IAR Embedded Workbench

C-SPY® Debugging Guide

for the Renesas

RH850 Family

UCSRH850-5

IAR SYSTEMS

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EDITION NOTICE

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This guide applies to version 2.x of IAR Embedded Workbench® for the Renesas RH850 Family.

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Brief contents

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Preface

Welcome to the *C-SPY® Debugging Guide*. 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 RH850 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 RH850 microcontroller (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 RH850.

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.
- *Analyzing code performance* describes how to use a C-SPY hardware debugger to analyze code performance in terms of clock cycles, interrupts, exceptions, and instructions.
- *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.

PART 3. ADVANCED DEBUGGING

- *Multicore debugging* describes how to debug a target with multiple cores.
- *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.

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, is available in the booklet Quick Reference (available in the product box) and the *Installation and Licensing Guide*.
- Using the IDE for project management and building, is available in the *IDE Project Management and Building Guide for RH850.*
- Using the IAR C-SPY® Debugger, is available in the *C-SPY® Debugging Guide for RH850.*
- Programming for the IAR C/C++ Compiler for RH850 and linking using the IAR ILINK Linker, is available in the *IAR C/C++ Development Guide for RH850.*
- Programming for the IAR Assembler for RH850, is available in the *IAR Assembler Reference Guide for RH850.*
- 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 RH850 Family.
- 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 `rh850\doc`, the full path to the location is assumed, for example `c:\Program Files\IAR Systems\Embedded Workbench N.n\rh850\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 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 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.
`[a|b|c]`	An optional part of a command with alternatives.
`{a|b|c}`	A mandatory part of a command 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 RH850	IAR Embedded Workbench®

Table 2: Naming conventions used in this guide

Brand name	Generic term
IAR Embedded Workbench® IDE for RH850	the IDE
IAR C-SPY® Debugger for RH850	C-SPY, the debugger
IAR C-SPY® Simulator	the simulator
IAR C/C++ Compiler™ for RH850	the compiler
IAR Assembler™ for RH850	the assembler
IAR ILINK Linker™	ILINK, the linker
IAR DLIB Runtime Environment™	the DLIB runtime environment

Table 2: Naming conventions used in this guide (Continued)

Part 1. Basic debugging

This part of the *C-SPY® Debugging Guide for RH850* 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
- 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 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:

- CMX
- Express Logic ThreadX
- FreeRTOS
- Micrium uC/OS-II
- 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.

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.

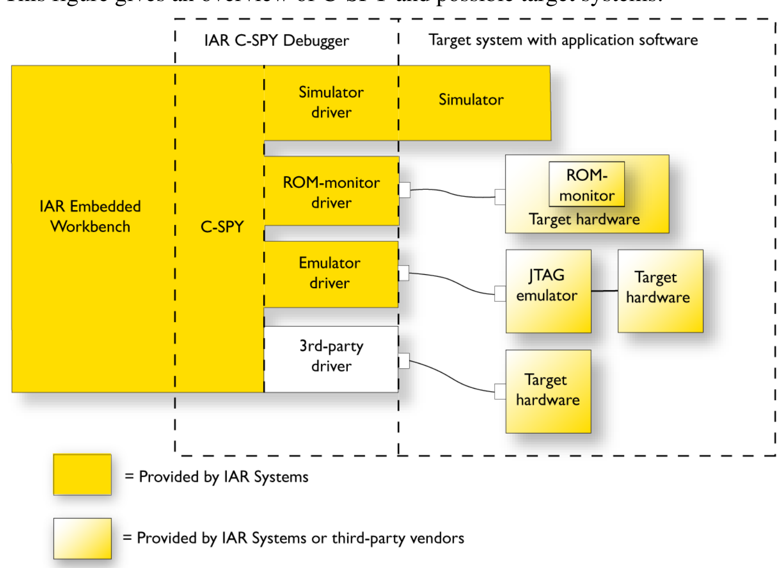
These topics are covered:

- 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:



Note: In IAR Embedded Workbench for RH850, there are no ROM-monitor drivers.

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 34.

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:

- Code Coverage, which is integrated in the IDE.
- 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 visualSTATE 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 visualSTATE.

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 RH850 microcontrollers is available with drivers for these target systems and evaluation boards:

- The IAR C-SPY Simulator
- E1/E2/E20 emulator

DIFFERENCES BETWEEN THE C-SPY DRIVERS

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

Feature	Simulator	E1/E2/E20 Emulator
Code breakpoints[1]	Unlimited	Yes[1]
Data breakpoints	Yes	Yes
Execution in real time	—	Yes
Zero memory footprint	Yes	Yes
Simulated interrupts	Yes	—
Real interrupts	—	Yes

Table 3: Driver differences

Feature	Simulator	E1/E2/E20 Emulator
Interrupt logging	Yes	Yes
Data logging	Yes	—
Live watch	Yes	Yes
Cycle counter	Yes	—
Execution time measurement	—	Yes
Code coverage	Yes	—
Data coverage	Yes	—
Function/instruction profiling	Yes	—
Trace	Yes	Yes
Multicore debugging [1]	Yes	Yes
Performance analysis	—	Yes

Table 3: Driver differences (Continued)

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

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.

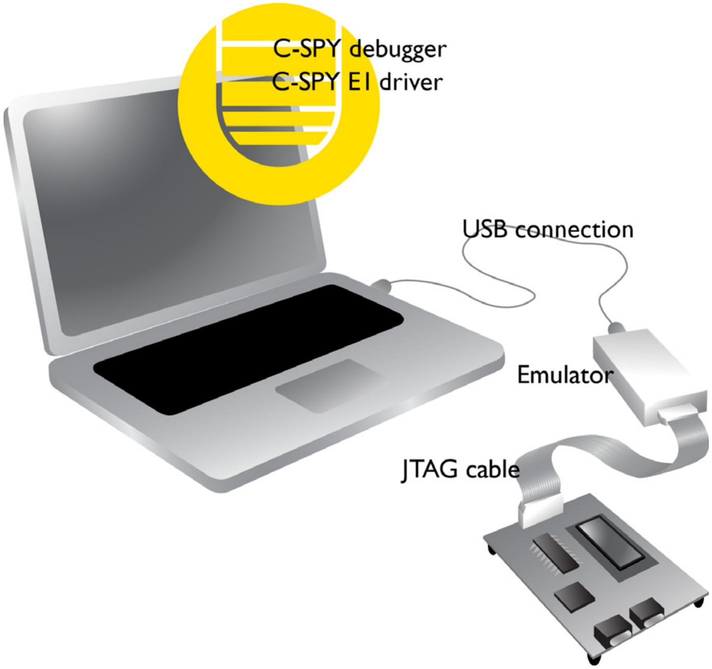
C-SPY Hardware debugger drivers

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

IAR Embedded Workbench for RH850 comes with a driver for the E1/E2/E20 emulator.

E1/E2/E20 EMULATOR

The C-SPY Hardware debugger driver uses USB to communicate with the E1/E2/E20 emulator.



When USB connection is used, a specific USB driver must be installed before you can use the probe over the USB port. You can find the USB driver on the IAR Embedded Workbench installation media.

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.

Note: By default, C-SPY switches to LPD 4-pin mode automatically when the debug session is started. For information about controlling the LPD connection and the communication speed and clock frequency, see *Setup*, page 354.

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. Install a USB driver or some other communication driver if your C-SPY driver requires it.

   For more information, see:

   - *Hardware installation*, page 37

2. 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.

3. In the **Category** list, select the appropriate C-SPY driver and make your settings.

   For information about these options, see *Debugger options*, page 349.

4. Click **OK**.

5. 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 RH850*.

See also *Adapting for target hardware*, page 45.

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

If no breakpoints are available when C-SPY starts, a warning message notifies you that single stepping will be required and that this is time-consuming. You can then continue execution in single-step mode or stop at the first instruction. If you choose to stop at the first instruction, the debugger starts executing with the `PC` (program counter) at the default reset location instead of the location you typed in the **Run to** box.

Note: This message will never be displayed in the C-SPY Simulator, where breakpoints are unlimited.

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 273. For an example of how to use a setup macro file, see *Initializing target hardware before C-SPY starts*, page 46.

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 are provided in the `RH850\config` directory and they have the filename extension `ddf`.

For more information about device description files, see *Adapting for target hardware*, page 45.

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 353.

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 images
- Editing in C-SPY windows

- Start debugging a running application

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.

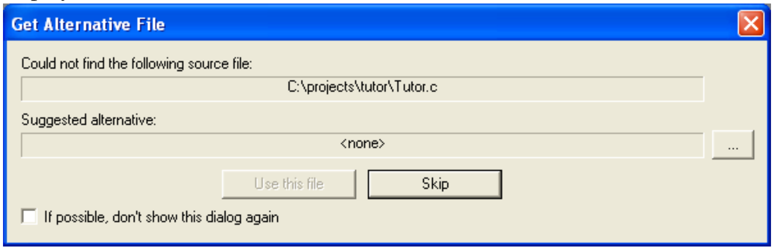
3 To start the executable file, click the **Download and Debug** button. The project can be reused whenever you rebuild your executable file.

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:



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 simply 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 53.

LOADING MULTIPLE IMAGES

Normally, a debuggable application consists of exactly one file that you debug. However, you can also load additional debug files (images). This means that the complete program consists of several 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 image has been loaded, you will have access to the combined debug information for all the loaded images. In the **Images** window you can choose whether you want to have access to debug information for one image or for all images.

To load additional images at C-SPY startup:

1. Choose **Project>Options>Debugger>Images** and specify up to three additional images to be loaded. For more information, see *Images*, page 351.
2. Start the debug session.

To load additional 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 275.

To display a list of loaded images:

Choose **Images** from the **View** menu. The **Images** window is displayed, see *Images window*, page 52.

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.

START DEBUGGING A RUNNING APPLICATION

Using an E1, E2, or E20 emulator, you can start debugging a running application at its current location, without resetting the target system.

Start debugging from the middle of execution

1. Make sure that the target board is powered by external power and disconnect the emulator from the target board.
2. Choose **Project>Attach to running target**. For information about this menu command, see the *IDE Project Management and Building Guide for RH850*.
3. When you are prompted, connect the emulator to the target board and click OK.
4. When the debug session starts, your application is still executing but now you can monitor RAM and look at variables in the **Live Watch** window.
5. To stop execution, click **Stop**.
6. You can now debug your application as usual.

You can leave the target system running by closing the debug session and disconnecting the emulator when you are prompted. Note that in that case you must reset the target system before you can connect again.

Adapting for target hardware

These tasks are covered:

- Modifying a device description file
- Initializing target hardware before C-SPY starts
- Using predefined C-SPY macros for device support

See also *Memory configuration for C-SPY hardware debugger drivers*, page 132.

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 41. They contain device-specific information such as:

- Memory information for device-specific memory zones, see *C-SPY memory zones*, page 130. If you are using a C-SPY hardware debugger driver, the memory information retrieved from the device description file is not always sufficient, see *Memory Configuration dialog box, for the C-SPY simulator*, page 162 and *Memory Configuration dialog box, in C-SPY hardware debugger drivers*, page 166.

- 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 249.
- Information used by the E1/E2/E20 emulator.

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 41.

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.

USING PREDEFINED C-SPY MACROS FOR DEVICE SUPPORT

For some RH850 devices, there are predefined C-SPY macros available for specific device support, typically provided by the chip manufacturer. These macros are useful for performing certain device-specific tasks,

You can easily access and execute these macros using the **Macro Quicklaunch** window.

Reference information on starting C-SPY

Reference information about:

- *C-SPY Debugger main window*, page 47
- *Images window*, page 52
- *Get Alternative File dialog box*, page 53
- *Operating Frequency dialog box*, page 54
- *Hardware Setup dialog box*, page 55

See also:

- Tools options for the debugger in the *IDE Project Management and Building Guide for RH850*.

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 trace setup 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

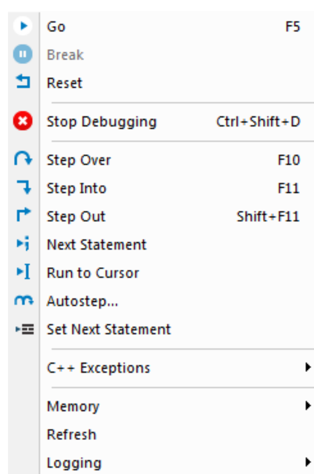
Provides commands for executing and debugging the source application. Most of the commands are also available as icon buttons on the debug toolbar.

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 357.

Debug menu

The **Debug** menu is available during a debug session. The **Debug** menu provides commands for executing and debugging the source application. Most of the 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.

Note: If you are using symmetric multicore debugging, the **Go** command starts only the core in focus.

Break

Stops the application execution.

Note: If you are using symmetric multicore debugging, the **Break** command stops only the core in focus.

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 77.

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 142.

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 143.

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 75.

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 73

C-SPY windows

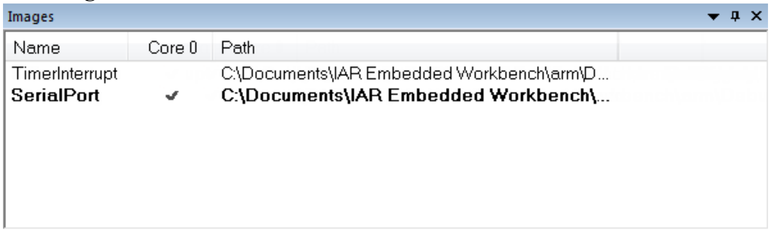
Depending on the C-SPY driver you are using, these windows specific to C-SPY are available during a debug session:

- 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 196
- 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.



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

Normally, a source application consists of exactly one image that you debug. However, you can also load additional images. This means that the complete debuggable unit consists of several images. See also *Loading multiple images*, page 43.

Requirements

None; this window is always available.

Display area

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

This area lists the loaded images in these columns:

Name

The name of the loaded image.

Core *N*

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

Path

The path to the loaded image.

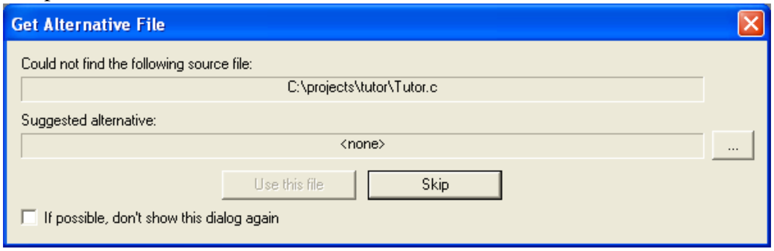
Related information

For related information, see:

- *Loading multiple images*, page 43
- *Images*, page 351
- *__loadImage*, page 298.

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.



See also *Starting a debug session with source files missing*, page 42.

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

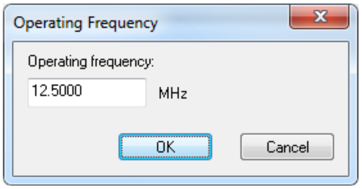
Instead of displaying the dialog box again for a missing source file, C-SPY will use the previously supplied response.

Related information

For related information, see *Starting a debug session with source files missing*, page 42.

Operating Frequency dialog box

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



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 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 logging feature to convert cycles to time and by the **Timeline** window to estimate the number of elapsed cycles.

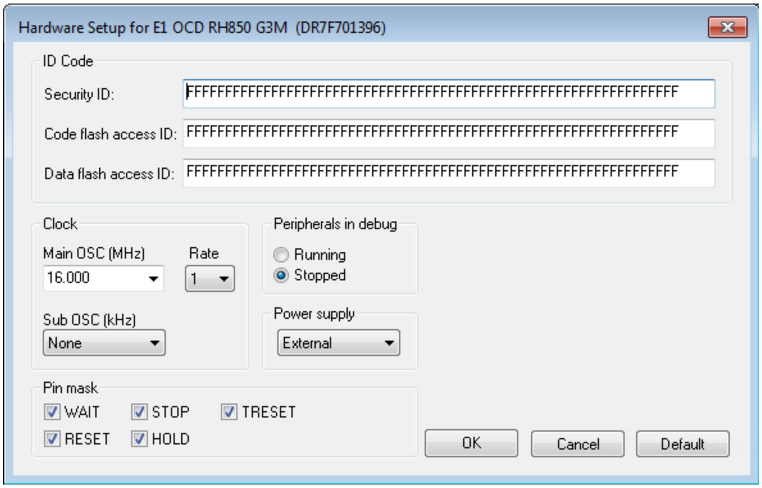
Related information

For related information, see:

- *Requirements for interrupt logging*, page 253
- *The application timeline*, page 191.

Hardware Setup dialog box

The **Hardware Setup** dialog box is available from the **C-SPY driver** menu.



Use this dialog box to configure the hardware debugger.

Requirements

A C-SPY hardware debugger driver.

Security ID

To start a debug session, you must specify the ID for CPUs that are read-protected with an RSU ID code, a 20-byte hexadecimal number. By default, all digits are `F`.

Code flash access ID

To start a debug session, you must specify the ID for CPUs whose code flash memory is protected with a 64-byte hexadecimal access ID code. By default, all digits are `F`. This ID is not needed for all devices.

Data flash access ID

To start a debug session, you must specify the ID for CPUs whose data flash memory is protected with a 64-byte hexadecimal access ID code. By default, all digits are `F`. This ID is not needed for all devices.

Main OSC

Selects the frequency of the clock oscillator before it is multiplied internally in the CPU.

Rate

Selects the multiplication rate of the main clock oscillator.

Sub OSC

Selects the frequency of an optional low frequency clock.

Peripherals in debug

Controls the status of the peripheral units when the application stops. Choose between:

Running
: Makes the peripheral units keep running when the application stops.

Stopped
: Makes the peripheral units stop when the application stops.

Power supply

Selects the source of power supply for the target board. Choose between:

External
: An external source supplies power.

3 V
: The E1/E2/E20 emulator supplies 3 V of power.

5 V
: The E1/E2/E20 emulator supplies 5 V of power.

Pin mask

Selects the non-connected pod pins, so that they do not disturb the execution of the CPU. If the **RESET** option is selected, the pod pin is not connected.

Executing your application

- Introduction to application 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 60 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 77.

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 ++;
}
```

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 106 and *Breakpoint consumers*, page 106.

- 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 133.
- 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.

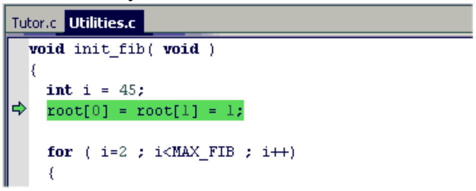
Note: If you are using symmetric multicore debugging, the **Go** command starts only the core in focus.

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.



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.

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 RH850*.

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 72 and *Terminal I/O Log File dialog box*, page 73.

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 75. 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.

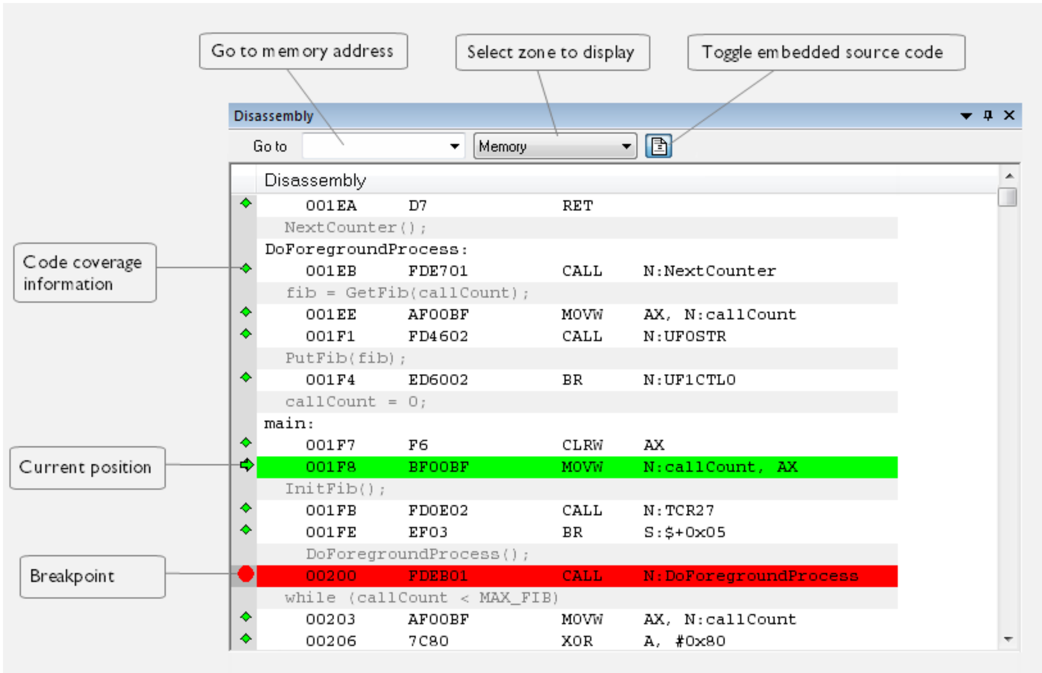
Reference information on application execution

Reference information about:

See also Terminal I/O options in the *IDE Project Management and Building Guide for RH850*.

Disassembly window

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



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 57.

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 130.

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.

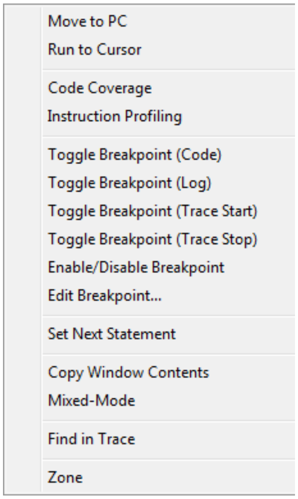
This area contains these graphic elements:

Green highlight	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	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 103.
Green diamond	Indicates code that has been executed—that is, code coverage.

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. Executed code is indicated by a green diamond.
Clear	Clears all code coverage information.

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 116.

Toggle Breakpoint (Performance Start)

Toggles a Performance Start breakpoint. If the breakpoint has been selected in the **Performance Analysis Setup** dialog box, the performance analysis starts when this breakpoint is triggered. Note that this menu command is only available if the C-SPY driver you are using supports performance analysis. For more information, see *Performance Analysis Start breakpoints dialog box*, page 236.

Toggle Breakpoint (Performance Stop)

Toggles a Performance Stop breakpoint. If the breakpoint has been selected in the **Performance Analysis Setup** dialog box, the performance analysis stops when this breakpoint is triggered. Note that this menu command is only available if the C-SPY driver you are using supports performance analysis. For more information, see *Performance Analysis Stop breakpoints dialog box*, page 237.

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 118.

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 184.

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 185.

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

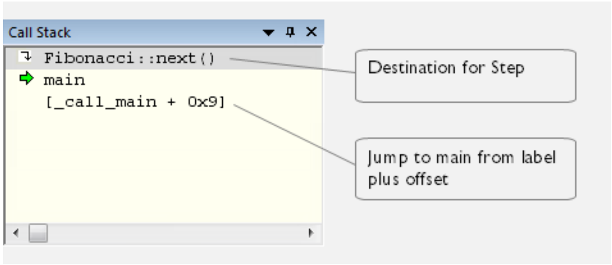
Searches the contents of the **Trace** window for occurrences of the given location—the position of the insertion point in the source code—and reports the result in the **Find in Trace** window. This menu command requires support for Trace in the C-SPY driver you are using, see *Differences between the C-SPY drivers*, page 34.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 130.

Call Stack window

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



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 62.

Requirements

None; this window is always available.

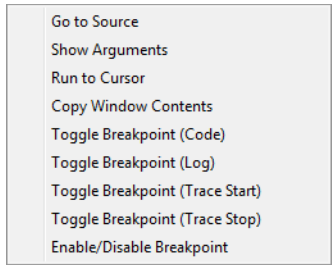
Display area

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 RH850*.
[*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)

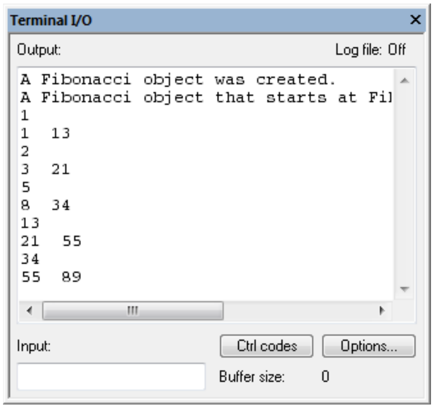
Toggles a Trace Stop breakpoint. When the breakpoint is triggered, trace data collection stops. Note that this menu command is only available if the C-SPY driver you are using supports it.

Enable/Disable Breakpoint

Enables or disables the selected breakpoint

Terminal I/O window

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



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

To use this window, you must:

- 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 63.

Requirements

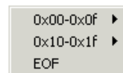
None; this window is always available.

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`.

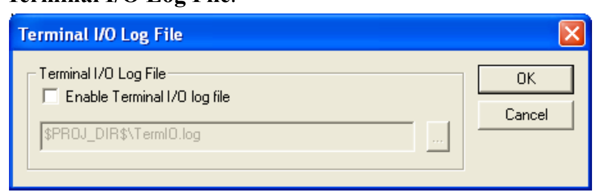


Options

Opens the **IDE Options** dialog box where you can set options for terminal I/O. For reference information about the options available in this dialog box, see *Terminal I/O options* in *IDE Project Management and Building Guide for RH850*.

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**.



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

See also *Terminal input and output*, page 63.

Requirements

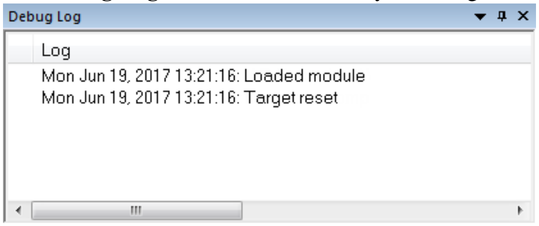
None; this dialog box is always available.

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**.



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 RH850*.

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>
```

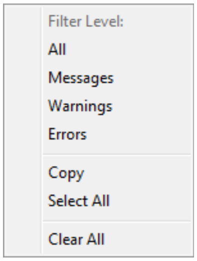
See also *Debug logging*, page 63 and *Log File dialog box*, page 75.

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

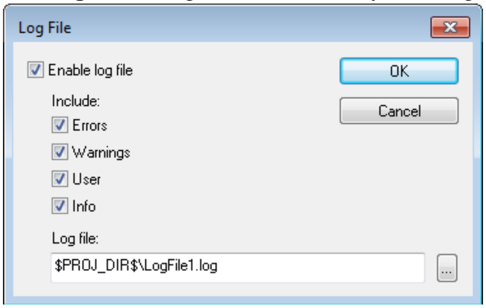
Selects the contents of the window.

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**.



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

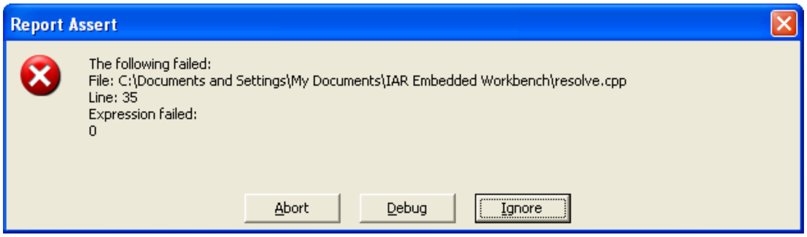
Messages from C-SPY macros, that is, your messages using the `__message` statement.

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.



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

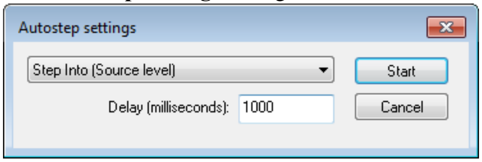
C-SPY stops the execution of the application and returns control to you.

Ignore

The assertion is ignored and the application continues to execute.

Autostep settings dialog box

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



Use this dialog box to customize autostepping.

The drop-down menu lists the available step commands, see *Single stepping*, page 58.

Requirements

None; this dialog box is always available.

Delay

Specify the delay between each step in milliseconds.

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.

For more information about these windows, see *Trace*, page 173.

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 45.

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.
`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 4: C-SPY assembler symbols expressions

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 5: 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 152.

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 274.

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 280.

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 193.

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 the these windows, except the **Trace** window—and thus is truncated, just point at the text with the mouse pointer and tooltip information is displayed.

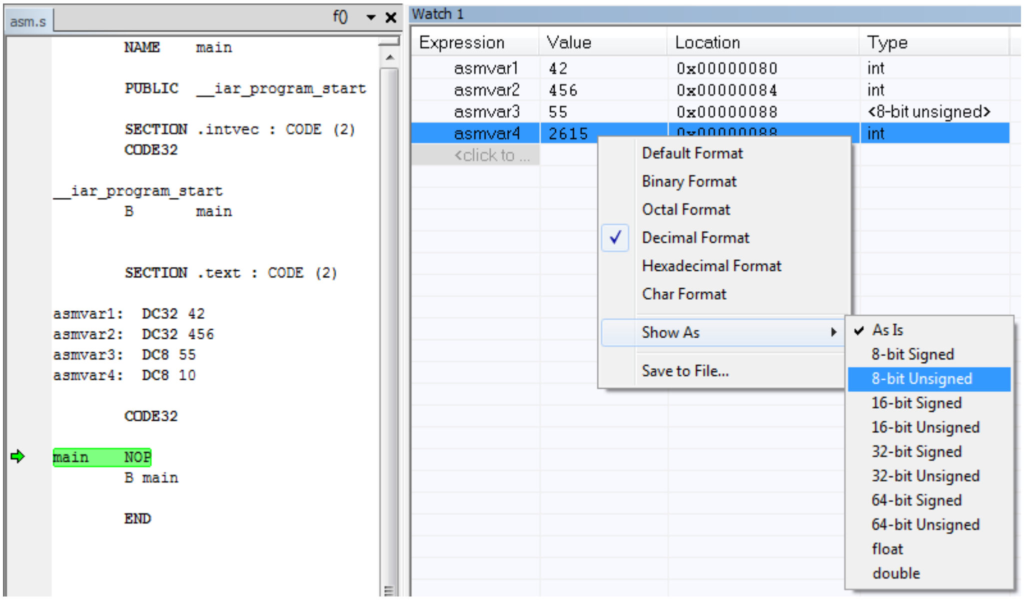
Right-click in any of the windows to access the context menu which contains additional commands. Convenient drag-and-drop between windows is supported, except for in the

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:



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

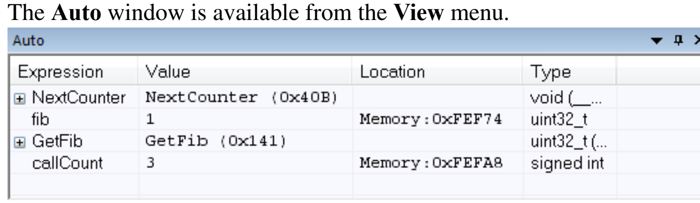
Reference information about:

See also:

- *Reference information on trace*, page 176 for trace-related reference information
- *Macro Quicklaunch window*, page 329

Auto window

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



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.

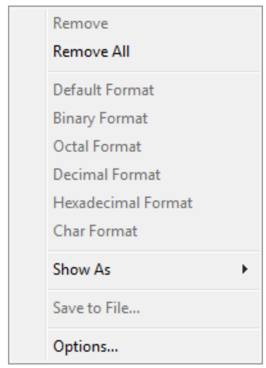
See also *Editing in C-SPY windows*, page 44.

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 84.

Save to File

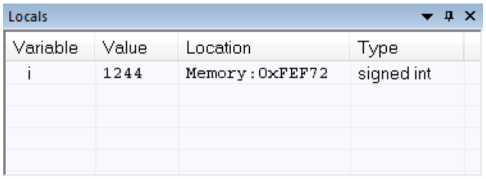
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options, for example the **Update interval** option. The default value of this option is 1000 milliseconds, which means the **Live Watch** window will be updated once every second during program execution.

Locals window

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



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.

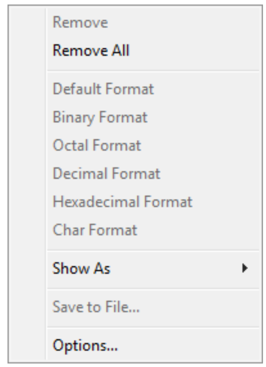
See also *Editing in C-SPY windows*, page 44.

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 84.

Save to File

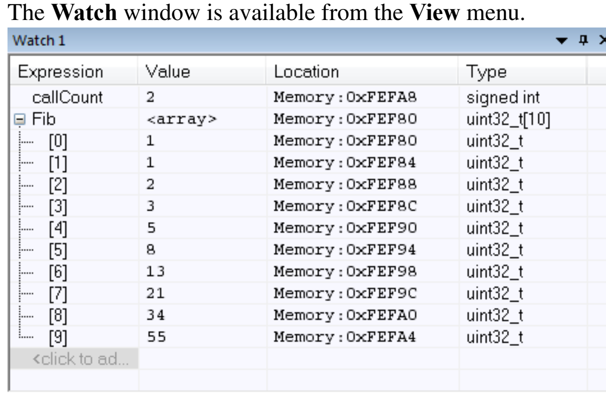
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options, for example the **Update interval** option. The default value of this option is 1000 milliseconds, which means the **Live Watch** window will be updated once every second during program execution.

Watch window

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



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 huge arrays can cause an out-of-memory crash. To avoid this, expansion is automatically performed in steps of 5000 elements.

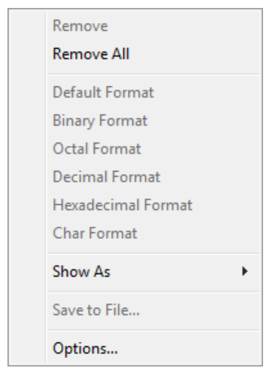
See also *Editing in C-SPY windows*, page 44.

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 84.

Save to File

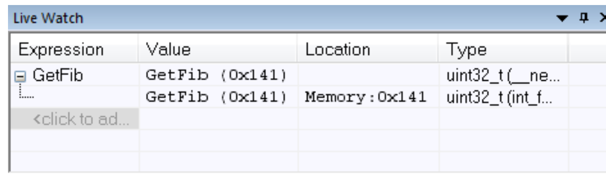
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options, for example the **Update interval** option. The default value of this option is 1000 milliseconds, which means the **Live Watch** window will be updated once every second during program execution.

Live Watch window

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



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 44.

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

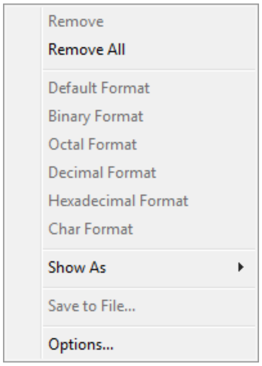
The location in memory where this variable is stored.

Type

The data type of the variable.

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 84.

Save to File

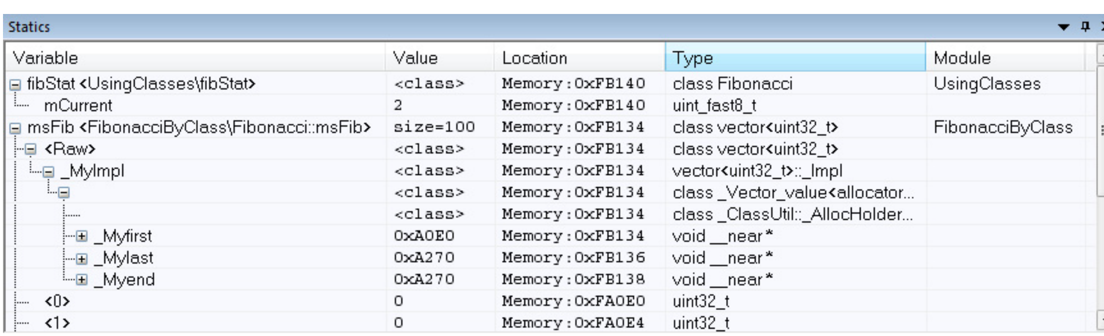
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options, for example the **Update interval** option. The default value of this option is 1000 milliseconds, which means the **Live Watch** window will be updated once every second during program execution.

Statics window

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



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 44.

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:

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

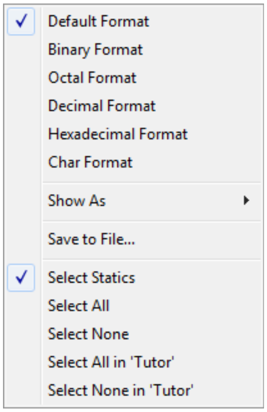
The data type of the variable.

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.

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*

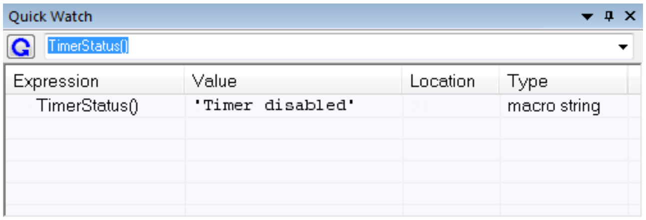
Selects all variables in the selected module.

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.



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 44.

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.

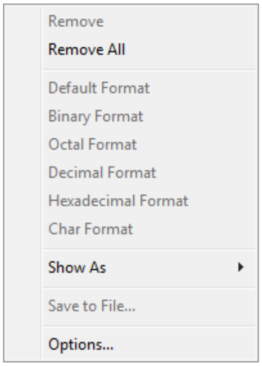
For an example, see *Using C-SPY macros*, page 275.

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 84.

Save to File

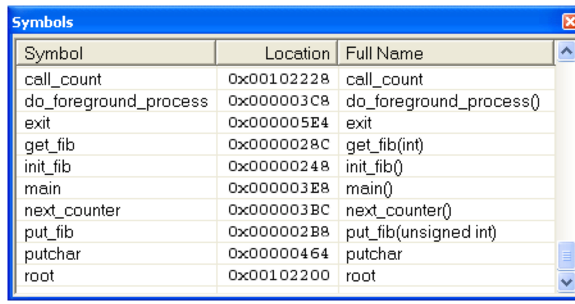
Saves content to a file in a tab-separated format.

Options

Displays the **IDE Options** dialog box where you can set various options, for example the **Update interval** option. The default value of this option is 1000 milliseconds, which means the **Live Watch** window will be updated once every second during program execution.

Symbols window

The **Symbols** window is available from the **View** menu after you have enabled the Symbols plugin module.



Symbol	Location	Full Name
call_count	0x00102228	call_count
do_foreground_process	0x000003C8	do_foreground_process()
exit	0x000005E4	exit
get_fib	0x0000028C	get_fib(int)
init_fib	0x00000248	init_fib()
main	0x000003E8	main()
next_counter	0x000003BC	next_counter()
put_fib	0x000002B8	put_fib(unsigned int)
putchar	0x00000464	putchar
root	0x00102200	root

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.

To enable the Symbols plugin module, choose **Project>Options>Debugger>Select plugins to load>Symbols**.

Requirements

None; this window is always available.

Display area

This area contains these columns:

Symbol

The symbol name.

Location

The memory address.

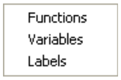
Full name

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

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

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

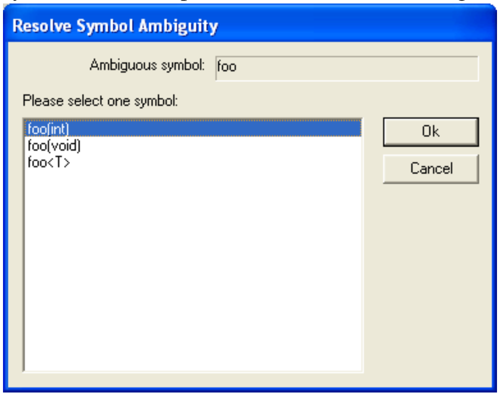
Toggles the display of variables on or off in the list.

Labels

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

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.



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 106.

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 58.

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.

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.

Timer Start and Stop breakpoints

Timer Start and Stop breakpoints set up a timer—a convenient way to measure the time on target hardware between two execution points. The executed time is displayed in the **Debug Log** window.

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 four 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.

Performance breakpoints

By default, if you enable performance analysis, it runs during the entire execution. Performance Start and Stop breakpoints are used for analyzing the performance over a smaller region of code. For reference information about these breakpoints, see *Analyzing code performance*, page 229.

Performance Start and Stop breakpoints share the same resources as hardware code breakpoints, see *Breakpoints in the C-SPY hardware debugger drivers*, page 106.

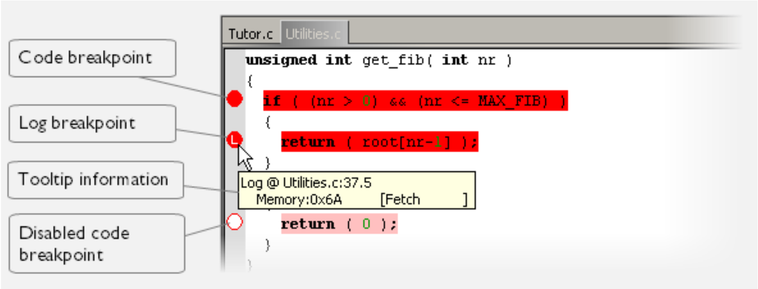
Immediate breakpoints

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:



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 RH850*.

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. The amount of breakpoints you can set depends on the number of *hardware breakpoints* available on the target system.

Exceeding the number of available hardware breakpoints causes the debugger to single step. This will significantly reduce the execution speed. For this reason you must be aware of the different breakpoint consumers.

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.

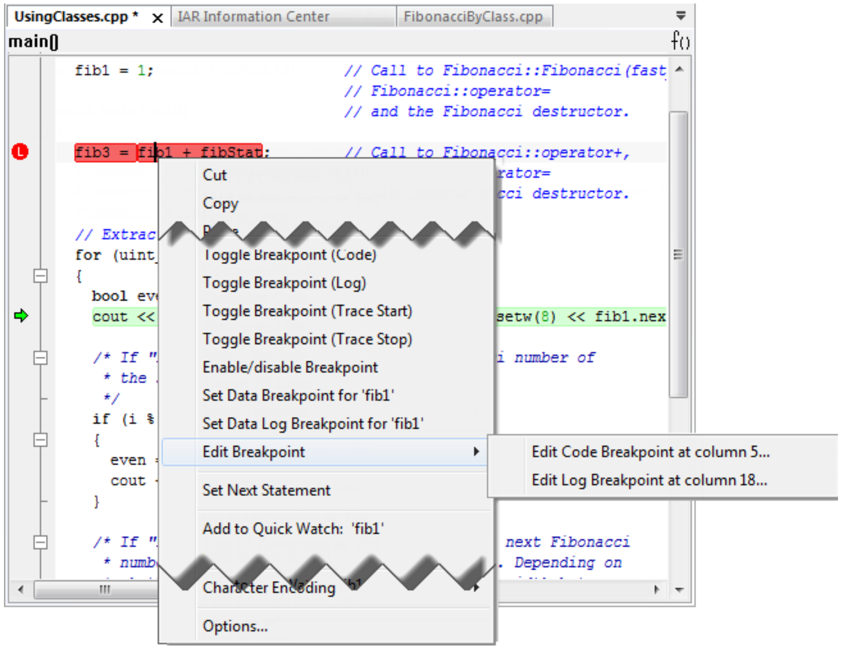
Depending on the C-SPY driver you are using, different breakpoint types are available.

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.



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	E1/E2/E20
`__setCodeBreak`	Yes	Yes
`__setDataBreak`	Yes	Yes
`__setLogBreak`	Yes	Yes
`__setDataLogBreak`	Yes	—
`__setSimBreak`	Yes	—
`__setTimerStartBreak`	—	Yes
`__setTimerStopBreak`	—	Yes

Table 6: C-SPY macros for breakpoints

C-SPY macro for breakpoints	Simulator	E1/E2/E20
`__setTraceStartBreak`	Yes	Yes
`__setTraceStopBreak`	Yes	Yes
`__clearBreak`	Yes	Yes

Table 6: C-SPY macros for breakpoints (Continued)

For information about each breakpoint macro, see *Reference information on C-SPY system macros*, page 287.

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 275.

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 very 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:

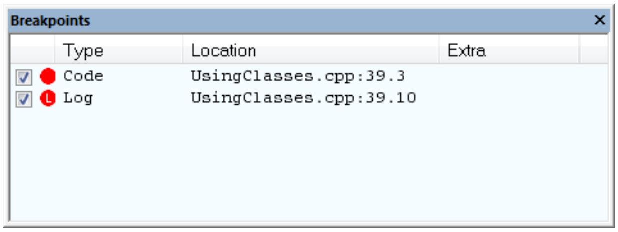
- *Breakpoints window*, page 113
- *Breakpoint Usage window*, page 115
- *Code breakpoints dialog box*, page 116
- *Log breakpoints dialog box*, page 118
- *Data breakpoints dialog box*, page 119
- *Data Log breakpoints dialog box*, page 121
- *Immediate breakpoints dialog box*, page 122
- *Timer Start breakpoints dialog box*, page 123
- *Timer Stop breakpoints dialog box*, page 124
- *Enter Location dialog box*, page 126
- *Resolve Source Ambiguity dialog box*, page 127.

See also:

- *Reference information on C-SPY system macros*, page 287
- *Reference information on trace*, page 176.
- *Reference information on performance analysis*, page 231.

Breakpoints window

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



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

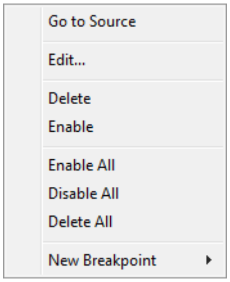
None; this window is always available.

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

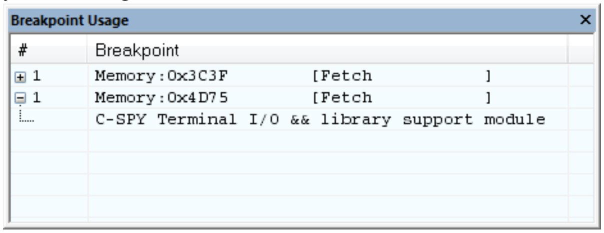
Deletes all defined breakpoints.

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.



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. If your target system has a limited number of hardware breakpoints exceeding the number of available hardware breakpoints will cause the debugger to single step. This will significantly reduce the execution speed. Therefore, in a debugger system with a limited amount of hardware breakpoints, you can 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 106.

Requirements

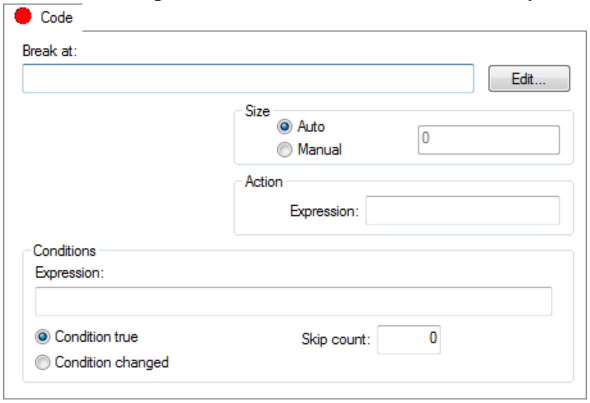
None; this window is always available.

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 108.

Requirements

None; this dialog box is always available.

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 126.

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 111.

Conditions

Specify simple or complex conditions:

Expression

Specify a valid C-SPY expression, see *C-SPY expressions*, page 80.

Condition true

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

Condition changed

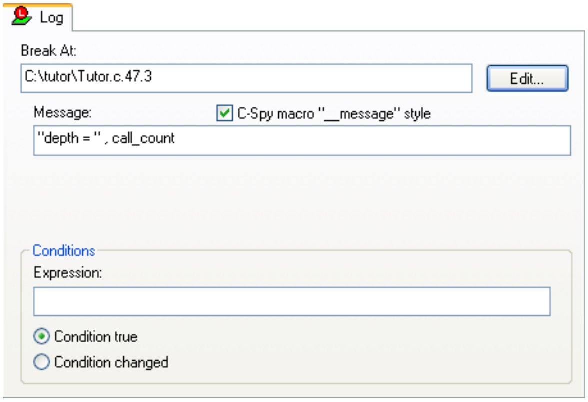
The breakpoint is triggered if the value of the expression has changed since it was last evaluated.

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.

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 108.

Requirements

None; this dialog box is always available.

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 126.

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 283.

Conditions

Specify simple or complex conditions:

Expression

Specify a valid C-SPY expression, see *C-SPY expressions*, page 80.

Condition true

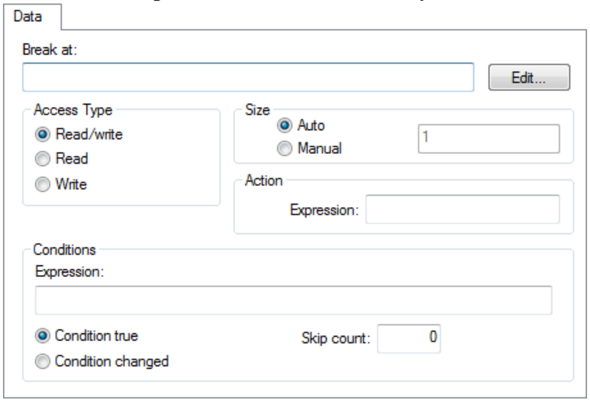
The breakpoint is triggered if the value of the expression is true.

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 108. Data breakpoints never stop execution within a single instruction. They are recorded and reported after the instruction is executed.

Requirements

None; this dialog box is always available.

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 126.

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 111.

Conditions

Specify simple or complex conditions:

Expression

Specify a valid C-SPY expression, see *C-SPY expressions*, page 80.

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.

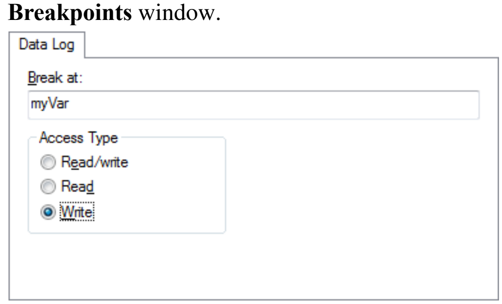
Note: Real-time execution performance of your application on hardware will deteriorate unless a data breakpoint condition fulfills these criteria:

- An expression must be on the form `variable operand constant`, where `variable` is the variable that the data breakpoint is set on, `operand` is either `==` or `!=`, and `constant` is a decimal or hexadecimal numerical constant.
- **Condition true** must be selected, not **Condition changed**.

If these conditions are met, real-time execution performance is preserved but the **Skip count** feature will not work.

Data Log breakpoints dialog box

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



This figure reflects the C-SPY simulator.

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 108.

See also *Data Log breakpoints*, page 105 and *Getting started using data logging*, page 195.

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 memory access that triggers the breakpoint:

Read/Write

Reads from or writes to location.

Read

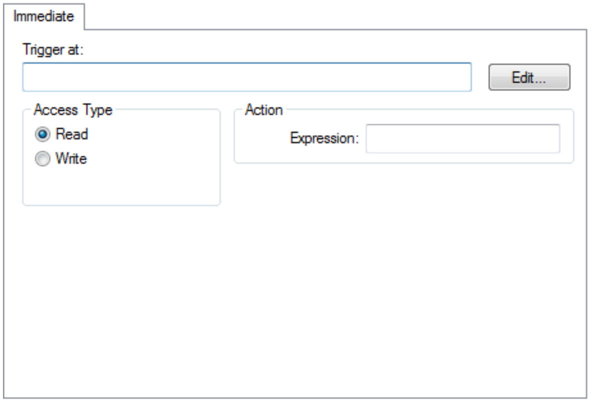
Reads from location.

Write

Writes to location.

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.



In the C-SPY simulator, use the **Immediate** breakpoints dialog box to set an immediate breakpoint, see *Setting breakpoints using the dialog box*, page 108. 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 126.

Access Type

Selects the type of memory access that triggers the breakpoint:

Read

Reads from location.

Write

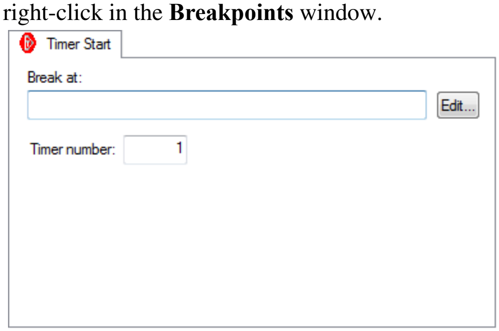
Writes to location.

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 111.

Timer Start breakpoints dialog box

The **Timer 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 Timer Start breakpoint where you want to start a timer to measure the execution time between two execution points. You must also set a Timer Stop breakpoint where you want the timer to stop. The executed time is displayed in the **Debug Log** window.

See also *Timer Stop breakpoints dialog box*, page 124.

To set a Timer Start breakpoint:

1 In the editor or **Disassembly** window, right-click and choose **Timer Start** from the context menu. Note that when you set a breakpoint this way, the timer number is always set to `1`. You can change the timer number in the **Timer Start** breakpoint dialog box.

Alternatively, open the **Breakpoints** window by choosing **View>Breakpoints**.

2 In the **Breakpoints** window, right-click and choose **New Breakpoint>Timer 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.

4 In the **Timer number** text box, specify which timer the breakpoint will start. Click **OK**.

5 When the breakpoint is triggered, the timer with the specified number starts.

Requirements

The C-SPY E1/E2/E20 driver.

Break at

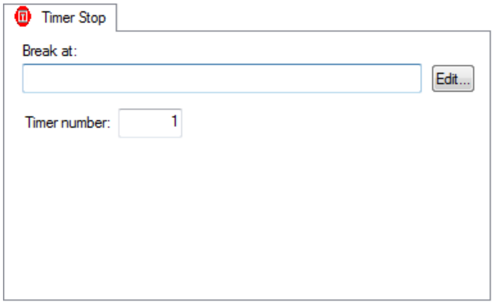
Specify the code location of the breakpoint. Alternatively, click the **Edit** button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 126.

Timer number

Specify an integer from `1–16` to identify the timer you are defining.

Timer Stop breakpoints dialog box

The **Timer 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 Timer Stop breakpoint where you want to stop a timer that measures the execution time between two execution points. You must also set a Timer Start breakpoint where you want the timer to start. The executed time is displayed in the **Debug Log** window.

See also *Timer Start breakpoints dialog box*, page 123.

To set a Timer Stop breakpoint:

1 In the editor or **Disassembly** window, right-click and choose **Timer Stop** from the context menu. Note that when you set a breakpoint this way, the timer number is always set to `1`. You can change the timer number in the **Timer Stop** breakpoint dialog box.

   Alternatively, open the **Breakpoints** window by choosing **View>Breakpoints**.

2 In the **Breakpoints** window, right-click and choose **New Breakpoint>Timer 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.

4 In the **Timer number** text box, specify which timer the breakpoint will stop. Click **OK**.

5 When the breakpoint is triggered, the timer with the specified number stops.

Requirements

The C-SPY E1/E2/E20 driver.

Break at

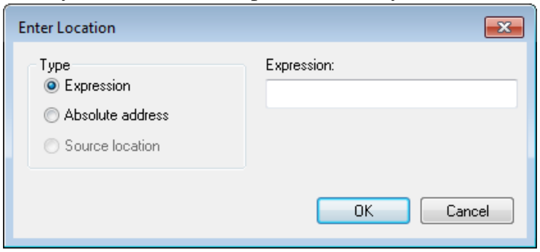
Specify the code location of the breakpoint. Alternatively, click the **Edit** button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 126.

Timer number

Specify an integer from `1–16` to identify the timer you are defining.

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 80.

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 130.

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.

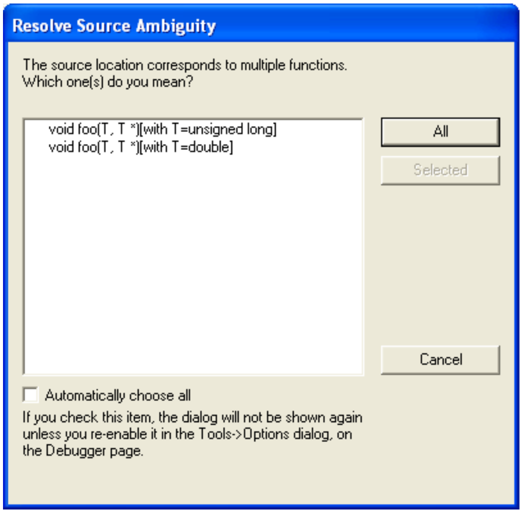
`column` specifies the column in which you want the breakpoint.

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.



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 RH850*.

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
- Memory configuration for C-SPY hardware debugger drivers

BRIEFLY ABOUT MONITORING MEMORY AND REGISTERS

C-SPY provides many windows for monitoring memory and registers, each 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

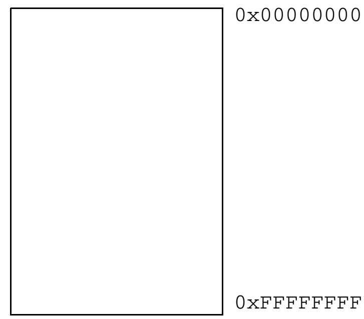
  Displays the currently defined SFRs that C-SPY has information about, both factory-defined (retrieved from the device description file) and custom-defined SFRs. If required, you can use the **Edit SFR** dialog box to customize the SFR definitions.

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 RH850 architecture has one zone, `Memory`, which covers the whole RH850 memory range.



Default zone `Memory`

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 41 and *Modifying a device description file*, page 45.

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 Configuration dialog box, for the C-SPY simulator*, page 162.

MEMORY CONFIGURATION FOR C-SPY HARDWARE DEBUGGER DRIVERS

To handle memory as efficiently as possible during debugging, C-SPY needs information about the memory configuration. By default, C-SPY uses a configuration based on information retrieved from the device description file.

You should make sure the memory address ranges match the memory available on your device. Providing C-SPY with information about the memory layout of the target system is helpful in terms of both performance and functionality:

- Reading (and writing) memory (if your debug probe is connected through a USB port) can be fast, but is usually the limiting factor when C-SPY needs to update many debugger windows. C-SPY can cache memory contents to speed up performance, provided it has correct information about the target memory.
- You can inform C-SPY that the content of certain memory address ranges will not be changed during a debug session. C-SPY can keep a copy of that memory readable even when the target system does not normally allow reading (such as when it is executing).

  Note that if you specify the cache type **ROM/Flash**, C-SPY treats such memory as constant during the whole debug session (which improves efficiency, when updating some C-SPY windows). If your application modifies flash memory during runtime, do not use the **ROM/Flash** cache type.
- You can prevent C-SPY from accessing memory outside specified memory address ranges, which can be important for certain hardware.

The **Memory Configuration** dialog box is automatically displayed the first time you start the C-SPY driver for a given project, unless the device description file contains a memory description which is explicitly tagged as correct and complete. Subsequent starts will not display the dialog box unless you have made project changes that might cause the memory configuration to change, for example if you have selected another device description file.

For more information, see *Memory Configuration dialog box, in C-SPY hardware debugger drivers*, page 166.

Monitoring memory and registers

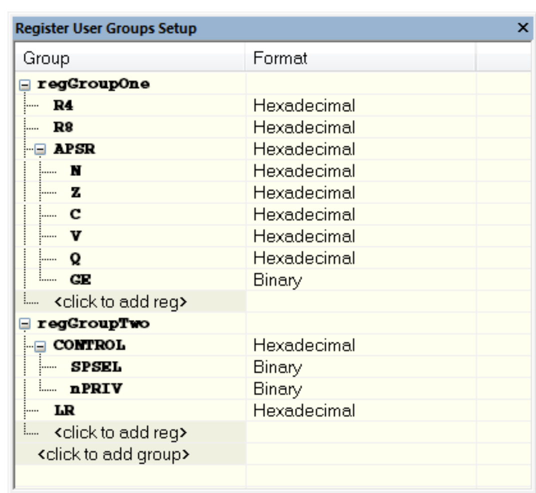
These tasks are covered:

- *Defining application-specific register groups*, page 133
- *Monitoring stack usage*, page 134

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.



Right-clicking in the window displays a context menu with commands. For information about these commands, see *Register User Groups Setup window*, page 155.

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.

Note: If a certain SFR that you need cannot be added to a group, you can register your own SFRs. For more information, see *SFR Setup window*, page 157.

MONITORING STACK USAGE

These are the two main use cases for the **Stack** window:

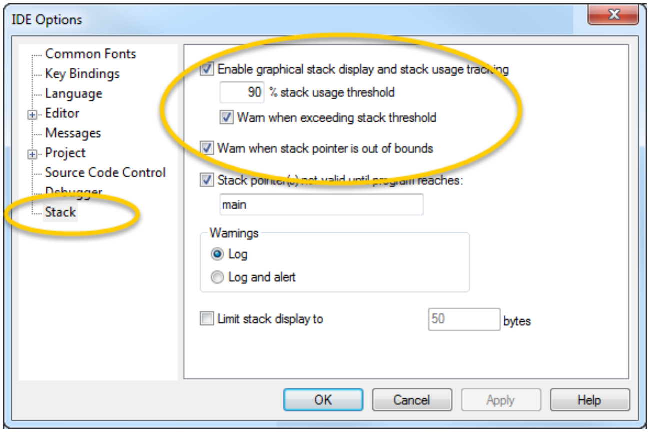
- Monitoring stack memory usage
- Monitoring the stack memory content.

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 about this, see the *IAR C/C++ Development Guide for RH850*.

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.
- Notice also the option **Warn when stack pointer is out of bounds**. Any such warnings are displayed in the **Debug Log** window.



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.

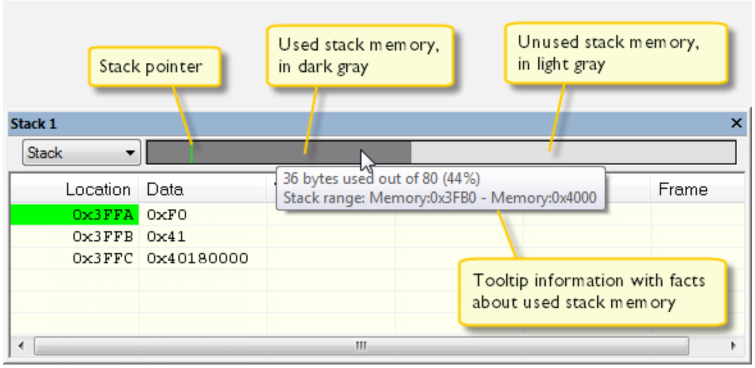
3 Choose **View>Stack>Stack 1** to open the **Stack** window.

Notice 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:



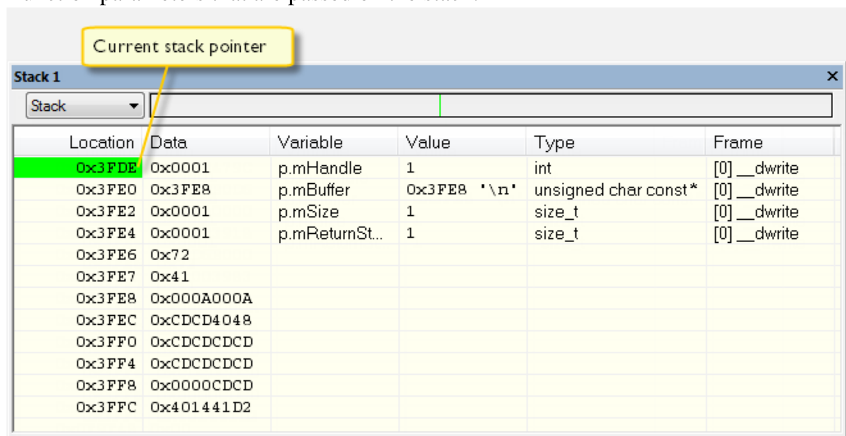
Note: Although this is a reasonably reliable way to track stack usage, there is no guarantee that a stack overflow is detected. For example, a stack *can* incorrectly grow outside its bounds, and even modify memory outside the stack area, without actually modifying any of the bytes near the end of the 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.

   Notice 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:

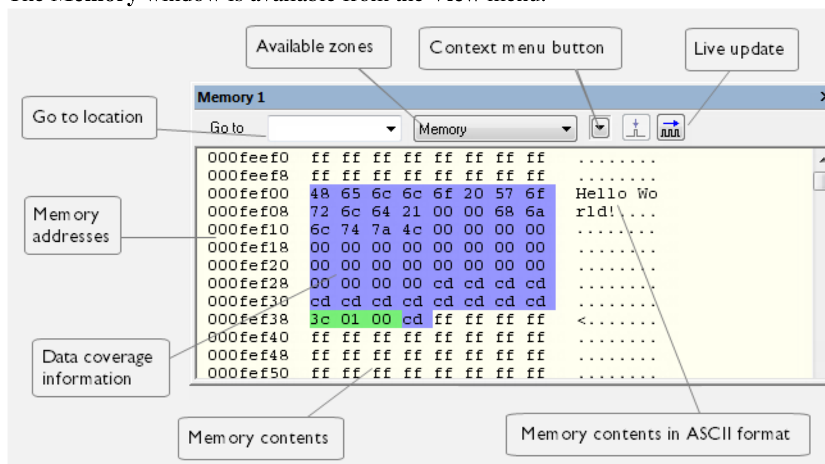


Reference information on memory and registers

Reference information about:

Memory window

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



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 44.

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 130.

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.

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.

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.

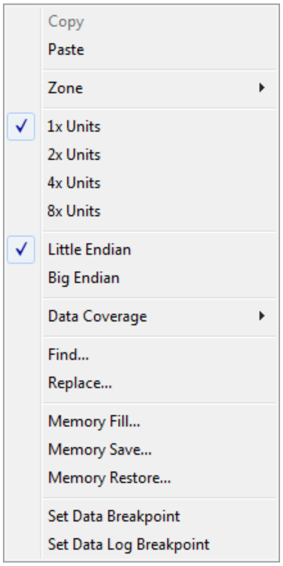
Data coverage is displayed with these colors:

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 130.

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 RH850*.

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 RH850*.

Memory Fill

Displays a dialog box, where you can fill a specified area with a value, see *Fill dialog box*, page 144.

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 142.

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 143.

Set Data Breakpoint

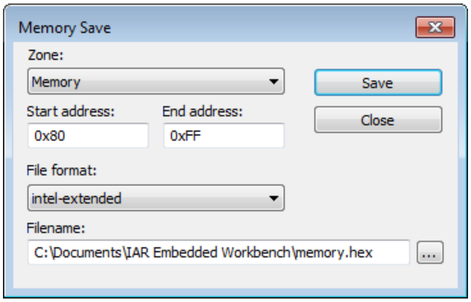
Sets breakpoints directly in the **Memory** window. The breakpoint is not highlighted; you can see, edit, and remove it in the **Breakpoints** dialog box. The breakpoints you set in this window will be triggered for both read and write access. For more information, see *Setting a data breakpoint in the Memory window*, page 110.

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 105 and *Getting started using data logging*, page 195.

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.



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 130.

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

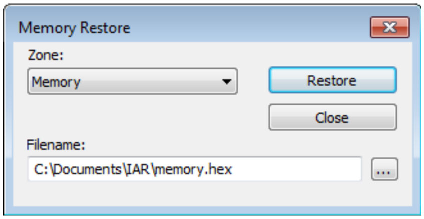
Specify the destination file to be used; a browse button is available for your convenience.

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.



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 130.

Filename

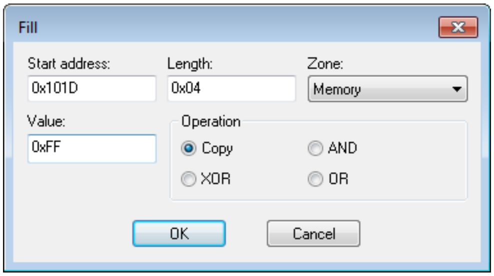
Specify the file to be read; a browse button is available for your convenience.

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.



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 130.

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

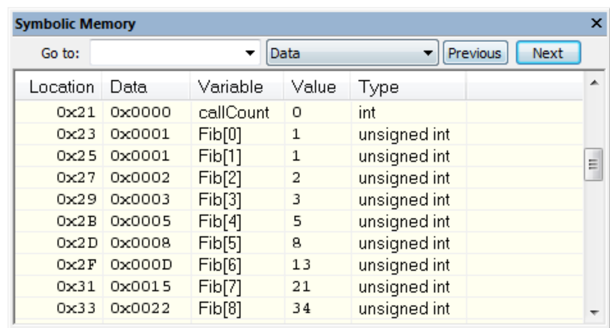
An `XOR` operation will be performed between Value and the existing contents of memory before writing the result to memory.

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.



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 44.

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 130.

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.

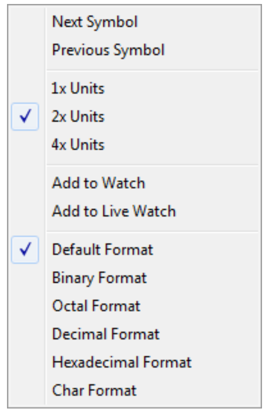
There are several different ways to navigate within the memory space:

- 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 which 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

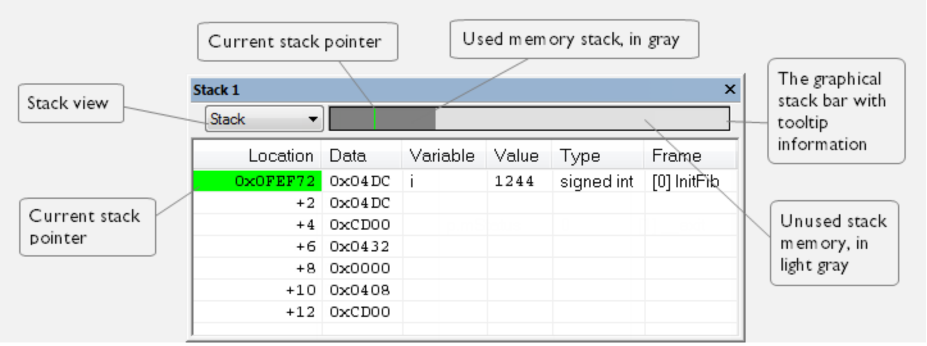
Displays the memory contents in hexadecimal format.

Char format

Displays the memory contents in char format.

Stack window

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



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 106.

For information about options specific to the **Stack** window, see the *IDE Project Management and Building Guide for RH850*.

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

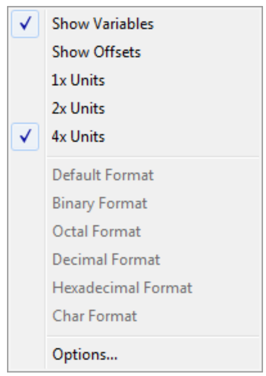
Displays the data type of the variable.

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:

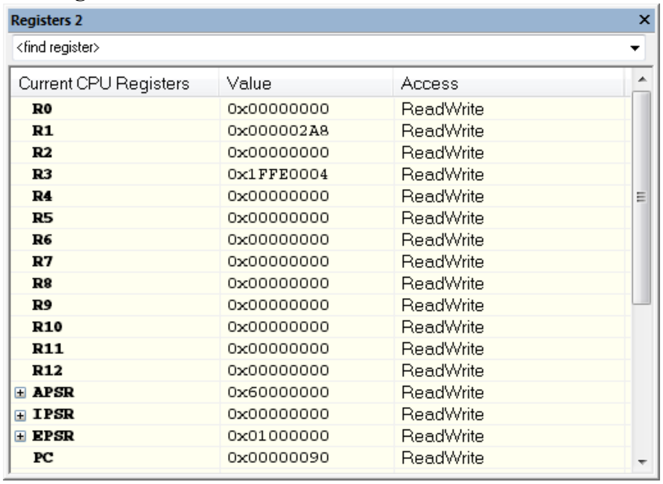
Variables	The display setting affects only the selected variable, not other variables.
Array elements	The display setting affects the complete array, that is, the same display format is used for each array element.
Structure fields	All elements with the same definition—the same field name and C declaration 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 RH850*.

Registers window

The **Registers** windows are available from the **View** menu.



These windows give an up-to-date display of the contents of the processor registers and special function registers, and allows you to edit the content 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 very convenient if you want to keep track of different register groups.

See also *Editing in C-SPY windows*, page 44.

To enable predefined register groups:

1. Select a device description file that suits your device, see *Selecting a device description file*, page 41.
2. Display the register groups that are defined in the device description file in the **Registers** window 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 133.

Requirements

None; this window is always available.

Toolbar

The toolbar contains:

<find register>

Specify the name of a register that you want to find. Press the Enter key and the first register group where this register is found is displayed. User-defined register groups are not searched. The register search box has a history depth of 20 search entries.

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.

Register group 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 it 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, some of the registers 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:

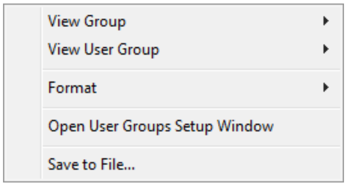
TIME Cleared when an application is started or reset and is incremented with the elapsed time during application execution. The time is displayed in nanoseconds.

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, by default **CPU Registers**. 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. If some of your SFRs are missing, you can register your own SFRs in a Custom group, see *SFR Setup window*, page 157.

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 133.

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

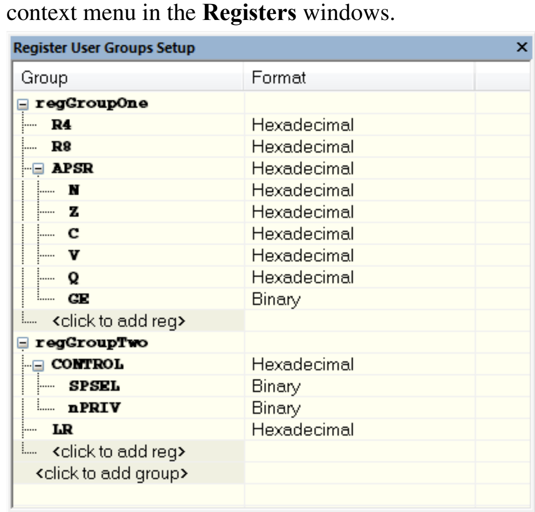
Opens a window where you can create your own user-defined register groups, see *Register User Groups Setup window*, page 155.

Save to File

Opens a standard save dialog box to save the contents of the window to a tab-separated text file.

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.



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.

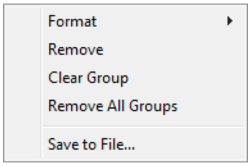
A dimmed register name indicates that it is not supported by the selected device.

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

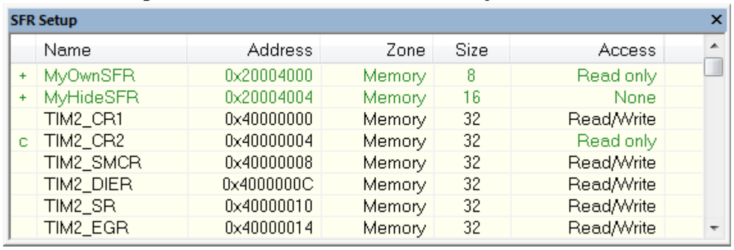
Deletes all user-defined register groups from your project.

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.



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 160. 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 130.

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`.

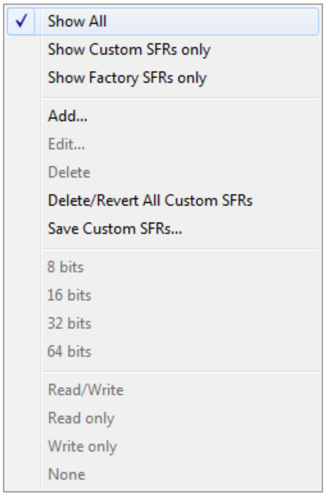
You can click a column header to sort the SFRs according to the column property.

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 160.

Edit

Displays the **Edit SFR** dialog box where you can edit an SFR, see *Edit SFR dialog box*, page 160.

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

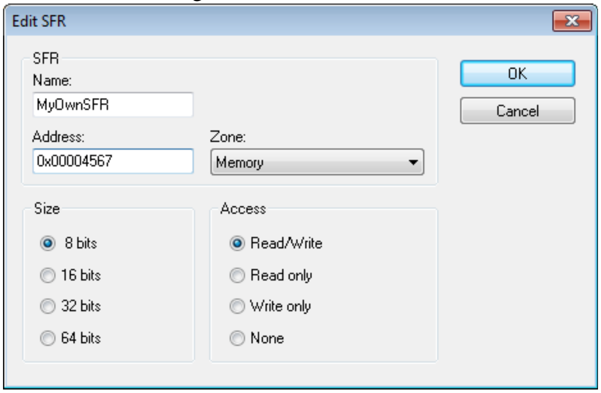
Selects display format for the selected SFR, which can be **8**, **16**, **32**, or **64** bits. Note that the display format can only be changed for custom-defined SFRs.

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.



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 157.

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

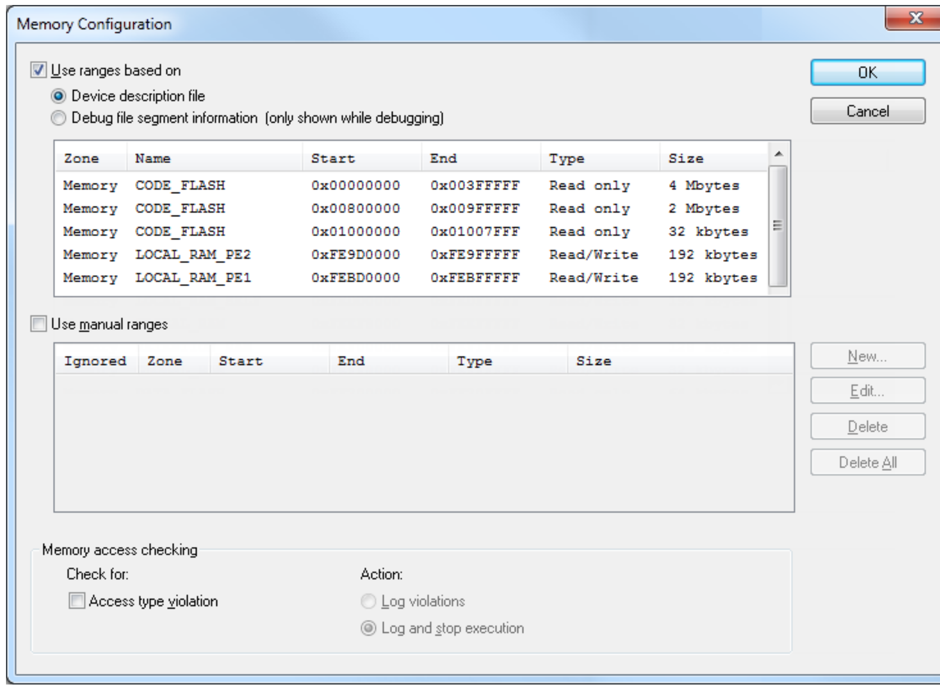
Selects the size of the SFR. Choose between **8**, **16**, **32**, or **64** bits. Note that the display format can only be changed for custom-defined SFRs.

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 Configuration dialog box, for the C-SPY simulator

The **Memory Configuration** dialog box is available from the C-SPY driver menu.



Use this dialog box to specify which set of memory address ranges to be used by C-SPY during debugging.

See also *Memory configuration for the C-SPY simulator*, page 131.

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 41.

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.

Memory information is displayed in these columns:

Zone

The memory zone, see *C-SPY memory zones*, page 130.

Name

The name of the memory address range.

Start

The start address for the memory address range, in hexadecimal notation.

End

The end address for the memory address range, in hexadecimal notation.

Type

The access type of the memory address range.

Size

The size of the memory address range.

Use manual ranges

Specify your own ranges manually via the **Edit Memory Range** dialog box. To open this dialog box, click **New** to specify a new memory address range, or select an existing memory address range and click **Edit** to modify it. For more information, see *Edit Memory Range dialog box, for the C-SPY simulator*, page 164.

The ranges you define manually are saved between debug sessions.

An **X** in the column **Ignored** means that C-SPY has detected that the specified manual range is illegal, for example because it overlaps another range. C-SPY will not use such an area.

Memory access checking

Check for determines what to check for:

- **Access type violation**.

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 the manual ranges:

New

Opens the **Edit Memory Range** dialog box, where you can specify a new memory address range and associate an access type with it, see *Edit Memory Range dialog box, for the C-SPY simulator*, page 164.

Edit

Opens the **Edit Memory Range** dialog box, where you can edit the selected memory address range. See *Edit Memory Range dialog box, for the C-SPY simulator*, page 164.

Delete

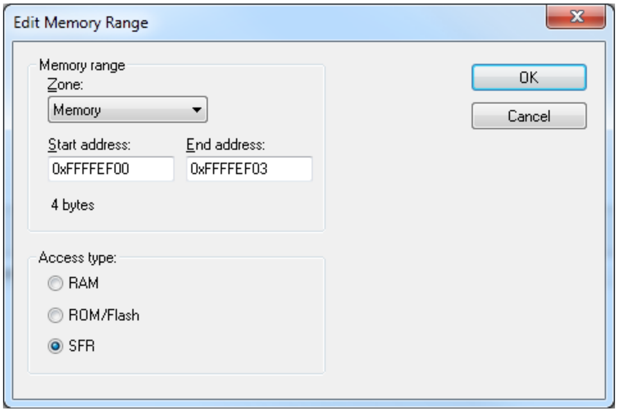
Deletes the selected memory address range definition.

Delete All

Deletes all defined memory address range definitions.

Edit Memory Range dialog box, for the C-SPY simulator

The **Edit Memory Range** dialog box is available from the **Memory Configuration** dialog box.



Use this dialog box to specify your own memory address ranges, and their access types.

See also *Memory Configuration dialog box, for the C-SPY simulator*, page 162

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 130.

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.

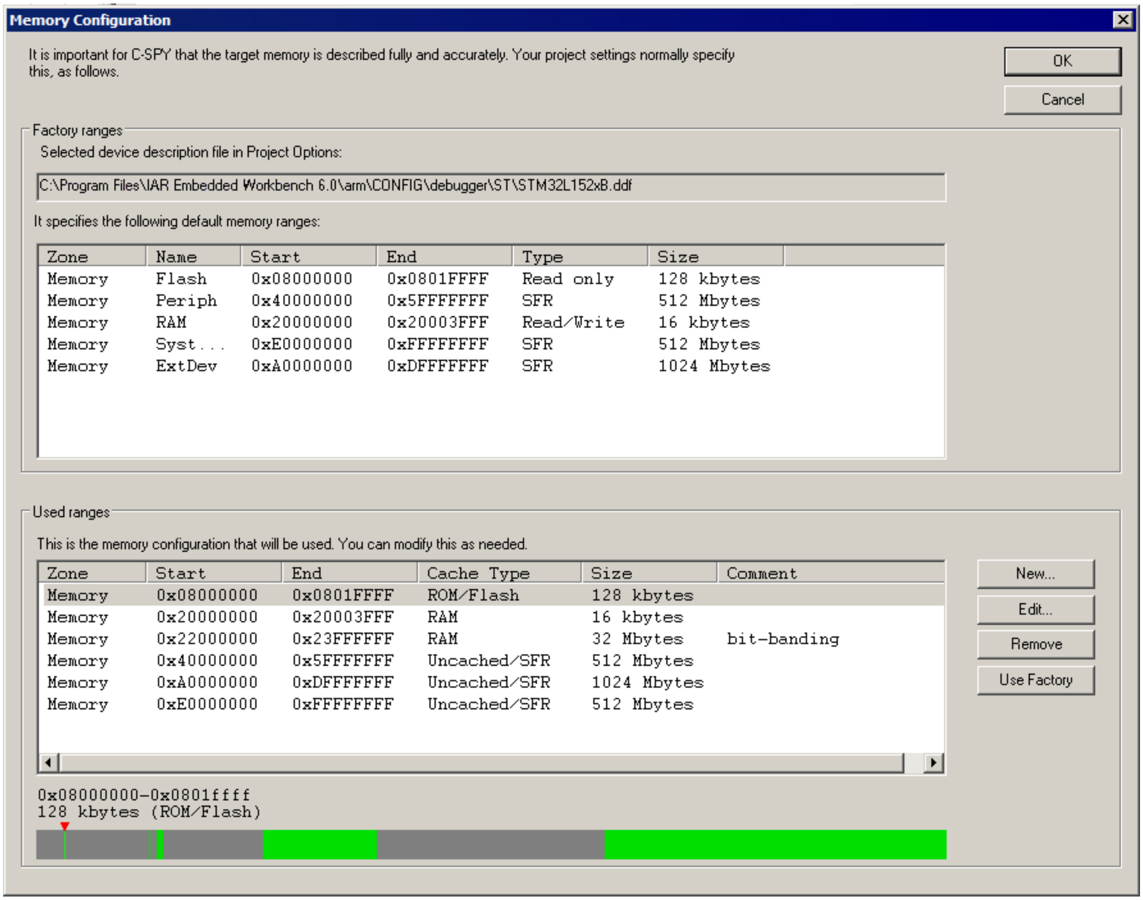
Access type

Selects an access type for the memory address range. Choose between:

- **RAM**, for read/write memory
- **ROM/Flash**, for read-only memory
- **SFR**, for SFR read/write memory.

Memory Configuration dialog box, in C-SPY hardware debugger drivers

The **Memory Configuration** dialog box is available from the C-SPY driver menu.



C-SPY uses a default memory configuration based on information retrieved from the device description file that you select, or if memory configuration is missing in the device description file, tries to provide a usable factory default. See *Selecting a device description file*, page 41.

Use this dialog box to verify, and if needed, modify the memory areas so that they match the memory available on your device. Providing C-SPY with information about the memory layout of the target system is helpful both in terms of performance and functionality:

- Reading (and writing) memory (if your debug probe is connected through a USB port) can be fast, but is usually the limiting factor when C-SPY needs to update many debugger windows. Caching memory can speed up the performance, but then C-SPY needs information about the target memory.
- If C-SPY has been informed that the content of certain memory areas will be changed during a debug session, C-SPY can keep a copy of that memory readable even when the target does not normally allow reading (such as when executing).
- C-SPY can prevent accesses to areas without any memory at all, which can be important for certain hardware.

The **Memory Configuration** dialog box is automatically displayed the first time you start the C-SPY driver for a given project, unless the device description file contains a memory description which is already specified as correct and complete. Subsequent starts will not display the dialog box unless you have made project changes that might cause the memory configuration to change, for example if you have selected another device description file.

You can only change the memory configuration when C-SPY is not running.

See also *Memory configuration for C-SPY hardware debugger drivers*, page 132.

Requirements

The C-SPY E1/E2/E20 driver.

Factory ranges

Identifies which device description file that is currently selected and lists the default memory address ranges retrieved from the file in these columns:

Zone

The memory zone, see *C-SPY memory zones*, page 130.

Name

The name of the memory address range.

Start

The start address for the memory address range, in hexadecimal notation.

End

The end address for the memory address range, in hexadecimal notation.

Type

The access type of the memory address range.

Size

The size of the memory address range.

Used ranges

These columns list the memory address ranges that will be used by C-SPY. The columns are normally identical to the factory ranges, unless you have added, removed, or modified ranges.

Zone

Selects a memory zone, see *C-SPY memory zones*, page 130.

Start

The start address for the memory address range, in hexadecimal notation.

End

The end address for the memory address range, in hexadecimal notation.

Cache Type

The cache type of the memory address range.

Size

The size of the memory address range.

Comment

Memory area information.

Use the buttons to override the default memory address ranges that are retrieved from the device description file.

Graphical bar

A graphical bar that visualizes the entire theoretical memory address range for the device. Defined ranges are highlighted in green.

Buttons

These buttons are available for manual ranges:

New

Opens the **Edit Memory Range** dialog box, where you can specify a new memory address range and associate a cache type with it, see *Edit Memory Range dialog box, for C-SPY hardware debugger drivers*, page 169.

Edit

Opens the **Edit Memory Range** dialog box, where you can edit the selected memory address area. See *Edit Memory Range dialog box, for C-SPY hardware debugger drivers*, page 169.

Remove

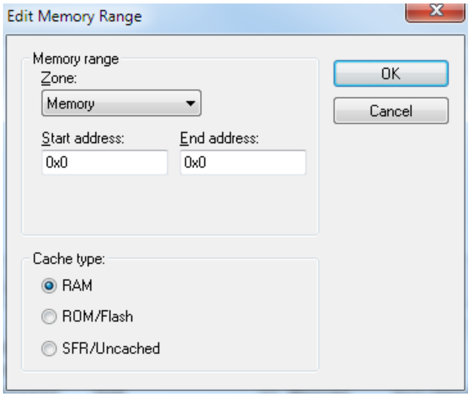
Removes the selected memory address range definition.

Use Factory

Restores the list of used ranges to the factory ranges.

Edit Memory Range dialog box, for C-SPY hardware debugger drivers

The **Edit Memory Range** dialog box is available from the **Memory Configuration** dialog box.



Use this dialog box to specify the memory address ranges, and assign a cache type to each range.

See also *Memory configuration for C-SPY hardware debugger drivers*, page 132.

Requirements

The C-SPY E1/E2/E20 driver.

Memory range

Defines the memory address range specific to your device:

Zone

Selects a memory zone, see *C-SPY memory zones*, page 130.

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.

Cache type

Selects a cache type to the memory address range. Choose between:

RAM

When the target CPU is not executing, all read accesses from memory are loaded into the cache. For example, if two **Memory** windows show the same part of memory, the actual memory is only read once from the hardware to update both windows. If you modify memory from a C-SPY window, your data is written to cache only. Before any target execution, even stepping a single machine instruction, the RAM cache is flushed so that all modified bytes are written to the memory on your hardware.

ROM/Flash

This memory is assumed not to change during a debug session. Any code within such a range that is downloaded when you start a debug session (or technically, any such code that is part of the application being debugged) is stored in the cache and remains there. Other parts of such ranges are loaded into the cache from memory on demand, but are then kept during the debug session. Note that C-SPY will not allow you to modify such memory from C-SPY windows.

Even though flash memory is normally used as a fixed read-only memory, there are applications that modify parts of flash memory at runtime. For example, some part of flash memory might be used for a file system or simply to store non-volatile information. To reflect this in C-SPY, you should choose the **RAM** cache type for those instead. Then C-SPY will assume that those parts can change at any time during execution.

SFR/Uncached

A range of this type is completely uncached. All read or write commands from a C-SPY window will access the hardware immediately. Typically, this type is useful for special function registers, which can have all sorts of unusual behavior, such as having different values at every read access. This can in turn have side-effects on other registers when they are written, not containing the same value as was previously written, etc.

If you do not have the appropriate information about your device, you can specify an entire memory as **SFR/Uncached**. This is not incorrect, but might make C-SPY slower when updating windows. In fact, this caching type is sometimes used by the default when there is no memory address range information available.

If required, you can disable caching; choose ***C-SPY driver*>Disable Debugger Cache**.

Part 2. Analyzing your application

This part of the *C-SPY® Debugging Guide for RH850* includes these chapters:

- Trace
- The application timeline
- Profiling
- Analyzing code performance
- Code coverage

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 195
- *Getting started using interrupt logging*, page 256
- *Profiling*, page 219

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.

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.

Note: Because interrupt logging uses the trace data, trace and interrupt logging cannot be used simultaneously. If you use interrupt logging, you should disable trace, and vice versa.

REQUIREMENTS FOR USING TRACE

Both the C-SPY simulator and the E1/E2/E20 emulator support trace-related functionality, and there are no specific requirements.

Collecting and using trace data

These tasks are covered:

- Getting started with trace
- Trace data collection using breakpoints
- Searching in trace data
- Browsing through trace data.

GETTING STARTED WITH TRACE

To collect trace data using the C-SPY simulator, no specific build settings are required.

To get started using trace:

1. After you have built your application and started C-SPY, open the Trace window—available from the driver-specific menu—and click the **Activate** button to enable collecting trace data.
2. 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 178.

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 **Trace Start** or **Trace Stop**.
- 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 184 and *Trace Stop breakpoints dialog box*, page 185, respectively.

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.

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 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 188.
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 189.

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.

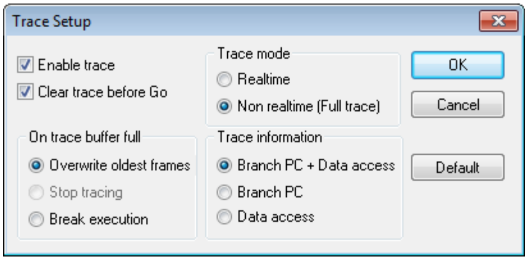
Reference information on trace

Reference information about:

- *Trace Setup dialog box*, page 177
- *Trace window*, page 178
- *Function Trace window*, page 183
- *Trace Start breakpoints dialog box*, page 184
- *Trace Stop breakpoints dialog box*, page 185
- *Trace Expressions window*, page 186
- *Find in Trace dialog box*, page 188
- *Find in Trace window*, page 189.

Trace Setup dialog box

The **Trace Setup** dialog box is available from the C-SPY driver menu.



Use this dialog box to configure trace generation and collection. Some of these settings are also used by the interrupt logging.

See also *Getting started with trace*, page 174.

Requirements

The C-SPY E1/E2/E20 driver. Note that trace requires that interrupt logging is disabled.

Enable trace

Enables trace data collection.

Clear trace before Go

Empties the trace buffer before each Go or step command is performed.

On trace buffer full

Controls what C-SPY does when the trace buffer is full. Choose between:

Overwrite oldest frames

The oldest frames are overwritten until a break occurs. If trace is disabled and interrupt logging is enabled, this setting means that the **Interrupt Log** window will display the last log entries before the break (~500 entries).

Stop tracing

The trace stops when the trace buffer is full.

Break execution

The trace stops and execution breaks when the trace buffer is full. If trace is disabled and interrupt logging is enabled, the **Interrupt Log** window will display all log entries in the buffer (~500 entries).

Trace mode

Controls how the trace collection is performed. Choose between:

Realtime

Trace is performed at full execution speed. At this speed, some trace data will not be collected, leading to gaps in the information displayed in the Trace window.

Non realtime (Full trace)

A full trace is performed. The trace collection starts at any Go or step command, and stops at break.

Trace information

Determines which types of trace data that C-SPY collects. Choose between:

Branch PC + Data access

Collects both the contents of the program counter on branches, and data access information.

Branch PC

Collects the contents of the program counter on branches that occurred during program execution.

Data access

Collects data access information.

Default

Restores the default settings.

Trace window

The **Trace** window is available from the C-SPY driver menu.

This window displays the collected trace data.

The content of the **Trace** window depends on the C-SPY driver you are using.

See also *Collecting and using trace data*, page 174.

Requirements

None; this window is always available.

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

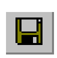
Toggles the **Trace** column between showing only disassembly or disassembly together with the corresponding source code.

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 188.



Save

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 C-SPY E1 and C-SPY E2 emulator drivers, this button displays the **Trace Setup** dialog box, see *Trace Setup dialog box*, page 177.

Edit Expressions (C-SPY simulator only)

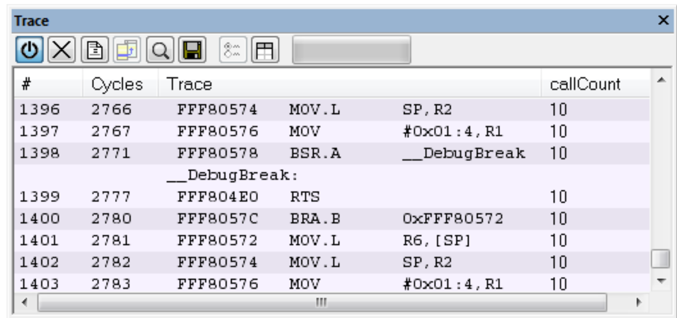
Opens the **Trace Expressions** window, see *Trace Expressions window*, page 186.

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.



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.

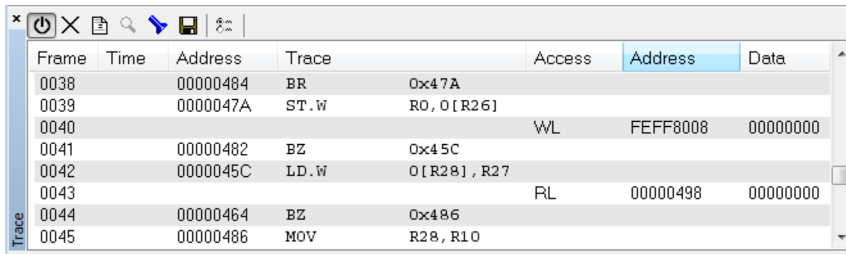
Expression

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 186.

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 (in the C-SPY E1 and C-SPY E2 drivers)

This area contains these columns for the C-SPY E1and C-SPY E2 drivers:



Frame

The frame number for trace data from the hardware debugger system. Restarts from zero each time data is collected.

Time

The timestamp of the collected PC information.

Address

The memory address of the branch destination.

Trace

The collected sequence of executed machine instructions. Optionally, the corresponding source code can also be displayed.

Access

The type of the memory access, `R` for read or `W` for write, and the size of the data read or written, `B` for byte, `W` for word, `L` for long, or `Q` for quad (64-bit data).

Address

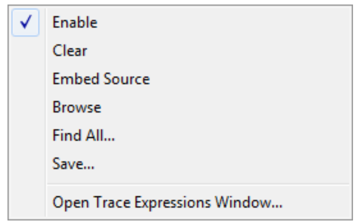
The memory address where the data access occurred.

Data

The data value that was read or written to the 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:

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.

Find All

Displays a dialog box where you can perform a search in the **Trace** window, see *Find in Trace dialog box*, page 188. The search results are displayed in the **Find in Trace** window—available by choosing the **View>Messages** command, see *Find in Trace window*, page 189.

Save

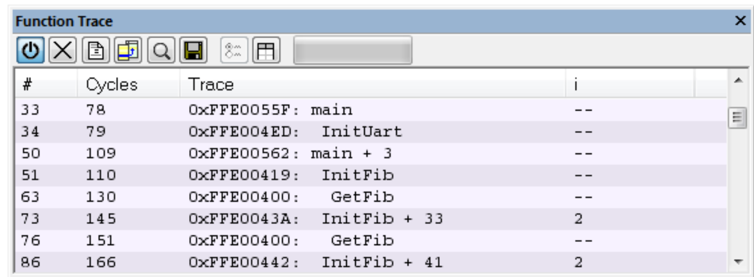
Displays a standard **Save As** dialog box where you can save the collected trace data to a text file, with tab-separated columns.

Open Trace Expressions Window

Opens the **Trace Expressions** window, see *Trace Expressions window*, page 186.

Function Trace window

The **Function Trace** window is available from the C-SPY driver menu during a debug session.



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.

See also *Memory configuration for the C-SPY simulator*, page 131.

Requirements

The C-SPY simulator.

Toolbar

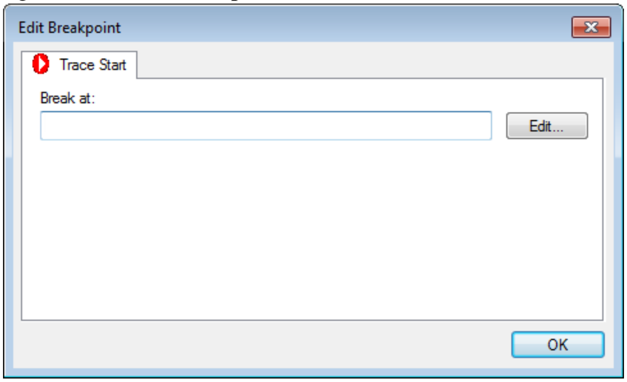
For information about the toolbar, see *Trace window*, page 178.

Display area

For information about the columns in the display area, see *Trace window*, page 178.

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 185 and *Trace data collection using breakpoints*, page 175.

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

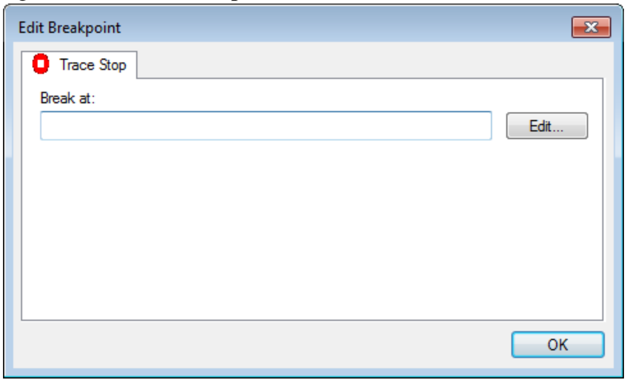
None; this window is always available.

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 126.

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 184 and *Trace data collection using breakpoints*, page 175.

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

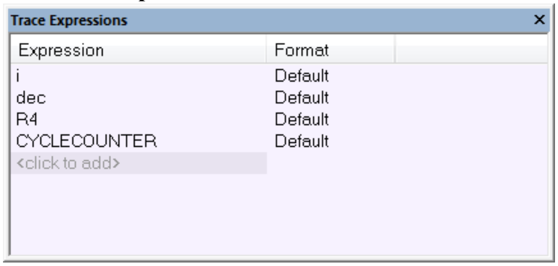
None; this window is always available.

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 126.

Trace Expressions window

The **Trace Expressions** window is available from the **Trace** window toolbar.



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.

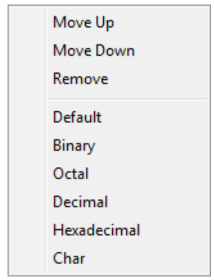
Format

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.

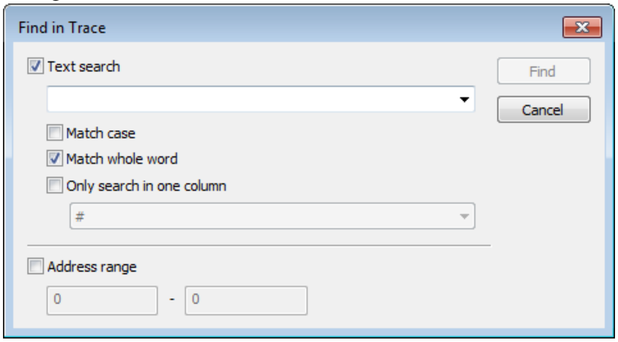
The display format setting affects different types of expressions in these ways:

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.



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 189.

See also *Searching in trace data*, page 175.

Requirements

None; this window is always available.

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** and **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

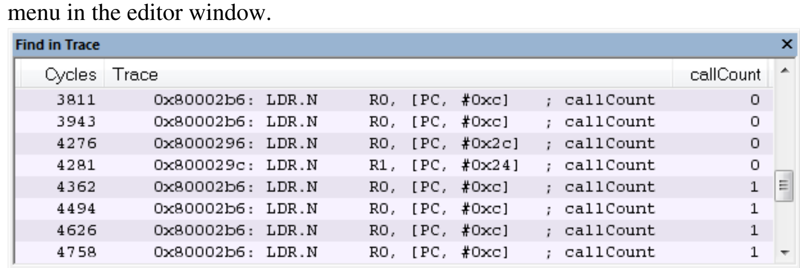
Searches only in the column you selected from the drop-down list.

Address Range

Specify the address range you want to display or search. The trace data within the address range is displayed. If you also have specified a text string in the **Text search** field, the text string is searched for within the address range.

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.



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 188.

See also *Searching in trace data*, page 175.

Requirements

None; this window is always available.

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.

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 173

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.

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 70 and *Function Trace window*, page 183, 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.
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*.

REQUIREMENTS FOR TIMELINE SUPPORT

Trace-based timeline information is supported for:

Target system	Call Stack	Data Logs	Interrupt Logs
C-SPY simulator	Yes	Yes	Yes
C-SPY hardware debugger drivers	—	—	Yes

Table 7: Supported graphs in the Timeline window

For more information about requirements related to trace data, see *Requirements for using trace*, page 174.

Analyzing your application's timeline

These tasks are covered:

- *Displaying a graph in the Timeline window*, page 193
- *Navigating in the graphs*, page 193
- *Analyzing performance using the graph data*, page 194
- *Getting started using data logging*, page 195
- *Getting started using data sampling*, page 196

See also:

- *Using the interrupt system*, page 254

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 191.

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 121.
5. 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 193, 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.

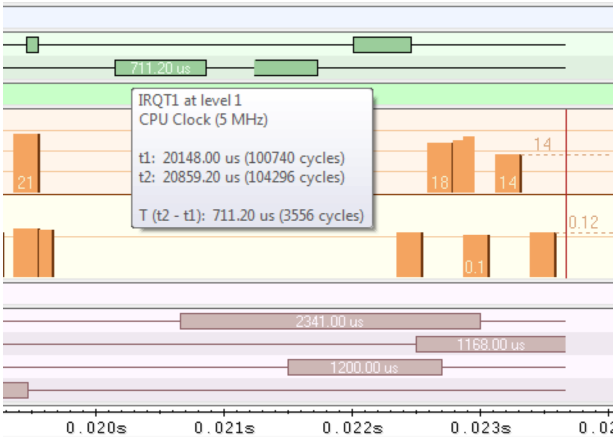
ANALYZING PERFORMANCE USING THE GRAPH DATA

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.

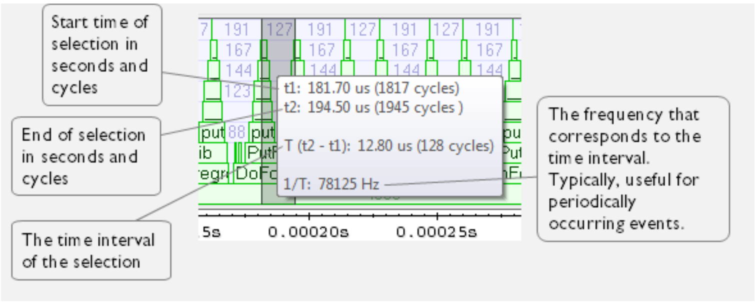
2. Execute your application to display a graph, following the steps described in *Displaying a graph in the Timeline window*, page 193.

3. Whenever execution stops, point at the graph with the mouse pointer to get detailed tooltip information for that location.



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.



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 105.

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.

Reference information on application timeline

Reference information about:

- *Timeline window—Call Stack graph*, page 197
- *Timeline window—Data Log graph*, page 200
- *Data Log window*, page 204
- *Data Log Summary window*, page 207
- *Sampled Graphs window*, page 210
- *Data Sample Setup window*, page 213

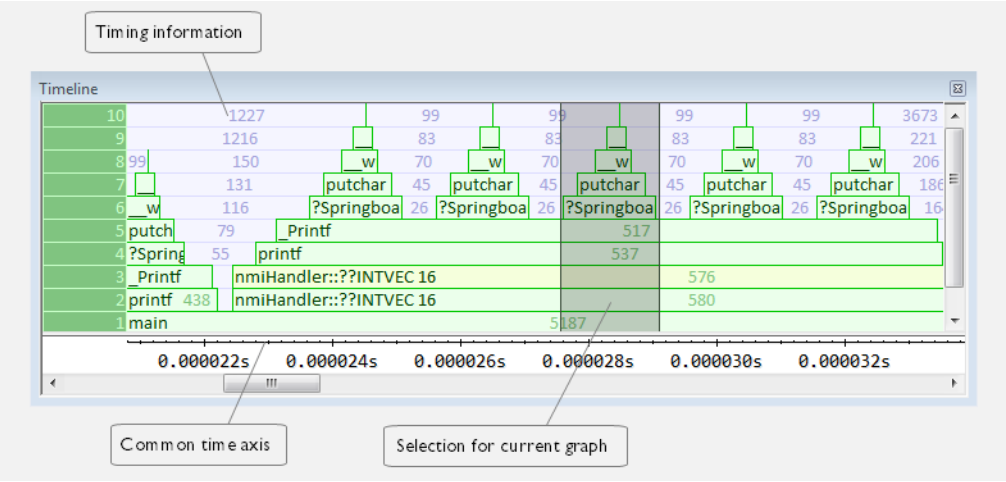
- *Data Sample window*, page 215
- *Viewing Range dialog box*, page 217

See also:

- *Timeline window—Interrupt Log graph*, page 268
- *Interrupt Log window*, page 263
- *Interrupt Log Summary window*, page 266

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 only through an assembler label
- Medium yellow for normal interrupt handlers, with debug information
- Light yellow for interrupt handlers known to the debugger only through an assembler label

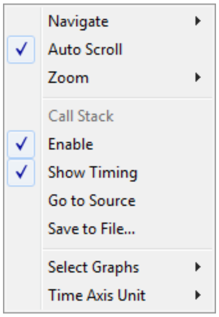
The timing information represents the number of cycles spent in, or between, the function invocations.

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**.

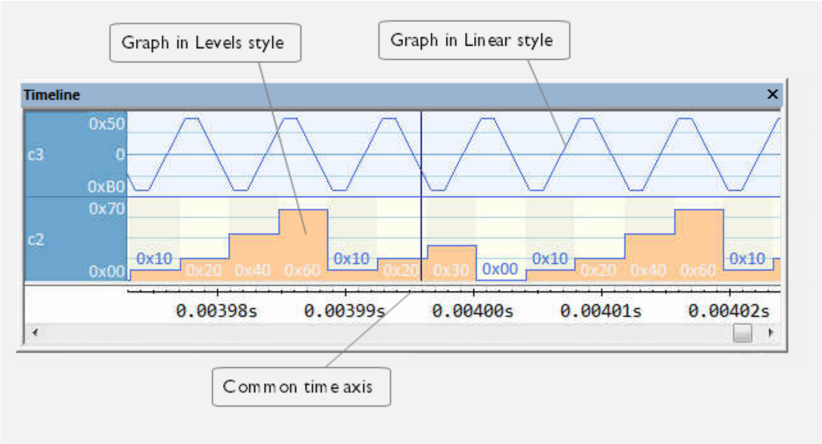
If **Cycles** is not available, the graphs are based on different clock sources. In that case you can view cycle values as tooltip information by pointing at the graph with your mouse pointer.

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

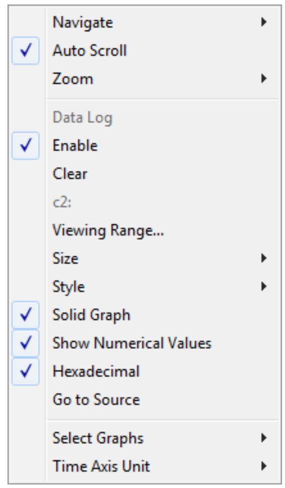
Where:

- 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 204.
- 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 happen also 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 217.

Size

Determines the vertical size of the graph; choose between **Small**, **Medium**, and **Large**.

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.

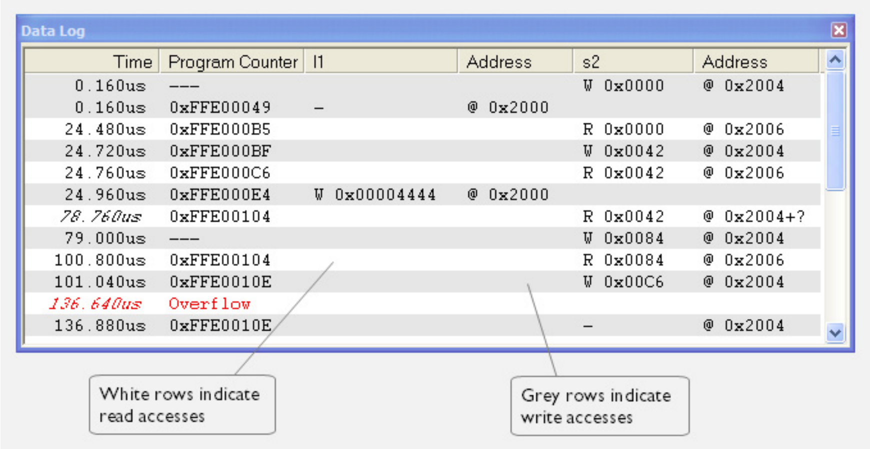
Time Axis Unit

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.



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 195.

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 105.

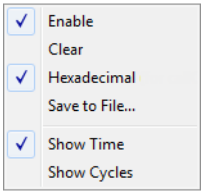
Address

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 happen also 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 195.

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 105.

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|cycles

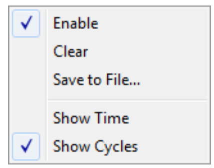
The information displayed depends on the C-SPY driver you are using.

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 happen also 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.

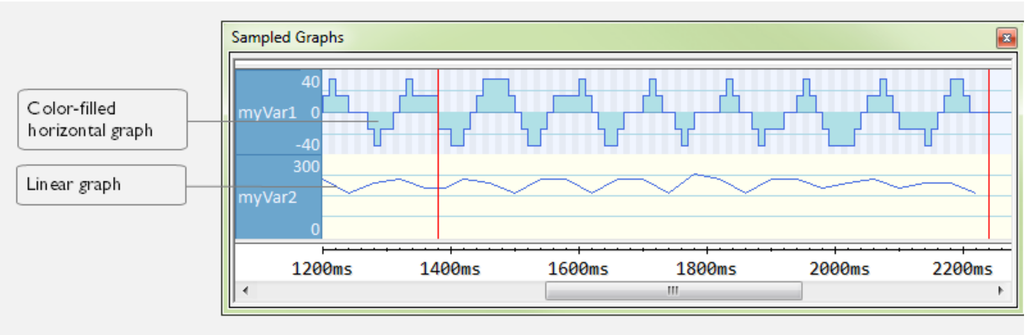
Show Cycles

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 215.
- 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.

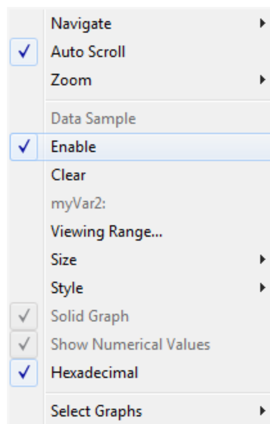
See also *Getting started using data sampling*, page 196.

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 217.

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

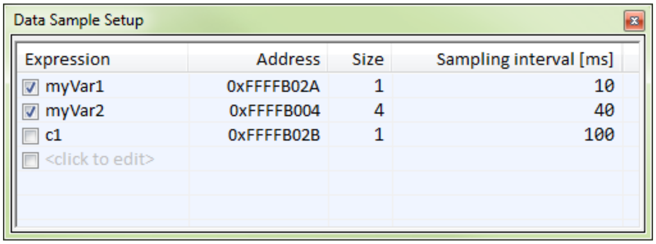
Shows the numerical value of the variable, in addition to the graph.

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.



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 196.

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.

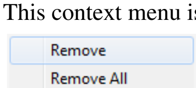
Sampling interval [ms]

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

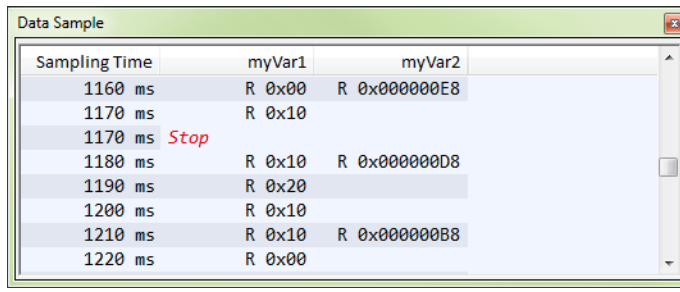
Removes the selected variable.

Remove All

Removes all variables.

Data Sample window

The **Data Sample** window is available from the C-SPY driver menu.



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 196.

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

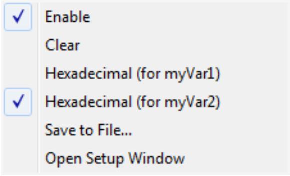
The column headers display the names of the variables that you selected in the **Data Sample Setup** window. The column cells display the sampling values for the variable.

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.

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

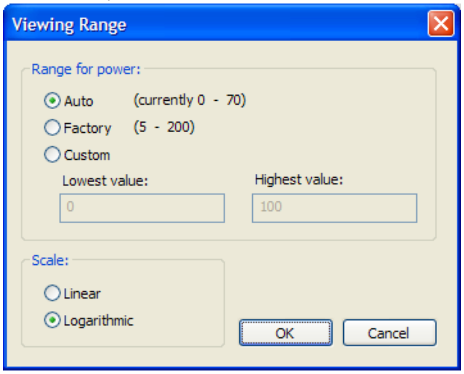
Displays a standard file selection dialog box where you can select the destination file for the log information. The entries in the log file are separated by `TAB` and `LF` characters. An **X** in the **Approx** column indicates that the timestamp is an approximation.

Open setup window

Opens the **Data Sample Setup** window.

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.



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
- Using the profiler
- Reference information on the profiler

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 RH850*.

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 support the profiler; there are no specific requirements.

This table lists the C-SPY driver profiling support:

C-SPY driver	Trace (calls)	Trace (flat)
C-SPY simulator	X	X
C-SPY hardware debugger driver	—	—

Table 8: C-SPY driver profiling support

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
Linker	Output>Include debug information in output

Table 9: Project options for enabling the profiler

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.

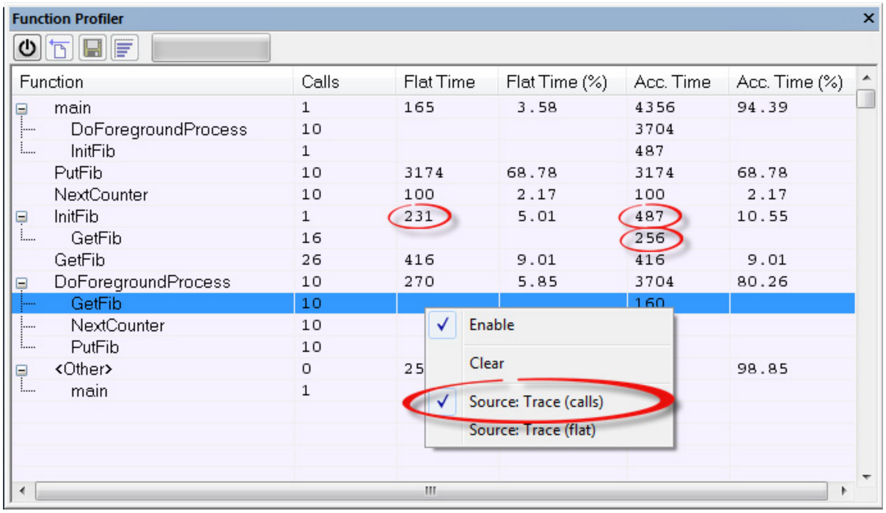
ANALYZING THE PROFILING DATA

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.

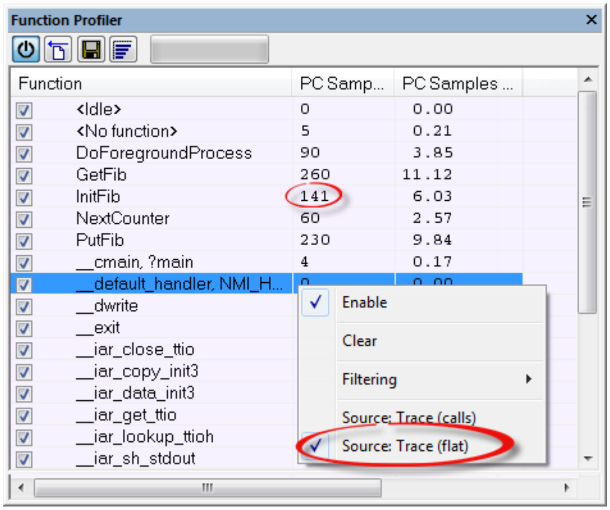
- For the **InitFib** function, **Flat Time** 231 is the time spent inside the function itself.
- For the **InitFib** function, **Acc Time** 487 is the time spent inside the function itself, including all functions InitFib calls.
- For the **InitFib/GetFib** function, **Acc Time** 256 is the time spent 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).



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.

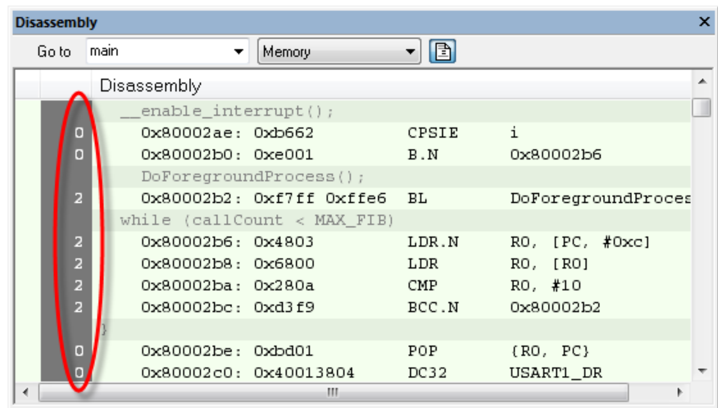


To secure valid data when using a debug probe, make sure to use the maximum trace buffer size and set a breakpoint in your code to stop the execution before the buffer is full.

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.



For each instruction, the number of times it has been executed is displayed.

Reference information on the profiler

Reference information about:

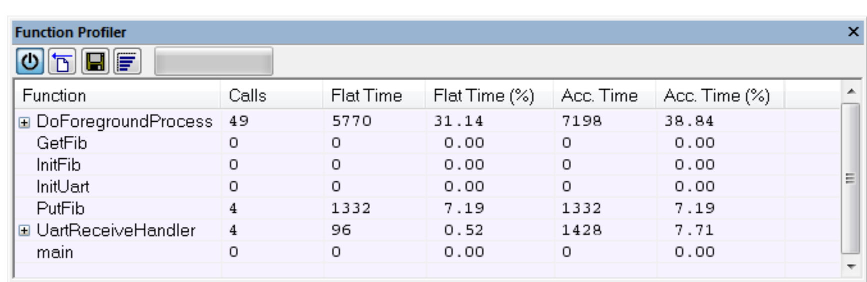
- *Function Profiler window*, page 224

See also:

- *Disassembly window*, page 65

Function Profiler window

The **Function Profiler** window is available from the C-SPY driver menu.



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 220.

Requirements

The C-SPY simulator.

Toolbar

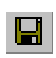
The toolbar contains:

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 220.

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 number of executed instructions 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 number of executed instructions 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))

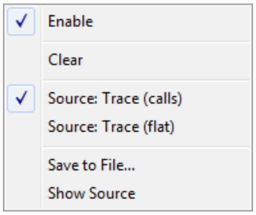
The number of PC samples associated with the function.

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 collect information also 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 220. 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.

* The available sources depend on the C-SPY driver you are using.

Analyzing code performance

- Introduction to performance analysis
- Analyzing performance
- Reference information on performance analysis.

Introduction to performance analysis

These topics are covered:

- Reasons for using performance analysis
- Briefly about performance analysis
- Requirements for performance analysis.

REASONS FOR USING PERFORMANCE ANALYSIS

The performance analyzing facility of the hardware debugger can measure a number of execution aspects to help you understand how well your application performs on the MCU.

Because performance analysis uses the debugger's performance measurement circuit to measure the execution time, it does not slow down the execution of your application.

BRIEFLY ABOUT PERFORMANCE ANALYSIS

The performance analysis is capable of measuring these execution aspects:

- the total number of executed instructions
- the number of executed instructions that trigger branching
- the number of accepted interrupts and other exceptions
- the total number of clock cycles
- the number of clock cycles, excluding the interrupt processing
- the number of cycles in which `DI`/`EI` interrupts are disabled
- the number of instruction fetch requests, and instruction cache non-wait responses for instruction fetch requests, issued by the IFU
- the number of flash ROM data requests.

The analysis can cover either the entire execution or execution between two breakpoints.

Performance analysis settings cannot be changed during the execution and the results of the analysis are displayed in the **Performance Analysis** window.

REQUIREMENTS FOR PERFORMANCE ANALYSIS

To use performance analysis, you need a hardware debugger system. The C-SPY simulator does not support performance analysis.

Note: If your code contains calls to I/O functions and has been linked with the C-SPY debug library, performance analysis will not work correctly because of internal breaks. To use performance analysis, you must either be sure that your code does not contain any calls to I/O functions or that you have disabled the linker option **Include C-SPY debugging support** on the **Project>Options>Linker>Library** page. On the command line, this is the linker option `--debug_lib`.

Analyzing performance

These tasks are covered:

- Using performance analysis.

USING PERFORMANCE ANALYSIS

Getting started analyzing code performance:

1. When you have built your application and started C-SPY, choose **C-SPY driver>Performance Analysis Setup** to open the **Performance Analysis Setup** dialog box. Select the **Enabled** check box for each counter that you want to use.
2. Use the **Measurement item** dropdown menu to specify what you want to analyze: executed instructions, the number of accepted interrupts or something else.
3. Select exactly which aspect you want to measure: the total count, the highest or lowest count, the newest count, or the pass count.
4. Use the dropdown menus **Start condition event** and **End condition event** to specify which part of the execution that you want to analyze: from the start of the execution or from a previously defined Performance Start breakpoint, to the end of the execution or to a previously defined Performance Stop breakpoint.
5. If you want to set a threshold for when to stop the measurement, select **Threshold violation mode** and specify a threshold value.
6. Click **OK** and start executing your application. Measurements are displayed in the **Performance Analysis** window.

When you start a new measurement, the old data is automatically cleared first.

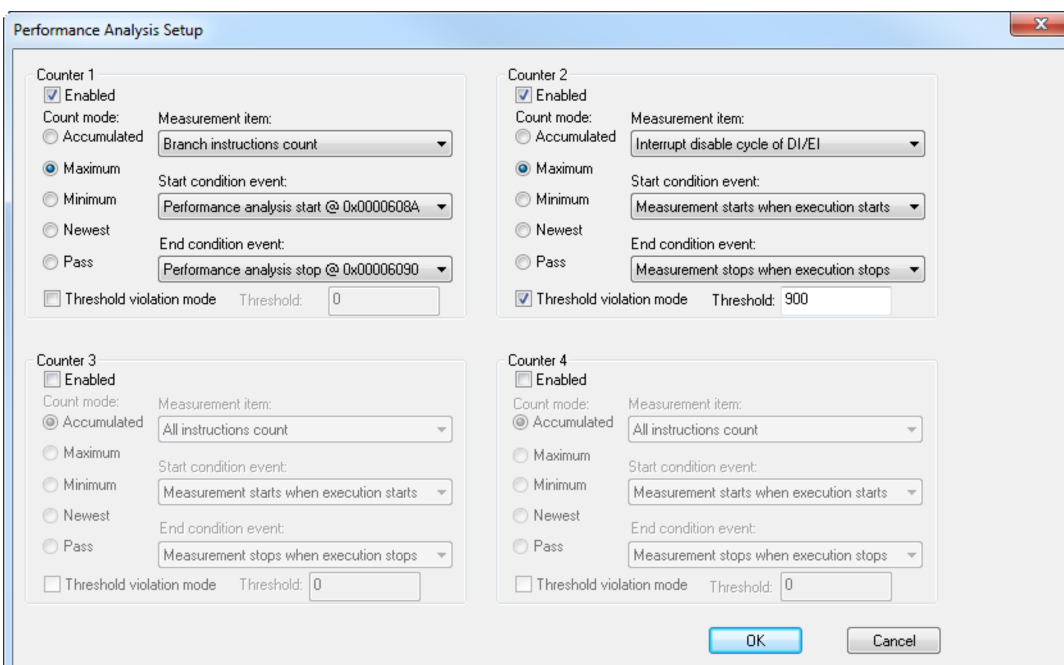
Reference information on performance analysis

Reference information about:

- *Performance Analysis Setup dialog box*, page 231
- *Performance Analysis window*, page 234
- *Performance Analysis Start breakpoints dialog box*, page 236
- *Performance Analysis Stop breakpoints dialog box*, page 237.

Performance Analysis Setup dialog box

The **Performance Analysis Setup** dialog box is available from the **Performance Analysis** window and from the **C-SPY driver** menu.



Use this dialog box to configure the analysis. You can configure up to four counters. In a multicore environment, four counters per core are available. The configuration in the dialog box applies to the currently selected core.

Requirements

A C-SPY hardware debugger driver.

Enabled

Select this check box to activate this counter.

Count mode

Most likely, the code between the start condition event and the end condition event will be executed several times. Use this option to select how to perform the measurement with regard to this. Choose between:

Accumulated
Records the total count of the selected measurement item over all execution passes.

Maximum
Records the count of the selected measurement item from the execution pass with the highest count.

Minimum
Records the count of the selected measurement item from the execution pass with the lowest count.

Newest
Records the count of the selected measurement item from the last execution pass.

Pass
Ignores the measurement item and instead counts the number of execution passes (the number of times the code between the start condition event and the end condition event is executed).

Measurement item

Selects what to measure. Choose between:

All instructions count
The number of times any instructions are executed.

Branch instructions count
The number of times any instructions that trigger branching are executed.

EI level interrupt count
The number of times `EI`-level interrupts are accepted.

FE level interrupt count

The number of times `FE`-level interrupts are accepted.

All instruction async exception count

The number of times any instruction-asynchronous exceptions are accepted.

All instruction sync exception count

The number of times any instruction-synchronous exceptions are accepted.

Clock cycle

The number of clock cycles.

Non-interrupt cycle

The number of cycles excluding the interrupt processing.

Interrupt disable cycle of DI/EI

The number of cycles in which `DI`/`EI` interrupts are disabled.

IFU instruction fetch request count

The number of instruction fetch requests issued by the Instruction Fetch Unit.

Response count for IFU issued instruction fetch

The number of instruction cache non-wait responses for instruction fetch requests issued by the Instruction Fetch Unit.

Flash ROM data request count

The number of flash ROM data requests.

Start condition event

The event that starts the performance measurement. Choose between:

Measurement starts when execution starts

The counter will start the measurement when C-SPY starts executing your application.

Performance analysis start @ *address*

The counter will start the measurement when the execution triggers this Performance Start breakpoint.

For information about Performance Start breakpoints, see *Performance Analysis Start breakpoints dialog box*, page 236.

End condition event

The event that stops the performance measurement. Choose between:

Measurement stops when execution stops

The counter will stop the measurement when C-SPY stops executing your application.

Performance analysis stop @ *address*

The counter will stop the measurement when the execution triggers this Performance Stop breakpoint.

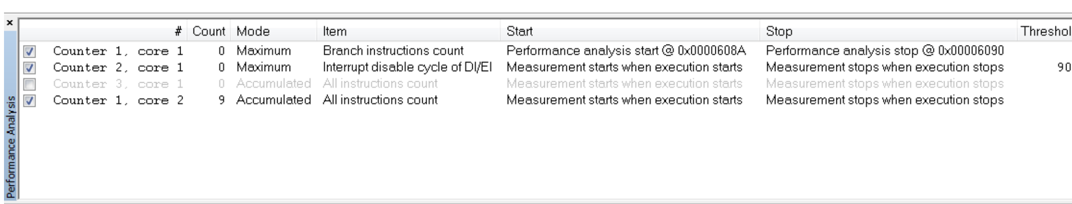
For information about Performance Stop breakpoints, see *Performance Analysis Stop breakpoints dialog box*, page 237.

Threshold violation mode

Select this option to specify a maximum limit for the count. When the count value reaches this limit, the measurement stops.

Performance Analysis window

The **Performance Analysis** window is available from the C-SPY driver menu during a debug session.



#	Count	Mode	Item	Start	Stop	Threshold
Counter 1, core 1	0	Maximum	Branch instructions count	Performance analysis start @ 0x0000608A	Performance analysis stop @ 0x00006090	0
Counter 2, core 1	0	Maximum	Interrupt disable cycle of DI/EI	Measurement starts when execution starts	Measurement stops when execution stops	900
Counter 3, core 1	0	Accumulated	All instructions count	Measurement starts when execution starts	Measurement stops when execution stops	0
Counter 1, core 2	9	Accumulated	All instructions count	Measurement starts when execution starts	Measurement stops when execution stops	0

This window displays the results of the performance analysis. Use the check boxes to the left to enable/disable the individual counters.

Requirements

A C-SPY hardware debugger driver.

Display area

The display area provides information in these columns:

\#

The number of the analysis counter.

Count

A decimal value that indicates the number of times the measurement has been performed. Any overflows will be indicated.

Mode

Indicates how the measurement is being performed.

Item

Indicates what is being measured. See the description for the *Performance Analysis Setup dialog box*, page 231.

Start

A description of the event that started the measurement. See *Performance Analysis Setup dialog box*, page 231.

Stop

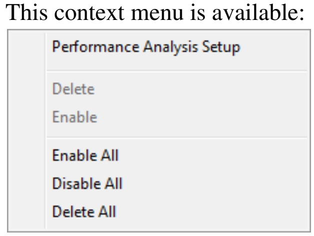
A description of the event that stopped the measurement. See *Performance Analysis Setup dialog box*, page 231.

Threshold

The maximum limit for the count, at which point the measurement stops.

Context menu

This context menu is available:



These commands are available:

Performance Analysis Setup

Opens the dialog box where you configure the analysis.

Delete

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

Enable

Enables the counter. 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 counter is disabled.

Disable

Disables the counter. 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 counter is enabled.

Enable All

Enables all defined counters.

Disable All

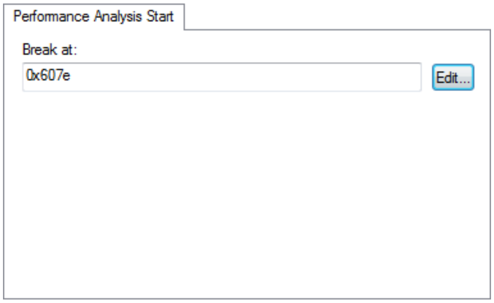
Disables all defined counters.

Delete All

Deletes all defined counters.

Performance Analysis Start breakpoints dialog box

The **Performance Analysis 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 Performance Start breakpoints.

To set a Performance Start breakpoint:

1. In the editor, **Breakpoints**, or **Disassembly** window, right-click and choose **Toggle Breakpoint (Performance Start)** from the context menu.

   Alternatively, to modify an existing breakpoint, select it in the **Breakpoints** window and choose **Edit** on the context menu.

2. In the **Break At** text box, specify an expression, an absolute address, or a source location.

3. When the breakpoint is triggered, the performance analysis starts.

Requirements

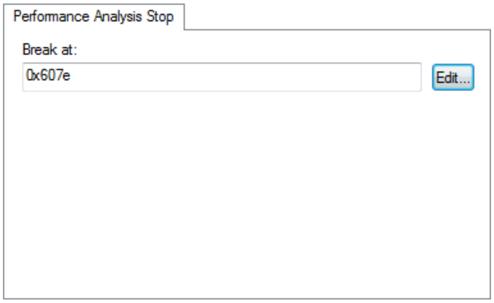
A C-SPY hardware debugger driver.

Break At

Specify the location for the breakpoint in the text box. Alternatively, click the **Edit** browse button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 126.

Performance Analysis Stop breakpoints dialog box

The **Performance Analysis 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 performance stop breakpoints.

To set a Performance Stop breakpoint:

1. In the editor, **Breakpoints**, or **Disassembly** window, right-click and choose **Toggle Breakpoint (Performance Stop)** from the context menu.

   Alternatively, to modify an existing breakpoint, select it in the **Breakpoints** window and choose **Edit** on the context menu.

2. In the **Break At** text box, specify an expression, an absolute address, or a source location.

3. When the breakpoint is triggered, the performance analysis stops.

Requirements

A C-SPY hardware debugger driver.

Break At

Specify the location for the breakpoint in the text box. Alternatively, click the **Edit** browse button to open the **Enter Location** dialog box, see *Enter Location dialog box*, page 126.

Code coverage

- Introduction to 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 there are no specific requirements or restrictions.

Reference information on code coverage

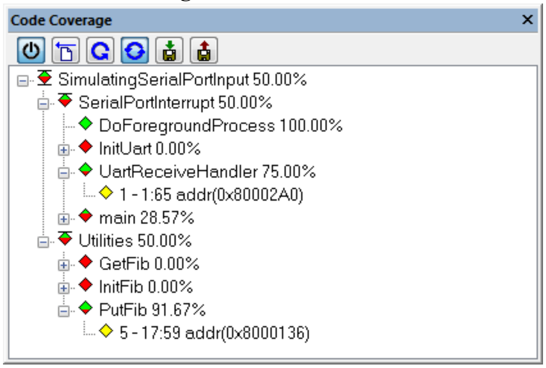
Reference information about:

- *Code Coverage window*, page 240.

See also *Single stepping*, page 58.

Code Coverage window

The **Code Coverage** window is available from the **View** menu.



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.

An asterisk (*) in the title bar indicates that C-SPY has continued to execute, and that the **Code Coverage** window must be refreshed because the displayed information is no longer up to date. To update the information, use the **Refresh** button.

To get started using code coverage:

1 Before using 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 10: 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, click the **Refresh** button to view the code coverage information.

Requirements

The C-SPY simulator.

Display area

The code coverage information is displayed in a tree structure, showing the program, module, function, and statement levels. The window displays only source code that was compiled with debug information. Thus, startup code, exit code, and library code is 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. 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	Signifies that 0% of the modules or functions has been executed.
Green diamond	Signifies that 100% of the modules or functions has been executed.
Red and green diamond	Signifies that some of the modules or functions have been executed.
Yellow diamond	Signifies a statement that has not been executed.

The percentage displayed at the end of every program, module, and function line shows the amount of statements that has been covered so far, that is, the number of executed statements divided with the total number of statements.

For statements that have not been executed (yellow diamond), the information displayed is the column number range and the row number of the statement in the source window, followed by the address of the step point:

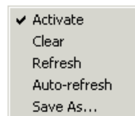
`<column_start>-<column_end>:row address`.

A statement is considered to be executed when one of its instructions has been executed. When a statement has been executed, it is removed from the window and the percentage is increased correspondingly.

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. Double-clicking a module on the program level expands or collapses the tree structure.

Context menu

This context menu is available:



These commands are available:

Activate

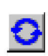
Switches code coverage on and off during execution.

Clear

Clears the code coverage information. All step points are marked as not executed.

Refresh

Updates the code coverage information and refreshes the window. All step points that have been executed since the last refresh are removed from the tree.



Auto-refresh

Toggles the automatic reload of code coverage information on and off. When turned on, the code coverage information is reloaded automatically when C-SPY stops at a breakpoint, at a step point, and at program exit.

Save As

Saves the current code coverage result in a text file.

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.

Part 3. Advanced debugging

This part of the *C-SPY® Debugging Guide for RH850* includes these chapters:

- Multicore debugging
- Interrupts
- C-SPY macros
- The C-SPY command line utility—cspybat

Multicore debugging

- Introduction to multicore debugging
- Debugging multiple cores
- Reference information on multicore debugging

Introduction to multicore debugging

These topics are covered:

- Briefly about application execution
- Symmetric multicore debugging
- Some considerations
- Requirements and restrictions for multicore debugging

BRIEFLY ABOUT MULTICORE DEBUGGING

Multicore debugging means that you can debug targets with multiple cores. The C-SPY debugger supports:

- *Symmetric multicore debugging* (SMP), which means debugging two or more identical cores. This is handled using a single instance of the IAR Embedded Workbench IDE.

SYMMETRIC MULTICORE DEBUGGING

Symmetric multicore debugging means that the target has two or more identical cores on the board (usually on the same chip) that typically can be accessed through a single debug probe.

In the debugger, at any given time the windows show the state of only one of the cores—the one in focus.

This is an overview of special support for symmetric multicore debugging:

- The cores start and stop simultaneously.
- You can control which core you want the debugger to focus on. This affects editor windows and the **Disassembly**, **Registers**, **Watch**, **Locals**, **Call Stack** window, etc.
- The **Cores** window shows a list of all available cores, and gives some information about each core, such as its execution state.

- The **Stack** window can show the stack for each core by means of dedicated stack sections.

SOME CONSIDERATIONS

When you debug more than one core, you should be aware of how this affects other aspects of debugger behavior:

- **Reset** and **Go** commands reset/start all cores. the **Go** command starts only the core in focus.
- All cores initialize their own system registers and variables located in their local RAM. The first core (`PE0` for G4 or `PE1` for G3) will also initialize all global RAM areas and the C++ constructors while the other cores wait for it to complete.
- Code breakpoints affect all cores
- The stack size settings in the **Project Options** dialog box affect all cores.
- Timer Start and Timer Stop breakpoints are valid for the core that is in focus when the execution starts.
- Trace collection is performed for the core that is in focus when the execution starts.
- The contents in the Memory window for the zones `LOCAL_RAM_SELF`, `LOCAL_RAM_PE1`, `LOCAL_RAM_PE2`, etc., are valid when the execution stops. Any manual edits in one of these memory zones are not reflected in the other zones until the next time that the execution stops.

REQUIREMENTS AND RESTRICTIONS FOR MULTICORE DEBUGGING

All C-SPY drivers support multicore debugging and there are no specific requirements.

Note: There might be restrictions in trace support due to limitations in the hardware you are using.

Debugging multiple cores

These tasks are covered:

- Setting up for symmetric multicore debugging
- Starting and stopping a multicore debug session

SETTING UP FOR SYMMETRIC MULTICORE DEBUGGING

Where the application starts is determined by the start label. For more information, including how to change this label, see the chapter *Developing embedded applications* in the *IAR C/C++ Development Guide for RH850*. If, for example, your application does not use all cores of the microcontroller, you might want to change the start label.

STARTING AND STOPPING A MULTICORE DEBUG SESSION

1. To start a multicore debug session, use the standard **Download and Debug** command.
2. To stop a multicore debug session use the standard **Stop Debugging** command, which will stop both debugging sessions.

Reference information on multicore debugging

Reference information about:

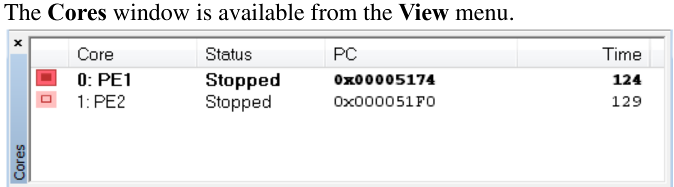
- *Cores window*, page 247

See also:

- *__getSelectedCore*, page 297
- *__selectCore*, page 307

Cores window

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



This window shows a list of all available cores, and gives some information about each core, such as its execution state. The line highlighted in bold is the core currently in focus, which means that any window showing information that is specific to a core will be updated to reflect the state of the core in focus. This includes highlights in editor windows and the **Disassembly**, **Registers**, **Watch**, **Locals**, **Call Stack** window, etc. Double-click a line to focus on that core.

See also *Debugging multiple cores*, page 246.

Requirements

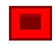
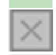
None; this window is always available.

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.

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 287
- *Breakpoints*, page 103
- The *IAR C/C++ Development Guide for RH850*

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 RH850 microcontroller
- Single-occasion or periodical interrupts based on the cycle counter
- Predefined interrupts for various devices

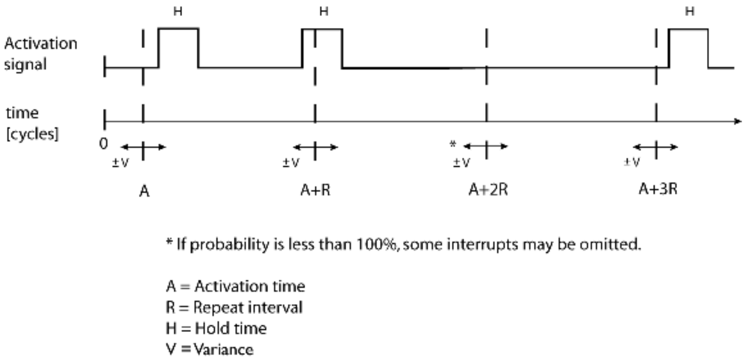
- Configuration of hold time, probability, and timing variation
- State information for locating timing problems
- Configuration of interrupts using a dialog box or a C-SPY system macro—that is, one interactive and one automating interface. In addition, you can instantly force an interrupt.
- A log window that continuously displays events for each defined interrupt.
- A status window that shows the current interrupt activities.

All interrupts you define using the **Interrupt Configuration** window 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 Configuration** window 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.

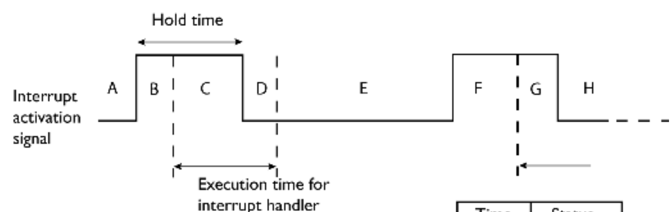
To define the periodicity of the interrupt generation you can specify the *repeat interval* which defines the amount of cycles after which a new interrupt should be generated. In addition to the repeat interval, the periodicity depends on the two options *probability*—

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*.

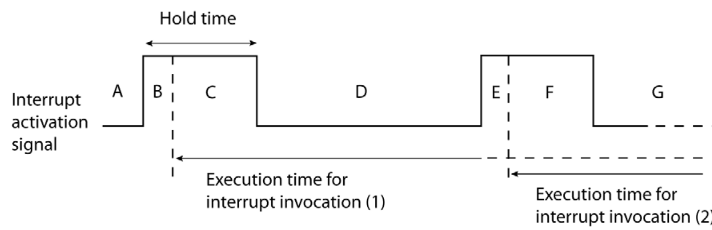
Normally, a repeatable interrupt has a specified repeat interval that is longer than the execution time. In this case, the status information at different times looks like this:



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:



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 Configuration** window.

For more information about each macro, see *Reference information on C-SPY system macros*, page 287.

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 41.

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. If you are using the C-SPY simulator, 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.

Note: Because interrupt logging uses the trace data, trace and interrupt logging cannot be used simultaneously. If you use interrupt logging, you should disable trace, and vice versa.

Requirements for interrupt logging

Interrupt logging is supported by the C-SPY simulator and by the E1/E2/E20 C-SPY driver. You must also have enabled the generation of interrupt instrumentation code in the compiler.

See also *Getting started using interrupt logging*, page 256.

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 275 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 <sdtio.h>
#include "iorh850.h"
#include <intrinsics.h>

volatile int ticks = 0;
void main (void)
{
 /* Add your timer setup code here */

 __enable_interrupt();        /* Enable interrupts */

 while (ticks < 100);         /* Endless loop */
 printf("Done\n");
}

/* Timer interrupt service routine */
#pragma vector = TIMER_VECTOR
__interrupt void basic_timer(void)
{
 ticks += 1;
}
```

2 Add your interrupt service routine to your application source code and add the file to your project.

3 Build your project and start the simulator.

4 Choose **Simulator>Interrupt Configuration** to open the **Interrupt Configuration** window. Right-click in the window and select **Enable Interrupt Simulation** on the context menu. For the timer example, verify these settings:

Option	Settings
Interrupt	TIMER_VECTOR
First activation	4000
Repeat interval	2000
Hold time	10
Probability (%)	100
Variance (%)	0

Table 11: Timer interrupt settings

Click **OK**.

5 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 4000
- Continuously repeat the interrupt after approximately 2000 cycles.

6 To watch the interrupt in action, choose **Simulator>Interrupt Log** to open the **Interrupt Log** window.

7 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 268.

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 Configuration** window 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 To set up for interrupt logging using the C-SPY hardware debugger driver, you must make settings in three different dialog boxes:

1. Choose **Project>Options>C/C++ Compiler>Output** and select the option **Generate interrupt instrumentation code**.
2. Choose ***C-SPY driver*>Operating Frequency** and specify the operating frequency that the MCU is running at.
3. Choose ***C-SPY driver*>Trace Setup** and set the option **On trace buffer full**. Choose between:
    - **Overwrite oldest frames** to display the last ~500 log entries before the break in execution, in the **Interrupt Log** window.
    - **Break execution** to display the first ~500 log entries from the start of execution, in the **Interrupt Log** window.

For the C-SPY simulator, no specific settings are required.

2 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.

3 From the context menu in the **Interrupt Log** window, choose **Enable** to enable the logging.

4 Start executing your application program to collect the log information.

5 To view the interrupt log information, look in the **Interrupt Log** or **Interrupt Log Summary** window, or at the Interrupt 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 interrupt logging, from the context menu in the **Interrupt Log** window, toggle **Enable** off.

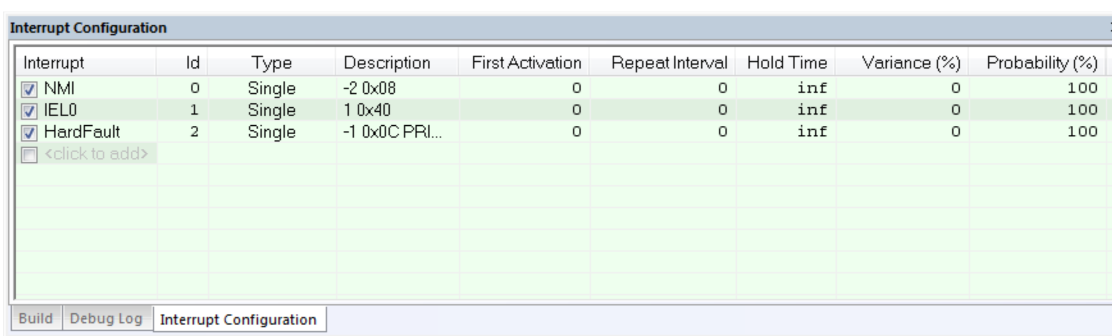
Reference information on interrupts

Reference information about:

- *Interrupt Configuration window*, page 257
- *Available Interrupts window*, page 260
- *Interrupt Status window*, page 261
- *Interrupt Log window*, page 263
- *Interrupt Log Summary window*, page 266.
- *Timeline window—Interrupt Log graph*, page 268.

Interrupt Configuration window

The **Interrupt Configuration** window is available by choosing **Simulator>Interrupt Configuration**.



This window lists all installed interrupts. Use this window to enable or disable individual interrupts or the interrupt simulation system, and to edit the properties of installed interrupts.

See also *Using the interrupt system*, page 254.

Requirements

The C-SPY simulator.

Display area

This area contains these columns:

Interrupt

Lists all installed 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 **Available Interrupts** 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)**.

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 number, the interrupt type (0 for NMI interrupts and 1 for INT interrupts), and the control register (only for INT interrupts), separated by space characters. For interrupts specified using the system macro `__orderInterrupt`, the **Description** box is empty.

First activation

The value of the cycle counter after which the specified interrupt will be generated. Click to edit.

Repeat interval

The periodicity of the interrupt in cycles. Click to edit.

Hold time

How long, in cycles, the interrupt remains pending until removed if it has not been processed. Click to edit. If you specify `inf`, the corresponding pending bit will be set until the interrupt is acknowledged or removed.

Variance %

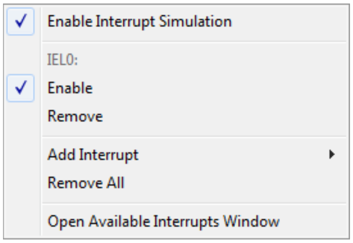
A timing variation range, as a percentage of the repeat interval, in which the interrupt might occur for a period. For example, if the repeat interval is 100 and the variance 5%, the interrupt might occur anywhere between T=95 and T=105, to simulate a variation in the timing. Click to edit.

Probability %

The probability, in percent, that the interrupt will actually occur within the specified period. Click to edit.

Context menu

This context menu is available:



These commands are available:

Enable Interrupt Simulation

Enables or disables the entire interrupt simulation system. 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.

Enable

Enables or disables the individual interrupt you clicked on.

Remove

Removes the individual interrupt you clicked on.

Add Interrupt

Selects an interrupt to install. 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.

Remove All

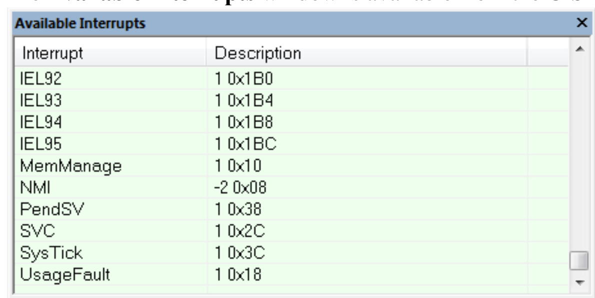
Removes all installed interrupts in the window.

Open Available Interrupts Window

Opens the **Available Interrupts** window, see *Available Interrupts window*, page 260.

Available Interrupts window

The **Available Interrupts** window is available from the C-SPY driver menu.



Use this window for an overview of all available interrupts for your project. You can also use it for forcing 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 Configuration window*, page 257.
2. Activate the interrupt by using the **Force Interrupt** command available on the context menu.

Requirements

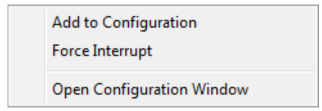
The C-SPY simulator.

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:



These commands are available:

Add to Configuration

Installs the selected interrupt and adds it to the **Interrupt Configuration** window.

Force Interrupt

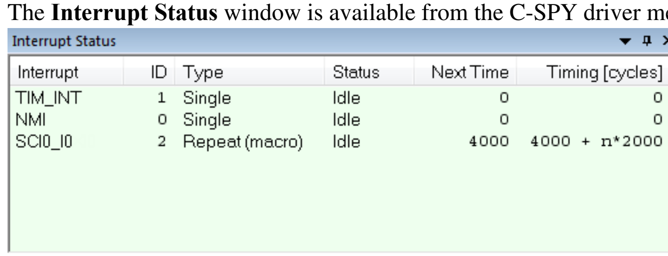
Triggers the selected interrupt.

Open Configuration Window

Opens the **Interrupt Configuration** window, see *Interrupt Configuration window*, page 257.

Interrupt Status window

The **Interrupt Status** window is available from the C-SPY driver menu.



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 **Available Interrupts** 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

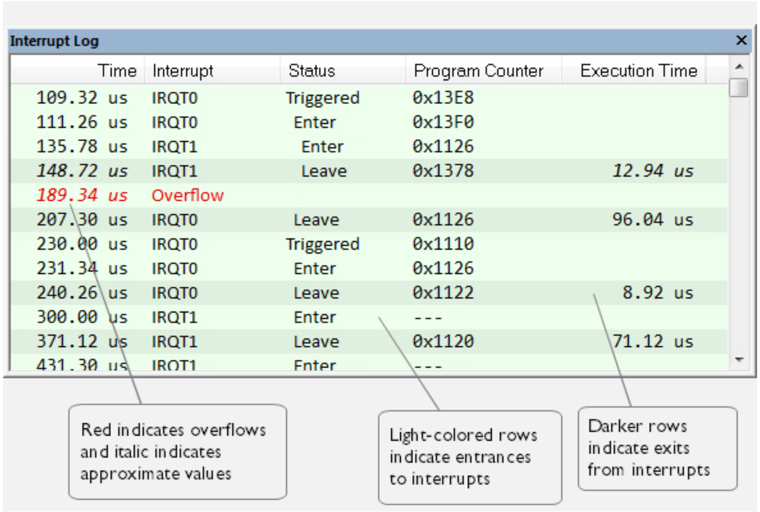
The next time an idle interrupt is triggered. Once a repeatable interrupt stats executing, a copy of the interrupt will appear with the state Idle and the next time set. For interrupts that do not have a next time—that is pending, executing, or suspended—the column will show `--`.

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.



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 in the Simulator, the oldest entries in the buffer are erased. Using a C-SPY hardware debugger driver, use the option **On trace buffer full** in the **Trace Setup** dialog box to configure which logs to save in the buffer when it fills up; see *Trace Setup dialog box*, page 177.

For more information, see *Getting started using interrupt logging*, page 256.

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 268.

Requirements

This window is always available. The compiler option **Generate interrupt instrumentation code** must be selected when you use a C-SPY hardware debugger driver.

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 **Available Interrupts** 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

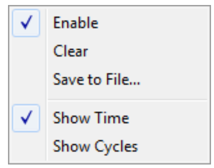
The value of the program counter when the event occurred.

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 happen also 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.

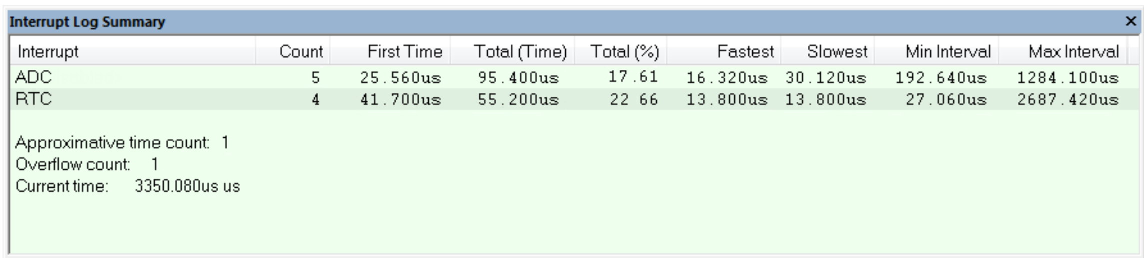
Show Cycles

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.



This window displays a summary of logs of entrances to and exits from interrupts.

For more information, see *Getting started using interrupt logging*, page 256.

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 268.

Requirements

This window is always available. The compiler option **Generate interrupt instrumentation code** must be selected when you use a C-SPY hardware debugger driver.

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

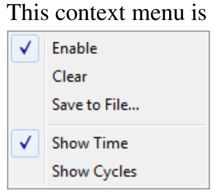
The longest time between two interrupts of this type.

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 happen also 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.

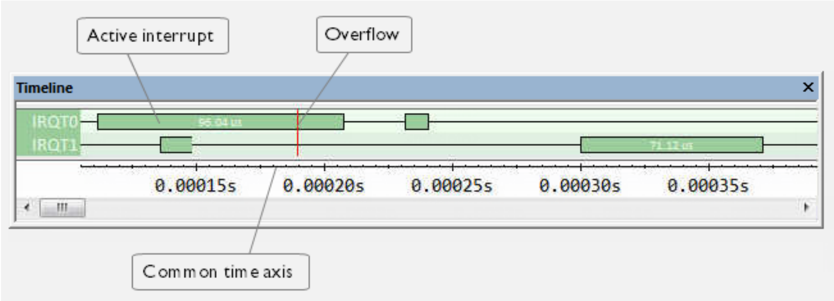
Show Cycles

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

This graph is always available. The compiler option **Generate interrupt instrumentation code** must be selected when you use a C-SPY hardware debugger driver.

Display area

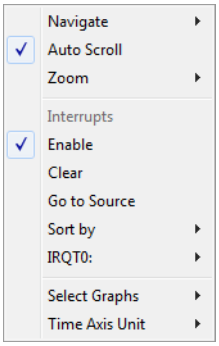
- The label area at the left end of the graph displays the names of the interrupts.
- The graph itself shows active interrupts as a thick green horizontal bar where the white figure indicates the time spent in the interrupt. This graph is a graphical representation of the information in the **Interrupt Log** window, see *Interrupt Log window*, page 263.
- 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 happen also 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, for instance reading I/O input from a file, see the file `setupsimple.mac` located in the directory `\rh850\tutor\`.

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 285.

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 280.

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 46.

REGISTERING C-SPY MACROS—AN OVERVIEW

C-SPY must know that you intend to use your defined macro functions, and thus 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 277.
- You can register macros interactively in the **Macro Registration** window, see *Macro Registration window*, page 325. Registered macros appear in the **Debugger Macros** window, see *Debugger Macros window*, page 327.
- 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 307.

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 277.
- 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 277.
- 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 329.
- 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 278.

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 */
}
```

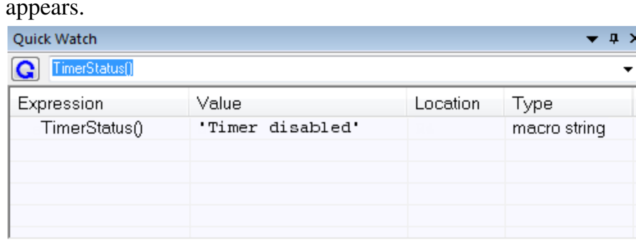
2 Save the macro function using the filename extension `mac`.

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.



The macro will automatically be displayed in the **Quick Watch** window.

For more information, see *Quick Watch window*, page 97.

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 118
- Use the **Condition** field instead of the **Action** field. For an example, see *Performing a task and continuing execution*, page 112.

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 283.

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 280
- *Macro variables*, page 280
- *Macro parameters*, page 281
- *Macro strings*, page 281
- *Macro statements*, page 282
- *Formatted output*, page 283.

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 80.

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 12: 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 344.

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 283.

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 80.

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 301.

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 274.

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 13: Summary of system macros

Macro	Description
`__closeFile`	Closes a file that was opened by `__openFile`
`__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`	Gets the number of the current core.
`__isBatchMode`	Checks if C-SPY is running in batch mode or not.
`__loadImage`	Loads an 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
`__registerMacroFile`	Registers macros from the specified file
`__resetFile`	Rewinds a file opened by `__openFile`
`__selectCore`	Switches focus from the current core to the specified core.

Table 13: Summary of system macros

Macro	Description
__setCodeBreak	Sets a code breakpoint
__setDataBreak	Sets a data breakpoint
__setDataLogBreak	Sets a data log breakpoint
__setLogBreak	Sets a log breakpoint
__setSimBreak	Sets a simulation breakpoint
__setTimerStartBreak	Sets a timer start breakpoint
__setTimerStopBreak	Sets a timer stop 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 13: Summary of system macros

__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 14: __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 103.

__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`.

__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 15: __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.

`"e1"` corresponds to the C-SPY E1/E2/E20 driver.

`"e2"` corresponds to the C-SPY E1/E2/E20 driver.

`"e20"` corresponds to the C-SPY E1/E2/E20 driver.

Return value

Result	Value
Successful	`1`
Unsuccessful	`0`

Table 16: __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 17: __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 18: __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 130.

`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 130.

`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 130.

`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

Syntax

```
__getSelectedCore()
```

Return value

The current core. The cores are numbered from `0` and upwards.

For use with

Description

Gets the number of the current core.

Example

```
test ()
{
  __message "Core: ", __getSelectedCore(), " pc = ", #PC:%x,
"\n";
  __selectCore(0);
  __message "Core: ", __getSelectedCore(), " pc = ", #PC:%x,
"\n";
  __selectCore(1);
  __message "Core: ", __getSelectedCore(), " pc = ", #PC:%x,
"\n";
```

A typical result of the above macro would be (assuming that the original core was number `1`):

```
Core: 1 pc = 0000213C
Core: 0 pc = 00000494
Core: 1 pc = 0000213C
```

See also

__selectCore, page 307.

__isBatchMode

Syntax

```
__isBatchMode()
```

Return value

Result	Value
True	`int 1`
False	`int 0`

Table 19: __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 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 RH850*.

`offset`

An integer that identifies the offset to the destination address for the downloaded 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 20: __loadImage return values

For use with

All C-SPY drivers.

Description

Loads an image (debug file).

Note: Images are only downloaded to RAM and no flash loading will be performed.

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 351 and *Loading multiple images*, page 43.

__memoryRestore

Syntax

```
__memoryRestore(zone, filename)
```

Parameters

zone

A string that specifies the memory zone, see *C-SPY memory zones*, page 130.

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 RH850*.

Return value

`int 0`

For use with

All C-SPY drivers.

Description

Reads the contents of a file and saves it to the specified memory zone.

Example

```
__memoryRestore("", "c:\\temp\\saved_memory.hex");
```

See also

Memory Restore dialog box, page 143.

__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 RH850*.

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 142.

__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 21: __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 22: __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 RH850*.

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 23: __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 RH850*.

__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 255.

__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 24: __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 130.

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 130.

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 130.

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 RH850*.

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 275.

__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

Syntax `__selectCore(int `*`core`*`)`

Parameters *`core`*

The core to switch to. The cores are numbered from `0` and upwards.

Return value

`int 0`

For use with

All C-SPY hardware debugger drivers.

Description

Switches focus from the current core to the specified core for the duration of the macro invocation or until any next invocation of `__selectCore`.

Example

```
test ()
{
  __message "Core: ", __getSelectedCore(), " pc = ", #PC:%x,
"\n";
  __selectCore(0);
  __message "Core: ", __getSelectedCore(), " pc = ", #PC:%x,
"\n";
  __selectCore(1);
  __message "Core: ", __getSelectedCore(), " pc = ", #PC:%x,
"\n";
```

A typical result of the above macro would be (assuming that the original core was number `1`):

```
Core: 1 pc = 0000213C
Core: 0 pc = 00000494
Core: 1 pc = 0000213C
```

See also

__getSelectedCore, page 297.

__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 126.

`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 25: __setCodeBreak return values

For use with

All C-SPY drivers.

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 103.

__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 more information about the location types, see Enter Location dialog box, page 25.

count

The number of times that a breakpoint condition must be fulfilled before a break occurs (integer).

condition

The breakpoint condition (string). For information about restrictions affecting real-time execution performance, see *Data breakpoints*, page 105.

cond_type

The condition type; either `"CHANGED"` or `"TRUE"` (string). For information about restrictions affecting real-time execution performance, see *Data breakpoints*, page 105.

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 26: __setDataBreak return values

For use with

All C-SPY drivers.

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 103.

__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-, 16-, and 32-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 27: __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 103 and *Getting started using data logging*, page 195.

__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 126.

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 28: __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 283 and *Breakpoints*, page 103.

__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 more information about the location types, see *Enter Location dialog box*, page 126.

`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 29: __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.

__setTimerStartBreak

Syntax

`__setTimerStartBreak(location, ID)`

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 126.

ID

The Timer number, an integer from 1–16 that identifies the timer that the breakpoint will start.

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 30: __setTimerStartBreak return values

For use with

The C-SPY hardware debugger drivers.

Description

Sets a breakpoint at the specified location. When that breakpoint is triggered, a timer is started that measures the execution time between two execution points.

Example

```
__var startTimerBp;
__var stopTimerBp;

timerOn()
{
  startTimerBp = __setTimerStartBreak
    ("{C:\\TEMP\\Utilities.c}.23.1", 3);
  stopTimerBp = __setTimerStopBreak
    ("{C:\\temp\\Utilities.c}.30.1", 3);
}

timerOff()
{
  __clearBreak(startTimerBp);
  __clearBreak(stopTimerBp);
}
```

See also

Breakpoints, page 103.

__setTimerStopBreak

Syntax

`__setTimerStopBreak(location, ID)`

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 126.

ID

The Timer number, an integer from 1–16 that identifies the timer that the breakpoint will stop.

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 31: __setTimerStopBreak return values

For use with

The C-SPY hardware debugger drivers.

Description

Sets a breakpoint at the specified location. When that breakpoint is triggered, the timer with the corresponding Timer number is stopped.

Example

See *__setTimerStartBreak*, page 314.

See also

Breakpoints, page 103.

__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 126.

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 32: __setTraceStartBreak return values

For use with

All C-SPY drivers.

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 103.

__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 126.

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 33: __setTraceStopBreak return values

For use with

All C-SPY drivers.

Description

Sets a breakpoint at the specified location. When that breakpoint is triggered, the trace system is stopped.

Example

See *__setTraceStartBreak*, page 316.

See also

Breakpoints, page 103.

__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 34: __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 281.

__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 281.

__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 281.

__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 281.

__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 281.

__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 35: __unloadImage return values

For use with
All C-SPY drivers.

Description
Unloads debug information from an already downloaded image.

See also
Loading multiple images, page 43 and *Images*, page 351.

__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 130.

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 130.

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 130.

Return value

`int 0`

For use with

All C-SPY drivers.

Description

Writes four bytes to a given memory location.

Example

```
__writeMemory32(0x5555FFFF, 0x8020, "");
```

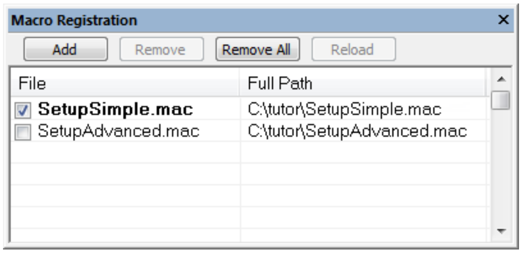
Graphical environment for macros

Reference information about:

- *Macro Registration window*, page 325
- *Debugger Macros window*, page 327
- *Macro Quicklaunch window*, page 329

Macro Registration window

The **Macro Registration** window is available from the **View>Macros** submenu during a debug session.



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 276.

Requirements

None; this window is always available.

Display area

This area contains these columns:

File

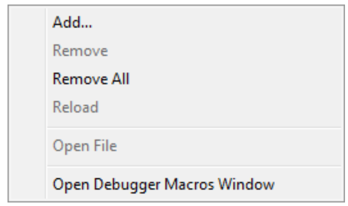
The name of an available macro file. To register the macro file, select the check box to the left of the filename. The name of a registered macro file appears in bold style.

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

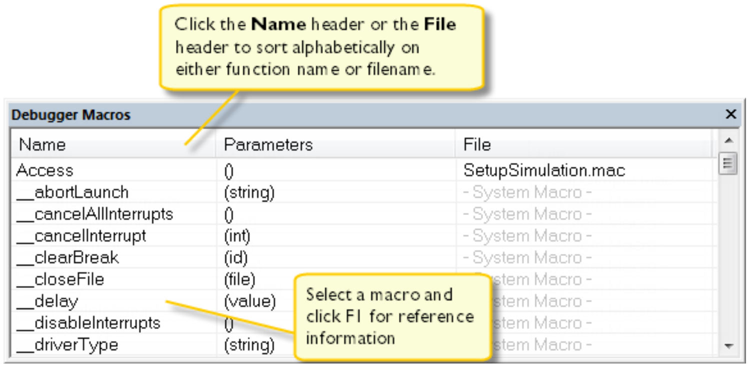
Opens the selected macro file in the editor window.

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.



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

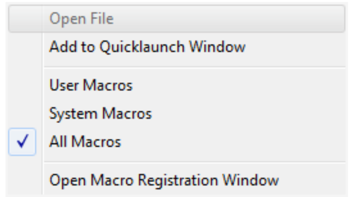
The parameters of the debugger macro.

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

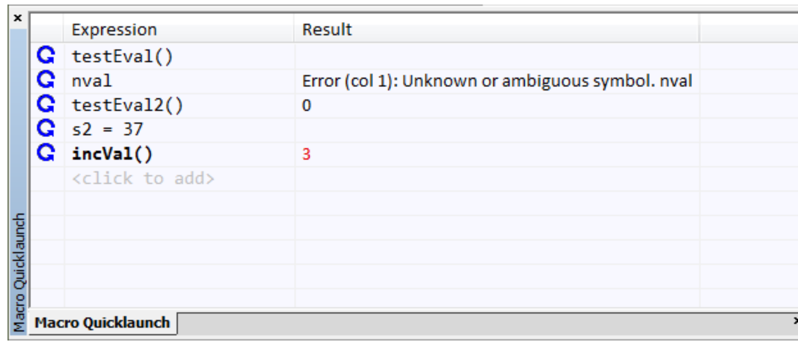
Lists all debugger macros, both predefined system macros and your own.

Open Macro Registration Window

Opens the **Macro Registration** window.

Macro Quicklaunch window

The **Macro Quicklaunch** window is available from the **View** menu.



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 276.

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 276.

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

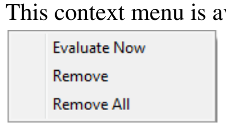
One or several expressions that you want to evaluate. Click <click to add> to add an expression. If the return value has changed since last time, the value will be displayed in red.

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.

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 345.

- 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 rh850\bin.
driver_DLL	The C-SPY driver DLL file; available in rh850\bin.
debug_file	The object file that you want to debug (filename extension out). See also *–debugfile*, page 338.
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 335.

Table 36: cspybat parameters

Parameter	Description
`--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 335.

Table 36: cspybat parameters (Continued)

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 driver

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.
`-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.
`--multicore_nr_of_cores`	Specify the number of cores on the device for multicore debugging.

OPTIONS AVAILABLE FOR THE C-SPY HARDWARE DRIVER

`--drv_communication`	Identifies which emulator you are using.
`--drv_suppress_download`	Suppresses download of the executable image.
`--drv_verify_download`	Verifies the executable image.
`--log_file`	Creates a log file.
`--LPD1_baud`	Selects the LPD 1-pin communication mode and sets the communication speed.
`--LPD4_freq`	Selects the LPD 4-pin communication mode and sets the clock frequency.

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, use **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.

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.

--core

Syntax

`--core {g3k|g3kh|g3m|g3mh|g4mh}`

Parameters

`g3k|g3kh|g3m|g3mh|g4mh`
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 RH850* for information about the cores.

Project>Options>General Options>Target>Device

--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 239, *--cycles*, page 337, *--timeout*, page 346.

To set this option, choose **View>Code Coverage**, right-click and choose **Save As** when the C-SPY debugger is running.

--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|e1|e2|e20}`

Parameters

`sim`	Specifies the simulator.
`e1`	Specifies the E1 emulator.
`e2`	Specifies the E2 emulator.
`e20`	Specifies the E20 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.

Project>Download>Download active application

Alternatively, to set a related option, choose:

Project>Options>Debugger>Setup and deselect **Run to**.

--drv_communication

Syntax

`--drv_communication {USB:`*`serial_no`*`}`

Parameters

`serial_no`

Specifies the serial number for the USB emulator you want to use.

For use with

All C-SPY hardware debugger drivers.

Description

If you have more than one Renesas E1, E2, or E20 emulator connected, use this option to identify which emulator you are using.

Example

`--drv_communication USB:9IM000019`

Project>Options>*Driver*>Setup>Serial No

--drv_suppress_download

Syntax

`--drv_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 `--drv_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

--drv_verify_download

Syntax

`--drv_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

-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.

To set this option, use **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 219.

***C-SPY driver*>Function Profiling**

--leave_target_running

Syntax `--leave_target_running`

For use with `cspybat`.

Any C-SPY hardware debugger driver.

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**

--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**

--LPD1_baud

Syntax `--LPD1_baud` *`speed`*

Parameters *`speed`*

The communication speed in kbit/s. If this parameter is set to 0, the hardware default speed will be used.

For use with Any C-SPY hardware debugger driver.

Description Use this option to select 1-pin LPD communication and to set the communication speed. If *`speed`* is 0, the hardware default speed will be used, which might be lower than the highest possible speed. The **Debug Log** window shows both your specified communication speed and the actual speed. If you specify a higher speed than the hardware supports, the connection will fail.

Project>Options>Debugger>*Driver***>Setup>LPD 1**

and

Project>Options>Debugger>*Driver***>Setup>Override default baud rate**

--LPD4_freq

Syntax `--LPD4_freq` *`clock_freq`*

Parameters *`clock_freq`*

The clock frequency in kHz. If this parameter is set to 0, the hardware default clock frequency will be used.

For use with Any C-SPY hardware debugger driver.

Description Use this option to select 4-pin LPD communication and to set the clock frequency. If *`clock_freq`* is 0, the hardware default clock frequency will be used, which might be lower than the highest possible frequency. The **Debug Log** window shows both your specified clock frequency and the actual clock frequency. If you specify a higher clock frequency than the hardware supports, the connection will fail.

Project>Options>Debugger>*Driver***>Setup>LPD 4**

and

Project>Options>Debugger>*Driver***>Setup>Override default clock frequency**

--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 274.

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 av value to a C-SPY macro parameter.This option can be used more than once on the command line.

See also *Macro parameters*, page 281.

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 *Memory configuration for the C-SPY simulator*, page 131.

To set related options, choose:

Simulator>Memory Configuration

--multicore_nr_of_cores

Syntax `--multicore_nr_of_cores=`*`cores`*

Parameters *`cores`*

The number of cores on your device. This must be an integer from 2–8.

For use with All C-SPY drivers.

Description Specify the number of cores on your device. This option is not needed for debugging a single-core system.

See also *Multicore debugging*, page 245.

This option is not available in the IDE.

-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 41.

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 `rh850bat.dll` located in the `\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 include also 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.

--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.

Part 4. Additional reference information

This part of the *C-SPY® Debugging Guide for RH850* includes these chapters:

- Debugger options
- Additional information on C-SPY drivers

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).

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 350.
3. On the **Setup** page, make sure to 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 hardware debugger	*Reference information on C-SPY hardware debugger driver options*, page 354

Table 37: 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.

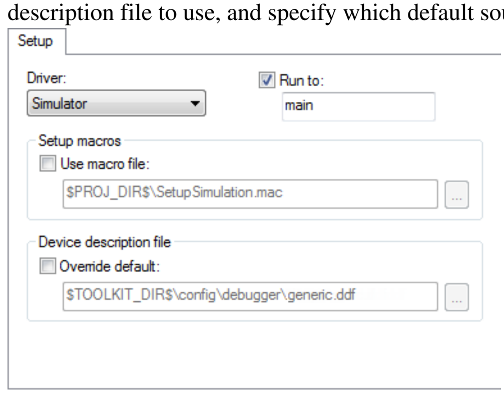
Reference information on general debugger options

Reference information about:

- Setup
- Images
- Extra Options
- Plugins

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.

If the option is deselected, the program counter will contain the regular hardware reset address at each reset.

See also *Executing from reset*, page 40.

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

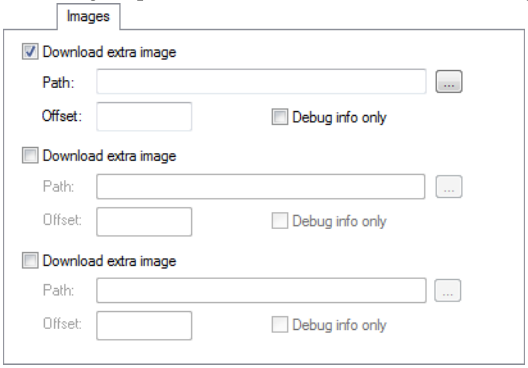
A default device description file is selected automatically based on your project settings. To override the default file, select **Override default** and specify an alternative file. A browse button is available for your convenience.

For information about the device description file, see *Modifying a device description file*, page 45.

Device description files for each RH850 device are provided in the directory `rh850\config` and have the filename extension `ddf`.

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 images, use the related C-SPY macro, see *__loadImage*, page 298.

For more information, see *Loading multiple images*, page 43.

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:

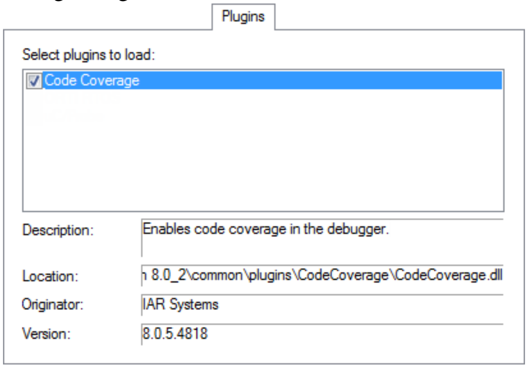
```
/* __argc, the number of arguments in __argv. */
__no_init int __argc;

/* __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.



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 rh850\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.

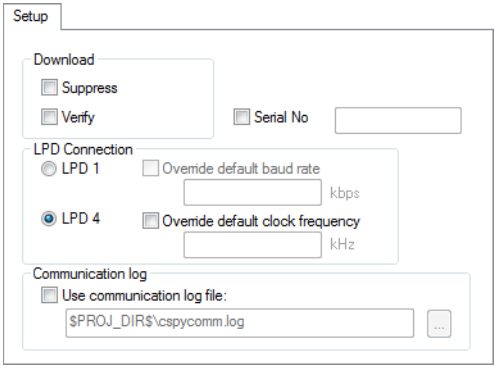
Reference information on C-SPY hardware debugger driver options

Reference information about:

- *Setup*, page 354

Setup

The **Setup** options control the E1/E2/E20 Emulator.



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.

Serial No

Selects which Renesas emulator to use, if more than one is connected to your host computer via USB.

LPD connection

Controls how the emulator connects to the target board. Choose between:

LPD 1

The emulator connects to the target board via the 1-pin debug interface. The communication speed is determined by the hardware and can be inspected in the **Debug Log** window. To change the communication speed, select the **Override default baud rate** option and specify a new value.

LPD 4

The emulator connects to the target board via the 4-pin debug interface. The clock frequency is determined by the hardware and can be inspected in the **Debug Log** window. To change the clock frequency, select the **Override default clock frequency** option and specify a new value.

Use communication log file

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 357
- *Simulator menu*, page 358
- *Emulator menu*, page 360

C-SPY driver

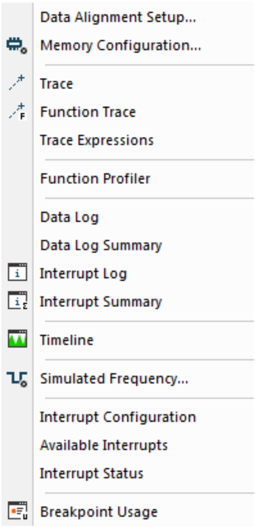
Before you start the C-SPY debugger, you must first specify a C-SPY driver in the **Options** dialog box, using the option **Debugger>Setup>Driver**.

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:

Data Alignment Setup

Displays a dialog box to control the behavior of the simulator when misaligned data accesses are detected, see *Data Alignment Setup dialog box*, page 362.

Memory Configuration

Displays a dialog box where you configure C-SPY to match the memory of your device, see *Memory Configuration dialog box, for the C-SPY simulator*, page 162.

Trace

Opens a window which displays the collected trace data, see *Trace window*, page 178.

Function Trace

Opens a window which displays the trace data for function calls and function returns, see *Function Trace window*, page 183.

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 186.

Function Profiler

Opens a window which shows timing information for the functions, see *Function Profiler window*, page 224.

Data Log

Opens a window which logs accesses to up to four different memory locations or areas, see *Data Log window*, page 204.

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 207.

Interrupt Log

Opens a window which displays the status of all defined interrupts, see *Interrupt Log window*, page 263.

Interrupt Log Summary

Opens a window which displays a summary of the status of all defined interrupts, see *Interrupt Log Summary window*, page 266.

Timeline

Opens a window which gives a graphical view of various kinds of information on a timeline, see *The application timeline*, page 191.

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.

Interrupt Configuration

Opens a window where you can configure C-SPY interrupt simulation, see *Interrupt Configuration window*, page 257.

Available Interrupts

Opens a window with an overview of all available interrupts. You can also force an interrupt instantly from this window, see *Available Interrupts window*, page 260.

Interrupt Status

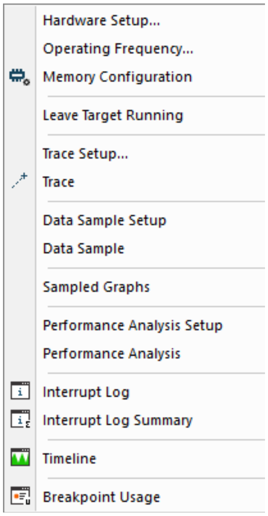
Opens a window from where you can instantly trigger an interrupt, see *Interrupt Status window*, page 261.

Breakpoint Usage

Displays a window which lists all active breakpoints, see *Breakpoint Usage window*, page 115.

Emulator menu

When you are using the C-SPY E1/E2/E20 driver, the **Emulator** menu is added to the menu bar.



Menu commands

These commands are available on the menu:

Hardware Setup

Displays a dialog box for basic configuration of the emulator, see *Hardware Setup dialog box*, page 55.

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 54.

Memory Configuration

Displays a dialog box; see *Memory Configuration dialog box, in C-SPY hardware debugger drivers*, page 166.

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.

Trace Setup

Displays a dialog box where you can configure the trace generation and collection, see *Trace Setup dialog box*, page 177.

Trace

Opens a window which displays the collected trace data, see *Trace window*, page 178.

Data Sample Setup

Opens a window where you can specify variables to sample data for, see *Data Sample Setup window*, page 213.

Data Sample

Opens a window where you can view the result of the data sampling, see *Data Sample window*, page 215.

Sampled Graphs

Opens a window which gives a graphical view of various kinds of sampled information, see *Data Sample window*, page 215.

Performance Analysis Setup

Displays a dialog box where you can configure the code performance analysis, see *Performance Analysis Setup dialog box*, page 231.

Performance Analysis

Opens a window which displays the results of the code performance analysis, see *Performance Analysis window*, page 234.

Interrupt Log

Opens a window which displays the status of all defined interrupts, see *Interrupt Log window*, page 263.

Interrupt Log Summary

Opens a window which displays a summary of the status of all defined interrupts, see *Interrupt Log Summary window*, page 266.

Timeline

Opens a window which gives a graphical view of various kinds of information on a timeline, see *The application timeline*, page 191.

Breakpoint Usage

Displays a window which lists all active breakpoints, see *Breakpoint Usage window*, page 115.

Reference information on the C-SPY simulator

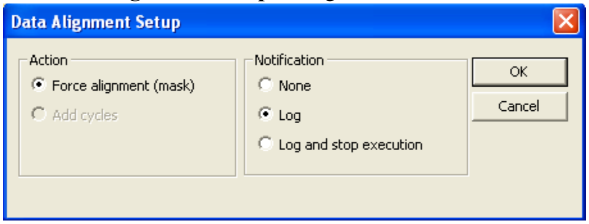
This section gives additional reference information the C-SPY simulator, reference information not provided elsewhere in this documentation.

Reference information about:

- *Data Alignment Setup dialog box*, page 362
- *Simulated Frequency dialog box*, page 363

Data Alignment Setup dialog box

The **Data Alignment Setup** dialog box is available from the **Simulator** menu.



Use this dialog box to control the behavior of the simulator when an access to misaligned data is detected.

Note: The hardware of your specific core might not support all actions.

Requirements

The C-SPY simulator.

Action

Selects the action to take when an access to misaligned data is detected. Choose between:

Force alignment

Forces misaligned data to a correct alignment.

Add cycles

Adds one extra bus cycle.

Notification

Selects a suitable notification method. Choose between:

None

Specifies that no notification will be issued.

Log

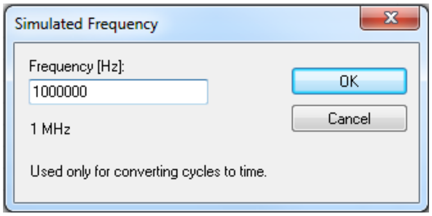
Displays a message in the Debug Log window.

Log and stop execution

Displays a message in the Debug Log window and stops the execution after the access to the misaligned data.

Simulated Frequency dialog box

The **Simulated Frequency** dialog box is available from the C-SPY driver menu.



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.

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.

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Symbols

Numerics