpoints are not available for the OCD driver when using an S1 core. The amount of code hardware breakpoints you can set is limited and depends on the number of *hardware breakpoints* available on the target system.

This table summarizes the characteristics of breakpoints for the different target systems:

C-SPY hardware debugger driver	Code and Log breakpoints	Trace breakpoints	Data breakpoints
The OCD driver			
using hardware breakpoints	Device-specific	Device-specific	Device-specific
using software breakpoints	Unlimited	—	—
IECUBE			
using hardware breakpoints	Device-specific	Device-specific	Device-specific
using software breakpoints	Unlimited	—	—

Table 8: Available breakpoints in C-SPY hardware debugger drivers

Note: Data and Trace breakpoints can be set using the **Edit Events** dialog box. Code breakpoints can be set using either the **Edit Events** dialog box or the **Code HW** breakpoints dialog box.

Note: If you are using the E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, or TK emulator, breakpoints are ignored in code during single stepping. See *Breakpoints when single stepping using the OCD driver*, page 65.

BREAKPOINT CONSUMERS

A debugger system includes several consumers of breakpoints.

User breakpoints

The breakpoints you define in the breakpoint dialog box or by toggling breakpoints in the editor window often consume one physical breakpoint each, but this can vary greatly. Some user breakpoints consume several physical breakpoints and conversely, several user breakpoints can share one physical breakpoint. User breakpoints are displayed in the same way both in the **Breakpoint Usage** window and in the **Breakpoints** window, for example **Data @[R] callCount**.

C-SPY itself

C-SPY itself also consumes breakpoints. C-SPY will set a breakpoint if:

- The debugger option **Run to** has been selected, and any step command is used. These are temporary breakpoints which are only set during a debug session. This means that they are not visible in the **Breakpoints** window.
- The linker option **Include C-SPY debugging support** has been selected.

  In the DLIB runtime environment, C-SPY will set a system breakpoint on the `__DebugBreak` label.

These types of breakpoint consumers are displayed in the **Breakpoint Usage** window, for example, **C-SPY Terminal I/O & libsupport module**.

C-SPY plugin modules

For example, modules for real-time operating systems can consume additional breakpoints. Specifically, by default, the **Stack** window consumes one physical breakpoint.

To disable the breakpoint used by the Stack window:

1. Choose **Tools>Options>Stack**.
2. Deselect the **Stack pointer(s) not valid until program reaches:** *label* option.

   To disable the **Stack** window entirely, choose **Tools>Options>Stack** and make sure all options are deselected.

Setting breakpoints

These tasks are covered:

- Various ways to set a breakpoint
- Toggling a simple code breakpoint
- Setting breakpoints using the dialog box
- Setting a data breakpoint in the Memory window
- Setting breakpoints using system macros
- Useful breakpoint hints

VARIOUS WAYS TO SET A BREAKPOINT

You can set a breakpoint in various ways:

- Toggling a simple code breakpoint.
- Using the **New Breakpoints** dialog box and the **Edit Breakpoints** dialog box available from the context menus in the editor window, **Breakpoints** window, and in the **Disassembly** window. The dialog boxes give you access to all breakpoint options.
- Setting a data breakpoint on a memory area directly in the **Memory** window.
- Using predefined system macros for setting breakpoints, which allows automation.

The different methods offer different levels of simplicity, complexity, and automation.

TOGGLING A SIMPLE CODE BREAKPOINT

Toggling a code breakpoint is a quick method of setting a breakpoint. The following methods are available both in the editor window and in the **Disassembly** window:

- Click in the gray left-side margin of the window
- Place the insertion point in the C source statement or assembler instruction where you want the breakpoint, and click the **Toggle Breakpoint** button in the toolbar
- Choose **Edit>Toggle Breakpoint**
- Right-click and choose **Toggle Breakpoint** from the context menu.

SETTING BREAKPOINTS USING THE DIALOG BOX

The advantage of using a breakpoint dialog box is that it provides you with a graphical interface where you can interactively fine-tune the characteristics of the breakpoints. You can set the options and quickly test whether the breakpoint works according to your intentions.

All breakpoints you define using a breakpoint dialog box are preserved between debug sessions.

You can open the dialog box from the context menu available in the editor window, **Breakpoints** window, and in the **Disassembly** window.

To set a new breakpoint:

1 Choose **View>Breakpoints** to open the **Breakpoints** window.

2 In the **Breakpoints** window, right-click, and choose **New Breakpoint** from the context menu.

3 On the submenu, choose the breakpoint type you want to set.

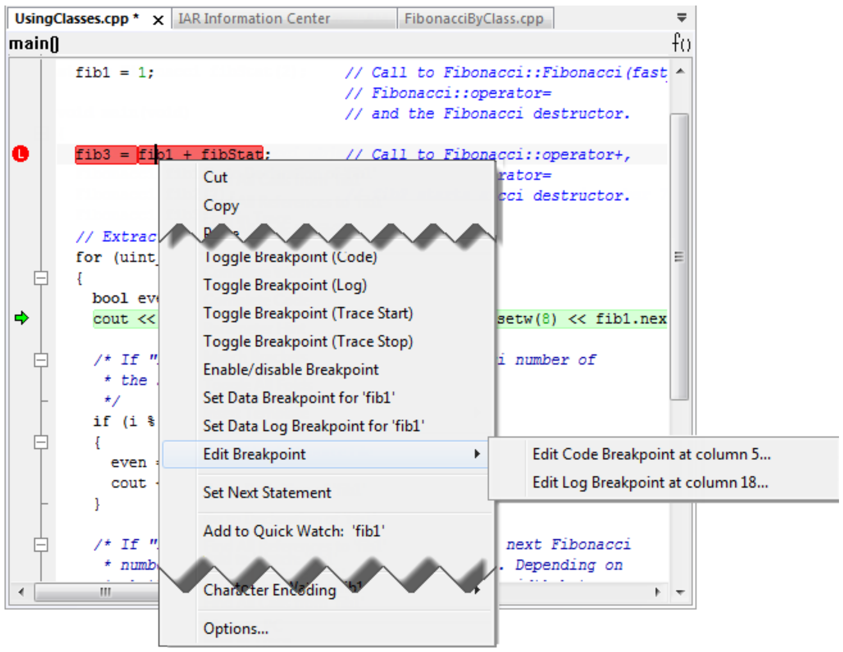
Depending on the C-SPY driver you are using, different breakpoint types are available.

4 In the breakpoint dialog box that appears, specify the breakpoint settings and click **OK**.

The breakpoint is displayed in the **Breakpoints** window.

To modify an existing breakpoint:

1 In the **Breakpoints** window, editor window, or in the **Disassembly** window, select the breakpoint you want to modify and right-click to open the context menu.


UsingClasses.cpp *
IAR Information Center
FibonacciByClass.cpp
main()
Cut
Copy
Toggle Breakpoint (Code)
Toggle Breakpoint (Log)
Toggle Breakpoint (Trace Start)
Toggle Breakpoint (Trace Stop)
Enable/disable Breakpoint
Set Data Breakpoint for 'fib1'
Set Data Log Breakpoint for 'fib1'
Edit Breakpoint
Edit Code Breakpoint at column 5...
Edit Log Breakpoint at column 18...
Set Next Statement
Add to Quick Watch: 'fib1'
Character Encoding
Options...

```
fib1 = 1;                 // Call to Fibonacci::Fibonacci(fast
                          // Fibonacci::operator=
                          // and the Fibonacci destructor.

fib3 = fib1 + fibStat;    // Call to Fibonacci::operator+,
                          rator=
                          cci destructor.

// Extrac
for (uint_
{
  bool ev
  cout <<                 setw(8) << fib1.nex

  /* If "                 i number of
   * the
   */
  if (i %
  {
    even
    cout
  }

  /* If "                 next Fibonacci
   * numb                 . Depending on
```

If there are several breakpoints on the same source code line, the breakpoints will be listed on a submenu.

2 On the context menu, choose the appropriate command.

3 In the breakpoint dialog box that appears, specify the breakpoint settings and click **OK**.

The breakpoint is displayed in the **Breakpoints** window.

SETTING A DATA BREAKPOINT IN THE MEMORY WINDOW

You can set breakpoints directly on a memory location in the **Memory** window. Right-click in the window and choose the breakpoint command from the context menu that appears. To set the breakpoint on a range, select a portion of the memory contents.

The breakpoint is not highlighted in the **Memory** window; instead, you can see, edit, and remove it using the **Breakpoints** window, which is available from the **View** menu. The breakpoints you set in the **Memory** window will be triggered for both read and write accesses. All breakpoints defined in this window are preserved between debug sessions.

Note: Setting breakpoints directly in the **Memory** window is only possible if the driver you use supports this.

SETTING BREAKPOINTS USING SYSTEM MACROS

You can set breakpoints not only in the breakpoint dialog box but also by using built-in C-SPY system macros. When you use system macros for setting breakpoints, the breakpoint characteristics are specified as macro parameters.

Macros are useful when you have already specified your breakpoints so that they fully meet your requirements. You can define your breakpoints in a macro file, using built-in system macros, and execute the file at C-SPY startup. The breakpoints will then be set automatically each time you start C-SPY. Another advantage is that the debug session will be documented, and that several engineers involved in the development project can share the macro files.

Note: If you use system macros for setting breakpoints, you can still view and modify them in the Breakpoints window. In contrast to using the dialog box for defining breakpoints, all breakpoints that are defined using system macros are removed when you exit the debug session.

These breakpoint macros are available:

C-SPY macro for breakpoints	Simulator	IECUBE	All other C-SPY drivers
`__setCodeBreak`	Yes	Yes	Yes
`__setCodeHWBreak`	--	Yes	Yes
`__setDataBreak`	Yes	—	—
`__setLogBreak`	Yes	Yes	Yes
`__setDataLogBreak`	Yes	—	—
`__setSimBreak`	Yes	—	—
`__setTraceStartBreak`	Yes	—	—
`__setTraceStopBreak`	Yes	—	—
`__clearBreak`	Yes	Yes	Yes

Table 9: C-SPY macros for breakpoints

For information about each breakpoint macro, see *Reference information on C-SPY system macros*, page 335.

Setting breakpoints at C-SPY startup using a setup macro file

You can use a setup macro file to define breakpoints at C-SPY startup. Follow the procedure described in *Using C-SPY macros*, page 323.

USEFUL BREAKPOINT HINTS

Below are some useful hints related to setting breakpoints.

Tracing incorrect function arguments

If a function with a pointer argument is sometimes incorrectly called with a `NULL` argument, you might want to debug that behavior. These methods can be useful:

- Set a breakpoint on the first line of the function with a condition that is true only when the parameter is `0`. The breakpoint will then not be triggered until the problematic situation actually occurs. The advantage of this method is that no extra source code is needed. The drawback is that the execution speed might become unacceptably low.

- You can use the `assert` macro in your problematic function, for example:

  ```
  int MyFunction(int * MyPtr)
  {
    assert(MyPtr != 0); /* Assert macro added to your source
                           code. */
    /* Here comes the rest of your function. */
  }
  ```

  The execution will break whenever the condition is true. The advantage is that the execution speed is only slightly affected, but the drawback is that you will get a small extra footprint in your source code. In addition, the only way to get rid of the execution stop is to remove the macro and rebuild your source code.

- Instead of using the `assert` macro, you can modify your function like this:

  ```
  int MyFunction(int * MyPtr)
  {
    if(MyPtr == 0)
       MyDummyStatement; /* Dummy statement where you set a
                            breakpoint. */
    /* Here comes the rest of your function. */
  }
  ```

  You must also set a breakpoint on the extra dummy statement, so that the execution will break whenever the condition is true. The advantage is that the execution speed is only very slightly affected, but the drawback is that you will still get a small extra footprint in your source code. However, in this way you can get rid of the execution stop by just removing the breakpoint.

Performing a task and continuing execution

You can perform a task when a breakpoint is triggered and then automatically continue execution.

You can use the **Action** text box to associate an action with the breakpoint, for instance a C-SPY macro function. When the breakpoint is triggered and the execution of your application has stopped, the macro function will be executed. In this case, the execution will not continue automatically.

Instead, you can set a condition which returns `0` (false). When the breakpoint is triggered, the condition—which can be a call to a C-SPY macro that performs a task—is evaluated and because it is not true, execution continues.

Consider this example where the C-SPY macro function performs a simple task:

```
__var my_counter;

count()
{
  my_counter += 1;
  return 0;
}
```

To use this function as a condition for the breakpoint, type `count()` in the **Expression** text box under **Conditions**. The task will then be performed when the breakpoint is triggered. Because the macro function `count` returns `0`, the condition is false and the execution of the program will resume automatically, without any stop.

Reference information on breakpoints

Reference information about:

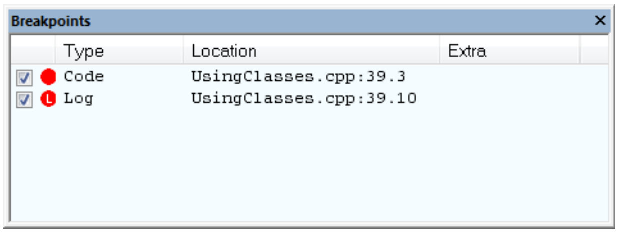
- *Breakpoints window*, page 137
- *Breakpoint Usage window*, page 139
- *Code breakpoints dialog box*, page 140
- *Code HW breakpoints dialog box*, page 141
- *Event breakpoints dialog box*, page 142
- *Log breakpoints dialog box*, page 143
- *Data breakpoints dialog box*, page 145
- *Data Log breakpoints dialog box*, page 147
- *Immediate breakpoints dialog box*, page 148
- *Enter Location dialog box*, page 149
- *Resolve Source Ambiguity dialog box*, page 150

See also:

- *Reference information on C-SPY system macros*, page 335
- *Reference information on trace*, page 199

Breakpoints window

The **Breakpoints** window is available from the **View** menu.



Breakpoints

	Type	Location	Extra
✓ ●	Code	UsingClasses.cpp:39.3	
✓ ●	Log	UsingClasses.cpp:39.10	

This window lists all breakpoints you define.

Use this window to conveniently monitor, enable, and disable breakpoints; you can also define new breakpoints and modify existing breakpoints.

Requirements

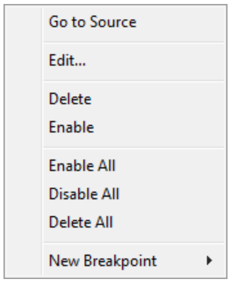
None; this window is always available.

Display area

This area lists all breakpoints you define. For each breakpoint, information about the breakpoint type, source file, source line, and source column is provided.

Context menu

This context menu is available:



These commands are available:

Go to Source

Moves the insertion point to the location of the breakpoint, if the breakpoint has a source location. Double-click a breakpoint in the **Breakpoints** window to perform the same command.

Edit

Opens the breakpoint dialog box for the breakpoint you selected.

Delete

Deletes the breakpoint. Press the Delete key to perform the same command.

Enable

Enables the breakpoint. The check box at the beginning of the line will be selected. You can also perform the command by manually selecting the check box. This command is only available if the breakpoint is disabled.

Disable

Disables the breakpoint. The check box at the beginning of the line will be deselected. You can also perform this command by manually deselecting the check box. This command is only available if the breakpoint is enabled.

Enable All

Enables all defined breakpoints.

Disable All

Disables all defined breakpoints.

Delete All

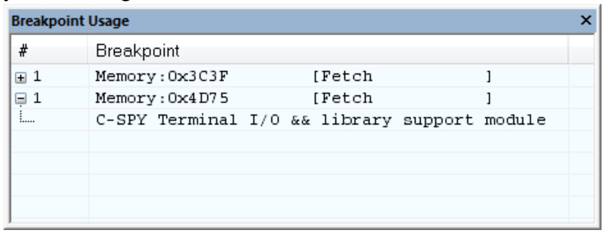
Deletes all defined breakpoints.

New Breakpoint

Displays a submenu where you can open the breakpoint dialog box for the available breakpoint types. All breakpoints you define using this dialog box are preserved between debug sessions.

Breakpoint Usage window

The **Breakpoint Usage** window is available from the menu specific to the C-SPY driver you are using.



```
#      Breakpoint
⊞ 1    Memory:0x3C3F      [Fetch          ]
⊟ 1    Memory:0x4D75      [Fetch          ]
       C-SPY Terminal I/O && library support module
```

This window lists all breakpoints currently set in the target system, both the ones you have defined and the ones used internally by C-SPY. The format of the items in this window depends on the C-SPY driver you are using.

The window gives a low-level view of all breakpoints, related but not identical to the list of breakpoints displayed in the **Breakpoints** window.

C-SPY uses breakpoints when stepping. Use the **Breakpoint Usage** window for:

- Identifying all breakpoint consumers
- Checking that the number of active breakpoints is supported by the target system
- Configuring the debugger to use the available breakpoints in a better way, if possible.

For more information, see *Breakpoints in the C-SPY hardware debugger drivers*, page 129.

Requirements

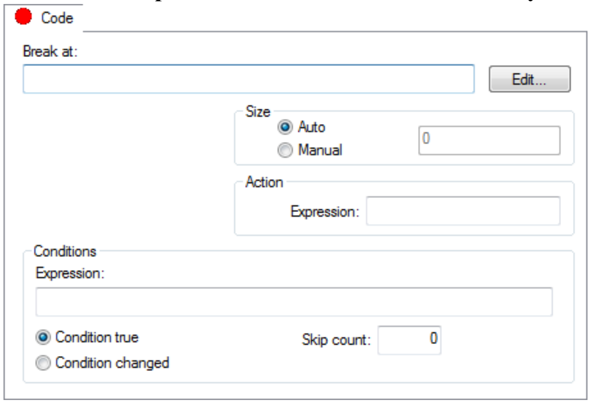
None; this window is always available.

Display area

For each breakpoint in the list, the address and access type are displayed. Each breakpoint in the list can also be expanded to show its originator.

Code breakpoints dialog box

The **Code** breakpoints dialog box is available from the context menu in the editor window, **Breakpoints** window, and in the **Disassembly** window.



This figure reflects the C-SPY simulator.

Use the **Code** breakpoints dialog box to set a code breakpoint, see *Setting breakpoints using the dialog box*, page 131.

Requirements

One of these alternatives:

- The C-SPY simulator
- The IECUBE emulator
- The E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, and TK emulators, but not for the S1 core.

Break At

Specify the code location of the breakpoint in the text box. Alternatively, click the **Edit** button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 149.

Size

Determines whether there should be a size—in practice, a range—of locations where the breakpoint will trigger. Each fetch access to the specified memory range will trigger the breakpoint. Select how to specify the size:

Auto

The size will be set automatically, typically to 1.

Manual

Specify the size of the breakpoint range in the text box.

Action

Specify a valid C-SPY expression, which is evaluated when the breakpoint is triggered and the condition is true. For more information, see *Useful breakpoint hints*, page 134.

Conditions

Specify simple or complex conditions:

Expression

Specify a valid C-SPY expression, see *C-SPY expressions*, page 100.

Condition true

The breakpoint is triggered if the value of the expression is true.

Condition changed

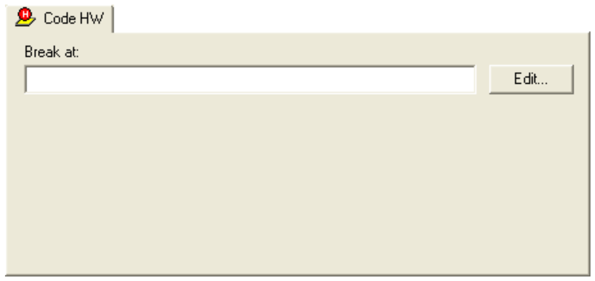
The breakpoint is triggered if the value of the expression has changed since it was last evaluated.

Skip count

The number of times that the breakpoint condition must be fulfilled before the breakpoint starts triggering. After that, the breakpoint will trigger every time the condition is fulfilled.

Code HW breakpoints dialog box

The **Code HW** breakpoints dialog box is available from the context menu in the editor window, **Breakpoints** window, and in the **Disassembly** window.



Use the **Code HW** breakpoints dialog box to set a code hardware breakpoint.

Code hardware breakpoints are triggered when an instruction is fetched from the specified location. If you have set the breakpoint on a specific machine instruction, the breakpoint will be triggered and the execution will stop. For implementation details and restrictions, see *Code hardware breakpoints*, page 126.

Requirements

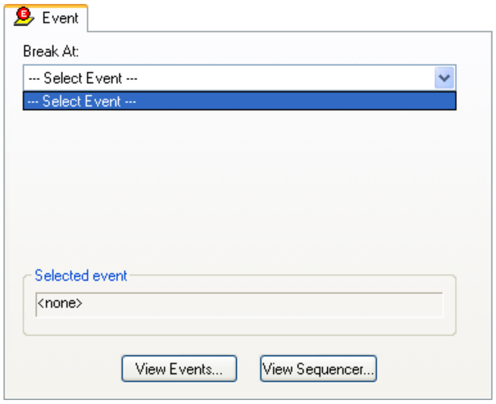
Any supported hardware debugger system.

Break At

Specify the code location of the breakpoint in the text box. Alternatively, click the **Edit** button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 149.

Event breakpoints dialog box

The **Event** breakpoints dialog box is available from the context menu in the **Breakpoints** window.



Use the **Event** breakpoints dialog box to specify an event as a breakpoint condition. You can make these event breakpoints either code or data breakpoints.

Requirements

Any supported hardware debugger system.

Break At

Select an event from the **Break At** list to use it as a condition for the breakpoint.

The list contains all events defined in the **Edit Events** or **Edit Sequencer** dialog boxes. The access type is identified by a bracketed tag:

`[F]`	Fetch

`[R]`	Read
`[W]`	Write
`[R/W]`	Read/write

For information about the access types, see *Edit Events dialog box*, page 90.

Selected event

Displays the current event to be used as a condition for the breakpoint.

View Events

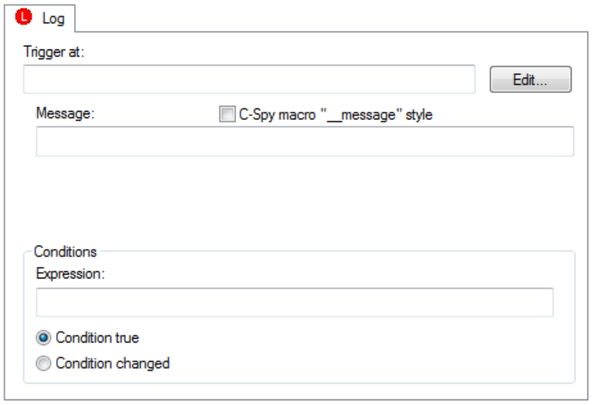
Displays the **Edit Events** dialog box in view-only mode, to let you inspect an event. To define or modify an event, open this dialog box from the **Emulator** menu. See *Edit Events dialog box*, page 90.

View Sequencer

Displays the **Edit Sequencer Events** dialog box in view-only mode, to let you inspect an event. To define or modify an event, open this dialog box from the **Emulator** menu. See *Edit Sequencer Events dialog box*, page 93.

Log breakpoints dialog box

The **Log** breakpoints dialog box is available from the context menu in the editor window, **Breakpoints** window, and in the **Disassembly** window.



This figure reflects the C-SPY simulator.

Use the **Log** breakpoints dialog box to set a log breakpoint, see *Setting breakpoints using the dialog box*, page 131.

Requirements

One of these alternatives:

- The C-SPY simulator
- The IECUBE emulator
- The E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, and TK emulators, but not for the S1 core.

Trigger at

Specify the code location of the breakpoint. Alternatively, click the **Edit** button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 149.

Message

Specify the message you want to be displayed in the C-SPY **Debug Log** window. The message can either be plain text, or—if you also select the option **C-SPY macro "__message" style**—a comma-separated list of arguments.

C-SPY macro "__message" style

Select this option to make a comma-separated list of arguments specified in the **Message** text box be treated exactly as the arguments to the C-SPY macro language statement `__message`, see *Formatted output*, page 331.

Conditions

Specify simple or complex conditions:

Expression

Specify a valid C-SPY expression, see *C-SPY expressions*, page 100.

Condition true

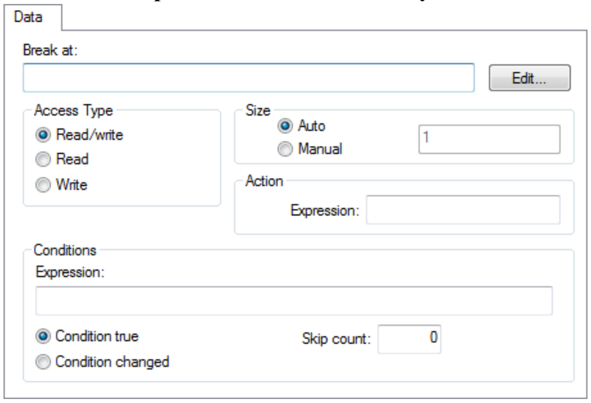
The breakpoint is triggered if the value of the expression is true.

Condition changed

The breakpoint is triggered if the value of the expression has changed since it was last evaluated.

Data breakpoints dialog box

The **Data** breakpoints dialog box is available from the context menu in the editor window, **Breakpoints** window, the **Memory** window, and in the **Disassembly** window.



This figure reflects the C-SPY simulator.

Use the **Data** breakpoints dialog box to set a data breakpoint, see *Setting breakpoints using the dialog box*, page 131. Data breakpoints never stop execution within a single instruction. They are recorded and reported after the instruction is executed.

Requirements

The C-SPY simulator.

Break At

Specify the data location of the breakpoint in the text box. Alternatively, click the **Edit** button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 149.

Access Type

Selects the type of memory access that triggers the breakpoint:

Read/Write

Reads from or writes to location.

Read

Reads from location.

Write

Writes to location.

Size

Determines whether there should be a size—in practice, a range—of locations where the breakpoint will trigger. Each fetch access to the specified memory range will trigger the breakpoint. Select how to specify the size:

Auto

The size will automatically be based on the type of expression the breakpoint is set on. For example, if you set the breakpoint on a 12-byte structure, the size of the breakpoint will be 12 bytes.

Manual

Specify the size of the breakpoint range in the text box.

For data breakpoints, this can be useful if you want the breakpoint to be triggered on accesses to data structures, such as arrays, structs, and unions.

Action

Specify a valid C-SPY expression, which is evaluated when the breakpoint is triggered and the condition is true. For more information, see *Useful breakpoint hints*, page 134.

Conditions

Specify simple or complex conditions:

Expression

Specify a valid C-SPY expression, see *C-SPY expressions*, page 100.

Condition true

The breakpoint is triggered if the value of the expression is true.

Condition changed

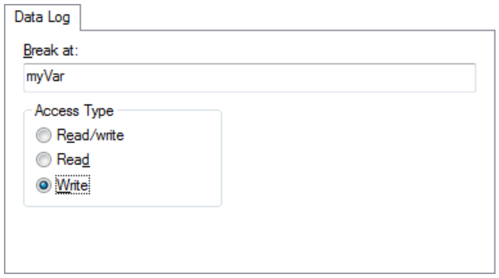
The breakpoint is triggered if the value of the expression has changed since it was last evaluated.

Skip count

The number of times that the breakpoint condition must be fulfilled before the breakpoint starts triggering. After that, the breakpoint will trigger every time the condition is fulfilled.

Data Log breakpoints dialog box

The **Data Log** breakpoints dialog box is available from the context menu in the **Breakpoints** window.



Use the **Data Log** breakpoints dialog box to set a maximum of four data log breakpoints on memory addresses, see *Setting breakpoints using the dialog box*, page 131.

See also *Data Log breakpoints*, page 127 and *Getting started using data logging*, page 226.

Requirements

The C-SPY simulator.

Break At

Specify a memory location as a variable (with static storage duration) or as an address.

Access Type

Selects the type of access to the variable that generates a log entry:

Read/Write

Read and write accesses from or writes to location of the variable.

Read

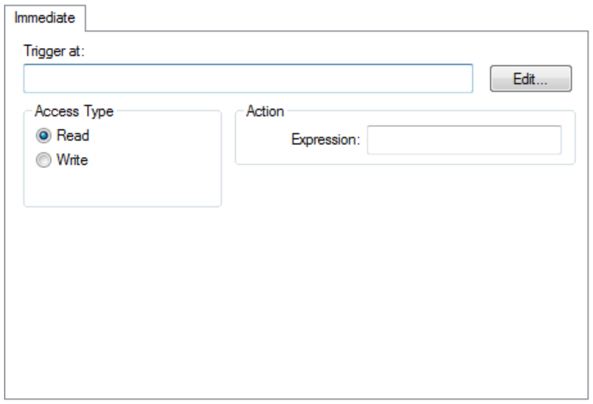
Read accesses from the location of the variable.

Write

Write accesses to location of the variable.

Immediate breakpoints dialog box

The **Immediate** breakpoints dialog box is available from the context menu in the editor window, **Breakpoints** window, the **Memory** window, and in the **Disassembly** window.



Access Type: [✓ Read] Write

In the C-SPY simulator, use the **Immediate** breakpoints dialog box to set an immediate breakpoint, see *Setting breakpoints using the dialog box*, page 131. Immediate breakpoints do not stop execution at all; they only suspend it temporarily.

Requirements

The C-SPY simulator.

Trigger at

Specify the data location of the breakpoint. Alternatively, click the **Edit** button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 149.

Access Type

Selects the type of memory access that triggers the breakpoint:

Read

Reads from location.

Write

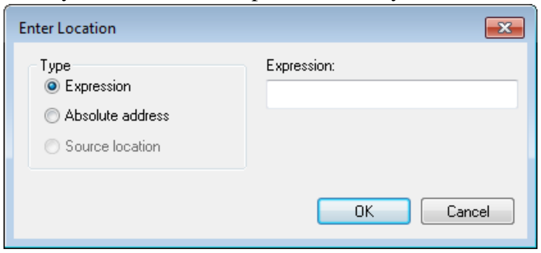
Writes to location.

Action

Specify a valid C-SPY expression, which is evaluated when the breakpoint is triggered and the condition is true. For more information, see *Useful breakpoint hints*, page 134.

Enter Location dialog box

The **Enter Location** dialog box is available from the breakpoints dialog box, either when you set a new breakpoint or when you edit a breakpoint.



Use the **Enter Location** dialog box to specify the location of the breakpoint.

Note: This dialog box looks different depending on the **Type** you select.

Type

Selects the type of location to be used for the breakpoint, choose between:

Expression

A C-SPY expression, whose value evaluates to a valid code or data location.

A code location, for example the function `main`, is typically used for code breakpoints.

A data location is the name of a variable and is typically used for data breakpoints. For example, `my_var` refers to the location of the variable `my_var`, and `arr[3]` refers to the location of the fourth element of the array `arr`. For static variables declared with the same name in several functions, use the syntax `my_func::my_static_variable` to refer to a specific variable.

For more information about C-SPY expressions, see *C-SPY expressions*, page 100.

Absolute address

An absolute location on the form *`zone`*`:`*`hexaddress`* or simply *`hexaddress`* (for example `Memory:0x42`). *`zone`* refers to C-SPY memory zones and specifies in which memory the address belongs, see *C-SPY memory zones*, page 154.

Source location

A location in your C source code using the syntax: `{`*`filename`*`}.`*`row`*`.`*`column`*`.`

`filename` specifies the filename and full path.

row specifies the row in which you want the breakpoint.

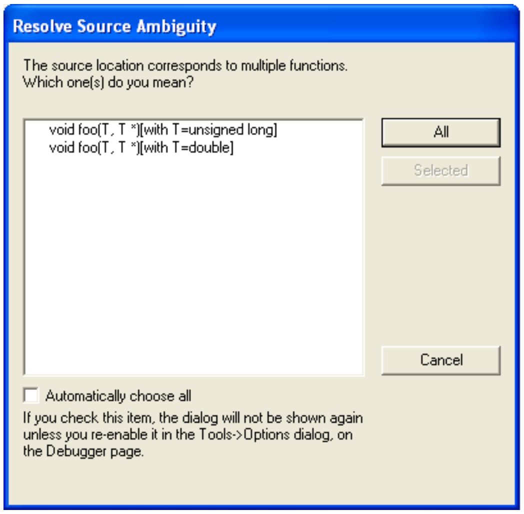
column specifies the column in which you want the breakpoint.

For example, `{C:\src\prog.c}.22.3` sets a breakpoint on the third character position on row 22 in the source file `prog.c`. Note that in quoted form, for example in a C-SPY macro, you must instead write `{C:\\src\\prog.c}.22.3`.

Note that the Source location type is usually meaningful only for code locations in code breakpoints. Depending on the C-SPY driver you are using, **Source location** might not be available for data and immediate breakpoints.

Resolve Source Ambiguity dialog box

The **Resolve Source Ambiguity** dialog box appears, for example, when you try to set a breakpoint on templates and the source location corresponds to more than one function.



Resolve Source Ambiguity

The source location corresponds to multiple functions.
Which one(s) do you mean?

```
void foo(T, T *)[with T=unsigned long]
void foo(T, T *)[with T=double]
```

If you check this item, the dialog will not be shown again unless you re-enable it in the Tools->Options dialog, on the Debugger page.

To resolve a source ambiguity, perform one of these actions:

- In the text box, select one or several of the listed locations and click **Selected**.
- Click **All**.

All

The breakpoint will be set on all listed locations.

Selected

The breakpoint will be set on the source locations that you have selected in the text box.

Cancel

No location will be used.

Automatically choose all

Determines that whenever a specified source location corresponds to more than one function, all locations will be used.

Note that this option can also be specified in the **IDE Options** dialog box, see Debugger options in the *IDE Project Management and Building Guide for RL78*.

Memory and registers

- Introduction to monitoring memory and registers
- Monitoring memory and registers
- Reference information on memory and registers

Introduction to monitoring memory and registers

These topics are covered:

- Briefly about monitoring memory and registers
- C-SPY memory zones
- Memory configuration for the C-SPY simulator

BRIEFLY ABOUT MONITORING MEMORY AND REGISTERS

C-SPY provides many windows for monitoring memory and registers, most of them available from the **View** menu:

- The **Memory** window

  Gives an up-to-date display of a specified area of memory—a memory zone—and allows you to edit it. *Data coverage* along with execution of your application is highlighted with different colors. You can fill specified areas with specific values and you can set breakpoints directly on a memory location or range. You can open several instances of this window, to monitor different memory areas. The content of the window can be regularly updated while your application is executing.
- The **Symbolic Memory** window

  Displays how variables with static storage duration are laid out in memory. This can be useful for better understanding memory usage or for investigating problems caused by variables being overwritten, for example by buffer overruns.
- The **Stack** window

  Displays the contents of the stack, including how stack variables are laid out in memory. In addition, integrity checks of the stack can be performed to detect and warn about problems with stack overflow. For example, the **Stack** window is useful for determining the optimal size of the stack. You can open up to two instances of this window, each showing different stacks or different display modes of the same stack.

- The **Register**s window

  Gives an up-to-date display of the contents of the processor registers and SFRs, and allows you to edit them. Because of the large amount of registers—memory-mapped peripheral unit registers and CPU registers—it is inconvenient to show all registers concurrently in the **Registers** window. Instead you can divide registers into *application-specific groups*. You can choose to load either predefined register groups or define your own groups. You can open several instances of this window, each showing a different register group.
- The **SFR Setup** window

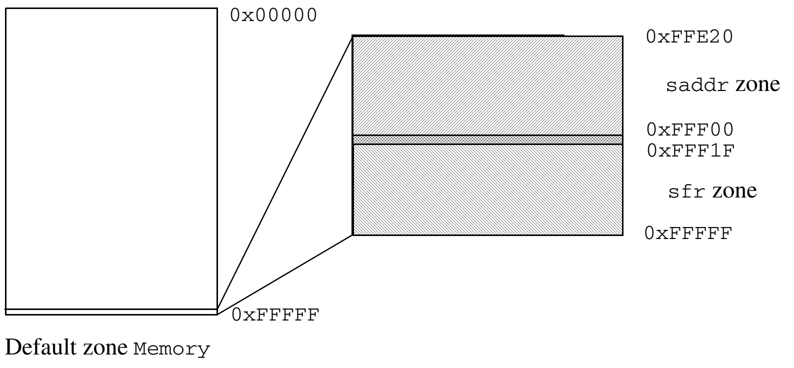
  Displays the currently defined SFRs that C-SPY has information about, both factory-defined (retrieved from the device description file) and custom-defined SFRs. If required, you can use the **Edit SFR** dialog box to customize the SFR definitions.

To view the memory contents for a specific variable, simply drag the variable to the **Memory** window or the **Symbolic** memory window. The memory area where the variable is located will appear.

Reading the value of some registers might influence the runtime behavior of your application. For example, reading the value of a UART status register might reset a pending bit, which leads to the lack of an interrupt that would have processed a received byte. To prevent this from happening, make sure that the **Registers** window containing any such registers is closed when debugging a running application.

C-SPY MEMORY ZONES

In C-SPY, the term *zone* is used for a named memory area. A memory address, or *location*, is a combination of a zone and a numerical offset into that zone. By default, the RL78 architecture has one zone, `Memory`, that covers the whole RL78 memory range (although, for convenience, there are two “shortcut” zones to the `saddr` and `sfr` areas).



Memory zones are used in several contexts, most importantly in the **Memory** and **Disassembly** windows, and in C-SPY macros. In the windows, use the **Zone** box to choose which memory zone to display.

Device-specific zones

Memory information for device-specific zones is defined in the *device description files*. When you load a device description file, additional zones that adhere to the specific memory layout become available.

See the device description file for information about available memory zones.

For more information, see *Selecting a device description file*, page 42 and *Modifying a device description file*, page 47.

MEMORY CONFIGURATION FOR THE C-SPY SIMULATOR

To simulate the target system properly, the C-SPY simulator needs information about the memory configuration. By default, C-SPY uses a configuration based on information retrieved from the device description file.

The C-SPY simulator provides various mechanisms to improve the configuration further:

- If the default memory configuration does not specify the required memory address ranges, you can specify the memory address ranges shall be based on:
  - The zones predefined in the device description file
  - The section information available in the debug file
  - Or, you can define your own memory address ranges, which you typically might want to do if the files do not specify memory ranges for the *specific* device that

you are using, but instead for a *family* of devices (perhaps with various amounts of on-chip RAM).

- For each memory address range, you can specify an *access type*. If a memory access occurs that does not agree with the specified access type, C-SPY will regard this as an illegal access and warn about it. In addition, an access to memory that is not defined is regarded as an illegal access. The purpose of memory access checking is to help you to identify memory access violations.

For more information, see *Memory Access Setup dialog box*, page 189.

Monitoring memory and registers

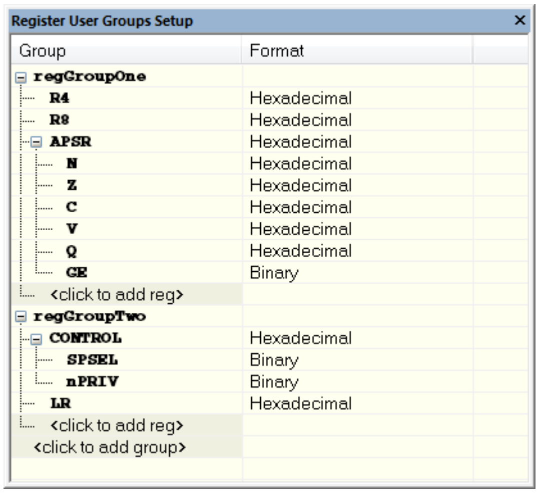
These tasks are covered:

- Defining application-specific register groups
- Monitoring stack usage

DEFINING APPLICATION-SPECIFIC REGISTER GROUPS

Defining application-specific register groups minimizes the amount of registers displayed in the **Registers** windows and makes the debugging easier.

1 Choose **View>Registers>Register User Groups Setup** during a debug session.



Register User Groups Setup

Group	Format
regGroupOne	
R4	Hexadecimal
R8	Hexadecimal
APSR	Hexadecimal
N	Hexadecimal
Z	Hexadecimal
C	Hexadecimal
V	Hexadecimal
Q	Hexadecimal
GE	Binary
<click to add reg>	
regGroupTwo	
CONTROL	Hexadecimal
SPSEL	Binary
nPRIV	Binary
LR	Hexadecimal
<click to add reg>	
<click to add group>	

Right-clicking in the window displays a context menu with commands. For information about these commands, see *Register User Groups Setup window*, page 182.

2 Click on `<click to add group>` and specify the name of your group, for example **My Timer Group** and press Enter.

3 Underneath the group name, click on `<click to add reg>` and type the name of a register, and press Enter. You can also drag a register name from another window in the IDE. Repeat this for all registers that you want to add to your group.

4 As an optional step, right-click any registers for which you want to change the integer base, and choose **Format** from the context menu to select a suitable base.

5 When you are done, your new group is now available in the **Registers** windows.

If you want to define more application-specific groups, repeat this procedure for each group you want to define.

MONITORING STACK USAGE

These are the two main use cases for the **Stack** window:

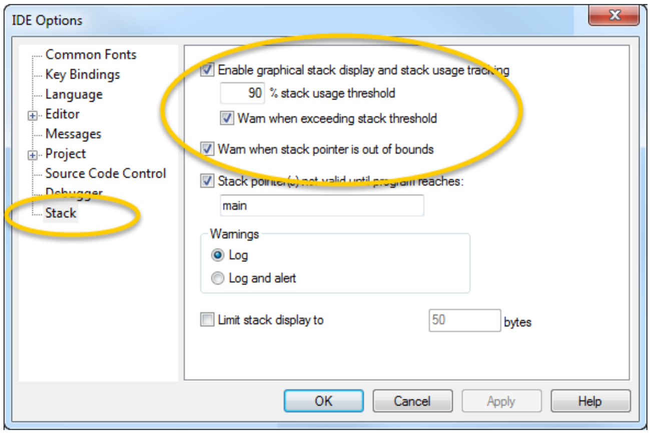
- Monitoring stack memory usage
- Monitoring the stack memory content.

In both cases, C-SPY retrieves information about the defined stack size and its allocation from the definition in the linker configuration file of the section holding the stack. If you, for some reason, have modified the stack initialization in the system startup code, `cstartup`, you should also change the section definition in the linker configuration file accordingly, otherwise the **Stack** window cannot track the stack usage. For more information, see the *IAR C/C++ Development Guide for RL78*.

To monitor stack memory usage:

1 Before you start C-SPY, choose **Tools>Options**. On the **Stack** page:

- Select **Enable graphical stack display and stack usage tracking**. This option also enables the option **Warn when exceeding stack threshold**. Specify a suitable threshold value.
- Note also the option **Warn when stack pointer is out of bounds**. Any such warnings are displayed in the **Debug Log** window.



☑ Enable graphical stack display and stack usage tracking
90 % stack usage threshold
☑ Warn when exceeding stack threshold
☑ Warn when stack pointer is out of bounds
☑ Stack pointer(s) not valid until program reaches:
main
Warnings
(● Log)
○ Log and alert
☐ Limit stack display to 50 bytes

2 Start C-SPY.

When your application is first loaded, and upon each reset, the memory for the stack area is filled with the dedicated byte value `0xCD` before the application starts executing.

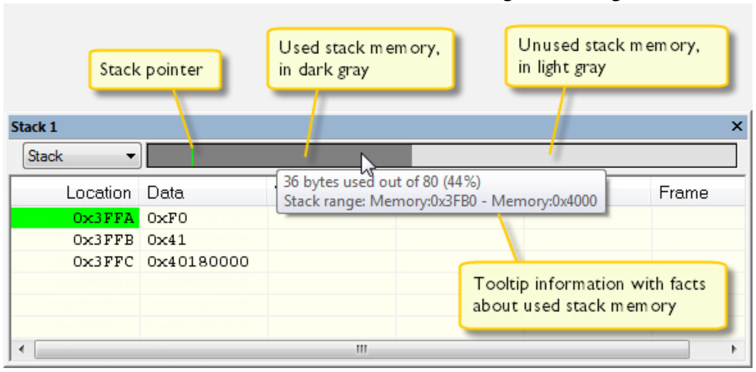
3 Choose **View>Stack>Stack 1** to open the **Stack** window.

Note that you can open up to two **Stack** windows, each showing a different stack—if several stacks are available—or the same stack with different display settings.

4 Start executing your application.

Whenever execution stops, the stack memory is searched from the end of the stack until a byte whose value is not `0xCD` is found, which is assumed to be how far the stack has been used. The light gray area of the stack bar represents the *unused* stack memory area, whereas the dark gray area of the bar represents the *used* stack memory.

For this example, you can see that only 44% of the reserved memory address range was used, which means that it could be worth considering decreasing the size of memory:


Stack pointer
Used stack memory, in dark gray
Unused stack memory, in light gray
Stack 1
Stack
Tooltip information with facts about used stack memory

36 bytes used out of 80 (44%)
Stack range: Memory:0x3FB0 - Memory:0x4000

Location	Data	Frame
0x3FFA	0xF0	
0x3FFB	0x41	
0x3FFC	0x40180000	

Note: Although this is a reasonably reliable way to track stack usage, there is no guarantee that a stack overflow is detected. For example, a stack *can* incorrectly grow outside its bounds, and even modify memory outside the stack area, without actually modifying any of the bytes near the end of the stack range. Likewise, your application might modify memory within the stack area by mistake.

To monitor the stack memory content:

1 Before you start monitoring stack memory, you might want to disable the option **Enable graphical stack display and stack usage tracking** to improve performance during debugging.

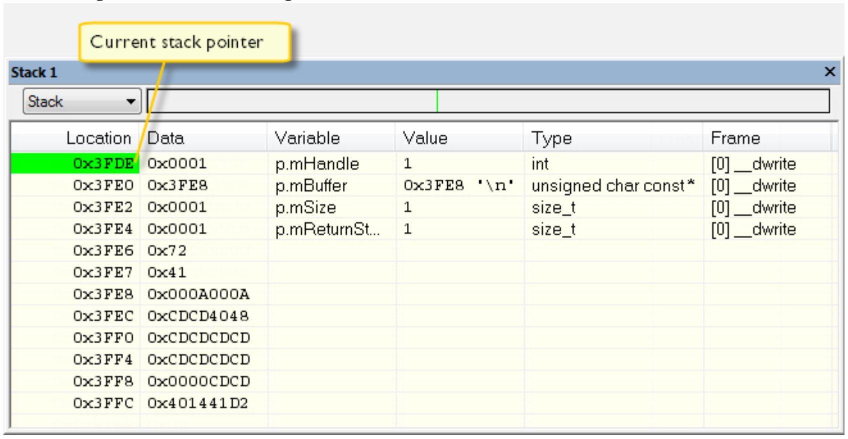
2 Start C-SPY.

3 Choose **View>Stack>Stack 1** to open the **Stack** window.

Note that you can access various context menus in the display area from where you can change display format, etc.

4 Start executing your application.

Whenever execution stops, you can monitor the stack memory, for example to see function parameters that are passed on the stack:



Location	Data	Variable	Value	Type	Frame
0x3FDE	0x0001	p.mHandle	1	int	[0] __dwrite
0x3FE0	0x3FE8	p.mBuffer	0x3FE8 '\n'	unsigned char const*	[0] __dwrite
0x3FE2	0x0001	p.mSize	1	size_t	[0] __dwrite
0x3FE4	0x0001	p.mReturnSt...	1	size_t	[0] __dwrite
0x3FE6	0x72				
0x3FE7	0x41				
0x3FE8	0x000A000A				
0x3FEC	0xCDCD4048				
0x3FF0	0xCDCDCDCD				
0x3FF4	0xCDCDCDCD				
0x3FF8	0x0000CDCD				
0x3FFC	0x401441D2				

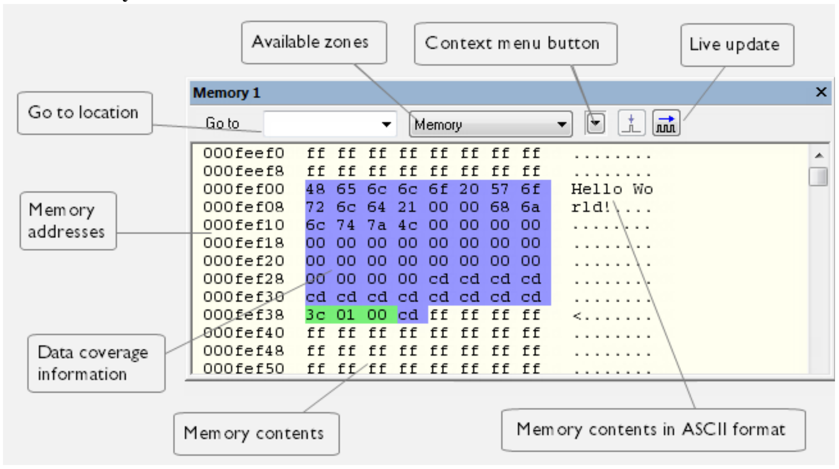
Reference information on memory and registers

Reference information about:

- *Memory window*, page 161
- *Data Flash Memory window*, page 165
- *Data Flash dialog box*, page 167
- *Memory Save dialog box*, page 168
- *Memory Restore dialog box*, page 169
- *Fill dialog box*, page 169
- *Symbolic Memory window*, page 171
- *Stack window*, page 174
- *Registers window*, page 178
- *Register User Groups Setup window*, page 182
- *SFR Setup window*, page 184
- *Edit SFR dialog box*, page 187
- *Memory Access Setup dialog box*, page 189
- *Edit Memory Access dialog box*, page 191

Memory window

The **Memory** window is available from the **View** menu.



```
000feef0  ff ff ff ff ff ff ff ff  ........
000feef8  ff ff ff ff ff ff ff ff  ........
000fef00  48 65 6c 6c 6f 20 57 6f  Hello Wo
000fef08  72 6c 64 21 00 00 68 6a  rld!....
000fef10  6c 74 7a 4c 00 00 00 00  ........
000fef18  00 00 00 00 00 00 00 00  ........
000fef20  00 00 00 00 00 00 00 00  ........
000fef28  00 00 00 00 cd cd cd cd  ........
000fef30  cd cd cd cd cd cd cd cd  ........
000fef38  3c 01 00 cd ff ff ff ff  <.......
000fef40  ff ff ff ff ff ff ff ff  ........
000fef48  ff ff ff ff ff ff ff ff  ........
000fef50  ff ff ff ff ff ff ff ff  ........
```

This window gives an up-to-date display of a specified area of memory—a memory zone—and allows you to edit it. You can open several instances of this window, which is very convenient if you want to keep track of several memory or register zones, or monitor different parts of the memory.

To view the memory corresponding to a variable, you can select it in the editor window and drag it to the **Memory** window.

See also *Editing in C-SPY windows*, page 45.

Requirements

None; this window is always available.

Toolbar

The toolbar contains:

Go to

The memory location or symbol you want to view.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

Context menu button

Displays the context menu.

Update Now

Updates the content of the **Memory** window while your application is executing. This button is only enabled if the C-SPY driver you are using has access to the target system memory while your application is executing.

E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, and TK: If any live watch variables exist, the **Memory** window will only show the ones covered by the variables.

Live Update

Updates the contents of the **Memory** window regularly while your application is executing. This button is only enabled if the C-SPY driver you are using has access to the target system memory while your application is executing. To set the update frequency, specify an appropriate frequency in the **IDE Options>Debugger** dialog box.

E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, and TK: If any live watch variables exist, the **Memory** window will only show the ones covered by the variables.

Display area

The display area shows the addresses currently being viewed, the memory contents in the format you have chosen, and—provided that the display mode is set to **1x Units**—the memory contents in ASCII format. You can edit the contents of the display area, both in the hexadecimal part and the ASCII part of the area.

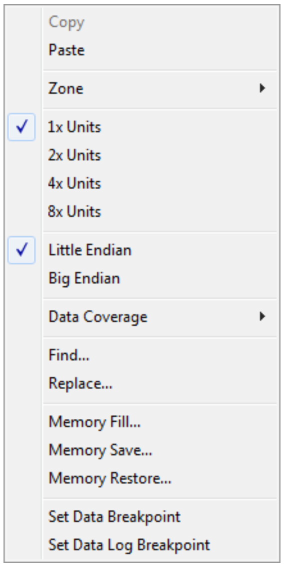
Data coverage is displayed with these colors:

Yellow	Indicates data that has been read.
Blue	Indicates data that has been written
Green	Indicates data that has been both read and written.

Note: Data coverage is not supported by all C-SPY drivers. Data coverage is supported by the C-SPY Simulator.

Context menu

This context menu is available:



These commands are available:

Copy, Paste

Standard editing commands.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

1x Units

Displays the memory contents as single bytes.

2x Units

Displays the memory contents as 2-byte groups.

4x Units

Displays the memory contents as 4-byte groups.

8x Units

Displays the memory contents as 8-byte groups.

Little Endian

Displays the contents in little-endian byte order.

Big Endian

Displays the contents in big-endian byte order.

Data Coverage

Choose between:

Enable toggles data coverage on or off.

Show toggles between showing or hiding data coverage.

Clear clears all data coverage information.

These commands are only available if your C-SPY driver supports data coverage.

Find

Displays a dialog box where you can search for text within the **Memory** window; read about the **Find** dialog box in the *IDE Project Management and Building Guide for RL78*.

Replace

Displays a dialog box where you can search for a specified string and replace each occurrence with another string; read about the **Replace** dialog box in the *IDE Project Management and Building Guide for RL78*.

Memory Fill

Displays a dialog box, where you can fill a specified area with a value, see *Fill dialog box*, page 169.

Memory Save

Displays a dialog box, where you can save the contents of a specified memory area to a file, see *Memory Save dialog box*, page 168.

Memory Restore

Displays a dialog box, where you can load the contents of a file in Intel-hex or Motorola s-record format to a specified memory zone, see *Memory Restore dialog box*, page 169.

Set Data Breakpoint

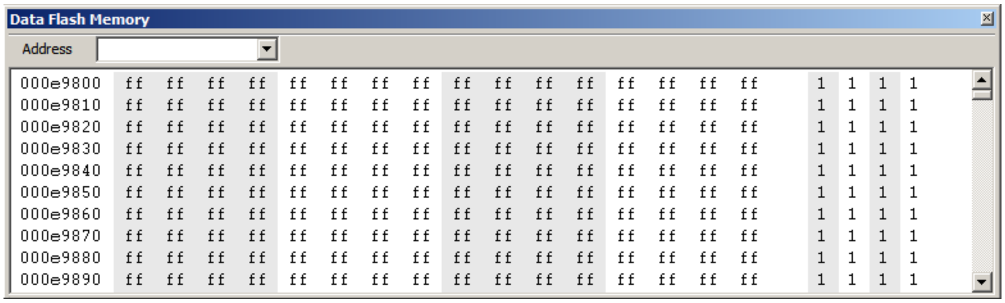
Sets breakpoints directly in the **Memory** window. The breakpoint is not highlighted; you can see, edit, and remove it in the **Breakpoints** dialog box. The breakpoints you set in this window will be triggered for both read and write access. For more information, see *Setting a data breakpoint in the Memory window*, page 132.

Set Data Log Breakpoint

Sets a breakpoint on the start address of a memory selection directly in the **Memory** window. The breakpoint is not highlighted; you can see, edit, and remove it in the **Breakpoints** dialog box. The breakpoints you set in this window will be triggered by both read and write accesses; to change this, use the **Breakpoints** window. For more information, see *Data Log breakpoints*, page 127 and *Getting started using data logging*, page 226.

Data Flash Memory window

The **Data Flash Memory** window is available from the **Emulator** menu.



```
000e9800  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
000e9810  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
000e9820  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
000e9830  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
000e9840  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
000e9850  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
000e9860  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
000e9870  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
000e9880  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
000e9890  ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff   1 1 1 1
```

Use this window to monitor and edit a specified area of the data flash memory.

The **Data Flash Memory** window lets you save and restore the data flash memory area. This saving/restoring includes the value and the ID tag.

Requirements

A device with data flash memory.

Address

Specify the location you want to view. This can be a memory address, or the name of a variable, function, or label.

Display area

Displays the addresses currently being viewed, the memory contents in the format you have chosen, and the ID tags. You can edit the contents of the **Memory** window.

Data coverage is displayed with these colors:

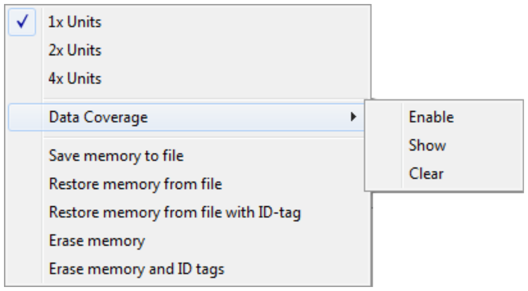
- Yellow indicates data that has been read
- Blue indicates data that has been written

- Green indicates data that has been both read and written.

To view the memory corresponding to a variable, select it in the editor window and drag it to the **Data Flash Memory** window.

Context menu

This context menu is available:

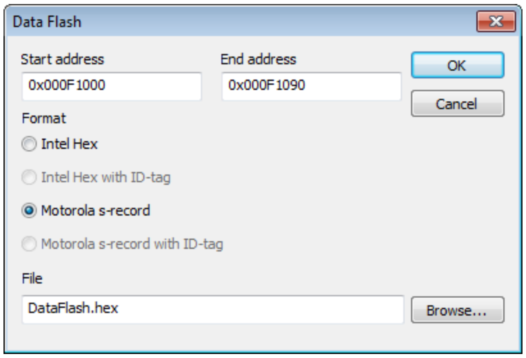


These commands are available on the context menu:

1x, 2x, 4x Units	Switches between displaying the memory contents in units of 8, 16, or 32 bits.
Data Coverage	Choose between: **Enable** toggles data coverage on and off. **Show** toggles between showing and hiding data coverage. **Clear** clears all data coverage information.
Save memory to file	Displays the **Data Flash** dialog box, where you can save the contents of a specified memory area to a file, see *Data Flash dialog box*, page 167.
Restore memory from file	Displays a standard **Open** dialog box, where you can choose the file to restore from.
Restore memory from file with ID-tag	Displays a standard **Open** dialog box, where you can choose the file to restore from.
Erase memory	Erases the memory contents but not the ID tags.
Erase memory and ID-tags	Erases the memory contents and the ID tags.

Data Flash dialog box

The **Data Flash** dialog box is available by choosing **Save Memory to File** from the context menu in the **Data Flash Memory** window.



Start address: 0x000F1000
End address: 0x000F1090
Format
Intel Hex
Intel Hex with ID-tag
[✓ Motorola s-record]
Motorola s-record with ID-tag
File: DataFlash.hex

Use this dialog box to save the contents of a specified memory area to a file.

Requirements

A a device with data flash memory.

Start address

Specify the start address of the memory range to be saved.

End address

Specify the end address of the memory range to be saved.

Format

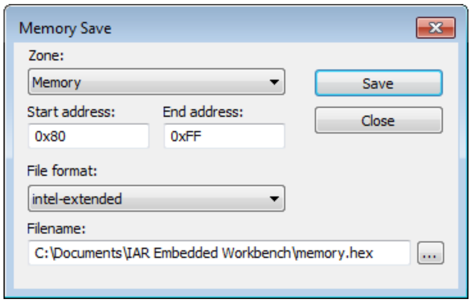
Selects the file format to be used.

File

Specify the destination file to be used; a browse button is available for your convenience.

Memory Save dialog box

The **Memory Save** dialog box is available by choosing **Debug>Memory>Save** or from the context menu in the **Memory** window.



Zone: Memory
Start address: 0x80
End address: 0xFF
File format: intel-extended
Filename: C:\Documents\IAR Embedded Workbench\memory.hex

Use this dialog box to save the contents of a specified memory area to a file.

Requirements

None; this dialog box is always available.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

Start address

Specify the start address of the memory range to be saved.

End address

Specify the end address of the memory range to be saved.

File format

Selects the file format to be used, which is Intel-extended by default.

Filename

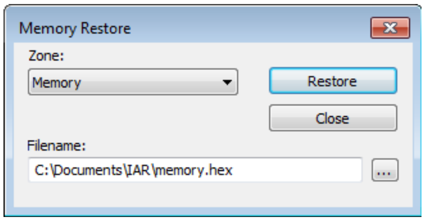
Specify the destination file to be used; a browse button is available for your convenience.

Save

Saves the selected range of the memory zone to the specified file.

Memory Restore dialog box

The **Memory Restore** dialog box is available by choosing **Debug>Memory>Restore** or from the context menu in the **Memory** window.



Zone: Memory

Filename: C:\Documents\IAR\memory.hex

Use this dialog box to load the contents of a file in Intel-extended or Motorola S-record format to a specified memory zone.

Requirements

None; this dialog box is always available.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

Filename

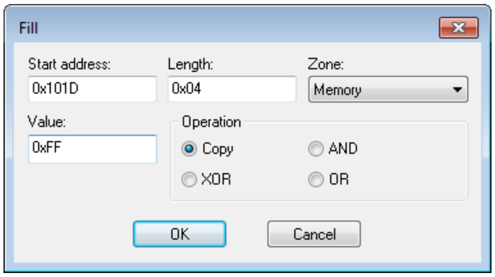
Specify the file to be read; a browse button is available for your convenience.

Restore

Loads the contents of the specified file to the selected memory zone.

Fill dialog box

The **Fill** dialog box is available from the context menu in the **Memory** window.



Start address: 0x101D

Length: 0x04

Zone: Memory

Value: 0xFF

Operation: [✓ Copy] AND XOR OR

Use this dialog box to fill a specified area of memory with a value.

Requirements

None; this dialog box is always available.

Start address

Type the start address—in binary, octal, decimal, or hexadecimal notation.

Length

Type the length—in binary, octal, decimal, or hexadecimal notation.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

Value

Type the 8-bit value to be used for filling each memory location.

Operation

These are the available memory fill operations:

Copy

Value will be copied to the specified memory area.

AND

An `AND` operation will be performed between Value and the existing contents of memory before writing the result to memory.

XOR

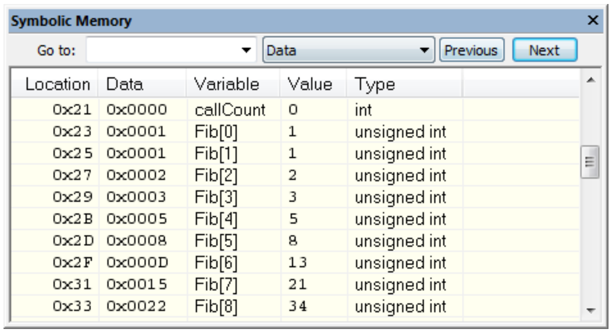
An `XOR` operation will be performed between Value and the existing contents of memory before writing the result to memory.

OR

An `OR` operation will be performed between Value and the existing contents of memory before writing the result to memory.

Symbolic Memory window

The **Symbolic Memory** window is available from the **View** menu during a debug session.



Location	Data	Variable	Value	Type
0x21	0x0000	callCount	0	int
0x23	0x0001	Fib[0]	1	unsigned int
0x25	0x0001	Fib[1]	1	unsigned int
0x27	0x0002	Fib[2]	2	unsigned int
0x29	0x0003	Fib[3]	3	unsigned int
0x2B	0x0005	Fib[4]	5	unsigned int
0x2D	0x0008	Fib[5]	8	unsigned int
0x2F	0x000D	Fib[6]	13	unsigned int
0x31	0x0015	Fib[7]	21	unsigned int
0x33	0x0022	Fib[8]	34	unsigned int

This window displays how variables with static storage duration, typically variables with file scope but also static variables in functions and classes, are laid out in memory. This can be useful for better understanding memory usage or for investigating problems caused by variables being overwritten, for example buffer overruns. Other areas of use are spotting alignment holes or for understanding problems caused by buffers being overwritten.

To view the memory corresponding to a variable, you can select it in the editor window and drag it to the **Symbolic Memory** window.

See also *Editing in C-SPY windows*, page 45.

Requirements

None; this window is always available.

Toolbar

The toolbar contains:

Go to

The memory location or symbol you want to view.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

Previous

Highlights the previous symbol in the display area.

Next

Highlights the next symbol in the display area.

Display area

This area contains these columns:

Location

The memory address.

Data

The memory contents in hexadecimal format. The data is grouped according to the size of the symbol. This column is editable.

Variable

The variable name; requires that the variable has a fixed memory location. Local variables are not displayed.

Value

The value of the variable. This column is editable.

Type

The type of the variable.

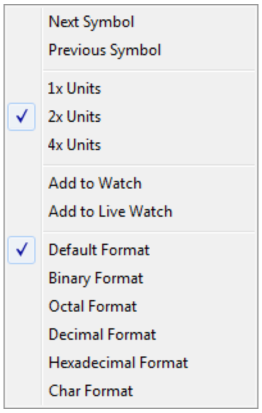
There are several different ways to navigate within the memory space:

- Text that is dropped in the window is interpreted as symbols
- The scroll bar at the right-side of the window
- The toolbar buttons **Next** and **Previous**
- The toolbar list box **Go to** can be used for locating specific locations or symbols.

Note: Rows are marked in red when the corresponding value has changed.

Context menu

This context menu is available:



These commands are available:

Next Symbol

Highlights the next symbol in the display area.

Previous Symbol

Highlights the previous symbol in the display area.

1x Units

Displays the memory contents as single bytes. This applies only to rows that do not contain a variable.

2x Units

Displays the memory contents as 2-byte groups.

4x Units

Displays the memory contents as 4-byte groups.

Add to Watch

Adds the selected symbol to the **Watch** window.

Add to Live Watch

Adds the selected symbol to the **Live Watch** window.

Default format

Displays the memory contents in the default format.

Binary format

Displays the memory contents in binary format.

Octal format

Displays the memory contents in octal format.

Decimal format

Displays the memory contents in decimal format.

Hexadecimal format

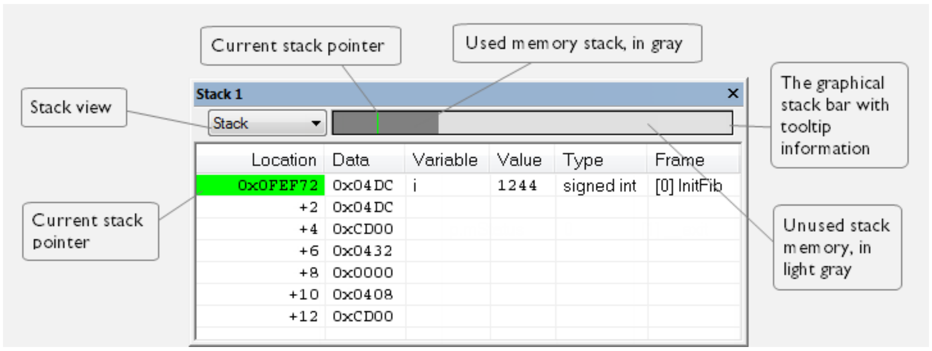
Displays the memory contents in hexadecimal format.

Char format

Displays the memory contents in char format.

Stack window

The **Stack** window is available from the **View** menu.


Current stack pointer
Used memory stack, in gray
Stack view
Stack 1
Stack
The graphical stack bar with tooltip information
Current stack pointer
Unused stack memory, in light gray

Location	Data	Variable	Value	Type	Frame
0x0FEF72	0x04DC	i	1244	signed int	[0] InitFib
+2	0x04DC				
+4	0xCD00				
+6	0x0432				
+8	0x0000				
+10	0x0408				
+12	0xCD00				

This window is a memory window that displays the contents of the stack. The graphical stack bar shows stack usage.

Note: By default, this window uses one physical breakpoint. For more information, see *Breakpoint consumers*, page 129.

For information about options specific to the **Stack** window, see the *IDE Project Management and Building Guide for RL78*.

Requirements

None; this window is always available.

Toolbar

The toolbar contains:

Stack

Selects which stack to view. This applies to microcontrollers with multiple stacks.

The graphical stack bar

Displays the state of the stack graphically.

The left end of the stack bar represents the bottom of the stack, in other words, the position of the stack pointer when the stack is empty. The right end represents the end of the memory address range reserved for the stack. The graphical stack bar turns red when the stack usage exceeds a threshold that you can specify.

To enable the stack bar, choose **Tools>Options>Stack>Enable graphical stack display and stack usage tracking**. This means that the functionality needed to detect and warn about stack overflows is enabled.

Place the mouse pointer over the stack bar to get tooltip information about stack usage.

Display area

This area contains these columns:

Location

Displays the location in memory. The addresses are displayed in increasing order. The address referenced by the stack pointer, in other words the top of the stack, is highlighted in a green color.

Data

Displays the contents of the memory unit at the given location. From the **Stack** window context menu, you can select how the data should be displayed; as a 1-, 2-, or 4-byte group of data.

Variable

Displays the name of a variable, if there is a local variable at the given location. Variables are only displayed if they are declared locally in a function, and located on the stack and not in registers.

Value

Displays the value of the variable.

Type

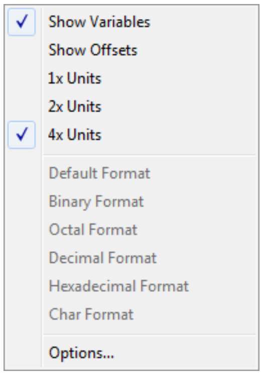
Displays the data type of the variable.

Frame

Displays the name of the function that the call frame corresponds to.

Context menu

This context menu is available:



These commands are available:

Show variables

Displays separate columns named **Variables**, **Value**, and **Frame** in the **Stack** window. Variables located at memory addresses listed in the **Stack** window are displayed in these columns.

Show offsets

Displays locations in the **Location** column as offsets from the stack pointer. When deselected, locations are displayed as absolute addresses.

1x Units

Displays the memory contents as single bytes.

2x Units

Displays the memory contents as 2-byte groups.

4x Units

Displays the memory contents as 4-byte groups.

Default Format
Binary Format
Octal Format
Decimal Format
Hexadecimal Format
Char Format

Changes the display format of expressions. The display format setting affects different types of expressions in different ways. Your selection of display format is saved between debug sessions. These commands are available if a selected line in the window contains a variable.

The display format setting affects different types of expressions in these ways:

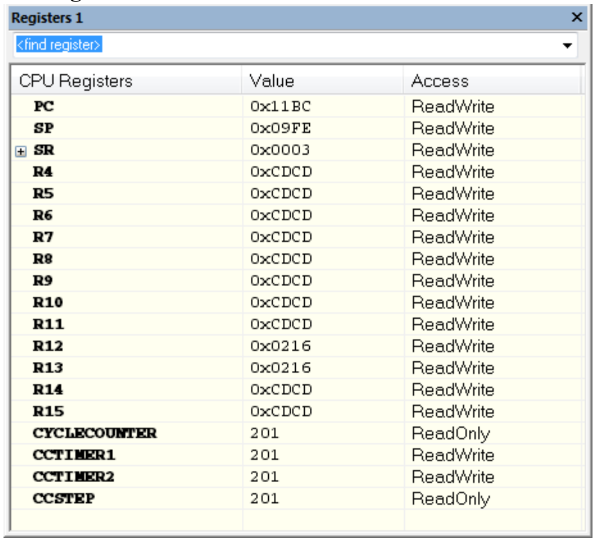
Variables	The display setting affects only the selected variable, not other variables.
Array elements	The display setting affects the complete array, that is, the same display format is used for each array element.
Structure fields	All elements with the same definition—the same field name and C declaration type—are affected by the display setting.

Options

Opens the **IDE Options** dialog box where you can set options specific to the **Stack** window, see the *IDE Project Management and Building Guide for RL78*.

Registers window

The **Registers** windows are available from the **View** menu.



Registers 1

<find register>

CPU Registers	Value	Access
PC	0x11BC	ReadWrite
SP	0x09FE	ReadWrite
⊞ SR	0x0003	ReadWrite
R4	0xCDCD	ReadWrite
R5	0xCDCD	ReadWrite
R6	0xCDCD	ReadWrite
R7	0xCDCD	ReadWrite
R8	0xCDCD	ReadWrite
R9	0xCDCD	ReadWrite
R10	0xCDCD	ReadWrite
R11	0xCDCD	ReadWrite
R12	0x0216	ReadWrite
R13	0x0216	ReadWrite
R14	0xCDCD	ReadWrite
R15	0xCDCD	ReadWrite
CYCLECOUNTER	201	ReadOnly
CCTIMER1	201	ReadWrite
CCTIMER2	201	ReadWrite
CCSTEP	201	ReadOnly

These windows give an up-to-date display of the contents of the processor registers and special function registers, and allow you to edit the contents of some of the registers. Optionally, you can choose to load either predefined register groups or your own user-defined groups.

You can open up to four instances of this window, which is convenient for keeping track of different register groups.

See also *Editing in C-SPY windows*, page 45.

To enable predefined register groups:

1 Select a device description file that suits your device, see *Selecting a device description file*, page 42. These files contain predefined register groups.

2 Display the registers of a register group by selecting it from the **Group** drop-down menu on the toolbar, or by right-clicking in the window and choosing **View Group** from the context menu.

For information about creating your own user-defined register groups, see *Defining application-specific register groups*, page 156.

Requirements

None; this window is always available.

Toolbar

The toolbar contains:

Find

Specify the name, or part of a name, of a register (or group) that you want to find. Press the Enter key and the first matching register, or group with a matching register, is displayed. User-defined register groups are not searched. The search box preserves a history of previous searches. To repeat a search, select it from the search history and press Enter.

Group

Selects which predefined register group to display. Additional register groups are predefined in the device description files that make SFR registers available in the **Registers** windows. The device description file contains a section that defines the special function registers and their groups.

Display area

Displays registers and their values. Some registers are expandable, which means that the register contains interesting bits or subgroups of bits.

If you drag a numerical value, a valid expression, or a register name from another part of the IDE to an editable value cell in a **Registers** window, the value will be changed to that of what you dragged. If you drop a register name somewhere else in the window, the window contents will change to display the first register group where this register is found.

Name

The name of the register.

Value

The current value of the register. Every time C-SPY stops, a value that has changed since the last stop is highlighted. Some of the registers are editable. To edit the contents of an editable register, click on the register and modify its value. Press Esc to cancel the change.

To change the display format of the value, right-click on the register and choose **Format** from the context menu.

Access

The access type of the register. Some of the registers are read-only, while others are write-only.

For the C-SPY Simulator, these additional support registers are available in the CPU Registers group:

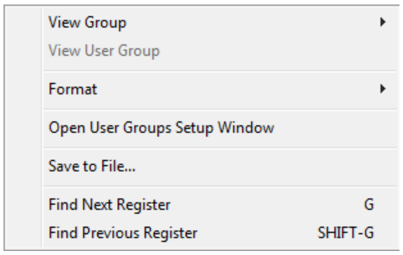
CYCLECOUNTER	Cleared when an application is started or reset, and is incremented with the number of used cycles during execution.
CCSTEP	Shows the number of used cycles during the last performed C/C++ source or assembler step.
CCTIMER1 and **CCTIMER2**	Two *trip counts* that can be cleared manually at any given time. They are incremented with the number of used cycles during execution.

For the C-SPY hardware debugger drivers, these additional support registers are available in the CPU Registers group:

TIME	Cleared when an application is started or reset, and is incremented with the elapsed time during application execution. The time is based on the time unit that you specify in the **Hardware Setup** dialog box.
TIMESTEP	Shows the time since the last performed C/C++ source or assembler step.
TIMER1 and **TIMER2**	Two *trip counts* that can be cleared manually at any given time. They are incremented with elapsed time from start to stop.

Context menu

This context menu is available:



These commands are available:

View Group

Selects which predefined register group to display.

View User Group

Selects which user-defined register group to display. For information about creating your own user-defined register groups, see *Defining application-specific register groups*, page 156.

Format

Changes the display format for the contents of the register you clicked on. The display format setting affects different types of registers in different ways. Your selection of display format is saved between debug sessions.

Open User Groups Setup Window

Opens a window where you can create your own user-defined register groups, see *Register User Groups Setup window*, page 182.

Save to File

Opens a standard Save dialog box to save the contents of the window to a tab-separated text file.

Find Next Register

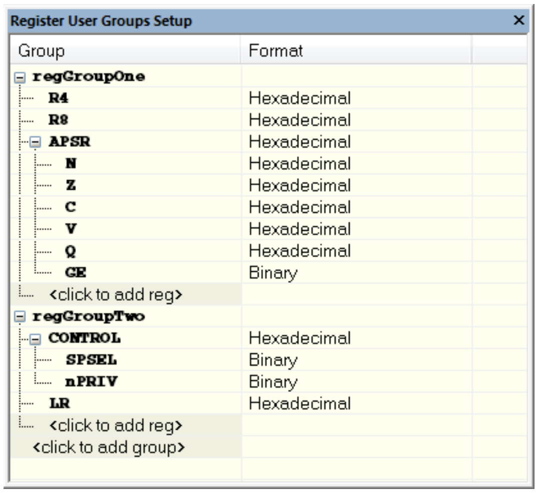
Finds the predefined register or register group that comes immediately after what your search found. After the last register was found, this search wraps around and finds the first register again.

Find Previous Register

Finds the matching predefined register or register group that comes immediately before what your search found. After the first register was found, this search wraps around and finds the last register again.

Register User Groups Setup window

The **Register User Groups Setup** window is available from the **View** menu or from the context menu in the **Registers** windows.



Group	Format
regGroupOne	
R4	Hexadecimal
R8	Hexadecimal
APSR	Hexadecimal
N	Hexadecimal
Z	Hexadecimal
C	Hexadecimal
V	Hexadecimal
Q	Hexadecimal
GE	Binary
<click to add reg>	
regGroupTwo	
CONTROL	Hexadecimal
SPSEL	Binary
nPRIV	Binary
LR	Hexadecimal
<click to add reg>	
<click to add group>	

Use this window to define your own application-specific register groups. These register groups can then be viewed in the **Registers** windows.

Defining application-specific register groups means that the **Registers** windows can display just those registers that you need to watch for your current debugging task. This makes debugging much easier.

Requirements

None; this window is always available.

Display area

This area contains these columns:

Group

The names of register groups and the registers they contain. Clicking on `<click to add group>` or `<click to add reg>` and typing the name of a register group or register, adds new groups and registers, respectively. You can also drag a register name from another window in the IDE. Click a name to change it.

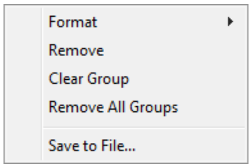
A dimmed register name indicates that it is not supported by the selected device.

Format

Shows the display format for the register's value. To change the display format of the value, right-click on the register and choose **Format** from the context menu. The selected format is used in all **Registers** windows.

Context menu

This context menu is available:



These commands are available:

Format

Changes the display format for the contents of the register you clicked on. The display format setting affects different types of registers in different ways. Your selection of display format is saved between debug sessions.

Remove

Removes the register or group you clicked on.

Clear Group

Removes all registers from the group you clicked on.

Remove All Groups

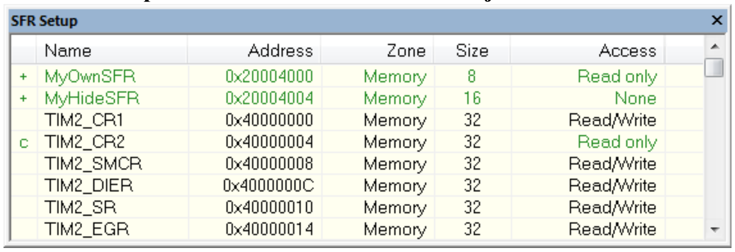
Deletes all user-defined register groups from your project.

Save to File

Opens a standard save dialog box to save the contents of the window to a tab-separated text file.

SFR Setup window

The **SFR Setup** window is available from the **Project** menu.



	Name	Address	Zone	Size	Access
+	MyOwnSFR	0x20004000	Memory	8	Read only
+	MyHideSFR	0x20004004	Memory	16	None
	TIM2_CR1	0x40000000	Memory	32	Read/Write
c	TIM2_CR2	0x40000004	Memory	32	Read only
	TIM2_SMCR	0x40000008	Memory	32	Read/Write
	TIM2_DIER	0x4000000C	Memory	32	Read/Write
	TIM2_SR	0x40000010	Memory	32	Read/Write
	TIM2_EGR	0x40000014	Memory	32	Read/Write

This window displays the currently defined SFRs that C-SPY has information about. You can choose to display only factory-defined or custom-defined SFRs, or both. If required, you can use the **Edit SFR** dialog box to customize the SFR definitions, see *Edit SFR dialog box*, page 187. For factory-defined SFRs (that is, retrieved from the `ddf` file in use), you can only customize the access type.

To quickly find an SFR, drag a text or hexadecimal number string and drop in this window. If what you drop starts with a `0` (zero), the **Address** column is searched, otherwise the **Name** column is searched.

Any custom-defined SFRs are added to a dedicated register group called Custom, which you can choose to display in the **Registers** window. Your custom-defined SFRs are saved in *`project`*`CustomSFR.sfr`. This file is automatically loaded in the IDE when you start C-SPY with a project whose name matches the prefix of the filename of the `sfr` file.

You can only add or modify SFRs when the C-SPY debugger is not running.

Requirements

None; this window is always available.

Display area

This area contains these columns:

Status

A character that signals the status of the SFR, which can be one of:

blank, a factory-defined SFR.

C, a factory-defined SFR that has been modified.

+, a custom-defined SFR.

?, an SFR that is ignored for some reason. An SFR can be ignored when a factory-defined SFR has been modified, but the SFR is no longer available, or it is located somewhere else or with a different size. Typically, this might happen if you change to another device.

Name

A unique name of the SFR.

Address

The memory address of the SFR.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

Size

The size of the register, which can be any of **8**, **16**, **32**, or **64**.

Access

The access type of the register, which can be one of **Read/Write**, **Read only**, **Write only**, or **None**.

You can click a name or an address to change the value. The hexadecimal `0x` prefix for the address can be omitted, the value you enter will still be interpreted as hexadecimal. For example, if you enter `4567`, you will get `0x4567`.

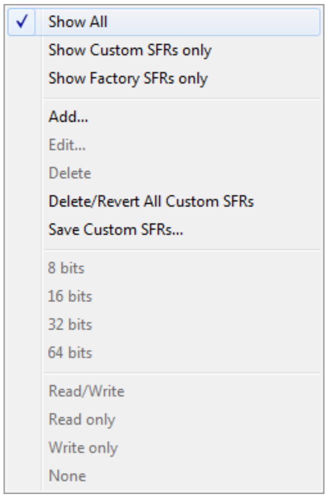
You can click a column header to sort the SFRs according to the column property.

Color coding used in the display area:

- Green, which indicates that the corresponding value has changed
- Red, which indicates an ignored SFR.

Context menu

This context menu is available:



These commands are available:

Show All

Shows all SFR.

Show Custom SFRs only

Shows all custom-defined SFRs.

Show Factory SFRs only

Shows all factory-defined SFRs retrieved from the ddf file.

Add

Displays the **Edit SFR** dialog box where you can add a new SFR, see *Edit SFR dialog box*, page 187.

Edit

Displays the **Edit SFR** dialog box where you can edit an SFR, see *Edit SFR dialog box*, page 187.

Delete

Deletes an SFR. This command only works on custom-defined SFRs.

Delete/revert All Custom SFRs

Deletes all custom-defined SFRs and reverts all modified factory-defined SFRs to their factory settings.

Save Custom SFRs

Opens a standard save dialog box to save all custom-defined SFRs.

8|16|32|64 bits

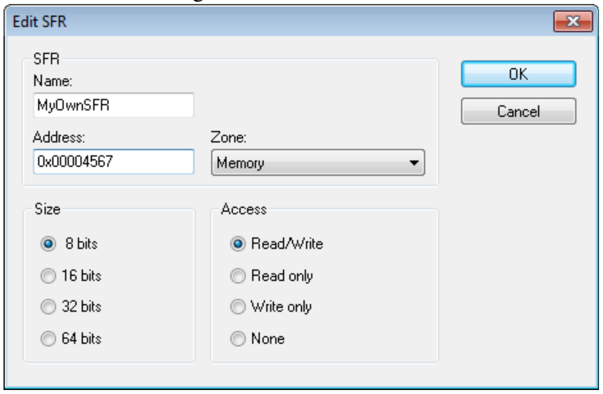
Selects display format for the selected SFR, which can be **8**, **16**, **32**, or **64** bits. Note that the display format can only be changed for custom-defined SFRs.

Read/Write|Read only|Write only|None

Selects the access type of the selected SFR, which can be **Read/Write**, **Read only**, **Write only**, or **None**. Note that for factory-defined SFRs, the default access type is indicated.

Edit SFR dialog box

The **Edit SFR** dialog box is available from the context menu in the **SFR Setup** window.



Name: MyOwnSFR
Address: 0x00004567
Zone: Memory

Size: [✓ 8 bits] 16 bits 32 bits 64 bits

Access: [✓ Read/Write] Read only Write only None

Definitions of the SFRs are retrieved from the device description file in use. Use this dialog box to either modify these factory-defined definitions or define new SFRs. See also *SFR Setup window*, page 184.

Requirements

None; this dialog box is always available.

Name

Specify the name of the SFR that you want to add or edit.

Address

Specify the address of the SFR that you want to add or edit. The hexadecimal `0x` prefix for the address can be omitted, the value you enter will still be interpreted as hexadecimal. For example, if you enter `4567`, you will get `0x4567`.

Zone

Selects the memory zone for the SFR you want to add or edit. The list of zones is retrieved from the `ddf` file that is currently used.

Size

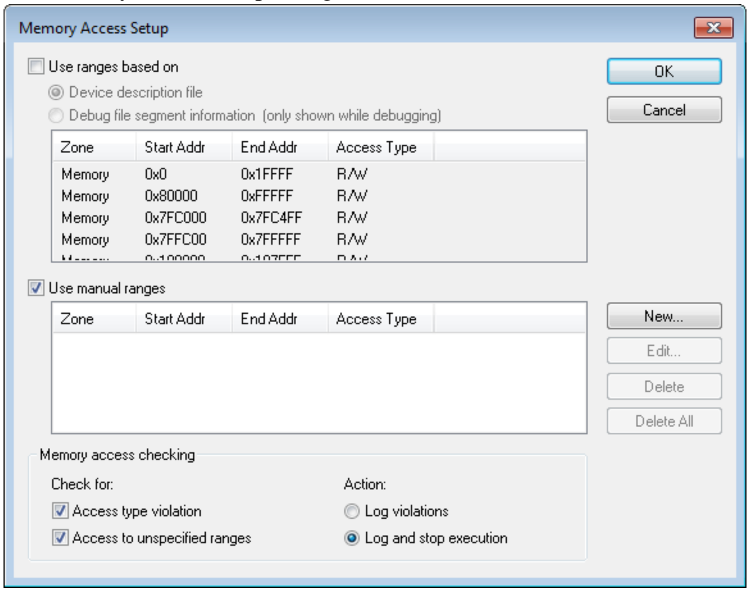
Selects the size of the SFR. Choose between **8**, **16**, **32**, or **64** bits. Note that the display format can only be changed for custom-defined SFRs.

Access

Selects the access type of the SFR. Choose between **Read/Write**, **Read only**, **Write only**, or **None**. Note that for factory-defined SFRs, the default access type is indicated.

Memory Access Setup dialog box

The **Memory Access Setup** dialog box is available from the C-SPY driver menu.



☐ Use ranges based on

● Device description file

○ Debug file segment information (only shown while debugging)

Zone	Start Addr	End Addr	Access Type
Memory	0x0	0x1FFFF	R/W
Memory	0x80000	0xFFFFF	R/W
Memory	0x7FC000	0x7FC4FF	R/W
Memory	0x7FFC00	0x7FFFFF	R/W

☑ Use manual ranges

Zone	Start Addr	End Addr	Access Type

Memory access checking

Check for:

☑ Access type violation

☑ Access to unspecified ranges

Action:

○ Log violations

● Log and stop execution

Use this dialog box to specify which set of memory address ranges to be used by C-SPY during debugging.

Note: If you enable both the **Use ranges based on** and the **Use manual ranges** option, memory accesses are checked for all defined ranges.

For information about the columns and the properties displayed, see *Edit Memory Access dialog box*, page 191. See also *Memory configuration for the C-SPY simulator*, page 155.

Requirements

The C-SPY simulator.

Use ranges based on

Specify if the memory configuration should be retrieved from a predefined configuration. Choose between:

Device description file

Retrieves the memory configuration from the device description file that you have specified. See *Selecting a device description file*, page 42.

This option is used by default.

Debug file segment information

Retrieves the memory configuration from the debug file, which has retrieved it from the linker configuration file. This information is only available during a debug session. The advantage of using this option is that the simulator can catch memory accesses outside the linked application.

Use manual ranges

Specify your own ranges manually via the **Edit Memory Access** dialog box. To open this dialog box, click **New** to specify a new memory address range, or select an existing memory address range and choose **Edit** to modify it. For more information, see *Edit Memory Access dialog box*, page 191.

The ranges you define manually are saved between debug sessions.

Memory access checking

Check for determines what to check for:

- **Access type violation**
- **Access to unspecified ranges**

Action selects the action to be performed if an access violation occurs. Choose between:

- **Log violations**
- **Log and stop execution**

Any violations are logged in the **Debug Log** window.

Buttons

These buttons are available for manual ranges:

New

Opens the **Edit Memory Access** dialog box, where you can specify a new memory address range and associate an access type with it, see *Edit Memory Access dialog box*, page 191.

Edit

Opens the **Edit Memory Access** dialog box, where you can edit the selected memory address range. See *Edit Memory Access dialog box*, page 191.

Delete

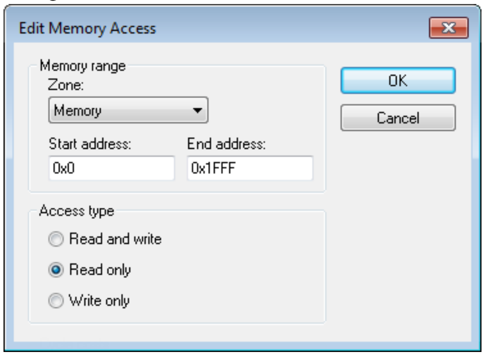
Deletes the selected memory address range definition.

Delete All

Deletes all defined memory address range definitions.

Edit Memory Access dialog box

The **Edit Memory Access** dialog box is available from the **Memory Access Setup** dialog box.



Use this dialog box to specify your memory address ranges for which you want to detect illegal accesses during the simulation, and assign an access type to each range.

Requirements

The C-SPY simulator.

Memory range

Defines the memory address range specific to your device:

Zone

Selects a memory zone, see *C-SPY memory zones*, page 154.

Start address

Specify the start address for the memory address range, in hexadecimal notation.

End address

Specify the end address for the memory address range, in hexadecimal notation.

Access type

Selects an access type to the memory address range. Choose between:

- **Read and write**

- **Read only**
- **Write only**.

Part 2. Analyzing your application

This part of the *C-SPY® Debugging Guide for RL78* includes these chapters:

- Trace
- The application timeline
- Profiling
- Code coverage
- Power debugging

Trace

- Introduction to using trace
- Collecting and using trace data
- Reference information on trace

Introduction to using trace

These topics are covered:

- Reasons for using trace
- Briefly about trace
- Requirements for using trace

See also:

- *Getting started using data logging*, page 226
- *Getting started using Smart Analog (event logging)*, page 227
- *Power debugging*, page 277
- *Getting started using interrupt logging*, page 304
- *Profiling*, page 261

REASONS FOR USING TRACE

By using trace, you can inspect the program flow up to a specific state, for instance an application crash, and use the trace data to locate the origin of the problem. Trace data can be useful for locating programming errors that have irregular symptoms and occur sporadically.

BRIEFLY ABOUT TRACE

To use trace in C-SPY requires that your target system can generate trace data. Once generated, C-SPY can collect it and you can visualize and analyze the data in various windows and dialog boxes.

Depending on your target system, different types of trace data can be generated.

Trace data is a continuously collected sequence of every executed instruction for a selected portion of the execution.

Trace features in C-SPY

In C-SPY, you can use the trace-related windows **Trace**, **Function Trace**, **Timeline**, and **Find in Trace**.

Depending on your C-SPY driver, you:

- Can set various types of trace breakpoints and triggers to control the collection of trace data.
- Have access to windows such as the **Interrupt Log**, **Interrupt Log Summary**, **Data Log**, and **Data Log Summary**.

In addition, several other features in C-SPY also use trace data, features such as Profiling, Code coverage, and Instruction profiling.

Trace in the E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators

The E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators can collect trace data from RL78 devices that support trace. In the emulator, the trace function has a circular frame buffer where the emulator can save frames. When the **Go** or a step command is executed, the trace function can save information for each executed branch, in the form of OP-fetch addresses and data.

Up to 256 frames can be saved in the trace buffer.

Note: The **Next Statement** and **Run to Cursor** commands do not collect any trace data for the E1, E2, E2 Lite/E2 On-Board, or EZ-CUBE2 emulators. Using these commands will disable trace data collection.

Trace in the IECUBE emulator

If you use the C-SPY IECUBE driver, you also have access to the **Snap Shot Function Settings** dialog box, see *Snap Shot Function Settings dialog box*, page 204.

In the IECUBE emulator, the trace function has a circular frame buffer where the emulator can save frames. When the **Go** or a step command is executed, the trace function can save information for each executed instruction. The information saved is:

- OP-fetch address and data
- Data-access address and data.

If you use the **Snap Shot Function Settings** dialog box, you can also choose to save:

- Memory area
- SFR
- CPU register.

REQUIREMENTS FOR USING TRACE

The C-SPY simulator and the IECUBE, E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators support trace-related functionality, and there are no specific requirements.

Trace data cannot be collected from the E20, EZ-CUBE, and TK emulators.

Collecting and using trace data

These tasks are covered:

- Getting started with trace
- Trace data collection using breakpoints
- Trace data collection using events
- Searching in trace data
- Browsing through trace data

GETTING STARTED WITH TRACE

To get started using trace:

1 Start C-SPY and choose **Emulator>Trace Setup**. In the **Trace Settings** dialog box that appears, check if you need to change any of the default settings.

Note: If you are using the C-SPY simulator you can ignore this step.

2 Open the Trace window—available from the driver-specific menu—and click the **Activate** button to enable collecting trace data.

3 Start the execution. When the execution stops, for example because a breakpoint is triggered, trace data is displayed in the Trace window. For more information about the window, see *Trace window*, page 206.

TRACE DATA COLLECTION USING BREAKPOINTS

A convenient way to collect trace data between two execution points is to start and stop the data collection using dedicated breakpoints. Choose between these alternatives:

- In the editor or **Disassembly** window, position your insertion point, right-click, and toggle a **Trace Start** or **Trace Stop** breakpoint from the context menu.
- In the **Breakpoints** window, choose **New Breakpoint>Trace Start** or **Trace Stop** from the context menu.
- The C-SPY system macros `__setTraceStartBreak` and `__setTraceStopBreak` can also be used.

For more information about these breakpoints, see *Trace Start breakpoints dialog box*, page 212 and *Trace Stop breakpoints dialog box*, page 213, respectively.

TRACE DATA COLLECTION USING EVENTS

For the IECUBE, E1, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators, you can specify dedicated start and stop events to collect trace data between two execution points.

Setting start and stop events:

1 Choose **Emulator>Edit Events** and create your start and stop events.

2 Choose **Emulator>Trace Settings** and select the start and stop events you just created.

3 Open the **Trace** window—available from the driver-specific menu—and click the **Activate** button to enable collecting trace data.

4 Start the execution. When the execution stops, for instance because a breakpoint is triggered, trace data is displayed in the **Trace** window. For more information about the window, see *Trace window*, page 206.

SEARCHING IN TRACE DATA

When you have collected trace data, you can perform searches in the collected data to locate the parts of your code or data that you are interested in, for example, a specific interrupt or accesses of a specific variable.

You specify the search criteria in the **Find in Trace** dialog box and view the result in the **Find in Trace** window.

Note: The **Find in Trace** dialog box depends on the C-SPY driver you are using.

The **Find in Trace** window is very similar to the **Trace** window, showing the same columns and data, but *only* those rows that match the specified search criteria. Double-clicking an item in the **Find in Trace** window brings up the same item in the **Trace** window.

To search in your trace data:

1 On the **Trace** window toolbar, click the **Find** button.

2 In the **Find in Trace** dialog box, specify your search criteria.

Typically, you can choose to search for:

- A specific piece of text, for which you can apply further search criteria
- An address range
- A data value
- A combination of these, like a specific piece of text within a specific address range.

For more information about the various options, see *Find in Trace dialog box*, page 216 and *Find in Trace dialog box (IECUBE)*, page 217.

3 When you have specified your search criteria, click **Find**. The **Find in Trace** window is displayed, which means you can start analyzing the trace data. For more information, see *Find in Trace window*, page 218.

BROWSING THROUGH TRACE DATA

To follow the execution history, simply look and scroll in the **Trace** window. Alternatively, you can enter *browse mode*.

To enter browse mode, double-click an item in the **Trace** window, or click the **Browse** toolbar button.

The selected item turns yellow and the source and disassembly windows will highlight the corresponding location. You can now move around in the trace data using the up and down arrow keys, or by scrolling and clicking; the source and **Disassembly** windows will be updated to show the corresponding location. This is like stepping backward and forward through the execution history.

Double-click again to leave browse mode.

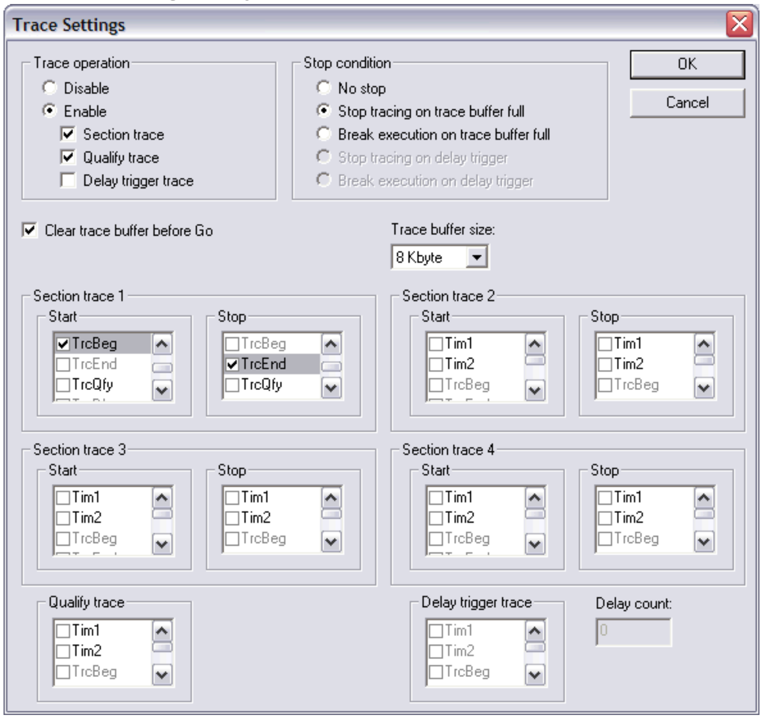
Reference information on trace

Reference information about:

- *Trace Settings dialog box for IECUBE*, page 200
- *Trace Settings dialog box for E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2*, page 202
- *Snap Shot Function Settings dialog box*, page 204
- *Trace window*, page 206
- *Function Trace window*, page 211
- *Trace Start breakpoints dialog box*, page 212
- *Trace Stop breakpoints dialog box*, page 213
- *Trace Expressions window*, page 214
- *Find in Trace dialog box*, page 216
- *Find in Trace dialog box (IECUBE)*, page 217
- *Find in Trace window*, page 218
- *Trace Save dialog box*, page 219

Trace Settings dialog box for IECUBE

The **Trace Settings** dialog box is available from the **Emulator** menu.



Trace operation: Disable [✓ Enable]; Section trace ✓; Qualify trace ✓; Delay trigger trace

Stop condition: No stop [✓ Stop tracing on trace buffer full]; Break execution on trace buffer full; Stop tracing on delay trigger; Break execution on delay trigger

Clear trace buffer before Go ✓

Trace buffer size: 8 Kbyte

Section trace 1 — Start: TrcBeg ✓, TrcEnd, TrcQfy; Stop: TrcBeg, TrcEnd ✓, TrcQfy

Section trace 2 — Start: Tim1, Tim2, TrcBeg; Stop: Tim1, Tim2, TrcBeg

Section trace 3 — Start: Tim1, Tim2, TrcBeg; Stop: Tim1, Tim2, TrcBeg

Section trace 4 — Start: Tim1, Tim2, TrcBeg; Stop: Tim1, Tim2, TrcBeg

Qualify trace: Tim1, Tim2, TrcBeg

Delay trigger trace: Tim1, Tim2, TrcBeg

Delay count: 0

Use this dialog box to configure trace generation and collection for the IECUBE emulator.

See also *Getting started with trace*, page 197.

Requirements

The IECUBE emulator.

Trace operation

To enable the trace operation, select the **Enable** option and choose between:

No suboption selected	A full trace is performed. The trace starts at any **Go** or step command, and stops at break.
Section trace	The trace starts and stops by the events defined in the **Start trace** and **Stop trace** lists, respectively.

Qualify trace	The trace is active as long as the qualify trace event is true. The qualify event is defined in the **Qualify trace** list.
Delay trigger trace	The trace stops by the events defined in the **Delay trigger trace** list, and after the **Delay count** number of frames.

To disable the trace operation, select the **Disable** option.

Stop condition

Controls how the trace buffer should be handled when it has become full or when the delay frame count is reached. Choose between:

No stop	The oldest frames are overwritten until a break occurs.
Stop tracing on trace buffer full	The trace stops when the trace buffer is full.
Break execution on trace buffer full	The trace stops and execution breaks when the trace buffer is full.
Stop tracing on delay trigger	The trace stops when the delay trigger events are fulfilled and after the delay count frames are traced.
Break execution on delay trigger	The trace stops and execution breaks when the delay trigger events are fulfilled and after the delay count frames are traced.

Clear trace buffer before Go

Clears the trace buffer before each **Go** or step command is performed.

Trace buffer size

Specify the size of the trace buffer.

Section trace

In the **Section Trace 1**, **2**, **3**, and **4** lists, select the section trace events that should control the trace. If more than one event is selected in the same list, the trace condition will be true when one of the selected events has occurred.

Qualify trace

Select the trace events that should control the qualify trace. If more than one event is selected in the same list, the trace condition will be true when one of the selected events has occurred.

Delay trigger trace

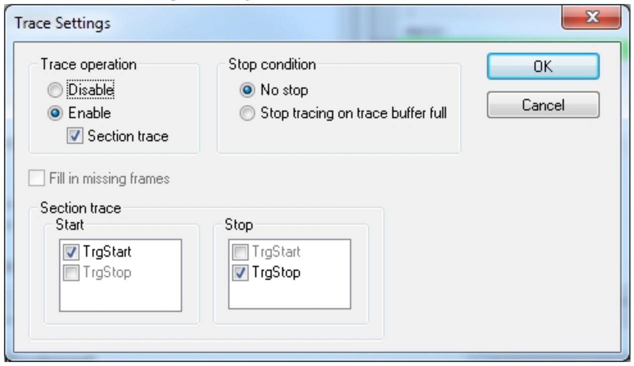
Select the trace events that should control the delay trigger trace and specify a delay in the **Delay count** box. If more than one event is selected in the same list, the trace condition will be true when one of the selected events has occurred.

Delay count

Specify the number of frames you want the tracing to continue after the condition has been met for the event selected in the **Delay trigger trace** list.

Trace Settings dialog box for E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2

The **Trace Settings** dialog box is available from the **Emulator** menu.


Trace Settings

Trace operation
- Disable
- [✓ Enable]
  - [✓] Section trace

Stop condition
- [✓ No stop]
- Stop tracing on trace buffer full

[ ] Fill in missing frames

Section trace
- Start: [✓] TrgStart, [ ] TrgStop
- Stop: [ ] TrgStart, [✓] TrgStop

Use this dialog box to configure trace generation and collection for the E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators.

See also *Getting started with trace*, page 197.

Requirements

One of these alternatives:

- The E1 emulator
- The E2 emulator
- The E2 Lite/E2 On-Board emulator
- The EZ-CUBE2 emulator.

Trace operation

Controls the trace operation. Choose between:

Disable	Disables the trace operation.
Enable	Enables the trace operation.
Section trace	The trace starts and stops by the events defined in the **Section trace** lists.

Stop condition

Controls how the trace buffer should be handled when it has become full. Choose between:

No stop	The oldest frames are overwritten until a break occurs.
Stop tracing on trace buffer full	The trace stops when the trace buffer is full.

Fill in missing frames

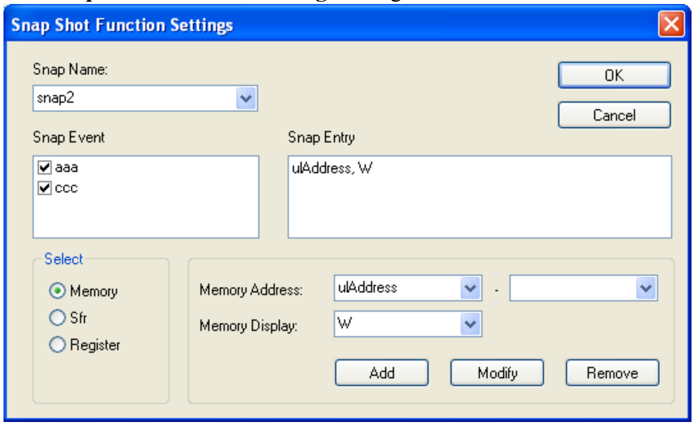
The trace only traces branches. Select this option to calculate and fill in the missing frames.

Section trace

In the **Section trace start** and **Section trace stop** lists, select the section trace events that should control the trace. If more than one event is selected in the same list, the trace condition will be true when one of the selected events has occurred.

Snap Shot Function Settings dialog box

The **Snap Shot Function Settings** dialog box is available from the **Emulator** menu.



Use this dialog box to control the event-controlled addition of further information to the **Trace** window. If the corresponding event occurred, this information can be added to the trace data:

- Memory area (displayed as byte, word, or double word)
- SFR
- CPU register (register bank must be specified).

The supported events are data accesses and execution events. Events that occur before execution cannot define a Snap Shot.

Note: You can combine different information types in one combined Snap Shot definition.

Requirements

The IECUBE emulator.

Snap Name

To define a new Snap Shot event, enter the name in the **Snap Name** drop-down list. Choose the appropriate characteristics and click **OK**.

To modify an existing Snap Shot event, choose the event from the **Snap Name** list, enter the new characteristics and click **OK**.

Snap Event

Displays the events that will trigger the addition of information to the **Trace** window.

Snap Entry

Displays the memory addresses, SFRs, and registers to be added to the **Trace** window.

Select

Select what to add to the **Trace** window:

Memory	Adds a memory address to the **Trace** window.
Sfr	Adds an SFR to the **Trace** window.
Register	Adds a register to the **Trace** window.

Depending on your choice, different sets of options appear to the right.

Memory Address

Specifies the memory address to add. Symbol names can be used instead of absolute addresses to define an address area.

Memory Display

Selects how to display the memory: **B** for byte, **W** for word, and **DW** for double word.

Sfr Name

The SFR that you want to add to the **Trace** window.

Register Name

The register that you want to add to the **Trace** window.

Register Bank

Specify the register bank. Choose between **0**, **1**, **2**, **3**, or **Current**.

Buttons

These buttons are available:

Add	Displays the new Snap Shot entry in the **Snap Entry** box.
Modify	Changes a selected item in the **Snap Entry** box.
Remove	Deletes a selected item in the **Snap Entry** box.

Trace window

The **Trace** window is available from the C-SPY driver menu.

This window displays the collected trace data.

See also *Collecting and using trace data*, page 197.

Requirements

One of these alternatives:

- The C-SPY Simulator
- The IECUBE emulator
- The E1, E2, E2 Lite/E2 On-Board, or EZ-CUBE2 emulator.

Trace toolbar

The toolbar in the **Trace** window and in the **Function Trace** window contains:

Enable/Disable

Enables and disables collecting and viewing trace data in this window. This button is not available in the **Function Trace** window.

Clear trace data

Clears the trace buffer. Both the **Trace** window and the **Function Trace** window are cleared.

Toggle source

Toggles the **Trace** column between showing only disassembly or disassembly together with the corresponding source code.

Browse

Toggles browse mode on or off for a selected item in the **Trace** window.

Find

Displays a dialog box where you can perform a search, see *Find in Trace dialog box*, page 216.

Save

For the IECUBE, E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators, this button displays the **Trace Save** dialog box, see *Trace Save dialog box*, page 219.

In the C-SPY simulator, this button displays a standard **Save As** dialog box where you can save the collected trace data to a text file, with tab-separated columns.

Edit Settings

In the C-SPY simulator, this button is not enabled.

For the IECUBE, E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators, this button displays the **Trace Settings** dialog box, see *Trace Settings dialog box for IECUBE*, page 200 or *Trace Settings dialog box for E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2*, page 202.

Edit Expressions (C-SPY simulator only)

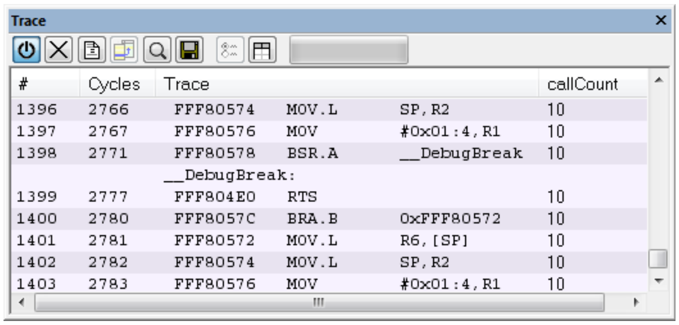
Opens the **Trace Expressions** window, see *Trace Expressions window*, page 214.

Progress bar

When a large amount of trace data has been collected, there might be a delay before all of it has been processed and can be displayed. The progress bar reflects that processing.

Display area (in the C-SPY simulator)

This area displays a collected sequence of executed machine instructions. In addition, the window can display trace data for expressions.



```
#      Cycles   Trace                                        callCount
1396   2766      FFF80574   MOV.L      SP,R2                 10
1397   2767      FFF80576   MOV        #0x01:4,R1            10
1398   2771      FFF80578   BSR.A      __DebugBreak          10
                __DebugBreak:
1399   2777      FFF804E0   RTS                              10
1400   2780      FFF8057C   BRA.B      0xFFF80572            10
1401   2781      FFF80572   MOV.L      R6,[SP]               10
1402   2782      FFF80574   MOV.L      SP,R2                 10
1403   2783      FFF80576   MOV        #0x01:4,R1            10
```

This area contains these columns for the C-SPY simulator:

#

A serial number for each row in the trace buffer. Simplifies the navigation within the buffer.

Cycles

The number of cycles elapsed to this point.

Trace

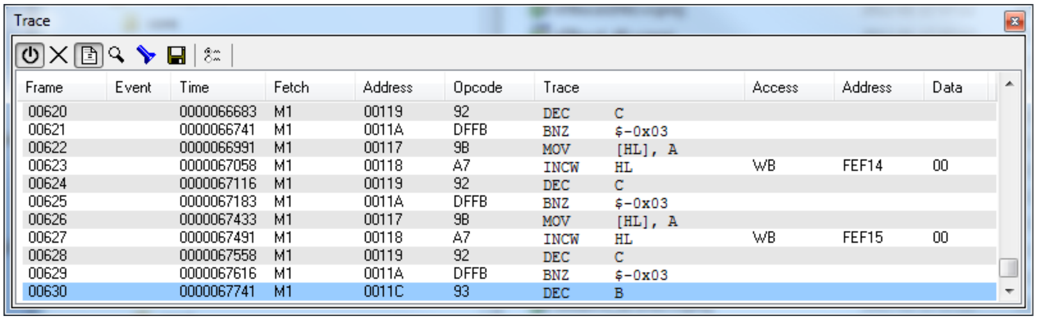
The collected sequence of executed machine instructions. Optionally, the corresponding source code can also be displayed.

Expression

Each expression you have defined to be displayed appears in a separate column. Each entry in the expression column displays the value *after* executing the instruction on the same row. You specify the expressions for which you want to collect trace data in the **Trace Expressions** window, see *Trace Expressions window*, page 214.

A red-colored row indicates that the previous row and the red row are not consecutive. This means that there is a gap in the collected trace data, for example because trace data has been lost due to an overflow.

Display area (for a supported emulator)



Frame	Event	Time	Fetch	Address	Opcode	Trace	Access	Address	Data
00620		0000066683	M1	00119	92	DEC C			
00621		0000066741	M1	0011A	DFFB	BNZ $-0x03			
00622		0000066991	M1	00117	9B	MOV [HL], A			
00623		0000067058	M1	00118	A7	INCW HL	WB	FEF14	00
00624		0000067116	M1	00119	92	DEC C			
00625		0000067183	M1	0011A	DFFB	BNZ $-0x03			
00626		0000067433	M1	00117	9B	MOV [HL], A			
00627		0000067491	M1	00118	A7	INCW HL	WB	FEF15	00
00628		0000067558	M1	00119	92	DEC C			
00629		0000067616	M1	0011A	DFFB	BNZ $-0x03			
00630		0000067741	M1	0011C	93	DEC B			

This area contains these columns for the supported C-SPY emulators:

Frame

The number of the trace buffer frame. By double-clicking the frame number, the collected fetch address will be displayed in the editor window.

Event

The name of the single events that have been triggered by the event conditions. For information about event conditions, see *Edit Events dialog box*, page 90 and *Edit Sequencer Events dialog box*, page 93.

Time

IECUBE: The time stamp of the trace frame.

E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2: This column is empty.

Fetch

The fetch type of the instruction associated with the trace frame. For the IECUBE emulator, this is always `M1`, an internal IECUBE code.

For the E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators, this is one of:

`F` — a verified trace frame

`S` — a verified trace frame based on section trace

`+` — a calculated trace frame

`Fi` — an interrupt trace frame

`+?` — a trace frame that might have been skipped (it cannot be determined whether it has been executed)

`...` — a trace restart (to resynchronize the trace and the execution)

Opcode

The operation code of the instruction associated with the trace frame. After the hexadecimal value, extra information can be displayed: x2 if two instructions were executed and C if the instruction was read from the I-Cache.

Trace

The collected sequence of executed machine instructions. Optionally, the corresponding source code can also be displayed.

Access

IECUBE: The access type of the instruction associated with the trace frame. DMA stands for DMA transfer. The address and data information shows which transfer that was performed.

E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2: This column is empty.

Address

IECUBE: The address of the access.

E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2: This column is empty.

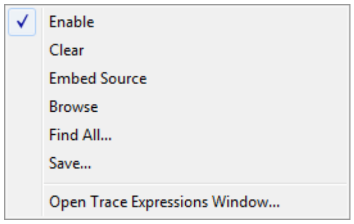
Data

IECUBE: The data the access has read or written.

E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2: The data the access has read or written.

Context menu

This context menu is available:



Note: The contents of this menu are dynamic and depend on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Enable

Enables and disables collecting and viewing trace data in this window.

Clear

Clears the trace buffer. Both the **Trace** window and the **Function Trace** window are cleared.

Embed source

Toggles the **Trace** column between showing only disassembly or disassembly together with the corresponding source code.

Browse

Toggles browse mode on or off for a selected item in the **Trace** window, see *Browsing through trace data*, page 199.

Find All

Displays a dialog box where you can perform a search in the **Trace** window, see *Find in Trace dialog box*, page 216. The search results are displayed in the **Find in Trace** window—available by choosing the **View>Messages** command, see *Find in Trace window*, page 218.

Save

For the IECUBE, E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators, this command displays the **Trace Save** dialog box, see *Trace Save dialog box*, page 219.

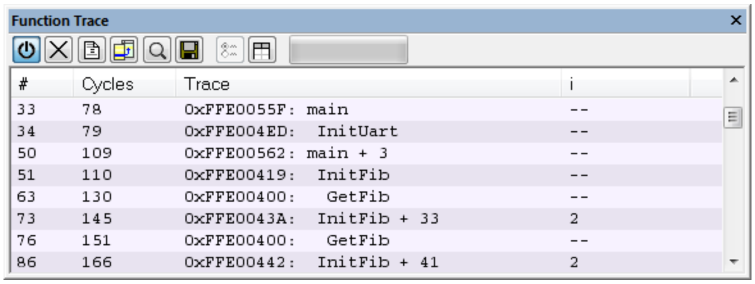
In the C-SPY simulator, this command displays a standard **Save As** dialog box where you can save the collected trace data to a text file, with tab-separated columns.

Open Trace Expressions Window

Opens the **Trace Expressions** window, see *Trace Expressions window*, page 214.

Function Trace window

The **Function Trace** window is available from the C-SPY driver menu during a debug session.



#	Cycles	Trace	i
33	78	0xFFE0055F: main	--
34	79	0xFFE004ED: InitUart	--
50	109	0xFFE00562: main + 3	--
51	110	0xFFE00419: InitFib	--
63	130	0xFFE00400: GetFib	--
73	145	0xFFE0043A: InitFib + 33	2
76	151	0xFFE00400: GetFib	--
86	166	0xFFE00442: InitFib + 41	2

This window displays a subset of the trace data displayed in the **Trace** window. Instead of displaying all rows, the **Function Trace** window shows:

- The functions called or returned to, instead of the traced instruction
- The corresponding trace data.

Requirements

One of these alternatives:

- The C-SPY Simulator
- The IECUBE emulator
- The E1, E2, E2 Lite/E2 On-Board, or EZ-CUBE2 emulator.

Toolbar

For information about the toolbar, see *Trace window*, page 206.

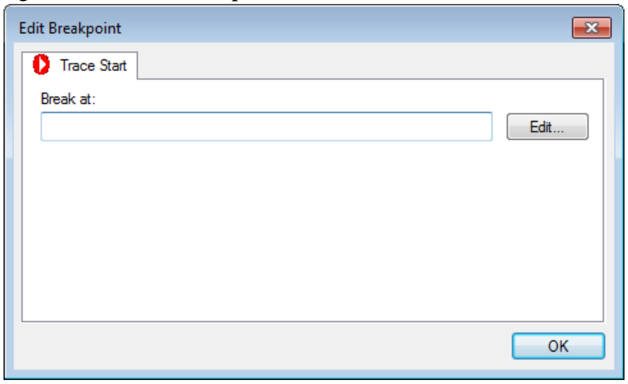
However, the **Save** button opens a standard **Save** dialog box also in the IECUBE, E1, E2, E2 Lite/E2 On-Board, and EZ-CUBE2 emulators.

Display area

For information about the columns in the display area, see *Trace window*, page 206

Trace Start breakpoints dialog box

The **Trace Start** dialog box is available from the context menu that appears when you right-click in the **Breakpoints** window.



Use this dialog box to set a Trace Start breakpoint where you want to start collecting trace data. If you want to collect trace data only for a specific range, you must also set a Trace Stop breakpoint where you want to stop collecting data.

See also *Trace Stop breakpoints dialog box*, page 213 and *Trace data collection using breakpoints*, page 197.

To set a Trace Start breakpoint:

1. In the editor or **Disassembly** window, right-click and choose **Trace Start** from the context menu.

   Alternatively, open the **Breakpoints** window by choosing **View>Breakpoints**.

2. In the **Breakpoints** window, right-click and choose **New Breakpoint>Trace Start**.

   Alternatively, to modify an existing breakpoint, select a breakpoint in the **Breakpoints** window and choose **Edit** on the context menu.

3. In the **Break at** text box, specify an expression, an absolute address, or a source location. Click **OK**.

4. When the breakpoint is triggered, the trace data collection starts.

Requirements

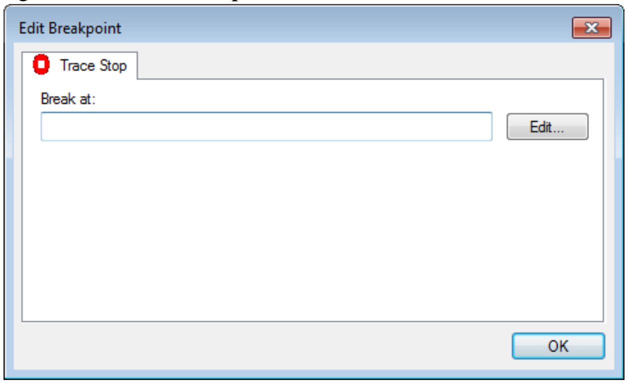
The C-SPY simulator.

Trigger at

Specify the code location of the breakpoint. Alternatively, click the **Edit** button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 149.

Trace Stop breakpoints dialog box

The **Trace Stop** dialog box is available from the context menu that appears when you right-click in the **Breakpoints** window.



Use this dialog box to set a Trace Stop breakpoint where you want to stop collecting trace data. If you want to collect trace data only for a specific range, you might also need to set a Trace Start breakpoint where you want to start collecting data.

See also *Trace Start breakpoints dialog box*, page 212 and *Trace data collection using breakpoints*, page 197.

To set a Trace Stop breakpoint:

1 In the editor or **Disassembly** window, right-click and choose **Trace Stop** from the context menu.

   Alternatively, open the **Breakpoints** window by choosing **View>Breakpoints**.

2 In the **Breakpoints** window, right-click and choose **New Breakpoint>Trace Stop**.

   Alternatively, to modify an existing breakpoint, select a breakpoint in the **Breakpoints** window and choose **Edit** on the context menu.

3 In the **Break at** text box, specify an expression, an absolute address, or a source location. Click **OK**.

4 When the breakpoint is triggered, the trace data collection stops.

Requirements

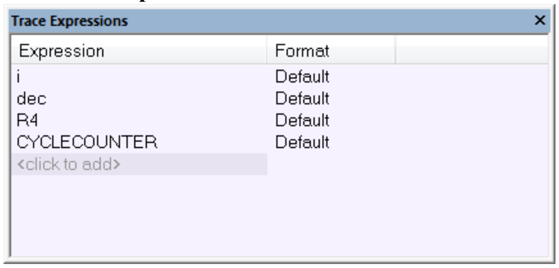
The C-SPY simulator.

Trigger at

Specify the code location of the breakpoint. Alternatively, click the **Edit** button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 149.

Trace Expressions window

The **Trace Expressions** window is available from the **Trace** window toolbar.



Expression	Format
i	Default
dec	Default
R4	Default
CYCLECOUNTER	Default
<click to add>	

Use this window to specify, for example, a specific variable (or an expression) for which you want to collect trace data.

Requirements

The C-SPY simulator.

Display area

Use the display area to specify expressions for which you want to collect trace data:

Expression

Specify any expression that you want to collect data from. You can specify any expression that can be evaluated, such as variables and registers.

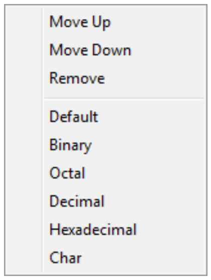
Format

Shows which display format that is used for each expression. Note that you can change display format via the context menu.

Each row in this area will appear as an extra column in the **Trace** window.

Context menu

This context menu is available:



These commands are available:

Move Up

Moves the selected expression upward in the window.

Move Down

Moves the selected expression downward in the window.

Remove

Removes the selected expression from the window.

Default Format
Binary Format
Octal Format
Decimal Format
Hexadecimal Format
Char Format

Changes the display format of expressions. The display format setting affects different types of expressions in different ways. Your selection of display format is saved between debug sessions. These commands are available if a selected line in the window contains a variable.

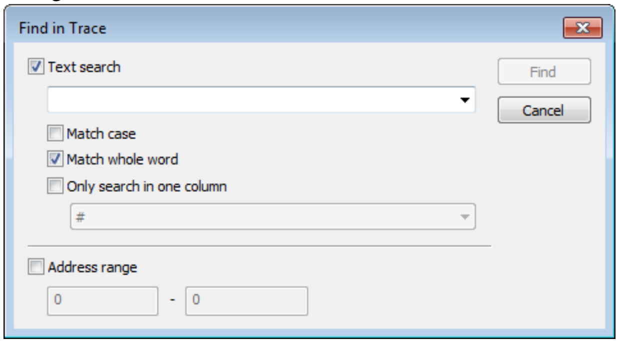
The display format setting affects different types of expressions in these ways:

Variables	The display setting affects only the selected variable, not other variables.
Array elements	The display setting affects the complete array, that is, the same display format is used for each array element.
Structure fields	All elements with the same definition—the same field name and C declaration type—are affected by the display setting.

Find in Trace dialog box

The **Find in Trace** dialog box is available by clicking the **Find** button on the **Trace** window toolbar or by choosing **Edit>Find and Replace>Find**.

Note that the **Edit>Find and Replace>Find** command is context-dependent. It displays the **Find in Trace** dialog box if the **Trace** window is the current window or the **Find** dialog box if the editor window is the current window.



☑ Text search

☐ Match case

☑ Match whole word

☐ Only search in one column

#

☐ Address range

0 - 0

Use this dialog box to specify the search criteria for advanced searches in the trace data.

The search results are displayed in the **Find in Trace** window—available by choosing the **View>Messages** command, see *Find in Trace window*, page 218.

See also *Searching in trace data*, page 198.

Requirements

One of these alternatives:

- The C-SPY Simulator
- The E1, E2, or E2 Lite/E2 On-Board emulator
- The EZ-CUBE2 emulator.

Text search

Specify the string you want to search for. To specify the search criteria, choose between:

Match Case

Searches only for occurrences that exactly match the case of the specified text. Otherwise **int** will also find **INT**, **Int**, and so on.

Match whole word

Searches only for the string when it occurs as a separate word. Otherwise **int** will also find **print**, **sprintf**, and so on.

Only search in one column

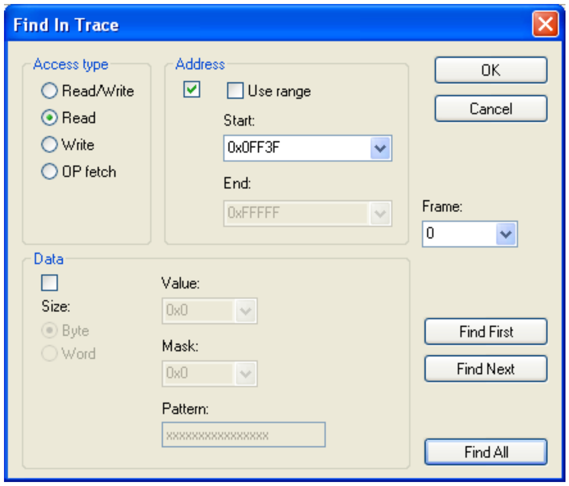
Searches only in the column you selected from the drop-down list.

Address Range

Specify the address range you want to display or search. The trace data within the address range is displayed. If you have also specified a text string in the **Text search** field, the text string is searched for within the address range.

Find in Trace dialog box (IECUBE)

The **Find in Trace** dialog box is available by clicking the **Find** button on the **Trace** window toolbar or by choosing **Edit>Find and Replace>Find**.



Use this dialog box to specify the search criteria for advanced searches in the trace data.

The search results are displayed in the **Find in Trace** window—available by choosing the **View>Messages** command, see *Find in Trace window*, page 218.

To start the search, enter the search conditions and click **Find First**. To search from the current position in the trace buffer or search from a frame set in the **Frame** list box, click **Find Next**. To find all frames that match your search criteria and display them in the **Find In Trace** window, click **Find All**.

Note that the **Edit>Find and Replace>Find** command is context-dependent. It displays the **Find in Trace** dialog box if the **Trace** window is the current window or the **Find** dialog box if the editor window is the current window.

See also *Searching in trace data*, page 198.

Access type

Specify the type of access you want to search for. Choose between:

- Read/Write
- Read
- Write
- OP fetch.

You must also specify the search conditions: Address, Data, or External probe signals.

Address

Specify the address or address range you want to search:

Use range	Select to define an address range to search.
Start	If **Use range** is *not* selected, enter a single address to search for accesses.
	If **Use range** *is* selected, enter the start value for the range to search for accesses. Note that you can enter a label instead of an address value.
End	Enter the end value for the range to search for accesses. Note that you can enter a label instead of an address value.

Data

Specify the data you want to search:

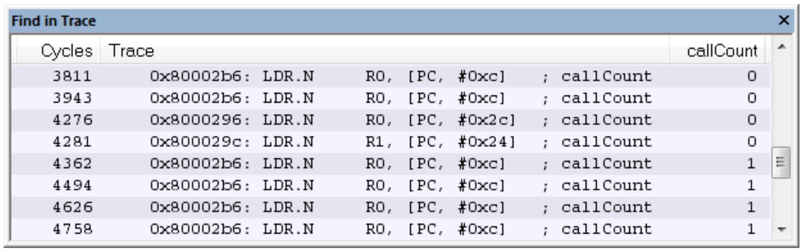
Size	Select the size of the access: **Byte** or **Word**.
Value	Specify the data value of the access you are searching for.
Mask	Specify the mask for the access you are searching for.
Pattern	Displays the bit pattern for the **Value** with the **Mask** applied.

Frame

Displays all found frames.

Find in Trace window

The **Find in Trace** window is available from the **View>Messages** menu. Alternatively, it is automatically displayed when you perform a search using the **Find in Trace** dialog box or perform a search using the **Find in Trace** command available from the context menu in the editor window.



Find in Trace

Cycles	Trace	callCount
3811	0x80002b6: LDR.N R0, [PC, #0xc] ; callCount	0
3943	0x80002b6: LDR.N R0, [PC, #0xc] ; callCount	0
4276	0x8000296: LDR.N R0, [PC, #0x2c] ; callCount	0
4281	0x800029c: LDR.N R1, [PC, #0x24] ; callCount	0
4362	0x80002b6: LDR.N R0, [PC, #0xc] ; callCount	1
4494	0x80002b6: LDR.N R0, [PC, #0xc] ; callCount	1
4626	0x80002b6: LDR.N R0, [PC, #0xc] ; callCount	1
4758	0x80002b6: LDR.N R0, [PC, #0xc] ; callCount	1

This window displays the result of searches in the trace data. Double-click an item in the **Find in Trace** window to bring up the same item in the **Trace** window.

Before you can view any trace data, you must specify the search criteria in the **Find in Trace** dialog box, see *Find in Trace dialog box*, page 216.

See also *Searching in trace data*, page 198.

Requirements

One of these alternatives:

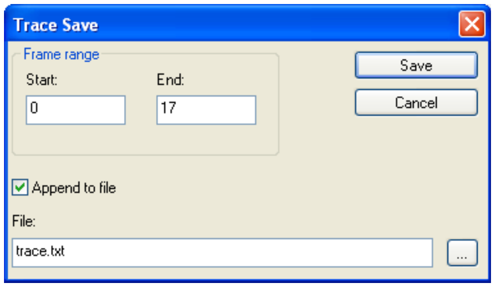
- The C-SPY Simulator
- The IECUBE emulator
- The E1, E2, E2 Lite/E2 On-Board, or EZ-CUBE2 emulator.

Display area

The **Find in Trace** window looks like the **Trace** window and shows the same columns and data, but *only* those rows that match the specified search criteria.

Trace Save dialog box

The **Trace Save** dialog box is available from the **Trace** window for the IECUBE, E1, E2 Lite/E2 On-Board, or EZ-CUBE2 emulators.



Trace Save

Frame range

Start: 0

End: 17

☑ Append to file

File: trace.txt

Use this dialog box to save the collected trace data to a text file.

Requirements

One of these alternatives:

- The IECUBE emulator
- The E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, and TK emulators, but not for the S1 core.

Frame range

Set the **Start** frame and the **End** frame of the interval to save. By default, the entire trace is saved.

Append to file

Adds the current trace data to the log file when you save it. If this option is deselected, the trace data you save will overwrite previously saved trace data in the same log file.

File

Type the name of the text file you want to save the trace data to. Use the browse button to navigate to the directory where you want to save the file.

The application timeline

- Introduction to analyzing your application’s timeline
- Analyzing your application’s timeline
- Reference information on application timeline

Introduction to analyzing your application’s timeline

These topics are covered:

- Briefly about analyzing the timeline
- Requirements for timeline support

See also:

- *Trace*, page 195

BRIEFLY ABOUT ANALYZING THE TIMELINE

C-SPY can provide information for various aspects of your application, collected when the application is running. This can help you to analyze the application’s behavior.

You can view the timeline information in different representations:

- As different *graphs* that correlate with the running application in relation to a shared *time axis*. The graphs appear either in the **Timeline** window or the **Sampled graphs** window, depending on the source of the data.
- As detailed logs
- As summaries of the logs.

Depending on the capabilities of your hardware, the debug probe, and the C-SPY driver you are using, timeline information can be provided for:

Call stack	Can be represented in the **Timeline** window, as a graph that displays the sequence of function calls and returns collected by the trace system. You get timing information between the function invocations. Note that there is also a related **Call Stack** window and a **Function Trace** window, see *Call Stack window*, page 77 and *Function Trace window*, page 211, respectively.

Data logging	Based on data logs collected by the trace system for up to four different variables or address ranges, specified by means of *Data Log breakpoints*. Choose to display the data logs: ● In the **Timeline** window, as a graph of how the values change over time. ● In the **Data Log** window and the **Data Log Summary** window.
Data sampling	Based on samples for up to four different variables. Choose to display the data logs: ● In the **Sampled Graphs** window, as a graph of how the values change over time. ● In the **Data Sample** window. Data sampling gives an indication of the data value over a length of time. Because it is a sampled value, data sampling is best suited for slow-changing data.
Event logging	Based on *event logs* produced from Smart Analog data collection. Choose to display the event logs: ● In the **Timeline** window, as a graph of the timing of the events. ● In the **Event Log** window and the **Event Log Summary** window. Event logging requires a hardware debugger driver that supports the feature, and a Renesas MCU with Smart Analog support.
Interrupt logging	Based on interrupt logs collected by the trace system. Choose to display the interrupt logs: ● In the **Timeline** window, as a graph of the interrupt events during the execution of your application. ● In the **Interrupt Log** window and the **Interrupt Log Summary** window. Interrupt logging can, for example, help you locate which interrupts you can fine-tune to make your application more efficient. For more information, see the chapter *Interrupts*.

Power logging	Based on logged power measurement samples generated by the debug probe or associated hardware. Choose to display the power logs:

- In the **Timeline** window, as a graph of the power measurement samples.
- In the **Power Log** window.

Power logs can be useful for finding peaks in the power consumption and by double-clicking on a value you can see the corresponding source code. The precision depends on the frequency of the samples, but there is a good chance that you find the source code sequence that caused the peak.

For more information, see the chapter *Power debugging*.

REQUIREMENTS FOR TIMELINE SUPPORT

Depending on the capabilities of the hardware, the debug probe, and the C-SPY driver you are using, trace-based timeline information is supported for:

Target system	Call Stack	Data logging	Data sampling	Interrupt logging	Power logging	Smart Analog event logging*
C-SPY simulator	Yes	Yes	—	Yes	—	—
E1, E2, E2 Lite, E2 On-Board, E20, EZ-CUBE2	—	—	Yes	—	Yes, E2	If supported by the device
IECUBE, EZ-CUBE, TK	—	—	Yes	—	—	—

Table 10: Supported graphs in the Timeline window

* This feature collects and displays Smart Analog data, which is supported by some Renesas MCUs.

For more information about requirements related to trace data, see *Requirements for using trace*, page 197.

Analyzing your application's timeline

These tasks are covered:

- Displaying a graph in the Timeline window
- Navigating in the graphs
- Analyzing performance using the graph data
- Getting started using data logging
- Getting started using data sampling

- Getting started using Smart Analog (event logging)

See also:

- *Debugging in the power domain*, page 283
- *Using the interrupt system*, page 301

DISPLAYING A GRAPH IN THE TIMELINE WINDOW

The **Timeline** window can display several graphs; follow this example procedure to display any of these graphs. For an overview of the graphs and what they display, see *Briefly about analyzing the timeline*, page 221.

1. Choose **Timeline** from the C-SPY driver menu to open the **Timeline** window.
2. In the **Timeline** window, right-click in the window and choose **Select graphs** from the context menu to select which graphs to be displayed.
3. In the **Timeline** window, right-click in the graph area and choose **Enable** from the context menu to enable a specific graph.
4. For the Data Log graph, you must set a Data Log breakpoint for each variable you want a graphical representation of in the **Timeline** window. See *Data Log breakpoints dialog box*, page 147.
5. For the Event graph, you must add a preprocessor macro to your application source code where you want events to be generated. See *Getting started using Smart Analog (event logging)*, page 227.
6. Click **Go** on the toolbar to start executing your application. The graphs that you have enabled appear.

NAVIGATING IN THE GRAPHS

After you have performed the steps in *Displaying a graph in the Timeline window*, page 224, you can use any of these alternatives to navigate in the graph:

- Right-click and from the context menu choose **Zoom In** or **Zoom Out**. Alternatively, use the + and – keys. The graph zooms in or out depending on which command you used.
- Right-click in the graph and from the context menu choose **Navigate** and the appropriate command to move backwards and forwards on the graph. Alternatively, use any of the shortcut keys: arrow keys, Home, End, and Ctrl+End.
- Double-click on a sample of interest to highlight the corresponding source code in the editor window and in the **Disassembly** window.
- Click on the graph and drag to select a time interval, which will correlate to the running application. The selection extends vertically over all graphs, but appears

highlighted in a darker color for the selected graph. Press Enter or right-click and from the context menu choose **Zoom>Zoom to Selection**. The selection zooms in. Use the navigation keys in combination with the Shift key to extend the selection.

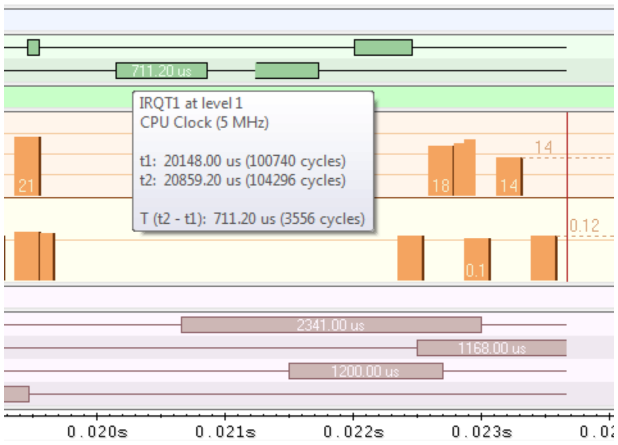
ANALYZING PERFORMANCE USING THE GRAPH DATA

The **Timeline** window provides a set of tools for analyzing the graph data.

1 In the **Timeline** window, right-click and choose **Time Axis Unit** from the context menu. Select which unit to be used on the time axis; choose between **Seconds** and **Cycles**. If **Cycles** is not available, the graphs are based on different clock sources.

2 Execute your application to display a graph, following the steps described in *Displaying a graph in the Timeline window*, page 224.

3 Whenever execution stops, point at the graph with the mouse pointer to get detailed tooltip information for that location.

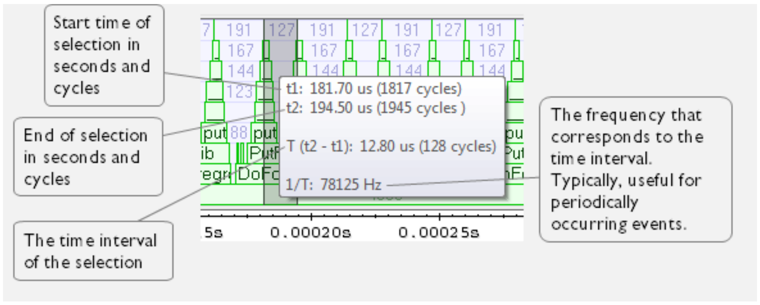

IRQT1 at level 1
CPU Clock (5 MHz)

t1: 20148.00 us (100740 cycles)
t2: 20859.20 us (104296 cycles)

T (t2 - t1): 711.20 us (3556 cycles)

Note that if you have enabled several graphs, you can move the mouse pointer over the different graphs to get graph-specific information.

4 Click in the graph and drag to select a time interval. Point in the graph with the mouse pointer to get timing information for the selection.


Start time of selection in seconds and cycles
End of selection in seconds and cycles
The time interval of the selection
The frequency that corresponds to the time interval. Typically, useful for periodically occurring events.
t1: 181.70 us (1817 cycles)
t2: 194.50 us (1945 cycles)
T (t2 - t1): 12.80 us (128 cycles)
1/T: 78125 Hz
0.00020s
0.00025s

GETTING STARTED USING DATA LOGGING

1 To set a data log breakpoint, use one of these methods:

- In the **Breakpoints** window, right-click and choose **New Breakpoint>Data Log** to open the breakpoints dialog box. Set a breakpoint on the memory location that you want to collect log information for. This can be specified either as a variable or as an address.
- In the **Memory** window, select a memory area, right-click and choose **Set Data Log Breakpoint** from the context menu. A breakpoint is set on the start address of the selection.
- In the editor window, select a variable, right-click and choose **Set Data Log Breakpoint** from the context menu. The breakpoint will be set on the part of the variable that the microcontroller can access using one instruction.

You can set up to four data log breakpoints. For more information about data log breakpoints, see *Data Log breakpoints*, page 127.

2 Choose ***C-SPY driver*>Data Log** to open the **Data Log** window. Optionally, you can also choose:

- ***C-SPY driver*>Data Log Summary** to open the **Data Log Summary** window
- ***C-SPY driver*>Timeline** to open the **Timeline** window to view the Data Log graph.

3 From the context menu, available in the **Data Log** window, choose **Enable** to enable the logging.

4 Start executing your application program to collect the log information.

5 To view the data log information, look in the **Data Log** window, the **Data Log Summary** window, or the Data graph in the **Timeline** window.

6 If you want to save the log or summary to a file, choose **Save to log file** from the context menu in the window in question.

7 To disable data logging, choose **Disable** from the context menu in each window where you have enabled it.

GETTING STARTED USING DATA SAMPLING

1 Choose ***C-SPY driver*>Data Sample Setup** to open the **Data Sample Setup** window.

2 In the **Data Sample Setup** window, perform these actions:

- In the **Expression** column, type the name of the variable for which you want to sample data. The variable must be an integral type with a maximum size of 32 bits and you can specify up to four variables. Make sure that the checkbox is selected for the variable that you want to sample.
- In the **Sampling interval** column, type the number of milliseconds to pass between the samples.

3 To view the result of data sampling, you must enable it in the window in question:

- Choose ***C-SPY driver*>Data Sample** to open the **Data Sample** window. From the context menu, choose **Enable**.
- Choose ***C-SPY driver*>Sampled Graphs** to open the **Sampled Graphs** window. From the context menu, choose **Enable**.

4 Start executing your application program. This starts the data sampling. When the execution stops, for example because a breakpoint is triggered, you can view the result either in the **Data Sample** window or as the Data Sample graph in the **Sampled Graphs** window

5 If you want to save the log or summary to a file, choose **Save to log file** from the context menu in the window in question.

6 To disable data sampling, choose **Disable** from the context menu in each window where you have enabled it.

GETTING STARTED USING SMART ANALOG (EVENT LOGGING)

If you use an emulator and a device that support Smart Analog data collection and display, you can view Smart Analog data as event logs.

1 To enable Smart Analog data collection, choose **Project>Options>Debugger>*Driver*>Setup** and select the option **Collect data**, see *Setup*, page 404.

2 To view collected Smart Analog data, you can choose between these alternatives:

- Choose ***C-SPY driver*>Timeline** to open the **Timeline** window and choose **Enable** from the context menu. You can now view collected Smart Analog data for each channel as a graph (Event graph). See also *Timeline window—Events graph*, page 249.

- Choose ***C-SPY driver*>Event Log** to open the **Event Log** window and choose **Enable** from the context menu. You can now view the collected Smart Analog data for each channel as numbers. See also *Event Log window*, page 253.
- Choose ***C-SPY driver*>Event Log Summary** to open the **Event Log Summary** window and choose **Enable** from the context menu. You will now get a summary of all collected Smart Analog data. See also *Event Log Summary window*, page 256.

Note: Whenever the Events graph or the **Event Log** window is enabled, you can also enable the **Event Log Summary** window to get a summary. However, if you have enabled the **Event Log Summary** window, but not the **Event Log** window or the Event graph in the **Timeline** window, you can get a summary but not detailed information about collected Smart Analog data.

3. Select the graph and right-click to view the context menu. Here you can choose to:
   - Change the radix (you can choose between displaying values in hexadecimal or in decimal format). Note that this setting affects also the **Event Log** window and the **Event Log Summary** window.
   - Show the numerical value of the variables
   - Show the value of the collected Smart Analog data
   - Select the style of the graph (as bars, levels, or linear)
   - Select the size of the graph (S, M, or L)
   - Go to source.
4. Start executing your application program to collect the log information.
5. To view the information, look at either the **Event Log** window, the **Event Log Summary** window, or the event graph for the specific channel in the **Timeline** window.
6. If you want to save the log or summary to a file, choose **Save to log file** from the context menu in the window.
7. To disable event logging, choose **Disable** from the context menu in each window where you have enabled it.

   Note: In Smart Analog debug mode, the only debug commands that can be used in the C-SPY Debugger are **Go**, **Break**, and **Stop Debugging**.

Reference information on application timeline

Reference information about:

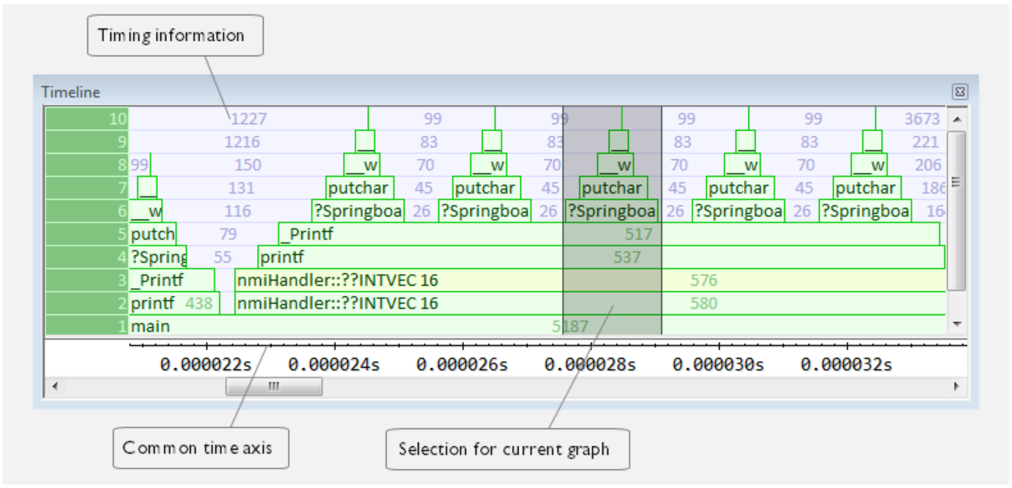
- *Timeline window—Call Stack graph*, page 230
- *Timeline window—Data Log graph*, page 233
- *Data Log window*, page 237
- *Data Log Summary window*, page 240
- *Sampled Graphs window*, page 243
- *Data Sample Setup window*, page 246
- *Data Sample window*, page 248
- *Timeline window—Events graph*, page 249
- *Event Log window*, page 253
- *Event Log Summary window*, page 256
- *Viewing Range dialog box*, page 259

See also:

- *Timeline window—Interrupt Log graph*, page 316
- *Interrupt Log window*, page 311
- *Interrupt Log Summary window*, page 314
- *Timeline window—Power graph*, page 290
- *Power Log window*, page 287

Timeline window—Call Stack graph

The **Timeline** window is available from the ***C-SPY driver*** menu during a debug session.



This window displays trace data represented as different graphs, in relation to a shared time axis.

The Call Stack graph displays the sequence of function calls and returns collected by the trace system.

Note: There is a limit on the number of saved logs. When this limit is exceeded, the oldest entries in the buffer are erased.

Requirements

The C-SPY simulator.

Display area for the Call Stack graph

Each function invocation is displayed as a horizontal bar which extends from the time of entry until the return. Called functions are displayed above its caller. The horizontal bars use four different colors:

- Medium green for normal C functions with debug information
- Light green for functions known to the debugger through an assembler label
- Medium yellow for normal interrupt handlers, with debug information
- Light yellow for interrupt handlers known to the debugger through an assembler label

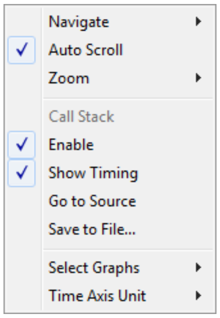
The timing information represents the number of cycles spent in, or between, the function invocations.

At the bottom of the window, there is a shared time axis that uses seconds or cycles as the time unit.

Click in the graph to display the corresponding source code.

Context menu

This context menu is available:



Note: The contents of this menu are dynamic and depend on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Navigate

Commands for navigating the graph(s). Choose between:

Next moves the selection to the next relevant point in the graph. Shortcut key: right arrow.

Previous moves the selection backward to the previous relevant point in the graph. Shortcut key: left arrow.

First moves the selection to the first data entry in the graph. Shortcut key: Home.

Last moves the selection to the last data entry in the graph. Shortcut key: End.

End moves the selection to the last data in any displayed graph, in other words the end of the time axis. Shortcut key: Ctrl+End.

Auto Scroll

Toggles automatic scrolling on or off. When on, the most recently collected data is automatically displayed when you choose **Navigate>End**.

Zoom

Commands for zooming the window, in other words, changing the time scale. Choose between:

Zoom to Selection makes the current selection fit the window. Shortcut key: Return.

Zoom In zooms in on the time scale. Shortcut key: +

Zoom Out zooms out on the time scale. Shortcut key: –

10ns, **100ns**, **1us**, etc makes an interval of 10 nanoseconds, 100 nanoseconds, 1 microsecond, respectively, fit the window.

1ms, **10ms**, etc makes an interval of 1 millisecond or 10 milliseconds, respectively, fit the window.

10m, **1h**, etc makes an interval of 10 minutes or 1 hour, respectively, fit the window.

Call Stack

A heading that shows that the Call stack-specific commands below are available.

Enable

Toggles the display of the graph on or off. If you disable a graph, that graph will be indicated as **OFF** in the window. If no data has been collected for a graph, **no data** will appear instead of the graph.

Show Timing

Toggles the display of the timing information on or off.

Go To Source

Displays the corresponding source code in an editor window, if applicable.

Save to File

Saves all contents (or the selected contents) of the Call Stack graph to a file. The menu command is only available when C-SPY is not running.

Select Graphs

Selects which graphs to be displayed in the **Timeline** window.

Time Axis Unit

Selects the unit used in the time axis; choose between **Seconds** and **Cycles**.

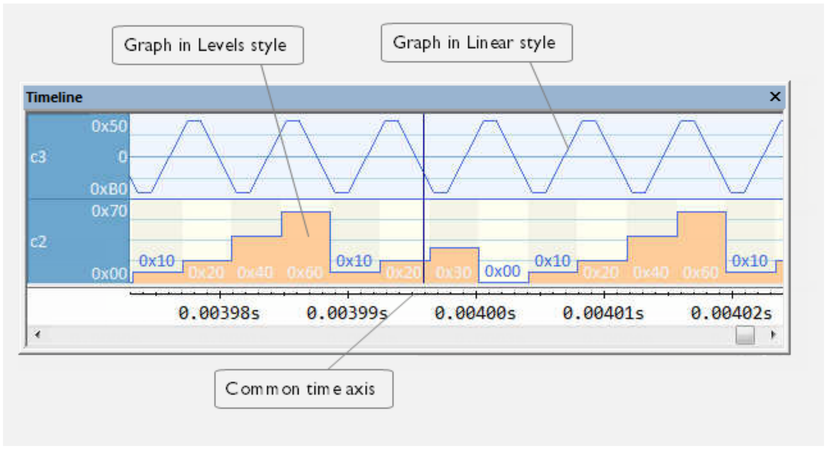
If **Cycles** is not available, the graphs are based on different clock sources. In that case you can view cycle values as tooltip information by pointing at the graph with your mouse pointer.

Profile Selection

Enables profiling time intervals in the **Function Profiler** window. Note that this command is only available if the C-SPY driver supports PC Sampling.

Timeline window—Data Log graph

The **Timeline** window is available from the C-SPY driver menu during a debug session.



This window displays trace data represented as different graphs, in relation to a shared time axis.

The Data Log graph displays the data logs collected by the trace system, for up to four different variables or address ranges specified as Data Log breakpoints.

Note: There is a limit on the number of saved logs. When this limit is exceeded, the oldest entries in the buffer are erased.

Requirements

The C-SPY simulator.

Display area for the Data Log graph

Where:

- The label area at the left end of the graph displays the variable name or the address for which you have specified the Data Log breakpoint.
- The graph itself displays how the value of the variable changes over time. The label area also displays the limits, or range, of the Y-axis for a variable. You can use the

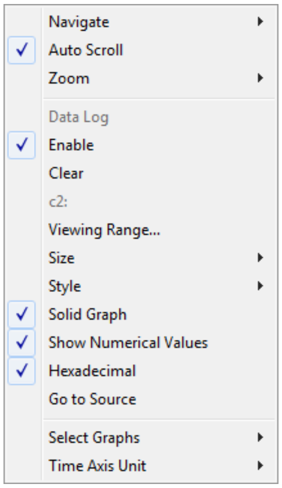
context menu to change these limits. The graph is a graphical representation of the information in the **Data Log** window, see *Data Log window*, page 237.

- The graph can be displayed either as a thin line between consecutive logs or as a rectangle for every log (optionally color-filled).
- A red vertical line indicates overflow, which means that the communication channel failed to transmit all data logs from the target system. A red question mark indicates a log without a value.

At the bottom of the window, there is a shared time axis that uses seconds or cycles as the time unit.

Context menu

This context menu is available:



Note: The contents of this menu are dynamic and depend on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Navigate

Commands for navigating the graph(s). Choose between:

Next moves the selection to the next relevant point in the graph. Shortcut key: right arrow.

Previous moves the selection backward to the previous relevant point in the graph. Shortcut key: left arrow.

First moves the selection to the first data entry in the graph. Shortcut key: Home.

Last moves the selection to the last data entry in the graph. Shortcut key: End.

End moves the selection to the last data in any displayed graph, in other words the end of the time axis. Shortcut key: Ctrl+End.

Auto Scroll

Toggles automatic scrolling on or off. When on, the most recently collected data is automatically displayed when you choose **Navigate>End**.

Zoom

Commands for zooming the window, in other words, changing the time scale. Choose between:

Zoom to Selection makes the current selection fit the window. Shortcut key: Return.

Zoom In zooms in on the time scale. Shortcut key: +

Zoom Out zooms out on the time scale. Shortcut key: –

10ns, **100ns**, **1us**, etc makes an interval of 10 nanoseconds, 100 nanoseconds, 1 microsecond, respectively, fit the window.

1ms, **10ms**, etc makes an interval of 1 millisecond or 10 milliseconds, respectively, fit the window.

10m, **1h**, etc makes an interval of 10 minutes or 1 hour, respectively, fit the window.

Data Log

A heading that shows that the Data Log-specific commands below are available.

Enable

Toggles the display of the graph on or off. If you disable a graph, that graph will be indicated as **OFF** in the window. If no data has been collected for a graph, **no data** will appear instead of the graph.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Variable

The name of the variable for which the Data Log-specific commands below apply. This menu command is context-sensitive, which means it reflects the Data Log graph you selected in the **Timeline** window (one of up to four).

Viewing Range

Displays a dialog box, see *Viewing Range dialog box*, page 259.

Size

Determines the vertical size of the graph; choose between **Small**, **Medium**, and **Large**.

Style

Selects the style of the graph. Choose between:

Bars, displays a vertical bar for each log

Columns, displays a column for each log

Levels, displays the graph with a rectangle for each log, optionally color-filled

Linear, displays the graph as a thin line between consecutive logs

Note that all styles are not available for all graphs.

Solid Graph

Displays the graph as a color-filled solid graph instead of as a thin line.

Show Numerical Value

Shows the numerical value of the variable, in addition to the graph.

Hexadecimal

Toggles between displaying the selected value in decimal or hexadecimal format. Note that this setting also affects the log window.

Go To Source

Displays the corresponding source code in an editor window, if applicable.

Select Graphs

Selects which graphs to be displayed in the **Timeline** window.

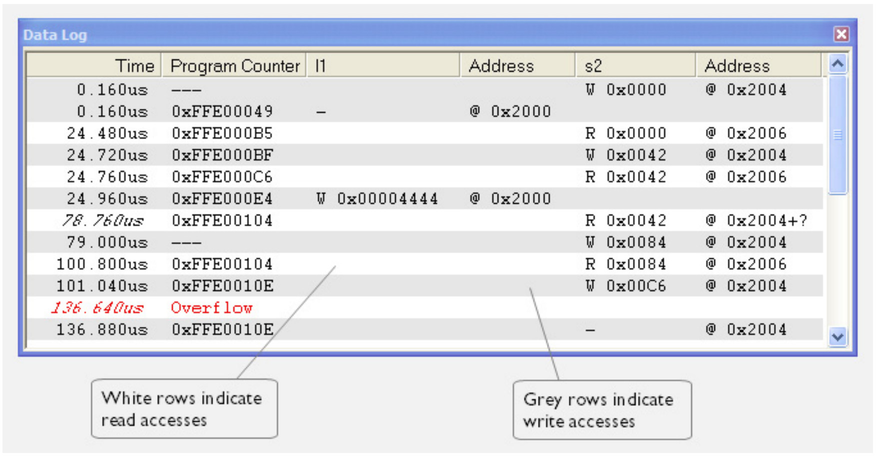
Time Axis Unit

Selects the unit used in the time axis; choose between **Seconds** and **Cycles**.

If **Cycles** is not available, the graphs are based on different clock sources. In that case you can view cycle values as tooltip information by pointing at the graph with your mouse pointer.

Data Log window

The **Data Log** window is available from the C-SPY driver menu.


Data Log
White rows indicate read accesses
Grey rows indicate write accesses

Time	Program Counter	l1	Address	s2	Address
0.160us	---			W 0x0000	@ 0x2004
0.160us	0xFFE00049	–	@ 0x2000		
24.480us	0xFFE000B5			R 0x0000	@ 0x2006
24.720us	0xFFE000BF			W 0x0042	@ 0x2004
24.760us	0xFFE000C6			R 0x0042	@ 0x2006
24.960us	0xFFE000E4	W 0x00004444	@ 0x2000		
78.760us	0xFFE00104			R 0x0042	@ 0x2004+?
79.000us	---			W 0x0084	@ 0x2004
100.800us	0xFFE00104			R 0x0084	@ 0x2006
101.040us	0xFFE0010E			W 0x00C6	@ 0x2004
136.640us	Overflow				
136.880us	0xFFE0010E			–	@ 0x2004

Use this window to log accesses to up to four different memory locations or areas.

Note: There is a limit on the number of saved logs. When this limit is exceeded, the oldest entries in the buffer are erased.

See also *Getting started using data logging*, page 226.

Requirements

The C-SPY simulator.

Display area

Each row in the display area shows the time, the program counter, and, for every tracked data object, its value and address. All information is cleared on reset. The information is displayed in these columns:

Time

If the time is displayed in italics, the target system has not been able to collect a correct time, but instead had to approximate it.

This column is available when you have selected **Show time** from the context menu.

Cycles

The number of cycles from the start of the execution until the event.

If a cycle is displayed in italics, the target system has not been able to collect a correct time, but instead had to approximate it.

This column is available when you have selected **Show cycles** from the context menu.

Program Counter*

Displays one of these:

An address, which is the content of the `PC`, that is, the address of the instruction that performed the memory access.

---, the target system failed to provide the debugger with any information.

Overflow in red, the communication channel failed to transmit all data from the target system.

Value

Displays the access type and the value (using the access size) for the location or area you want to log accesses to. For example, if zero is read using a byte access it will be displayed as `0x00`, and for a long access it will be displayed as `0x00000000`.

To specify what data you want to log accesses to, use the **Data Log** breakpoint dialog box. See *Data Log breakpoints*, page 127.

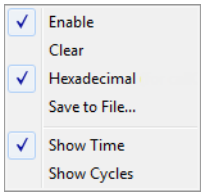
Address

The actual memory address that is accessed. For example, if only a byte of a word is accessed, only the address of the byte is displayed. The address is calculated as base address + offset, where the base address is retrieved from the **Data Log** breakpoint dialog box and the offset is retrieved from the logs. If the log from the target system does not provide the debugger with an offset, the offset contains `+ ?`.

* You can double-click a line in the display area. If the value of the `PC` for that line is available in the source code, the editor window displays the corresponding source code (this does not include library source code).

Context menu

This context menu is available:



These commands are available:

Enable

Enables the logging system. The system will log information also when the window is closed.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Hexadecimal

Toggles between displaying the selected value in decimal or hexadecimal format. Note that this setting also affects the log window.

Save to File

Displays a standard file selection dialog box where you can select the destination file for the log information. The entries in the log file are separated by `TAB` and `LF` characters. An **X** in the **Approx** column indicates that the timestamp is an approximation.

Show Time

Displays the **Time** column.

If the **Time** column is displayed by default in the C-SPY driver you are using, this menu command is not available.

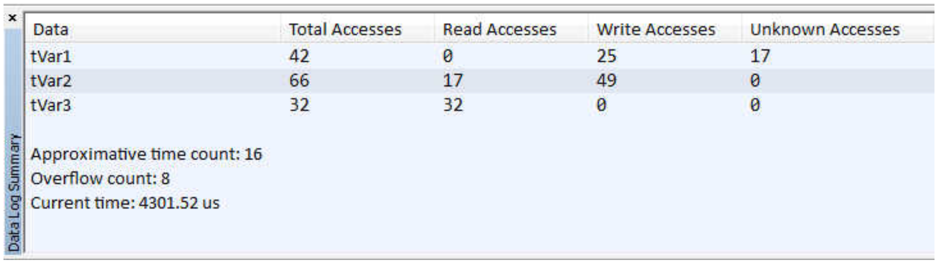
Show Cycles

Displays the **Cycles** column.

If the **Cycles** column is not supported in the C-SPY driver you are using, this menu command is not available.

Data Log Summary window

The **Data Log Summary** window is available from the C-SPY driver menu.



Data	Total Accesses	Read Accesses	Write Accesses	Unknown Accesses
tVar1	42	0	25	17
tVar2	66	17	49	0
tVar3	32	32	0	0

Approximative time count: 16
Overflow count: 8
Current time: 4301.52 us

This window displays a summary of data accesses to specific memory location or areas.

See also *Getting started using data logging*, page 226.

Requirements

The C-SPY simulator.

Display area

Each row in this area displays the type and the number of accesses to each memory location or area in these columns. Summary information is listed at the bottom of the display area.

Data

The name of the data object you have selected to log accesses to. To specify what data object you want to log accesses to, use the **Data Log** breakpoint dialog box. See *Data Log breakpoints*, page 127.

Total Accesses

The total number of accesses.

If the sum of read accesses and write accesses is less than the total accesses, the target system for some reason did not provide valid access type information for all accesses.

Read Accesses

The total number of read accesses.

Write Accesses

The total number of write accesses.

Unknown Accesses

The number of unknown accesses, in other words, accesses where the access type is not known.

Approximative time count

The information displayed depends on the C-SPY driver you are using.

For some C-SPY drivers, this information is not displayed or the value is always zero. In this case, all logs have an exact time stamp.

For other C-SPY drivers, a non-zero value is displayed. The value represents the amount of logs with an approximative time stamp. This might happen if the bandwidth in the communication channel is too low compared to the amount of data packets generated by the CPU or if the CPU generated packets with an approximative time stamp.

Overflow count

The information displayed depends on the C-SPY driver you are using.

For some C-SPY drivers, this information is not displayed or the value is always zero.

For other C-SPY drivers, the number represents the amount of overflows in the communication channel which can cause logs to be lost. If this happens, it indicates that logs might be incomplete. To solve this, make sure not to use all C-SPY log features simultaneously or check used bandwidth for the communication channel.

Current time
/Current cycles

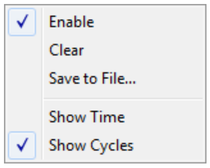
The information displayed depends on the C-SPY driver you are using.

For some C-SPY drivers, the value is always zero or not visible at all.

For other C-SPY drivers, the number represents the current time or cycles—the number of cycles or the execution time since the start of execution.

Context menu

This context menu is available:



These commands are available:

Enable

Enables the logging system. The system will log information also when the window is closed.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Save to File

Displays a standard file selection dialog box where you can select the destination file for the log information. The entries in the log file are separated by `TAB` and `LF` characters. An **X** in the **Approx** column indicates that the timestamp is an approximation.

Show Time

Displays the **Time** column.

If the **Time** column is displayed by default in the C-SPY driver you are using, this menu command is not available.

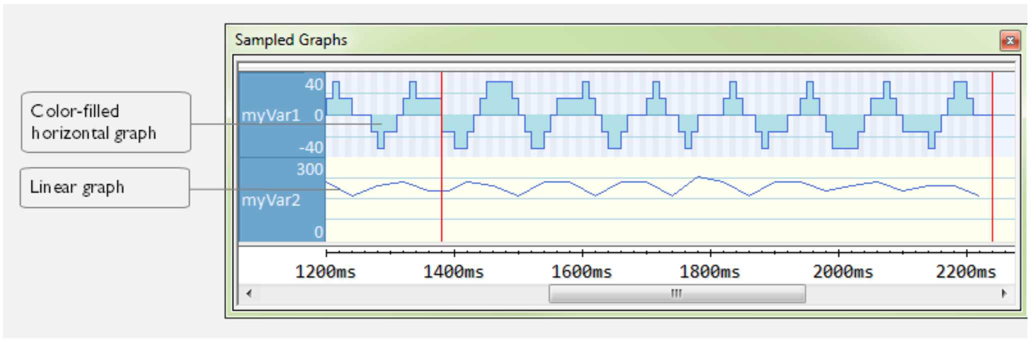
Show Cycles

Displays the **Cycles** column.

If the **Cycles** column is not supported in the C-SPY driver you are using, this menu command is not available.

Sampled Graphs window

The **Sampled Graphs** window is available from the C-SPY driver menu.



Use this window to display graphs for up to four different variables, and where:

- The graph displays how the value of the variable changes over time. The area on the left displays the limits, or range, of the Y-axis for the variable. You can use the context menu to change these limits. The graph is a graphical representation of the information in the **Data Sample** window, see *Data Sample window*, page 248.
- The graph can be displayed as levels, where a horizontal line—optionally color-filled—shows the value until the next sample. Alternatively, the graph can be linear, where a line connects consecutive samples.
- A red vertical line indicates the time of application execution stops.

At the bottom of the window, there is a shared time axis that uses seconds as the time unit.

To navigate in the graph, use any of these alternatives:

- Right-click and choose **Zoom In** or **Zoom Out** from the context menu. Alternatively, use the + and – keys to zoom.
- Right-click in the graph and choose **Navigate** and the appropriate command to move backward and forward on the graph. Alternatively, use any of the shortcut keys: arrow keys, Home, End, and Ctrl+End.
- Double-click on a sample to highlight the corresponding source code in the editor window and in the **Disassembly** window.
- Click on the graph and drag to select a time interval. Press Enter or right-click and choose **Zoom>Zoom to Selection** from the context menu. The selection zooms in.

Hover with the mouse pointer in the graph to get detailed tooltip information for that location.

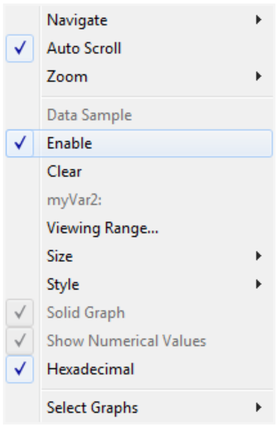
See also *Getting started using data sampling*, page 227.

Requirements

Any supported hardware debugger system.

Context menu

This context menu is available:



These commands are available:

Navigate

Commands for navigating in the graphs. Choose between:

Next moves the selection to the next relevant point in the graph. Shortcut key: right arrow.

Previous moves the selection to the previous relevant point in the graph. Shortcut key: left arrow.

First moves the selection to the first data entry in the graph. Shortcut key: Home.

Last moves the selection to the last data entry in the graph. Shortcut key: End.

End moves the selection to the last data in any displayed graph, in other words the end of the time axis. Shortcut key: Ctrl+End.

Auto Scroll

Toggles automatic scrolling on or off. When on, the most recently collected data is automatically displayed when you choose **Navigate>End**.

Zoom

Commands for zooming the window, in other words, changing the time scale. Choose between:

Zoom to Selection makes the current selection fit the window. Shortcut key: Return.

Zoom In zooms in on the time scale. Shortcut key: +

Zoom Out zooms out on the time scale. Shortcut key: -

1us, **10us**, **100us** makes an interval of 1 microseconds, 10 microseconds, or 100 microseconds, respectively, fit the window.

1ms, **10ms**, **100ms** makes an interval of 1 millisecond, 10 milliseconds, or 100 milliseconds, respectively, fit the window.

1s, **10s**, **100s** makes an interval of 1 second, 10 seconds, or 100 seconds, respectively, fit the window.

1k s, **10k s**, **100k s** makes an interval of 1,000 seconds, 10,000 seconds, or 100,000 seconds, respectively, fit the window.

1M s, **10M s**, makes an interval of 1,000,000 seconds or 10,000,000 seconds, respectively, fit the window.

Data Sample

A menu item that shows that the Data Sample-specific commands below are available.

Open Setup window (Data Sample Graph)

Opens the **Data Sample Setup** window.

Enable

Toggles the display of the graph on or off. If you disable a graph, that graph will be indicated as **OFF** in the window. If no data has been collected for a graph, **no data** will appear instead of the graph.

Clear

Clears the sampled data.

Variable

The name of the variable for which the Data Sample-specific commands below apply. This menu item is context-sensitive, which means it reflects the Data Sample graph you selected in the **Sampled Graphs** window (one of up to four).

Viewing Range

Displays a dialog box, see *Viewing Range dialog box*, page 259.

Size

Controls the vertical size of the graph; choose between **Small**, **Medium**, and **Large**.

Style

Choose how to display the graph. Choose between:

Levels, where a horizontal line—optionally color-filled—shows the value until the next sample.

Linear, where a line connects consecutive samples.

Solid Graph

Displays the graph as a color-filled solid graph instead of as a thin line. This is only possible if the graph is displayed as Levels.

Hexadecimal

Toggles between displaying the selected value in decimal or hexadecimal format. Note that this setting also affects the log window.

Show Numerical Value

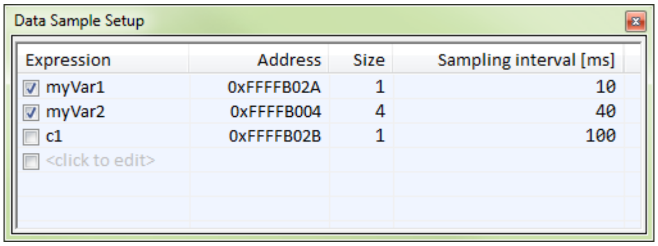
Shows the numerical value of the variable, in addition to the graph.

Select Graphs

Selects which graphs to display in the **Sampled Graphs** window.

Data Sample Setup window

The **Data Sample Setup** window is available from the C-SPY driver menu.



Data Sample Setup

Expression	Address	Size	Sampling interval [ms]
✓ myVar1	0xFFFFB02A	1	10
✓ myVar2	0xFFFFB004	4	40
☐ c1	0xFFFFB02B	1	100
☐ <click to edit>			

Use this window to specify up to four variables to sample data for. You can view the sampled data for the variables either in the **Data Sample** window or as graphs in the **Sampled Graphs** window.

See also *Getting started using data sampling*, page 227.

Requirements

Any supported hardware debugger system.

Display area

This area contains these columns:

Expression

Type the name of the variable which must be an integral type with a maximum size of 32 bits. Click the check box to enable or disable data sampling for the variable.

Alternatively, drag an expression from the editor window and drop it in the display area.

Variables in the expressions must be statically located, for example global variables.

Address

The actual memory address that is accessed. The column cells cannot be edited.

Size

The size of the variable, either 1, 2, or 4 bytes. The column cells cannot be edited.

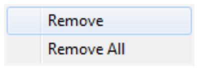
Sampling interval [ms]

Type the number of milliseconds to pass between the samples. The shortest allowed interval is 10 ms and the interval you specify must be a multiple of that.

Note that the sampling time you specify is just the interval (according to the Microsoft Windows calculations) for how often C-SPY checks with the C-SPY driver (which in turn must check with the MCU for a value). If this takes longer than the sampling interval you have specified, the next sampling will be omitted. If this occurs, you might want to consider increasing the sampling time.

Context menu

This context menu is available:



These commands are available:

Remove

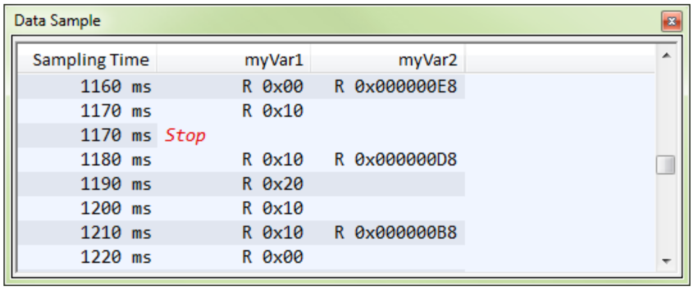
Removes the selected variable.

Remove All

Removes all variables.

Data Sample window

The **Data Sample** window is available from the C-SPY driver menu.



Sampling Time	myVar1	myVar2
1160 ms	R 0x00	R 0x000000E8
1170 ms	R 0x10	
1170 ms	Stop	
1180 ms	R 0x10	R 0x000000D8
1190 ms	R 0x20	
1200 ms	R 0x10	
1210 ms	R 0x10	R 0x000000B8
1220 ms	R 0x00	

Use this window to view the result of the data sampling for the variables you have selected in the **Data Sample Setup** window.

Choose **Enable** from the context menu to enable data sampling.

See also *Getting started using data sampling*, page 227.

Requirements

Any supported hardware debugger system.

Display area

This area contains these columns:

Sampling Time

The time when the data sample was collected. Time starts at zero after a reset. Every time the execution stops, a red `Stop` indicates when the stop occurred.

The selected expression

The column headers display the names of the variables that you selected in the **Data Sample Setup** window. The column cells display the sampling values for the variable.

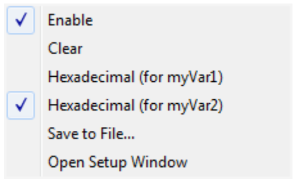
There can be up to four columns of this type, one for each selected variable.

* You can double-click a row in the display area. If you have enabled the data sample graph in the **Sampled Graphs** window, the selection line will be moved to reflect the time of the row you double-clicked.

Note: Only 8- or 16-bit values can be guaranteed to be displayed correctly, and the data must be located at an even address.

Context menu

This context menu is available:



These commands are available:

Enable

Enables data sampling.

Clear

Clears the sampled data.

Hexadecimal

Toggles between displaying the selected value in decimal or hexadecimal format. Note that this setting also affects the log window.

Save to File

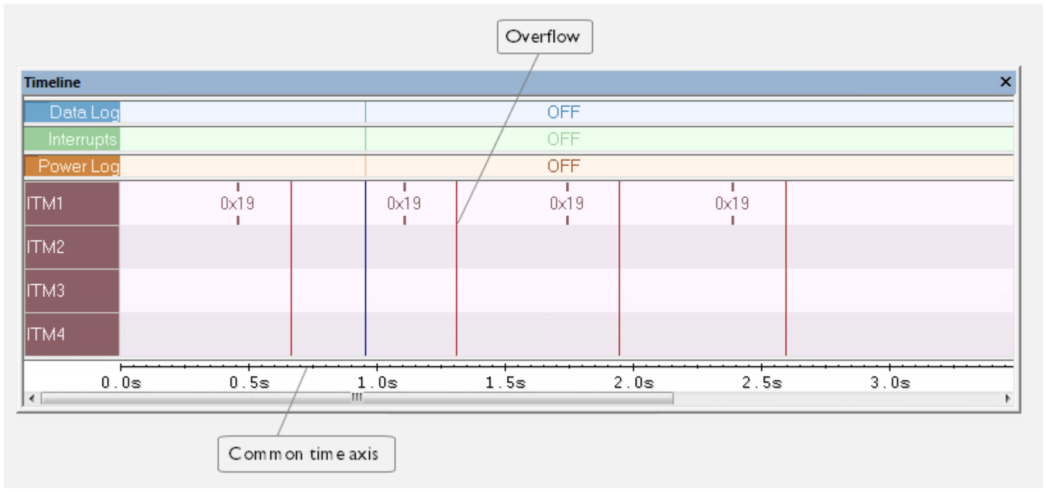
Displays a standard file selection dialog box where you can select the destination file for the log information. The entries in the log file are separated by `TAB` and `LF` characters. An **X** in the **Approx** column indicates that the timestamp is an approximation.

Open setup window

Opens the **Data Sample Setup** window.

Timeline window—Events graph

The **Timeline** window is available from the C-SPY driver menu during a debug session.



This window displays trace data represented as different graphs, in relation to a shared time axis.

The Events graph displays the collected Smart Analog data.

Note: There is a limit on the number of saved logs. When this limit is exceeded, the oldest entries in the buffer are erased.

Requirements

- An E1, E2, E20, E2 Lite/E2 On-Board, or EZ-CUBE2 emulator
- A device that supports Smart Analog data collection and display

Display area for the Events graph

Where:

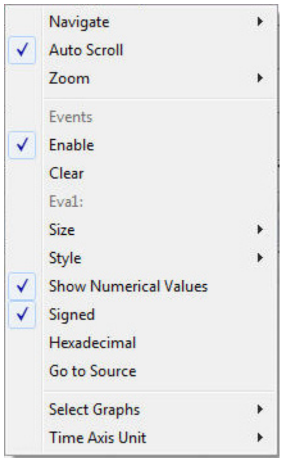
- The label area at the left end of the graph displays the name of the channel.
- For each channel, there will be a vertical line that indicates when the data was collected. Optionally, you can choose to display the data value.
- The graph can be displayed in different styles—as a thin line between consecutive logs, as a rectangle for every log (optionally color-filled), or as vertical bars.
- A red vertical line indicates overflow, which means that the communication channel failed to transmit all data logs from the target system.

At the bottom of the window, there is a shared time axis that uses seconds or cycles as the time unit.

See also *Getting started using Smart Analog (event logging)*, page 227.

Context menu

This context menu is available:



These commands are available:

Navigate

Commands for navigating the graph(s). Choose between:

Next moves the selection to the next relevant point in the graph. Shortcut key: right arrow.

Previous moves the selection backward to the previous relevant point in the graph. Shortcut key: left arrow.

First moves the selection to the first data entry in the graph. Shortcut key: Home.

Last moves the selection to the last data entry in the graph. Shortcut key: End.

End moves the selection to the last data in any displayed graph, in other words the end of the time axis. Shortcut key: Ctrl+End.

Auto Scroll

Toggles automatic scrolling on or off. When on, the most recently collected data is automatically displayed when you choose **Navigate>End**.

Zoom

Commands for zooming the window, in other words, changing the time scale. Choose between:

Zoom to Selection makes the current selection fit the window. Shortcut key: Return.

Zoom In zooms in on the time scale. Shortcut key: +

Zoom Out zooms out on the time scale. Shortcut key: –

10ns, **100ns**, **1us**, etc makes an interval of 10 nanoseconds, 100 nanoseconds, 1 microsecond, respectively, fit the window.

1ms, **10ms**, etc makes an interval of 1 millisecond or 10 milliseconds, respectively, fit the window.

10m, **1h**, etc makes an interval of 10 minutes or 1 hour, respectively, fit the window.

Events

A heading that shows that the Events-specific commands below are available.

Enable

Toggles the display of the graph on or off. If you disable a graph, that graph will be indicated as **OFF** in the window. If no data has been collected for a graph, **no data** will appear instead of the graph.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Variable

The name of the channel for which the Events-specific commands below apply. This menu command is context-sensitive, which means it reflects the channel in the Events graph you selected in the **Timeline** window (one of up to four).

Viewing Range

Displays a dialog box, see *Viewing Range dialog box*, page 259.

Size

Determines the vertical size of the graph; choose between **Small**, **Medium**, and **Large**.

Style

Selects the style of the graph. Choose between:

Bars, displays a vertical bar for each log

Columns, displays a column for each log

Levels, displays the graph with a rectangle for each log, optionally color-filled

Linear, displays the graph as a thin line between consecutive logs

Note that all styles are not available for all graphs.

Show Numerical Value

Shows the numerical value of the variable, in addition to the graph.

Signed

Toggles between displaying the selected value as a signed or unsigned number. Note that this setting also affects the log window.

Hexadecimal

Toggles between displaying the selected value in decimal or hexadecimal format. Note that this setting also affects the log window.

Go To Source

Displays the corresponding source code in an editor window, if applicable.

Select Graphs

Selects which graphs to be displayed in the **Timeline** window.

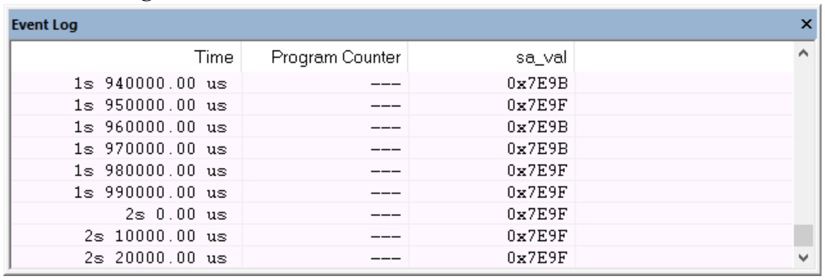
Time Axis Unit

Selects the unit used in the time axis; choose between **Seconds** and **Cycles**.

If **Cycles** is not available, the graphs are based on different clock sources. In that case you can view cycle values as tooltip information by pointing at the graph with your mouse pointer.

Event Log window

The **Event Log** window is available from the C-SPY driver menu.



Event Log

Time	Program Counter	sa_val
1s 940000.00 us	---	0x7E9B
1s 950000.00 us	---	0x7E9F
1s 960000.00 us	---	0x7E9B
1s 970000.00 us	---	0x7E9B
1s 980000.00 us	---	0x7E9F
1s 990000.00 us	---	0x7E9F
2s 0.00 us	---	0x7E9F
2s 10000.00 us	---	0x7E9F
2s 20000.00 us	---	0x7E9F

This window displays the collected Smart Analog data.

Note: There is a limit on the number of saved logs. When this limit is exceeded, the oldest entries in the buffer are erased.

See also *Getting started using Smart Analog (event logging)*, page 227.

Requirements

- An E1, E2, E20, E2 Lite/E2 On-Board, or EZ-CUBE2 emulator
- A device that supports Smart Analog data collection and display

Display area

Each row in the display area shows the events in these columns:

Cycles

The number of cycles from the start of the execution until the Smart Analog data was collected. This information is cleared at reset.

If a cycle is displayed in italics, the target system has not been able to collect a correct time, but instead had to approximate it.

This column is available when you have selected **Show cycles** from the context menu.

Program Counter

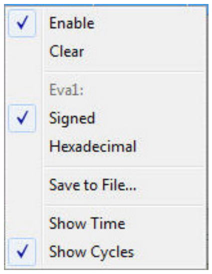
---, the target system does not provide the debugger with any information.

sa_val

The Smart Analog channel for which data is collected.

Context menu

This context menu is available:



These commands are available:

Enable

Enables the logging system. The system will log information also when the window is closed.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Variable

The name of the channel for which the Events-specific commands below apply. This menu command is context-sensitive, which means it reflects the channel in the Events graph you selected in the **Timeline** window (one of up to four).

Signed

Toggles between displaying the selected value as a signed or unsigned number. Note that this setting also affects the log window.

Hexadecimal

Toggles between displaying the selected value in decimal or hexadecimal format. Note that this setting also affects the log window.

Save to File

Displays a standard file selection dialog box where you can select the destination file for the log information. The entries in the log file are separated by `TAB` and `LF` characters. An **X** in the **Approx** column indicates that the timestamp is an approximation.

Show Time

Displays the **Time** column.

If the **Time** column is displayed by default in the C-SPY driver you are using, this menu command is not available.

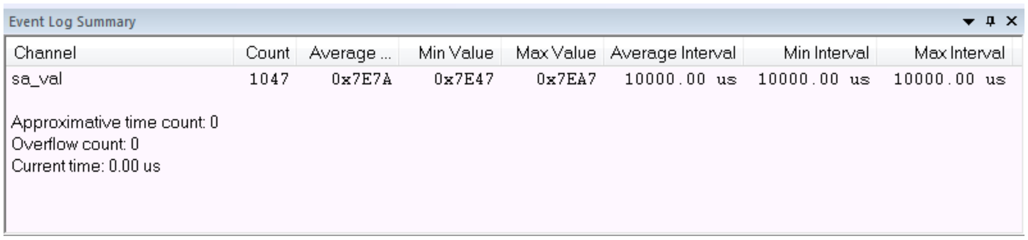
Show Cycles

Displays the **Cycles** column.

If the **Cycles** column is not supported in the C-SPY driver you are using, this menu command is not available.

Event Log Summary window

The **Event Log Summary** window is available from the C-SPY driver menu.



Event Log Summary

Channel	Count	Average ...	Min Value	Max Value	Average Interval	Min Interval	Max Interval
sa_val	1047	0x7E7A	0x7E47	0x7EA7	10000.00 us	10000.00 us	10000.00 us

Approximative time count: 0
Overflow count: 0
Current time: 0.00 us

This window displays a summary of collected Smart Analog data.

See also *Getting started using Smart Analog (event logging)*, page 227.

Requirements

- An E1, E2, E20, E2 Lite/E2 On-Board, or EZ-CUBE2 emulator
- A device that supports Smart Analog data collection and display

Display area

Each row displays the type and the number of accesses to each location in your application code in these columns. Summary information is listed at the bottom of the display area.

Channel

The name of the communication channel for which data is collected.

Count

The number of logged values.

Average Value

The average value of all received values.

Min Value

The smallest value of all received values.

Max Value

The largest value of all received values.

Average Interval

The average time (in cycles) between logged values.

Min Interval

The shortest time (in cycles) between two logged values.

Max Interval

The longest time (in cycles) between two logged values.

Approximative time count

The information displayed depends on the C-SPY driver you are using.

For some C-SPY drivers, this information is not displayed or the value is always zero. In this case, all logs have an exact time stamp.

For other C-SPY drivers, a non-zero value is displayed. The value represents the amount of logs with an approximative time stamp. This might happen if the bandwidth in the communication channel is too low compared to the amount of data packets generated by the CPU or if the CPU generated packets with an approximative time stamp.

Overflow count

The information displayed depends on the C-SPY driver you are using.

For some C-SPY drivers, this information is not displayed or the value is always zero.

For other C-SPY drivers, the number represents the amount of overflows in the communication channel which can cause logs to be lost. If this happens, it indicates that logs might be incomplete. To solve this, make sure not to use all C-SPY log features simultaneously or check used bandwidth for the communication channel.

Current time|cycles

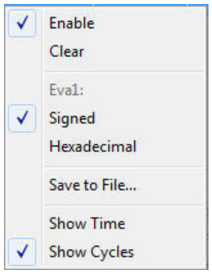
The information displayed depends on the C-SPY driver you are using.

For some C-SPY drivers, the value is always zero or not visible at all.

For other C-SPY drivers, the number represents the current time or cycles—the number of cycles or the execution time since the start of execution.

Context menu

This context menu is available:



These commands are available:

Enable

Enables the logging system. The system will log information also when the window is closed.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Variable

The name of the channel for which the Events-specific commands below apply. This menu command is context-sensitive, which means it reflects the channel in the Events graph you selected in the **Timeline** window (one of up to four).

Signed

Toggles between displaying the selected value as a signed or unsigned number. Note that this setting also affects the log window.

Hexadecimal

Toggles between displaying the selected value in decimal or hexadecimal format. Note that this setting also affects the log window.

Save to File

Displays a standard file selection dialog box where you can select the destination file for the log information. The entries in the log file are separated by `TAB` and `LF` characters. An **X** in the **Approx** column indicates that the timestamp is an approximation.

Show Time

Displays the **Time** column.

If the **Time** column is displayed by default in the C-SPY driver you are using, this menu command is not available.

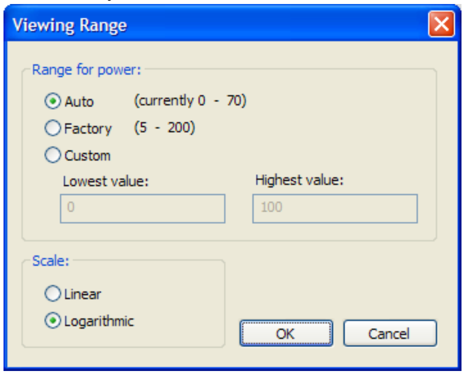
Show Cycles

Displays the **Cycles** column.

If the **Cycles** column is not supported in the C-SPY driver you are using, this menu command is not available.

Viewing Range dialog box

The **Viewing Range** dialog box is available from the context menu that appears when you right-click in any graph in the **Timeline** window that uses the linear, levels or columns style.



Range for power:
(✓) Auto (currently 0 - 70)
( ) Factory (5 - 200)
( ) Custom
Lowest value: 0
Highest value: 100

Scale:
( ) Linear
(✓) Logarithmic

Use this dialog box to specify the value range, that is, the range for the Y-axis for the graph.

Requirements

The C-SPY simulator.

Range for ...

Selects the viewing range for the displayed values:

Auto

Uses the range according to the range of the values that are actually collected, continuously keeping track of minimum or maximum values. The currently computed range, if any, is displayed in parentheses. The range is rounded to reasonably *even* limits.

Factory

For the Power Log graph: Uses the range according to the properties of the measuring hardware (only if supported by the product edition you are using).

For the other graphs: Uses the range according to the value range of the variable, for example 0–65535 for an unsigned 16-bit integer.

Custom

Use the text boxes to specify an explicit range.

Scale

Selects the scale type of the Y-axis:

- **Linear**
- **Logarithmic**.

Profiling

Introduction to the profiler

These topics are covered:

- Reasons for using the profiler
- Briefly about the profiler
- Requirements for using the profiler

REASONS FOR USING THE PROFILER

Function profiling can help you find the functions in your source code where the most time is spent during execution. You should focus on those functions when optimizing your code. A simple method of optimizing a function is to compile it using speed optimization. Alternatively, you can move the data used by the function into more efficient memory. For detailed information about efficient memory usage, see the *IAR C/C++ Development Guide for RL78*.

Alternatively, you can use *filtered profiling*, which means that you can exclude, for example, individual functions from being profiled. To profile only a specific part of your code, you can select a *time interval*—using the **Timeline** window—for which C-SPY produces profiling information.

Instruction profiling can help you fine-tune your code on a very detailed level, especially for assembler source code. Instruction profiling can also help you to understand where your compiled C/C++ source code spends most of its time, and perhaps give insight into how to rewrite it for better performance.

BRIEFLY ABOUT THE PROFILER

Function profiling information is displayed in the **Function Profiler** window, that is, timing information for the functions in an application. Profiling must be turned on explicitly using a button on the window's toolbar, and will stay enabled until it is turned off.

Instruction profiling information is displayed in the **Disassembly** window, that is, the number of times each instruction has been executed.

Profiling sources

The profiler can use different mechanisms, or *sources*, to collect profiling information. Depending on the available trace source features, one or more of the sources can be used for profiling:

- *Trace (calls)*

  The full instruction trace is analyzed to determine all function calls and returns. When the collected instruction sequence is incomplete or discontinuous, the profiling information is less accurate.
- *Trace (flat)*

  Each instruction in the full instruction trace or each PC Sample is assigned to a corresponding function or code fragment, without regard to function calls or returns. This is most useful when the application does not exhibit normal call/return sequences, such as when you are using an RTOS, or when you are profiling code which does not have full debug information.

REQUIREMENTS FOR USING THE PROFILER

The C-SPY simulator driver supports the profiler; there are no specific requirements.

The C-SPY hardware debugger drivers do not support profiling.

Using the profiler

These tasks are covered:

- Getting started using the profiler on function level
- Analyzing the profiling data
- Getting started using the profiler on instruction level

GETTING STARTED USING THE PROFILER ON FUNCTION LEVEL

To display function profiling information in the Function Profiler window:

1 Build your application using these options:

Category	Setting
C/C++ Compiler	Output>Generate debug information

Table 11: Project options for enabling the profiler

Category	Setting
Linker	Output>Include debug information in output

Table 11: Project options for enabling the profiler (Continued)

2 When you have built your application and started C-SPY, choose ***C-SPY driver*>Function Profiler** to open the **Function Profiler** window, and click the **Enable** button to turn on the profiler. Alternatively, choose **Enable** from the context menu that is available when you right-click in the **Function Profiler** window.

3 Start executing your application to collect the profiling information.

4 Profiling information is displayed in the **Function Profiler** window. To sort, click on the relevant column header.

5 When you start a new sampling, you can click the **Clear** button—alternatively, use the context menu—to clear the data.

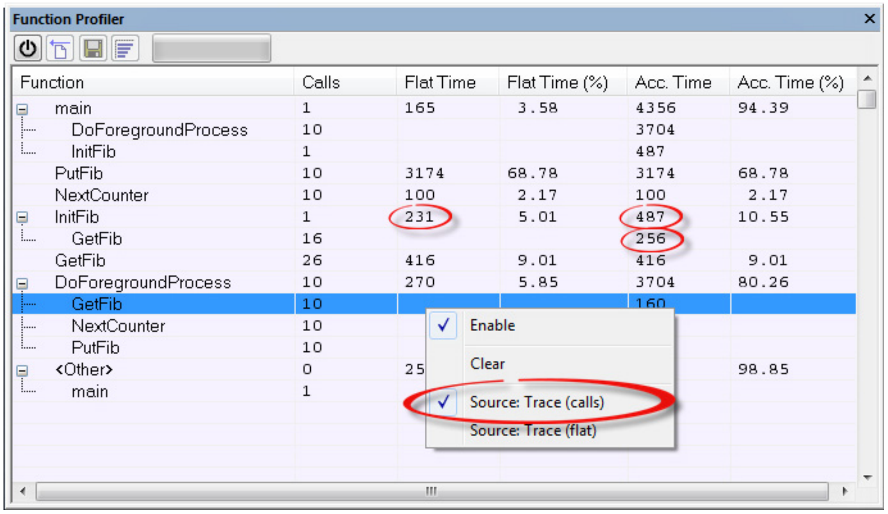
ANALYZING THE PROFILING DATA

Here follow some examples of how to analyze the data.

The first figure shows the result of profiling using **Source: Trace (calls)**. The profiler follows the program flow and detects function entries and exits.

- For the **InitFib** function, **Flat Time** 231 is the time spent inside the function itself.
- For the **InitFib** function, **Acc Time** 487 is the time spent inside the function itself, including all functions InitFib calls.
- For the **InitFib/GetFib** function, **Acc Time** 256 is the time spent inside **GetFib** (but only when called from **InitFib**), including any functions **GetFib** calls.

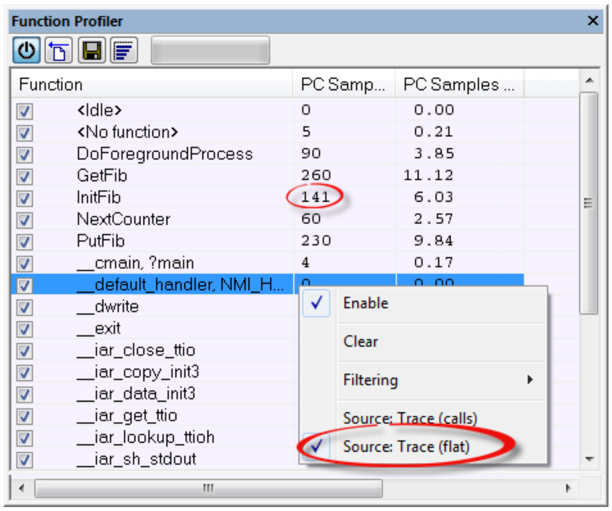
- Further down in the data, you can find the **GetFib** function separately and see all of its subfunctions (in this case none).



Function	Calls	Flat Time	Flat Time (%)	Acc. Time	Acc. Time (%)
main	1	165	3.58	4356	94.39
DoForegroundProcess	10			3704	
InitFib	1			487	
PutFib	10	3174	68.78	3174	68.78
NextCounter	10	100	2.17	100	2.17
InitFib	1	231	5.01	487	10.55
GetFib	16			256	
GetFib	26	416	9.01	416	9.01
DoForegroundProcess	10	270	5.85	3704	80.26
GetFib	10			160	
NextCounter	10				
PutFib	10				
<Other>	0	25			98.85
main	1				

The second figure shows the result of profiling using **Source: Trace (flat)**. In this case, the profiler does not follow the program flow, instead the profiler only detects whether the `PC` address is within the function scope. For incomplete trace data, the data might contain minor errors.

For the **InitFib** function, **Flat Time** 231 is the time (number of hits) spent inside the function itself.



	Function	PC Samp...	PC Samples ...
✓	<Idle>	0	0.00
✓	<No function>	5	0.21
✓	DoForegroundProcess	90	3.85
✓	GetFib	260	11.12
✓	InitFib	141	6.03
✓	NextCounter	60	2.57
✓	PutFib	230	9.84
✓	__cmain, ?main	4	0.17
✓	__default_handler, NMI_H...	0	0.00
✓	__dwrite		
✓	__exit		
✓	__iar_close_ttio		
✓	__iar_copy_init3		
✓	__iar_data_init3		
✓	__iar_get_ttio		
✓	__iar_lookup_ttioh		
✓	__iar_sh_stdout		

To secure valid data when using a debug probe, make sure to use the maximum trace buffer size and set a breakpoint in your code to stop the execution before the buffer is full.

Note: The `<No function>` entry represents PC values that are not within the known C-SPY ranges for the application.

GETTING STARTED USING THE PROFILER ON INSTRUCTION LEVEL

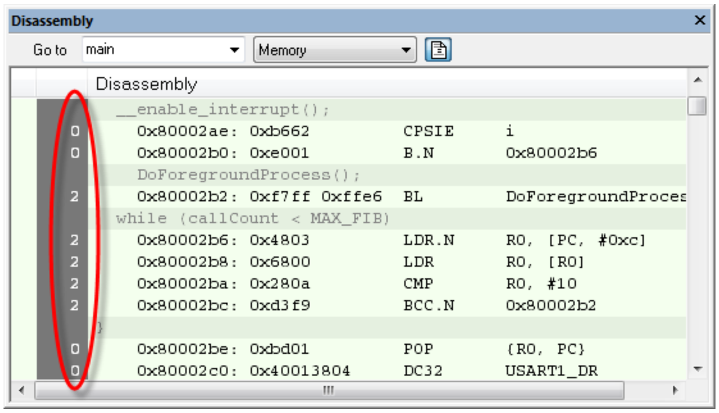
To display instruction profiling information in the Disassembly window:

1 When you have built your application and started C-SPY, choose **View>Disassembly** to open the **Disassembly** window, and choose **Instruction Profiling>Enable** from the context menu that is available when you right-click in the left-hand margin of the **Disassembly** window.

2 Make sure that the **Show** command on the context menu is selected, to display the profiling information.

3 Start executing your application to collect the profiling information.

4 When the execution stops, for instance because the program exit is reached or a breakpoint is triggered, you can view instruction level profiling information in the left-hand margin of the window.


Disassembly

Go to main ▾ Memory ▾

```
Disassembly
     __enable_interrupt();
0      0x80002ae: 0xb662          CPSIE     i
0      0x80002b0: 0xe001          B.N       0x80002b6
       DoForegroundProcess();
2      0x80002b2: 0xf7ff 0xffe6   BL        DoForegroundProces
     while (callCount < MAX_FIB)
2      0x80002b6: 0x4803          LDR.N     R0, [PC, #0xc]
2      0x80002b8: 0x6800          LDR       R0, [R0]
2      0x80002ba: 0x280a          CMP       R0, #10
2      0x80002bc: 0xd3f9          BCC.N     0x80002b2
   }
0      0x80002be: 0xbd01          POP       {R0, PC}
0      0x80002c0: 0x40013804      DC32      USART1_DR
```

For each instruction, the number of times it has been executed is displayed.

Reference information on the profiler

Reference information about:

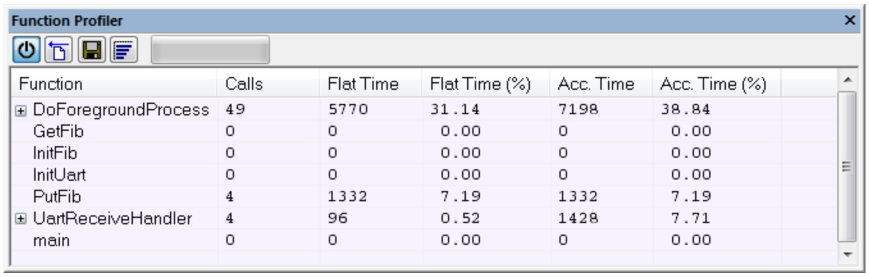
- *Function Profiler window*, page 266

See also:

- *Disassembly window*, page 72

Function Profiler window

The **Function Profiler** window is available from the C-SPY driver menu.


Function Profiler

Function	Calls	Flat Time	Flat Time (%)	Acc. Time	Acc. Time (%)
⊞ DoForegroundProcess	49	5770	31.14	7198	38.84
GetFib	0	0	0.00	0	0.00
InitFib	0	0	0.00	0	0.00
InitUart	0	0	0.00	0	0.00
PutFib	4	1332	7.19	1332	7.19
⊞ UartReceiveHandler	4	96	0.52	1428	7.71
main	0	0	0.00	0	0.00

This window displays function profiling information.

When Trace (flat) is selected, a checkbox appears on each line in the left-side margin of the window. Use these checkboxes to include or exclude lines from the profiling. Excluded lines are dimmed but not removed.

See also *Using the profiler*, page 262.

Requirements

The C-SPY simulator.

Toolbar

The toolbar contains:

Enable/Disable

Enables or disables the profiler.

Clear

Clears all profiling data.

Save

Opens a standard **Save As** dialog box where you can save the contents of the window to a file, with tab-separated columns. Only non-expanded rows are included in the list file.

Graphical view

Overlays the values in the percentage columns with a graphical bar.

Progress bar

Displays a backlog of profiling data that is still being processed. If the rate of incoming data is higher than the rate of the profiler processing the data, a backlog is accumulated. The progress bar indicates that the profiler is still processing data, but also approximately how far the profiler has come in the process.

Note that because the profiler consumes data at a certain rate and the target system supplies data at another rate, the amount of data remaining to be processed can both increase and decrease. The progress bar can grow and shrink accordingly.

Display area

The content in the display area depends on which source that is used for the profiling information:

- *For the Trace (calls) source*, the display area contains one line for each function compiled with debug information enabled. When some profiling information has been collected, it is possible to expand rows of functions that have called other functions. The child items for a given function list all the functions that have been called by the parent function and the corresponding statistics.

- *For the Trace (flat) source*, the display area contains one line for each C function of your application, but also lines for sections of code from the runtime library or from other code without debug information, denoted only by the corresponding assembler labels. Each executed `PC` address from trace data is treated as a separate sample and is associated with the corresponding line in the **Profiling** window. Each line contains a count of those samples.

For information about which views that are supported in the C-SPY driver you are using, see *Requirements for using the profiler*, page 262.

More specifically, the display area provides information in these columns:

Function (All sources)

The name of the profiled C function.

Calls (Trace (calls))

The number of times the function has been called.

Flat time (Trace (calls))

The time expressed as the estimated number of cycles spent inside the function.

Flat time (%) (Trace (calls))

Flat time expressed as a percentage of the total time.

Acc. time (Trace (calls))

The time expressed as the estimated number of cycles spent inside the function and everything called by the function.

Acc. time (%) (Trace (calls))

Accumulated time expressed as a percentage of the total time.

PC Samples (Trace (flat))

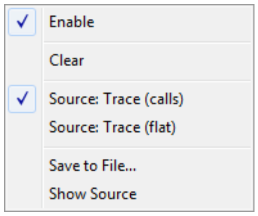
The number of PC samples associated with the function.

PC Samples (%) (Trace (flat))

The number of PC samples associated with the function as a percentage of the total number of samples.

Context menu

This context menu is available:



The contents of this menu depend on the C-SPY driver you are using.

These commands are available:

Enable

Enables the profiler. The system will also collect information when the window is closed.

Clear

Clears all profiling data.

Filtering

Selects which part of your code to profile. Choose between:

Check All—Excludes all lines from the profiling.

Uncheck All—Includes all lines in the profiling.

Load—Reads all excluded lines from a saved file.

Save—Saves all excluded lines to a file. Typically, this can be useful if you are a group of engineers and want to share sets of exclusions.

These commands are only available when using Trace (flat).

Source

Selects which source to be used for the profiling information. See also *Profiling sources*, page 262.

Note that the available sources depend on the C-SPY driver you are using.

Choose between:

Trace (calls)—the instruction count for instruction profiling is only as complete as the collected trace data.

Trace (flat)—the instruction count for instruction profiling is only as complete as the collected trace data.

Save to File

Saves all profiling data to a file.

Show Source

Opens the editor window (if not already opened) and highlights the selected source line.

Code coverage

- Introduction to code coverage
- Using code coverage
- Reference information on code coverage

Introduction to code coverage

These topics are covered:

- Reasons for using code coverage
- Briefly about code coverage
- Requirements and restrictions for using code coverage

REASONS FOR USING CODE COVERAGE

The code coverage functionality is useful when you design your test procedure to verify whether all parts of the code have been executed. It also helps you identify parts of your code that are not reachable.

BRIEFLY ABOUT CODE COVERAGE

The **Code Coverage** window reports the status of the current code coverage analysis for C code. For every program, module, and function, the analysis shows the percentage of code that has been executed since code coverage was turned on up to the point where the application has stopped. In addition, all statements that have not been executed are listed. The analysis will continue until turned off.

Note: Assembler code is not covered by the code coverage analysis. To view assembler code, use the **Disassembly** window.

REQUIREMENTS AND RESTRICTIONS FOR USING CODE COVERAGE

Code coverage is supported by the C-SPY Simulator and by some hardware debugger drivers, and there are no specific requirements or restrictions. See *Differences between the C-SPY drivers*, page 35.

Using code coverage

These tasks are covered:

- Getting started using code coverage

GETTING STARTED USING CODE COVERAGE

To get started using code coverage:

1 Before you can use the code coverage functionality, you must build your application using these options:

Category	Setting
C/C++ Compiler	Output>Generate debug information
Linker	Output>Include debug information in output
Debugger	Plugins>Code Coverage

Table 12: Project options for enabling code coverage

2 After you have built your application and started C-SPY, choose **View>Code Coverage** to open the **Code Coverage** window.

3 Click the **Activate** button, alternatively choose **Activate** from the context menu, to switch on code coverage.

4 Start the execution. When the execution stops, for instance because the program exit is reached or a breakpoint is triggered, the code coverage information is updated automatically.

Reference information on code coverage

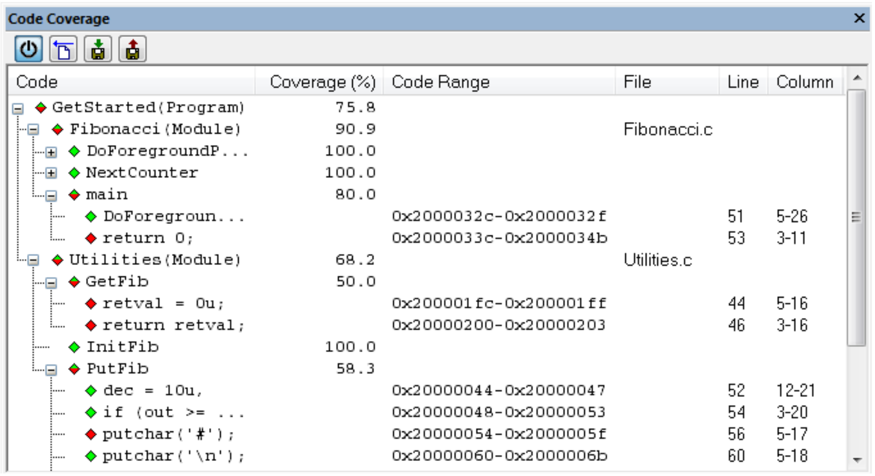
Reference information about:

- *Code Coverage window*, page 273

See also *Single stepping*, page 64.

Code Coverage window

The **Code Coverage** window is available from the **View** menu.



Code Coverage

Code	Coverage (%)	Code Range	File	Line	Column
GetStarted(Program)	75.8				
Fibonacci(Module)	90.9		Fibonacci.c		
DoForegroundP...	100.0				
NextCounter	100.0				
main	80.0				
DoForegroun...		0x2000032c-0x2000032f		51	5-26
return 0;		0x2000033c-0x2000034b		53	3-11
Utilities(Module)	68.2		Utilities.c		
GetFib	50.0				
retval = 0u;		0x200001fc-0x200001ff		44	5-16
return retval;		0x20000200-0x20000203		46	3-16
InitFib	100.0				
PutFib	58.3				
dec = 10u,		0x20000044-0x20000047		52	12-21
if (out >= ...		0x20000048-0x20000053		54	3-20
putchar('#');		0x20000054-0x2000005f		56	5-17
putchar('\n');		0x20000060-0x2000006b		60	5-18

This window reports the status of the current code coverage analysis. For every program, module, and function, the analysis shows the percentage of code that has been executed since code coverage was turned on up to the point where the application has stopped. In addition, all statements that have not been executed are listed. The analysis will continue until turned off.

Only source code that was compiled with debug information is displayed. Therefore, startup code, exit code, and library code are not displayed in the window. Furthermore, coverage information for statements in inlined functions is not displayed. Only the statement containing the inlined function call is marked as executed.

A statement is considered to be executed when all its instructions have been executed. By default, when a statement has been executed, it is removed from the window and the percentage is increased correspondingly.

Requirements

One of these alternatives:

- The C-SPY Simulator
- The IECUBE emulator.

Toolbar

The toolbar contains buttons for switching code coverage on and off, clearing the code coverage information, and saving/restoring the code coverage session. See the description of the context menu for more detailed information.

The toolbar contains these buttons:

Activate

Switches code coverage on and off during execution.

Clear

Clears the code coverage information. All step points are marked as not executed.

Save session

Saves your code coverage session data to a `*.dat` file. This is useful if you for some reason must abort your debug session, but want to continue the session later on. This command might not be supported by the C-SPY driver you are using.

Restore session

Restores previously saved code coverage session data. This is useful if you for some reason must abort your debug session, but want to continue the session later on. This command might not be supported by the C-SPY driver you are using.

Display area

Double-clicking a statement or a function in the **Code Coverage** window displays that statement or function as the current position in the editor window, which becomes the active window.

These columns are available:

Code

The code coverage information as a tree structure, showing the program, module, function, and statement levels. The plus sign and minus sign icons allow you to expand and collapse the structure.

These icons give you an overview of the current status on all levels:

- Red diamond: 0% of the modules or functions has been executed.
- Green diamond: 100% of the modules or functions has been executed.
- Red and green diamond: Some of the modules or functions have been executed.

Red, green, and yellow colors can be used as highlight colors in the source editor window. In the editor window, the yellow color signifies partially executed.

Coverage (%)

The amount of statements that has been covered so far, that is, the number of executed statements divided with the total number of statements.

Code Range

The address range in code memory where the statement is located.

File

The source file where the step point is located.

Line

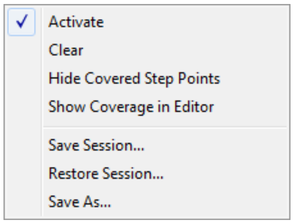
The source file line where the step point is located.

Column

The source file column where the step point is located.

Context menu

This context menu is available:



These commands are available:

Activate

Switches code coverage on and off during execution.

Clear

Clears the code coverage information. All step points are marked as not executed.

Hide Covered Step Points

Toggles the display of covered step points on and off. When this option is selected, executed statements are removed from the window.

Show Coverage in Editor

Toggles the red, green, and yellow highlight colors that indicate code coverage in the source editor window on and off.

Save session

Saves your code coverage session data to a `*.dat` file. This is useful if you for some reason must abort your debug session, but want to continue the session later on. This command is available on the toolbar. This command might not be supported by the C-SPY driver you are using.

Restore session

Restores previously saved code coverage session data. This is useful if you for some reason must abort your debug session, but want to continue the session later on. This command is available on the toolbar. This command might not be supported by the C-SPY driver you are using.

Save As

Saves the current code coverage result in a text file.

Power debugging

Introduction to power debugging

These topics are covered:

- Reasons for using power debugging
- Briefly about power debugging
- Requirements and restrictions for power debugging

REASONS FOR USING POWER DEBUGGING

Long battery lifetime is a very important factor for many embedded systems in almost any market segment: medical, consumer electronics, home automation, etc. The power consumption in these systems does not only depend on the hardware design, but also on how the hardware is used. The system software controls how it is used.

For examples of when power debugging can be useful, see *Optimizing your source code for power consumption*, page 278.

BRIEFLY ABOUT POWER DEBUGGING

Power debugging is based on the ability to sample the power consumption—more precisely, the power being consumed by the CPU and the peripheral units—and correlate each sample with the application's instruction sequence and hence with the source code and various events in the program execution.

Traditionally, the main software design goal has been to use as little memory as possible. However, by correlating your application's power consumption with its source code you can gain insight into how the software affects the power consumption, and thus how it can be minimized.

Measuring power consumption

The debug probe measures the voltage drop across a small resistor in series with the supply power to the device. The voltage drop is measured by a differential amplifier and then sampled by an AD converter.

Power debugging using C-SPY

C-SPY provides an interface for configuring your power debugging and a set of windows for viewing the power values:

- The **Power Log Setup** window is where you can specify a threshold and an action to be executed when the threshold is reached. This means that you can enable or disable the power measurement or you can stop the application's execution and determine the cause of unexpected power values.
- The **Power Log** window displays all logged power values. This window can be used for finding peaks in the power logging and because the values are correlated with the executed code, you can double-click on a value in the **Power Log** window to get the corresponding code. The precision depends on the frequency of the samples, but there is a good chance that you find the source code sequence that caused the peak.
- The Power graph in the **Timeline** window displays power values on a time scale. This provides a convenient way of viewing the power consumption in relation to the other information displayed in the window. The **Timeline** window is correlated to both the **Power Log** window, the source code window, and the **Disassembly** window, which means you are just a double-click away from the source code that corresponds to the values you see on the timeline.

REQUIREMENTS AND RESTRICTIONS FOR POWER DEBUGGING

To use the features in C-SPY for power debugging, you need an E2 emulator which must be powering the target board. E2 Lite and E2 on-board do not support power debugging.

Important! Power measurement for the E2 emulator is based on collecting pairs of current measurements and timestamps after the application execution stops. This slows down debugging performance considerably, so make sure that power logging is only enabled when you are actively using the feature. It also means that if the IDE seems to stall now and then, it might be because of this performance reduction.

Optimizing your source code for power consumption

This section gives some examples where power debugging can be useful and hopefully help you identify source code constructions that can be optimized for low power consumption.

These topics are covered:

- Waiting for device status
- Software delays
- DMA versus polled I/O
- Low-power mode diagnostics
- CPU frequency
- Detecting mistakenly unattended peripherals
- Peripheral units in an event-driven system
- Finding conflicting hardware setups
- Analog interference

WAITING FOR DEVICE STATUS

One common construction that could cause unnecessary power consumption is to use a poll loop for waiting for a status change of, for example a peripheral device. Constructions like this example execute without interruption until the status value changes into the expected state.

```
while (USBD_GetState() < USBD_STATE_CONFIGURED);
while ((BASE_PMC->PMC_SR & MC_MCKRDY) != PMC_MCKRDY);
```

To minimize power consumption, rewrite polling of a device status change to use interrupts if possible, or a timer interrupt so that the CPU can sleep between the polls.

SOFTWARE DELAYS

A software delay might be implemented as a `for` or `while` loop like for example:

```
i = 10000;  /* A software delay */
do i--;
while (i != 0);
```

Such software delays will keep the CPU busy with executing instructions performing nothing except to make the time go by. Time delays are much better implemented using a hardware timer. The timer interrupt is set up and after that, the CPU goes down into a low power mode until it is awakened by the interrupt.

DMA VERSUS POLLED I/O

DMA has traditionally been used for increasing transfer speed. For MCUs there are plenty of DMA techniques to increase flexibility, speed, and to lower power consumption. Sometimes, CPUs can even be put into sleep mode during the DMA transfer. Power debugging lets you experiment and see directly in the debugger what effects these DMA techniques will have on power consumption compared to a traditional CPU-driven polled solution.

LOW-POWER MODE DIAGNOSTICS

Many embedded applications spend most of their time waiting for something to happen: receiving data on a serial port, watching an I/O pin change state, or waiting for a time delay to expire. If the processor is still running at full speed when it is idle, battery life is consumed while very little is being accomplished. So in many applications, the microcontroller is only active during a very small amount of the total time, and by placing it in a low-power mode during the idle time, the battery life can be extended considerably.

A good approach is to have a task-oriented design and to use an RTOS. In a task-oriented design, a task can be defined with the lowest priority, and it will only execute when there is no other task that needs to be executed. This idle task is the perfect place to implement power management. In practice, every time the idle task is activated, it sets the microcontroller into a low-power mode. Many microprocessors and other silicon devices have a number of different low-power modes, in which different parts of the microcontroller can be turned off when they are not needed. The oscillator can for example either be turned off or switched to a lower frequency. In addition, individual peripheral units, timers, and the CPU can be stopped. The different low-power modes have different power consumption based on which peripherals are left turned on. A power debugging tool can be very useful when experimenting with different low-level modes.

CPU FREQUENCY

Power consumption in a CMOS MCU is theoretically given by the formula:

```
P = f * U2 * k
```

where `f` is the clock frequency, `U` is the supply voltage, and `k` is a constant.

Power debugging lets you verify the power consumption as a factor of the clock frequency. A system that spends very little time in sleep mode at 50 MHz is expected to spend 50% of the time in sleep mode when running at 100 MHz. You can use the power data collected in C-SPY to verify the expected behavior, and if there is a non-linear dependency on the clock frequency, make sure to choose the operating frequency that gives the lowest power consumption.

DETECTING MISTAKENLY UNATTENDED PERIPHERALS

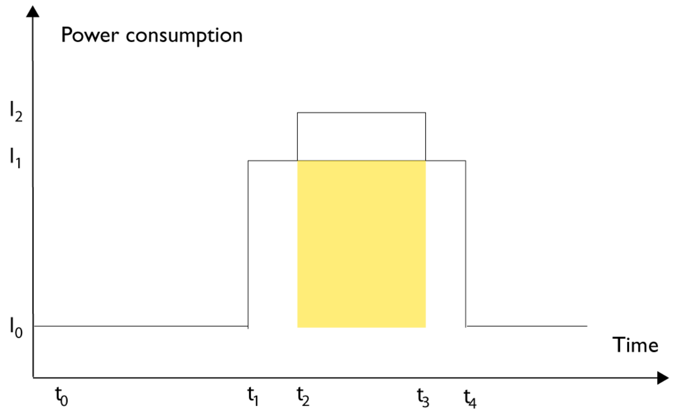
Peripheral units can consume much power even when they are not actively in use. If you are designing for low power, it is important that you disable the peripheral units and not just leave them unattended when they are not in use. But for different reasons, a peripheral unit can be left with its power supply on; it can be a careful and correct design decision, or it can be an inadequate design or just a mistake. If not the first case, then more power than expected will be consumed by your application. This will be easily revealed by the Power graph in the **Timeline** window. Double-clicking in the **Timeline** window where the power consumption is unexpectedly high will take you to the corresponding source code and disassembly code. In many cases, it is enough to disable the peripheral unit when it is inactive, for example by turning off its clock which in most cases will shut down its power consumption completely.

However, there are some cases where clock gating will not be enough. Analog peripherals like converters or comparators can consume a substantial amount of power even when the clock is turned off. The **Timeline** window will reveal that turning off the clock was not enough and that you need to turn off the peripheral completely.

PERIPHERAL UNITS IN AN EVENT-DRIVEN SYSTEM

Consider a system where one task uses an analog comparator while executing, but the task is suspended by a higher-priority task. Ideally, the comparator should be turned off when the task is suspended and then turned on again once the task is resumed. This would minimize the power being consumed during the execution of the high-priority task.

This is a schematic diagram of the power consumption of an assumed event-driven system where the system at the point of time t_0 is in an inactive mode and the current is I_0:



At t_1, the system is activated whereby the current rises to I_1 which is the system's power consumption in active mode when at least one peripheral device turned on, causing the current to rise to I_1. At t_2, the execution becomes suspended by an interrupt which is handled with high priority. Peripheral devices that were already active are not turned off, although the task with higher priority is not using them. Instead, more peripheral devices are activated by the new task, resulting in an increased current I_2 between t_2 and t_3 where control is handed back to the task with lower priority.

The functionality of the system could be excellent and it can be optimized in terms of speed and code size. But in the power domain, more optimizations can be made. The shadowed area represents the energy that could have been saved if the peripheral devices that are not used between t_2 and t_3 had been turned off, or if the priorities of the two tasks had been changed.

If you use the **Timeline** window, you can make a closer examination and identify that unused peripheral devices were activated and consumed power for a longer period than necessary. Naturally, you must consider whether it is worth it to spend extra clock cycles to turn peripheral devices on and off in a situation like in the example.

FINDING CONFLICTING HARDWARE SETUPS

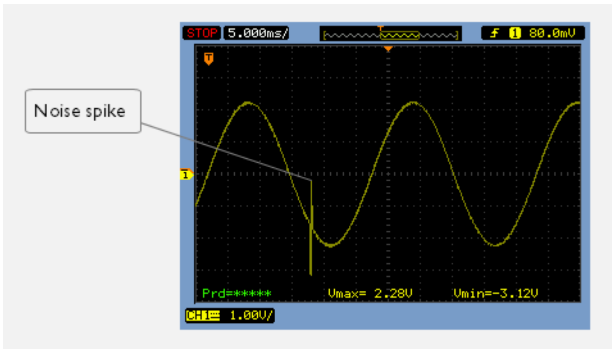
To avoid floating inputs, it is a common design practice to connect unused MCU I/O pins to ground. If your source code by mistake configures one of the grounded I/O pins as a logical `1` output, a high current might be drained on that pin. This high unexpected current is easily observed by reading the current value from the Power graph in the **Timeline** window. It is also possible to find the corresponding erratic initialization code by looking at the Power graph at application startup.

A similar situation arises if an I/O pin is designed to be an input and is driven by an external circuit, but your code incorrectly configures the input pin as output.

ANALOG INTERFERENCE

When mixing analog and digital circuits on the same board, the board layout and routing can affect the analog noise levels. To ensure accurate sampling of low-level analog signals, it is important to keep noise levels low. Obtaining a well-mixed signal design requires careful hardware considerations. Your software design can also affect the quality of the analog measurements.

Performing a lot of I/O activity at the same time as sampling analog signals causes many digital lines to toggle state at the same time, which might introduce extra noise into the AD converter.



Power debugging will help you investigate interference from digital and power supply lines into the analog parts. Power spikes in the vicinity of AD conversions could be the source of noise and should be investigated. All data presented in the **Timeline** window is correlated to the executed code. Simply double-clicking on a suspicious power value will bring up the corresponding C source code.

Debugging in the power domain

These tasks are covered:

- Displaying a power profile and analyzing the result
- Detecting unexpected power usage during application execution
- Changing the graph resolution

See also:

- *Timeline window—Power graph*, page 290

DISPLAYING A POWER PROFILE AND ANALYZING THE RESULT

To view the power profile:

1 Start the debugger.

2 Choose ***C-SPY driver*>Power Log Setup**. Enable power logging and make the required settings. If you are using an E2 emulator, you must also open the **Hardware Setup** dialog box and make sure that the target board is powered by the emulator.

3 Choose ***C-SPY driver*>Timeline** to open the **Timeline** window.

4 Right-click in the graph area and choose **Enable** from the context menu to enable the power graph you want to view.

5 Choose ***C-SPY driver*>Power Log** to open the **Power Log** window.

6 Optionally, before you start executing your application you can configure the viewing range of the Y-axis for the power graph. See *Viewing Range dialog box*, page 259.

7 Click **Go** on the toolbar to start executing your application. In the **Power Log** window, all power values are displayed. In the **Timeline** window, you will see a graphical representation of the power values. For information about how to navigate on the graph, see *Navigating in the graphs*, page 224.

DETECTING UNEXPECTED POWER USAGE DURING APPLICATION EXECUTION

To detect unexpected power consumption:

1 Choose ***C-SPY driver*>Power Log Setup** to open the **Power Setup** window.

2 In the **Power Setup** window, specify a threshold value and the appropriate action, for example **Log All and Halt CPU Above Threshold**.

3 Choose ***C-SPY driver*>Power Log** to open the **Power Log** window. If you continuously want to save the power values to a file, choose **Choose Live Log File** from the context menu. In this case you also need to choose **Enable Live Logging to**.

4 Start the execution.

When the power consumption passes the threshold value, the execution will stop and perform the action you specified.

If you saved your logged power values to a file, you can open that file in an external tool for further analysis.

CHANGING THE GRAPH RESOLUTION

To change the resolution of a Power graph in the Timeline window:

1 In the **Timeline** window, select the Power graph, right-click and choose **Open Setup Window** to open the **Power Log Setup** window.

2 From the context menu in the **Power Log Setup** window, choose a suitable unit of measurement.

3 In the **Timeline** window, select the Power graph, right-click and choose **Viewing Range** from the context menu.

4 In the **Viewing Range** dialog box, select **Custom** and specify range values in the **Lowest value** and the **Highest value** text boxes. Click **OK**.

5 The graph is automatically updated accordingly.

Reference information on power debugging

Reference information about:

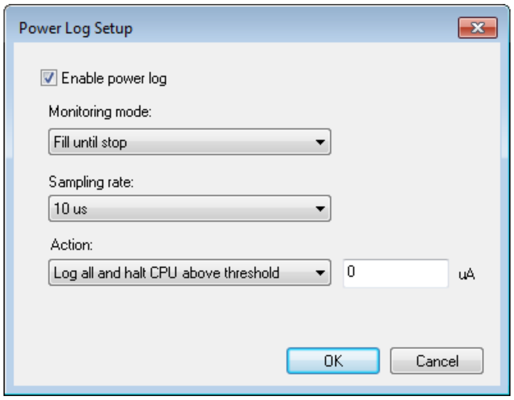
- *Power Log Setup window*, page 285
- *Power Log window*, page 287
- *Timeline window—Power graph*, page 290

See also:

- *Trace window*, page 206
- *The application timeline*, page 221
- *Viewing Range dialog box*, page 259

Power Log Setup window

The **Power Log Setup** window is available from the C-SPY driver menu during a debug session.


Power Log Setup

☑ Enable power log

Monitoring mode: Fill until stop

Sampling rate: 10 us

Action: Log all and halt CPU above threshold | 0 uA

Use this window to configure the power measurement.

Note: To enable power logging, choose **Enable** from the context menu in the **Power Log** window or from the context menu in the power graph in the **Timeline** window.

See also *Debugging in the power domain*, page 283.

Requirements

An E2 emulator.

Enable power log

Enables/disables power logging for the C-SPY E2 emulator driver.

Monitoring mode

Controls the collection of power data. Chose between:

- **Fill until stop**—collects data as long as the application is executing. If the buffer fills up, the oldest data is cleared as new data is written.
- **Fill until full**—collects data until the buffer is full, but continues executing the application.
- **Stop program when full**—stops executing the application when the buffer is full.

Sampling rate

Sets the sampling rate in microseconds.

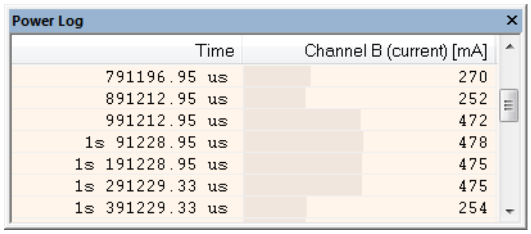
Action

Controls how power data is logged. Choose between:

- **Log all**—logs all collected data.
- **Log all and halt CPU above threshold**—logs all data and stops executing the application when the measured current exceeds the specified value.
- **Log all and halt CPU below threshold**—logs all data and stops executing the application when the measured current falls below the specified value.

Power Log window

The **Power Log** window is available from the C-SPY driver menu during a debug session.



Power Log

Time	Channel B (current) [mA]
791196.95 us	270
891212.95 us	252
991212.95 us	472
1s 91228.95 us	478
1s 191228.95 us	475
1s 291229.33 us	475
1s 391229.33 us	254

This window displays collected power values.

A row with only Time/Cycles displayed in pink denotes a logged power value for a channel that was active during the actual collection of data but currently is disabled in the **Power Log Setup** window.

Note: There is a limit on the number of saved logs. When this limit is exceeded, the oldest entries in the buffer are erased.

See also *Debugging in the power domain*, page 283.

Requirements

An E2 emulator.

Display area

This area contains these columns:

Time

The time from the application reset until the event, based on the clock frequency.

If the time is displayed in italics, the target system could not collect a correct time, but instead had to approximate it.

This column is available when you have selected **Show Time** from the context menu.

Cycles

The number of cycles from the application reset until the event, based on the operating frequency specified in the **Operating Frequency** dialog box, see *Operating Frequency dialog box*, page 55. This information is cleared at reset.

If a cycle is displayed in italics, the target system could not collect a correct time, but instead had to approximate it.

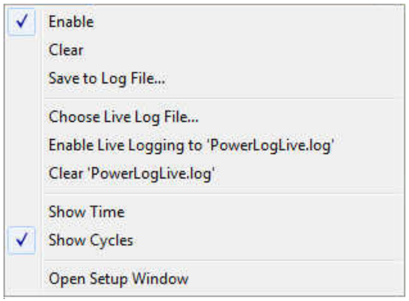
This column is available when you have selected **Show Cycles** from the context menu.

Name [unit]

The power measurement value expressed in the unit you specified in the **Power Setup** window.

Context menu

This context menu is available:



These commands are available:

Enable

Enables the logging system, which means that power values are saved internally within the IDE. The values are displayed in the **Power Log** window and in the Power graph in the **Timeline** window (if enabled). The system will log information also when the window is closed.

Note: For the E2 emulator, this command only toggles the display of power log data. The power log system can only be enabled/disabled in the **Power Log Setup** window.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger, or if you change the execution frequency in the **Operating Frequency** dialog box.

Save to File

Displays a standard file selection dialog box where you can select the destination file for the log information. The entries in the log file are separated by `TAB` and `LF` characters. An **X** in the **Approx** column indicates that the timestamp is an approximation.

Choose Live Log File

Displays a standard file selection dialog box where you can choose a destination file for the logged power values. The power values are continuously saved to that file during execution. The content of the live log file is never automatically cleared, the logged values are simply added at the end of the file.

Enable Live Logging to

Toggles live logging on or off. The logs are saved in the specified file.

Clear *log file*

Clears the content of the live log file.

Show Time

Displays the **Time** column.

This menu command might not be available in the C-SPY driver you are using, which means that the **Time** column is displayed by default.

Show Cycles

Displays the **Cycles** column.

This menu command might not be available in the C-SPY driver you are using, which means that the **Cycles** column is not supported.

Open Setup Window

Opens the **Power Log Setup** window.

The format of the log file

The log file has a tab-separated format. The entries in the log file are separated by `TAB` and line feed. The logged power values are displayed in these columns:

Time/Cycles

The time from the application reset until the power value was logged.

Approx

An **x** in the column indicates that the power value has an approximative value for time/cycle.

PC

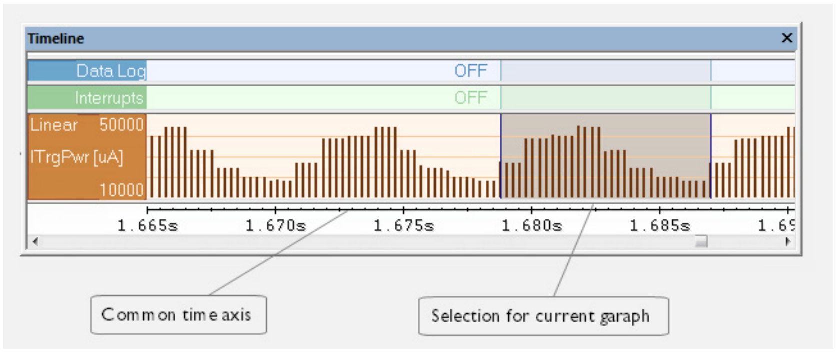
The value of the program counter close to the point where the power value was logged. For the E2 emulator, this will be ---- for all values, because the C-SPY E2 emulator driver does not support this feature.

***Name*[*unit*]**

The corresponding value from the **Power Log** window, where *Name* and *unit* are according to your settings in the **Power Log Setup** window. For the E2 emulator, this will be `Current [mA]` for all values.

Timeline window—Power graph

The power graph in the **Timeline** window is available from the C-SPY driver menu during a debug session.



The power graph displays a graphical view of power measurement samples generated by the debug probe or associated hardware in relation to a common time axis.

Note: There is a limit on the number of saved logs. When this limit is exceeded, the oldest entries in the buffer are erased.

For more information about the **Timeline** window, how to display a graph, and the other supported graphs, see *The application timeline*, page 221.

See also *Requirements and restrictions for power debugging*, page 278.

Requirements

An E2 emulator.

Display area

Where:

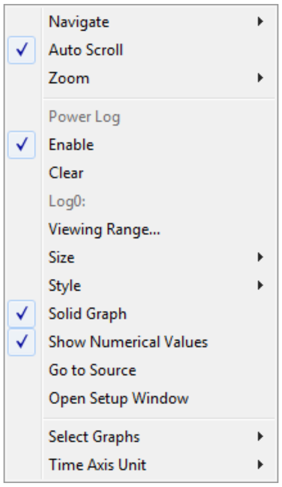
- The label area at the left end of the graph displays the name of the measurement channel.
- The graph itself shows power measurement samples generated by the debug probe or associated hardware.

- The graph can be displayed as a thin line between consecutive logs, as a rectangle for every log (optionally color-filled), or as columns.
- The resolution of the graph can be changed.
- A red vertical line indicates overflow, which means that the communication channel failed to transmit all interrupt logs from the target system.

At the bottom of the window, there is a common time axis that uses seconds as the time unit.

Context menu

This context menu is available:



Note: The exact contents of the context menu you see on the screen depends on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Navigate

Commands for navigating the graph(s). Choose between:

Next moves the selection to the next relevant point in the graph. Shortcut key: right arrow.

Previous moves the selection backward to the previous relevant point in the graph. Shortcut key: left arrow.

First moves the selection to the first data entry in the graph. Shortcut key: Home.

Last moves the selection to the last data entry in the graph. Shortcut key: End.

End moves the selection to the last data in any displayed graph, in other words the end of the time axis. Shortcut key: Ctrl+End.

Auto Scroll

Toggles automatic scrolling on or off. When on, the most recently collected data is automatically displayed when you choose **Navigate>End**.

Zoom

Commands for zooming the window, in other words, changing the time scale. Choose between:

Zoom to Selection makes the current selection fit the window. Shortcut key: Return.

Zoom In zooms in on the time scale. Shortcut key: +

Zoom Out zooms out on the time scale. Shortcut key: –

10ns, **100ns**, **1us**, etc makes an interval of 10 nanoseconds, 100 nanoseconds, 1 microsecond, respectively, fit the window.

1ms, **10ms**, etc makes an interval of 1 millisecond or 10 milliseconds, respectively, fit the window.

10m, **1h**, etc makes an interval of 10 minutes or 1 hour, respectively, fit the window.

Power Log

A heading that shows that the Power Log-specific commands below are available.

Enable

Toggles the display of the graph on or off. If you disable a graph, that graph will be indicated as **OFF** in the window. If no data has been collected for a graph, **no data** will appear instead of the graph.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Viewing Range

Displays a dialog box, see *Viewing Range dialog box*, page 259.

Size

Determines the vertical size of the graph; choose between **Small**, **Medium**, and **Large**.

Style

Selects the style of the graph. Choose between:

Bars, displays a vertical bar for each log

Columns, displays a column for each log

Levels, displays the graph with a rectangle for each log, optionally color-filled

Linear, displays the graph as a thin line between consecutive logs

Note that all styles are not available for all graphs.

Solid Graph

Displays the graph as a color-filled solid graph instead of as a thin line.

Show Numerical Value

Shows the numerical value of the variable, in addition to the graph.

Go To Source

Displays the corresponding source code in an editor window, if applicable.

Open Setup Window

Opens the **Power Log Setup** window.

Select Graphs

Selects which graphs to be displayed in the **Timeline** window.

Time Axis Unit

Selects the unit used in the time axis; choose between **Seconds** and **Cycles**.

If **Cycles** is not available, the graphs are based on different clock sources. In that case you can view cycle values as tooltip information by pointing at the graph with your mouse pointer.

Profile Selection

Enables profiling time intervals in the **Function Profiler** window. Note that this command is only available if the C-SPY driver supports PC Sampling.

Part 3. Advanced debugging

This part of the *C-SPY® Debugging Guide for RL78* includes these chapters:

- Interrupts
- C-SPY macros
- The C-SPY command line utility—cspybat

Interrupts

- Introduction to interrupts
- Using the interrupt system
- Reference information on interrupts

Introduction to interrupts

These topics are covered:

- Briefly about the interrupt simulation system
- Interrupt characteristics
- Interrupt simulation states
- C-SPY system macros for interrupt simulation
- Target-adapting the interrupt simulation system
- Briefly about interrupt logging

See also:

- *Reference information on C-SPY system macros*, page 335
- *Breakpoints*, page 125
- The *IAR C/C++ Development Guide for RL78*

BRIEFLY ABOUT THE INTERRUPT SIMULATION SYSTEM

By simulating interrupts, you can test the logic of your interrupt service routines and debug the interrupt handling in the target system long before any hardware is available. If you use simulated interrupts in conjunction with C-SPY macros and breakpoints, you can compose a complex simulation of, for instance, interrupt-driven peripheral devices.

The C-SPY Simulator includes an interrupt simulation system where you can simulate the execution of interrupts during debugging. You can configure the interrupt simulation system so that it resembles your hardware interrupt system.

The interrupt system has the following features:

- Simulated interrupt support for the RL78 microcontroller
- Single-occasion or periodical interrupts based on the cycle counter
- Predefined interrupts for various devices

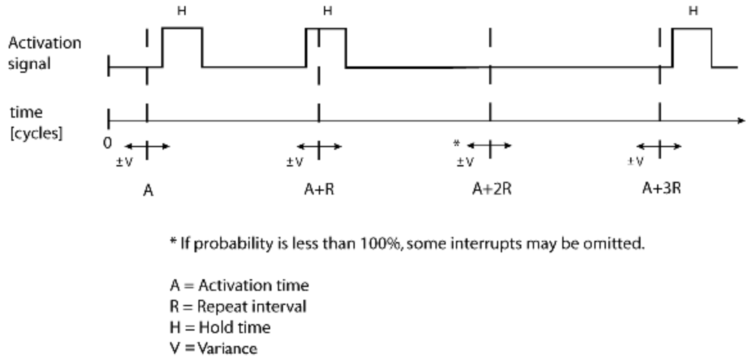
- Configuration of hold time, probability, and timing variation
- State information for locating timing problems
- Configuration of interrupts using a dialog box or a C-SPY system macro—that is, one interactive and one automating interface. In addition, you can instantly force an interrupt.
- A log window that continuously displays events for each defined interrupt.
- A status window that shows the current interrupt activities.

All interrupts you define using the **Interrupt Setup** dialog box are preserved between debug sessions, unless you remove them. A forced interrupt, on the other hand, exists only until it has been serviced and is not preserved between sessions.

The interrupt simulation system is activated by default, but if not required, you can turn off the interrupt simulation system to speed up the simulation. To turn it off, use either the **Interrupt Setup** dialog box or a system macro.

INTERRUPT CHARACTERISTICS

The simulated interrupts consist of a set of characteristics which lets you fine-tune each interrupt to make it resemble the real interrupt on your target hardware. You can specify a *first activation time*, a *repeat interval*, a *hold time*, a *variance*, and a *probability*.



The interrupt simulation system uses the cycle counter as a clock to determine when an interrupt should be raised in the simulator. You specify the *first activation time*, which is based on the cycle counter. C-SPY will generate an interrupt when the cycle counter has passed the specified activation time. However, interrupts can only be raised between instructions, which means that a full assembler instruction must have been executed before the interrupt is generated, regardless of how many cycles an instruction takes.

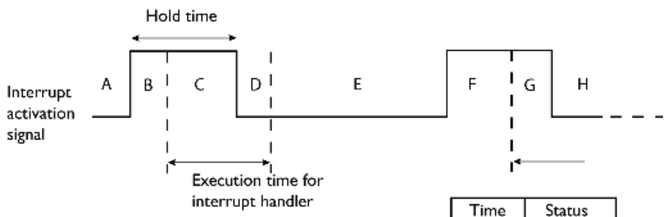
To define the periodicity of the interrupt generation you can specify the *repeat interval* which defines the amount of cycles after which a new interrupt should be generated. In addition to the repeat interval, the periodicity depends on the two options *probability*—

the probability, in percent, that the interrupt will actually appear in a period—and *variance*—a time variation range as a percentage of the repeat interval. These options make it possible to randomize the interrupt simulation. You can also specify a *hold time* which describes how long the interrupt remains pending until removed if it has not been processed. If the hold time is set to *infinite*, the corresponding pending bit will be set until the interrupt is acknowledged or removed.

INTERRUPT SIMULATION STATES

The interrupt simulation system contains status information that you can use for locating timing problems in your application. The **Interrupt Status** window displays the available status information. For an interrupt, these states can be displayed: *Idle*, *Pending*, *Executing*, or *Suspended*.

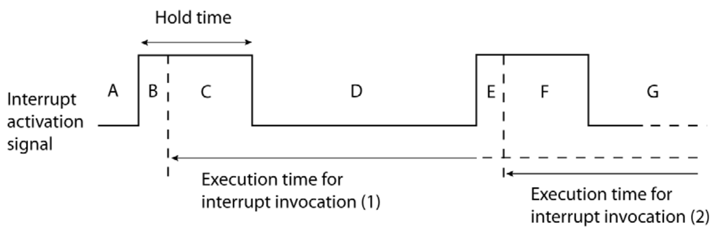
Normally, a repeatable interrupt has a specified repeat interval that is longer than the execution time. In this case, the status information at different times looks like this:

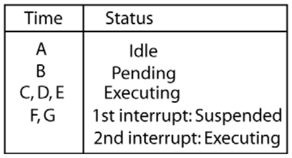

Hold time
Interrupt activation signal
A
B
C
D
E
F
G
H
Execution time for interrupt handler

Time	Status
A	Idle
B	Pending
C, D	Executing
E	Idle
F	Pending
G, H	Executing

Note: The interrupt activation signal—also known as the pending bit—is automatically deactivated the moment the interrupt is acknowledged by the interrupt handler.

However, if the interrupt repeat interval is shorter than the execution time, and the interrupt is reentrant (or non-maskable), the status information at different times looks like this:


Hold time
Interrupt activation signal
A
B
C
D
E
F
G
Execution time for interrupt invocation (1)
Execution time for interrupt invocation (2)



Time	Status
A	Idle
B	Pending
C, D, E	Executing
F, G	1st interrupt: Suspended 2nd interrupt: Executing

An execution time that is longer than the repeat interval might indicate that you should rewrite your interrupt handler and make it faster, or that you should specify a longer repeat interval for the interrupt simulation system.

C-SPY SYSTEM MACROS FOR INTERRUPT SIMULATION

Macros are useful when you already have sorted out the details of the simulated interrupt so that it fully meets your requirements. If you write a macro function containing definitions for the simulated interrupts, you can execute the functions automatically when C-SPY starts. Another advantage is that your simulated interrupt definitions will be documented if you use macro files, and if you are several engineers involved in the development project you can share the macro files within the group.

The C-SPY Simulator provides these predefined system macros related to interrupts:

`__enableInterrupts`

`__disableInterrupts`

`__orderInterrupt`

`__cancelInterrupt`

`__cancelAllInterrupts`

`__popSimulatorInterruptExecutingStack`

The parameters of the first five macros correspond to the equivalent entries of the **Interrupt Setup** dialog box.

For more information about each macro, see *Reference information on C-SPY system macros*, page 335.

TARGET-ADAPTING THE INTERRUPT SIMULATION SYSTEM

The interrupt simulation system is easy to use. However, to take full advantage of the interrupt simulation system you should be familiar with how to adapt it for the processor you are using.

The interrupt simulation has the same behavior as the hardware. This means that the execution of an interrupt is dependent on the status of the global interrupt enable bit. The execution of maskable interrupts is also dependent on the status of the individual interrupt enable bits.

To simulate device-specific interrupts, the interrupt system must have detailed information about each available interrupt. This information is provided in the device description files.

For information about device description files, see *Selecting a device description file*, page 42.

BRIEFLY ABOUT INTERRUPT LOGGING

Interrupt logging provides you with comprehensive information about the interrupt events. This might be useful, for example, to help you locate which interrupts you can fine-tune to become faster. You can log entrances and exits to and from interrupts. You can also log internal interrupt status information, such as triggered, expired, etc. In the IDE:

- The logs are displayed in the **Interrupt Log** window
- A summary is available in the **Interrupt Log Summary** window
- The Interrupt graph in the **Timeline** window provides a graphical view of the interrupt events during the execution of your application.

Requirements for interrupt logging

Interrupt logging is supported by the C-SPY simulator.

See also *Getting started using interrupt logging*, page 304.

Using the interrupt system

These tasks are covered:

- Simulating a simple interrupt
- Simulating an interrupt in a multi-task system

- Getting started using interrupt logging

See also:

- *Using C-SPY macros*, page 323 for details about how to use a setup file to define simulated interrupts at C-SPY startup
- The tutorial *Simulating an interrupt* in the Information Center.

SIMULATING A SIMPLE INTERRUPT

This example demonstrates the method for simulating a timer interrupt. However, the procedure can also be used for other types of interrupts.

To simulate and debug an interrupt:

1 Assume this simple application which contains an interrupt service routine for a timer, which increments a tick variable. The main function sets the necessary status registers. The application exits when 100 interrupts have been generated.

```
#pragma language = extended
#include <stdio.h>
#include "iorl78.h"
#include <intrinsics.h>

volatile int ticks = 0;
void main (void)
{
 /* Timer setup code */

 __disable_interrupt(); /* Disable all interrupts */
 TMIF00 = 0;            /* Reset interrupt request flag */
 TMMK00 = 0;            /* Enable timer interrupts */
 TS0 |= 0;              /* Start the timer */
 __enable_interrupt();        /* Enable all interrupts */

{
 ticks += 1;
}
 while (ticks < 100);         /* Endless loop */
 printf("Done\n");
}

/* Timer interrupt service routine */
#pragma vector = INTTM00_vect
{
 ticks += 1;
}
```

2 Add your interrupt service routine to your application source code and add the file to your project.

3 Choose **Project>Options>Debugger>Setup** and select a device description file. The device description file contains information about the interrupt that C-SPY needs to be able to simulate it. Use the **Use device description file** browse button to locate the `ddf` file.

4 Build your project and start the simulator.

5 Choose **Simulator>Interrupt Setup** to open the **Interrupts Setup** dialog box. Select the **Enable interrupt simulation** option to enable interrupt simulation. Click **New** to open the **Edit Interrupt** dialog box. For the timer example, verify these settings:

Option	Settings
Interrupt	INTTM00
First activation	1000
Repeat interval	500
Hold time	10
Probability (%)	100
Variance (%)	0

Table 13: Timer interrupt settings

Click **OK**.

6 Execute your application. If you have enabled the interrupt properly in your application source code, C-SPY will:

- Generate an interrupt when the cycle counter has passed 1000
- Continuously repeat the interrupt after approximately 500 cycles.

7 To watch the interrupt in action, choose **Simulator>Interrupt Log** to open the Interrupt Log window.

8 From the context menu, available in the Interrupt Log window, choose **Enable** to enable the logging. If you restart program execution, status information about entrances and exits to and from interrupts will now appear in the Interrupt Log window.

For information about how to get a graphical representation of the interrupts correlated with a time axis, see *Timeline window—Interrupt Log graph*, page 316.

SIMULATING AN INTERRUPT IN A MULTI-TASK SYSTEM

If you are using interrupts in such a way that the normal instruction used for returning from an interrupt handler is not used, for example in an operating system with task-switching, the simulator cannot automatically detect that the interrupt has finished executing. The interrupt simulation system will work correctly, but the status information in the **Interrupt Setup** dialog box might not look as you expect. If too many interrupts are executing simultaneously, a warning might be issued.

To simulate a normal interrupt exit:

1. Set a code breakpoint on the instruction that returns from the interrupt function.
2. Specify the `__popSimulatorInterruptExecutingStack` macro as a condition to the breakpoint.

   When the breakpoint is triggered, the macro is executed and then the application continues to execute automatically.

GETTING STARTED USING INTERRUPT LOGGING

1. Choose ***C-SPY driver*>Interrupt Log** to open the **Interrupt Log** window. Optionally, you can also choose:
   - ***C-SPY driver*>Interrupt Log Summary** to open the **Interrupt Log Summary** window
   - ***C-SPY driver*>Timeline** to open the **Timeline** window and view the Interrupt graph.
2. From the context menu in the **Interrupt Log** window, choose **Enable** to enable the logging.
3. Start executing your application program to collect the log information.
4. To view the interrupt log information, look in the **Interrupt Log** or **Interrupt Log Summary** window, or the Interrupt graph in the **Timeline** window.
5. If you want to save the log or summary to a file, choose **Save to log file** from the context menu in the window in question.
6. To disable interrupt logging, from the context menu in the **Interrupt Log** window, toggle **Enable** off.

Reference information on interrupts

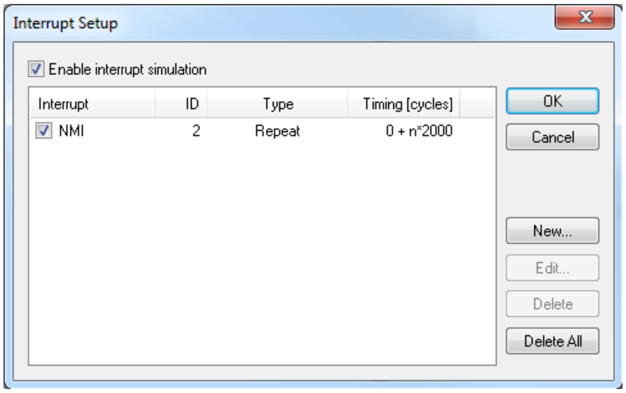
Reference information about:

- *Interrupt Setup dialog box*, page 305
- *Edit Interrupt dialog box*, page 307
- *Forced Interrupt window*, page 308
- *Interrupt Status window*, page 309
- *Interrupt Log window*, page 311

- *Interrupt Log Summary window*, page 314
- *Timeline window—Interrupt Log graph*, page 316

Interrupt Setup dialog box

The **Interrupt Setup** dialog box is available by choosing **Simulator>Interrupt Setup**.



☑ Enable interrupt simulation

Interrupt	ID	Type	Timing [cycles]
☑ NMI	2	Repeat	0 + n*2000

This dialog box lists all defined interrupts. Use this dialog box to enable or disable the interrupt simulation system, as well as to enable or disable individual interrupts.

See also *Using the interrupt system*, page 301.

Requirements

The C-SPY simulator.

Enable interrupt simulation

Enables or disables interrupt simulation. If the interrupt simulation is disabled, the definitions remain but no interrupts are generated. Note that you can also enable and disable installed interrupts individually by using the check box to the left of the interrupt name in the list of installed interrupts.

Display area

This area contains these columns:

Interrupt

Lists all interrupts. Use the checkbox to enable or disable the interrupt.

ID

A unique interrupt identifier.

Type

Shows the type of the interrupt. The type can be one of:

Forced, a single-occasion interrupt defined in the **Forced Interrupt** window.

Single, a single-occasion interrupt.

Repeat, a periodically occurring interrupt.

If the interrupt has been set from a C-SPY macro, the additional part **(macro)** is added, for example: **Repeat(macro)**.

Timing

The timing of the interrupt. For a **Single** and **Forced** interrupt, the activation time is displayed. For a **Repeat** interrupt, the information has the form: `Activation Time + n*Repeat Time`. For example, `2000 + n*2345`. This means that the first time this interrupt is triggered, is at 2000 cycles and after that with an interval of 2345 cycles.

Buttons

These buttons are available:

New

Opens the **Edit Interrupt** dialog box, see *Edit Interrupt dialog box*, page 307.

Edit

Opens the **Edit Interrupt** dialog box, see *Edit Interrupt dialog box*, page 307.

Delete

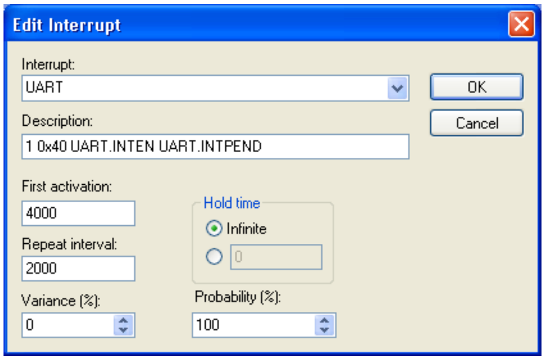
Removes the selected interrupt.

Delete All

Removes all interrupts.

Edit Interrupt dialog box

The **Edit Interrupt** dialog box is available from the **Interrupt Setup** dialog box.



Interrupt: UART

Description: 1 0x40 UART.INTEN UART.INTPEND

First activation: 4000

Repeat interval: 2000

Variance (%): 0

Hold time: [✓ Infinite] 0

Probability (%): 100

Use this dialog box to interactively fine-tune the interrupt parameters. You can add the parameters and quickly test that the interrupt is generated according to your needs.

Note: You can only edit or remove non-forced interrupts.

See also *Using the interrupt system*, page 301.

Requirements

The C-SPY simulator.

Interrupt

Selects the interrupt that you want to edit. The drop-down list contains all available interrupts. Your selection will automatically update the **Description** box. The list is populated with entries from the device description file that you have selected.

Description

A description of the selected interrupt, if available. The description is retrieved from the selected device description file and consists of a string describing the vector address, default priority, enable bit, request bit, and priority bit, separated by space characters. For interrupts specified using the system macro `__orderInterrupt`, the **Description** box is empty.

First activation

Specify the value of the cycle counter after which the specified type of interrupt will be generated.

Repeat interval

Specify the periodicity of the interrupt in cycles.

Variance %

Selects a timing variation range, as a percentage of the repeat interval, in which the interrupt might occur for a period. For example, if the repeat interval is 100 and the variance 5%, the interrupt might occur anywhere between T=95 and T=105, to simulate a variation in the timing.

Hold time

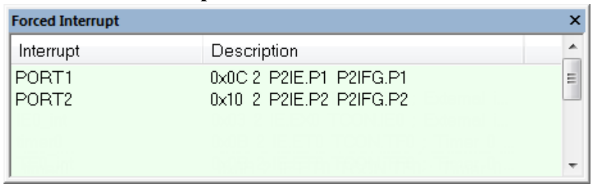
Specify how long, in cycles, the interrupt remains pending until removed if it has not been processed. If you select **Infinite**, the corresponding pending bit will be set until the interrupt is acknowledged or removed.

Probability %

Selects the probability, in percent, that the interrupt will actually occur within the specified period.

Forced Interrupt window

The **Forced Interrupt** window is available from the C-SPY driver menu.



Interrupt	Description
PORT1	0x0C 2 P2IE.P1 P2IFG.P1
PORT2	0x10 2 P2IE.P2 P2IFG.P2

Use this window to force an interrupt instantly. This is useful when you want to check your interrupt logic and interrupt routines. Just start typing an interrupt name and focus shifts to the first line found with that name.

The hold time for a forced interrupt is infinite, and the interrupt exists until it has been serviced or until a reset of the debug session.

To sort the window contents, click on either the **Interrupt** or the **Description** column header. A second click on the same column header reverses the sort order.

To force an interrupt:

1. Enable the interrupt simulation system, see *Interrupt Setup dialog box*, page 305.
2. Double-click the interrupt in the **Forced Interrupt** window, or activate it by using the **Force** command available on the context menu.

Requirements

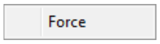
The C-SPY simulator.

Display area

This area lists all available interrupts and their definitions. This information is retrieved from the selected device description file. See this file for a detailed description.

Context menu

This context menu is available:



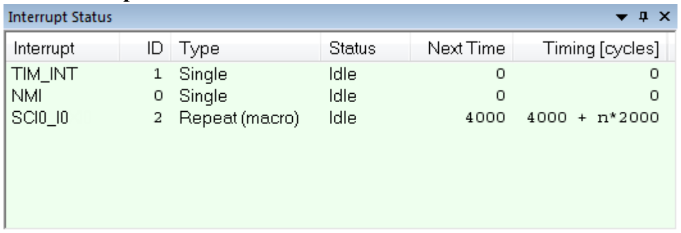
This command is available:

Force

Triggers the interrupt you selected in the display area.

Interrupt Status window

The **Interrupt Status** window is available from the C-SPY driver menu.



Interrupt	ID	Type	Status	Next Time	Timing [cycles]
TIM_INT	1	Single	Idle	0	0
NMI	0	Single	Idle	0	0
SCI0_I0	2	Repeat (macro)	Idle	4000	4000 + n*2000

This window shows the status of all the currently active interrupts, in other words interrupts that are either executing or waiting to be executed.

Requirements

The C-SPY simulator.

Display area

This area contains these columns:

Interrupt

Lists all interrupts.

ID

A unique interrupt identifier.

Type

The type of the interrupt. The type can be one of:

Forced, a single-occasion interrupt defined in the **Forced Interrupt** window.

Single, a single-occasion interrupt.

Repeat, a periodically occurring interrupt.

If the interrupt has been set from a C-SPY macro, the additional part **(macro)** is added, for example: **Repeat(macro)**.

Status

The state of the interrupt:

Idle, the interrupt activation signal is low (deactivated).

Pending, the interrupt activation signal is active, but the interrupt has not been yet acknowledged by the interrupt handler.

Executing, the interrupt is currently being serviced, that is the interrupt handler function is executing.

Suspended, the interrupt is currently suspended due to execution of an interrupt with a higher priority.

(deleted) is added to **Executing** and **Suspended** if you have deleted a currently active interrupt. **(deleted)** is removed when the interrupt has finished executing.

Next Time

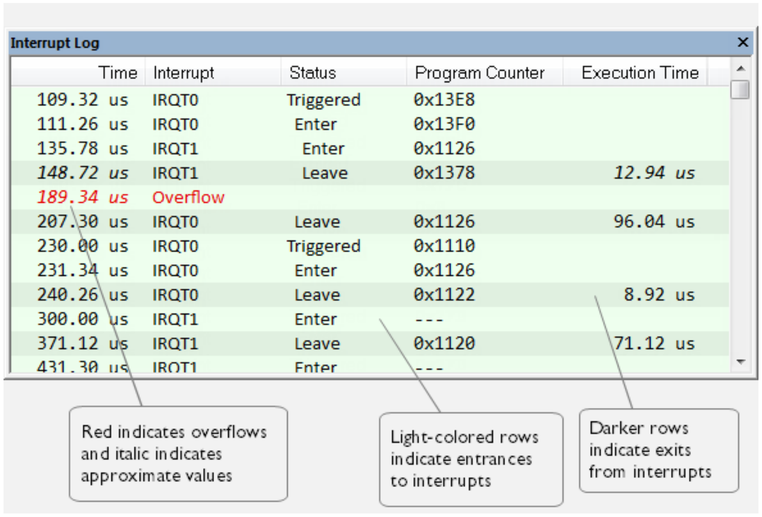
The next time an idle interrupt is triggered. Once a repeatable interrupt stats executing, a copy of the interrupt will appear with the state Idle and the next time set. For interrupts that do not have a next time—that is pending, executing, or suspended—the column will show `--`.

Timing

The timing of the interrupt. For a **Single** and **Forced** interrupt, the activation time is displayed. For a **Repeat** interrupt, the information has the form: `Activation Time + n*Repeat Time`. For example, `2000 + n*2345`. This means that the first time this interrupt is triggered, is at 2000 cycles and after that with an interval of 2345 cycles.

Interrupt Log window

The **Interrupt Log** window is available from the C-SPY driver menu.


Interrupt Log
Red indicates overflows and italic indicates approximate values
Light-colored rows indicate entrances to interrupts
Darker rows indicate exits from interrupts

Time	Interrupt	Status	Program Counter	Execution Time
109.32 us	IRQT0	Triggered	0x13E8	
111.26 us	IRQT0	Enter	0x13F0	
135.78 us	IRQT1	Enter	0x1126	
148.72 us	IRQT1	Leave	0x1378	*12.94 us*
189.34 us	Overflow			
207.30 us	IRQT0	Leave	0x1126	96.04 us
230.00 us	IRQT0	Triggered	0x1110	
231.34 us	IRQT0	Enter	0x1126	
240.26 us	IRQT0	Leave	0x1122	8.92 us
300.00 us	IRQT1	Enter	---	
371.12 us	IRQT1	Leave	0x1120	71.12 us
431.30 us	IRQT1	Enter	---	

This window logs entrances to and exits from interrupts. The C-SPY simulator also logs internal state changes.

The information is useful for debugging the interrupt handling in the target system. When the **Interrupt Log** window is open, it is updated continuously at runtime.

Note: There is a limit on the number of saved logs. When this limit is exceeded, the oldest entries in the buffer are erased.

For more information, see *Getting started using interrupt logging*, page 304.

For information about how to get a graphical view of the interrupt events during the execution of your application, see *Timeline window—Interrupt Log graph*, page 316.

Requirements

The C-SPY simulator.

Display area

This area contains these columns:

Time

The time for the interrupt entrance, based on an internally specified clock frequency.

This column is available when you have selected **Show Time** from the context menu.

Cycles

The number of cycles from the start of the execution until the event.

This column is available when you have selected **Show Cycles** from the context menu.

Interrupt

The interrupt as defined in the device description file.

Status

Shows the event status of the interrupt:

Triggered, the interrupt has passed its activation time.

Forced, the same as Triggered, but the interrupt was forced from the **Forced Interrupt** window.

Enter, the interrupt is currently executing.

Leave, the interrupt has been executed.

Expired, the interrupt hold time has expired without the interrupt being executed.

Rejected, the interrupt has been rejected because the necessary interrupt registers were not set up to accept the interrupt.

Program Counter

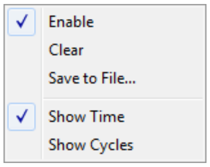
The value of the program counter when the event occurred.

Execution Time/Cycles

The time spent in the interrupt, calculated using the Enter and Leave timestamps. This includes time spent in any subroutines or other interrupts that occurred in the specific interrupt.

Context menu

This context menu is available:



These commands are available:

Enable

Enables the logging system. The system will log information also when the window is closed.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Save to File

Displays a standard file selection dialog box where you can select the destination file for the log information. The entries in the log file are separated by `TAB` and `LF` characters. An **X** in the **Approx** column indicates that the timestamp is an approximation.

Show Time

Displays the **Time** column.

If the **Time** column is displayed by default in the C-SPY driver you are using, this menu command is not available.

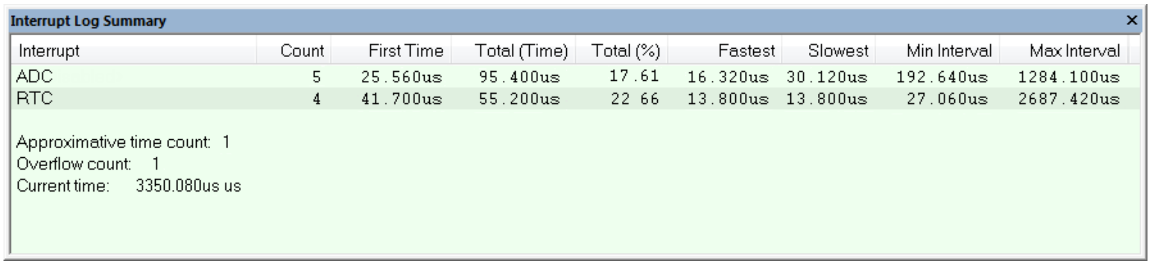
Show Cycles

Displays the **Cycles** column.

If the **Cycles** column is not supported in the C-SPY driver you are using, this menu command is not available.

Interrupt Log Summary window

The **Interrupt Log Summary** window is available from the C-SPY driver menu.


Interrupt Log Summary

Interrupt	Count	First Time	Total (Time)	Total (%)	Fastest	Slowest	Min Interval	Max Interval
ADC	5	25.560us	95.400us	17.61	16.320us	30.120us	192.640us	1284.100us
RTC	4	41.700us	55.200us	22.66	13.800us	13.800us	27.060us	2687.420us

Approximative time count: 1
Overflow count: 1
Current time: 3350.080us us

This window displays a summary of logs of entrances to and exits from interrupts.

For more information, see *Getting started using interrupt logging*, page 304.

For information about how to get a graphical view of the interrupt events during the execution of your application, see *Timeline window—Interrupt Log graph*, page 316.

Requirements

The C-SPY simulator.

Display area

Each row in this area displays statistics about the specific interrupt based on the log information in these columns:

Interrupt

The type of interrupt that occurred.

Count

The number of times the interrupt occurred.

First time

The first time the interrupt was executed.

Total (Time)**

The accumulated time spent in the interrupt.

Total (%)

The time in percent of the current time.

Fastest**

The fastest execution of a single interrupt of this type.

Slowest**

The slowest execution of a single interrupt of this type.

Min interval

The shortest time between two interrupts of this type.

The interval is specified as the time interval between the entry time for two consecutive interrupts.

Max interval

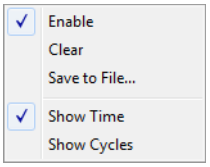
The longest time between two interrupts of this type.

The interval is specified as the time interval between the entry time for two consecutive interrupts.

** Calculated in the same way as for the Execution time/cycles in the **Interrupt Log** window.

Context menu

This context menu is available:



These commands are available:

Enable

Enables the logging system. The system will log information also when the window is closed.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Save to File

Displays a standard file selection dialog box where you can select the destination file for the log information. The entries in the log file are separated by `TAB` and `LF` characters. An **X** in the **Approx** column indicates that the timestamp is an approximation.

Show Time

Displays the **Time** column.

If the **Time** column is displayed by default in the C-SPY driver you are using, this menu command is not available.

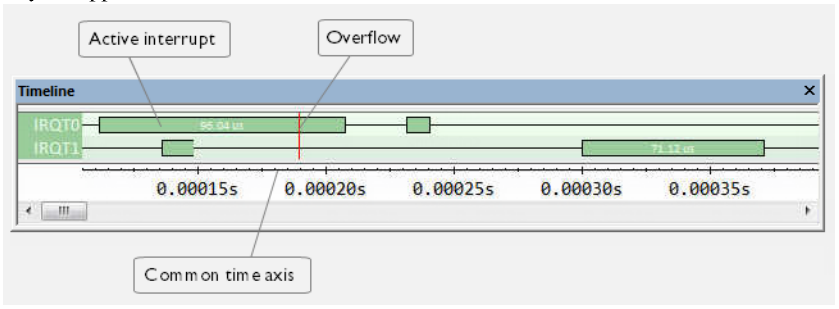
Show Cycles

Displays the **Cycles** column.

If the **Cycles** column is not supported in the C-SPY driver you are using, this menu command is not available.

Timeline window—Interrupt Log graph

The Interrupt Log graph displays interrupts collected by the trace system. In other words, the graph provides a graphical view of the interrupt events during the execution of your application.



Note: There is a limit on the number of saved logs. When this limit is exceeded, the oldest entries in the buffer are erased.

Requirements

The C-SPY simulator.

Display area

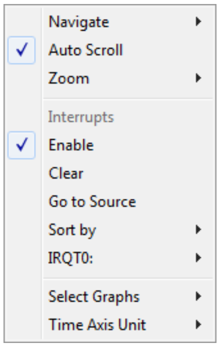
- The label area at the left end of the graph displays the names of the interrupts.
- The graph itself shows active interrupts as a thick green horizontal bar where the white figure indicates the time spent in the interrupt. This graph is a graphical representation of the information in the **Interrupt Log** window, see *Interrupt Log window*, page 311.
- If the bar is displayed without horizontal borders, there are two possible causes:
  - The interrupt is reentrant and has interrupted itself. Only the innermost interrupt will have borders.
  - There are irregularities in the interrupt enter-leave sequence, probably due to missing logs.

- If the bar is displayed without a vertical border, the missing border indicates an approximate time for the log.
- A red vertical line indicates overflow, which means that the communication channel failed to transmit all interrupt logs from the target system.

At the bottom of the window, there is a common time axis that uses seconds as the time unit.

Context menu

This context menu is available:



Note: The exact contents of the context menu you see on the screen depends on which features that your combination of software and hardware supports. However, the list of menu commands below is complete and covers all possible commands.

These commands are available:

Navigate

Commands for navigating the graph(s). Choose between:

Next moves the selection to the next relevant point in the graph. Shortcut key: right arrow.

Previous moves the selection backward to the previous relevant point in the graph. Shortcut key: left arrow.

First moves the selection to the first data entry in the graph. Shortcut key: Home.

Last moves the selection to the last data entry in the graph. Shortcut key: End.

End moves the selection to the last data in any displayed graph, in other words the end of the time axis. Shortcut key: Ctrl+End.

Auto Scroll

Toggles automatic scrolling on or off. When on, the most recently collected data is automatically displayed when you choose **Navigate>End**.

Zoom

Commands for zooming the window, in other words, changing the time scale. Choose between:

Zoom to Selection makes the current selection fit the window. Shortcut key: Return.

Zoom In zooms in on the time scale. Shortcut key: +

Zoom Out zooms out on the time scale. Shortcut key: –

10ns, **100ns**, **1us**, etc makes an interval of 10 nanoseconds, 100 nanoseconds, 1 microsecond, respectively, fit the window.

1ms, **10ms**, etc makes an interval of 1 millisecond or 10 milliseconds, respectively, fit the window.

10m, **1h**, etc makes an interval of 10 minutes or 1 hour, respectively, fit the window.

Interrupt

A heading that shows that the Interrupt Log-specific commands below are available.

Enable

Toggles the display of the graph on or off. If you disable a graph, that graph will be indicated as **OFF** in the window. If no data has been collected for a graph, **no data** will appear instead of the graph.

Clear

Deletes the log information. Note that this will also happen when you reset the debugger.

Go To Source

Displays the corresponding source code in an editor window, if applicable.

Sort by

Sorts the entries according to their ID or name. The selected order is used in the graph when new interrupts appear.

source

Goes to the previous/next log for the selected source.

Select Graphs

Selects which graphs to be displayed in the **Timeline** window.

Time Axis Unit

Selects the unit used in the time axis; choose between **Seconds** and **Cycles**.

If **Cycles** is not available, the graphs are based on different clock sources. In that case you can view cycle values as tooltip information by pointing at the graph with your mouse pointer.

C-SPY macros

- Introduction to C-SPY macros
- Using C-SPY macros
- Reference information on the macro language
- Reference information on reserved setup macro function names
- Reference information on C-SPY system macros
- Graphical environment for macros

Introduction to C-SPY macros

These topics are covered:

- Reasons for using C-SPY macros
- Briefly about using C-SPY macros
- Briefly about setup macro functions and files
- Briefly about the macro language

REASONS FOR USING C-SPY MACROS

You can use C-SPY macros either by themselves or in conjunction with complex breakpoints and interrupt simulation to perform a wide variety of tasks. Some examples where macros can be useful:

- Automating the debug session, for instance with trace printouts, printing values of variables, and setting breakpoints.
- Hardware configuring, such as initializing hardware registers.
- Feeding your application with simulated data during runtime.
- Simulating peripheral devices, see the chapter *Interrupts*. This only applies if you are using the simulator driver.
- Developing small debug utility functions.

BRIEFLY ABOUT USING C-SPY MACROS

To use C-SPY macros, you should:

- Write your macro variables and functions and collect them in one or several *macro files*
- Register your macros
- Execute your macros.

For registering and executing macros, there are several methods to choose between. Which method you choose depends on which level of interaction or automation you want, and depending on at which stage you want to register or execute your macro.

BRIEFLY ABOUT SETUP MACRO FUNCTIONS AND FILES

There are some reserved *setup macro function names* that you can use for defining macro functions which will be called at specific times, such as:

- Once after communication with the target system has been established but before downloading the application software
- Once after your application software has been downloaded
- Each time the reset command is issued
- Once when the debug session ends.

To define a macro function to be called at a specific stage, you should define and register a macro function with one of the reserved names. For instance, if you want to clear a specific memory area before you load your application software, the macro setup function `execUserPreload` should be used. This function is also suitable if you want to initialize some CPU registers or memory-mapped peripheral units before you load your application software.

You should define these functions in a *setup macro file*, which you can load before C-SPY starts. Your macro functions will then be automatically registered each time you start C-SPY. This is convenient if you want to automate the initialization of C-SPY, or if you want to register multiple setup macros.

For more information about each setup macro function, see *Reference information on reserved setup macro function names*, page 333.

BRIEFLY ABOUT THE MACRO LANGUAGE

The syntax of the macro language is very similar to the C language. There are:

- *Macro statements*, which are similar to C statements.
- *Macro functions*, which you can define with or without parameters and return values.

- Predefined built-in *system macros*, similar to C library functions, which perform useful tasks such as opening and closing files, setting breakpoints, and defining simulated interrupts.
- *Macro variables*, which can be global or local, and can be used in C-SPY expressions.
- *Macro strings*, which you can manipulate using predefined system macros.

For more information about the macro language components, see *Reference information on the macro language*, page 328.

Example

Consider this example of a macro function which illustrates the various components of the macro language:

```
__var oldVal;
CheckLatest(val)
{
 if (oldVal != val)
 {
  __message "Message: Changed from ", oldVal, " to ", val, "\n";
  oldVal = val;
 }
}
```

Note: Reserved macro words begin with double underscores to prevent name conflicts.

Using C-SPY macros

These tasks are covered:

- Registering C-SPY macros—an overview
- Executing C-SPY macros—an overview
- Registering and executing using setup macros and setup files
- Executing macros using Quick Watch
- Executing a macro by connecting it to a breakpoint
- Aborting a C-SPY macro

For more examples using C-SPY macros, see:

- The tutorial about simulating an interrupt, which you can find in the Information Center
- *Initializing target hardware before C-SPY starts*, page 47

REGISTERING C-SPY MACROS—AN OVERVIEW

C-SPY must know that you intend to use your defined macro functions, and therefore you must *register* your macros. There are various ways to register macro functions:

- You can register macro functions during the C-SPY startup sequence, see *Registering and executing using setup macros and setup files*, page 325.
- You can register macros interactively in the **Macro Registration** window, see *Macro Registration window*, page 372. Registered macros appear in the **Debugger Macros** window, see *Debugger Macros window*, page 374.
- You can register a file containing macro function definitions, using the system macro `__registerMacroFile`. This means that you can dynamically select which macro files to register, depending on the runtime conditions. Using the system macro also lets you register multiple files at the same moment. For information about the system macro, see *__registerMacroFile*, page 356.

Which method you choose depends on which level of interaction or automation you want, and depending on at which stage you want to register your macro.

EXECUTING C-SPY MACROS—AN OVERVIEW

There are various ways to execute macro functions:

- You can execute macro functions during the C-SPY startup sequence and at other predefined stages during the debug session by defining setup macro functions in a setup macro file, see *Registering and executing using setup macros and setup files*, page 325.
- The **Quick Watch** window lets you evaluate expressions, and can thus be used for executing macro functions. For an example, see *Executing macros using Quick Watch*, page 325.
- The **Macro Quicklaunch** window is similar to the **Quick Watch** window, but is more specified on designed for C-SPY macros. See *Macro Quicklaunch window*, page 376.
- A macro can be connected to a breakpoint; when the breakpoint is triggered the macro is executed. For an example, see *Executing a macro by connecting it to a breakpoint*, page 326.

Which method you choose depends on which level of interaction or automation you want, and depending on at which stage you want to execute your macro.

REGISTERING AND EXECUTING USING SETUP MACROS AND SETUP FILES

It can be convenient to register a macro file during the C-SPY startup sequence. To do this, specify a macro file which you load before starting the debug session. Your macro functions will be automatically registered each time you start the debugger.

If you use the reserved setup macro function names to define the macro functions, you can define exactly at which stage you want the macro function to be executed.

To define a setup macro function and load it during C-SPY startup:

1 Create a new text file where you can define your macro function.

For example:

```
execUserSetup()
{
 ...
 __registerMacroFile("MyMacroUtils.mac");
 __registerMacroFile("MyDeviceSimulation.mac");

}
```

This macro function registers the additional macro files `MyMacroUtils.mac` and `MyDeviceSimulation.mac`. Because the macro function is defined with the function name `execUserSetup`, it will be executed directly after your application has been downloaded.

2 Save the file using the filename extension `mac`.

3 Before you start C-SPY, choose **Project>Options>Debugger>Setup**. Select **Use Setup file** and choose the macro file you just created.

The macros will now be registered during the C-SPY startup sequence.

EXECUTING MACROS USING QUICK WATCH

The **Quick Watch** window lets you dynamically choose when to execute a macro function.

1 Consider this simple macro function that checks the status of a timer enable bit:

```
TimerStatus()
{
  if ((TimerStatreg & 0x01) != 0)/* Checks the status of reg */
    return "Timer enabled"; /* C-SPY macro string used */
  else
    return "Timer disabled"; /* C-SPY macro string used */
}
```

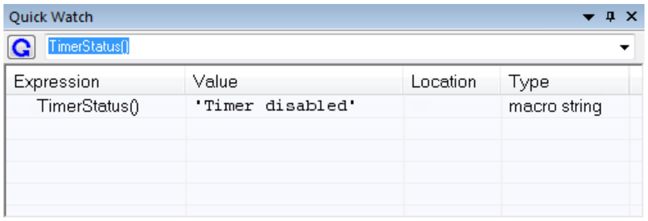
2 Save the macro function using the filename extension `mac`.

3 To load the macro file, choose **View>Macros>Macro Registration**. The **Macro Registration** window is displayed. Click **Add** and locate the file using the file browser. The macro file appears in the list of macros in the **Macro Registration** window.

4 Select the macro you want to register and your macro will appear in the **Debugger Macros** window.

5 Choose **View>Quick Watch** to open the **Quick Watch** window, type the macro call `TimerStatus()` in the text field and press Return,

Alternatively, in the macro file editor window, select the macro function name `TimerStatus()`. Right-click, and choose **Quick Watch** from the context menu that appears.



Expression	Value	Location	Type
TimerStatus()	'Timer disabled'		macro string

The macro will automatically be displayed in the **Quick Watch** window. For more information, see *Quick Watch window*, page 118.

EXECUTING A MACRO BY CONNECTING IT TO A BREAKPOINT

You can connect a macro to a breakpoint. The macro will then be executed when the breakpoint is triggered. The advantage is that you can stop the execution at locations of particular interest and perform specific actions there.

For instance, you can easily produce log reports containing information such as how the values of variables, symbols, or registers change. To do this you might set a breakpoint on a suspicious location and connect a log macro to the breakpoint. After the execution you can study how the values of the registers have changed.

To create a log macro and connect it to a breakpoint:

1 Assume this skeleton of a C function in your application source code:

```
int fact(int x)
{
  ...
}
```

2 Create a simple log macro function like this example:

```
logfact()
{
 __message "fact(" ,x, ")";
}
```

The `__message` statement will log messages to the **Debug Log** window.

Save the macro function in a macro file, with the filename extension `mac`.

3 To register the macro, choose **View>Macros>Macro Registration** to open the **Macro Registration** window and add your macro file to the list. Select the file to register it. Your macro function will appear in the **Debugger Macros** window.

4 To set a code breakpoint, click the **Toggle Breakpoint** button on the first statement within the function `fact` in your application source code. Choose **View>Breakpoints** to open the **Breakpoints** window. Select your breakpoint in the list of breakpoints and choose the **Edit** command from the context menu.

5 To connect the log macro function to the breakpoint, type the name of the macro function, `logfact()`, in the **Action** field and click **OK** to close the dialog box.

6 Execute your application source code. When the breakpoint is triggered, the macro function will be executed. You can see the result in the **Debug Log** window.

Note that the expression in the **Action** field is evaluated only when the breakpoint causes the execution to really stop. If you want to log a value and then automatically continue execution, you can either:

- Use a **Log** breakpoint, see *Log breakpoints dialog box*, page 143
- Use the **Condition** field instead of the **Action** field. For an example, see *Performing a task and continuing execution*, page 135.

7 You can easily enhance the log macro function by, for instance, using the `__fmessage` statement instead, which will print the log information to a file. For information about the `__fmessage` statement, see *Formatted output*, page 331.

For an example where a serial port input buffer is simulated using the method of connecting a macro to a breakpoint, see the tutorial *Simulating an interrupt* in the Information Center.

ABORTING A C-SPY MACRO

To abort a C-SPY macro:

1 Press Ctrl+Shift+. (period) for a short while.

2 A message that says that the macro has terminated is displayed in the **Debug Log** window.

This method can be used if you suspect that something is wrong with the execution, for example because it seems not to terminate in a reasonable time.

Reference information on the macro language

Reference information about:

- *Macro functions*, page 328
- *Macro variables*, page 328
- *Macro parameters*, page 329
- *Macro strings*, page 329
- *Macro statements*, page 330
- *Formatted output*, page 331

MACRO FUNCTIONS

C-SPY macro functions consist of C-SPY variable definitions and macro statements which are executed when the macro is called. An unlimited number of parameters can be passed to a macro function, and macro functions can return a value on exit.

A C-SPY macro has this form:

```
macroName (parameterList)
{
  macroBody
}
```

where `parameterList` is a list of macro parameters separated by commas, and `macroBody` is any series of C-SPY variable definitions and C-SPY statements.

Type checking is neither performed on the values passed to the macro functions nor on the return value.

MACRO VARIABLES

A macro variable is a variable defined and allocated outside your application. It can then be used in a C-SPY expression, or you can assign application data—values of the variables in your application—to it. For more information about C-SPY expressions, see *C-SPY expressions*, page 100.

The syntax for defining one or more macro variables is:

```
__var nameList;
```

where `nameList` is a list of C-SPY variable names separated by commas.

A macro variable defined outside a macro body has global scope, and it exists throughout the whole debugging session. A macro variable defined within a macro body is created when its definition is executed and destroyed on return from the macro.

By default, macro variables are treated as signed integers and initialized to 0. When a C-SPY variable is assigned a value in an expression, it also acquires the type of that expression. For example:

Expression	What it means
`myvar = 3.5;`	`myvar` is now type `double`, value `3.5`.
`myvar = (int*)i;`	`myvar` is now type pointer to `int`, and the value is the same as `i`.

Table 14: Examples of C-SPY macro variables

In case of a name conflict between a C symbol and a C-SPY macro variable, C-SPY macro variables have a higher precedence than C variables. Note that macro variables are allocated on the debugger host and do not affect your application.

MACRO PARAMETERS

A macro parameter is intended for parameterization of device support. The named parameter will behave as a normal C-SPY macro variable with these differences:

- The parameter definition can have an initializer
- Values of a parameters can be set through options (either in the IDE or in `cspybat`).
- A value set from an option will take precedence over a value set by an initializer
- A parameter must have an initializer, be set through an option, or both. Otherwise, it has an undefined value, and accessing it will cause a runtime error.

The syntax for defining one or more macro parameters is:

```
__param param[=value, ...;]
```

Use the command line option `--macro_param` to specify a value to a parameter, see *--macro_param*, page 391.

MACRO STRINGS

In addition to C types, macro variables can hold values of *macro strings*. Note that macro strings differ from C language strings.

When you write a string literal, such as `"Hello!"`, in a C-SPY expression, the value is a macro string. It is not a C-style character pointer `char*`, because `char*` must point to a sequence of characters in target memory and C-SPY cannot expect any string literal to actually exist in target memory.

You can manipulate a macro string using a few built-in macro functions, for example `__strFind` or `__subString`. The result can be a new macro string. You can concatenate macro strings using the `+` operator, for example `str + "tail"`. You can also access individual characters using subscription, for example *str*`[3]`. You can get the length of a string using `sizeof(str)`. Note that a macro string is not NULL-terminated.

The macro function `__toString` is used for converting from a NULL-terminated C string in your application (`char*` or `char[]`) to a macro string. For example, assume this definition of a C string in your application:

```
char const *cstr = "Hello";
```

Then examine these macro examples:

```
__var str;          /* A macro variable */
str = cstr          /* str is now just a pointer to char */
sizeof str          /* same as sizeof (char*), typically 2 or 4 */
str = __toString(cstr,512)  /* str is now a macro string */
sizeof str          /* 5, the length of the string */
str[1]              /* 101, the ASCII code for 'e' */
str += " World!"    /* str is now "Hello World!" */
```

See also *Formatted output*, page 331.

MACRO STATEMENTS

Statements are expected to behave in the same way as the corresponding C statements would do. The following C-SPY macro statements are accepted:

Expressions

```
expression;
```

For more information about C-SPY expressions, see *C-SPY expressions*, page 100.

Conditional statements

```
if (expression)
  statement

if (expression)
  statement
else
  statement
```

Loop statements

```
for (init_expression; cond_expression; update_expression)
  statement

while (expression)
  statement

do
  statement
while (expression);
```

Return statements

```
return;

return expression;
```

If the return value is not explicitly set, `signed int 0` is returned by default.

Blocks

Statements can be grouped in blocks.

```
{
  statement1
  statement2
  .
  .
  .
  statementN
}
```

FORMATTED OUTPUT

C-SPY provides various methods for producing formatted output:

`__message argList;`	Prints the output to the **Debug Log** window.
`__fmessage file, argList;`	Prints the output to the designated file.
`__smessage argList;`	Returns a string containing the formatted output.

where *`argList`* is a comma-separated list of C-SPY expressions or strings, and *`file`* is the result of the `__openFile` system macro, see *__openFile*, page 351.

To produce messages in the **Debug Log** window:

```
var1 = 42;
var2 = 37;
__message "This line prints the values ", var1, " and ", var2,
" in the Debug Log window.";
```

This produces this message in the **Debug Log** window:

```
This line prints the values 42 and 37 in the Debug Log window.
```

To write the output to a designated file:

```
__fmessage myfile, "Result is ", res, "!\n";
```

To produce strings:

```
myMacroVar = __smessage 42, " is the answer.";
```

`myMacroVar` now contains the string `"42 is the answer."`.

Specifying display format of arguments

To override the default display format of a scalar argument (number or pointer) in *`argList`*, suffix it with a `:` followed by a format specifier. Available specifiers are:

`%b`	for binary scalar arguments
`%o`	for octal scalar arguments
`%d`	for decimal scalar arguments
`%x`	for hexadecimal scalar arguments
`%c`	for character scalar arguments

These match the formats available in the **Watch** and **Locals** windows, but number prefixes and quotes around strings and characters are not printed. Another example:

```
__message "The character '", cvar:%c, "' has the decimal value
", cvar;
```

Depending on the value of the variables, this produces this message:

```
The character 'A' has the decimal value 65
```

Note: A character enclosed in single quotes (a character literal) is an integer constant and is not automatically formatted as a character. For example:

```
__message 'A', " is the numeric value of the character ",
'A':%c;
```

would produce:

```
65 is the numeric value of the character A
```

Note: The default format for certain types is primarily designed to be useful in the **Watch** window and other related windows. For example, a value of type `char` is formatted as 'A' (0x41), while a pointer to a character (potentially a C string) is formatted as 0x8102 "Hello", where the string part shows the beginning of the string (currently up to 60 characters).

When printing a value of type `char*`, use the `%x` format specifier to print just the pointer value in hexadecimal notation, or use the system macro `__toString` to get the full string value.

Reference information on reserved setup macro function names

There are reserved setup macro function names that you can use for defining your setup macro functions. By using these reserved names, your function will be executed at defined stages during execution. For more information, see *Briefly about setup macro functions and files*, page 322.

Reference information about:

- `execUserPreload`
- `execUserExecutionStarted`
- `execUserExecutionStopped`
- `execUserSetup`
- `execUserPreReset`
- `execUserReset`
- `execUserExit`

execUserPreload

Syntax	`execUserPreload`
For use with	All C-SPY drivers.
Description	Called after communication with the target system is established but before downloading the target application.
	Implement this macro to initialize memory locations and/or registers which are vital for loading data properly.

execUserExecutionStarted

Syntax	`execUserExecutionStarted`
For use with	All C-SPY drivers.
Description	Called when the debugger is about to start or resume execution. The macro is not called when performing a one-instruction assembler step, in other words, Step or Step Into in the **Disassembly** window.

execUserExecutionStopped

Syntax	`execUserExecutionStopped`
For use with	All C-SPY drivers.
Description	Called when the debugger has stopped execution. The macro is not called when performing a one-instruction assembler step, in other words, Step or Step Into in the **Disassembly** window.

execUserSetup

Syntax	`execUserSetup`
For use with	All C-SPY drivers.
Description	Called once after the target application is downloaded.

Implement this macro to set up the memory map, breakpoints, interrupts, register macro files, etc.

If you define interrupts or breakpoints in a macro file that is executed at system start (using `execUserSetup`) we strongly recommend that you also make sure that they are removed at system shutdown (using `execUserExit`). An example is available in `SetupSimple.mac`, see the tutorials in the Information Center.

The reason for this is that the simulator saves interrupt settings between sessions and if they are not removed they will get duplicated every time `execUserSetup` is executed again. This seriously affects the execution speed.

execUserPreReset

Syntax	`execUserPreReset`
For use with	All C-SPY drivers.
Description	Called each time just before the reset command is issued. Implement this macro to set up any required device state.

execUserReset

Syntax	`execUserReset`
For use with	All C-SPY drivers.
Description	Called each time just after the reset command is issued. Implement this macro to set up and restore data.

execUserExit

Syntax	`execUserExit`
For use with	All C-SPY drivers.
Description	Called once when the debug session ends. Implement this macro to save status data etc.

Reference information on C-SPY system macros

This section gives reference information about each of the C-SPY system macros.

This table summarizes the pre-defined system macros:

Macro	Description
`__abortLaunch`	Aborts the launch of the debugger
`__cancelAllInterrupts`	Cancels all ordered interrupts
`__cancelInterrupt`	Cancels an interrupt
`__clearBreak`	Clears a breakpoint

Table 15: Summary of system macros

Macro	Description
`__closeFile`	Closes a file that was opened by `__openFile`
`__dataflashMemoryRestore`	Restores the contents of a file to data flash memory
`__dataflashMemorySave`	Saves the contents of a specified data flash memory area to a file
`__delay`	Delays execution
`__disableInterrupts`	Disables generation of interrupts
`__driverType`	Verifies the driver type
`__enableInterrupts`	Enables generation of interrupts
`__evaluate`	Interprets the input string as an expression and evaluates it
`__fillMemory8`	Fills a specified memory area with a byte value
`__fillMemory16`	Fills a specified memory area with a 2-byte value
`__fillMemory32`	Fills a specified memory area with a 4-byte value
`__getSelectedCore`	Only for use with IAR Embedded Workbench products that support multicore debugging
`__isBatchMode`	Checks if C-SPY is running in batch mode or not.
`__loadImage`	Loads a debug image
`__memoryRestore`	Restores the contents of a file to a specified memory zone
`__memorySave`	Saves the contents of a specified memory area to a file
`__messageBoxYesCancel`	Displays a Yes/Cancel dialog box for user interaction
`__messageBoxYesNo`	Displays a Yes/No dialog box for user interaction
`__openFile`	Opens a file for I/O operations
`__orderInterrupt`	Generates an interrupt
`__popSimulatorInterruptExecutingStack`	Informs the interrupt simulation system that an interrupt handler has finished executing
`__readFile`	Reads from the specified file
`__readFileByte`	Reads one byte from the specified file
`__readMemory8`, `__readMemoryByte`	Reads one byte from the specified memory location
`__readMemory16`	Reads two bytes from the specified memory location
`__readMemory32`	Reads four bytes from the specified memory location

Table 15: Summary of system macros (Continued)

Macro	Description
`__registerMacroFile`	Registers macros from the specified file
`__resetFile`	Rewinds a file opened by `__openFile`
`__selectCore`	Only for use with IAR Embedded Workbench products that support multicore debugging
`__setCodeBreak`	Sets a code breakpoint
`__setCodeHWBreak`	Sets a code hardware breakpoint
`__setDataBreak`	Sets a data breakpoint
`__setDataLogBreak`	Sets a data log breakpoint
`__setLogBreak`	Sets a log breakpoint
`__setSimBreak`	Sets a simulation breakpoint
`__setTraceStartBreak`	Sets a trace start breakpoint
`__setTraceStopBreak`	Sets a trace stop breakpoint
`__sourcePosition`	Returns the file name and source location if the current execution location corresponds to a source location
`__strFind`	Searches a given string for the occurrence of another string
`__subString`	Extracts a substring from another string
`__targetDebuggerVersion`	Returns the version of the target debugger
`__toLower`	Returns a copy of the parameter string where all the characters have been converted to lower case
`__toString`	Prints strings
`__toUpper`	Returns a copy of the parameter string where all the characters have been converted to upper case
`__unloadImage`	Unloads a debug image
`__writeFile`	Writes to the specified file
`__writeFileByte`	Writes one byte to the specified file
`__writeMemory8`, `__writeMemoryByte`	Writes one byte to the specified memory location
`__writeMemory16`	Writes a two-byte word to the specified memory location
`__writeMemory32`	Writes a four-byte word to the specified memory location

Table 15: Summary of system macros (Continued)

__abortLaunch

Syntax

`__abortLaunch(`*`message)`*

Parameters

`message`

A string that is printed as an error message when the macro executes.

Return value

None.

For use with

All C-SPY drivers.

Description

This macro can be used for aborting a debugger launch, for example if another macro sees that something goes wrong during initialization and cannot perform a proper setup.

This is an emergency stop when launching, not a way to end an ongoing debug session like the C library function `abort()`.

Example

```
if (!__messageBoxYesCancel("Do you want to mass erase to unlock
                           the device?", "Unlocking device"))
{ __abortLaunch("Unlock canceled. Debug session cannot
                continue."); }
```

__cancelAllInterrupts

Syntax

`__cancelAllInterrupts()`

Return value

`int 0`

For use with

The C-SPY Simulator.

Description

Cancels all ordered interrupts.

__cancelInterrupt

Syntax

`__cancelInterrupt(`*`interrupt_id`*`)`

Parameters

`interrupt_id`

The value returned by the corresponding `__orderInterrupt` macro call (`unsigned long`).

Return value

Result	Value
Successful	`int 0`
Unsuccessful	Non-zero error number

Table 16: __cancelInterrupt return values

For use with

The C-SPY Simulator.

Description

Cancels the specified interrupt.

__clearBreak

Syntax

`__clearBreak(`*`break_id`*`)`

Parameters

`break_id`

The value returned by any of the set breakpoint macros.

Return value

`int 0`

For use with

All C-SPY drivers.

Description

Clears a user-defined breakpoint.

See also

Breakpoints, page 125.

__closeFile

Syntax

`__closeFile(`*`fileHandle`*`)`

Parameters

`fileHandle`

A macro variable used as filehandle by the `__openFile` macro.

Return value

`int 0`

For use with

All C-SPY drivers.

Description

Closes a file previously opened by `__openFile`.

__dataflashMemoryRestore

Syntax `__dataflashMemoryRestore(`*`filename`*`)`

Parameters *`filename`*

A string that specifies the file to be read. The filename must include a path, which must either be absolute or use argument variables. For information about argument variables, see the *IDE Project Management and Building Guide for RL78*.

Return value `0` if something was written to data flash memory, even if an error occurred and not all data was written, otherwise `1`.

For use with The C-SPY hardware debugger drivers.

Description Reads the contents of the specified file and writes it to data flash memory. The address ranges are checked, and addresses which are not part of the data flash memory are skipped, while valid addresses are processed.

Invalid addresses result in a warning and the processing continues.

Example

```
__dataflashMemoryRestore("c:\\temp\\saved_memory.hex");
```

See also *Data Flash Memory window*, page 165.

__dataflashMemorySave

Syntax `__dataflashMemorySave(`*`start, stop, format, filename`*`)`

Parameters *`start`*

A string that specifies the first location of the data flash memory area to be saved.

`stop`

A string that specifies the last location of the data flash memory area to be saved.

`format`

A string that specifies the format to be used for the saved data flash memory. Choose between:

`intel-extended`

`motorola-s37`

filename

A string that specifies the file to write to. The filename must include a path, which must either be absolute or use argument variables. For information about argument variables, see the *IDE Project Management and Building Guide for RL78*.

Return value

`0` if something was written, even if an error occurred and not all data was written, otherwise `1`.

For use with

The C-SPY hardware debugger drivers.

Description

Saves the contents of a specified data flash memory area to a file. The address ranges are checked, and addresses which are not part of the data flash memory are skipped, while valid addresses are processed.

Invalid addresses result in a warning and the processing continues.

Example

```
__dataflashMemorySave("0xF1000", "0xF1FFF", "intel-extended",
"c:\\temp\\saved_memory.hex");
```

See also

Data Flash dialog box, page 167.

__delay

Syntax

`__delay(`*`value`*`)`

Parameters

value

The number of milliseconds to delay execution.

Return value

`int 0`

For use with

All C-SPY drivers.

Description

Delays execution the specified number of milliseconds.

__disableInterrupts

Syntax

`__disableInterrupts()`

Return value

Result	Value
Successful	`int 0`
Unsuccessful	Non-zero error number

Table 17: __disableInterrupts return values

For use with

The C-SPY Simulator.

Description

Disables the generation of interrupts.

__driverType

Syntax

`__driverType(`*`driver_id`*`)`

Parameters

`driver_id`

A string corresponding to the driver you want to check for. Choose one of these:

`"sim"` corresponds to the simulator driver

`"iecube"` corresponds to the IECUBE emulator

`"e1"` corresponds to the E1 emulator

`"e2"` corresponds to the E2 emulator

`"e2lite"` corresponds to the E2 Lite/E2 On-Board or EZ-CUBE2 emulator

`"e20"` corresponds to the E20 emulator

`"ezcube"` corresponds to the EZ-CUBE emulator

`"tk"` corresponds to the TK emulator

Return value

Result	Value
Successful	`1`
Unsuccessful	`0`

Table 18: __driverType return values

For use with

All C-SPY drivers

Description

Checks to see if the current C-SPY driver is identical to the driver type of the *driver_id* parameter.

Example

```
__driverType("sim")
```

If the simulator is the current driver, the value `1` is returned. Otherwise `0` is returned.

__enableInterrupts

Syntax

```
__enableInterrupts()
```

Return value

Result	Value
Successful	`int 0`
Unsuccessful	Non-zero error number

Table 19: __enableInterrupts return values

For use with

The C-SPY Simulator.

Description

Enables the generation of interrupts.

__evaluate

Syntax

`__evaluate(`*`string, valuePtr`*`)`

Parameters

string

Expression string.

valuePtr

Pointer to a macro variable storing the result.

Return value

Result	Value
Successful	`int 0`
Unsuccessful	`int 1`

Table 20: __evaluate return values

For use with

All C-SPY drivers.

Description

This macro interprets the input string as an expression and evaluates it. The result is stored in a variable pointed to by *valuePtr*.

Example

This example assumes that the variable `i` is defined and has the value 5:

```
__evaluate("i + 3", &myVar)
```

The macro variable `myVar` is assigned the value 8.

__fillMemory8

Syntax

```
__fillMemory8(value, address, zone, length, format)
```

Parameters

`value`

An integer that specifies the value.

`address`

An integer that specifies the memory start address.

`zone`

A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

`length`

An integer that specifies how many bytes are affected.

`format`

A string that specifies the exact fill operation to perform. Choose between:

`Copy`	*`value`* will be copied to the specified memory area.
`AND`	An `AND` operation will be performed between *`value`* and the existing contents of memory before writing the result to memory.
`OR`	An `OR` operation will be performed between *`value`* and the existing contents of memory before writing the result to memory.
`XOR`	An `XOR` operation will be performed between *`value`* and the existing contents of memory before writing the result to memory.

Return value

`int 0`

For use with

All C-SPY drivers.

Description

Fills a specified memory area with a byte value.

Example

```
__fillMemory8(0x80, 0x700, "", 0x10, "OR");
```

__fillMemory16

Syntax	`__fillMemory16(`*`value, address, zone, length, format`*`)`

Parameters

`value`

An integer that specifies the value.

`address`

An integer that specifies the memory start address.

`zone`

A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

`length`

An integer that defines how many 2-byte entities to be affected.

`format`

A string that specifies the exact fill operation to perform. Choose between:

`Copy`	*`value`* will be copied to the specified memory area.
`AND`	An `AND` operation will be performed between *`value`* and the existing contents of memory before writing the result to memory.
`OR`	An `OR` operation will be performed between *`value`* and the existing contents of memory before writing the result to memory.
`XOR`	An `XOR` operation will be performed between *`value`* and the existing contents of memory before writing the result to memory.

Return value

`int 0`

For use with

All C-SPY drivers.

Description

Fills a specified memory area with a 2-byte value.

Example

```
__fillMemory16(0xCDCD, 0x7000, "", 0x200, "Copy");
```

__fillMemory32

Syntax

`__fillMemory32(`*`value, address, zone, length, format`*`)`

Parameters

`value`

An integer that specifies the value.

`address`

An integer that specifies the memory start address.

`zone`

A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

`length`

An integer that defines how many 4-byte entities to be affected.

`format`

A string that specifies the exact fill operation to perform. Choose between:

`Copy`	*`value`* will be copied to the specified memory area.
`AND`	An `AND` operation will be performed between *`value`* and the existing contents of memory before writing the result to memory.
`OR`	An `OR` operation will be performed between *`value`* and the existing contents of memory before writing the result to memory.
`XOR`	An `XOR` operation will be performed between *`value`* and the existing contents of memory before writing the result to memory.

Return value `int 0`

For use with All C-SPY drivers.

Description Fills a specified memory area with a 4-byte value.

Example

```
__fillMemory32(0x0000FFFF, 0x4000, "", 0x1000, "XOR");
```

__getSelectedCore

Description This macro returns `0` for a single-core system. It is only useful for IAR Embedded Workbench products that support multicore debugging.

__isBatchMode

Syntax `__isBatchMode()`

Return value

Result	Value
True	`int 1`
False	`int 0`

Table 21: __isBatchMode return values

For use with All C-SPY drivers.

Description This macro returns True if the debugger is running in batch mode, otherwise it returns False.

__loadImage

Syntax `__loadImage(`*`path`*`, `*`offset, debugInfoOnly`*`)`

Parameters

`path`

A string that identifies the path to the debug image to download. The path must either be absolute or use argument variables. For information about argument variables, see the *IDE Project Management and Building Guide for RL78*.

`offset`

An integer that identifies the offset to the destination address for the downloaded debug image.

`debugInfoOnly`

A non-zero integer value if no code or data should be downloaded to the target system, which means that C-SPY will only read the debug information from the debug file. Or, 0 (zero) for download.

Return value

Value	Result
Non-zero integer number	A unique module identification.
`int 0`	Loading failed.

Table 22: __loadImage return values

For use with All C-SPY drivers.

Description Loads a debug image (debug file).

Example 1

Your system consists of a ROM library and an application. The application is your active project, but you have a debug file corresponding to the library. In this case you can add this macro call in the `execUserSetup` macro in a C-SPY macro file, which you associate with your project:

```
__loadImage("ROMfile", 0x8000, 1);
```

This macro call loads the debug information for the ROM library *`ROMfile`* without downloading its contents (because it is presumably already in ROM). Then you can debug your application together with the library.

Example 2

Your system consists of a ROM library and an application, but your main concern is the library. The library needs to be programmed into flash memory before a debug session. While you are developing the library, the library project must be the active project in the IDE. In this case you can add this macro call in the `execUserSetup` macro in a C-SPY macro file, which you associate with your project:

```
__loadImage("ApplicationFile", 0x8000, 0);
```

The macro call loads the debug information for the application and downloads its contents (presumably into RAM). Then you can debug your library together with the application.

See also

Images, page 401 and *Loading multiple debug images*, page 45.

__memoryRestore

Syntax

```
__memoryRestore(zone, filename)
```

Parameters

`zone`

A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

`filename`

A string that specifies the file to be read. The filename must include a path, which must either be absolute or use argument variables. For information about argument variables, see the *IDE Project Management and Building Guide for RL78*.

Return value

`0` if successful, otherwise `1`

For use with

All C-SPY drivers.

Description

Reads the contents of a file and saves it to the specified memory zone.This macro does not work with data flash memory.

Example

```
__memoryRestore("", "c:\\temp\\saved_memory.hex");
```

See also

Memory Restore dialog box, page 169.

__memorySave

Syntax

`__memorySave(`*`start, stop, format, filename`*`)`

Parameters

`start`

A string that specifies the first location of the memory area to be saved.

`stop`

A string that specifies the last location of the memory area to be saved.

`format`

A string that specifies the format to be used for the saved memory. Choose between:

`intel-extended`

`motorola`

`motorola-s19`

`motorola-s28`

`motorola-s37`.

`filename`

A string that specifies the file to write to. The filename must include a path, which must either be absolute or use argument variables. For information about argument variables, see the *IDE Project Management and Building Guide for RL78*.

Return value

`int 0`

For use with

All C-SPY drivers.

Description

Saves the contents of a specified memory area to a file.

Example

```
__memorySave(":0x00", ":0xFF", "intel-extended",
"c:\\temp\\saved_memory.hex");
```

See also

Memory Save dialog box, page 168.

__messageBoxYesCancel

Syntax `__messageBoxYesCancel(`*`message, caption`*`)`

Parameters

`message`

A message that will appear in the message box.

`caption`

The title that will appear in the message box.

Return value

Result	Value
Yes	`1`
No	`0`

Table 23: __messageBoxYesCancel return values

For use with All C-SPY drivers.

Description Displays a Yes/Cancel dialog box when called and returns the user input. Typically, this is useful for creating macros that require user interaction.

__messageBoxYesNo

Syntax `__messageBoxYesNo(`*`message, caption`*`)`

Parameters

`message`

A message that will appear in the message box.

`caption`

The title that will appear in the message box.

Return value

Result	Value
Yes	`1`
No	`0`

Table 24: __messageBoxYesNo return values

For use with All C-SPY drivers.

Description Displays a Yes/No dialog box when called and returns the user input. Typically, this is useful for creating macros that require user interaction.

__openFile

Syntax

`__openFile(filename, access)`

Parameters

`filename`

The file to be opened. The filename must include a path, which must either be absolute or use argument variables. For information about argument variables, see the *IDE Project Management and Building Guide for RL78*.

`access`

The access type (string).

These are mandatory but mutually exclusive:

`"a"` append, new data will be appended at the end of the open file

`"r"` read (by default in text mode; combine with `b` for binary mode: `rb`)

`"w"` write (by default in text mode; combine with `b` for binary mode: `wb`)

These are optional and mutually exclusive:

`"b"` binary, opens the file in binary mode

`"t"` ASCII text, opens the file in text mode

This access type is optional:

`"+"` together with `r`, `w`, or `a; r+` or `w+` is *read* and *write*, while `a+` is *read* and *append*

Return value

Result	Value
Successful	The file handle
Unsuccessful	An invalid file handle, which tests as False

Table 25: __openFile return values

For use with

All C-SPY drivers.

Description

Opens a file for I/O operations. The default base directory of this macro is where the currently open project file (`*.ewp`) is located. The argument to `__openFile` can specify a location relative to this directory. In addition, you can use argument variables such as `$PROJ_DIR$` and `$TOOLKIT_DIR$` in the path argument.

Example

```
__var myFileHandle;          /* The macro variable to contain */
                             /* the file handle */
myFileHandle = __openFile("$PROJ_DIR$\\Debug\\Exe\\test.tst",
"r");
if (myFileHandle)
{
    /* successful opening */
}
```

See also

For information about argument variables, see the *IDE Project Management and Building Guide for RL78*.

__orderInterrupt

Syntax

```
__orderInterrupt(specification, first_activation,
                 repeat_interval, variance, infinite_hold_time,
                 hold_time, probability)
```

Parameters

specification

The interrupt (string). The specification can either be the full specification used in the device description file (`ddf`) or only the name. In the latter case the interrupt system will automatically get the description from the device description file.

first_activation

The first activation time in cycles (integer)

repeat_interval

The periodicity in cycles (integer)

variance

The timing variation range in percent (integer between 0 and 100)

infinite_hold_time

1 if infinite, otherwise 0.

hold_time

The hold time (integer)

probability

The probability in percent (integer between 0 and 100)

Return value

The macro returns an interrupt identifier (`unsigned long`).

If the syntax of *specification* is incorrect, it returns -1.

For use with The C-SPY Simulator.

Description Generates an interrupt.

Example This example generates a repeating interrupt using an infinite hold time first activated after 4000 cycles:

```
__orderInterrupt( "USARTR_VECTOR", 4000, 2000, 0, 1, 0, 100 );
```

__popSimulatorInterruptExecutingStack

Syntax `__popSimulatorInterruptExecutingStack(void)`

Return value `int 0`

For use with The C-SPY Simulator.

Description Informs the interrupt simulation system that an interrupt handler has finished executing, as if the normal instruction used for returning from an interrupt handler was executed.

This is useful if you are using interrupts in such a way that the normal instruction for returning from an interrupt handler is not used, for example in an operating system with task-switching. In this case, the interrupt simulation system cannot automatically detect that the interrupt has finished executing.

See also *Simulating an interrupt in a multi-task system*, page 303.

__readFile

Syntax `__readFile(`*`fileHandle`*`, `*`valuePtr`*`)`

Parameters

`fileHandle`

A macro variable used as filehandle by the `__openFile` macro.

`valuePtr`

A pointer to a variable.

Return value

Result	Value
Successful	0
Unsuccessful	Non-zero error number

Table 26: __readFile return values

For use with

All C-SPY drivers.

Description

Reads a sequence of hexadecimal digits from the given file and converts them to an `unsigned long` which is assigned to the *`value`* parameter, which should be a pointer to a macro variable.

Only printable characters representing hexadecimal digits and white-space characters are accepted, no other characters are allowed.

Example

```
__var number;
if (__readFile(myFileHandle, &number) == 0)
{
  // Do something with number
}
```

In this example, if the file pointed to by `myFileHandle` contains the ASCII characters `1234 abcd 90ef`, consecutive reads will assign the values `0x1234 0xabcd 0x90ef` to the variable `number`.

__readFileByte

Syntax

`__readFileByte(`*`fileHandle`*`)`

Parameters

`fileHandle`

A macro variable used as filehandle by the `__openFile` macro.

Return value

`-1` upon error or end-of-file, otherwise a value between `0` and `255`.

For use with

All C-SPY drivers.

Description

Reads one byte from a file.

Example

```
__var byte;
while ( (byte = __readFileByte(myFileHandle)) != -1 )
{
  /* Do something with byte */
}
```

__readMemory8, __readMemoryByte

Syntax

`__readMemory8(`*`address`*`, `*`zone`*`)`
`__readMemoryByte(`*`address`*`, `*`zone`*`)`

Parameters	*`address`*
	The memory address (integer).
	`zone`
	A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

Return value	The macro returns the value from memory.
For use with	All C-SPY drivers.
Description	Reads one byte from a given memory location.
Example	`__readMemory8(0x0108, "");`

__readMemory16

Syntax	`__readMemory16(`*`address`*`, `*`zone`*`)`

Parameters	*`address`*
	The memory address (integer).
	`zone`
	A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

Return value	The macro returns the value from memory.
For use with	All C-SPY drivers.
Description	Reads a two-byte word from a given memory location.
Example	`__readMemory16(0x0108, "");`

__readMemory32

Syntax	`__readMemory32(`*`address`*`, `*`zone`*`)`

Parameters	*`address`*
	The memory address (integer).
	`zone`
	A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

Return value	The macro returns the value from memory.
For use with	All C-SPY drivers.
Description	Reads a four-byte word from a given memory location.
Example	`__readMemory32(0x0108, "");`

__registerMacroFile

Syntax `__registerMacroFile(`*`filename`*`)`

Parameters *`filename`*

A file containing the macros to be registered (string). The filename must include a path, which must either be absolute or use argument variables. For information about argument variables, see the *IDE Project Management and Building Guide for RL78*.

Return value `int 0`

For use with All C-SPY drivers.

Description Registers macros from a setup macro file. With this function you can register multiple macro files during C-SPY startup.

Example `__registerMacroFile("c:\\testdir\\macro.mac");`

See also *Using C-SPY macros*, page 323.

__resetFile

Syntax `__resetFile(`*`fileHandle`*`)`

Parameters *`fileHandle`*

A macro variable used as filehandle by the `__openFile` macro.

Return value `int 0`

For use with All C-SPY drivers.

Description Rewinds a file previously opened by `__openFile`.

__selectCore

Description

This macro can only be used with IAR Embedded Workbench products that support multicore debugging.

__setCodeBreak

Syntax

`__setCodeBreak(location, count, condition, cond_type, action)`

Parameters

location

A string that defines the code location of the breakpoint, either a valid C-SPY expression whose value evaluates to a valid address, an absolute location, or a source location. For more information about the location types, see *Enter Location dialog box*, page 149.

count

The number of times that a breakpoint condition must be fulfilled before a break occurs (integer).

condition

The breakpoint condition. This must be a valid C-SPY expression, for instance a C-SPY macro function.

cond_type

The condition type; either `"CHANGED"` or `"TRUE"` (string).

action

An expression, typically a call to a macro, which is evaluated when the breakpoint is detected.

Return value

Result	Value
Successful	An unsigned integer uniquely identifying the breakpoint. This value must be used to clear the breakpoint.
Unsuccessful	0

Table 27: __setCodeBreak return values

For use with

The C-SPY simulator.

Description

Sets a code breakpoint, that is, a breakpoint which is triggered just before the processor fetches an instruction at the specified location.

Examples

```
__setCodeBreak("{D:\\src\\prog.c}.12.9", 3, "d>16", "TRUE",
"ActionCode()");
```

This example sets a code breakpoint on the label `main` in your source:

```
__setCodeBreak("main", 0, "1", "TRUE", "");
```

See also

Breakpoints, page 125.

__setCodeHWBreak

Syntax

`__setCodeHWBreak(`*`location`*`)`

Parameters

`location`

A string that defines the code location of the breakpoint, either a valid C-SPY expression whose value evaluates to a valid address, an absolute location, or a source location. For more information about the location types, see *Enter Location dialog box*, page 149.

Return value

Result	Value
Successful	An unsigned integer uniquely identifying the breakpoint. This value must be used to clear the breakpoint.
Unsuccessful	0

Table 28: __setCodeHWBreak return values

For use with

The C-SPY hardware debugger drivers.

Description

Sets a code hardware breakpoint, that is, a breakpoint that is triggered just before the processor fetches an instruction at the specified location.

Examples

```
__setCodeHWBreak("{D:\\src\\prog.c}.12.9");
```

See also

Breakpoints, page 125.

__setDataBreak

Syntax

```
__setDataBreak(location, count, condition, cond_type, access,
               action)
```

Parameters

location

A string that defines the data location of the breakpoint, either a valid C-SPY expression whose value evaluates to a valid address or an absolute location. For information about the location types, see *Enter Location dialog box*, page 149.

count

The number of times that a breakpoint condition must be fulfilled before a break occurs (integer).

condition

The breakpoint condition (string).

cond_type

The condition type; either `"CHANGED"` or `"TRUE"` (string).

access

The memory access type: `"R"`, for read, `"W"` for write, or `"RW"` for read/write.

action

An expression, typically a call to a macro, which is evaluated when the breakpoint is detected.

Return value

Result	Value
Successful	An unsigned integer uniquely identifying the breakpoint. This value must be used to clear the breakpoint.
Unsuccessful	0

Table 29: __setDataBreak return values

For use with

The C-SPY Simulator.

Description

Sets a data breakpoint, that is, a breakpoint which is triggered directly after the processor has read or written data at the specified location.

Example

```
__var brk;
brk = __setDataBreak(":0x4710", 3, "d>6", "TRUE",
      "W", "ActionData()");
...
__clearBreak(brk);
```

See also

Breakpoints, page 125.

__setDataLogBreak

Syntax

`__setDataLogBreak(`*`variable, access`*`)`

Parameters

`variable`

A string that defines the variable the breakpoint is set on, a variable of integer type with static storage duration. The microcontroller must also be able to access the variable with a single-instruction memory access, which means that you can only set data log breakpoints on 8 and 16-bit variables.

`access`

The memory access type: `"R"`, for read, `"W"` for write, or `"RW"` for read/write.

Return value

Result	Value
Successful	An unsigned integer uniquely identifying the breakpoint. This value must be used to clear the breakpoint.
Unsuccessful	0

Table 30: __setDataLogBreak return values

For use with

The C-SPY Simulator.

Description

Sets a data log breakpoint, that is, a breakpoint which is triggered when a specified variable is accessed. Note that a data log breakpoint does not stop the execution, it just generates a data log.

Example

```
__var brk;
brk = __setDataLogBreak("MyVar", "R");
...
__clearBreak(brk);
```

See also

Breakpoints, page 125 and *Getting started using data logging*, page 226.

__setLogBreak

Syntax

```
__setLogBreak(location, message, msg_type, condition,
              cond_type)
```

Parameters

location

A string that defines the code location of the breakpoint, either a valid C-SPY expression whose value evaluates to a valid address, an absolute location, or a source location. For more information about the location types, see *Enter Location dialog box*, page 149.

message

The message text.

msg_type

The message type; choose between:

`TEXT`, the message is written word for word.

`ARGS`, the message is interpreted as a comma-separated list of C-SPY expressions or strings.

condition

The breakpoint condition (string).

cond_type

The condition type; either `"CHANGED"` or `"TRUE"` (string).

Return value

Result	Value
Successful	An unsigned integer uniquely identifying the breakpoint. The same value must be used when you want to clear the breakpoint.
Unsuccessful	0

Table 31: __setLogBreak return values

For use with

All C-SPY drivers.

Description

Sets a log breakpoint, that is, a breakpoint which is triggered when an instruction is fetched from the specified location. If you have set the breakpoint on a specific machine instruction, the breakpoint will be triggered and the execution will temporarily halt and print the specified message in the C-SPY **Debug Log** window.

Example

```
__var logBp1;
__var logBp2;

logOn()
{
  logBp1 = __setLogBreak ("{C:\\temp\\Utilities.c}.23.1",
    "\"Entering trace zone at :\", #PC:%X", "ARGS", "1", "TRUE");
  logBp2 = __setLogBreak ("{C:\\temp\\Utilities.c}.30.1",
    "Leaving trace zone...", "TEXT", "1", "TRUE");
}

logOff()
{
  __clearBreak(logBp1);
  __clearBreak(logBp2);
}
```

See also

Formatted output, page 331 and *Breakpoints*, page 125.

__setSimBreak

Syntax

`__setSimBreak(`*`location, access, action`*`)`

Parameters

`location`

A string that defines the data location of the breakpoint, either a valid C-SPY expression whose value evaluates to a valid address or an absolute location. For information about the location types, see *Enter Location dialog box*, page 149.

`access`

The memory access type: `"R"` for read or `"W"` for write.

`action`

An expression, typically a call to a macro, which is evaluated when the breakpoint is detected.

Return value

Result	Value
Successful	An unsigned integer uniquely identifying the breakpoint. This value must be used to clear the breakpoint.
Unsuccessful	`0`

Table 32: __setSimBreak return values

For use with

The C-SPY Simulator.

Description

Use this system macro to set *immediate* breakpoints, which will halt instruction execution only temporarily. This allows a C-SPY macro function to be called when the processor is about to read data from a location or immediately after it has written data. Instruction execution will resume after the action.

This type of breakpoint is useful for simulating memory-mapped devices of various kinds (for instance serial ports and timers). When the processor reads at a memory-mapped location, a C-SPY macro function can intervene and supply the appropriate data. Conversely, when the processor writes to a memory-mapped location, a C-SPY macro function can act on the value that was written.

__setTraceStartBreak

Syntax

`__setTraceStartBreak(`*`location`*`)`

Parameters

`location`

A string that defines the code location of the breakpoint, either a valid C-SPY expression whose value evaluates to a valid address, an absolute location, or a source location. For more information about the location types, see *Enter Location dialog box*, page 149.

Return value

Result	Value
Successful	An unsigned integer uniquely identifying the breakpoint. The same value must be used when you want to clear the breakpoint.
Unsuccessful	0

Table 33: __setTraceStartBreak return values

For use with

The C-SPY Simulator.

Description

Sets a breakpoint at the specified location. When that breakpoint is triggered, the trace system is started.

Example

```
__var startTraceBp;
__var stopTraceBp;

traceOn()
{
  startTraceBp = __setTraceStartBreak
    ("{C:\\TEMP\\Utilities.c}.23.1");
  stopTraceBp = __setTraceStopBreak
    ("{C:\\temp\\Utilities.c}.30.1");
}

traceOff()
{
  __clearBreak(startTraceBp);
  __clearBreak(stopTraceBp);
}
```

See also

Breakpoints, page 125.

__setTraceStopBreak

Syntax

`__setTraceStopBreak(`*`location`*`)`

Parameters

`location`

A string that defines the code location of the breakpoint, either a valid C-SPY expression whose value evaluates to a valid address, an absolute location, or a source location. For more information about the location types, see *Enter Location dialog box*, page 149.

Return value

Result	Value
Successful	An unsigned integer uniquely identifying the breakpoint. The same value must be used when you want to clear the breakpoint.
Unsuccessful	`int 0`

Table 34: __setTraceStopBreak return values

For use with

The C-SPY Simulator.

Description

Sets a breakpoint at the specified location. When that breakpoint is triggered, the trace system is stopped.

Example

See *__setTraceStartBreak*, page 363.

See also *Breakpoints*, page 125.

__sourcePosition

Syntax `__sourcePosition(`*`linePtr, colPtr`*`)`

Parameters

`linePtr`

Pointer to the variable storing the line number

`colPtr`

Pointer to the variable storing the column number

Return value

Result	**Value**
Successful	Filename string
Unsuccessful	Empty (`""`) string

Table 35: __sourcePosition return values

For use with All C-SPY drivers.

Description If the current execution location corresponds to a source location, this macro returns the filename as a string. It also sets the value of the variables, pointed to by the parameters, to the line and column numbers of the source location.

__strFind

Syntax `__strFind(macro`*`String`*`, `*`pattern`*`, `*`position`*`)`

Parameters

`macroString`

A macro string.

`pattern`

The string pattern to search for

`position`

The position where to start the search. The first position is `0`

Return value The position where the pattern was found or `-1` if the string is not found.

For use with All C-SPY drivers.

Description

This macro searches a given string (*macroString*) for the occurrence of another string (*pattern*).

Example

```
__strFind("Compiler", "pile", 0)  = 3
__strFind("Compiler", "foo", 0)   = -1
```

See also

Macro strings, page 329.

__subString

Syntax

`__subString(macroString, position, length)`

Parameters

macroString

A macro string.

position

The start position of the substring. The first position is 0.

length

The length of the substring

Return value

A substring extracted from the given macro string.

For use with

All C-SPY drivers.

Description

This macro extracts a substring from another string (*macroString*).

Example

```
__subString("Compiler", 0, 2)
```

The resulting macro string contains `Co`.

```
__subString("Compiler", 3, 4)
```

The resulting macro string contains `pile`.

See also

Macro strings, page 329.

__targetDebuggerVersion

Syntax

`__targetDebuggerVersion()`

Return value

A string that represents the version number of the C-SPY debugger processor module.

For use with

All C-SPY drivers.

Description

This macro returns the version number of the C-SPY debugger processor module.

Example

```
__var toolVer;
toolVer = __targetDebuggerVersion();
__message "The target debugger version is, ", toolVer;
```

__toLower

Syntax

`__toLower(`*`macroString`*`)`

Parameters

`macroString`

A macro string.

Return value

The converted macro string.

For use with

All C-SPY drivers.

Description

This macro returns a copy of the parameter *`macroString`* where all the characters have been converted to lower case.

Example

```
__toLower("IAR")
```

The resulting macro string contains `iar`.

```
__toLower("Mix42")
```

The resulting macro string contains `mix42`.

See also

Macro strings, page 329.

__toString

Syntax

`__toString(C`*`_string, maxlength`*`)`

Parameters

`C_string`

Any null-terminated C string.

`maxlength`

The maximum length of the returned macro string.

Return value

Macro string.

For use with

All C-SPY drivers.

Description
This macro is used for converting C strings (`char*` or `char[]`) into macro strings.

Example
Assuming your application contains this definition:

```
char const * hptr = "Hello World!";
```

this macro call:

```
__toString(hptr, 5)
```

would return the macro string containing `Hello`.

See also
Macro strings, page 329.

__toUpper

Syntax
`__toUpper(`*`macroString`*`)`

Parameters
`macroString`
A macro string.

Return value
The converted string.

For use with
All C-SPY drivers.

Description
This macro returns a copy of the parameter *`macroString`* where all the characters have been converted to upper case.

Example

```
__toUpper("string")
```

The resulting macro string contains `STRING`.

See also
Macro strings, page 329.

__unloadImage

Syntax
`__unloadImage(`*`module_id`*`)`

Parameters
`module_id`
An integer which represents a unique module identification, which is retrieved as a return value from the corresponding `__loadImage` C-SPY macro.

Return value

Value	Result
module_id	A unique module identification (the same as the input parameter).
`int 0`	The unloading failed.

Table 36: __unloadImage return values

For use with

All C-SPY drivers.

Description

Unloads debug information from an already downloaded debug image.

See also

Loading multiple debug images, page 45 and *Images*, page 401.

__writeFile

Syntax

`__writeFile(`*`fileHandle, value`*`)`

Parameters

fileHandle

A macro variable used as filehandle by the `__openFile` macro.

value

An integer.

Return value

`int 0`

For use with

All C-SPY drivers.

Description

Prints the integer value in hexadecimal format (with a trailing space) to the file *`file`*.

Note: The `__fmessage` statement can do the same thing. The `__writeFile` macro is provided for symmetry with `__readFile`.

__writeFileByte

Syntax

`__writeFileByte(`*`fileHandle`*`, `*`value`*`)`

Parameters

fileHandle

A macro variable used as filehandle by the `__openFile` macro.

value

An integer.

Return value `int 0`

For use with All C-SPY drivers.

Description Writes one byte to the file *`fileHandle`*.

__writeMemory8, __writeMemoryByte

Syntax

```
__writeMemory8(value, address, zone)
__writeMemoryByte(value, address, zone)
```

Parameters

`value`

An integer.

`address`

The memory address (integer).

`zone`

A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

Return value `int 0`

For use with All C-SPY drivers.

Description Writes one byte to a given memory location.

Example

```
__writeMemory8(0x2F, 0x8020, "");
```

__writeMemory16

Syntax

```
__writeMemory16(value, address, zone)
```

Parameters

`value`

An integer.

`address`

The memory address (integer).

`zone`

A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

Return value `int 0`

For use with	All C-SPY drivers.
Description	Writes two bytes to a given memory location.
Example	`__writeMemory16(0x2FFF, 0x8020, "");`

__writeMemory32

Syntax `__writeMemory32(`*`value, address, zone`*`)`

Parameters

`value`

An integer.

`address`

The memory address (integer).

`zone`

A string that specifies the memory zone, see *C-SPY memory zones*, page 154.

Return value `int 0`

For use with All C-SPY drivers.

Description Writes four bytes to a given memory location.

Example `__writeMemory32(0x5555FFFF, 0x8020, "");`

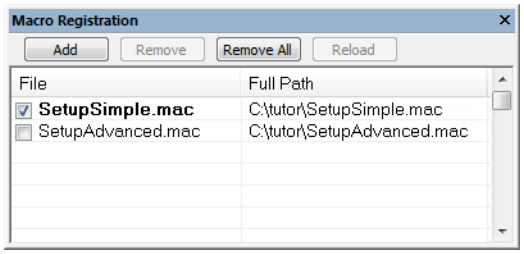
Graphical environment for macros

Reference information about:

- *Macro Registration window*, page 372
- *Debugger Macros window*, page 374
- *Macro Quicklaunch window*, page 376

Macro Registration window

The **Macro Registration** window is available from the **View>Macros** submenu during a debug session.



File	Full Path
✓ **SetupSimple.mac**	C:\tutor\SetupSimple.mac
☐ SetupAdvanced.mac	C:\tutor\SetupAdvanced.mac

Use this window to list, register, and edit your debugger macro files.

Double-click a macro file to open it in the editor window and edit it.

See also *Registering C-SPY macros—an overview*, page 324.

Requirements

None; this window is always available.

Display area

This area contains these columns:

File

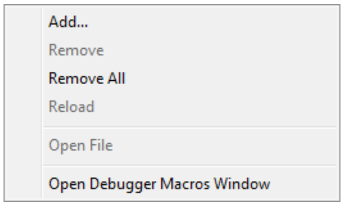
The name of an available macro file. To register the macro file, select the check box to the left of the filename. The name of a registered macro file appears in bold style.

Full path

The path to the location of the added macro file.

Context menu

This context menu is available:



These commands are available:

Add

Opens a file browser where you can locate the macro file that you want to add to the list. This menu command is also available as a function button at the top of the window.

Remove

Removes the selected debugger macro file from the list. This menu command is also available as a function button at the top of the window.

Remove All

Removes all macro files from the list. This menu command is also available as a function button at the top of the window.

Reload

Registers the selected macro file. Typically, this is useful when you have edited a macro file. This menu command is also available as a function button at the top of the window.

Open File

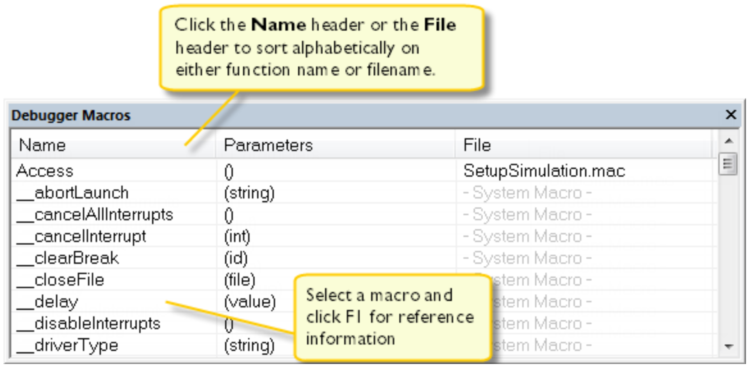
Opens the selected macro file in the editor window.

Open Debugger Macros Window

Opens the **Debugger Macros** window.

Debugger Macros window

The **Debugger Macros** window is available from the **View>Macros** submenu during a debug session.


Click the **Name** header or the **File** header to sort alphabetically on either function name or filename.
Select a macro and click F1 for reference information

Debugger Macros

Name	Parameters	File
Access	()	SetupSimulation.mac
__abortLaunch	(string)	- System Macro -
__cancelAllInterrupts	()	- System Macro -
__cancelInterrupt	(int)	- System Macro -
__clearBreak	(id)	- System Macro -
__closeFile	(file)	- System Macro -
__delay	(value)	- System Macro -
__disableInterrupts	()	- System Macro -
__driverType	(string)	- System Macro -

Use this window to list all registered debugger macro functions, either predefined system macros or your own. This window is useful when you edit your own macro functions and want an overview of all available macros that you can use.

- Click the column headers **Name** or **File** to sort alphabetically on either function name or filename.
- Double-clicking a macro defined in a file opens that file in the editor window.
- To open a macro in the **Macro Quicklaunch** window, drag it from the **Debugger Macros** window and drop it in the **Macro Quicklaunch** window.
- Select a macro and press F1 to get online help information for that macro.

Requirements

None; this window is always available.

Display area

This area contains these columns:

Name

The name of the debugger macro.

Parameters

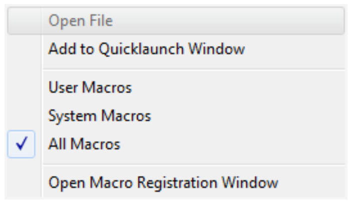
The parameters of the debugger macro.

File

For macros defined in a file, the name of the file is displayed. For predefined system macros, `-System Macro-` is displayed.

Context menu

This context menu is available:



These commands are available:

Open File

Opens the selected debugger macro file in the editor window.

Add to Quicklaunch Window

Adds the selected macro to the **Macro Quicklaunch** window.

User Macros

Lists only the debugger macros that you have defined yourself.

System Macros

Lists only the predefined system macros.

All Macros

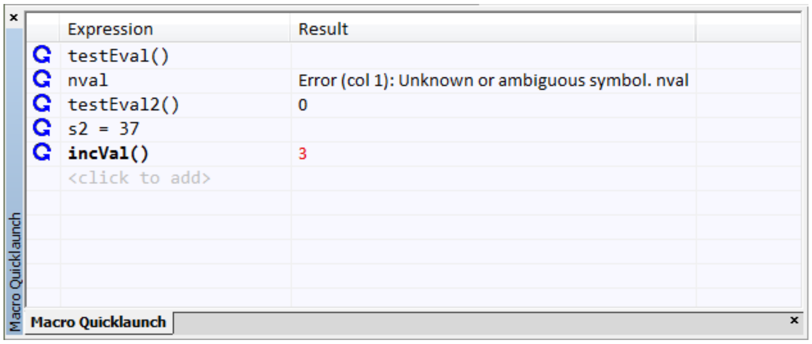
Lists all debugger macros, both predefined system macros and your own.

Open Macro Registration Window

Opens the **Macro Registration** window.

Macro Quicklaunch window

The **Macro Quicklaunch** window is available from the **View** menu.



Expression	Result
testEval()	
nval	Error (col 1): Unknown or ambiguous symbol. nval
testEval2()	0
s2 = 37	
incVal()	3
<click to add>	

Use this window to evaluate expressions, typically C-SPY macros.

For some devices, there are predefined C-SPY macros available with device support, typically provided by the chip manufacturer. These macros are useful for performing certain device-specific tasks. The macros are available in the **Macro Quicklaunch** window and are easily identified by their green icon,

The **Macro Quicklaunch** window is similar to the **Quick Watch** window, but is primarily designed for evaluating C-SPY macros. The window gives you precise control over when to evaluate an expression.

See also *Executing C-SPY macros—an overview*, page 324.

To add an expression:

1 Choose one of these alternatives:

- Drag the expression to the window
- In the **Expression** column, type the expression you want to examine.

If the expression you add and want to evaluate is a C-SPY macro, the macro must first be registered, see *Registering C-SPY macros—an overview*, page 324.

To evaluate an expression:

1 Double-click the **Recalculate** icon to calculate the value of that expression.

Requirements

None; this window is always available.

Display area

This area contains these columns:

Recalculate icon

To evaluate the expression, double-click the icon. The latest evaluated expression appears in bold style.

Expression

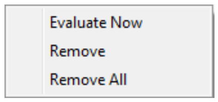
One or several expressions that you want to evaluate. Click `<click to add>` to add an expression. If the return value has changed since last time, the value will be displayed in red.

Result

Shows the return value from the expression evaluation.

Context menu

This context menu is available:



These commands are available:

Evaluate Now

Evaluates the selected expression.

Remove

Removes the selected expression.

Remove All

Removes all selected expressions.

The C-SPY command line utility—cspybat

- Using C-SPY in batch mode
- Summary of C-SPY command line options
- Reference information on C-SPY command line options

Using C-SPY in batch mode

You can execute C-SPY in batch mode if you use the command line utility `cspybat`, installed in the directory `common\bin`.

These topics are covered:

- Starting cspybat
- Output
- Invocation syntax

STARTING CSPYBAT

1 To start `cspybat` you must first create a batch file. An easy way to do that is to use one of the batch files that C-SPY automatically generates when you start C-SPY in the IDE.

C-SPY generates a batch file `*projectname.buildconfiguration*.cspy.bat` every time C-SPY is initialized. In addition, two more files are generated:

- `*project.buildconfiguration*.general.xcl`, which contains options specific to `cspybat`.
- `*project.buildconfiguration*.driver.xcl`, which contains options specific to the C-SPY driver you are using.

You can find the files in the directory `$PROJ_DIR$\settings`. The files contain the same settings as the IDE, and provide hints about additional options that you can use.

2 To start `cspybat`, you can use this command line:

```
project.cspybat.bat [debugfile]
```

Note that `debugfile` is optional. You can specify it if you want to use a different debug file than the one that is used in the `project.buildconfiguration.general.xcl` file.

Before you run cspybat for the first time using an emulator debugger, you must:

1. Start the IAR Embedded Workbench IDE and set up the hardware debugger in the **Hardware Setup** dialog box—available from the ***C-SPY driver*** menu when you start a debug session. Save the project. The settings are saved to a file.
2. Set up the environment variable `CSPYBAT_INIFILE` to point to the saved hardware settings file (`.dnx`) in the `settings` subdirectory in your project directory.

   For example, `SET CSPYBAT_INIFILE=C:\my_proj\settings\myproject.dnx`. Note that no quotation marks should be used around the path, even if there are blank characters.

OUTPUT

When you run `cspybat`, these types of output can be produced:

- *Terminal output from* `cspybat` *itself*

  All such terminal output is directed to `stderr`. Note that if you run `cspybat` from the command line without any arguments, the `cspybat` version number and all available options including brief descriptions are directed to `stdout` and displayed on your screen.
- *Terminal output from the application you are debugging*

  All such terminal output is directed to `stdout`, provided that you have used the `--plugin` option. See *--plugin*, page 393.
- *Error return codes*

  `cspybat` returns status information to the host operating system that can be tested in a batch file. For *successful*, the value `int 0` is returned, and for *unsuccessful* the value `int 1` is returned.

INVOCATION SYNTAX

The invocation syntax for `cspybat` is:

```
cspybat processor_DLL driver_DLL debug_file
        [cspybat_options] --backend driver_options
```

Note: In those cases where a filename is required—including the DLL files—you are recommended to give a full path to the filename.

Parameters

The parameters are:

Parameter	Description
`processor_DLL`	The processor-specific DLL file; available in `rl78\bin`.
`driver_DLL`	The C-SPY driver DLL file; available in `rl78\bin`.
`debug_file`	The object file that you want to debug (filename extension `out`). See also *--debugfile*, page 387.
`cspybat_options`	The command line options that you want to pass to `cspybat`. Note that these options are optional. For information about each option, see *Reference information on C-SPY command line options*, page 383.
`--backend`	Marks the beginning of the parameters to the C-SPY driver; all options that follow will be sent to the driver. Note that this option is mandatory.
`driver_options`	The command line options that you want to pass to the C-SPY driver. Note that some of these options are mandatory and some are optional. For information about each option, see *Reference information on C-SPY command line options*, page 383.

Table 37: cspybat parameters

Summary of C-SPY command line options

Reference information about:

- General cspybat options
- Options available for all C-SPY drivers
- Options available for the simulator driver
- Options available for the C-SPY hardware debugger drivers

GENERAL CSPYBAT OPTIONS

`--application_args`	Passes command line arguments to the debugged application.
`--attach_to_running_target`	Makes the debugger attach to a running application at its current location, without resetting the target system.
`--backend`	Marks the beginning of the parameters to be sent to the C-SPY driver (mandatory).

`--code_coverage_file`	Enables the generation of code coverage information and places it in a specified file.
`--cycles`	Specifies the maximum number of cycles to run.
`--debugfile`	Specifies an alternative debug file.
`--download_only`	Downloads a code image without starting a debug session afterwards.
`-f`	Extends the command line.
`--leave_target_running`	Makes the debugger leave the application running on the target hardware after the debug session is closed.
`--macro`	Specifies a macro file to be used.
`--macro_param`	Assigns a value to a C-SPY macro parameter.
`--plugin`	Specifies a plugin file to be used.
`--silent`	Omits the sign-on message.
`--timeout`	Limits the maximum allowed execution time.

OPTIONS AVAILABLE FOR ALL C-SPY DRIVERS

`--core`	Specifies the core to be used.
`-d`	Specifies the C-SPY target system.
`--near_const_location`	Specifies the location for `__near`-declared constants and strings.
`--near_const_size`	Specifies the size in Kbytes of the near constants area.
`--near_const_start`	Specifies the start address for the near constants RAM area.
`-p`	Specifies the device description file to be used.

OPTIONS AVAILABLE FOR THE SIMULATOR DRIVER

`--disable_interrupts`	Disables the interrupt simulation.
`--function_profiling`	Analyzes your source code to find where the most time is spent during execution.
`--mapu`	Activates memory access checking.

OPTIONS AVAILABLE FOR THE C-SPY HARDWARE DEBUGGER DRIVERS

`--exec_dll`	Specifies the Exec DLL file.
`--live_debug`	Makes C-SPY use the live debug feature that is available on some core S3 devices.
`--log_file`	Creates a log file.
`--suppress_download`	Suppresses download of the executable image.
`--suppress_exchange_adapter`	Suppresses the IECUBE message that asks you to check the connection of the exchange adapter.
`--verify_download`	Verifies the executable image.

Reference information on C-SPY command line options

This section gives detailed reference information about each `cspybat` option and each option available to the C-SPY drivers.

--application_args

Syntax

`--application_args="`*`arg0 arg1`*` ..."`

Parameters

`arg`

A command line argument.

For use with

`cspybat`

Description

Use this option to pass command line arguments to the debugged application. These variables must be defined in the application:

```
/* __argc, the number of arguments in __argv. */
__no_init int __argc;

/* __argv, an array of pointers to the arguments (strings); must
be large enough to fit the number of arguments.*/
__no_init const char * __argv[MAX_ARGS];

/* __argvbuf, a storage area for __argv; must be large enough to
hold all command line arguments. */
__no_init __root char __argvbuf[MAX_ARG_SIZE];
```

Example `--application_args="--logfile log.txt --verbose"`

To set related options, choose:

Project>Options>Debugger>Extra Options

--attach_to_running_target

Syntax `--attach_to_running_target`

For use with `cspybat`.

Note: This option might not be supported by the combination of C-SPY driver and device that you are using. If you are using this option with an unsupported combination, C-SPY produces a message.

Description Use this option to make the debugger attach to a running application at its current location, without resetting the target system.

If you have defined any breakpoints in your project, the C-SPY driver will set them during attachment. If the C-SPY driver cannot set them without stopping the target system, the breakpoints will be disabled. The option also suppresses download and the **Run to** option.

When you use this option, the hot-plugin feature that is available on some core S3 devices is used. The RAM, SFRs, and the registers `A`, `X`, `B`, `C`, `D`, `E`, `H`, and `L` can be read and written to during execution.

Project>Attach to Running Target

--backend

Syntax `--backend {`*`driver options`*`}`

Parameters *`driver options`*

Any option available to the C-SPY driver you are using.

For use with `cspybat` (mandatory).

Description Use this option to send options to the C-SPY driver. All options that follow `--backend` will be passed to the C-SPY driver, and will not be processed by `cspybat` itself.

This option is not available in the IDE.

--code_coverage_file

Syntax `--code_coverage_file file`

Note that this option must be placed before the `--backend` option on the command line.

Parameters *`file`*

The name of the destination file for the code coverage information.

For use with `cspybat`

Description Use this option to enable the generation of a text-based report file for code coverage information. The code coverage information will be generated after the execution has completed and you can find it in the specified file. Because most embedded applications do not terminate, you might have to use this option in combination with `--timeout` or `--cycles`.

Note that this option requires that the C-SPY driver you are using supports code coverage. If you try to use this option with a C-SPY driver that does not support code coverage, an error message will be directed to `stderr`.

See also *Code coverage*, page 271, *--cycles*, page 386, *--timeout*, page 395.

To set this option, choose **View>Code Coverage**, right-click and choose **Save As** when the C-SPY debugger is running.

--core

Syntax `--core {s1|s2|s3}`

Parameters `s1|s2|s3`

The core you are using. This option reflects the corresponding compiler option.

For use with All C-SPY drivers.

Description Use this option to specify the core you are using.

See also The *IAR C/C++ Development Guide for RL78* for information about the cores.

Project>Options>General Options>Target>Device>Core

--cycles

Syntax

`--cycles cycles`

Note that this option must be placed before the `--backend` option on the command line.

Parameters

`cycles`
The number of cycles to run.

For use with

`cspybat`

Description

Use this option to specify the maximum number of cycles to run. If the target program executes longer than the number of cycles specified, the target program will be aborted. Using this option requires that the C-SPY driver you are using supports a cycle counter, and that it can be sampled while executing.

This option is not available in the IDE.

-d

Syntax

`-d {sim|iecube|e1|e2|e2lite|e20|ezcube|tk}`

Parameters

`sim`	Specifies the simulator.
`iecube`	Specifies the IECUBE emulator.
`e1`	Specifies the E1 emulator.
`e2`	Specifies the E2 emulator.
`e2lite`	Specifies the E2 Lite/E2 On-Board or EZ-CUBE2 emulator.
`e20`	Specifies the E20 emulator.
`ezcube`	Specifies the EZ-CUBE emulator.
`tk`	Specifies the TK emulator.

For use with

All C-SPY drivers.

Description

Use this option to specify the C-SPY target system you are using.

Project>Options>Debugger>*`Driver`*

--debugfile

Syntax

`--debugfile` *`filename`*

Parameters

`filename`

The name of the debug file to use.

For use with

`cspybat`

This option can be placed both before and after the `--backend` option on the command line.

Description

Use this option to make `cspybat` use the specified debug file instead of the one used in the generated `cpsybat.bat` file.

This option is not available in the IDE.

--disable_interrupts

Syntax

`--disable_interrupts`

For use with

The C-SPY Simulator driver.

Description

Use this option to disable the interrupt simulation.

To set this option, choose **Simulator>Interrupt Setup** and deselect the **Enable interrupt simulation** option.

--download_only

Syntax

`--download_only`

Note that this option must be placed before the `--backend` option on the command line.

For use with

`cspybat`

Description

Use this option to download the code image without starting a debug session afterwards.

To set a related option, choose:

Project>Options>Debugger>Setup and deselect **Run to**.

--exec_dll

Syntax `--exec_dll=`*`filename`*

Parameters

`filename`
The name of the Exec DLL file.

For use with All C-SPY hardware debugger drivers.

Description Use this option to specify the Exec DLL file that will be used for controlling the emulator.

This option is not available in the IDE.

-f

Syntax `-f` *`filename`*

Parameters

`filename`
A text file that contains the command line options (default filename extension `xcl`).

For use with `cspybat`

This option can be placed either before or after the `--backend` option on the command line.

Description Use this option to make `cspybat` read command line options from the specified file.

In the command file, you format the items exactly as if they were on the command line itself, except that you may use multiple lines, because the newline character is treated like a space or tab character.

Both C/C++ style comments are allowed in the file. Double quotes behave in the same way as in the Microsoft Windows command line environment.

Project>Options>Debugger>Extra Options.

--function_profiling

Syntax `--function_profiling filename`

Parameters *`filename`*

The name of the log file where the profiling data is saved.

For use with The C-SPY simulator driver.

Description Use this option to find the functions in your source code where the most time is spent during execution. The profiling information is saved to the specified file. For more information about function profiling, see *Profiling*, page 261.

***C-SPY driver*>Function Profiling**

--leave_target_running

Syntax `--leave_target_running`

For use with `cspybat`.

For any of these emulators, provided that the target board is supplied with external power:

- E1
- E2
- E2 Lite/E2 On-Board
- E20
- EZ-CUBE
- EZ-CUBE2
- TK

Note: Even if this option is supported by the C-SPY driver you are using, there might be device-specific limitations.

Description Use this option to make the debugger leave the application running on the target hardware after the debug session is closed.

Any existing breakpoints will not be automatically removed. You might want to consider disabling all breakpoints before using this option.

***C-SPY driver*>Leave Target Running**

--live_debug

Syntax

`--live_debug`

For use with

The E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, and TK emulators for some devices.

Description

Use this option to use the live debug feature that is available on some core S3 devices. The live debug feature means that RAM, SFRs, and the registers `A`, `X`, `B`, `C`, `D`, `E`, `H`, and `L` can be read and written to during execution.

Use this option with care.

This option is not available in the IDE.

--log_file

Syntax

`--log_file=`*`filename`*

Parameters

`filename`

The name of the log file.

For use with

Any C-SPY hardware debugger driver.

Description

Use this option to log the communication between C-SPY and the target system to a file. To interpret the result, detailed knowledge of the communication protocol is required.

Project>Options>Debugger>*Driver*>Communication Log

--macro

Syntax

`--macro` *`filename`*

Note that this option must be placed before the `--backend` option on the command line.

Parameters

`filename`

The C-SPY macro file to be used (filename extension `mac`).

For use with `cspybat`

Description Use this option to specify a C-SPY macro file to be loaded before executing the target application. This option can be used more than once on the command line.

See also *Briefly about using C-SPY macros*, page 322.

Project>Options>Debugger>Setup>Setup macros>Use macro file

--macro_param

Syntax `--macro_param [param=value]`

Note that this option must be placed before the `--backend` option on the command line.

Parameters `param=value`

`param` is a parameter defined using the `__param` C-SPY macro construction. `value` is a value.

For use with `cspybat`

Description Use this option to assign a value to a C-SPY macro parameter. This option can be used more than once on the command line.

See also *Macro parameters*, page 329.

Project>Options>Debugger>Extra Options

--mapu

Syntax `--mapu`

For use with The C-SPY simulator driver.

Description Specify this option to use the section information in the debug file for memory access checking. During the execution, the simulator will then check for accesses to unspecified memory ranges. If any such access is found, the C function call stack and a message will be printed on `stderr` and the execution will stop.

See also *Monitoring memory and registers*, page 156.

To set related options, choose:

Simulator>Memory Access Setup

--near_const_location

Syntax

```
--near_const_location {ram|rom0|rom1}
```

Parameters

`ram`	`__near`-declared constants and strings are located in RAM, in the memory range `0xF0000–0xFFFFF`.
`rom0`	`__near`-declared constants and strings are located in ROM, in the memory range `0x00000–0x0FFFF`. They are mirrored by hardware to RAM, in the range `0xF0000–0xFFFFF`.
`rom1`	`__near`-declared constants and strings are located in ROM, in the memory range `0x10000–0x1FFFF`. They are mirrored by hardware to RAM, in the range `0xF0000–0xFFFFF`.

For use with

All C-SPY drivers.

Description

Use this option to specify the location for `__near`-declared constants and strings.

Project>Options>General Options>Target>Near constant location

--near_const_size

Syntax

```
--near_const_size size
```

Parameters

`size`	The size in Kbytes of the near constants area. This is a decimal value from `1.00` to `59.75`, where the mandatory decimal part must be one of `00`, `25`, `50`, or `75`.

For use with

All C-SPY drivers.

Description

Use this option to specify the size in Kbytes of the near constants area.

Project>Options>General Options>Target>Near constant location>Size

--near_const_start

Syntax	`--near_const_start` *`address`*
Parameters	*`address`* The start address for the near constants RAM area, in hexadecimal notation.
For use with	All C-SPY drivers.
Description	Use this option to specify the start address for the near constants RAM area.

Project>Options>General Options>Target>Near constant location>Start address

-p

Syntax	`-p` *`filename`*
Parameters	*`filename`* The device description file to be used.
For use with	All C-SPY drivers.
Description	Use this option to specify the device description file to be used.
See also	*Selecting a device description file*, page 42.

Project>Options>Debugger>Setup>Device description file

--plugin

Syntax	`--plugin` *`filename`* Note that this option must be placed before the `--backend` option on the command line.
Parameters	*`filename`* The plugin file to be used (filename extension `dll`).
For use with	`cspybat`

Description

Certain C/C++ standard library functions, for example `printf`, can be supported by C-SPY—for example, the C-SPY **Terminal I/O** window—instead of by real hardware devices. To enable such support in `cspybat`, a dedicated plugin module called `rl78bat.dll` located in the `rl78\bin` directory must be used.

Use this option to include this plugin during the debug session. This option can be used more than once on the command line.

Note: You can use this option to also include other plugin modules, but in that case the module must be able to work with `cspybat specifically`. This means that the C-SPY plugin modules located in the `common\plugin` directory cannot normally be used with `cspybat`.

Project>Options>Debugger>Plugins

--silent

Syntax

`--silent`

Note that this option must be placed before the `--backend` option on the command line.

For use with

`cspybat`

Description

Use this option to omit the sign-on message.

This option is not available in the IDE.

--suppress_download

Syntax

`--suppress_download`

For use with

Any C-SPY hardware debugger driver.

Description

Use this option to suppress the downloading of the executable image to a non-volatile type of target memory. The image corresponding to the debugged application must already exist in the target.

If this option is combined with the option `--verify_download`, the debugger will read back the executable image from memory and verify that it is identical to the debugged application.

Project>Options>Debugger>*Driver*>Setup>Download>Suppress

--suppress_exchange_adapter

Syntax	`--suppress_exchange_adapter`
For use with	The IECUBE emulator driver.
Description	Use this option to suppress the message that asks you to check the connection of the exchange adapter every time you start an IECUBE emulator debug session.
	Project>Options>Debugger>IECUBE>Suppress exchange adapter message

--timeout

Syntax	`--timeout` *`milliseconds`*
	Note that this option must be placed before the `--backend` option on the command line.
Parameters	*`milliseconds`* The number of milliseconds before the execution stops.
For use with	`cspybat`
Description	Use this option to limit the maximum allowed execution time.
	This option is not available in the IDE.

--verify_download

Syntax	`--verify_download`
For use with	Any C-SPY hardware debugger driver.
Description	Use this option to verify that the downloaded code image can be read back from target memory with the correct contents.
	Project>Options>Debugger>*Driver*>Setup>Download>Verify

Part 4. Additional reference information

This part of the *C-SPY® Debugging Guide for RL78* includes these chapters:

- Debugger options
- Additional information on C-SPY drivers
- OCD emulators reserved resources

Debugger options

- Setting debugger options
- Reference information on general debugger options
- Reference information on C-SPY hardware debugger driver options

Setting debugger options

Before you start the C-SPY debugger you might need to set some options—both C-SPY generic options and options required for the target system (C-SPY driver-specific options). This section gives detailed information about the options in the **Debugger** category.

To set debugger options in the IDE:

1 Choose **Project>Options** to display the **Options** dialog box.

2 Select **Debugger** in the **Category** list.

For more information about the generic options, see *Reference information on general debugger options*, page 400.

3 On the **Setup** page, select the appropriate C-SPY driver from the **Driver** drop-down list.

4 To set the driver-specific options, select the appropriate driver from the **Category** list. Depending on which C-SPY driver you are using, different options are available.

C-SPY driver	Available options pages
C-SPY emulator	*Reference information on C-SPY hardware debugger driver options*, page 404

Table 38: Options specific to the C-SPY drivers you are using

5 To restore all settings to the default factory settings, click the **Factory Settings** button.

6 When you have set all the required options, click **OK** in the **Options** dialog box.

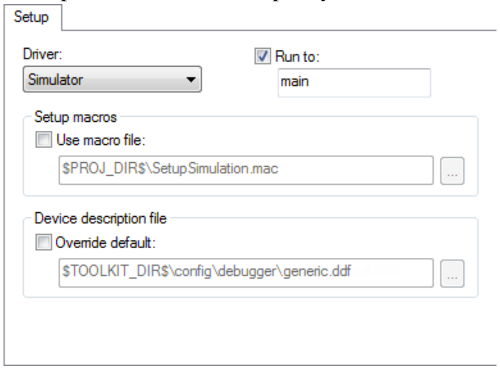
Reference information on general debugger options

Reference information about:

- *Setup*, page 400
- *Images*, page 401
- *Extra Options*, page 402
- *Plugins*, page 403

Setup

The general **Setup** options select the C-SPY driver, the setup macro file, and device description file to use, and specify which default source code location to run to.



Driver

Selects the C-SPY driver for the target system you have.

Run to

Specifies the location C-SPY runs to when the debugger starts after a reset. By default, C-SPY runs to the `main` function.

To override the default location, specify the name of a different location you want C-SPY to run to. You can specify assembler labels or whatever can be evaluated as such, for example function names.

See also *Executing from reset*, page 42.

Setup macros

Registers the contents of a setup macro file in the C-SPY startup sequence. Select **Use macro file** and specify the path and name of the setup file, for example

`SetupSimple.mac`. If no extension is specified, the extension `mac` is assumed. A browse button is available for your convenience.

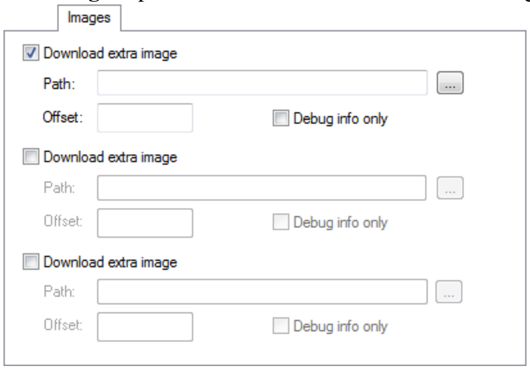
Device description file

A default device description file is selected automatically based on your project settings. To override the default file, select **Override default** and specify an alternative file. A browse button is available for your convenience.

For information about the device description file, see *Modifying a device description file*, page 47.

Images

The **Images** options control the use of additional debug files to be downloaded.



Note: Images are only downloaded to RAM and no flash loading will be performed.

Download extra Images

Controls the use of additional debug files to be downloaded:

Path

Specify the debug file to be downloaded. A browse button is available for your convenience.

Offset

Specify an integer that determines the destination address for the downloaded debug file.

Debug info only

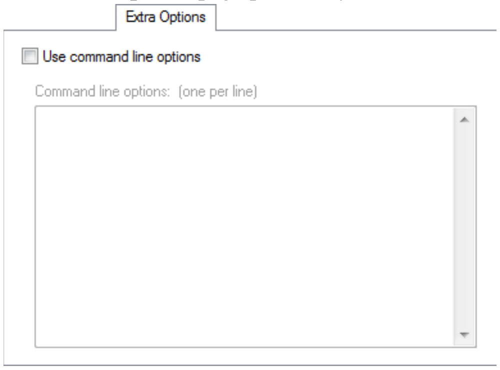
Makes the debugger download only debug information, and not the complete debug file.

If you want to download more than three debug images, use the related C-SPY macro, see *__loadImage*, page 347.

For more information, see *Loading multiple debug images*, page 45.

Extra Options

The **Extra Options** page provides you with a command line interface to C-SPY.



Use command line options

Specify command line arguments that are not supported by the IDE to be passed to C-SPY.

Note that it is possible to use the `/args` option to pass command line arguments to the debugged application.

Syntax: `/args arg0 arg1 ...`

Multiple lines with `/args` are allowed, for example:

```
/args --logfile log.txt

/args --verbose
```

If you use `/args`, these variables must be defined in your application:

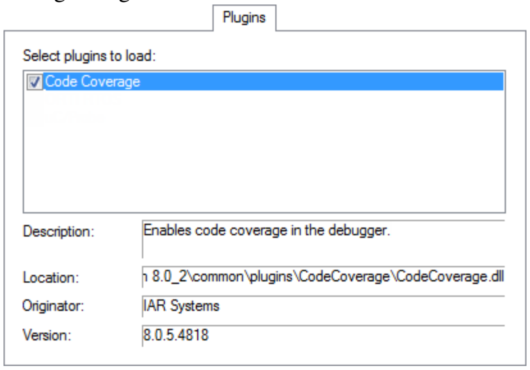
```
/* __argc, the number of arguments in __argv. */
__no_init int __argc;

/* __argv, an array of pointers to strings that holds the
arguments; must be large enough to fit the number of
parameters.*/
__no_init const char * __argv[MAX_ARGS];

/* __argvbuf, a storage area for __argv; must be large enough to
hold all command line parameters. */
__no_init __root char __argvbuf[MAX_ARG_SIZE];
```

Plugins

The **Plugins** options select the C-SPY plugin modules to be loaded and made available during debug sessions.



☑ Code Coverage

Description: Enables code coverage in the debugger.

Location: ı 8.0_2\common\plugins\CodeCoverage\CodeCoverage.dll

Originator: IAR Systems

Version: 8.0.5.4818

Select plugins to load

Selects the plugin modules to be loaded and made available during debug sessions. The list contains the plugin modules delivered with the product installation.

Description

Describes the plugin module.

Location

Informs about the location of the plugin module.

Generic plugin modules are stored in the `common\plugins` directory. Target-specific plugin modules are stored in the `rl78\plugins` directory.

Originator

Informs about the originator of the plugin module, which can be modules provided by IAR Systems or by third-party vendors.

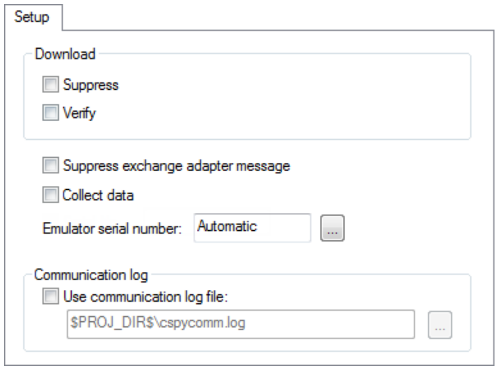
Version

Informs about the version number.

Reference information on C-SPY hardware debugger driver options

Setup

By default, C-SPY downloads the application to RAM or flash when a debug session starts. The **Download** options let you modify the behavior of the download.



Download

Sets options for the code image to debug.

Suppress	Disables the downloading of code, while preserving the present content of the flash. This command is useful if you want to debug an application that already resides in target memory. If this option is combined with the **Verify** option, the debugger will read back the code image from non-volatile memory and verify that it is identical to the built application.
Verify	Verifies that the downloaded code image can be read back from target memory with the correct contents.

Suppress exchange adapter message

Suppresses the message that asks you to check the connection of the exchange adapter every time you start an IECUBE emulator debug session. This option only exists for the IECUBE emulator.

Collect data

Enables data collection for devices that support Smart Analog data collection and display. If this option has been selected, the only debug commands that can be used in the C-SPY Debugger are **Go**, **Break**, and **Stop Debugging**. The collected data is displayed in the **Timeline**, **Event Log**, and **Event Log Summary** windows.

This option only exists for the E1, E2, E20, and E2 Lite/E2 On-Board emulators.

Emulator serial number

Selects which Renesas emulator to use, if more than one is connected to your host computer via USB. This option only exists for the E1, E2, E20, E2 Lite/E2 On-Board, and EZCube2 emulators.

Log communication

Logs the communication between C-SPY and the target system to a file. To interpret the result, detailed knowledge of the interface is required.

Additional information on C-SPY drivers

This chapter describes the additional menus and features provided by the C-SPY® drivers. You will also find some useful hints about resolving problems.

Reference information on C-SPY driver menus

Reference information about:

- *C-SPY driver*, page 407
- *Simulator menu*, page 408
- *Emulator menu*, page 410

C-SPY driver

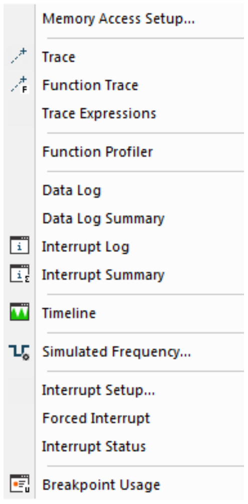
Before you start the C-SPY debugger, you must first specify a C-SPY driver in the **Options** dialog box, using the option **Debugger>Setup>Driver**.

When you start a debug session, a menu specific to that C-SPY driver will appear on the menu bar, with commands specific to the driver.

When we in this guide write “choose ***C-SPY driver*>**” followed by a menu command, ***C-SPY driver*** refers to the menu. If the feature is supported by the driver, the command will be on the menu.

Simulator menu

When you use the simulator driver, the **Simulator** menu is added to the menu bar.



Menu commands

These commands are available on the menu:

Memory Access Setup

Displays a dialog box to simulate memory access checking by specifying memory areas with different access types, see *Memory Access Setup dialog box*, page 189.

Trace

Opens a window which displays the collected trace data, see *Trace window*, page 206.

Function Trace

Opens a window which displays the trace data for function calls and function returns, see *Function Trace window*, page 211.

Trace Expressions

Opens a window where you can specify specific variables and expressions for which you want to collect trace data, see *Trace Expressions window*, page 214.

Function Profiler

Opens a window which shows timing information for the functions, see *Function Profiler window*, page 266.

Data Log

Opens a window which logs accesses to up to four different memory locations or areas, see *Data Log window*, page 237.

Data Log Summary

Opens a window which displays a summary of data accesses to specific memory location or areas, see *Data Log Summary window*, page 240.

Interrupt Log

Opens a window which displays the status of all defined interrupts, see *Interrupt Log window*, page 311.

Interrupt Log Summary

Opens a window which displays a summary of the status of all defined interrupts, see *Interrupt Log Summary window*, page 314.

Timeline

Opens a window which gives a graphical view of various kinds of information on a timeline, see *The application timeline*, page 221.

Simulated Frequency

Opens the **Simulated Frequency** dialog box where you can specify the simulator frequency used when the simulator displays time information, for example in the log windows. Note that this does not affect the speed of the simulator. For more information, see *Simulated Frequency dialog box*, page 414.

Interrupt Setup

Displays a dialog box where you can configure C-SPY interrupt simulation, see *Interrupt Setup dialog box*, page 305.

Forced Interrupts

Opens a window from where you can instantly trigger an interrupt, see *Forced Interrupt window*, page 308.

Interrupt Status

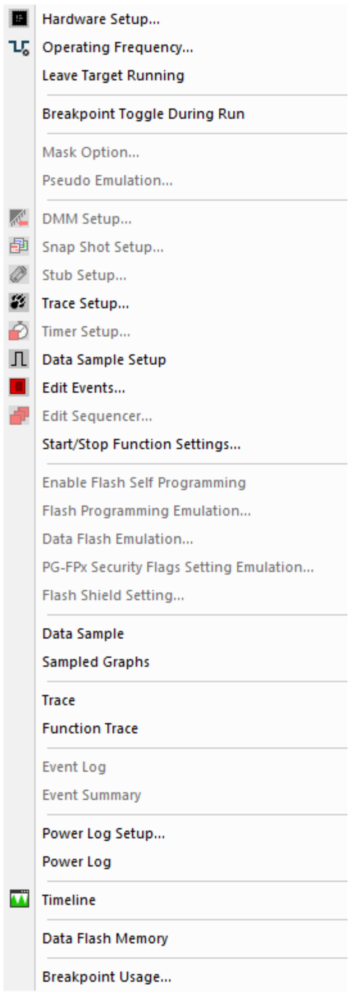
Opens a window from where you can instantly trigger an interrupt, see *Interrupt Status window*, page 309.

Breakpoint Usage

Displays a window which lists all active breakpoints, see *Breakpoint Usage window*, page 139.

Emulator menu

When you are using the C-SPY hardware debugger drivers, the **Emulator** menu is added to the menu bar.



Menu commands

These commands are available on the menu:

Hardware Setup

Displays the driver-specific **Hardware Setup** dialog box, where you can make the basic configuration for the emulator. See *Hardware Setup*, page 56.

When C-SPY is not running, select this menu command to automatically display the **Hardware Setup** dialog box the next time you start C-SPY.

Operating Frequency

Displays a dialog box where you can inform the emulator of the operating frequency that the MCU is running at, see *Operating Frequency dialog box*, page 55.

Leave Target Running

Leaves the application running on the target hardware after the debug session is closed.

Any existing breakpoints will not be automatically removed. You might want to consider disabling all breakpoints before using this menu command.

If this menu command is not available, it is not supported by the C-SPY driver you are using.

Breakpoint Toggle During Run

Allows toggling breakpoints on or off during emulator execution. Toggling a breakpoint on or off will temporarily halt the emulator.

Mask Option

Displays the **Mask Option Settings** dialog box, in which the mask option and pin mode settings can be changed.

Pseudo Emulation

Displays the **Pseudo Emulation** dialog box, in which the pseudo emulation behavior can be defined.

DMM Setup

Displays the **DMM Function Settings** dialog box, see *DMM Function Settings dialog box*, page 87.

Snap Shot Setup

Displays the **Snap Shot Function Settings** dialog box, see *Snap Shot Function Settings dialog box*, page 204.

Stub Setup

Displays the **Stub Function Settings** dialog box, see *Stub Function Settings dialog box*, page 89.

Trace Setup

Displays a dialog box where you can configure the trace generation and collection, see *Reference information on trace*, page 199.

Timer Setup

Displays the **Timer Settings** dialog box, in which the timer behavior can be defined; see *Timer Settings dialog box*, page 95.

Data Sample Setup

Opens a window where you can specify variables to sample data for, see *Data Sample Setup window*, page 246

Edit Events

Displays the driver-specific **Edit Events** dialog box, in which the events used as breakpoint, trace, timer, trigger output, and sequencer events can be defined; see *Edit Events dialog box*, page 90. When this dialog box is active, you can still access other elements in the IDE.

Edit Sequencer

Displays the driver-specific **Edit Sequencer Events** dialog box, in which you can define sequences of events that must occur before a sequencer event is triggered; see *Edit Sequencer Events dialog box*, page 93.

Start/Stop Function Settings

Displays a dialog box where you can configure the emulator to execute specific routines of your application immediately before the execution starts and/or after it halts, see *Start/Stop Function Settings dialog box*, page 84.

Enable Flash Self Programming

Enables the flash self-programming feature and makes the **Flash Programming Emulation** and **PG-FPx Security Flags Setting Emulation** commands available. Only IECUBE for devices with flash memory. If flash programming emulation is enabled, the internal ROM size defined in the device description file must be used and cannot be changed.

Flash Programming Emulation

Opens the **Flash Programming Emulation** dialog box, in which you can set up the flash programming emulation. Only IECUBE devices with flash memory. See *Flash Programming Emulation dialog box*, page 417.

Data Flash Emulation

Displays the **Data Flash Emulation** dialog box, see *Data Flash Emulation dialog box*, page 422.

PG-FPx Security Flags Setting Emulation

Opens the **PG-FPx Security Flags Setting Emulation** dialog box, in which you can configure the emulation of PG-FPx security. Only IECUBE devices with flash memory. See *Programmer PG-FPx Security Flags dialog box*, page 420.

Flash Shield Setting

Opens the **Flash Shield Setting** dialog box, in which you can open a range of flash memory blocks for modification by the flash self programming. Only IECUBE for devices with flash memory. See *Flash Shield Setting dialog box*, page 421.

Data Sample

Opens a window where you can view the result of the data sampling, see *Data Sample window*, page 248.

Sampled Graphs

Opens a window which gives a graphical view of various kinds of sampled information, see *Data Sample window*, page 248.

Trace

Opens a window which displays the collected trace data, see *Trace window*, page 206.

Function Trace

Opens a window which displays the trace data for function calls and function returns, see *Function Trace window*, page 211.

Event Log

Opens a window where you can configure the collection of Smart Analog data (event logging); see *Event Log window*, page 253.

Event Summary

Opens a window where you can view the collected Smart Analog data; see *Event Log Summary window*, page 256.

Power Log Setup

Opens a window where you can configure the power measurement; see *Power Log Setup window*, page 285.

Power Log

Opens a window that displays collected power values; see *Power Log window*, page 287.

Timeline

Opens a window which gives a graphical view of various kinds of information on a timeline, see *The application timeline*, page 221.

Data Flash Memory

Displays the Data Flash Memory window, see *Data Flash Memory window*, page 165.

Breakpoint Usage

Displays a window which lists all active breakpoints, see *Breakpoint Usage window*, page 139.

Reference information on the C-SPY simulator

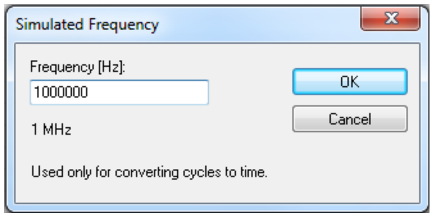
This section gives additional reference information the C-SPY simulator, reference information not provided elsewhere in this documentation.

Reference information about:

- *Simulated Frequency dialog box*, page 414

Simulated Frequency dialog box

The **Simulated Frequency** dialog box is available from the C-SPY driver menu.



Frequency [Hz]: 1000000

1 MHz

Used only for converting cycles to time.

Use this dialog box to specify the simulator frequency used when the simulator displays time information.

Requirements

The C-SPY simulator.

Frequency

Specify the frequency in Hz.

Reference information on the C-SPY hardware debugger drivers

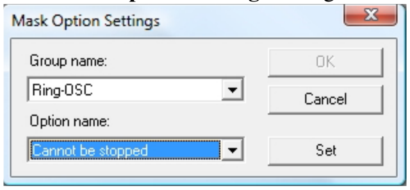
This section gives additional reference information on the C-SPY hardware debugger drivers, reference information not provided elsewhere in this documentation.

Reference information about:

- *Mask Option Settings dialog box*, page 415
- *Pseudo Emulation dialog box*, page 416
- *Flash Programming Emulation dialog box*, page 417
- *Edit Flash Emulation Events dialog box*, page 418
- *Edit Flash Emulation Timing dialog box*, page 419
- *Programmer PG-FPx Security Flags dialog box*, page 420
- *Flash Shield Setting dialog box*, page 421
- *Data Flash Emulation dialog box*, page 422

Mask Option Settings dialog box

The **Mask Option Settings** dialog box is available from the **Emulator** menu.



Use this dialog box to change the mask option and pin mode settings.

Requirements

The IECUBE emulator.

Group name

Select the group name of the pin you want to change. By default, the current option setting is shown, marked with an asterisk.

Option name

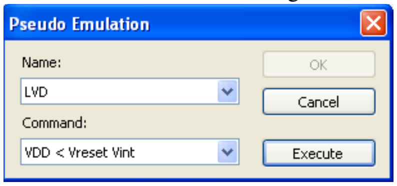
Select the option name of the mask you want to change. By default, the current option setting is shown, marked with an asterisk.

Click **Set** to save the new settings.

For more information, see the in-circuit emulator and the emulation board documentation.

Pseudo Emulation dialog box

The **Pseudo Emulation** dialog box is available from the **Emulator** menu.



Use this dialog box to execute pseudo emulation commands. For information about pseudo emulation commands, see the documentation delivered with the emulator and the emulation board.

Requirements

The IECUBE emulator.

Name

The name of the emulation you want to run.

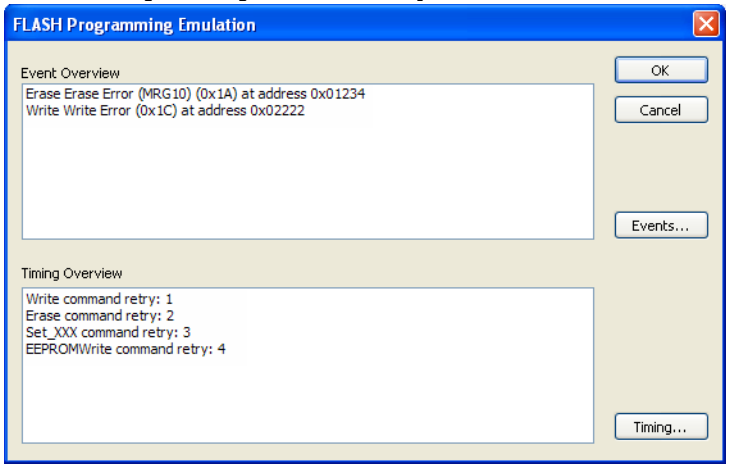
Command

Select the command you want to execute.

Click **Execute** to execute the command.

Flash Programming Emulation dialog box

The **Flash Programming Emulation** dialog box is available from the **Emulator** menu.



```
Erase Erase Error (MRG10) (0x1A) at address 0x01234
Write Write Error (0x1C) at address 0x02222
```

```
Write command retry: 1
Erase command retry: 2
Set_XXX command retry: 3
EEPROMWrite command retry: 4
```

Use this dialog box to get an overview of the current flash programming settings.

Requirements

The IECUBE emulator and a device with flash memory.

Event Overview

Displays the active flash emulation events.

Timing Overview

Displays the user-defined flash emulation timing.

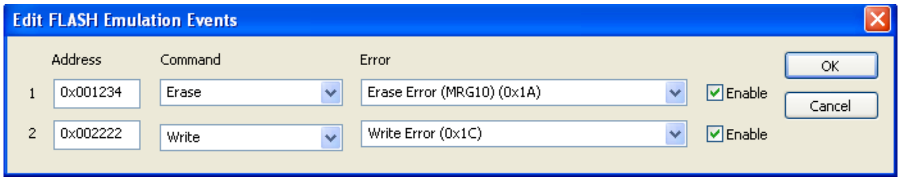
Buttons

These buttons are available:

Events	Displays the **Edit Flash Emulation Events** dialog box where you can edit the events.
Timing	Displays the **Edit Flash Emulation Timing** dialog box where you can set up the timing.

Edit Flash Emulation Events dialog box

The **Edit Flash Emulation Events** dialog box is available from the **Flash Programming Emulation** dialog box.



	Address	Command	Error	
1	0x001234	Erase	Erase Error (MRG10) (0x1A)	✓ Enable
2	0x002222	Write	Write Error (0x1C)	✓ Enable

Use this dialog box to set up events to test the flash self programming error handling. You can define up to two events.

Requirements

The IECUBE emulator and a device with flash memory.

Address

Specify the address where the emulation shall generate the defined error (in hexadecimal notation). The maximum value is determined by the ROM size of the device. The error will not be generated at any other address.

Command

Choose flash control firmware function to be executed. See the *Flash Memory Programming* documentation for your device.

Error

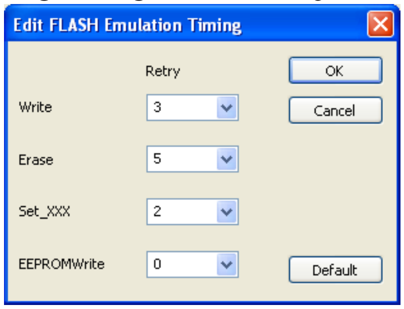
Choose the operation of the self library function that generates the returned error. See the *Flash Memory Programming* documentation for your device.

Enable

Enables the event definition.

Edit Flash Emulation Timing dialog box

The **Edit Flash Emulation Timing** dialog box is available from the **Flash Programming Emulation** dialog box.



Write	3
Erase	5
Set_XXX	2
EEPROMWrite	0

Use this dialog box to edit the timing of the flash emulation.

Requirements

The IECUBE emulator and a device with flash memory.

Retry

Sets the timing of the flash emulation command. The default retry value is `0` (=no retry), which results in the fastest timing. The higher the retry value, the more delayed the timing will be.

Emulation commands

You can set the timing for these commands:

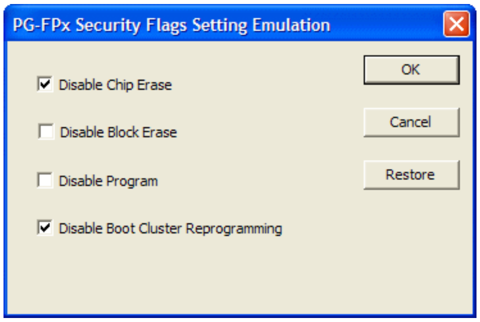
Write	The `write` command.
Erase	The `erase` command.
Set_XXX	The `set_info` command.
EEPROMWrite	The `eeprom_write` command.

Default

Restores the retry values to the factory settings.

Programmer PG-FPx Security Flags dialog box

The **Programmer PG-FPx Security Flags** dialog box is available from the **Emulator** menu.



[✓] Disable Chip Erase

[ ] Disable Block Erase

[ ] Disable Program

[✓] Disable Boot Cluster Reprogramming

Use this dialog box to set the initial value of the flash programming security flags.

Requirements

The IECUBE emulator and a device with flash memory.

Disable Chip Erase

Sets a security flag that protects the entire chip contents from being erased.

Disable Block Erase

Sets a security flag that protects the contents of the current block from being erased.

Disable Program

Sets a security flag that write-protects the flash memory.

Disable Boot Cluster Reprogramming

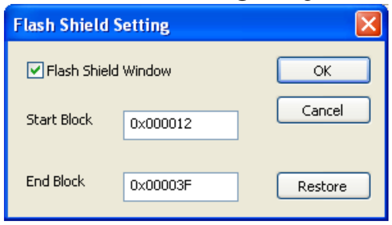
Sets a security flag that write-protects the boot area. Only for devices that support this feature.

Restore

Resets the flags to the values they had when you opened the dialog box.

Flash Shield Setting dialog box

The **Flash Shield Setting** dialog box is available from the **Emulator** menu.



[✓] Flash Shield Window

Start Block: 0x000012

End Block: 0x00003F

By default, the entire flash memory is write-protected by a *flash shield*.

Use this dialog box to specify that a memory range can be modified by the flash self-programming.

Note: When you open this dialog box, the specified values have been changed either by the debugger or by your application, since you closed the dialog box last time.

Requirements

The IECUBE emulator and a device with flash memory.

Flash Shield Window

Opens up a “window” in the flash shield, a range of memory blocks can be modified by the flash self-programming.

Start Block

Specify the number of the first memory block of the flash shield window, in hexadecimal or decimal notation.

End Block

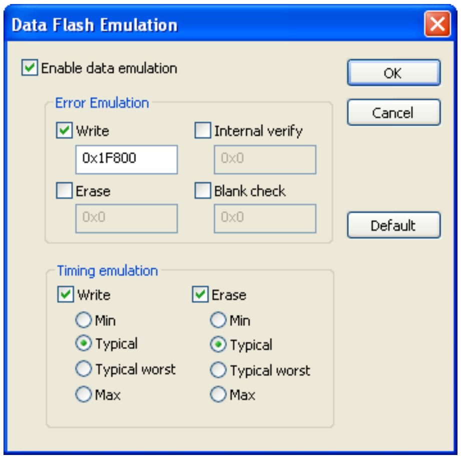
Specify the number of the last memory block of the flash shield window.

Restore

Restores the values to what they were when you opened the dialog box.

Data Flash Emulation dialog box

The **Data Flash Emulation** dialog box is available from the **Emulator** menu.



Data Flash Emulation

[✓] Enable data emulation

Error Emulation

[✓] Write: 0x1F800
[ ] Internal verify: 0x0
[ ] Erase: 0x0
[ ] Blank check: 0x0

Timing emulation

[✓] Write: Min [✓ Typical] Typical worst Max
[✓] Erase: Min [✓ Typical] Typical worst Max

Use this dialog box to access the data flash memory from the **Data Flash Memory** window, and to test error handling and timing issues in the data flash memory.

Requirements

The IECUBE emulator and a device with flash memory.

Enable data emulation

Enables the error emulation and timing emulation.

Error Emulation

Specify which type of error to emulate. Choose between:

- **Write**
- **Erase**
- **Internal verify**
- **Blank check**.

You must also specify a generation address, the address where the error occurs. If this address is outside the data flash memory area, an error message is issued.

By default, error emulation is not set.

Timing Emulation

Specify the timing for write errors and erase errors. Choose between:

- **Min**
- **Typical** (default)
- **Typical worst** (worst case)
- **Max**.

Resolving problems

These topics are covered:

- Write failure during load
- No contact with the target hardware

Debugging using the C-SPY hardware debugger systems requires interaction between many systems, independent from each other. For this reason, setting up this debug system can be a complex task. If something goes wrong, it might be difficult to locate the cause of the problem.

This section includes suggestions for resolving the most common problems that can occur when debugging with the C-SPY hardware debugger systems.

For problems concerning the operation of the evaluation board, refer to the documentation supplied with it, or contact your hardware distributor.

WRITE FAILURE DURING LOAD

There are several possible reasons for write failure during load. The most common is that your application has been incorrectly linked:

- Check the contents of your linker configuration file and make sure that your application has not been linked to the wrong address
- Check that you are using the correct linker configuration file.

In the IDE, the linker configuration file is automatically selected based on your choice of device.

To choose a device:

1. Choose **Project>Options.**
2. Select the **General Options** category.
3. Click the **Target** tab.
4. Choose the appropriate device from the **Device** drop-down list.

To override the default linker configuration file:

1. Choose **Project>Options.**
2. Select the **Linker** category.
3. Click the **Config** tab.
4. Choose the appropriate linker configuration file in the **Linker configuration file** area.

NO CONTACT WITH THE TARGET HARDWARE

There are several possible reasons for C-SPY to fail to establish contact with the target hardware. Do this:

- Check the communication devices on your host computer
- Verify that the cable is properly plugged in and not damaged or of the wrong type
- Make sure that the evaluation board is supplied with sufficient power
- Check that the correct options for communication have been specified in the IAR Embedded Workbench IDE.

Examine the linker configuration file to make sure that the application has not been linked to the wrong address.

OCD emulators reserved resources

This chapter contains important information about using the RL78 microcontroller together with one of the emulators that use the OCD driver: E1, E2, E2 Lite/E2 On-Board, E20, EZ-CUBE, EZ-CUBE2, and TK.

Reserving resources when debugging

When an OCD emulator is debugging an application, some resources cannot be used by the application and must be reserved. Any modification of these areas is prohibited.

All ROM areas used by the monitor program must be reserved by your application. Any modification of these areas is prohibited. These areas must be excluded from the usable address space in the linker configuration file.

Device-specific linker configuration files to be used as templates are included in the `$TOOLKIT_DIR$\config\` directory.

If unused ROM addresses are filled, you must use `ielftool` to exclude the resources required by the debug monitor program.

ROM AREAS USED FOR ON-CHIP DEBUGGING

These ROM areas must be reserved:

- The reset vector. Will be overwritten by the monitor program during debugging.
- The IRQ vector at address `0x0002,0x0003`. Used by the monitor program.
- The OCD option byte area address at `0x00C3`. Used for configuring the OCD interface.
- The User option byte area address at `0x00C0–0x00C2`. Used for device configuration such as watchdog, voltage detection, on-chip oscillator, etc.
- The Security ID area at `0x00C4–0x00CD`. Contains the authentication code.
- Monitor area 1 at `0x00CE–0x00D7`. Used by the monitor program.
- Monitor area 2, 256 or 512 bytes at the end of the internal ROM. Used by the monitor program. If the pseudo RRM feature is not used in 2-wire mode, this area is only 88 bytes.

RAM SPACE

An additional 6 bytes of the stack area must be reserved.

PINS

The `TOOL0` pin must be reserved.

SECURITY ID AND OPTION BYTES

The area `0x00C0–0x00C3` of the RL78 flash memory is called the *Option byte area*. This area holds the User option byte (`0x00C0–0x00C2`) and the On-chip debug option byte (`0x00C3`). During power-up and reset of an application, the Option byte area is automatically referenced by the device, so you must make sure that it is correctly configured. Refer to the hardware user manual for your device.

The Security ID allows an authentication check before the debug session is started. The behavior in case of a using an incorrect security ID can be configured. The Security ID of an erased device is 10 times `0xFF` (this means that `0xFF` is reserved, and that you cannot use it as an ID code).

Define the Security ID and option bytes using one of two methods:

- In specific constant sections
- By absolute memory allocation.

Examples

1 Using specific constant sections:

```
#pragma constseg=.option_byte
__root const unsigned char optbyte[4] = {v0,v1,v2,v3};
#pragma constseg=.security_id
__root const unsigned char secu_ID[10]= {s0,s1,s2,s3,s4,s5,s6,
                                         s7,s8,s9};
#pragma constseg=default
```

2 Using absolute memory allocation:

```
__root const unsigned char optbyte[4] @ 0x00C0 =
{v0,v1,v2,v3};
__root const unsigned char secu_ID[10] @ 0x00C4 =
{s0,s1,s2,s3,s4,s5,s6,s7,s8,s9};
```

3 In assembler language:

```
ORG 0x00C0
; Option bytes
DB 0x00,0xFE,0xFF,0x85

ORG 0x00C4
; Security ID
DB 0xFF,0xFF,0xFF,0xFF,0xFF,0xFF,0xFF,0xFF,0xFF,0xFF
END
```

The ten bytes `s0–s9` make up the ID Code that you are defining. By default, all values are `0xFF`. See *Hardware Setup*, page 56.

You can change the section names `.option_byte` and `.security_id`. New names must be defined in the linker configuration file.

The device-specific values `v0-v2` are described in the device documentation. The value `v3` configures the OCD interface. For more information, refer to the *User's Manual* for your emulator, available from the Renesas website `www.renesas.eu/e1`.

RESERVING THE ROM MEMORY AREA FOR THE MONITOR

The addresses `0x02, 0x03`, the area between `0x00CE–0x00D7`, and the last 256 or 512 bytes of the internal ROM must be reserved for the debug monitor program. If this area is rewritten by the flash self-programming, on-chip debugging can no longer be performed. Make sure to reserve these areas in your linker configuration file.

Device-specific linker configuration file templates reserving all necessary areas are included with the product. The templates are located in the `$TOOLKIT_DIR$\config\` directory. The naming convention is transparent; the template for a device is named `lnk`*`devicename`*`.icf`.

STACK AREA FOR DEBUGGING

On-chip debugging requires another 6 bytes of stack. Therefore, the stack size of the application must be increased. In the IAR Embedded Workbench IDE, choose **Project>Options** and open the **Stack/Heap** page in the **General Options** category. If you are debugging from the command line, the stack size is defined in the linker configuration file:

```
//-----------------------------------------------------------------
// Size of the stack.
//-----------------------------------------------------------------
--config_def _STACK_SIZE=128
```

CAUTIONS

There are a number of important things you need to know when debugging with an OCD emulator. Refer to the *User's Manual* for your emulator, available from the Renesas website `www.renesas.eu/e1`.

Further reading

For more information about using your OCD emulator, see the *User's Manual* for your emulator, available from the Renesas website `www.renesas.eu/docuweb`.

For information about known problems and for a list of supported devices, see the *Universal Flash Memory Programmer and Serial On-chip Debugger Operating Precautions* guide for your emulator. It is available from the Renesas website `www.renesas.eu/docuweb`.

TARGET SYSTEM DESIGN

The target system design is described in the User's Manual for all microcontroller series.

FLASH PROGRAMMING

Using an OCD emulator as a flash programmer is described in User's Manual for all microcontroller series.