

Ozone

User Guide & Reference Manual

Document: UM08025
Software Version: 2.60
Revision: 3
Date: Dezember 12, 2018



A product of SEGGER Microcontroller GmbH

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Manual versions

This manual describes the current software version. If you find an error in the manual or a problem in the software, please report it to us and we will try to assist you as soon as possible.

Contact us for further information on topics or functions that are not yet documented.

Print date: Dezember 12, 2018

Manual version	Revision	Date	By	Description
2.60	3	181212	JD	Section File Path Resolution updated. Contact information updated.
2.60	2	181023	JD	Moved Section Expressions to Chapter Debugging With Ozone. Moved Section File Path Resolution to Chapter Debugging With Ozone. Chapter Appendix updated.
2.60	1	181019	JD	Chapter Appendix updated.
2.60	0	181008	JD	Section Instruction Trace Export Dialog added. Chapter Appendix updated.
2.57	4	180330	JD	Chapter Appendix updated.
2.57	3	180330	JD	Section Setting Up Trace added. Section Power Graph Window added. Section J-Link Control Panel added. Section Data Breakpoints added. Chapter Debugging With Ozone restructured. Section Timeline Window updated. Section Instruction Trace Window updated. Section Call Stack Window updated. Section Data Graph Window updated. Section Trace Settings Dialog updated. Section File Path Resolution updated. Section Features of Ozone updated. Section View Menu updated. Chapter Appendix updated.
2.57	2	180711	JD	Section Trace Settings Dialog updated. Chapter Appendix updated.
2.57	1	180227	JD	Section Trace Cache renamed to Instruction Cache. Section Trace.ExportCSV added. Section Errors and Warnings added.
2.57	0	180227	JD	Section Selective Tracing added. Section Environment Variables added. Section Expressions updated. Chapter Appendix updated. The user manual was ported to emDoc.
2.56	1	180227	JD	Section Downloading Program Files added. Section Register Initialization added. Section Incorporating a Bootloader into Ozone's Startup Sequence added. Chapter Appendix updated.
2.56	0	180214	JD	Removed suffix "Co KG" from the company name. Section Memory Window updated. Section Tools Menu updated.
2.55	1	180129	JD	Added a new user action category Tools Actions. Updated the description of user action Script.Exec.
2.55	0	180122	JD	Section Supported Target Devices updated. Section Target Support Plugins added. Documented breakpoint callback functions. Section Action Tables updated.
2.54	0	171205	JD	Section Memory Usage Window updated.
2.53	1	171121	JD	Section Memory Usage Window added.
2.53	0	171113	JD	Section File.OpenRecent added. Section Type Casts added. Section Supported Target Devices updated. Section Coprocessor Register Descriptor updated.
2.52	1	171029	JD	Improved the layout and readability of multiple sections.

Manual version	Revision	Date	By	Description
2.52	0	171022	JD	Chapter Appendix updated. Section Newline Formats added. Section Code Profile Export Formats added. Section Memory Window updated. Section Terminal Window updated.
2.50	1	170918	JD	Section Supported Programming Languages added.
2.50	0	170911	JD	Updated the version number to 2.50.
2.47	0	170905	JD	Sections 4.1.12, 7.8.9.9 added. Sections 1.2, 3.9.7, 3.11.10, 4.7.13, 5.13.1.1, 7.3.1, 7.7.13 updated. Sections 3.11.11, 7.7.2, 7.8.2.3 removed.
2.46	0	170817	JD	Updated the version number to 2.46
2.45	1	170810	JD	Section Command Line Arguments updated.
2.45	0	170808	JD	Section Trace Cache added. Section Filter Bar added.
2.44	0	170712	JD	Section Command Line Arguments added. Section User Files added. Chapter Appendix updated.
2.42	0	170621	JD	Updated multiple figures and sections.
2.40	0	170515	JD	Updated multiple figures and sections.
2.32	0	170410	JD	Corrected spelling errors. Section Call Frame Blocks updated. Chapter Appendix updated.
2.31	0	170404	JD	Section Timeline Window added. Section Project.RelocateSymbols added.
2.30	0	170313	JD	Updated the version number to 2.30.
2.29	1	170306	JD	Added system variable VAR_TRACE_PORT_WIDTH.
2.29	0	170129	JD	Section Call Graph Window added.
2.22	3	170118	JD	Section Project.AddRootPath updated.
2.22	2	161123	JD	Section Advanced Program Analysis And Optimization Hints added.
2.22	1	161111	JD	Section <i>Data Graph Settings Dialog</i> added. Section User Actions updated.
2.22	0	161031	JD	Updated the version number to 2.22.
2.20	1	160928	JD	Section Project.SetJLinkLogFile added.
2.20	0	160915	JD	Updated the version number to 2.20.
2.18	0	160802	JD	Section Data Graph Window updated.
2.17	6	160718	JD	Renamed "User Guide" to "User Manual".
2.17	5	160623	JD	Correct spelling errors.
2.17	4	160622	JD	Integrated documentation about editable data breakpoints. Updated all content menu graphics and hotkey descriptions. Removed obsolete user actions.
2.17	3	160616	JD	Removed obsolete user actions.
2.17	2	160613	JD	Fixed spelling and grammatical errors.
2.17	1	160606	JD	Section Coprocessor Register Descriptor added.
2.17	0	160520	JD	Section Data Graph Window added. Section Expressions updated.
2.15	1	160427	JD	Section Live Watches added. Section Expressions added.
2.15	0	160324	JD	Changed the product name to "Ozone - the J-Link Debugger".
2.12	2	160225	JD	Moved sections.
2.12	1	160215	JD	Section File Path Resolution added. Section Hardware Requirements updated.

Manual version	Revision	Date	By	Description
2.12	0	160122	JD	Section Code Profile Window added. Section Instruction Trace Window updated. Section Watched Data Window updated. Section Source Viewer updated.
2.10	2	160115	JD	Fixed a typo in section Target Actions.
2.10	1	151208	JD	Section Directory Macros added.
2.10	0	151203	JD	Update the version number to 2.10.
1.79	0	151118	JD	Section <i>Conditional Breakpoints</i> added. Section <i>Big Endian Support</i> added.
1.72	0	150505	JD	Original version.

About this document

Assumptions

This document assumes that you already have a solid knowledge of the following:

- The software tools used for building your application (assembler, linker, C compiler).
- The C programming language.
- The target processor.
- DOS command line.

If you feel that your knowledge of C is not sufficient, we recommend *The C Programming Language* by Kernighan and Richie (ISBN 0-13-1103628), which describes the standard in C programming and, in newer editions, also covers the ANSI C standard.

How to use this manual

This manual explains all the functions and macros that the product offers. It assumes you have a working knowledge of the C language. Knowledge of assembly programming is not required.

Typographic conventions for syntax

This manual uses the following typographic conventions:

Style	Used for
Body	Body text.
Keyword	Text that you enter at the command prompt or that appears on the display (that is system functions, file- or pathnames).
Parameter	Parameters in API functions.
Sample	Sample code in program examples.
Sample comment	Comments in program examples.
Reference	Reference to chapters, sections, tables and figures or other documents.
GUIElement	Buttons, dialog boxes, menu names, menu commands.
Emphasis	Very important sections.

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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 debuggers usage and functionality. The reader is welcome to send feedback about this manual and suggestions for improvement to support@segger.com.

1.1 What is Ozone?

Ozone is a source-level debugger for embedded software applications written in C/ C++ and 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.

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 chapter 3 as well as later chapters of the manual.

1.2.1 Unlimited Flash Breakpoints

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

1.2.2 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)

1.2.3 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.

1.2.4 Extensive Printf-Support

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

1.2.5 Peripheral and CP15 Register Support

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

1.2.6 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 workflow 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 debuggers console window.

1.2.7 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.

1.2.8 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.

1.2.9 Power Profiling

The Power Graph Window tracks the current drawn by the target at resolutions of down to 1 microseconds and displays the resulting graph in an interactive signal plot.

1.2.10 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.

1.2.11 Timeline

Ozone's Timeline Window visualizes the course of the program's call stack over time. It provides advanced navigation features that allow users to quickly understand relative and absolute call frame sizes and positions, which make it a great profiling tool as well.

1.2.12 Disassembly Export

Ozone includes a performant disassembler that is able to create a whole-program disassembly export in the form of a single recompilable GNU-syntax assembly code file.

1.2.13 Advanced Memory View

Ozone's memory window is fully editable and has many advanced features such as disk-IO, periodic updating and copy/paste of clipboard content. An unlimited number of memory windows can be opened at the same time.

1.2.14 Source Editor

Ozone's combined source code viewer/editor allows users to perform quick adjustments to source code without having to switch to the IDE window. Ozone automatically detects changes made to the program file via an external compiler and prompts the user if the modified file should be reloaded.

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 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.

1.2.17 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.

1.3 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 megabytes (MB) available hard disk space
- J-Link or J-Trace debug probe
- JTAG or SWD data cable to connect the target 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 architecture profiles:

1.5.1 ARM

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

1.5.2 RISC-V

- RV32I

1.5.3 Target Support Plugins

Ozone features a generic target support plugin API that simplifies the process of extending device support to new MCU architectures.

1.6 Supported Debug Interfaces

Ozone communicates with the target via a J-Link or J-Trace debug probe. Other debug probes / hardware interfaces are not supported.

The following target interfaces are supported:

- JTAG
- SWD
- cJTAG

1.7 Supported Programming Languages

Ozone supports debugging of programs that were written in:

- C
- C++

It is likely that applications written in programming languages other than the ones listed above can be debugged satisfactory using Ozone, as ELF debugging information is stored in a mostly language-independent format.

Chapter 2

Getting Started

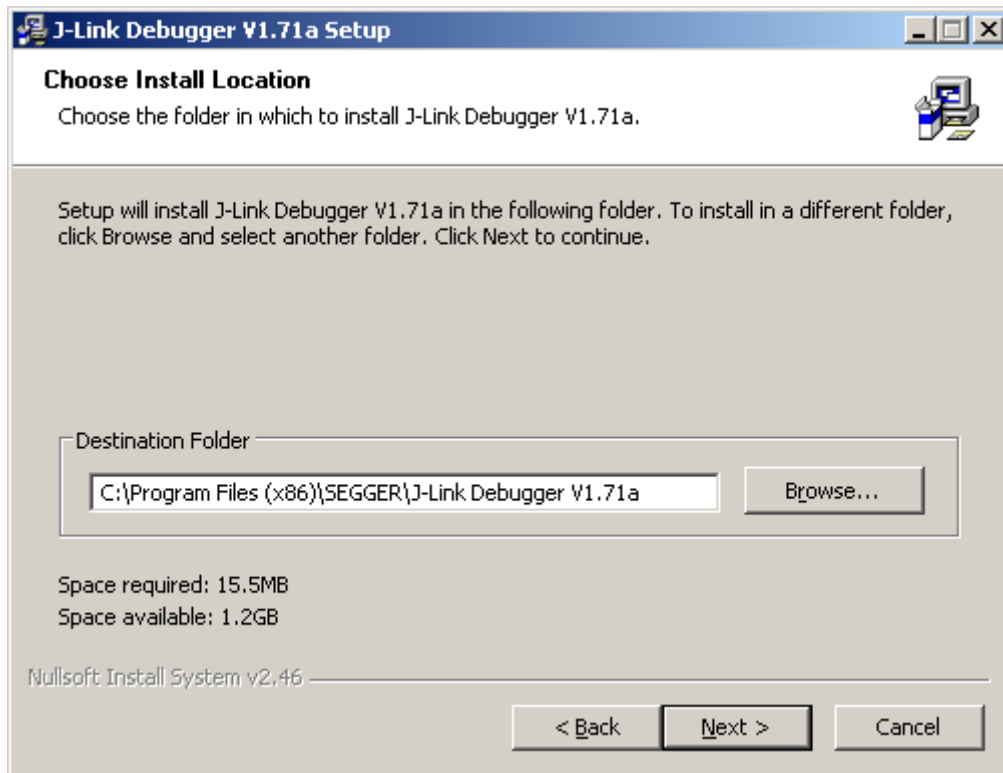
This chapter contains a quick start guide. It covers the installation procedure and explains how to use the Project Wizard in order to create a basic project file. The chapter completes by explaining how a debug session is entered.

2.1 Installation

This section explains how Ozone is installed and uninstalled 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.



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 debuggers 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 29).

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
- libxext6 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 29).

2.1.4.1 Uninstall Commands

Debian

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

RedHat

```
sudo yum remove Ozone
```

2.1.4.2 Removing Application Settings

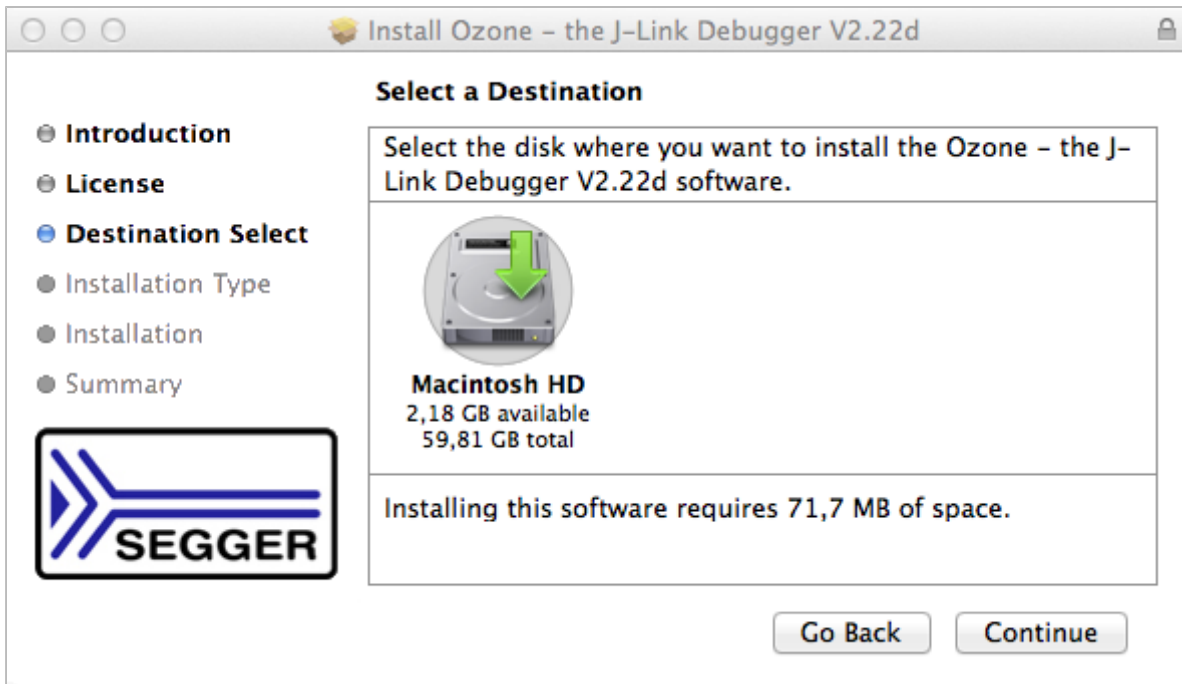
Ozone's persistent application settings are stored within the hidden file "\$Home/.config/SEGGER/Ozone.conf". In order to erase Ozone's persistent application settings, please delete this file.

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.



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

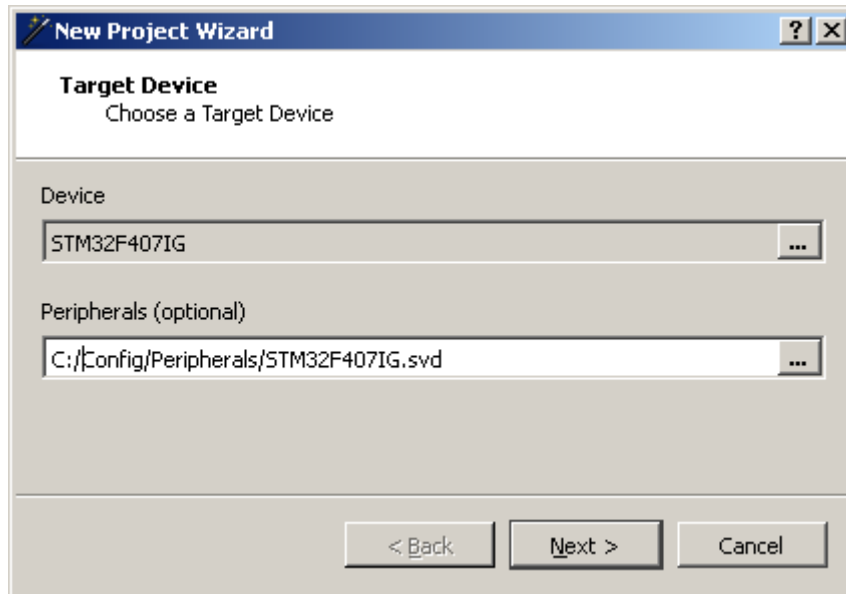
Ozone's persistent application settings are stored in the hidden file `$Home/Library/ Preferences/com.segger.Ozone.plist`. In order to erase Ozone's persistent application settings, please delete this file.

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.



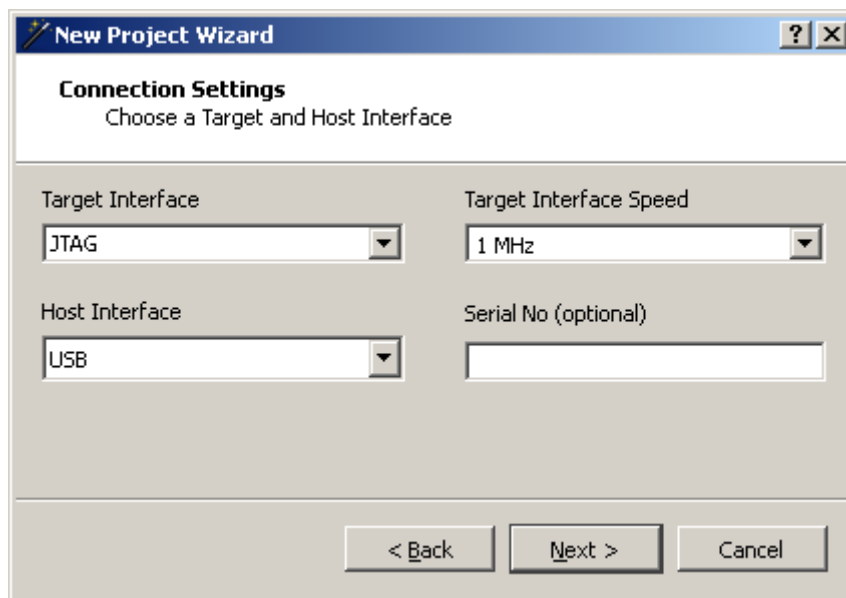
First page of the Project Wizard

Device

On the Project Wizard's first page, the user is asked to select the target 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 target. 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 113).



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 target. Ozone currently supports the JTAG and SWD target interfaces.

Target Interface Speed

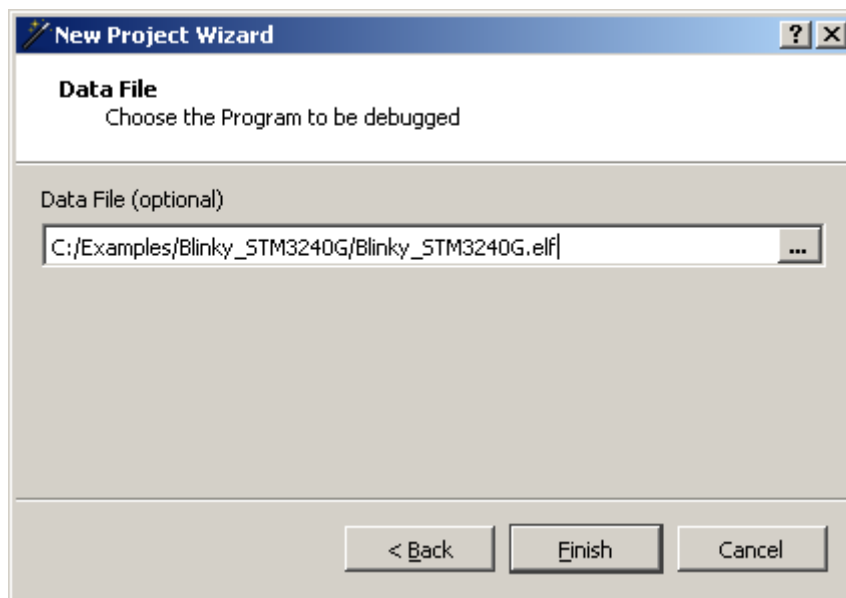
The target interface speed parameter controls the communication speed with the target. The range of accepted values is 1 kHz to 50 MHz. Some MCUs require a low, others an adaptive target interface speed throughout the initial connection phase. Usually, the target interface speed can be increased after the initial connection, when certain peripheral registers of the target 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.



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 135).

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 target has not yet been established. At this point, only windows whose content does not depend on target 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 toolbar or by hitting the shortcut F5. After the startup procedure is complete, the user may start to debug the program using the controls of the Debug Menu. The debugging workflow 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

Section *Action Tables* on page 35 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 Executing User Actions

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

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.

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. Section *User Actions* on page 35 provides information about which method of execution is available for the different user actions.

3.1.2.1 User Action Hotkeys

A user action that belongs to a particular debug window may share the same hotkey with another window-local user action. As a rule of thumb, a window-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.

3.1.3 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.

3.2 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 number of times the program was stepped since the value has changed. The table below depicts the default colors that are assigned to the different change levels.

Change Level	Meaning
Level 1	The value has changed one program step ago.
Level 2	The value has changed two program steps ago.
Level 3	The value has changed three program steps ago.
Level 4 (and above)	The value has changed 4 or more program steps ago or does not display change levels.

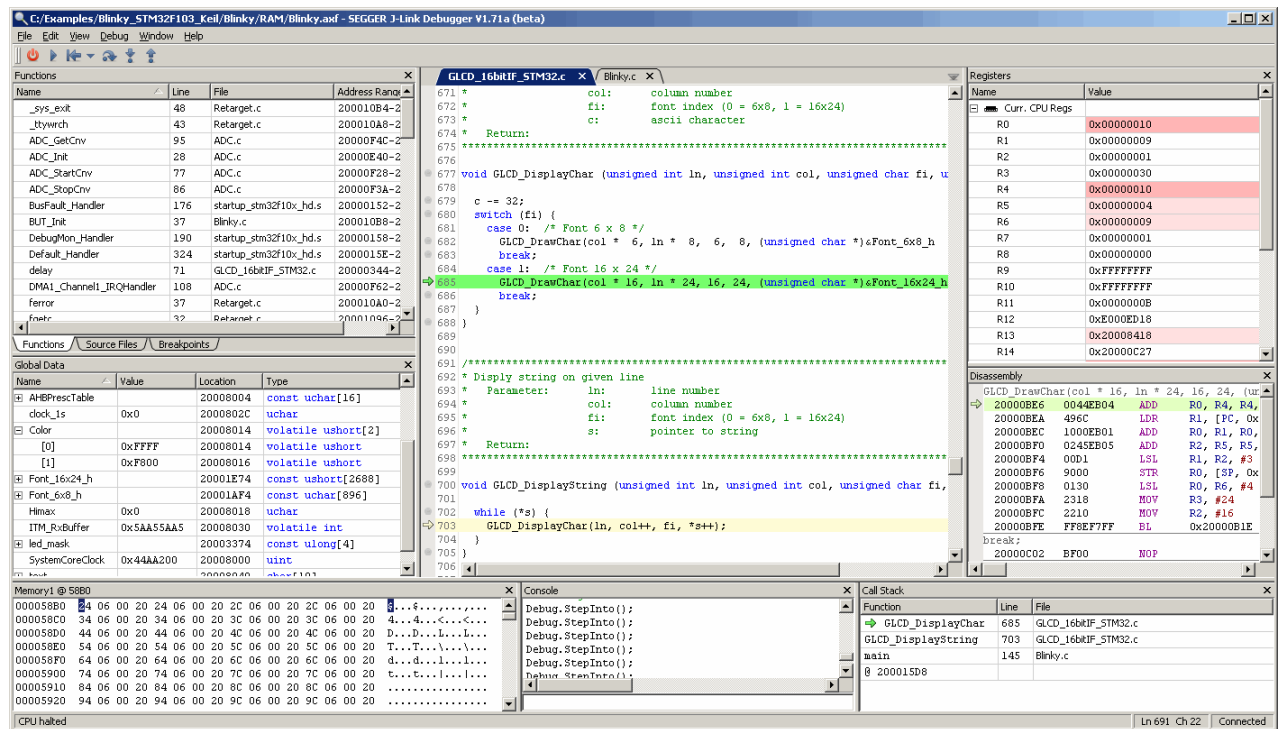
Both foreground and background colors used for change level highlighting can be adjusted via the User Preference Dialog (see *User Preference Dialog* on page 52 or via user action *Edit.Color* (see *Edit.Color* on page 204).

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:



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 section *Window Layout* on page 44. The only window that cannot be arranged or repositioned is the Source Viewer itself.

3.4 Menu Bar

Ozone's Main Window provides a menu bar that categorizes all user actions into five functional groups. 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 192).

New

This submenu hosts actions to create a new project and to run the Project Wizard (see *Project Wizard* on page 31).

Open

Opens a project-, program-, data- or source-file (see *File.Open* on page 197).

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.

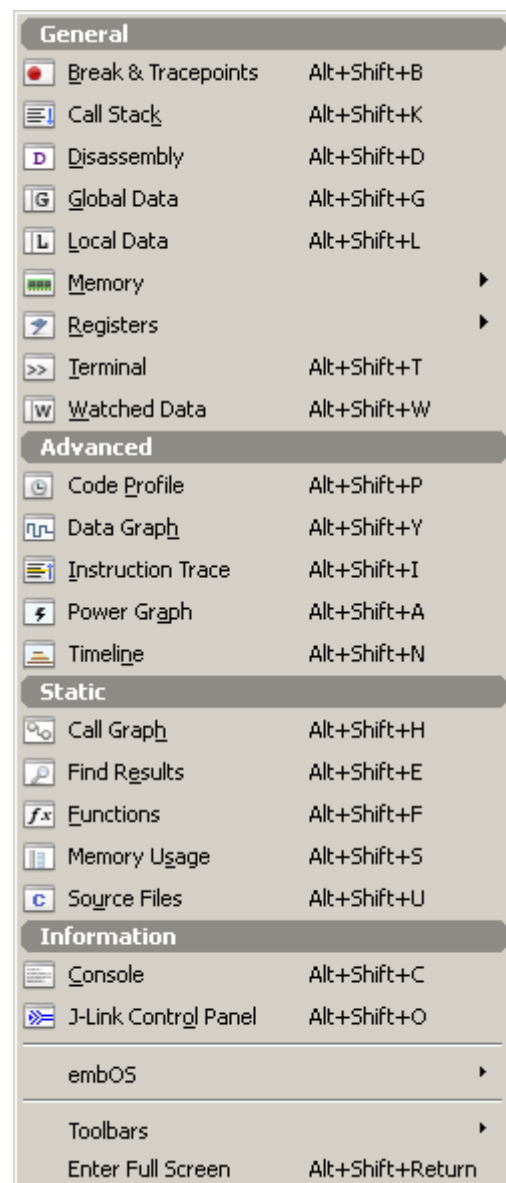
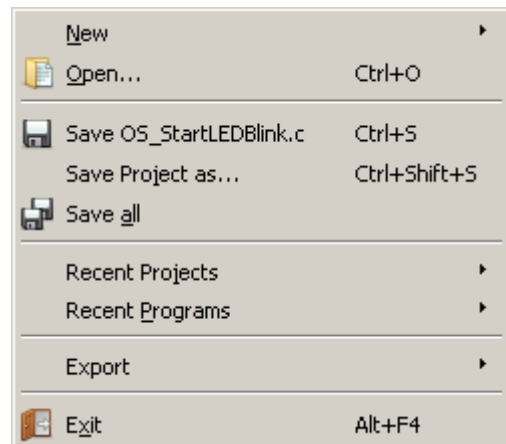
Export

A submenu that hosts the following entries:

Disassembly The disassembly export creates a single assembly code text file containing the self-contained and recompilable assembly code image of the program.

Exit

Exits the application.



3.4.2 View Menu

The View Menu hosts actions that add debug information windows and toolbars to the Main Window (see *View Actions* on page 195).

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 51).

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 223).

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 42).

Enter/Exit Full Screen

Enters or exit fullscreen mode.

3.4.3 Find Menu

The Find Menu hosts actions that facilitate navigation to program entities.

Find Text

Opens the Find Dialog (see *Find Dialog* on page 61).

Find Function

Opens an input widget that when edited, scrolls the source viewer or disassembly window to the given function.

Find Symbol

Opens an input widget that when edited, scrolls the source viewer to declaration of the given variable.

3.4.4 Debug Menu

The Debug Menu hosts actions that control program execution (*Debug Actions* on page 191).

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 141).

Reset

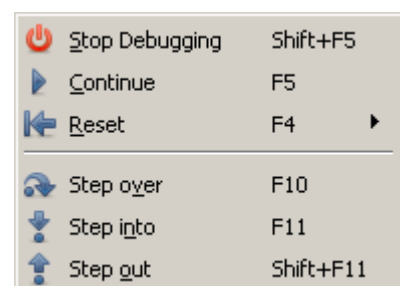
Resets the program using the last employed reset mode. Other reset modes can be executed from the action's submenu (see *Reset* on page 140).

Step Over

Steps over the current source code line or machine instruction, depending on the active code window (see *Active Code Window* on page 45 and *Step* on page 140).

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 45 and *Step* on page 140).



Step Out

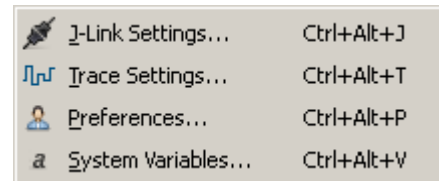
Steps out of the current subroutine (see *Step* on page 140).

3.4.5 Tools Menu

The Tools Menu hosts four dialog actions that allow users to edit Ozone's graphical and behavioral settings (see *Tools Actions* on page 194).

J-Link Settings

Opens the J-Link-Settings Dialog that allows users to specify the hardware setup, i.e. the target device and debugging interface to be used (see *J-Link Settings Dialog* on page 59).



Trace Settings

Opens the Trace Settings Dialog that is provided to configure Ozone's trace data input channel (see *Trace Settings Dialog* on page 67).

Preferences

Opens the User Preference Dialog that allows users to configure Ozone's graphical user interface (see *User Preference Dialog* on page 52).

System Variables

Opens the System Variable Editor that allows users to configure behavioral settings of the debugger (see *System Variable Editor* on page 21).

3.4.6 Window Menu

The Window Menu lists all open windows and documents and provides actions to alter the window and document state.

Close Window

Closes the debug window that contains the input focus.

Close All Windows

Closes all debug windows.

Undock

Undocks the debug window that contains the input focus.

Window List

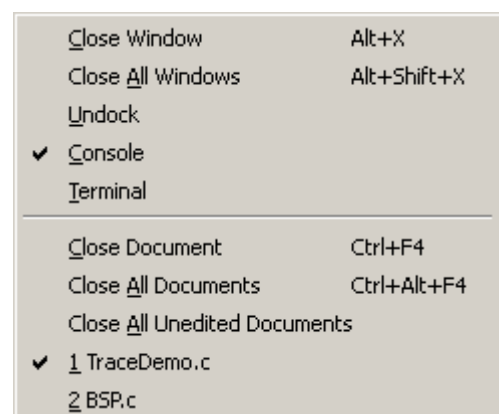
The list of open debug information windows. By selecting an item, the corresponding debug window is focused.

Close Document

Closes the active source document.

Close All Documents

Closes all source documents.



Close All Unedited Documents

Closes all unedited source documents.

Document List

The list of open source documents is appended to the window menu.

3.4.7 Help Menu

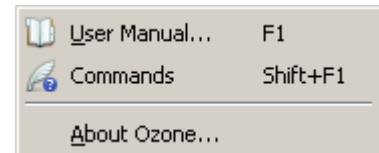
User help related actions.

User Guide

Opens the user guide and reference manual.





Command Help

Prints a description of all user actions to the Console Window



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. In addition, a breakpoint toolbar is provided.

Category	Toolbar
File	
Debug	
View	
Breakpoints	

3.5.1 Showing and Hiding Toolbars

Toolbars can be added to the Main Window via the toolbar menu (View → Toolbars) or by executing user action `Toolbar.Show` using the toolbar's name as parameter (e.g. `Toolbar.Show("Debug")`). Removing toolbars from the Main Window works the same way using action `Toolbar.Close` (see *Toolbar.Close* on page 209).

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 *Showing and Hiding Toolbars* on page 42.

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



Status bar

3.6.1 Status Message

On the left side of the status bar, a 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

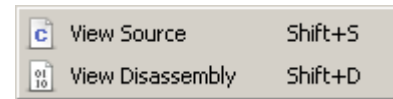
The right section of the status bar informs about the debugger's J-Link connection state. When the debugger is connected to the target, the data transmission speed is displayed as well.

3.7 Debug Information Windows

Ozone features a set of 22 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 chapter *Debug Information Windows* on page 44.

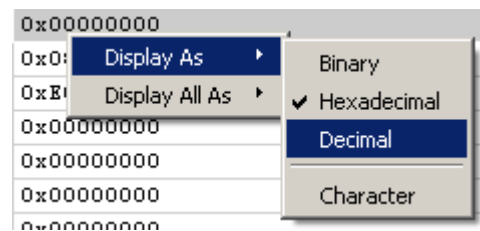
3.7.1 Context Menu

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 displayed within the window. If supported, the value display format can be changed via the window's context menu or via user actions `Window.SetDisplayFormat` and `Edit.DisplayFormat` (see *Window Actions* on page 195).



3.7.3 Window Layout

Section *Window Layout* on page 44 describes how debug information windows are added to, removed from and arranged on the Main Window.

3.7.4 Change Level Highlighting

Multiple debug information windows highlight numeric values according to recency of their last change (see *Change Level Highlighting* on page 44).

Value
0x10
0x10
0x20
0x20008041

3.7.5 Code Windows

Ozone includes two debug information windows that display the program's source code and assembly code, respectively. The code windows share several common properties that are described in *Code Windows* on page 44.

3.7.6 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 44.

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 assembly 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 118 and *Disassembly Window* on page 89.

3.8.1 Program Counter Tracking

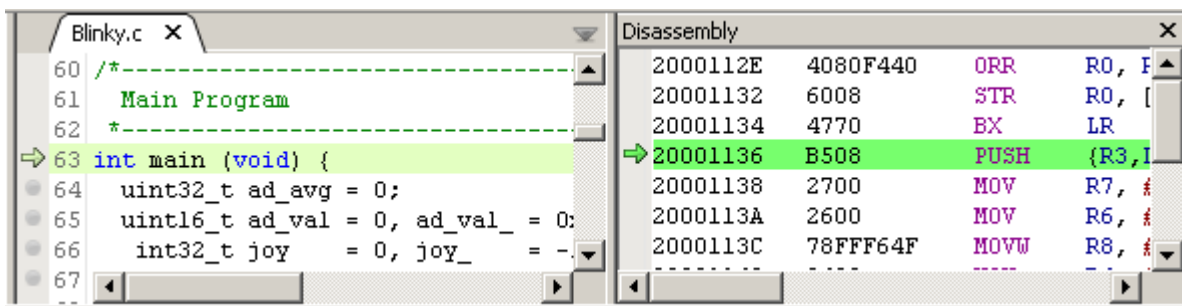
Ozone's code windows automatically scroll to the position of the PC line when the user steps or halts the program. In case of the Source Viewer, the document containing the PC line is automatically opened if required.

3.8.1.1 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.

3.8.1.2 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).



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

3.8.1.3 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.

3.8.2 Sidebar










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

3.8.2.1 Showing and Hiding the Sidebar

The display of the sidebar can be toggled from the User Preference Dialog (see *User Preference Dialog* on page 52) or via user action `Edit.Preference` (see *Edit.Preference* on page 203).

3.8.2.2 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.
	The code line contains a tracepoint that starts trace.
	The code line contains a tracepoint that stops trace.

3.8.3 Code Line Highlighting

Each code window applies distinct highlights to particular code lines. The table below explains the meaning of each highlight. Code line highlighting colors can be adjusted via the User Preference Dialog (see *User Preference Dialog* on page 52) or via the user action `Edit.Color` (see *Edit.Color* on page 204).

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.
<code>for (int i = 0) {</code>	The code line contains the instruction that is currently selected within the instruction trace window (see <i>Backtrace Highlighting</i> on page 97).

3.8.4 Breakpoints

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

3.8.4.1 Toggling Breakpoints

Both code windows provide the following options 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

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 190).

3.8.4.2 Enabling and Disabling Breakpoints

The code windows allow users to disable and enable the breakpoint on the selected code line by pressing the hotkey Shift-F9. 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 190).

3.8.4.3 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 58) or programmatically via user actions `Break.Edit` (see *Break.Edit* on page 244) and `Break.SetType` (see *Break.SetType* on page 242).

3.8.5 Code Profile Information

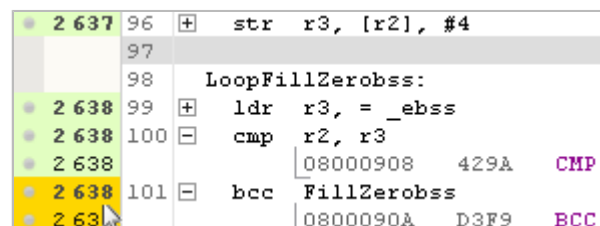
The code windows are able to display code profile information within their sidebar areas.

3.8.5.1 Hardware Requirements

The code profile features of Ozone require the employed hardware setup to support instruction tracing (see *Hardware Requirements* on page 47). The user experience can be enhanced by employing a J-Trace PRO debug probe (see *Streaming Trace* on page 147).

3.8.5.2 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.



Counter	Address	Instruction	Comment
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 429A CMP	
2 638	101	bcc FillZerobss	
2 638		0800090A D3F9 BCC	

Resetting Execution Counters

The execution counters are reset automatically at the same time the program is reset. A manual reset option is provided within the code window context menu.

Toggling Execution Counters

The display of execution counters can be toggled from the code window context menu.

3.8.5.3 Execution Counter Highlighting

Execution Counters are highlighted in different colors. The default colors and their meanings are explained below.

Color	Description
10 000	Line has been executed.
10 000	Line has been partially executed.
10 000	Line has not been executed.

These default colors can be adjusted via the User Preference Dialog (see *User Preference Dialog* on page 52) or programmatically via user action `Edit.Color` (see *Edit.Color* on page 204).

Executed Line

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

Partially Executed Line

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

Not Executed Line

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

3.8.5.4 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

Fetched:      5 409 641
Executed:     5 409 641 (100.0%)
Not-Executed: 0 (0.0%)
Load:        1.3%
```


3.9 Table Windows

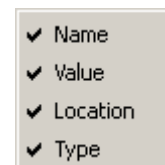
Several of Ozone's debug information windows are based on a joint table layout that provides a common set of features. The Breakpoint Window illustrated below is an example of a table-based debug information window (or table window for short).

Breakpoints				
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

Table Window Example

3.9.1 Selectable 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.



3.9.2 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.

3.9.3 Filter Bar

Each table window provides a filter bar that allows users to filter table contents. When a filter is set on a table column, only table rows whose column value matches the filter stay visible. The display state of the filter bar (shown or hidden) can be toggled via the context menu of the table window.

Name	Location	Size	Type
_B	*	4-8	*
_BaseAddr	2000 0624	4	uint
OS_JLINKMEM_Buffe	0800 3A2C	4	const uint

3.9.3.1 Value Range Filters

Columns that display numerical data accept value range filter input. A value range filter is specified in any of the following formats:

Format	Description
x-y	keep items whose column value is contained within the range [x,y].
>x	keep items whose column value is greater than x.
≥x	keep items whose column value is greater than or equal to x.
<x	keep items whose column value is less than x.
≤x	keep items whose column value is less than or equal to x.

3.9.3.2 Filter Bar Context Menu

In addition to the standard text interaction options, the filter bar context menu provides the following actions:

Clear All Filters

Clears all column filters.

Set Filter...

Opens the filter input dialog.






Undo	Ctrl+Z
Redo	Ctrl+Y
Cut	Ctrl+X
Copy	Ctrl+C
Paste	Ctrl+V
Delete	
Select All	Ctrl+A
Clear All Filters	
Set Filter...	

3.9.4 Editable Table Cells

Certain table cells such as variable values are editable. When a value that is stored in target 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 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 on the right.

 pCurrentTask
 [0]
 pNext
 [0]
 pStack

3.9.6 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.

3.10 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

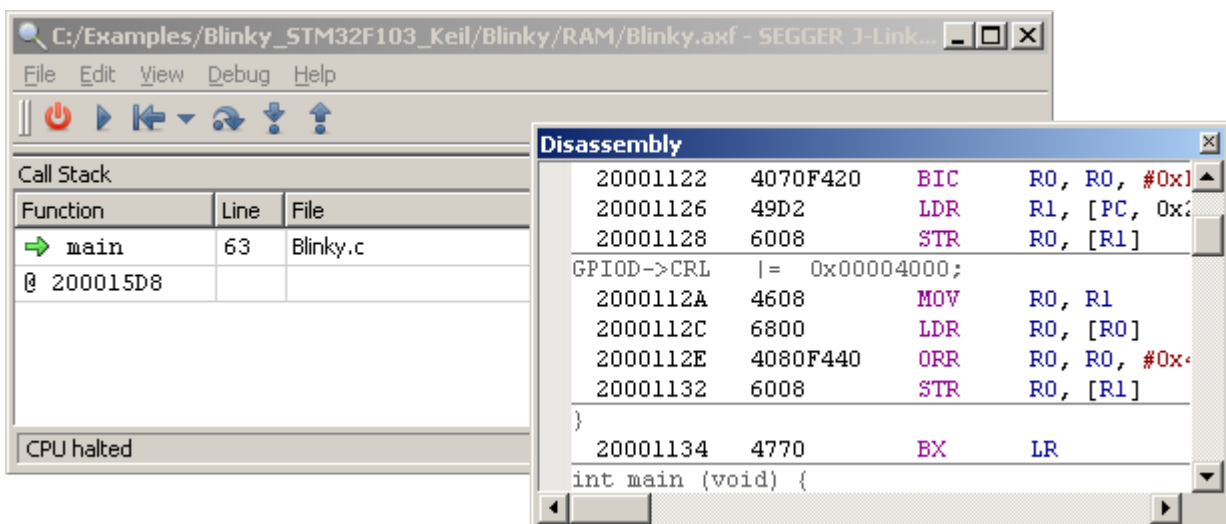
Windows are opened by clicking on the affiliated view menu item (e.g. View → Breakpoints) or by executing the command `Window.Show` using the window's name as parameter (e.g. `Window.Show("Breakpoints")`). When a window is opened, it is added to its last known position on the user interface.

Closing Windows Programmatically

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

3.10.2 Undocking Windows

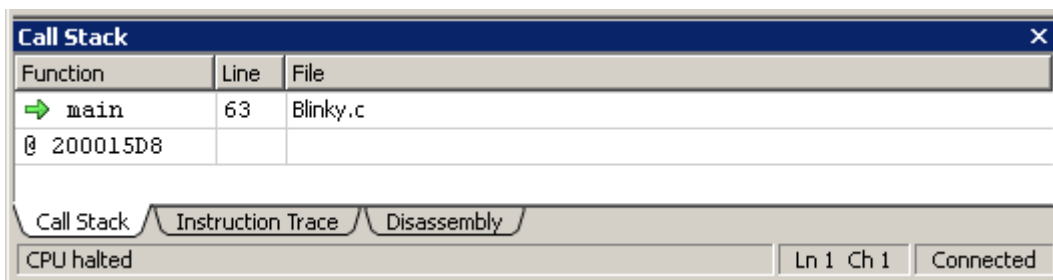
Windows can be undocked from the Main Window by dragging or double-clicking the window's title bar. An undocked window can be freely positioned and resized on the desktop.



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.



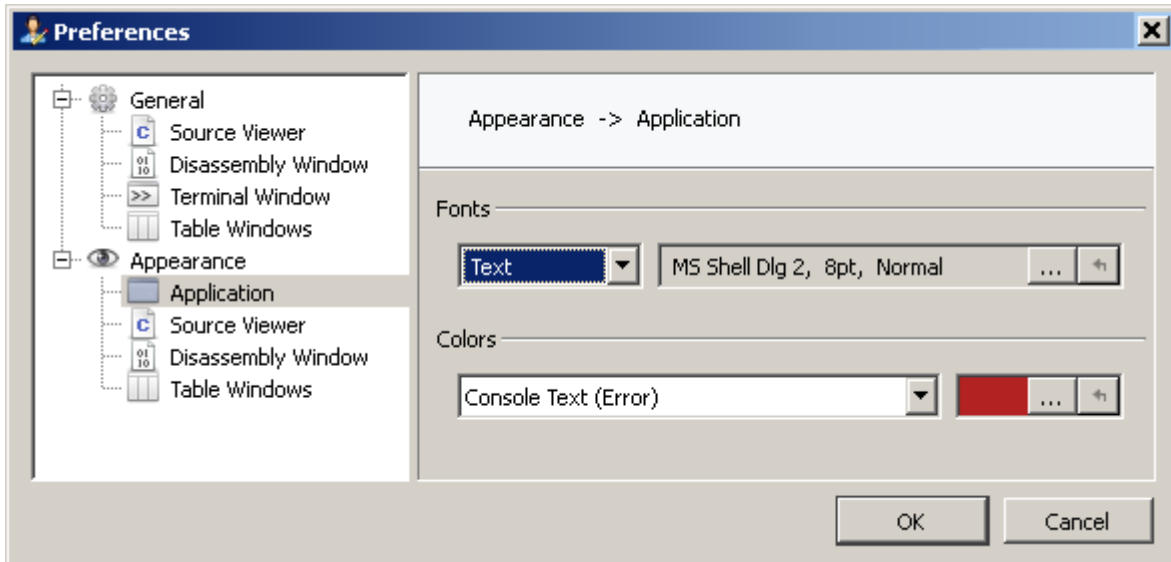
Stacked debug information windows

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.



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 user action Tools.Preferences (see *Tools.Preferences* on page 202).

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

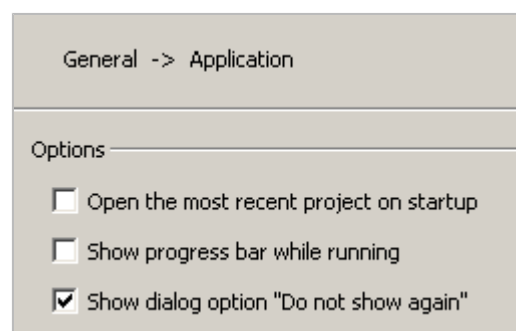
This settings page lets users adjust general application settings.

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.

Show progress bar while running

Indicates if a moving progress bar should be an-



imated within Ozone's status bar area while the program is executing.

Show dialog option "Do not show again"

Indicates if popup-dialogs should contain a checkbox that allows users to stop the dialog from popping up.

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 120).

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.

Show Code Profile

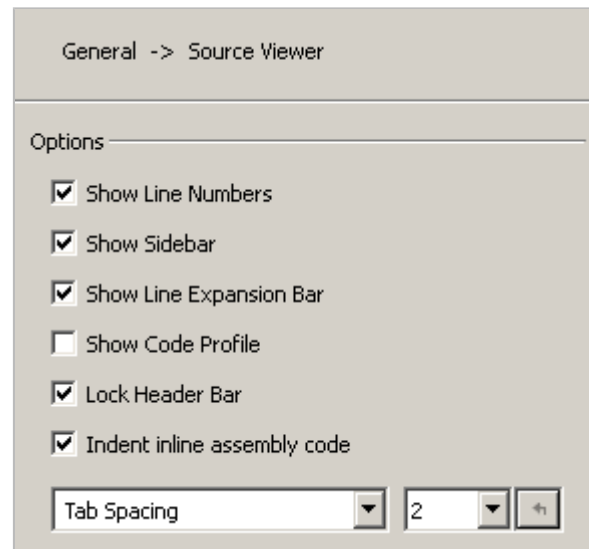
Specifies if code profile information should be displayed within the sidebar area of the Source Viewer (see *Execution Counters* on page 47).

Lock Header Bar

Specifies if the Source-Viewer's header bar should be visible at all times or only when hovered with the mouse.

Tab Spacing

Sets the number of whitespaces drawn for each tabulator in the source text.



3.11.1.5 Disassembly Window Settings

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

Show Source

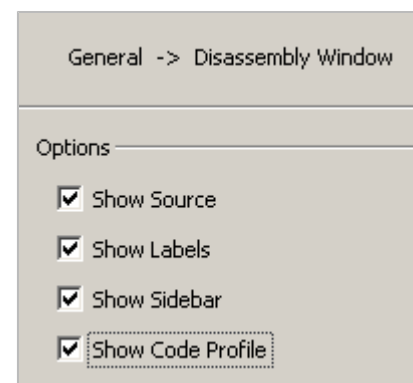
Specifies if assembly code should be augmented with source code text to improve readability (see *Mixed Mode* on page 91).

Show Labels

Specifies if assembly code should be augmented with labels to improve readability (see *Mixed Mode* on page 91).

Show Sidebar

Specifies if the Disassembly Window displays a sidebar (see *Sidebar* on page 46).



Show Code Profile

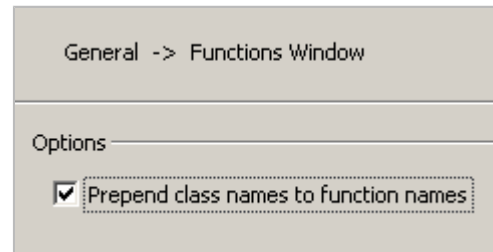
Specifies if code profile information should be displayed within the sidebar area of the Disassembly Window (see *Execution Counters* on page 47).

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 175).



3.11.1.7 Terminal Window Settings

This settings page lets users adjust general display options of the Terminal Window (see *Terminal Window* on page 123).

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 175).

Clear On Reset

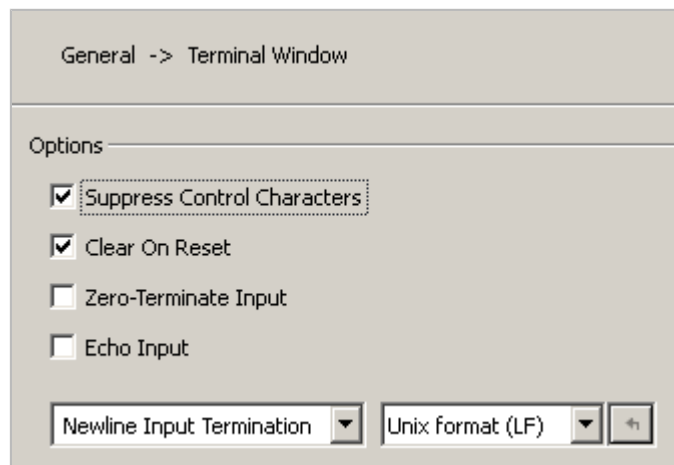
When checked, the window's text area is cleared following each program reset.

Zero-Terminate Input

Indicates if a string termination character (\0) is appended to terminal input before the input is sent to the debuggee.

Echo Input

When checked, each terminal input is appended to the terminal window's text area.



Newline Input Termination

Specifies the type of line break to be appended to terminal input before the input is sent to the debuggee (see *Newline Formats* on page 172).

3.11.1.8 Table Window Settings

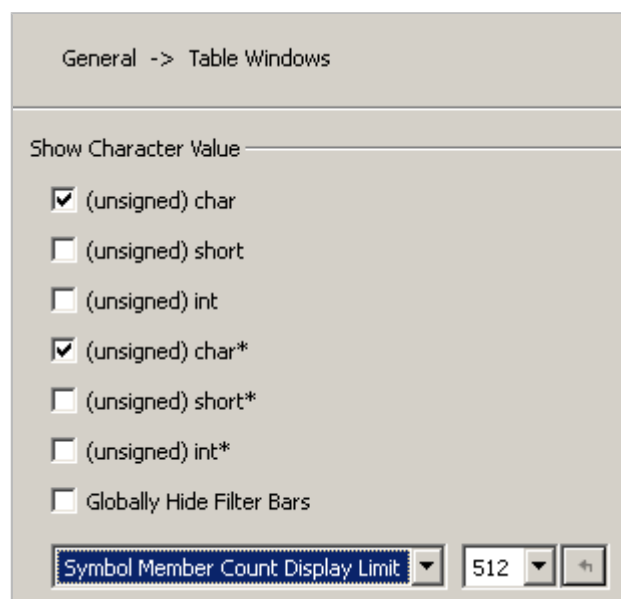
This settings page lets users adjust general display options of the Table Windows (see *Table Windows* on page 49).

Show Character Value

By checking a data type's option, all symbols of this data type display their value in the format "<number> (<text representation>)" instead of just "<number>".

Globally Hide Filter Bars

When this option is set, the display of table



filter bars is globally disabled (see *Filter Bar* on page 49).

Symbol Member Count Display Limit

Specifies the maximum amount of members that are displayed for complex-type symbols such as arrays.

3.11.1.9 Appearance Settings

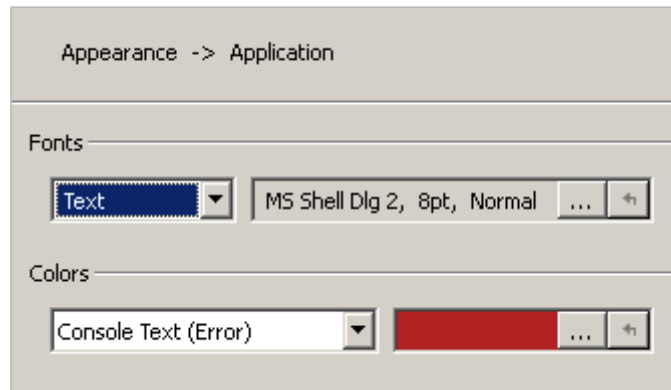
On the appearance settings pages, fonts and colors of a particular window or window group can be adjusted. Within the window group “Application”, the default appearance settings for all windows and dialogs can be specified.

Fonts

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

Colors

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



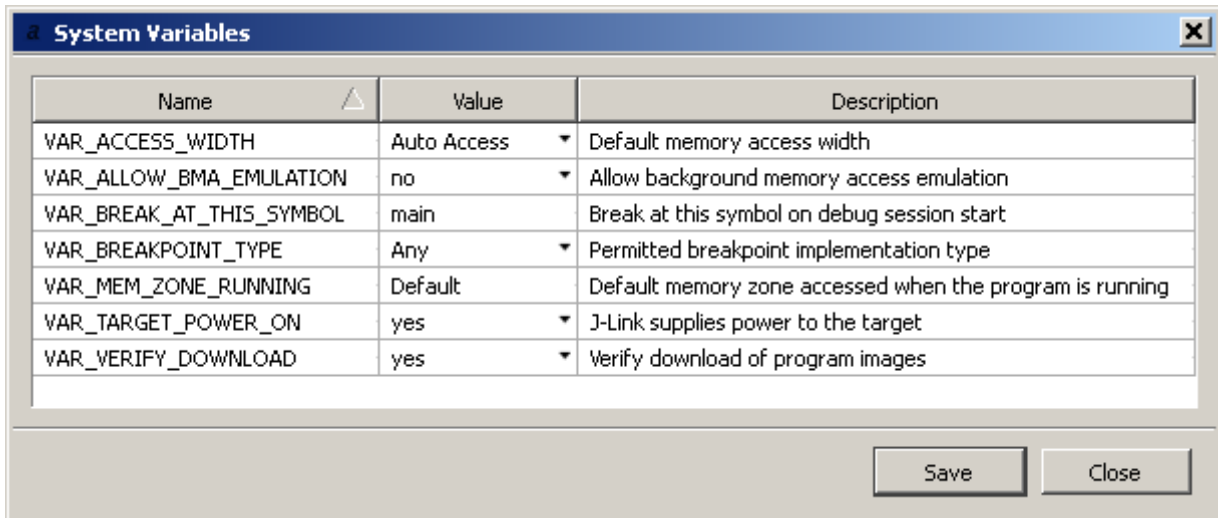
3.11.1.10 Specifying User Preferences Programmatically

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. The table below gives an overview of the available user preference actions.

User Preference Category	Affiliated User Action(s)
General Settings	Edit.Preference (see <i>Edit.Preference</i> on page 203)
Appearance Settings	Edit.Color (see <i>Edit.Color</i> on page 204) and Edit.Font (see <i>Edit.Font</i> on page 204)

3.11.2 System Variable Editor

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



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 user action `Tools.SysVars` (see *Tools.SysVars* on page 202).

3.11.2.2 Editing System Variables Programmatically

The user action *Edit.SysVar* on page 203 is provided to manipulate system variables inside script functions or at the command prompt (see *Command Prompt* on page 81).

3.11.2.3 Applying Changes

Save

By clicking the save button, the displayed system settings are written as Ozone API commands to the project file and thereby applied persistently.

Close

By clicking the close button, the selected system settings are applied to the current session only.

3.11.3 Data Breakpoint Dialog

The Data Breakpoint Dialog allows users to place data breakpoints on global program variables and individual memory addresses. Please refer to *Data Breakpoints* on page 144 for further information on data breakpoints in Ozone.

The dialog can be accessed from the context menu of the Breakpoints/Tracepoints window (see *Breakpoints/Tracepoints Window* on page 71) or from the context menu of the data symbol windows.

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.

Access Condition

The access condition pane allows users to specify the type and size of a memory access that triggers the data breakpoint.

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.

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

OK Button

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

Cancel Button

Closes the dialog without setting the data breakpoint.

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 Breakpoints/Tracepoints Window. Breakpoint properties can also be set programmatically using actions `Break.Edit` (see *Break.Edit* on page 244) and `Break.SetType` (see *Break.SetType* on page 242).

State

Enables or disables the breakpoint.

Permitted Implementation

Sets the breakpoint's permitted implementation type (see *Break.SetType* on page 242).

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.

Reload

When unchecked, the skip count condition is deactivated as soon as the program halts at the breakpoint for the first time.

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

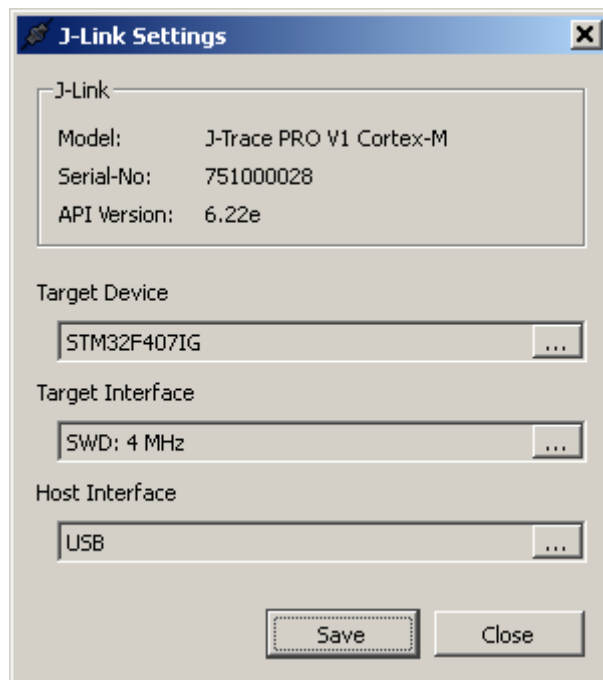
An integer-type or boolean-type symbol expression that must be met in order for program execution to halt at the breakpoint. When option "trigger when true" is selected, the expression must evaluate to a non-zero value in order for the breakpoint to be triggered. When option "trigger when changed" is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

Extra Actions

Specifies the additional actions that are performed when the breakpoint is hit. The provided options are a text message that is printed to the Console Window, a message that is displayed within a popup dialog and a script function that is executed.

3.11.5 J-Link Settings Dialog

The J-Link-Settings-Dialog allows users to configure J-Link related settings, such as the target model and the debugging interface. Please refer to *Project Wizard* on page 31 for further details on these settings.



J-Link Settings Dialog

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 user action `Tools.JLinkSettings` (see *Tools.JLinkSettings* on page 202).

3.11.5.2 Applying Changes

Save

By clicking the save button, the selected J-Link settings are written as Ozone API commands to the project file and thereby applied persistently.

Close

By clicking the close button, the selected J-Link settings are applied to the current session only.

3.11.6 Generic Memory Dialog

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

- Dump target memory data to a binary file
- Download data from a binary file to target memory
- Fill a target 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

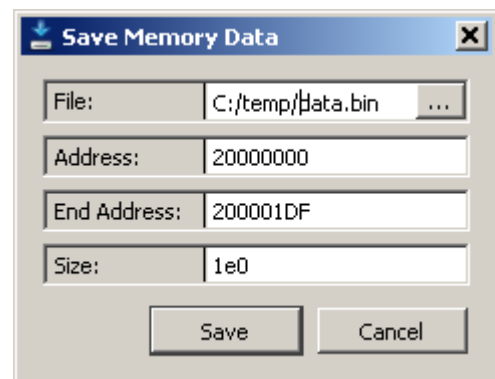
In its first application, the Generic Memory Dialog is used to save target memory data to a binary file.

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 addresses 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 target memory.

File

The binary file (*.bin) whose contents are to be written to target 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.

End Address / Size

The number of bytes that should be written to target 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

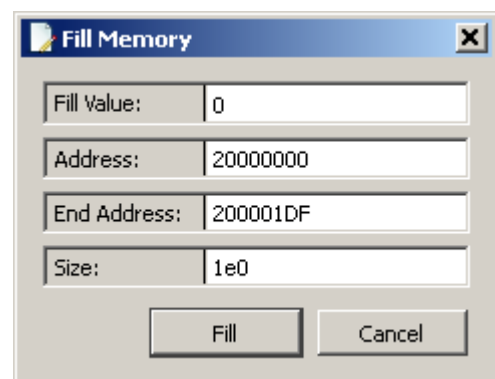
The fill value.

Address

The start and end addresses (inclusive) of the memory area.

End Address / Size

The size of the memory area.



3.11.7 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* below).

Look In

Specifies the search location. The search location defines the source code documents that are to be included in the search (see *Search Locations* on page 62).

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 is displayed within the Find Results Window.

Find All

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

Find Next

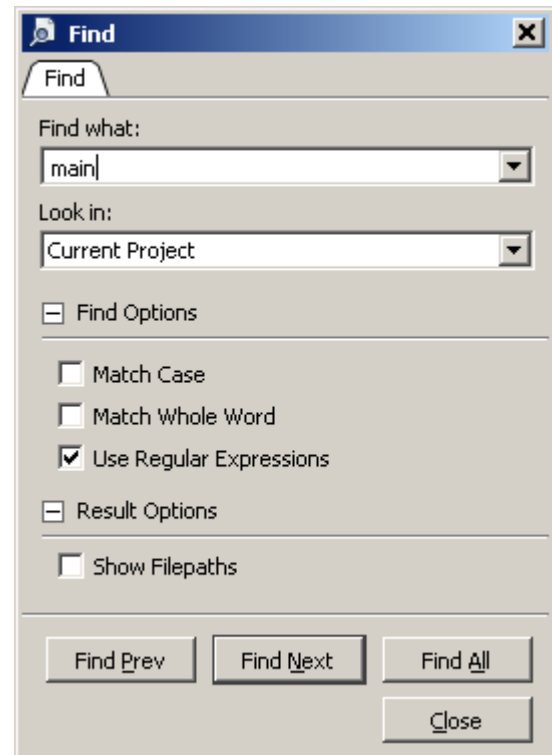
Finds the next occurrence of the search pattern in the selected search location. When a match is found, it is highlighted within the Source Viewer. After closing the find dialog, the next occurrence of the search pattern can still be located using hotkey F3.

Find Prev

Finds the previous occurrence of the search pattern in the selected search location. When a match is found, it is highlighted within the Source Viewer. After closing the find dialog, the next occurrence of the search pattern can still be located using the hotkey Shift+F3.

Close

Closes the dialog.



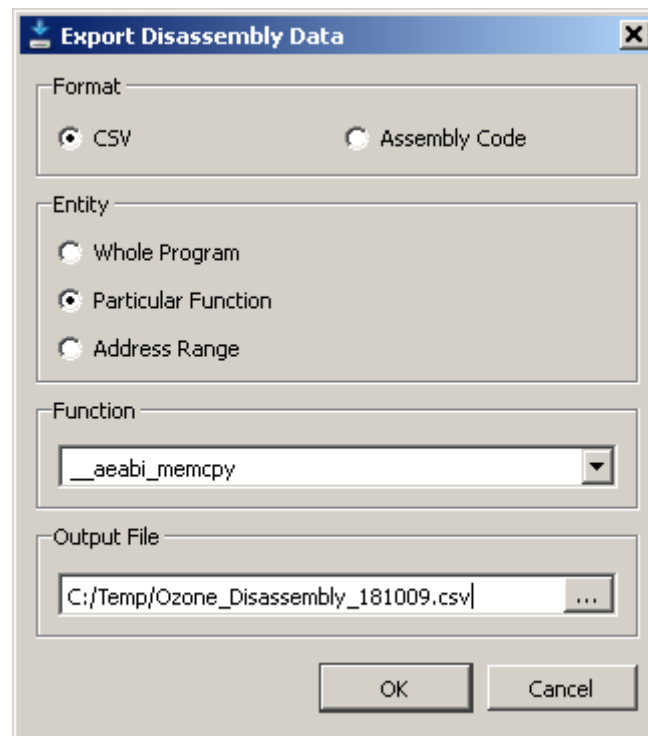
3.11.7.1 Search Locations

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 debuggee.

3.11.8 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 and assembly code files.



Disassembly Export Dialog

CSV

Disassembly data is exported in CSV format.

Assembly Code

Disassembly data is exported to a single recompilable GNU-syntax assembly code file.

Entity/Function

Selects the address range to be exported.

3.11.8.1 Exemplary Output

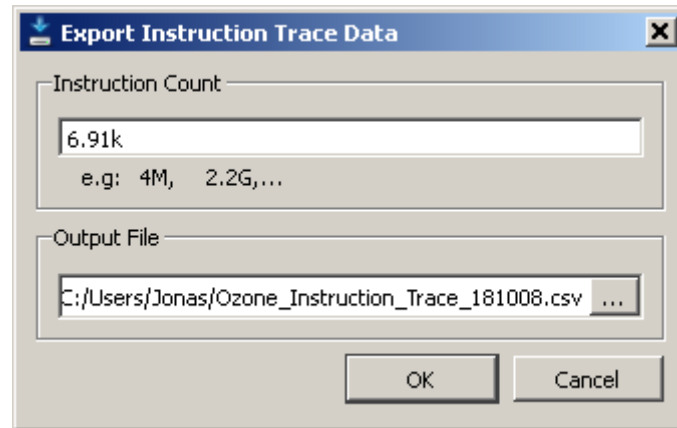
Shown below is an excerpt of a CSV file that was generated using the Disassembly Export Dialog.

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 = &_SEC
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		

CSV content generated by the Disassembly Export Dialog

3.11.9 Instruction Trace Export Dialog

The Instruction Trace Export Dialog is provided to save the current instruction trace record to a CSV file.



Instruction Trace Export Dialog

Instruction Count

Maximum amount of instructions to export.

Output File

Output file.

3.11.9.1 Exemplary Output

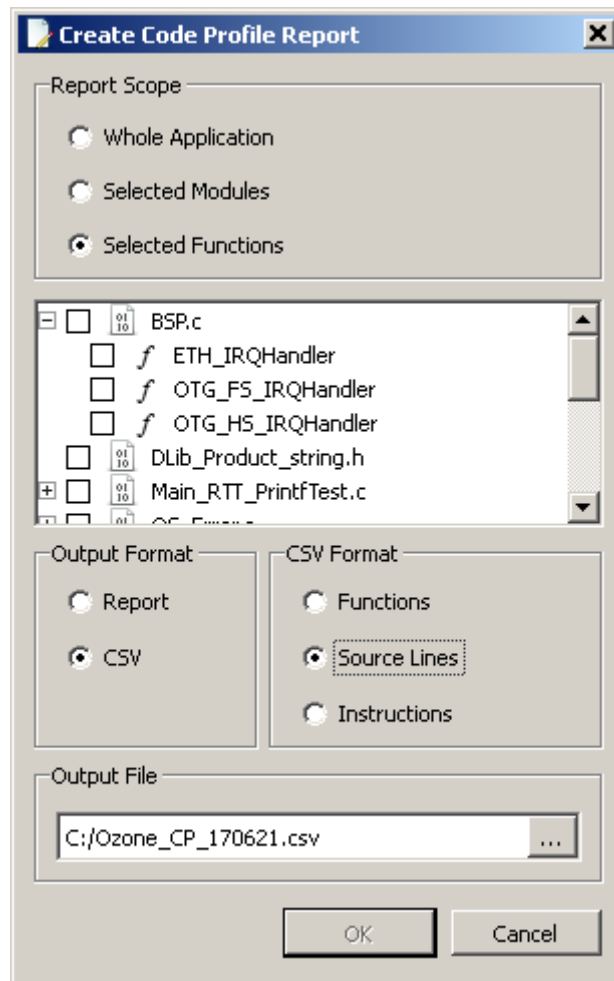
Shown below is an excerpt of a CSV file that was generated using the Instruction Trace Export Dialog.

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 = &_SEC
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		

CSV content generated by the Instruction Trace 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 77).



Code Profile Export Dialog

Report Scope

Program scope to be covered by the output file.

Tree View

Allows users to define the report scope by selecting the files and functions to be 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.

CSV Format

Available when output file format is "CSV". Specifies which program entities within the selected report scope are to be exported. For example, if the report scope contains a single file and the selected CSV format is "Instructions", then a code profile report about all instructions within the selected file is generated.

Output File

Output file path.

3.11.10.1 Code Profile Report

Shown below is the content 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%

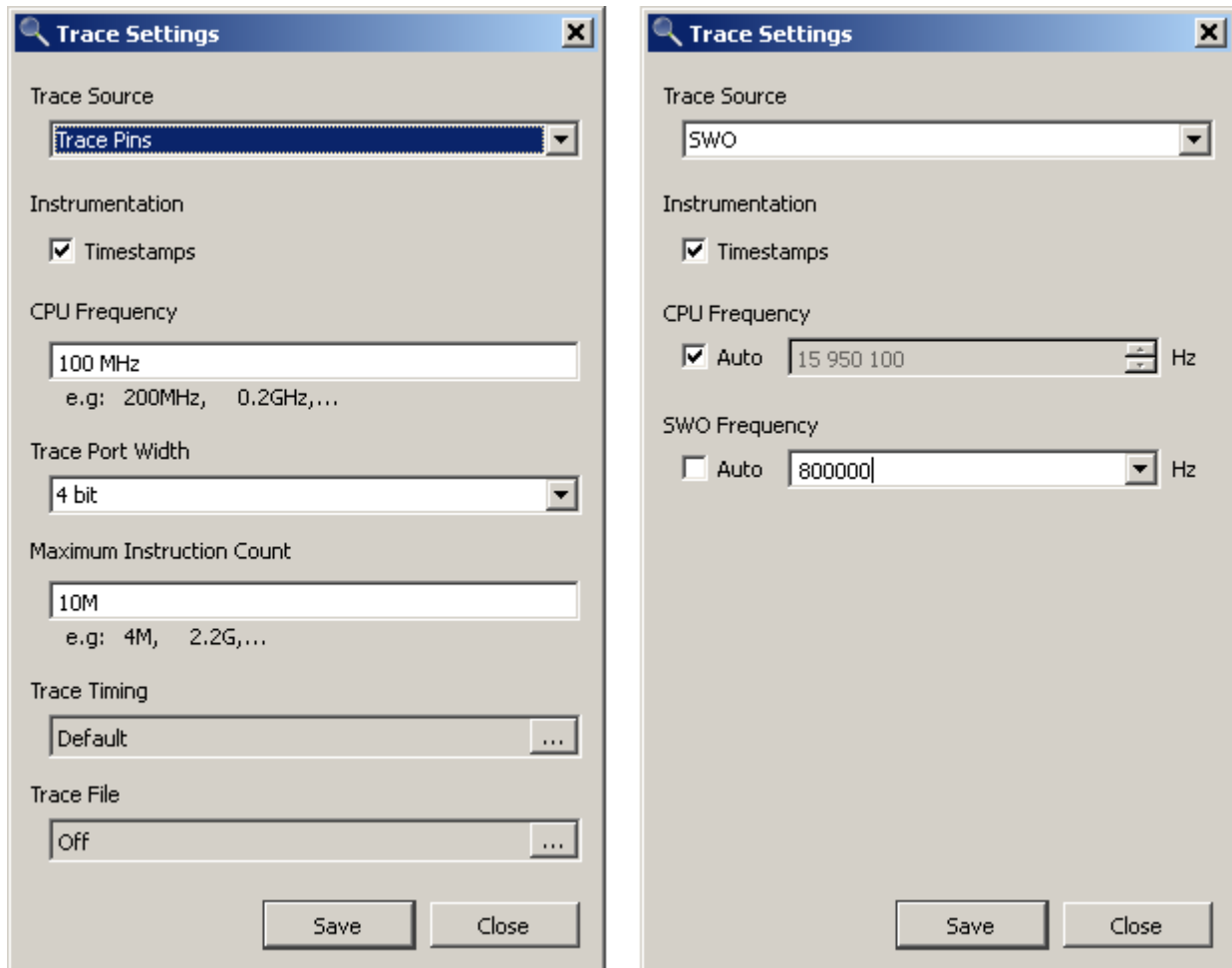
Code Profile Summary

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

Code Profile Report Example

3.11.11 Trace Settings Dialog

The Trace Settings Dialog allows the user to configure the available trace data channels.



Trace Settings Dialog

Trace Source

Selects the trace data channel to be used:

Trace Source	Description
Trace Pins	Instruction Trace (ETM) data is read realtime-continuously from the target's trace pins and supplied to Ozone's Trace Windows. This option requires a J-Trace debug probe to be employed (see <i>Streaming Trace</i> on page 147).
Trace Buffer	Instruction Trace (ETM) data is read from the target's trace data buffer and supplied to Ozone's Trace Windows.
SWO	"Printf-type" textual application (ITM) data is read via the SWO channel and supplied to Ozone's <i>Terminal Window</i> on page 123.

For detailed information on ETM and ITM trace and how to set up your hardware and software accordingly, please consult the [J-Link User Guide](#).

Note

The simultaneous use of multiple trace data channels in Ozone is currently not supported.

Timestamps

Specifies if the target is to output cycle counters (instruction execution timestamps) multiplexed with the pin trace. The cycle counters are employed by various debug windows to present users with information about the CPU time spend inside different program entities. Trace timestamps can also be enabled from inside script functions via command *Edit.SysVar* on page 203 using argument `VAR_TRACE_TIMESTAMP_ENABLED`.

CPU Frequency

Specifies the constant conversion factor to use when converting cycle counters to time values and vice versa.

Trace Port Width

Specifies the number of trace pins comprising the target's trace port (see *Project.SetTracePortWidth* on page 226).

Maximum Instruction Count

The maximum number of instructions that are read from the selected trace source before readout is stopped.

Trace Timing

Specifies the software delays to be applied to the individual trace port data lines. This essentially performs a software phase correction of the trace port's data signals (see *Project.SetTraceTiming* on page 226).

Trace File

When set, all trace data that was read out from the target is exported to the specified file. (see *Project.SetTraceFile* on page 226).

SWO Clock

Specifies the signal frequency of the SWO trace interface in Hz. (see *Project.ConfigSWO* on page 227).

CPU Clock

Specifies the core frequency of the target in Hz. (see *Project.ConfigSWO* on page 227).

3.11.11.1 Opening the Trace Settings Dialog

The Trace Settings Dialog can be opened from the Main Menu (Edit → Trace Settings) or by executing user action *Tools.TraceSettings* (see *Tools.TraceSettings* on page 202).

3.11.11.2 Applying Changes

Save

By clicking the save button, the selected trace settings are written as Ozone API commands to the project file and thereby applied persistently.

Close

By clicking the close button, the selected trace settings are applied to the current session only.

3.12 Application Messages

This section provides a brief description of Ozone's application message and user notification system.

3.12.1 Message Format

The format of Ozone application messages is:

```
<type>(<code>): <message>
```

where <type> is either error, warning or info and <code> is a unique message number.

3.12.2 Message Codes

Ozone partitions message numbers into groups, depending on the origin and type of the message. As an example, warning messages emitted from the ELF parser start at code 1000.

Section *Errors and Warnings* on page 185 lists all user-visible application exceptions by their code and provides an overview of the cause and possible solutions to each exception.

3.12.3 Logging Sinks

Application messages are output to any of the following destinations:

- Ozone's Console Window
- Debug Console
- Application Logfile

Application messages printed to the Console Window have the highest priority and become immediately noticeable to the user.

The allocation of message types to logging sinks is depicted in the table below.

Message Type	Ozone Console	Debug Console	Logfile
Error	x	x	x
Warning (important)	x	x	x
Info (important)	x	x	x
Warning		x	x
Info		x	x

3.12.4 Debug Console

When Ozone is started with command line argument *-debug*, a debug console will open next to the Main Window. The debug console displays all application messages of lower significance that would otherwise only be visible to the software developer.

3.12.5 Application Logfile

The global logfile storing all application messages is disabled per default. It can be enabled via command line argument *-logfile <path>* (see *Command Line Arguments* on page 180).

3.12.6 Other Logfiles

Messages output to the Console Window or Terminal Window can additionally be logged to a separate logfile (see *Project.SetConsoleLogFile* on page 231 and *Project.SetTerminalLogFile* on page 231).

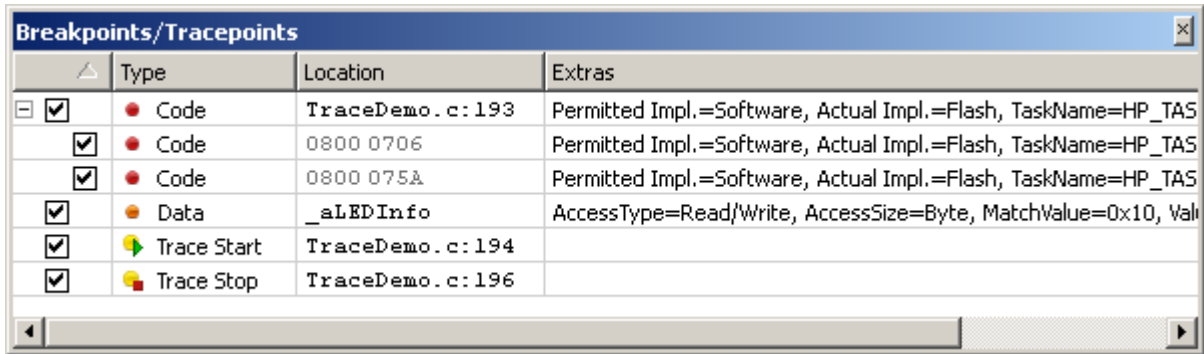
Chapter 4

Debug Information Windows

This chapter provides individual descriptions of Ozone's 22 debug information windows, starting with the Breakpoint Window.

4.1 Breakpoints/Tracepoints Window

Ozone's Breakpoints/Tracepoints Window lists all breakpoints, data breakpoints and tracepoints that have been set by the user during the current debug session.



For reasons of simplicity, the terms breakpoint and tracepoint are used interchangeably in this section.

4.1.1 Breakpoint Properties

The Breakpoint Window displays the following information about breakpoints:

Column	Description
State	Indicates if the breakpoint is enabled or disabled.
Type	One of CODE, DATA, TRACE_START and TRACE_STOP.
Location	Source line or instruction address location.
Extras	Lists all advanced breakpoint properties that are set to non-default values. Advanced breakpoint properties are summarized in <i>Advanced Breakpoint Properties</i> on page 142 and <i>Data Breakpoint Attributes</i> on page 144. Tracepoints do not carry advanced properties.

4.1.2 Derived Breakpoints

Source breakpoints can be expanded in order to reveal their derived instruction breakpoints (see *Derived Breakpoints* on page 71).

4.1.3 Breakpoint Dialog

The breakpoint dialog allows users to place breakpoints on:

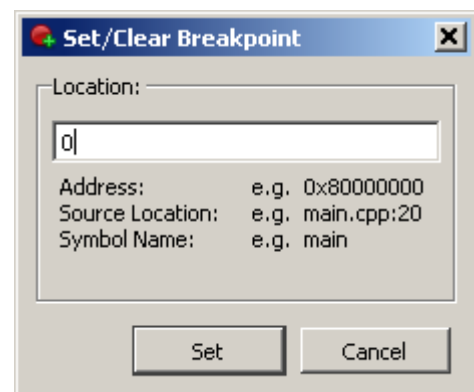
- Memory addresses of machine instructions
- Source code lines
- Functions and other code symbols such as assembly code labels

Source Line Input

Source code lines are specified in a predefined format (see *Source Code Location Descriptor* on page 168).

Opening the Breakpoint Dialog

The Breakpoint Dialog can be accessed via the context menu of the Breakpoint Window.



4.1.4 Editing Breakpoints Programmatically

Ozone provides multiple user actions that allow users to edit breakpoints inside script functions or at the command prompt (see *Breakpoint Actions* on page 190 and *Trace Actions* on page 194).

4.1.5 Context Menu

The Breakpoint Window's context menu hosts the following actions (see *Breakpoint Actions* on page 190):

Clear

Clears the selected breakpoint.

Enable / Disable

Enables or disables the selected breakpoint.

Edit

Edits advanced properties of the selected Breakpoint such as its trigger condition (see *Breakpoint Properties Dialog* on page 58).

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 assembly code line associated with the selected breakpoint.

Set Breakpoint...

Opens the Breakpoint Dialog (see *Breakpoint Dialog* on page 71).

Set Data Breakpoint...

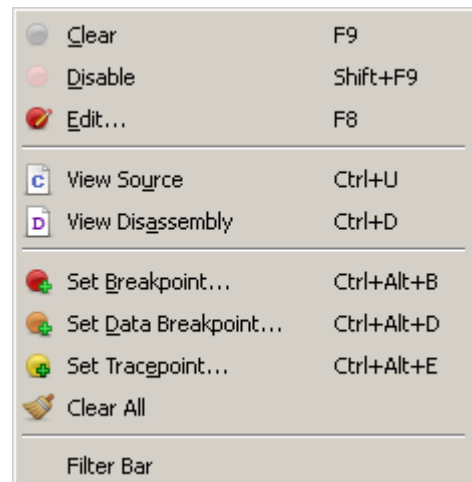
Opens the Data Breakpoint Dialog (see *Data Breakpoint Dialog* on page 57).

Set Tracepoint...

Opens the Tracepoint Dialog.

Clear All

Clears all breakpoints.



4.1.6 Offline Breakpoint Modification

Breakpoints can be modified even when the target connection was not yet established.

4.1.7 Table Window

The Breakpoint Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 49).

4.2 Call Graph Window

Ozone's Call Graph Window informs about the application's function call paths and stack usage.

Call Graph					
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

4.2.1 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.

4.2.2 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.

4.2.3 Table Window

The Call Graph Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 49).

4.2.4 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 for the uncertainty. R stands for recursion and FP stands for function pointer call.

4.2.5 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 74).

4.2.6 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. A function pointer call is indicated by the display name "<fp-call>".

4.2.7 Context Menu

View Call Site

Displays the call location of the selected function within the Source Viewer (see *Source Viewer* on page 118). 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 118).

Show path with max stack usage

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

Group By Root Functions




Indicates if the top-level shows root functions only, i.e. functions that are not called by any other functions. If unchecked, the top level shows all program functions.

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
<input checked="" type="checkbox"/>	Group By Root Functions	Ctrl+R
<input checked="" type="checkbox"/>	Group Callees	Ctrl+G
<input checked="" type="checkbox"/>	Filter Bar	
	Collapse All	Alt+-

4.2.8 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).

4.3 Call Stack Window

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

Call Stack				
Function	Stack Info	Source	PC	Return Address
→ _Delay	16 @ 2000 F608	LCDConf.c:837	0806 76DC	R14: 0806 7968
_Init9325	8 @ 2000 F618	LCDConf.c:939	0806 7964	[2000F61C]: 0806 7B04
_InitController	16 @ 2000 F620	LCDConf.c:1005	0806 7B00	[2000F62C]: 0806 7BD0
LCD_X_DisplayDriver	32 @ 2000 F630	LCDConf.c:1089	0806 7BCC	[2000F64C]: 0804 CDA8
_GetDevFunc_Init	0 @ 2000 F650		0804 CDA4	<no symbols>
Top of stack - No unwinding symbols at 0x0804CDA4				

4.3.1 Overview

The topmost entry of the Call Stack Window informs about the current program execution point. Each of the other entries displays information about a previous program execution point. As an example consider the illustration above. Here, the fourth row describes the program context that was attained when the PC was within function `LCD_X_DisplayDriver` on the instruction that called function `_InitController`.

4.3.2 Table Columns

The Call Stack Window partitions program execution point information into 5 columns:

Table Column	Description
Function	The calling function's name.
Stack Info	Size and position of the stack frame of the calling function.
Source	Source code location of the function call.
PC	Instruction address of the function call (call site PC).
Return Address	PC that will be attained when the program returns from the function call. This field is actually displayed as "location:value", where "location" is the target data location of the return address.

Note

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.

4.3.3 Unwinding Stop Reasons

The reason why call stack unwinding stopped is displayed at the bottom of the stack. Section *Errors and Warnings* on page 185 gives possible causes of, and solutions to, incomplete call stacks.

4.3.4 Active Call Frame

By selecting a table row within the Call Stack Window, the affiliated call frame becomes the active program execution point context of the debugger. At this point, the Register and Local Data Windows display content no longer for the current PC, but for the active call frame. The active frame can be distinguished from the other frames in the call stack by its color highlight.

4.3.5 Context Menu

The Call Stack Windows's context menu hosts actions that navigate to a call site's source code or assembly code line (see *View Actions* on page 195).

View Source

Displays the selected call site within the Source Viewer (see *Source Viewer* on page 118). This action can also be triggered by double-clicking a table row.

View Disassembly

Displays the selected call site within the Disassembly Window (see *Disassembly Window* on page 89).

Current Frame On Top

Selects the ordering of the frames on the call stack.

4.3.6 User Preferences

The table below lists all users preferences pertaining to the call stack (see *Edit.Preference* on page 203).

User Preference	Description
PREF_CALLSTACK_LAYOUT	Specifies if the current frame is displayed at the top or at the bottom of the call stack (see <i>User Preference Identifiers</i> on page 175).
PREF_CALLSTACK_DEPTH_LIMIT	Selects the maximum amount of frames the call stack can hold.

4.3.7 Table Window

The Call Stack Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 49).

4.4 Code Profile Window

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

Code Profile						
File / Function	Source Coverage ▾	Inst. Coverage	Run Cour	Load		
+ f SystemInit	100.0% (11/11)	✓ 100.0% (36/36)	1	✓ 0.00%		
+ f Reset_Handler	100.0% (5/5)	✓ 100.0% (5/5)	1	✓ 0.00%		
+ f SEGGER_RTT_printf	100.0% (3/3)	✓ 100.0% (8/8)	1 082	✓ 1.02%		
+ f main	98.7% (78/79)	✓ 99.7% (310/311)	1	✓ 1.47%		
+ f SEGGER_RTT_vprintf	84.1% (58/69)	✓ 92.9% (236/254)	1 082	✓ 96.79%		
- f SEGGER_RTT_WriteString	81.8% (9/11)	✓ 82.4% (14/17)	3	✓ 0.09%		
+ c 165: Len = 0;	100.0% (1/1)	✓ 100.0% (2/2)	3	✓ 0.00%		
- c 166: if (s == NULL) {	0.0% (0/1)	✓ 50.0% (1/2)	3	✓ 0.00%		
0800 0792 CMP R3, #0	N/A	✓ 100.0% (1/1)	3	✓ 0.00%		
0800 0794 BNE <_strlen>+0	N/A	✓ 0.0% (0/1)	3	✓ 0.00%		
+ c 167: return 0;	0.0% (0/1)	✓ 0.0% (0/2)	0	✓ 0.00%		
+ c 170: if (*s == 0) {	100.0% (1/1)	✓ 100.0% (3/3)	121	✓ 0.04%		
+ c 173: Len++;	100.0% (1/1)	✓ 100.0% (1/1)	118	✓ 0.01%		
+ c 174: s++;	100.0% (1/1)	✓ 100.0% (1/1)	118	✓ 0.01%		
+ c 175: } while (1);	100.0% (1/1)	✓ 100.0% (1/1)	118	✓ 0.01%		
+ c 176: return Len;	100.0% (1/1)	✓ 100.0% (1/1)	3	✓ 0.00%		
+ c 351: int SEGGER_RTT_WriteString(L	100.0% (1/1)	✓ 100.0% (1/1)	3	✓ 0.00%		
+ c 354: Len = _strlen(s);	100.0% (1/1)	✓ 100.0% (1/1)	3	✓ 0.00%		
+ c 355: return SEGGER_RTT_Write(Buf	100.0% (1/1)	✓ 100.0% (2/2)	3	✓ 0.00%		
+ f _PrintUnsigned	78.8% (26/33)	✓ 93.1% (94/101)	1 086			

4.4.1 Setup

Section *Setting Up Trace* on page 152 explains how to configure Ozone and the hardware setup for instruction trace, thereby enabling the Code Profile Window.

4.4.2 Code Statistics

The Code Profile Window displays 4 different code statistics about program entities. A program entity is either a source file, a function, an executable source line or a machine instruction. Table items can be expanded to show the contained child entities.

Instruction Coverage

Amount of machine instructions of the program entity that have been covered since code profile data was reset. A machine instruction is considered covered if it has been "fully" executed. In the case of conditional instructions, "full execution" means that the condition was both met and not met. In the title figure, 99.7% or 310 of 311 machine instructions within function main were covered.

Source Coverage

Amount of executable source code lines of the program entity 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 fully executed. In the title figure, 98.7% or 78 of 79 executable source codes lines within function main were covered.

Run Count

Amount of times a program entity was executed since code profile data was reset.

Load

Amount of instruction fetches that occurred within the program entities address range divided by the total amount of instruction fetches that occurred since code profile data was reset.

Fetch Count

Amount of instruction fetches that occurred within the address range of the program entity.

4.4.3 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 78.

4.4.4 Table Window

The Code Profile Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 49).

4.4.5 Filters

Individual program entities can be filtered from the code profile statistic. In particular, there are two different type of filters that can be applied to program entities, as described below.

Profile Filter

When a profile filter is set on a program entity, its CPU load is filtered from the code profile statistic. After filtering, the load column displays the distribution of the remaining CPU load across all none-filtered program entities.

Coverage Filter

When a coverage filter is set on a program entity, its code coverage value is filtered from the code profile statistic. After filtering, the code coverage columns displays coverage values computed as if the filtered program entities do not exist.

4.4.5.1 Adding and Removing Profile Filters

A profile filter can be set and removed via user actions Profile.Exclude and Profile.Include (see *Code Profile Actions* on page 190). In Addition, the load column of the Code Profile Window provides a checkbox for each item that allows users to quickly set or unset the filter on the item.

4.4.5.2 Adding and Removing Coverage Filters

A coverage filter can be set and removed via user actions Coverage.Exclude and Coverage.Include (see *Code Profile Actions* on page 190). In Addition, the code coverage columns of the Code Profile Window provide a checkbox for each item that allows users to quickly set or unset the filter on the item.

4.4.5.3 Filtering Code Alignment Instructions

Compilers may place alignment instructions into program code that have no particular operation and do never get executed. These so-called NOP-instructions can be filtered from the code coverage statistic via context menu entry "Filter All NOP Instructions" or programmatically via user action Coverage.ExcludeNOPs (see *Coverage.ExcludeNOPs* on page 233).

4.4.5.4 Observing the List of Active Filters

The *Code Profile Filter Dialog* can be accessed from the context menu and displays all filters that were set, alongside the affiliated user action commands that were executed.

4.4.6 Context Menu

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

View Source

Displays the selected item within the Source Viewer (see *Source Viewer* on page 118).

View Disassembly

Displays the selected item within the Disassembly Window (see *Disassembly Window* on page 89).

Include/Exclude from

Filters or unfilters the selected item from the load, code coverage or both statistics.

Exclude All NOP Instructions

Excludes all “no operation” (code alignment) instructions from the code coverage statistic.

Exclude (Dialog)

Moves multiple items to the filtered set (see *Profile.Exclude* on page 232).

Include (Dialog)

Removes multiple items from the filtered set (see *Profile.Include* on page 232).

Remove All Filters

Removes all filters.

Show Filters

Opens a dialog that displays an overview of the currently active filters.

Reset Execution Counters

Resets all execution counters (see *Execution Counters* on page 78).

Show Execution Counters in Source

Displays execution counters within the Source Viewer (see *Source Viewer* on page 118).

Show Execution Counters in Disassembly

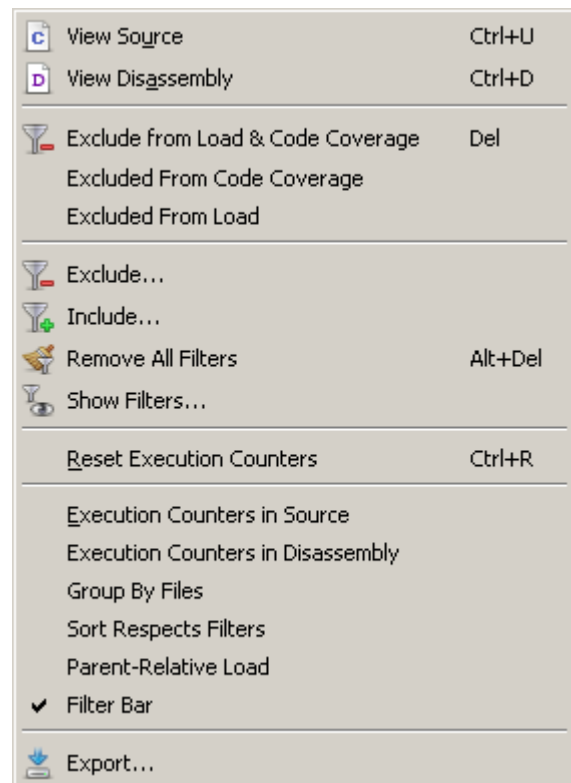
Displays execution counters within the Disassembly Window (see *Disassembly Window* on page 89).

Group by Files

Groups all functions into expandable source file nodes.

Sort Respects Filters

When this option is checked, filtered items are moved to the bottom of the table.



Parent Relative Load

When this option is checked, the CPU load of a table item is calculated as the total amount of instructions executed within the item divided by the total amount of instructions executed within the parent item. Otherwise, the total amount of instructions executed is used as the divisor.

Export

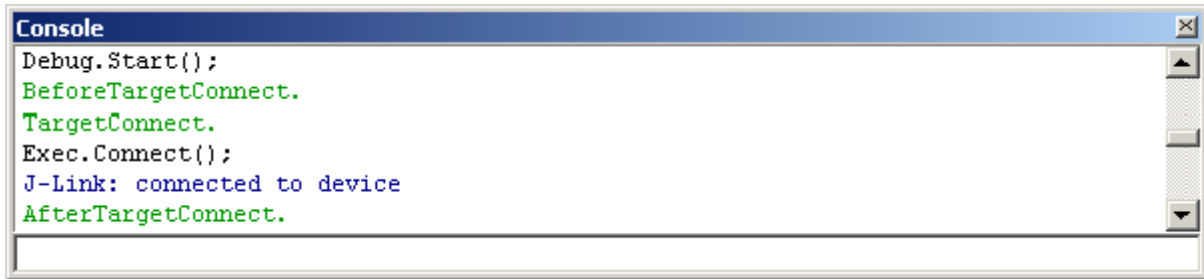
Opens the Code Profile Report Dialog (see *Code Profile Report Dialog* on page 65).

4.4.7 Selective Tracing

Ozone can instruct the target to constrain trace data output to individual address ranges (see *Tracepoints* on page 154). When selective tracing is active, it acts as a hardware prefilter of code profile data.

4.5 Console Window

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



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 35). 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 35 – 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.
```

4.5.3 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 213).

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

4.5.4 Message Colors

Messages printed to the Console Window are colored according to their type. The message colors can be adjusted via user action Edit.Color (see *Edit.Color* on page 204) or via the User Preference Dialog (see *User Preference Dialog* on page 52).

4.5.5 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

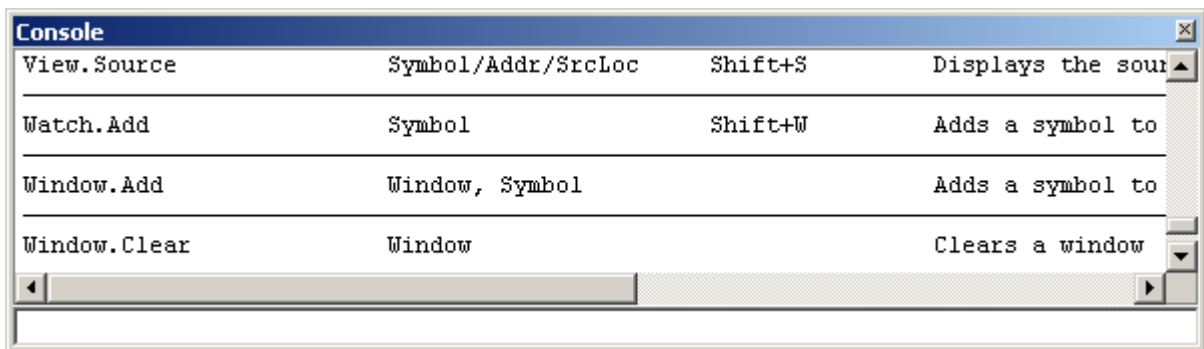
Clears the Console Window.

Commands

Prints the command help.

4.5.6 Command Help

When 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 220). The command help can be triggered from the Console Window's context menu or from the main menu (`Help → Commands`).



View.Source	Symbol/Addr/SrcLoc	Shift+S	Displays the source
Watch.Add	Symbol	Shift+W	Adds a symbol to
Window.Add	Window, Symbol		Adds a symbol to
Window.Clear	Window		Clears a window

Command help displayed within the Console Window

4.6 Data Graph Window

Ozone's Data Graph Window traces the values of expressions over time (see *Expressions* on page 181).

4.6.1 Overview

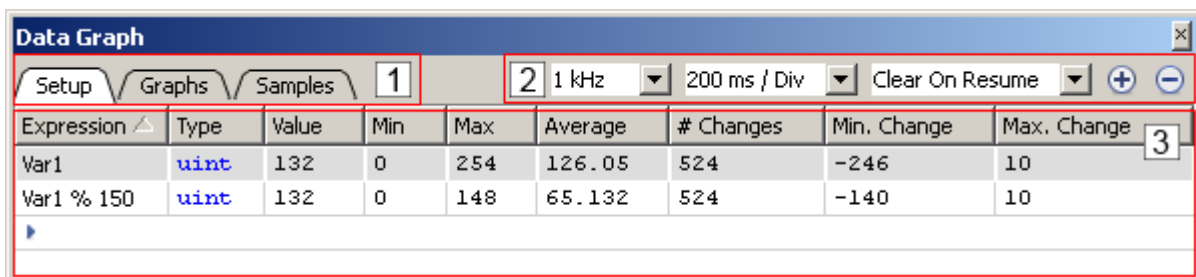
The Data Graph Window employs J-Link's High-Speed Sampling (HSS) API to trace the values of user-defined expressions at time resolutions of up to 1 microseconds. The sampling of expressions starts automatically each time the program is resumed and stops automatically each time the program halts. Users 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 Guide*.

4.6.2 Requirements

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

4.6.3 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 tab bar (1). In addition, a toolbar (2) is provided that provides quick access to the most important window settings.



4.6.4 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 181). An expression can be added to the list in any of the following ways:

- via context menu entry *Add Symbol*.
- via user action *Window.Add* (see *Window.Add* on page 207).
- 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 Setup View.

and removed from the list via:

- context menu entry *Remove*.
- user action *Window.Remove* (see *Window.Remove* on page 208).

A graphed expression must satisfy the following constraints:

- the expression must evaluate to a numeric value of size less or equal to 8 bytes.
- all symbol operands of the expression must be either static variables or constants.

4.6.4.1 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.

4.6.4.2 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

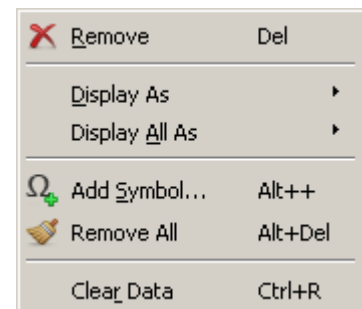
Opens an input box that lets users add an expression to the window.

Remove All

Removes all expression from the window.

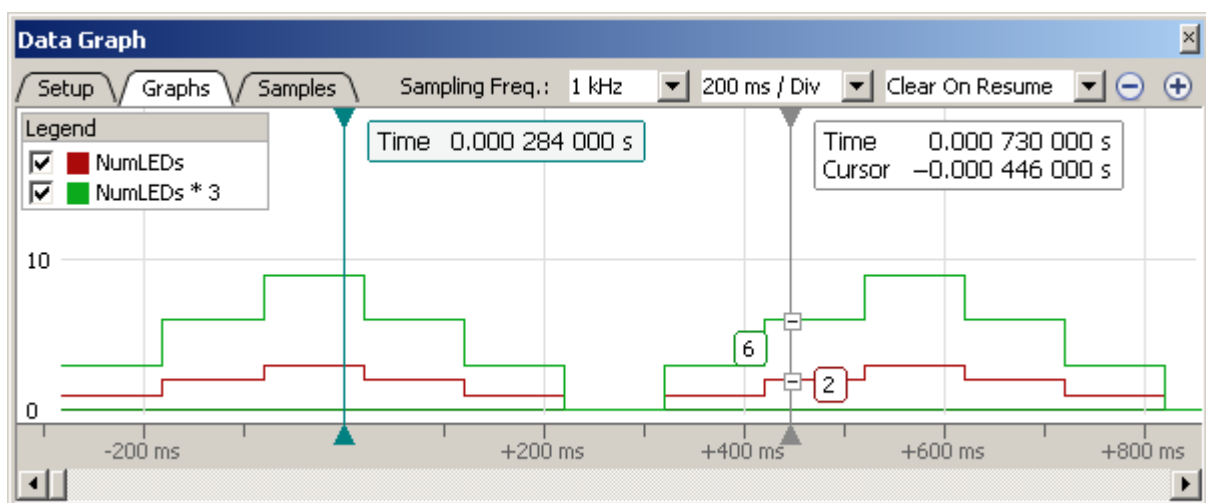
Clear Data

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



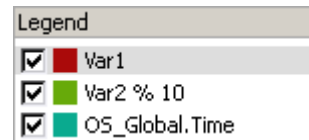
4.6.5 Graphs View

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 on a broad and on a narrow time scale.



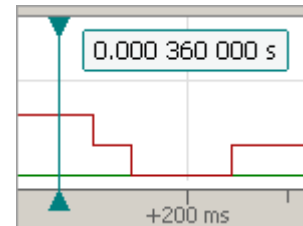
4.6.5.1 Plot Legend

The plot legend links each graph to the 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.



4.6.5.2 Sample Cursor

The origin of the timescale is attached to the sample cursor. The sample cursor also marks the time position of the data sample that is currently selected within the Samples View (see *Samples View* on page 87). The sample cursor can be displaced by dragging it to a new position or double-clicking on the signal plot.

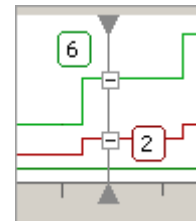


Pinned Sample Cursor

The sample cursor can be pinned to a fixed window position via context menu entry "Cursor". When pinned to the window, the sample cursor will always stay visible regardless of any view modification.

4.6.5.3 Hover Cursor

The hover cursor is a vertical line displayed below the mouse cursor that follows the movements of the mouse. At the intersection point of the hover cursor with each graph, a value box is displayed that indicates the graph's signal value at that position. Each value box has got an expansion indicator that can be clicked to show or hide the value box.



4.6.5.4 Interaction

Timescale

The plot's timescale 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:

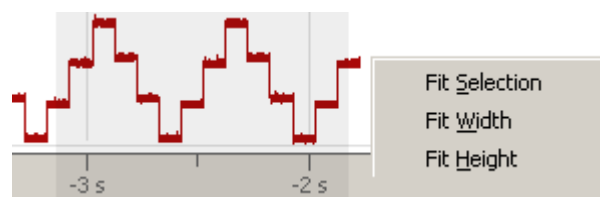
- by scrolling the mouse wheel up or down
- by using the drop-down list displayed within the toolbar
- by selecting a timescale via the context menu

Mouse Zooming

When the mouse wheel is scrolled, the plot scales around the position of the mouse cursor. Thus, by moving the mouse cursor to a plot position of interest and then scrolling the mouse wheel, users can quickly and precisely zoom into regions of the signal plot.

Selection Zooming

By holding down the right mouse button and moving the pointer, a selection rectangle is drawn. When a plot region was selected, the context menu entry "Fit Selection" can be used to fit the selected region into view.



Mouse Panning

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

Measuring Time Distances

A label is displayed next to the hover cursor that shows the time distance between the positions of the hover and the sample cursor. By first positioning the sample cursor on a point of interest and then moving the mouse cursor to another point of interest, the time distance between these two positions can be precisely measured.

Vertical Auto-Scale

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

Further interactive options are provided via the context menu, as summarized below.

4.6.5.5 Context Menu

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

Fit Width

Adjusts the timescale so that all graphs are visible and occupy the whole window width.

Fit Height

Adjusts the timescale so that all graphs are visible and occupy the whole window height.

Go To Cursor

Scrolls the Sample Cursor into view.

Go To Time

Opens a time input dialog that when accepted, sets the Sample Cursor to the given time and scrolls it into view.

Clear Data

Clears all sampling data, effectively resetting all graphs.

Cursor

Pins the sample cursor to a fixed window position or unpins it.

Sampling Frequency

The frequency at which all expressions are sampled (see *Sampling Frequency* on page 87).

Timescale

Timescale used to plot the graphs of expressions (see *Timescale* on page 87).

Clear Event

The debugging event upon which the signal plot is cleared (see *Clear Event* on page 88).

Draw Points

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

Fit <u>W</u> idth	Ctrl+W
Fit <u>H</u> eight	Ctrl+H
<u>G</u> o To Cursor	Ctrl+G
<u>G</u> o To Time...	Ctrl+G
<u>C</u> lear Data	Ctrl+R
<u>C</u> ursor	▶
<u>S</u> ampling Freq.	▶
<u>T</u> ime Scale	▶
<u>C</u> lear Event	▶
Draw <u>P</u> oints	
<u>U</u> niform Sample Spacing	
✓ <u>T</u> oolbar	

Uniform Sample Spacing

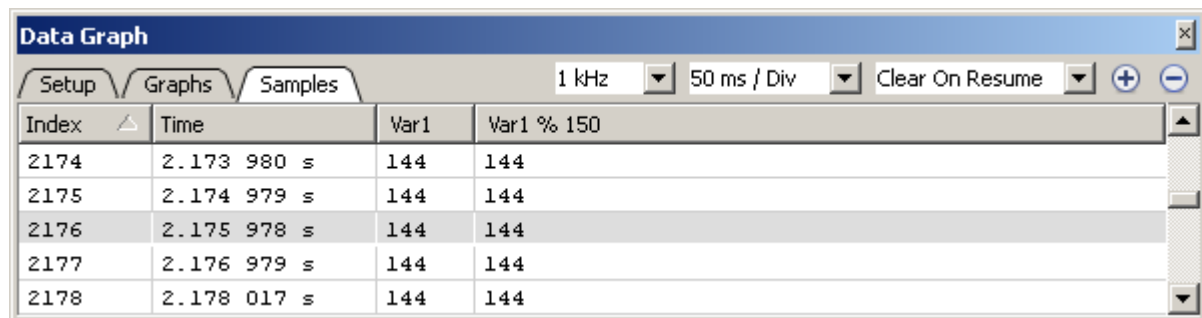
When checked, the timestamp of a graph sample is computed by multiplying the inverse of the sampling frequency with the sample index. When unchecked, the timestamp given by J-Link is used.

Toolbar

Toggles the toolbar.

4.6.6 Samples View

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

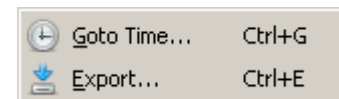


Index	Time	Var1	Var1 % 150
2174	2.173 980 s	144	144
2175	2.174 979 s	144	144
2176	2.175 978 s	144	144
2177	2.176 979 s	144	144
2178	2.178 017 s	144	144

The selected table row and the position of the Sample Cursor are automatically synchronized: changing one will also change the other.

4.6.6.1 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 sample cursor on a particular time position.

Export

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

4.6.7 Toolbar

The Data Graph Window's toolbar provides quick access to the most important window settings (see *Window Layout* on page 83). The settings affiliated with each toolbar element are described below, going from left to right on the toolbar.

4.6.7.1 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 56) or programmatically via user action `Edit.SysVar` (see *Edit.SysVar* on page 203).

4.6.7.2 Timescale

The timescale input box allows users to adjust the signal plot's x-axis scale. The timescale 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 timescale as well.

4.6.7.3 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

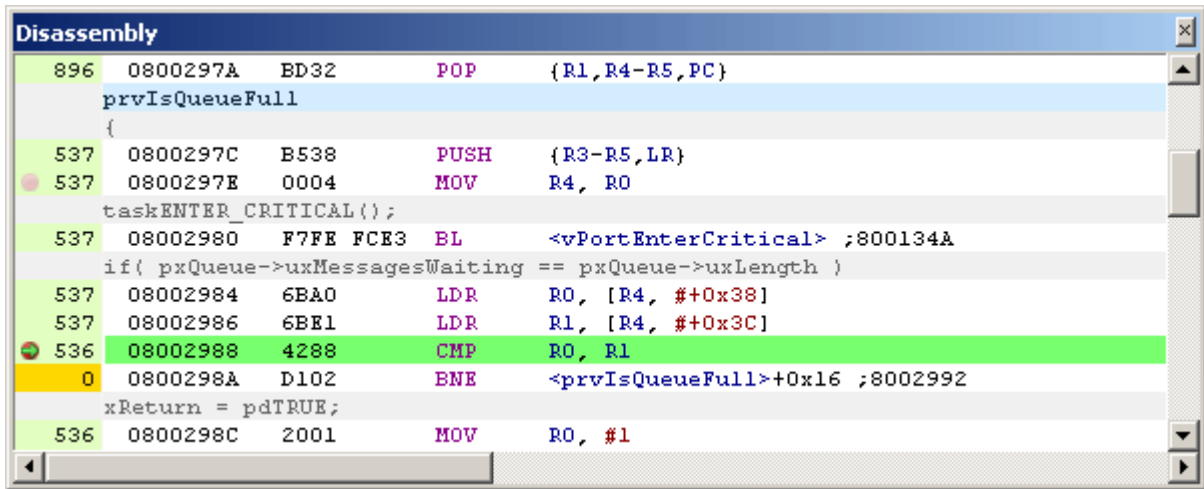
Sampling data is never cleared automatically.

4.6.8 Power Graph Synchronization

Ozone keeps the sample cursors of the Data Graph Window and the Power Graph Window synchronized at all times. This allows users to get a quick sense about which parts of program code use how much power (see *Cursor Synchronization* on page 111).

4.7 Disassembly Window

Ozone's Disassembly Window displays the assembly code interpretation of target 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.



4.7.1 Assembly Code

Each standard text line of the Disassembly Window displays information about a particular machine instruction. The instruction information is divided into 4 parts:

Address	Encoding	Mnemonic	Operand
0800297C	B538	PUSH	{R3-R5,LR}

Instruction Encoding

The encoding of a machine instruction is identical to the data stored at the instruction's memory address. It is possible to toggle the display of instruction encodings (see *Disassembly Window Settings* on page 53).

Syntax Highlighting

The Disassembly Window applies syntax highlighting to assembly code. The syntax highlighting colors can be adjusted via user action *Edit.Color* (see *Edit.Color* on page 204) or via the User Preference Dialog (see *User Preference Dialog* on page 52).

4.7.2 Execution Counters

Within its sidebar area on the left, the Disassembly Window displays the execution counts of individual instructions (see *Execution Counters* on page 89).

4.7.3 Base Address

The address of the first instruction displayed within the Disassembly Window is referred to as the window's base address.

4.7.3.1 Setting the Base Address

The base address of the Disassembly Window can be modified in any of the following ways:

- via context menu action *GoTo*.
- via user action *View.Disassembly* (see *View.Disassembly* on page 211).

Note that user action View.Disassembly is accessible from the context menus of most symbol windows.

4.7.3.2 Scrolling the Base Address

The base address of the Disassembly Window may be scrolled in any of the following ways:

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

4.7.4 Context Menu

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

Set/Clear/Edit Breakpoint

Sets/Clears or Edits a breakpoint on the selected machine instruction (see *Instruction Breakpoints* on page 142).

Set Tracepoint (Start/Stop)

Sets a tracepoint on the selected machine instruction (see *Tracepoints* on page 154).

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

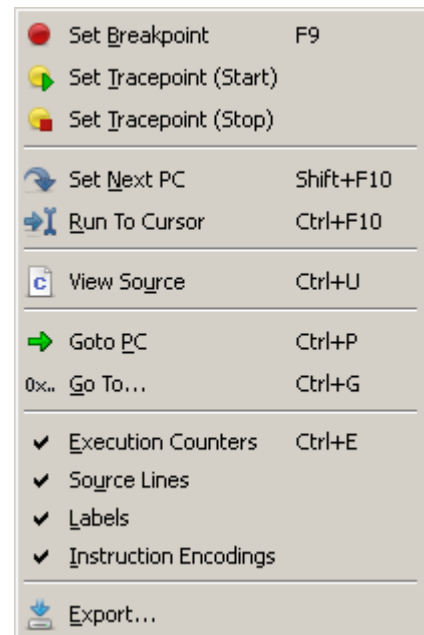
Scrolls the viewport to the PC line.

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 Execution Counters (see *Execution Counters* on page 89).



4.7.5 Offline Functionality

The disassembly window is functional even when Ozone is not connected to the target. In this case, machine instruction data is read from the program file. In fact, disassembly is only performed on target memory when the program file does not provided data for the requested address range.

4.7.6 Mixed Mode

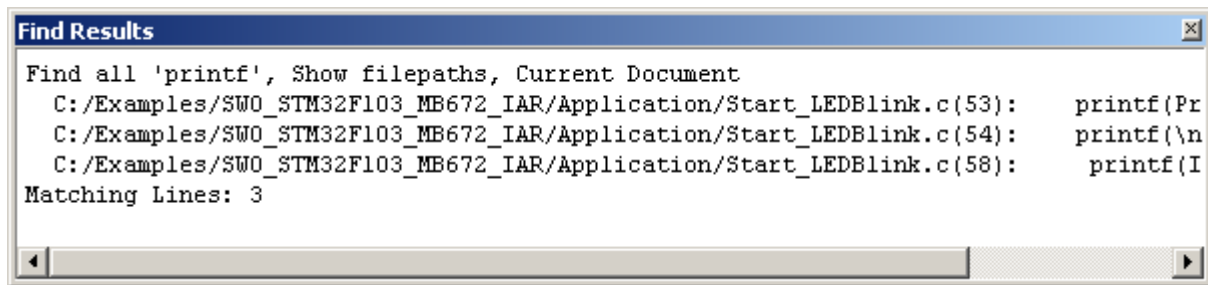
The Disassembly Window provides two display options – *Show Source* and *Show Labels* – that augment assembly code text lines with source code and symbol information, respectively. These display options can be adjusted via the context menu or the User Preference Dialog (see *User Preference Dialog* on page 52).

4.7.7 Code Window

The Disassembly Window shares multiple features with Ozone's second code window, the Source Viewer. Refer to Code Windows (see *Code Windows* on page 45) for a shared description of these windows.

4.8 Find Results Window

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



4.8.1 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.

4.8.2 Text Search

A new text pattern search is performed using the Find Dialog (see *Find Dialog* on page 61).

4.8.3 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

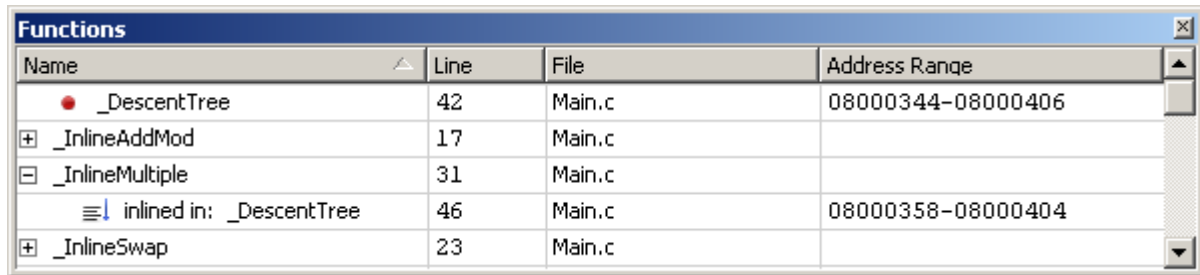
Selects all text lines.

Clear

Clears the Find Results Window.

4.9 Functions Window

Ozone's Functions Window lists all functions linked to assemble the debuggee, including functions implemented within external code.



Name	Line	File	Address Range
• _DescentTree	42	Main.c	08000344-08000406
+ _InlineAddMod	17	Main.c	
- _InlineMultiple	31	Main.c	
≡ inlined in: _DescentTree	46	Main.c	08000358-08000404
+ _InlineSwap	23	Main.c	

4.9.1 Function Properties

The Functions Window displays the following information about functions:

Table Column	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.

4.9.2 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 the figure above. Here, function `_InlineMultiple` has one expansion site: it is inline expanded within function `_DescentTree`.

4.9.3 Breakpoint Indicators

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

4.9.4 Context Menu

The Function Windows' context menu hosts actions that navigate to a function's source code or assembly code line (see *View Actions* on page 195).

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 (see *Source Viewer* on page 118). 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 (see *Disassembly Window* on page 89). If an inline expansion site is selected, this site's first machine instruction is displayed instead.

View Call Graph

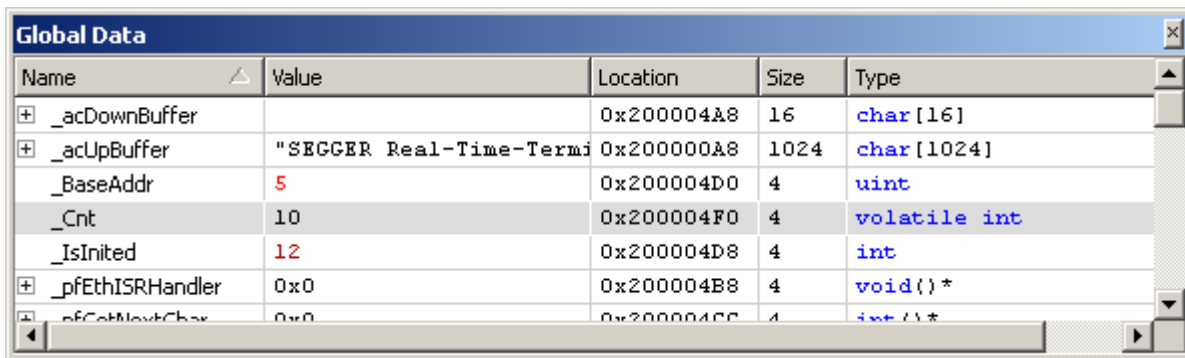
Displays the call graph of the function within the Call Graph Window (see *Call Graph Window* on page 73).

4.9.5 Table Window

The Function Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 49).

4.10 Global Data Window

Ozone's Global Data Window displays global program variables.



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()*
+ _pfCmNextChar	0x0	0x200004C0	4	int**

4.10.1 Data Breakpoint Indicator

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

4.10.2 Context Menu

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

Set/Clear Data Breakpoint

Sets or clears a data breakpoint on the selected global variable (see *Data Breakpoints* on page 144).

Edit Data Breakpoint

Opens the Data Breakpoint Dialog (see *Data Breakpoint Dialog* on page 57).

Watch

Adds the selected global variable to the Watched Data Window (see *Watched Data Window* on page 130).

View Source

Displays the source code declaration location of the selected global variable in the Source Viewer (see *Source Viewer* on page 118).

View Data

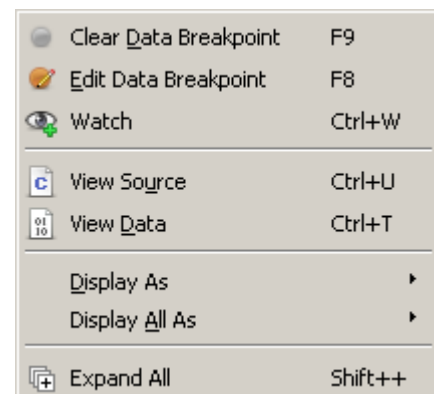
Displays the data location of the selected local variable in either the Memory Window (see *Memory Window* on page 104) or the Register Window (see *Register Window* on page 113).

Display (All) As

Changes the display format of the selected global variable or of all global variables (see *Display Format* on page 44).

Expand / Collapse All

Expands or collapses all top-level nodes.



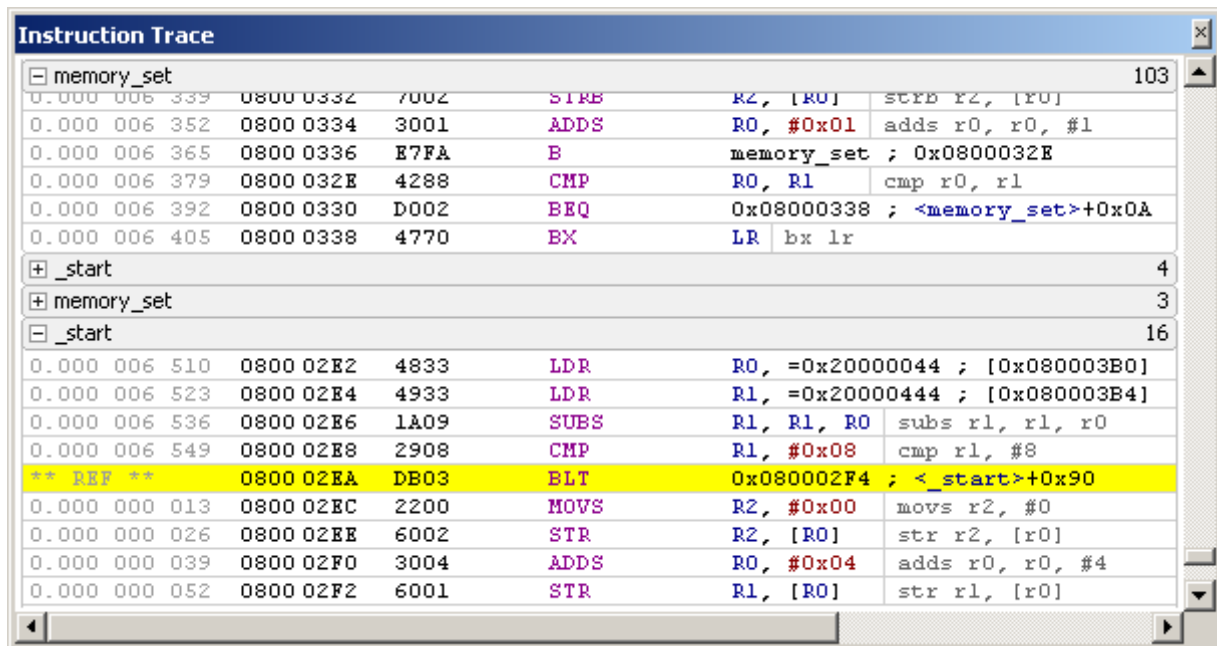
	Clear Data Breakpoint	F9
	Edit Data Breakpoint	F8
	Watch	Ctrl+W
	View Source	Ctrl+U
	View Data	Ctrl+T
	Display As	▶
	Display All As	▶
	Expand All	Shift++

4.10.3 Table Window

The Global Data Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 49).

4.11 Instruction Trace Window

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



4.11.1 Setup

Section *Setting Up Trace* on page 152 explains how to configure Ozone and the hardware setup for trace, thereby enabling the Instruction Trace Window.

4.11.2 Instruction Row

The information displayed within a single text line of the Instruction Trace Window is partitioned in the following way:

Timestamp	Address	Encoding	Mnemonic	Operands
0.000 100 005	0800297C	B538	PUSH	{R3-R5,LR}

4.11.3 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 rebuilt 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.

4.11.4 Call Frame Blocks

The instruction stack is partitioned into call frame blocks. Each call frame block contains the set of instructions that were executed between entry to and exit from a program function. Call frame blocks can be collapsed or expanded to hide or reveal the affiliated instructions. The number of instructions executed within a particular call frame block is displayed on the right side of the block's header.

4.11.5 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 user action *Edit.Color* (see *Edit.Color* on page 204) or via the User Preference Dialog (see *User Preference Dialog* on page 52).

4.11.6 Hotkeys

The Instruction Trace Window provides multiple hotkeys to navigate instruction rows. The table below gives an overview.

Hotkey	Function
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 call frame block.
Shift+Down	Selects and scroll to the first (bottommost) instruction of the currently selected call frame block.
PgUp	Scrolls one page up.
PgDn	Scrolls one page down.

4.11.7 Context Menu

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

Set / Clear Breakpoint

Sets or clears a breakpoint on the selected instruction.

Set Tracepoint (Start/Stop)

Sets a tracepoint on the selected machine instruction (see *Tracepoints* on page 154).

View Source

Displays the source code line associated with the selected instruction in the `bref{Source Viewer}`

View Disassembly

Displays the selected instruction in the Disassembly Window (see *Disassembly Window* on page 89)

Toggle Reference

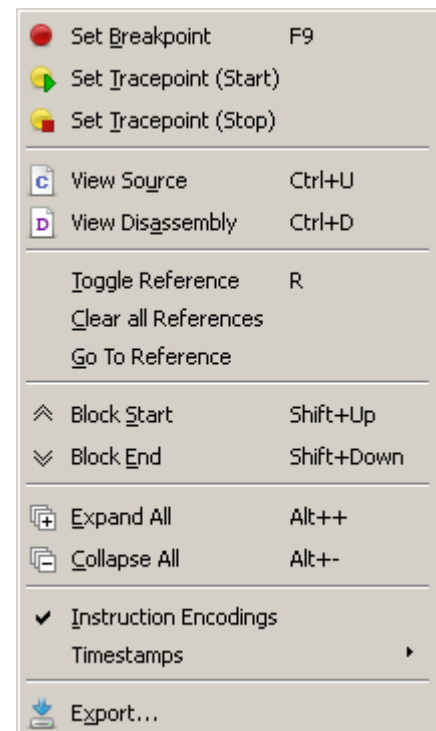
Toggles the time reference point on the selected instruction.

Go To Reference

Scrolls to the time reference point preceding the selected instruction.

Clear All References

Clears all time reference points



Block Start/End

Scrolls to the first/last instruction of the selected call frame.

Expand/Collapse All

Expands/Collapses all call frame blocks.

Instruction Encodings

Toggles the display of instruction encodings.

Timestamps

Selects the timestamp display format (nanoseconds, CPU cycles, instruction count or off).

Export

Opens a dialog that allows users to export the window contents to a CSV file.

4.11.8 Selective Tracing

Ozone can instruct the target to constrain trace data output to individual address ranges (see *Tracepoints* on page 154). When selective tracing is active, it acts as a hardware prefilter of trace data.

4.11.9 Export

Opens a dialog that can be used to export the contents of the Instruction Trace Window to a CSV file. The same can be achieved programmatically by executing command `Trace.ExportCSV`.

4.11.10 Automatic Data Reload

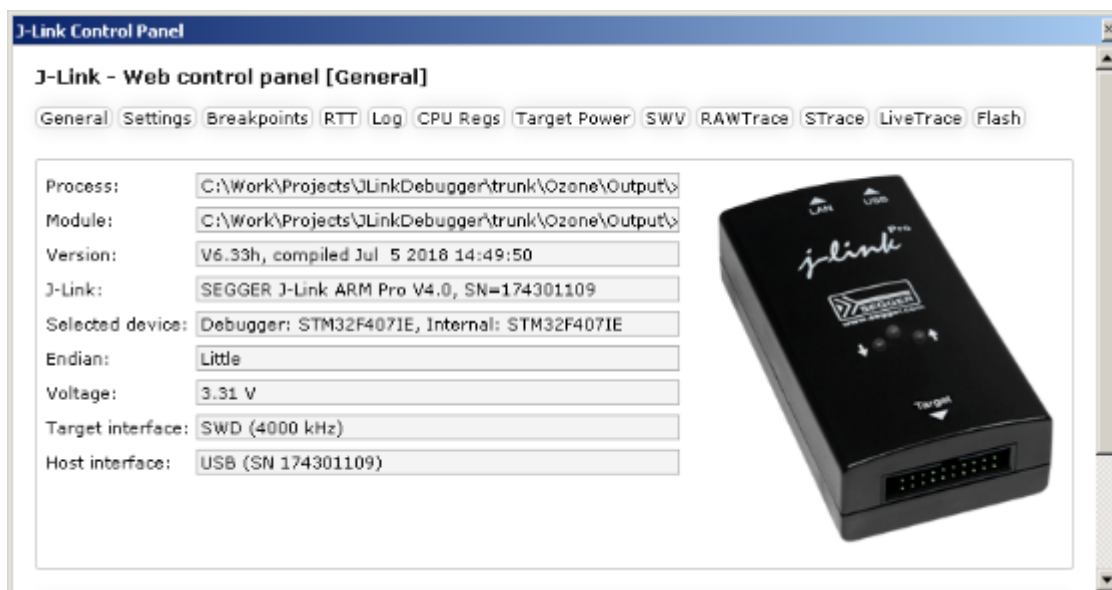
The Instruction Trace Window automatically adds more trace data to the instruction stack each time the editor is scrolled up and the first row becomes visible.

4.11.11 Limitations

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

4.12 J-Link Control Panel

The J-Link Control Panel displays the state of the debug probe and the state of ongoing data transmissions between the target and the host PC. The control panel also allows users to edit basic debug probe settings.



4.12.1 Overview

The J-Link control panel categorizes J-Link settings into multiple groups as summarized below.

Control Panel Group	Description
General	Displays J-Link status information
Settings	Provides basic settings such as the log file and flash breakpoints.
Breakpoints	Displays the target's breakpoint, data breakpoint, and vector catch state.
RTT	Displays RTT output and provides basic RTT control settings.
Log	Displays the contents of the J-Link logfile.
CPU Regs	Displays the state of the target's core registers.
Target Power	Allows users to configure power output to the target and shows the power status of the target.
SWV	Displays data that was received on the serial wire viewer from the target.
RAWTrace	Displays unprocessed ETM trace data received from the target.
STrace	Displays processed ETM trace data.
LiveTrace	Displays the streaming trace session status.
Flash	Displays information about the target's flash memory range.

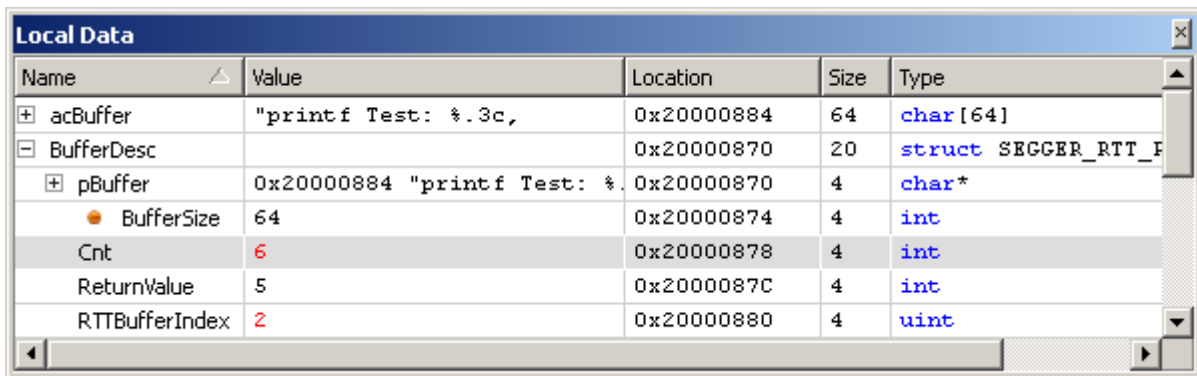
Note

The control panel maintains a private communication channel with the debug probe. Ozone is not notified about setting changes undertaken within the control panel. As Ozone maintains an internal state of J-Link settings, editing settings via the control panel may cause the debugger to attain an inconsistent state and display erroneous behavior. For this reason,

users are advised to edit J-Link settings via the J-Link Settings Dialog (see *J-Link Settings Dialog* on page 59) or Ozone API commands (see *User Actions* on page 35) only.

4.13 Local Data Window

Ozone's Local Data Window displays local variables and function parameters.



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

4.13.1 Overview

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, the output will switch back to the current function.

4.13.2 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 variables. Auto mode is inactive by default and can be toggled from the window's context menu.

4.13.3 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 144).

Edit Data Breakpoint

Opens the Data Breakpoint Dialog (see *Data Breakpoint Dialog* on page 57).

Watch

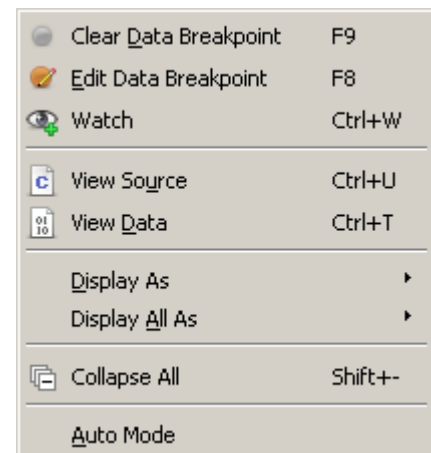
Adds the selected local variable to the Watched Data Window (see *Watched Data Window* on page 130).

View Source

Displays the source code declaration location of the selected local variable in the Source Viewer (see *Source Viewer* on page 118).

View Data

Displays the data location of the selected local variable in either the Memory Window (see *Memory Window* on page 104) or the Register Window (see *Register Window* on page 113).



	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	

Display (All) As

Changes the display format of the selected symbol or of all symbols (see *Display Format* on page 44).

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 102).

4.13.4 Data Breakpoint Indicator

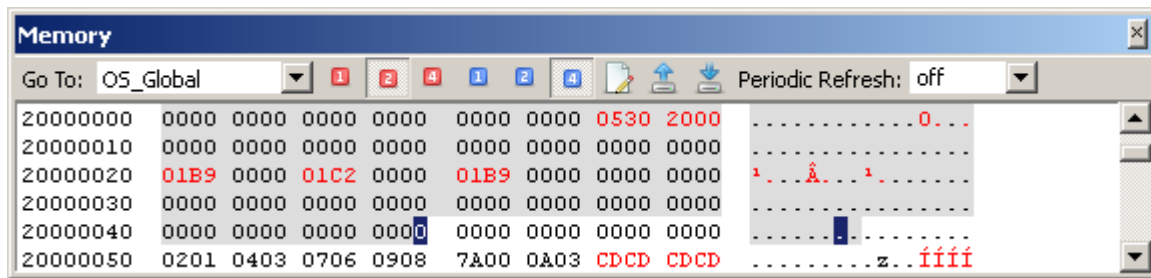
A breakpoint icon preceding a local variable’s name indicates that a data breakpoint is set on the variable.

4.13.5 Table Window

The Local Data Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 49).

4.14 Memory Window

Ozone's Memory Window displays target memory content.



4.14.1 Window Layout

The memory window displays target memory content in two different formats:

Hex Section

The central data section displays memory content as hexadecimal values. The value block size can be adjusted to 1, 2 or 4 bytes. In the illustration above, the display mode is set to 2 bytes per block value.

Text Section

The data section on the right side of the Memory Window displays the textual interpretation (Latin1-decoding) of target memory data.

4.14.2 Base Address

The address of the first byte displayed within the Memory Window is referred to as the window's base address.

4.14.3 Setting the Base Address

The base address of the Memory Window can be set in any of the following ways:

- via user action `View.Data` (see *View.Data* on page 210).
- via the goto-dialog accessible from the context menu.
- via the toolbar's input box.

In each case, the following input formats are understood:

Input Format	Example
Address	0x20000000
Address range	0x20000000, 0x200
Symbol	OS_Global
Register Name	SP
Expression	OS_Global->pTask + 0x4

For details on supported expressions, see *Expressions* on page 181. When the base address input has a deducible byte size, the corresponding address range is selected and highlighted.

4.14.3.1 Scrolling the Base Address

The base address 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

4.14.4 Symbol Drag & Drop

The Memory Window accepts drops of symbol and register window items. When an item is dropped onto the window, the item's address range is highlighted and scrolled into view.

4.14.5 Toolbar



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 Box

The toolbar's address box provides a quick way of modifying the base address, i.e. the memory address of the first byte that is displayed within the Memory Window. When a pointer expression is input into the address box, the Memory Window automatically scrolls to the address pointed to each time it changes.

Access Width

The blue tool buttons allow 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 red tool buttons let users choose the display mode. There are three display modes that correspond to the byte size of each hexadecimal value displayed within the hex section. The display mode can be set to 1, 2 or 4 bytes per value.

Fill Memory



Opens the *Fill Memory Dialog* (see *Generic Memory Dialog* on page 60)

Save Memory Data



Opens the *Save Memory Dialog* (see *Generic Memory Dialog* on page 60)

Load Memory Data



Opens the *Load Memory Dialog* (see *Generic Memory Dialog* on page 60)

Update Interval



Opens the *Auto Refresh Dialog* (see *Periodic Update* on page 106).

4.14.6 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 105).

4.14.7 Change Level Highlighting

The Memory Window employs change level highlighting (see *Change Level Highlighting* on page 106).

4.14.8 Periodic Update

The Memory Window is capable of periodically updating the displayed memory area at a fixed rate. The refresh interval can be specified via the Auto Refresh Dialog that can be accessed from the toolbar or from the context menu. The periodic refresh 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.

4.14.9 User Input

The current input cursor is shown as a blue box highlight. By pressing a nibble or text key, an edit box will pop up over the selected hexadecimal value that allows the value to be edited. Pressing enter will accept the changes and write the modified value to target memory.

4.14.10 Copy and Paste

The Memory Window allows users to select memory regions and copy the selected content into the clipboard in one of multiple formats (see *Context Menu* on page 102). The current clipboard content can be pasted into a target memory by setting the cursor at the desired base address and then pressing hotkey Ctrl+V.

4.14.11 Context Menu

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

Copy

Copies the text selected within the hex-section to the clipboard.

Copy Special

A submenu with 4 entries:

- Copy Text: copies the selected text-section content to the clipboard.
- Copy Hex: copies the selected hexadecimal in textual format to the clipboard.
- Copy Hex As C-Initializer: copies the selected hexadecimal as comma separated list in textual format to the clipboard (e.g. "0xAB, 0x23, 0x00")
- Copy Binary: copies the selected hexadecimal as octet-8 raw binary data to the clipboard.

Display Mode

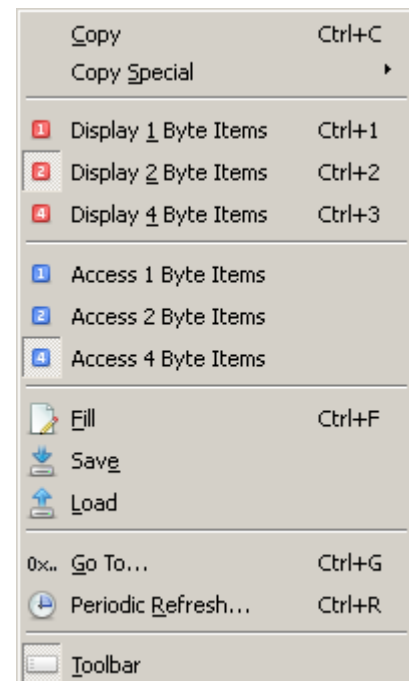
Sets the display mode to either 1, 2 or 4 bytes per hexadecimal block.

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 *Generic Memory Dialog* on page 105).



Save

Opens the Save Memory Dialog (see *Generic Memory Dialog* on page 105).

Load

Opens the Load Memory Dialog (see *Generic Memory Dialog* on page 105).

Go To

Opens an input dialog that allows users to change the base address (see *Base Address* on page 104).

Periodic Refresh

Opens the Auto Refresh Dialog from which the window's periodic update interval can be set (see *Periodic Update* on page 106).

Toolbar

Toggles the display of the window's toolbar.

4.14.12 Multiple Instances

Users may add as many Memory Windows to the Main Window as desired.

4.15 Memory Usage Window

Ozone's Memory Usage Window displays the type and content hierarchy of target memory.

4.15.1 Overview

The Memory Usage Window's main areas of application are:

Identifying invalid memory usage

A program data symbol may have been erroneously stored to a special-purpose RAM region

such as a trace buffer. Another example would be a function that was downloaded to a non-executable memory area.

Identifying erroneous build settings

A linker may have placed program functions outside the target's FLASH address range or program variables outside the RAM address range.

4.15.2 Requirements

The Memory Usage Window requires the program file to be of ELF or compatible format.

4.15.3 Window Layout

Memory regions are grouped into three columns: segments, data sections, and symbols.

Segments

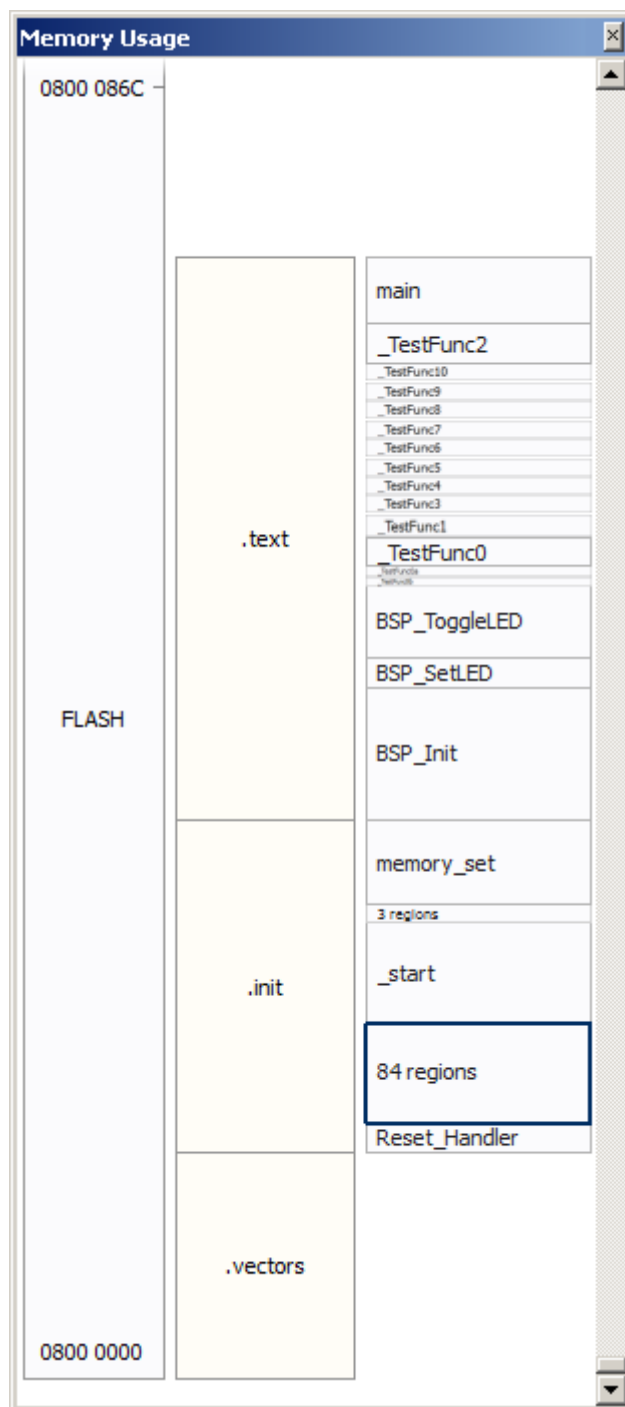
The first column shown within the Memory Usage Window displays the memory type. Usually, the target will have a flash and a RAM segment which are displayed here. When no memory segment information was made available to the window, the segment column will be invisible.

Data Sections

The central column of the Memory Usage Window displays the arrangement of ELF file data sections within the containing segment.

Symbols

The right-hand column of the Memory Usage Window displays the arrangement of program symbols (functions and variables) within the containing data section.



4.15.4 Setup

Section and symbol regions are automatically initialized from ELF program file data when the program file is opened. Segment information must be supplied via a map file (see below).

4.15.4.1 Supplying Segment Information

Ozone obtains memory segment information from the memory map file that was set via command `Target.LoadMemoryMap` (see *Target.LoadMemoryMap* on page 239). Individual segments can be added to the memory map via command `Target.AddMemorySegment` (see *Target.AddMemorySegment* on page 239).

4.15.5 Interaction

The Memory Usage Window provides multiple interactive features that allow users to quickly understand the target's memory map on a broad and narrow scale. The interactive features are described below.

4.15.5.1 Scrolling

The address range currently displayed within the Memory Usage Window can be scrolled in any of the following ways:

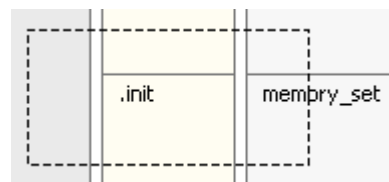
- via the window's scrollbars.
- via the horizontal or vertical mouse wheel
- by clicking somewhere and dragging the clicked spot to a new location.

4.15.5.2 Zooming

The vertical scale of the memory usage plot is given as the number of bytes that fit into view. The vertical scale can be adjusted in the ways described below.

ROI Zooming

When the mouse cursor is moved over the memory usage plot while the left mouse button is held down, a selection rectangle is shown. Once the mouse button is released, the view will be scaled up (zoomed in) in order to match the selected region. The ROI selection process can be canceled using the ESC key.



Mouse Zooming

The view can be scaled around the mouse cursor position by scrolling the vertical mouse wheel while holding down a control key. Using mouse wheel zooming, the region under the cursor will not change position while the plot's zoom level is adjusted.

Zooming via Hotkey

The view can be zoomed in or out by pressing the plus or minus key.

Double-Click Zooming

A double-click on a region fits the region into view.

4.15.6 Context Menu

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

View Source

Shows the source code location of the selected memory region within the Source Viewer (see *Source Viewer* on page 118).

View Disassembly

Shows the disassembly of with the selected memory region within the Disassembly Window (see *Disassembly Window* on page 89).

View Data

Shows the selected memory region within the Memory Window (see *Memory Window* on page 104).

Zoom In

Increases the zoom level.

Zoom Out

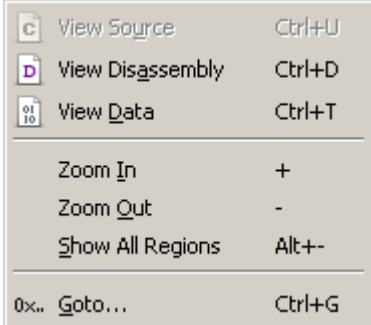
Decreases the zoom level.




Show All Regions

Resets the zoom level so that all memory regions are fully visible.

Goto...

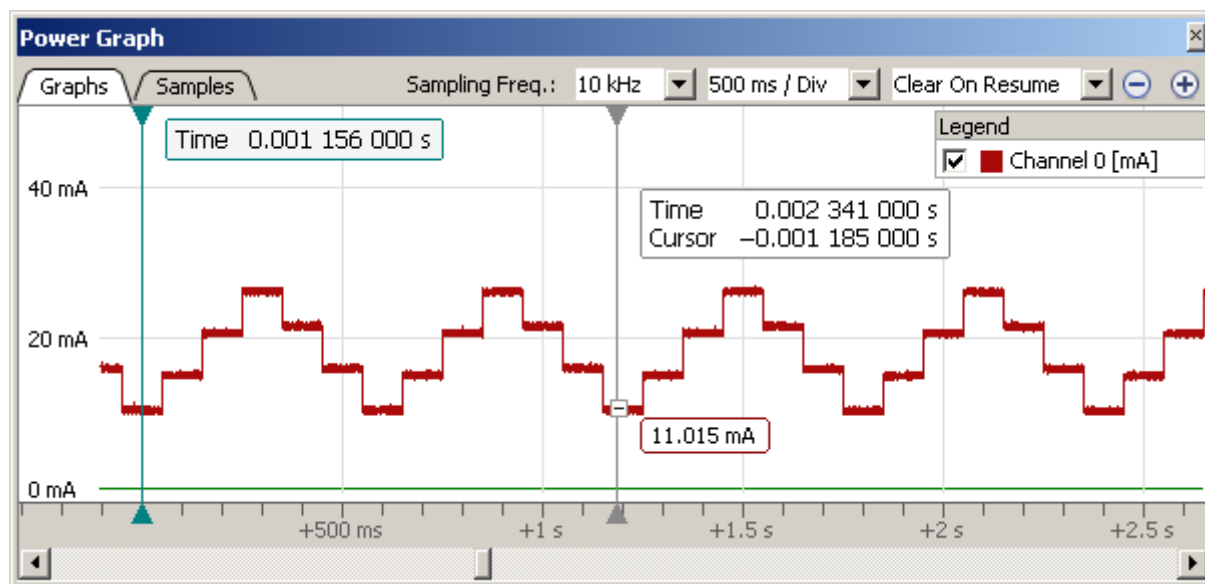
Opens an input dialog that allows users to input the address range or symbol name to scroll to.



	View Source	Ctrl+U
	View Disassembly	Ctrl+D
	View Data	Ctrl+T
Zoom In		+
Zoom Out		-
Show All Regions		Alt+-
0x... Goto...		Ctrl+G

4.16 Power Graph Window

Ozone's Power Graph Window tracks the current drawn by the target and displays the resulting graph in an interactive signal plot.



4.16.1 Hardware Requirements

The Power Graph Window requires the target to be powered by J-Link (over the debug interface). Please refer to your MCU model's user manual or contact SEGGER if unsure about the capabilities of your target.

In case your target does not support power via J-Link, you may still want to check out the capabilities of the Power Graph Window using SEGGER's lightweight Cortex-M trace reference board.

4.16.2 Setup

J-Link power output to the target is switched off per default. Therefore, Ozone must be instructed to activate power output to the target before a target connection is established. To do this, system variable `VAR_TARGET_POWER_ON` is provided. The expected way to enable power output to the target is to add the statement

```
Edit.SysVar(VAR_TARGET_POWER_ON,1);
```

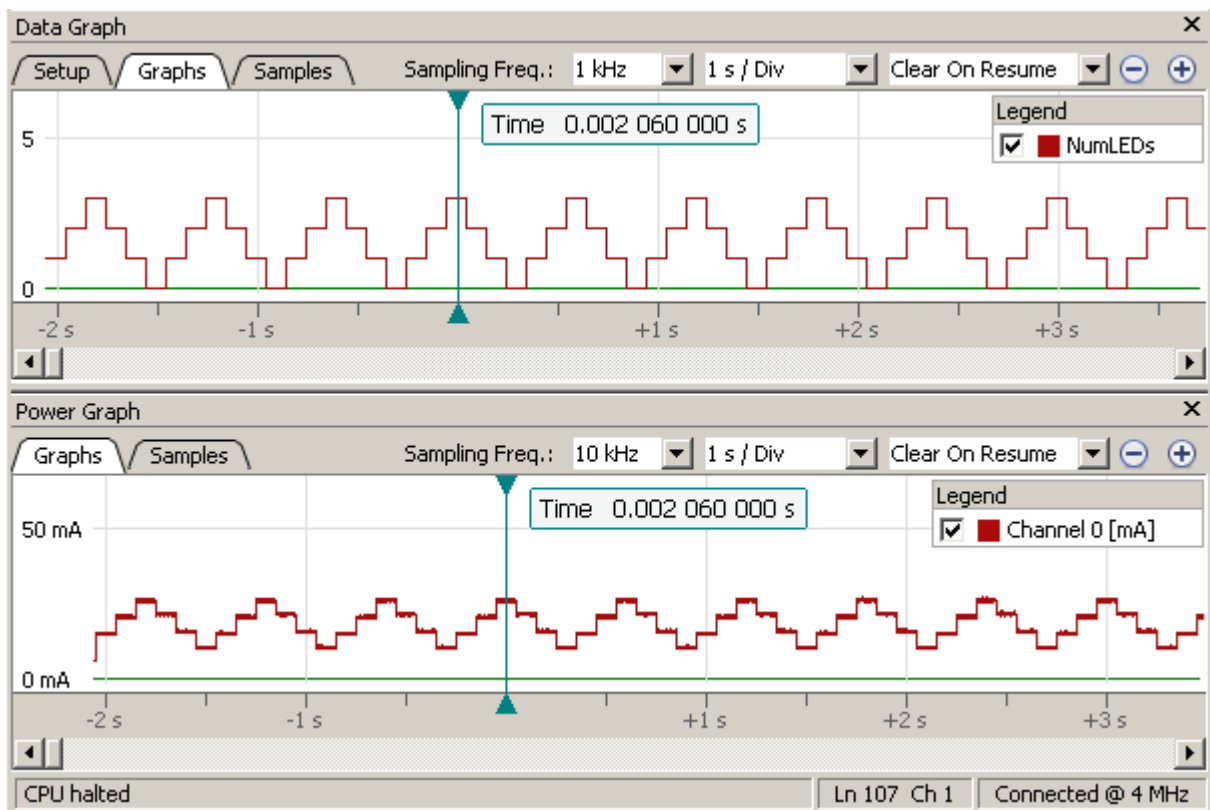
to project file function `OnProjectLoad` (see *Event Handler Functions* on page 160).

4.16.3 Usage

The Power Graph Window's user interface and interaction possibilities are identical to that of the Data Graph Window (see *Data Graph Window* on page 83). Please refer to the Data Graph Window's section in order to learn about using the Power Graph Window.

4.16.4 Cursor Synchronization

The sample cursors of the Power Graph and Data Graph windows are automatically synchronized. Moving one of the cursors will also move the other.



The synchronization of sample cursors allows users to establish a link between target power consumption and program execution. In the example above, the debuggee switched 3 LED's on and off in short succession. Global variable NumLEDs was incremented or decremented each time an LED was switched on or off. As can be seen, the target's power consumption is directly proportional to the number of active LEDs. The power graph trails the data graph by around 50 us, which is expected as the LED register is written shortly after the global variable is updated.

4.17 Register Window

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

4.17.1 SVD Files

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

Core, FPU and CP15 Registers

Ozone ships with an SVD file for each supported ARM architecture profile. When users select a target 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 target must be specified manually. For this purpose, user action `Project.AddSvdFile` is provided (see *Project.AddSvdFile* on page 228). Ozone does not ship with peripheral SVD files out of the box; users have to obtain the file from their MCU vendor.

4.17.2 Register Groups

The Register Window partitions target registers into multiple groups:

Current CPU Registers

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

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 target possesses a floating point unit.

CP15 Registers


Coprocessor-15 registers. This category is only available when the target 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 113).

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 (nzcvg)
 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	

4.17.3 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 lowercase 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.

4.17.4 Processor Operating Mode

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

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

ARM processor operating modes

4.17.5 Context Menu

The Register Windows's 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 a memory address).

Display (All) As

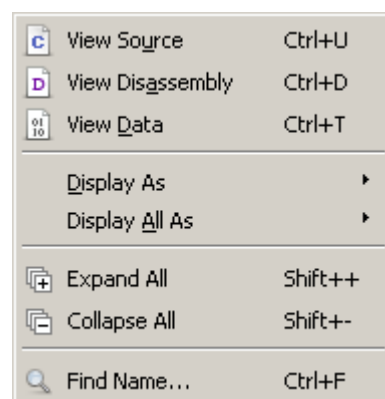
Sets the display format of the selected item or the whole window.

Expand / Collapse All

Expands or collapses all top-level nodes.

Find Name

Scrolls to and selects a particular register.



4.17.6 Table Window

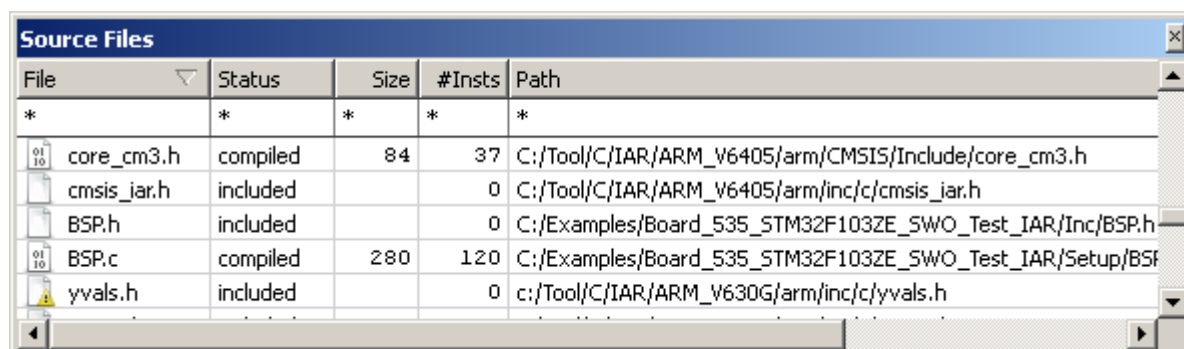
The Register Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 49).






4.17.7 Multiple Instances

Users may add as many Register Windows to the Main Window as desired.

4.18 Source Files Window

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



File	Status	Size	#Insts	Path
*	*	*	*	*
 core_cm3.h	compiled	84	37	C:/Tool/C/IAR/ARM_V6405/arm/CMSIS/Include/core_cm3.h
 cmsis_jar.h	included		0	C:/Tool/C/IAR/ARM_V6405/arm/inc/c/cmsis_jar.h
 BSP.h	included		0	C:/Examples/Board_535_STM32F103ZE_SWO_Test_IAR/Inc/BSP.h
 BSP.c	compiled	280	120	C:/Examples/Board_535_STM32F103ZE_SWO_Test_IAR/Setup/BSP.c
 yvals.h	included		0	c:/Tool/C/IAR/ARM_V630G/arm/inc/c/yvals.h

4.18.1 Source File Information

The Source Files Window displays the following information about source files:

File

Filename. An icon preceding the filename indicates the file status.

Status

Indicates how the compiler used the source file to generate the debuggee. 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.

Size

Byte size of the program machine code encompassed by the source file.

#Insts

The number of instructions encompassed by the source file.

Path

File system path of the source file.

4.18.2 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 151). The user may also edit and correct file paths directly within the Source Files Window.

4.18.3 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 (see *Source Viewer* on page 118). The same can be achieved by double-clicking on the file.

Locate File

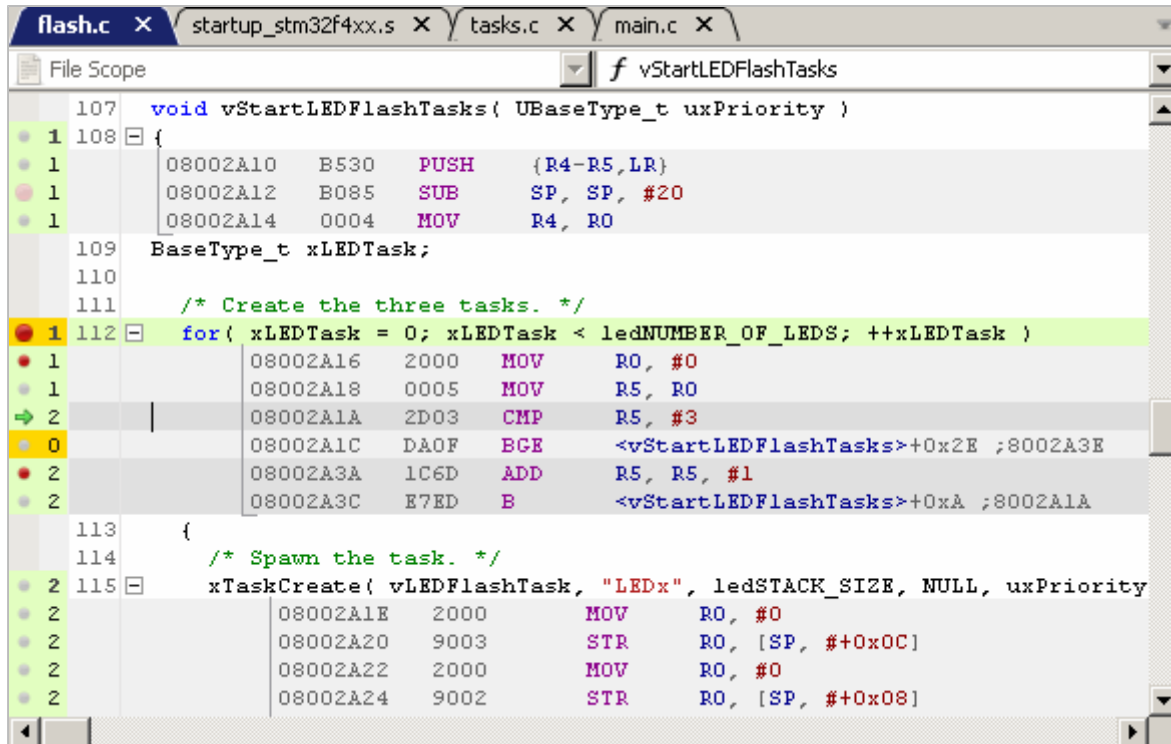
Opens a file dialog that lets users locate the selected file on the file system. This context menu is displayed when the selected source file is missing.

4.18.4 Table Window

The Source Files Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 49).

4.19 Source Viewer

The Source Code Viewer (or Source Viewer for short) allows users to observe program execution on the source-code level, set source breakpoints and perform quick adjustment of the program code. Individual source code lines can be expanded to reveal the affiliated assembly code instructions.



4.19.1 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

4.19.2 Execution Counters

Within its sidebar area on the left, the Source Viewer displays the execution counts of individual source lines and instructions (see *Execution Counters* on page 118).

4.19.3 Opening and Closing Documents

Documents can be opened via the file dialog (see *File Menu* on page 38) or programmatically via user actions File.Open and File.Close (see *File Actions* on page 192).

4.19.4 Editing Documents

Ozone's Source Viewer provides all standard text editing capabilities and keyboard shortcuts. Please refer to section *Key Bindings* on page 120 for an overview of the key bindings available for editing documents. It is advised to recompile the program following source code modifications as source-level debug information may otherwise be impaired.

4.19.5 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.

4.19.5.1 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.

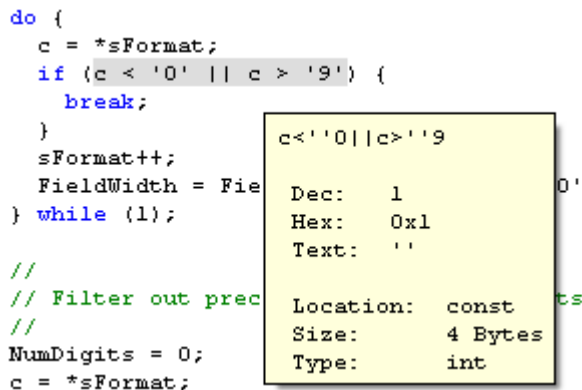
4.19.6 Document Header Bar



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.

4.19.7 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 181).



4.19.8 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.

4.19.9 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 behavior will be the same as if the Disassembly Window was the active code window (see *Stepping Expanded Source Code Lines* on page 140).

4.19.10 Key Bindings

This section gives an overview of the special-purpose and standard keys that can be used with the Source Viewer.

Hotkeys

The table below provides an overview of the Source Viewer's special-purpose key bindings.

Hotkey	Description
Ctrl+Tab	Selects the next document in the list of open documents.
Ctrl+Plus	Expands the current line.
Ctrl+Minus	Collapses the current line.
Alt+Plus	Expands all lines within the current document.
Alt+Minus	Collapses all lines within the current document.
Alt+Left	Shows the previous location in the text cursor history.
Alt+Right	Shows the next location in the text cursor history.
Ctrl+Wheel	Adjusts the font size.

Special-Purpose key bindings of the Source Viewer

Standard Keys The table below provides an overview of the Source Viewer's standard key bindings. The Shift key can be held together with any of the below accelerators to extend the text selection to the new cursor position.

Arrow key	Moves the text cursor in the specified direction.
Page Up	Moves the text cursor one page up.
Page Down	Moves the text cursor one page down.
Home	Moves the text cursor to the start of the line.
End	Moves the text cursor to the end of the line.
Ctrl+Left	Moves the cursor to the previous word.
Ctrl+Right	Moves the cursor to the next word.
Ctrl+Home	Moves the text cursor to the start of the document.
Ctrl+End	Moves the text cursor to the end of the document.
F3	Finds the next occurrence of the current search string.
Ctrl+F3	Finds the next occurrence of the word under the cursor.

Standard key bindings of the Source Viewer

4.19.11 Syntax Highlighting

The Source Viewer applies syntax highlighting to source code. The syntax highlighting colors can be adjusted via user action `Edit.Color` (see *Edit.Color* on page 204) or via the User Preference Dialog (see *User Preference Dialog* on page 52).

4.19.12 Source Line Numbers

The display of source line numbers can be toggled by executing user action `Edit.Preference` using parameter `PREF_SHOW_LINE_NUMBERS` (see *Edit.Preference* on page 203) or via the User Preference Dialog (see *User Preference Dialog* on page 52).

4.19.13 Context Menu

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

Set / Clear / Edit Breakpoint

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

Break On Change

Sets a data breakpoint on the variable under the cursor. The breakpoint is triggered when the variable's value changes.

Set Tracepoint (Start/Stop)

Sets a tracepoint on the selected source code line (see *Tracepoints* on page 154).

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 Source

Jumps to the source code declaration location of the symbol under the cursor.

View Disassembly

Displays the first machine instruction of the selected source code line in the Disassembly Window (see *Disassembly Window* on page 89).

View Data

Displays the data location of the symbol under the cursor within the Memory Window (see *Memory Window* on page 104).

View Call Graph

Displays the call graph of the function under the cursor within the Call Graph Window (see *Call Graph Window* on page 73).

Watch















Adds the symbol under the cursor to the Watched Data Window (see *Watched Data Window* on page 130).

Goto PC

Displays the PC line. 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 the line number obtained from an input dialog.

	Clear Breakpoint	F9
	Edit Breakpoint...	F8
	Set Next Statement	Shift+F10
	Run To Cursor	Ctrl+F10
	View Source	Ctrl+U
	View Disassembly	Ctrl+D
	View Data	Ctrl+T
	View Call Graph	Ctrl+H
	Watch	Ctrl+W
	Goto PC	Ctrl+P
	Goto Line...	Ctrl+L
	Collapse Line	Ctrl+Left
	Expand All	Shift++
	Collapse All	Shift+-
	Select All	Ctrl+A
	Find...	Ctrl+F
	Numbering	
	Show Execution Counters	Ctrl+E

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.

Numbering

Displays a submenu that allows users to specify the line numbering frequency.

Show Execution Counters

Toggles the display of Execution Counters (see *Execution Counters* on page 118).

4.19.14 Font Adjustment

The Source Viewer's font can be adjusted by executing user action *Edit.Font* (see *Edit.Font* on page 204) or via the User Preference Dialog (see *User Preference Dialog* on page 52).

Quick Adjustment of the Font Size

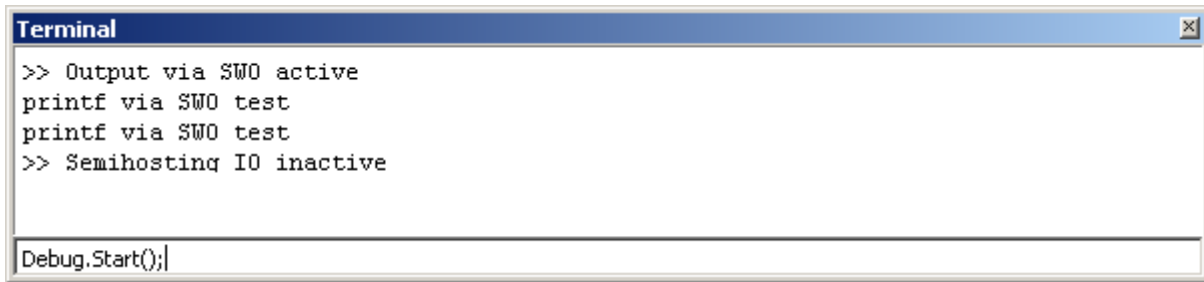
The font size can be quick-adjusted by scrolling the mouse wheel while holding down the control key.

4.19.15 Code Window

The Source Viewer shares multiple features with Ozone's second code window, the Disassembly Window. Refer to *Code Windows* on page 45 for a shared description of these windows.

4.20 Terminal Window

Ozone's Terminal Window provides bi-directional text IO between the debugger and the debuggee.



4.20.1 Supported IO Techniques

The Terminal Window supports three communication techniques for transmission of textual data from the debugger to the debuggee and vice versa that are described in *Terminal IO* on page 148.

4.20.2 Terminal Prompt

The Terminal Window's input text box is used to send textual data to the debuggee. The terminal prompt is located at the bottom of the Terminal Window.

Input Termination

A string-termination character or a line break may be automatically appended to terminal input before the text is sent to the debuggee. Input termination behavior can be adjusted via the context menu or via user action *Edit.Preference* (see *Edit.Preference* on page 203).

Asynchronous Input

Typically, the debuggee 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 sent to the debuggee when there is no pending input request. In this case, the text will be stored at the next free RTT memory buffer location.

4.20.3 Context Menu

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

Copy

Copies the selected text to the clipboard.

Select All

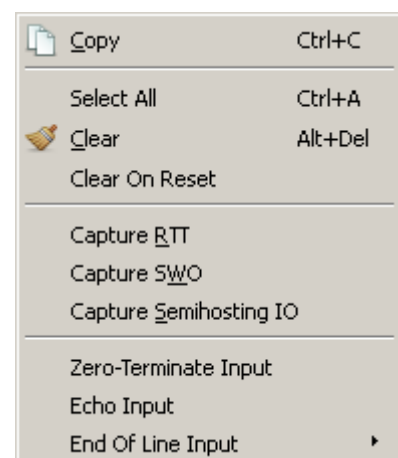
Selects all text lines.

Clear

Clears the Terminal Window.

Clear On Reset

When checked, the window's text area is cleared following each program reset.



Capture RTT

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

Capture SWO

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

Capture Semihosting IO

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

Zero-Terminate Input

Indicates if a string termination character (\0) is appended to user input before the input is sent to the debuggee.

Echo Input

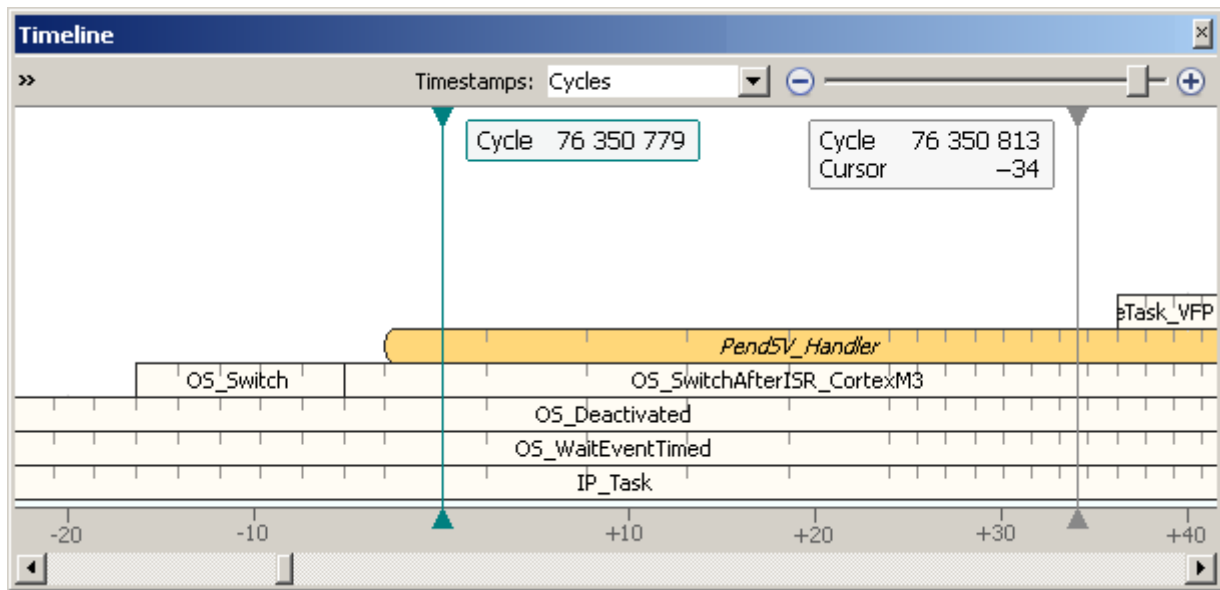
When checked, each terminal input is appended to the terminal window's text area.

End Of Line Input

Specifies the type of line break to be appended to terminal input before the input is sent to the debuggee (see *Newline Formats* on page 172).

4.21 Timeline Window

Ozone's Timeline Window visualizes the course of the program's call stack over time.



4.21.1 Setup

Section *Setting Up Trace* on page 152 explains how to configure Ozone and the hardware setup for trace, thereby enabling the Timeline Window. In order to obtain a consistent output when debugging multi-threaded applications, an OS-awareness plugin must have been specified (see *RTOS Awareness Plugin* on page 134).

4.21.2 Overview

Each horizontal bar of the timeline plot represents a function invocation, or call frame. The left and right boundaries of a call frame denote the points in time when the program entered and exited the called function.

The current program execution point (PC) is located at the right side of the timeline plot. Similar to the Code Windows, the PC is scrolled into view each time the program was stepped or halted. When the program is halted, users may scroll the timeline plot to the left in order to observe the call stack and execution path of the program at increasingly past points in time. Trace data is automatically reloaded when timeline plot does not wholly cover the window.

4.21.3 Exception Frames

An exception handler or interrupt service routine frame is painted with rounded corners and a deeper color saturation level (see *PendSV_Handler* in the title figure).

4.21.4 Frame Tooltips

When the mouse cursor hovers over a call frame of the timeline plot, a tooltip pops up that informs about distinct frame properties such as the amount of encompassed instructions.

4.21.5 Timescale

The timeline's x-axis scale provides an overview of the time distances between timeline events. The unit of the timescale can be toggled between the following options (see *Context Menu* on page 123):

Timescale Unit	Description
Time	The distance between timescale ticks is displayed in a time unit with a nanosecond resolution.
Cycles	The distance between timescale ticks is displayed in CPU cycles.
Instruction Count	The distance between timescale ticks is displayed in number of instructions.

A fourth option “off” allows to hide the timescale.

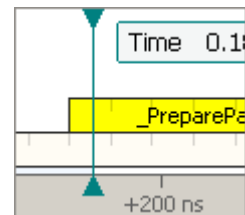
4.21.6 Sample Cursor

The sample cursor marks the backtrace context instruction (see *Backtrace Highlighting* on page 97). It also defines the position of the timescale origin. Next to the sample cursor, a label showing its absolute time position is displayed.

Positioning the Sample Cursor

The sample cursor can be positioned by:

- double-clicking on the timeline plot
- dragging it to a new position
- pressing the left or right arrow key (+/- 1 instruction)
- pressing the left or right arrow key while holding down the shift key (+/- 1 div)
- pressing the page up or page down key (+/- 1 page)
- pressing the home or end key

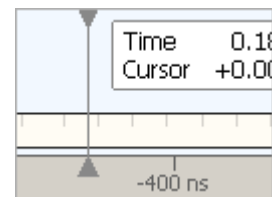


Pinned Sample Cursor

The sample cursor can be pinned to a fixed window position (see *Context Menu* on page 123). When pinned to the window, the sample cursor will always stay visible regardless of any view modification.

4.21.7 Hover Cursor

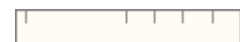
The hover cursor follows the movements of the mouse over the Timeline Window. The time position of the hover cursor, as well as the time distance to the sample cursor, are displayed next to the hover cursor.



4.21.8 Instruction Ticks

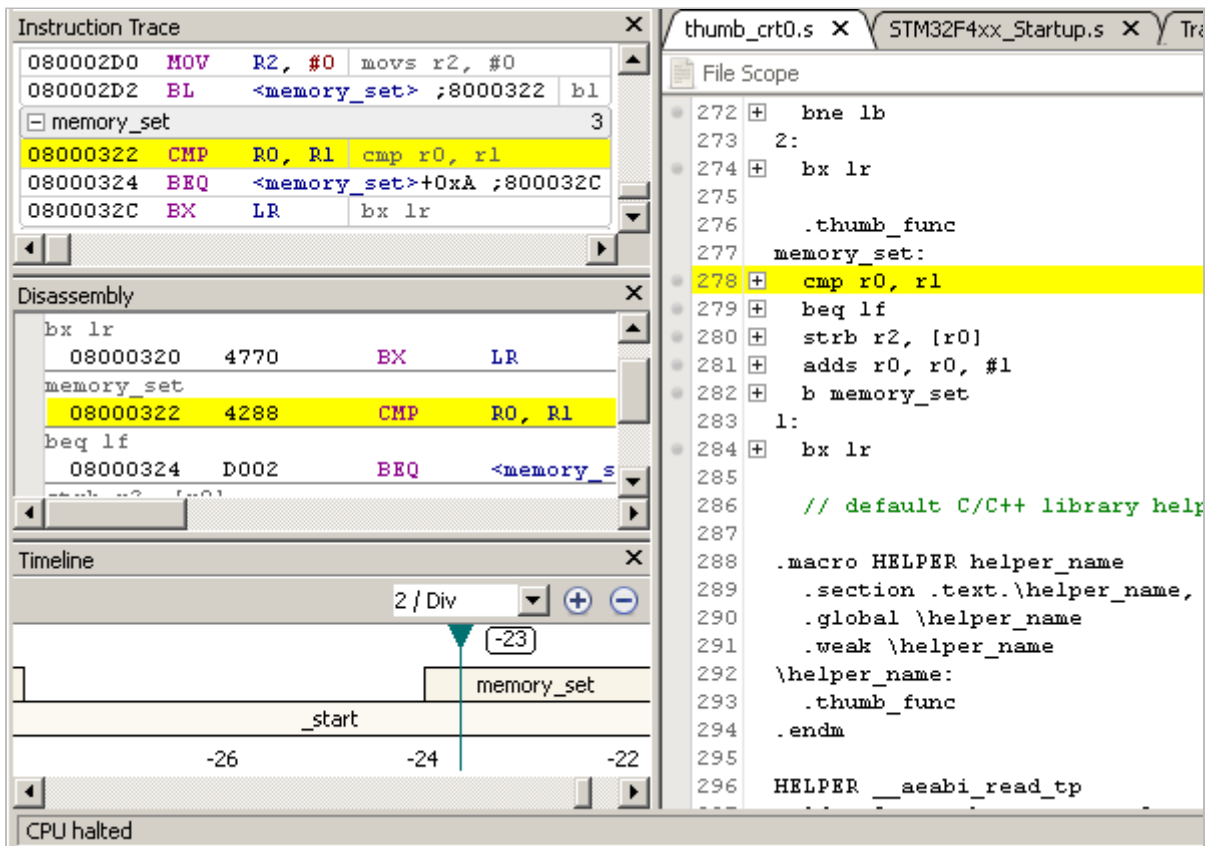
At high levels of zoom, vertical line indicators are displayed inside of all call frames. Each neighbouring pair of these instruction ticks bound the start and end of a single instruction execution.

In the example illustration to the right, the first instruction required 3 cycles to execute, while the following instructions were all executed in a single cycle.



4.21.9 Backtrace Highlighting

Whenever the position of the sample cursor changes, the selected instruction is highlighted and scrolled into view within the Code Windows and the Instruction Trace Window. Users thus get a complete insight into the source code, disassembly and call stack context of any instruction that is selected within the timeline.

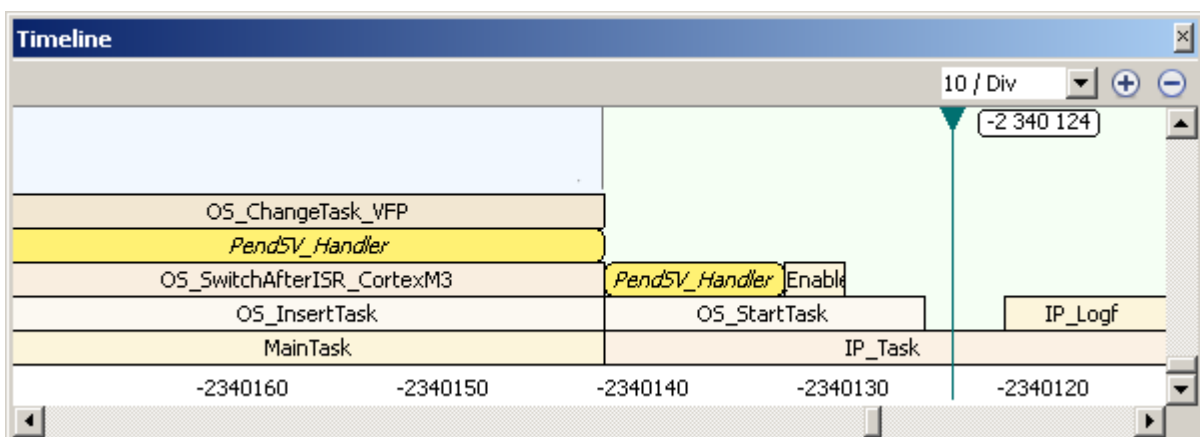


The sample cursor is synchronized with Ozone's code and instruction windows.

The default color used for backtrace highlighting is yellow and can be adjusted via user action *Edit.Color* (see *Edit.Color* on page 204) or via the User Preference Dialog (see *User Preference Dialog* on page 52).

4.21.10 Task Context Highlighting

Instruction blocks that were executed by different threads of the target application are distinguishable through the window background color. The task context highlighting feature requires an OS-awareness-plugin to have been specified (see *RTOS Awareness Plugin* on page 134).



Task Context Highlighting.

4.21.11 Interaction

4.21.11.1 Panning

The timeline plot can be shifted horizontally or vertically by using the scrollbars or by clicking on a window position and dragging the clicked position to a new location.

4.21.11.2 Zooming

The horizontal scale of the timeline plot can be increased or decreased in any of the following ways:

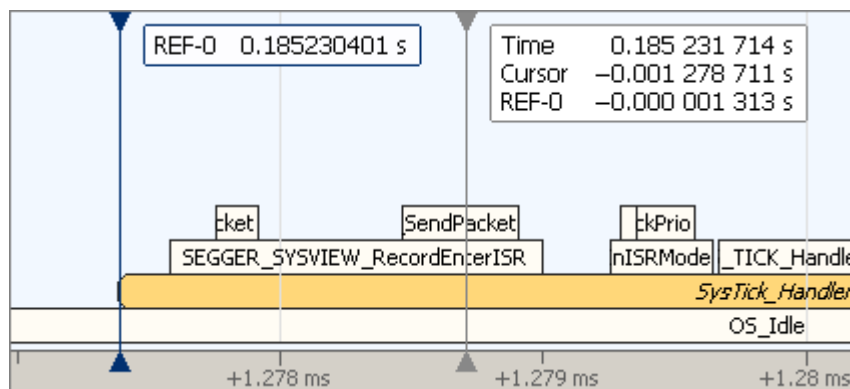
- by scrolling the mouse wheel up or down
- by using the toolbar's zoom slider
- by using the plus and minus buttons displayed within the toolbar

The vertical scale of the timeline plot is fixed.

4.21.11.3 Measuring Time Distances

The time distance between two timeline events can be measured by first setting the sample cursor onto one event and then pointing with the hover cursor at the other; the hover cursor label will then display the time distance between the events in the selected timescale unit.

4.21.12 Time Reference Points



To ease the measurement of time distances, the context menu provides an option to toggle a time reference point at the position of the sample cursor. For each time reference point, an additional label will be displayed next to the hover cursor that shows the time distance between the hover cursor and the time reference point.

4.21.13 Settings

The following system variable settings are evaluated by the Timeline Window (see *Edit.Sys-Var* on page 203):

Variable	Description
VAR_TRACE_MAX_INST_CNT	Maximum number of instructions that can be processed and displayed by the Timeline Window.
VAR_TRACE_CORE_CLOCK	Conversion factor used to convert execution times between CPU cycles and time units.

4.21.14 Context Menu

The Timeline window's context menu hosts the following actions:

← Go to start of Reset_Handler	Ctrl+Left
→ Go to end of Reset_Handler	Ctrl+Right
← Go To previous function on level	
→ Go To next function on level	
← Go to previous execution of Reset_Handler	Ctrl+Shift+Left
→ Go to next execution of Reset_Handler	Ctrl+Shift+Right
Toggle Reference	R
Clear all References	
Go To Reference	
Go To Cursor	Ctrl+G
Cursor	▶
Timestamps	▶
✓ Toolbar	

Goto start/end of frame

Scrolls to the first/last instruction of the selected frame.

Goto next/previous function on level

Scrolls to the first/last instruction of the previous/next frame.

Goto next/previous execution of frame

Scrolls to the next/previous execution of the selected frame

Toggle Reference

Toggles the time reference point at the position of the sample cursor.

Go To Reference

Scrolls to the nearest time reference point preceding the selected instruction.

Clear All References

Clears all time reference points.

Go To Cursor

Scrolls the sample cursor into view (see *Sample Cursor* on page 126).

Cursor

Pins the Sample Cursor to a fixed window position.

Timestamps

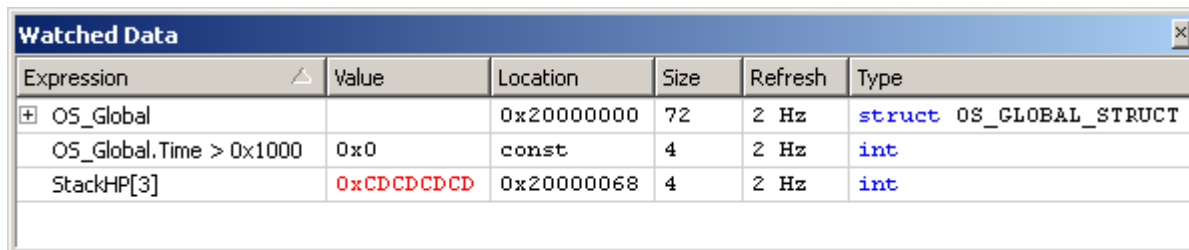
Selects the timescale unit (nanoseconds, CPU cycles, instruction count or off).

Toolbar

Toggles the toolbar.

4.22 Watched Data Window

Ozone's Watched Data Window tracks the values of C-style expressions that the user chose for explicit observation (see *Expressions* on page 181).



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

4.22.1 Adding Expressions

An expression can be watched, i.e. added to the Watched Data Window, in any of the following ways:

- via context menu entry *Watch* of any symbol window.
- via user action *Window.Add* (see *Window.Add* on page 207).
- via context menu entry "Watch..." that opens an input dialog.
- by dragging a symbol onto the window.

4.22.2 Local Variables

The Watched Data Window supports expressions that contain local variables. An expression containing 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.

4.22.3 Live Watches

The Watched Data Window supports live updating of hosted expressions while the program is running. Each expression can be assigned an individual update frequency via the windows context menu or programmatically via user action *Edit.RefreshRate* (see *Edit.RefreshRate* on page 205).

Note

The live watches feature requires the target to support background memory access or the connected J-Link debug probe to support BMA emulation.

4.22.4 Table Window

The Watched Data Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 49).

4.22.5 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 144).

Edit Data Breakpoint

Opens the Data Breakpoint Dialog (see *Data Breakpoint Dialog* on page 57).

View Source

Displays the source code declaration location of the selected variable in the Source Viewer (see *Source Viewer* on page 118).

View Data

Displays the data location of the selected variable in either the Memory Window (see *Memory Window* on page 104) or the Register Window (see *Register Window* on page 113).

Display (All) As

Changes the display format of the selected item or of all items (see *Display Format* on page 44).

Refresh Rate

Sets the refresh rate of the selected expression (see *Live Watches* on page 130).

Expand/Collapse All









Expands or collapses all top-level nodes.

Watch

Opens the Watch Dialog (see *Expressions* on page 181).

Clear

Removes all items from the Watched Data Window.

	Remove	Del
	Clear Data Breakpoint	F9
	Edit Data Breakpoint	F8
<hr/>		
	View Source	Ctrl+U
	View Data	Ctrl+T
<hr/>		
	Display As	▶
	Display All As	▶
	Refresh Rate	▶
<hr/>		
	Collapse All	Shift+-
<hr/>		
	Watch...	Alt++
	Clear	Alt+Del

Chapter 5

Debugging With Ozone

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 Project Files

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

5.1.1 Project File Example

Illustrated below is an example project file that was created with the Project Wizard (see *Project Wizard* on page 31). 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");
}

```

5.1.2 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 197)

5.1.3 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 31). The Project Wizard creates minimal project files that specify only the required settings.

5.1.4 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 35).

5.1.4.1 Specifying Project Settings

Project settings are specified by inserting user action commands into the obligatory script function "OnProjectLoad" (see *Project File Example* on page 133).

5.1.4.2 Program File

The program to be debugged can be specified via 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 197). Furthermore, please consider section *Supported Program File Types* on page 135 for the list of supported program file types.

5.1.4.3 Hardware Settings

Hardware settings configure the debugger to be used with a particular target and debug interface. The affiliated user actions belong to the “Project” category (see *Project Actions* on page 193).

5.1.4.4 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 223). Ozone currently ships with two RTOS awareness plugins - one for SEGGER’s embOS and one for FreeRTOS.

5.1.4.5 Target Support Plugin

The user action *Project.SetCorePlugin* specifies the file path of the plugin that adds support for a particular MCU architecture to the debugger (see *Project.SetCorePlugin* on page 223). Ozone currently ships with two target support plugins – one for ARM and one for RISC-V.

5.1.4.6 Source File Resolution Settings

Settings that allow Ozone to find source files that have been moved to a new location after the program file was build are described in *File Path Resolution* on page 183.

5.1.4.7 Behavioral Settings

Settings that modify the behavior of debugging operations are referred to as “system variables”. System variables can be edited via user action *Edit.SysVar* (see *Edit.SysVar* on page 203).

5.1.4.8 Required Project Settings

A valid project file must specify the following settings:

Setting	Description
<i>Project.SetDevice</i>	The name of the target device.
<i>Project.SetHostIF</i>	Specifies how the J-Link debug probe is connected to the Host-PC.
<i>Project.SetTargetIF</i>	Specifies how the J-Link debug probe is connected to the target.
<i>Project.SetTifSpeed</i>	Specifies the data transmission speed.

5.1.5 User Files

When a project is closed, Ozone associates a user file (*.user) with the project and stores it next to the project file. The user file contains window layout information and other appearance settings in an editable format. The next time the project is opened, Ozone restores the user interface layout from the user file. User files may be shared along with project files in order to migrate the project-individual look and feel.

5.2 Program Files

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

5.2.1 Supported Program 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)

5.2.2 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 target'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.

5.2.3 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 197).

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 93), Source Files Window (see *Source Files Window* on page 116), Global Data Window (see *Global Data Window* on page 95) and Code Profile Window (see *Code Profile Window* on page 77).

5.2.4 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 target is set to the program file's data encoding if supported by the target. The target's endianness mode can also be specified independently via the J-Link Settings Dialog (see *J-Link Settings Dialog* on page 59).

5.3 Starting the Debug Session

After a project was opened or created and a program file was specified, the debug session can be started. The debug session is started via user action `Debug.Start` (see *Debug.Start* on page 215). This action can be triggered from the Debug Menu or by pressing the hotkey F5.

5.3.1 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 216). The different connection modes are described below.

5.3.1.1 Download & Reset Program

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

Startup Phase	Description
Phase 1: Connect	A software connection to the target 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 target is performed.
Phase 4: Download	The debuggee is downloaded to target memory.
Phase 5: Finish	The initial program operation is performed (see <i>Initial Program Operation</i> on page 136).

Flow Chart

Section *Startup Sequence Flow Chart* on page 184 provides a flow chart of the Download & Reset Program startup sequence. This chart can be used as a reference when reprogramming the sequence via the scripting interface.

5.3.1.2 Attach to Running Program

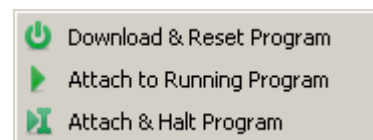
This connection mode attaches the debugger to the debuggee by performing phases 1 and 2 of the default startup sequence (see *Download & Reset Program* on page 136).

5.3.1.3 Attach & Halt Program

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

5.3.1.4 Setting the Connection Mode

The connection mode can be set via user action `Debug.SetConnectMode` (see *Debug.SetConnectMode* on page 216), via the System Variable Editor (see *System Variable Editor* on page 56) or via the Connection Menu (Debug → Start Debugging). The Connection Menu is illustrated on the right.



5.3.2 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 140):

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.

5.3.3 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 162.

5.3.4 Visible Effects

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

5.4 Register Initialization

5.4.1 Overview

Ozone initializes the program counter register (PC) and possibly also the stack pointer register (SP) in an architecture-specific manner each time...

- a program file was downloaded to target memory.
- a hardware-reset of the target was performed.

In the download case, register initialization takes place after file contents have been written to target memory and before the initial program operation is performed (see *Initial Program Operation* on page 136).

Note

Ozone performs a hardware reset of the target...

- before a program file is downloaded
- when the program is user-reset

5.4.2 Register Reset Values

The standard register initialization values are depicted in the table below. The depicted values apply for both download and hardware reset.

Architecture	Initial PC	Initial SP
Legacy ARM	0	
Cortex-A/R	0	
Cortex-M	[0x4]	[0x0]
RISCV-V	0	

An empty table cell indicates that Ozone leaves the register uninitialized. A value in square brackets means that the value is interpreted as a memory location from which the register reset value is read.

5.4.3 Manual Register Initialization

Users are able to override Ozone's default register initialization behaviour by implementing script functions `AfterTargetDownload` and/or `AfterTargetReset`. When one of these script functions is implemented, Ozone skips the standard register initialization procedure of the named event. In this case, users are required to implement the script function in a manner such that target registers are initialized according to their needs. Ozone's scripting system is discussed in detail in chapter *Scripting Interface* on page 20.

5.4.4 Project-Default Register Initialization

Ozone projects generated via the Project Wizard implement both script functions `AfterTargetDownload` and `AfterTargetReset` and therefore override Ozone's default register initialization behaviour per default (see *Project Wizard* on page 31). The register initialization scheme of wizard-generated projects is depicted in the table below. The depicted values apply for both download and hardware reset.

Architecture	Initial PC	Initial SP
Legacy ARM	<baseaddr>	
Cortex-A/R	<baseaddr>	
Cortex-M	[<baseaddr> + 4]	[<baseaddr>]
RISCV-V	<baseaddr>	

<baseaddr> stands for the lowest memory address that was written to during download. A value in square brackets means that the value is interpreted as a memory location from which the register reset value is read.

5.5 Debugging Controls

Ozone provides multiple debugging controls that modify the program execution point in a defined way.

5.5.1 Reset

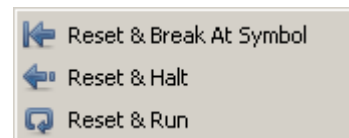
The program can be reset via user action `Debug.Reset` (see *Debug.Reset* on page 217). The action can be executed from the Debug Menu (see *Debug Menu* on page 39) or by pressing F4.

5.5.1.1 Reset Mode

The reset behavior depends on the value of the reset mode parameter (see *Reset Modes* on page 171). The reset mode specifies which one of the three initial program operations is performed after the target has been hardware-reset (see *Initial Program Operation* on page 136).

Setting the Reset Mode

The reset mode can be set via user action `Debug.SetResetMode` (see *Debug.SetResetMode* on page 217), via the System Variable Editor (see *System Variable Editor* on page 56) or via the Reset Menu (Debug → Reset). The Reset Menu is illustrated on the right. The symbol to break at can be specified by settings System Variable `VAR_BREAK_AT_THIS_SYMBOL`.



5.5.2 Step

Ozone provides three user actions that step the program in defined ways. The debugger's stepping behavior also depends on whether the Source Viewer or the Disassembly Window is the active code window (see *Active Code Window* on page 45). The table below considers each situation and describes the resulting behavior.

Action	Source Viewer is Active Code Window	Disassembly Window is Active Code Window
<code>Debug.StepInto</code>	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).
<code>Debug.StepOver</code>	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.
<code>Debug.StepOut</code>	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.

5.5.2.1 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 assembly code instructions, the debugger will use its instruction stepping mode instead of performing source line steps.

5.5.3 Resume

The program can be resumed via user action `Debug.Continue` (see *Debug.Continue* on page 216). The action can be executed from the Debug Menu or by pressing the hotkey F5.

5.5.4 Halt

The program can be halted via user action `Debug.Halt` (see *Debug.Halt* on page 216). The action can be executed from the Debug Menu or by pressing the hotkey F6.

5.5.5 Run To

User action `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 219). 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.

5.5.6 Set Next Statement

User action `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 (see *Debug.SetNextStatement* on page 218). The action is accessible from the context menu of the Source Viewer.

5.5.7 Set Next PC

User action `Debug.SetNextPC` advances program execution to a particular instruction address (see *Debug.SetNextPC* on page 218). The action sets the execution point directly, i.e. all instructions between the current execution point and the destination execution point will be skipped. The action is accessible from the context menu of the Disassembly Window.

5.6 Breakpoints

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

5.6.1 Source Breakpoints

A breakpoint that is set on a source code line is referred to as a source breakpoint. Technically, a source breakpoint is set on the memory addresses of one or multiple machine instructions affiliated with the source code line.

5.6.1.1 Editing Source Breakpoints

Source breakpoints can be edited within the Source Viewer (see *Source Viewer* on page 118), within the Breakpoints/Tracepoints Window (see *Breakpoints/Tracepoints Window* on page 71) or via user actions `Break.SetOnSrc`, `Break.ClearOnSrc`, `Break.EnableOnSrc`, `Break.DisableOnSrc` and `Break.ClearAll` (see *Breakpoint Actions* on page 190). Source code locations are specified in a predefined format (see *Source Code Location Descriptor* on page 168).

5.6.2 Instruction Breakpoints

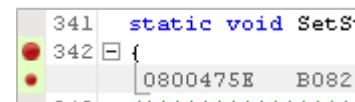
A breakpoint that is set on the memory address of a machine instruction is referred to as an instruction breakpoint.

5.6.2.1 Editing Instruction Breakpoints

Instruction breakpoints can be edited within the Disassembly Window (see *Disassembly Window* on page 89), within the Breakpoints/Tracepoints Window (see *Breakpoints/Tracepoints Window* on page 71) or via user actions `Break.Set`, `Break.Clear`, `Break.Enable`, `Break.Disable` and `Break.ClearAll` (see *Breakpoint Actions* on page 190).

5.6.3 Derived Breakpoints

An instruction breakpoint that was set implicitly by Ozone in order to implement a source breakpoint is referred to as a derived breakpoint. As a fixed part of their parent source breakpoint, derived breakpoints cannot be cleared individually. Derived breakpoints can be distinguished from user-set breakpoints by their smaller diameter icon as depicted on the right.



5.6.4 Advanced Breakpoint Properties

Each breakpoint can be assigned a set of advanced ("extra") properties that are evaluated/performed when the breakpoint is hit. The advanced properties of a breakpoint can be edited via the Breakpoint Properties Dialog (see *Breakpoint Properties Dialog* on page 58) or programmatically via user action `Break.Edit` (see *Break.Edit* on page 244). Please refer to section *Breakpoint Properties* on page 71 for an overview of all available advanced breakpoint properties.

5.6.5 Permitted Implementation Types

Each breakpoint can be assigned a permitted implementation type (see *Breakpoint Implementation Types* on page 171). The permitted implementation type of a breakpoint can be edited via the Breakpoint Properties Dialog (see *Breakpoint Properties Dialog* on page 58), via the Breakpoints/Tracepoints Window (see *Breakpoints/Tracepoints Window* on page 71) or programmatically via user action `Break.SetType` (see *Break.SetType* on page 242).

Default Permitted Implementation Type

For all breakpoints that have not been assigned a permitted implementation type, the value of system variable `VAR_BREAKPOINT_TYPE` is used (see *System Variable Identifiers* on page 177).

5.6.6 Flash Breakpoints

All J-Link/J-Trace debug probes come with a unique feature that allows the user to set an unlimited number of software breakpoints when debugging in flash memory. Without this feature, the user would be limited to the number of breakpoints supported by the target CPU.

Note

For J-Link base debug probes, the “unlimited flash breakpoints” feature requires a separate software license from SEGGER.

5.6.7 Breakpoint Callback Functions

Each breakpoint can be assigned a script function that is executed when the breakpoint is hit. The script callback function can be assigned via the Breakpoint Properties Dialog (see *Breakpoint Properties Dialog* on page 58) or programmatically via commands `Break.SetCommand` (see *Break.SetCommand* on page 250) and `Break.SetCmdOnAddr` (see *Break.SetCmdOnAddr* on page 250).

5.6.8 Offline Breakpoint Modification

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 target will be applied when the debug session is started.

5.7 Data Breakpoints

Data breakpoints 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 are most commonly used to monitor accesses to global program variables.

5.7.1 Data Breakpoint Attributes

A data breakpoint is defined by the following attributes:

Attribute	Description
Address	Memory address that is monitored for IO (access) events.
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 <i>Access Types</i> on page 171).
Access Size	Number of bytes that need to be accessed in order to trigger the data breakpoint (see <i>Memory Access Widths</i> on page 171). 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 <code>0xFFFFFFFF</code> disables the value condition.

5.7.2 Editing Data Breakpoints

Data breakpoints can be set, cleared and edited via the Data Breakpoint Dialog (see *Data Breakpoint Dialog* on page 57). This dialog is accessible from the context menus of the Code Windows and the Breakpoints/Tracepoints Window.

Data breakpoints can also be manipulated inside script functions. For this, the actions listed in *Breakpoint Actions* on page 190 that end on either "Data" or "Symbol" are provided.

Note

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 target.

5.8 Program Inspection

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

5.8.1 Execution Point

Users may navigate to the current position of program execution, also called the PC line, via user actions *View.PC* (see *View.PC* on page 212) and *View.PCLine* (see *View.PCLine* on page 212).

5.8.2 Static Program Entities

Ozone provides 4 debug windows allowing users to inspect static program content that does not change with the execution point. The capabilities of these windows are summarized below.

Debug Window	Description
Functions Window	Lists all functions linked to assemble the debuggee, including functions implemented within external code.
Source Files Window	Displays the source code files that were used to build the debuggee.
Memory Usage Window	Displays the partitioning of target memory into Flash, RAM and other memory areas as well as the usage of these areas by the debuggee.
Call Graph Window	Displays all possible function call paths, giving the user a clear picture on the possible execution flow.

5.8.3 Data Symbols

Ozone provides 3 symbol windows that allow users to observe, edit and modify program variables and function parameters. The capabilities of these windows are summarized below.

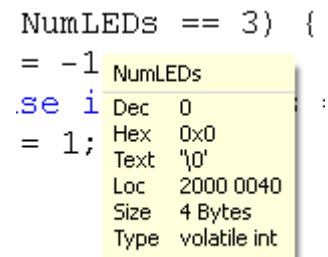
Debug Window	Description
Local Data Window	Allows users to observe and manipulate the local variables and function parameters that are in scope at the execution point. Furthermore, the Local Data Window is able to display the variables and parameters of any function on the call stack. By selecting a called function within the Call Stack Window or within the Source Viewer, the local symbols of that function are displayed.
Global Data Window	Allows users to observe and edit global program variables
Watched Data Window	Any program variable can be put under, and removed from, explicit observation via user actions <i>Window.Add</i> and <i>Window.Remove</i> (see <i>Window Actions</i> on page 195). Observed variables are displayed within the Watched Data Window (see <i>Watched Data Window</i> on page 130).

5.8.4 Symbol Data Navigation

The data location of a variable or function parameter can be navigated-to by executing the user action *View.Data* (see *View.Data* on page 210). This action is available from the context menu of all symbol windows.

5.8.5 Symbol Tooltips

When hovering the mouse cursor over a data symbol within the Source Viewer, a tooltip will pop up that displays the symbol's value (see *Expression Tooltips* on page 119).



5.8.6 Call Stack

The sequence of function calls that led to the current execution point can be observed within the Call Stack Window (see *Call Stack Window* on page 75).

5.8.7 Target Registers

The current state of the target's core and peripheral registers can be inspected and edited via Ozone's Register Window (see *Register Window* on page 113). The user actions `Target.GetReg` and `Target.SetReg` are provided to read and write core and peripheral registers inside script functions or at the command prompt (see *Target Actions* on page 194).

5.8.8 Target Memory

The current state of target memory can be inspected and edited via Ozone's Memory Window (see *Memory Window* on page 104).

The user actions:

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

are provided to read and write target memory inside script functions or at the command prompt (see *Target Actions* on page 194). These actions access memory byte (U8), half-word (U16) and word-wise (U32).

5.8.8.1 Default Memory Access Width

The default access width that Ozone employs when reading or writing memory strides of arbitrary size can be specified via the user action `Target.SetAccessWidth` (see *Target.SetAccessWidth* on page 237).

5.8.9 Inspecting a Running Program

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

Limitation	Description
Frozen CPU registers	CPU registers are not updated and cannot be edited.
Frozen symbol windows	Values within symbol windows are not updated and cannot be edited.
Deactivated debugging controls	All debug controls except "halt" and "disconnect" are deactivated.
No execution point context	Debug windows that show execution point context when the program is halted (Callstack, Local Data,...) are empty.

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

5.8.9.1 Live Watches

In situations where the value of a data symbol needs to be monitored while the program is running, users can resort to Ozone's Watched Data Window (see *Watched Data Window* on page 130). The Watched Data Window allows users to set refresh rates between 1 and 5 Hz for each watched item individually.

5.8.9.2 Symbol Trace

In situations where a high-resolution trace of a data symbol is required, users can resort to Ozone's Data Graph Window (see *Data Graph Window* on page 83). The Data Graph Window supports sampling rates of up to 1 MHz and provides advanced navigation tools for exploring the resulting data graph.

5.8.9.3 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 155. For further information on streaming trace, please consult the [J-Link User Guide](#) or [SEGGER's website](#).

5.8.9.4 Power Trace

The Power Graph Window tracks the current drawn by the target while executing the debuggee and displays the resulting graph in an interactive signal plot.

5.9 Terminal IO

Ozone supports printf-style debugging of the debuggee. A debuggee may send text messages to the debugger by employing one or multiple of the IO techniques described below. Text output from the debuggee is shown within the Terminal Window (see *Terminal Window* on page 123).

5.9.1 Real-Time Transfer

SEGGER's Real-Time Transfer (RTT) is a bi-directional data transmission technique based on a shared target 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 [SEGGER's website](#).

5.9.1.1 RTT Configuration

Ozone will automatically sense whether the debuggee supports Text-IO via RTT. If RTT support is detected, the debugger automatically starts to capture data on the RTT interface. Text-IO via RTT generally does not need to be configured within Ozone. However, when no program file download is performed on debug start, it may be necessary to supply RTT buffer location information (see *Project.AddRTTSearchRange* on page 224). On the application program side, a special global program variable must be provided. Please refer to [SEGGER's website](#) for further information on how to set up and use RTT within your debuggee.

5.9.2 SWO

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

5.9.2.1 SWO Configuration

Text-IO via SWO must be configured both within the debuggee and within Ozone. Within the debugger, it is enabled and configured via the Trace Settings Dialog (see *Trace Settings Dialog* on page 67) or programmatically via user actions *Project.SetTraceSource* (see *Project.SetTraceSource* on page 224) and *Project.ConfigSWO* (see *Project.ConfigSWO* on page 227). The SWO interface can also 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 set up and use printf via SWO in your application.

5.9.3 Semihosting

Ozone is able to communicate with the debuggee via the Semihosting mechanism. Next to providing bi-directional text I/O via the Terminal Window, the debuggee 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](#).

5.9.3.1 Semihosting Configuration

The Semihosting interface can be enabled or disabled via user action *Project.SetSemihosting* (see *Project.SetSemihosting* on page 225) or via the Terminal Window's context menu item "Capture Semihosting IO". Semihosting configuration parameters can be edited via command *Project.ConfigSemihosting* (see *Project.ConfigSemihosting* on page 225). The debuggee must also apply special assembly code to emit semihosted text messages. Please refer to the ARM Information Center for details on how to set up and use semihosting within your debuggee.

5.10 Downloading Program Files

For the purpose of downloading program files to target memory, Ozone provides four distinct user actions:

- File.Open: (see *File.Open* on page 197)
- File.Load: (see *File.Load* on page 198)
- Exec.Download: (see *Exec.Download* on page 240)
- Target.LoadMemory: (see *Target.LoadMemory* on page 238)

These actions differ in the way the download is performed in regards to the following aspects:

- HWRESET: is a hardware reset of the target performed prior to download?
- SCRIPT: are script functions called at specific moments of the download?
- REGINIT: are registers initialized after download?
- FINISH: is the initial program operation performed after download?
- SYMBOLS: are program symbols loaded into Ozone's symbol windows when the program file is opened for download?

5.10.1 Download Behaviour Comparison

The table below compares the mentioned actions regarding the named aspects. Only user action File.Open triggers the standard download sequence that is also performed during debug session startup (see *Starting the Debug Session* on page 136). The hardware reset is identical to the operation performed by user action Exec.Reset (see *Exec.Reset* on page 240). For a description of the initial program operation, please refer to section *Initial Program Operation* on page 136.

User Action	HWRESET	SCRIPT	REGINIT	FINISH	SYMBOLS
File.Open	x	x	x	x	x
File.Load		x	x		x
Exec.Download					
Target.LoadMemory					

5.10.2 Script Callback Behaviour Comparison

Ozone's download actions furthermore differ in regards to the script functions executed during the download sequence. The table below gives an overview.

Script Function	File.Open	File.Load	Exec.Download	Target.LoadMemory
BeforeTargetReset	x	x		
TargetReset	x			
AfterTargetReset	x	x		
BeforeTargetDownload	x	x		
TargetDownload	x			
AfterTargetDownload	x	x		

5.10.3 Avoiding Script Function Recursions

In order to avoid infinite script function recursions, users are advised to not use actions File.Open and File.Load within any script function that is itself an event handler for the command. Users are advised to use actions Exec.Download and Target.LoadMemory in these places instead.

5.10.4 Downloading Bootloaders

For details on how to configure Ozone for the download and execution of a bootloader prior to the download of the debuggee, please refer to section *Incorporating a Bootloader into Ozone's Startup Sequence* on page 165.

5.11 Locating Missing Source Files

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

5.11.1 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.

5.11.2 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 a file dialog to locate the file (see *Unresolved Source Files* on page 116).

5.11.3 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 183 for further details.

5.12 Setting Up Trace

This section describes the configuration of trace within Ozone. For a general overview on trace with J-Link and J-Trace, please refer to the [J-Link User Guide](#) and [SEGGER's website](#).

5.12.1 Trace Features Overview

Ozone's trace features consist of the following elements:

- Instruction Trace Window (see *Instruction Trace Window* on page 97)
- Timeline Window (see *Timeline Window* on page 125)
- Code Profile Window (see *Code Profile Window* on page 77)
- Execution Counters (see *Execution Counters* on page 118)

5.12.2 Target Requirements

Ozone currently supports trace on the following MCU architectures:

- Cortex-M
- Cortex-A

ARM's Cortex MCU architecture principally allows two ways how trace data may be moved from the target to the PC: in a buffered (ETB) and a streaming (ETM) fashion. ETM trace has many advantages over ETB trace but also an extended hardware requirement (see *Streaming Trace* on page 147).

5.12.2.1 Target Requirements for ETB Trace

Buffered trace requires the target to contain an embedded trace buffer (ETB). The trace buffer must be accessible to J-Link, i.e. accessible via the selected target interface. ETB-Trace otherwise poses no additional requirements on the hardware setup.

5.12.2.2 Target Requirements for ETM Trace

Streaming trace requires the target CPU to contain an embedded trace macrocell (ETM) or a program trace macrocell (PTM). The trace data generated by these units is emitted via dedicated CPU pins. It is target dependent if these trace pins are present and to what type of debug header they are connected, if any. Most commonly, the trace pins are routed to a 19-pin Samtec FTSH "trace" header.

5.12.3 Debug Probe Requirements

- ETB trace is supported by all J-Link and J-Trace models.
- ETM trace requires a J-Trace PRO model to be employed.

5.12.4 Trace Settings

- ETB trace does not need to be configured in Ozone.
- ETM trace has multiple configuration settings in the form of Ozone system variables which are summarized below.

System Variable	Description	Default
VAR_TRACE_SOURCE	Selects the trace source to use. See <i>Trace Sources</i> on page 172 for the list of valid values.	none
VAR_TRACE_PORT_WIDTH	Specifies the number of trace pins provided by the target. Permitted values are 1, 2 and 4.	4
VAR_TRACE_PORT_DELAY_n	Configures the sampling delay of trace pin n (n=1...4). The valid value range is -5 to	2.0ns

System Variable	Description	Default
	+5 nanoseconds at steps of 50 ps. See <i>Project.SetTraceTiming</i> on page 226 for further information.	
VAR_TRACE_MAX_INST_CNT	Specifies the maximum amount of instructions that Ozone can process and store during a streaming trace session.	1M
VAR_TRACE_TIMESTAMPS_ENABLED	Specifies whether the target is to output (and J-Link/Ozone is to process) PC timestamps multiplexed into the trace data stream.	1
VAR_TRACE_CORE_CLOCK	CPU frequency in Hz. Ozone uses this variable to convert instruction timestamps from CPU cycle count to time format (see <i>VAR_TRACE_TIMESTAMPS_ENABLED</i>).	100kHz
VAR_TRACE_FILE_ENABLED	When enabled, Ozone stores all trace data read from the target to the file specified by <i>VAR_TRACE_FILE_PATH</i> .	0
VAR_TRACE_FILE_PATH	Specifies the file path of the trace file.	
VAR_TRACE_FILE_MAX_SIZE	Specifies the maximum size of the trace file in bytes.	4GB
VAR_TRACE_FILE_KEEP_START	Specifies the trace file overflow behaviour. When set to 1, trace file recording stops when the file is full. When set to 0, the oldest recorded data is overwritten.	0

All of the above system variables can be edited via the Trace Settings Dialog (see *Trace Settings Dialog* on page 67) or programmatically via user action *Edit.SysVar* (see *Edit.SysVar* on page 203). Most system variables pertaining to instruction trace are accompanied by a project setting that accomplishes the same task (see *Project Actions* on page 193).

Note

When instruction timestamps are not required, the option should be disabled to enhance the overall tracing performance.

5.12.5 Instruction Cache

All instruction-trace and disassembly related features of Ozone require the prior initialization of the instruction cache with the program code to be debugged. In case a download is performed on debug session start, Ozone automatically initializes the instruction cache with the downloaded bytes. In situations where the instruction cache is not fully initialized from the downloaded bytes, e.g. when:

- program code areas are initialized at runtime (e.g. RAM-Debug)
- no program file is specified
- attaching to a running program

the instruction cache has to be initialized manually via command *Debug.ReadIntoInstCache* (see *Debug.ReadIntoInstCache* on page 219). When the instruction cache is not initialized, Ozone will display a warning message indicating that debugging information will be inaccurate.

5.13 Selective Tracing

5.13.1 Overview

Many ARM-Cortex targets allow trace data output to be limited to a set of user-defined program address ranges. When selective tracing is active, the target's trace buffer is only filled with trace data that matches the configured constraints. This makes selective tracing particularly valuable on hardware setups with limited trace buffer size and no streaming trace capability.

5.13.2 Requirements

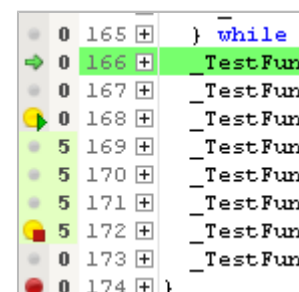
It is to a high degree target dependant if selective tracing is supported and to what extent. A generic requirements guideline cannot be given. Instead, refer to your MCU model's user manual or contact the manufacturer when unsure about the capabilities of your target.

5.13.3 Tracepoints

Selective tracing is implemented in Ozone using start and stop-type tracepoints. Tracepoints can be toggled on program instructions and source lines just like ordinary breakpoints. Each matching pair of start and stop tracepoints marks an address range whose instructions are included in the target's trace output. All instruction fetches occurring outside of tracepoint-configured address ranges will not generate trace data.

Tracepoint Imprecision

An MCU possibly commands its tracepoints hardware unit asynchronously to its instruction execution unit. This means that trace data capture may be started and stopped a few cycles after the affiliated instruction has been fetched for execution.



5.13.4 Scope

All of the features summarized in *Trace Features Overview* on page 152 are affected by selective tracing.

5.14 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 111.

5.14.1 Program Performance Optimization

5.14.1.1 Scenario

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

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

Code Profile				
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 spends 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 spent, 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".

Filtering Instructions

A compiler may furthermore emit code alignment instructions (NOP's) that are likewise not relevant for code optimization. NOP Instructions can be filtered from the code profile statistic by clicking on context menu entry "Exclude NOP Instructions" or programmatically via user action `Coverage.ExcludeNOPs` (see *Coverage.ExcludeNOPs* on page 233).

Code Profile				
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. Other functions which affect the CPU load but cannot be optimized any further can be filtered accordingly in order to find remaining functions worth optimizing. In this example, a quarter of the remaining CPU time is spent in function `vTraceStoreEvent1`. Let's now assume the user wants to optimize the runtime of this function. By double-clicking on the function, the function 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.

	693	/* Store an event with
	694	void vTraceStoreEvent1(
11 966	695	{
	696	TRACE_ALLOC_CRITICAL
	697	
11 966	698	PSF_ASSERT(eventID <
11 966		08001F58 88FB
11 966		08001F5A F5B35
11 966		08001F5E D303
0		08001F60 2001
0		08001F62 F000F
0		08001F66 E052
	699	
11 966	700	TRACE_ENTER_CRITICAL_

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 target's core frequency may indicate that the target is thwarted by an excessive hardware IRQ load.

Code Profile Instruction Count: 136 094 231 in 541.9s (251 142/s)

Connected @ 2 MHz

5.15 Other Debugging Activities

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

5.15.1 Finding Text Occurrences

Ozone's Find Dialog allows users to search for text patterns within source code documents (see *Find Dialog* on page 61). The Find Dialog supports regular expressions and can be opened via user action *Edit.Find* or via the Source Viewer's context menu (see *Edit.Find* on page 203).

5.15.2 Configuring Message Logging

Refer to section *Application Messages* on page 69 for details on how to enable message logging to the application and console log files.

5.15.3 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 130) or programmatically via user action *Elf.GetExprValue* (see *Elf.GetExprValue* on page 251). Please refer to *Expressions* on page 181 for more information on Ozone expressions.

5.15.4 Saving And Loading Memory

Ozone allows users to store target memory content to a binary data file and vice versa.

Memory-To-File

Target memory blocks can be saved (dumped) to a binary data file via user action- *Target.SaveMemory* (see *Target.SaveMemory* on page 238) or via the *Save Memory Dialog* (see *Generic Memory Dialog* on page 105).

File-To-Memory

File contents can be downloaded to target memory via user action *Target.LoadMemory* (see *Target.LoadMemory* on page 238) or via the *Load Memory Dialog* (see *Generic Memory Dialog* on page 105).

5.15.5 Relocating Symbols

To allow the debugging of runtime-relocated programs such as bootloaders, Ozone provides user action *Project.RelocateSymbols* (see *Project.RelocateSymbols* on page 230). This command shifts the absolute addresses of a set of program symbols by a constant offset. It can thus be used to realign symbol addresses to a modified program base address.

5.15.6 Terminal Input Requests

The debuggee (debuggee) can request user input via the Semihosting or RTT data IO techniques (see *Terminal IO* on page 148). This common debugging technique allows users to manipulate the program state at application-defined execution points and to observe the resulting runtime behavior. Ozone provides the Terminal Prompt for answering user input requests (see *Terminal Prompt* on page 123).

5.15.7 Stopping the Debug Session

The debug session can be stopped via user action `Debug.Stop` (see *Debug.Stop* on page 215). 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 target 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. Ozone currently requires all script code to be contained within functions. Statements and declarations occurring outside of function bodies are invalid syntax. However, global constants can be defined using action `Script.DefineConst` (see *Script.DefineConst* on page 214).

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 workflow. The different function categories are described below.

6.1.3 Event Handler Functions

Ozone defines a set of 11 event handler functions that the debugger executes upon the entry of defined debugging events. The Table below 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
<code>void OnProjectLoad();</code>	Executed when the project file is opened.
<code>void BeforeTargetReset();</code>	Executed before the target is reset.
<code>void AfterTargetReset();</code>	Executed after the target was reset.
<code>void BeforeTargetDownload();</code>	Executed before the program file is downloaded.
<code>void AfterTargetDownload();</code>	Executed after the program file was downloaded.
<code>void BeforeTargetConnect();</code>	Executed before a J-Link connection to the target is established.
<code>void AfterTargetConnect();</code>	Executed after a J-Link connection to the target was established.
<code>void BeforeTargetDisconnect();</code>	Executed before the debugger disconnects from the target.
<code>void AfterTargetDisconnect();</code>	Executed after the debugger disconnected from the target.
<code>void AfterTargetHalt();</code>	Executed after the target processor was halted.
<code>void BeforeTargetResume();</code>	Executed before the target processor is resumed.

Example Event Handler Implementation

Illustrated below is an example implementation of the event handler function `AfterTargetReset`. In this example, a peripheral register at memory address `0x40004002` is initialized after the target was reset.

```

/*****
 *
 *      AfterTargetReset
 *
 * Function description
 *      Executed after the target was reset.
 *
 *****/
void AfterTargetReset(void) {
    Target.WriteU32(0x40004002, 0xFF);
}

```

6.1.3.1 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.

6.1.3.2 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 *Process Replacement Functions* on page 161. The table below gives an overview:

Process Replacement Function	Description
<code>void DebugStart();</code>	Replaces the default debug session startup routine.
<code>void TargetReset();</code>	Replaces the default target hardware reset routine.
<code>void TargetConnect();</code>	Replaces the default target connection routine.
<code>void TargetDownload();</code>	Replaces the default program download routine.

6.1.4 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 35). 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).

6.1.5 Executing Script Functions

Ozone provides user action `Script.Exec` (see *Script.Exec* on page 214) that allows users to execute individual script functions from the Command Prompt (see *Command Prompt* on page 81).

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

The table below lists the different phases of Ozone's default debug session startup sequence (see *Download & Reset Program* on page 136). 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	Process Replacement Function
Phase 1: Connect	A software connection to the target is established via J-Link.	<code>TargetConnect</code>
Phase 2: Breakpoints	Pending (data) breakpoints that were set in offline mode are applied.	
Phase 3: Reset	A hardware reset of the target is performed.	<code>TargetReset</code>
Phase 4: Download	The debuggee is downloaded to target memory.	<code>TargetDownload</code>
Phase 5: Finish	The initial program operation is performed (see <i>Initial Program Operation</i> on page 136).	

Flow Chart

Appendix *Startup Sequence Flow Chart* on page 184 provides a graphical flowchart of the startup sequence. Most notably, the flowchart illustrates at what points during the startup sequence certain event handler functions are called (see *Event Handler Functions* on page 160).

Breakpoint Phase

Phase 2 (Breakpoints) of the default startup sequence is always executed implicitly after the connection to the target 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/blinkyp.axf");
}

```

6.2.2 TargetConnect

When the script function `TargetConnect` is present in the project file, the debugger's default target 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 target memory along with the debuggee. A corresponding implementation of the script function `TargetDownload` is illustrated below.

```

/*****
 *
 *      TargetDownload
 *
 * Function description
 *      Downloads an additional program image to target memory
 *
 *****/
void TargetDownload(void) {
    Util.Log("Downloading Program.");
    /* 1. Download the debuggee */
    Debug.Download();
    /* 2. Download the additional program image */
    Target.LoadMemory("C:/AdditionalProgramData.hex", 0x20000400);
}

```

6.2.4 TargetReset

When the script function `ttTargetReset` is defined within the project file, the debugger's default target 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 "JLINKAR-M_Reset". Please refer to the [J-Link User Guide](#) for details on this routine and its target-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 debuggee is downloaded to a memory address other than zero, for example the RAM base address.

Problem

The standard reset routine of the firmware assumes that the debuggee's vector table is located at address 0 (Cortex-M) or that the initial PC is 0 (Cortex-A/R, Legacy ARM). As this is not true for RAM debug, the reset routine must be replaced with a custom implementation that initializes the PC and SP registers to correct values.

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 target's reset pin and halting the processor are performed. Next, a custom reset routine needs to initialize the PC and SP registers so that the target is ready to execute the first program instruction.

Example

The figure below displays the typical implementation of a custom hardware reset routine for RAM debug on a Cortex-M target. This implementation is included in all project files generated by the Project Wizard that are set up for a Cortex-M target device.

```

/*****
*
*      TargetReset
*
* Function description
*   Resets a program downloaded to a Cortex-M target's 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 hardware 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);
}

```

6.3 Incorporating a Bootloader into Ozone's Startup Sequence

An important use case of Ozone's scripting system is to configure the debug session startup sequence in a manner such that a hardware initialization program (bootloader) is executed before download of the debuggee. This section explains how users are expected to write an Ozone script that serves this particular purpose. The following example is written for the Cortex-M architecture but the demonstrated concepts are universally valid.

OnProjectLoad

```

/*****
 *
 *   OnProjectLoad
 *
 * Function description
 *   Project load routine. Required.
 *
 *****/
void OnProjectLoad (void)
{
    ...
    File.Open("debuggee.elf"); // open main image
}

```

The script's entry point function loads the debuggee instead of the bootloader. This ensures that the debug windows that show static program information are initialized even when the debug session was not yet started.

TargetDownload

```

/*****
 *
 *   TargetDownload
 *
 * Function description
 *   Downloads the bootloader instead of the main image.
 *
 *****/
void TargetDownload (void)
{
    Exec.Download("Bootloader.hex");
}

```

Script function `TargetDownload` instructs Ozone to download the bootloader instead of the main image when the debug session is started. Note that command `Exec.Download` is used to download the bootloader. The reason for this is that this command does not trigger any other script functions when executed (see *Download Behaviour Comparison* on page 149).

AfterTargetDownload

```

/*****
 *
 *      AfterTargetDownload
 *
 * Function description
 *      Initializes PC and SP for either bootloader or debuggee execution
 *
 *****/
void AfterTargetDownload (void)
{
    unsigned int Addr;

    if (TargetIsHaltedAtBootloaderEnd()) {
        Addr = <main_image_download_address>; // init regs for debuggee exec.
    } else {
        Addr = <bootloader_download_address>; // init regs for bootloader exec.
    }
    Target.SetReg("SP", Target.ReadU32(Addr));
    Target.SetReg("PC", Target.ReadU32(Addr + 4));
}

```

Script function `AfterTargetDownload` instructs Ozone to initialize the PC and SP registers to the required values for either bootloader or main image execution, depending on which file was downloaded.

AfterTargetHalt

```

/*****
 *
 *      AfterTargetHalt
 *
 * Function description
 *      Checks if the bootloader finished execution and if so, loads the debuggee
 *
 *****/
void AfterTargetHalt (void)
{
    if (TargetIsHaltedAtBootloaderEnd())
    {
        File.Load("debuggee.elf", 0);
    }
}

```

The key to incorporating a bootloader into Ozone's debug session startup sequence is to detect the point in time when the bootloader has finished execution. The expected way to do this is to have the bootloader run into a software breakpoint instruction at the end of its execution. Once the bootloader hits this breakpoint, Ozone senses that the target has halted and executes script function `AfterTargetHalt`. Helper function `TargetIsHaltedAtBootloaderEnd` tests if the current PC is identical to the PC of the software breakpoint. If the test succeeds, the download of the main image is performed. A key aspect here is that command `"File.Load"` is used to perform the download of the main image. This way, the target is not hardware-reset prior to the download (which would possibly revert changes performed by the bootloader) and script function `AfterTargetDownload` is executed after the download. For an overview of the behavioral differences of Ozone's downloading user actions, please refer to section *Download Behaviour Comparision* on page 149.

Chapter 7

Appendix

The Appendix provides descriptions on all Ozone API commands (user actions) and informs about Ozone system variables and constants.

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]"
```

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:

- steel-blue (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"
```

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.

7.1.5.1 ARM

A CPRD on ARM can be specified in the following way:

```
"<CpNum> , <CRn> , <CRm> , <Op1> , <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 target. Note that the field "CpNum" is currently limited to the value 15 (Coprocessor-15).

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

The table below lists permitted values for the host interface parameter (see *Project.SetHostIF* on page 221).

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.

7.2.2 Target Interfaces

The table below lists permitted values for the target interface parameter (See *Project.Set-TargetIF* on page 221).

Constant	Description
JTAG	Use this value when the J-Link debug probe is connected to the target via JTAG.
cJTAG	Use this value when the J-Link debug probe is connected to the target via cJTAG.
SWD	Use this value when the J-Link debug probe is connected to the target via SWD.

7.2.3 Boolean Value Constants

The table below 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.

7.2.4 Value Display Formats

The table below lists permitted values for the display format parameter (see *Window.Set-DisplayFormat* on page 207).

Constant	Description
DISPLAY_FORMAT_AUTO	Displays values in the format that is best suited.
DISPLAY_FORMAT_BINARY	Displays integer values in binary notation.
DISPLAY_FORMAT_DECIMAL	Displays integer values in decimal notation.
DISPLAY_FORMAT_HEXADECEMAL	Displays integer values in hexadecimal notation.
DISPLAY_FORMAT_CHARACTER	Displays the text representation of the value.

7.2.5 Memory Access Widths

The table below lists permitted values for the memory access width parameter (see *Target.SetAccessWidth* on page 237).

Constant	Description
AW_AUTO	Automatic access.
AW_BYTE	Byte access.
AW_HALF_WORD	Half word access.
AW_WORD	Word access.

7.2.6 Access Types

The table below lists permitted values for the access type parameter (see *Break.SetOnData* on page 245).

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.

7.2.7 Connection Modes

The table below lists permitted values for the connection mode parameter (see *Debug.SetConnectMode* on page 216).

Constant	Description
CM_DOWNLOAD_RESET	The debugger connects to the target and resets it. The program is downloaded to target memory and program execution is advanced to the main function.
CM_ATTACH	The debugger connects to the target and attaches itself to the executing program.
CM_ATTACH_HALT	The debugger connects to the target, attaches itself to the executing program and halts program execution.

7.2.8 Reset Modes

The table below lists permitted values for the reset mode parameter (see *Debug.SetResetMode* on page 217).

Constant	Description
RM_RESET_HALT	Resets the target and halts the program at the reset vector.
RM_BREAK_AT_SYMBOL	Resets the target and advances program execution to the function specified by system variable <code>VAR_BREAK_AT_THIS_SYMBOL</code> .
RN_RESET_AND_RUN	Resets the target and starts executing the program.

7.2.9 Breakpoint Implementation Types

The table below lists permitted values for the breakpoint implementation type parameter (see *Break.SetType* on page 242).

Constant	Description
BB_TYPE_ANY	The debugger chooses the implementation type.
BP_TYPE_HARD	The breakpoint is implemented using the target's hardware breakpoint unit.
BP_TYPE_SOFT	The breakpoint is implemented in software (by amending the program code with particular instructions).

For breakpoints that have not been assigned a permitted implementation type, the system variable default `VAR_BREAKPOINT_TYPE` is used (see *System Variable Identifiers* on page 177).

7.2.10 Trace Sources

The Table below lists permitted values for the trace source parameter (see *Project.SetTraceSource* on page 224).

Constant	Display Name	Description
TRACE_SOURCE_NONE	None	All trace features of Ozone are disabled.
TRACE_SOURCE_ETM	Trace Pins	Instruction trace data is read from the target's trace pins (in realtime) and provided to Ozone's trace windows. This mode requires a J-Trace debug probe.
TRACE_SOURCE_ETB	Trace Buffer	Instruction trace data is read from the target's embedded trace buffer (ETB).
TRACE_SOURCE_SWO	SWO	Printf data is read via the Serial Wire Output interface and output to the Terminal Window.

Only one trace source can be active at any given time. The J-Link team plans to remove this constraint in the near future. Please consult the [J-Link User Guide](#) for further information about tracing with J-Link or J-Trace debug probes.

7.2.11 Tracepoint Operation Types

The table below lists permitted values for the tracepoint operation parameters required by tracepoint manipulating actions (see *Trace Actions* on page 194).

Constant	Description
TP_OP_START_TRACE	Trace is started when the tracepoint is hit.
TP_OP_STOP_TRACE	Trace is stopped when the tracepoint is hit.

7.2.12 Newline Formats

The table below lists supported newline formats.

Constant	Description
EOL_FORMAT_WIN	Text lines are terminated with "\r\n"
EOL_FORMAT_UNIX	Text lines are terminated with "\n"
EOL_FORMAT_MAC	Text lines are terminated with "\r"
EOL_FORMAT_NONE	No line break.

7.2.13 Trace Timestamp Formats

The table below lists supported units for trace timestamps.

Constant	Description
TIMESTAMP_FORMAT_OFF	Timestamps are not displayed
TIMESTAMP_FORMAT_INST_CNT	Selects "number of instructions" as timestamp unit
TIMESTAMP_FORMAT_CYCLES	Selects CPU cycles as timestamp unit
TIMESTAMP_FORMAT_TIME	Selects nanoseconds as timestamp unit

7.2.14 Code Profile Export Formats

The table below lists formats that can be specified when exporting code profile data to CSV files.

Constant	Description
CSV_FUNCS	Export all program functions.
CSV_LINES	Export all executable source code lines.
CSV_INSTS	Export all program instructions.

7.2.15 Session Save Flags

The following flags identify session information that can be disabled within User Files (see *User Files* on page 134).

Flag	Description
DISABLE_SAVE_WINDOW_LAYOUT	Do not save the layout of debug information windows.
DISABLE_SAVE_TABLE_LAYOUT	Do not save arrangements of table columns and sort indicators.
DISABLE_SAVE_OPEN_FILES	Do not save the list of open source files.
DISABLE_SAVE_BREAKPOINTS	Do not save breakpoints.
DISABLE_SAVE_EXPRESSIONS	Do not save watched and graphed expressions.
DISABLE_SAVE_SELECTED_REGS	Do not save the register window's display configuration.

7.2.16 Font Identifiers

The following constants identify application fonts within Ozone (see *Edit.Font* on page 204).

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	assembly code text font.
FONT_CONSOLE	Console Window text font.

Constant	Description
FONT_LINE_NUMBERS	Line number text font.
FONT_SRC_ASM_CODE	Source-inlined assembly code font.
FONT_EXEC_COUNTERS	Font used for execution counters.

7.2.17 Color Identifiers

The following constants identify application colors within Ozone (see *Edit.Color* on page 204).

Constant	Description
COLOR_SELECTION_HIGHLIGHT	Selection highlight color.
COLOR_CHANGE_LEVEL_1_BG	Change Level 1 background color (see <i>Change Level Highlighting</i> on page 106).
COLOR_CHANGE_LEVEL_2_BG	Change Level 2 background color (see <i>Change Level Highlighting</i> on page 106).
COLOR_CHANGE_LEVEL_3_BG	Change Level 3 background color (see <i>Change Level Highlighting</i> on page 106).
COLOR_CHANGE_LEVEL_1_FG	Change Level 1 foreground color (see <i>Change Level Highlighting</i> on page 106).
COLOR_CHANGE_LEVEL_2_FG	Change Level 2 foreground color (see <i>Change Level Highlighting</i> on page 106).
COLOR_CHANGE_LEVEL_3_FG	Change Level 3 foreground color (see <i>Change Level Highlighting</i> on page 106).
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 assembly code register operands.
COLOR_SYNTAX_LABEL	Syntax color of assembly code labels.
COLOR_SYNTAX_MNEMONIC	Syntax color of assembly code mnemonics.
COLOR_SYNTAX_IMMEDIATE	Syntax color of assembly code immediates.
COLOR_SYNTAX_INTEGER	Syntax color of assembly 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 <i>Console Window</i> on page 81).
COLOR_LOGGING_USER	Console Window command feedback message color (see <i>Console Window</i> on page 81).

Constant	Description
COLOR_LOGGING_ERROR	Console Window error message color (see <i>Console Window</i> on page 81).
COLOR_LOGGING_JLINK	Console Window J-Link message color (see <i>Console Window</i> on page 81).
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.
COLOR_EXEC_PROFILE_GOOD_INST	Code profile highlighting – good instruction.
COLOR_EXEC_PROFILE_BAD_INST	Code profile highlighting – bad instruction.
COLOR_INLINE_ASM_BACKG	Source Viewer – assembly code fill color.
COLOR_INLINE_ASM_BACKG_ALT	Source Viewer – alternate assembly code fill color.
COLOR_ASM_LABEL_BACKG	Disassembly Window – symbol label fill color.
COLOR_TIMESTAMP_DARK	Timestamp color.
COLOR_TIMESTAMP_LIGHT	Interpolated timestamp color.

Color identifiers

7.2.18 User Preference Identifiers

The following constants identify user preferences within Ozone (see *Edit.Preference* on page 203).

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_SHOW_SRC_CODE_PROFILE	Specifies if execution counters are displayed within the Source Viewer
PREF_SHOW_ASM_CODE_PROFILE	Specifies if execution counters are displayed within the Disassembly Window.
PREF_SHOW_SYMBOL_ICONS	Specifies if symbol names are preceded by an icon.
PREF_INDENT_INLINE_ASSEMBLY	Specifies whether the Source Viewer aligns in-line assembly code to source code statements.
PREF_LINE_NUMBER_FREQ	Specifies the Source Viewer's line number frequency. Possible values are: off (0), current line (1), all lines (2), every 5 lines (3) and every 10 lines (4).
PREF_LOCK_HEADER_BAR	Specifies whether the Source Viewer header bar's auto-hide feature is disabled.
PREF_ASM_SHOW_SOURCE	Specifies whether the Disassembly Window augments assembly code with source code (see <i>Mixed Mode</i> on page 91).

Constant	Description
PREF_ASM_SHOW_LABELS	Specifies whether the Disassembly Window augments assembly code with symbol labels.
PREF_TAB_SPACING	Source Viewer tabulator spacing.
PREF_START_WITH_MOST_RECENT_PROJ	Specifies if the most recent project is automatically opened on application start.
PREF_PREPEND_FUNC_CLASS_NAMES	Specifies if the class name should be prepended to C++ member functions.
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_SHOW_PROGBAR_WHILE_RUNNING	Specifies if a moving progress indicator is displayed within the status bar while the program is running.
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)".
PREF_DIALOG_SHOW_DNSA	Indicates if a checkbox should be added to popup dialogs that allows users to prevent the dialog from popping up.
PREF_SHOW_HEX_BLOCKS	Specifies whether large hexadecimal numbers are divided into two blocks for better readability.
PREF_SHOW_SYMBOL_TOOLTIPS	Specifies whether symbol tooltips are enabled.
PREF_FILTER_BARS_DISABLED	Specifies whether table filter bars are globally disabled.
PREF_MAX_SYMBOL_MEMBERS	Specifies the maximum amount of members to be displayed for expanded symbol items.
PREF_SHOW_ENCODINGS_ITRACE	Toggles the display of instruction encodings within the Instruction Trace Window.
PREF_SHOW_ENCODINGS_ASM	Toggles the display of instruction encodings within the Disassembly Window.
PREF_RESTRICT_SRC_EDIT	Specifies the editing restriction that applies to source files (0: no restriction, 1: editing disallowed when debugging, 2: never allowed)
PREF_TERMINAL_EOL_FORMAT	Specifies the linebreak characters that the Terminal Window appends to user input before the input is send to the debuggee (see <i>Newline Formats</i> on page 172).

Constant	Description
PREF_TERMINAL_ECHO_INPUT	Specifies if terminal window input is appended to Terminal Window output.
PREF_TERMINAL_ZERO_TERM_INPUT	Specifies if the string termination character (0) is appended to Terminal Window input before the input is send to the debuggee.
PREF_TERMINAL_CLEAR_ON_RESET	When set, the terminal window is cleared each time the program is reset.
PREF_TERMINAL_NO_CONTROL_CHARS	Specifies whether the Terminal Window outputs printable ASCII characters only.
PREF_RESIZE_COL_ON_EXPAND	Specifies whether table columns resize to contents after item expansions.
PREF_RESIZE_COL_ON_COLLAPSE	Specifies whether table columns resize to contents after item collapses.
PREF_TIMESTAMP_FORMAT	Specifies the format of the time-axis scales shown within Ozone's trace windows. For the list of supported values, refer to <i>Trace Time-stamp Formats</i> on page 172.
PREF_CG_GROUP_BY_ROOT_FUNCS	Specifies if the call graph window displays root functions on the top level only (1) or all program functions (0).
PREF_CALLSTACK_LAYOUT	Specifies if the current frame is displayed at the top or at the bottom of the call stack. Possible values are <code>LAYOUT_CURR_FRAME_ON_TOP</code> (0) and <code>LAYOUT_CURR_FRAME_ON_BOTTOM</code> (1).
PREF_CALLSTACK_DEPTH_LIMIT	Selects the maximum amount of frames the call stack can hold.
PREF_TIMELINE_TOOLTIPS	Enables/disables tooltips within the Timeline Window.

User Preferences

7.2.19 System Variable Identifiers

The following constants identify system variables within Ozone (see *Edit.SysVar* on page 203).

Constant	Description
VAR_RESET_MODE	Program reset mode (see <i>Reset Modes</i> on page 171 for permitted values).
VAR_CONNECT_MODE	Connection mode (see <i>Connection Modes</i> on page 171 for permitted values).
VAR_SEMIHOSTING_ENABLED	Specifies whether the Terminal Window captures Semi-hosting IO (see <i>Terminal IO</i> on page 148).
VAR_RTT_ENABLED	Specifies whether the Terminal Window captures Real-Time Transfer IO (see <i>Terminal IO</i> on page 148).
VAR_TIF_SPEED	Target interface speed (see <i>Project Wizard</i> on page 31 for details and <i>Frequency Descriptor</i> on page 168 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 targets is 4.

Constant	Description
VAR_SWO_CPU_SPEED	SWO calibration parameter: target processor frequency (see <i>Frequency Descriptor</i> on page 168 for permitted values).
VAR_SWO_SPEED	SWO calibration parameter: data transmission frequency (see <i>Frequency Descriptor</i> on page 168 for permitted values).
VAR_ACCESS_WIDTH	Memory access width (see <i>Memory Access Widths</i> on page 171 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 target 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 83). 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_SOURCE	Selects the trace source to use. See <i>Trace Sources</i> on page 172 for the list of valid values.
VAR_TRACE_PORT_WIDTH	Configures the trace port width in bits. Permitted values are 1, 2 and 4.
VAR_TRACE_PORT_DELAY_n	Configures the sampling delay of trace pin n (n=1...4). The valid value range is -5 to +5 nanoseconds at steps of 50 ps.
VAR_TRACE_PORT_WIDTH	Configures the trace port width in bits. Permitted values are 1, 2 and 4.
VAR_TRACE_INIT_ON_ATTACH	Specifies whether Ozone should initialize the trace instruction cache when attaching to a program that already resides in target memory. The trace instruction cache is automatically initialized by J-Link at the moment the program file is downloaded.
VAR_TRACE_CORE_CLOCK	Ozone uses this variable to convert CPU cycle counts to CPU times in all applications related to trace timestamps (see VAR_TRACE_TIMESTAMPS_ENABLED).
VAR_TRACE_TIMESTAMPS_ENABLED	Specifies whether the target is to output (and J-Link/Ozone is to process) PC timestamps multiplexed into the trace data stream.
VAR_TRACE_MAX_INST_CNT	Specifies the maximum amount of instructions that Ozone can process and store during a live trace session.
VAR_TRACE_FILE_ENABLED	When enabled, Ozone stores all trace data read from the target to the file specified by VAR_TRACE_FILE_PATH.
VAR_TRACE_FILE_PATH	Specifies the file path of the trace file.
VAR_TRACE_FILE_MAX_SIZE	Specifies the maximum size of the trace file in bytes.
VAR_TRACE_FILE_KEEP_START	Specifies the trace file overflow behavior. When set to 1, trace file recording stops when the file is full. When set to 0, the oldest recorded data is overwritten.
VAR_MAX_POWER_SAMPLES	Specifies the maximum amount of power trace samples that Ozone can process and store.

Constant	Description
VAR_POWER_SAMPLING_SPEED	Specifies the rate in Hz at which J-Link power-samples the target.
VAR_TARGET_POWER_ON	Specifies whether J-Link supplies power to the target via a dedicated target interface pin. This setting must be active in order to use Ozone's power profiling features.
VAR_MEM_ZONE_RUNNING	Selects the default memory zone to be accessed when the program is running.

System Variables

7.3 Command Line Arguments

When Ozone is started from the command line, it is possible to specify additional parameters that configure the debugger in a certain way. The list of available command line arguments is given below.

Please note that all arguments containing white spaces must be quoted.

7.3.1 Project Generation

Command line arguments that generate a startup project. The device, target interface and host interface settings are mandatory.

Parameter	Description
-device <device>	Selects the target device (for example ST-M32F407IG).
-if <IF>	Assigns the target interface (SWD or JTAG).
-speed <speed>	Specifies the target interface speed in kHz.
-select <hostif> [= <ID>]	Assigns the host interface. <hostif> can be set to either USB or IP. The optional parameter <ID> can be set to the serial number or SP address of the J-Link to connect to.
-usb [<SN>]	Sets the host interface to USB and optionally specifies the serial number of the J-Link to connect to.
-ip <IP>	Sets the host interface to IP and specifies the IP address of the J-Link to connect to.
-programfile	Sets the program file to open on startup.
-project	Specifies the file path of the generated project. If the project already exists, the new settings are applied to it. If the project does not exist, it is created.
-jlinkscriptfile	Specified the file path to the J-Link script that is executed when the debug session is started.
-jtagconfig <DRPre>,<IRLen>	Configures the JTAG interface (see <i>Project.SetJTAG-Config</i> on page 222).

7.3.2 Appearance and Logging

Command line arguments that adjust appearance and logging settings.

Argument	Description
-style <style>	Sets Ozone's GUI theme. Possible values for <style> "windows", "cleanlooks", "plastique", "motif" and "macintosh".
-logfile <filepath>	When set, Ozone outputs all application-generated messages to the specified text file.
-loginterval <bytes>	The byte interval at which the log file is updated.
-debug	Opens a debug console window along with Ozone.

7.4 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.

7.4.1 Areas of Application

Ozone employs expressions in the following areas:

- As monitorable entities within the Watched Data Window (see *Watched Data Window* on page 130).
- As monitorable entities within the Data Graph Window (see *Data Graph Window* on page 83).
- As specifiers for the data locations of data breakpoints (see *Data Breakpoints* on page 144).
- As specifiers for the trigger conditions of conditional breakpoints (see *Advanced Breakpoint Properties* on page 142).

7.4.2 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`)
- Program defines (e.g. `MAX_SPEED`)
- Ozone variables & constants (e.g. `VAR_TIF_SPEED`, `FREQ_1_MHZ`)
- User-defined constants (see *Script.DefineConst* on page 214)

7.4.3 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 (++ , --)
- Type-casts (see *Type Casts* on page 181)

The evaluation order of an expression can be controlled by bracketing sub-expressions.

7.4.4 Type Casts

The typecast operator “(<dest>)<src>” supports the following source and destination types:

<src>

- Integers (e.g. `0x20000000`)
- Program Variables (e.g. `OS_Global`)

<dest>

- Pointers and References (e.g. `int*` / `Type&` / `Type*`)
- Arrays (e.g. `char[128]` / `Type[20]`)

7.5 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 Ozone 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 (macOS).

7.5.1 Environment Variables

Ozone allows file path arguments to contain environment variables. The following environment variable formats are understood:

Format	Operating System(s)
<code>%<varname>%</code>	windows
<code>\$<varname></code>	unix
<code>\$(<varname>)</code>	all platforms

`<varname>` stands for the name of the environment variable (e.g. `HOME` on windows or `HOME` on Unix).

7.6 File Path Resolution

This section describes Ozone's 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.

7.6.1 File Path Resolution Sequence

Step 1 - Path Substitution

This step is applied to source file paths only. Any parts of the unresolved file path that match a user-set path substitute are replaced with the substitute (see *Project.AddPathSubstitute* on page 229). If the file path obtained from path substitution 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 228). If the alias points to a valid file on the file system, resolution is complete.

Step 3 - Path Expansion

All directory macros and environment variables contained within the file path are expanded (see *Directory Macros* on page 182). If the expanded file path points to a valid file on the file system, resolution is complete.

Step 4 - Source File Root Paths

Step 4 of file path resolution is only applied to relative file paths. Unresolved relative file paths are appended successively to each source file root path (see *Project.AddRootPath* on page 228). If any of the so-obtained file paths points to a valid file on the file system, resolution is complete.

Step 5 - Application Directories

Step 5 of file path resolution is only applied to relative file paths. Unresolved relative file paths are appended successively to each of the application directories listed in *Directory Macros* on page 182. If any of the so-obtained file paths points to a valid file on the file system, resolution is complete.

Step 6 - Search Directories

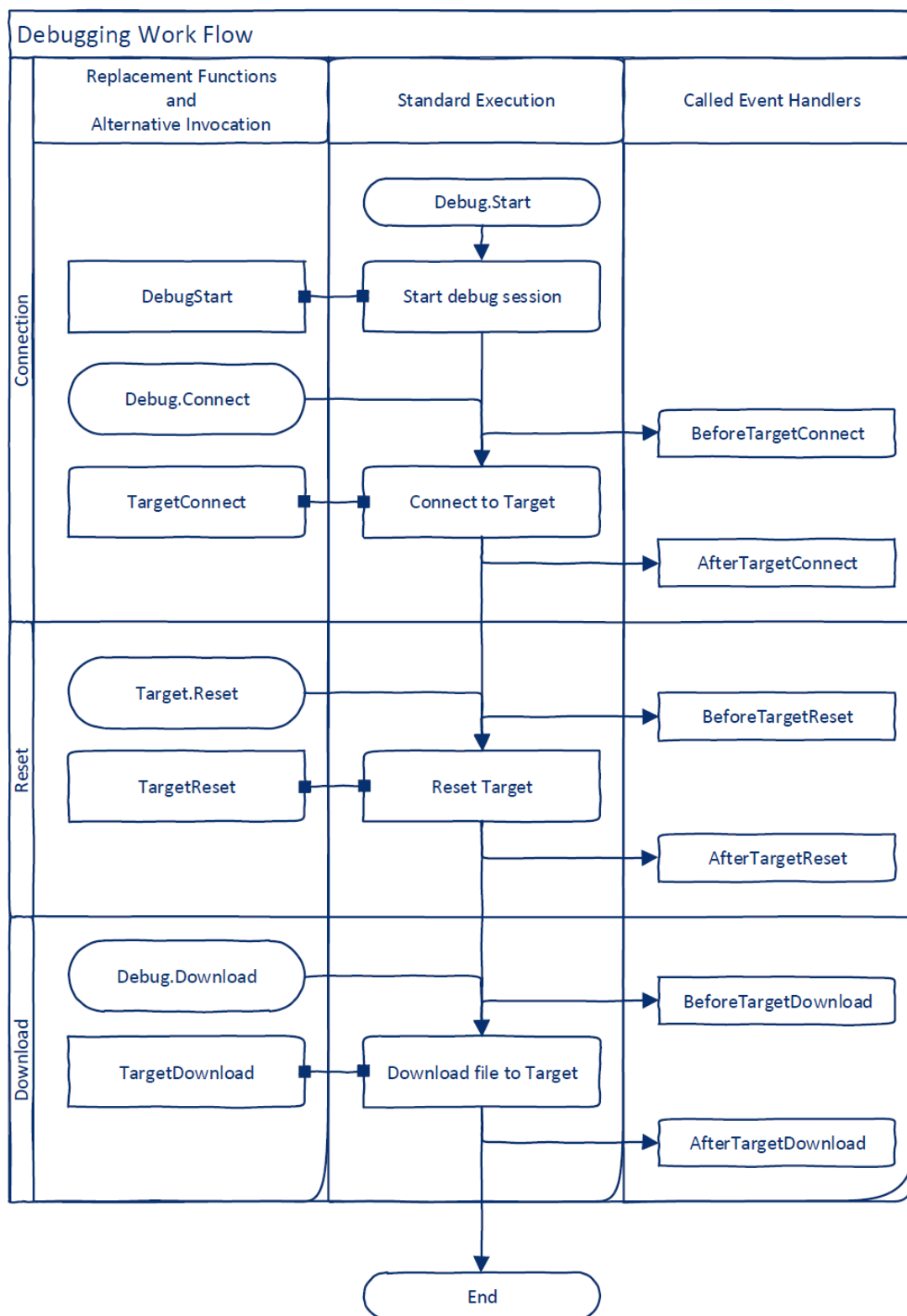
Step 6 of file path resolution is applied to both absolute and relative file paths. The file name of unresolved file paths is searched within all user-specified search directories (see *Project.AddSearchPath* on page 229). If any of the search directories contains a file with the sought name, resolution is complete.

7.6.2 Operating System Specifics

File path arguments are case-insensitive on Windows and case sensitive on Linux and macOS. 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.

7.7 Startup Sequence Flow Chart

The figure below illustrates the different phases of the "Debug & Download Program" startup sequence and how it interoperates with script functions (see *Download & Reset Program* on page 136). 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.



Startup Sequence Flow Chart.

7.8 Errors and Warnings

This section lists all application errors and warnings that may occur during the debugging workflow. For each exception, possible causes and solutions are summarized.

For details on how to conduct solution proposals that contain toolchain (compiler/linker/IDE) settings, please refer to the user guide of the concerning software tool.

Follow the instructions in *Support* on page 256 when the problem persists.

Note

Work on the application message tables is currently ongoing.

Code	Description	Possible Causes	Solution Proposals
1000	The ELF parser is out of memory.	The ELF file contains more debug symbols than fit into Host PC RAM.	Reduce the amount of debugging information emitted to the program file (e.g. use -g1 instead of -g3 on GCC and similar measures).
1001	The ELF parser encountered an internal error while parsing a data section.	Software bug in the employed toolchain or in Ozone's ELF parser.	Contact SEGGER support (see <i>Support</i> on page 256).
1002	The ELF parser encountered an empty data section.	Incorrect toolchain settings.	Check toolchain settings.
1003	The ELF parser encountered an invalid debug symbol reference (specified as file offset). The file offset does not point to the base of a debug symbol.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1004	The ELF parser encountered an invalid symbol location reference (specified as file offset). The file offset does not point to the base of a symbol location record.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1005	The ELF parser encountered an unsupported symbol attribute format.	Unsupported debug symbol format or extension.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1006	The program file does not contain debug information.	The toolchain settings are not set to not generate DWARF debug information.	Change toolchain settings to generate DWARF debug information.
1007	The ELF parser encountered a compilation unit whose byte size is less than expected from the unit's header information.	Software bug in the employed toolchain or in Ozone's ELF parser.	Contact SEGGER support (see <i>Support</i> on page 256).

Code	Description	Possible Causes	Solution Proposals
1008	The ELF parser encountered a debug symbol encoded in an unsupported format.	Unsupported debug symbol format or extension.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1009	The symbol location decoder encountered an unsupported operand.	Unsupported debug symbol format or extension.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1010	ELF data section <i>debug_loc</i> has an unexpected byte size.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1011	ELF data section <i>debug_line</i> has an unexpected byte size.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1012	ELF data section <i>debug_frame</i> has an unexpected byte size.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1013	The address mapping table decoder encountered an invalid file index.	Software bug in the employed toolchain or in Ozone's ELF parser.	Contact SEGGER support (see <i>Support</i> on page 256).
1014	The address mapping table decoder encountered an invalid directory index.	Software bug in the employed toolchain or in Ozone's ELF parser.	Contact SEGGER support (see <i>Support</i> on page 256).
1015	ELF data section <i>debug_frame</i> contains an unsupported address size field.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1016	ELF data section <i>debug_frame</i> contains an unsupported segment size field.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1017	The ELF parser encountered an inconsistency within call frame information data.	Software bug in the employed toolchain.	Contact SEGGER support (see <i>Support</i> on page 256).
1018	ELF data section <i>debug_frame</i> contains an unsupported data augmentation.	Unsupported debug symbol format or extension.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1019	The call frame information decoder encountered an internal error state.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).

Code	Description	Possible Causes	Solution Proposals
1020	ELF data section <i>debug_frame</i> is encoded in an unsupported format.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1021	The ELF parser encountered an invalid address range reference (specified as file offset). The file offset does not point to the base of an address range record.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1022	The program macro information decoder encountered an internal error state.	1. Unsupported debug symbol format or extension. 2. Software bug in the employed toolchain or in Ozone's ELF parser.	Change the debug information output format (e.g. from DWARF-5 to DWARF-4).
1023	The ELF parser attempted to load an ELF file that does not contain the ELF file byte identification pattern.	1. Wrong file selected 2. File corrupted.	Rebuild the ELF file.
1024	The ELF parser attempted to load an ELF file that is not an executable program (instead, the file is most likely a shared object).	Incorrect toolchain settings or build target.	Check toolchain settings.
1025	The ELF parser attempted to load an ELF file having an unspecified class (<code>ELF_CLASS_NONE</code>).	Incorrect toolchain settings or build target.	Check toolchain settings.
1026	The ELF parser attempted to load an ELF file having an unspecified data encoding (<code>ELF_DATA_NONE</code>).	Incorrect toolchain settings or build target.	Check toolchain settings.
1027	The ELF parser attempted to load an ELF file whose header version number is not <code>EV_CURRENT</code> .	Incorrect toolchain settings or build target.	Check toolchain settings.
1028	The ELF parser attempted to load an ELF file that has an unsupported file version number.	Incorrect toolchain settings or unsupported file format.	Check toolchain settings.
1029	The ELF parser attempted to load an ELF file but the maximum number of ELF files that can be simultaneously opened is already open.	ELF files previously opened in Ozone were not closed correctly.	Contact SEGGER support (see <i>Support</i> on page 256).
1030	The ELF parser attempted to load an ELF file but	1. Incorrect file access permissions. 2. Corrupt file header.	1. Check your file system access permissions 2. Check that the file is

Code	Description	Possible Causes	Solution Proposals
	could not open the file for reading.		not in use by another process 3. contact the system administrator.
1031	The ELF parser attempted to load an ELF file whose internal file size information does not match the actual file size.	1. File was binary modified by an external tool (e.g. readelf or install_name_tool).	Rebuild the ELF file.
1032	Not enough free memory to load the ELF file.	Insufficient target RAM.	Upgrade RAM.
1033	The ELF parser attempted to load an ELF file but encountered an error while reading file contents from the hard disk.	1. Incorrect file access permissions. 2. Corrupt file header.	1. Check your file system access permissions 2. Check that the file is not in use by another process 3. contact the system administrator.
1034	The ELF parser attempted to load an ELF file but failed in reading non-DWARF debug symbols.	Unsupported debug symbol format.	Contact SEGGER support (see <i>Support</i> on page 256).
1035	The ELF parser attempted to load an ELF file that cannot be executed on the selected target.	Incorrect toolchain settings or build target, e.g. word size mismatch (32-bit/64-bit) or target processor type mismatch.	1 Check toolchain settings.
1036	The ELF parser attempted to load an ELF file whose data endianness does not match the target settings.	1. Project setting "Target.SetEndianness" not present or set incorrectly 2. Incorrect toolchain settings pertaining to the byte order of the output file.	1. Project setting "Target.SetEndianness" not present or set incorrectly 2. Incorrect toolchain settings pertaining to the byte order of the output.
1037	The ELF parser attempted to load an ELF file whose instruction endianness does not match the target settings.	1. Project setting "Target.SetEndianness" not present or set incorrectly 2. Incorrect toolchain settings pertaining to the byte order of the output file.	1. Project setting "Target.SetEndianness" not present or set incorrectly 2. Incorrect toolchain settings pertaining to the byte order of the output.
2000	An incorrect memory zone name was input by the user.	1. Incorrect user input. 2. Ozone failed to determine the names of the target's memory zones.	The list of available memory zones is printed along with this warning. If an incorrect input can be ruled out, contact SEGGER support (see <i>Support</i> on page 256).
3000	A requested power sampling frequency is not supported by the hardware setup.	J-Link/J-Trace debug probes currently support power sampling rates of up to 100 khz, depending on the model.	1. Update J-Link software drivers (e.g. by using the J-Link DLL Updater tool).
3001	Power sampling could not be started.	1. Power output to the target is not enabled	1. Enable power output (see <i>Power Graph Win-</i>

Code	Description	Possible Causes	Solution Proposals
		(see <i>System Variable Identifiers</i> on page 177). 2. The hardware setup does not support power sampling.	dow on page 111). 2. Update J-Link software drivers (e.g. by using the J-Link DLL Updater tool).

7.9 Action Tables

The following tables provide a quick reference on user actions provided by Ozone (see *User Actions* on page 35).

7.9.1 Breakpoint Actions

Actions that modify the debugger's breakpoint state.

Action	Description
Break.Set	Sets an instruction breakpoint.
Break.SetEx	Sets an instruction breakpoint.
Break.Clear	Clears an instruction breakpoint.
Break.Enable	Enables an instruction breakpoint.
Break.Disable	Disables an instruction breakpoint.
Break.SetOnSrc	Sets a source breakpoint.
Break.SetOnSrcEx	Sets a source breakpoint.
Break.ClearOnSrc	Clears a source breakpoint.
Break.EnableOnSrc	Enables a source breakpoint.
Break.DisableOnSrc	Disables a source breakpoint.
Break.ClearAll	Clears all instruction and source breakpoints.
Break.Edit	Edits a breakpoint's advanced properties.
Break.SetType	Sets a breakpoint's implementation type.
Break.SetCommand	Assigns a script callback function to a breakpoint.
Break.SetCmdOnAddr	Assigns a script callback function to a breakpoint.
Break.SetOnData	Sets a data breakpoint.
Break.ClearOnData	Clears a data breakpoint.
Break.EnableOnData	Enables a data breakpoint.
Break.DisableOnData	Disables a data breakpoint.
Break.EditOnData	Edits a data breakpoint.
Break.SetOnSymbol	Sets a data breakpoint on a symbol.
Break.ClearOnSymbol	Clears a data breakpoint on a symbol.
Break.EnableOnSymbol	Enables a data breakpoint on a symbol.
Break.DisableOnSymbol	Disables a data breakpoint on a symbol.
Break.EditOnSymbol	Edits a data breakpoint on a symbol.
Break.ClearAllOnData	Clears all data breakpoints.

7.9.2 Code Profile Actions

Code profile related actions.

Action	Description
Profile.Export	Exports the current code profile data to a text file.
Profile.ExportCSV	Exports the current code profile data to a CSV file.
Profile.Exclude	Filters program entities from the code profile statistic.
Profile.Include	Re-adds program entities to the code profile statistic.
Coverage.Exclude	Filters program entities from the code coverage statistic.

Action	Description
Coverage.Include	Re-adds program entities to the code coverage statistic.
Coverage.ExcludeNOPs	Filters NOP instructions from the code coverage statistic.

7.9.3 Debug Actions

Actions that modify the program execution point and that configure the debugger's connection, reset and stepping behavior.

Action	Description
Debug.Start	Starts the debug session.
Debug.Stop	Stops the debug session.
Debug.Connect	Establishes a J-Link connection to the target.
Debug.Disconnect	Disconnects the J-Link connection to the target.
Debug.Download	Downloads the program file to the target.
Debug.Continue	Resumes program execution.
Debug.Halt	Halts program execution.
Debug.Reset	Reset the program.
Debug.StepInto	Steps into the current function.
Debug.StepOver	Steps over the current function.
Debug.StepOut	Steps out of the current function.
Debug.SetNextPC	Sets the next machine instruction to be executed.
Debug.SetNextStatement	Sets the next source statement to be executed.
Debug.RunTo	Advances program execution to a particular location.
Debug.SetResetMode	Sets the reset mode.
Debug.SetConnectMode	Sets the connection mode.
Debug.ReadIntoInstCache	Initializes the instruction cache with target memory data.

7.9.4 Edit Actions

Actions that edit behavioral and appearance settings of the debugger.

Action	Description
Edit.Preference	Edits a user preference.
Edit.SysVar	Edits a system variable.
Edit.Color	Edits an application color.
Edit.Font	Edits an application font.
Edit.DisplayFormat	Edits an object's value display format.
Edit.RefreshRate	Edits a watched expression's refresh rate.
Edit.MemZone	Edits a watched expression's memory zone.
Edit.Find	Displays the Find Dialog.

7.9.5 ELF Actions

Actions for retrieving ELF program file information.

Action	Description
Elf.GetBaseAddr	Returns the program file's download address.
Elf.GetEntryPointPC	Returns the initial value of the program counter.
Elf.GetEntryFuncPC	Returns the first PC of the program's entry function.
Elf.GetExprValue	Evaluates a symbol expression.
Elf.GetEndianness	Returns the program file's byte order.

7.9.6 File Actions

Actions that perform file system and related operations.

Action	Description
File.NewProject	Creates a new project.
File.NewProjectWizard	Opens the Project Wizard.
File.Open	Opens a file.
File.OpenRecent	Reopens a recently opened program file.
File.Load	Loads a file.
File.Close	Closes a source code document.
File.CloseAll	Closes all open source code documents.
File.CloseAllButThis	Closes all but the active source code document.
File.Find	Searches for a text pattern.
File.SaveProjectAs	Saves the project file under a new file path.
File.SaveAll	Saves all modified files.
File.Exit	Closes the application.

7.9.7 Find Actions

Actions that locate program entities.

Action	Description
Find.Text	Opens the Find Dialog.
Find.Function	Locates a program function.
Find.GlobalData	Locates a global symbol.

7.9.8 Help Actions

Actions that display help related information.

Action	Description
Help.About	Shows the About Dialog.
Help.Commands	Prints the command help to the Console Window.
Help.Manual	Displays the user manual.

7.9.9 J-Link Actions

Actions that perform J-Link operations.

Action	Description
Exec.Connect	Establishes the connection between J-Link and target.
Exec.Reset	Hardware-resets the target (in a default, target-specific way).
Exec.Download	Downloads a program or a data file to target memory.
Exec.Command	Executes a J-Link command.

7.9.10 Project Actions

Actions that configure the debugger for operation in a particular software and hardware environment.

Action	Description
Project.SetDevice	Specifies the target device.
Project.AddSvdFile	Adds a register set description file.
Project.SetHostIF	Specifies the host interface.
Project.SetTargetIF	Specifies the target interface.
Project.SetTIFSpeed	Specifies the target interface speed.
Project.SetJTAGConfig	Configures the JTAG target interface.
Project.SetTraceSource	Selects the trace source to use.
Project.SetTracePortWidth	Specifies the number of trace pins comprising the TP.
Project.SetTraceTiming	Configures the trace pin sampling delays.
Project.SetTraceFile	Specifies the file to which target trace data is stored to.
Project.ConfigSWO	Configures the Serial Wire Output (SWO) interface.
Project.SetSemihosting	Enables or disables the Semihosting IO interface.
Project.ConfigSemihosting	Configures the Semihosting IO interface.
Project.SetRTT	Configures the Real-Time Transfer (RTT) IO interface.
Project.AddRTTSearchRange	RTT configuration command.
Project.AddFileAlias	Sets a file path alias.
Project.AddPathSubstitute	Replaces substrings within source file paths.
Project.AddRootPath	Specifies the program's root path.
Project.AddSearchPath	Adds a path to the program's list of search paths.
Project.SetCorePlugin	Specifies the file path of the target support plugin.
Project.SetOSPlugin	Specifies the RTOS awareness plugin to be used.
Project.SetBPType	Sets the allowed breakpoint implementation type.
Project.SetMemZoneRunning	Sets the default zone accessed when the CPU is running.
Project.SetJLinkScript	Sets the J-Link-Script to be executed on debug start.
Project.SetJLinkLogFile	Sets the text file that receives J-Link logging output.
Project.RelocateSymbols	Relocates one or multiple symbols.
Project.SetConsoleLogFile	Sets the text file that receives console window output.
Project.SetTerminalLogFile	Sets the text file that receives terminal window output.
Project.DisableSessionSave	Disables saving of individual session information.

7.9.11 Script Actions

Actions that perform script operations.

Action	Description
Script.Exec	Executes a project file script function.
Script.DefineConst	Defines an integer constant to be used within scripts.

7.9.12 Target Actions

Actions that perform target memory and register IO.

Action	Description
Target.SetReg	Writes a target register.
Target.GetReg	Reads a target register.
Target.WriteU32	Writes a word to target memory.
Target.WriteU16	Writes a half word to target memory.
Target.WriteU8	Writes a byte to target memory.
Target.ReadU32	Reads a word from target memory.
Target.ReadU16	Reads a half word from target memory.
Target.ReadU8	Reads a byte from target memory.
Target.FillMemory	Fills a block of target memory with a particular value.
Target.SaveMemory	Saves a block of target memory to a binary data file.
Target.LoadMemory	Downloads the contents of a data file to target memory.
Target.SetAccessWidth	Specifies the memory access width.
Target.SetEndianness	Configures the debugger for a particular data endianness.
Target.LoadMemoryMap	Initializes the target's memory map from file contents.
Target.AddMemorySegment	Adds a memory segment to the memory map.

7.9.13 Tools Actions

Actions that open tool dialogs.

Action	Description
Tools.JLinkSettings	Opens the J-Link Settings Dialog.
Tools.TraceSettings	Opens the Trace Settings Dialog.
Tools.Preferences	Opens the User Preference Dialog.
Tools.SysVars	Displays the System Variable Editor.

7.9.14 Toolbar Actions

Actions that modify the state of toolbars.

Action	Description
Toolbar.Show	Displays a toolbar.
Toolbar.Close	Hides a toolbar.

7.9.15 Trace Actions

Trace-related actions.

Action	Description
Trace.SetPoint	Sets a tracepoint.
Trace.ClearPoint	Clears a tracepoint.
Trace.EnablePoint	Enables a tracepoint.
Trace.DisablePoint	Disables a tracepoint.
Trace.ClearAllPoints	Clears all tracepoints.
Trace.ExportCSV	Exports trace data to a CSV file.

7.9.16 Utility Actions

Script function utility actions.

Action	Description
Util.Sleep	Pauses the current operation for a given amount of time.
Util.Log	Prints a message to the console window.
Util.LogHex	Prints a formatted message to the console window.

7.9.17 View Actions

Actions that navigate to particular objects displayed on the graphical user interface.

Action	Description
View.Data	Displays the data location of a program variable.
View.Source	Displays the source code location of an object.
View.Disassembly	Displays the assembly code of an object.
View.CallGraph	Displays the call graph of a function.
View.InstTrace	Displays a position in the instruction execution history.
View.Memory	Displays a memory location.
View.Line	Displays a text line in the active document.
View.PC	Displays the PC instruction in the Disassembly Window.
View.PCLine	Displays the PC line in the Source Viewer.
View.NextResult	Displays the next search result item.
View.PrevResult	Displays the previous search result item.

7.9.18 Window Actions

Actions that edit the state of debug information windows.

Action	Description
Window.Show	Shows a window.
Window.Close	Closes a window.
Window.SetDisplayFormat	Sets a window's item display format.
Window.Add	Adds a symbol to a window.
Window.Remove	Removes a symbol from a window.
Window.Clear	Clears a window.
Window.ExpandAll	Expands all items of a window.
Window.CollapseAll	Collapses all items of a window.

7.9.19 Watch Actions

Actions affiliated with the Watched Data Window.

Action	Description
Watch.Add	Adds an expression to the Watched Data Window
Watch.Insert	Inserts an expression into the Watched Data Window
Watch.Remove	Removes an expression from the Watched Data Window

7.10 User Actions

7.10.1 File Actions

7.10.1.1 File.NewProject

Creates a new project (see *File Menu* on page 38).

Prototype

```
int File.NewProject();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → File → New → New Project (Ctrl+N)

7.10.1.2 File.NewProjectWizard

Opens the Project Wizard (see *Project Wizard* on page 31).

Prototype

```
int File.NewProjectWizard();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → File → New → New Project Wizard (Ctrl+Alt+N)

7.10.1.3 File.Open

Opens a file (see *File Menu* on page 38). When a program file is opened and the debug session is running, the program is automatically downloaded to target memory.

Note

Special care must be taken when placing this command within script functions (see *Avoiding Script Function Recursions* on page 149).

Prototype

```
int File.Open(const char* sFilePath);
```

Argument	Meaning
sFilePath	File path of a project-, source- or program-file. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).

Return Value

-1: error

0: success

GUI Access

Main Menu → File → Open (Ctrl+O)

7.10.1.4 File.OpenRecent

Reopens a recently opened program file.

Prototype

```
int File.OpenRecent(int Index);
```

Argument	Meaning
Index	Position of the file within the file menu's recent programs list, starting at index 0.

Return Value

-1: error
0: success

GUI Access

Main Menu → File → Recent Programs

7.10.1.5 File.Find

Searches a text pattern in source code documents (see *Find Dialog* on page 61).

Prototype

```
int File.Find(const char* sFindWhat);
```

Return Value

-1: error
0: success

GUI Access

Source Viewer → Context Menu → Find (Ctrl+F)

7.10.1.6 File.Load

Downloads a program or data file to target memory. This command essentially performs the same operation as File.Open, but it does not reset the target prior to download and does not perform the initial program operation (see *Download Behaviour Comparison* on page 149). When an ELF or compatible program file is specified, its debug symbols replace any previously loaded debug symbols.

Note

Special care must be taken when placing this command within script functions (see *Avoiding Script Function Recursions* on page 149).

Prototype

```
int File.Load(const char* sFilePath, U32 Address);
```

Argument	Meaning
sFilePath	Path to a program or data file. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).
Address	Memory address to download the data contents to. In case the address is provided by the file itself, 0 can be specified.

Return Value

-1: error
0: success

GUI Access

None

7.10.1.7 File.Close

Closes a document (see *Source Viewer* on page 118).

Prototype

```
int File.Close(const char* sFilePath);
```

Argument	Meaning
sFilePath	File path (or name) of a source file. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).

Return Value

-1: error
0: success

GUI Access

Document Tab → Context Menu → Close (Ctrl+F4)

7.10.1.8 File.CloseAll

Closes all open documents (see *File Menu* on page 38).

Prototype

```
int File.CloseAll();
```

Return Value

-1: error
0: success

GUI Access

Hotkey (Ctrl+Alt+F4)

7.10.1.9 File.CloseAllButThis

Closes all but the active document (see *Source Viewer* on page 118).

Prototype

```
int File.CloseAllButThis();
```

Return Value

-1: error
0: success

GUI Access

Document Tab → Context Menu → Close All But This (Ctrl+Shift+F4)

7.10.1.10 File.SaveAll

Saves all modified files.

Prototype

```
int File.SaveAll();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → File → Save all

7.10.1.11 File.SaveProjectAs

Saves the project file under a new file path.

Prototype

```
int File.SaveProjectAs(const char* sFilePath);
```

Argument	Meaning
sFilePath	File path (or name) of a .jdebug file. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).

Return Value

-1: error
0: success

GUI Access

Main Menu → File → Save Project as (Ctrl+Shift+S)

7.10.1.12 File.Exit

Closes the application (see *File Menu* on page 38).

Prototype

```
int File.Exit();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → File → Exit (Alt+F4)

7.10.2 Find Actions

7.10.2.1 Find.Text

Searches a text pattern in the current document (see *Find Dialog* on page 61).

Prototype

```
int Find.Text(const char* sText);
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Find → Find Text (Ctrl+F)

7.10.2.2 Find.Function

Locates a program function.

Prototype

```
int Find.Function(const char* sFunction);
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Find → Find Function (Ctrl+M)

7.10.2.3 Find.GlobalData

Locates a global data symbol.

Prototype

```
int Find.GlobalData(const char* sSymbol);
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Find → Find Global Data (Ctrl+L)

7.10.3 Tools Actions

7.10.3.1 Tools.JLinkSettings

Opens the J-Link Settings Dialog (see *J-Link Settings Dialog* on page 59).

Prototype

```
int Tools.JLinkSettings();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Tools → J-Link Settings (Ctrl+Alt+J)

7.10.3.2 Tools.TraceSettings

Opens the Trace Settings Dialog (see *Trace Settings Dialog* on page 67).

Prototype

```
int Tools.TraceSettings();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Tools → Trace-Settings (Ctrl+Alt+T)

7.10.3.3 Tools.Preferences

Displays the User Preference Dialog (see *User Preference Dialog* on page 52).

Prototype

```
int Tools.Preferences();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Tools → Preferences (Ctrl+Alt+P)

7.10.3.4 Tools.SysVars

Displays the System Variable Editor (see *System Variable Editor* on page 56).

Prototype

```
int Tools.SysVars();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Tools → System Variables (Ctrl+Alt+V)

7.10.4 Edit Actions

7.10.4.1 Edit.Preference

Edits a user preference.

Prototype

```
int Edit.Preference(int ID, int Value);
```

Argument	Meaning
ID	User preference identifier (see <i>User Preference Identifiers</i> on page 175).
Value	User preference value. Certain user preferences are specified in a predefined format (see <i>Value Descriptors</i> on page 168).

Return Value

-1: error
0: success

GUI Access

None.

7.10.4.2 Edit.SysVar

Edits a system variable (see *System Variable Identifiers* on page 177).

Prototype

```
int Edit.SysVar(int ID, int Value);
```

Argument	Meaning
ID	System variable identifier (see <i>System Variable Identifiers</i> on page 177).
Value	System variable value. Certain system variable values are specified in a predefined format (see <i>Value Descriptors</i> on page 168).

Return Value

-1: error
0: success

GUI Access

None.

7.10.4.3 Edit.Find

Searches a text pattern in the active document (see *Source Viewer* on page 118). Once executed, hotkey F3 can be used to locate the next occurrence.

Prototype

```
int Edit.Find(const char* sFindWhat);
```

Return Value

-1: error
0: success

GUI Access

Source Viewer → Context Menu → Find (Ctrl+F)

7.10.4.4 Edit.Color

Edits an application color (see *Color Identifiers* on page 174).

Prototype

```
int Edit.Color(int ID, int Value);
```

Argument	Meaning
ID	Color identifier (see <i>Color Identifiers</i> on page 174).
Value	Color descriptor (see <i>Color Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → Preferences → Appearance

7.10.4.5 Edit.Font

Edits an application font (see *Font Identifiers* on page 173).

Prototype

```
int Edit.Font(int ID, const char* sFont);
```

Argument	Meaning
ID	Font identifier (see <i>Font Identifiers</i> on page 173).
sFont	Font descriptor (see <i>Font Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → Preferences → Appearance

7.10.4.6 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 Formats (see <i>Value Display Formats</i> on page 170).

Return Value

-1: error
0: success

GUI Access

Window → Context Menu → Display As

7.10.4.7 Edit.RefreshRate

Sets the refresh rate of a watched expression (see *Live Watches* on page 147).

Prototype

```
int Edit.RefreshRate (const char* sExpression, int Frequency);
```

Argument	Meaning
sExpression	C-Language expression (see <i>Expressions</i> on page 181).
Frequency	Update frequency in Hz (see <i>Frequency Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Watched Data Window → Context Menu → Refresh Rate

7.10.4.8 Edit.MemZone

Assigns a memory zone to a watched expression (see *Live Watches* on page 147). Whenever an update of the expression's value is requested, the specified memory zone is accessed.

Prototype

```
int Edit.MemZone (const char* sExpression, const char* sMemZone);
```

Argument	Meaning
sExpression	C-Language expression (see <i>Expressions</i> on page 181).
sMemZone	Memory zone name

Return Value

-1: error
0: success

GUI Access

Watched Data Window → Context Menu → Memory Zone

7.10.5 Window Actions

7.10.5.1 Window.Show

Shows a window (see *Window Layout* on page 108).

Prototype

```
int Window.Show(const char* sWindow);
```

Argument	Meaning
sWindow	Name of the window (e.g. "Source Files"). See <i>View Menu</i> on page 38.

Return Value

-1: error
0: success

GUI Access

Main Menu → View → Window Name (Shift+Alt+Letter)

7.10.5.2 Window.Close

Closes a window (see *Window Layout* on page 108).

Prototype

```
int Window.Close(const char* sWindow);
```

Argument	Meaning
sWindow	Name of the window (e.g. "Source Files"). See <i>View Menu</i> on page 38.

Return Value

-1: error
0: success

GUI Access

Close handle on window title bar (Alt+X)

7.10.5.3 Window.CloseAll

Closes all windows (see *Window Layout* on page 108).

Prototype

```
int Window.CloseAll();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Window → Close All Window (Alt+Shift+X)

7.10.5.4 Window.SetDisplayFormat

Set's a window's value display format (see *Display Format* on page 44).

Prototype

```
int Window.SetDisplayFormat(const char* sWindow, int Format);
```

Argument	Meaning
sWindow	Name of the window (e.g. "Source Files"). See <i>View Menu</i> on page 38.
Format	Value display format (see <i>Value Display Formats</i> on page 170).

Return Value

-1: error
0: success

GUI Access

Window → Context Menu → Display All As (Alt+Number)

7.10.5.5 Window.Add

Adds a symbol to a debug window (see *Debug Information Windows* on page 70).

Prototype

```
int Window.Add(const char* sWindow, const char* sSymbol);
```

Return Value

-1: error
0: success

GUI Access

Window → Context Menu → Add (Alt+Plus)

7.10.5.6 Window.Insert

Inserts a symbol into a debug window (see *Debug Information Windows* on page 70).

Prototype

```
int Window.Insert (const char* sWindow, const char* sSymbol, const char* sSymbolBefore);
```

Argument	Meaning
sWindow	Name of the window (e.g. "Source Files"). See <i>View Menu</i> on page 38.
sSymbol	Name of the symbol to insert.
sSymbolBefore	Insert before this symbol. When empty, append the symbol.

Return Value

-1: error
0: success

GUI Access

None

7.10.5.7 Window.Remove

Removes a symbol from a debug window (see *Debug Information Windows* on page 70).

Prototype

```
int Window.Remove(const char* sWindow, const char* sSymbol);
```

Return Value

-1: error
0: success

GUI Access

Window → Context Menu → Remove (Del)

7.10.5.8 Window.Clear

Clears a window.

Prototype

```
int Edit.TerminalSettings();
```

Return Value

-1: error
0: success

GUI Access

Window → Context Menu → Clear (Alt+Del)

7.10.5.9 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)

7.10.5.10 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)

7.10.6 Toolbar Actions

7.10.6.1 Toolbar.Show

Displays a toolbar (see *Showing and Hiding Toolbars* on page 42).

Prototype

```
int Toolbar.Show(const char* sToolbar);
```

Return Value

-1: error
0: success

GUI Access

Main Menu → View → Toolbars → Toolbar Name

7.10.6.2 Toolbar.Close

Hides a toolbar (see *Showing and Hiding Toolbars* on page 42).

Prototype

```
int Toolbar.Show(const char* sToolbar);
```

Return Value

-1: error
0: success

GUI Access

Main Menu → View → Toolbars → Toolbar Name

7.10.7 View Actions

7.10.7.1 View.Memory

Displays a memory location within the Memory Window (see *Memory Window* on page 104).

Prototype

```
int View.Memory(unsigned int Address);
```

Return Value

-1: error
0: success

GUI Access

Memory Window → Context Menu → Goto Address (Ctrl+G)

7.10.7.2 View.Source

Displays the source code location of a variable, function or machine instruction within the Source Viewer (see *Source Viewer* on page 118).

Prototype

```
int View.Source(const char* sLocation);
```

Argument	Meaning
sLocation	Variable Name: displays a variable's source location. 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 <i>Source Code Location Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Symbol Windows → Context Menu → View Source (Ctrl+U)

7.10.7.3 View.Data

Displays the data location of a global or local program variable within the Register Window (see *Register Window* on page 113) or the Memory Window (see *Memory Window* on page 104).

Prototype

```
int View.Data(const char* sVariable);
```

Return Value

-1: error
0: success

GUI Access

Symbol Windows → Context Menu → View Data (Ctrl+T)

7.10.7.4 View.Disassembly

Displays the assembly code of a function or source code statement within the Disassembly Window (see *Disassembly Window* on page 89).

Prototype

```
int View.Disassembly(const char* sLocation);
```

Argument	Meaning
sLocation	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 <i>Source Code Location Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Symbol Windows → Context Menu → View Disassembly (Ctrl+D)

7.10.7.5 View.CallGraph

Displays the call graph of a function.

Prototype

```
int View.CallGraph (const char* sFuncName);
```

Return Value

-1: error
0: success

GUI Access

→ Source Viewer → Context Menu → View Call Graph (Ctrl+H)

7.10.7.6 View.InstTrace

Displays a position in the history (stack) of executed machine instructions.

Prototype

```
int View.InstTrace (int StackPos);
```

Argument	Meaning
StackPos	Position 1 = most recently executed machine instruction.

Return Value

-1: error
0: success

GUI Access

→ Context Menu → Goto Position

7.10.7.7 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)

7.10.7.8 View.PC

Displays the program's execution point within the Disassembly Window (see *Disassembly Window* on page 89).

Prototype

```
int View.PC();
```

Return Value

-1: error
0: success

GUI Access

Disassembly Window → Context Menu → Goto PC (Ctrl+P)

7.10.7.9 View.PCLine

Displays the program's execution point within the Source Viewer (see *Source Viewer* on page 118).

Prototype

```
int View.PCLine();
```

Return Value

-1: error
0: success

GUI Access

Source Viewer → Context Menu → Goto PC (Ctrl+P)

7.10.7.10 View.NextResult

Displays the next search result.

Prototype

```
int View.NextResult();
```

Return Value

-1: error
0: success

GUI Access

None.

7.10.7.11 View.PrevResult

Displays the previous search result.

Prototype

```
int View.PrevResult();
```

Return Value

-1: error
0: success

GUI Access

None.

7.10.8 Utility Actions**7.10.8.1 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

7.10.8.2 Util.Log

Prints a message to the Console Window (see *Console Window* on page 81).

Prototype

```
int Util.Log(const char* sMessage);
```

Return Value

-1: error
0: success

GUI Access

None

7.10.8.3 Util.LogHex

Appends an integer value to a text message and prints the result to the Console Window (see *Console Window* on page 81).

Prototype

```
int Util.LogHex(const char* sMessage, unsigned int IntValue);
```

Return Value

-1: error
0: success

GUI Access

None

7.10.9 Script Actions

7.10.9.1 Script.Exec

Executes a project file script function. The command currently only supports script functions with void parameter or with up to seven arguments of type `__int64`.

Prototype

```
int Script.Exec(const char* sFuncName, __int64 Para1, __int64 Para2,...);
```

Return Value

Return value of the executed function (-1 if execution failed).

GUI Access

None

7.10.9.2 Script.DefineConst

Defines a constant integer value to be used within the project file script.

Prototype

```
int Script.DefineConst(const char* sName, const char* sExpression);
```

Argument	Meaning
sName	Name of the constant.
sExpression	Symbol expression that evaluates to a numeric value of size ≤ 8 bytes (see <i>Expressions</i> on page 181). The symbol expression cannot contain local variables.

Return Value

-1: error
0: success

GUI Access

None

7.10.10 Debug Actions

7.10.10.1 Debug.Start

Starts the debug session (see *Starting the Debug Session* on page 136). The startup routine can be reprogrammed (see *TargetConnect* on page 163).

Prototype

```
int Debug.Start();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Debug → Start Debugging (F5)

7.10.10.2 Debug.Stop

Stops the debug session (see *Stopping the Debug Session* on page 158).

Prototype

```
int Debug.Stop();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Debug → Stop Debugging (Shift+F5)

7.10.10.3 Debug.Disconnect

Disconnects the debugger from the target.

Prototype

```
int Debug.Disconnect();
```

Return Value

-1: error
0: success

GUI Access

None

7.10.10.4 Debug.Connect

Establishes a J-Link connection to the target and starts the debug session in the default way. A reprogramming of the startup procedure via script function "Target- Connect" is ignored.

Prototype

```
int Debug.Connect();
```

Return Value

-1: error
0: success

GUI Access

None

7.10.10.5 Debug.SetConnectMode

Sets the connection mode (see *Connection Mode* on page 136).

Prototype

```
int Debug.SetConnectMode(int Mode);
```

Argument	Meaning
Mode	Connection mode (see <i>Connection Modes</i> on page 171).

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → System Variables (Ctrl+Alt+V)

7.10.10.6 Debug.Continue

Resumes program execution (see *Resume* on page 141).

Prototype

```
int Debug.Continue();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Debug → Continue (F5)

7.10.10.7 Debug.Halt

Halts program execution (see *Halt* on page 141).

Prototype

```
int Debug.Halt();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Debug → Halt (Ctrl+F5)

7.10.10.8 Debug.Reset

Resets the target and the debuggee (see *Reset* on page 140). The reset operation can be customized via the scripting interface (see *TargetReset* on page 163).

Prototype

```
int Debug.Reset();
```

Argument	Meaning
Mode	Reset mode (see <i>Reset Modes</i> on page 171).

Return Value

-1: error
0: success

GUI Access

Main Menu → Debug → Reset (F4)

7.10.10.9 Debug.SetResetMode

Sets the reset mode. The reset mode determines how the program is reset (see *Reset Mode* on page 140).

Prototype

```
int Debug.SetResetMode(int Mode);
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → System Variables (Ctrl+Alt+V)

7.10.10.10 Debug.StepInto

Steps into the current subroutine (see *Step* on page 140).

Prototype

```
int Debug.StepInto();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Debug → Step Into (F11)

7.10.10.11 Debug.StepOver

Steps over the current subroutine (see *Step* on page 140).

Prototype

```
int Debug.StepOver();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Debug → Step Over (F12)

7.10.10.12 Debug.StepOut

Steps out of the current subroutine. (see *Step* on page 140).

Prototype

```
int Debug.StepOut();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Debug → StepOut (Shift+F11)

7.10.10.13 Debug.SetNextPC

Sets the execution point to a particular machine instruction (see *Execution Point* on page 145).

Prototype

```
int Debug.SetNextPC(unsigned int Address);
```

Return Value

-1: error
0: success

GUI Access

Disassembly Window → Context Menu → Set Next PC (Shift+F10)

7.10.10.14 Debug.SetNextStatement

Sets the execution point to a particular source code line (see *Execution Point* on page 145).

Prototype

```
int Debug.SetNextStatement(const char* sStatement);
```

Argument	Meaning
sStatement	Function Name: displays the first source line of a function. Source Location: displays a particular source location (see <i>Source Code Location Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Source Viewer → Context Menu → Set Next Statement (Shift+F10)

7.10.10.15 Debug.RunTo

Advances the program execution point to a particular source code line, function or instruction address (see *Execution Point* on page 145).

Prototype

```
int Debug.RunTo(const char* sLocation);
```

Argument	Meaning
sStatement	Function Name: advances program execution to the first source line of a function. Memory Address: advances program execution to a particular instruction address. Source Location: advances program execution to a particular source code line (see <i>Source Code Location Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Code Window → Context Menu → Run To Cursor (Ctrl+F10)

7.10.10.16 Debug.Download

Downloads the debuggee to the target (see *Program Files* on page 135). The download operation can be reprogrammed (see *TargetDownload* on page 163).

Prototype

```
int Debug.Download();
```

Return Value

-1: error
0: success

GUI Access

None

7.10.10.17 Debug.ReadIntoInstCache

Initializes the instruction cache with target memory data (see *Instruction Cache* on page 153).

Prototype

```
int Debug.ReadIntoInstCache(U32 Address, U32 Size);
```

Argument	Meaning
Address	Start address of the target memory block to be read into the instruction cache.
Size	Byte size of the target memory block to be read into the instruction cache.

Return Value

-1: error
0: success

GUI Access

None

7.10.11 Help Actions

7.10.11.1 Help.About

Shows the About Dialog.

Prototype

```
int Help.About();
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Help → About

7.10.11.2 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 Guide (F1)

7.10.11.3 Help.Commands

Prints the command help to the Console Window (see *Command Help* on page 82)

Prototype

```
int Help.Commands();
```

Return Value

-1: error
0: success

GUI Access

Console Window → Context Menu → Help (Shift+F1)

7.10.12 Project Actions**7.10.12.1 Project.SetDevice**

Specifies the target device (see *J-Link Settings Dialog* on page 59).

Prototype

```
int Project.SetDevice(const char* sDeviceName);
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → J-Link Settings (Ctrl+Alt+J)

7.10.12.2 Project.SetHostIF

Specifies the host interface (see *Host Interfaces* on page 170).

Prototype

```
int Project.SetHostIF(const char* sHostIF, const char* sHostID);
```

Argument	Meaning
sHostIF	Host interface (see <i>Host Interfaces</i> on page 170).
sHostID	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)

7.10.12.3 Project.SetTargetIF

Specifies the target interface (see *Target Interfaces* on page 170).

Prototype

```
int Project.SetTargetIF(const char* sTargetIF);
```

Argument	Meaning
sTargetIF	Target interface (see <i>Target Interfaces</i> on page 170).

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → J-Link Settings (Ctrl+Alt+J)

7.10.12.4 Project.SetTIFSpeed

Specifies the target interface speed (see *J-Link Settings Dialog* on page 59).

Prototype

```
int Project.SetTIFSpeed(const char* sFrequency);
```

Argument	Meaning
sFrequency	Frequency Descriptor (see <i>Frequency Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → J-Link Settings (Ctrl+Alt+J)

7.10.12.5 Project.SetJTAGConfig

Configures the JTAG target interface scan chain parameters.

Prototype

```
int Project.SetJTAGConfig(int DRPre, int IRPre);
```

Argument	Meaning
DRPre	Position of the target in the JTAG scan chain. 0 is closest to TDO.
IRPre	Sums of IR-Lens of devices 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)

7.10.12.6 Project.SetBPTType

Sets the permitted breakpoint implementation type, i.e. restricts breakpoints to be implemented in the way specified by the command argument.

Prototype

```
int Project.SetBPTType(int Type);
```

Argument	Meaning
Type	Breakpoint Implementation Types (see <i>Breakpoint Implementation Types</i> on page 171).

Return Value

-1: error
0: success

GUI Access

Code Window → Context Menu → Edit Breakpoint (F8)

7.10.12.7 Project.SetCorePlugin

Overrides the default file path of the target support plugin (see *Target Support Plugins* on page 24).

Prototype

```
int Project.SetCorePlugin(const char* sFilePath);
```

Argument	Meaning
sFilePath	Plugin file path or name. Valid plugin file extensions are .dll on Windows, .so on linux and .dylib on macOS. The file path may be specified case-insensitively.

Return Value

-1: error
0: success

GUI Access

None

7.10.12.8 Project.SetOSPlugin

Specifies the file path or name of the plugin that adds RTOS awareness to the debugger.

Prototype

```
int Project.SetOSPlugin(const char* sFilePath);
```

Argument	Meaning
sFilePath	Plugin file path or name. Use argument "embosPlugin" to configure embOS awareness and "FreeRTOSPlugin" to configure FreeRTOS awareness. Valid plugin file extensions are .dll on Windows, .so on Linux and .dylib on macOS. The file path may be specified case-insensitively. The file extension may be omitted.

Return Value

-1: error
0: success

GUI Access

None

7.10.12.9 Project.SetRTT

Enables or disables the Real-Time Transfer (RTT) IO interface (see *Real-Time Transfer* on page 148).

Prototype

```
int Project.SetRTT(int OnOff);
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → System Variables (Ctrl+Alt+V)

7.10.12.10 Project.AddRTTSearchRange

Configures the Real-Time Transfer (RTT) IO interface (see *Real-Time Transfer* on page 148). This command makes it possible to use RTT (and only needs to be supplied) when both:

- Ozone (J-Link) has no information about the target's data memory address range and
- the connection mode is "ATTACH" or "ATTACH_HALT".

For further details, refer to the [J-Link User Guide](#).

Prototype

```
int Project.AddRTTSearchRange(U32 StartAddr, U32 Size);
```

Argument	Meaning
StartAddr – Size	Address range to be considered in the RTT buffer localization routine.

Return Value

-1: error
0: success

GUI Access

None

7.10.12.11 Project.SetTraceSource

Selects the trace source to be used.

Prototype

```
int Project.SetTraceSource(const char* sTraceSrc);
```

Argument	Meaning
sTraceSrc	Display name of the trace source to be used (see <i>Trace Sources</i> on page 172).

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → Trace Settings (Ctrl+Alt+T)

7.10.12.12 Project.SetSemihosting

Enables or disables the Semihosting IO interface (see *Semihosting* on page 148).

Prototype

```
int Project.SetSemihosting(int OnOff);
```

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → System Variables (Ctrl+Alt+V)

7.10.12.13 Project.ConfigSemihosting

Configures the Semihosting IO interface (see *Semihosting* on page 148).

Prototype

```
int Project.ConfigSemihosting(const char* sConfig);
```

Argument	Meaning
sConfig	Configuration string of the format "setting1=value,setting2=value...". The valid settings are architecture-dependant and described below.

ARM

Setting	Meaning
Vector	Semihosting vector address. The debugger will set a breakpoint on this address in order to catch Semihosting requests by the debuggee via the SWI instruction. The default value for this parameter is the SWI exception vector (0x8). In case the debuggee makes pronounced use of SWI's that are not Semihosting requests, it will be advantageous to set the Semihosting vector to an instruction within a customized SWI handler. Please refer to the ARM ADS debug target guide for further information.
UseSVC	Indicates if the debuggee issues Semihosting requests via SWI. The default value of this parameter is 1. When set to 0, the debugger will not set a breakpoint on the Semihosting vector. This can potentially improve the run performance of the debuggee whilst using Semihosting.

Return Value

-1: error
0: success

GUI Access

None

7.10.12.14 Project.SetTracePortWidth

Specifies the number of trace pins (data lines) comprising the target's trace port. This setting is only relevant when the selected trace source is "Trace Pins" / ETM (see *Project.SetTraceSource* on page 224).

Prototype

```
int Project.SetTracePortWidth(int PortWidth);
```

Argument	Meaning
PortWidth	Number of trace data lines provided by the target. Possible values are 1, 2 or 4.

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → Trace Settings (Ctrl+Alt+T)

7.10.12.15 Project.SetTraceTiming

This command adjusts the trace pin sampling delays. The delays may be necessary in case the target hardware does not provide sufficient setup and hold times for the trace pins. In such cases, delaying TCLK can compensate this and make tracing possibly anyhow. This setting is only relevant when the selected trace source is "Trace Pins" / ETM (see *Project.SetTraceSource* on page 224).

Prototype

```
int Project.SetTraceTiming(int d1, int d2, int d3, int d4);
```

Argument	Meaning
dn	Trace data pin n sampling delay in picoseconds. Only the first parameters are relevant when your hardware has less than 4 trace pins.

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → Trace Settings (Ctrl+Alt+T)

7.10.12.16 Project.SetTraceFile

Assigns the trace file. All trace data read from the target is stream-exported to the selected file.

Prototype

```
int Project.SetTraceFile(const char* sFilePath);
```

Argument	Meaning
sFilePath	Path to the trace file. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → Trace Settings (Ctrl+Alt+T)

7.10.12.17 Project.ConfigSWO

Configures the Serial Wire Output (SWO) IO interface (see *SWO* on page 148). This setting is only relevant when the selected trace source is SWO (see *Project.SetTraceSource* on page 224).

Prototype

```
int Project.ConfigSWO(const char* sSWOFreq, char* sCPUFreq);
```

Argument	Meaning
sSWOFreq	Specifies the data transmission speed on the SWO interface (see <i>Frequency Descriptor</i> on page 168).
sCPUFreq	Specifies the target's processor frequency (see <i>Frequency Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → Trace Settings (Ctrl+Alt+T)

7.10.12.18 Project.SetMemZoneRunning

Specifies the default memory zone that is accessed when the program is running. The debugger uses this memory zone for any memory access that has not been explicitly assigned to a particular memory zone.

Prototype

```
int Project.SetMemZoneRunning(const char* sMemoryZone);
```

Argument	Meaning
sMemoryZone	Name of the default memory zone

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → System Variables (Ctrl+Alt+T)

7.10.12.19 Project.AddSvdFile

Adds a register set description file to be loaded by the Register Window (see *SVD Files* on page 113).

Prototype

```
int Project.AddSvdFile(const char* sFilePath);
```

Argument	Meaning
sFilePath	Path to a CMSIS-SVD file. Both .svd and .xml file extensions are supported. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).

Return Value

-1: error
0: success

GUI Access

None

7.10.12.20 Project.AddFileAlias

Adds a file path alias (see *File Path Resolution Sequence* on page 183).

Prototype

```
int Project.AddFileAlias(const char* sFilePath, const char* sAliasPath);
```

Argument	Meaning
sFilePath	Original file path as it appears within the program file or elsewhere.
sAliasPath	Replacement for the original file path.

Return Value

-1: error
0: success

GUI Access

Source Files Window → Context Menu → Locate File (Space)

7.10.12.21 Project.AddRootPath

Adds a source file root path. The root path helps the debugger resolve relative file path arguments (see *File Path Resolution* on page 183). Typically a project will have a single source file root path.

Prototype

```
int Project.SetRootPath(const char* sRootPath);
```

Argument	Meaning
sRootPath	Fully qualified path of a file system directory.

Return Value

-1: error
0: success

GUI Access

None

7.10.12.22 Project.AddPathSubstitute

Replaces a substring within unresolved source file path arguments (see *File Path Resolution* on page 183).

Prototype

```
int Project.AddPathSubstitute(const char* sSubStr, const char* sAlias);
```

Argument	Meaning
sSubStr	Substring of the original file path.
sAlias	Replacement for the given substring.

Return Value

-1: error
0: success

GUI Access

None

7.10.12.23 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 183).

Prototype

```
int Project.AddSearchPath(const char* sSearchPath);
```

Argument	Meaning
sSearchPath	Fully qualified path of a file system directory.

Return Value

-1: error
0: success

GUI Access

None

7.10.12.24 Project.SetJLinkScript

Specifies the J-Link script file that is to be executed at the moment the debug session is started. Refer to the [J-Link User Guide](#) for an overview on J-Link script files.

Prototype

```
int Project.SetJLinkScript(const char* sFilePath);
```

Argument	Meaning
sFilePath	Path to a J-Link script file. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).

Return Value

-1: error
0: success

GUI Access

None

7.10.12.25 Project.SetJLinkLogFile

Specifies the text file that receives J-Link logging output.

Prototype

```
int Project.SetJLinkLogFile(const char* sFilePath);
```

Argument	Meaning
sFilePath	Path to a text file. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).

Return Value

-1: error
0: success

GUI Access

None

7.10.12.26 Project.RelocateSymbols

Relocates one or multiple symbols.

Prototype

```
int Project.RelocateSymbols(const char* sSymbols, int Offset);
```

Argument	Meaning
sSymbols	Specifies the symbols to be relocated. The wildcard character "*" selects all symbols. A symbol name specifies a single symbol. A section name such as ".text" specifies a particular ELF data section.
Offset	The offset that is added to the base addresses of all specified symbols.

Return Value

-1: error
0: success

GUI Access

None

7.10.12.27 Project.SetConsoleLogFile

Sets the text file to which Console Window messages are logged.

Prototype

```
int Project.SetConsoleLogFile(const char* sFilePath);
```

Argument	Meaning
sFilePath	Logfile. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).

Return Value

-1: error
0: success

GUI Access

None

7.10.12.28 Project.SetTerminalLogFile

Sets the text file to which Terminal Window messages are logged.

Prototype

```
int Project.SetTerminalLogFile(const char* sFilePath);
```

Argument	Meaning
sFilePath	Logfile. The file path may contain directory macros (see <i>Directory Macros</i> on page 182).

Return Value

-1: error
0: success

GUI Access

None

7.10.12.29 Project.DisableSessionSave

Selects the session information that is not to be saved to the user file.

Prototype

```
int Project.DisableSessionSave(unsigned int Flags);
```

Argument	Meaning
Flags	Bitwise-OR combination of individual flags. Each flag specifies a session information that is not to be saved to (and restored from) the user file. Refer to <i>Session Save Flags</i> on page 173 for the list of supported flags.

Return Value

-1: error
0: success

GUI Access

None

7.10.13 Code Profile Actions

7.10.13.1 Profile.Exclude

Filters program entities from the code profile (load) statistic. The code profile statistic is re-evaluated as if the filtered items had never belonged to the program.

Prototype

```
int Profile.Exclude (const char* sFilter);
```

Argument	Meaning
sFilter	Specifies the items to be filtered. All items 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...

7.10.13.2 Profile.Include

Re-adds filtered items to the code profile load statistic.

Prototype

```
int Profile.Include (const char* sFilter);
```

Argument	Meaning
sFilter	Specifies the items to be unfiltered. All items 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...

7.10.13.3 Coverage.Exclude

Filters program entities from the code coverage statistic. The code coverage statistic is re-evaluated as if the filtered items had never belonged to the program.

Prototype

```
int Coverage.Exclude (const char* sFilter);
```

Argument	Meaning
sFilter	Specifies the items to be filtered. All items 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...

7.10.13.4 Coverage.Include

Re-adds filtered items to the code coverage statistic.

Prototype

```
int Coverage.Include (const char* sFilter);
```

Argument	Meaning
sFilter	Specifies the items to be unfiltered. All items 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...

7.10.13.5 Coverage.ExcludeNOPs

Excludes instructions without operation (alignment instructions) from the code coverage statistics.

Prototype

```
int Coverage.ExcludeNOPs ();
```

Return Value

-1: error
0: success

GUI Access

Code Profile Window → Context Menu → Exclude All NOP Instructions...

7.10.13.6 Profile.Export

Exports the current code profile dataset to a text file (as a human-readable report).

Prototype

```
int Profile.Export (const char* sFilePath);
```

Argument	Meaning
sFilePath	Destination text file.

Return Value

-1: error
0: success

GUI Access

Code Profile Window → Context Menu → Export...

7.10.13.7 Profile.ExportCSV

Exports the current code profile dataset to a CSV file.

Prototype

```
int Profile.ExportCSV (const char* sFilePath, int Format);
```

Argument	Meaning
sFilePath	Destination CSV file.
Format	Specifies which program entities are be exported to the CSV file (see <i>Code Profile Export Formats</i> on page 173)

Return Value

-1: error
0: success

GUI Access

Code Profile Window → Context Menu → Export...

7.10.14 Target Actions

7.10.14.1 Target.SetReg

Writes a target register (see *Target Registers* on page 146).

Prototype

```
int Target.SetReg(const char* sRegName, unsigned int Value);
```

Argument	Meaning
sRegName	Name of a core, FPU or coprocessor register (see <i>Coprocessor Register Descriptor</i> on page 169).
Value	Register value to write.

Return Value

-1: error
0: success

GUI Access

None

7.10.14.2 Target.GetReg

Reads a target register (see *Target Registers* on page 146).

Prototype

```
U32 Target.GetReg(const char* RegName);
```

Argument	Meaning
sRegName	Name of a core, FPU or coprocessor register (see <i>Coprocessor Register Descriptor</i> on page 169).

Return Value

-1: error
register value: success

GUI Access

None

7.10.14.3 Target.WriteU32

Writes a word to target memory (see *Target Memory* on page 146).

Prototype

```
int Target.WriteU32(U32 Address, U32 Value);
```

Return Value

-1: error
0: success

GUI Access

None

7.10.14.4 Target.WriteU16

Writes a half word to target memory (see *Target Memory* on page 146).

Prototype

```
int Target.WriteU16(U32 Address, U16 Value);
```

Return Value

-1: error
0: success

GUI Access

None

7.10.14.5 Target.WriteU8

Writes a byte to target memory (see *Target Memory* on page 146).

Prototype

```
int Target.WriteU8(U32 Address, U8 Value);
```

Return Value

-1: error
0: success

GUI Access

None

7.10.14.6 Target.ReadU32

Reads a word from target memory (see *Target Memory* on page 146).

Prototype

```
U32 Target.ReadU32(U32 Address);
```

Return Value

-1: error
Memory value: success

GUI Access

None

7.10.14.7 Target.ReadU16

Reads a half word from target memory (see *Target Memory* on page 146).

Prototype

```
U16 Target.ReadU16(U32 Address);
```

Return Value

-1: error
Memory value: success

GUI Access

None

7.10.14.8 Target.ReadU8

Reads a byte from target memory (see *Target Memory* on page 146).

Prototype

```
U32 Target.ReadU8(U32 Address);
```

Return Value

-1: error
Memory value: success

GUI Access

None

7.10.14.9 Target.SetAccessWidth

Specifies the default access width to be used when accessing target memory (see *Target.SetAccessWidth* on page 237).

Prototype

```
int Target.SetAccessWidth(U32 AccessWidth);
```

Argument	Meaning
AccessWidth	Memory access width (See <i>Memory Access Widths</i> on page 171).

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → System Variables (Ctrl+Alt+V)

7.10.14.10 Target.FillMemory

Fills a block of target memory with a particular value (see *Target.FillMemory* on page 237).

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)

7.10.14.11 Target.SaveMemory

Saves a block of target memory to a binary data file (see *Target.SaveMemory* on page 238).

Prototype

```
int Target.SaveMemory(const char* sFilePath, U32 Address, U32 Size);
```

Argument	Meaning
sFilePath	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)

7.10.14.12 Target.LoadMemory

Downloads the contents of a binary data file to target memory (see *Download Behaviour Comparison* on page 149).

Prototype

```
int Target.LoadMemory(const char* sFilePath, U32 Address);
```

Argument	Meaning
sFilePath	Path to the binary data file (*.bin). The file path may contain directory macros (see <i>Directory Macros</i> on page 182).
Address	Download address.

Return Value

-1: error
0: success

GUI Access

Memory Window → Context Menu → Load (Ctrl+L)

7.10.14.13 Target.SetEndianness

Sets the data endianness mode of the target.

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)

7.10.14.14 Target.LoadMemoryMap

Initializes the target's memory map from the contents of a memory map file. The initialized memory map can be observed using the *Memory Usage Window* on page 108.

Prototype

```
int Target.LoadMemoryMap(const char* sFilePath);
```

Argument	Meaning
sFilePath	Path to a memory map file. Currently, the only supported file format is Segger Embedded Studio.

Return Value

-1: error
0: success

GUI Access

None

7.10.14.15 Target.AddMemorySegment

Adds a segment to the target's memory map (see *Supplying Segment Information* on page 109).

Prototype

```
int Target.AddMemorySegment(const char* sName, U32 Addr, U32 Size);
```

Argument	Meaning
sName	Segment name.
Addr	Segment base address.
Size	Segment byte size.

Return Value

-1: error
0: success

GUI Access

None.

7.10.15 J-Link Actions

7.10.15.1 Exec.Connect

Establishes a J-Link connection to the target and triggers the default startup sequence (see *TargetConnect* on page 163).

Prototype

```
int Exec.Connect();
```

Return Value

-1: error
0: success

GUI Access

None

7.10.15.2 Exec.Reset

Performs a hardware reset of the target (see *Reset* on page 140).

Prototype

```
int Exec.Reset();
```

Return Value

-1: error
0: success

GUI Access

None

7.10.15.3 Exec.Download

Downloads the contents of a program or data file to target memory (see *Download Behaviour Comparison* on page 149).

Prototype

```
int Exec.Download(const char* sFilePath);
```

Return Value

-1: error
0: success

GUI Access

None

7.10.15.4 Exec.Command

Executes a J-Link command.

Prototype

```
int Exec.Command(const char* sCommand);
```


Argument	Meaning
sCommand	J-Link command to execute (refer to the J-Link User Guide for an overview on the available commands).

Return Value

-1: error
0: success

GUI Access

None

7.10.16 Breakpoint Actions

7.10.16.1 Break.Set

Sets an instruction breakpoint (see *Instruction Breakpoints* on page 142).

Prototype

```
int Break.Set(U32 Address);
```

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Set / Clear (Alt+Plus)

7.10.16.2 Break.SetEx

Sets an instruction breakpoint of a particular implementation type (see *Instruction Breakpoints* on page 142).

Prototype

```
int Break.SetEx(U32 Address, int Type);
```

Argument	Meaning
Address	Instruction address.
Type	Breakpoint Implementation Types (see <i>Breakpoint Implementation Types</i> on page 171).

Return Value

-1: error
0: success

GUI Access

None

7.10.16.3 Break.SetOnSrc

Sets a source breakpoint (see *Source Breakpoints* on page 142).

Prototype

```
int Break.SetOnSrc(const char* sLocation);
```

Argument	Meaning
sLocation	Function Name: displays the first source line of a function. Source Location: displays a particular source location (see <i>Source Code Location Descriptor</i> on page 168).

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Set / Clear (Alt+Plus)

7.10.16.4 Break.SetOnSrcEx

Sets a source breakpoint of a particular implementation type (see *Source Breakpoints* on page 142).

Prototype

```
int Break.SetOnSrc(const char* sLocation, int Type);
```

Argument	Meaning
sLocation	Function Name: displays the first source line of a function. Source Location: displays a particular source location (see <i>Source Code Location Descriptor</i> on page 168).
Type	Breakpoint Implementation Types (see <i>Breakpoint Implementation Types</i> on page 171).

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Set / Clear (Alt+Plus)

7.10.16.5 Break.SetType

Sets a breakpoint's permitted implementation type (see *Breakpoint Implementation Types* on page 171).

Prototype

```
int Break.SetType(const char* sLocation, int Type);
```

Argument	Meaning
sLocation	Location of the breakpoint as displayed within the first column of the Breakpoint Window (see <i>Breakpoints/Tracepoints Window</i> on page 71).
Type	Breakpoint Implementation Types (see <i>Breakpoint Implementation Types</i> on page 171).

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Edit (F8)

7.10.16.6 Break.Clear

Clears an instruction breakpoint (see *Instruction Breakpoints* on page 142).

Prototype

```
int Break.Clear(U32 Address);
```

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Set / Clear (F9)

7.10.16.7 Break.ClearOnSrc

Clears a source breakpoint (see *Source Breakpoints* on page 142).

Prototype

```
int Break.ClearOnSrc(const char* sLocation);
```

Parameter Description

Refer to *Break.SetOnSrc* on page 241.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Set / Clear (F9)

7.10.16.8 Break.Enable

Enables an instruction breakpoint (see *Instruction Breakpoints* on page 142).

Prototype

```
int Break.Enable(U32 Address);
```

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Enable (Shift+F9)

7.10.16.9 Break.Disable

Disables an instruction breakpoint (see *Instruction Breakpoints* on page 142).

Prototype

```
int Break.Disable(U32 Address);
```

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Disable (Shift+F9)

7.10.16.10 Break.EnableOnSrc

Enables a source breakpoint (see *Source Breakpoints* on page 142).

Prototype

```
int Break.EnableOnSrc(const char* sLocation);
```

Parameter Description

Refer to *Break.SetOnSrc* on page 241.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Enable (Shift+F9)

7.10.16.11 Break.DisableOnSrc

Disables a source breakpoint (see *Source Breakpoints* on page 142).

Prototype

```
int Break.DisableOnSrc(const char* sLocation);
```

Parameter Description

Refer to *Break.SetOnSrc* on page 241.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Disable (Shift+F9)

7.10.16.12 Break.Edit

Edits a breakpoint's advanced properties.

Prototype

```
int Break.Edit(const char* sLocation, const char* sCondition, int DoTriggerOnChange, int SkipCount, const char* sTaskFilter, const char* sConsoleMsg, const char* sMsgBoxMsg);
```

Argument	Meaning
sLocation	Location of the breakpoint as displayed within the Breakpoints/Tracepoints Window.
sCondition	Symbol expression that must evaluate to non-zero for the breakpoint to be triggered (see <i>Expressions</i> on page 181).
DoTriggerOnChange	Indicates whether 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 program 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 Project.SetOSPlugin.
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

Breakpoint Window → Context Menu → Edit (F8)

7.10.16.13 Break.SetOnData

Sets a data breakpoint (see *Data Breakpoints* on page 144).

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 <i>Connection Modes</i> on page 171).
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.

Argument	Meaning
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

Breakpoint Window → Context Menu → Set (Alt+Plus)

7.10.16.14 Break.ClearOnData

Clears a data breakpoint (see *Data Breakpoints* on page 144).

Prototype

```
int Break.ClearOnData(U32 Address, U32 AddressMask, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnData* on page 245.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Clear (F9)

7.10.16.15 Break.ClearAll

Clears all breakpoints (see *Data Breakpoints* on page 144).

Prototype

```
int Break.ClearAll();
```

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Clear All (Alt+Del)

7.10.16.16 Break.ClearAllOnData

Clears all data breakpoints (see *Data Breakpoints* on page 144).

Prototype

```
int Break.ClearAllOnData();
```

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Clear All (Alt+Del)

7.10.16.17 Break.EnableOnData

Enables a data breakpoint (see *Data Breakpoints* on page 144).

Prototype

```
int Break.EnableOnData(U32 Address, U32 AddressMask, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnData* on page 245.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Enable (Shift+F9)

7.10.16.18 Break.DisableOnData

Disables a data breakpoint (see *Data Breakpoints* on page 144).

Prototype

```
int Break.DisableOnData(U32 Address, U32 AddressMask, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnData* on page 245.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Disable (Shift+F9)

7.10.16.19 Break.EditOnData

Edits a data breakpoint (see *Data Breakpoints* on page 144).

Prototype

```
int Break.EditOnData(U32 Address, U32 AddressMask, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnData* on page 245.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Edit (F8)

7.10.16.20 Break.SetOnSymbol

Sets a data breakpoint on a symbol (see *Data Breakpoints* on page 144).

Prototype

```
int Break.SetOnSymbol(const char* sSymbolName, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Argument	Meaning
sSymbolName	Name of the symbol that is monitored by the data breakpoint.
AccessType	Type of access that is monitored by the data breakpoint (see <i>Connection Modes</i> on page 171).
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

Breakpoint Window → Context Menu → Set (Alt+Plus)

7.10.16.21 Break.ClearOnSymbol

Clears a data breakpoint on a symbol (see *Data Breakpoints* on page 144).

Prototype

```
int Break.ClearOnSymbol(const char* sSymbolName, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```


Parameter Description

Refer to *Break.SetOnSymbol* on page 248.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Clear (F9)

7.10.16.22 Break.EnableOnSymbol

Enables a data breakpoint on a symbol (see *Data Breakpoints* on page 144).

Prototype

```
int Break.EnableOnSymbol(const char* sSymbolName, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnSymbol* on page 248.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Enable (Shift+F9)

7.10.16.23 Break.DisableOnSymbol

Disables a data breakpoint on a symbol (see *Data Breakpoints* on page 144).

Prototype

```
int Break.DisableOnSymbol(const char* sSymbolName, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnSymbol* on page 248.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Disable (Shift+F9)

7.10.16.24 Break.EditOnSymbol

Edits a data breakpoint on a symbol (see *Data Breakpoints* on page 144).

Prototype

```
int Break.EditOnSymbol (const char* sSymbolName, U8 AccessType, U8 AccessSize,
U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnSymbol* on page 248.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Edit (F8)

7.10.16.25 Break.SetCommand

Assigns a script function to a breakpoint that is executed when the breakpoint is hit.

Prototype

```
int Break.SetCommand (const char* sLocation, const char* sFuncName);
```

Argument	Meaning
sLocation	Location of the breakpoint as displayed within the first column of the Breakpoint Window (see <i>Breakpoints/Tracepoints Window</i> on page 71).
sFuncName	Name of the script function to callback when the breakpoint is hit.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Edit (F8)

7.10.16.26 Break.SetCmdOnAddr

Assigns a script function to a breakpoint that is executed when the breakpoint is hit.

Prototype

```
int Break.SetCmdOnAddr (unsigned int Address, const char* sFuncName);
```

Argument	Meaning
Address	Instruction address.
sFuncName	Name of the script function to callback when the breakpoint is hit.

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Edit (F8)

7.10.17 ELF Actions

7.10.17.1 Elf.GetBaseAddr

Returns the program file's download address.

Prototype

```
int Elf.GetBaseAddr();
```

Return Value

-1: error
Base address: success

GUI Access

None

7.10.17.2 Elf.GetEntryPointPC

Returns the initial PC of program execution.

Prototype

```
int Elf.GetEntryPointPC();
```

Return Value

Initial PC of program execution (-1 on error)

GUI Access

None

7.10.17.3 Elf.GetEntryFuncPC

Return the initial PC of the program's entry (or main) function.

Prototype

```
int Elf.GetEntryFuncPC();
```

Return Value

PC of the program entry function (-1 on error)

GUI Access

None

7.10.17.4 Elf.GetExprValue

Evaluates a symbol expression.

Prototype

```
int Elf.GetExprValue(const char* sExpression);
```

Return Value

-1: error
 Expression value: success

GUI Access

None

7.10.17.5 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

7.10.18 Trace Actions

Actions performing trace related operations.

7.10.18.1 Trace.SetPoint

Sets a tracepoint

Prototype

```
int Trace.SetPoint(int Op, const char* sLocation);
```

Argument	Meaning
Op	Operation to be performed when the tracepoint is hit (see <i>Tracepoint Operation Types</i> on page 172).
sLocation	Location of the tracepoint as displayed within the Breakpoints/Tracepoints Window (see <i>Breakpoints/Tracepoints Window</i> on page 71)).

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Set Tracepoint (Ctrl+Alt+E)

7.10.18.2 Trace.ClearPoint

Clears a tracepoint.

Prototype

```
int Trace.SetPoint(const char* sLocation);
```

Argument	Meaning
sLocation	Location of the tracepoint as displayed within the Breakpoints/Tracepoints Window (see <i>Breakpoints/Tracepoints Window</i> on page 71)).

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Clear (F9)

7.10.18.3 Trace.EnablePoint

Enables a tracepoint.

Prototype

```
int Trace.EnablePoint(const char* sLocation);
```

Argument	Meaning
sLocation	Location of the tracepoint as displayed within the Breakpoints/Tracepoints Window (see <i>Breakpoints/Tracepoints Window</i> on page 71)).

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Enable (Shift+F9)

7.10.18.4 Trace.DisablePoint

Disables a tracepoint.

Prototype

```
int Trace.DisablePoint(const char* sLocation);
```

Argument	Meaning
sLocation	Location of the tracepoint as displayed within the Breakpoints/Tracepoints Window (see <i>Breakpoints/Tracepoints Window</i> on page 71)).

Return Value

-1: error
0: success

GUI Access

Breakpoint Window → Context Menu → Disable (Shift+F9)

7.10.18.5 Trace.ClearAllPoints

Clears all tracepoints.

Prototype

```
int Trace.ClearAllPoints();
```

Return Value

-1: error
0: success

GUI Access

Breakpoint Toolbar → Clear All Tracepoints

7.10.18.6 Trace.ExportCSV

Exports the contents of the Instruction Trace Window to a CSV file.

Prototype

```
int Trace.ExportCSV(const char* sFilePath);
```

Return Value

-1: error
0: success

GUI Access

Instruction Trace Window → Context Menu → Export

7.10.19 Watch Actions**7.10.19.1 Watch.Add**

Adds an expression to the Watched Data Window (see *Watched Data Window* on page 130).

Prototype

```
int Watch.Add(const char* sExpression);
```

Return Value

-1: error
0: success

GUI Access

Watched Data Window → Context Menu → Watch... (Alt+Plus)

7.10.19.2 Watch.Insert

Inserts an expression into the Watched Data Window (see *Watched Data Window* on page 130).

Prototype

```
int Watch.Insert(const char* sExpression);
```

Return Value

-1: error

0: success

GUI Access

None

7.10.19.3 Watch.Remove

Removes an expression from the Watched Data Window (see *Watched Data Window* on page 130).

Prototype

```
int Watch.Remove(const char* sExpression);
```

Return Value

-1: error
0: success

GUI Access

Watched Data Window → Context Menu → Remove (Del)

Chapter 8

Support

How to Report Bugs

Users are kindly asked to include the following information in Ozone bug reports:

- A detailed description of the problem
- Your OS and version
- Your debug probe model (e.g. J-Trace PRO Cortex-M V2)
- Information about your target hardware (processor, board, etc.)
- When possible an Ozone-log of the problem (for this, start Ozone with argument “-logfile <filepath>”)

Users without a support agreement with SEGGER are kindly asked to report bugs at the general room of [SEGGER's forum](#).

Users which are entitled to support should use the contact information below.

Contact Information

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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.

BMA

Background Memory Access. Targets featuring BMA support memory accesses while the CPU is running.

Command Prompt

The console window's command input field.

Debuggee

Same as Program.

Debugger

Ozone.

Device

The Microcontroller on which the debuggee 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.

J-Link OB

A J-Link debug probe that is integrated into the target ("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.

RTOS

Real Time Operating System.

SVD

System View Description, a standard by ARM.

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

Short for debug information window.

Word

A 32-bit unit of information. Contents are taken as being an unsigned integer unless otherwise stated.