

# ***Ozone***

*the J-Link Debugger*

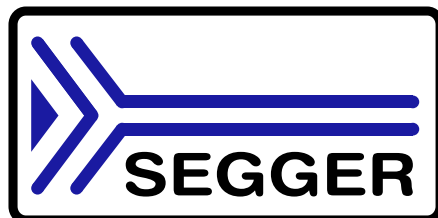
## ***User Manual***



**Software Version V2.30**  
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## Revisions

This manual describes the J-Link Debugger software.

For further information on topics or routines not yet specified, please contact us

Revision	Date	By	Explanation
V2.30 Rev. 0	170313	JD	Updated the version number to 2.30.
V2.29 Rev. 1	170306	JD	Added system variable VAR_TRACE_PORT_WIDTH.
V2.29 Rev. 0	170129	JD	Added section 4.7: "Call Graph Window".
V2.22 Rev. 4	170118	JD	Edited sections 6.3 and 7.7.9 to account for changed command "Project.AddRootPath".
V2.22 Rev. 3	161123	JD	Added section 5.11: Code Optimization. Updated multiple sections, figures and tables.
V2.22 Rev. 2	161111	JD	Added section 2.11.9: Data Graph Settings Dialog. Updated section 7.6: User Actions.
V2.22 Rev. 1	161031	JD	Updated the version number to 2.22.
V2.20 Rev. 1	160928	JD	Added user action "Project.SetJLinkLogFile".
V2.20 Rev. 0	160915	JD	Updated the version number to 2.20.
V2.18 Rev. 0	160802	JD	Reworked section 4.17 "Data Graph Window".
V2.17 Rev. 6	160718	JD	Renamed "User Guide" to "User Manual".
V2.17 Rev. 5	160623	JD	Corrected spelling errors.

Revision	Date	By	Explanation
V2.17 Rev. 4	160622	JD	Integrated documentation for editable data breakpoints. Updated all context menu graphics and hot-key descriptions. Removed obsolete user actions.
V2.17 Rev. 3	160616	JD	Removed obsolete user action table entries.
V2.17 Rev. 2	160613	JD	Fixed spelling and grammatical errors.
V2.17 Rev. 1	160606	JD	Added section 7.1.5 "CP Register Descriptor" and affiliated documentation.
V2.17 Rev. 0	160520	JD	Added section 4.17 "Data Graph Window" and affiliated documentation. Updated section 7.3.
V2.15 Rev. 1	160427	JD	Added description of Watched Data "Live Updates". Added section 7.3 "Expressions".
V2.15 Rev. 0	160324	JD	Changed name to Ozone - the J-Link Debugger.
V2.12 Rev. 2	160225	JD	Moved section 5.4 to 6.3 and 7.1.5 to 7.3.
V2.12 Rev. 1	160215	JD	Added section 5.4: File Path Resolution. Updated file path argument descriptions. Updated requirements description for trace.
V2.12 Rev. 0	160122	JD	Added: Code Profile Window. Updated: Instruction Trace Window, Watched Data Window, SourceView
V2.10 Rev. 2	160115	JD	Fixed a typo in section 7.5.11.2.
V2.10 Rev. 1	151208	JD	Added Section 5.13.7: Path Macros.
V2.10 Rev. 0	151203	JD	Updated the Version Number.
V1.79 Rev. 0	151118	JD	Conditional Breakpoints / Big Endian Support.
V1.72 Rev. 0	150505	JD	Original Version.

# About this document

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This user manual describes the features and usage of J-Link Debugger, SEGGER's source-level debugger for embedded systems.

## Typographic Conventions

Throughout this manual, the following typographic conventions are followed:

Style	Used for
Body	Normal text
<i>Reference</i>	<i>References to chapters, tables and illustrations</i>
<i>User Action</i>	<i>Text commands of user actions</i>
Title	<b>Titles of tables and illustrations</b>

Table 1.1. Typographic conventions

## Naming Conventions

Please refer to the glossary for the complete list of terms and abbreviations used in this manual.



**SEGGER Microcontroller GmbH & Co. KG** develops and distributes software development tools and ANSI C software components (middleware) for embedded systems in several industries such as telecom, medical technology, consumer electronics, automotive industry and industrial automation.

SEGGER's intention is to cut software development-time for embedded applications by offering compact flexible and easy to use middleware, allowing developers to concentrate on their application.

Our most popular products are emWin, a universal graphic software package for embedded applications, and embOS, a small yet efficient real-time kernel. emWin, written entirely in ANSI C, can easily be used on any CPU and most any display. It is complemented by the available PC tools: Bitmap Converter, Font Converter, Simulator and Viewer. embOS supports most 8/16/32-bit CPUs. Its small memory footprint makes it suitable for single-chip applications.

Apart from its main focus on software tools, SEGGER develops and produces programming tools for flash microcontrollers, as well as J-Link, a JTAG emulator to assist in development, debugging and production, which has rapidly become the industry standard for debug access to ARM cores.

**Corporate Office:**  
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## EMBEDDED SOFTWARE (Middleware)



### emWin

#### Graphics software and GUI

emWin is designed to provide an efficient, processor- and display controller-independent graphical user interface (GUI) for any application that operates with a graphical display. Starterkits, eval- and trial-versions are available.



### embOS

#### Real Time Operating System

embOS is an RTOS designed to offer the benefits of a complete multitasking system for hard real time applications with minimal resources. The profiling PC tool embOSView is included.



### emFile

#### File system

emFile is an embedded file system with FAT12, FAT16 and FAT32 support. emFile has been optimized for minimum memory consumption in RAM and ROM while maintaining high speed. Various Device drivers, e.g. for NAND and NOR flashes, SD/MMC and CompactFlash cards, are available.



### emUSB

#### USB device stack

A USB stack designed to work on any embedded system with a USB client controller. Bulk communication and most standard device classes are supported.

## SEGGER TOOLS

### Flasher

#### Flash programmer

Flash Programming tool primarily for microcontrollers.

### J-Link

#### JTAG emulator for ARM cores

USB driven JTAG interface for ARM cores.

### J-Trace

#### JTAG emulator with trace

USB driven JTAG interface for ARM cores with Trace memory. supporting the ARM ETM (Embedded Trace Macrocell).

### J-Link / J-Trace Related Software

Add-on software to be used with SEGGER's industry standard JTAG emulator, this includes flash programming software and flash breakpoints.





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# Chapter 1

## Introduction

---

Ozone is SEGGER's user-friendly and high-performance debugger for ARM Microcontroller programs. This manual explains the debugger's usage and functionality. The reader is welcome to send feedback about this manual and suggestions for improvement to [support\\_jlink@segger.com](mailto:support_jlink@segger.com).

## 1.1 What is Ozone?

Ozone is a source-level debugger for embedded software applications running on ARM-Microcontroller units. It was developed with three design goals in mind: user-friendly, high performance and advanced feature set.

Ozone is tightly coupled with SEGGER's set of J-Link debug probes to ensure optimal performance and user experience. J-Link's instruction set simulation capability makes Ozone one of the fastest stepping debuggers for embedded systems on the market.

Users are encouraged to send feedback and suggestions for improvement to [support\\_jlink@segger.com](mailto:support_jlink@segger.com).

## 1.2 Features of Ozone

Ozone has a rich set of features and capabilities. The following list gives a quick overview. Each feature and its usage is explained in more detail in section 3 as well as later sections of the manual.

### 1.2.1 Unlimited Flash Breakpoints

Ozone integrates SEGGER's flash-breakpoint technology which allows users to set an unlimited number of software breakpoints in flash memory.

### 1.2.2 Source-Level Debugging

Ozone allows users to examine program execution both on a source code and a machine code level. The debugger makes heavy use of source code debug information to improve information quality and stepping performance throughout the debugging work-flow.

### 1.2.3 Wide Range of Supported File Formats

Ozone supports a wide range of program and data file formats:

- ELF or compatible files (\*.elf, \*.out, \*.axf)
- Motorola s-record files (\*.srec, \*.mot)
- Intel hex files (\*.hex)
- Binary data files (\*.bin)

### 1.2.4 Fully Customizable User Interface

Ozone features a fully customizable multi-window user interface. All windows can be undocked from the main window and freely positioned and resized on the desktop. Fonts, colors and toolbars can be adjusted according to the user's preference. Content can be moved amongst windows via Drag&Drop.

### 1.2.5 Data Breakpoints

Ozone allows users to set data breakpoints with customizable trigger conditions.

### 1.2.6 Extensive Printf-Support

Ozone can capture printf-output by the embedded application via the Cortex-M SWO capability, Semihosting and SEGGER's Real Time Transfer (RTT) technology that provides extremely fast IO coupled with low MCU intrusion.



## 1.2.7 Peripheral and CP15 Register Support

Ozone supports [System View Description](#) files that describe the memory-mapped (peripheral) register set of the selected MCU. Once an SVD-File is specified, the register window displays peripheral registers and their bit-fields next to the core registers of the selected MCU. Additionally, the register window allows users to observe and edit coprocessor-15 registers of the selected MCU.

## 1.2.8 Scripting Interface

Ozone features a C-programming language conformant programming (scripting) interface that enables users to reconfigure the graphical user interface and most parts of the debugging work flow via script files. All actions that are accessible via the graphical user interface have an affiliated script function that can be evoked from script files or the debugger's console window.

## 1.2.9 Instruction Trace

Ozone is able to trace program execution on a machine instruction level. The history of executed machine instructions is accessible via the instruction trace window and – used in conjunction with the call stack window – gives the developer additional insight into the program's execution path.

## 1.2.10 Code Profiling

Ozone's code profiling features assist users in optimizing their program code. The Code Profile Window displays CPU load and code coverage statistics selectively at a file, function or instruction level. Code profiles can be saved to disk in human-readable or in CSV format for further processing. Ozone's code windows display code profile statistics inlined with the code. A color coding scheme is used to indicate to users source code lines and machine instructions that can be removed or improved.

## 1.2.11 Data Graphs

Ozone is able to trace symbol values and values of arbitrary C-style expressions at time resolutions of down to 1 microseconds and visualize the resulting time signals within the Data Graph Window.

## 1.2.12 Change-Level Highlighting

Ozone emphasizes changes to user interface values with a set of three different colors depending on the recency of the change. Change levels are updated each time program execution is advanced.

## 1.2.13 Mixed-Mode Disassembly

Ozone's disassembly window augments machine code with source code text fragments to improve readability.

## 1.2.14 Advanced Memory Window

Ozone's memory window implements an asynchronous scrolling approach that has been optimized for scrolling performance at both high and low MCU interface speeds. The memory window is fully editable and has many advanced features such as disk-IO, periodic updating and copy/paste of clipboard content.

## 1.2.15 System Variable Editor

Ozone's System Variable Editor enables users to modify behavioral debugger settings from a central location.

## 1.2.16 Easy Data Member Navigation

All of Ozone's symbol windows are based on a tree-structure which permits users to easily navigate through the data hierarchy of complex symbols.

## 1.2.17 Automatic Reloading of Modified Program Files

Ozone can detect changes made to the program file via an external compiler and provides the user with the option to reload the modified file.

## 1.3 Requirements

To use Ozone, the following hardware and software requirements must be met:

- Windows 2000 or later operating system
- 1 gigahertz (GHz) or faster 32-bit (x86) or 64-bit (x64) processor
- 1 gigabyte (GB) RAM
- 100 megabyte (MB) available hard disk space
- J-Link or J-Trace debug probe
- JTAG or SWD data cable to connect the MCU with the debug probe  
(not needed for J-Link OB)

## 1.4 Supported Operating Systems

Ozone currently supports the following operating systems:

- Microsoft Windows 2000
- Microsoft Windows XP
- Microsoft Windows XP x64
- Windows Vista Microsoft
- Windows Vista x64
- Windows 7
- Windows 7 x64
- Windows 8
- Windows 8 x64
- Windows 10
- Linux
- macOS/OS X

## 1.5 Supported Target Devices

Ozone currently works in conjunction with Microcontrollers (target devices) based on the following ARM architecture profiles:

- ARM7
- ARM9
- ARM11
- Cortex-M
- Cortex-A
- Cortex-R

## 1.6 Supported Debug Interfaces

Ozone communicates with the MCU via SEGGER's J-Link or J-Trace debug probe. Other debug probes or communication technologies are not supported.

# Chapter 2

## Getting Started

---

This chapter contains a quick start guide. It covers the installation procedure and explains how to use the Project Wizard in order to create a basic project file. The chapter completes by explaining how a debug session is entered.

## 2.1 Installation

This section explains how Ozone is installed and deinstalled from the operating system.

### 2.1.1 Installation on Windows

Ozone for Windows ships as an executable file that installs the debugger into a user-specified destination folder. The installer consists of four pages and guides the user through the installation process. The pages themselves are self-explanatory and users should have no difficulty following the instructions.



**Figure 2.1. First page of the windows installer**

After installation, Ozone can be started by double-clicking on the executable file that is located in the destination folder. Alternatively, the debugger can be started by executing the desktop or start menu shortcuts.

#### 2.1.1.1 Multiple Installed Versions

Multiple versions of Ozone can co-exist on the host system if they are installed into different folders. Application settings, such as user interface fonts, are shared amongst the installed versions.

### 2.1.2 Uninstallation on Windows

Ozone can be uninstalled from the operating system by running the uninstaller's executable file (Uninstall.exe) that is located in the installation folder. The uninstaller is very simple to use; it only displays a single page that offers the option to keep the debugger's application settings intact or not. After clicking the uninstall button, the uninstallation procedure is complete.

## 2.1.3 Installation on Linux

Ozone for Linux ships as an installer (.deb or .rpm) or alternatively as a binary archive (.tgz).

### 2.1.3.1 Installer

The Linux installer requires no user interaction and installs Ozone into folder /opt/SEGGER/ozone/<version>. A symlink to the executable file is copied to folder /usr/bin. The installer automatically resolves unmet library dependencies so that users do not have to install libraries manually.

SEGGER provides two individual Linux installers for debian and redhat distributions. Both installers behave exactly the same way and require an internet connection.

### 2.1.3.2 Binary Archive

The binary archive includes all relevant files in a single compacted folder. This folder can be extracted to any location on the file system. When using the binary archive to install Ozone, please also make sure that the host system satisfies all library dependencies (see "Library Dependencies" on page 21).

### 2.1.3.3 Library Dependencies

The following libraries must be present on the host system in order to run Ozone:

- libfreetype6      2.4.8    or above
- libfontconfig1    2.8.0    or above
- libext6            1.3.0    or above
- libstdc++6        4.6.3    or above
- libgcc1            4.6.3    or above
- libc6              2.15     or above

Please note that Ozone's Linux installer automatically resolves unmet dependencies and installs library files as required.

### 2.1.3.4 Multiple Installed Versions

Multiple versions of Ozone can co-exist on the host system if they are installed into different folders. Application settings, such as user interface fonts, are shared amongst the installed versions.

## 2.1.4 Uninstallation on Linux

Ozone can be uninstalled from Linux either by using a graphical package manager such as synaptic or by executing a shell command (see "Uninstall Commands" on page 21).

### 2.1.4.1 Uninstall Commands

#### **Debian**

```
sudo dpkg --remove Ozone
```

#### **Redhat**

```
sudo yum remove Ozone
```

### 2.1.4.2 Removing Application Settings

Ozone's persistent application settings are stored within the hidden file "\$Home/.config/SEGGER/Ozone.conf". In order to erase Ozone's persistent application settings, please delete this file.

## 2.1.5 Installation on macOS

Ozone for macOS ships as an installer or alternatively as a disk image. The same installer or disk image is used for both 32 and 64 bit systems since it provides universal binaries.

### 2.1.5.1 Installer

The macOS-installer installs Ozone into the application folder. It provides a single installation option, which is the choice of the installation disk (see figure *MacOS installer* on page 22).



Figure 2.2. MacOS installer

### 2.1.5.2 Disk Image

The disk image mounts as an external drive that contains the Ozone executable and its user documentation. Ozone can be run from the mounted disk out of the box - no further setup steps are required.

### 2.1.5.3 Multiple Installed Versions

Currently only one version of Ozone can be installed on macOS. Installing a version will overwrite the previously installed version.

## 2.1.6 Uninstallation on macOS

To uninstall Ozone from macOS, move its application folder to the trash bin. The application folder is `"/applications/SEGGER/ozone"`.

### 2.1.6.1 Removing Application Settings

Ozone's persistent application settings are stored in the hidden file `$Home/Library/Preferences/com.segger.Ozone.plist`. In order to erase Ozone's persistent application settings, please delete this file.

## 2.2 Using Ozone for the first time

When running Ozone for the first time, users are presented with a default user interface layout and the Project Wizard pops up. The Project Wizard will continue to pop up on start-up until the first project was created or opened.

### 2.2.1 Project Wizard

The Project Wizard provides a graphical facility to specify the required settings needed to start a debug session. The wizard hosts a total of three settings pages that are described in more detail below. The user may navigate forward and backward through these pages via the next and back buttons.

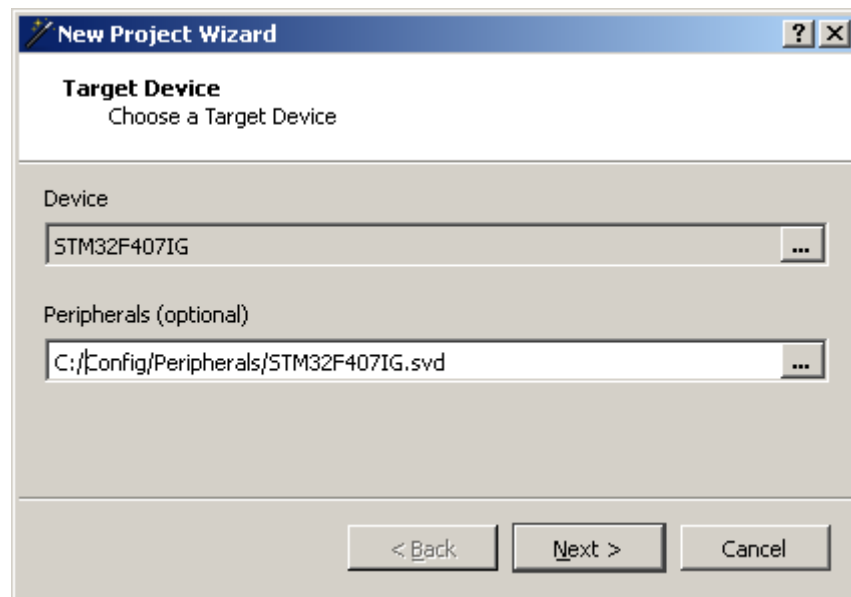


Figure 2.3. First page of the Project Wizard

#### **Device**

On the Project Wizard's first page, the user is asked to select the MCU to be debugged on. By clicking on the dotted button, a complete list of MCU's grouped by vendors is opened in a separate dialog from which the user can choose the desired device.

#### **Peripherals**

The user may optionally specify a peripheral register set description file that describes the memory-mapped register set of the selected MCU. If a valid register-set description file is specified, peripheral registers will be observable and editable via the debugger's Register Window (see "Register Window" on page 85).

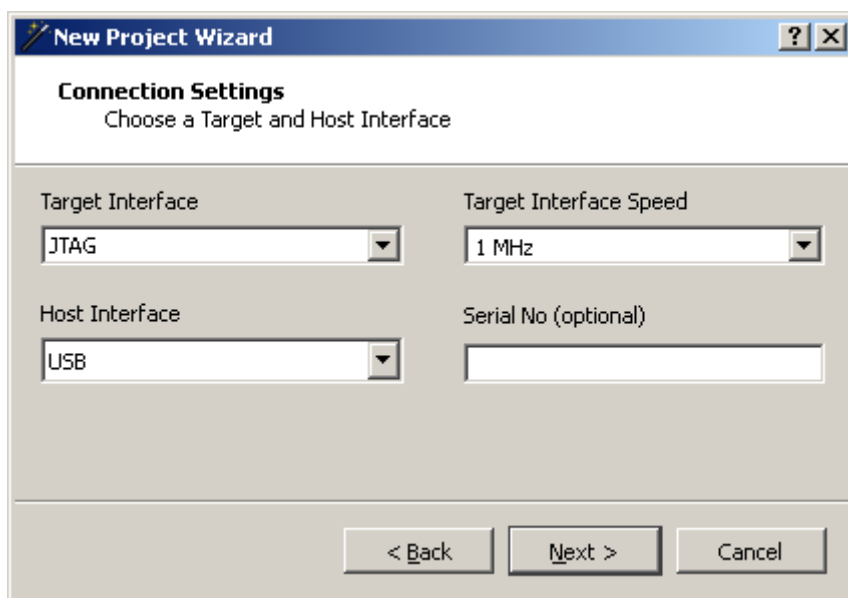


Figure 2.4. Second page of the Project Wizard

On the second page of the Project Wizard, J-Link settings are defined.

### ***Target Interface***

The target interface setting specifies how the J-Link debug probe is connected to the MCU. Ozone currently supports the JTAG and SWD target interfaces.

### ***Target Interface Speed***

The target interface speed parameter controls the communication speed with the MCU. The range of accepted values is 1 kHz to 50 MHz. Please note that some MCUs require a low, others an adaptive target interface speed throughout the initial connection phase. Usually, the target interface speed can be increased after initial connection, when certain peripheral registers of the MCU were initialized. In case the connection fails, it is advised to retry connecting at a low or adaptive target interface speed.

### ***Host Interface***

The host interface parameter specifies how the J-Link debug probe is connected to the PC hosting the debugger (host-PC). All J-Link models provide a USB interface. Some J-Link models provide an additional Ethernet interface which is especially useful for debugging an embedded application from a remote host-PC.

### ***Serial No / IP Address***

In case multiple debug probes are connected to the host-PC via USB, the user may enter the serial number of the debug probe he/she wishes to use. If no serial number is given, the user will need to specify the serial number via a dialog that pops up when starting the debug session. If Ethernet is selected as host interface, the caption of this field changes to IP Address and the user may enter the IP address of the debug probe to connect to.



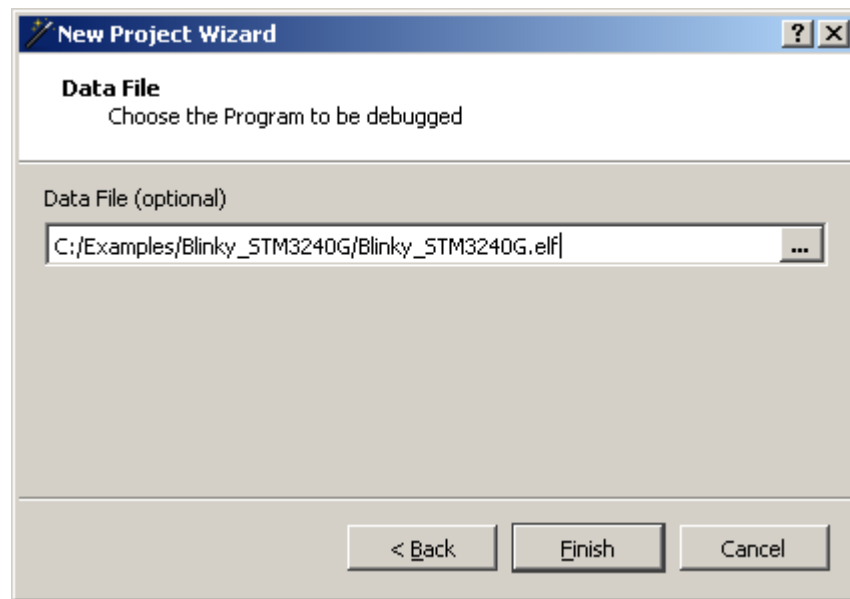


Figure 2.5. Last page of the Project Wizard

On the last page of the Project Wizard, the user specifies the debuggee.

### **Data File**

This input field allows the user to specify the desired program to debug. Please note that only ELF or compatible program files contain symbol information. When specifying a program file without symbol information, the debugging features of Ozone are limited (see “Symbol Information” on page 107).

### **Applying Project Changes Persistently**

Project settings applied via the Project Wizard are persistent, i.e. remain valid after the debugger is closed. In addition, any manual changes carried out within the project file are persistent. However, project settings applied by other means – for instance via the System Variable Editor – are only valid for the current session.

### **Completing the Project Wizard**

When the user completes the Project Wizard, a new project with the specified settings is created. The project can be saved to disk thereafter.

### **State after Completing the Project Wizard**

After completing the Project Wizard, the source file containing the program's entry function is opened inside the Source Viewer. However, the debugger is still offline, i.e. a J-Link connection to the MCU has not yet been established. At this point, only windows whose content does not depend on MCU data are operational and display content. To put the remaining windows into use and to begin debugging the program, the debug session must be started.

## **2.2.2 Starting the Debug Session**

The debug session is started by clicking on the green start button in the debug tool bar or by hitting the shortcut F5. After the startup procedure is complete, the user may start to debug the application program using the controls of the Debug Menu. The debugging work flow is described in detail in Chapter 5.



# Chapter 3

## Graphical User Interface

---

This chapter provides a description of Ozone's graphical user interface and its usage. The focus lies on a brief description of graphical elements. Chapter 5 will revisit the debugger from a functional perspective.

## 3.1 User Actions

A user action (or action for short) is a particular operation within the debugger that can be triggered via the user interface or programmatically from a script function. Ozone provides a set of around 200 user actions.

### 3.1.1 Action Tables

Appendix 7.6 provides multiple tables that contain quick facts on all user actions. The action tables are particularly well suited as a reference when running the debugger from the command prompt or when writing script functions.

### 3.1.2 Local and Global User Actions

A user action is either a local or a global action. A local action is sensitive to the position of the input focus or the current selection, while a global action is not. Amongst other things, this has implications on using hotkeys, as is explained in section 3.1.3.

### 3.1.3 Executing User Actions

User actions can (potentially) be executed in any of the ways listed in Table 3.1.

Execution Method	Description
Menu	A user action can be executed by clicking on its menu item.
Toolbar	A user action can be executed by clicking on its tool button.
Hotkey	A user action can be executed by pressing its hotkey.
Command Prompt	A user action can be executed by entering its command into the command prompt.
Script Function	A user action can be executed by placing its command into a script function.

Table 3.1. Alternative ways of executing user actions

However, some user actions do not have an associated text command and thus cannot be executed from the command prompt or from a script function. On the other hand, some actions can only be executed from these locations, but have no affiliated user interface element. Furthermore, some actions do not provide a hotkey. Appendix 7.7 provides information about which method of execution is available for the different user actions.

#### 3.1.3.1 Hotkeys

Multiple local user actions may share the same hotkey. As a consequence, a local user action can only be triggered via its hotkey when the window containing the action is visible and has the input focus. On the contrary, global user actions have unique hotkeys that can be triggered without restriction.

### 3.1.4 Dialog Actions

Several user actions execute a dialog. The fact that a user action executes a dialog is indicated by three dots that follow the action's name within user interface menus.

### 3.1.5 Omissible Arguments

When a required argument is omitted from a user action command, an input dialog will pop up that allows the user to complete the missing argument at execution time.

## 3.2 Change Level Highlighting

Ozone emphasizes changed values with a set of three different colors that indicate the recency of the change. The change level of a particular value is defined as the amount of times the program was stepped since the value has changed. Table 3.2 depicts the default colors that are assigned to the different change levels.

Change Level	Meaning
Level1	The value has changed one program step ago.
Level2	The value has changed two program steps ago.
Level3	The value has changed three program steps ago.
Level4 (and above)	The value has changed 4 or more program steps ago or does not display change levels.

**Table 3.2. Value change levels**

Both foreground and background colors used for change level highlighting can be adjusted via the User Preference Dialog (see “User Preference Dialog” on page 43) or via the user action *Edit.Color* (see “Edit.Color” on page 156).

## 3.3 Main Window

Ozone's Main Window consists of the following elements, listed by their location within the window from top to bottom:

- Menu Bar
- Tool Bar
- Content Area
- Status Bar

These components will be explained further down this chapter. First, the Main Window is described (see the illustration below):

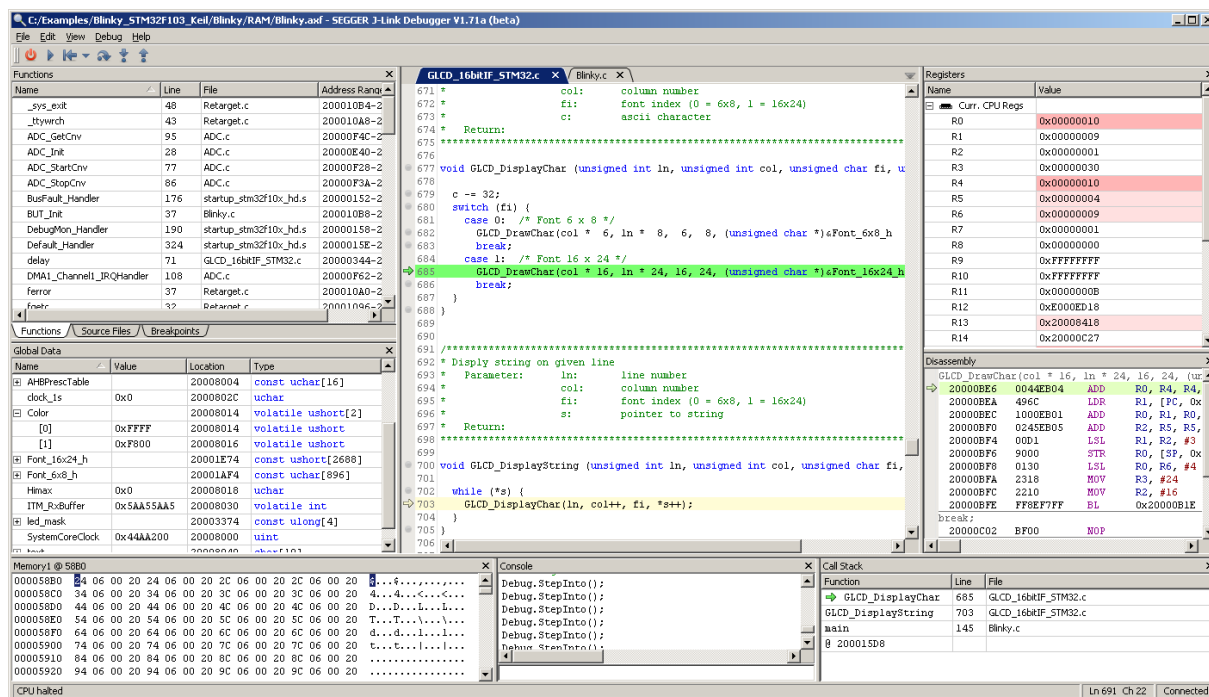


Figure 3.3. Main window hosting debug information windows

In its center, the Main Window hosts the source code document viewer, or Source Viewer for short. The Source Viewer is surrounded by three content areas to the left, right and on the bottom. In these areas, users may arrange debug information windows as desired. The layout process is described in "Window Layout" on page 42. The only window that cannot be undocked or repositioned is the Source Viewer itself.

## 3.4 Menu Bar

File Edit View Debug Help

Ozone's Main Window provides a menu bar that categorizes all user actions into five functional groups (see the illustration above). It is possible to control the debugger from the menu bar alone. The five menu groups are described below.

### 3.4.1 File Menu

The File Menu hosts actions that perform file system and related operations (see "File Actions" on page 145).

#### **New**

This submenu hosts actions to create a new project and to run the Project Wizard (see "Project Wizard" on page 23).

#### **Open**

Opens a project-, program-, data- or source-file (see "File.Open" on page 150).

#### **Save Project as**

Opens a dialog that lets users save the current project to the file system.

#### **Save All**

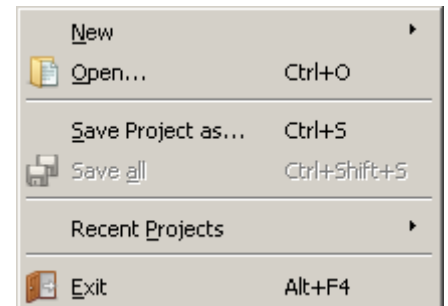
Saves all modified workspace files.

#### **Recent Projects**

The "Recent Projects" submenu contains a list of recently used projects. When an entry is selected, the associated project is opened.

#### **Exit**

Exits the application.



### 3.4.2 Edit Menu

The Edit Menu hosts three dialog actions that allow users to edit Ozone's graphical and behavioral settings (see "Edit Actions" on page 145).

#### **J-Link-Settings**

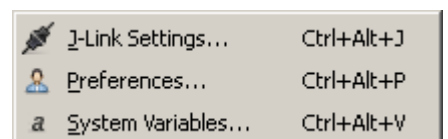
Opens the J-Link-Settings Dialog that allows users to specify the hardware setup, i.e. the MCU model and debugging interface to be used (see "J-Link Settings Dialog" on page 49).

#### **Preferences**

Opens the User Preference Dialog that allows users to configure Ozone's graphical user interface (see "User Preference Dialog" on page 43).

#### **System Variables**

Opens the System Variable Editor that allows users to configure behavioral settings of the debugger (see "System Variable Editor" on page 46).



### 3.4.3 View Menu

The View Menu hosts actions that add debug information windows and toolbars to the Main Window (see “View Actions” on page 146).

#### Views

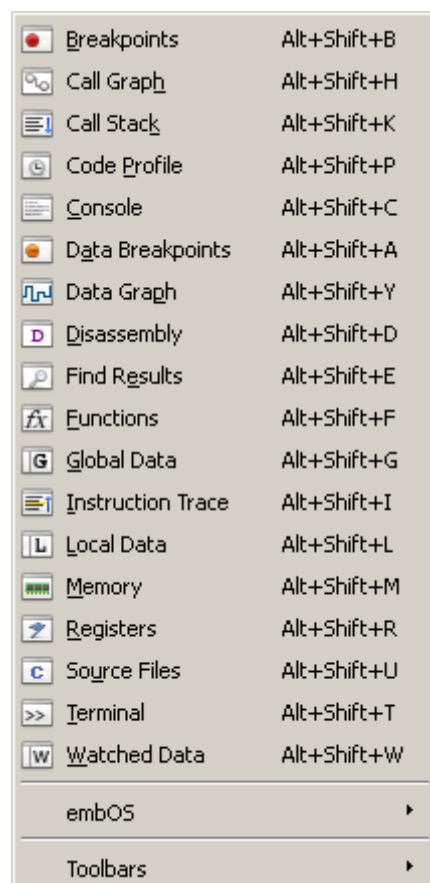
The View Menu contains an entry for each debug information window. By clicking on an entry, the corresponding window is added to the Main Window at the last used position (see “Opening and Closing Windows” on page 42).

#### embOS

If an RTOS-awareness-Plugin has been set using action *Project.SetOSPlugin*, a submenu is added to the View Menu that hosts additional debug information windows provided by the RTOS-awareness-Plugin (see “Project.SetOSPlugin” on page 173).

#### Toolbars

This submenu hosts three checkable actions that define whether the file-, debug- and help-toolbars are visible (see “Showing and Hiding Toolbars” on page 33).



### 3.4.4 Debug Menu

The Debug Menu hosts actions that control program execution (see “Debug Actions” on page 147).

#### Start/Stop Debugging

Starts the debug session, if it is not already started. Stops the debug session otherwise.

#### Continue/Halt

Resumes program execution, if the program is halted. Halts program execution otherwise (see “Resume” on page 112).

#### Reset

Resets the program using the last employed reset mode. Other reset modes can be executed from the action's sub menu (see “Reset” on page 111).

#### Step Over

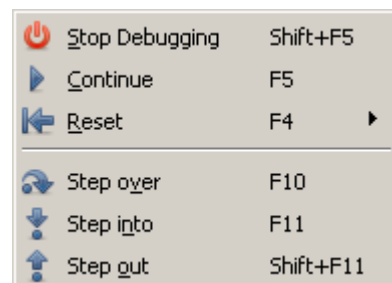
Steps over the current source code line or machine instruction, depending on the active code window (see “Active Code Window” on page 36 and “Step” on page 111).

#### Step Into

Steps into the current subroutine or performs a single instruction step, depending on the active code window (see “Active Code Window” on page 36 and “Step” on page 111).

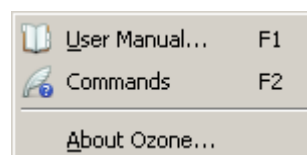
#### Step Out

Steps out of the current subroutine (see “Step” on page 111).



### 3.4.5 Help Menu

The Help Menu hosts the debugger's user manual, command help and About Dialog (see “Help Actions” on page 147)





## 3.5 Toolbars

Three of Ozone's Main Menu groups – File, Debug and View – have affiliated toolbars that can be docked to the Main Window or positioned freely on the desktop (see the illustration below). In addition, a breakpoint toolbar is provided.

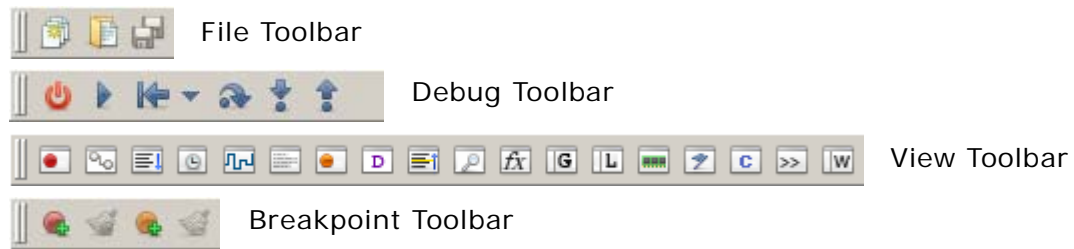


Figure 3.4. Menu toolbars

### 3.5.1 Showing and Hiding Toolbars

Individual toolbars can be added to the Main Window via the toolbars menu (View Toolbars) or by executing the user action *Toolbar.Show* using the toolbar's name as parameter (e.g. *Toolbar.Show("Debug")*). Removing toolbars from the Main Window works identically using action *Toolbar.Close*. Please see page 160 for further information on these actions.

### 3.5.2 Arranging Toolbars

Toolbars can be arranged either next to each other or above each other within the toolbar area as desired. To reposition a toolbar, pick the toolbar's handle and drag it to the desired position.

### 3.5.3 Docking and Undocking Toolbars

Toolbars can be undocked from the toolbar area and positioned anywhere on the desktop. To undock a toolbar, pick the toolbar's handle and drag it outside the toolbar area. To hide an undocked toolbar, follow the instructions of section 3.5.1.

## 3.6 Status Bar

Ozone's status bar displays information about the debugger's current state. The status bar is divided into three sections (from left to right):

- Status message and progress bar
- Window context information
- Connection state



Figure 3.5. Status bar

### 3.6.1 Status Message

On the left side of the status bar, the status message is displayed. The status message informs about the following objects, depending on the situation:

#### ***Program State***

By default, the status message informs about the program state, e.g. "Program running".

#### ***Operation Status***

When the debugger performs a lengthy operation, the status message displays the name of the operation. In addition, a progress bar is displayed that indicates the progress of the operation.

#### ***Context Help***

When hovering the mouse cursor over a user interface element, the status message displays a short description of the element.

### 3.6.2 Window Context Information

The middle section of the status bar displays information about the active debug information window.

### 3.6.3 Connection State

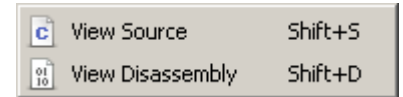
The right section of the status bar informs about the debugger's J-Link connection state. When the debugger is connected to the MCU, the data transmission speed is displayed as well.

## 3.7 Debug Information Windows

Ozone features a set of 18 debug information windows that cover different functional areas of the debugger. This section describes the common features shared by all debug information windows. An individual description of each debug information window is given in “Debug Information Windows” on page 57.

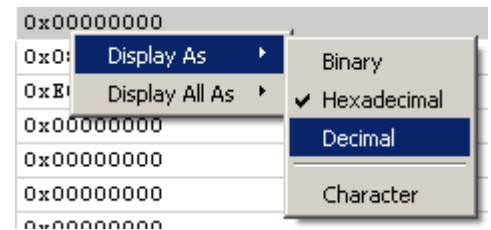
### 3.7.1 Context Menu

Each debug information window owns a context menu that provides access to the window's options. The context menu is opened by right-clicking on the window.



### 3.7.2 Display Format

Several debug information windows allow users to change the value display format of a particular (or all) items hosted by the window. If supported, the value display format can be changed via the window's context menu or via the user actions *Window.SetDisplayFormat* (see page 158) and *Edit.DisplayFormat* (see page 156).



### 3.7.3 Change Level Highlighting

The following debug information windows employ change level highlighting (see “Change Level Highlighting” on page 29):

- Registers
- Memory
- Local Data
- Global Data
- Watched Data

Value
0x10
0x10
0x20
0x20008041

### 3.7.4 Code Windows

Ozone includes two debug information windows that display the program's source code and assembler code, respectively. The code windows share several common properties that are described in “Code Windows” on page 36.

### 3.7.5 Table Windows

Several of Ozone's debug information windows are based on a joint table layout that provides a common set of features. A shared description of the table-based debug information windows is given in “Table Windows” on page 40.

### 3.7.6 Window Layout

Section “Window Layout” on page 42 describes how debug information windows are added to, removed from and arranged on the Main Window.

## 3.8 Code Windows

Ozone includes two debug information windows that display program code: the Source Viewer and the Disassembly Window. These windows display the program's source code and assembler code, respectively. Both windows share multiple properties which are described below. For an individual description of each window, please refer to "Source Viewer" on page 58 and "Disassembly Window" on page 62.

### 3.8.1 Program Counter Tracking

Ozone's code windows automatically scroll to the position of the PC line when the user steps or halts the program. In case of the Source Viewer, the document containing the PC line is automatically opened if required.

### 3.8.2 Active Code Window

At any point in time, either the Source Viewer or the Disassembly Window is the active code window. The active code window determines the debugger's stepping behavior, i.e. whether the program is stepped per source code line or per machine instruction.

#### 3.8.2.1 Recognizing the Active Code Window

The active code window can be distinguished from the inactive code window by a higher color saturation level of the PC line (see the illustration below).

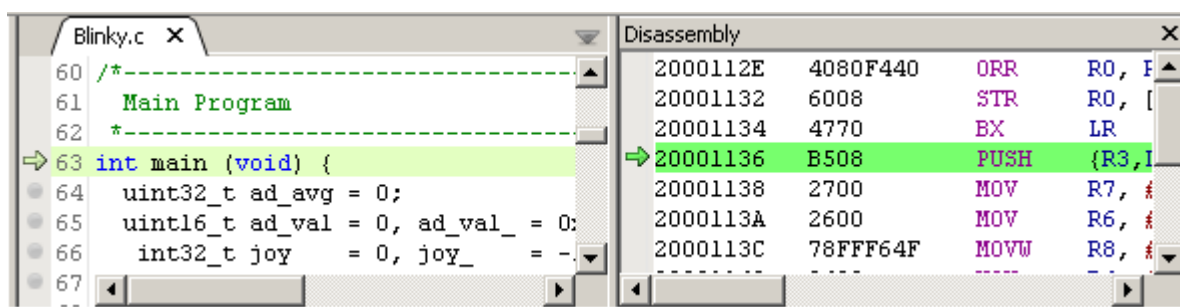


Figure 3.6. Source Viewer (inactive, left) and Disassembly Window (active, right)

#### 3.8.2.2 Switching the Active Code Window

A switch to the active code window occurs either manually or automatically.

##### **Manual Switch**

A manual switch of the active code window can be performed by clicking on one of the code windows. The selected window will become active while the other code window will become inactive.

##### **Automatic Switch to the Disassembly Window**

When the user steps or halts the program and the PC is not affiliated with a source code line via the program's address mapping table, the debugger will automatically switch to the Disassembly Window. The user can hereupon continue stepping the program on a machine instruction level.

##### **Automatic Switch to the Source Viewer**

When the program was reset and the PC is affiliated with a source code line, the debugger will switch to the Source Viewer as its active code window.

### 3.8.3 Sidebar

Each code window hosts a sidebar on its left side. The sidebar displays icons that provide additional information about code lines. Breakpoints can be toggled by clicking on the sidebar. If desired, the sidebar can be hidden.

#### 3.8.3.1 Showing and Hiding the Sidebar

The display of the sidebar can be toggled from the User Preference Dialog (see “User Preference Dialog” on page 43) or via the user action *Edit.Preference* (see “Edit.Preference” on page 155).

#### 3.8.3.2 Sidebar Icons

The following table gives an overview of the sidebar icons and their meanings:








Icon	Meaning
	The code line does not contain executable code.
	The code line contains executable code.
	A breakpoint is set on the code line.
	The code line contains the PC instruction and will be executed next.
	The code line contains a call site of a function on the call stack.
	The code line contains the PC instruction and a breakpoint is set on the line.
	The code line contains a call site and a breakpoint is set on the line.

Table 3.7. Sidebar Icons

#### 3.8.3.3 Showing and Hiding the Sidebar

The display of the sidebar can be toggled from the User Preference Dialog (see “User Preference Dialog” on page 43) or via the user action *Edit.Preference* (see “Edit.Preference” on page 155).

### 3.8.4 Code Line Highlighting

Each code window applies distinct highlights to particular code lines. Table 3.8 explains the meaning of each highlight. Code line highlighting colors can be adjusted via the User Preference Dialog (see “User Preference Dialog” on page 43) or via the user action *Edit.Color* (see “Edit.Color” on page 156).

Highlight	Meaning
<code>for (int i = 0) {</code>	The code line contains the program execution point (PC).
<code>Function(x,y);</code>	The code line contains the call site of a function on the call stack.
<code>for (int i = 0) {</code>	The code line is the selected line.

Table 3.8. Code Line Highlights

#### 3.8.4.1 Call-Site Highlighting Requirement

Call site highlighting will only take place when the Call Stack Window is open, i.e. floating or docked to the Main Window.

### 3.8.5 Breakpoints

Ozone’s code windows provide multiple options to set, clear, enable, disable and edit breakpoints. The different options are described below.

### 3.8.5.1 Toggling Breakpoints

Table 3.9 gives an overview of the options that both code windows provide to set or clear breakpoints on the selected code line.

Method	Set	Clear
Context Menu	Menu Item "Set Breakpoint"	Menu Item "Clear Breakpoint"
Hotkey	F9	F9
Sidebar	Single-Click	Single-Click

Table 3.9. Alternative ways of toggling breakpoints on code lines

Breakpoints on arbitrary addresses and code lines can be toggled using the actions *Break.Set*, *Break.SetOnSrc*, *Break.Clear* and *Break.ClearOnSrc* (see "Breakpoint Actions" on page 148).

### 3.8.5.2 Enabling and Disabling Breakpoints

The code windows allow users to disable and enable the breakpoint on the selected code line by pressing the hotkey F8. Breakpoints on arbitrary addresses and code lines can be enabled and disabled using actions *Break.Enable*, *Break.Disable*, *Break.EnableOnSrc* and *Break.DisableOnSrc* (see "Breakpoint Actions" on page 148).

### 3.8.5.3 Editing Advanced Breakpoint Properties

Advanced breakpoint properties, such as the trigger condition or implementation type, can be edited via the Breakpoint Properties Dialog (see "Breakpoint Properties Dialog" on page 48) or programmatically via the user actions *Break.Edit* (see "Break.Edit" on page 186) and *Break.SetType* (see "Break.SetType" on page 184).

## 3.8.6 Code Profile Information

The code windows are able to display code profile information within their sidebar areas.

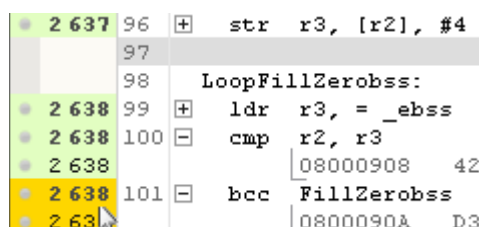
### 3.8.6.1 Hardware Requirements

The code profile features of Ozone require the employed hardware setup to support instruction tracing (see "Hardware Requirements" on page 65). The user experience can be enhanced by employing a J-Trace PRO debug probe (see "Streaming Trace" on page 118).

### 3.8.6.2 Execution Counters

When code profiling features are supported by the hardware setup, the code windows display a counter next to each text line that contains executable code. The counter indicates how often the source code line or instruction was executed.

The execution counters are reset at the same time the program is reset. The code window context menu provides actions to reset and toggle the display of execution counters as well.



2 637	96	+	str r3, [r2], #4
	97		
	98		LoopFillZerobss:
2 638	99	+	ldr r3, =_ebss
2 638	100	-	cmp r2, r3
2 638			08000908 42
2 638	101	-	bcc FillZerobss
2 638			0800090A D3

### 3.8.6.3 Execution Profile Tooltips

When hovering the sidebar area next to executable code, an execution profile tooltip is displayed.

#### ***Fetches***

Number of times the instruction was fetched from memory.

#### ***Executed***

Number of times the instruction was executed. A conditional instruction may not be executed after having been fetched from memory.

#### ***Not-Executed***

Number of times the instruction was fetched from memory but not executed.

#### ***Load***

Number of times the instruction was fetched divided by the total amount of instructions fetched during program execution.

Please note that the execution profile of source code lines is identical to the execution profile of the first machine instruction affiliated with the source code line.

Execution Profile for SEGGER_RTT.c: 276	
Fetches:	5 409 641
Executed:	5 409 641 {100.0%}
Not-Executed:	0 {0.0%}
Load:	1.3%

### 3.8.6.4 Code Profile Highlighting Colors

The code windows employ different highlighting colors in conjunction with code profile information. The default colors and their meanings are shown below.



Line has been executed.



Line has been partially executed.



Line has not been executed.

These default colors can be adjusted via the User Preference Dialog (see "User Preference Dialog" on page 43) or programatically via user action *Edit.Color* (see "Edit.Color" on page 156).

### 3.8.6.5 Executed Line

All instructions of the line have been executed and all conditions have been met and not met.

### 3.8.6.6 Partially Executed Line

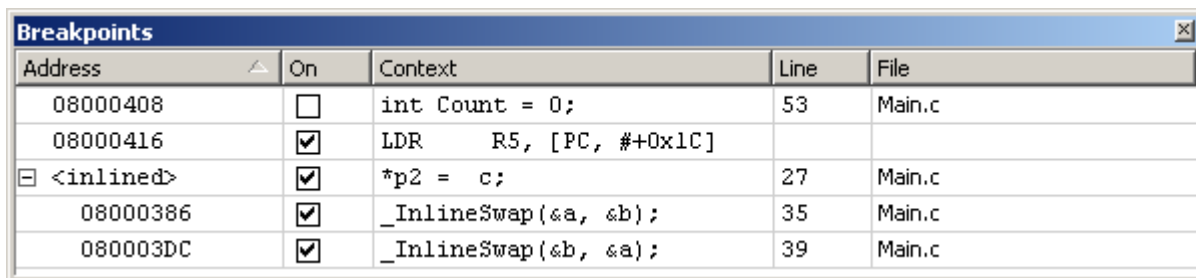
Not all instructions of the line have been executed or conditions are only partially met.

### 3.8.6.7 Not Executed Line

No instruction of the line has been fetched from memory or executed.

## 3.9 Table Windows

Several of Ozone's debug information windows are based on a joint table layout that provides a common set of features. The Breakpoint Window illustrated below is an example of a table-based debug information window (or table window for short).



Address	On	Context	Line	File
08000408	<input type="checkbox"/>	int Count = 0;	53	Main.c
08000416	<input checked="" type="checkbox"/>	LDR R5, [PC, #+0x1C]		
<inlined>	<input checked="" type="checkbox"/>	*p2 = c;	27	Main.c
08000386	<input checked="" type="checkbox"/>	_InlineSwap(&a, &b);	35	Main.c
080003DC	<input checked="" type="checkbox"/>	_InlineSwap(&b, &a);	39	Main.c

Figure 3.10. Table window

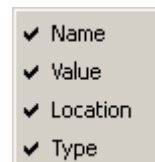
### 3.9.1 List of Table Windows

The following debug information windows are table-based:

- Breakpoints
- Data Breakpoints
- Functions
- Call Stack
- Global Data
- Local Data
- Watched Data
- Data Graph
- Call Graph
- Code Profile
- Registers
- Source Files

### 3.9.2 Switchable Table Columns

Each table column has a checkable entry in the context menu of the table header. When an entry is checked or unchecked, the corresponding table column is shown or hidden. The table header context menu can be opened by right-clicking on the table header.



### 3.9.3 Sortable Table Rows

Table rows can be sorted according to the values displayed in a particular column. To sort a table according to a particular column, a left click on the column header suffices. A sort indicator in the form of a small arrow indicates the column according to which the table is currently sorted. The sort strategy depends on the data type of the column.

### 3.9.4 Editable Table Cells

Certain table cells such as variable values are editable. When a value that is stored in MCU hardware is edited, a data readback is performed. This mechanism ensures that the displayed value is always synchronized with the hardware state.

### 3.9.5 Letter Key Navigation

By repeatedly pressing a letter key within a table window, the table rows that start with the given letter are scrolled into view one after the other.



### 3.9.6 Tree Structure

A table row that displays a button on its left side can be expanded to reveal its child rows. A table window where multiple rows have been expanded attains a tree structure as illustrated in the picture to the right.


[-] pCurrentTask
[-] [0]
[-] pNext
[+] [0]
[+] pStack

## 3.10 Window Layout

This section describes how debug information windows can be added to, removed from and arranged on the Main Window.

### 3.10.1 Opening and Closing Windows

#### Opening Windows

Windows are opened by clicking on the affiliated view menu item (e.g. View  Breakpoints) or by executing the command *Window.Show* using the window's name as parameter (e.g. *Window.Show("Breakpoints")*). When a window is opened, it is added to its last known position on the user interface.

#### Closing Windows Programmatically

Windows can be closed programatically via the user action *Window.Close* using the window's name as parameter.

### 3.10.2 Undocking Windows

Windows can be undocked from the main window by dragging or double-clicking the window's title bar. An undocked window can be freely positioned and resized on the desktop.

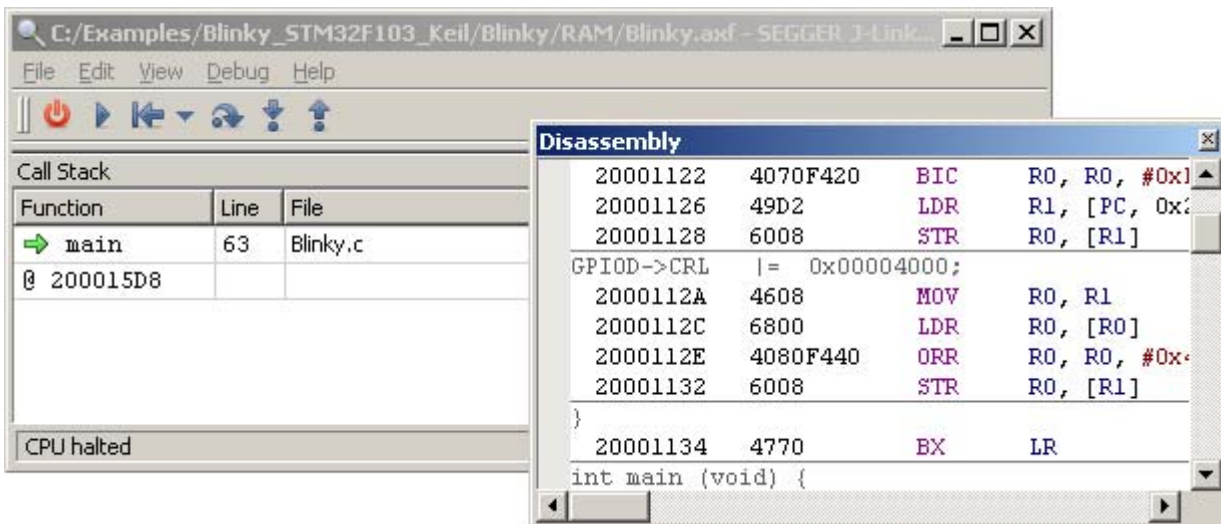


Figure 3.11. Undocked Disassembly Window floating over the Main Window

### 3.10.3 Docking and Stacking Windows

Windows can be docked on the left, right or bottom side of the main window by dragging and dropping the window at the desired position. If a window is dragged and dropped over another window the windows are stacked. More than two windows can be stacked above each other.

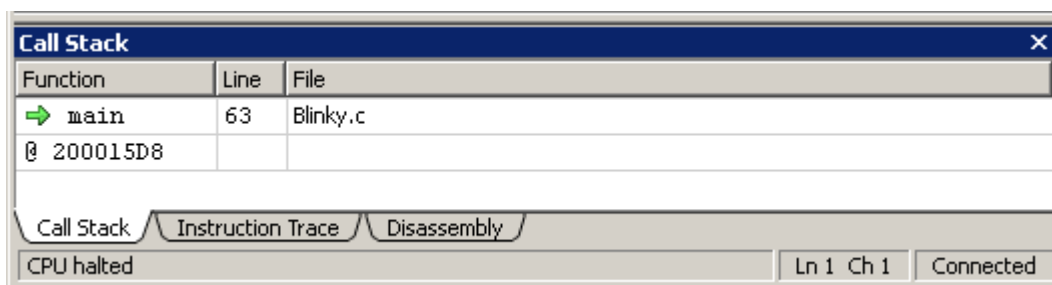


Figure 3.12. Stacked debug information windows

## 3.11 Dialogs

This section describes the different dialogs that are employed within Ozone.

### 3.11.1 User Preference Dialog

The User Preference Dialog provides multiple options that allow users to customize the graphical user interface of Ozone. In particular, fonts, colors and toggleable items such as line numbers and sidebars can be customized.

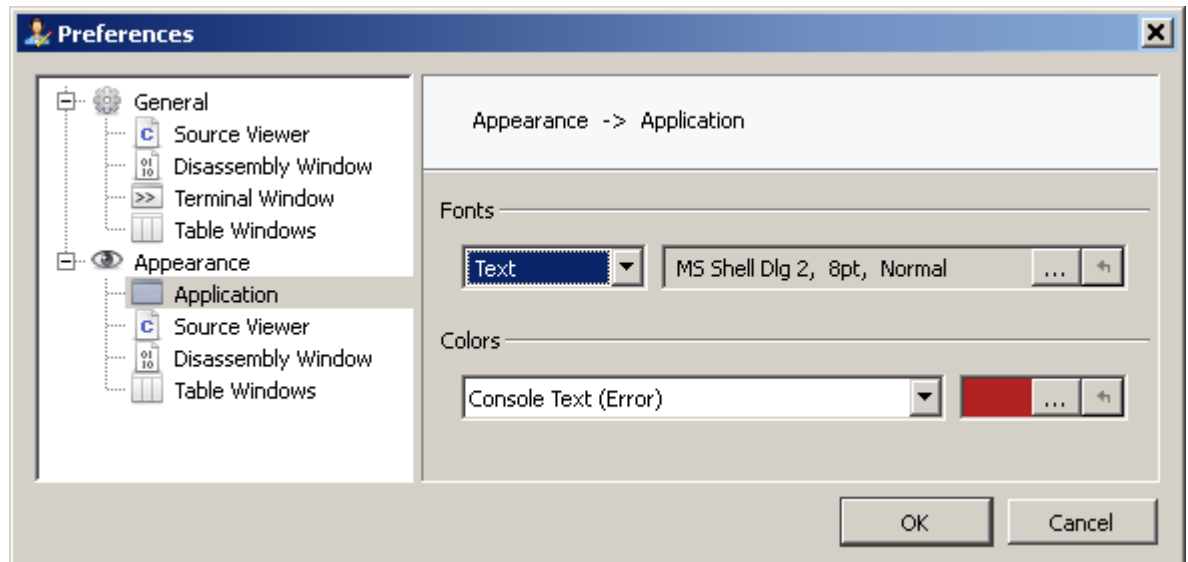


Figure 3.13. User Preference Dialog

#### 3.11.1.1 Opening the User Preference Dialog

The User Preference Dialog can be opened from the Main Menu (Edit → Preferences) or by executing the user action *Edit.Preferences* (see “Edit.Preferences” on page 154).

#### 3.11.1.2 Dialog Components

##### **Page Navigator**

The Page Navigator on the left side of the User Preference Dialog displays the available settings pages grouped into two categories: general and appearance. Each settings page applies to a single or multiple debug information windows, as indicated by the page name.

##### **Settings Pane**

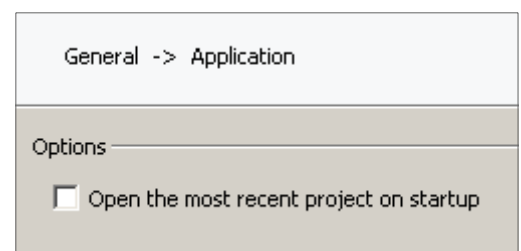
The Settings Pane on the right side of the User Preference Dialog displays the settings associated with the selected page.

#### 3.11.1.3 General Application Settings

This settings page lets users adjust general application settings.

##### **Open the most recent Project on Startup**

Specifies if the most recent project should be opened when the debugger is started instead of displaying the Welcome Dialog.



### 3.11.1.4 Source Viewer Settings

This settings page lets users adjust general display options of the Source Viewer.

#### **Show Line Numbers**

Specifies if the Source Viewer displays source code line numbers (see “Source Line Numbers” on page 59).

#### **Show Sidebar**

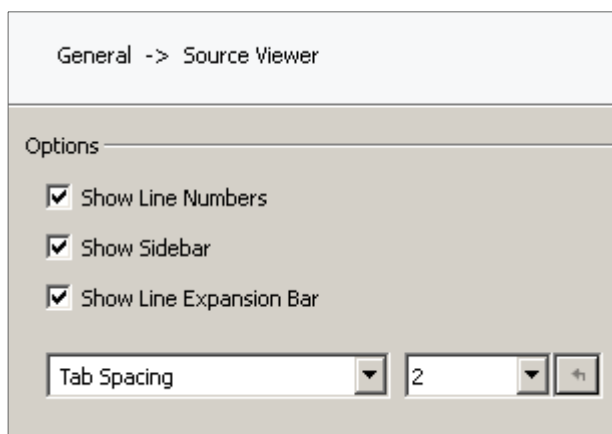
Specifies if the Source Viewer displays a sidebar.

#### **Show Line Expansion Bar**

Specifies if the Source Viewer displays line expansion indicators next to source code lines.

#### **Tab Spacing**

Sets the number of whitespaces drawn for each tabulator.



### 3.11.1.5 Disassembly Window Settings

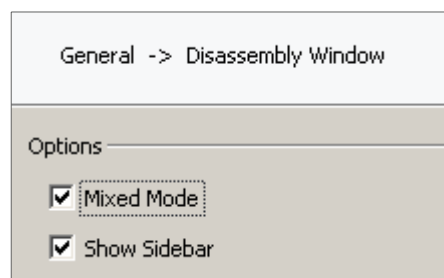
This settings page lets users adjust general display options of the Disassembly Window.

#### **Mixed Mode**

Specifies if the Disassembly Window augments assembler code with source code text to improve readability (see “Mixed Mode Disassembly” on page 63).

#### **Show Sidebar**

Specifies if the Disassembly Window displays a sidebar (see “Sidebar” on page 37).

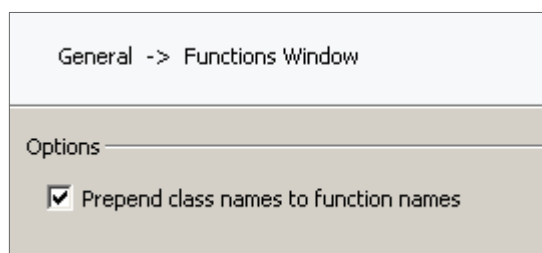


### 3.11.1.6 Function Window Settings

This settings page lets users adjust general display options of the Functions Window.

#### **Prepend Class Names to Func Names**

Specifies if the class name of a member function should be preceding the function name itself (see “User Preference Identifiers” on page 140).

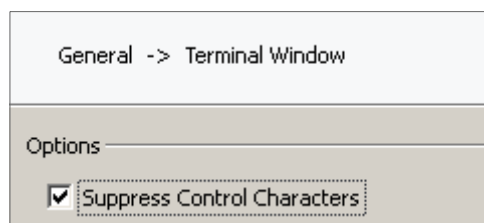


### 3.11.1.7 Terminal Window Settings

This settings page lets users adjust general display options of the Terminal Window.

#### **Suppress Control Characters**

Specifies if non-printable and control characters are filtered from IO data prior to terminal output (see “User Preference Identifiers” on page 140).



### 3.11.1.8 Table Windows Settings

This settings page lets users adjust general display options of the Table Windows (see "Table Windows" on page 35).

#### **Show Character Value**

The provided options allow users to specify which values are displayed in character representation next to the number representation. By checking a data type's option, all symbols of this data type display their value in the format "number (character)" instead of just "number".

### 3.11.1.9 Appearance Settings

On the appearance settings pages, fonts and colors of a particular window or window group can be adjusted. Within the window group "Application", the default appearance settings for all windows and dialogs can be specified.

#### **Fonts**

Lets users adjust individual fonts of the window or window group.

#### **Colors**

Lets users adjust individual colors of the window or window group.

### 3.11.1.10 Specifying User Preferences Programmatically

Each setting provided by the User Preference Dialog is affiliated with an user action. User preference actions allow users to change the preference from a script function or at the command prompt. Table 3.14 gives an overview of the user preference actions (see "Edit Actions" on page 154).

Settings Category	Affiliated User Action(s)
General Settings	<i>Edit.Preference</i>
Appearance Settings	<i>Edit.Color and Edit.Font</i>

Table 3.14. User preference actions

## 3.11.2 System Variable Editor

Ozone defines a set of 15 system variables that control behavioral aspects of the debugger. The System Variable Editor lets users observe and edit these variables in a tabular fashion.

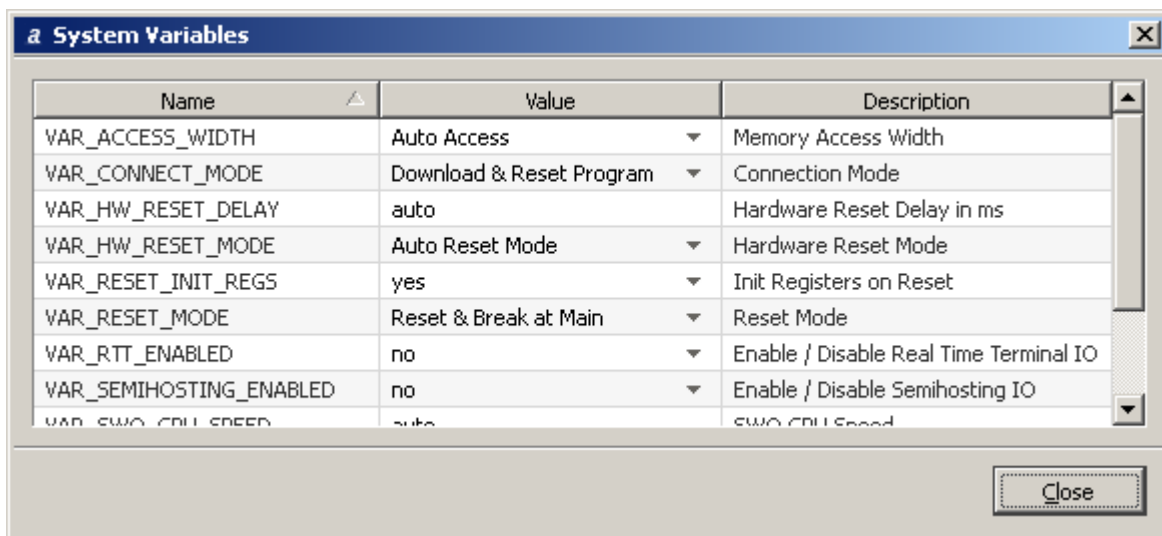


Figure 3.15. System Variable Editor

### 3.11.2.1 Opening the System Variable Editor

The System Variable Editor can be opened from the Main Menu (Edit → System Variables) or by executing the user action *Edit.SysVars* (see “Edit.SysVar” on page 155).

### 3.11.2.2 Editing System Variables Programmatically

The user action *Edit.SysVar* is provided to manipulate system variables from script functions or at the command prompt (see “Command Prompt” on page 71).

### 3.11.2.3 Applying Changes

In general, changes to system variables are not applied immediately upon closing the System Variable Editor. Instead, the debug session must be restarted for new settings to take effect. There are exceptions to this rule: the target interface speed parameter, for example, is applied immediately.

### 3.11.3 Data Breakpoint Dialog

The Data Breakpoint Dialog allows users to place data breakpoints on global program variables and individual memory addresses. The dialog can be accessed from the context menu of the Data Breakpoint Window (see "Data Breakpoint Window" on page 78).

#### **Data Location**

The data location pane allows users to specify the memory address(es) to be monitored for IO accesses. When the "From Symbol" field is checked, the memory address is adapted from the data location of a global variable. Otherwise, the memory addresses need to be specified manually. Please refer to "Data Breakpoints" on page 114 for further information.

#### **Access Condition**

The access condition pane allows users to specify the type and size of a memory access that triggers the data breakpoint. Please refer to "Data Breakpoints" on page 114 for further information.

#### **Value Condition**

The value condition pane allows users to specify the IO-value required to trigger the data breakpoint. The value condition can be disabled by checking the "Ignored" field. Please refer to "Data Breakpoints" on page 114 for further information.

#### **OK Button**

By pressing the OK button, a data breakpoint with the specified attributes is set in MCU hardware and added to the Data Breakpoint Window. In case the debugger is disconnected from the MCU, the data breakpoint is added to the Data Breakpoint Window and scheduled to be set in MCU hardware when the debug session is started.

#### **Cancel Button**

Closes the dialog without setting the data breakpoint.

**Set Data Breakpoint**

**Data Location**

☐ From Symbol ☒ Manual

Address: 0

Mask: 0

**Access Condition**

Write Only

Access Size: Byte

**Value Condition**

☐ Ignored

Value: 100

Mask: 0xFFFFFFFF

OK Cancel

### 3.11.4 Breakpoint Properties Dialog

The Breakpoint Properties Dialog allows users to edit advanced breakpoint properties such as the trigger condition and the implementation type. The dialog can be accessed via the context menu of the Source Viewer, Disassembly Window or Breakpoint Window. Advanced breakpoint properties can also be set programmatically using actions *Break.Edit* (see “Break.Edit” on page 186) and *Break.SetType* (see “Break.SetType” on page 184).

#### State

Enables or disables the breakpoint.

#### Type

Sets the breakpoint's implementation type (see “Break.SetType” on page 184).

#### Skip Count

Program execution can only halt each Skip-Count+1 amount of times the breakpoint is hit. Furthermore, the remaining trigger conditions must be met in order for program execution to halt at the breakpoint.

#### Task

Specifies the RTOS task that must be running in order for the breakpoint to be triggered. The RTOS task that triggers the breakpoint can be specified either via its name or via its ID. When the field is left empty, the breakpoint is task-insensitive.

#### Condition

An integer-type or boolean-type C-language-expression that must be met in order for program execution to halt at the breakpoint. When option “Trigger when true” is selected, the expression must evaluate to a non-zero value in order for the breakpoint to be triggered. When option “Trigger when changed” is selected, the breakpoint is triggered each time the expression value changed since the last time the breakpoint was encountered.

#### Skip Count

Program execution can only halt each SkipCount+1 amount of times the breakpoint is encountered. In addition, the remaining trigger conditions must be met in order for program execution to halt at the breakpoint.

#### Task Filter

Specifies the RTOS task that must be running in order for the breakpoint to be triggered. The RTOS task that triggers the breakpoint can be specified either via its name or via its ID. When the field is left empty, the breakpoint is task-insensitive.

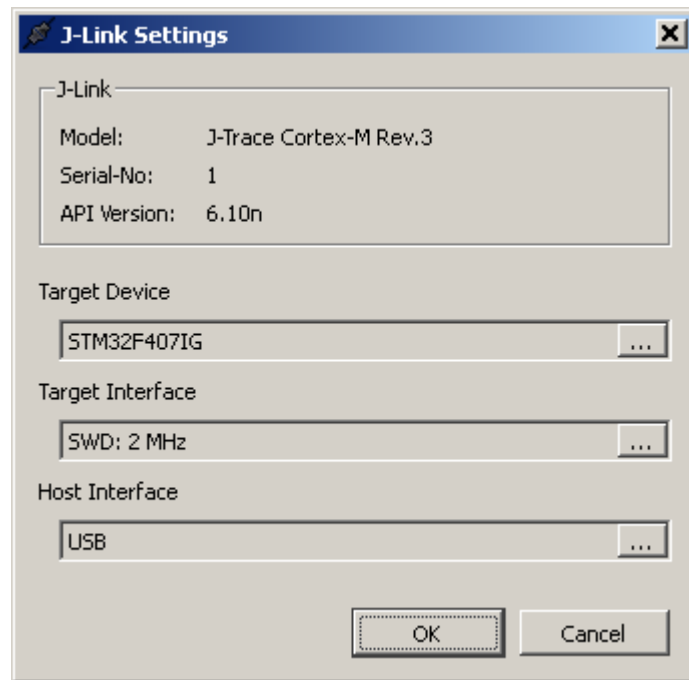
#### Extra Actions

Specifies the additional actions that are performed when the MCU is halted at the breakpoint. The provided options are a text message that is printed to the Console Window or a message that is displayed within a popup dialog.



### 3.11.5 J-Link Settings Dialog

The J-Link-Settings-Dialog allows users to configure J-Link related settings, such as the MCU model and the debugging interface. Please refer to “Project Wizard” on page 23 for further details on these settings.



#### 3.11.5.1 Opening the J-Link Settings Dialog

The J-Link Settings Dialog can be opened from the Main Menu (Edit → J-Link Settings) or by executing the user action *Edit.JLinkSettings* (see “Edit.JLinkSettings” on page 154).

#### 3.11.5.2 Applying Changes

J-Link settings are not applied immediately upon pressing the OK button. Instead, the debug session must be restarted for new settings to take effect. The only exception to this rule is the target interface speed parameter; provided that the debugger is connected to the MCU, this parameter will be applied on-the-fly.

### 3.11.6 Generic Memory Dialog

The Generic Memory Dialog is a multi-functional dialog that is used to:

- Dump MCU memory data to a binary file
- Download data from a binary file to MCU memory
- Fill a memory area with a specific value

All values entered into the Generic Memory Dialog are interpreted as hexadecimal numbers, even when not prefixed with "0x".

#### 3.11.6.1 Save Memory Data

In its first application, the Generic Memory Dialog is used to save MCU memory data to a binary file.

##### **File**

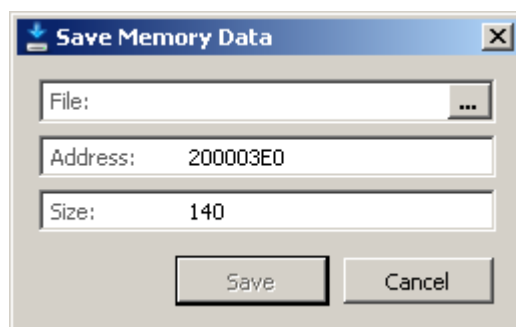
The destination binary file (\*.bin) into which memory data should be stored. By clicking on the dotted button, a file dialog is displayed that lets users select the destination file.

##### **Address**

The address of the first byte stored to the destination file.

##### **Size**

The number of bytes stored to the destination file.



#### 3.11.6.2 Load Memory Data

In its second application, the Generic Memory Dialog is used to write data from a binary file to MCU memory.

##### **File**

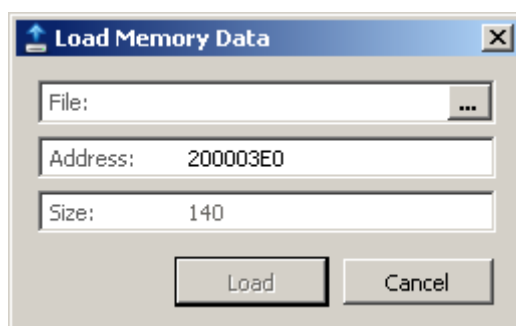
The binary file (\*.bin) whose contents are to be written to MCU memory. By clicking on the dotted button, a file dialog is displayed that lets users choose the data file.

##### **Address**

The download address, i.e. the memory address that should store the first byte of the data content.

##### **Size**

The number of bytes that should be written to MCU memory starting at the download address.



#### 3.11.6.3 Fill Memory

In its third application, the Generic Memory Dialog is used to fill a memory area with a specific value.

##### **Fill Value**

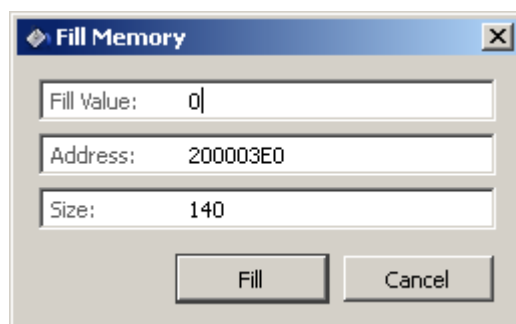
The fill value.

##### **Address**

The start address of the memory area.

##### **Size**

The size of the memory area.



## 3.11.7 Terminal Settings Dialog

The Terminal Settings Dialog is provided to define the settings of the data IO-interfaces between the debugger and the application program. Currently, only the Serial Wire Output (SWO) interface is parameterized.

### 3.11.7.1 SWO Settings

The SWO Settings Pane hosts J-Link settings that calibrate the SWO interface. Please refer to the J-Link User Manual for further details on these settings.

#### **CPU Clock**

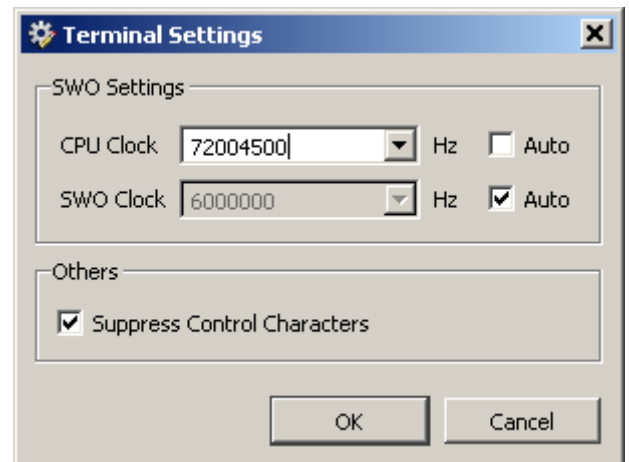
Core processor frequency of the employed MCU.

#### **SWO Clock**

Data transmission speed of the SWO interface.

#### **Auto Settings**

When the "auto" field of a setting is checked, the debugger auto-detects the optimal value for the setting. Auto-detection is ticked by default.



### 3.11.7.2 Suppress Control Characters

When this option is checked, control characters (such as color selection control characters) are removed from the text stream prior to output.

### 3.11.7.3 Opening the Terminal Settings Dialog

The Terminal Settings Dialog can be opened from the Terminal Window's context menu (see "Terminal Window" on page 93).

### 3.11.7.4 Applying Changes

Terminal IO settings are applied upon pressing the OK button; a restart of the debug session is not required.

### 3.11.8 Find Dialog

The Find Dialog allows users to search for text patterns within source code documents.

#### **Find What**

Defines the search pattern. The search pattern is either a plain text string or a regular expression, depending on the type of the search (see "Use Regular Expressions").

#### **Look In**

Specifies the search location. The search location defines the source code documents that are to be included in the search (see section 3.11.8.1).

#### **Match Case**

Specifies if a substring is considered a match only when its letter casing corresponds to that of the search string.

#### **Match Whole Word**

Specifies if a substring is considered a match only when it constitutes a single word and is not a substring of another word.

#### **Use Regular Expressions**

Indicates if the search string is interpreted as a regular expression (checked) or as plain text (unchecked). In the first case, the search is conducted on the basis of a regular expression pattern match. In the latter case, the search is conducted on the basis of a substring match.

#### **Show Filepaths**

Indicates if the file path of matching locations should be included in the search result. The search result are displayed within the Find Results Window.

#### **Find Next**

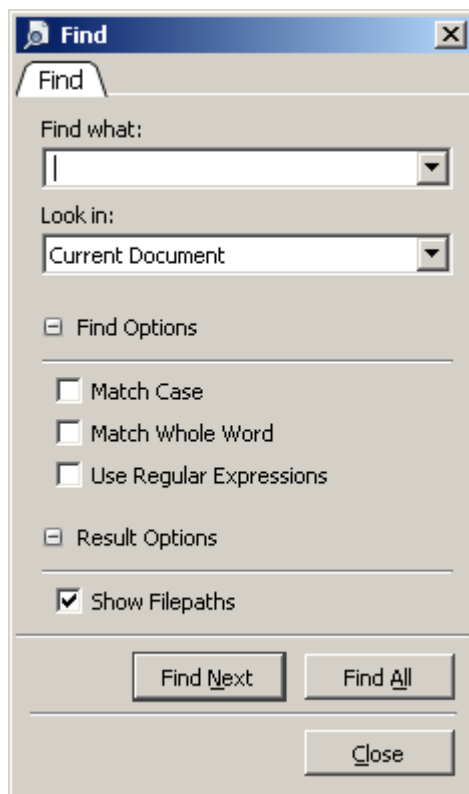
Finds the next occurrence of the search pattern in the selected source code documents. When a match is found, it is highlighted within the Source Viewer.

#### **Find All**

Finds all occurrences of the search pattern in the selected source code documents. The search result is printed to the Find Results Window.

#### **Close**

Closes the dialog.



#### 3.11.8.1 Search Locations

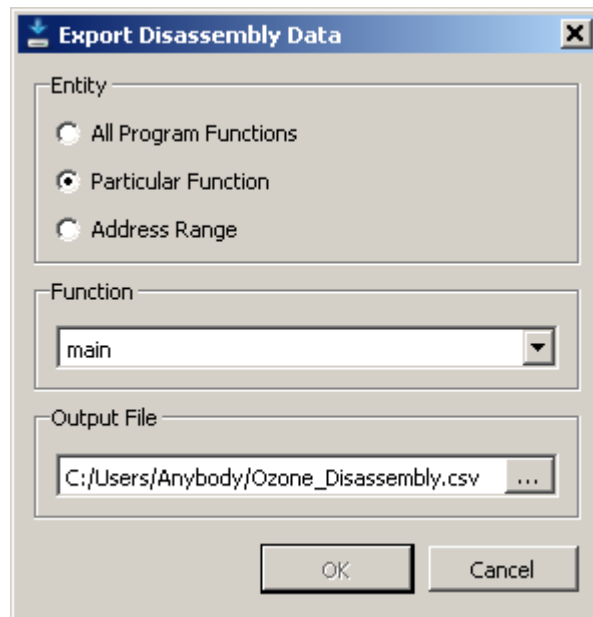
Text search can be conducted in three individual locations. The desired search location can be specified via the "Look In" selection box of the Find Dialog.

Search Location	Description
Current Document	The search is conducted within the active document.
All Open Documents	The search is conducted within all documents that are open within the Source Viewer.
Current Project	The search is conducted within all source files used to compile the application program.

Table 3.16. Search locations

### 3.11.9 Disassembly Export Dialog

The Disassembly Export Dialog is provided to save the disassembly of arbitrary memory address ranges, including source code and symbol information, to CSV files.



#### **Entity**

Specifies the set of memory address ranges to be covered by the output file.

#### **Function / Address Range**

Selects the function or address range to be covered by the output file.

#### **Output File**

Output file.

#### 3.11.9.1 Exemplary Output

Figure 2.17 shows the contents of a CSV file that was generated using the Disassembly Export Dialog.

Address	Encoding	Length	Type	Opcode	Operands	Label	Source
8001340	B480	2	THUMB	PUSH	{R7}	_Dolnit	static void
8001342	B083	2	THUMB	SUB	SP, SP, #12		
8001344	AF00	2	THUMB	ADD	R7, SP, #0		
8001346	4B21	2	THUMB	LDR	R3, [0x080013CE]	\$t	p = &_SEG
8001348	607B	2	THUMB	STR	R3, [R7, #+0x04]		
0800134A	687B	2	THUMB	LDR	R3, [R7, #+0x04]		p->MaxNur
0800134C	2202	2	THUMB	MOV	R2, #2		
0800134E	611A	2	THUMB	STR	R2, [R3, #+0x10]		
8001350	687B	2	THUMB	LDR	R3, [R7, #+0x04]		p->MaxNur
8001352	2202	2	THUMB	MOV	R2, #2		

Figure 3.17. CSV content generated by the Disassembly Export Dialog.

### 3.11.10 Code Profile Report Dialog

The Code Profile Report Dialog is provided to save the application's code profile to a text or a CSV file (see "Code Profile Window" on page 68).

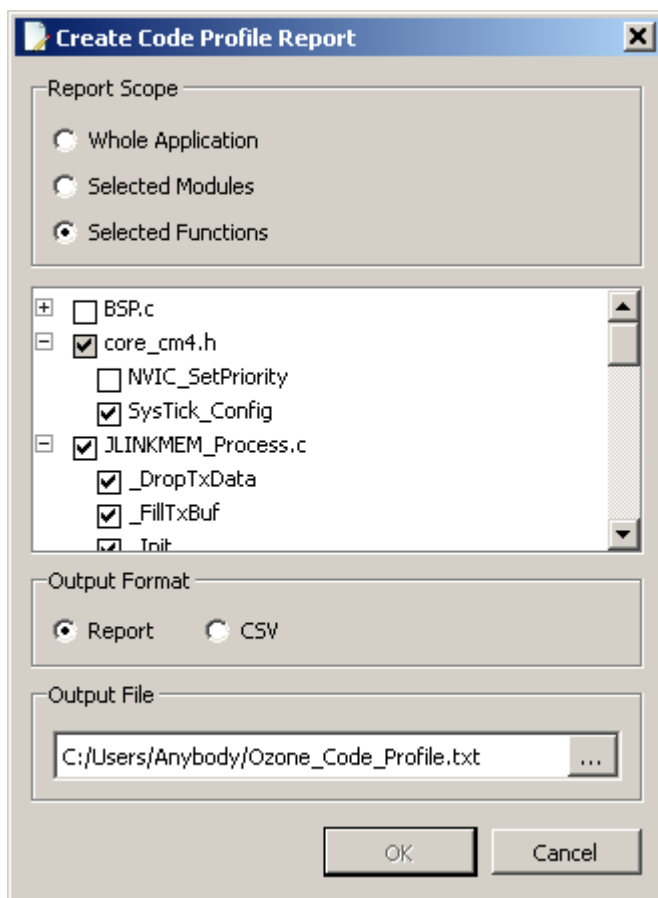


Figure 3.18. Code Profile Export Dialog.

#### **Report Scope**

Program scope covered by the output file.

#### **Tree View**

Selected files and functions are covered by the output file.

#### **Output Format**

Output file format. The default option "Report" generates a human-readable text file. The alternate option "CSV" generates a comma-separated values file that can be used with table-processing software such as excel.

#### **Output File**

Output file path.

### 3.11.10.1 Code Profile Report

Figure 2.21 shows the contents of a text file generated by the Code Profile Report Dialog.

Ozone Code Profile Report

Project: C:/Examples/Board\_686\_STM32F407IG\_embOS\_Percepio

Application: C:/Examples/Board\_686\_STM32F407IG\_embOS\_Percepio

Date: 23 Nov 2016

Code Coverage Summary

Module/Function	Source Lines	Instructions
core_cm4.h		
NVIC_SetPriority	3 / 5    60.0%	23 / 33    69.7%
SysTick_Config	7 / 8    87.5%	25 / 28    89.3%
Main.c		
main	4 / 11    36.4%	19 / 45    42.2%
Total	14 / 24    58.3%	67 / 106    63.2%

Code Profile Summary

Module/Function	Run Count	Load
core_cm4.h		
NVIC_SetPriority	2	48
SysTick_Config	1	26
Main.c		
main	1	20
Total	4	94

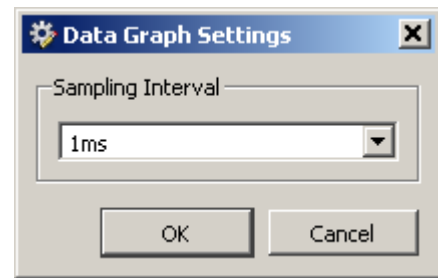
Figure 3.19. Code Profile Report Example

### 3.11.11 Data Graph Settings Dialog

The Data Graph Settings Dialog is provided to configure the Data Graph debug information window.

#### ***Sampling Interval***

Common sampling interval used to sample all expressions that were added to the Data Graph Window (see “Data Graph Window” on page 95).



#### 3.11.11.1 Opening the Data Graph Settings Dialog

The Data Graph Settings Dialog can be opened from the Data Graph Window's context menu or by entering command *Edit.DataGraphSettings* into the Console Window's command prompt (see “Edit.DataGraphSettings” on page 154).



# Chapter 4

## Debug Information Windows

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This chapter provides individual descriptions of Ozone's 18 debug information windows, starting with the Source Viewer.

## 4.1 Source Viewer

The Source Code Viewer (or Source Viewer for short) allows users to observe program execution on the source-code level, set source-code breakpoints and specify the next statement to be executed. Individual source code lines can be expanded to reveal the affiliated assembler code instructions.

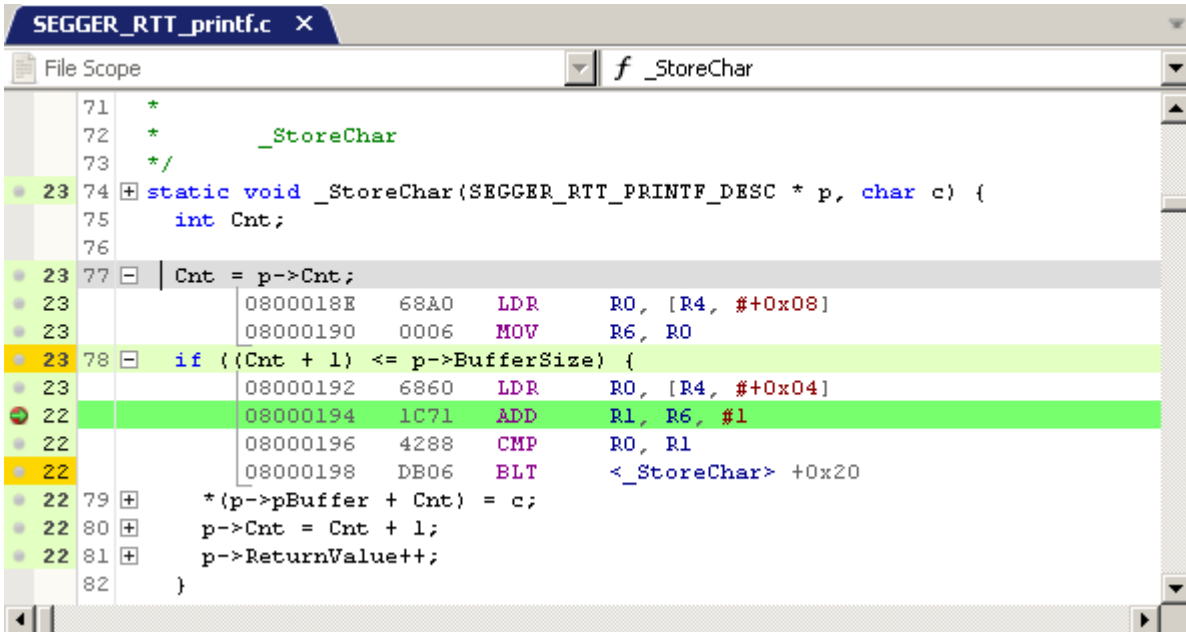


Figure 4.1. Source Viewer

### 4.1.1 Code Window

The Source Viewer shares multiple features with Ozone's second code window, the Disassembly Window. Please see "Code Windows" on page 36 for a shared description of these windows.

### 4.1.2 Supported File Types

The Source Viewer is able to display documents of the following file types:

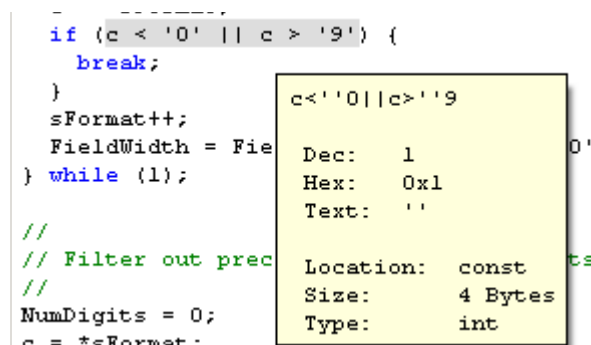
- C source code files: \*.c, \*.cpp, \*.h, \*.hpp
- Assembly code files: \*.s

### 4.1.3 Font

The Source Viewer's font can be adjusted by executing the user action *Edit.Font* (see "Edit.Font" on page 156) or via the User Preference Dialog (see "User Preference Dialog" on page 43). In particular, the font size can be quick-adjusted by scrolling the mouse-wheel while holding down the control key.

### 4.1.4 Expression Tooltips

When text is selected within the Source Viewer, it is evaluated as an expression and the result is displayed in a tooltip (see "Expressions" on page 142).



## 4.1.5 Symbol Tooltips

By hovering the mouse cursor over a variable, the variable's value is displayed in a tooltip. Please note that this feature only works for local variables when the function that contains the local variable is the active function of the Local Data Window. A function can be activated by selecting it within the Source Viewer.

## 4.1.6 Document Tab Bar

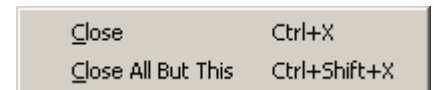
The document tab bar hosts a tab for each source code document that has been opened in the Source Viewer. The tab of the visible (or active) document is highlighted. Users can switch the active document by clicking on its tab or by selecting it from the tab bar's drop down button. The drop-down button is located on the right side of the tab bar (see the illustration below).



Figure 4.2. Document Tab Bar

### 4.1.6.1 Tab Bar Context Menu

The tab bar's context menu hosts two actions that can be used to close the active document, or all documents but the active one.



## 4.1.7 Document Header Bar

The document header bar provides users with the ability to quickly navigate to a particular function within the active document. The header bar hosts two drop-down lists. The drop-down list on the left side contains all function scopes (namespaces or classes) present within the active document. The drop-down list on the right side lists all functions that are contained within the selected scope. When a function is selected, the corresponding source line is highlighted and scrolled into view.

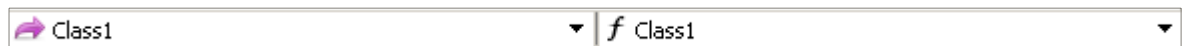


Figure 4.3. Document Header Bar

## 4.1.8 Opening and Closing Documents

For the purpose of opening and closing source code documents programmatically, the user actions *File.Open* and *File.Close* are provided (see "File Actions" on page 145).

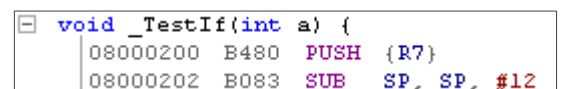
## 4.1.9 Source Line Numbers

The display of source line numbers can be toggled by executing the user action *Edit.Preference* using parameter `PREF_SHOW_LINE_NUMBERS` (see "Edit.Preference" on page 155) or via the User Preference Dialog (see "User Preference Dialog" on page 43).

## 4.1.10 Expandable Source Lines

Each text line of the active source code document that contains executable code can be expanded or collapsed to reveal or hide the affiliated machine instructions.

Each such text line is preceded by an expansion indicator that toggles the line's expansion state. Furthermore, when the PC Line is expanded, the debugger's stepping behaviour will be the same as if the Disassembly Window was the active code window (see "Stepping Expanded Source Code Lines" on page 111).



## 4.1.11 Context Menu

The Source Viewer's context menu provides the following actions:

### ***Set / Clear Breakpoint***

Sets or clears a breakpoint on the selected source code line.

### ***Edit Breakpoint***

Opens the Breakpoint Properties Dialog (see "Breakpoint Properties Dialog" on page 48).

### ***Set Next Statement***

Sets the PC to the first machine instruction of the selected source code line. Any code between the current PC and the selected instruction will be skipped, i.e. will not be executed.

### ***Run To Cursor***

Advances program execution to the current cursor position. All code between the current PC and the cursor position is executed.

### ***View Disassembly***

Displays the first machine instruction of the selected source code line in the Disassembly Window.

### ***View Call Graph***

Displays the call graph of the function that contains the selected line within the Call Graph Window.

### ***Goto PC***

Displays the PC line, i.e. the source code line that contains the next machine instruction to be executed. If the source code document containing the PC line is not open or visible, it is opened and brought to the front.

### ***Goto Line***

Scrolls the active document to a particular source code line. The line number can be specified via an input dialog that will pop up when executing this menu item.

### ***Expand / Collapse All***

Expands or Collapses all expandable lines within the current document.

### ***Select All***

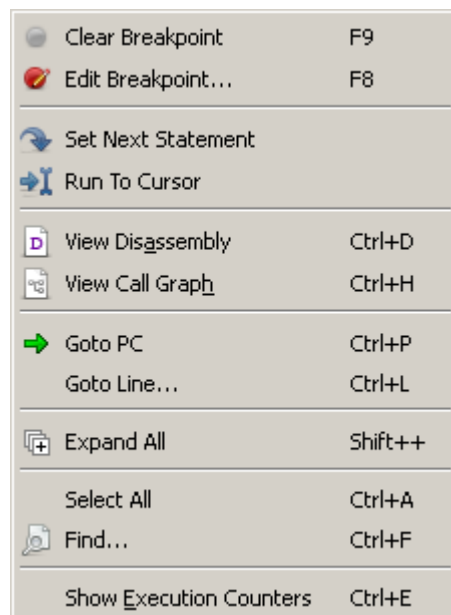
Selects all text lines.

### ***Find***

Displays a search dialog that lets users search for text occurrences within the active document.

### ***Show Execution Counters***

Toggles the display of execution counters (see "Execution Counters" on page 38).



### 4.1.12 Text Selection Context Menu

The Source Viewer's text selection context menu is displayed when users right-click on selected text within the Source Viewer.

#### **Copy**

Copies the selected text to the clipboard.

#### **View Source**

Displays the source code location of the symbol identified by the selected text.

#### **View Disassembly**

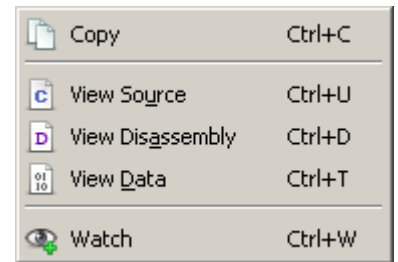
Displays the disassembly of the symbol identified by the selected text.

#### **View Data**

Displays the data location of the symbol identified by the selected text.

#### **Watch**

Adds the selected text as an expression to the Watched Data Window (see "Watched Data Window" on page 91).



### 4.1.13 Syntax Highlighting

The Source Viewer applies syntax highlighting to source code. The syntax highlighting colors can be adjusted via the user action *Edit.Color* (see "Edit.Color" on page 156) or via the User Preference Dialog (see "User Preference Dialog" on page 43).

### 4.1.14 Cursor Location History

The Source Viewer maintains a history of past text cursor positions. Past text cursor positions can be conveniently navigated and scrolled into view by using hotkeys Ctrl+Plus and Ctrl+Minus.

## 4.2 Disassembly Window

Ozone's Disassembly Window displays the assembler code interpretation of MCU memory content. The window automatically scrolls to the position of the program counter when the program is stepped; this allows users to follow program execution on the machine instruction level.

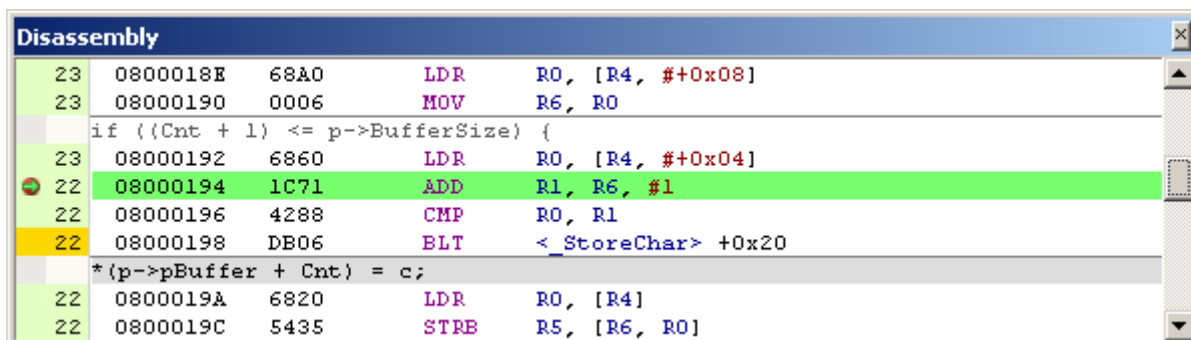


Figure 4.4. Disassembly Window

### 4.2.1 Code Window

The Disassembly Window shares multiple features with Ozone's second code window, the Source Viewer. Please refer to "Code Windows" on page 36 for a shared description of these windows.

### 4.2.2 Instruction Rows

Each text row within the Disassembly Window displays information about a particular ARM machine instruction. The instruction information is divided into 4 parts:

Address	Encoding	Mnemonic	Operands
08000152	0304F107	ADD	R3, R7, #0x04

Table 4.6. Instruction row information

The encoding of a machine instruction is identical to the data stored at the instruction's memory address. The term "mnemonic" refers to the abbreviated name of a machine instruction.

### 4.2.3 Viewport

The address range displayed within the Disassembly Window is referred to as the window's viewport. The viewport can be modified in multiple ways that are described below.

#### Positioning the Viewport

The address of the first instruction displayed within the Disassembly Window can be set using action *View.Disassembly*. When the action is executed from the context menu or without an address argument, an input dialog will pop up that allows users to enter the address.

#### Scrolling the Viewport

The Disassembly Window's viewport can be scrolled in any of the ways depicted in the table below.

Mouse Wheel	Arrow Keys	Page Keys	Scroll Bar
4 Lines	1 Line	1 Page	1 Line

Table 4.7. Viewport scrolling methods

## 4.2.4 Mixed Mode Disassembly

The Disassembly Window's "Mixed Mode" display option changes standard output in the following manner:

- If a machine instruction is associated with a source code line, the source code line is displayed above the machine instruction row.
- Absolute and relative branch offsets such as "0x4" are replaced with label offsets such as "main+0x4" where possible.

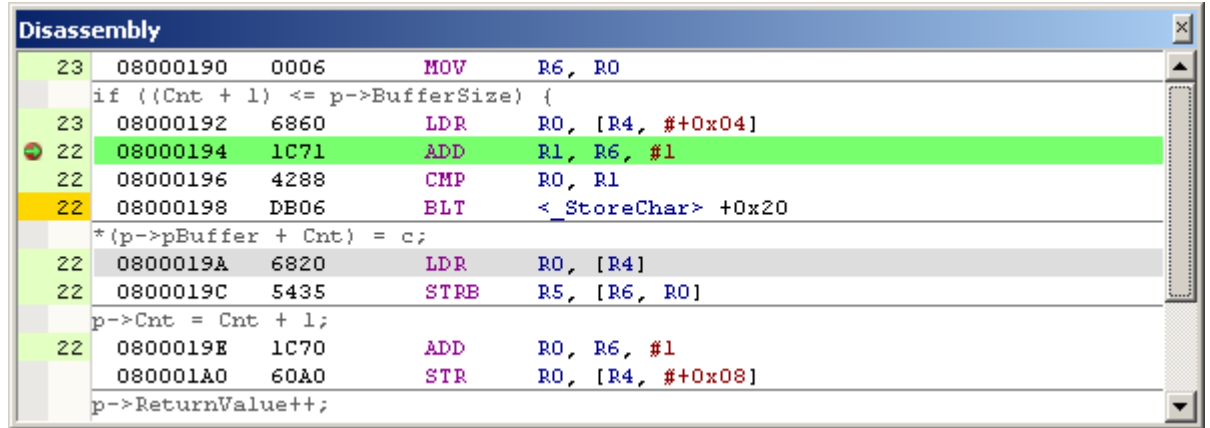


Figure 4.8. Mixed mode output in the Disassembly Window

The result is depicted above. The mixed mode display option can be activated from the context menu of the Disassembly Window or via the user action *Edit.Preference* using parameter `PREF_MIXED_MODE_ASM` (refer to "Edit.Preference" on page 155).

## 4.2.5 Syntax Highlighting

The Disassembly Window applies syntax highlighting to assembler code. The syntax highlighting colors can be adjusted via the user action *Edit.Color* (see "Edit.Color" on page 156) or via the User Preference Dialog (see "User Preference Dialog" on page 43).

## 4.2.6 Supported Instruction Sets

The Disassembly Window supports all instruction sets encompassed by the set of MCUs that Ozone supports (see "Supported Target Devices" on page 18). This means specifically that the disassembly of ARM, Thumb and Thumb-2 machine instructions is supported.

## 4.2.7 Interworking Code Support

The Disassembly Window is able to disassemble ARM interworking code, i.e. code that is a mixture of ARM 32 bit and Thumb 16/32 bit instructions. The type of an instruction is determined by the following characteristics:

- The instruction set of the selected MCU
- the MCUs current instruction set decoding state (thumb bit)
- the encoding of an instruction
- the ELF program file's memory code type information

The Disassembly Window employs a sophisticated heuristic on above parameters that leads to a correct output regardless of the hardware and software setup being used.

## 4.2.8 File Export

The disassembly of arbitrary memory address ranges can be exported to CSV files using the Disassembly Export Dialog (see "Disassembly Export Dialog" on page 53).

## 4.2.9 Context Menu

The Disassembly Window's context menu provides the following actions:

### **Set / Clear Breakpoint**

Sets a breakpoint on the selected machine instruction (see "Instruction Breakpoints" on page 113).

### **Edit Breakpoint**

Opens the Breakpoint Properties Dialog (see "Breakpoint Properties Dialog" on page 48).

### **Set Next PC**

Specifies that the selected machine instruction should be executed next. Any instructions that would usually execute when advancing the program to the selected instruction will be skipped.

### **Run To Cursor**

Advances the program execution point to the current cursor position. All code between the current PC and the cursor position is executed.

### **View Source**

Displays the first source code line that is associated with the selected machine instruction (as a result of code optimization during the compilation phase, a single machine instruction might be affiliated with multiple source code lines).

### **Goto PC**

Scrolls the viewport to the PC line.

### **Goto Address**

Sets the viewport to an arbitrary memory address. The address is obtained via an input dialog that pops up when executing this menu item.

### **Show Execution Counters**

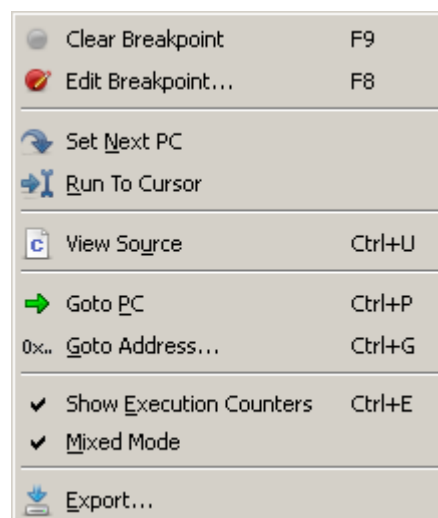
Toggles the display of instruction execution counters (see "Execution Counters" on page 38).

### **Mixed Mode**

Enables or disables the "mixed mode" display option (see "Mixed Mode Disassembly" on page 63).

### **Export**

Opens the Disassembly Export Dialog (see "Disassembly Export Dialog" on page 53)





## 4.3 Instruction Trace Window

Ozone's Instruction Trace Window displays the history of executed machine instructions.

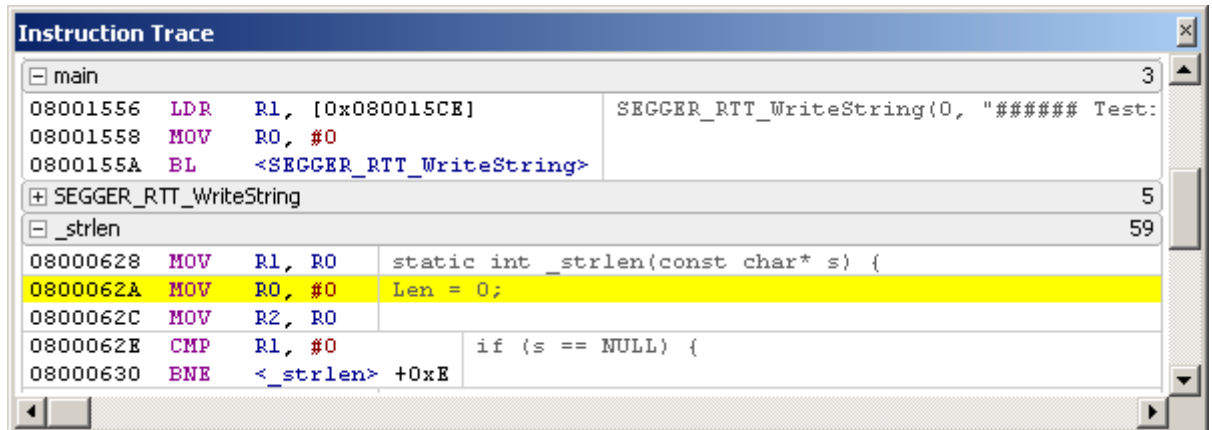


Figure 4.9. Instruction Trace Window

### 4.3.1 Hardware Requirements

The Instruction Trace Window uses the Embedded Trace Macrocell (ETM) and the trace pins with a J-Trace or the optional Embedded Trace Buffer (ETB) with a J-Link or J-Trace. It is target dependent if tracing via ETB, tracing via trace pins or tracing at all is supported. For more information about trace with J-Link / J-Trace, please refer to the J-Link User Manual.

### 4.3.2 Limitations

The Instruction Trace Window currently cannot be used in conjunction with the Terminal Window's printf via SWO feature.

### 4.3.3 Instruction Stack

The Instruction Trace Window displays the program's instruction execution history as a stack of machine instructions. The instruction at the bottom of the stack has been executed most recently. The instruction at the top of the stack was executed least recently. The instruction stack is rebuild when the program is stepped or halted. Please note that the PC instruction is not the bottommost instruction of the stack, as this instruction has not yet been executed.

### 4.3.4 Window Elements

The Instruction Trace Window consists of the elements described below.

#### 4.3.4.1 Instruction Blocks

The instruction stack is divided into a set of contiguous instruction blocks. Each instruction block displays a list of consecutively executed machine instructions. Each time program execution is halted, a new instruction block is added to the window. The added block contains not all - but rather only the first chunk of instructions that were executed since the program was resumed. The next chunk of instructions can be added to the instruction block by clicking on the "display more" button. The empty area that is displayed between consecutive instruction blocks resembles a portion of the instruction stack that is not (yet) displayed.

### 4.3.4.2 Display More Button

Each instruction block features a "display more" button on its top side. By clicking on this button, the instruction block is extended with the next chunk of instructions that were traced during the resume/halt cycle affiliated with the block.

### 4.3.4.3 Function Nodes

Instruction blocks are partitioned into function nodes. Each function node represents a function call. Function nodes can be collapsed or expanded to hide or reveal the instructions executed within the affiliated function. The number of instructions executed within a particular function is displayed on the right side of the function node's header.

### 4.3.5 Context Menu

The context menu of the Instruction Trace Window provides the following operations:

#### **View Source**

Displays the source code line associated with the selected instruction in the Source Viewer (see "Source Viewer" on page 58).

#### **View Disassembly**







Displays the selected instruction in the Disassembly Window (see "Disassembly Window" on page 62).

#### **Block Start / End**

Selects the topmost or bottommost instruction row of the active function node.

#### **Expand / Collapse All**

Expands/collapses all function nodes.

	View Source	Ctrl+U
	View Disassembly	Ctrl+D
	Block Start	Shift+Up
	Block End	Shift+Down
	Expand All	Shift++
	Collapse All	Shift+-

### 4.3.6 Hotkeys

The Instruction Trace Window provides multiple hotkeys to navigate instruction rows. Table 4.10 gives an overview.

Hotkey	Description
Right or +	Expands the currently selected function node.
Left or -	Collapses the currently selected function node. If an instruction is selected, the function containing the selected instruction is collapsed.
Up	Selects and scrolls to the next instruction.
Down	Selects and scrolls to the previous instruction.
Shift+Up	Selects and scroll to the last (topmost) instruction of the currently selected function node.
Shift+Down	Selects and scroll to the first (bottommost) instruction of the currently selected function node.
PgUp	Scrolls one page up.
PgDn	Scrolls one page down.

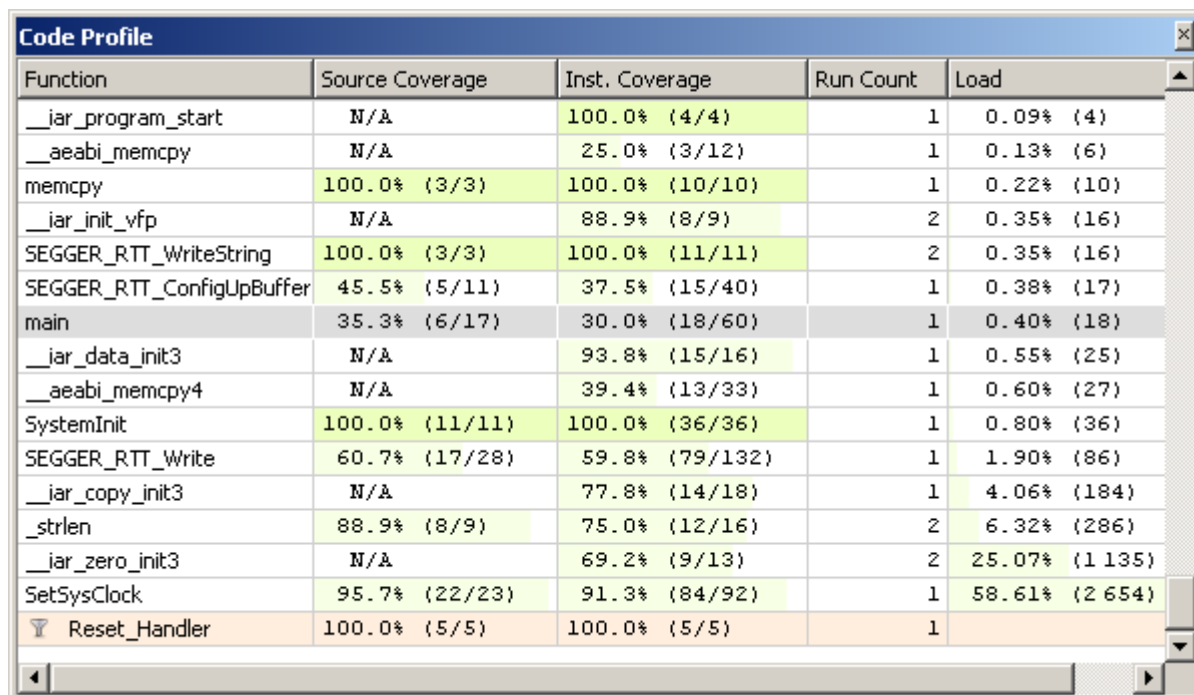
**Table 4.10. Instruction Trace Window Hotkeys.**

### 4.3.7 Backtrace Highlighting

Both code windows highlight the instruction that is selected within the Instruction Trace Window. This allows users to quickly understand past program flow while key-navigating through instruction rows. The default color used for backtrace highlighting is yellow and can be adjusted via the user action *Edit.Color* (see “Edit.Color” on page 156) or via the User Preference Dialog (see “User Preference Dialog” on page 43).

## 4.4 Code Profile Window

Ozone's Code Profile Window displays runtime code statistics of the application being debugged.



Function	Source Coverage	Inst. Coverage	Run Count	Load
__iar_program_start	N/A	100.0% (4/4)	1	0.09% (4)
__aeabi_memcpy	N/A	25.0% (3/12)	1	0.13% (6)
memcpy	100.0% (3/3)	100.0% (10/10)	1	0.22% (10)
__iar_init_vfp	N/A	88.9% (8/9)	2	0.35% (16)
SEGGER_RTT_WriteString	100.0% (3/3)	100.0% (11/11)	2	0.35% (16)
SEGGER_RTT_ConfigUpBuffer	45.5% (5/11)	37.5% (15/40)	1	0.38% (17)
main	35.3% (6/17)	30.0% (18/60)	1	0.40% (18)
__iar_data_init3	N/A	93.8% (15/16)	1	0.55% (25)
__aeabi_memcpy4	N/A	39.4% (13/33)	1	0.60% (27)
SystemInit	100.0% (11/11)	100.0% (36/36)	1	0.80% (36)
SEGGER_RTT_Write	60.7% (17/28)	59.8% (79/132)	1	1.90% (86)
__iar_copy_init3	N/A	77.8% (14/18)	1	4.06% (184)
_strlen	88.9% (8/9)	75.0% (12/16)	2	6.32% (286)
__iar_zero_init3	N/A	69.2% (9/13)	2	25.07% (1 135)
SetSysClock	95.7% (22/23)	91.3% (84/92)	1	58.61% (2 654)
Reset_Handler	100.0% (5/5)	100.0% (5/5)	1	

Figure 4.11. Code Profile Window

### 4.4.1 Table Window

The Code Profile Window shares multiple features with other table-based debug information windows (see "Table Windows" on page 40).

### 4.4.2 Hardware Requirements

The base hardware requirements for code profiling are the same as those for instruction tracing (see "Hardware Requirements" on page 65). However, Ozone's code profile functionality can be greatly enhanced by employing a J-Trace PRO debug probe (see "Streaming Trace" on page 118).

### 4.4.3 Code Statistics

The Code Profile Window displays 4 different code statistics about program functions.

#### Source Coverage

Amount of executable source code lines of a function that have been covered since code profile data was reset. An executable source code line is considered covered if all of its machine instructions were fetched from memory at least once. In Figure 4.11, 35.6% or 6 of 17 executable source codes lines within function main were covered.

#### Instruction Coverage

Amount of machine instructions of a function that have been covered since code profile data was reset. A machine instruction is considered covered if it has been fetched from memory at least once. In the case of conditional instructions, the instruction is furthermore only considered covered when its condition was both met and not met. In Figure 4.11, 73.0% or 18 of 60 machine instructions within function main were covered.

### **Run Count**

Amount of times a function was called since code profile data was reset.

### **Load**

Amount of instruction fetches that occurred within a function's address range divided by the total amount of instruction fetches that occurred since code profile data was reset.

## **4.4.4 Execution Counters**

The execution count, coverage and load information can be shown in the Code Windows, as well. For more information, refer to "Execution Counters" on page 38.

## **4.4.5 Function Filters**

The CPU load of individual functions can be filtered from the code profile statistic. After filtering, the load column displays the distribution of the remaining CPU load across all none-filtered functions.

### **Adding and Removing Function Filters**

A function filter can be set and removed via context menu entries *Exclude* and *Include* or programatically via user actions *Profile.Exclude* and *Profile.Include* (see "Code Profile Actions" on page 149).

### **Filter Indicators**

Functions that have been filtered from the code profile statistic display a filter symbol and are highlighted in red.

## **4.4.6 Context Menu**

The context menu of the Code Profile Window provides the following actions:

### **View Source**

Displays the selected function in the Source Viewer (see "Source Viewer" on page 58).

### **View Disassembly**

Displays the selected function in the Disassembly Window (see "Disassembly Window" on page 62).

### **Include / Exclude**

Filters or unfilters the selected function.

### **Exclude...**

Moves multiple functions to the filtered set (see "Profile.Exclude" on page 177).

### **Include...**

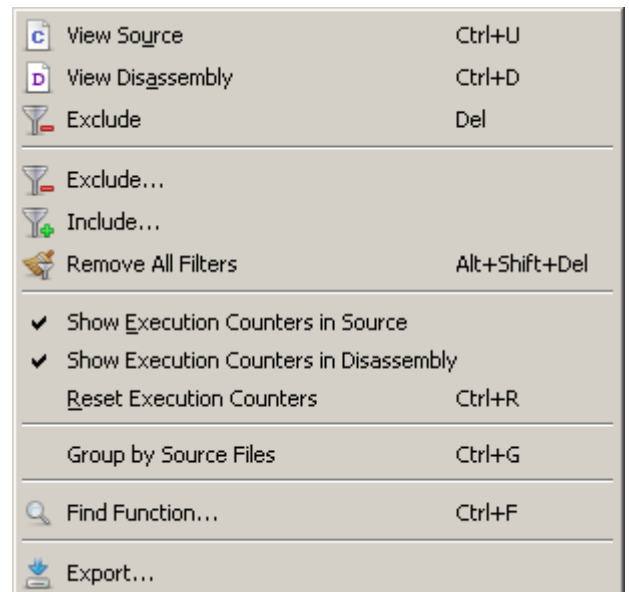
Removes multiple functions from the filtered set (see "Profile.Include" on page 177).

### **Remove All Filters**

Removes all filters.

### **Show Execution Counters in Source**

Displays execution counters within the Source Viewer (see "Source Viewer" on page 58).



***Show Execution Counters in Disassembly***

Displays execution counters within the Disassembly Window (see "Disassembly Window" on page 62).

***Reset Execution Counters***

Removes all filters.

***Group by Source Files***

Groups all functions into expandable source file nodes.

***Find Function***

Scrolls to a particular function and highlights it.

***Export***

Opens the Code Profile Report Dialog (see "Code Profile Report Dialog" on page 54).

## 4.5 Console Window

Ozone's Console Window displays both application- and user-induced logging output.

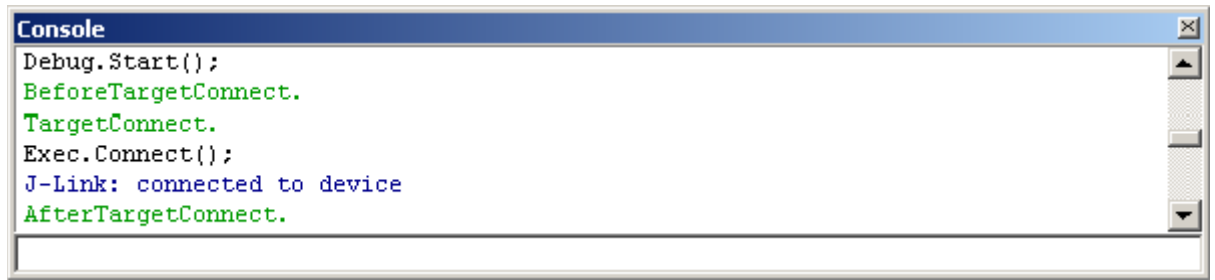


Figure 4.12. Console Window

### 4.5.1 Command Prompt

The Console Window contains a command prompt at its bottom side that allows users to execute any user action that has a text command (see "User Actions" on page 28). It is possible to control the debugger from the command prompt alone.

### 4.5.2 Message Types

The type of a console message depends on its origin. There are three different message sources and hence there are three different message types. The message types are described below.

#### 4.5.2.1 Command Feedback Messages

When a user action is executed – be it via the Console Window's command prompt or any of the other ways described in "Executing User Actions" on page 28 – the action's command text is added to the Console Window's logging output. This process is termed command feedback. When the command is entered erroneously, the command feedback is highlighted in red.

```
Window.Show("Console");
```

#### 4.5.2.2 J-Link Messages

Control and status messages emitted by the J-Link firmware are a distinct message type.

```
J-Link: Device STM32F13ZE selected.
```

#### 4.5.2.3 Script Function Messages

The user action *Util.Log* outputs a user supplied message to the Console Window. *Util.Log* can be used to output logging messages from inside script functions (see "Util.Log" on page 164).

```
Executing Script Function "BeforeTargetConnect".
```

### 4.5.3 Message Colors

Messages printed to the Console Window are colored according to their type. The message colors can be adjusted via the user action *Edit.Color* (see "Edit.Color" on page 156) or via the User Preference Dialog (see "User Preference Dialog" on page 43).

## 4.5.4 Context Menu

The context menu of the Console Window provides the following actions:

### **Copy**

Copies the selected text to the clipboard.

### **Select All**

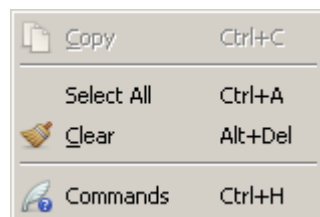
Selects all text lines.

### **Clear**

Clears the Console Window.

### **Commands**

Prints the command help.



## 4.5.5 Command Help

When the user action *Help.Commands* is executed, a quick facts table on all user actions including their commands, hotkeys and purposes is printed to the Console Window (see “Help.Commands” on page 170). The command help can be triggered from the Console Window’s context menu or from the help menu.

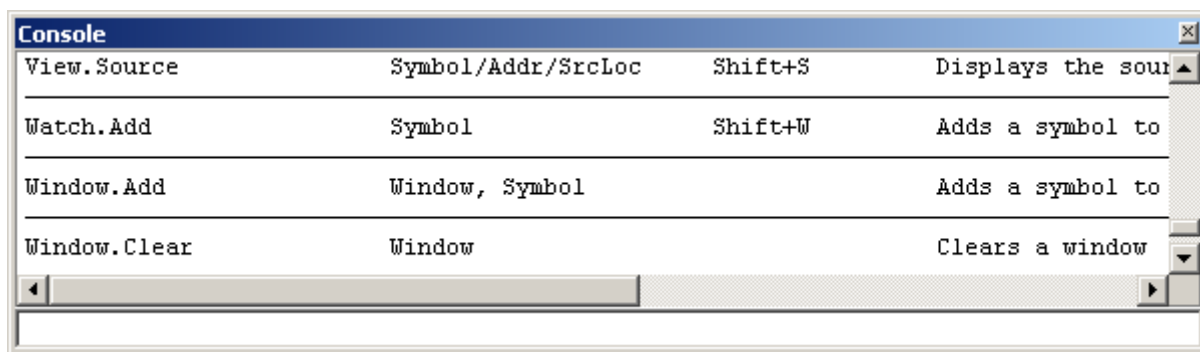
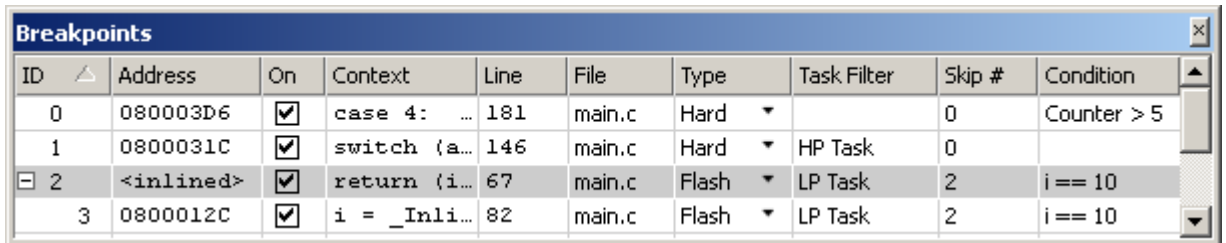


Figure 4.13. Command help displayed within the Console Window



## 4.6 Breakpoint Window

Ozone's Breakpoint Window allows users to observe and edit breakpoints.



ID	Address	On	Context	Line	File	Type	Task Filter	Skip #	Condition
0	080003D6	<input checked="" type="checkbox"/>	case 4: ...	181	main.c	Hard		0	Counter > 5
1	0800031C	<input checked="" type="checkbox"/>	switch {a...	146	main.c	Hard	HP Task	0	
2	<inlined>	<input checked="" type="checkbox"/>	return {i...	67	main.c	Flash	LP Task	2	i == 10
3	0800012C	<input checked="" type="checkbox"/>	i = _Inli...	82	main.c	Flash	LP Task	2	i == 10

Figure 4.14. Breakpoint Window

### 4.6.1 Table Window

The Breakpoint Window shares multiple features with other table-based debug information windows (see "Table Windows" on page 40).

### 4.6.2 Breakpoint Attributes

The Breakpoint Window displays the following information about breakpoints:

Attribute	Description
ID	The ID of the breakpoint.
Address	The breakpoint's memory address.
On	Indicates if the breakpoint is enabled or disabled. A breakpoint can be enabled or disabled by checking or unchecking its checkbox.
Context	Source code or assembler code line associated with the breakpoint.
Line	Source code line number associated with the breakpoint.
File	File name of the source code document containing the breakpoint.
Type	Implementation type of the breakpoint.
Task Filter	The name or ID of the RTOS task that triggers the breakpoint.
Skip Count	The amount of times the breakpoint is skipped when it is encountered.
Condition	C-language expression (see "Break.Edit" on page 186).

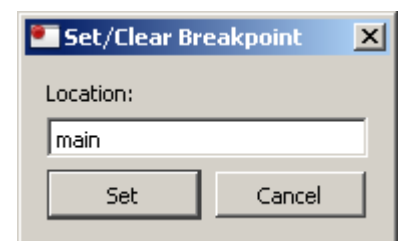
Table 4.15. Breakpoint attributes

### 4.6.3 Breakpoint Dialog

The Breakpoint Dialog allows users to place breakpoints on:

- Memory addresses of machine instructions
- Source code lines
- Functions

Source code lines are specified in a predefined format (see "Source Code Location Descriptor" on page 134). The Breakpoint Dialog can be accessed via the context menu of the Breakpoint Window.



### 4.6.4 Inlined Breakpoints

A code breakpoint that is set within an inlined function is marked as "inlined" within the Breakpoint Window. An inlined breakpoint can be expanded to reveal the affiliated instruction breakpoints (see "Inlined Code Breakpoints" on page 113).

## 4.6.5 Editing Breakpoints Programmatically

Ozone provides multiple user actions that allow users to edit breakpoints from script functions or at the command prompt (see “Breakpoint Actions” on page 148).

## 4.6.6 Conditional Breakpoints

Advanced breakpoint properties such as the trigger condition and additional trigger actions can be set via the Breakpoints Properties Dialog (see “Breakpoint Properties Dialog” on page 48) or via the user action *Break.Edit* (see “Break.Edit” on page 186).

## 4.6.7 Context Menu

The Breakpoint Window’s context menu hosts actions that manipulate breakpoints and that navigate to a breakpoint’s source code or assembler code line (see “Breakpoint Actions” on page 148).

### **Clear**

Clears the selected breakpoint.

### **Enable / Disable**

Enables or disables the selected breakpoint.

### **Edit**

Edits the selected Breakpoint (see “Breakpoint Properties Dialog” on page 48).

### **View Source**

Displays the source code line associated with the selected breakpoint. This action can also be triggered by double-clicking a table row.

### **View Disassembly**

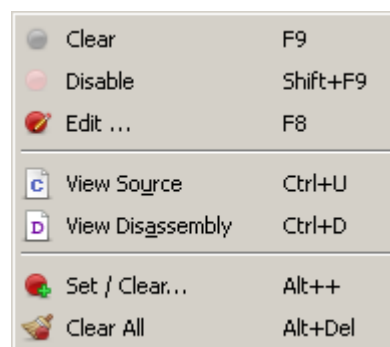
Displays the assembler code line associated with the selected breakpoint.

### **Set / Clear**

Opens the Breakpoint Dialog (see “Breakpoint Dialog” on page 73).

### **Clear All**

Clears all breakpoints.

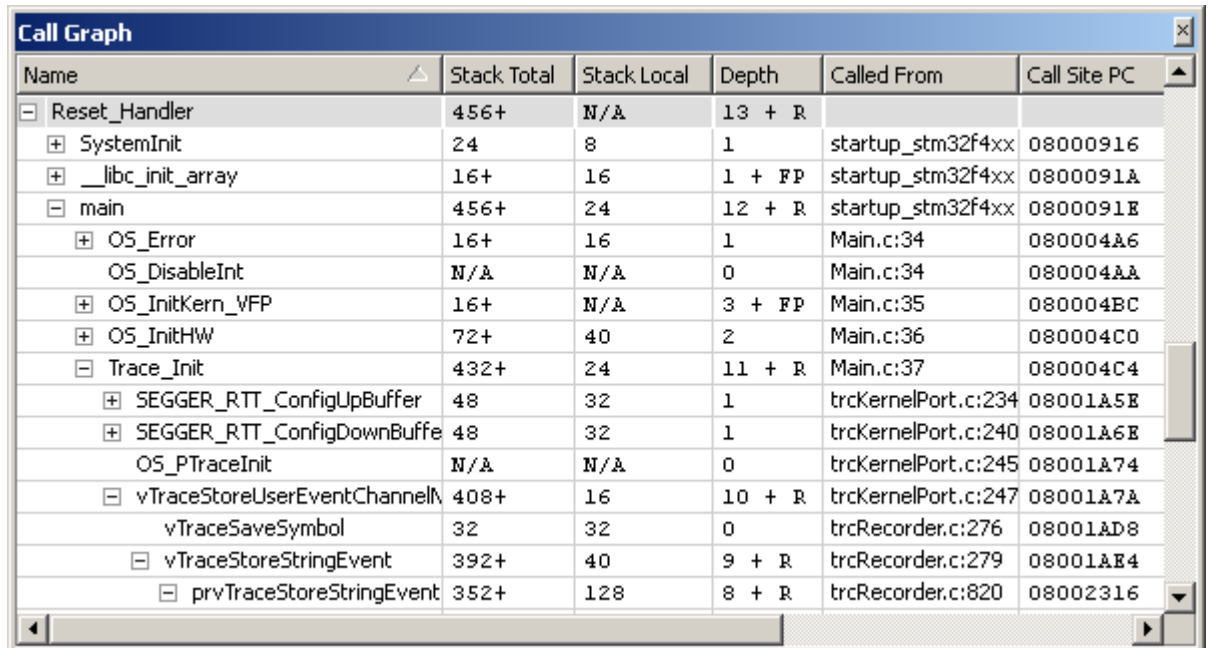


## 4.6.8 Offline Breakpoint Manipulation

The Breakpoint Window is operational both in offline and in online mode (see “Offline Breakpoint Manipulation” on page 115).

## 4.7 Call Graph Window

Ozone's Call Graph Window informs about the application's function calling hierarchy and stack usage.



Name	Stack Total	Stack Local	Depth	Called From	Call Site PC
[-] Reset_Handler	456+	N/A	13 + R		
[+] SystemInit	24	8	1	startup_stm32f4xx	08000916
[+] __libc_init_array	16+	16	1 + FP	startup_stm32f4xx	0800091A
[-] main	456+	24	12 + R	startup_stm32f4xx	0800091E
[+] OS_Error	16+	16	1	Main.c:34	080004A6
OS_DisableInt	N/A	N/A	0	Main.c:34	080004AA
[+] OS_InitKern_VFP	16+	N/A	3 + FP	Main.c:35	080004BC
[+] OS_InitHW	72+	40	2	Main.c:36	080004C0
[-] Trace_Init	432+	24	11 + R	Main.c:37	080004C4
[+] SEGGER_RTT_ConfigUpBuffer	48	32	1	trcKernelPort.c:234	08001A5E
[+] SEGGER_RTT_ConfigDownBuffer	48	32	1	trcKernelPort.c:240	08001A6E
OS_PTraceInit	N/A	N/A	0	trcKernelPort.c:245	08001A74
[-] vTraceStoreUserEventChannel	408+	16	10 + R	trcKernelPort.c:247	08001A7A
vTraceSaveSymbol	32	32	0	trcRecorder.c:276	08001AD8
[-] vTraceStoreStringEvent	392+	40	9 + R	trcRecorder.c:279	08001AE4
[-] prvTraceStoreStringEvent	352+	128	8 + R	trcRecorder.c:820	08002316

Figure 4.16. Call Graph Window

### 4.7.1 Table Window

The Call Graph Window shares multiple features with other table-based debug information windows provided by Ozone (see "Table Windows" on page 40).

### 4.7.2 Overview

Each table row of the Call Graph Window provides information about a single function call. The top level rows of the call graph are populated with the program's entry point functions. Individual functions can be expanded in order to reveal their callees.

### 4.7.3 Table Columns

#### **Name**

Name of the function.

#### **Stack Total**

The maximum amount of stack space used by any call path that originates at the function, including the function's local stack usage.

#### **Stack Local**

The amount of stack space used exclusively by the function.

#### **Depth**

The maximum length of any non-recursive call path that originates at the function.

#### **Called From**

Source code location of the function call.

#### **Call Site PC**

Instruction memory location of the function call.

## 4.7.4 Uncertain Values

A plus (+) sign that follows a table value indicates that the value is not exact but rather a lower bound estimate of the true value. A trailing "R" or "FP" further indicates the reason of the uncertainty. R stands for recursion and FP stands for function pointer call.

## 4.7.5 Recursive Call Paths

In order to obtain meaningful values for recursive call paths, the Call Graph Window only evaluates these paths up to the point of recursion. This means that the total stack usage and depth values obtained for recursive call paths are only lower bound estimates of the true values (see "Uncertain Values" on page 76).

## 4.7.6 Function Pointer Calls

The Call Graph Window is able to detect function calls via function pointers. Currently, these calls are restricted to be leaf nodes of the call graph.

## 4.7.7 Accelerated Initialization

The Call Graph Window employs an optimized initialization routine when the ELF program file provides address relocation information. Please consult your compiler's user manual for information on how to include address relocation information in the output file (GCC uses the compile switch -q).

## 4.7.8 Context Menu

### **View Call Site**

Displays the call location of the selected function within the Source Viewer (see *Source Viewer* on page 58). This action can also be triggered by double-clicking a table row.

### **View Implementation**

Displays the implementation of the selected function within the Source Viewer (see *Source Viewer* on page 58).

### **Show path with max stack usage**





Expands all table rows on the call path with the highest stack usage.

### **Group Callees**

Displays all calls made to the same function as a single table row.

### **Expand All / Collapse All**

Expands or collapses all top-level entry point functions.

	View Call Site	Ctrl+L
	View Implementation	Ctrl+I
	Show path with max stack usage	Ctrl+P
	Group Callees	Ctrl+G
	Collapse All	Shift+-

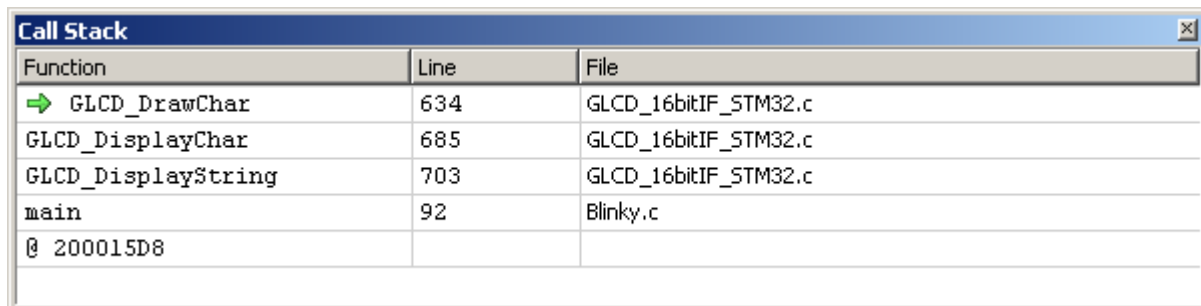
## 4.7.9 Tooltips

The tooltip of a function call informs about the longest call path and the call path with the highest stack usage that originate at the function.

<b>RNG_DeInit</b>	
Total Stack:	24
	RNG_DeInit->RCC_AHB2PeriphResetCmd
Local Stack:	8
Maximum Depth:	1
	RNG_DeInit->RCC_AHB2PeriphResetCmd

## 4.8 Call Stack Window

Ozone's Call Stack Window displays the function calling hierarchy that led to the current program execution point.



Function	Line	File
→ GLCD_DrawChar	634	GLCD_16bitIF_STM32.c
GLCD_DisplayChar	685	GLCD_16bitIF_STM32.c
GLCD_DisplayString	703	GLCD_16bitIF_STM32.c
main	92	Blinky.c
0 200015D8		

Figure 4.17. Call Stack Window

### 4.8.1 Table Window

The Call Stack Window shares multiple features with other table-based debug information windows (see "Table Windows" on page 40).

### 4.8.2 Function Call Sites

The topmost entry of the Call Stack Window displays the location of the program counter. Each of the other entries displays the call site of a function on the call stack. As an example consider Figure 4.17. Here, the fourth row (the row that starts with "main") describes the call site of the function "GLCD\_DisplayString". Both PC and call site locations are described in the following way:

Table Column	Description
Function	The function containing the PC or call site.
Line	Position of the PC or call site in the source code document.
File	Source code document containing the PC or call site.

Table 4.18. Call site information

### 4.8.3 Branch Sites



A call site that the debugger cannot affiliate with a source code line is displayed as the address of the machine instruction that caused the branch to the called function. (Compare with the bottom row in Figure 4.17)

### 4.8.4 Active Call Frame

The active frame, i.e. the frame about which the Register and Local Data Windows currently display information, can be distinguished by its color highlight.

### 4.8.5 Context Menu

The Call Stack Windows's context menu hosts actions that navigate to a call site's source code or assembler code line (see "View Actions" on page 161).

	View Source	Ctrl+U
	View Disassembly	Ctrl+D

#### View Source

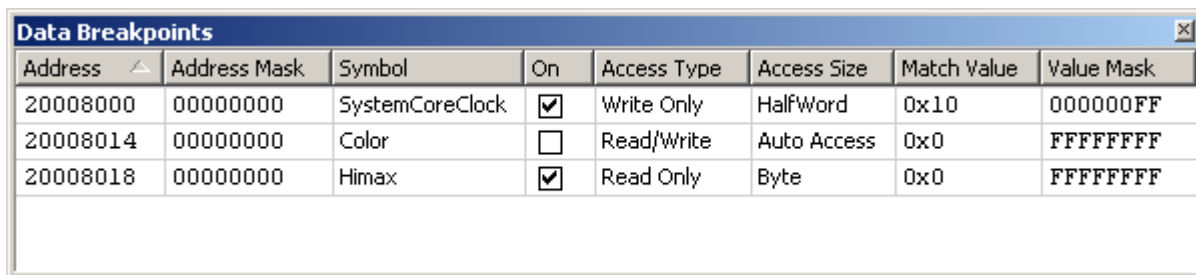
Displays the selected call site within the Source Viewer (*Source Viewer* on page 58). This action can also be triggered by double-clicking a table row.

#### View Disassembly

Displays the selected call site within the Disassembly Window (*Disassembly Window* on page 62).

## 4.9 Data Breakpoint Window

Ozone's Data Breakpoint Window allows users to observe and edit data breakpoints (see "Data Breakpoints" on page 114). Data breakpoints (watchpoints) are breakpoints that monitor memory areas for specific types of I/O accesses.



Address	Address Mask	Symbol	On	Access Type	Access Size	Match Value	Value Mask
20008000	00000000	SystemCoreClock	<input checked="" type="checkbox"/>	Write Only	HalfWord	0x10	000000FF
20008014	00000000	Color	<input type="checkbox"/>	Read/Write	Auto Access	0x0	FFFFFFFF
20008018	00000000	Himax	<input checked="" type="checkbox"/>	Read Only	Byte	0x0	FFFFFFFF

Figure 4.19. Data Breakpoint Window

### 4.9.1 Table Window

The Data Breakpoint Window shares multiple features with other table-based debug information windows (see "Table Windows" on page 40).

### 4.9.2 Data Breakpoint Attributes

Each column of the Data Breakpoint Window displays a different data breakpoint attribute. The attributes are described in "Data Breakpoint Attributes" on page 114.

### 4.9.3 Data Breakpoint Dialog

Data breakpoints are set via the Data Breakpoint Dialog. This dialog can be opened from the window's context menu (see "Data Breakpoint Dialog" on page 47).

### 4.9.4 Context Menu

The Data Breakpoint Window's context menu hosts actions that manipulate data breakpoints and that navigate to a data breakpoint's source code or assembler code location (see "Breakpoint Actions" on page 148).

#### **Clear**

Clears the selected data breakpoint.

#### **Enable / Disable**

Enables or disables the selected data breakpoint.

#### **Edit**

Opens the Data Breakpoint Dialog in editing mode (see "Data Breakpoint Dialog" on page 47).

#### **View Source**

Displays the source code line associated with the selected data breakpoint within the Source Viewer (see "Source Viewer" on page 58). This action can also be triggered by double-clicking a table row.

#### **View Data**

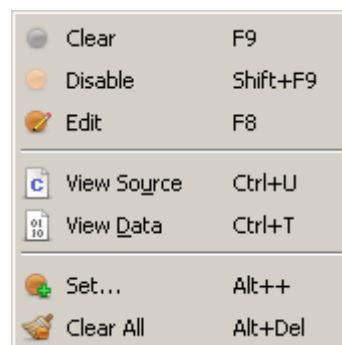
Displays the data location associated with the selected data breakpoint within the memory Window (see "Memory Window" on page 82).

#### **Set / Clear**

Opens the Data Breakpoint Dialog (see "Data Breakpoint Dialog" on page 47).

#### **Clear All**

Clears all data breakpoints.



Clear	F9
Disable	Shift+F9
Edit	F8
View Source	Ctrl+U
View Data	Ctrl+T
Set...	Alt++
Clear All	Alt+Del

### **4.9.5 Offline Data Breakpoint Manipulation**

The Data Breakpoint Window is operational both in offline and online mode (see “Offline Breakpoint Manipulation” on page 74).

### **4.9.6 Editing Data Breakpoints Programmatically**

Ozone provides multiple user actions that allow users to edit data breakpoints from script functions or at the command prompt (see “Breakpoint Actions” on page 148).

## 4.10 Functions Window

Ozone's Functions Window lists the functions defined within the application program.

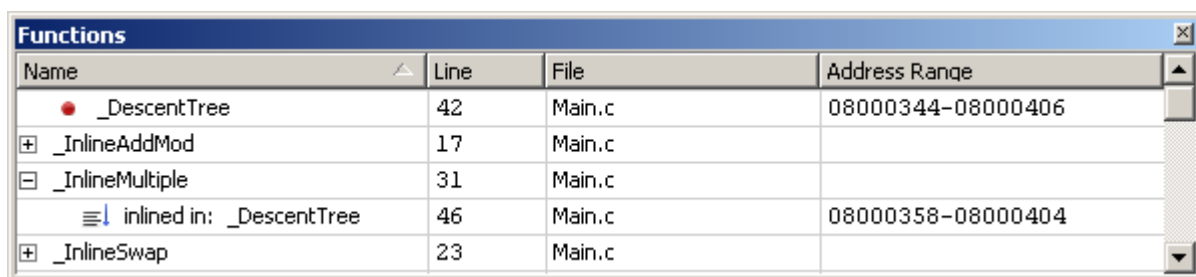


Figure 4.20. Functions Window

### 4.10.1 Table Window

The Function Window shares multiple features with other table-based debug information windows (see “Table Windows” on page 40).

### 4.10.2 Function Attributes

The Functions Window displays the following information about functions:

Attribute	Description
Name	Name of the function.
Line	Line number of the function's first source code line.
File	Source code document that contains the function.
Address Range	Memory address range covered by the function's machine code.

Table 4.21. Function attributes

### 4.10.3 Inline Expanded Functions

A function that is inline expanded in one or multiple other functions can be expanded and collapsed within the Functions Window to show or hide its expansion sites. As an example, consider Figure 4.20. Here, the Function `_InlineMultiple` has one expansion site: it is inline expanded within the function `_DescentTree`.

### 4.10.4 Breakpoint Indicators

A breakpoint icon preceding a function's name indicates that one or multiple breakpoints are set within the function.

### 4.10.5 Context Menu

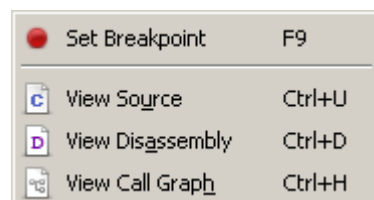
The Function Windows' context menu hosts actions that navigate to a function's source code or assembler code line (see “View Actions” on page 146).

#### **Set / Clear Breakpoint**

Sets or clears a breakpoint on the function's first machine instruction.

#### **View Source**

Displays the first source code line of the selected function within the Source Viewer. If an inline expansion site is selected, this site is shown instead.





***View Disassembly***

Displays the first machine instruction of the selected function within the Disassembly Window. If an inline expansion site is selected, this site's first machine instruction is displayed instead.

***View Call Graph***

Displays the call graph of the function within the Call Graph Window.

## 4.11 Memory Window

Ozone's Memory Window displays MCU memory content.

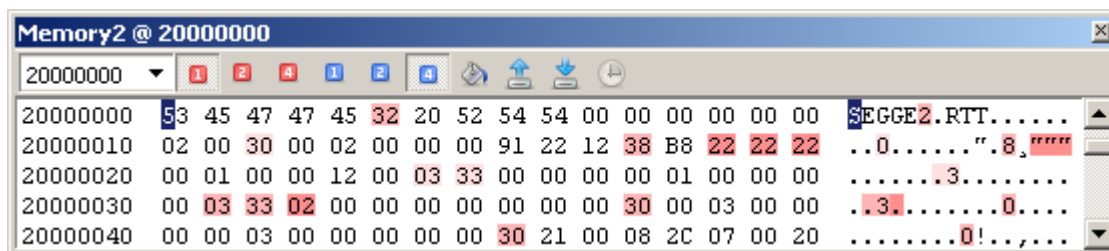


Figure 4.22. Memory Window

### 4.11.1 Change Level Highlighting

The Memory Window employs change level highlighting (see “Change Level Highlighting” on page 29).

### 4.11.2 Data Sections

The Memory Window's data sections display memory content in two different formats.

#### Hex Section

The Memory Window's central data section displays memory content as hexadecimal blocks. The amount of hexadecimal digits that are displayed per block can be adjusted to 2, 4 or 8 nibbles per block. In the illustration above, the display mode is set to 2 nibbles (or 1 byte) per block.

#### ASCII Section

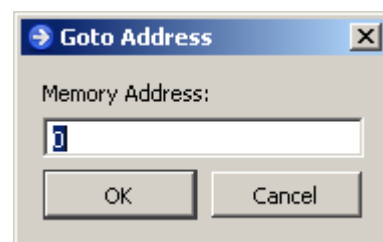
The data section on the right side of the Memory Window displays the textual interpretation (ASCII decoding) of MCU memory data.

### 4.11.3 Viewport

The address range displayed within the Memory Window is referred to as the window's viewport. The viewport can be modified in any of the following ways:

#### 4.11.3.1 Positioning the Viewport

The address of the first byte displayed within the Memory Window can be set via the action *View.Memory*. When the action is executed from the context menu or without an argument, an input dialog will show up that allows users to enter the viewport address (see illustration on the right).



#### 4.11.3.2 Scrolling the Viewport

The Memory Window's viewport can be scrolled in any of the following ways:

Mouse Wheel	Arrow Keys	Page Keys	Scroll Bar
4 Lines	1 Line	1 Page	1 Line

Table 4.23. Viewport scrolling methods

## 4.11.4 Toolbar



Figure 4.24. Toolbar of the Memory Window.

The Memory Window's toolbar provides quick access to the window's options. All toolbar actions can also be accessed via the window's context menu. The toolbar elements are described below.

### **Address Bar**

The toolbar's address bar provides a quick way of modifying the viewport address, i.e. the memory address of the first byte that is displayed within the Memory Window.

### **Access Width**

The red tool button allows users to specify the memory access width. The access width determines whether memory is accessed in chunks of bytes (access width 1), half words (access width 2) or words (access width 4).

### **Display Mode**

The blue tool buttons let users choose the display mode. There are three display modes that differ in the amount of hexadecimal figures (nibbles) that are displayed per block in the window's hex section. The display mode can be set to 1, 2 or 4 bytes per hexadecimal block, which corresponds to 2, 4, or 8 nibbles per block.

### **Fill Memory**



Opens the Fill Memory Dialog (see "Fill Memory" on page 50).

### **Save Memory Data**



Opens the Save Memory Dialog (see "Save Memory Data" on page 50).

### **Load Memory Data**



Opens the Load Memory Dialog (see "Load Memory Data" on page 50).

### **Update Interval**



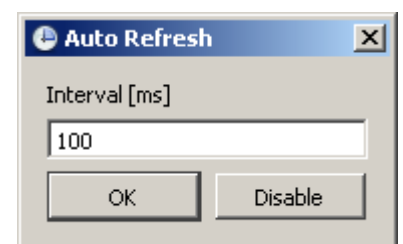
Displays the Auto Refresh Dialog (see "Automatic Update" on page 83).

## 4.11.5 Generic Memory Dialog

The "Fill Memory", "Save Memory" and "Load Memory" features of the Memory Window are implemented by the Generic Memory Dialog (see "Generic Memory Dialog" on page 50).

## 4.11.6 Automatic Update

The Memory Window offers an automatic refresh mode that updates the displayed memory area at a periodic interval. The refresh interval can be specified via the Auto Refresh Dialog that can be accessed from the toolbar or from the context menu. The auto update feature is automatically enabled when the program is resumed and is deactivated when the program is halted. It is globally disabled by clicking on the dialog's disable button.



## 4.11.7 Context Menu

The Memory Window's context menu provides the following actions:

### **Goto Address**

Opens an input dialog that allows users to enter the Memory Window's viewport address.

### **Display Mode**

Sets the display mode to either 1, 2 or 4 bytes per hexadecimal block.

### **Access Mode**

Sets the memory access width to either byte (1), half-word (2) or word (4) access.

### **Fill**

Opens the Fill Memory Dialog (see "Fill Memory" on page 50).

### **Save**

Opens the Save Memory Dialog (see "Save Memory Data" on page 50).

### **Load**

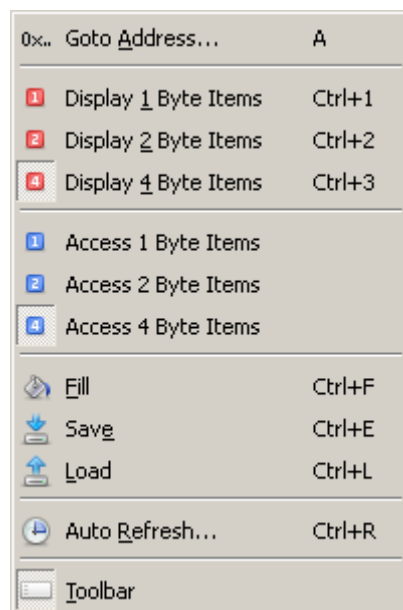
Opens the Load Memory Dialog (see "Load Memory Data" on page 50).

### **Auto Refresh**

Opens the Auto Refresh Dialog where the editor's refresh rate can be edited (see "Automatic Update" on page 83).

### **Toolbar**

Toggles the display of the window's toolbar.



## 4.11.8 Pasting Of Clipboard Content

The current clipboard content can be pasted into the Memory Window's text section at the cursor position by pressing the hotkey Ctrl+V.

## 4.11.9 Multiple Instances

Up to 4 distinct Memory Windows can be added to the Main Window. The Memory Window is the only debug information window that can be added multiple times to the Main Window.

## 4.12 Register Window

Ozone's Register Window displays the core, peripheral and FPU registers of the selected MCU.

### 4.12.1 Table Window

The Registers Window shares multiple features with other table-based debug information windows provided by Ozone (see "Table Windows" on page 40).

### 4.12.2 SVD Files

The Register Window relies on [System View Description](#) files (\*.svd) that describe the register set of the selected MCU. The SVD standard is widely adopted – many MCU vendors provide SVD register set description files for their MCUs.

#### **Core, FPU and CP15 Registers**

Ozone ships with an SVD file for each supported ARM architecture profile. When users select an MCU within the debugger, the register window is automatically initialized with the proper SVD file so that core, FPU and CP15 registers are displayed correctly.

#### **Peripheral Registers**

The SVD file describing the peripheral register set of the selected MCU must be specified manually. For this purpose, the user action *Project.AddSvdFile* is provided (see "Project.AddSvdFile" on page 174). Ozone does not ship with peripheral SVD files out of the box; users have to obtain the file from their MCU vendor.

Registers	
Name	Value
[-] Curr. CPU Regs	Sys Mode
R0	0x00000008
R1	0x00000000
R2	0x00000002
R3	0x00000000
R4	0x00000002
R5	0x00000008
R6	0x00000000
R7	0x00000000
R8	0x00000000
R9	0x00000000
R10	0x00000000
R11	0x00000000
R12	0x00000000
R13	0x2000B84
R14	0x0800A25
R15	0x0800FD8
[+] APSR	0x00 (nzcvcq)
[-] EPSR	0x0400 (T)
ICI/IT HighBits	b'00
ICI/IT LowBits	b'000000
T	b'1
IPSR	0x000
PriMask	0x0
BasePri	0x00
FaultMask	0x0
[+] Control	0x0 (fsm)
CycleCount	0x000021A6
[+] All CPU Regs	
[+] Peripherals	

### 4.12.3 Register Groups

The Register Window partitions MCU registers into four different groups:

#### **Current CPU Registers**

CPU registers that are in use given the current operating mode of the MCU.

#### **All CPU Registers**

All CPU registers, i.e. the combination of all operating mode registers.

#### **FPU Registers**

Floating point registers. This category is only available when the MCU possesses a floating point unit.


#### **CP15 Registers**

Coprocessor-15 registers. This category is only available when the MCU core contains a CP15 unit.

#### **Peripheral Registers**

Memory mapped registers. This category is only available when a peripheral register set description file was specified. (see "SVD Files" on page 85).

## 4.12.4 Bit Fields

 A register that does not contain a single value but rather one or multiple bit fields can be expanded or collapsed within the Register Window so that its bit fields are shown or hidden. Bit fields can be edited just like normal register values.

### Flag Strings

A bit field register that contains only bit fields of length 1 (flags) displays the state of its flags as a symbol string. These symbol strings are composed in the following way: the first letter of a flag's name is displayed uppercase when the flag is set and lower-case when it is not set.

### Editable Registers and Bit-Fields

Both registers and bit fields that are not marked as read-only within the loaded SVD file can be edited.

## 4.12.5 Processor Operating Mode

An ARM processor's current operating mode is displayed as the value of the current CPU registers group (see the figure on page 68). An ARM processor can be in any of 7 operating modes:

USR	SVC	ABT	IRQ	FIQ	SYS	UND
User	Supervisor	Abort	Interrupt	Fast Interrupt	System	Undefined

Table 4.25. ARM processor operating modes

## 4.12.6 Context Menu

The Register Windows' context menu provides the following actions:

### View Source

Displays the source code line affiliated with the register value (interpreted as instruction address).

### View Disassembly

Displays the disassembly at the register value.

### View Disassembly

Displays the memory at the register value (interpreted as memory address).

### Display (All) As

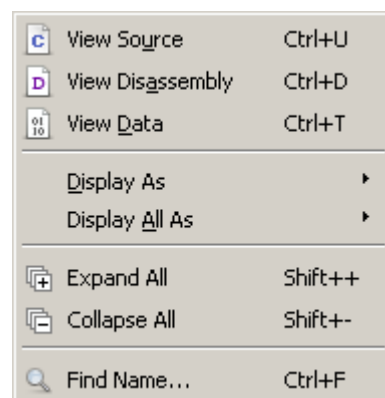
Sets the display format of the selected item or the whole window.

### Expand / Collapse All

Expands or collapses all top-level nodes.

### Find Name

Scrolls to and selects a particular register.



## 4.13 Source Files Window

Ozone's Source Files Window lists the source files that were used to generate the application program.

File	Status	Path	Address Range
USB_OS_embOS.c	compiled	C:/work/Projects/JScope/Examples/emIDE/SEGGE	0806A030-0806A1BE
virtfile.c	included	C:/work/Projects/JScope/Examples/emIDE/SEGGE	
virtfile.h	included	C:/work/Projects/JScope/Examples/emIDE/SEGGE	
Webserver.c	compiled	C:/work/Projects/JScope/Examples/emIDE/SEGGE	08064E30-08065F90
core_cm4.h	compiled	Setup/CoreSupport/core_cm4.h	08066EB0-08069BC8

Figure 4.26. Source Files Window

### 4.13.1 Table Window

The Source Files Window shares multiple features with other table-based debug information windows (see "Table Windows" on page 40).

### 4.13.2 Source File Information

The Source Files Window displays – alongside the file name and path – the following additional information about source files:

#### **Status**

Indicates how the compiler used the source file to generate the application program. A source file that contains program code is displayed as a "compiled" file. A source file that was used to extract type definitions is displayed as an "included" file.

#### **Address Range**

Memory address range covered by the source file's program code.

### 4.13.3 Unresolved Source Files

A source file that the debugger could not locate on the file system is indicated by a yellow icon within the Source Files Window. Ozone supplies users with multiple options to locate missing source files (see "Locating Missing Source Files" on page 123).

### 4.13.4 Context Menu

The context menu of the Source Files Window adapts to the selected file.



#### **Open File**

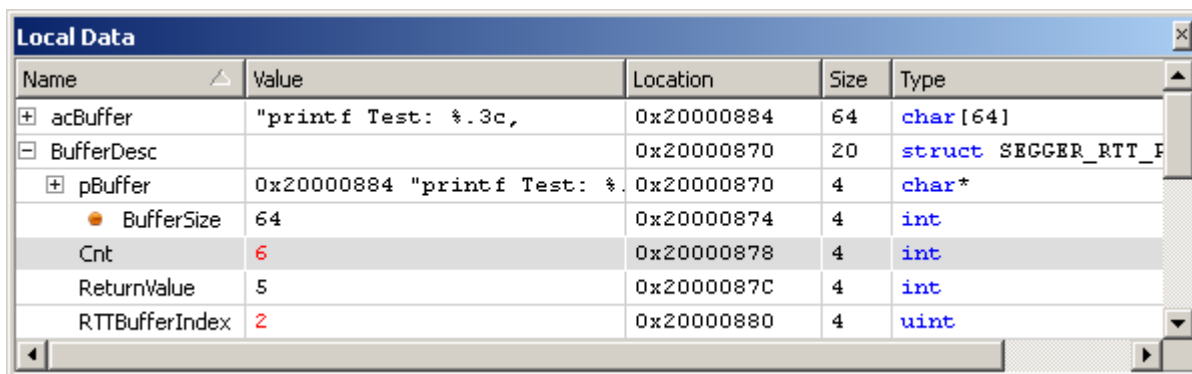
Opens the selected file in the Source Viewer. The same can be achieved by double-clicking on the file. See "Source Viewer" on page 58.

#### **Locate File**

Opens a file dialog that lets users locate the selected file on the file system. This context menu is displayed when the selected source file is missing.

## 4.14 Local Data Window

Ozone's Local Data Window displays the local symbols (variables and function parameters) of a function.



Name	Value	Location	Size	Type
acBuffer	"printf Test: %.3c,	0x20000884	64	char[64]
BufferDesc		0x20000870	20	struct SEGGER_RTT_F
pBuffer	0x20000884 "printf Test: %.	0x20000870	4	char*
BufferSize	64	0x20000874	4	int
Cnt	6	0x20000878	4	int
ReturnValue	5	0x2000087C	4	int
RTTBufferIndex	2	0x20000880	4	uint

Figure 4.27. Local Data Window

### 4.14.1 Table Window

The Local Data Window shares multiple features with other table-based debug information windows provided by Ozone (see "Table Windows" on page 40).

### 4.14.2 Call Site Symbols

The Local Data Window allows users to inspect the local variables of any function on the call stack. To change the Local Data Window's output to an arbitrary function on the call stack, the function must be selected within the Source Viewer or the Call Stack Window. Once the program is stepped, output will switch back to the current function.

### 4.14.3 Auto Mode

The Local Data Window provides an "auto mode" display option; when this option is active, the window displays all global variables referenced within the current function alongside the function's local symbols. Auto mode is inactive by default and can be toggled from the window's context menu.

### 4.14.4 Context Menu

The Local Data Window's context menu provides the following actions:

#### **Set / Clear Data Breakpoint**

Sets a data breakpoint on the selected symbol or clears it (see "Data Breakpoints" on page 114).

#### **Edit Data Breakpoint**

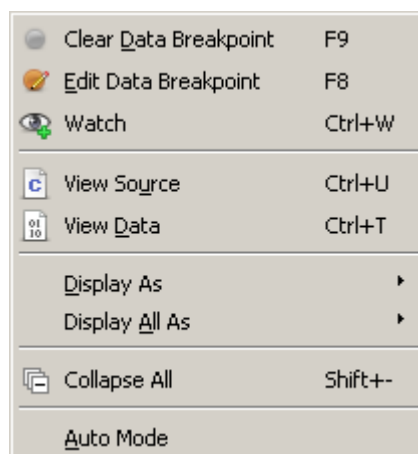
Opens the Data Breakpoint Dialog (see "Data Breakpoint Dialog" on page 47).

#### **Watch**

Adds the selected local variable to the Watched Data Window (see "Watched Data Window" on page 91).

#### **View Source**

Displays the source code declaration location of the selected local variable in the Source Viewer (see "Source Viewer" on page 58).



	Clear Data Breakpoint	F9
	Edit Data Breakpoint	F8
	Watch	Ctrl+W
	View Source	Ctrl+U
	View Data	Ctrl+T
	Display As	▶
	Display All As	▶
	Collapse All	Shift+-
	Auto Mode	



***View Data***

Displays the data location of the selected local variable in either the Memory Window (see "Memory Window" on page 82) or the Register Window (see "Register Window" on page 85).

***Display (All) As***

Changes the display format of the selected symbol or of all symbols (see "Display Format" on page 35).

***Expand / Collapse All***

Expands or collapses all top-level nodes.

***Auto Mode***

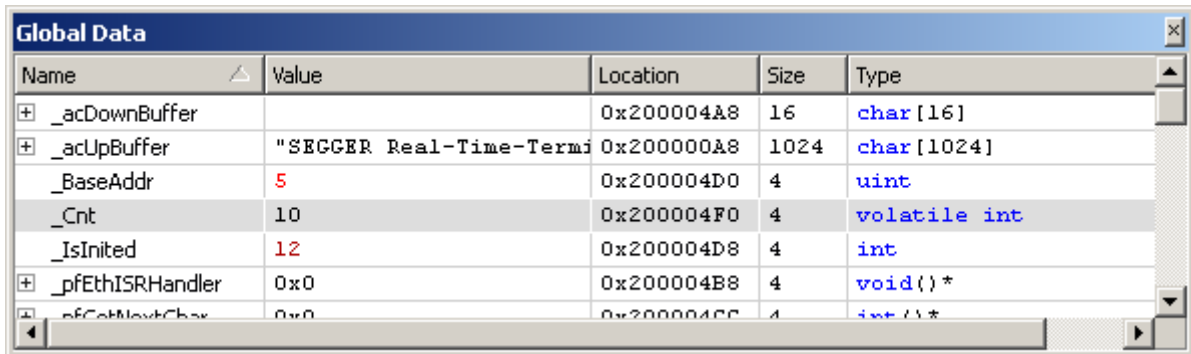
Specifies whether the "auto mode" display option is active (see "Auto Mode" on page 88).

## **4.14.5 Data Breakpoint Indicators**

A breakpoint icon preceding a local variable's name indicates that a data breakpoint is set on the variable.

## 4.15 Global Data Window

Ozone's Global Data Window displays the global variables defined within the application program.



Name	Value	Location	Size	Type
+ _acDownBuffer		0x200004A8	16	char[16]
+ _acUpBuffer	"SEGGER Real-Time-Termi	0x200000A8	1024	char[1024]
_BaseAddr	5	0x200004D0	4	uint
_Cnt	10	0x200004F0	4	volatile int
_IsInitd	12	0x200004D8	4	int
+ _pfEthISRHandler	0x0	0x200004B8	4	void() *
+ _pfCobNextChk	0x0	0x200004CC	4	int **

Figure 4.28. Global Data Window

### 4.15.1 Table Window

The Global Data Window shares multiple features with other table-based debug information windows provided by Ozone (see "Table Windows" on page 40).

### 4.15.2 Context Menu

The Global Data Window's context menu provides the following actions:

#### **Set / Clear Data Breakpoint**

Sets a data breakpoint on the selected global variable or clears it (see "Data Breakpoints" on page 114).

#### **Edit Data Breakpoint**

Opens the Data Breakpoint Dialog (see "Data Breakpoint Dialog" on page 47).

#### **Watch**

Adds the selected global variable to the Watched Data Window (see "Watched Data Window" on page 91).

#### **View Source**

Displays the source code declaration location of the selected global variable in the Source Viewer (see "Source Viewer" on page 58).

#### **View Data**

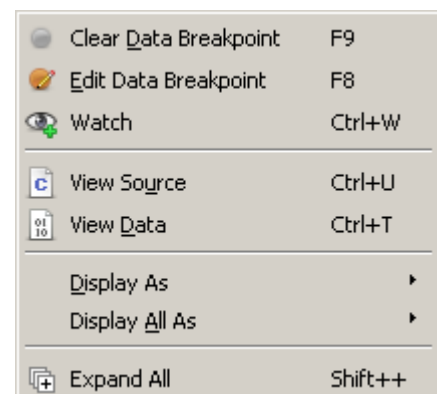
Displays the data location of the selected local variable in either the Memory Window (see "Memory Window" on page 82) or the Register Window (see "Register Window" on page 85).

#### **Display (All) As**

Changes the display format of the selected global variable or of all global variables (see "Display Format" on page 35).

#### **Expand / Collapse All**

Expands or collapses all top-level nodes.

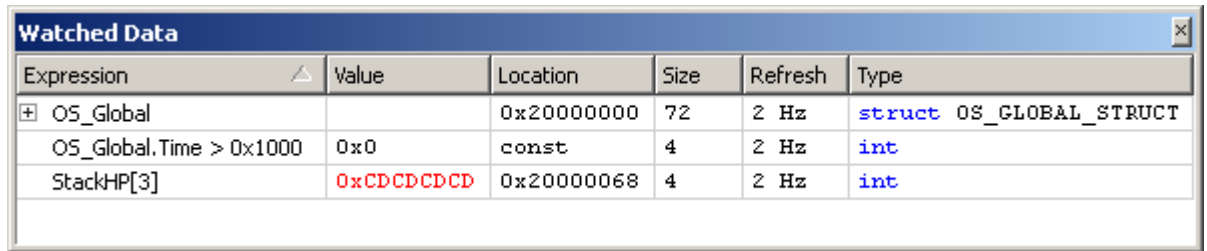


### 4.15.3 Data Breakpoint Indicators

A breakpoint icon preceding a global variable's name indicates that a data breakpoint is set on the variable.

## 4.16 Watched Data Window

Ozone's Watched Data Window tracks the values of C-style expressions that the user chose for explicit observation.



Expression	Value	Location	Size	Refresh	Type
OS_Global		0x20000000	72	2 Hz	struct OS_GLOBAL_STRUCT
OS_Global.Time > 0x1000	0x0	const	4	2 Hz	int
StackHP[3]	0xCD CDCD CD	0x20000068	4	2 Hz	int

Figure 4.29. Watched Data Window

### 4.16.1 Table Window

The Watched Data Window shares multiple features with other table-based debug information windows provided by Ozone (see "Table Windows" on page 40).

### 4.16.2 Expressions

The Watched Data Window is provided to evaluate and monitor arbitrary C-style expressions (see "Expressions" on page 142). An expression can be watched, i.e. added to the Watched Data Window, in any of the following ways:

- Via the context menu item "Watch" of any symbol window.
- Via the user action *Window.Add* (see "Window.Add" on page 159).
- By dragging a symbol onto the window.

### 4.16.3 Live Watches

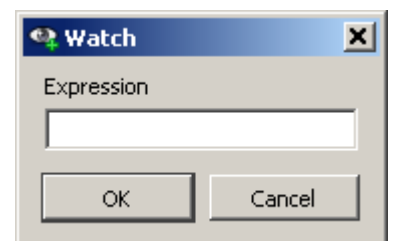
The Watched Data Window supports live updating of hosted expressions while the program is running when the employed MCU supports background memory access. Each expression can be assigned an individual update frequency via the windows context menu or programatically via user action *Edit.RefreshRate* (see "Edit.RefreshRate" on page 157).

### 4.16.4 Variable Scope

A local variable that is out of scope, i.e. whose parent function is not the current function, displays the location text "out of scope" within the Watched Data Window. The same text is also displayed for variables whose data location cannot be resolved.

### 4.16.5 Watch Dialog

The Watch Dialog provides a graphical facility to add expressions to the Watched Data Window. The dialog can be accessed from the context menu.



## 4.16.6 Context Menu

The Watched Data Window's context menu provides the following actions:

### **Remove**

Removes an expression from the window.

### **Set / Clear Data Breakpoint**

Sets a data breakpoint on the selected expression or clears it (see "Data Breakpoints" on page 114).

### **Edit Data Breakpoint**

Opens the Data Breakpoint Dialog (see "Data Breakpoint Dialog" on page 47).

### **View Source**

Displays the source code declaration location of the selected variable in the Source Viewer (see "Source Viewer" on page 58).

### **View Data**

Displays the data location of the selected variable in either the Memory Window (see "Memory Window" on page 82) or the Register Window (see "Register Window" on page 85).

### **Display (All) As**

Changes the display format of the selected item or of all items (see "Display Format" on page 35).

### **Refresh Rate**

Sets the refresh rate of the selected expression (see *Live Watches* on page 91).

### **Expand / Collapse All**

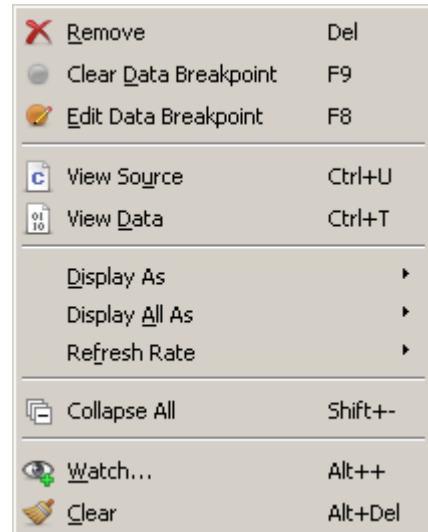
Expands or collapses all top-level nodes.

### **Watch**

Opens the Watch Dialog (see "Watch Dialog" on page 91).

### **Clear**

Removes all items from the Watched Data Window.



## 4.17 Terminal Window

Ozone's Terminal Window provides bi-directional text IO between the debugger and the application program (debugee).

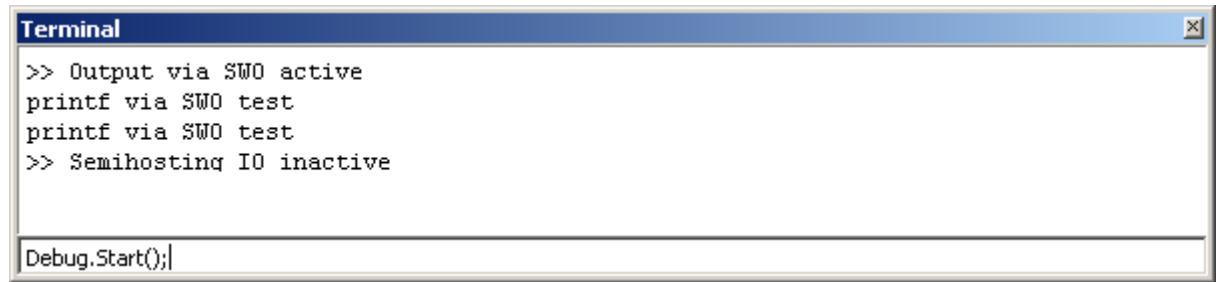


Figure 4.30. Terminal Window

### 4.17.1 Supported IO Techniques

The Terminal Window supports three communication techniques for transmission of textual data from the debugger to the debugee and vice versa that are described in *Program Output* on page 122.

### 4.17.2 Terminal Prompt

The Terminal Window's command prompt is used to reply to Semihosting or RTT user input requests and to send textual data to the application program. The terminal prompt is located at the bottom of the Terminal Window.

### 4.17.3 Context Menu

The Terminal Window's context menu provides the following actions:

#### **Copy**

Copies the selected text to the clipboard.

#### **Select All**

Selects all text lines.

#### **Clear**

Clears the Terminal Window.

#### **Capture SWO**

Indicates whether the Terminal Window captures text messages that are output by the debugee via the SWO interface.

#### **Capture Real Time IO**

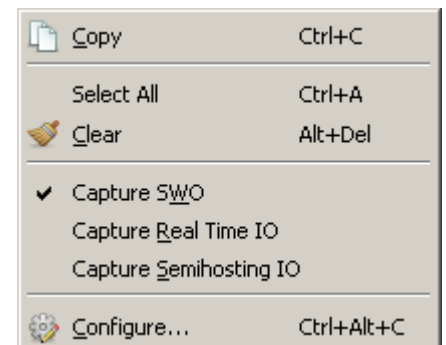
Indicates whether the Terminal Window captures text messages that are output by the debugee via SEGGER's RTT technique.

#### **Capture Semihosting IO**

Indicates whether the Terminal Window listens to the debugee's Semihosting requests.

#### **Configure**

Opens the Terminal Settings Dialog (see "Terminal Settings Dialog" on page 51).



## 4.17.4 Asynchronous User Input

Typically, the application program will request user input via the Semihosting or the RTT technique upon which users reply via the terminal prompt. However, textual data can also be send to the application program when there is no pending input request. In this case, the text will be stored at the next free RTT memory buffer location. RTT thus enables the application program to process asynchronous user input.

## 4.18 Data Graph Window

Ozone's Data Graph Window traces the values of expressions over time (see "Expressions" on page 142).

### 4.18.1 Overview

The Data Graph Window employs SEGGER's High Speed Sampling (HSS) feature to trace the values of user-defined expressions at time resolutions of up to 1 microsecond. Sampling of expressions starts automatically each time the program is resumed and stops automatically each time the program halts. Users simply have to add expressions to the window, similarly to the use case of the Watched Data Window. For further information on HSS, please consult the J-Link user manual.

### 4.18.2 Requirements

The Data Graph Window requires the connected MCU to support background memory access (BMA).

### 4.18.3 Window Layout

The Data Graph Window features three content panes – or views (3) – of which only one is visible at any given time. The view can be switched by selecting the corresponding tab within the tabbar (1). In addition, a toolbar (2) is provided that provides quick access to the most important window settings.

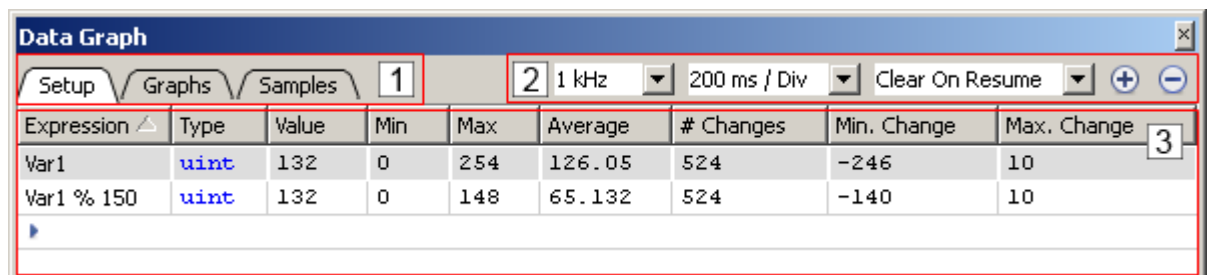


Figure 4.31. Data Graph Window Layout

### 4.18.4 Setup View

The *Setup View* allows users to assemble the list of expressions whose values are to be traced while the program is running (see "Expressions" on page 142). An expression can be added to the list in any of the following ways:

- via the *Setup View's* context menu entry *Add Symbol*.
- via user action *Window.Add* (see "Window.Add" on page 159).
- via the last table row that acts as an input field.
- by dragging a symbol from a symbol window or the source viewer onto the Data Graph Window.

and removed from the list via:

- the window's context menu entry *Remove*.
- user action *Window.Remove* (see "Window.Remove" on page 159).

Please note that only expressions that evaluate to base data types of size less or equal to 8 bytes can be added to the list.

### 4.18.4.1 Signal Statistics

Next to its editing functionality, the *Setup View* provides basic signal statistics for each traced expression. The meanings of the displayed values are explained below.

#### **Min, Max, Average**

Minimum, maximum and average signal values.

#### **#Changes**

The amount of times the signal value has changed between two consecutive samples.

#### **Min. Change**

The largest negative change between two consecutive samples of the symbol value.

#### **Max. Change**

The largest positive change between two consecutive samples of the symbol value.

### 4.18.4.2 Context Menu

The context menu of the *Setup View* provides the following actions:

#### **Remove**

Removes an expression from the window.

#### **Display (All) As**

Allows users to change the display format of the selected expression or all expressions.

#### **Add Symbol**

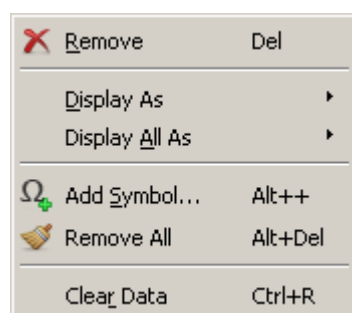
Opens an input box that lets users add an expression to the window.

#### **Remove All**

Removes all expression from the window.

#### **Clear Data**

Clears the HSS sampling data, i.e resets the window to its initial state.



### 4.18.4.3 Shared Table Features

The *Setup View* shares multiple features with other table-based debug information windows provided by Ozone (see “Table Windows” on page 40).



## 4.18.5 Graphs View

The *Graphs View* displays the sampling data as graphs within a two dimensional signal plot. The signal plot provides multiple interactive features that allow users to quickly understand the time course of expressions both at a broad and at a narrow time scale.

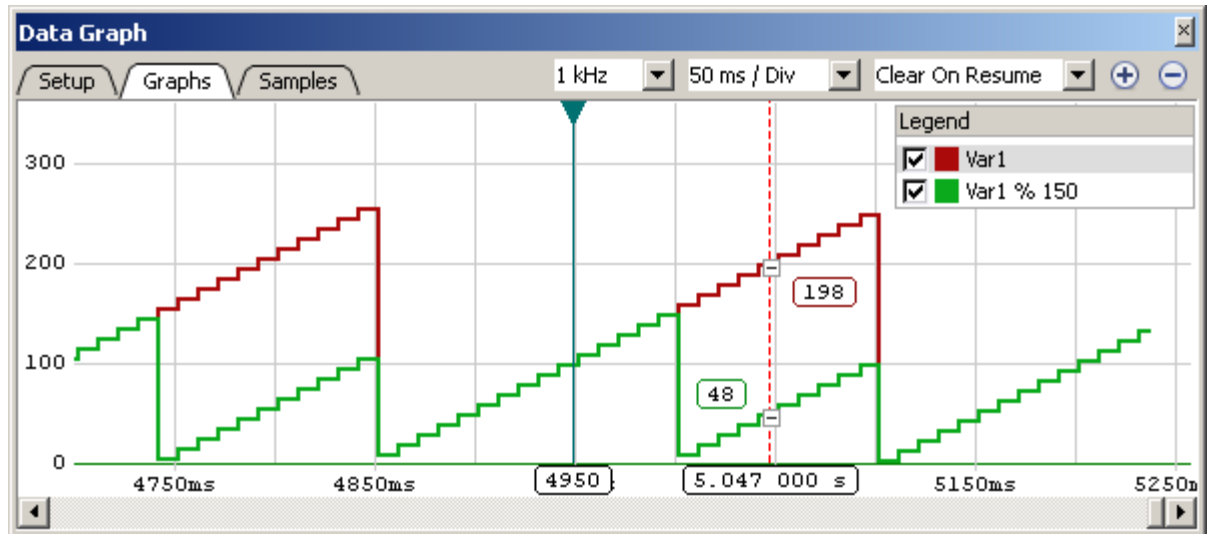


Figure 4.32. Graphs View

### 4.18.5.1 Plot Scaling

The scale of the signal plots x-axis (time scale) is given as the time-distance between adjacent vertical grid lines (time per div). The "time per divisor" can be increased or decreased in any of the following ways:

- by scrolling the mouse wheel up or down
- by using the drop-down list displayed within the toolbar
- by selecting a time scale via the window context menu

#### **Vertical Auto Scaling**

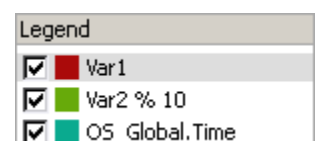
The scale of the y-axis cannot be modified. Instead, the y-axis auto-scales at all times so that all visible graphs fit completely into the available vertical window space.

### 4.18.5.2 Zoom Cursor

The zoom cursor is indicated by a triangular handle on top of it. It marks the time position that is kept window-centered whenever the time scale of the signal plot is adjusted. By first setting the zoom cursor on a particular point in time and then scrolling the mouse wheel, users can quickly and precisely zoom into a region of the signal plot. The zoom cursor can be positioned by left-clicking on the signal plot or by dragging the triangular handle. The sample index affiliated with the zoom cursor is displayed on top of it.

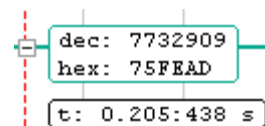
### 4.18.5.3 Plot Legend

The plot legend links each signal graph to its affiliated expression. The legend can be moved around the plot by dragging its title bar. The context menu of the plot legend allows users to select individual graphs for display and to adjust the display colors of graphs. Checkboxes are provided to toggle the display of individual graphs.



#### 4.18.5.4 Timeline

The signal plot displays a vertical timeline below the mouse cursor that updates its position whenever the mouse is moved over the plot. At the intersection point of the timeline with each graph, a value box is displayed that indicates the graph's signal value at the timeline position. Each value box has got an expansion indicator that can be clicked to show or hide the value box.



#### 4.18.5.5 Mouse Panning

The x-Axis-origin of the signal plot can be displaced by clicking on the plot and then dragging the clicked position to the left or to the right.

#### 4.18.5.6 Context Menu

The context menu of the *Graphs View* provides the following actions:

##### **Sampling Frequency**

The frequency at which all expressions are sampled (see "Sampling Frequency" on page 100).

##### **Time Scale**

Time scale used to plot the graphs of expressions (see "Time Scale" on page 100).

##### **Clear Event**

The debugging event upon which HSS sampling data is cleared (see "Clear Event" on page 100).

##### **Draw Points**

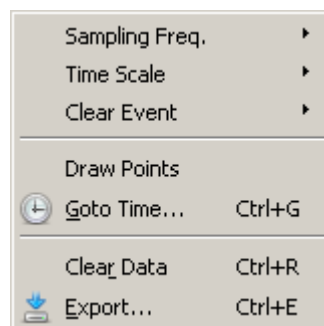
When checked, sampling data is visualized as points instead of continuous signal graphs.

##### **Goto Time**

Opens an input dialog that allows users to set the zoom cursor on a particular time position.

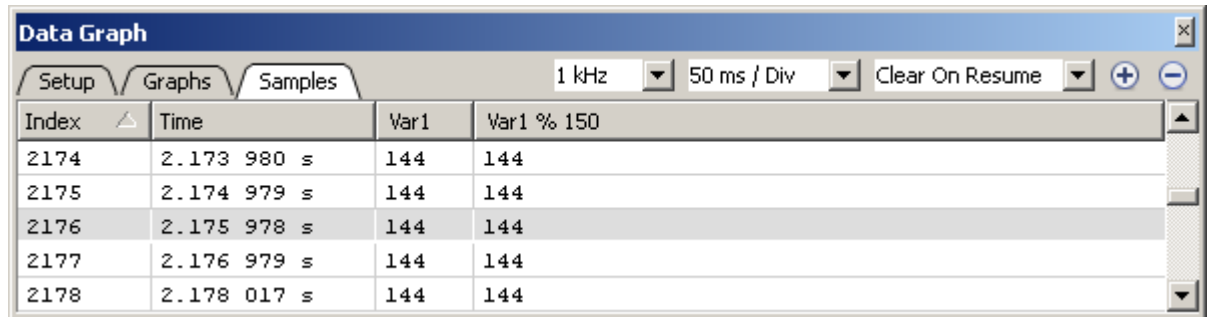
##### **Export**

Opens a file dialog that allows users to export the sampling data to a CSV file.



## 4.18.6 Samples View

The *Samples View* displays the sampling data in a tabular fashion. Following two columns that display the index and timestamp of a sample, the remaining columns display the values of each traced expression at the time the sample was taken.



Index	Time	Var1	Var1 % 150
2174	2.173 980 s	144	144
2175	2.174 979 s	144	144
2176	2.175 978 s	144	144
2177	2.176 979 s	144	144
2178	2.178 017 s	144	144

Figure 4.33. Samples View

### 4.18.6.1 Context Menu

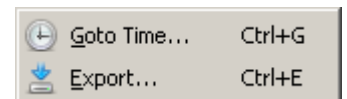
The context menu of the *Samples View* provides the following actions:

#### **Goto Time**

Opens an input dialog that allows users to set the zoom cursor on a particular time position.

#### **Export**

Opens a file dialog that allows users to export the sampling data to a CSV file.



### 4.18.6.2 Selection Behaviour

When the user selects a sample within the samples list, the zoom cursor is moved to the affiliated time position. This means that after switching back to the *Graphs View*, users may conveniently zoom into the time region of the selected sample.

### 4.18.6.3 Shared Table Features

The *Samples View* shares multiple features with other table-based debug information windows provided by Ozone (see "Table Windows" on page 40).

## 4.18.7 Toolbar

The Data Graph Window's toolbar provides quick access to the most important window settings (see Figure "Data Graph Window Layout" on page 95). The settings affiliated with each toolbar element are described below, going from left to right on the toolbar.

### 4.18.7.1 Sampling Frequency

All expressions added to the Data Graph Window are sampled together at the same points in time. This common sampling frequency is stored as Ozone's system variable "VAR\_HSS\_SPEED". In addition to the *Data Graph Window's* toolbar and context menu, the sampling frequency can also be edited via the *System Variable Editor* (see "System Variable Editor" on page 46) or programatically via user action *Edit.SysVar* (see "Edit.SysVar" on page 155).

### 4.18.7.2 Time Scale

The time scale input box allows users to adjust the signal plot's x-axis scale. The time scale is given as the time distance between adjacent vertical grid lines (time per div). The "+" and "-" buttons on the right side of the toolbar can be used to increase or decrease the time scale as well.

### 4.18.7.3 Clear Event

The toolbar's "clear event" input box selects the debugging event upon which all HSS sampling data is automatically cleared. The available options are:

#### ***Clear On Resume***

Sampling data is cleared when program execution resumes or when the program is reset.

#### ***Clear On Reset***

Sampling data is cleared when the program is reset.

#### ***Clear Never***

Sampling data is never cleared automatically.

## 4.19 Find Results Window

Ozone's Find Results Window displays the results of previous text searches.

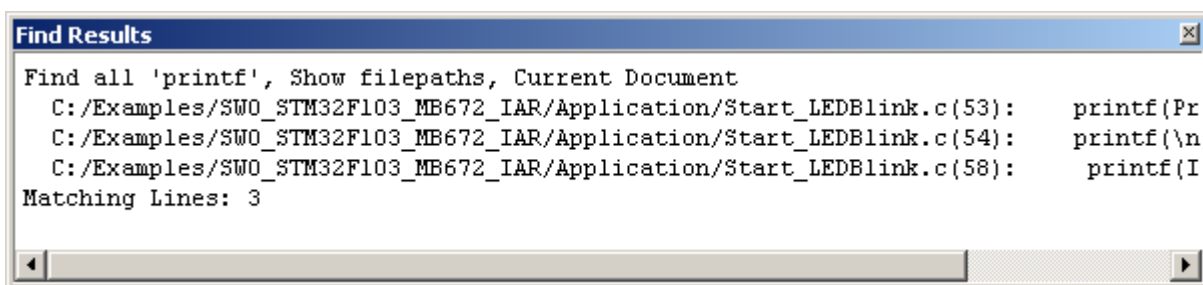


Figure 4.34. Find Results Window

### 4.19.1 Search Results

The Find Results Window displays the results of text searches as a list of source code locations that matched the search string. The search settings itself are displayed in the first row of the search result text.

### 4.19.2 Find Dialog

A new text pattern search is performed using the Find Dialog (see "Find Dialog" on page 52).

### 4.19.3 Context Menu

The Find Results Window's context menu provides the following actions:

#### **Copy**

Copies the selected text to the clipboard.

#### **Show In Editor**

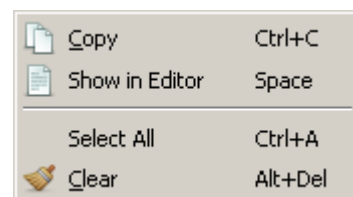
Displays the selected match result in the Source Viewer. The same operation is performed by double clicking on a match result.

#### **Select All**

Selects all text lines.

#### **Clear**

Clears the Find Results Window.





# Chapter 5

## Debugging with Ozone

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This chapter explains how to debug an embedded application using Ozone's basic and advanced debugging features. The chapter covers all activities that incur during a typical debugging session – from opening the project file to closing the debug session.

## 5.1 Debugging Work Flow

Table 5.1 summarizes the debugging work flow. Phases 1 and 2 are executed once while phases 3 and 4 are executed repeatedly until the bug is found. Ozone's implementation of each phase of the debugging work flow is discussed in separate sections of this chapter. The chapter starts by explaining how to work with Ozone project files.

Debugging Work Flow Phase	Described in sections...
Phase 1: Opening or creating a project	5.2 – 5.3
Phase 2: Starting the debug session	5.4
Phase 3: Modifying the program's execution point	5.5 – 5.7
Phase 4: Inspecting the program state	5.8 – 5.14

**Table 5.1. Debugging work flow**



## 5.2 Projects

A Ozone project (.jdebug) stores settings that configure the debugger so that it is ready to debug an application program on a particular hardware setup (microcontroller and debug interface). When a project is opened or created, the debugger is initialized with the project settings.

### 5.2.1 Project File Example

Illustrated below is an example project file that was created with the Project Wizard (*Project Wizard* on page 23). As can be seen, project settings are specified in a C-like syntax and are placed inside a function. This is due to the fact that Ozone project files are in fact programmable script files. Chapter 6 covers the scripting facility in detail.

```



/*****
 *
 *      OnProjectLoad
 *
 * Function description
 * Executed when the project file is opened. Required.
 *
 *****/
void OnProjectLoad (void) {
    Project.SetDevice ("STM32F103ZE");
    Project.SetHostIF ("USB", "0");
    Project.SetTargetIF ("SWD");
    Project.SetTIFSpeed ("2 MHz");
    File.Open ("C:/Examples/Blinky_STM32F103_Keil/Blinky/RAM/Blinky.axf");
}

```

Figure 5.2. Basic project file

### 5.2.2 Opening Project Files

A project file can be opened in any of the following ways:

- Main Menu (File  Open)
- Recent Projects List (File  Recent Projects)
- Hotkey Ctrl+O
- User action *File.Open* (see "File.Open" on page 150)

### 5.2.3 Creating Project Files

A project file can be created manually using a text editor or with the aid of Ozone's Project Wizard (see "*Project Wizard*" on page 23). The Project Wizard creates minimal project files that specify only the required settings.

## 5.2.4 Project Settings

Any user action that configures the debugger in some way is a valid project setting – this also includes user actions that alter the appearance of the debugger (see "User Actions" on page 28).

### 5.2.4.1 Specifying Project Settings

Project settings are specified by inserting user action commands into the obligatory script function "OnProjectLoad" (see Figure 5.2 on page 105).

### 5.2.4.2 Program File

The application program (debuggee) can be specified via the user action *File.Open*. The file path argument can be specified as an absolute path or relative to the project file directory, amongst others (see "File.Open" on page 150). Furthermore, please consider section 1.2.3 for the list of supported program file types.

### 5.2.4.3 Hardware Settings

Hardware settings configure the debugger to be used with a particular MCU and debug interface. The affiliated user actions belong the "Project" category (see "Project Actions" on page 171).

### 5.2.4.4 RTOS-Awareness-Plugin

The user action *Project.SetOSPlugin* specifies the file path or name of the plugin that adds RTOS awareness to the debugger (see "Project.SetOSPlugin" on page 173). Ozone currently ships with two RTOS-awareness-plugins - one for SEGGER's embOS and one for FreeRTOS.

### 5.2.4.5 Behavioral Settings

Settings that modify the behaviour of debugging operations are referred to as "system variables". System variables can be edited via the user action *Edit.SysVar* (see "Edit.SysVar" on page 155).

### 5.2.4.6 Appearance Settings

Appearance settings allow users to specify a user interface "look & feel" inside a project file and share it with other users. Appearance settings can be specified via the user action *Edit.Preference* (see "Edit.Preference" on page 155).

### 5.2.4.7 Required Project Settings

A valid project file must specify the following settings:

Project Setting	Description
Project.SetDevice	The name of the employed MCU model.
Project.SetHostIF	Specifies how the J-Link debug probe is connected to the Host-PC.
Project.SetTargetIF	Specifies how the J-Link debug probe is connected to the MCU.
Project.SetTifSpeed	Specifies the data transmission speed.

Table 5.4. Required project settings

## 5.3 Program Files

The program to be debugged (debuggee) is specified as part of the project settings or is opened manually from the user interface.

### 5.3.1 Supported File Types

Ozone supports the following program file types:

- ELF or compatible files (\*.elf, \*.out, \*.axf)
- Motorola s-record files (\*.srec, \*.mot)
- Intel hex files (\*.hex)
- Binary data files (\*.bin)


### 5.3.2 Symbol Information

Only ELF or compatible program files contain symbol information. When specifying a program or data file of different type, source-level debugging features will be unavailable. In addition, all debugger functionality requiring symbol information – such as the variable or function windows – will be unavailable.

#### ***Debugging without Symbol Information***

Ozone provides many facilities that allow insight into programs that do not contain symbol information. With the aid of the Disassembly Window, program execution can be observed and controlled on a machine code level. The MCU's memory and register state can be observed and modified via the Memory and Register Windows. Furthermore, many advanced debugging features such as instruction trace and terminal IO are operational even when the program file does not provide symbol information.

### 5.3.3 Opening Program Files

When the program file is not specified as part of the project settings (using action *File.Open*), it needs to be opened manually. A program file can be opened via the Main Menu (File  Open), or by entering user action command *File.Open* into the Console Window's command prompt (see "File.Open" on page 150).

#### ***Effects of opening a Program File***

When an ELF- or compatible program file is opened, the program's main function is displayed within the Source Viewer. Furthermore, all debug information windows that display static program entities are initialized. Specifically, these are the Functions Window (see "Functions Window" on page 80), Source Files Window (see "Source Files Window" on page 87), Global Data Window (see "Global Data Window" on page 90) and Code Profile Window (see "Code Profile Window" on page 68).

### 5.3.4 Automatic Download

When a program or data file is opened while a debug session is running, the file contents will be automatically downloaded to target memory. Please note that the file contents will overwrite any existing program or data at the download location.

### 5.3.5 Data Encoding

When an ELF or compatible program file is opened, Ozone senses the program file's data encoding (data endianness) and configures itself for that encoding. Additionally, the endianness mode of the attached MCU is set to the program file's data encoding if supported by the MCU. The MCU's endianness mode can also be specified independently via the J-Link-Settings-Dialog (see "J-Link Settings Dialog" on page 49).

## 5.4 Starting the Debug Session

After a project was opened or created and a program file was specified, the next step in the debugging work flow is to start the debug session. The debug session is started via the user action *Debug.Start* (see “*Debug.Start*” on page 165). This action can be triggered from the Debug Menu or by pressing the hotkey F5.

### 5.4.1 Connection Mode

The operations that are performed during the startup sequence depend on the value of the connection mode parameter (see “*Debug.SetConnectMode*” on page 166). The different connection modes are described below.

#### 5.4.1.1 Download & Reset Program

The default connection mode “Download & Reset Program” performs the following operations:

Startup Phase	Description
Phase 1: Connect	A software connection to the MCU is established via J-Link.
Phase 2: Breakpoints	Pending (data) breakpoints that were set in offline mode are applied.
Phase 3: Reset	A hardware reset of the MCU is performed.
Phase 4: Download	The application program is downloaded to MCU memory.
Phase 5: Finish	The initial program operation is performed (see “Initial Program Operation” on page 109).

Table 5.5. Phases of the “Download & Reset Program” startup sequence

#### Flow Chart

Appendix 7.5 provides a flow chart of the “Download & Reset” startup sequence. This chart can be used as a reference when reprogramming the sequence via the scripting interface.


#### 5.4.1.2 Attach to Running Program

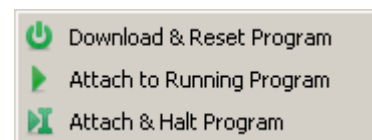
This connection mode attaches the debugger to the application program by performing phases 1 and 2 of the default startup sequence (Table 5.5).

#### 5.4.1.3 Attach & Halt Program

This connection mode performs the same operations as “Attach To Running Program” and additionally halts the program.

#### 5.4.1.4 Setting the Connection Mode

The connection mode can be set via user action *Debug.SetConnectMode* (see “*Debug.SetConnectMode*” on page 166), via the System Variable Editor (see “System Variable Editor” on page 46) or via the Connection Menu (Debug  Start Debugging). The Connection Menu is illustrated to the right.



## 5.4.2 Initial Program Operation

When the connection mode is set to "Download & Reset Program", the debugger finishes the startup sequence in one of the following ways, depending on the reset mode (see "Reset Mode" on page 111):

Reset Mode	Initial Program Operation
Reset & Break at Symbol	The Program is reset and advanced to a particular function.
Reset & Halt	The program is halted at the reset vector.
Reset & Run	The program is restarted.

Table 5.6. Initial program operations

## 5.4.3 Reprogramming the Startup Sequence

Parts or all of the "Download & Reset Program" startup sequence can be reprogrammed. The process is discussed in detail in "DebugStart" on page 128.

## 5.4.4 Visible Effects

When the start-up procedure is complete, the debug information windows that display MCU data will be initialized and the code windows will display the program execution point (PC Line).

## 5.5 Execution Point

The current position of program execution is referred to as the execution point. The execution point is identified by the memory address of the machine instruction that is going to be executed next (PC register value).

### 5.5.1 Observing the Execution Point

The application program's execution point is displayed both within the Source Viewer and within the Disassembly Window, where it is referred to as the "PC line".

#### **Source Viewer**

The PC line can be brought into view via the window's context menu entry "Goto PC" or by executing the user action *View.PCLine* (see "View.PCLine" on page 163).

#### **Disassembly Window**

The PC line can be brought into view via the window's context menu entry "Goto PC" or by executing the user action *View.PC* (see "View.PC" on page 163).

### 5.5.2 Setting the Execution Point

The execution point can be set to arbitrary source code lines or machine instructions via the user actions *Debug.RunTo*, *Debug.SetNextStmnt* and *Debug.SetNextPC* (see page 168).

#### 5.5.2.1 **Debug.RunTo**

*Debug.RunTo* advances program execution to a particular function, source code line or instruction address, depending on the command line parameter given (see "Debug.RunTo" on page 169). All instructions between the current PC and the destination are executed. Both code windows provide a context menu entry "Run To Cursor" that advance program execution to the selected code line.

#### 5.5.2.2 **Debug.SetNextStatement**

*Debug.SetNextStatement* advances program execution to a particular source code line or function. The action sets the execution point directly, i.e. all instructions between the current execution point and the destination location will be skipped.

#### 5.5.2.3 **Debug.SetNextPC**

*Debug.SetNextPC* advances program execution to a particular instruction address. The action sets the execution point directly, i.e. all instructions between the current execution point and the destination execution point will be skipped.

## 5.6 Debugging Controls

Ozone provides the following debugging controls that allow users to modify the program execution point.


### 5.6.1 Reset

The program can be reset via the user action *Debug.Reset* (see “*Debug.Reset*” on page 166). The action can be executed from the Debug Menu or by pressing F4.

#### 5.6.1.1 Reset Mode

The reset behaviour depends on the value of the reset mode parameter (see “*Reset Modes*” on page 137). The reset mode specifies which of the three initial program operations is performed after the MCU has been hardware-reset (see “*Initial Program Operation*” on page 109).

##### Setting the Reset Mode

The reset mode can be set via user action *Debug.SetResetMode* (see “*Debug.SetResetMode*” on page 167), via the System Variable Editor (see “*System Variable Editor*” on page 46) or via the Reset Menu (Debug  Reset). The Reset Menu is illustrated to the right. The symbol to break at can be specified by settings System Variable “*VAR\_BREAK\_AT\_THIS\_SYMBOL*”.



### 5.6.2 Step

Ozone provides three user actions that step the program in defined ways. The debugger's stepping behaviour also depends on whether the Source Viewer or the Disassembly Window is the active code window (see “*Active Code Window*” on page 36). Table 5.7 considers each situation and describes the resulting behaviour.

	Active Code Window	
Action	Source Viewer	Disassembly Window
<i>Debug.StepInto</i>	Steps the program to the next source code line. If the current source code line calls a function, the function is entered.	Advances the program by a single machine instruction by executing the current instruction (single step).
<i>Debug.StepOver</i>	Steps the program to the next source code line. If the current source code line calls a function, the function is overstepped, i.e. executed but not entered.	Performs a single step with the particularity that branch with link instructions (BL) are overstepped, i.e. instructions are executed until the PC assumes the address following that of the branch.
<i>Debug.StepOut</i>	Steps the program out of the current function to the source code line following the function's call site.	Steps the program out of the current function to the machine instruction following the function's call site.

Table 5.7. Program stepping behaviors

#### 5.6.2.1 Stepping Expanded Source Code Lines

When the Source Viewer is the active code window and the source line containing the PC is expanded to reveal its assembler code instructions, the debugger will use its instruction stepping mode instead of performing source line steps.

### 5.6.3 Resume

The program can be resumed via the user action *Debug.Continue* (see page 166). The action can be executed from the Debug Menu or by pressing the hotkey F5.

### 5.6.4 Halt

The program can be halted via the user action *Debug.Halt* (see page 166). The action can be executed from the Debug Menu or by pressing the hotkey F6.



## 5.7 Breakpoints

Ozone provides many alternative ways of setting, clearing, enabling and disabling breakpoints on machine instructions, source code lines, functions and program variables.

### 5.7.1 Instruction Breakpoints

A breakpoint that is set on the memory address of a machine instruction is referred to as an instruction breakpoint.

#### 5.7.1.1 Editing Instruction Breakpoints

Instruction breakpoints can be edited within the Disassembly Window (see “Disassembly Window” on page 62), within the Breakpoint Window (see “Breakpoint Window” on page 73) or via the user actions *Break.Set*, *Break.Clear*, *Break.Enable*, *Break.Disable* and *Break.ClearAll* (see “Breakpoint Actions” on page 148).

### 5.7.2 Code Breakpoints

A breakpoint that is set on a source code line is referred to as a code breakpoint. Technically, a code breakpoint is set on the memory address of the first machine instruction affiliated with the source code line. An exception to this rule are inlined code breakpoints (see “Inlined Code Breakpoints” on page 113).

#### 5.7.2.1 Editing Code Breakpoints

Code breakpoints can be edited within the Source Viewer (see “Source Viewer” on page 58), within the Breakpoint Window (see “Breakpoint Window” on page 73) or via the user actions *Break.SetOnSrc*, *Break.ClearOnSrc*, *Break.EnableOnSrc*, *Break.DisableOnSrc* and *Break.ClearAll* (see “Breakpoint Actions” on page 148). Source code locations are specified in a predefined format (see “Source Code Location Descriptor” on page 134).

#### 5.7.2.2 Inlined Code Breakpoints

A code breakpoint that is placed within an inline expanded function may be set on multiple machine instruction addresses – one for each inline expansion of the function. This type of code breakpoint is referred to as an inlined code breakpoint. Inlined code breakpoints can be expanded within the Breakpoints Window to reveal their individual instruction breakpoints.

### 5.7.3 Function Breakpoints

A breakpoint that is set on the first machine instruction of a function is referred to as a function breakpoint.

#### 5.7.3.1 Editing Function Breakpoints

Function breakpoints can be edited in the same way as code breakpoints but the function name is used as argument instead of a source code location descriptor.

### 5.7.4 Conditional Breakpoints

Each instruction, code or function breakpoint can be assigned a trigger condition and a trigger action that is evaluated/performed when the breakpoint is hit. The trigger condition and trigger action are set via the Breakpoint Properties Dialog (see “Breakpoint Properties Dialog” on page 48) or programatically via the user action *Break.Edit* (see “Break.Edit” on page 186).

## 5.7.5 Data Breakpoints

Data breakpoints (watchpoints) monitor memory areas for specific types of IO accesses. When a memory access occurs that matches the data breakpoint's trigger condition, the program is halted. Data breakpoints can be used to monitor program variables that reside in MCU memory.

### 5.7.5.1 Data Breakpoint Attributes

Data breakpoints are defined via the following attributes:

#### **Address**

Memory address that is monitored for IO (access) events.

#### **Address Mask**

Specifies which bits of the address are ignored when monitoring access events. By means of the address mask, a single data breakpoint can be set to monitor accesses to several individual memory addresses. More precisely, when  $n$  bits are set in the address mask, the data breakpoint monitors  $2^n$  many memory addresses.

#### **Symbol**

Variable or function parameter whose data location corresponds to the memory address of the data breakpoint.

#### **On**

Indicates if the data breakpoint is enabled or disabled.

#### **Access Type**

Type of IO access that is monitored by the data breakpoint (see "Access Types" on page 137).

#### **Access Size**

Number of bytes that need to be accessed in order to trigger the data breakpoint (see "Memory Access Widths" on page 137). As an example, a data breakpoint with an access size of 4 bytes (word) will only be triggered when a word is written to one of the monitored memory locations. It will not be triggered when, say, a byte is written.

#### **Match Value**

Value condition required to trigger the data breakpoint. A data breakpoint will only be triggered when the match value is written to or read from one of the monitored memory addresses.

#### **Value Mask**

Indicates which bits of the match value are ignored when monitoring access events. A value mask of 0xFFFFFFFF disables the value condition.

### 5.7.5.2 Editing Data Breakpoints

Ozone provides the following facilities to set and edit data breakpoints:

#### **Data Breakpoint Dialog**

Data breakpoints are set via the Data Breakpoint Dialog (see "Data Breakpoint Dialog" on page 47).

### **Data Breakpoint Window**

Data breakpoints can be cleared, enabled, disabled and edited via the Data Breakpoint Window (see "Data Breakpoint Window" on page 78).

### **User Actions**

Data breakpoints can be manipulated programmatically via the user actions *Break.SetOn[X]*, *Break.ClearOn[X]*, *Break.EnableOn[X]*, *Break.DisableOn[X]*, *Break.EditOn[X]*, and *Break.ClearAllOnData*, where [X] stands for either "Data" or "Symbol" (see "Breakpoint Actions" on page 148).

### **5.7.5.3 Data Breakpoint Limitations**

The amount of data breakpoints that can be set, as well as the supported values of the address mask parameter, depend on the capabilities of the selected MCU.

### **5.7.6 Breakpoint Implementation**

The concrete way in which a breakpoint is implemented – in MCU hardware or as a software interrupt – can be configured via the Breakpoint Properties Dialog (see "Breakpoint Properties Dialog" on page 48) or programmatically via the user action *Break.SetType* (see "Break.SetType" on page 184). Furthermore, the default breakpoint implementation type is stored as a system variable (see "System Variable Identifiers" on page 141).

### **5.7.7 Offline Breakpoint Manipulation**

All types of breakpoints can be modified both while the debugger is online and offline. Any modifications made to breakpoints while the debugger is disconnected from the MCU will be applied when the debug session is started.

### **5.7.8 Unlimited Flash Breakpoints**

An unlimited number of software interrupt breakpoints in flash memory can only be set if a valid licence for the "Unlimited Flash Breakpoints" feature has been bought from SEGGER.

## 5.8 Program State

This section explains how users can inspect and modify the state of the application program when it is halted at an arbitrary execution point.

### 5.8.1 Data Symbols

Ozone's symbol windows allow users to observe and edit data symbols (variables and function parameters). In addition, data symbols can be read and written programmatically via user actions.

#### **Local Symbols**

The Local Data Window allows users to observe and manipulate the local symbols that are in scope at the execution point (see "Local Data Window" on page 88).

#### **Call Site Symbols**

The Local Data Window can display the local symbols of any function on the call stack. By selecting a called function within the Call Stack Window (see "Call Stack Window" on page 77) or within the Source Viewer (see "Source Viewer" on page 58), the local symbols of that function are displayed.

#### **Global Variables**

The Global Data Window allows users to observe and edit global program variables (see "Global Data Window" on page 90).

#### **Watched Variables**

Any program variable can be put under, and removed from, explicit observation via the user actions *Window.Add* and *Window.Remove* (see "Window Actions" on page 146). Observed variables are displayed within the Watched Data Window (see "Watched Data Window" on page 91).

#### **Data Locations**

The register or memory location of a data symbol can be displayed by executing the user action *View.Data* (see "View.Data" on page 161). The action is available from the context menu of the symbol window. The data location of a symbol can be read or written programmatically via the user actions listed in section 5.9.

### 5.8.2 Function Calling Hierarchy

The hierarchy of function calls that led to the current execution point can be observed within the Call Stack Window (see "Call Stack Window" on page 77).

### 5.8.3 Instruction Execution History

Ozone's allows users to inspect the machine instructions that were executed between two consecutive execution points (see "Instruction Trace Window" on page 65). The user action *View.InstrTrace* is provided to display arbitrary positions within the instruction execution stack (see "View.InstrTrace" on page 162).

### 5.8.4 Symbol Tooltips

When hovering the mouse cursor over a variable within the Source Viewer, a tooltip will pop up that displays the variable's value (see "Symbol Tooltips" on page 59).

## 5.9 Hardware State

This section describes how users of Ozone can inspect and modify the MCUs hardware state.

### 5.9.1 MCU Registers

MCU Register can be inspected and edited via Ozone's Register Window (see "Register Window" on page 85). The user actions *Target.GetReg* and *Target.SetReg* are provided to allow the readout or manipulation of both core and coprocessor registers from script functions or at the command prompt (see "Target Actions" on page 148).

### 5.9.2 MCU Memory

MCU memory can be inspected and edited via Ozone's Memory Window (see "Memory Window" on page 82). The user actions:

- *Target.ReadU8*
- *Target.ReadU16*
- *Target.ReadU32*
- *Target.WriteU8*
- *Target.WriteU16*
- *Target.WriteU32*

are provided to read and manipulate MCU memory from script functions or at the command prompt (see "Target Actions" on page 148). These actions access memory byte (U8), half-word (U16) and word-wise (U32).

#### 5.9.2.1 Memory Access Width

The access width that the J-Link firmware employs when reading or writing memory strides of arbitrary size can be specified via the user action *Width* (see "Target.SetAccessWidth" on page 180).

## 5.10 Inspecting a Running Program

When the application program is running, program inspection and manipulation is limited in the following ways:

Limitation	Description
No register IO	Register values are not updated and cannot be edit.
Freezed symbol windows	Values within symbol windows are not updated and cannot be edited.
No call stack and instruction trace information	The Call Stack- and Instruction Trace Windows do not display content.

**Table 5.8. Limitations on program inspection while the program is running**

All other features, such as terminal-IO and breakpoint manipulation, remain operational while the application program is running.

### 5.10.1 Live Watches

In situations where the value of a symbol or an expression needs to be monitored while the program is running, users can resort to Ozone's Watched Data Window (see "Watched Data Window" on page 91). The Watched Data Window allows users to set refresh rates between 1 and 5 Hz for each expression individually.

### 5.10.2 Symbol Trace

In situations where a high resolution trace of a symbol or an expression is required, users can resort to Ozone's Data Graph Window (see "Data Graph Window" on page 95). The Data Graph Window supports sampling rates of up to 1 MHz and provides advanced navigation tools for exploring signal graphs.

### 5.10.3 Streaming Trace

When used in conjunction with a SEGGER J-Trace PRO debug probe on hardware that supports instruction tracing, Ozone is able to update the application's code profile statistics continuously while the program is running. In contrast to non-streaming trace, the trace data is recorded and sent continuously to the host PC, instead of being limited by the trace probe buffer size. This allows "endless" recording of trace data and real-time analysis of the execution trace while the target is running. For use-cases of streaming trace, refer to "Advanced Program Analysis And Optimization Hints" on page 119. For further information on streaming trace, please consult the J-Trace PRO user manual or consult SEGGER's homepage.

## 5.11 Advanced Program Analysis And Optimization Hints

This section describes use-cases of advanced program analysis using the (streaming) instruction trace and code profiling capabilities of Ozone.

For code profiling hardware requirements, see "Hardware Requirements" on page 68.

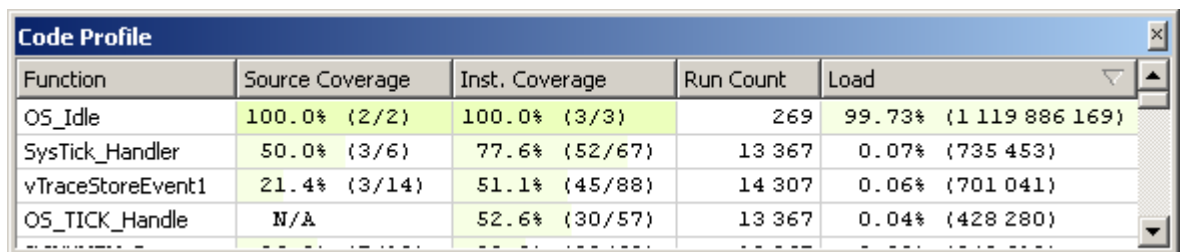
### 5.11.1 Program Performance Optimization

#### 5.11.1.1 Scenario

The user wants to optimize the runtime performance of the debuggee.

#### 5.11.1.2 Workflow

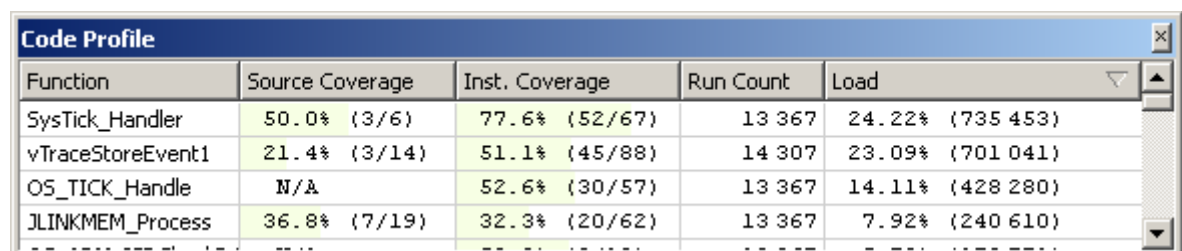
To get an overview about the program functions in which most CPU time is spend, it is usually good to start by looking at the Code Profile Window and to sort its functions list according to CPU load:



Function	Source Coverage	Inst. Coverage	Run Count	Load
OS_Idle	100.0% (2/2)	100.0% (3/3)	269	99.73% (1 119 886 169)
SysTick_Handler	50.0% (3/6)	77.6% (52/67)	13 367	0.07% (735 453)
vTraceStoreEvent1	21.4% (3/14)	51.1% (45/88)	14 307	0.06% (701 041)
OS_TICK_Handle	N/A	52.6% (30/57)	13 367	0.04% (428 280)

#### Filtering Functions

In this example, the program is 99% of its CPU time in the idle loop, which is not relevant for optimizations. To get a clear picture about where the rest of the CPU time is spend, the idle loop can be filtered from the code profile statistic. This can be done by selecting function OS\_Idle and clicking on the context menu entry "Exclude".



Function	Source Coverage	Inst. Coverage	Run Count	Load
SysTick_Handler	50.0% (3/6)	77.6% (52/67)	13 367	24.22% (735 453)
vTraceStoreEvent1	21.4% (3/14)	51.1% (45/88)	14 307	23.09% (701 041)
OS_TICK_Handle	N/A	52.6% (30/57)	13 367	14.11% (428 280)
JLINKMEM_Process	36.8% (7/19)	32.3% (20/62)	13 367	7.92% (240 610)

After filtering, the Code Profile Window shows where the application spends the remaining CPU time. All other functions which affect the CPU load and cannot be optimized any further can be filtered accordingly, to find remaining functions worth optimizing. In this example, a quarter of the remaining CPU time is spend in function vTraceStoreEvent1. Let's now assume the user wants to optimize the runtime of this function. By double-clicking on the function it is displayed within the Source Viewer.

#### Evaluating Execution Counters

The Source Viewer’s execution counters indicate that an assertion macro within function `vTraceStoreEvent1` has been executed a significant amount of times. The Source Viewer also indicates that the last 3 instructions of the assertion macro have never been executed. This means that the assertion was always true when it was evaluated.

**Deriving Improvement Concepts**

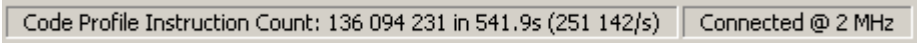
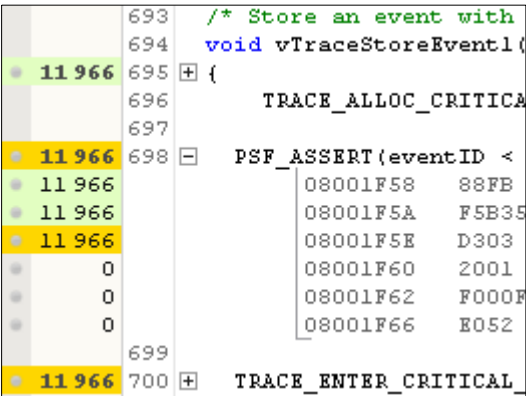
At this point, the user could think about removing the assertion or ensuring that the assertion is only evaluated when the program is run in debug mode.

**Impact Estimation**

To get an idea of the impact of the optimization, the execution counters may provide a first idea. In general, optimizing source lines which are executed more often can result in higher optimization. If the function code is fully sequential, i.e. if there are no loops or branches in the code, the impact can be estimated exactly.

**Code Profile Status Information**

The status information of the Code Profile Window displays the target’s actual instruction execution frequency. An instructions per second value that is significantly below the targets core frequency may indicate that the target is thwarted by an excessive hardware IRQ load.





## 5.12 Static Program Entities

This section explains how users can inspect static program entities within Ozone. Static program entities are objects that do not change with the execution point.

### 5.12.1 Functions

Ozone's Functions Window displays the functions defined within the application program (see "Functions Window" on page 80). By double-clicking on a function, the function is displayed within the Source Viewer (see "Source Viewer" on page 58).

### 5.12.2 Source Files

Ozone's Source Files Window displays the source code files that were used to build the application program (see "Source Files Window" on page 87). By double-clicking on a source code file, the file is opened within the Source Viewer (see *Source Viewer* on page 58). The Source Files Window features a context menu entry that allows users to locate missing source files (see "Locating Missing Source Files" on page 123).

## 5.13 Program Output

Ozone supports printf-style debugging of the application program. An application program may send text messages to the debugger by employing one or multiple of the IO techniques described below. Text output from the application program is shown within the Terminal Window (see “Terminal Window” on page 93).

### 5.13.1 Real Time Transfer

SEGGER's *Real Time Transfer* (RTT) is a bi-directional data transmission technique based on a shared MCU memory buffer. Compared to SWO and semihosting, RTT provides a significantly higher data transmission speed. For further information on *Real Time Transfer*, please refer to [www.segger.com](http://www.segger.com).

### 5.13.2 SWO

The Terminal Window can capture and display textual data that is sent by the application program to the debugger via the MCUs Serial Wire Output (SWO) interface. SWO is an unidirectional technology; it cannot be used to send data from the debugger to a debuggee.

#### 5.13.2.1 SWO Configuration

Text-IO via SWO must be configured both within the application program and within Ozone. Within the debugger, it is configured via the user action *Project.SetSwo* (see “Project Actions” on page 149) or via the Terminal Settings Dialog (see “Terminal Settings Dialog” on page 51). Furthermore, the SWO interface must be enabled by checking the Terminal Window's context menu item “Capture SWO IO”. Please refer to the [ARM Information Center](#) for details on how to setup and use printf via SWO in your application program.

### 5.13.3 Semihosting

Ozone is able to communicate with the application program via the Semihosting mechanism. Next to providing bi-directional text I/O via the Terminal Window, the application program can employ Semihosting to perform advanced operations on the Host-PC such as reading from files. For a complete discussion on Semihosting, please refer to the [ARM Information Center](#).

#### 5.13.3.1 Semihosting Configuration

Text-IO via the Semihosting mechanism does not need to be configured within Ozone. However, the application program must apply special assembler code to emit semihosted text messages. Please refer to the [ARM Information Center](#) for details on how to setup and use semihosting within your application program. The semihosting interface can be enabled or disabled via the user action *Project.SetSemihosting* or via the Terminal Window's context menu item “Capture Semihosting IO” (see “Project.SetSemihosting” on page 174).

#### 5.13.3.2 RTT Configuration

Text-IO via SEGGER's *Real Time Transfer* technology does not need to be configured within Ozone. The debugger will automatically sense whether the application program supports RTT. If RTT support is detected, the debugger automatically starts to capture data on the RTT interface. On the application program side, a special global program variable must be provided. Please refer to [www.segger.com](http://www.segger.com) for further information on how to setup and use RTT within your application program.

## 5.14 Other Debugging Activities

This section describes all debugging activities that were not covered by the previous sections.

### 5.14.1 Responding to Input Requests

The application program (debuggee) can request user input via the Semihosting or RTT data IO techniques (see “Program Output” on page 122). This common debugging technique allows users to manipulate the program state at application-defined execution points and to observe the resulting runtime behaviour. Ozone provides the Terminal Prompt for answering user input requests (see “Terminal Prompt” on page 93).

### 5.14.2 Finding Text Occurrences

Ozone’s Find Dialog allows users to search for text patterns within source code documents (see “Find Dialog” on page 52). The Find Dialog supports regular expressions and can be opened via the user action *Edit.Find* or via the Source Viewer’s context menu (see “Edit.Find” on page 157).

### 5.14.3 Inspecting Log Messages

The Console Window displays user- and application-induced log messages (see “Console Window” on page 71). In particular, the Console Window logs all actions executed by the user. Additionally, application errors and messages emitted from script functions are logged.

### 5.14.4 Evaluating Expressions

C-style expressions that perform some kind of computation on program symbols and numbers can be evaluated by adding them to the Watched Data Window (see “Watched Data Window” on page 91) or programatically via user action *Elf.GetExprValue* (see “Elf.GetExprValue” on page 192). Please refer to “Expressions” on page 142 for more information on Ozone expressions.

### 5.14.5 Downloading Program Files

The data contents of a program file can be downloaded to MCU memory without opening the file in the debugger. For this purpose, the user action *Exec.Download* is provided (see “Exec.Download” on page 182). The program file that is currently open in the debugger can be downloaded to MCU memory via the user action *Debug.Download* (see “Debug.Download” on page 169).

### 5.14.6 Locating Missing Source Files

This section discusses the handling of source code files that Ozone could not locate on the file system.

#### 5.14.6.1 Causes for Missing Source Files

When a source code file has been moved from its compile-time location to a different directory on the file system, the debugger is (in most cases) not able to locate the file anymore. Due to performance reasons, Ozone only performs a limited file system search to locate unresolved source code files.

##### **Invalid Root Path**

A second reason why one or multiple source files might be missing is that the debugger was not able to determine the program’s root path correctly. The program’s root path is defined as the common directory prefix that needs to be prepended to relative file paths specified within the program file.

### 5.14.6.2 Missing File Indicators



A missing source file is marked with a yellow warning sign within the Source Files Window. Additionally the Source Viewer will display an informative text instead of file contents when the program's execution point is within a missing source code file. The context menu of missing source files provide an entry that lets users open the Locate File Dialog (see "Source Files Window" on page 87).

### 5.14.6.3 Configuration Options

Ozone provides multiple configuration options that allow users to correct the file paths of missing source code files. Please refer to section "File Path Resolution" on page 131 for more details.

## 5.14.7 Performing Memory IO

Ozone allows users to store MCU memory content to binary data files and vice versa.

### **Memory-To-File**

MCU memory blocks can be saved (dumped) to binary data files via the user action *Target.SaveMemory* (see "Target.SaveMemory" on page 181) or via the Save Memory Dialog (see "Save Memory Data" on page 50).

### **File-To-Memory**

File contents can be downloaded to MCU memory via the user action *Target.LoadMemory* (see "Target.LoadMemory" on page 181) or via the Load Memory Dialog (see "Load Memory Data" on page 50).

## 5.14.8 Stopping the Debug Session

The debug session can be stopped via the user action *Debug.Stop* (see "Debug.Stop" on page 165). The action can be executed from the Debug Menu or by pressing the hotkey Shift-F5.

# Chapter 6

## Scripting Interface

---

This chapter describes Ozone's scripting interface. The scripting interface allows users to reprogram key operations within Ozone.

## 6.1 Script Files

Ozone project files (\*.jdebug) contain user-implemented script functions that the debugger executes upon entry of defined events or debug operations. By implementing script functions, users are able to reprogram key operations within Ozone such as the hardware reset sequence that puts the MCU into its initial state.

### 6.1.1 Scripting Language

Project files are written in a simplified C language that supports most C language constructs such as functions and control structures.

### 6.1.2 Script Functions

Project file script functions belong to three different categories: event handler functions, process replacement functions and user functions. Each script function may contain simplified C code that configures the debugger in some way or replaces a default operation of the debugging work flow. The different function categories are described below.

#### 6.1.2.1 Event Handler Functions

Ozone defines a set of 11 event handler functions that the debugger executes upon the entry of defined debugging events. Table 6.1 lists the event handler functions and their associated events. The event handler function "OnProjectLoad" is obligatory, i.e. it must be present in the project file.

Event Handler Function	Description
void OnProjectLoad();	Executed when the project file is opened.
void BeforeTargetReset();	Executed before the MCU is reset.
void AfterTargetReset();	Executed after the MCU was reset.
void BeforeTargetDownload();	Executed before the program file is downloaded.
void AfterTargetDownload();	Executed after the program file was downloaded.
void BeforeTargetConnect();	Executed before a J-Link connection to the MCU is established.
void AfterTargetConnect();	Executed after a J-Link connection to the MCU was established.
void BeforeTargetDisconnect();	Executed before the debugger disconnects from the MCU.
void AfterTargetDisconnect();	Executed after the debugger disconnected from the MCU.
void AfterTargetHalt();	Executed after the MCU processor was halted.
void BeforeTargetResume();	Executed before the MCU processor is resumed.

**Table 6.1. Event handler functions**

### Example Event Handler Implementation

Illustrated below is an example implementation of the event handler function "After-TargetReset". In this example, a peripheral register at memory address 0x40004002 is initialized after the MCU was reset.

```

/*****
 *
 *      AfterTargetReset
 *
 * Function description
 *      Executed after the MCU was reset.
 *
 *****/
void AfterTargetReset (void) {
    Target.WriteU32(0x40004002, 0xFF);
}

```

Figure 6.2. Event handler function "AfterTargerReset"

## 6.1.2.2 User Functions

Users are free to add custom functions to the project file. These "helper" or user functions are not called by the debugger directly; instead, user functions need to be called from other script functions.

## 6.1.2.3 Process Replacement Functions

Ozone defines 4 script functions that can be implemented within the project file to replace the default implementations of certain debugging operations. The behavior that is expected from process replacement functions is described in section 6.2. Table 6.3 gives an overview:

Process Replacement Function	Description
void DebugStart();	Replaces the default debug session startup routine.
void TargetReset();	Replaces the default MCU hardware reset routine as performed by the J-Link firmware.
void TargetConnect();	Replaces the default MCU connection routine as performed by the J-Link firmware.
void TargetDownload();	Replaces the default program download routine as performed by the J-Link firmware.

Table 6.3. Process replacement functions

## 6.1.3 API Functions

In the context of Ozone's scripting functionality, any user action that has a text command is referred to as an API function (see "Action Tables" on page 145). API functions can be used to trigger debugging operations or to send and receive data to/from the debugger. In short, API functions resemble the debugger's programming interface (or API).

## 6.1.4 Executing Script Files

Ozone does not yet support the processing of arbitrary script files. For now, only one script file is allowed per debug session – which is the project file.

## 6.2 Process Replacement Functions

This section describes how users are expected to implement each of the four process replacement functions defined within Ozone's scripting interface.

### 6.2.1 DebugStart

When the script function "DebugStart" is present in the project file, the default startup sequence of the debug session is replaced with the operation defined by the script function.

#### 6.2.1.1 Startup Sequence

Table 6.4 lists the different phases of Ozone's default debug session startup sequence (see "Phases of the "Download & Reset Program" startup sequence" on page 108). The last column of the table indicates the process replacement function that can be implemented to replace a particular phase of the startup sequence. The complete startup sequence can be replaced by implementing the script function "DebugStart".

Startup Phase	Description	Script Function
Phase 1: Connect	A software connection to the MCU is established via J-Link.	TargetConnect
Phase 2: Breakpoints	Pending (data) breakpoints that were set in offline mode are applied.	
Phase 3: Reset	A hardware reset of the MCU is performed.	TargetReset
Phase 4: Download	The application program is downloaded to MCU memory.	TargetDownload
Phase 5: Finish	The initial program operation is performed (see "Initial Program Operation" on page 109).	

**Table 6.4. Phases of the default startup sequence and associated process replacement functions**

#### **Flow Chart**

Appendix 7.5 provides a graphical flow chart of the startup sequence. Most notably, the flow chart illustrates at what points during the startup sequence certain event handler functions are called (see "Event Handler Functions" on page 126).

#### **Breakpoint Phase**

Phase 2 (Breakpoints) of the default startup sequence is always executed implicitly after the connection to the MCU was established.

#### 6.2.1.2 Writing a Custom Startup Routine

A custom startup routine that performs all phases of the default sequence but the initial program operation is displayed below.

```

/*****
 *
 *      DebugStart
 *
 * Function description
 *      Custom debug session startup routine that skips phase 5
 *
 *****/
void DebugStart (void) {
    Exec.Connect();
    Exec.Reset();
    Exec.Download("c:/examples/keil/stm32f103/blinky.axf");
}

```



## 6.2.2 TargetConnect

When the script function "TargetConnect" is present in the project file, the debugger's default MCU connection behavior is replaced with the operation defined by the script function.

## 6.2.3 TargetDownload

When the script function "TargetDownload" is present in the project file, the debugger's default program download behavior is replaced with the operation defined by the script function.

### 6.2.3.1 Writing a Multi-Image Download Routine

An application that requires the implementation of a custom download routine is when one or multiple additional program images (or data files) need to be downloaded to MCU memory along with the application program. A corresponding implementation of the script function "TargetDownload" is illustrated below.

```

/*****
 *
 *      TargetDownload
 *
 * Function description
 *      Downloads an additional program image to MCU memory
 *
 *****/
void TargetDownload (void) {
    Util.Log("Downloading Program.");

    /* 1. Download the application program */
    Debug.Download();

    /* 2. Download the additional program image */
    Target.LoadMemory("C:\AdditionalProgramData.hex", 0x20000400);
}

```

Figure 6.6. Custom program download routine

## 6.2.4 TargetReset

When the script function "TargetReset" is defined within the project file, the debugger's default MCU hardware reset operation is replaced with the operation defined by the script function.

### 6.2.4.1 J-Link Reset Routine

Ozone's default hardware reset routine is based on the J-Link firmware routine "JLINKARM\_Reset". Please refer to the J-Link user manual for details on this routine and its MCU-dependant behavior.

### 6.2.4.2 Writing a Reset Routine for RAM Debug

A typical example where the J-Link hardware reset routine must be replaced with a custom reset routine is when the application program is downloaded to a memory address other than zero, for example the RAM base address.

#### **Problem**

The J-Link firmware does not know about the application program's location in MCU memory and assumes it is located at address 0 (or at address 0xFFFF0000 when high vectors are enabled). As the application program's reset code (or the initial values of

the PC and SP registers for Cortex-M MCUs) are stored within the first few data bytes of the application program, the J-Link firmware is not able to reset the program correctly when it is not downloaded to memory address 0.

### **Solution**

A custom reset routine for RAM debug typically first executes the default J-Link hardware reset routine. This ensures that tasks such as pulling the MCUs reset pin and halting the processor are performed. Next, a custom reset routine needs to initialize the PC and SP registers so that the MCU is ready to execute the first program instruction.

### **Example**

Figure 6.7 displays the typical implementation of a custom hardware reset routine for RAM debug of an application program. This implementation is included in project files generated by the Project Wizard, though it is out commented by default.

```

/*****
 *
 *      TargetReset
 *
 * Function description
 *      Resets a program downloaded to a Cortex-M MCUs RAM section
 *
 *****/
void TargetReset (void) {
    unsigned int SP;
    unsigned int PC;
    unsigned int ProgramAddr;

    Util.Log("Performing custom hardware reset for RAM debug.");
    ProgramAddr = 0x20000000;
    /* 1. Perform default J-Link firmware reset operation */
    Exec.Reset();

    /* 2. Initialize SP */
    SP = Target.ReadU32(ProgramAddr);
    Target.SetReg("SP", SP);

    /* 3. Initialize PC */
    PC = Target.ReadU32(ProgramAddr + 4);
    Target.SetReg("PC", PC);
}

```

**Figure 6.7. Hardware reset routine for RAM debug on Cortex-M**

## 6.3 File Path Resolution

Ozone features an automatic file path resolution mechanism that is employed whenever a file path argument is encountered that does not point to a valid file on the file system. File path resolution is employed for all file types and is not restricted to source files. The sequence of operations and its configuration options are described below.

Please ensure that all file path resolution settings are made before the program file is opened.

### 6.3.1 File Path Resolution Sequence

#### Step 1 - Directory Macro Expansion

All directory macros contained within the file path are expanded (see "Directory Macros" on page 143). If the expanded file path points to a valid file on the file system, resolution is complete.

#### Step 2 - Alias Name Substitution

If the user has specified an alias for the file path to resolve, the path is replaced with the alias (see "Project.AddFileAlias" on page 174). If the alias points to a valid file on the file system, resolution is complete.

#### Step 3 - Path-Substitution

Any parts of the unresolved file path that match a user-set path substitute are replaced with the substitute (see "Project.AddPathSubstitute" on page 175). If the file path obtained from path substitution points to a valid file on the file system, resolution is complete.

#### Step 4 - Special Directory Lookup

Step 4 of file path resolution is only applied to relative file paths. Unresolved relative file paths are appended successively to each of the special directories listed in "Directory Macros" on page 143. Relative source file paths are additionally appended to the user-specified root directories (see "Project.AddRootPath" on page 175). If any of the so-obtained file paths points to a valid file on the file system, resolution is complete.

#### Step 5 - Search Path Lookup

The file name<sup>1</sup> of unresolved file paths is searched within all user-specified search directories (see "Project.AddSearchPath" on page 175). If any of the search directories contains a file with the sought name, resolution is complete.

### 6.3.2 Operating System Specifics

Please note that file path arguments are case-insensitive on Windows and case sensitive on Linux and Mac OSX. When debugging an application on a system that differs from the build platform, adjustments to the project file's path resolution settings might be required in order for the debugger to be able to locate all files.

---

1. The file name denotes the last part of a file path, i.e. "filename.c" for a file path that reads "/p1/p2/filename.c"



# Chapter 7

## Appendix

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The Appendix contains table and other large objects that did not fit into their respective chapters.

## 7.1 Value Descriptors

This section describes how certain objects such as fonts and source code locations are specified textually to be used as arguments for user actions and script functions.

### 7.1.1 Frequency Descriptor

Frequency parameters need to be specified in any of the following ways:

- 103000
- 103000 Hz
- 103.5 kHz (or 103.5k)
- 0.13 MHz (or 0.13M)
- 1.1 GHz (or 1.1G)

A frequency parameter without a dimension is interpreted as a Hz value. The permitted dimensions to be used with frequency descriptors are Hz, kHz, MHz and GHz. The capitalization of the dimension is irrelevant. The dimensions can also be specified using the letters h, k, M and G. The decimal point can also be specified as a comma.

### 7.1.2 Source Code Location Descriptor

A source code location descriptor defines a character position within a source code document. It has the following format:

"File name: line number: [column number]"

**Figure 7.1. Source Location Descriptor**

Thus, a valid source location descriptor might be "main.c: 100: 1".

#### ***File Name***

The file name of the source file (e.g. "main.c") or its complete file path (e.g. "c:/examples/blinky/source/main.c").

#### ***Line Number***

The line number of the source code location.

#### ***Column Number***

The column number of the source code location. This parameter can be omitted in situations where it suffices to specify a source code line.

### 7.1.3 Color Descriptor

Color parameters are specified in any of the following ways:

- steelblue (SVG color keyword)
- #RRGGBB (hexadecimal triple)

Thus, any SVG color keyword name is a valid color descriptor. In addition, a color can be blended manually by specifying three hexadecimal values for the red, green and blue color components.

## 7.1.4 Font Descriptor

Font parameters must be specified in the following format (please note the comma separation):

"Font Family, Point Size [pt], Font Style"

**Figure 7.2. Font Descriptor**

Thus, a valid font descriptor might be "Arial, 12pt, bold".

### **Font Family**

Ozone supports a wide variety of font families, including common families such as Arial, Times New Roman and Courier New. When using font descriptors, the family name must be capitalized correctly.

### **Point Size**

The point size attribute specifies the point size of the font and must be followed by the measurement unit. Currently, only the measurement unit "pt" is supported.

### **Font Style**

Permitted values for the style attribute are: normal, **bold** and *italic*.

## 7.1.5 Coprocessor Register Descriptor

A coprocessor register descriptor (CPRD) is a string that identifies a coprocessor register of an ARM MCU. A CPRD can be specified in any of the following ways:

- "<CRn> , <CRm> , <Op1> , <Op2>"
- "<CpNum> , <CRn> , <CRm> , <Op1> , <Op2>"
- "CpNum=<CpNum>, CRn=<CRn>, CRm=<CRm>, Op1=<Op1>, Op2=<Op2>"

Values enclosed by "<>" denote numbers. These numbers are the fields of the ARM MRC or MCR instruction that is used to read the coprocessor register. For details, please refer to the ARM architecture reference manual applicable to your MCU.

The first format can be used to specify a CP15 register while the second format can be used to specify any coprocessor register. The third format is just a more concise version of the second format.

## 7.2 System Constants

Ozone defines a set of global integer constants that can be used as parameters for script functions and user actions.

### 7.2.1 Host Interfaces

Table 1 lists permitted values for the host interface parameter (See “Project.SetHostIF” on page 171).

Constant	Description
USB	Use this value when the J-Link debug probe is connected to the host-PC via USB.
IP	Use this value when the J-Link debug probe is connected to the host-PC via Ethernet.

Table 7.3. Host Interfaces

### 7.2.2 Target Interfaces

Table 2 lists permitted values for the target interface parameter (See “Project.SetTargetIF” on page 171).

Constant	Description
JTAG	Use this value when the J-Link debug probe is connected to the MCU via JTAG.
SWD	Use this value when the J-Link debug probe is connected to the MCU via SWD.

Table 7.4. Target Interfaces

### 7.2.3 Boolean Value Constants

Table 4 lists the Boolean value constants defined within Ozone. Please note that the capitalization is irrelevant.

Constant	Description
Yes, True, Active, On, Enabled	The option is set.
No, Off, False, Inactive, Disabled	The option is not set.

Table 7.5. Boolean Values

### 7.2.4 Value Display Formats

Table 4 lists permitted values for the display format parameter (See “Window.SetDisplayFormat” on page 158).

Constant	Description
DISPLAY_FORMAT_AUTO	Displays values in the most appropriate display format.
DISPLAY_FORMAT_BINARY	Displays integer values in binary notation.
DISPLAY_FORMAT_DECIMAL	Displays integer values in decimal notation.
DISPLAY_FORMAT_HEXADECIMAL	Displays integer values in hexadecimal notation.
DISPLAY_FORMAT_CHARACTER	Displays the text representation of the value.

Table 7.6. Display formats



## 7.2.5 Memory Access Widths

Table 5 lists permitted values for the memory access width parameter (See “Target.SetAccessWidth” on page 180).

Constant	Description
AW_AUTO	Automatic access.
AW_BYTE	Byte access.
AW_HALF_WORD	Half word access.
AW_WORD	Word access.

Table 7.7. Memory Access Widths

## 7.2.6 Access Types

Table 6 lists permitted values for the access type parameter (See “Break.SetOnData” on page 187).

Constant	Description
AT_READ_ONLY	Read-only access.
AT_WRITE_ONLY	Write-only access.
AT_READ_WRITE	Read and write access.
AT_NO_ACCESS	Access not permitted.

Table 7.8. Access Types

## 7.2.7 Connection Modes

Table 3 lists permitted values for the connection mode parameter (See “Debug.SetConnectMode” on page 166).

Constant	Description
CM_DOWNLOAD_RESET	The debugger connects to the MCU and resets it. The program is downloaded to MCU memory and program execution is advanced to the main function.
CM_ATTACH	The debugger connects to the MCU and attaches itself to the executing program.
CM_ATTACH_HALT	The debugger connects to the MCU, attaches itself to the executing program and halts program execution.

Table 7.9. Connection Modes

## 7.2.8 Reset Modes

Table 6 lists permitted values for the reset mode parameter (See “Debug.SetResetMode” on page 167).

Constant	Description
RM_RESET_HALT	Resets the MCU and halts the program at the reset vector.
RM_BREAK_AT_SYMBOL	Resets the MCU and advances program execution to the function specified by system variable VAR_BREAK_AT_THIS_SYMBOL.
RM_RESET_AND_RUN	Reset the MCU and starts executing the program.

Table 7.10. Reset Modes

## 7.2.9 Breakpoint Implementation Types

The Table below lists permitted values for the breakpoint implementation type parameter (see “Breakpoint Implementation” on page 115).

Constant	Description
BP_TYPE_ANY	The debugger chooses the implementation type.
BP_TYPE_HARD	The breakpoint is implemented using the MCU's hardware breakpoint unit.
BP_TYPE_SOFT	The breakpoint is implemented by amending the program code with particular instructions.

Table 7.11. Breakpoint Implementation Types

## 7.2.10 Stepping Behaviour Flags

Below is a description of the available binary options (flags) that modify the debugger's stepping behaviour. The flags can be OR-combined see “Debug.SetStepping-Mode” on page 168).

Constant	Description
SF_ALLOW_INVISIBLE_BREAKPOINTS	Allows stepping operations to enhance stepping performance by employing invisible breakpoints.
SF_HALT_AT_CIRCULAR_INSTR_SEQUENCE	Halts the program when a circular instruction sequence is detected during a stepping operation.
SF_STEP_OVER_CIRCULAR_INSTR_SEQUENCE	Allows stepping operations to enhance stepping performance by stepping over circular instruction sequences.

Table 7.12. Stepping Flags

## 7.2.11 Font Identifiers

The following constants identify application fonts within Ozone (see “Edit.Font” on page 156).

Constant	Description
FONT_APP	Default application font.
FONT_APP_MONO	Default monospace application font.
FONT_ITEM_NAME	Symbol name text font.
FONT_ITEM_VALUE	Symbol value text font.
FONT_TABLE_HEADER	Table header text font.
FONT_SRC_CODE	Source code text font.
FONT_ASM_CODE	Assembler code text font.
FONT_CONSOLE	Console Window text font.

Table 7.13. Font Identifiers

## 7.2.12 Color Identifiers

The following constants identify application colors within Ozone (See "Edit.Color" on page 156).

Constant	Description
COLOR_EMPTY_WINDOW_BACKG	Background color of empty debug information windows.
COLOR_HIGHLIGHT_DARK	Dark selection highlight.
COLOR_HIGHLIGHT_LIGHT	Light selection highlight.
COLOR_CHANGE_LEVEL_1_BG	Change Level 1 background color (See "Change Level Highlighting" on page 35).
COLOR_CHANGE_LEVEL_2_BG	Change Level 2 background color (See "Change Level Highlighting" on page 35).
COLOR_CHANGE_LEVEL_3_BG	Change Level 3 background color (See "Change Level Highlighting" on page 35).
COLOR_CHANGE_LEVEL_1_FG	Change Level 1 foreground color (See "Change Level Highlighting" on page 35).
COLOR_CHANGE_LEVEL_2_FG	Change Level 2 foreground color (See "Change Level Highlighting" on page 35).
COLOR_CHANGE_LEVEL_3_FG	Change Level 3 foreground color (See "Change Level Highlighting" on page 35).
COLOR_PC_ACTIVE	PC Line highlight (active window).
COLOR_PC_INACTIVE	PC Line highlight (inactive window).
COLOR_PC_BACKTRACE	Color used for highlighting the PC line when the instruction trace window is focused.
COLOR_CALL_SITE_ACTIVE	Function call site highlight (active window).
COLOR_CALL_SITE_INACTIVE	Function call site highlight (inactive window).
COLOR_SIDEBAR_BACKGROUND	Sidebar background color.
COLOR_TABLE_GRID_LINES	Table grid color.
COLOR_SYNTAX_REGNAME	Syntax color of assembler code register operands.
COLOR_SYNTAX_LABEL	Syntax color of assembler code labels.
COLOR_SYNTAX_MNEMONIC	Syntax color of assembler code mnemonics.
COLOR_SYNTAX_IMMEDIATE	Syntax color of assembler code immediates.
COLOR_SYNTAX_INTEGER	Syntax color of assembler code integer values.
COLOR_SYNTAX_KEYWORD	Syntax color of source code keywords.
COLOR_SYNTAX_DIRECTIVE	Syntax color of source code directives.
COLOR_SYNTAX_STRING	Syntax color of source code strings.
COLOR_SYNTAX_COMMENT	Syntax color of source code comments.
COLOR_SYNTAX_TEXT	Source code text color.
COLOR_LINE_NUMBERS	Color of source code line numbers.
COLOR_LINE_NUMBER_SEPARATOR	Color of the line number separator bar.
COLOR_LOGGING_SCRIPT	Console Window script message color (See "Console Window" on page 71).
COLOR_LOGGING_USER	Console Window command feedback message color (See "Console Window" on page 71).
COLOR_LOGGING_ERROR	Console Window error message color (See "Console Window" on page 71).
COLOR_LOGGING_JLINK	Console Window J-Link message color (See "Console Window" on page 71).

Table 7.14. Color Identifiers

Constant	Description
COLOR_PROGRESS_BAR_PROGRESS	Color used for drawing a progress bar's progress portion.
COLOR_PROGRESS_BAR_REMAINING	Color used for drawing a progress bar's remaining portion.
COLOR_TABLE_ITEM_INACTIVE	Text color of inactive table items.

Table 7.14. Color Identifiers

## 7.2.13 User Preference Identifiers

The following constants identify user preferences within Ozone (see "Edit.Preference" on page 155).

Constant	Description
PREF_SHOW_LINE_NUMBERS	Specifies whether the Source Viewer displays line numbers.
PREF_SHOW_EXPANSION_BAR	Specifies whether the Source Viewer displays source line expansion indicators.
PREF_SHOW_SIDEBAR_SRC	Specifies whether the Source Viewer displays its sidebar.
PREF_SHOW_SIDEBAR_ASM	Specifies whether the Disassembly Window displays its sidebar.
PREF_LOCK_HEADER_BAR	Specifies whether the Source Viewer header bar's auto-hide feature is disabled.
PREF_MIXED_MODE_ASM	Specifies whether the Disassembly Window augments assembler code with source text (see <i>Mixed Mode Disassembly</i> on page 63).
PREF_TERMINAL_NO_CONTROL_CHARS	Specifies whether the Terminal Window outputs non-control ascii characters only.
PREF_TAB_SPACING	Source Viewer Tab-Spacing.
PREF_START_WITH_MOST_RECENT_PROJ	Specifies if the most recent project is opened when the debugger is started.
PREF_PREPEND_FUNC_CLASS_NAMES	Specifies if C++ member functions should be displayed with prepended class names.
PREF_SHOW_CHAR_TEXT	Specifies whether values of (u)char-type symbols are display as "value (character)".
PREF_SHOW_SHORT_TEXT	Specifies whether values of (u)short-type symbols are display as "value (character)".
PREF_SHOW_INT_TEXT	Specifies whether values of (u)int-type symbols are display as "value (character)".
PREF_SHOW_CHAR_PTR_TEXT	Specifies whether values of (u)char*-type symbols are display as "value (text)".
PREF_SHOW_SHORT_PTR_TEXT	Specifies whether values of (u)short*-type symbols are display as "value (text)".
PREF_SHOW_INT_PTR_TEXT	Specifies whether values of (u)int*-type symbols are display as "value (text)".

Table 7.15. User Preference Identifiers

## 7.2.14 System Variable Identifiers

The following constants identify system variables within Ozone (see "Edit.SysVar" on page 155).

Constant	Description
VAR_RESET_MODE	Program reset mode (see <i>Reset Modes</i> on page 137 for permitted values).
VAR_CONNECT_MODE	Connection mode (see <i>Connection Modes</i> on page 137 for permitted values).
VAR_SEMIHOSTING_ENABLED	Specifies whether the Terminal Window captures Semihosting IO (see <i>Inspecting a Running Program</i> on page 118).
VAR_SWO_ENABLED	Specifies whether the Terminal Window captures SWO output (see <i>Inspecting a Running Program</i> on page 118).
VAR_RTT_ENABLED	Specifies whether the Terminal Window captures Real Time Transfer IO (see <i>Inspecting a Running Program</i> on page 118).
VAR_TIF_SPEED	Target interface speed (see <i>Project Wizard</i> on page 23 for details and <i>Frequency Descriptor</i> on page 134 for permitted values).
VAR_TIF_SCAN_CHAIN_POS	Position of the target device on the JTAG scan chain. 0 is closest to TDO.
VAR_TIF_SCAN_CHAIN_LEN	Sum of IR-Lens of devices that are positioned closer to TDO on the JTAG scan chain. IRLen of ARM MCU's is 4.
VAR_SWO_CPU_SPEED	SWO calibration parameter: MCU processor frequency (see <i>Frequency Descriptor</i> on page 134 for permitted values).
VAR_SWO_SPEED	SWO calibration parameter: data transmission frequency (see <i>Frequency Descriptor</i> on page 134 for permitted values).
VAR_ACCESS_WIDTH	Memory access width (see <i>Memory Access Widths</i> on page 137 for permitted values).
VAR_BREAKPOINT_TYPE	Specifies the default breakpoint implementation type to use when setting breakpoints.
VAR_VERIFY_DOWNLOAD	Specifies if a program data should be read-back from MCU memory and compared to original file contents to detect download errors.
VAR_BREAK_AT_THIS_SYMBOL	Specifies the function where program execution should be stopped when reset mode "Reset & Break at Symbol" is used.
VAR_HSS_SPEED	Specifies the sampling frequency of expressions added to the Data Graph Window (see <i>Data Graph Window</i> on page 95). The allowed value range is 1 Hz to 10 kHz. When set to 0, the maximum frequency supported by the hardware is used.
VAR_TRACE_PORT_WIDTH	Configures the trace port width in bits. Permitted values are 1, 2 and 4.

Table 7.16. System Variable Identifiers

## 7.3 Expressions

In Ozone, an expression is a term that combines symbol identifiers or numbers via arithmetic and non-arithmetic operators and that computes to a single value or symbol. Ozone-style expressions are for the most part C-language conformant with certain limitations as described below.

### 7.3.1 Areas of Application

Ozone employs expressions in the following areas:

- As monitorable entities within the Watched Data Window (see “Watched Data Window” on page 91).
- As monitorable entities within the Data Graph Window (see “Data Graph Window” on page 95).
- As specifiers for the data locations of data breakpoints (see “Data Breakpoints” on page 114).
- As specifiers for the trigger conditions of conditional breakpoints (see “Conditional Breakpoints” on page 113).

### 7.3.2 Operands

The following list gives an overview of valid expression operands:

- Global and Local Variables (e.g.: OS\_Global, PixelSizeX)
- Variable Members (e.g.: OS\_Global.pTask->ID, OS\_Global.Time)
- Numbers (e.g.: 0xAE01, 12.4567, 1000)

### 7.3.3 Operators

The following list gives an overview of valid expression operators:

- Number arithmetic (+, -, \*, /, %)
- Bitwise arithmetic (~, &, |, ^)
- Logical comparison (&&, ||)
- Bit-shift (>>, <<)
- Address-of (@)
- size-of (sizeof)
- Number comparison (>, <, >=, <=, ==, !=)
- Pointer-operations (\*, [], ->)
- Integer-operations (++ , --)

The evaluation order of an expression can be controlled by bracketing sub-expressions.

## 7.4 Directory Macros

The following macros can be used as placeholders for certain directory names wherever file path arguments are required:

<code>\$(DocDir)</code>	The document directory. Expands to " <code>\${InstallDir}/doc</code> ".
<code>\$(PluginDir)</code>	The plugin directory. Expands to " <code>\${InstallDir}/plugins/</code> ".
<code>\$(ConfigDir)</code>	The configuration directory. Expands to " <code>\${InstallDir}/config</code> ".
<code>\$(LibraryDir)</code>	The library directory. Expands to " <code>\${InstallDir}/lib</code> ".
<code>\$(ProjectDir)</code>	The project file directory.
<code>\$(InstallDir)</code>	The directory where Ozone was installed to.
<code>\$(AppDir)</code>	The directory of the program file / debuggee.
<code>\$(ExecutableDir)</code>	The directory of Ozone's executable file.
<code>\$(AppBundleDir)</code>	The application bundle directory (Mac OSX).

## 7.5 Startup Sequence Flow Chart

Figure 7.17 illustrates the different phases of the "Debug & Download Program" startup sequence and how it interoperates with script functions (see "Download & Reset Program" on page 108). Please note that phases 2 (Breakpoints) and 5 (Initial Program Operation) of the startup sequence are not displayed in the chart as these phases cannot be reimplemented and do not trigger any event handler functions.

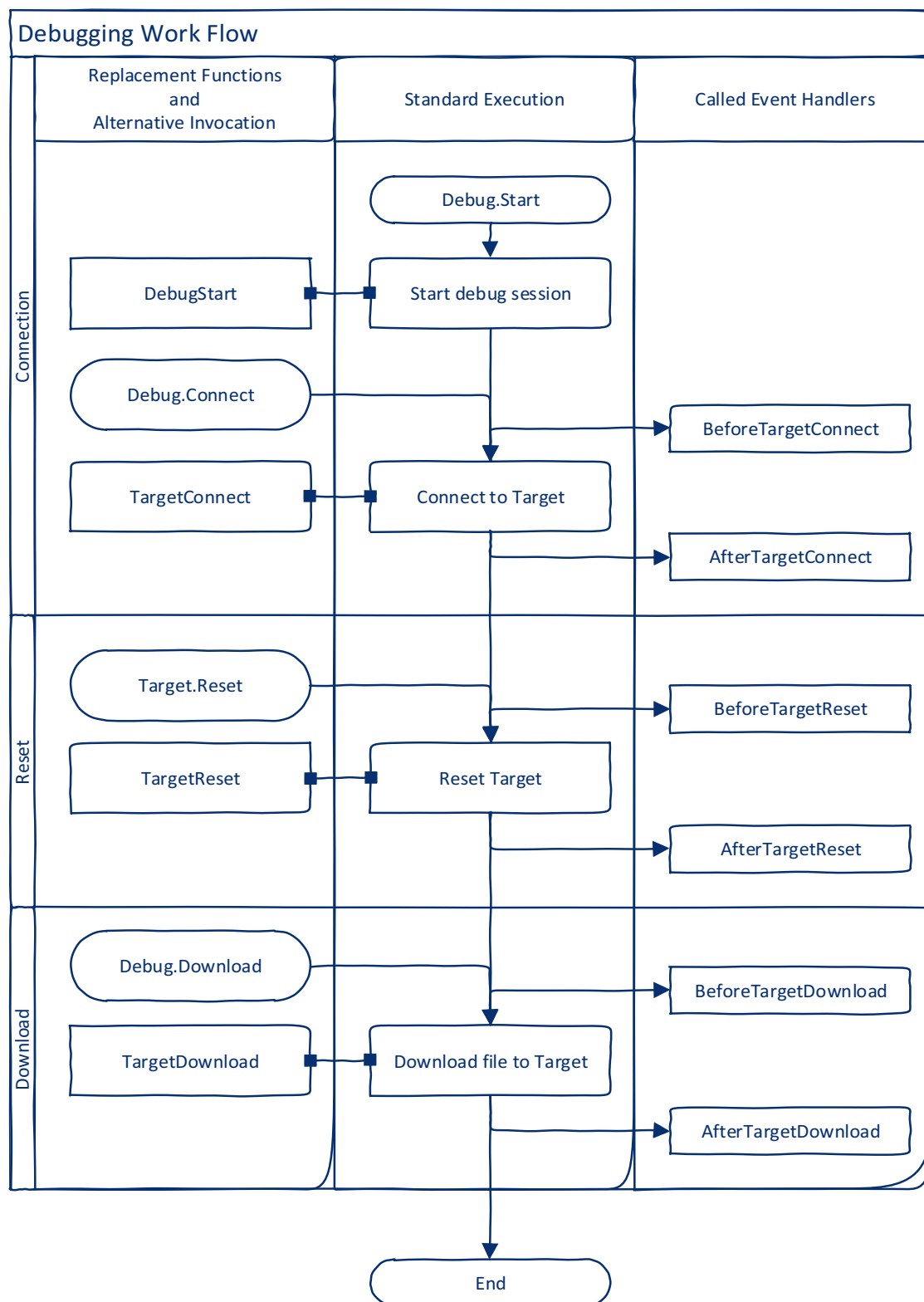


Figure 7.17. Startup Sequence Flow Chart



## 7.6 Action Tables

The following tables provide a quick reference on the user actions provided by Ozone (see “User Actions” on page 28).

### 7.6.1 File Actions

Actions that perform file system and related operations.

Action	Description
<a href="#">File.NewProject</a>	Creates a new project.
<a href="#">File.NewProjectWizard</a>	Opens the Project Wizard.
<a href="#">File.Open</a>	Opens a file.
<a href="#">File.Load</a>	Loads a file.
<a href="#">File.Close</a>	Closes a source code document.
<a href="#">File.CloseAll</a>	Closes all open source code documents.
<a href="#">File.CloseAllButThis</a>	Closes all but the active source code document.
<a href="#">File.Find</a>	Searches for a text pattern.
<a href="#">File.SaveProjectAs</a>	Saves the project file under a new file path.
<a href="#">File.SaveAll</a>	Saves all modified files.
<a href="#">File.Exit</a>	Closes the application.

Table 7.18. File Actions

### 7.6.2 Edit Actions

Actions that edit the behavioral and appearance settings of the debugger.

Action	Description
<a href="#">Edit.JLinkSettings</a>	Opens the J-Link Settings Dialog.
<a href="#">Edit.TerminalSettings</a>	Opens the Terminal Settings Dialog.
<a href="#">Edit.DataGraphSettings</a>	Opens the Data Graph Settings Dialog.
<a href="#">Edit.Preferences</a>	Opens the User Preference Dialog.
<a href="#">Edit.SysVars</a>	Displays the System Variable Editor.
<a href="#">Edit.Preference</a>	Edits a user preference.
<a href="#">Edit.SysVar</a>	Edits a system variable.
<a href="#">Edit.Color</a>	Edits an application color.
<a href="#">Edit.Font</a>	Edits an application font.
<a href="#">Edit.DisplayFormat</a>	Edits an object's value display format.
<a href="#">Edit.RefreshRate</a>	Edits a watched expression's refresh rate.
<a href="#">Edit.Find</a>	Displays the Find Dialog.

Table 7.19. Edit Actions

### 7.6.3 ELF Actions

ELF Program file information actions.

Action	Description
<a href="#">Elf.GetBaseAddr</a>	Returns the program file's download address.
<a href="#">Elf.GetEntryPointPC</a>	Returns the initial value of the program counter.
<a href="#">Elf.GetEntryFuncPC</a>	Returns the first PC of the program's entry function.
<a href="#">Elf.GetExprValue</a>	Evaluates a symbol expression.
<a href="#">Elf.GetEndianness</a>	Returns the program file's byte order.

Table 7.20. ELF Actions

## 7.6.4 Utility Actions

Script function utility actions.

Action	Description
<a href="#">Util.Sleep</a>	Pauses the current operation for a given amount of time.
<a href="#">Util.Log</a>	Prints a message to the console window.

Table 7.21. Utility Actions

## 7.6.5 View Actions

Actions that navigate to particular objects displayed on the graphical user interface.

Action	Description
<a href="#">View.Data</a>	Displays the data location of a program variable.
<a href="#">View.Source</a>	Displays the source code location of an object.
<a href="#">View.Disassembly</a>	Displays the assembler code of an object.
<a href="#">View.CallGraph</a>	Displays the call graph of a function.
<a href="#">View.InstrTrace</a>	Displays a position in the instruction execution history.
<a href="#">View.Memory</a>	Displays a memory location.
<a href="#">View.Line</a>	Displays a text line in the active document.
<a href="#">View.PC</a>	Displays the PC instruction in the Disassembly Window.
<a href="#">View.PCLine</a>	Displays the PC line in the Source Viewer.
<a href="#">View.NextResult</a>	Displays the next search result item.
<a href="#">View.PrevResult</a>	Displays the previous search result item.

Table 7.22. View Actions

## 7.6.6 Toolbar Actions

Actions that modify the state of toolbars.

Action	Description
<a href="#">Toolbar.Show</a>	Displays a toolbar.
<a href="#">Toolbar.Close</a>	Hides a toolbar.

Table 7.23. Toolbar Actions

## 7.6.7 Window Actions

Actions that edit the state of debug information windows.

Action	Description
<a href="#">Window.Show</a>	Shows a window.
<a href="#">Window.Close</a>	Closes a window.
<a href="#">Window.SetDisplayFormat</a>	Sets a window's item display format.
<a href="#">Window.Add</a>	Adds a symbol to a window.
<a href="#">Window.Remove</a>	Removes a symbol from a window.
<a href="#">Window.Clear</a>	Clears a window.
<a href="#">Window.ExpandAll</a>	Expands all items of a window.
<a href="#">Window.CollapseAll</a>	Collapses all items of a window.

Table 7.24. Window Actions

## 7.6.8 Debug Actions

Actions that modify the program execution point and that configure the debugger's connection, reset and stepping behaviour.

Action	Description
<a href="#">Debug.Start</a>	Starts the debug session.
<a href="#">Debug.Stop</a>	Stops the debug session.
<a href="#">Debug.Connect</a>	Establishes a J-Link connection to the MCU.
<a href="#">Debug.Disconnect</a>	Disconnects the J-Link connection to the MCU.
<a href="#">Debug.Download</a>	Downloads the program file to the MCU.
<a href="#">Debug.Continue</a>	Resumes program execution.
<a href="#">Debug.Halt</a>	Halts program execution.
<a href="#">Debug.Reset</a>	Reset the program.
<a href="#">Debug.StepInto</a>	Steps into the current function.
<a href="#">Debug.StepOver</a>	Steps over the current function.
<a href="#">Debug.StepOut</a>	Steps out of the current function.
<a href="#">Debug.SetNextPC</a>	Sets the next machine instruction to be executed.
<a href="#">Debug.SetNextStmnt</a>	Sets the next source statement to be executed.
<a href="#">Debug.RunTo</a>	Advances program execution to a particular location.
<a href="#">Debug.SetResetMode</a>	Sets the reset mode.
<a href="#">Debug.SetConnectMode</a>	Sets the connection mode.
<a href="#">Debug.SetSteppingMode</a>	Sets the stepping mode.

Table 7.25. Debug Actions

## 7.6.9 J-Link Actions

Actions that perform basic J-Link operations.

Action	Description
<a href="#">Exec.Connect</a>	Establishes a J-Link connection to the MCU.
<a href="#">Exec.Reset</a>	Executes a J-Link firmware hardware reset of the MCU.
<a href="#">Exec.Download</a>	Downloads a program or a data file to MCU memory.
<a href="#">Exec.Command</a>	Executes a J-Link command.

Table 7.26. J-Link Actions

## 7.6.10 Help Actions

Actions that display help related information.

Action	Description
<a href="#">Help.About</a>	Shows the About Dialog.
<a href="#">Help.Commands</a>	Prints the command help to the Console Window.
<a href="#">Help.Manual</a>	Displays the user manual.

Table 7.27. Help Actions

## 7.6.11 Target Actions

Actions that perform MCU memory and register IO.

Action	Description
<a href="#">Target.SetReg</a>	Writes a MCU register.
<a href="#">Target.GetReg</a>	Reads a MCU register.
<a href="#">Target.WriteU32</a>	Writes a word to MCU memory.
<a href="#">Target.WriteU16</a>	Writes a half word to MCU memory.
<a href="#">Target.WriteU8</a>	Writes a byte to MCU memory.
<a href="#">Target.ReadU32</a>	Reads a word from MCU memory.
<a href="#">Target.ReadU16</a>	Reads a half word from MCU memory.
<a href="#">Target.ReadU8</a>	Reads a byte from MCU memory.
<a href="#">Target.FillMemory</a>	Fills a block of MCU memory with a particular value.
<a href="#">Target.SaveMemory</a>	Saves a block of MCU memory to a binary data file.
<a href="#">Target.LoadMemory</a>	Downloads the contents of a data file to MCU memory.
<a href="#">Target.SetAccessWidth</a>	Specifies the memory access width.
<a href="#">Target.SetEndianness</a>	Configures the debugger for a particular data endianness.

Table 7.28. Target Actions

## 7.6.12 Breakpoint Actions

Actions that modify the debugger's breakpoint state.

Action	Description
<a href="#">Break.Set</a>	Sets an instruction breakpoint.
<a href="#">Break.SetEx</a>	Sets an instruction breakpoint.
<a href="#">Break.Clear</a>	Clears an instruction breakpoint.
<a href="#">Break.Enable</a>	Enables an instruction breakpoint.
<a href="#">Break.Disable</a>	Disables an instruction breakpoint.
<a href="#">Break.SetOnSrc</a>	Sets a code breakpoint.
<a href="#">Break.SetOnSrcEx</a>	Sets a code breakpoint.
<a href="#">Break.ClearOnSrc</a>	Clears a code breakpoint.
<a href="#">Break.EnableOnSrc</a>	Enables a code breakpoint.
<a href="#">Break.DisableOnSrc</a>	Disables a code breakpoint.
<a href="#">Break.ClearAll</a>	Clears all instruction and code breakpoints.
<a href="#">Break.Edit</a>	Edits a breakpoints advanced properties.
<a href="#">Break.SetType</a>	Sets a breakpoint's implementation type.
<a href="#">Break.SetOnData</a>	Sets a data breakpoint.
<a href="#">Break.ClearOnData</a>	Clears a data breakpoint.
<a href="#">Break.EnableOnData</a>	Enables a data breakpoint.
<a href="#">Break.DisableOnData</a>	Disables a data breakpoint.
<a href="#">Break.EditOnData</a>	Edits a data breakpoint.
<a href="#">Break.SetOnSymbol</a>	Sets a data breakpoint on a symbol.
<a href="#">Break.ClearOnSymbol</a>	Clears a data breakpoint on a symbol.
<a href="#">Break.EnableOnSymbol</a>	Enables a data breakpoint on a symbol.
<a href="#">Break.DisableOnSymbol</a>	Disables a data breakpoint on a symbol.
<a href="#">Break.EditOnSymbol</a>	Edits a data breakpoint on a symbol.
<a href="#">Break.ClearAllOnData</a>	Clears all data breakpoints.

Table 7.29. Breakpoint Actions

## 7.6.13 Project Actions

Actions that configure the debugger for a particular software and hardware environment.

Action	Description
<a href="#">Project.SetDevice</a>	Specifies the MCUs model name.
<a href="#">Project.AddSvdFile</a>	Adds a register set description file.
<a href="#">Project.SetHostIF</a>	Specifies the host interface.
<a href="#">Project.SetTargetIF</a>	Specifies the target interface.
<a href="#">Project.SetTIFSpeed</a>	Specifies the target interface speed.
<a href="#">Project.SetTIFScanChain</a>	Specified the JTAG scan chain parameters.
<a href="#">Project.SetSWO</a>	Configures the Serial Wire Output (SWO) interface.
<a href="#">Project.SetSemihosting</a>	Configures the Semihosting IO interface.
<a href="#">Project.SetRTT</a>	Configures the Real Time Transfer IO interface.
<a href="#">Project.AddFileAlias</a>	Sets a file path alias.
<a href="#">Project.AddPathSubstitute</a>	Replaces substrings within source file paths.
<a href="#">Project.AddRootPath</a>	Specifies the program's root path.
<a href="#">Project.AddSearchPath</a>	Adds a path to the program's list of search paths.
<a href="#">Project.SetOSPlugin</a>	Specifies the RTOS-awareness plugin to be used.
<a href="#">Project.SetBPType</a>	Sets a breakpoint's implementation type.
<a href="#">Project.SetJLinkScript</a>	Sets the J-Link-Script to be executed on debug start.
<a href="#">Project.SetJLinkLogFile</a>	Sets the text file that receives J-Link logging output.

Table 7.30. Project Actions

## 7.6.14 Code Profile Actions

Code profile related actions.

Action	Description
<a href="#">Profile.Exclude</a>	Filters functions from the code profile statistic.
<a href="#">Profile.Include</a>	Re-adds functions to the code profile statistic.

Table 7.31. Code Profile Actions

## 7.7 User Actions

### 7.7.1 File Actions

#### 7.7.1.1 File.NewProject

Creates a new project (see “File Menu” on page 31)

##### Prototype

```
int File.NewProject();
```

##### Return Value

```
-1: error
0: success
```

##### GUI Access

Main Menu  File  New  New Project (Ctrl+N)

#### 7.7.1.2 File.NewProjectWizard

Opens the Project Wizard (see “Project Wizard” on page 23).

##### Prototype

```
int File.NewProjectWizard();
```

##### Return Value

```
-1: error
0: success
```

##### GUI Access

Main Menu  File  New  New Project Wizard (Ctrl+Alt+N)

#### 7.7.1.3 File.Open

Opens a file (see “File Menu” on page 31).

##### Prototype

```
int File.Open(const char* FileName);
```

Argument	Meaning
FileName	A project-, source- or program- file path. It is possible to specify the file path relative to any of the directories listed in section “Directory Macros” on page 143.

##### Return Value

```
-1: error
0: success
```

##### GUI Access

Main Menu  File  Open (Ctrl+O)

### 7.7.1.4 File.Find

Searches a text pattern in source code documents (see “Find Dialog” on page 52).

#### Prototype

```
int File.Find(const char* FindWhat);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Source Viewer  Context Menu  Find (**Ctrl+F**)

### 7.7.1.5 File.Load

Loads a data file. This essentially performs the same operation as *File.Open*, but does not reset the MCU prior to downloading the data contents and does not perform the initial program operation after the data contents where downloaded.

#### Prototype

```
int File.Load(const char* FileName, U32 Address);
```

Argument	Meaning
FileName	Path to a program or data file. It is possible to specify the file path relative to any of the directories listed in section “Directory Macros” on page 143.
Address	Memory address to download the data contents to. In case the address is provided by the file itself, an empty string can be specified.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

### 7.7.1.6 File.Close

Closes a document (see “Source Viewer” on page 58).

#### Prototype



```
int File.Close(const char* FileName);
```

Argument	Meaning
FileName	Fully qualified Path or name of a source file.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Document Tab  Context Menu  Close (**Ctrl+X**)

### 7.7.1.7 File.CloseAll

Closes all open documents (*File Menu* on page 31).

#### Prototype

```
int File.CloseAll();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Hotkey (**Ctrl+Shift+W**)

### 7.7.1.8 File.CloseAllButThis

Closes all but the active document (see “Source Viewer” on page 58).



#### Prototype

```
int File.CloseAllButThis();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Document Tab  Context Menu  Close All But This (**Ctrl+Shift+X**)

### 7.7.1.9 File.SaveProjectAs

Saves the project file under a new file path.

#### Prototype

```
int File.SaveProjectAs(const char* FileName);
```

Argument	Meaning
FileName	Fully qualified file path that points to a .jdebug file

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  File  Save Project as (**Ctrl+Shift+S**)

### 7.7.1.10 File.SaveAll

Saves all modified files.

#### Prototype

```
int File.SaveAll();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  File  Save all



### 7.7.1.11 File.Exit

Closes the application (see “File Menu” on page 31).


#### Prototype

```
int File.Exit();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Main Menu  File  Exit (**Alt+F4**)

## 7.7.2 Edit Actions

### 7.7.2.1 Edit.JLinkSettings

Opens the J-Link Settings Dialog (see “J-Link Settings Dialog” on page 49).


#### Prototype

```
int Edit.JLinkSettings();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Main Menu  Edit  J-Link Settings (**Ctrl+Alt+J**)

### 7.7.2.2 Edit.TerminalSettings

Opens the Terminal Settings Dialog (see “Terminal Settings Dialog” on page 51).

#### Prototype

```
int Edit.TerminalSettings();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Terminal Window  Context Menu  Configure (**Ctrl+Alt+T**)

### 7.7.2.3 Edit.DataGraphSettings

Opens the Data Graph Settings Dialog (see “Data Graph Settings Dialog” on page 56).

#### Prototype

```
int Edit.DataGraphSettings();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Data Graph Window  Context Menu  Configure (**Ctrl+Alt+C**)

### 7.7.2.4 Edit.Preferences

Displays the User Preference Dialog (see “User Preference Dialog” on page 43).

#### Prototype

```
int Edit.Preferences();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Main Menu  Edit  Preferences (**Ctrl+Alt+P**)

### 7.7.2.5 Edit.SysVars

Displays the System Variable Editor (see “System Variable Editor” on page 46).


#### Prototype

```
int Edit.SysVars();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  System Variables (**Ctrl+Alt+V**)

### 7.7.2.6 Edit.Preference

Edits a user preference.

#### Prototype

```
int Edit.Preference(int ID, int Value);
```

Argument	Meaning
ID	User preference identifier (See “User Preference Identifiers” on page 140).
Value	User preference value. Certain user preferences are specified in a pre-defined format (See “Value Descriptors” on page 134).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  Preferences  General

### 7.7.2.7 Edit.SysVar

Edits a system variable (see “System Variable Identifiers” on page 141).

#### Prototype

```
int Edit.SysVar(int ID, int Value);
```

Argument	Meaning
ID	System variable identifier (See “System Variable Identifiers” on page 141).
Value	System variable value. Certain system variables are specified in a pre-defined format. Please refer to (See “Value Descriptors” on page 134).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  System Variables

### 7.7.2.8 Edit.Color

Edits an application color (see “Color Identifiers” on page 139).

#### Prototype

```
int Edit.Color(int ID, int Value);
```

Argument	Meaning
ID	Color identifier (See “Color Identifiers” on page 139).
Value	Color descriptor (See “Color Descriptor” on page 134).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  Preferences  Appearance

### 7.7.2.9 Edit.Font

Edits an application font (see “Font Identifiers” on page 138).

#### Prototype

```
int Edit.Font(int ID, const char* Font);
```

Argument	Meaning
ID	Font identifier (See “Font Identifiers” on page 138).
Font	Font descriptor (See “Font Descriptor” on page 135).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  Preferences  Appearance

### 7.7.2.10 Edit.DisplayFormat

Edits an object’s value display format.

#### Prototype

```
int Edit.DisplayFormat(const char* sObject, int Format);
```

Argument	Meaning
sObject	Name of a debug information window, program variable or register.
Format	Value display format (See “Value Display Formats” on page 136).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Window  Context Menu  Display As

### 7.7.2.11 Edit.RefreshRate

Sets the refresh rate of a watched expression (see “Live Watches” on page 91).

#### Prototype

```
int Edit.RefreshRate (const char* sExpression, int Frequency);
```

Argument	Meaning
sExpression	C-Language expression (see “Expressions” on page 91).
Frequency	Rate in Hz at which the given expression is updated when the program is running (see “Frequency Descriptor” on page 134).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Watched Data Window  Context Menu  Refresh Rate

### 7.7.2.12 Edit.Find

Searches a text pattern in the active document (see “Source Viewer” on page 58).

#### Prototype

```
int Edit.Find(const char* FindWhat);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Source Viewer  Context Menu  Find (**Ctrl+F**)

## 7.7.3 Window Actions

### 7.7.3.1 Window.Show

Shows a window (see “Window Layout” on page 35).

#### Prototype

```
int Window.Show(const char* WindowName);
```

Argument	Meaning
WindowName	Name of the window (e.g. “Source Files”). See “View Menu” on page 32.

#### Return Value

-1: error  
0: success

#### GUI Access

Main Menu  View  Window Name (**Shift+Alt+Letter**)

### 7.7.3.2 Window.Close

Closes a window (See “Window Layout” on page 35).

#### Prototype

```
int Window.Close(const char* WindowName);
```

Argument	Meaning
WindowName	Name of the window (e.g. “Source Files”). See “View Menu” on page 32.

#### Return Value

-1: error  
0: success

#### GUI Access

Close handle on window title bar (**Alt+X**)

### 7.7.3.3 Window.SetDisplayFormat

Set's a window's value display format (see “Display Format” on page 35).

#### Prototype

```
int Window.SetDisplayFormat(const char* WindowName, int Format);
```

Argument	Meaning
WindowName	Name of the window (e.g. “Source Files”). See “View Menu” on page 32.
Format	Value display format (See “Value Display Formats” on page 136).

#### Return Value

-1: error  
0: success

#### GUI Access

Window  Context Menu  Display All As (**Alt+Number**)

### 7.7.3.4 Window.Add

Adds a variable to a window (see “Watched Data Window” on page 91).

#### Prototype

```
int Window.Add(const char* WindowName, const char* VariableName);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Window  Context Menu  Add (**Alt+Plus**)

### 7.7.3.5 Window.Remove

Removes a variable from a window (see “Watched Data Window” on page 91).

#### Prototype

```
int Window.Remove(const char* WindowName, const char* VariableName);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Window  Context Menu  Remove (**Del**)

### 7.7.3.6 Window.Clear

Clears a window.

#### Prototype

```
int Edit.TerminalSettings();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Window  Context Menu  Clear (**Alt+Del**)

### 7.7.3.7 Window.ExpandAll

Expands all expandable window items.

#### Prototype

```
int Window.ExpandAll();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Window  Context Menu  Expand All (**Shift+Plus**)

### 7.7.3.8 Window.CollapseAll

Collapses all collapsible window items.



#### Prototype

```
int Window.CollapseAll();
```

#### Return Value

-1: error  
0: success

#### GUI Access

Window  Context Menu  Clear (**Shift+Minus**)

## 7.7.4 Toolbar Actions

### 7.7.4.1 Toolbar.Show

Displays a toolbar (see “Showing and Hiding Toolbars” on page 33).

#### Prototype

```
int Toolbar.Show(const char* ToolbarName);
```

#### Return Value

-1: error  
0: success

#### GUI Access

Main Menu  View  Toolbars  Toolbar Name

### 7.7.4.2 Toolbar.Close

Hides a toolbar (see “Showing and Hiding Toolbars” on page 33).

#### Prototype

```
int Toolbar.Show(const char* ToolbarName);
```

#### Return Value

-1: error  
0: success

#### GUI Access

Main Menu  View  Toolbars  Toolbar Name



## 7.7.5 View Actions

### 7.7.5.1 View.Memory

Displays a memory location within the Memory Window (see “Memory Window” on page 82).



#### Prototype

```
int View.Memory(unsigned int Address);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Memory Window  Context Menu  Goto Address (A)

### 7.7.5.2 View.Source

Displays the source code location of a variable, function or machine instruction within the Source Viewer (see “Source Viewer” on page 58).

#### Prototype


```
int View.Source(const char* GenValStr);
```

Argument	Type	Meaning
GenValStr	Variable Name	Displays a variable's source code declaration.
	Function Name	Displays the first source line of a function.
	Memory Address	Displays the source line affiliated with an instruction.
	Source Location	Displays a particular source location (See “Source Code Location Descriptor” on page 134).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Symbol Windows  Context Menu  View Source (Ctrl+U)

### 7.7.5.3 View.Data

Displays the data location of a global or local program variable within the Register Window (see “Register Window” on page 85) or the Memory Window (see “Memory Window” on page 82).

#### Prototype

```
int View.Data(const char* VariableName);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Symbol Windows  Context Menu  View Data (Ctrl+T)

### 7.7.5.4 View.Disassembly

Displays the assembler code of a function or source code statement within the Disassembly Window (see “Disassembly Window” on page 62).

#### Prototype



```
int View.Disassembly(const char* GenValStr);
```

Argument	Type	Meaning
GenValStr	Function Name	Displays the assembler code of a function.
	Source Location	Displays the assembler code of a source code line (See “Source Code Location Descriptor” on page 134).
	Memory Address	Displays the assembler code of a machine instruction.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Symbol Windows  Context Menu  View Disassembly (**Ctrl+D**)

### 7.7.5.5 View.CallGraph

Displays the call graph of a function.

#### Prototype

```
int View.CallGraph (const char* sFuncName);
```

Argument	Meaning
sFuncName	Function name.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

 Source Viewer  Context Menu  View Call Graph (**Ctrl+H**)

### 7.7.5.6 View.InstrTrace

Displays a position in the history (stack) of executed machine instructions.

#### Prototype


```
int View.InstrTrace (int StackPos);
```

Argument	Meaning
StackPos	Position 1 = most recently executed machine instruction

#### Return Value

```
-1: error
0: success
```

#### GUI Access

 Context Menu  Goto Position

### 7.7.5.7 View.Line

Displays a text line in the active document.

#### Prototype

```
int View.Line(unsigned int Line);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Source Viewer  Context Menu  Goto Line (**Ctrl+L**)

### 7.7.5.8 View.PC

Displays the program's execution point within the Disassembly Window (see "Disassembly Window" on page 62).

#### Prototype

```
int View.PC();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Disassembly Window  Context Menu  Goto PC (**Ctrl+P**)

### 7.7.5.9 View.PCLine

Displays the program's execution point within the Source Viewer (see "Source Viewer" on page 58).

#### Prototype

```
int View.PCLine();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Source Viewer  Context Menu  Goto PC (**Shift+P**)

### 7.7.5.10 View.NextResult

Displays the next search result.

#### Prototype

```
int View.NextResult();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None.

### 7.7.5.11 View.PrevResult

Displays the previous search result.

**Prototype**

```
int View.PrevResult();
```

**Return Value**

```
-1: error  
0: success
```

**GUI Access**

None.

## 7.7.6 Utility Actions

### 7.7.6.1 Util.Sleep

Pauses the current operation for a given amount of time.

**Prototype**

```
int Util.Sleep(int milliseconds);
```

**Return Value**

```
-1: error  
0: success
```

**GUI Access**

None

### 7.7.6.2 Util.Log

Prints a message to the Console Window (see “Console Window” on page 71)

**Prototype**

```
int Util.Log(const char* Message);
```

**Return Value**

```
-1: error  
0: success
```

**GUI Access**

None

## 7.7.7 Debug Actions

### 7.7.7.1 Debug.Start

Starts the debug session (see “Starting the Debug Session” on page 108). The startup routine can be reprogrammed (see “TargetConnect” on page 129).

#### Prototype

```
int Debug.Start();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Debug  Start Debugging (**F5**)

### 7.7.7.2 Debug.Stop

Stops the debug session (see “Stopping the Debug Session” on page 124).

#### Prototype

```
int Debug.Stop();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Debug  Stop Debugging (**Shift+F5**)

### 7.7.7.3 Debug.Disconnect

Disconnects the debugger from the MCU.

#### Prototype

```
int Debug.Disconnect();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

### 7.7.7.4 Debug.Connect

Establishes a J-Link connection to the MCU and starts the debug session in the default way. A reprogramming of the startup procedure via script function “TargetConnect” is ignored.

#### Prototype

```
int Debug.Connect();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

### 7.7.7.5 Debug.SetConnectMode

Sets the connection mode (see “Connection Mode” on page 108).

#### Prototype



```
int Debug.SetConnectMode(int Mode);
```

Argument	Meaning
Mode	Connection mode (See “Connection Modes” on page 137).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  System Variables (**Ctrl+Alt+V**)

### 7.7.7.6 Debug.Continue

Resumes program execution (see “Resume” on page 112).


#### Prototype

```
int Debug.Continue();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Debug  Continue (**F5**)

### 7.7.7.7 Debug.Halt

Halts program execution (see “Halt” on page 112).

#### Prototype

```
int Debug.Halt();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Debug  Halt (**F6**)

### 7.7.7.8 Debug.Reset

Resets the MCU and the application program (see “Reset” on page 111). The reset operation can be customized via the scripting interface (see “TargetReset” on page 129).

#### Prototype

```
int Debug.Reset();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Debug  Reset (**F4**)

### 7.7.7.9 Debug.SetResetMode

Sets the reset mode. The reset mode determines how the program is reset (see “Reset Mode” on page 111).

#### Prototype

```
int Debug.SetResetMode(int Mode);
```

Argument	Meaning
Mode	Reset mode (See “Reset Modes” on page 137).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  System Variables (**Ctrl+Alt+V**)

### 7.7.7.10 Debug.StepInto

Steps into the current subroutine (see “Step” on page 111).



#### Prototype

```
int Debug.StepInto();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Debug  Step Into (**F11**)

### 7.7.7.11 Debug.StepOver

Steps over the current subroutine (see “Step” on page 111).



#### Prototype

```
int Debug.StepOver();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Debug  Step Over (**F12**)

### 7.7.7.12 Debug.StepOut

Steps out of the current subroutine. (see “Step” on page 111).

#### Prototype

```
int Debug.StepOut();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Debug  StepOut (**Shift+F11**)

### 7.7.7.13 Debug.SetSteppingMode

Sets the program stepping behaviour (see “Stepping Behaviour Flags” on page 138).

#### Prototype

```
int Debug.SetSteppingMode(int Mode);
```

Argument	Meaning
Mode	Combination of stepping options (See “Stepping Behaviour Flags” on page 138)

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

### 7.7.7.14 Debug.SetNextPC

Sets the execution point to a particular machine instruction (see “Setting the Execution Point” on page 110).

#### Prototype

```
int Debug.SetNextPC(unsigned int Address);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Disassembly Window  Context Menu  Set Next PC

### 7.7.7.15 Debug.SetNextStmnt

Sets the execution point to a particular source code line (see “Setting the Execution Point” on page 110).

#### Prototype

```
int Debug.SetNextStmnt(const char* Statement);
```

Argument	Type	Meaning
Statement	Function Name	Sets the execution point to the first source code line of a function.
	Source Location	Sets the execution point a particular source code line (See “Source Code Location Descriptor” on page 134).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Source Viewer  Context Menu  Set Next Statement



### 7.7.7.16 Debug.RunTo

Advances the program execution point to a particular source code line, function or instruction address (see “Setting the Execution Point” on page 110).

#### Prototype


```
int Debug.RunTo(const char* sLocation);
```

Argument	Type	Meaning
sLocation	Function Name	Advances program execution to the first source code line of a function.
	Source Location	Advances program execution to a particular source code line (See “Source Code Location Descriptor” on page 134).
	Address	Advances program execution to a particular instruction address.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Code Window  Context Menu  Run To Cursor

### 7.7.7.17 Debug.Download

Downloads the application program to the MCU (see “Program Files” on page 107). The download operation can be reprogrammed (see “TargetDownload” on page 129).

#### Prototype

```
int Debug.Download();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

## 7.7.8 Help Actions

### 7.7.8.1 Help.About

Shows the About Dialog.



#### Prototype

```
int Help.About();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Main Menu  Help  About

### 7.7.8.2 Help.Commands

Prints the command help to the Console Window (see “Command Help” on page 72)

#### Prototype

```
int Help.Commands();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Console Window  Context Menu  Help (F2)

### 7.7.8.3 Help.Manual

Opens Ozone’s user manual within the default PDF viewer.

#### Prototype

```
int Help.Manual();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Main Menu  Help  User Manual (F1)

## 7.7.9 Project Actions

### 7.7.9.1 Project.SetDevice

Specifies the model name of the MCU (see “J-Link Settings Dialog” on page 49).

#### Prototype

```
int Project.SetDevice(const char* DeviceName);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  J-Link Settings (**Ctrl+Alt+J**)

### 7.7.9.2 Project.SetHostIF

Specifies the host interface (see “Host Interfaces” on page 136).

#### Prototype

```
int Project.SetHostIF(const char* HostIF, const char* HostID);
```

Argument	Meaning
HostIF	Host interface (See “Host Interfaces” on page 136).
HostID	Host identifier (USB serial number or IP address).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  J-Link Settings (**Ctrl+Alt+J**)

### 7.7.9.3 Project.SetTargetIF

Specifies the target interface (see “Target Interfaces” on page 136).

#### Prototype

```
int Project.SetTargetIF(const char* TargetIF);
```

Argument	Meaning
TargetIF	Target interface (See “Target Interfaces” on page 136).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  J-Link Settings (**Ctrl+Alt+J**)

### 7.7.9.4 Project.SetTIFSpeed

Specifies the target interface speed (see “J-Link Settings Dialog” on page 49).

#### Prototype

```
int Project.SetTIFSpeed(const char* Frequency);
```

Argument	Meaning
Frequency	Frequency descriptor (See “Frequency Descriptor” on page 134).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  J-Link Settings (**Ctrl+Alt+J**)

### 7.7.9.5 Project.SetTIFScanChain

Configures the target interface JTAG scan chain parameters.

#### Prototype

```
int Project.SetTIFScanChain(int DRPre, int IRPre);
```

Argument	Meaning
DRPre	Position of the MCU in the JTAG scan chain. 0 is closest to TDO.
IRLen	Sums of IR-Lens of MCUs closer to TDO. IRLen of ARM devices is 4.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  J-Link Settings (**Ctrl+Alt+J**)

### 7.7.9.6 Project.SetBPType

Specifies the default breakpoint implementation type.

#### Prototype

```
int Project.SetBPType(int Type);
```

Argument	Meaning
type	Breakpoint implementation type (see “Breakpoint Implementation Types” on page 138)

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Code Window  Context Menu  Edit Breakpoint (**F8**)

### 7.7.9.7 Project.SetOSPlugin

Specifies the file path or name of the plugin that adds RTOS-awareness to the debugger.

#### Prototype

```
int Project.SetOSPlugin(const char* FilePathOrName);
```

Argument	Meaning
FilePathOrName	File path or name of the plugin that adds RTOS-awareness to Ozone. Use argument "embosPlugin" to configure embOS-Awareness and "freeRTOSPlugin" to configure FreeRTOS-awareness.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

### 7.7.9.8 Project.SetRTT

Configures the Real Time Transfer (RTT) IO interface (see "Real Time Transfer" on page 122).

#### Prototype

```
int Project.SetRTT(int OnOff);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  System Variables (**Ctrl+Alt+V**)

### 7.7.9.9 Project.SetSWO

Configures the Serial Wire Output (SWO) IO interface (see "SWO" on page 122).

#### Prototype

```
int Project.SetSWO(int OnOff, const char* SWOFreq, char* CPUFreq);
```

Argument	Meaning
OnOff	Specifies weather the SWO interface is enabled or disabled.
SWOFreq	Specifies the data transmission speed on the SWO interface (See "Frequency Descriptor" on page 134).
CPUFreq	Specifies the MCUs processor frequency (See "Frequency Descriptor" on page 134).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  System Variables (**Ctrl+Alt+V**)

### 7.7.9.10 Project.SetSemihosting

Configures the Semihosting IO interface (see “Semihosting” on page 122).



#### Prototype

```
int Project.SetSemihosting(int OnOff);
```

#### Return Value

-1: error  
0: success

#### GUI Access

Main Menu  Edit  System Variables (**Ctrl+Alt+V**)

### 7.7.9.11 Project.AddSvdFile

Adds a register set description file to be loaded by the Registers Window (see “SVD Files” on page 85).

#### Prototype

```
int Project.AddSvdFile(const char* FileName);
```

Argument	Meaning
FileName	Path to a CMSIS-SVD file. Both .svd and .xml file extensions are supported. It is possible to specify the file path relative to any of the directories listed in section “Directory Macros” on page 143.

#### Return Value

-1: error  
0: success

#### GUI Access

None

### 7.7.9.12 Project.AddFileAlias

Adds a file path alias (see “File Path Resolution Sequence” on page 131).

#### Prototype



```
int Project.AddFileAlias(const char* FilePath, const char* AliasPath);
```

Argument	Meaning
FilePath	Original file path as it appears within the program file or elsewhere.
AliasPath	Replacement for the original file path.

#### Return Value

-1: error  
0: success

#### GUI Access

Source Files Window  Context Menu  Locate File (**Space**)

### 7.7.9.13 Project.AddRootPath

Adds a root path to the debugger's file path resolution settings (see "File Path Resolution" on page 131).

#### Prototype

```
int Project.SetRootPath(const char* RootPath);
```

Argument	Meaning
RootPath	Fully qualified path of a file system directory.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

### 7.7.9.14 Project.AddPathSubstitute

Replaces a substring within unresolved file path arguments (see "File Path Resolution" on page 131).

#### Prototype

```
int Project.AddPathSubstitute(const char* SubStr, const char* Alias);
```

Argument	Meaning
SubStr	Substring (directory name) within original file paths.
AliasPath	Replacement for the given substring.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

### 7.7.9.15 Project.AddSearchPath

Adds a directory to the list of search directories. Search directories help the debugger resolve invalid file path arguments (see "File Path Resolution" on page 131).

#### Prototype

```
int Project.AddSearchPath(const char* SearchPath);
```

Argument	Meaning
SearchPath	Fully qualified path of a file system directory.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

### 7.7.9.16 Project.SetJLinkScript

Specifies the J-Link script file that is to be executed at the moment the debug session is started.

#### Prototype

```
int Project.SetJLinkScript(const char* FileName);
```

Argument	Meaning
FileName	Path to a J-Link script file. It is possible to specify the file path relative to any of the directories listed in section "Directory Macros" on page 143. Please refer to the J-Link user manual for further information on J-Link script files.

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

None

### 7.7.9.17 Project.SetJLinkLogFile

Specifies the text file that receives J-Link logging output.

#### Prototype

```
int Project.SetJLinkLogFile(const char* FileName);
```

Argument	Meaning
FileName	Path to a text file. It is possible to specify the file path relative to any of the directories listed in section "Directory Macros" on page 143.

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

None



## 7.7.10 Code Profile Actions

### 7.7.10.1 Profile.Exclude

Filters functions from the code profile statistic. The code profile statistic is re-evaluated as if the filtered functions had never belonged to the program.

#### Prototype

```
int Profile.Exclude (const char* sFilter);
```

Argument	Meaning
FilterStr	Specifies the functions to be filtered. All functions that exactly match the filter string are moved to the filtered set. Wildcard (*) characters can be placed at the front or end of the filter string to perform partial match filtering.

#### Return Value

-1: error  
0: success

#### GUI Access

Code Profile Window  Context Menu  Exclude...

### 7.7.10.2 Profile.Include

Re-adds filtered functions to the code profile statistic.

#### Prototype

```
int Profile.Include (const char* sFilter);
```

Argument	Meaning
FilterStr	Specifies the functions to be unfiltered. All functions that exactly match the filter string are removed from the filtered set. Wildcard (*) characters can be placed at the front or end of the filter string to perform partial match unfiltering.

#### Return Value

-1: error  
0: success

#### GUI Access

Code Profile Window  Context Menu  Include...

## 7.7.11 Target Actions

### 7.7.11.1 Target.SetReg

Writes an MCU register (see “MCU Registers” on page 117).

#### Prototype

```
int Target.SetReg(const char* RegName, unsigned int Value);
```

Argument	Meaning
RegName	Name of a core, FPU or coprocessor register (see “Coprocessor Register Descriptor” on page 135).
Value	Register Value to write

#### Return Value

-1: error  
0: success

#### GUI Access

None

### 7.7.11.2 Target.GetReg

Reads an MCU register (see “MCU Registers” on page 117).

#### Prototype

```
U32 Target.GetReg(const char* RegName);
```

Argument	Meaning
RegName	Name of a core, FPU or coprocessor register (see “Coprocessor Register Descriptor” on page 135).

#### Return Value

-1: error  
register value: success

#### GUI Access

None

### 7.7.11.3 Target.WriteU32

Writes a word to MCU memory (see “MCU Memory” on page 117).

#### Prototype

```
int Target.WriteU32(U32 Address, U32 Value);
```

#### Return Value

-1: error  
0: success

#### GUI Access

None

#### 7.7.11.4 Target.WriteU16

Writes a half word to MCU memory (see “MCU Memory” on page 117).

##### Prototype

```
int Target.WriteU16(U32 Address, U16 Value);
```

##### Return Value

```
-1: error
0: success
```

##### GUI Access

None

#### 7.7.11.5 Target.WriteU8

Writes a byte to MCU memory (see “MCU Memory” on page 117).

##### Prototype

```
int Target.WriteU8(U32 Address, U8 Value);
```

##### Return Value

```
-1: error
0: success
```

##### GUI Access

None

#### 7.7.11.6 Target.ReadU32

Reads a word from MCU memory (see “MCU Memory” on page 117).

##### Prototype

```
U32 Target.ReadU32(U32 Address);
```

##### Return Value

```
-1: error
Memory Value: success
```

##### GUI Access

None

#### 7.7.11.7 Target.ReadU16

Reads a half word from MCU memory (see “MCU Memory” on page 117).

##### Prototype

```
U16 Target.ReadU16(U32 Address);
```

##### Return Value

```
-1: error
Memory Value: success
```

##### GUI Access

None

### 7.7.11.8 Target.ReadU8

Reads a byte from MCU memory (see “MCU Memory” on page 117).

#### Prototype

```
U32 Target.ReadU8(U32 Address);
```

#### Return Value

```
-1: error
Memory Value: success
```

#### GUI Access

None

### 7.7.11.9 Target.SetAccessWidth

Specifies the memory access width (see “Target.SetAccessWidth” on page 180).

#### Prototype

```
int Target.SetAccessWidth(U32 AccessWidth);
```

Argument	Meaning
AccessWidth	Memory access width (See “Memory Access Widths” on page 137)

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  System Variables (**Ctrl+Alt+V**)

### 7.7.11.10 Target.FillMemory

Fills a block of MCU memory with a particular value (see “Target.FillMemory” on page 180).

#### Prototype

```
int Target.FillMemory(U32 Address, U32 Size, U8 FillValue);
```

Argument	Meaning
Address	Start address of the memory block to fill.
Size	Size of the memory block to fill.
FillValue	Value to fill the memory block with.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Memory Window  Context Menu  Fill (**Ctrl+F**)

### 7.7.11.11 Target.SaveMemory

Saves a block of MCU memory to a binary data file (see “Target.SaveMemory” on page 181).

#### Prototype

```
int Target.SaveMemory(const char* FilePath, U32 Address, U32 Size);
```

Argument	Meaning
FilePath	Fully qualified path of the destination binary data file (*.bin).
Address	Start address of the memory block to save to the destination file.
Size	Size of the memory block to save to the destination file.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Memory Window  Context Menu  Save (**Ctrl+E**)

### 7.7.11.12 Target.LoadMemory

Downloads the contents of a binary data file to MCU memory (see “Target.LoadMemory” on page 181).

#### Prototype

```
int Target.LoadMemory(const char* FileName, U32 Address);
```

Argument	Meaning
FileName	Path to the binary data file (*.bin). It is possible to specify the file path relative to any of the directories listed in section “Directory Macros” on page 143.
Address	Download address.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Memory Window  Context Menu  Load (**Ctrl+L**)

### 7.7.11.13 Target.SetEndianness

Sets the endianness of the selected MCU.

#### Prototype

```
int Target.SetEndianness(int BigEndian);
```

Argument	Meaning
BigEndian	When 0, little endian is selected. Otherwise, big endian is selected.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Main Menu  Edit  J-Link-Settings  Target Device (**Ctrl+Alt+J**)

## 7.7.12 J-Link Actions

### 7.7.12.1 Exec.Connect

Establishes a J-Link connection to the MCU and triggers the default startup sequence (see “TargetConnect” on page 129).

#### Prototype

```
int Exec.Connect();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

None

### 7.7.12.2 Exec.Reset

Performs a hardware reset of the MCU (see “Reset” on page 111).

#### Prototype

```
int Exec.Reset();
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

None

### 7.7.12.3 Exec.Download

Downloads the contents of a program or data file to MCU memory (see “Downloading Program Files” on page 123).

#### Prototype

```
int Exec.Download(const char* FilePath);
```

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

None

### 7.7.12.4 Exec.Command

Executes a J-Link command.

#### Prototype

```
int Exec.Command(const char* sCommand);
```

Argument	Meaning
sCommand	J-Link command to execute (please refer to the J-Link user manual for further information).

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

None

## 7.7.13 Breakpoint Actions

### 7.7.13.1 Break.Set

Sets an instruction breakpoint (see “Instruction Breakpoints” on page 113).

#### Prototype

```
int Break.Set(U32 Address);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Set / Clear (**Alt+Plus**)

### 7.7.13.2 Break.SetEx

Sets an instruction breakpoint of a particular implementation type (see “Instruction Breakpoints” on page 113).

#### Prototype

```
int Break.SetEx(U32 Address, int Type);
```

Argument	Meaning
Address	Instruction address.
Type	Breakpoint implementation type (see “Breakpoint Implementation Types” on page 138).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

None

### 7.7.13.3 Break.SetOnSrc

Sets a code breakpoint (see “Code Breakpoints” on page 113).

#### Prototype

```
int Break.SetOnSrc(const char* GenValStr);
```

Argument	Type	Meaning
GenValStr	Function Name	Sets the breakpoint on the first source code line of a function.
	Source Location	Sets the breakpoint on a particular source code line (See “Source Code Location Descriptor” on page 134).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Set / Clear (**Alt+Plus**)

### 7.7.13.4 Break.SetOnSrcEx

Sets a code breakpoint of a particular implementation type (see “Code Breakpoints” on page 113).

#### Prototype

```
int Break.SetOnSrc(const char* sLocation, int Type);
```

Argument	Type	Meaning
sLocation	Function Name	Sets the breakpoint on the first source code line of a function.
	Source Location	Sets the breakpoint on a particular source code line (See “Source Code Location Descriptor” on page 134).
Type	Breakpoint implementation type (see “Breakpoint Implementation Types” on page 138).	

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Set / Clear (**Alt+Plus**)

### 7.7.13.5 Break.SetType

Sets a breakpoint's implementation type (see “Breakpoint Implementation” on page 115).

#### Prototype

```
int Break.SetType(U32 ID, U32 Type);
```

Argument	Meaning
ID	ID of the breakpoint as displayed within the first column of the Breakpoint Window or the Breakpoint Properties Dialog (see “Breakpoint Window” on page 73).
Type	Breakpoint implementation type (see “Breakpoint Implementation Types” on page 138).

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Edit (**F8**)

### 7.7.13.6 Break.Clear

Clears an instruction breakpoint (see “Instruction Breakpoints” on page 113).

#### Prototype

```
int Break.Clear(U32 Address);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Set / Clear (**F9**)



### 7.7.13.7 Break.ClearOnSrc

Clears a code breakpoint (see “Code Breakpoints” on page 113).

#### Prototype

```
int Break.ClearOnSrc(const char* GenValStr);
```



#### Parameter Description

Please refer to “Break.SetOnSrc” on page 183.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Set / Clear (**F9**)

### 7.7.13.8 Break.Enable

Enables an instruction breakpoint (see “Instruction Breakpoints” on page 113).

#### Prototype

```
int Break.Enable(U32 Address);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Enable (**Shift+F9**)

### 7.7.13.9 Break.Disable

Disables an instruction breakpoint (see “Instruction Breakpoints” on page 113).



#### Prototype

```
int Break.Disable(U32 Address);
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Disable (**Shift+F9**)

### 7.7.13.10 Break.EnableOnSrc

Enables a code breakpoint (see “Code Breakpoints” on page 113).

#### Prototype

```
int Break.EnableOnSrc(const char* GenValStr);
```

#### Parameter Description

Please refer to “Break.SetOnSrc” on page 183.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Enable (**Shift+F9**)

### 7.7.13.11 Break.DisableOnSrc

Disables a code breakpoint (see “Code Breakpoints” on page 113).

#### Prototype

```
int Break.DisableOnSrc(const char* GenValStr);
```



#### Parameter Description

Please refer to “Break.SetOnSrc” on page 183.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Disable (**Shift+F9**)

### 7.7.13.12 Break.Edit

Edits a breakpoints advanced properties.

#### Prototype

```
int Break.Edit(int BpID, const char* sCondition, int DoTriggerOnChange,
               int SkipCount, const char* sTaskFilter,
               const char* sConsoleMsg, const char* sMsgBoxMsg);
```

Argument	Meaning
BpID	ID of the breakpoint as displayed within the <i>Breakpoint Window</i> .
sCondition	C-Expression evaluating to a number or boolean value. The expression can include local and global program variable names as well as their members (f.ex. "pTask->ID == 3").
DoTriggerOnChange	Indicates weather the condition is met when the expression value has changed since the last time it was evaluated (DoTriggerOnChange=1) or when it does not equal zero (DoTriggerOnChange=0).
SkipCount	Indicates how many times the breakpoint is skipped, i.e. how many times the MCU is resumed when the breakpoint is hit.
sTaskFilter	The name or ID of the RTOS task that triggers the breakpoint. When empty, all RTOS tasks trigger the breakpoint. The task filter is only operational when an RTOS plugin was specified using command <i>Project.SetOSPlugin</i> .
sConsoleMsg	Message printed to the Console Window when the breakpoint is triggered.
sMsgBoxMsg	Message displayed in a message box when the breakpoint is triggered.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Edit (**F8**)

### 7.7.13.13 Break.SetOnData

Sets a data breakpoint (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.SetOnData(U32 Address, U32 AddressMask, U8 AccessType,
                   U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Argument	Meaning
Address	Memory address that is monitored for IO (access) events.
AddressMask	Specifies which bits of the address are ignored when monitoring access events. By means of the address mask, a single data breakpoint can be set to monitor accesses to several individual memory addresses.
AccessType	Type of access that is monitored by the data breakpoint (See “Connection Modes” on page 137).
AccessSize	Access size condition required to trigger the data breakpoint. As an example, a data breakpoint with an access size of 4 bytes (word) will only be triggered when a word is written to one of the monitored memory locations. It will not be triggered when, say, a byte is written.
MatchValue	Value condition required to trigger the data breakpoint. A data breakpoint will only be triggered when the match value is written to or read from one of the monitored memory addresses.
ValueMask	Indicates which bits of the match value are ignored when monitoring access events. A value mask of 0xFFFFFFFF means that all bits are ignored, i.e. the value condition is disabled.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Set (**Alt+Plus**)

### 7.7.13.14 Break.ClearOnData

Clears a data breakpoint (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.ClearOnData(U32 Address, U32 AddressMask, U8 AccessType,
                     U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

#### Parameter Description

Please refer to “Break.SetOnData” on page 187.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Clear (**F9**)

### 7.7.13.15 Break.ClearAll

Clears all breakpoints (see “Data Breakpoints” on page 114).



#### Prototype

```
int Break.ClearAll();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Breakpoint Window  Context Menu  Clear All (**Alt+Del**)

### 7.7.13.16 Break.ClearAllOnData

Clears all data breakpoints (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.ClearAllOnData();
```

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Clear All (**Alt+Del**)

### 7.7.13.17 Break.EnableOnData

Enables a data breakpoint (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.EnableOnData(U32 Address, U32 AddressMask, U8 AccessType,
                       U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

#### Parameter Description

Please refer to “Break.SetOnData” on page 187.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Enable (**Shift+F9**)

### 7.7.13.18 Break.DisableOnData

Disables a data breakpoint (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.DisableOnData(U32 Address, U32 AddressMask, U8 AccessType,
                       U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

#### Parameter Description

Please refer to “Break.SetOnData” on page 187.

#### Return Value

```
-1: error
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Disable (**Shift+F9**)

### 7.7.13.19 Break.EditOnData

Edits a data breakpoint (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.EditOnData(U32 Address, U32 AddressMask, U8 AccessType,
                    U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

#### Parameter Description

Please refer to “Break.SetOnData” on page 187.

#### Return Value

```
-1: error
 0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Edit (**F8**)

### 7.7.13.20 Break.SetOnSymbol

Sets a data breakpoint on a symbol (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.SetOnSymbol(const char* SymbolName, U8 AccessType,
                     U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Argument	Meaning
SymbolName	Name of the symbol that is monitored by the data breakpoint.
AccessType	Type of access that is monitored by the data breakpoint (See “Connection Modes” on page 137).
AccessSize	Access size condition required to trigger the data breakpoint. As an example, a data breakpoint with an access size of 4 bytes (word) will only be triggered when a word is written to one of the monitored memory locations. It will not be triggered when, say, a byte is written.
MatchValue	Value condition required to trigger the data breakpoint. A data breakpoint will only be triggered when the match value is written to or read from one of the monitored memory addresses.
ValueMask	Indicates which bits of the match value are ignored when monitoring access events. A value mask of 0xFFFFFFFF means that all bits are ignored, i.e. the value condition is disabled.

#### Return Value

```
-1: error
 0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Set (**Alt+Plus**)

### 7.7.13.21 Break.ClearOnSymbol

Clears a data breakpoint on a symbol (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.ClearOnSymbol(const char* SymbolName, U8 AccessType,  
                        U8 AccessSize, U32 MatchValue, U32 ValueMask);
```



#### Parameter Description

Please refer to “Break.SetOnSymbol” on page 189.

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Clear (**F9**)

### 7.7.13.22 Break.EnableOnSymbol

Enables a data breakpoint on a symbol (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.EnableOnSymbol(const char* SymbolName, U8 AccessType,  
                         U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

#### Parameter Description

Please refer to “Break.SetOnSymbol” on page 189.

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Enable (**Shift+F9**)

### 7.7.13.23 Break.DisableOnSymbol

Disables a data breakpoint on a symbol (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.DisableOnSymbol(const char* SymbolName, U8 AccessType,  
                          U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

#### Parameter Description

Please refer to “Break.SetOnSymbol” on page 189.

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Disable (**Shift+F9**)

### 7.7.13.24 Break.EditOnSymbol

Edits a data breakpoint on a symbol (see “Data Breakpoints” on page 114).

#### Prototype

```
int Break.EditOnSymbol (const char* SymbolName, U8 AccessType,  
                        U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

#### Parameter Description

Please refer to “Break.SetOnSymbol” on page 189.

#### Return Value

```
-1: error  
0: success
```

#### GUI Access

Data Breakpoint Window  Context Menu  Edit (**F8**)

## 7.7.14 ELF Actions

### 7.7.14.1 Elf.GetBaseAddr

Returns the program file's download address.

**Prototype**

```
int Elf.GetBaseAddr();
```

**Return Value**

Program file download address.

**GUI Access**

None

### 7.7.14.2 Elf.GetEntryPointPC

Returns the initial PC of program execution.

**Prototype**

```
int Elf.GetEntryPointPC();
```

**Return Value**

Initial PC of program execution.

**GUI Access**

None

### 7.7.14.3 Elf.GetEntryFuncPC

Return the initial PC of the program's entry (or main) function.

**Prototype**

```
int Elf.GetEntryFuncPC();
```

**Return Value**

Initial PC of the program entry function.

**GUI Access**

None

### 7.7.14.4 Elf.GetExprValue

Evaluates a C-language expression.

**Prototype**

```
int Elf.GetExprValue(const char* sExpression);
```

**Return Value**

Expression value (0 on error)

**GUI Access**

None



### 7.7.14.5 Elf.GetEndianness

Returns the program file's data encoding scheme.

#### Prototype

```
int Elf.GetEndianness(const char* sExpression);
```

#### Return Value

0: Little Endian, 1: Big Endian

#### GUI Access

None



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# Chapter 9

## Glossary

---

This chapter explains the meanings of key terms and abbreviations used throughout this manual.

**Big-endian**

Memory organization where the least significant byte of a word is at a higher address than the most significant byte. See Little-endian.

**Command Prompt**

The console window's command input field.

**Debugger**

Ozone.

**Device**

The Microcontroller on which the application program is running.

**Halfword**

A 16-bit unit of information.

**Host**

The PC that hosts and executes Ozone.

**ID**

Identifier.

**Joint Test Action Group (JTAG)**

The name of the standards group which created the IEEE 1149.1 specification.

**Little-endian**

Memory organization where the least significant byte of a word is at a lower address than the most significant byte. See also Big-endian.

**MCU**

Microcontroller Unit. A small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

**Memory coherency**

A memory is coherent if the value read by a data read or instruction fetch is the value that was most recently written to that location. Obtaining memory coherency is difficult when there are multiple possible physical locations that are involved, such as a system that has main memory, a write buffer, and a cache.

**J-Link OB**

A J-Link debug probe that is integrated into MCU hardware ("on-board").

**PC**

Program Counter. The program counter is the address of the machine instruction that is executed next.

**Processor Core**

The part of a microprocessor that reads instructions from memory and executes them, including the instruction fetch unit, arithmetic and logic unit, and the register bank. It excludes optional coprocessors, caches, and the memory management unit.

**Program**

Application Program that is being debugged and that is running on the Target Device.

**Remapping**

Changing the address of physical memory or devices after the application has started executing. This is typically done to make RAM replace ROM once the initialization has been done.

**RTOS**

Real Time Operating System.

**Target**

Same as Device. Sometimes also referred to as "Target Device".

**Target Application**

Same as Program.

**User Action**

A particular operation of Ozone that can be triggered via the user interface or programmatically from a script function.

**Window**

One of Ozone's debug information windows.

**Word**

A 32-bit unit of information. Contents are taken as being an unsigned integer unless otherwise stated.

