Ozone

User Guide & Reference Manual

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A product of SEGGER Microcontroller GmbH

www.segger.com

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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.

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Manual version	Revision	Date	By	Description
3.40	4	260212	SB	Added description of Project.SetSWO.
3.40	3	260129	AD	Added RISC-V instruction set extensions Zcmt, Zcmp and Zcb.
3.40	2	251216	AD	Added SmartView plugin for uKOS-X.
3.40	2	251120	AD	Added GDB server types.
3.40	1	250911	AD	Updated Debug Settings Dialog.
3.40	0	250828	AD	Removed background memory access emulation (BMA emulation). Updated visibility of some elements in the View Menu. Added GDB Client and Debugging via GDB Server.
3.38	7	250730	SB	Removed section DLL Plugins. Marked emulated BMA as deprecated in Data Sampling Window.
3.38	6	250711	SB	Added Automation Socket Interface section.
3.38	5	250514	AD	Updated section System Variable Identifiers and description of Code Pane in secttion Timeline Window
3.38	4	250523	SB	Added Available RTOS Plugins to RTOS Window, updated related sections.
3.38	3	250410	AD	Added command to Semihosting.
3.38	2	250304	SB	Fixed identifiers in TargetInterface Class.
3.38	1	241212	AD	Added description of Symbol or PC to Stop Target during Startup. Added project script function `OnDebugStartBreakSymReached`.
3.38	0	240927	AD	Added support for Rust programming language.
3.36	1	240904	AD	Reworked handling of escaped quotes.
3.36	0	240822	AD	Added description for Interworking with External Applications Reworked section Terminal Window, in particular added description of Ansi Escape Sequences
3.34	0	240516	AD	Added Instruction Based Call Stack Unwinding to section Call Stack Window Added description for Custom Toolbar Reworked section Incorporating a Bootloader into Ozone's Startup Sequence
3.32	0	240222	AD	Added description for Context Aware Stepping Added EBREAK instruction for RISC-V semihosting
3.30c	3	231201	AD	Added *.asm and *.arm files to list of assembly code files Added description of option allowing to download programs into virtual addresses rather than physical addresses (see Target Download Addresses) Fixed numbers in tables in section Errors and Warnings Updated Trace Settings Dialog
3.30b	2	230915	AD	Added description for disassembler flag for Zfinx extension
3.30a	1	230628	AD	Add hints that toolbars may be shown/hidden via context menu
3.30	0	230605	AD	updated section Memory Dialog updated section Target Actions added target action Target.FillMemoryEx updated section Timeline Window
3.28	4	230328	AD	updated section Installation. updated section Timeline Window
3.28	3	230119	AD	Added description of Set Offset To Code feature.
3.28	2	221129	AD	Updated Find In Files Dialog. Updated Find In Trace Dialog. Updated Quick Find Widget. Added string display limit to Table Window Settings.

Manual version	Revision	Date	By	Description
				Added desription of semihosting configuration parameter ExitMode in Project.ConfigSemihosting
3.28	1	221102	AD	Added notes on breakpoint callback functions not being supported for data breakpoints.
3.28	0	221007	AD	Added documentation of SmartView Window and SmartView Plugin-scripts Added documentation for new TargetInterface Class methods. Added description of Project.SetFlashLoader Updated section Project Wizard
3.26	4	220912	AD	Chapter Directory Macros updated, added macros for date and time.
3.26	3	220707	AD	Chapter Terminal Window updated Updated context menu description of break point window Added command Exec.AddCommandOnOpen
3.26	2	220314	AD	Chapter Terminal Window updated Updated context menu description of some windows
3.26	1	220125	AD	Chapter Elf.GetFileClass added
3.26	0	211129	AD	Updated to revision 3.26. Chapter Minidumps updated. Chapter Disassembly Plugin updated. Chapter RTOS Awareness Plugins updated. Chapter Compatibility with Embedded Studio updated. Chapter Event Handler Functions updated. Chapter getInstInfo updated. Updated context menu description in chapter Source Viewer. Updated context menu description in chapter Console Window.
3.24	2	210913	AD	Added NuttX to list of supported RTOSes in chapter RTOS Awareness. Chapter TargetInterface.peekBytes updated.
3.24	1	210701	AD	Chapter Sampling Frequency updated. Chapter Timeline Window updated.
3.24	0	210617	AD	Updated to revision 3.24.
3.22	0	201204	JD	Updated to revision 3.22.
3.20	1	200901	JD	Updated chapters Appendix and Support.
3.20	0	200518	JD	Section Project Load Diagnostics Dialog added. Section Project Files updated. Chapter Graphical User Interface updated. Chapter Debug Information Windows updated. Chapter Debugging With Ozone updated. Chapter Appendix updated.
3.11	3	200326	JD	Broken document references fixed.
3.11	2	200320	JD	Section Find In Trace Dialog added. Chapter Graphical User Interface updated. Chapter Debug Information Windows updated. Chapter Appendix updated.
3.11	1	200204	JD	Chapter Appendix updated.
3.11	0	200203	JD	Section Startup Completion Point added. Section Export Actions added. Section Instruction Trace Window updated. Section Registers Window updated. Section Table Windows updated. Chapter Appendix updated.
3.10	0	191206	JD	Chapter Scripting Interface updated. Chapter Appendix updated. Multiple images updated. Multiple text improvements.
2.71	1	191029	JD	Chapter Disassembly Plugin added. Chapter Disassembly Window updated. Chapter Timeline Window rewritten. Chapter Appendix updated. Chapter Data Graph Window renamed Data Sampling Window. Chapter Power Graph Window renamed Power Sampling Window.
2.71	0	191007	JD	Chapter Appendix updated.

Manual version	Revision	Date	By	Description
2.70	1	190923	JD	Section Register Initialization updated.
2.70	0	190830	JD	Section Quick Watch Dialog added. Section Project File updated. Section Project Script updated. Chapter Appendix updated.
2.63	2	190819	JD	Section Semihosting added. Section Semihosting Settings Dialog added. Chapter Appendix updated.
2.63	1	190808	JD	Section J-Link Control Panel removed. Chapter Appendix updated.
2.63	0	190718	JD	Section Debug Snapshots added. Section Snapshot Programming added. Section Snapshot Dialog added. Section Minidumps added. Chapter Debug Information Windows updated. Chapter Graphical User Interface updated. Chapter Appendix updated.
2.62	1	190409	JD	Section Appendix updated.
2.62	0	190405	JD	Section RTOS Window added. Section RTOS Awareness Plugin added. Section JavaScript Classes added. Section Quick Find Widget added. Section Features of Ozone updated. Section Timeline Window updated. Section Project Files updated. Section Working With Expressions updated. Section Find Dialog renamed Find In Files Dialog Chapter Appendix updated. Contact information updated.
2.61	1	181207	JD	Renamed user action category “View” to “Show”. Section File Path Resolution Sequence updated. Chapter Appendix updated.
2.61	0	181026	JD	Version number 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	180830	JD	Chapter Appendix updated.
2.57	3	180830	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 Sequence 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 Setting Up The 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 Working With Expressions updated. Chapter Appendix updated.

Manual version	Revision	Date	By	Description
				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 System Register Descriptor updated.
2.52	1	171029	JD	Improved the layour and readability of multiple sections.
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 Frames 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 *Data Graph Settings Dialog* 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.

Manual version	Revision	Date	By	Description
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 System Register Descriptor added.
2.17	0	160520	JD	Section Data Graph Window added. Section Working With Expressions updated.
2.15	1	160427	JD	Section Live Watches added. Section Working With 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 Sequence added. Section Hardware Requirements updated.
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 *Conditional Breakpoints* added. Section *Big Endian Support* 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 Ritchie (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.

Table of contents

Chapter 1

Introduction

Ozone is SEGGER’s user-friendly and high-performance debugger for Arm and RISC-V 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++ or Rust and running on embedded targets. 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 and J-Trace debug probes to ensure optimal performance and user experience.

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 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 among windows via Drag&Drop.

1.2.2 Scripting Interface

A C-language scripting interface enables users to reconfigure Ozone's 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 command that can be executed from script code or from the debuggers console window.

1.2.3 RTOS Awareness

Ozone's RTOS Window displays RTOS-specific debug information and is controlled by a JavaScript plugin. By implementing new plugins, users are able to add support for any embedded operating system of their choice. Ozone ships with RTOS-awareness plugins for embOS, FreeRTOS, ChibiOS, NuttX and Zephyr out of the box.

1.2.4 Code Profiling

Ozone's code profiling features assist users in optimizing their 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.

1.2.5 Power Profiling

Ozone's Timeline Window displays the current drawn by the target relative to program execution flow. Power sampling resolutions of down to 5 us are supported.

1.2.6 Symbol Trace

The values of program variables and arbitrary C-style expressions can be tracked at time resolutions of down to 100 us and visualized within the Timeline Window.

1.2.7 Instruction Trace

Ozone's Instruction Trace Window provides a history of executed machine instructions. The history is updated incrementally following each program halt or step and may display millions of instructions, limited by Host-PC RAM only. When an instruction is selected, its execution context is shown within all debug windows.

1.2.8 Unlimited Flash Breakpoints

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

1.2.9 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)

1.2.10 Peripheral and System Register Support

Ozone supports *System View Description* files that describe the memory-mapped (peripheral) register set of the target. Once an SVD file has been selected, its registers become accessible via the Registers Window and script commands.

1.2.11 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.

1.2.12 Snapshots

Ozone enables users to save and restore the entire debug session, including advanced target state, to/from a session file called debug snapshot.

1.2.13 Custom Instruction Support

Ozone features a powerful disassembler that can be extended and reprogrammed via a javascript plugin file.

1.2.14 Instruction Set Simulation

Using J-Link's instruction set simulation capability, Ozone achieves one of the fastest stepping performances of any debugger for embedded systems on the market.

1.2.15 SmartView

The plugin-based SmartView window allows to present information from complex data structures in the target software in easy to comprehend, human readable tables. Users may implement new plugins tailored to their own needs, thus enabling the feature for virtually any embedded software component.

1.2.16 GDB Client

Ozone integrates a GDB client which allows communication with debug probes via a GDB server. By that means Ozone is capable of targeting 3rd party debug probes. Depending on the capabilities of the respective GDB server, not all features offered by Ozone may be available.

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's target support is based on a generic 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 debug probe. Direct communication with the debug probe is available only for SEGGER J-Link and J-Trace probes. This is the recommended use case providing the best debug experience for the end-user.

J-Link/J-Trace probes support the following target interfaces:

- JTAG
- SWD
- cJTAG

Ozone also offers a GDB client which allows communication with debug probes via a GDB server. By that means Ozone is capable of targeting a 3rd party debug probe. Depending on the capabilities of the respective GDB server, not all features offered by Ozone may be available.

1.7 Supported Programming Languages

Ozone supports debugging of programs whose source language is:

- C
- C++
- Rust
- Assembler

Ozone offers source level debugging. This includes stepping through the code on a per-source-line basis, setting breakpoints onto locations specified by filename and line number, evaluatig C-language expressions in the watched data window, syntax highlighting, and many more.

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 Ozone project. 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 among 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 33).

2.1.3.3 Library Dependencies

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

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

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

2.1.3.4 Multiple Installed Versions

Multiple versions of Ozone can co-exist on the host system if they are installed into different folders. Application settings, such as user interface fonts, are shared among 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 33).

2.1.4.1 Uninstall Commands

Debian

sudo dpkg -remove Ozone

RedHat

sudo yum remove Ozone

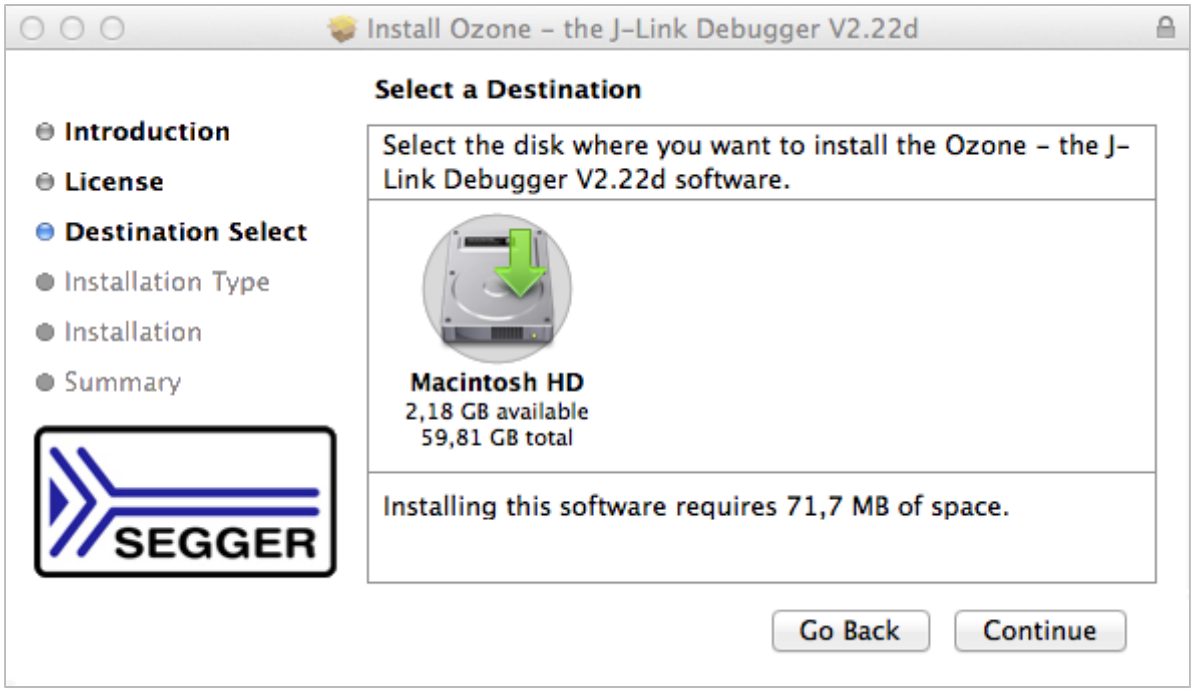
2.1.4.2 Removing Application Settings

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, delete this file and re-login to the OS.

2.1.5 Installation on macOS

Ozone for macOS ships as an 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

2.1.5.1 Multiple Installed Versions

Installing multiple versions of Ozone is supported. Each version is installed into a dedicated directory in the Applications folder which incorporates the version number. Thus it is easily possible to select the desired version to be launched.

In addtion, an alias to the version installed the latest is created in the Applications folder.

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<version>".

2.1.6.1 Removing Application Settings

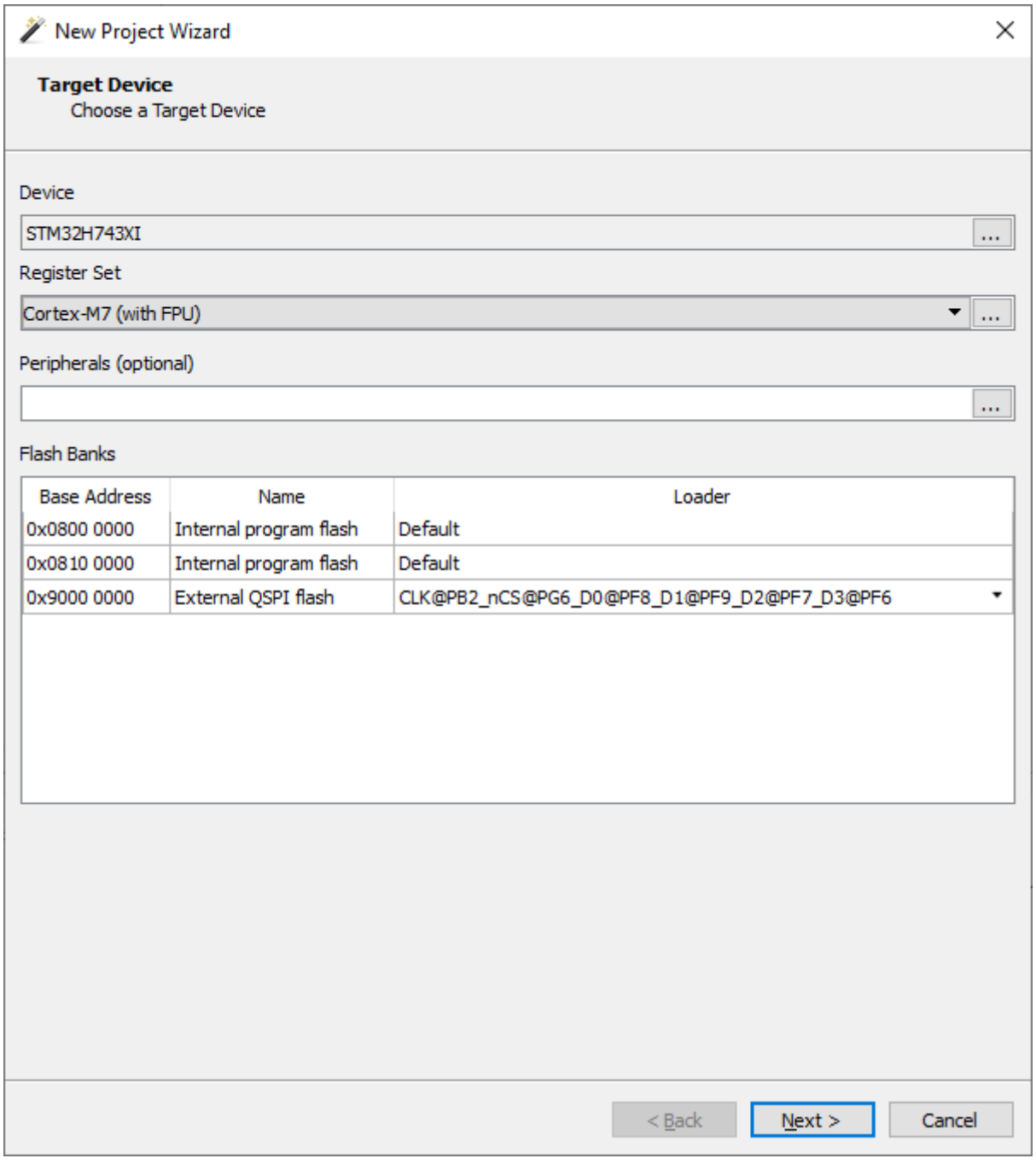
Ozone’s persistent application settings are stored in the hidden file $Home/Library/Preferences/com.segger.Ozone.plist. In order to erase Ozone’s persistent application settings, delete this file and re-login to the OS.

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.

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. Note that the Project Wizard will continue to pop up on start-up until the first project was created or opened.



First page of the Project Wizard

Device

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

Register Set

The dotted button of the register set description field is used to select an SVD file that describes the register set of the target device. An additional drop-down box enables users to select any of the standard SVD files shipped with Ozone. The selection made here governs which CPU registers will be accessible via the Registers Window and script commands.

Instruction Set Extension

By specifying the instruction set extension in use by the debuggee - if any - enhances the correctness of disassembly and other instruction-level information. The drop-down box lists all extensions which are natively supported by Ozone. Users may add support for further extensions by implementing disassembly plugins (see *Disassembly Plugin* on page 119).

Peripherals

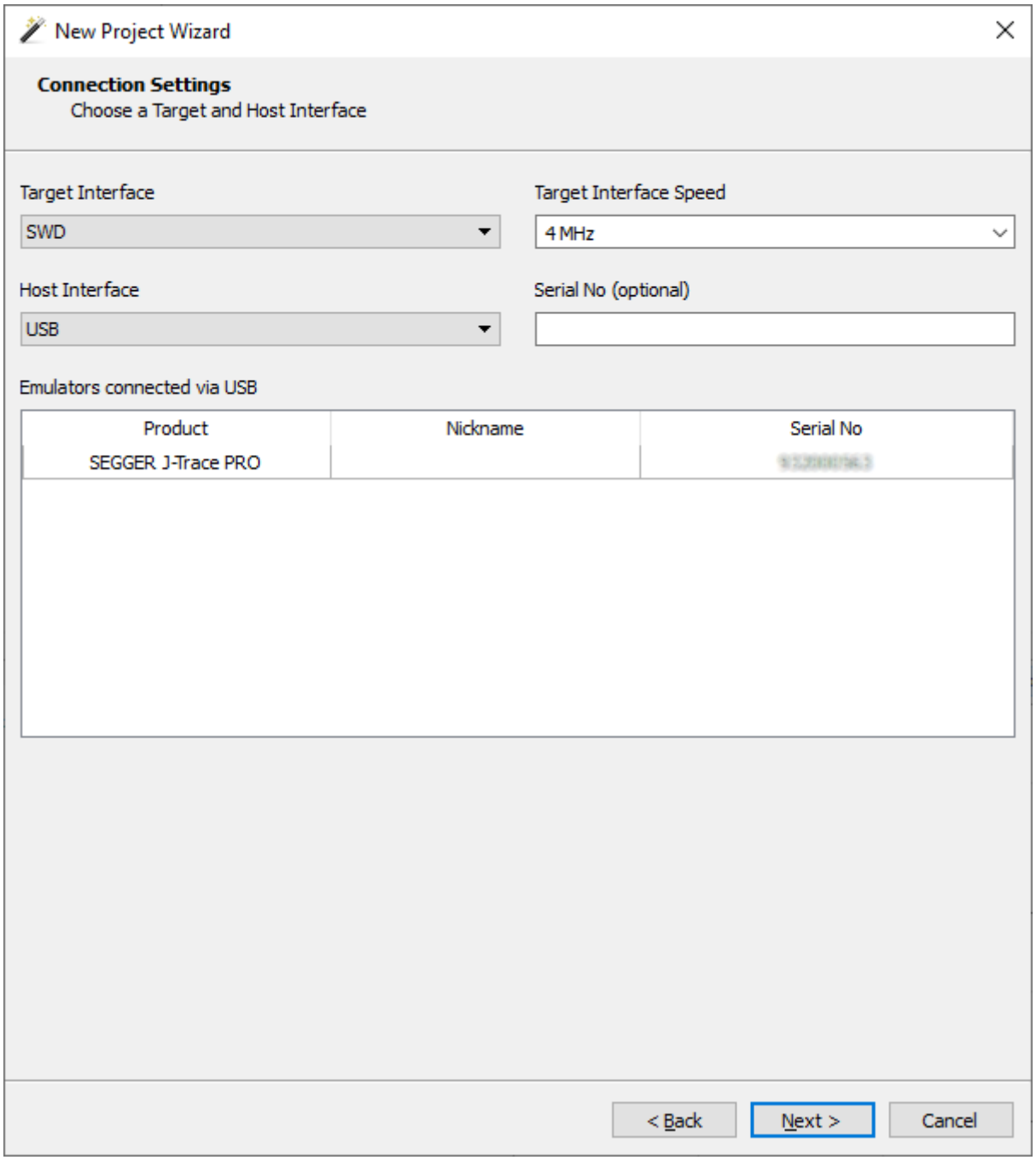
The user may optionally specify an SVD file that describes the vendor-specific peripheral register set of the target. If a valid SVD is specified here, vendor-specific peripheral registers will become accessible via the debugger's Registers Window and script commands.

Flash Banks

For some devices J-Link offers a choice of flash loaders which may be used for a flash bank. This table lists all the flash banks of a device and the flash loaders available for each bank. Initially, the default flash loaders are displayed, but the user may change that by changing the flash loader for one or more flash banks by selecting the desired flash loader from a drop-dwon menu.

In case a flash bank does not support multiple flash loaders there is no drop-down menu for that bank.

On the second page of the Project Wizard, connection settings are defined.



Second page of the Project Wizard

Target Interface

The target interface setting specifies how the J-Link/J-Trace 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 debug probe connected to the target is to be addressed by Ozone. All J-Link/J-Trace models provide a USB interface. For making use of that interface, select “USB” in the drop-down menu.

Some J-Link/J-Trace models provide an additional Ethernet interface, which can be used for debugging an embedded application remotely (see *Remote Debugging* on page 217). Please select “IP” in case this connection is to be used.

In case the debug probe is to be accessed via a GDB server, please select “GDB Server” in the drop-down menu (see *Debugging via GDB Server* on page 219).

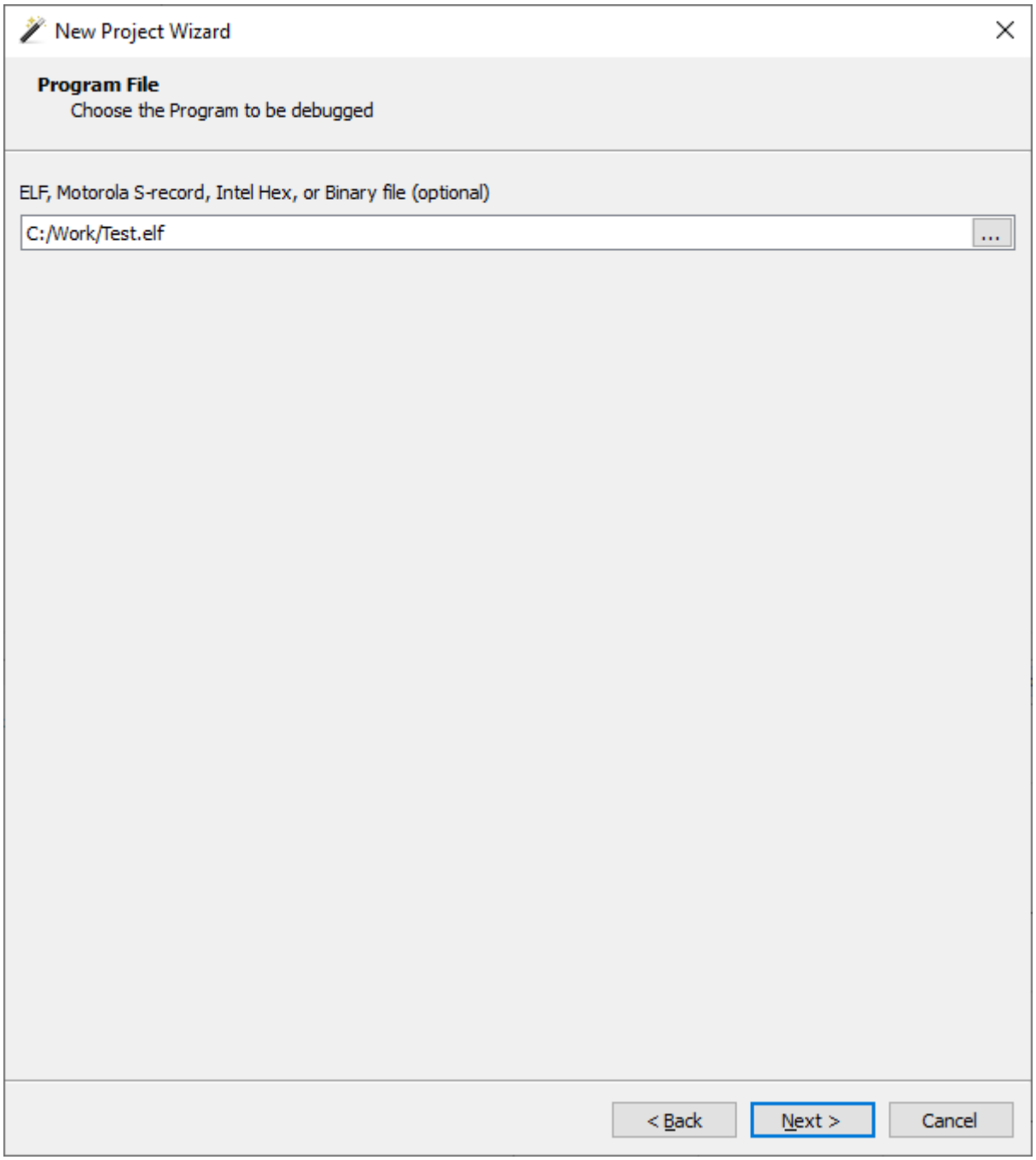
Serial No. / IP Address

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 Ethernet is selected as host interface, the caption of this field changes to IP Address and the user may either enter the IP address of the debug probe to connect to. For remote debugging, the credentials of a remote server are expected to be input here (see *Remote Debugging* on page 217).

In case a GDB Server shall be connected, the caption of the field is set to IP Address as well and the user may enter the IP address and port number of the GDB server (see *Debugging via GDB Server* on page 219).

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

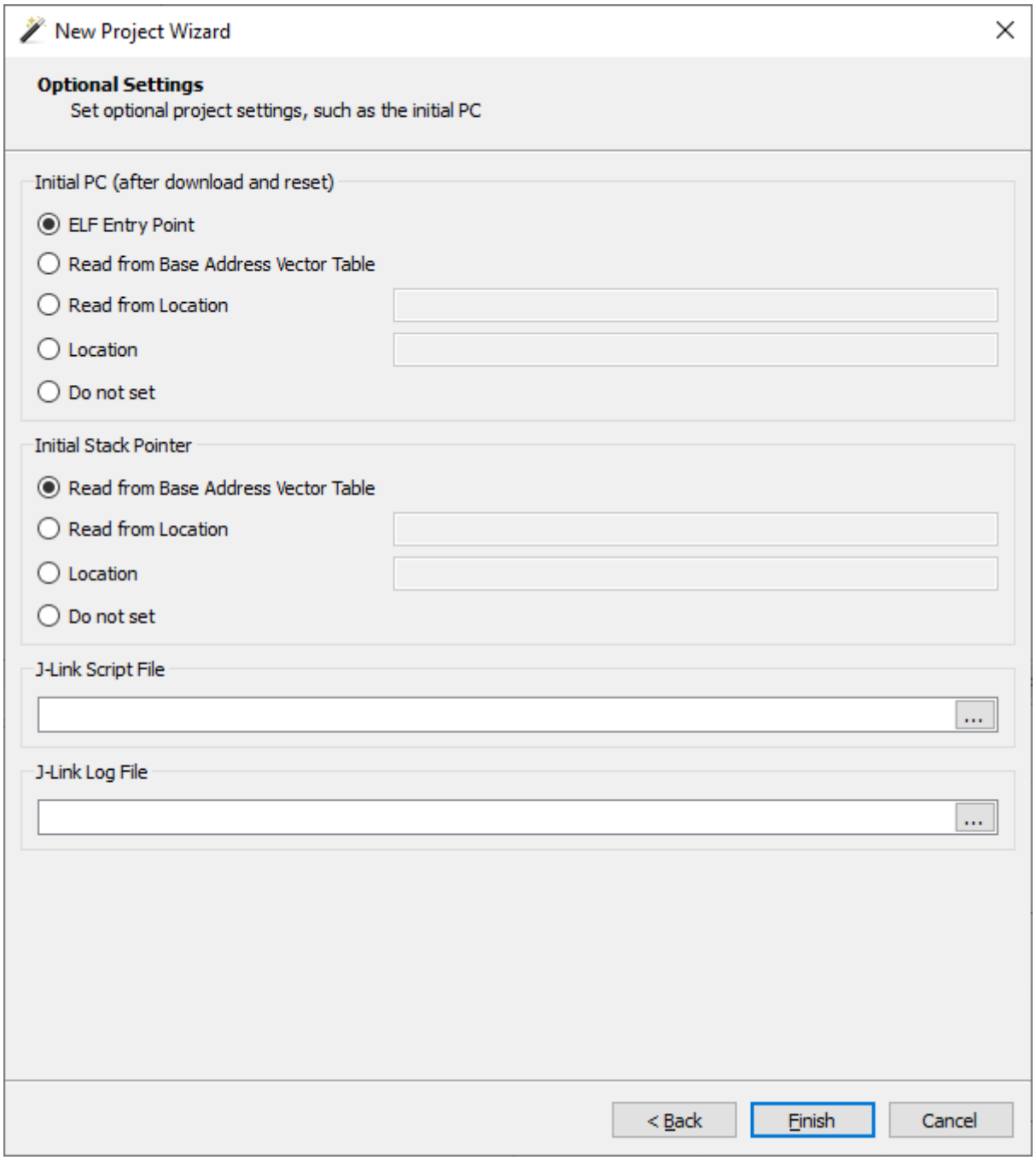


Third page of the Project Wizard

Program File

This input field specifies the program to debug. Please note that only ELF or compatible program files contain symbol information. When specifying a program file without symbol information, the debug features of Ozone are limited (see *Symbol Information* on page 183).

On the last page of the Project Wizard, advanced project settings are defined.



Last page of the Project Wizard

Initial PC

Indicates how the debugger is to set the initial value of the PC register. The first option is the default option. When the third option is checked, an Ozone expression denotes the memory location of the initial PC value (see *Working With Expressions* on page 205). When the fourth option is checked, an Ozone expression (constant) denotes the initial PC value.

Initial SP

Indicates how the debugger is to set the initial value of the SP register. The first option is the default option. When the third option is checked, an Ozone expression denotes the memory location of the initial SP value (see *Working With Expressions* on page 205). When the fourth option is checked, an Ozone expression (constant) denotes the initial SP value.

J-Link Script File

Sets the J-Link script which is to be executed upon target connection (see *Project.SetJLinkScript* on page 352.

J-Link Log File

Sets the log file that is to receive logging output of the J-Link library (see *Project.SetJLinkLogFile* on page 352.

Completing the Project Wizard

When the user completes the Project Wizard, a new project with the specified settings is created and the source file containing the program's entry function is opened inside the Source Viewer. The debugger is still offline, i.e. a 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 already 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 pressing the shortcut F5. After the startup procedure is complete, users may start to debug the program using the controls of the Debug Menu. The debugging workflow when using Ozone 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 Ozone that can be triggered via the user interface or programmatically from a script function. Ozone provides a set of around 250 user actions.

3.1.1 Action Tables

Section *Action Tables* on page 43 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 Console Window's 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 43 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

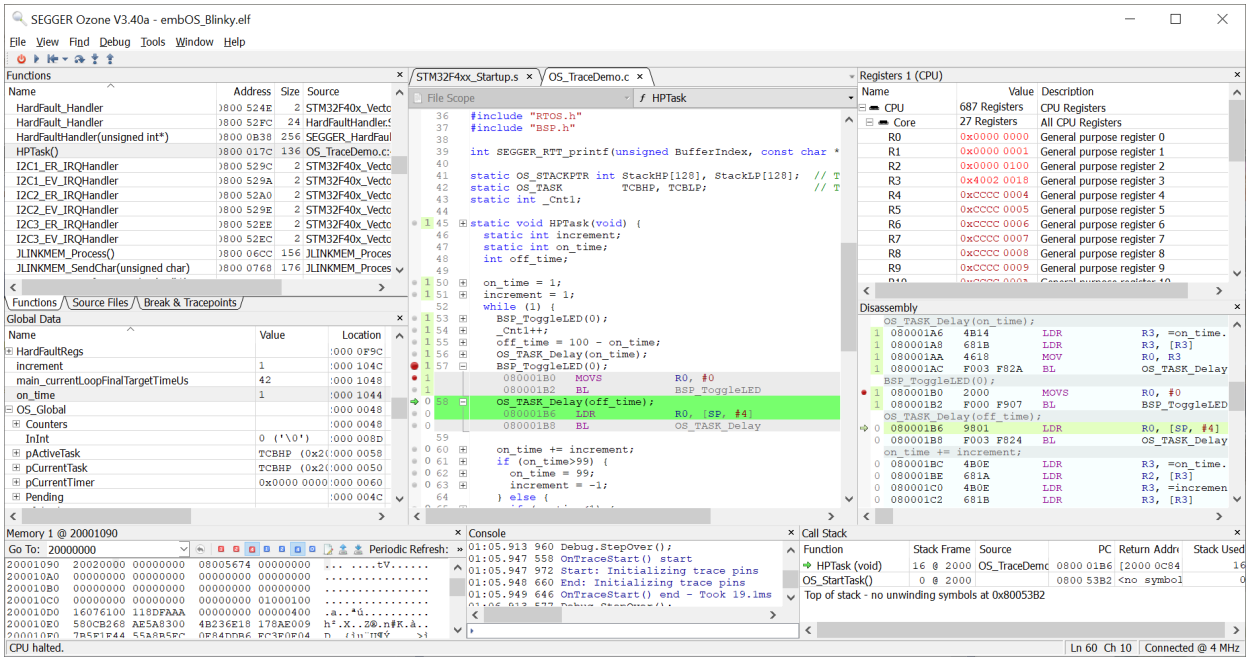
Several user actions execute a dialog. The fact that a user action executes a dialog is indicated by three dots that follow the action's name within user interface menus.

3.2 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:



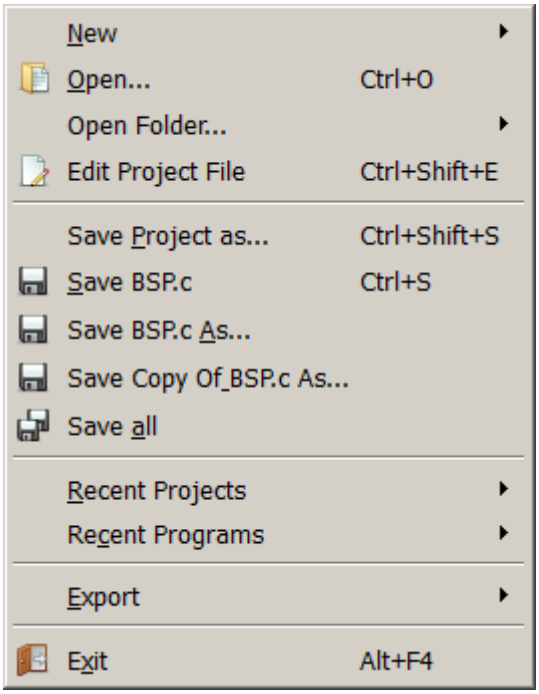
Main Window hosting debug information windows

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, as described in section *Window Layout* on page 52. The only window that cannot be undocked or repositioned is the Source Viewer itself.

3.3 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.

3.3.1 File Menu



The File Menu hosts actions that perform file system and related operations (see *File Actions* on page 292).

New

This submenu hosts actions to create a new project and to run the Project Wizard (see *Project Wizard* on page 35).

Open

Opens a project-, program-, data- or source-file (see *File.Open* on page 301).

Open Folder...

A submenu with multiple entries to open a specific directory in the standard file explorer:

- Project Folder: opens the project file directory
- Application Folder: opens the directory containing the program file
- Source Folder: opens the directory containing the active source document
- Ozone Folder: opens the directory containing the Ozone executable

(see *File.Open* on page 301).

Edit Project File

Opens the project file within the Source Viewer.

Save Project as

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

Save <file>

Saves all changes made to the active document, i.e. the document currently shown within the Source Viewer.

Save <file> As...

Opens a dialog that lets users save the active document under a new path to the file system. The active document will be closed and reopened from its new location.

Save Copy Of <file> As...

Opens a dialog that lets users save a copy of the active document to the file system.

Save All

Saves all modified Source Viewer documents and project files.

Recent Projects

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

Recent Programs

The "Recent Programs" submenu contains a list of recently opened program files. When an entry is selected, the associated program file is opened.

Export

A submenu that hosts an entry for each of Ozone's data exports:

Export	Dialog	Command
Code profile	Code Profile Export Dialog	Export.CodeProfile
Disassembly	Disassembly Export Dialog	Export.Disassembly
Instruction	Instruction Trace Export Dialog	Export.Trace
Power graphs	Power Sampling Window	Export.PowerGraphs
Data graphs	Data Sampling Window	Export.DataGraphs

3.3.2 View Menu

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 61).

embOS

If an RTOS awareness plugin has been loaded using action Project.SetOSPlugin, the entry for the RTOS Window (see *RTOS Window* on page 151) in the View Menu becomes active.

SmartView

If a SmartView plugin has been loaded using action Project.SetSmartViewPlugin, the entry for the SmartView Window (see *SmartView Window* on page 143) in the view menu becomes active.

Toolbars

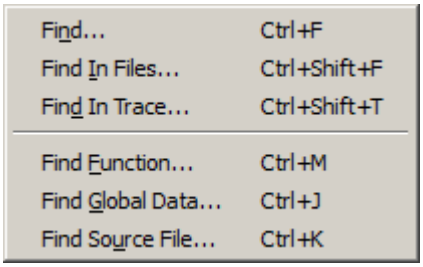
This submenu hosts three checkable actions that define which toolbars are visible (see *Toolbars* on page 50).

Enter/Exit Full Screen

Enters or exit full screen mode.

3.3.3 Find Menu

The Find Menu hosts actions that locate program symbols and text patterns.



Find...

Opens the Quick Find Widget in text search mode.

Find In Files...

Opens the Find In Files Dialog

Find In Trace...

Opens the Find In Trace Dialog

Find Function...

Opens the Quick Find Widget in function search mode.

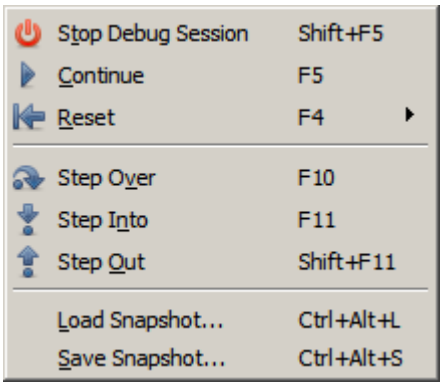
Find Global Data...

Opens the Quick Find Widget in global data search mode.

Find Source Files...

Opens the Quick Find Widget in source file search mode.

3.3.4 Debug Menu



The Debug Menu hosts actions that control program execution (*Debug Actions* on page 291).

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.

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 190).

Step Over

Steps over the current source code line or machine instruction, depending on the active code window (see *Active Code Window* on page 53 and *Step* on page 190). Context aware stepping is supported, if enabled.

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 53 and *Step* on page 190).

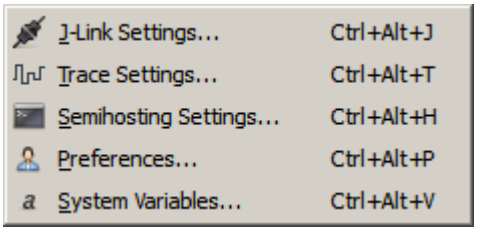
Step Out

Steps out of the current subroutine (see *Step* on page 190).

Load/Save Snapshot

Opens the Snapshot Dialog (see *Snapshot Dialog* on page 79).

3.3.5 Tools Menu



The Tools Menu hosts dialog actions that allow users to edit Ozone's graphical and behavioral settings (see *Tools Actions* on page 296).

Debug Settings

Opens the Debug Settings Dialog that enables users to specify J-Link/J-Trace specific settings such as the

target device and debug interface, including connection to a GDB server, to be used (see *Debug Settings Dialog* on page 68).

Trace Settings

Opens the Trace Settings Dialog that is provided to configure trace (see *Trace Settings Dialog* on page 84).

Semihosting Settings

Opens the Semihosting Settings Dialog that is provided to configure semihosting operations (see *Semihosting Settings Dialog* on page 82).

Preferences

Opens the User Preference Dialog that enables users to specify behavioral and visual preferences of the debugger (see *User Preference Dialog* on page 86).

System Variables

Opens the System Variable Editor that enables users to configure project-specific behavioral settings of the debugger (see *System Variable Editor* on page 83).

3.3.6 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

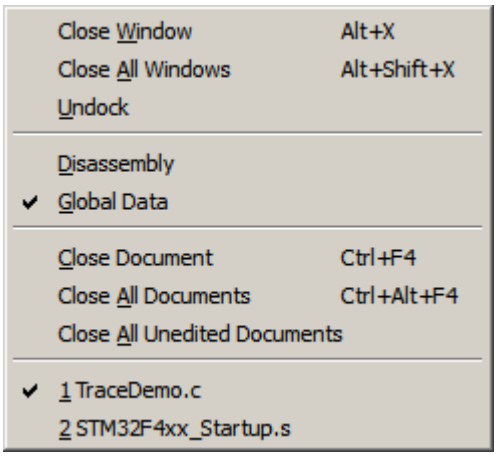
Closes all debug windows.

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 opened and gains the input focus.



Close Document

Closes the active source document.

Close All Documents

Closes all source documents.

Close All Unedited Documents

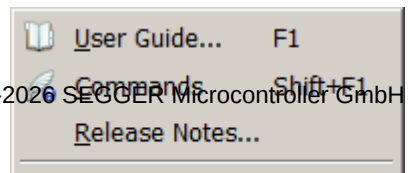
Closes all unedited source documents.

Document List

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

3.3.7 Help Menu

User help related actions.



User Guide

Opens the user guide and reference manual.

Commands

Prints a description of all user actions to the Console Window

Release Notes

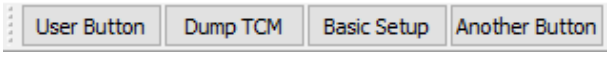
Shows the release notes within the web browser.

About Ozone

Opens the about dialog.

3.4 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 as well as a toolbar for accommodating custom buttons.

Category	Toolbar
File	
Debug	
View	
Break-points	
Custom	

3.4.1 Showing and Hiding Toolbars

Toolbars can be added to the Main Window via the toolbar menu (View → Toolbars) or by executing command 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 319).

3.4.2 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 handle and drag it to the desired position.

3.4.3 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 50.

3.4.4 Custom Toolbar

In contrast to the other toolbars the custom toolbar can be populated by the user. The user may add buttons by means of the command Toolbar.AddCustomButton and when pressing the button, a user function (see *User Functions* on page 228) in the Ozone project file will be performed. In fact, pressing a button will have the same effect as invoking the function via Script.Exec in the Command Prompt in the Console Window or directly inside the Ozone project script (.jdebug).

The command specified to be executed when pressing the button is not checked upon creation of the button. It is possible to specify a function call to a function that does not exist or add unsuitable parameters. When pressing the button with an invalid command, an error message will be displayed in the Console Window. If a legal command is passed, the output that is to be expected when manually issuing the command will be displayed in the Console Window.

The custom tool bar allows to disable buttons by means of the command Toolbar.DisableCustomButton and re-enable a button via Toolbar.EnableCustomButton. After creation a button is always enabled. Clicking onto a disabled button does not have any effect.

A custom button may be removed by issuing the command Toolbar.RemoveCustomButton.

3.5 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

3.5.1 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.

3.5.2 Window Context Information

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

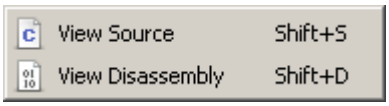
3.5.3 Connection State

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

3.6 Debug Information Windows

Ozone provides multiple 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 52.

3.6.1 Context Menu



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

The state of switchable context menu options is maintained across sessions, i.e binary window options remain unchanged after Ozone was closed and restarted.

3.6.2 Standard Shortcuts

Each debug information window supports the following set of standard hotkeys:

Hotkey	Description
ESC	Moves the input focus to the Source Viewer.
F6	Moves the input focus to next debug information window.
Shift+F6	Moves the input focus to previous debug information window.
Alt+x	Closed the current debug information window.

3.6.3 Window Layout

Section *Window Layout* on page 52 describes how debug information windows are added to, removed from and arranged on the Main Window.

3.6.4 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 52.

3.6.5 Table Windows

Several of Ozone's debug information windows are based on a joint table layout that provides a common set of features. A shared description of the table-based debug information windows is given in *Table Windows* on page 52.

3.7 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, refer to *Source Viewer* on page 156 and *Disassembly Window* on page 117.

3.7.1 Program Execution Point

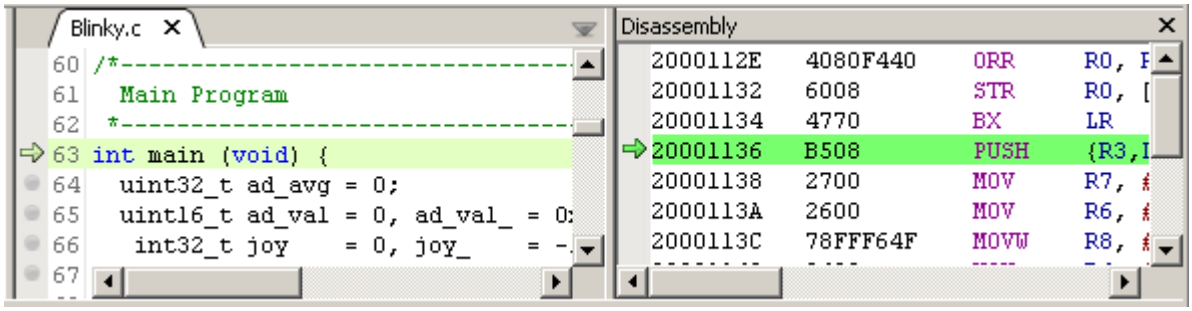
Ozone's code windows automatically scroll to the position of the PC line when the user steps or halts the program. In case of the Source Viewer, the document containing the PC line is automatically opened if required.

3.7.1.1 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.

3.7.1.2 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)

3.7.1.3 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 or halted and the PC is affiliated with a source code line, the debugger will switch to the Source Viewer as its active code window.

3.7.2 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 86) or via the command Edit.Color (see *Edit.Color* on page 309).

Highlight	Meaning
for (int i = 0) {	The code line contains the program execution point (PC).
Function(x,y);	The code line contains the call site of a function on the call stack.
for (int i = 0) {	The code line is the selected line.
for (int i = 0) {	The code line contains the instruction that is currently selected within the instruction trace window (see *Backtrace Highlighting* on page 129).

3.7.3 Breakpoints

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

3.7.3.1 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
Breakpoint Bar	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 290).

3.7.3.2 Enabling and Disabling Breakpoints

The breakpoint on the selected code line can be enabled or disabled 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 290).

3.7.3.3 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 63) or via commands Break.Edit (see *Break.Edit* on page 370) and Break.SetType (see *Break.SetType* on page 367).

3.7.3.4 Breakpoint Bar

Each code window hosts a breakpoint bar on its left side. The breakpoint bar displays distinct icons that provide additional information about code lines. The following table gives an overview.

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.

Icon	Meaning
	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.

The display of the breakpoint bar can be toggled from the User Preference Dialog (see *User Preference Dialog* on page 86) or via command Edit.Preference (see *Edit.Preference* on page 308).

3.7.4 Code Profile Information

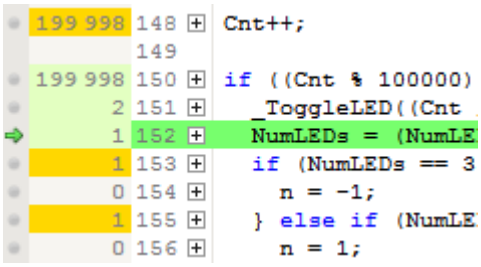
The code windows are able to display code profile information within a switchable sidebar area on the left side of the window.

3.7.4.1 Hardware Requirements

The code profile features of Ozone require the employed hardware setup to support instruction tracing (see *Instruction Trace Window* on page 128). To use Ozone's full set of trace features, a J-Trace PRO debug probe (see *Streaming Trace* on page 197) must be employed.

3.7.4.2 Code 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.



Resetting Execution Counters

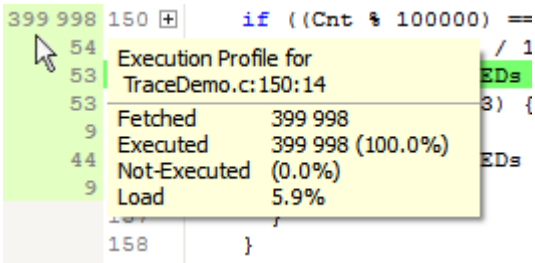
The execution counters are reset automatically at the same time the program is reset. A manual reset can be performed via context menu or command Profile.Reset.

Toggling Execution Counters

The display of execution counters can be toggled via the context menu.

3.7.4.3 Execution Profile Tooltips

When hovering the mouse cursor over an execution counter, the execution profile of the affiliated source line or instruction is displayed within a tooltip:



Fetched: number of times the instruction was fetched from memory.

Executed: number of times the instruction was executed.

Not-Executed: number of times the (conditional) 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.

The execution profile of a source line is identical to the execution profile of the first instruction of the source line.

When user preference PREF_EXEC_PROFILE_RESPECTS_FILTERS is set, an instruction filtered from the code coverage statistic will not be accounted for when computing the execution profiles of source lines and instructions. (see *Adding and Removing Coverage Filters* on page 108).

3.7.4.4 Execution Profile Color-Codes

The background of an execution counter is painted in a style which conveys the execution profile of the affiliated source line or instruction. The following styles are used:

Conditional instructions:

Style	Description
	instruction was never fetched for execution.
	instruction has taken both execution paths.
	instruction was always executed.
	instruction was never executed.

Non-conditional instructions:

Style	Description
	instruction was never fetched for execution.
	instruction was executed.

Source lines:

Style	Description
	no instruction of the source line was fetched for execution.
	some instructions of the source line were fetched for execution, but not all.
	all instructions of the source line were fetched for execution and at least one conditional instruction of the source lines was always executed.
	all instructions of the source line were fetched for execution and at least one conditional instruction of the source lines was never executed.
	all instructions of the source line were executed at least once and all conditional instructions have taken both execution paths.

Changing Code Profile Colors

The colors used in the styles above can be adjusted via the User Preference Dialog (see *User Preference Dialog* on page 86) or via command Edit.Color (see *Edit.Color* on page 309).

3.7.5 Text Cursor Navigation Shortcuts

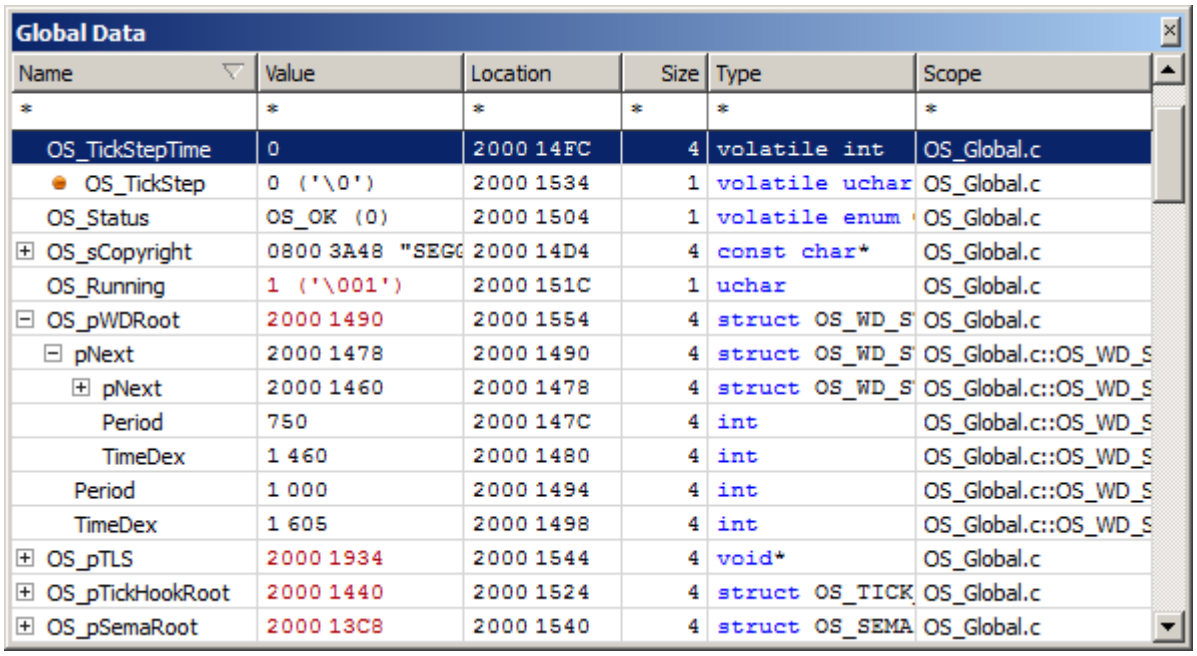
Ozone's code windows provide standard text navigation/selection hotkeys. The Shift key can be held together with any of the below keys to extend the text selection to the new cursor position.

Arrow key	Moves the text cursor in the specified direction.
PgUp	Moves the text cursor one page up.
PgDn	Moves the text cursor one page down.

Arrow key	Moves the text cursor in the specified direction.
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 text cursor to the previous word.
Ctrl+Right	Moves the text 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.
Ctrl+PgUp	Moves the text cursor to the first visible line.
Ctrl+PgDn	Moves the text cursor to the last visible line.

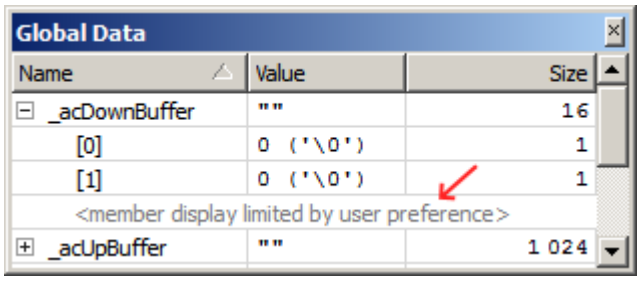
3.8 Table Windows

Several of Ozone's debug information windows are based on a joint table layout that provides a common set of features. The Global Data Window illustrated below is an example of a table-based debug information window.



3.8.1 Member Rows

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



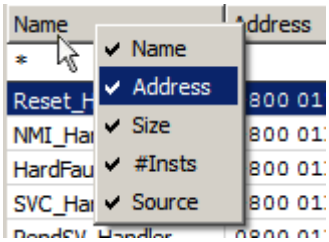
Member Display Limit

The number of child entries that can be displayed for a table row can be limited via the User Preference Dialog. When table rows are not shown due to the display limit, an indication is displayed as shown on the right.

3.8.2 Column Header

Hiding Columns

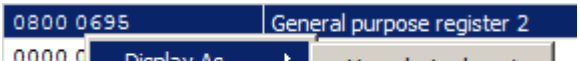
Each table column has an entry in the context menu of the table header. When an entry is checked or unchecked, the corresponding table column is shown or hidden. The table header context menu can be opened by right-clicking on the table header.



Sorting Columns

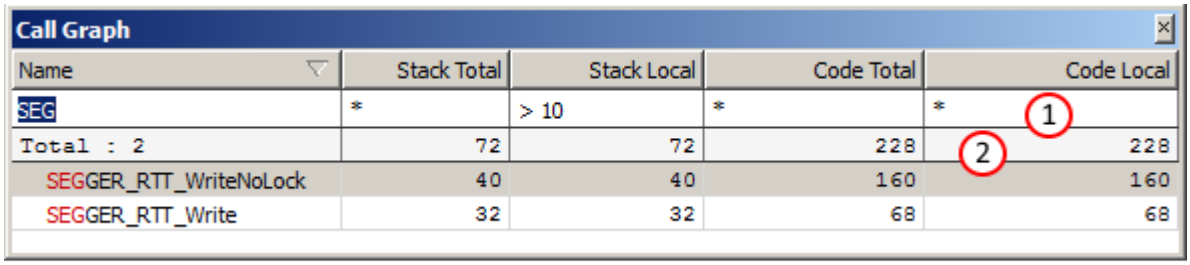
Table rows can be sorted according to the values displayed in a particular column. To sort a table according to a particular column, a left click on the column header suffices. A sort indicator in the form of a small arrow indicates the column according to which the table is currently sorted. The sort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

3.8.3 Display Format



The table windows enable users to change the value display format of a particular (or all) value items. If supported, the value display format can be changed via the window's context menu or via commands Window.SetDisplayFormat and Edit.DisplayFormat (see *Window Actions* on page 297).

3.8.4 Filter and Total Value Bars



Each table window provides two distinct header rows that are always visible, regardless of the scroll bar positions.

The *filter bar* (1) enables users to filter the table content. When a filter is set on a table column, only table rows whose column value matches the filter stay visible.

The *total value bar* (2) informs about the aggregate value of a table column. The aggregate value is the sum of all values currently shown within the column.

The display state of the filter and total value bars (shown or hidden) can be toggled via the context menu of the table window.

3.8.4.1 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.

3.8.4.2 Filter Bar Context Menu

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

Clear All Filters

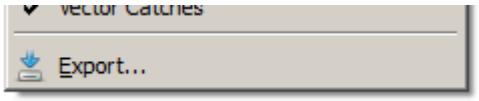
Clears all column filters.

Set Filter...

Opens the filter input dialog.

3.8.5 CSV Export

All table windows provide a context menu entry that enables users to export the (filtered) table content to a comma-separated values file.



3.8.6 Change Level Highlighting

Multiple debug information windows highlight numeric values according to recency of their last change (see *Change Level Highlighting* on page 59).

3.8.7 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.

3.8.8 Table Window Preferences

Section *Table Window Settings* on page 89 lists all user preference settings pertaining to table windows.

3.9 Window Layout

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

3.9.1 Opening and Closing Windows

Opening Windows

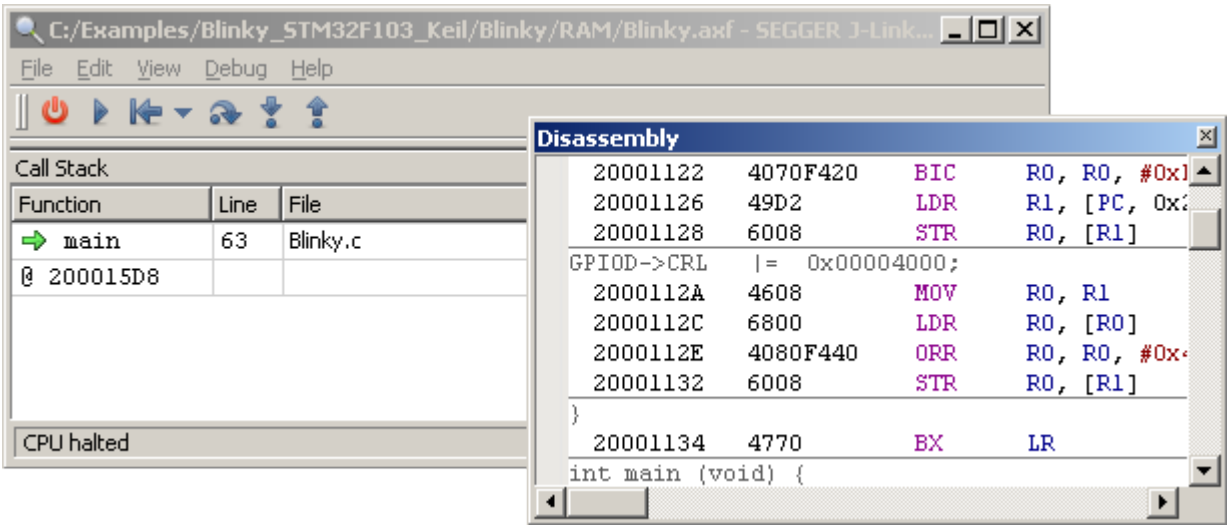
Windows are opened by clicking on the affiliated view menu item (e.g. View → Breakpoints) or by executing the command Window.Show using the window's name as parameter (e.g. `Window.Show("Breakpoints")`). When a window is opened, it is added to its last known position on the user interface.

Closing Windows Programmatically

Windows can be closed via command Window.Close using the window's name as parameter.

3.9.2 Undocking Windows

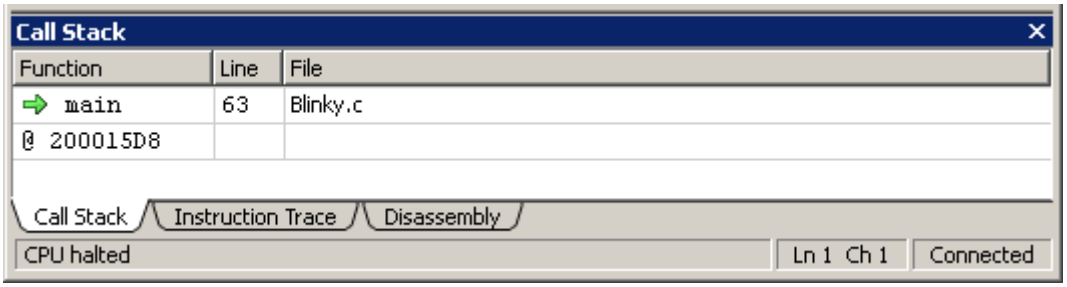
Windows can be undocked from the Main Window by dragging or double-clicking the window's title bar. An undocked window can be freely positioned and resized on the desktop.



Undocked disassembly window floating over the Main Window

3.9.3 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

3.10 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.

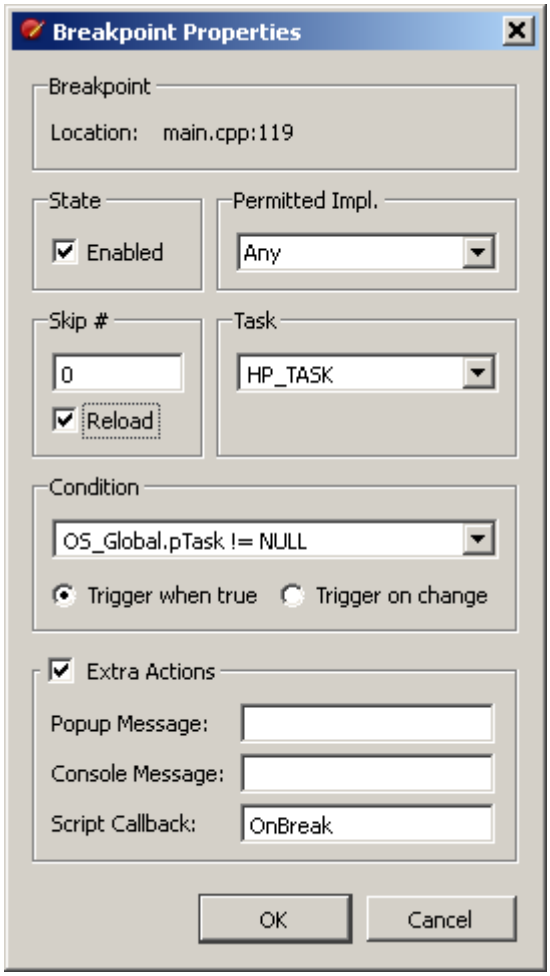
Both foreground and background colors used for change level highlighting can be adjusted via the User Preference Dialog (see *User Preference Dialog* on page 86 or via command Edit.Color (see *Edit.Color* on page 309).

3.11 Dialogs

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

3.11.1 Breakpoint Properties Dialog

The Breakpoint Properties Dialog enables 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 370) and Break.SetType (see *Break.SetType* on page 367).



State

Enables or disables the breakpoint.

Permitted Implementation

Sets the breakpoint's permitted implementation type (see *Break.SetType* on page 367).

Skip Count

Program execution can only halt each Skip-Count+1 number 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

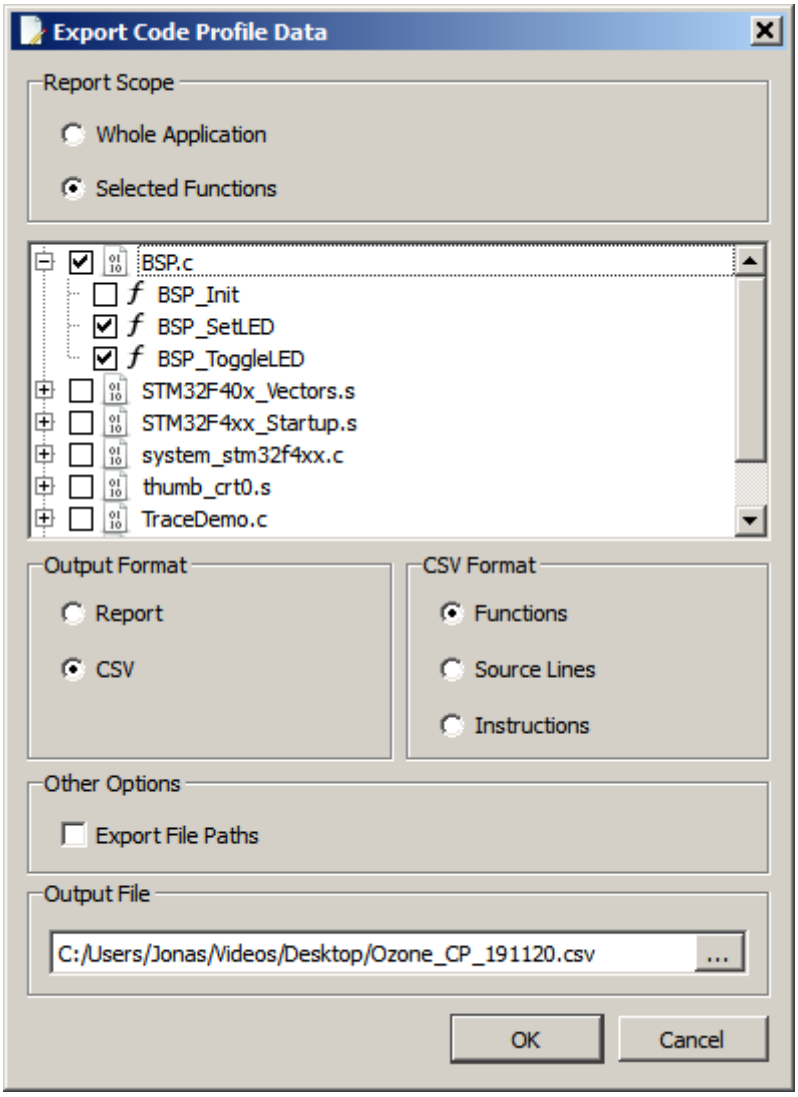
Specifies the additional actions that are performed when the breakpoint is hit. The provided options are a text message that is printed to the Console Window, a message that is displayed within a popup dialog and a script function that is executed (see *Project Script* on page 226).

> **Note**

> Due to hardware limitations, executing a script function is not supported for data break points.

3.11.2 Code Profile Export Dialog

The Code Profile Export Dialog is provided to save the application's code profile to a text or a CSV file (see *Code Profile Window* on page 106).



Code Profile Export Dialog

Report Scope

Functions to be covered by the output file.

Tree View

Allows users to select the 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.

Export File Paths

Specifies if absolute file paths (checked) or file names (unchecked) are to be exported.

Output File

Output file path.

3.11.2.1 Commands

The functionality of the code profile export dialog can be accessed from script functions using command *Export.CodeProfile* on page 311.

3.11.2.2 Code Profile Report

Shown below is the content of a text file generated by the Code Profile Export Dialog.

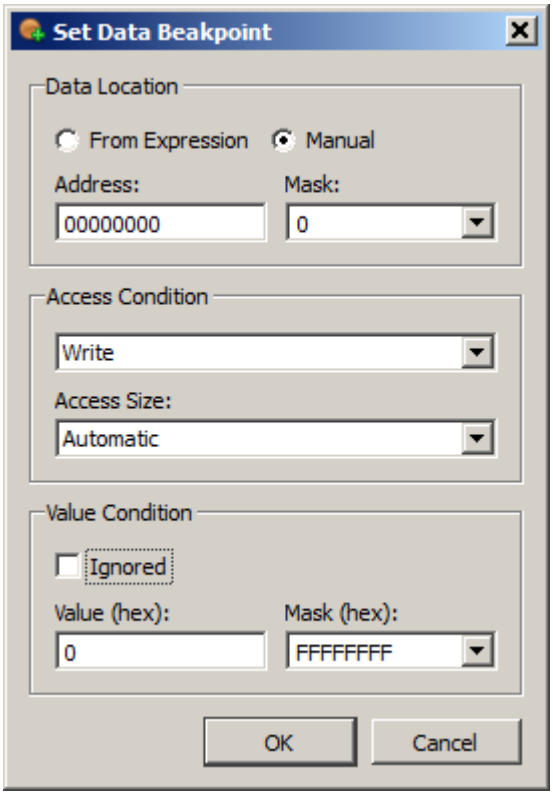
```
Ozone Code Profile Report

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

3.11.3 Data Breakpoint Dialog

The Data Breakpoint Dialog enables users to place data breakpoints on global program variables and individual memory addresses. Please refer to *Data Breakpoints* on page 194 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 96) or from the context menu of the data symbol windows.



Data Location

The data location pane enables users to specify the memory address(es) to be monitored for IO accesses. When field "From Expression" is checked, the memory address results from the evaluation of a symbol expression (see *Working With Expressions* on page 205. Otherwise, the memory address is specified manually. The Mask field specifies the bits of the input address which are ignored when evaluating the location condition. An address mask of 0 monitors exactly and only the input address for IO accesses. An address mask of `0xFFFFFFFF` monitors all memory addresses.

Access Condition

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

Value Condition

The value condition pane enables users to specify the memory data value required to trigger the data breakpoint. The mask field specifies the bits of the memory data value which are to be ignored when evaluating the condition. A value mask of 0 performs an exact match against the value entered within the "Value" field. A value mask of `0xFFFFFFFF` matches any value and has the same effect as selecting "Ignored". The value condition can be disabled by checking the "Ignored" field.

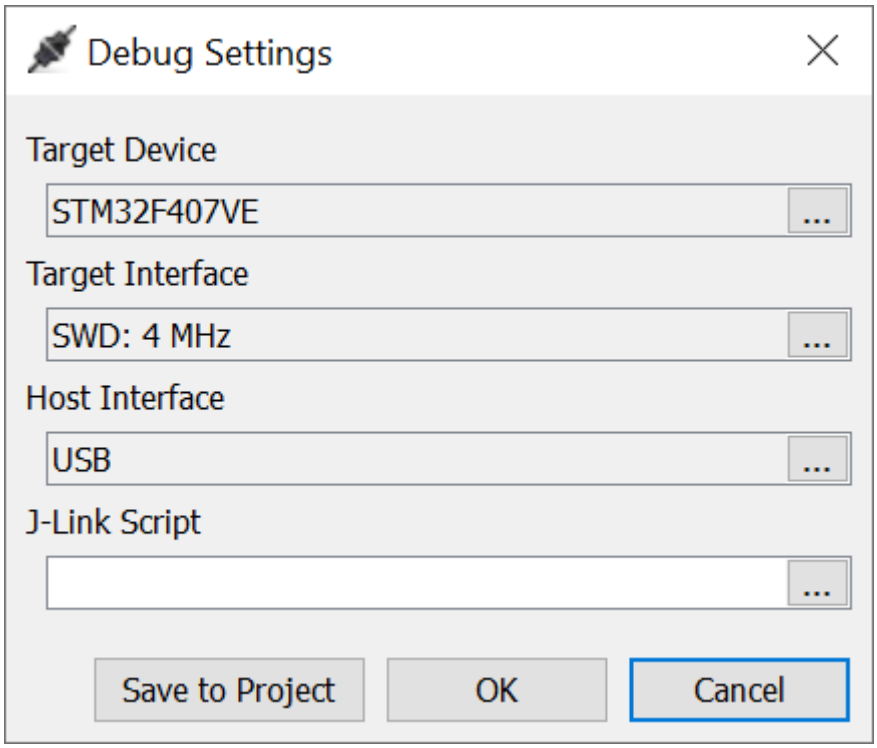
3.11.3.1 Applying Changes

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.

> **Note**
>
> Due to hardware limitations, executing a script function, as is available for source- or instruction breakpoints, is not supported for data break points.

3.11.4 Debug Settings Dialog

The Debug Settings Dialog enables users to configure J-Link/J-Trace related settings, such as the target model and the debug interface. The choice of debug interfaces also includes the connection to a GDB server. Refer to *Project Wizard* on page 35 for a description of these settings.



Debug Settings Dialog

3.11.4.1 Opening the Debug Settings Dialog

The Debug Settings Dialog can be opened from the Tools Menu or by executing the command Tools.DebugSettings.

3.11.4.2 Applying Changes

Save To Project

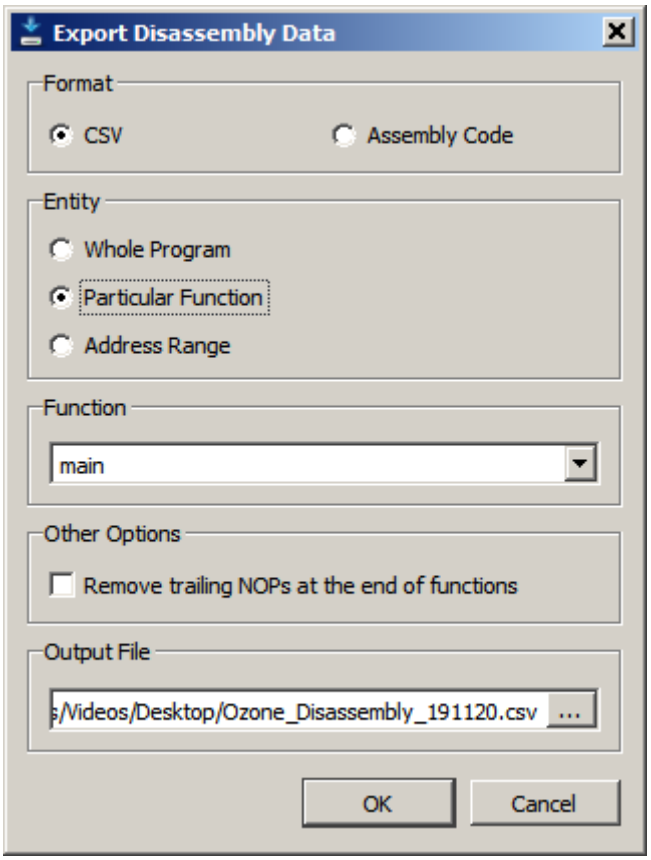
By clicking the “Save To Project” button, the selected Debug settings are written to the project file and thereby applied persistently.

OK

By clicking the Ok button, the selected Debug settings are applied to the current session only.

3.11.5 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. This option is currently only available when debugging on Cortex-M.

The interrupt vector table is created based on a heuristic detecting the location and size of the vector table from the information in the ELF file. In some cases this heuristic does not yield the correct result. In that case you may specify the base address and size of the vector table by means of the system variables `VAR_VECTORTABLE_ADDR` and `VAR_VECTORTABLE_SIZE`.

Entity / Function

Selects the address range to be exported.

Remove Trailing NOPs at the end of functions

Indicates if "no-operation" instructions, emitted by the compiler for function alignment purposes, are to be filtered from the output.

3.11.5.1 Exemplary Output

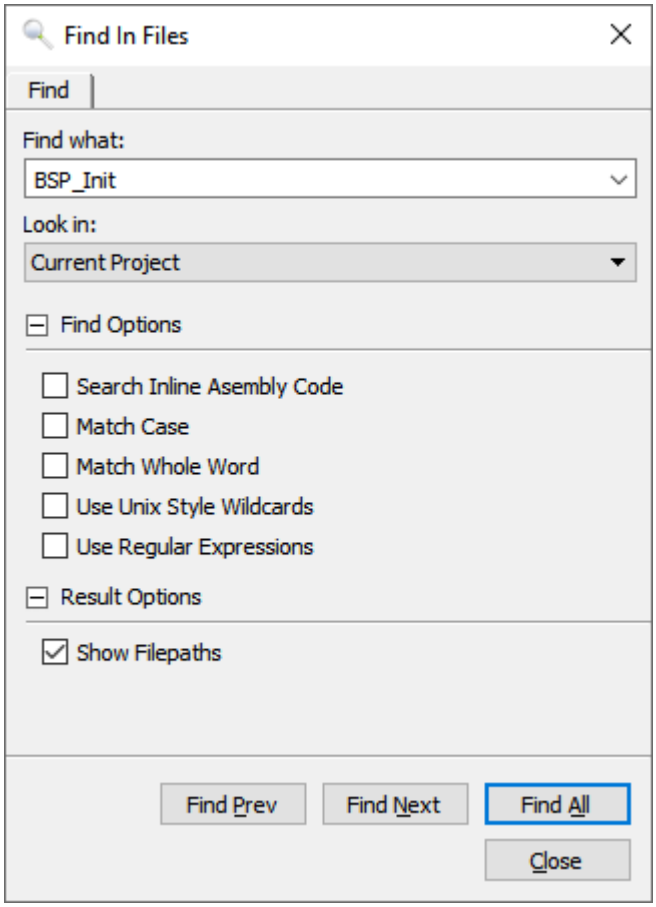
Shown below is an excerpt of a CSV file that was generated using the Disassembly Export Dialog.

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

CSV content generated by the Disassembly Export Dialog

3.11.6 Find In Files Dialog

The Find In Files Dialog enables users to search for text patterns within multiple source code documents.



Find What

Defines the search pattern. The search pattern is either a plain text, an expression containing wild cards (see *Use Unix Style Wildcards*) or a regular expression (see *Use Regular Expressions*), depending on the type of the search below.

Look In

Selects the source code documents that are to be included in the search (see *File Search Scope* on page 72).

Search Inline Assembly Code

Also search within source-inline assembly code lines.

Match Case

Specifies if the letter casing of the search pattern is relevant.

Match Whole Word

Specifies if a match must start and end at word boundaries.

This setting is mutual exclusive with using wild cards and regular expressions.

Use Unix Style Wildcards

Indicates if the search pattern is to be interpreted as an expression containing wildcards.

This setting is mutual exclusive with matching whole words and using regular expressions.

Use Regular Expressions

Indicates if the search pattern is to be interpreted as a regular expression. In that case, the search is conducted on the basis of a regular expression pattern match.

This setting is mutual exclusive with matching whole words and using wild cards.

Show File Paths

Indicates if the file path of matches should be included in the search result. The search result is displayed within the Find Results Window (see *Find Results Window* on page 121).

Find All

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

Find Next/Previous

Finds the next/previous occurrence of the search pattern in the selected search scope. When a match is found, it is highlighted within the Source Viewer. After closing the Find

In Files Dialog, the next/previous occurrence of the search pattern can be located using shortcut F3/Shift+F3.

In Addtion, shortcut Ctrl+F3 is provided to locate the next occurrence of the word under the cursor without the need to open the Find In Files Dialog.

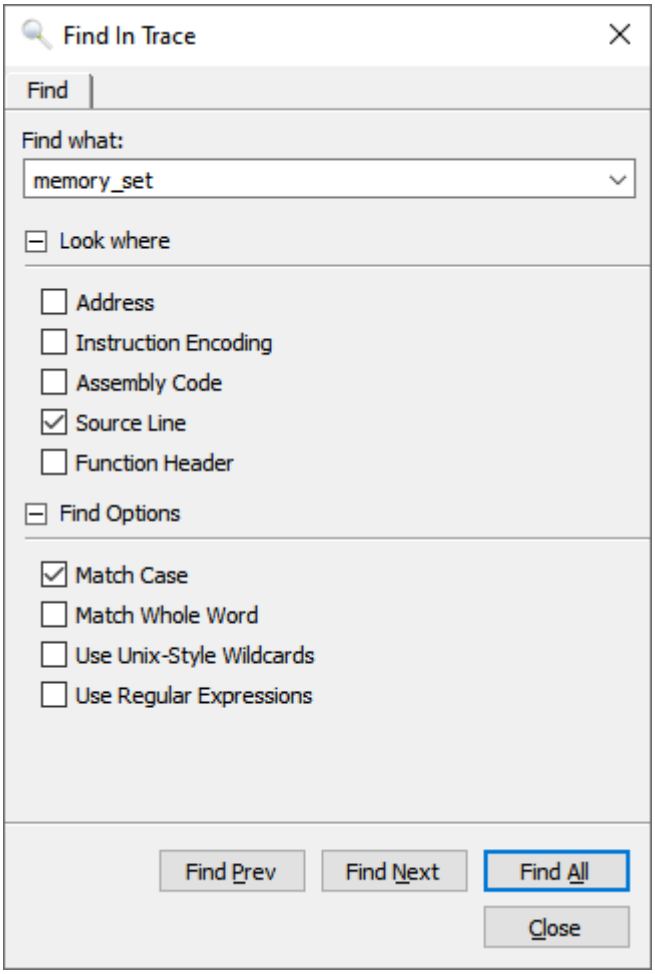
3.11.6.1 File Search Scope

Find in files can be conducted in one of three search scopes. The desired search scope can be specified via the “Look In” selection box of the Find In Files Dialog.

Search Scope	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.

3.11.7 Find In Trace Dialog

The Find In Trace Dialog enables users to search for text patterns within the content of the Instruction Trace Window (see *Instruction Trace Window* on page 128).



Find what

Defines the search pattern. The search pattern is either a plain text, an expression containing wild cards (see *Use Unix Style Wildcards*) or a regular expression (see *Use Regular Expressions*), depending on the type of the search below.

Look where

Defines the text columns to include within the search. When a match spans multiple text columns, the checkboxes of these text columns must be checked in order for the match to be accounted.

Address

Defines if the address text column is included within the search.

Encoding

Defines if the instruction encoding text column is included within the search.

Assembly Code

Defines if the assembly code text column (including mnemonics, operands and assembly comments) is included within the search.

Source Code

Defines if the source code text column is included within the search.

Function Header

Defines if call frame header titles are included within the text search (see Call Frames).

Match Case

Specifies if the letter casing of the search pattern is relevant.

Match Whole Word

Specifies if a match must start and end at word boundaries.

This setting is mutual exclusive with using wild cards and regular expressions.

Use Unix Style Wildcards

Indicates if the search pattern is to be interpreted as an expression containing wildcards.

This setting is mutual exclusive with matching whole words and using regular expressions.

Use Regular Expressions

Indicates if the search pattern is to be interpreted as a regular expression. In that case, the search is conducted on the basis of a regular expression pattern match.

This setting is mutual exclusive with matching whole words and using wild cards.

Find All

Finds all occurrences of the search pattern within the selected text columns. The search result is printed to the Find Results Window.

Find Next/Previous

Finds the next/previous occurrence of the search pattern within the selected text columns. When a match is found, it is highlighted within the Instruction Trace Window. After closing the Find In Trace Dialog, the next/previous occurrence of the search pattern can be located using shortcut F3/Shift+F3.

In Addtion, shortcut Ctrl+F3 is provided to locate the next occurrence of the word under the cursor without the need to open the Find In Trace Dialog.

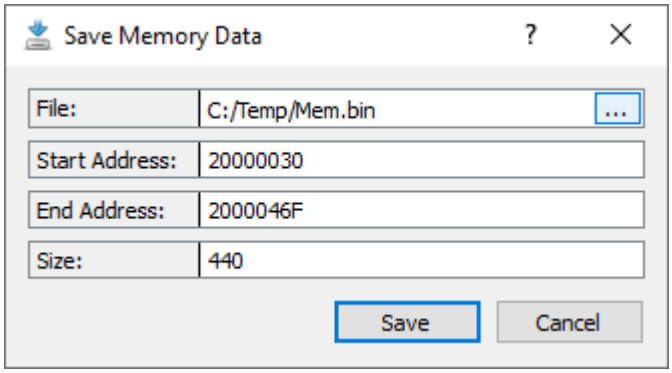
3.11.8 Memory Dialog

The 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 Memory Dialog are interpreted as hexadecimal numbers, even when not prefixed with "0x".

3.11.8.1 Save Memory Data



In its first application, the 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.

3.11.8.2 Load Memory Data

In its second application, the 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.

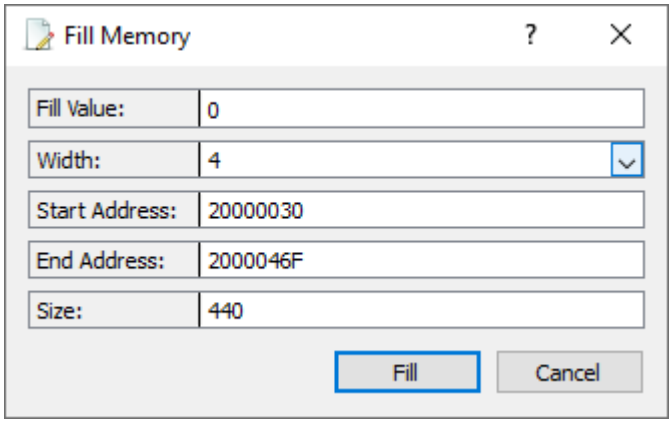
Address

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.

3.11.8.3 Fill Memory



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

Fill Value

The fill value.

Width

The word width (i.e. the number of bytes) the fill value consumes. Sup-

ported values are 1, 2, 3, 4 and 8 bytes. This allows for memory being filled byte- word- or double-word wise, and also supports filling frame buffers encoding a color in 3 bytes.

Address

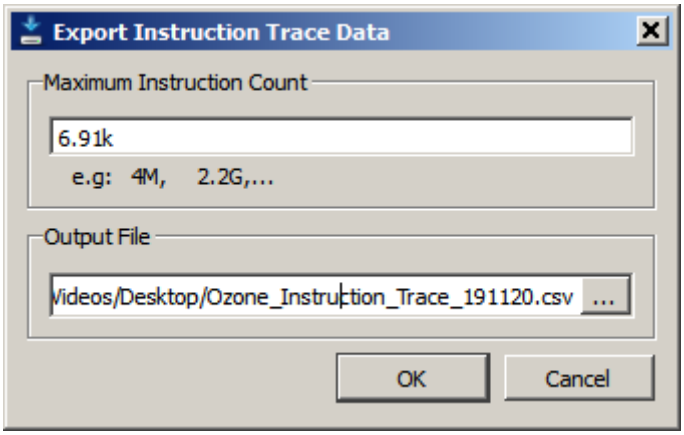
The start and end addresses (inclusive) of the memory area.

End Address / Size

The size of the memory area.

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

Maximum Instruction Count

Maximum number of instructions to export.

Output File

Output file.

3.11.9.1 Exemplary Output

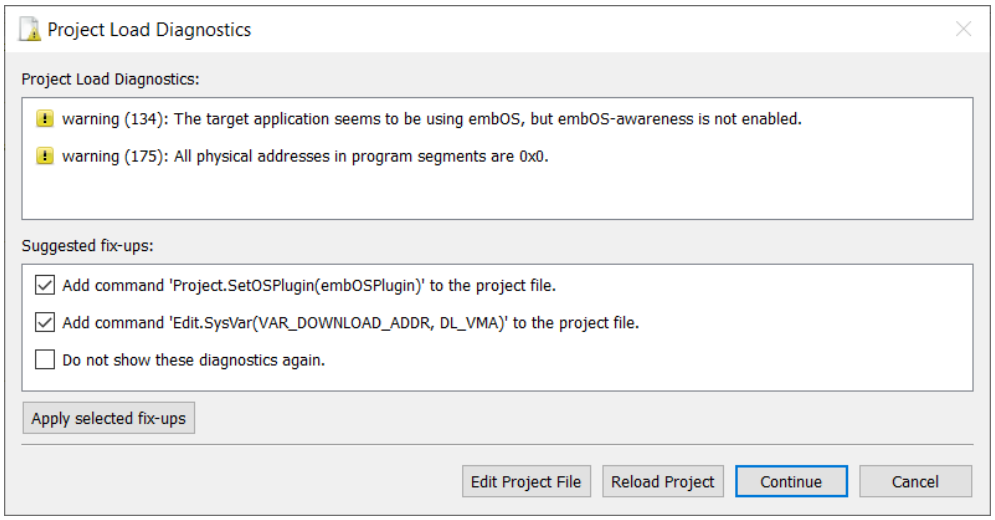
Shown below is an excerpt of a CSV file that was generated using the Instruction Trace Export Dialog.

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

CSV content generated by the Instruction Trace Export Dialog

3.11.10 Project Load Diagnostics Dialog

The Project Load Diagnostics Dialog notifies users about erroneous project settings and other project loading issues, such as syntax errors. This dialog is only shown when required, and only during loading of a project file.



Project Load Diagnostics Dialog

3.11.10.1 Project Load Diagnostics

For each issue encountered during project loading, an entry is added to the load diagnostics table. This entry provides a basic description of the issue and an index into Ozone's application message table. The application message table usually provides further information about the issue (see *Errors and Warnings* on page 283).

3.11.10.2 Suggested Fix-Ups

For each issue that the debugger knows how to resolve automatically, an entry is added to the fix-ups table.

3.11.10.3 Buttons

Apply selected fix-ups

Applies the selected fix-ups and updates the project file.

Edit Project File

Closes the dialog, cancels project loading and opens the project file within the Source Viewer.

Reload Project

Closes the dialog and reloads the project file.

Continue

Closes the dialog and continues project file loading.

Cancel

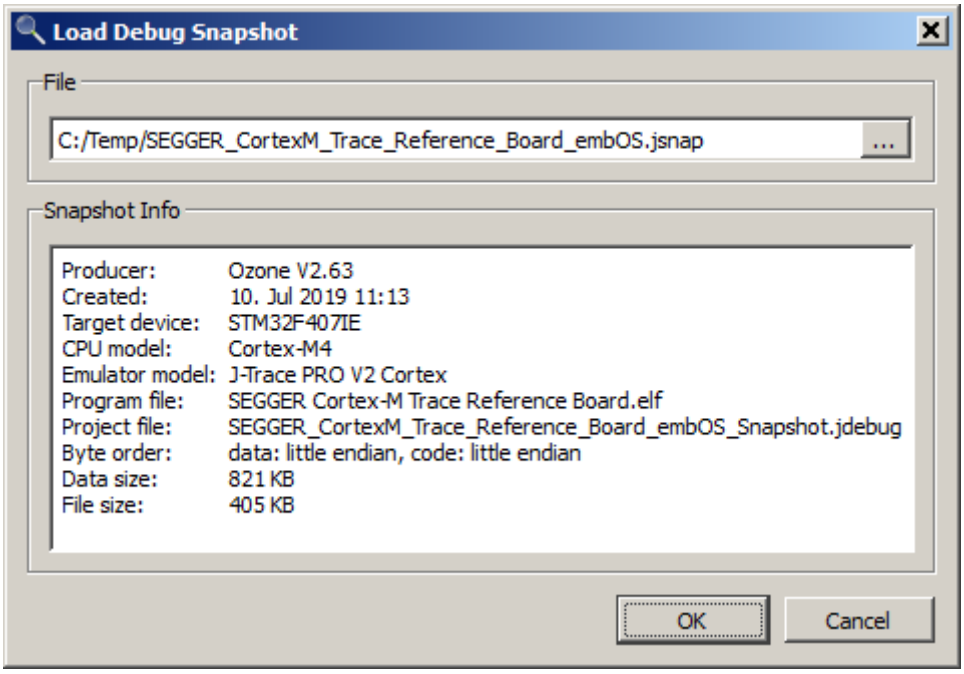
Closes the dialog and unloads the project.

3.11.11 Snapshot Dialog

The snapshot dialog enables users to save and load debug snapshots (see *Debug Snapshots* on page 215). The dialog has two display modes: a "save snapshot" and a "load snapshot" mode.

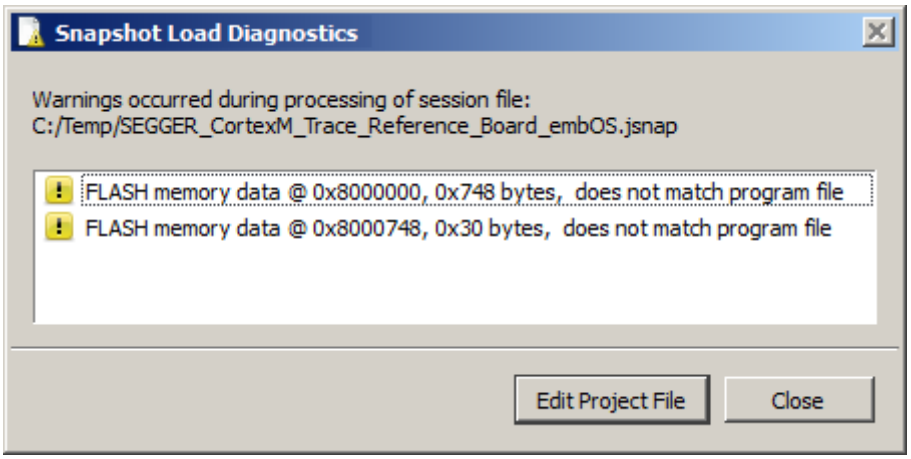
3.11.11.1 Load Snapshot

When opened in load mode, the snapshot dialog informs about basic properties of the snapshot to be loaded, such as the employed target device and program file. The snapshot dialog can be opened in load mode from the Debug Menu or by executing command Debug.LoadSnapshot.



Snapshot Load Diagnostics

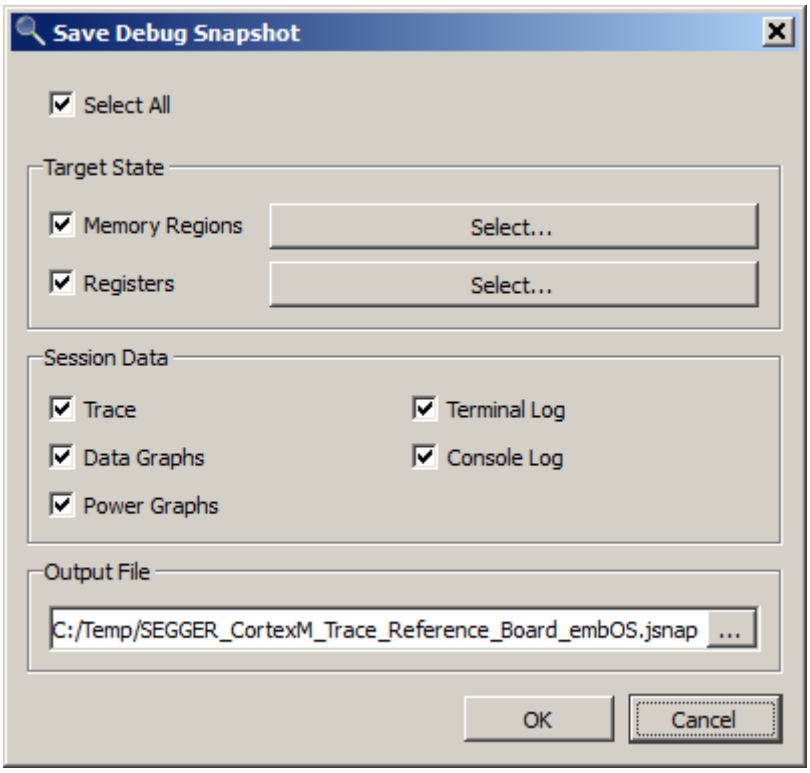
A requirement for the successful restoration of a debug session from a snapshot is that the snapshot settings match the project settings. In particular, the program file must binary-match the program file at the time the snapshot was saved. When any mismatches occur, the snapshot load diagnostics dialog will be shown to inform the user.



3.11.11.2 Save Snapshot

When opened in save mode, the snapshot dialog enables users to define what data will be saved to the snapshot. In particular, the dialog provides two sub-dialogs that allow to define

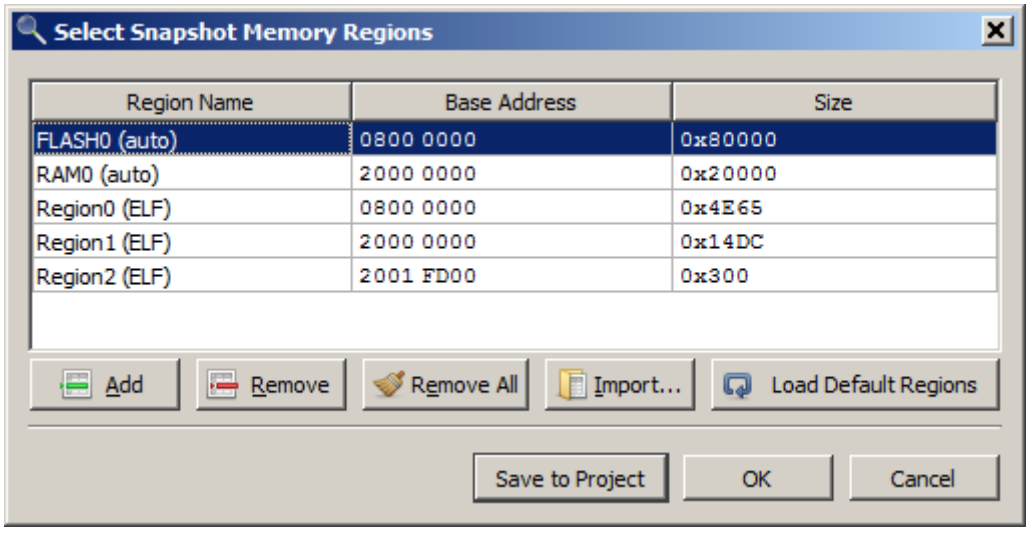
what components of the system state, i.e. which target memory regions and registers, are to be saved.



The snapshot dialog can be opened in save mode from the Debug Menu or by executing command Debug.SaveSnapshot.

3.11.11.3 Memory Selection

The "Memory Selection" sub-dialog of the snapshot dialog enables users to define the target memory regions to be stored to the snapshot.



Import

Adds the memory regions defined by an Embedded Studio memory map file to the list.

Restore Defaults

Resets to the default configuration, which is:

- all FLASH and RAM region defined for the target by J-Link/J-Trace.
- all ELF program data sections with the allocatable flag (A) set.

Save to Project

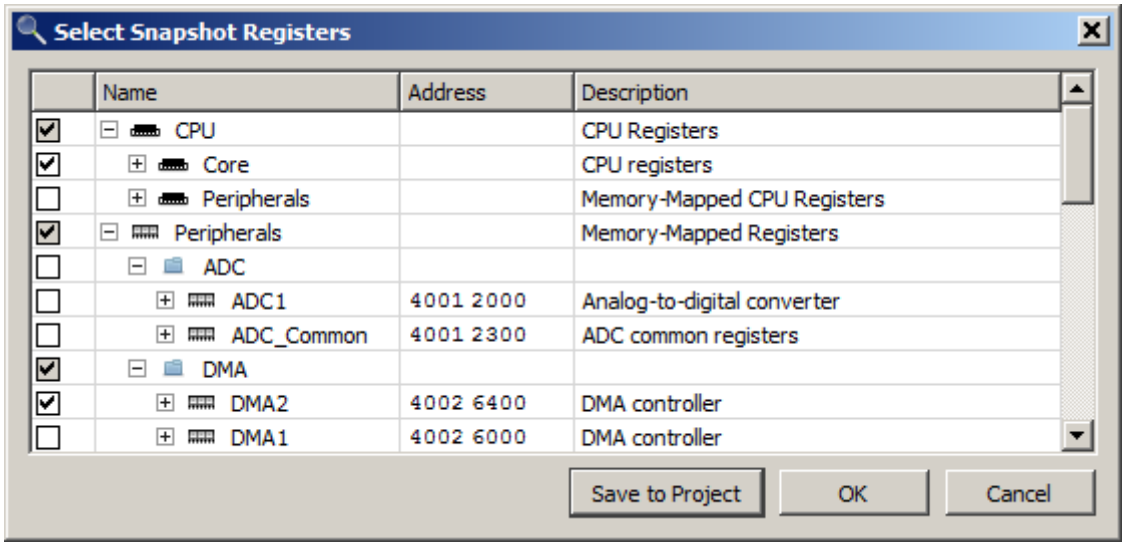
Applies changes persistently by writing them to the user file of the project.

Ok

Applies changes to the current session only.

3.11.11.4 Register Selection

The "Register Selection" sub-dialog of the snapshot dialog enables users to define the target registers to be stored to the snapshot.



Users may save CPU registers and peripheral registers to the snapshot, although only CPU registers will be automatically restored when the snapshot is loaded (see *Advanced System Restore* on page 215).

Save to Project

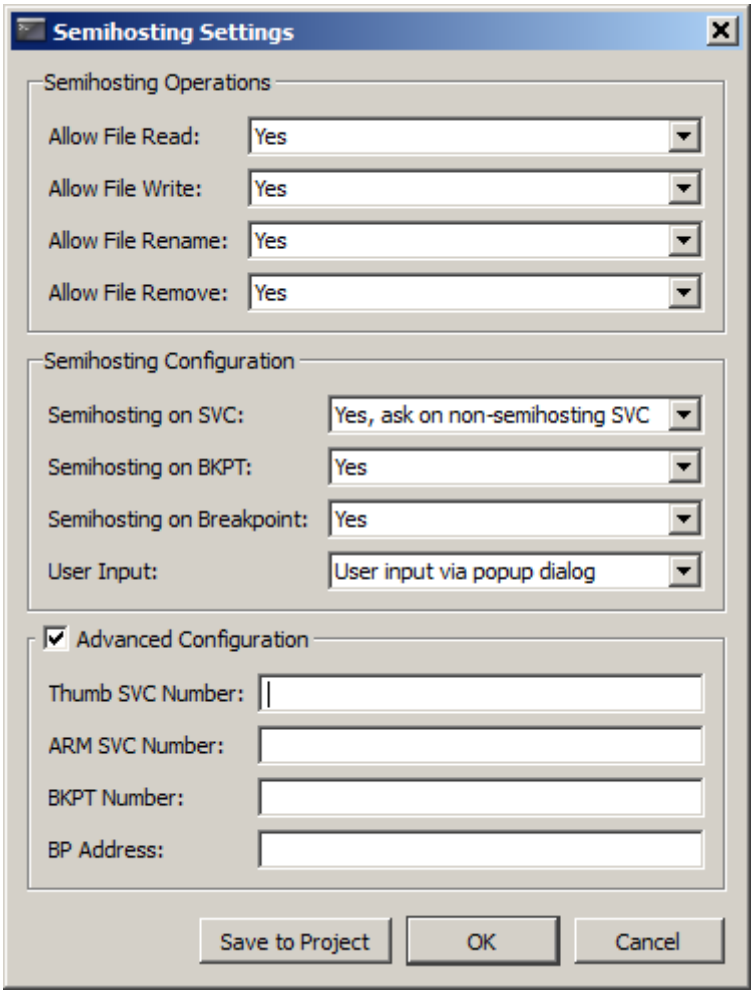
Applies changes persistently by writing them to the user file of the project.

Ok

Applies changes to the current session only.

3.11.12 Semihosting Settings Dialog

The semihosting settings dialog enables users to conveniently edit any of the semihosting settings described in section *Project.ConfigSemihosting* on page 345. The dialog can be opened from the tools menu or the context menu of the Terminal Window (see *Terminal Window* on page 162). An elaborate description of Ozone's semihosting facility can be found in section *Semihosting* on page 200.



Save to Project

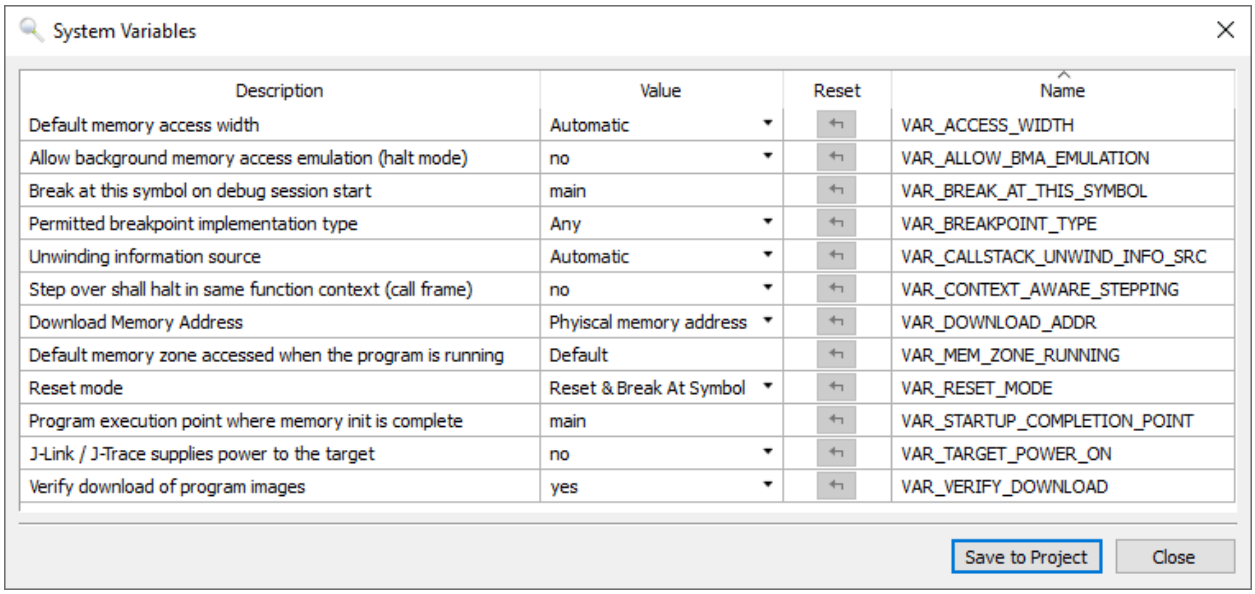
Applies changes persistently by writing them to the user file of the project.

OK

Applies changes to the current session only.

3.11.13 System Variable Editor

Ozone defines a set of system variables that control project-specific behavioral aspects of the debugger. The System Variable Editor lets users observe and edit these variables in a tabular fashion. A description of each system variable is provided by section *System Variable Identifiers* on page 277.



System Variable Editor

3.11.13.1 Opening the System Variable Editor

The System Variable Editor can be opened from the Main Menu (Edit → System Variables) or by executing command Tools.SysVars.

3.11.13.2 Editing System Variables Programmatically

The command *Edit.SysVar* on page 309 is provided to manipulate system variables within script functions or at the command prompt (see *Command Prompt* on page 111).

3.11.13.3 Applying Changes

Save To Project

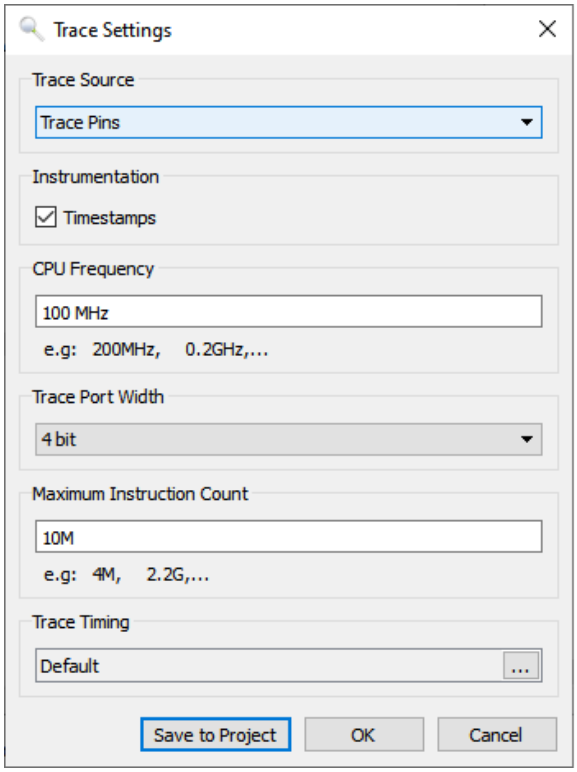
By clicking the “Save To Project” button, the displayed system variable state is written to the project file and thereby applied persistently.

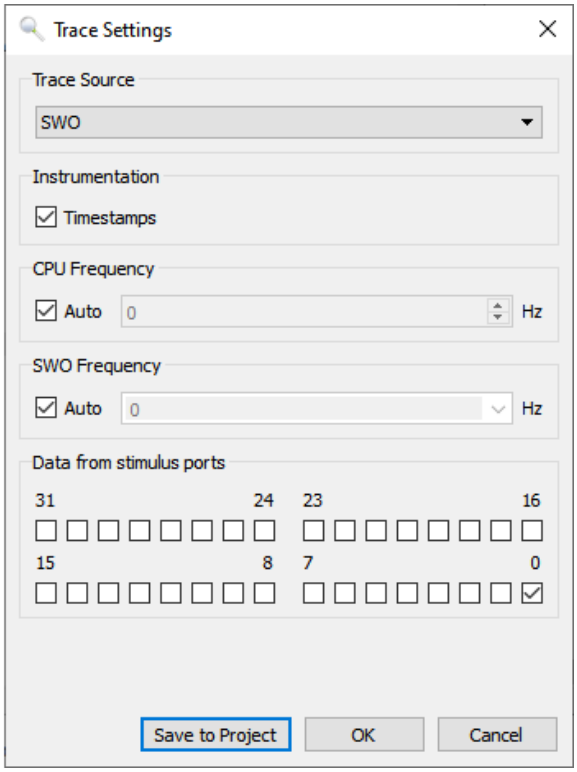
Ok

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

3.11.14 Trace Settings Dialog

The Trace Settings Dialog enables the user to configure the available trace input sources.





Trace Source

Selects the trace source 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 *Streaming Trace* on page 197).
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 *Terminal Window* on page 162.

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 sources in Ozone is currently not supported.

Timestamps (Trace Pins, SWO)

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 individual program entities.

CPU Frequency (Trace Pins)

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

Trace Port Width (Trace Pins)

Specifies the number of trace pins comprising the target's trace port (see *Project.SetTracePortWidth* on page 348).

Maximum Instruction Count (Trace Pins)

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

Trace Timing (Trace Pins)

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 348).

CPU frequency (SWO)

Specifies the core frequency of the target in Hz. (see *Project.ConfigSWO* on page 349).

SWO Frequency (SWO)

Specifies the signal frequency of the SWO trace interface in Hz. (see *Project.ConfigSWO* on page 349).

Data from stimulus ports (SWO)

Specifies the stimulus ports that are used for transferring SWO data. (see Edit.SysVar using argument `VAR_SWO_PORTMASK`).

3.11.14.1 Opening the Trace Settings Dialog

The Trace Settings Dialog can be opened from the Main Menu (Edit → Trace Settings) or by executing command Tools.TraceSettings.

3.11.14.2 Applying Changes

Save To Project

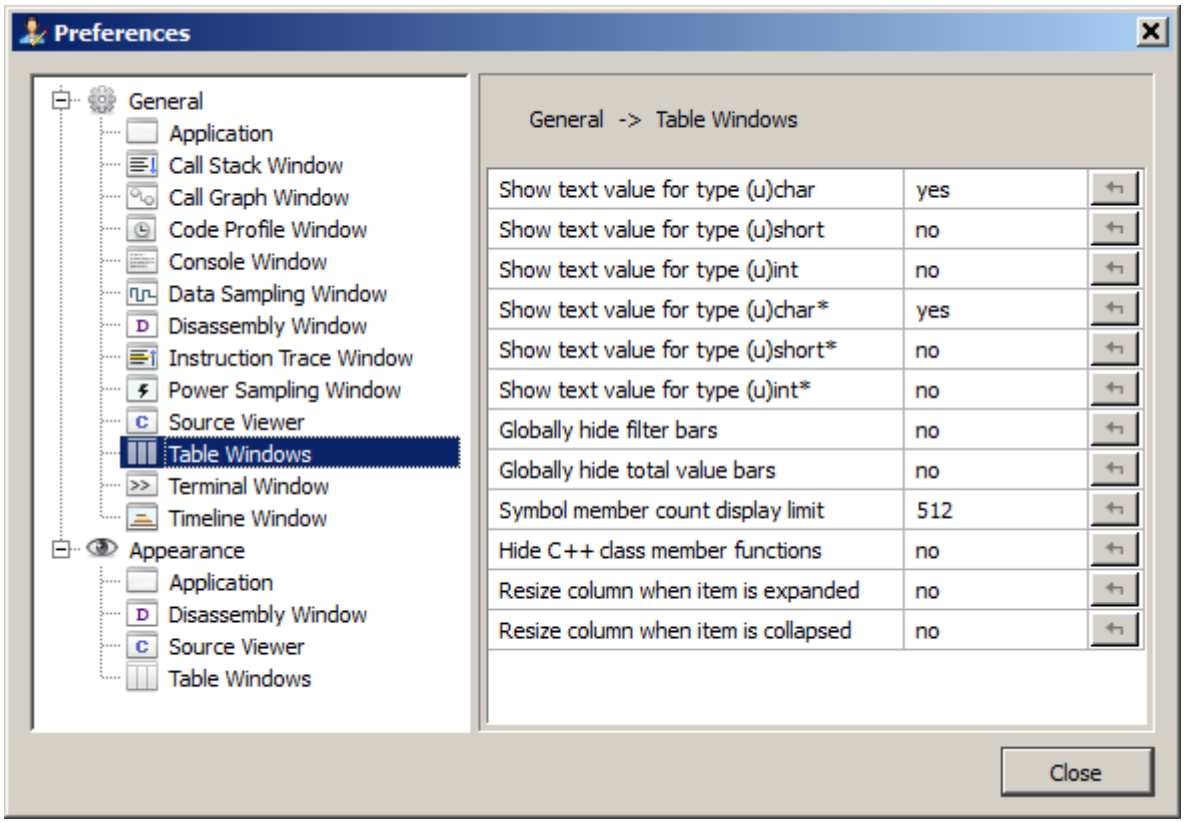
By clicking the "Save To Project" button, the selected trace settings are written as Ozone commands to the project file and thereby applied persistently.

Ok

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

3.11.15 User Preference Dialog

The User Preference Dialog provides multiple user-specific options. In particular, fonts, colors and switchable items such as line numbers and sidebars can be customized.



User preference dialog

3.11.15.1 Opening the User Preference Dialog

The User Preference Dialog can be opened from the Main Menu (Edit → Preferences) or by executing command Tools.Preferences (see *Tools.Preferences* on page 307).

3.11.15.2 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.

3.11.15.3 General Application Settings

This settings page lets users adjust general application settings.

Setting	Description
Open the most recent project on startup	When set, the most recent project is opened when the debugger is started. When unset, a welcome screen is displayed when the debugger is started.
Show a popup dialog when project settings are erroneous	When set, a popup dialog is displayed when the project file contains errors or inconsistent settings.

Setting	Description
Show progress bar while running	When set, a moving progress bar is animated within Ozone's status bar area while the program is executing.
Show dialog option "Do not show again"	When set, popup-dialogs contain a checkbox that enables users to stop the dialog from popping up.
Reset all dialog options "do not show again"	When set, the users choice for all dialog options "Do not show again" is reset when the preference dialog is closed.
Show tooltips	Toggles the display of mouse-over tooltips.
Append type signatures to function names	When set, type signatures are appended to function names.
Prepend class names to C++ member functions	When set, C++ member functions are prefixed with the class name.
Allow automatic creation of output directory paths	When set, directory paths are automatically created as necessary for file output operations.
Disable target exception dialog	When set, a CPU fault does not cause the target exception dialog to pop up.
Block Separator	Separator character used to delimit blocks within the display texts of large integer numbers.

3.11.15.4 Call Stack Window Settings

Setting	Description
Callstack layout	Selects if the current frame is displayed on top or at the bottom of the call stack.
Callstack depth limit	Maximum number of frames that are displayed within the Call Stack Window.
Show parameter names/values/types	When set, the display text of a call frame is augmented with the names/values/types of the parameters of the affiliated function.

3.11.15.5 Call Graph Window Settings

Setting	Description
Group by root functions	When set, the call graph window contains an (expandable) entry for each root function of the program. When unset, the top level contains an entry for each program function.

3.11.15.6 Code Profile Window Settings

Setting	Description
Highlight source code lines	When set, source code text is syntax-highlighted.
Highlight assembly code	When set, assembly code is syntax-highlighted.
Show instruction encodings	When set, instruction encodings are syntax-highlighted.
Show source line numbers	When set, source line numbers are prefixed to source code text lines.
Show breakpoints	When set, breakpoint indicators are displayed.

3.11.15.7 Console Window Settings

Setting	Description
Show timestamps	When set, all messages logged to the Console Window are prefixed with a time stamp.

3.11.15.8 Data Sampling Window Settings

Setting	Description
Data limit	Data limit, in KB, of the data sampling window. When the data limit is surpassed, the oldest data is overwritten.

3.11.15.9 Disassembly Window Settings

Setting	Description
Show source	When set, the assembly code is augmented with source code text to improve readability.
Show labels	When set, the assembly code is augmented with labels to improve readability.
Show breakpoint bar	Toggles the breakpoint bar (see *Breakpoint Bar* on page 54).
Show execution counters	Toggles instruction execution counters (see *Code Execution Counters* on page 55).
Show instruction encodings	Toggles instruction encodings.
Show pseudo instructions	When set, pseudo instruction syntax is prefered over normal syntax within disassembly.
Register name format	Selects the register name format.
Hide mapping symbol labels	Specifies if mapping symbol labels should be hidden from disassembly.

3.11.15.10 Instruction Trace Window Settings

Setting	Description
Show instruction encodings	Toggles instruction encodings.
Timestamp Format	Selects the time stamp format (see *Trace Timestamp Formats* on page 269}.
Sync With Code	Specifies if the row selection is synchronized with the code windows (see *Backtrace Highlighting* on page 129).

3.11.15.11 Power Sampling Window Settings

Setting	Description
Maximum sample count	Maximum number of samples than can be processed and displayed by the Power Sampling Window.

3.11.15.12 Source Viewer Settings

Setting	Description
Show breakpoint bar	Toggles the breakpoint bar (see *Breakpoint Bar* on page 54).
Show expansion indicators	Toggles expansion indicators.
Show execution counters	Toggles execution counters (see *Code Execution Counters* on page 55).
Show instruction encodings	Toggles instruction encodings within inline assembly code text lines.
Lock header bar	When set, the header bar is visible at all times. When unset, the header bar is only visible when hovered with the mouse.
Indent inline assembly code	When set, inline assembly code text lines are indented in relation to the affiliated source statement.
Document editing restriction	Selects when editing of source code documents is disabled.
Line number frequency	Selects the frequency of source code text lines that display line numbers.
Tab Spacing	Number of white spaces drawn for each tabulator in the source text.

3.11.15.13 Table Window Settings

Setting	Description
Show text value for…	By setting a data type's option to yes, all symbols of this data type display their value in the format "<number> (<text representation>)" instead of just "<number>".
Globally hide filter bars	When set, the display of table filter bars is globally disabled (see *Filter and Total Value Bars* on page 59).
Globally hide total value bars	When set, the display of total value bars is globally disabled (see *Filter and Total Value Bars* on page 59).
Symbol member count display limit	Maximum number of members that are displayed for complex-type symbols such as arrays.
String display limit	The maximum number of characters that are displayed for strings.
Hide C++ class member functions	Do not display C++ class member functions.
Resize column when item is expanded	Adjust the column size when a table item is expanded.
Resize column when item is collapsed	Adjust the column size when a table item is collapsed.

3.11.15.14 Terminal Window Settings

Setting	Description
Suppress control characters	When set, non-printable and control characters are filtered from IO data prior to terminal output (see *User Preference Identifiers* on page 273).

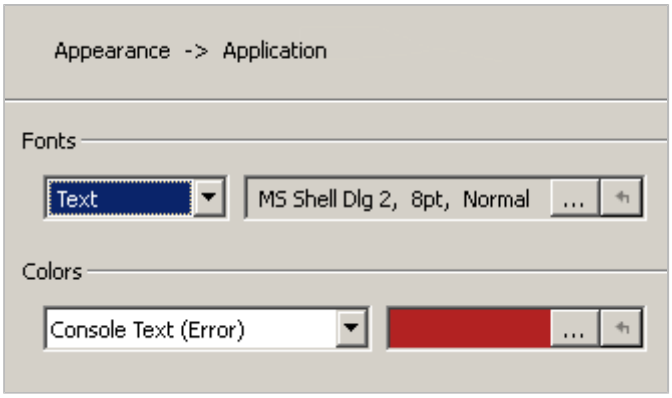
Setting	Description
Clear on reset	When set, the window's text area is cleared following each program reset.
Data limit	Date limit, in KB, of the Terminal Window.
Zero-terminate input	When set, a string termination character (\0) is appended to terminal input before the input is sent to the debuggee.
Echo input	When set, each terminal input is appended to the terminal window's text area.
Newline input termination format	Selects the type of line break to be appended to terminal input before the input is send to the debuggee (see *Newline Formats* on page 269).

3.11.15.15 Timeline Window Settings

Setting	Description
Cursor labels	Selects the cursor labels to be displayed
Mouse wheel action	Selects the action to be performed when the mouse wheel is scrolled (scroll time-axis, scroll Y-axis, zoom time-axis, zoom Y-axis, none)
Time origin	Selects the time origin (CPU halt, program start)
Auto scroll	Selects the auto-scrolling behavior(do not auto scroll, auto scroll while program is running)
Clear event	Selects the debug event upon which the timeline is cleared (see Clear Event).

3.11.15.16 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.

3.11.15.17 Specifying User Preferences Programmatically

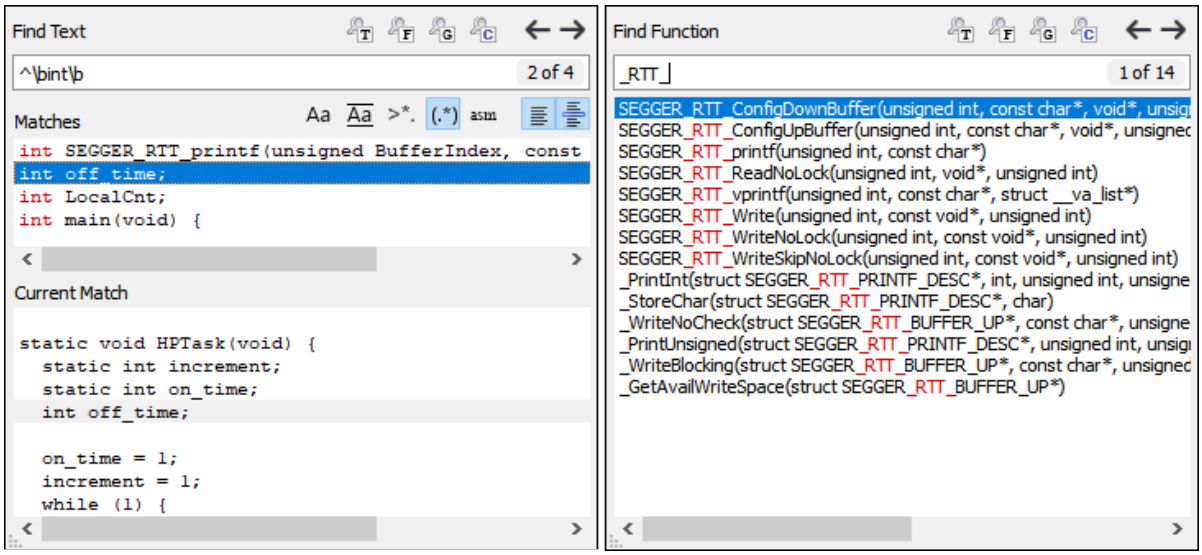
Each setting provided by the User Preference Dialog is affiliated with an user action. User preference actions allow users to change the preference from a script function or at the command prompt. The table below gives an overview of the available user preference actions.

User Preference Category	Affiliated User Action(s)
General Settings	Edit.Preference (see *Edit.Preference* on page 308)

User Preference Category	Affiliated User Action(s)
Appearance Settings	Edit.Color (see *Edit.Color* on page 309) and Edit.Font (see *Edit.Font* on page 310)

3.11.16 Quick Find Widget

The Quick Find Widget is a pop-up screen that facilitates locating program symbols and text patterns.



Quick Find Widget in text mode (left) and symbol mode (right).

How to use the quick find widget

As letters are typed into the input box, the list of match suggestions updates and shrinks. The user selects the desired match via the arrow keys and upon pressing return, the selected match will be shown and highlighted within its containing debug window.

3.11.16.1 Search Modes

The search mode of the Quick Find Widget can be selected using keyboard shortcuts or the toolbar at the top.

Mode	Hotkey	Initial Match List Content
Find Text	Ctrl+F	All text lines of the active document.
Find Function	Ctrl+M	All functions.
Find Global Data	Ctrl+J	All global variables.
Find Source File	Ctrl+K	All source code files.

3.11.16.2 Text Search Options

When in text search mode, additional search options are provided via the toolbar below the find text line:

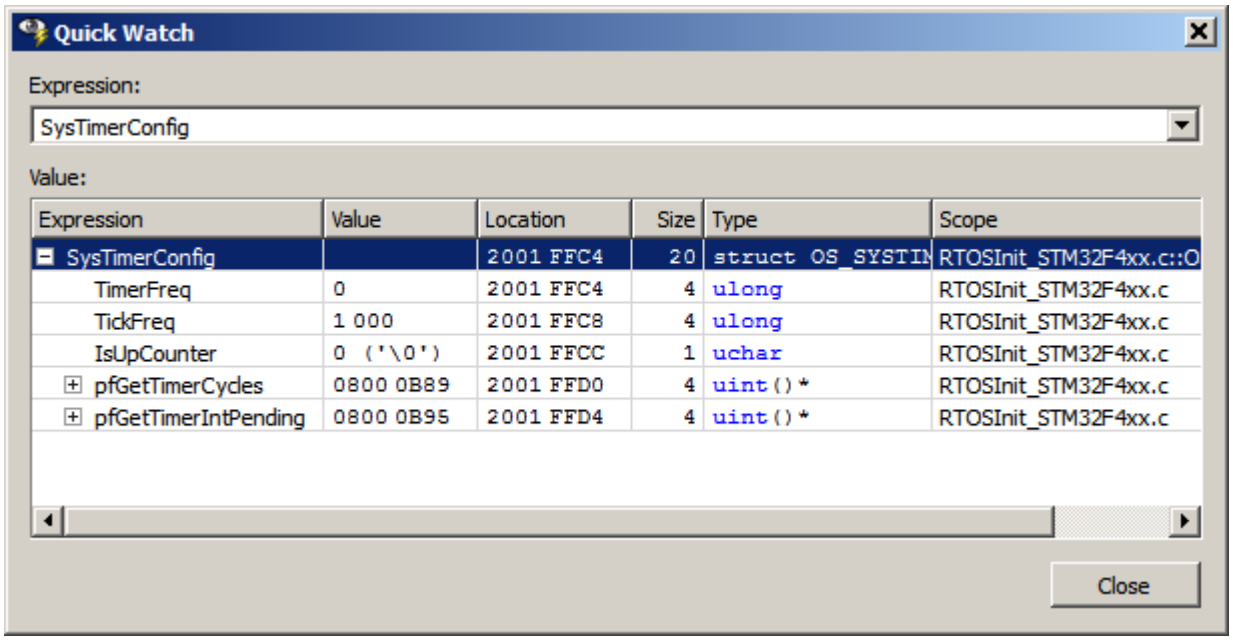
Search Option	Description
Match case	The search is case sensitive.
Match whole word	Matching text must begin and end at word boundaries. This setting is mutual exclusive with using wild cards and regular expressions.
Use Unix Style Wildcards	The input text is interpreted as an expression containing wildcards. This setting is mutual exclusive with matching whole words and using regular expressions.
Use regular expression	The input text is interpreted as a regular expression. This setting is mutual exclusive with matching whole words and using wild cards.

Search Option	Description
Include inline assembly code	The search includes the active document’s inline assembly code lines.

Furthermore, text search mode provides two buttons to toggle the “Matches” and “Current Match” panes in the toolbar below the find text line.

3.11.17 Quick Watch Dialog

The Quick Watch Dialog enables users to observe the value of the expression under the cursor (see *Working With Expressions* on page 205).



Quick Watch Dialog showing a symbol expression.

How to use the Quick Watch Dialog

The Quick Watch Dialog can be brought up by pressing hotkey Shift+F9 while the text cursor is over the expression/symbol to be evaluated. A recently evaluated expression can be select from the drop-down box. The values of symbols and member symbols can be edited by double-clicking on a table row or by pressing spacebar.

3.11.17.1 Context Menu

The context menu of the Quick Watch Dialog provides options to select the display mode of all or individual items. In addition, the context menu of the table header row enables to toggle individual table columns.

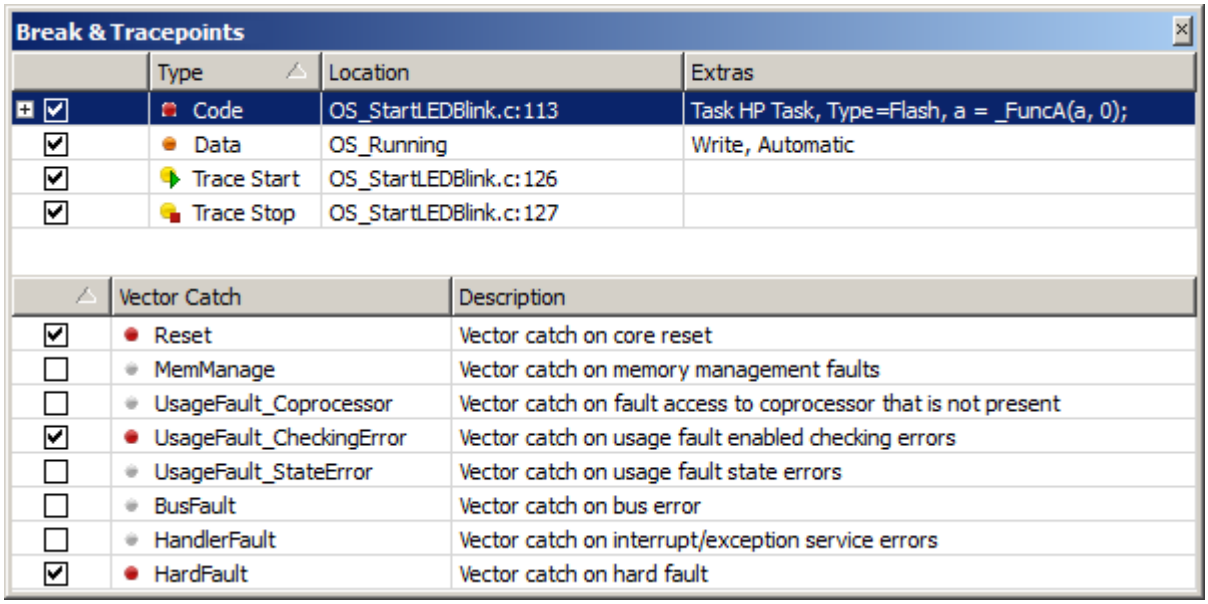
Chapter 4

Debug Information Windows

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

4.1 Breakpoints/Tracepoints Window

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



Breakpoints window showing the state of breakpoints (top) and vector catches (bottom).

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

4.1.1 Breakpoint Properties

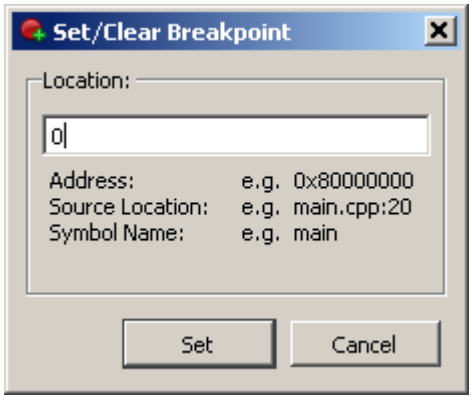
The Breakpoint Window displays the following information about breakpoints:

Column	Description
State	Indicates if the breakpoint is enabled or disabled.
Type	One of CODE, DATA, TRACE_START and TRACE_STOP.
Location	Source code or instruction address location of the breakpoint.
Extras	Lists all advanced breakpoint properties that are set to non-default values. Advanced breakpoint properties are summarized in *Advanced Breakpoint Properties* on page 192 and *Data Breakpoint Attributes* on page 194. Tracepoints do not carry advanced properties.

4.1.2 Breakpoint Dialog

The breakpoint dialog enables users to place breakpoints on:

- Machine instructions
- Source 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 264).

Opening the Breakpoint Dialog

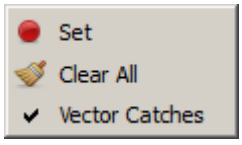
The Breakpoint Dialog can be accessed via the con-

text menu of the Breakpoint Window.

4.1.3 Derived Breakpoints

Source breakpoints can be expanded in order to reveal their derived instruction breakpoints.

4.1.4 Vector Catches



The list of supported vector catches and their states are shown within a separate table of the Breakpoint Window (see title figure). The context menu of this table hosts the following actions:

Set/Clear

Sets or clears the selected vector catch.

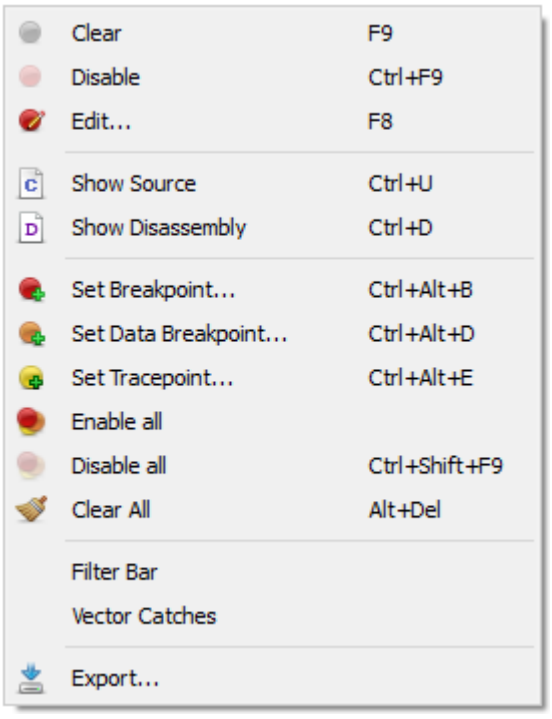
Clear All

Clears all vector catches.

Vector Catches

Shows or hides the vector catch table.

4.1.5 Context Menu



The Breakpoint Window's context menu hosts the following actions (see *Breakpoint Actions* on page 290):

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 63).

Show Source

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

Show Disassembly

Displays the assembly code line associated with the selected breakpoint.

Set Breakpoint...

Opens the Breakpoint Dialog (see *Breakpoint Dialog* on page 96).

Set Data Breakpoint...

Opens the Data Breakpoint Dialog (see *Data Breakpoint Dialog* on page 67).

Set Tracepoint...

Opens the Tracepoint Dialog.

Enable All

Enables all breakpoints. The vector catches remain untouched.

Disable All

Disables all breakpoints. The vector catches remain untouched.

Clear All

Clears all breakpoints.

Filter Bar

Shows or hides the filter bar.

Vector Catches

Shows or hides the vector catch table.

Export

Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.1.6 Editing Breakpoints and Vector Catches Programmatically

Ozone provides multiple user actions that allow users to edit breakpoints from script code or from the command prompt (see *Breakpoint Actions* on page 290 and *Trace Actions* on page 297).

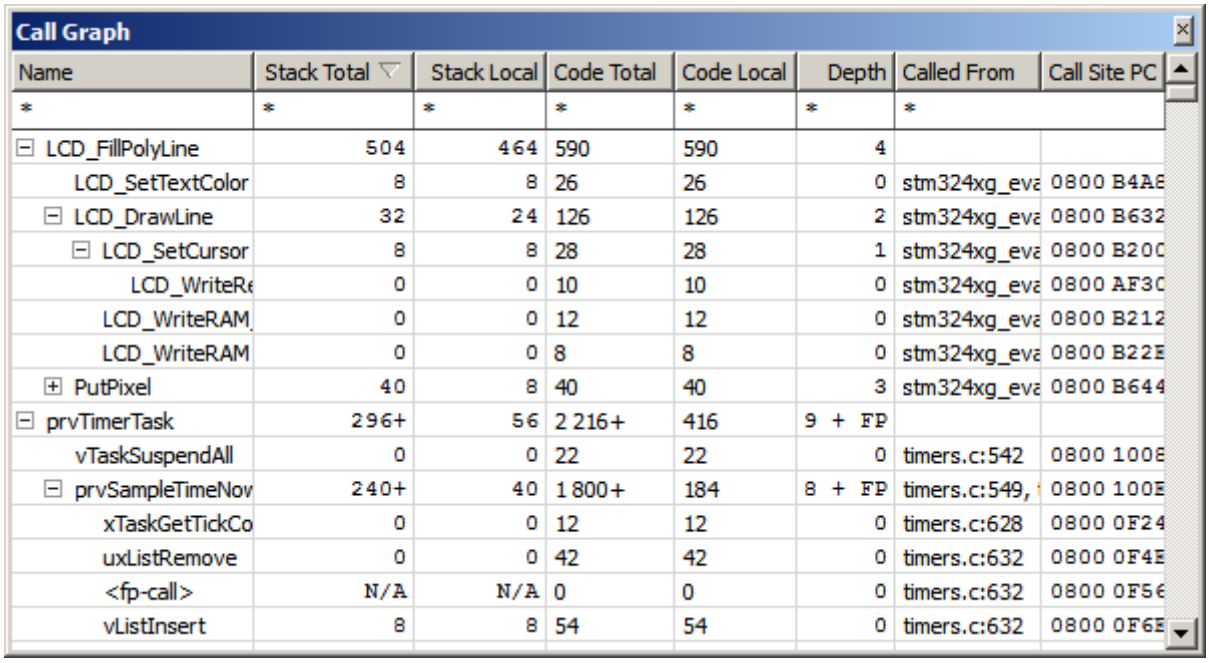
User action Break.SetVectorCatch (see *Break.SetVectorCatch* on page 376) is provided to set and clear vector catches within script functions or plugins.

4.1.7 Table Window

The Breakpoint Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 58).

4.2 Call Graph Window

Ozone's Call Graph Window informs about function call paths and stack usages.



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 Setup

In order to obtain correct output when debugging applications that include custom instructions, a disassembly support plugin must have been loaded (see *Project.SetDisassemblyPlugin* on page 343).

4.2.3 Table Columns

Name

Name of the function.

Stack Total

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

Stack Local

The amount of stack space used exclusively by the function.

Code Total

The maximum code size of any call path that originates at the function, including the function's local code size.

Code Local

The function's code size, including code-inline data pools if present.

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.

> **Note**
>
> Instruction-level information may not be accessible to Ozone before debug session startup completion (see *Startup Completion Point* on page 188). Ozone will display a warning sign next to table values which may be unavailable due to this reason.

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 100).

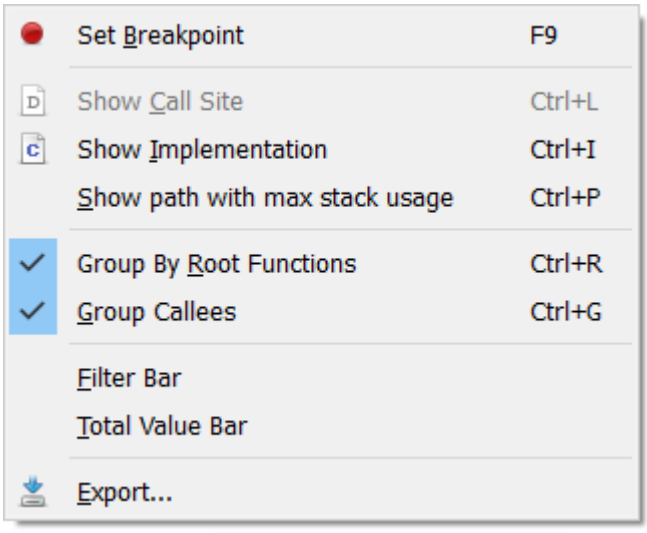
4.2.6 Function Pointer Calls

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 Table Window

The Call Graph Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 58).

4.2.8 Context Menu



Set/Clear Breakpoint

Sets or clears a breakpoint on the selected function.

Show Call Site

Displays the call location of the selected function within the Source Viewer (see *Source Viewer* on page 156). This action can also be triggered by double-clicking a table row.

Show Implementation

Displays the implementation of the se-

lected function within the Source Viewer (see *Source Viewer* on page 156).

Show path with max stack usage

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

Expand All / Collapse All

Expands or collapses all top-level entry point functions.

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.

Filter Bar / Total Value Bar

Toggles the named table header bar.

Export

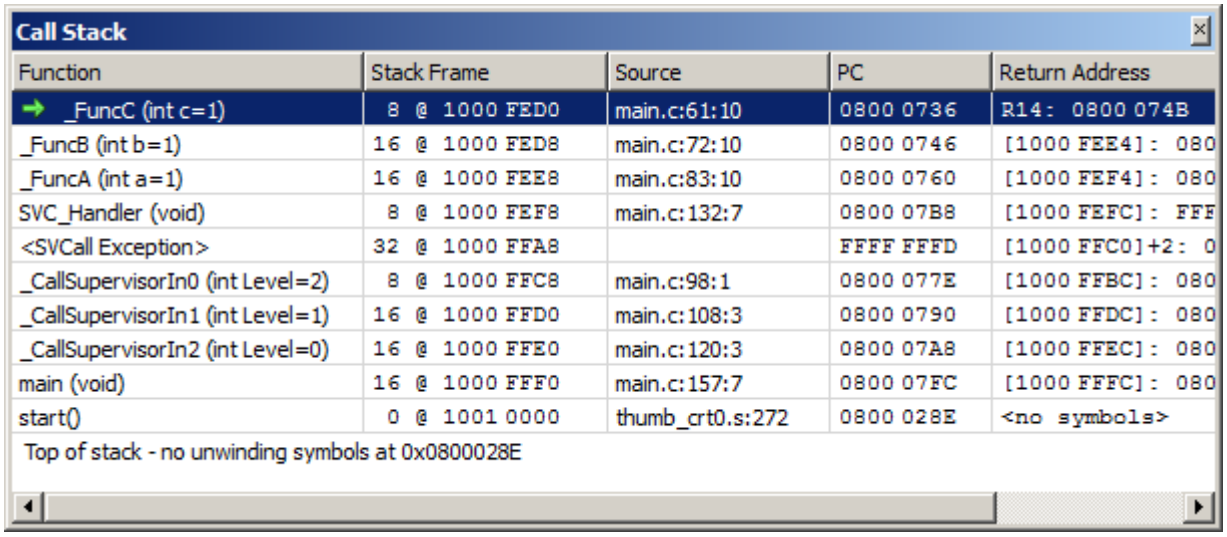
Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.2.9 Call Graph Window Preferences

Section *Call Graph Window Settings* on page 87 lists all user preference settings pertaining to the Call Graph Window.

4.3 Call Stack Window

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



4.3.1 Overview

The topmost row of the Call Stack Window informs about the current program execution point. Each of the other rows display information about a function call that led to the current program execution point. In the illustration above, the second row informs about the call site where function _FuncB called function _FuncC.

The preference "Callstack Layout" for the Call Stack Window allows to reverse the order of rows such that the current program execution point is displayed at the bottom, not the top. Changing that preference is also possible via the context menu of the call stack window.

4.3.2 Table Columns

The Call Stack Window provides the following information about function call sites:

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.
Return Address	PC that will be attained when the program returns from the function call. This field is 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 Call Site Parameter Values

The Call Stack Window may display the values and types of all local function parameters. This settings can be toggled via the window's context menu and via the preferences for the Call Stack Window.

4.3.4 Instruction Based Call Stack Unwinding

The debug information found in the ELF file provides so called unwinding information which describes where to find and how to interpret the information on the stack for finding the sequence of function calls that led to the currently executing code. This debug information also allows reconstruction of some of the register values that were valid inside a function. The format of such unwinding information is documented in the DWARF standard.

Ozone uses that unwinding information for obtaining the sequence of function calls as well as the values of parameters passed in each call.

In some ELF files the unwinding information is incomplete or missing. This may be caused by having configured the build tool chain incorrectly. There are also build tool chains which are incapable of creating the unwinding information according to the DWARF standard.

In case the unwinding information is missing in the ELF file, Ozone offers deriving the unwinding information from an analysis of the instructions rather than from the ELF file. This can be enabled via the system variable "Unwinding information source".

The unwinding information in the ELF file normally contains information only for high-level language code, not for assembly language. Therefore the call stack displayed in the call stack window normally ends with the firsts function for which unwinding information is available. For applications without an RTOS this may be the `main` function, for applications incorporating an RTOS this is often a function inside the RTOS code.

Instruction analysis, however, is oblivious of an instruction being part of high-level language code or assembly language code. Thus the analysis does not necessarily stop at `main` and may stretch into the startup or RTOS code.

Call Stack

Function	Stack Frame	Source	PC	Return Address	Stack Used
CallLvl7 (void)	0 @ 2001 FFB0	main.c:17:1	0800 0A6E	R14: 0800 0FCC	80
CallLvl6 (void)	8 @ 2001 FFB0	main.c:20:3	0800 0FC8	[2001 FFB4]: 0800 0FD4	80
CallLvl5 (void)	8 @ 2001 FFB8	main.c:24:3	0800 0FD0	[2001 FFBC]: 0800 0FDC	72
CallLvl4 (void)	8 @ 2001 FFC0	main.c:28:3	0800 0FD8	[2001 FFC4]: 0800 0FE4	64
CallLvl3 (void)	8 @ 2001 FFC8	main.c:32:3	0800 0FE0	[2001 FFCC]: 0800 0FEC	56
CallLvl2 (void)	8 @ 2001 FFD0	main.c:36:3	0800 0FE8	[2001 FFD4]: 0800 0FF4	48
CallLvl1 (void)	8 @ 2001 FFD8	main.c:40:3	0800 0FF0	[2001 FFDC]: 0800 0E9C	40
main (void)	32 @ 2001 FFE0	main.c:477:3	0800 0E98	[2001 FFFC]: 0800 00CA	32
_start()	0 @ 2002 0000	SEGGER_THUMB_Startup.s:187	0800 00C6	<no symbols>	0

Top of stack - invalid stack pointer location: N/A

Call stack window operating on instruction analysis

For some branch instructions the destination address cannot be determined. If a function call takes place in a code sequence that is reached only by such a branch instruction, the call stack ends prematurely in that very place. Once the code execution leaves that code sequence, the call stack is displayed correctly.

> **Note**
>
> As of now, instruction based call stack unwinding is available only for 16/32-bit ARM architectures, it is not yet supported for RISC-V.

4.3.5 Unwinding Stop Reasons

The reason why call stack unwinding stopped is displayed at the bottom of the stack. Normally, the reason "Top of stack - no unwinding symbols at <Address>" indicates a complete evaluation of the call stack. In case the system variable "Unwinding information source" is set to "Instruction Analysis" a regular call stack evaluation ends with "Invalid return address location: N/A". The message "depth limit reached" is displayed if the number of call frames displayed in the window exceeds the preference "Callstack Depth Limit" for the Call Stack Window. In that case you may wish to increase the value for that preference.

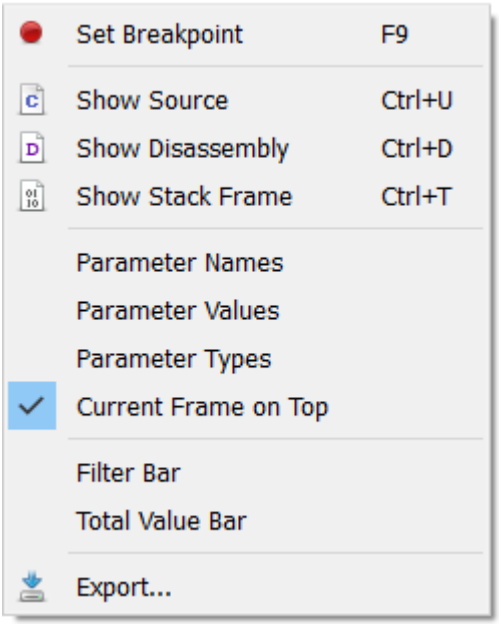
Any other message indicates missing or erroneous unwinding information in the ELF file.

4.3.6 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 the preceding arrow dsiplayed left of the function name.

4.3.7 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 *Show Actions* on page 295).



Set/Clear Breakpoint

Sets or clears a breakpoint on the function of the selected frame.

Show Source

Displays the selected call site within the Source Viewer (see *Source Viewer* on page 156). This action can also be triggered by double-clicking a table row.

Show Disassembly

Displays the selected call site within the Disassembly Window (see *Disassembly Window* on page 117).

Show Stack Frame

Displays the base of the selected call frame within the Memory Window (see *Memory Window* on page 135).

Parameter Names / Values / Types

Toggles the display of function parameter names / values / types.

Current Frame On Top

Selects the ordering of the frames on the call stack.

Filter Bar / Total Value Bar

Toggles the named table header bar.

Export

Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.3.8 Settings

The call stack window evaluates the following system variables settings:

System Variable	Description
`VAR_CALLSTACK_UNWIND_INFO_SRC`	Unwinding information is obtained from the ELF file ("DWARF information"), by instruction analysis ("In-

System Variable	Description
	struction Analysis”), or the source is automatically chosen (“Automatic”).

Section *Call Stack Window Settings* on page 87 lists all user preference settings pertaining to the call stack window.

4.3.9 Table Window

The Call Stack Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 58).

4.4 Code Profile Window

Ozone's Code Profile Window displays the program's execution profile selectively at a file, function, source line or instruction level.

4.4.1 Setup

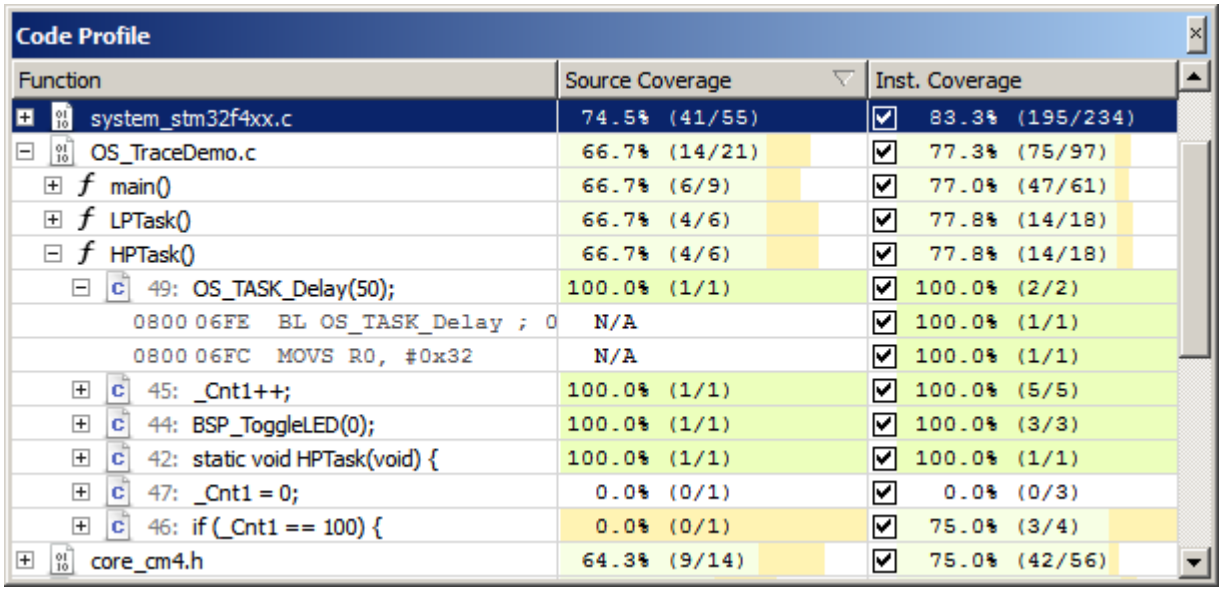
Section *Setting Up Trace* on page 210 explains how to configure Ozone and the hardware setup for trace, thereby enabling the Code Profile Window.

> **Note**
>
> Instruction-level information may not be accessible to Ozone before debug session startup completion (see *Startup Completion Point* on page 188). Ozone will display a warning sign next to table values which may be unavailable due to this reason.

4.4.2 Overview

Each table row displays the execution profile of a single program entity (*PE*). A program entity is either a source file, a function, an executable source line or a machine instruction. Table rows can be expanded to show their contained PEs. Table values continuously update while the program is running.

4.4.3 Code Coverage



Code profile window displaying code coverage statistics.

Table columns code coverage and instruction coverage provide information about the program's code coverage.

Instruction Coverage

Percentage of machine instructions of the PE 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, 77.0% or 47 of 61 machine instructions within function main were covered.

Source Coverage

Percentage of executable source code lines of the PE 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 case of conditional instructions, "full execution" means that the condition was both met and not met. In the title figure, 66.7% or 6 of 9 executable source codes lines within function main were covered.

4.4.3.1 Color Bars

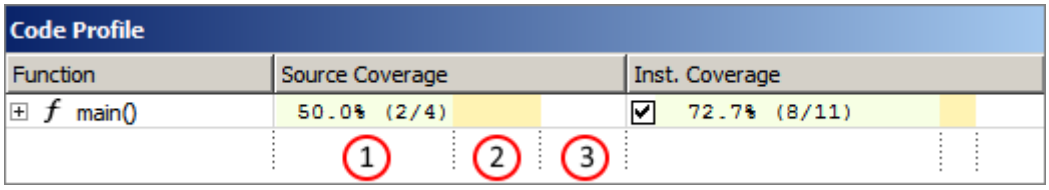


Table columns *code coverage* and *instruction coverage* display color bars to help identify PE's whose code can potentially be optimized.

A color bar is split vertically into a green (1), orange (2) and a white (3) segment. Each segment visualizes a percentage value. The percentage values of all 3 segments add up to 100.

Segment	Source Coverage	Instruction Coverage	Prognosis
	Percentage of source lines that are fully covered. Identical to the value displayed within the table cell.	Percentage of instructions that are fully covered. Identical to the value displayed within the table cell.	Little to no potential for optimization
	Percentage of source lines that are partially covered	Percentage of instructions that are partially covered	Good potential for optimization
	Percentage of source lines that are not covered	Percentage of instructions that are not covered	Potential for removal

A source line or instruction is considered:

- fully covered, if its execution profile color code is solid-green
- partially covered, if its execution profile color code is orange or split orange-green
- not covered, if its execution profile color code is gray

Refer to *Execution Profile Color-Codes* on page 56.

4.4.4 Program Load

Table columns *Run Count*, *Fetch Count* and *Load* inform about the CPU usage of PE's.

Run Count

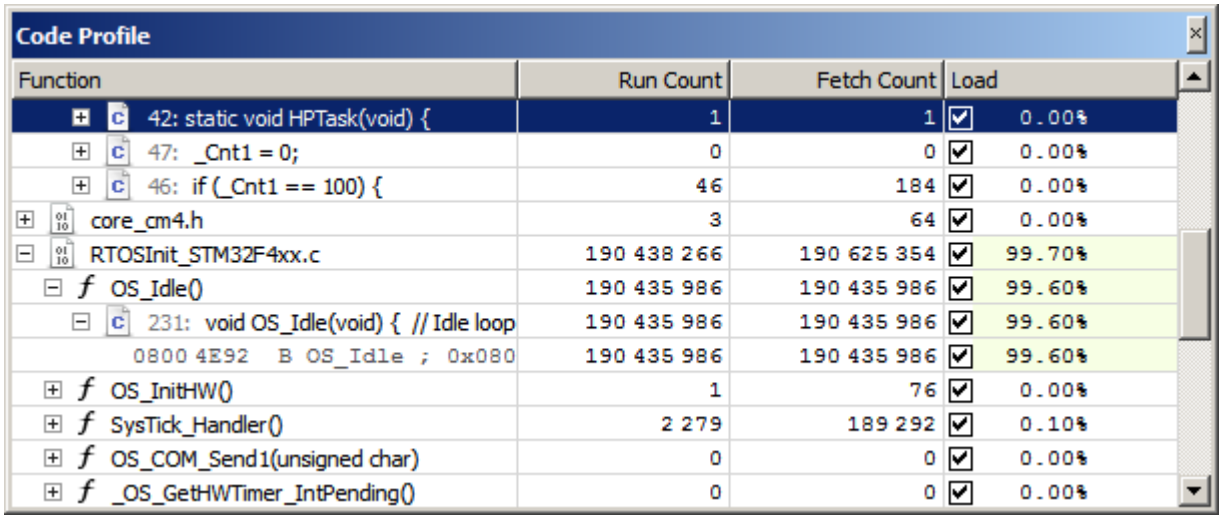
Number of times the PE was executed since code profile data was reset.

Load

Number of instruction fetches that occurred within the PE's address range divided by the total number of instruction fetches that occurred since code profile data was reset.

Fetch Count

Number of instruction fetches that occurred within the address range of the PE.



Code profile window displaying PE load statistics.

4.4.5 Execution Counters

Ozone also shows the program's execution profile inlined with the code. For more information, refer to *Code Profile Information* on page 55.

4.4.6 Filters

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

Profile Filter

When a profile filter is set on a PE, 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 PE's.

Coverage Filter

When a coverage filter is set on a PE, 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 PE does not exist.

4.4.6.1 Adding and Removing Profile Filters

A profile filter can be set and removed via commands Profile.Exclude and Profile.Include (see *Code Profile Actions* on page 290). In Addition, the load column of the Code Profile Window provides a check box for each item that enables users to quickly set or unset the filter on the item.

4.4.6.2 Adding and Removing Coverage Filters

A coverage filter can be set and removed via commands Coverage.Exclude and Coverage.Include (see *Code Profile Actions* on page 290). In Addition, the code coverage columns of the Code Profile Window provide a check box for each item that enables users to quickly set or unset the filter on the item.

4.4.6.3 Filtering Code Alignment Instructions

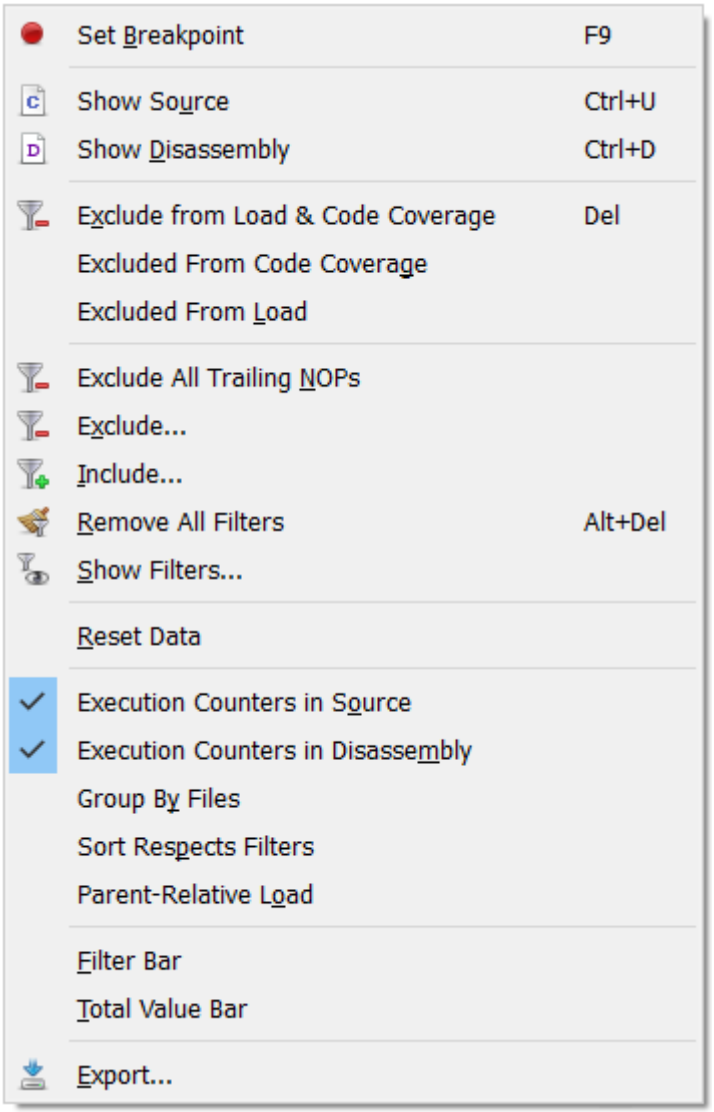
Compilers may place alignment instructions into program code that have no particular operation and do never get executed. These so-called NOP-instructions can be filtered from the code coverage statistic via context menu entry "Exclude All Trailing NOPs" or via command Coverage.ExcludeNOPs (see *Coverage.ExcludeNOPs* on page 356).

4.4.6.4 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.

4.4.7 Context Menu

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



Set/Clear Breakpoint

Sets or clears a breakpoint on the selected function, source line or instruction.

Show Source

Displays the selected item within the Source Viewer (see *Source Viewer* on page 156).

Show Disassembly

Displays the selected item within the Disassembly Window (see *Disassembly Window* on page 117).

Include/Exclude from

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

Exclude All Trailing NOPs

Excludes all "no operation" (code alignment) instructions, which trail the function's code body, from the code coverage statistic.

Exclude (Dialog)

Moves multiple items to the filtered set (see *Profile.Exclude* on page 355).

Include (Dialog)

Removes multiple items from the filtered set (see *Profile.Include* on page 355).

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 *Code Execution Counters* on page 55).

Reset Data

Resets the session's trace and sampling data. This action can also be executed from the project script using command Timeline.Reset (see *Timeline.Reset* on page 363).

Execution Counters in Source

Displays execution counters within the Source Viewer (see *Source Viewer* on page 156).

Execution Counters in Disassembly

Displays execution counters within the Disassembly Window (see *Disassembly Window* on page 117).

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 number of instructions executed within the item divided by the total number of instructions executed within the parent item. Otherwise, the total number of instructions executed is used as the divisor.

Filter Bar / Total Value Bar

Toggles the named table header bar.

Export

Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.4.8 User Preference Settings

The User Preference Dialog allows users to specify appearance-related settings of the Code Profile Window. The available settings are listed in section *Code Profile Window Settings* on page 87.

4.4.9 Selective Tracing

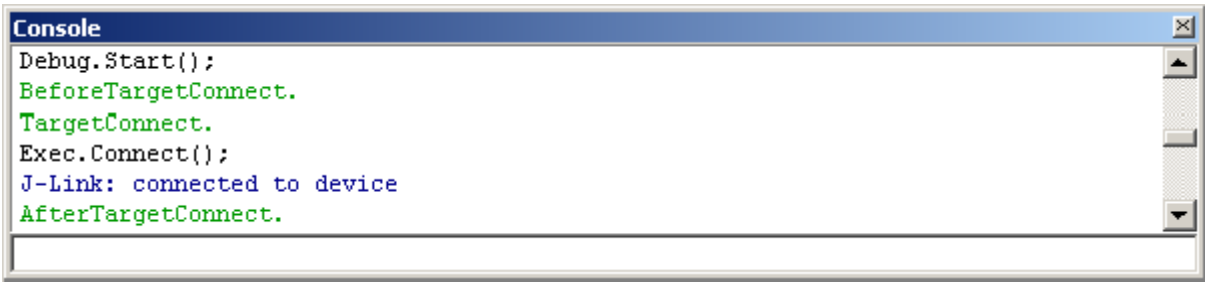
Ozone can instruct the target to constrain trace data output to individual address ranges (see *Tracepoints* on page 212). When selective tracing is active, it acts as a hardware prefilter of code profile data.

4.4.10 Table Window

The Code Profile Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 58).

4.5 Console Window

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



4.5.1 Command Prompt

The Console Window displays a command prompt below its text area that enables users to execute any user action that has a command (see *User Actions* on page 43). 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 43 – the action's command text is added to the Console Window. This process is termed command feedback. For actions that query a value, the returned value is displayed in a trailing comment.

```
Target.GetReg("PC"); // returns 0x8000284
```

4.5.2.2 Error Messages

When an unexpected condition occurs and depending on the severity of the condition, an error or warning message is logged to the Console Window. Most error and warning messages are accompanied by a message code. The message code is an index into table *Errors and Warnings* on page 283, which provides additional information about the exception.

```
Target.GetReg("ProgramCounter"): unknown register "ProgramCounter".
```

4.5.2.3 J-Link/J-Trace Messages

Control and status messages emitted by the debug probe API are a distinct message type.

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

4.5.2.4 Script Messages

Messages emitted from script functions are a distinct message type.

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

The commands Util.Log (see *Util.Log* on page 321) and TargetInterface.message (see *TargetInterface.message* on page 388) can be employed within project scripts and JavaScript plugins, respectively, to log a message to the Console Window. Command Util.Error (see

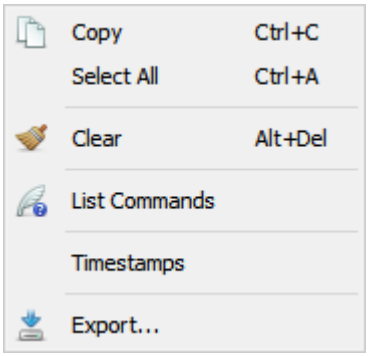
Util.Error on page 321) is provided to display an error message box and stop the debug session.

4.5.3 Message Colors

Messages printed to the Console Window are colored according to their type.

The message colors can be adjusted via command Edit.Color (see *Edit.Color* on page 309) or via the User Preference Dialog (see *User Preference Dialog* on page 86). The default coloring scheme is depicted above.

4.5.4 Context Menu



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

Copy

Copies the selected text to the clipboard.

Select All

Selects all text lines.

Clear

Clears the Console Window.

List Commands

Prints the command help.

Timestamps

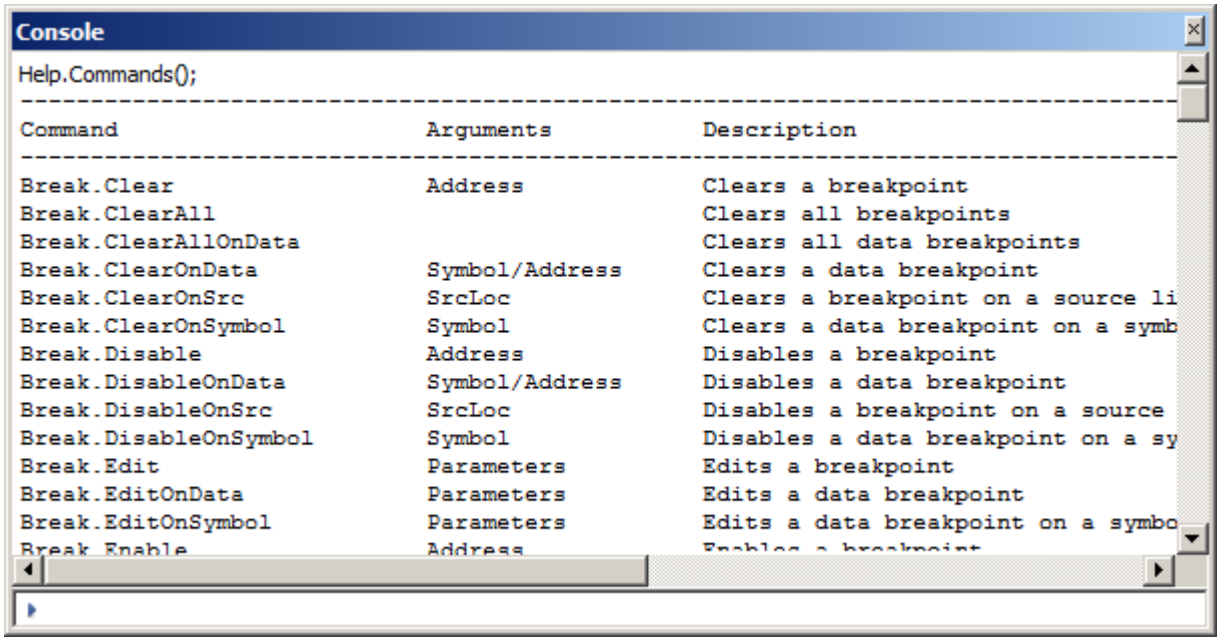
Toggles the display of message timestamps.

Export

Opens a file dialog that enables users to export the content of the console window to a CSV file. This action can also be executed from the project script using command Window.Export.

4.5.5 Command Help

When command 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 339). The command help can be triggered from the Console Window's context menu or from the main menu (Help → Commands).



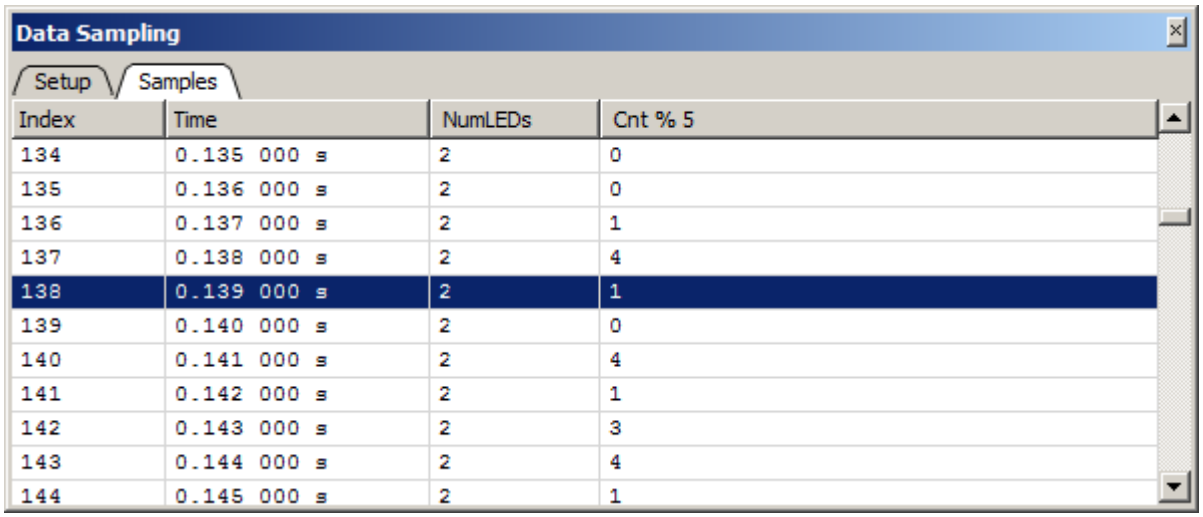
Command help displayed within the Console Window

4.5.6 Console Window Preferences

Section *Console Window Settings* on page 88 lists all user preference settings pertaining to the Console Window.

4.6 Data Sampling Window

Ozone's Data Sampling Window employs SEGGER's High-Speed Sampling (HSS) API to trace the values of user-defined expressions at time resolutions of down to 100 us (see *Working With Expressions* on page 205 and *J-Link User Guide*).



4.6.1 Hardware Requirements

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

4.6.2 Sampling Frequency

The sampling request of all expressions that are added to the Data Sampling Window is sent to the debug probe at the same time. This common sampling frequency can be adjusted via the context menu or via command Edit.SysVar using argument VAR_HSS_SPEED. A sampling frequency of 0 disables data sampling.

The sampling frequency can be assigned persistently to the project by placing its command into project script function `OnProjectLoad`.

The sampling of expressions starts automatically each time the program is resumed and stops automatically each time the program halts.

4.6.3 Data Limit

User preference PREF_DATA_SAMPLING_DATA_LIMIT sets the data limit of the data sampling window. The default data limit is 16MB. When the data limit is reached, data acquisition will continue but the oldest data will be overwritten.

4.6.4 Window Layout

The Data Sampling Window provides two content panes – or views – which can be switched by selecting the corresponding tab within the tab bar.

4.6.5 Setup View

The Setup View enables users to assemble the list of expressions whose values are to be traced while the program is running. An expression can be added to the list in any of the following ways:

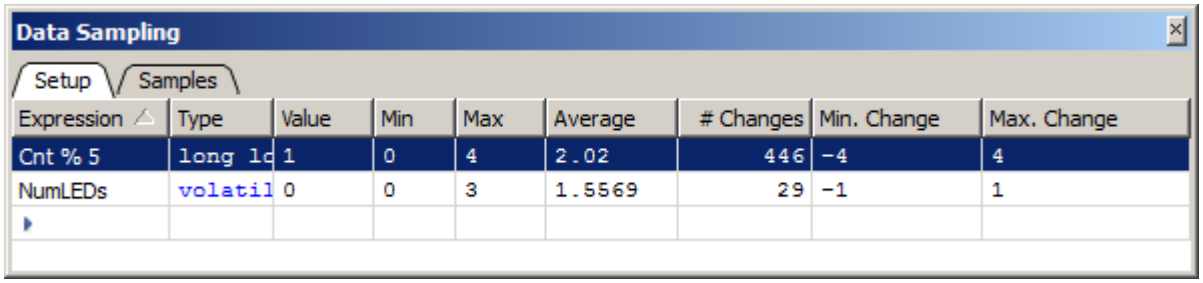
- via context menu entry *Add Expression*.
- via command Window.Add (see *Window.Add* on page 316).
- via the last table row that acts as an input field.
- by dragging a symbol from a symbol window or the Source Viewer onto the Setup View.

and removed from the list via:

- context menu entry *Remove*.
- command Window.Remove (see *Window.Remove* on page 317).

A traced 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.



Setup view of the Data Sampling Window.

The setup view's toolbar provides quick access to the sample frequency. The toolbar can be shown and hidden via the context menu entry "Toolbar". If this entry is checked, the toolbar is shown, if it is unchecked, the toolbar is hidden.

4.6.5.1 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 number 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.

4.6.5.2 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.

Sampling Frequency

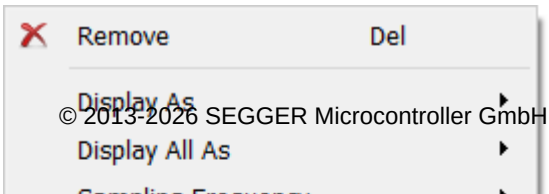
Selects the data sampling frequency.

Add Expression

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

Remove All

Removes all expression from the window.



Reset Data

Resets the session's trace and sampling data. This action can also be executed from the project script using command Timeline.Reset (see *Timeline.Reset* on page 363).

Toolbar

Toggles the display of the toolbar.

Filter Bar / Total Value Bar

Toggles the named table header bar.

Export

Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

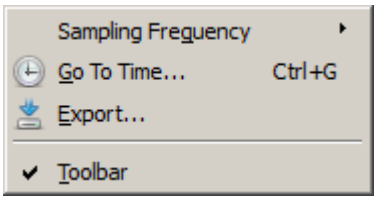
4.6.6 Samples View

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

The samples view's toolbar provides quick access to the sample frequency. The toolbar can be shown and hidden via the context menu entry "Toolbar". If this entry is checked, the toolbar is shown, if it is unchecked, the toolbar is hidden.

4.6.6.1 Context Menu

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



Sampling Frequency

Selects the data sampling frequency.

Goto Time

Opens an input dialog that enables users to scroll to a particular samples table row.

Export

Opens a file dialog that enables users to export the sampling data to a CSV file. This action can also be executed from the project script using command Export.DataGraphs.

Toolbar

Toggles the toolbar.

4.6.7 Timeline

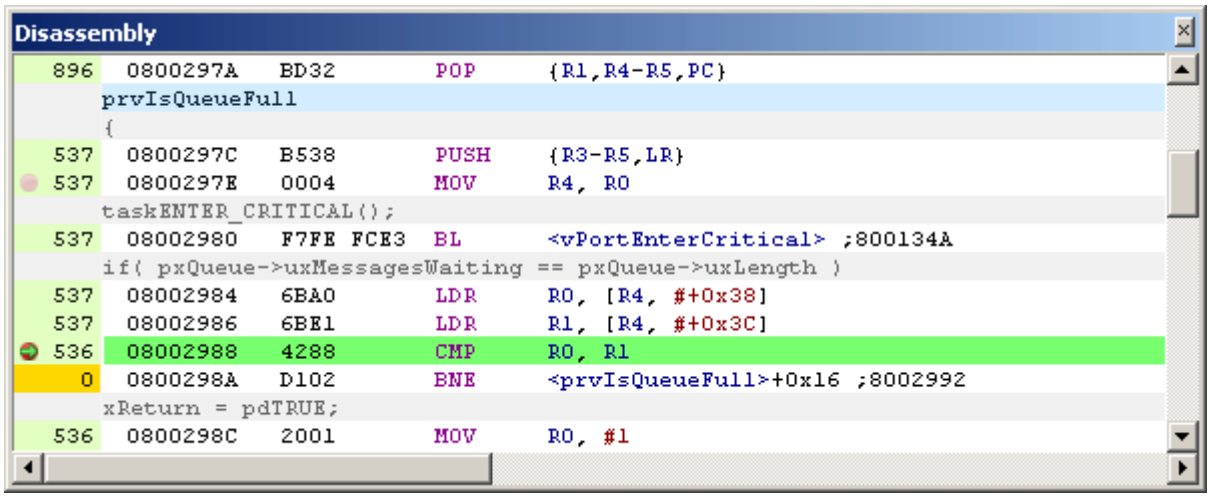
HSS sampling data, together with power and instruction trace data, is visualized in a combined signal plot (see *Timeline Window* on page 165). This enables users to establish a link between the values of selected variables and program execution. To further support this correspondence, the selected table row of the Data Sampling Window is synchronized with the sample cursor of the Timeline Window.

4.6.8 Data Sampling Window Preferences

Section *Data Sampling Window Settings* on page 88 lists all user preference settings pertaining to the Data Sampling Window.

4.7 Disassembly Window

Ozone's Disassembly Window displays the assembly code interpretation of target memory. The window automatically scrolls to the position of the program counter when the program is stepped; this enables 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 via the context menu or permanently via the User Preference Dialog (see *Disassembly Window Settings* on page 88).

Syntax Highlighting

The Disassembly Window applies syntax highlighting to assembly code. The syntax highlighting colors can be adjusted via command Edit.Color (see *Edit.Color* on page 309) or via the User Preference Dialog (see *User Preference Dialog* on page 86).

4.7.2 Execution Counters

The Disassembly Window may show the execution counts of individual instructions within its left sidebar area (see *Code Execution Counters* on page 55).

4.7.3 Key Bindings

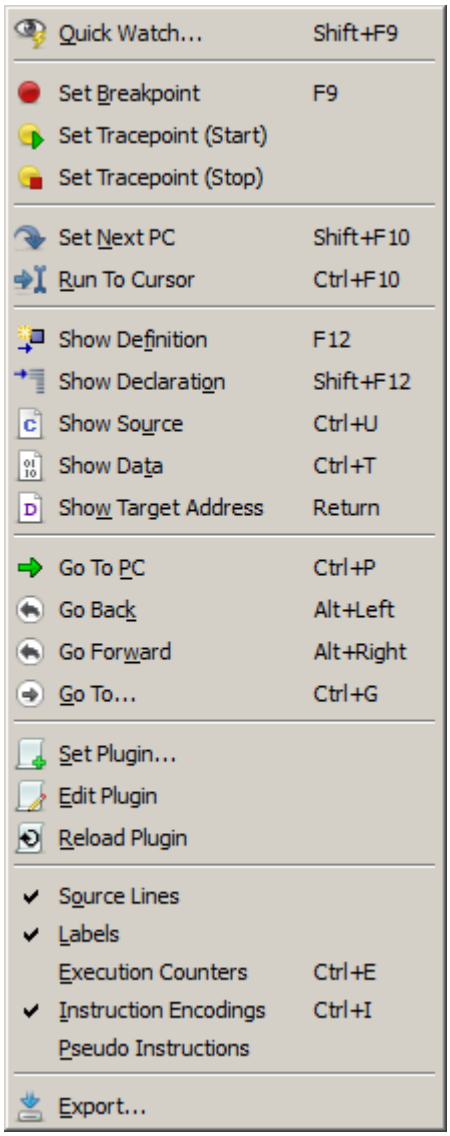
The disassembly window's special-purpose key bindings are:

Hotkey	Description
Enter	Navigates to the target address of the selected instruction.
Space	Show the selected instruction within the Source Viewer.
Alt+Left	Returns to the previous waypoint.
Alt+Right	Shows the next waypoint.

Next to these keyboard shortcuts, the disassembly window also supports the standard hotkeys provided by debug windows (see *Standard Shortcuts* on page 52) and code windows {see *Text Cursor Navigation Shortcuts* on page 56}.

4.7.4 Context Menu

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



Quick Watch

Opens the Quick Find Widget (see *Quick Find Widget* on page 92) for the text selection or word under the cursor.

Set/Clear/Edit Breakpoint

Sets/Clears or Edits a breakpoint on the selected machine instruction (see *Instruction Breakpoints* on page 192).

Set Tracepoint (Start/Stop)

Sets a tracepoint on the selected machine instruction (see *Tracepoints* on page 212).

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.

Show Definition

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

Show Declaration

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

Show 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).

Show Data

Displays the selected data item within the Memory Window (see *Memory Window* on page 135).

Show Target Address

Navigates to the target address of the selected instruction.

Goto PC

Scrolls the viewport to the PC line.

Go Back

Returns to the previous waypoint.

Go Forward

Shows the next waypoint.

Go To

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

Set Plugin

Sets the disassembly plugin to be used with the current project (see *Disassembly Plugin* on page 119).

Edit Plugin

Opens the script file of the loaded disassembly plugin within the Source Viewer.

Reload Plugin

Reloads the disassembly plugin.

Source Lines

Toggles the display of source lines.

Labels

Toggles the display of assembly labels.

Execution Counters

Toggles the display of Code Execution Counters (see *Code Execution Counters* on page 55).

Instruction Encodings

Toggles the display of instruction encodings.

Pseudo Instructions

Enables or disables pseudo-instruction display.

Find In Trace

Opens the Find In Trace Dialog with the word under the cursor (see *Find In Trace Dialog* on page 73).

Export

Opens the Disassembly Export Dialog (see *Disassembly Export Dialog* on page 69).

4.7.5 Disassembly Plugin

The disassembly window can be extended to include the assembly code and code profiling information of custom instructions (see *Disassembly Plugin* on page 119). A disassembly plugin can be assigned to the project via context menu action *Set Plugin* or command Project.SetDisassemblyPlugin.

4.7.6 Offline Disassembly

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.

4.7.7 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 53) for a shared description of these windows.

4.7.8 Disassembler Options

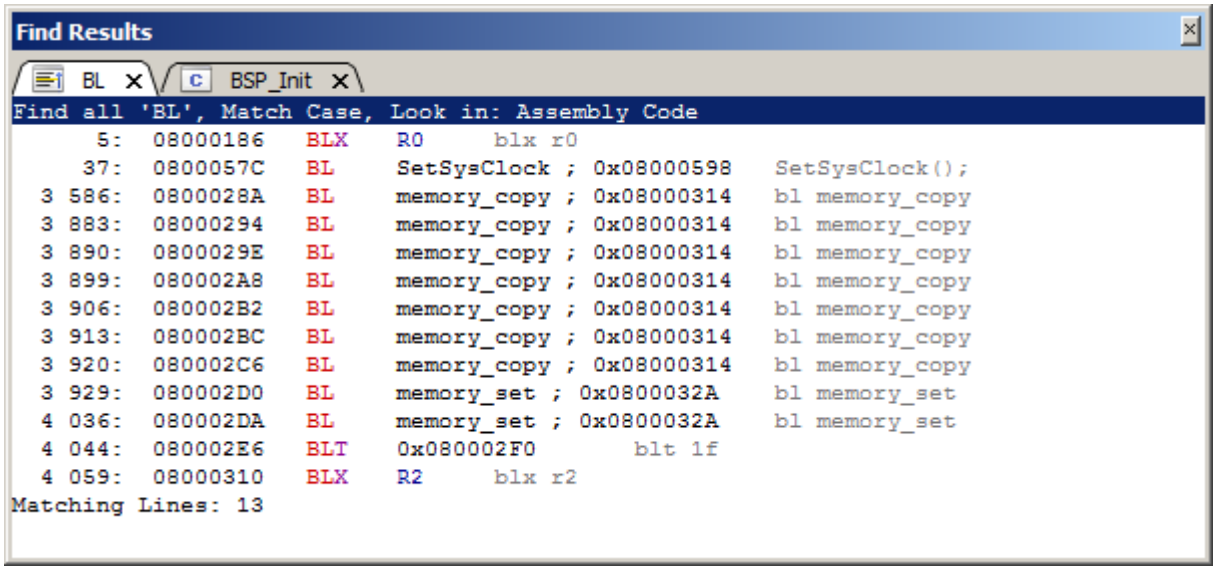
Command Project.ConfigDisassembly (see *Project.ConfigDisassembly* on page 353) is provided to control behavioral aspects of the disassembler.

4.7.9 Appearance Settings

Section *Disassembly Window Settings* on page 88 lists all appearance-related settings pertaining to the disassembly window.

4.8 Find Results Window

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



Find Results Window displaying the results of a text search within the Instruction Trace Window.

4.8.1 Find Result Tabs

The Find Results Window adds a result tab for each text search that was performed. The result of the text search is displayed as a list of text lines that matched the search pattern. The search settings are displayed in the first row of the search result text. Tabs can be closed and rearranged freely.

4.8.2 Supported Text Search Locations

Text searches are currently supported in the following locations:

- Source code documents
- Instruction Trace Window contents

A new text search is performed using the:

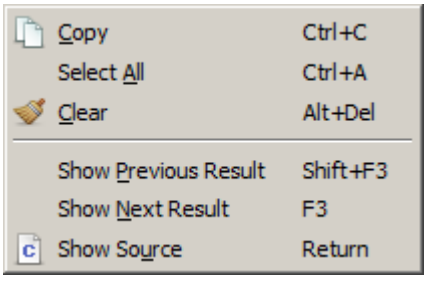
- Find In Files Dialog or
- Find In Trace Dialog

4.8.3 Match Highlighting

By double-clicking on a table row or by pressing Return, the match is selected within the Source Viewer or Instruction Trace Window.

4.8.4 Context Menu

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



Copy

Copies the selected text to the clipboard.

Clear

Clears the match list.

Show Source

Shows the selected match within the Source Viewer. Can also be performed by double-clicking on a match result.

Show Next Result

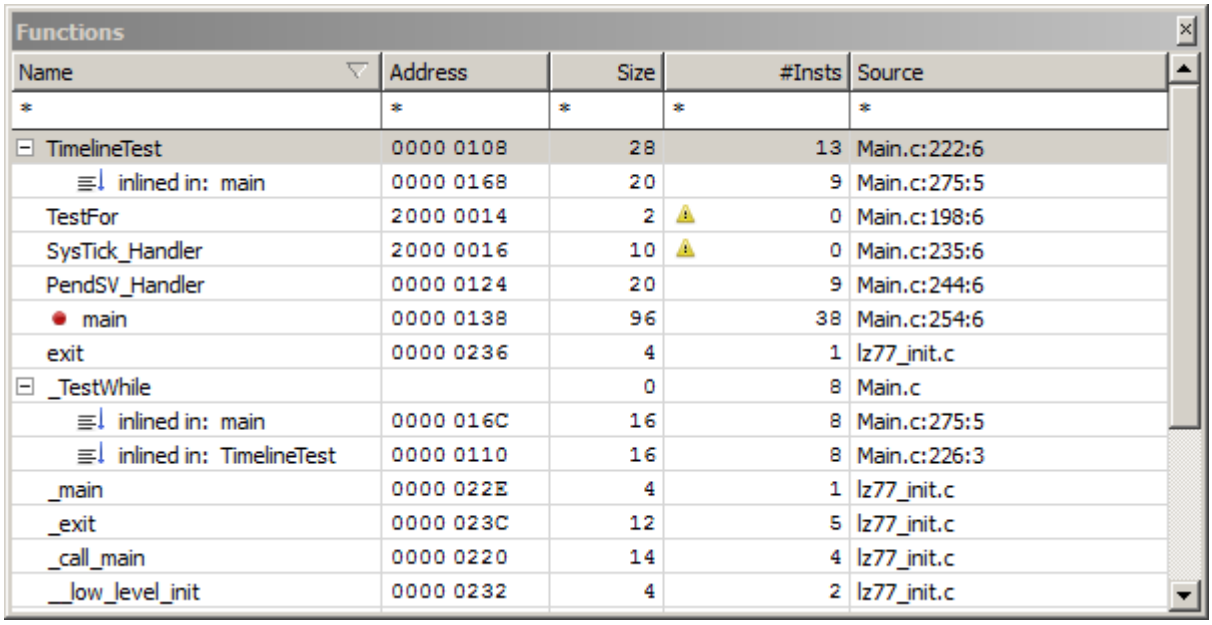
Displays the next match within the Source Viewer.

Show Previous Result

Displays the previous match within the Source Viewer.

4.9 Functions Window

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



Note

When a function is missing from the Functions Window, it was not linked into the executable image of the debuggee. This is in most cases the result of a compiler/linker optimization.

4.9.1 Function Properties

The Functions Window displays the following information about functions:

Table Column	Description
Name	Name of the function.
Address	base address of the function's machine code.
Size	Byte size of the function's machine code.
#Insts	Number of instructions encompassed by the function.
Source	Source code implementation location of the function.

#Insts: instruction-level information may not be accessible to Ozone before debug session startup completion (see *Startup Completion Point* on page 188). Ozone will display a warning sign next to table values which may be unavailable due to this reason (see the title figure).

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. Function `_TestWhile` is inline-expanded within within functions `main` and `TimelineTest`.

4.9.3 Context Menu

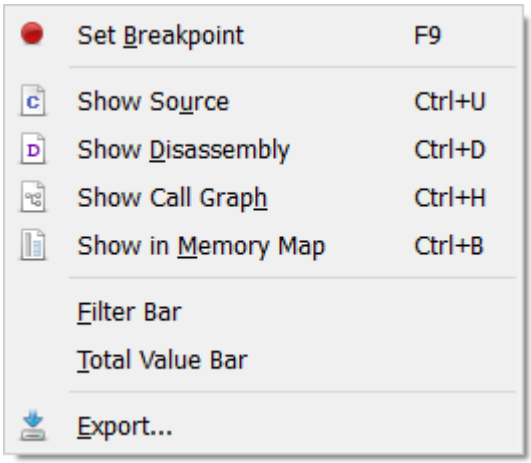
The Function Windows' context menu hosts actions that navigate to a function's source code or assembly code line (see *Show Actions* on page 295).

Set Clear Breakpoint

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

Show Source

Displays the first source code line of the selected function within the Source Viewer (see *Source Viewer* on page 156). If an inline expansion site is selected, this site is shown instead.



Show Disassembly

Displays the first machine instruction of the selected function within the Disassembly Window (see *Disassembly Window* on page 117). If an inline expansion site is selected, this site's first machine instruction is displayed instead.

Show Call Graph

Displays the call graph of the function within the Call Graph Window (see *Call Graph Window* on page 99).

Show In Memory Map

Displays the function symbol within the Memory Usage Window (see *Memory Usage Window* on page 139).

Filter Bar / Total Value Bar

Toggles the named table header bar.

Export

Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.9.4 Breakpoint Indicators

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

4.9.5 Function Display Names

The display of function names can be configured via the following user preferences (see *User Preference Dialog* on page 86):

User Preference	Description
PREF_SHOW_FUNC_TYPE_SIGNATURES	Append the type signature to the function name.
PREF_PREFIX_FUNC_CLASS_NAMES	Prepend the class name to C++ member function names.

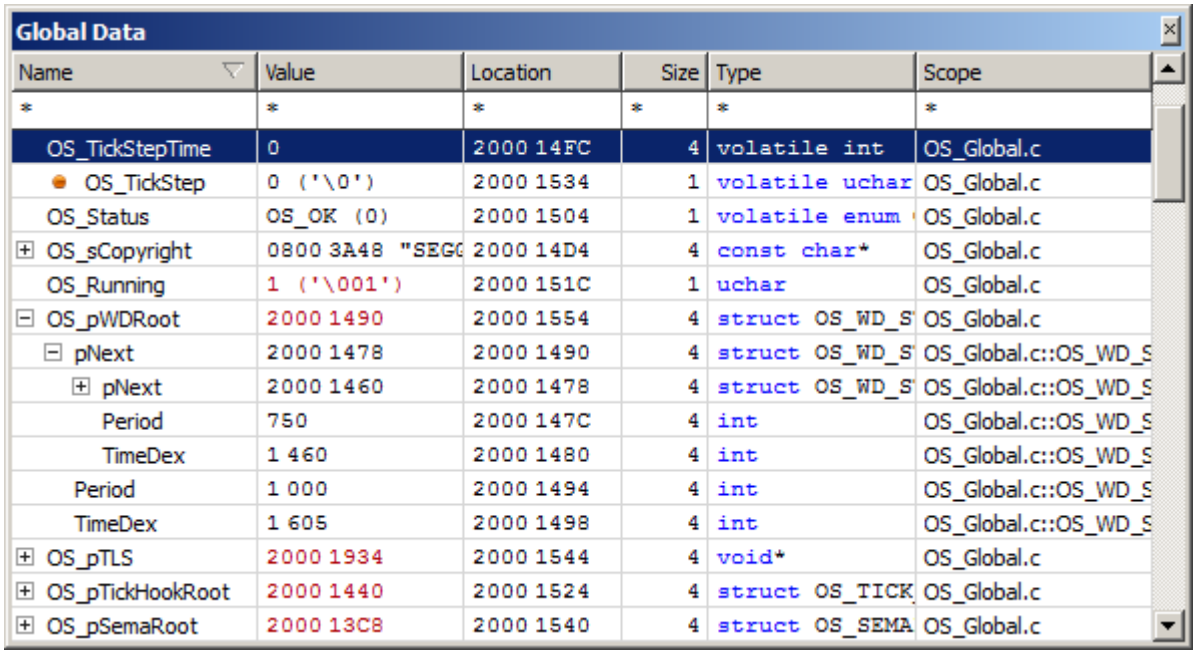
The above settings apply to the functions window and to all GUI elements that display function names. This includes debug windows, export dialogs and drop-down lists.

4.9.6 Table Window

The Function Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 58).

4.10 Global Data Window

Ozone's Global Data Window displays the list of global program variables used by the debuggee.



> **Note**
>
> When a variable is missing from the Global Data Window, it was not linked into the data image of the debuggee. This is in most cases the result of a compiler/linker optimization.

4.10.1 Table Window

The Global Data Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 58).

4.10.2 Data Breakpoint Indicator

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

4.10.3 Context Menu

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

Set/Clear/Edit Data Breakpoint

Sets/clears/edits a data breakpoint on the selected global variable (see *Data Breakpoints* on page 194).

Watch

Adds the selected global variable to the Watched Data Window.

Quick Watch

Shows the selected global variable within the Quick Watch Dialog.

Graph

Adds the selected global variable to the Data Sampling Window.

Show Value in Source

Displays the source code declaration location of the symbol pointed to within the Source Viewer. Only shown for pointer-type variables.

Show Value in Disassembly

Displays the disassembly location of the symbol pointed to within the Disassembly Window. Only shown for pointer-type variables.

Show Value in Data

Displays the memory location of the symbol pointed to within the Memory Window. Only shown for pointer-type variables.

Show Source

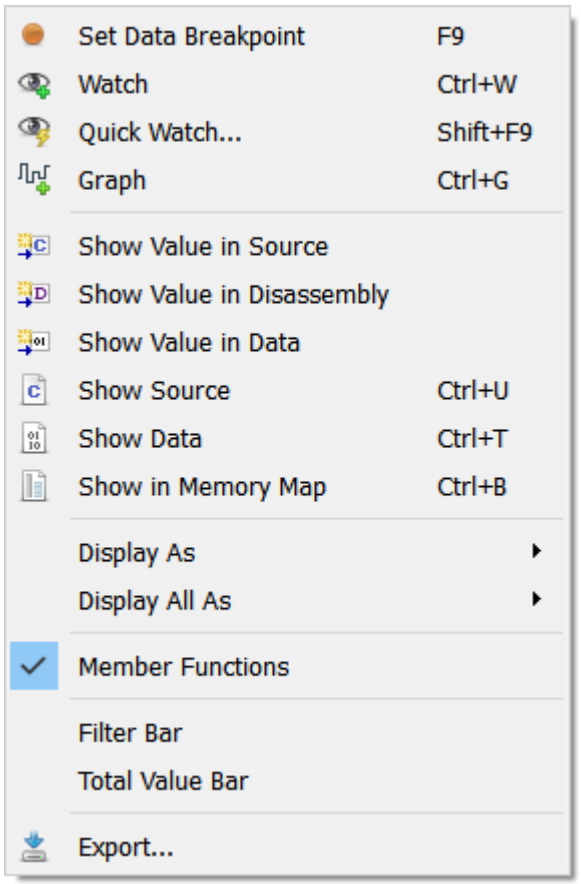
Displays the source code declaration location of the selected global variable within the Source Viewer (see *Source Viewer* on page 156).

Show Data

Displays the data location of the selected local variable in either the Memory Window (see *Memory Window* on page 135) or the Registers Window (see *Registers Window* on page 147).

Show In Memory Map

Displays the data location of the selected local variable within the Memory Usage Window (see *Memory Usage Window* on page 139).



Display (All) As

Changes the display format of the selected global variable or of all global variables (see *Display Format* on page 58).

Expand / Collapse All

Expands or collapses all top-level nodes.

Member Functions

Toggles the display of class member functions.

Filter Bar / Total Value Bar

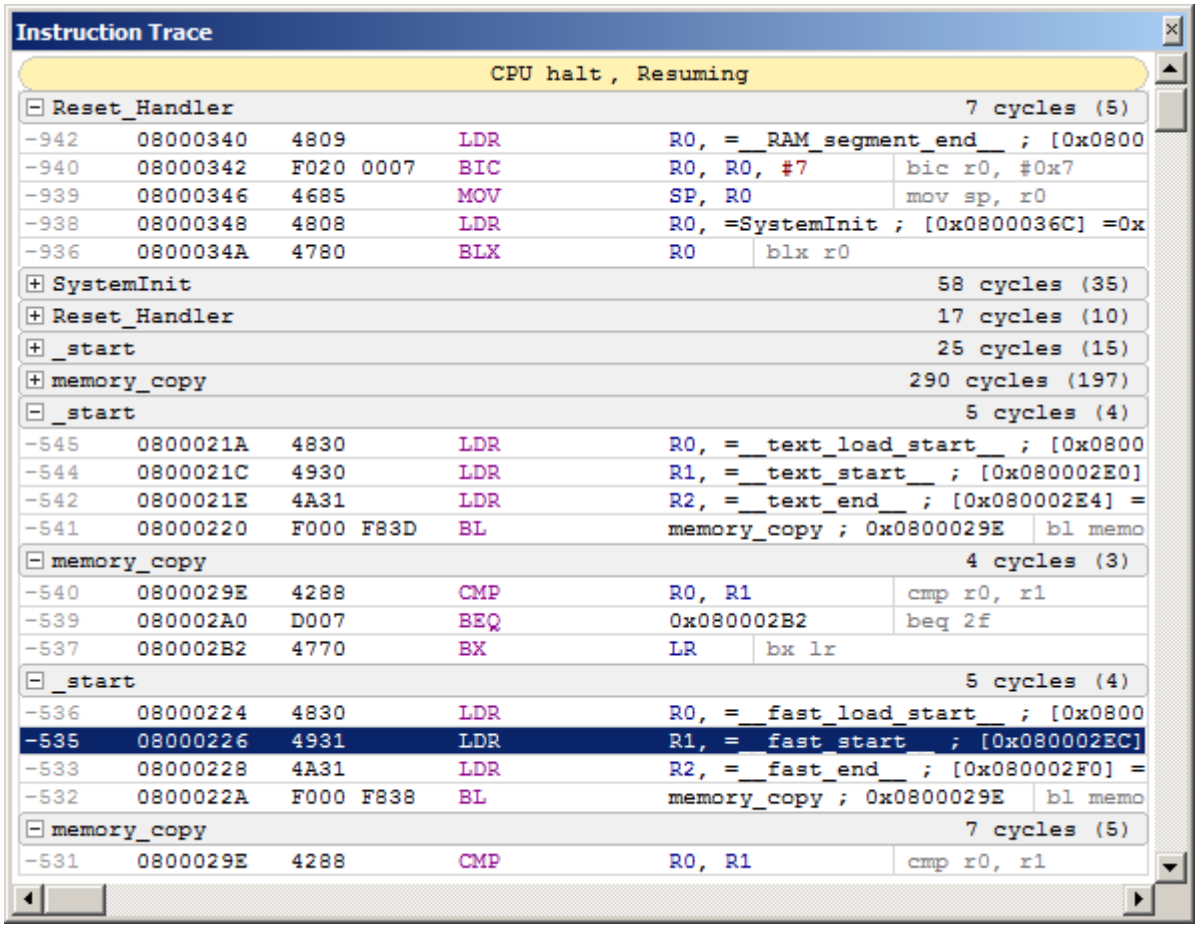
Toggles the named table header bar.

Export

Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

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 210 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.

4.11.4 Trace Blocks

The instruction stack is partitioned into trace blocks. A trace block contains the instructions that were executed between two consecutive program halt events. Each time the target halts on a new PC, an additional trace block is appended to the bottom of the instructions stack.

A trace block may not contain all instructions that were executed between two consecutive halt events. This may be due to hardware limitations, such as a finite trace buffer capacity, or due to the software limit opposed by VAR_TRACE_MAX_INST_CNT. As a result, trace blocks may be disconnected.

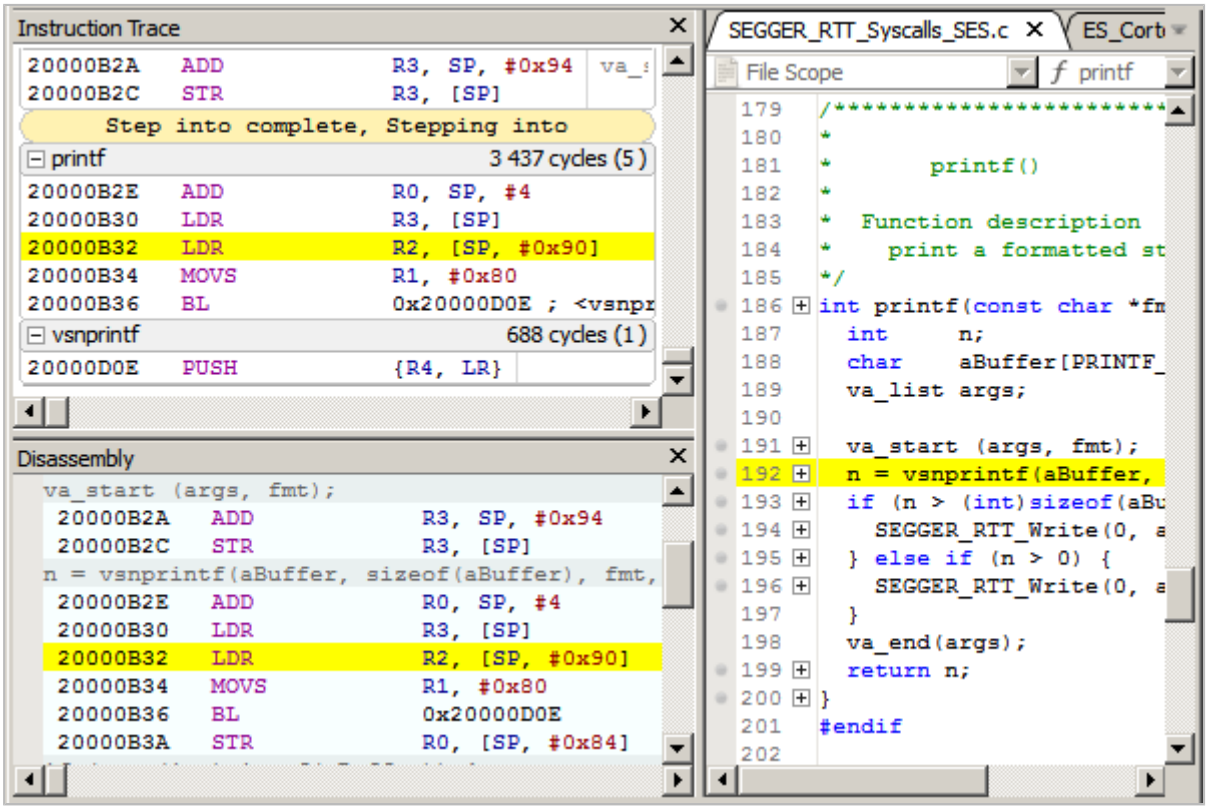
Each trace block has got a header bar which acts as a visual separator between trace blocks. The trace block header informs about the debug event that caused the program to halt and also informs about the debug event that caused the program to resume.

4.11.5 Call Frames

A trace block is partitioned into a set of call frames. Each call frame contains the set of instructions that were executed between entry to and exit from a program function. Call frames can be collapsed or expanded to hide or reveal the affiliated instructions.

The header of a call frame informs about the function name, the number of instructions executed and the total CPU time spend in the call frame.

4.11.6 Backtrace Highlighting



Both code windows highlight the instruction that is selected within the Instruction Trace Window. This enables 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 command Edit.Color (see *Edit.Color* on page 309) or via the User Preference Dialog (see *User Preference Dialog* on page 86). The backtrace highlighting feature can be toggled via the User Preference Dialog or via the context menu of the Instruction Trace Window.

4.11.7 Text Search

Ozone provides the Find In Trace Dialog to perform text pattern searches within the data contents of the Instruction Trace Window.

4.11.8 Key Bindings

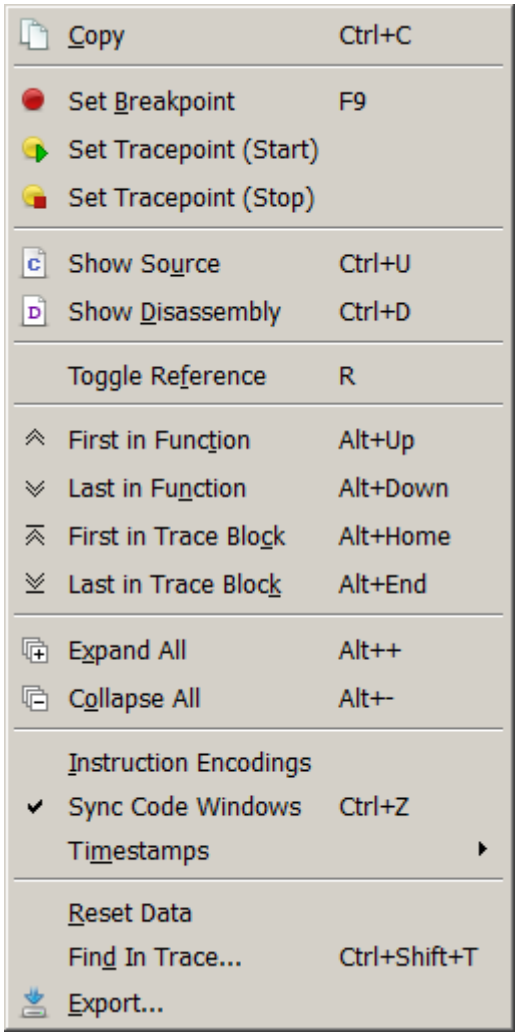
The table below provides an overview of the Instruction Trace Window's special-purpose key bindings.

Hotkey	Description
+	Expands the selected call frame.
–	Collapses the selected call frame.
Alt+Up	Selects and scroll to the first (topmost) instruction of the call frame.
Alt+Down	Selects and scroll to the last (bottommost) instruction of the call frame.
Alt+Home	Selects and scroll to the first (topmost) instruction of the trace block.
Alt+End	Selects and scroll to the last (bottommost) instruction of the trace block.

Next to these keyboard shortcuts, the Instruction Trace Window also supports the standard hotkeys provided by debug windows (see *Standard Shortcuts* on page 52) and code windows {see *Text Cursor Navigation Shortcuts* on page 56}.

4.11.9 Context Menu

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



Copy

Copies the selected text to the clipboard.

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 212).

Show Source

Displays the source code line associated with the selected instruction in the Source Viewer (see *Source Viewer* on page 156)

Show Disassembly

Displays the selected instruction in the Disassembly Window (see *Disassembly Window* on page 117)

Toggle Reference

Toggles the time reference point on the selected instruction.

Clear All References

Clears all time reference points

Go To Reference

Scrolls to the time reference point preceding the

selected instruction.

First in Function

Scrolls to the least recent instruction of the selected call frame.

Last in Function

Scrolls to the most recent instruction of the selected call frame.

First in Trace Block

Scrolls to the least recent instruction of the current trace block.

Last in Trace Block

Scrolls to the most recent instruction of the current trace block.

Expand/Collapse All

Expands/Collapses all call frame.

Instruction Encodings

Toggles the display of instruction encodings.

Timestamps

Selects the time stamp format (see *Trace Timestamp Formats* on page 269).

Reset Data

Resets the session’s trace and sampling data. This action can also be executed from the project script using command Timeline.Reset (see *Timeline.Reset* on page 363).

Find In Trace

Opens the Find In Trace Dialog with the word under the cursor (see *Find In Trace Dialog* on page 73).

Export

Opens a dialog that enables users to export the window contents to a CSV file. This action can also be executed from the project script using command Export.Trace.

4.11.10 Instruction Trace Window Preferences

Section *Instruction Trace Window Settings* on page 88 lists all user preference settings pertaining to the Instruction Trace Window.

4.11.11 Selective Tracing

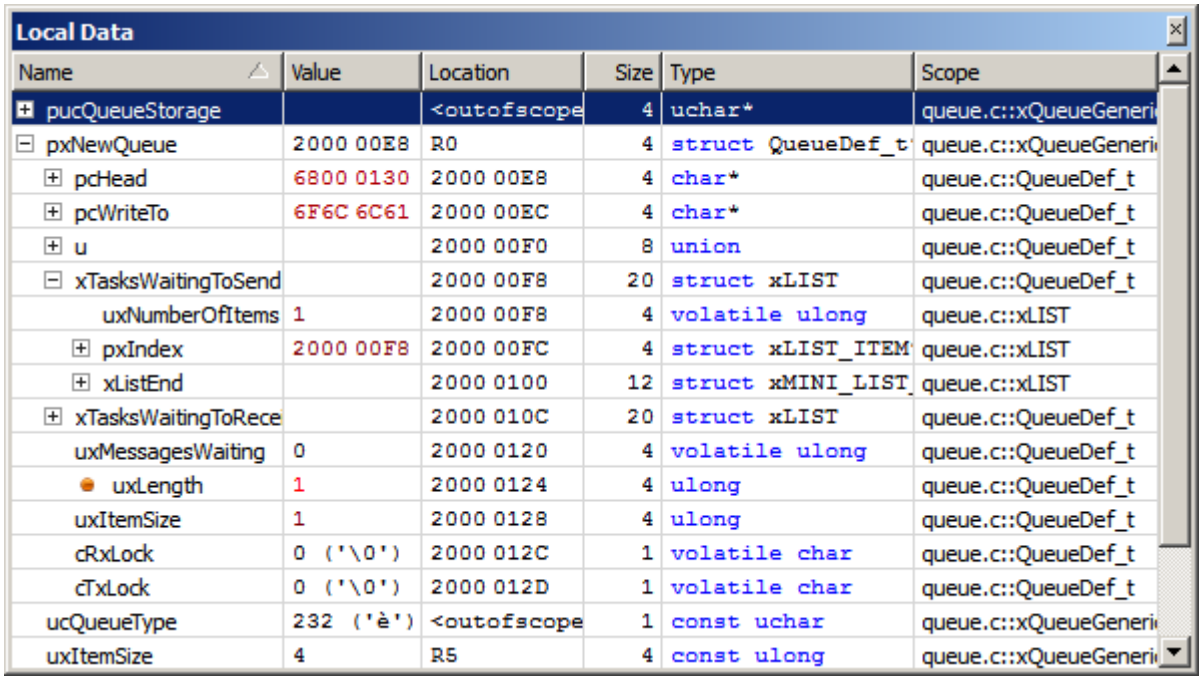
Ozone can instruct the target to constrain trace data output to individual address ranges (see *Tracepoints* on page 212). When selective tracing is active, it acts as a hardware prefilter of trace data.

4.11.12 Limitations

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

4.12 Local Data Window

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



4.12.1 Overview

The Local Data Window enables 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.

4.12.2 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.

4.12.3 Data Breakpoint Indicator

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

4.12.4 Context Menu

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

Set/Clear/Edit Data Breakpoint

Sets/clears/edits a data breakpoint on the selected symbol (see *Data Breakpoints* on page 194).

Watch

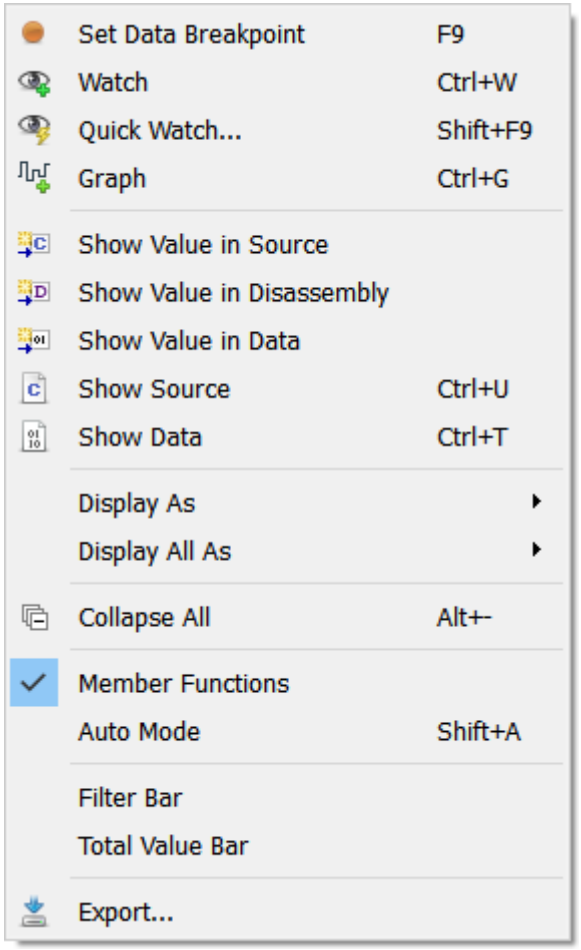
Adds the selected local variable to the Watched Data Window (see *Watched Data Window* on page 176).

Quick Watch

Shows the selected local variable within the Quick Watch Dialog (see *Quick Watch Dialog* on page 94).

Graph

Adds the selected local variable to the Data Sampling Window (see *Data Sampling Window* on page 114).



Show Value in Source

Displays the source code declaration location of the symbol pointed to within the Source Viewer. Only shown for pointer-type variables.

Show Value in Disassembly

Displays the disassembly location of the symbol pointed to within the Disassembly Window. Only shown for pointer-type variables.

Show Value in Data

Displays the memory location of the symbol pointed to within the Memory Window. Only shown for pointer-type variables.

Show Source

Displays the source code declaration location of the selected local variable in the Source Viewer (see *Source Viewer* on page 156).

Show Data

Displays the data location of the selected local variable in either the Memory Window (see *Memory Window* on page 135) or the Registers Window (see *Registers Window* on page 147).

Display (All) As

Changes the display format of the selected symbol or of all symbols (see *Display Format* on page 58).

Expand / Collapse All

Expands or collapses all top-level nodes.

Member Functions

Toggles the display of class member functions. This item is only visible when the debuggee's source language is C++.

Auto Mode

Specifies whether the "auto mode" display option is active (see *Auto Mode* on page 132).

Filter Bar / Total Value Bar

Toggles the named table header bar.

Export

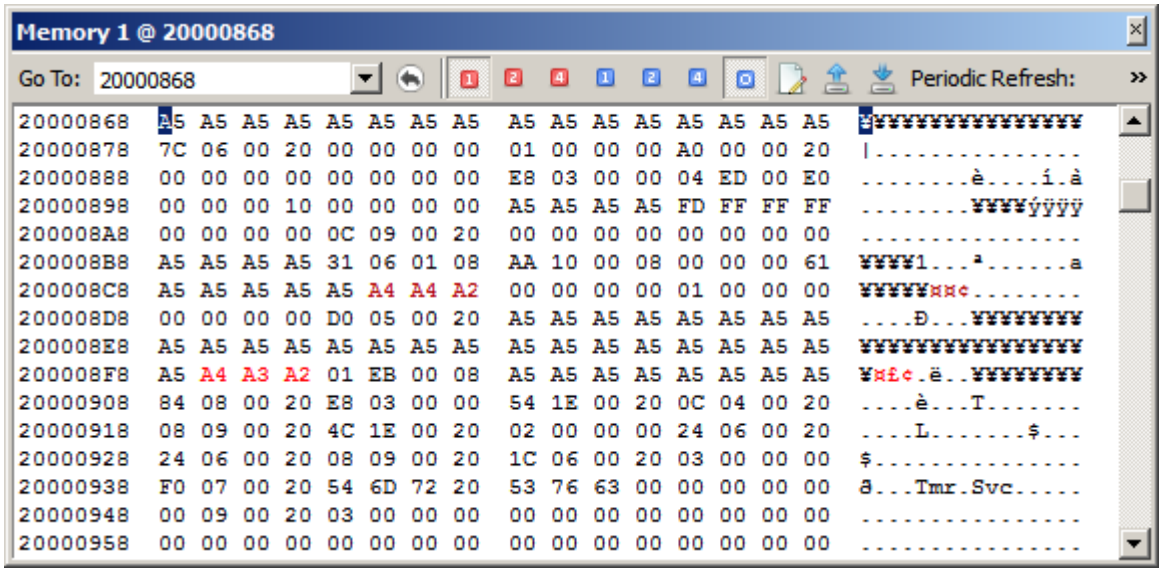
Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.12.5 Table Window

The Local Data Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 58).

4.13 Memory Window

Ozone's Memory Window enables users to observe and edit target memory content.



4.13.1 Window Layout

The memory window displays target memory content using the following layout:

Address Section

The data column on the left side of the Memory Window displays the row's start address.

Hex Section

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

4.13.2 Base Address

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

4.13.2.1 Setting the Base Address

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

- via command Show.Data.
- 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`

Input Format	Example
Register Name	SP
Expression	`OS_Global->pTask + 0x4`

For details on supported expressions, see *Working With Expressions* on page 205. When the base address input has a deducible byte size, the corresponding address range is selected and highlighted.

4.13.3 Drag & Drop

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

4.13.4 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 can be shown and hidden via the context menu entry "Toolbar". If this entry is checked, the toolbar is shown, if it is unchecked, the toolbar is hidden.

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 *Memory Dialog* on page 75)

Save Memory Data

Opens the *Save Memory Dialog* (see *Memory Dialog* on page 75)

Load Memory Data

Opens the *Load Memory Dialog* (see *Memory Dialog* on page 75)

Periodic Refresh

Specifies the periodic refresh interval while the program is running (see *Periodic Update* on page 137).

4.13.5 Memory Dialog

The *Fill Memory*, *Save Memory* and *Load Memory* features of the Memory Window are implemented by means of the Memory Dialog (see *Memory Dialog* on page 137).

4.13.6 Change Level Highlighting

The Memory Window employs change level highlighting (see *Change Level Highlighting* on page 137).

4.13.7 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.

4.13.8 User Input

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

4.13.9 Copy and Paste

The Memory Window enables users to select memory regions and copy the selected content into the clipboard in one of multiple formats (see *Context Menu* on page 132). 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.

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

Show Disassembly

Displays the address under the cursor within the Disassembly Window (see *Disassembly Window* on page 117).

Show Data

Sets the base address to the address under the cursor.

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), word (4) or automatic (0) access.

Fill

Opens the Fill Memory Dialog (see *Memory Dialog* on page 137).

Save

Opens the Save Memory Dialog (see *Memory Dialog* on page 137).

Load

Opens the Load Memory Dialog (see *Memory Dialog* on page 137).

Go Back

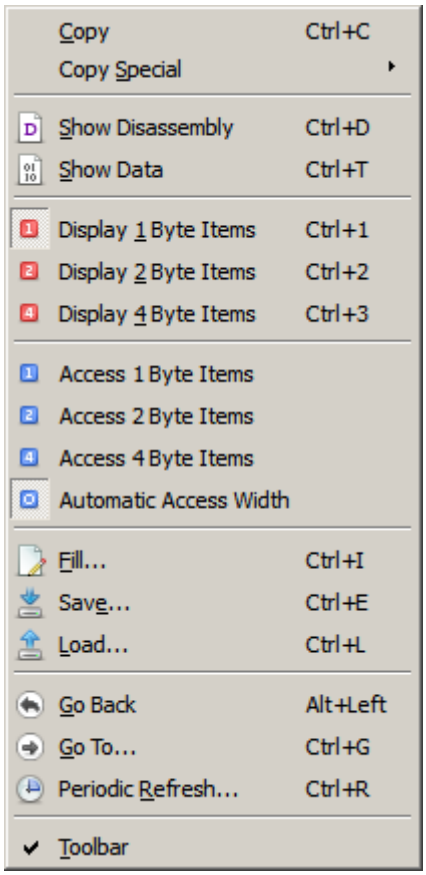
Sets the base address to its previous value.

Go To

Opens an input dialog that enables users to change the base address (see *Base Address* on page 135).

Toolbar

Opens the Auto Refresh Dialog from which the window's periodic update interval can be set (see *Periodic Update* on page 137).



Toolbar

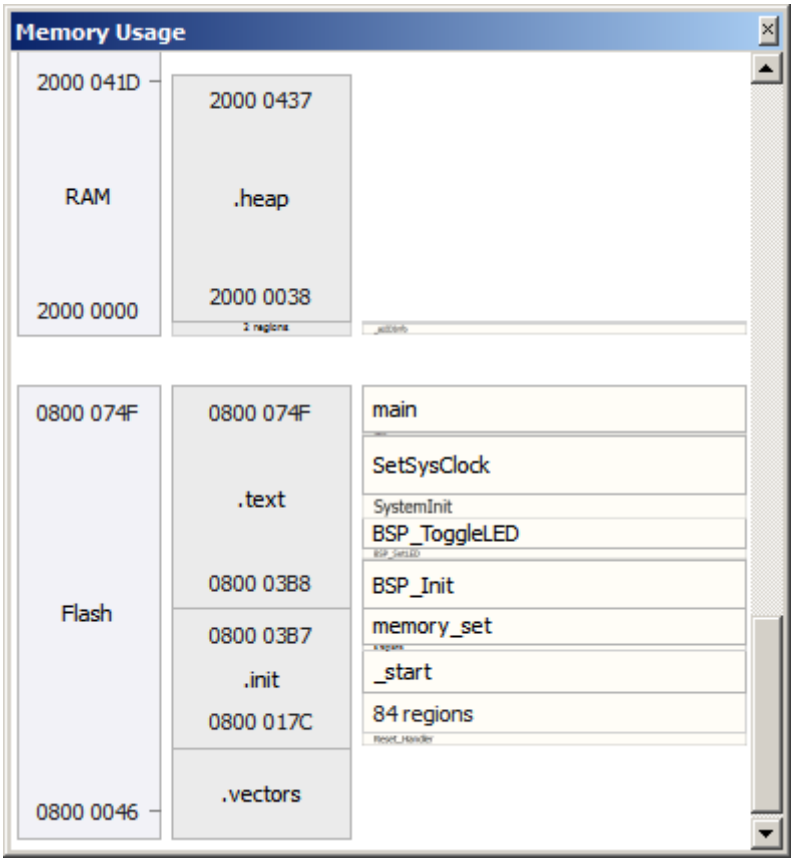
Toggles the display of the window's toolbar.

4.13.11 Multiple Instances

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

4.14 Memory Usage Window

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



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.

4.14.1 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

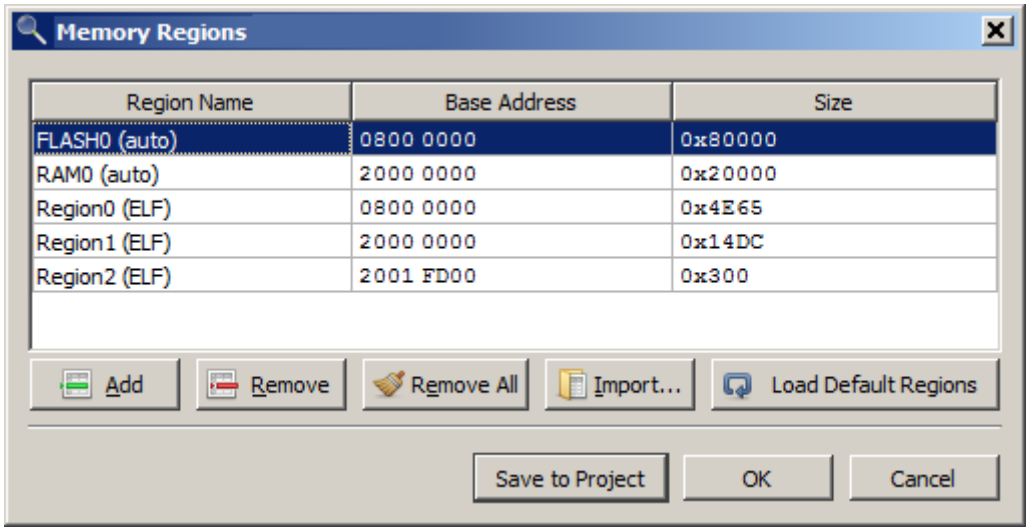
The right-hand column of the Memory Usage Window displays the arrangement of program symbols (functions and variables) within the containing data section.

4.14.2 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).

4.14.2.1 Supplying Memory Segment Information

Ozone obtains memory segment information from the memory map file that was set via command Target.LoadMemoryMap (see *Target.LoadMemoryMap* on page 362). Individual segments can be added to the memory map via command Target.AddMemorySegment (see *Target.AddMemorySegment* on page 363).



Memory segments can also be specified using the Memory Regions dialog shown above, which can be accessed from the context menu. Button “Import” adds memory segments from an Embedded Studio memory map file.

4.14.3 Interaction

This section describes how users can interact with the Memory Usage Window.

4.14.3.1 Scrolling

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

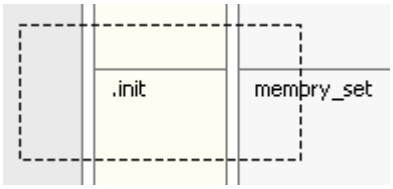
- via the window’s scrollbars.
- via the horizontal or vertical mouse wheel
- by clicking somewhere and dragging the clicked spot to a new location.

4.14.3.2 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.

Zooming via slider control in toolbar

The toolbar of the memory usage window offers a slider allowing to control the zoom level. The toolbar can be shown and hidden via the context menu entry "Toolbar". If this entry is checked, the toolbar is shown, if it is unchecked, the toolbar is hidden.

4.14.4 Context Menu

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

Set/Clear Breakpoint

Sets or clears a breakpoint on the selected function.

Show Source

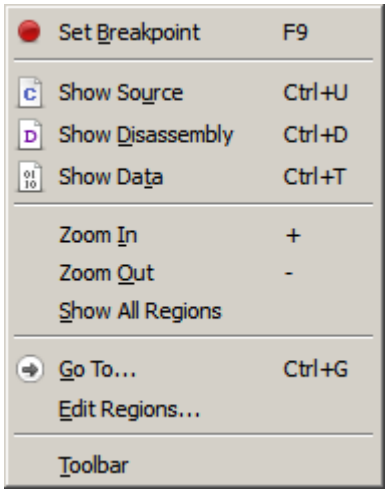
Shows the source code location of the selected memory region within the Source Viewer (see *Source Viewer* on page 156).

Show Disassembly

Shows the disassembly of with the selected memory region within the Disassembly Window (see *Disassembly Window* on page 117).

Show Data

Shows the selected memory region within the Memory Window (see *Memory Window* on page 135).



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.

Go To...

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

Edit Regions

Opens the memory segment dialog (see *Supplying Memory Segment Information* on page 140).

Toolbar

Toggles the display of the toolbar.

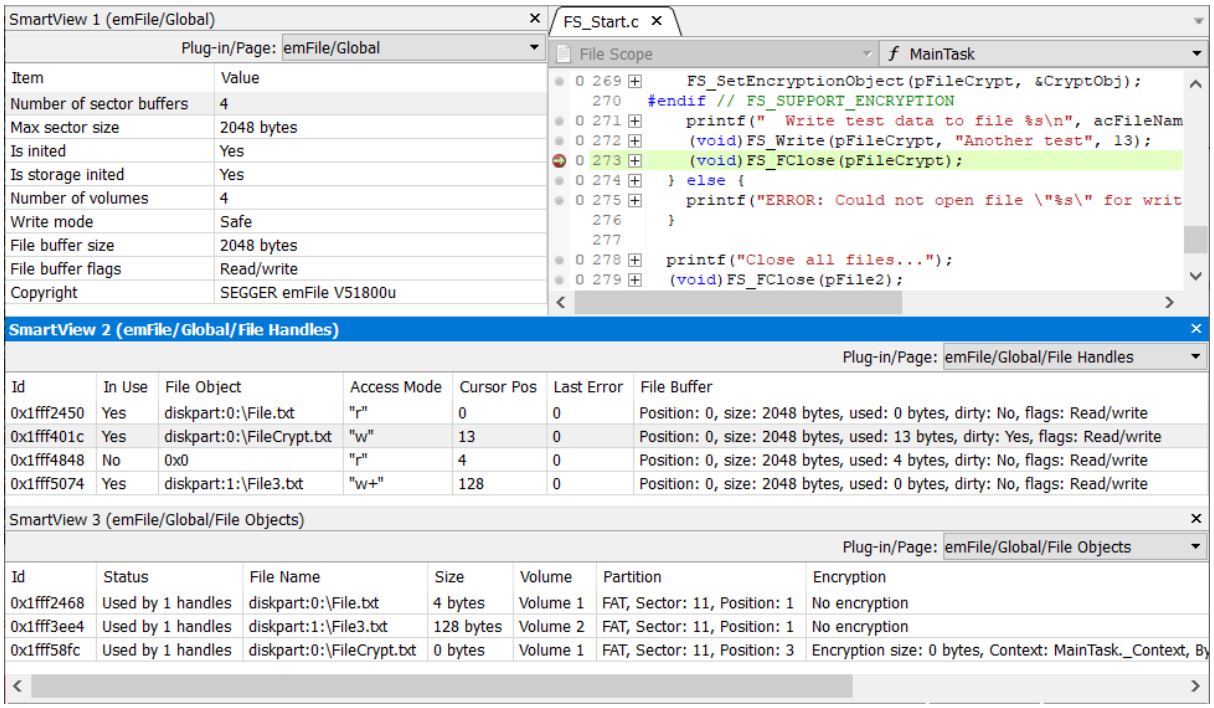
4.15 SmartView Window

The SmartView window allows an in-depth look into internal data structures of the application or the core by retrieving the information from the target and arranging it in an easy to comprehend table view. Linked lists, for example, can be examined inside the watched data window, each next pointer opening a new sub-tree containing the next element's data, however this is a bit cumbersome. The SmartView window allows stepping through the whole list, extract all the information or just the information of interest, and display the data of all list elements in a table.

Each plugin can provide multiple pages, allowing to focus on a different aspect of the respective target software.

Multiple plugins can be loaded at the same time. This is handy for target applications consisting of multiple building blocks (such as the SEGGER middleware libraries). Once a script is written for a building block it can be used in all applications where this building block is used, alongside the scripts for the other building blocks present in the respective target software.

Multiple SmartView windows may be opened at the same time. This allows for displaying multiple pages of multiple scripts at the same time.



Three SmartView Windows displaying emFile information.

4.15.1 SmartView Plugin Concept

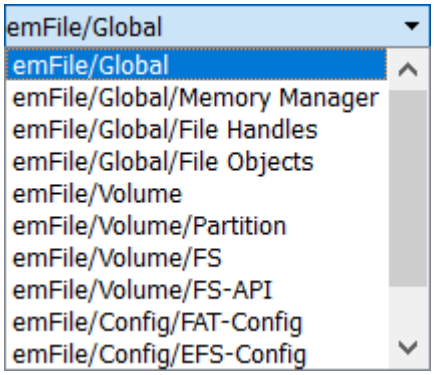
The SmartView window's logic is provided by a JavaScript plugin. By implementing a new plugin following the rules laid out in section *SmartView Plugin* on page 244 support for a new building block can be added to Ozone. It is also possible to quickly implement a script allowing for displaying the content of a complex data structure in user code in a comprehensive, human-readable way.

A plugin is loaded by means of the command *Project.SetSmartViewPlugin* on page 344. When this command is placed into project script function `OnProjectLoad`, the plugin will be loaded each time the project is opened. Refer to *Project File Example* on page 180 for further information.

4.15.1.1 Available SmartView Plugins

Middleware	File Name
emFile	`emFile.js`
emNet	`emNet.js`
uKOS-X	`uKOS.js`

4.15.2 Selecting Pages



The page to be displayed in a dedicated SmartView window can be selected via the drop-down box on the right side of the toolbar. If the toolbar is not visible it can be shown via the context menu (see section *Context Menu* on page 141).

The drop-down box displays all pages provided by all plugins which are currently loaded in the Ozone project. For each available page the plugin name precedes the page name.

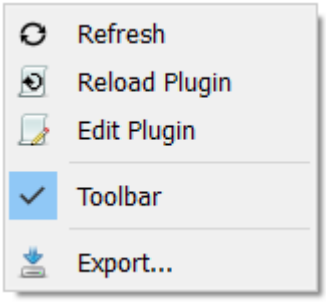
4.15.3 Context Menu

Refresh

Refreshes the content of the page currently displayed in the respective SmartView window.

Reload Plugin

Reloads the JavaScript plugin. This action must be triggered in order for changes to the script file to take effect.



Edit Plugin

Opens the JavaScript source code file within the Source Viewer, where it can be edited.

Toolbar

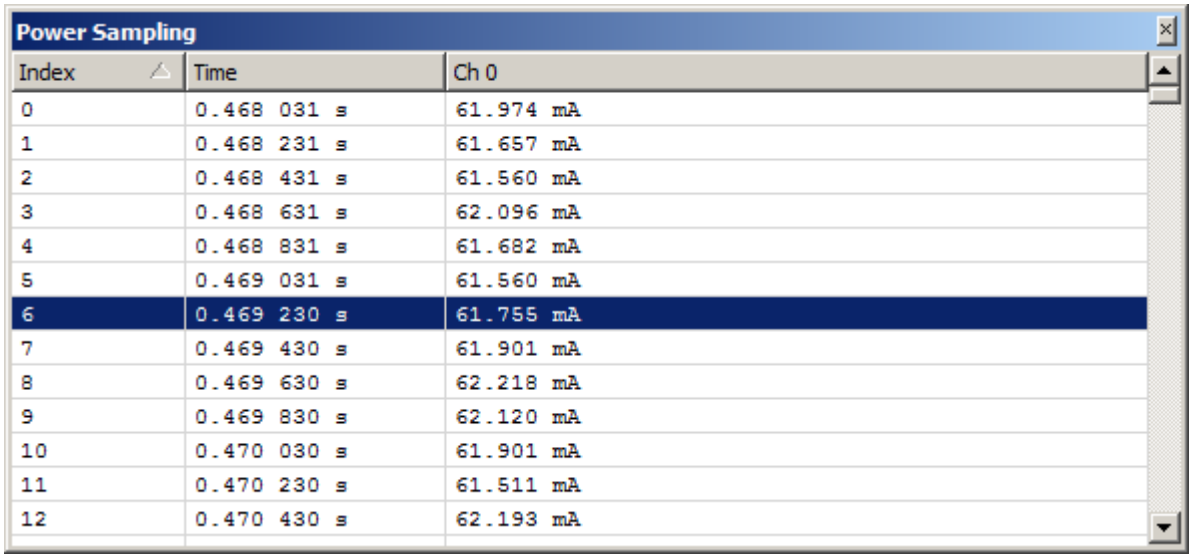
Shows or hides the toolbar. Allows gaining some space in the vertical dimension for content display on the cost of the ability to switch to a different page.

Export...

Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.16 Power Sampling Window

Ozone's Power Sampling Window employs SEGGER's Power Trace (PTRACE) API to track the current drawn by the target. The resulting sampling data is displayed in a tabular fashion.



4.16.1 Hardware Requirements

The Power Sampling Window requires the target to be powered by J-Link/J-Trace, i.e. over the debug interface. It is to a high degree target-dependent if power supply via the target interface is supported. Please contact SEGGER if unsure about the capabilities of your device.

In case your target does not support power via J-Link/J-Trace, you may still want to check out Ozone's power profiling capabilities using SEGGER's Cortex-M trace reference board.

4.16.2 Setup

Power output of the debug probe 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 script function `OnProjectLoad` (see *Event Handler Functions* on page 227).

Power sampling also requires that a positive sampling rate is configured, see below.

4.16.3 Sampling Frequency

The power sampling frequency can be adjusted via the context menu or via command Edit.SysVar using argument `VAR_POWER_SAMPLING_SPEED`. A sampling frequency of 0 disables power sampling.

The sampling frequency can be assigned persistently to the project by placing its command into project script function `OnProjectLoad`.

The sampling frequency can also be changed via the drop-down field in the toolbar. If the toolbar is not shown it can be made visibile via the context menu.

Power sampling starts automatically each time the program is resumed and stops automatically each time the program halts.

4.16.4 Data Limit

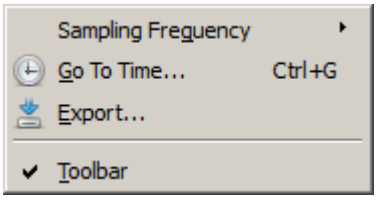
User preference PREF_MAX_POWER_SAMPLES sets the data limit of the power sampling window. The default data limit is 10M samples. When the data limit is reached, data acquisition will continue but the oldest samples will be overwritten.

4.16.5 Timeline

Power sampling data, together with symbol and instruction trace data, is visualized in a combined signal plot (see *Timeline Window* on page 165). This enables users to establish a link between target power consumption and program execution. To further support this correspondence, the selected table row of the Power Sampling Window is synchronized with the sample cursor of the Timeline Window.

4.16.6 Context Menu

The context menu of the Power Sampling Window provides the following actions:



Sampling Frequency

Selects the power sampling frequency.

Goto Time

Opens an input dialog that enables users to scroll to a particular table row.

Export

Opens a file dialog that enables users to export the sampling data to a CSV file. This action can also be executed from the project script using command Export.PowerGraphs.

Reset Data

Resets the session's sampling data. This action can also be executed from the project script using command Timeline.Reset (see *Timeline.Reset* on page 363).

Toolbar

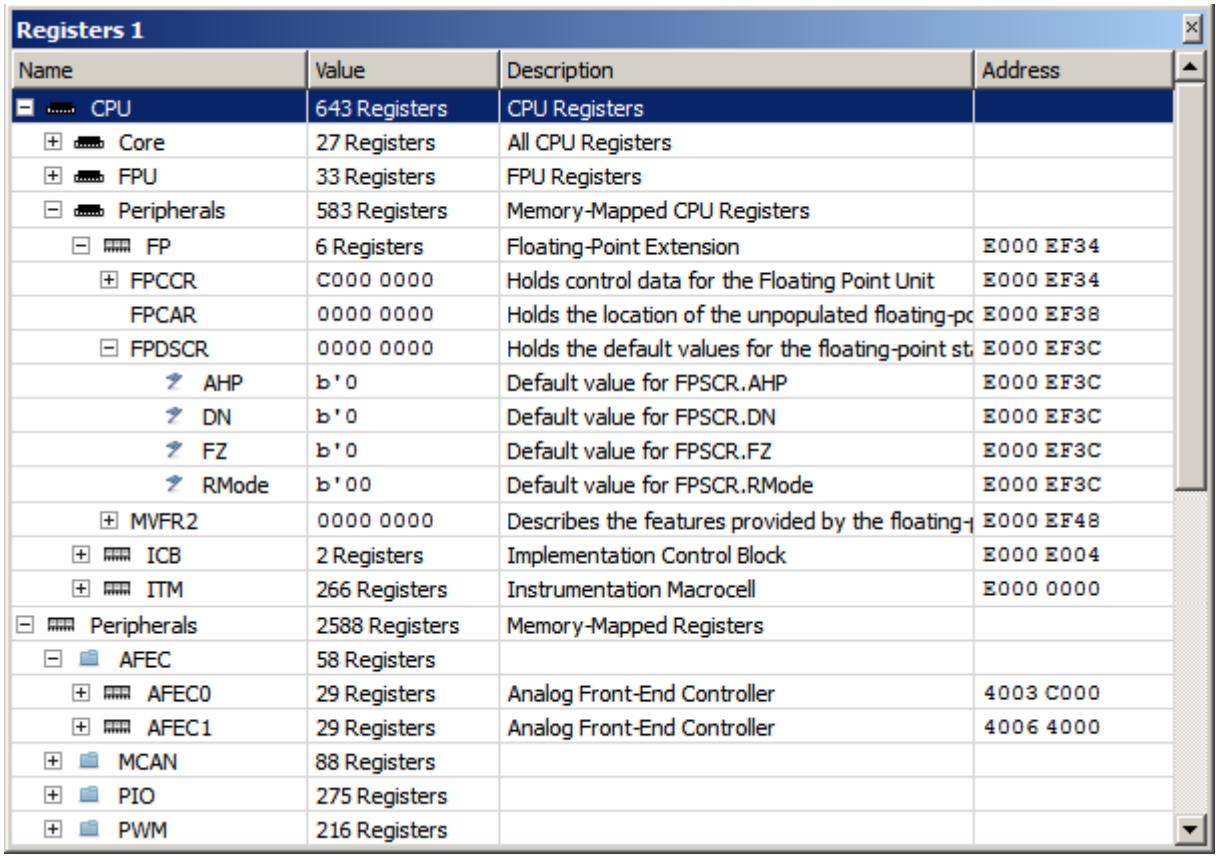
Toggles the toolbar.

4.16.7 Power Sampling Window Preferences

Section *Power Sampling Window Settings* on page 88 lists all user preference settings pertaining to the Power Sampling Window.

4.17 Registers Window

Ozone's Registers Window displays the state of the target's core, system and peripheral registers.



Registers window displaying Cortex-M peripherals.

4.17.1 SVD Files

The Registers 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.

Architecture-specific SVD-Files

Ozone ships with an SVD file for each supported target architecture. These files provide descriptions of all architecture-defined CPU, system and peripheral registers. Users select the SVD file that matches their target on the first page of the Project Wizard (see *Project Wizard* on page 35).

Vendor-specific SVD-Files

The project wizard also enables users to select an additional vendor-specific SVD file which describes the vendor-specific peripheral register set of the target. Note that Ozone does not ship with vendor-specific SVD files out of the box; users have to obtain the file from their MCU vendor.

Assigning SVD files to the Project

The SVD file selection can be assigned to a project by making corresponding calls to command Project.AddSvdFile from project script function `OnProjectLoad`. These calls are added automatically to Project Wizard generated projects.

4.17.2 Register Groups

The Registers Window partitions target registers into the following groups:

Core Registers (Now)

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

Core Registers (All)

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

FP Registers

Floating-point registers. This category is only available when the target includes a floating point unit.

System Registers (e.g. CP-15)

Architecture-defined registers that monitor and control system functions, such as coprocessor-15 registers on Cortex-A/R. As a defining criteria, these registers are mapped to machine instructions and not to memory. System registers can be accessed using commands Target.SetReg (see *Target.SetReg* on page 357) and Target.GetReg (see *Target.GetReg* on page 358).

Peripheral Registers (CPU)

Architecture-defined special function registers. As a defining criteria, these registers are memory-mapped. This group is shown below the CPU node.

Peripheral Registers

Implementation (or vendor)-defined special function registers. As a defining criteria, these registers are memory-mapped. This group is only shown when a vendor-specific register set description file was specified (see *SVD Files* on page 147).

Peripheral registers can be accessed using commands:

- Target.ReadU32 (see *Target.ReadU32* on page 359)
- Target.WriteU32 (see *Target.WriteU32* on page 358)
- Target.GetReg (see *Target.GetReg* on page 358)
- Target.SetReg (see *Target.SetReg* on page 357)

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 Registers 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 it’s 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

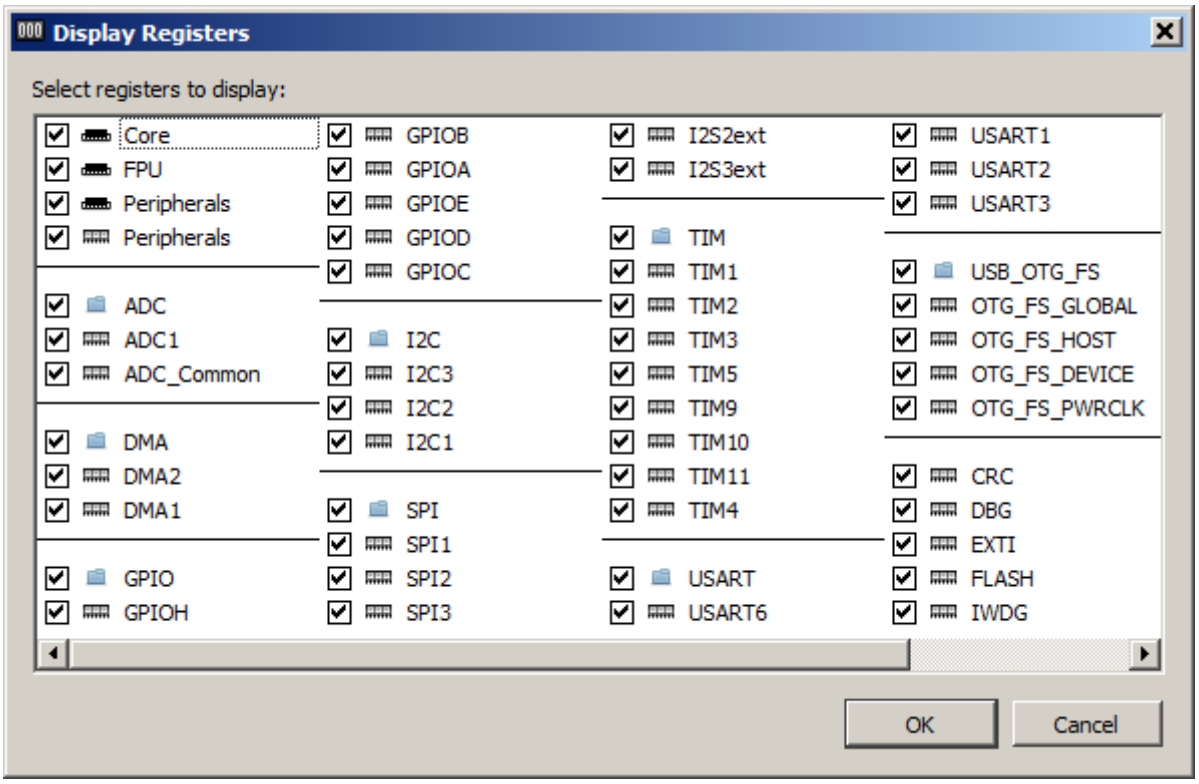
An ARM processor's current operating mode is displayed as the value of the current CPU registers group (compare with the title figure). An ARM processor can be in any of 7 operating modes:

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

ARM processor operating modes

4.17.5 Register Display

Accessible from the context menu, the Register Display dialog enables users to specify which registers and register groups are shown by the Registers Window and which ones are hidden from display.



4.17.6 Context Menu

The Registers Windows's context menu provides the following actions:

Show Source

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

Show Disassembly

Displays the disassembly at the register value.

Show Data

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

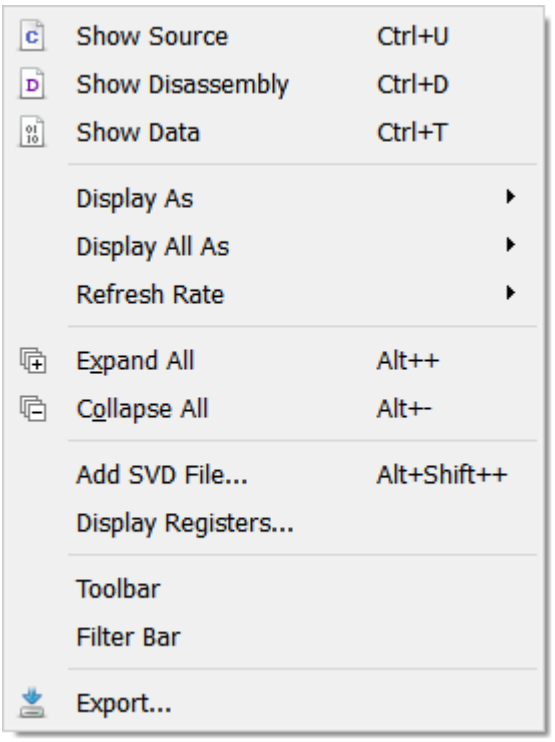
Display (All) As

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

Refresh Rate

Selects the refresh rate which is used to sample all peripheral registers that are selected for periodic update.

The refresh rate can also be specified via the drop-down-box in the toolbar. If the toolbar is not shown it may be enabled via the context menu.



Expand / Collapse All

Expands or collapses all top-level nodes.

Add SVD File

Opens a file dialog which enables users to add an extra SVD file to the debug session. The change is not persistent and will be lost when the project is closed.

Display Registers

Displays the Register Display dialog that enables users to define which registers are visible.

Toolbar / Filter bar

Toggles display of the toolbar or filter bar, respectively.

Export

Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.17.7 Table Window

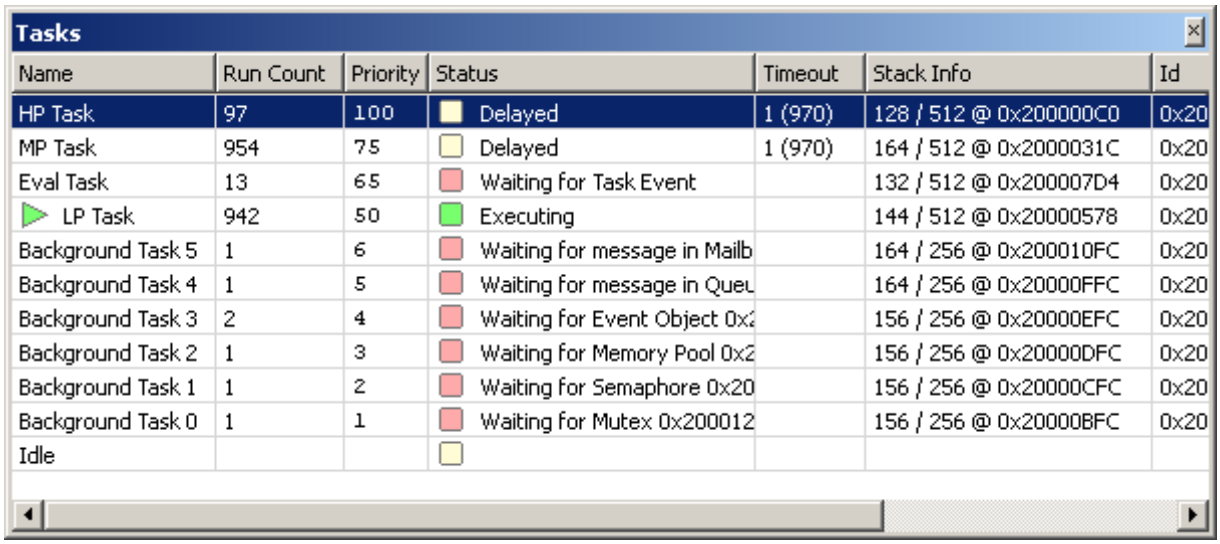
The Registers Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 58).

4.17.8 Multiple Instances

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

4.18 RTOS Window

Ozone's RTOS Window displays RTOS-specific application information and enables users to set the execution context of any RTOS task as the current context displayed by the debugger.



Tasks

Name	Run Count	Priority	Status	Timeout	Stack Info	Id
HP Task	97	100	Delayed	1 (970)	128 / 512 @ 0x200000C0	0x20
MP Task	954	75	Delayed	1 (970)	164 / 512 @ 0x2000031C	0x20
Eval Task	13	65	Waiting for Task Event		132 / 512 @ 0x200007D4	0x20
LP Task	942	50	Executing		144 / 512 @ 0x20000578	0x20
Background Task 5	1	6	Waiting for message in Mailb		164 / 256 @ 0x200010FC	0x20
Background Task 4	1	5	Waiting for message in Queu		164 / 256 @ 0x20000FFC	0x20
Background Task 3	2	4	Waiting for Event Object 0x2		156 / 256 @ 0x20000EFC	0x20
Background Task 2	1	3	Waiting for Memory Pool 0x2		156 / 256 @ 0x20000DFC	0x20
Background Task 1	1	2	Waiting for Semaphore 0x20		156 / 256 @ 0x20000CFC	0x20
Background Task 0	1	1	Waiting for Mutex 0x200012		156 / 256 @ 0x20000BFC	0x20
Idle						

RTOS Window displaying a task list.

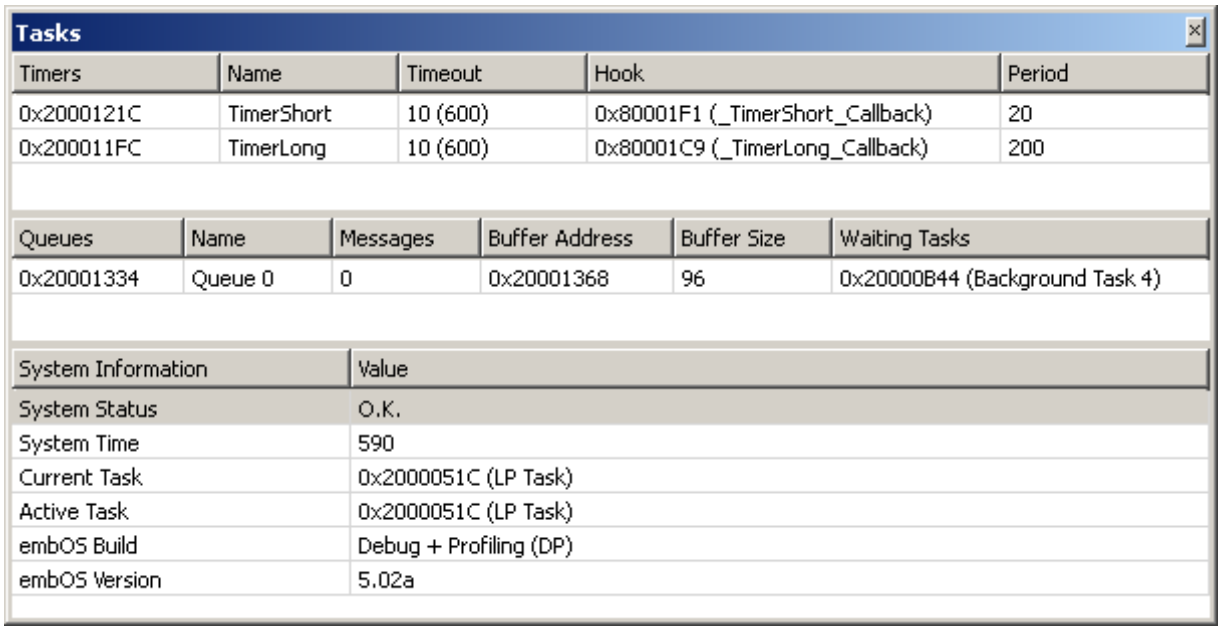
4.18.1 RTOS Plugin

The RTOS Window's application logic is provided by a JavaScript plugin. By implementing a new plugin following the rules laid out in section *RTOS Awareness Plugin* on page 237, support for a specific embedded operating system can be added to the RTOS Window.

Command *Project.SetOSPlugin* on page 343 loads an RTOS plugin. When this command is placed into project script function `OnProjectLoad`, the plugin will be loaded each time the project is opened. Refer to *Project File Example* on page 180 for further information.

Ozone ships with multiple RTOS-awareness plugins. See *Available RTOS Plugins* on page 152 for a complete list.

4.18.2 RTOS Informational Views



Tasks

Timers	Name	Timeout	Hook	Period
0x2000121C	TimerShort	10 (600)	0x80001F1 (_TimerShort_Callback)	20
0x200011FC	TimerLong	10 (600)	0x80001C9 (_TimerLong_Callback)	200

Queues	Name	Messages	Buffer Address	Buffer Size	Waiting Tasks
0x20001334	Queue 0	0	0x20001368	96	0x20000B44 (Background Task 4)

System Information	Value
System Status	O.K.
System Time	590
Current Task	0x2000051C (LP Task)
Active Task	0x2000051C (LP Task)
embOS Build	Debug + Profiling (DP)
embOS Version	5.02a

RTOS window showing multiple RTOS informational views.

Users – or rather RTOS plugin code – may add multiple tables to the RTOS Window, allowing the display of multiple types of RTOS information and resources. For example, a task list may be shown in one table and a semaphore list in another. Section *RTOS Awareness Plugin* on page 237 describes the programming possibilities of the RTOS Window in detail.

RTOS informational views are laid out vertically within the RTOS Window's display area and can be resized freely.

4.18.3 Task Context Activation

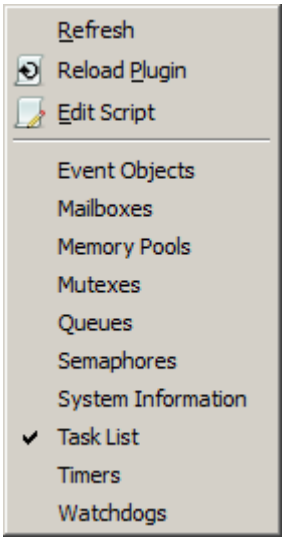
By activating a table row of the task list, the register set of the corresponding task is made the active execution context of the debugger. What this means is that:

- the Registers Window will show the values of the core registers at the time the task was interrupted or suspended.
- the Call Stack Window will show the function calling hierarchy at the execution point of the task.
- the Local Data Window will show the local variables and parameters at the execution point of the task.

Identifying the Active Task

The active task can be identified by the arrow icon displayed at the left side of its table row.

4.18.4 Context Menu



Refresh

Refreshes all RTOS informational views currently visible.

Reload Plugin

Reloads the JavaScript RTOS plugin. This action must be triggered in order for changes to the script file to take effect.

Edit Script

Opens the JavaScript RTOS plugin within the Source Viewer, where it can be edited.

Views

The context menu of the RTOS Window shows an entry for each RTOS informational view. By toggling an item, the affiliated view is shown or hidden.

4.18.5 Available RTOS Plugins

RTOS	File Name
ChibiOS	`ChibiOSPlugin.js`
embOS	`embOSPlugin.js`
embOS Ultra	`embOSUltraPlugin.js`
FreeRTOS for Cortex-A	`FreeRTOSPlugin_Cortex-A.js`
FreeRTOS for Cortex-M	`FreeRTOSPlugin_Cortex-M.js`
FreeRTOS for Legacy-ARM	`FreeRTOSPlugin_ARM.js`
FreeRTOS for RISC-V	`FreeRTOSPlugin_RISC-V.js`
NuttX	`NuttXPlugin.js`
ThreadX	`ThreadXPlugin.js`

RTOS	File Name
Zephyr	ZephyrPlugin.js

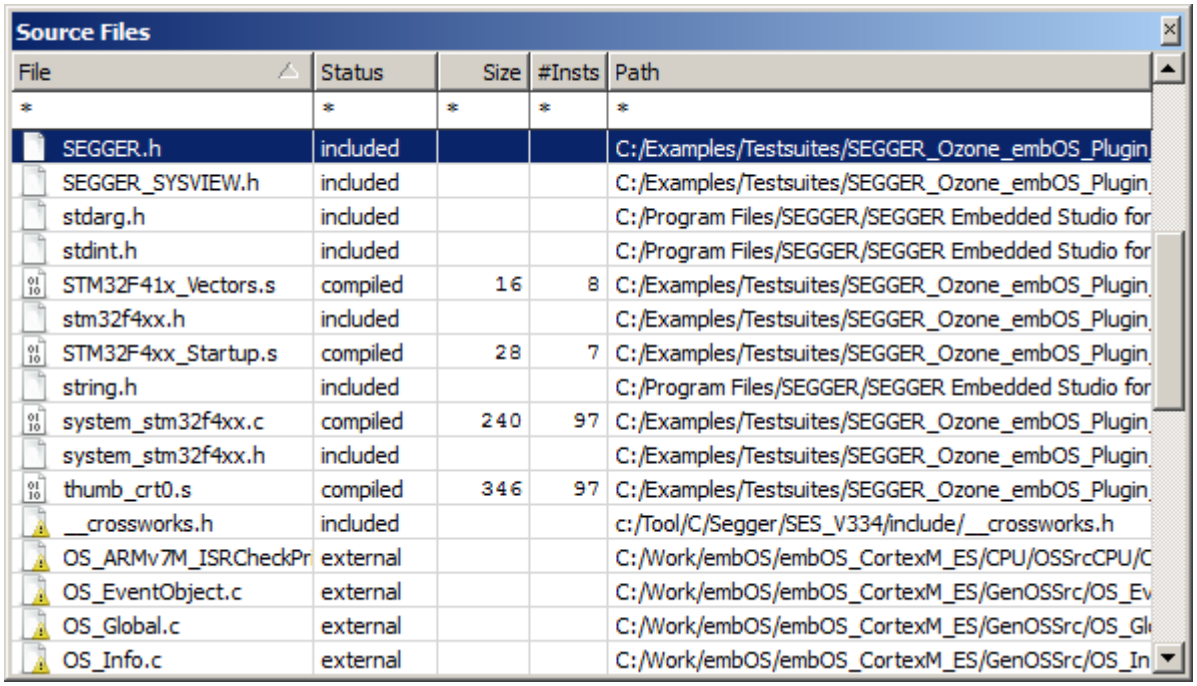
Following plugins are not maintained anymore and are left over for compatibility. They are subject to be removed in a future Ozone release.

- FreeRTOSPlugin_CA9.js
- FreeRTOSPlugin_CM0.js
- FreeRTOSPlugin_CM3.js
- FreeRTOSPlugin_CM4.js
- FreeRTOSPlugin_CM7.js

A programming guide for RTOS plugins is provided by section *RTOS Awareness Plugin* on page 237.

4.19 Source Files Window

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



4.19.1 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.

> **Note**
>
> Instruction-level information may not be accessible to Ozone before debug session startup completion (see *Startup Completion Point* on page 188). Ozone will display a warning sign next to table values which may be unavailable due to this reason.

Path

File system path of the source file.

4.19.2 Unresolved Source Files

A source file that the debugger could not locate on the file system is indicated

by a warning sign within the Source Files Window. Ozone supplies users with multiple options to locate missing source files (see *Locating Missing Source Files* on page 207). The user may also edit and correct file paths directly within the Source Files Window.

4.19.3 Context Menu

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

Show Source

Opens the selected file in the Source Viewer (see *Source Viewer* on page 156). 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.

Select In File Explorer

Selects the file within the default file explorer of the operating system.

Filter Bar / Total Value Bar

Toggles the named table header bar.

Export

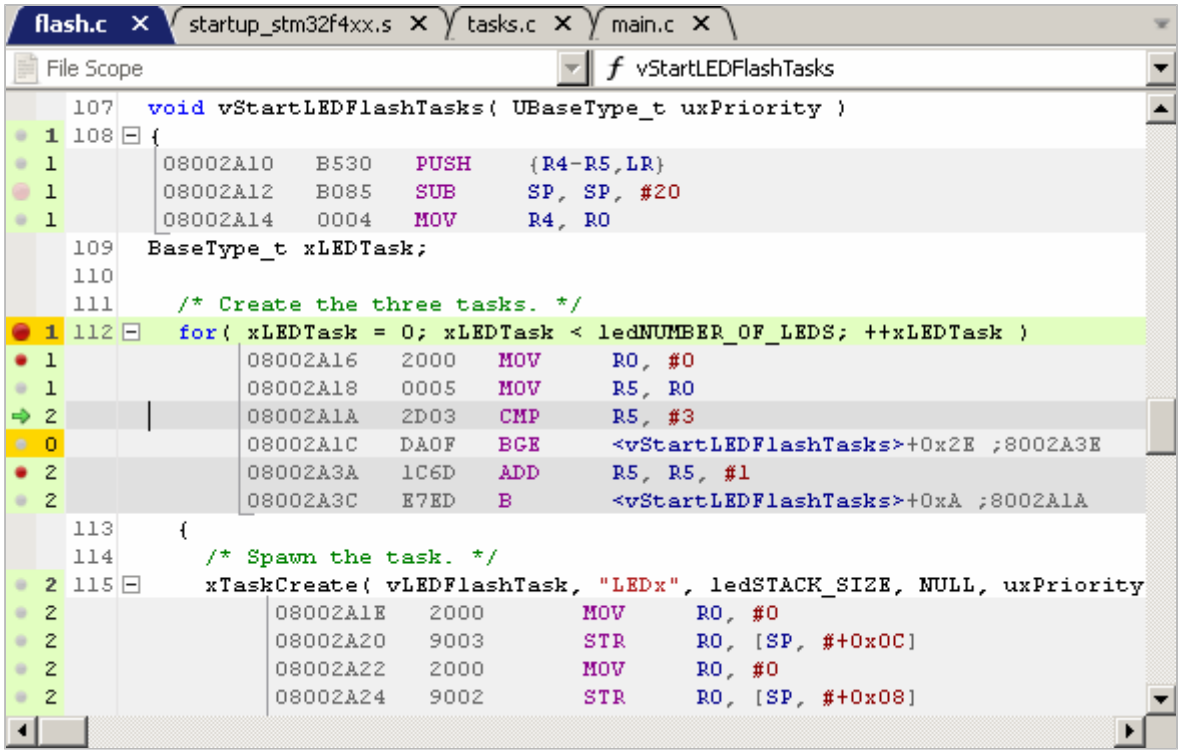
Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.19.4 Table Window

The Source Files Window shares multiple features with other table-based debug information windows (see *Table Windows* on page 58).

4.20 Source Viewer

The Source Code Viewer (or Source Viewer for short) enables 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.



4.20.1 Supported File Types

The Source Viewer is able to display text documents of any file extension. Syntax highlighting is limited to the following file types:

- C source code files: *.c, *.cpp, *.h, *.hpp, *.cc
- Assembly code files: *.s, *.asm, *.arm

4.20.2 Execution Counters

Within a switchable sidebar on the left, the Source Viewer may display the execution counts of individual source lines and instructions (see *Code Execution Counters* on page 55).

4.20.3 Opening and Closing Documents

Documents can be opened via the file dialog (see *File Menu* on page 45) or using commands File.Open and File.Close (see *File Actions* on page 292).

4.20.4 Editing Documents

Ozone's Source Viewer provides all standard text editing capabilities and keyboard shortcuts. Please refer to section *Key Bindings* on page 130 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.

4.20.5 Document Tab Bar

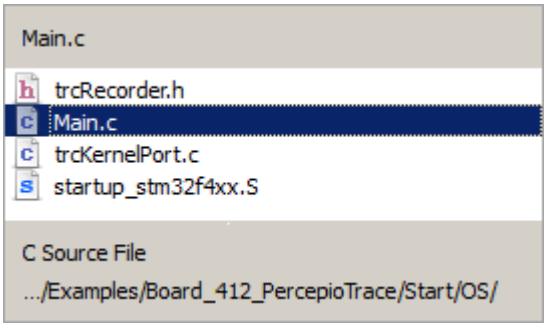
The document tab bar hosts a tab for each source code document that has been opened in the Source Viewer. The tab of the visible (or active) document is highlighted. Users can switch the active document by clicking on its tab or by selecting it from the tab bar's drop-down button. The drop-down button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

4.20.5.1 Tab Bar Context Menu

The tab bar's context menu hosts actions that can be used to close documents, to select the active document within the operating system's file explorer, and to reload the active document from disk.

4.20.5.2 Tab Selection Widget

Shortcut Ctrl+Tab brings up the Source Viewer's document tab selection widget. This widget facilitates the activation of document tabs. While the tab selection widget is visible, hotkeys Ctrl +Tab and Ctrl+Shift+Tab can be pressed to select the next or previous document tab, respectively. When the control key is released, the selected document is activated.



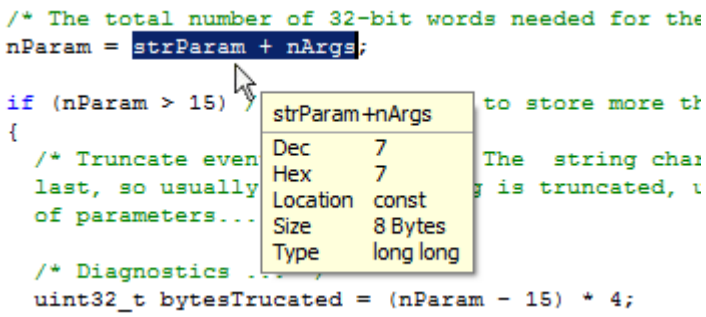
4.20.6 Document Header Bar

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.

4.20.7 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 Call Stack Window.

4.20.8 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 *Working With Expressions* on page 205).

4.20.9 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 190).

4.20.10 Key Bindings

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+Shift+Tab	Selects the previous 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.
F3	Finds the next occurrence of the current search string.
Ctrl+F3	Finds the next occurrence of the word under the cursor.

Next to these keyboard shortcuts, the source viewer also supports the standard hotkeys provided by debug windows (see *Standard Shortcuts* on page 52) and code windows {see *Text Cursor Navigation Shortcuts* on page 56}.

4.20.11 Syntax Highlighting

The Source Viewer applies syntax highlighting to source code. The syntax highlighting colors can be adjusted via command Edit.Color (see *Edit.Color* on page 309) or via the User Preference Dialog (see *User Preference Dialog* on page 86).

4.20.12 Source Line Numbers

The display of source line numbers can be toggled by executing command Edit.Preference using parameter `PREF_SHOW_LINE_NUMBERS` (see *Edit.Preference* on page 308) or via the User Preference Dialog (see *User Preference Dialog* on page 86).

4.20.13 Context Menu

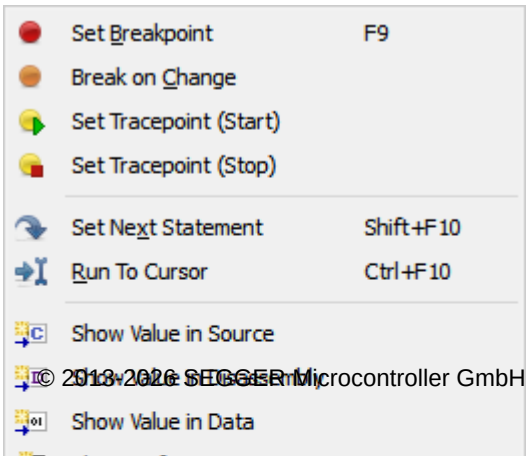
The Source Viewer's context menu provides the following actions:

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 212).

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.

Show Value in Source

Displays the source code declaration location of the symbol pointed to within the Source Viewer. Only shown for pointer-type variables.

Show Value in Disassembly

Displays the disassembly location of the symbol pointed to within the Disassembly Window. Only shown for pointer-type variables.

Show Value in Data

Displays the memory location of the symbol pointed to within the Memory Window. Only shown for pointer-type variables.

Show Definition

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

Show Declaration

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

Show Disassembly

Displays the first machine instruction of the selected source code line in the Disassembly Window (see *Disassembly Window* on page 117).

Show Data

Displays the data location of the symbol under the cursor within the Memory Window (see *Memory Window* on page 135).

Show Call Graph

Displays the call graph of the function under the cursor within the Call Graph Window (see *Call Graph Window* on page 99).

Show in Memory Map

Shows the symbol under the cursor within the Memory Usage Window (see *Memory Usage Window* on page 139). Call Graph Window (see *Call Graph Window* on page 99).

Watch

Adds the expression under the cursor to the Watched Data Window (see *Watched Data Window* on page 176).

Quick Watch

Shows the expression under the cursor within the Quick Watch Dialog (see *Quick Watch Dialog* on page 94).

Graph

Adds the expression under the cursor to the Data Sampling Window (see *Data Sampling Window* on page 114).

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.

Find

Opens the Quick Find Widget with the word under the cursor (see *Quick Find Widget* on page 92).

Find In Trace

Opens the Find In Trace Dialog with the word under the cursor (see *Find In Trace Dialog* on page 73).

Expand / Collapse All

Expands or Collapses all expandable lines within the current document.

Cut/Copy/Paste

Standard text editor actions.

Line Numbers

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

Execution Counters

Toggles the display of Code Execution Counters (see *Code Execution Counters* on page 55).

Instruction Encodings

Toggles the display of instruction encodings within inline assembly code.

Pseudo Instructions

Enables or disables pseudo-instruction display.

Export

Opens a file dialog that enables users to export the content of the current source window, including side bar information, to a CSV file. This action can also be executed from the project script using command Window.Export.

4.20.14 Font

The Source Viewer's font can be adjusted by executing command Edit.Font (see *Edit.Font* on page 310) or via the User Preference Dialog (see *User Preference Dialog* on page 86).

Quick Adjustment of the Font Size

The font size can be quick-adjusted by scrolling the mouse wheel while holding down the control key. This action will also bring up the font size selection widget shown to the right. The font size selection

widget provides additional controls that facilitate font resizing. It can be used to save the selected font size session-persistently and to reset the font size to the last saved value.

4.20.15 Code Window

The Source Viewer shares multiple features with Ozone's second code window, the Disassembly Window. Refer to *Code Windows* on page 53 for a shared description of these windows.

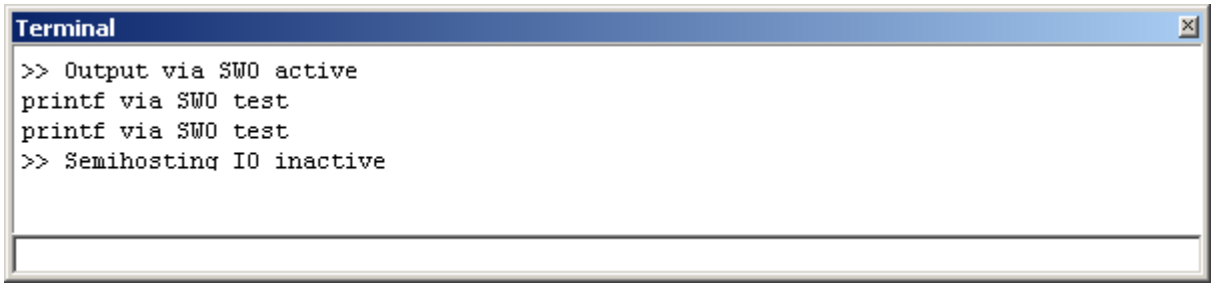
4.20.16 Source Viewer Preferences

Section *Source Viewer Settings* on page 89 lists all user preference settings pertaining to the source viewer.

4.21 Terminal Window

Ozone's Terminal Window provides text transmission of textual information from and to the debuggee. Text output generated by the debugee is displayed in the terminal window.

Non-printable control characters are either removed or transformed into octal C-string-sequences. ANSI escape sequences carrying color information are supported.



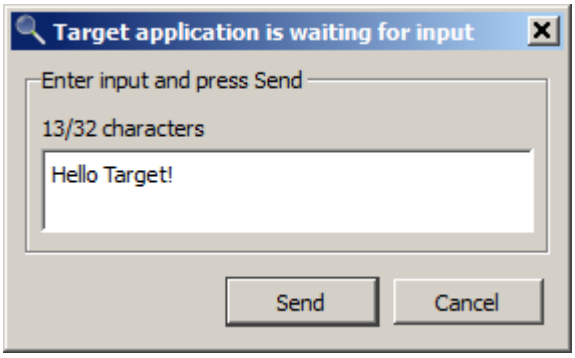
4.21.1 Supported IO Techniques

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 200.

4.21.2 Terminal Input

A debuggee may request user input via the Semihosting or RTT technique. RTT input requests are answered over the terminal prompt, while Semihosting input requests can be answered over the terminal prompt or alternatively over a popup dialog.

This common debugging technique enables users to manipulate the program state at application-defined execution points and to observe the resulting runtime behavior.



4.21.2.1 Terminal Prompt

The Terminal Window's input text box is used to respond to user input requests via RTT. or semihosting. 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 command Edit.Preference (see *Edit.Preference* on page 308).

Asynchronous Input

Textual data can be send to the debuggee even when there is no pending input request. In this case, the text will be stored at the next free RTT memory buffer location.

4.21.3 Ansi Escape Sequences

ANSI sequences for coloring text are supported. The following features the ANSI standard offers, are supported:

- Standard color palette for foreground and background.
- High-intensity basic color palette for foreground and background.

- 8-bit color ID palettes for selecting one of 256 entries from a color palette offering the standard colors, high-intensity colors, grayscale colors and 216 8-bit colors
- 24-bit RGB-values for true color usage for foreground and background
- Bold formatting leads to high-intensity foreground color when using the standard color palette.
- Underline formatting leads to high-intensity background color when using the standard color palette.

An ANSI escape sequence has the format

`<esc>"["<parameter 1>[";"<parameter 2>[…";"<parameter n>]]"m".`

The sequence "`<esc>[93;48;5;21m`" will display subsequent text in bright yellow color on blue background.

The following table describes the parameter values supported by Ozone:

Parameter	Description
30 - 37	Set foreground color in one of the standard colors.
90 - 97	Set foreground color in one of the standard high-intensity colors.
40 - 47	Set background color in one of the standard colors.
100 - 107	Set background color in one of the standard high-intensity colors.
38;5	Set foreground color via Color ID.
48;5	Set background color via Color ID.
38;2	Set foreground color via RGB value.
48;2	Set background color via RGB value.
1	Set foreground to bold mode, which makes the foreground color bright.
4	Set underline mode, background color set to high-intensity.
24	Reset the underline mode, background set to normal intensity.
0	Reset, set default colors for foreground and background.

Other features the ANSI standard offers are not supported.

4.21.4 Logging

In addition to displaying the data received from the debugee in the terminal window, Ozone can write the information into a log file. Logging can be enabled and the name of the log file can be specified by means of the command Project.SetTerminalLogFile.

4.21.5 Control Character Handling

The terminal window's handling of non-printable control characters can be controlled via the preference `PREF_TERMINAL_NO_CONTROL_CHARS`. This allows to either suppress the display of such control characters or transform it into an octal sequence as found in a C-string.

4.21.6 Terminal Window Limit

The amount of data displayed in the terminal window can be limited. For that purpose there is the preference `PREF_TERMINAL_DATA_LIMIT` which specifies the amount of data up to which the terminal window will accept incoming data. Once that limit is reached, a message is displayed in the console window and additional incoming data is rejected.

4.21.7 Context Menu

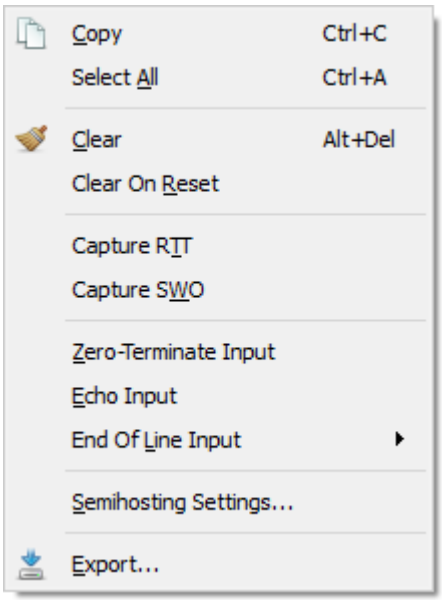
The Terminal Window's context menu provides the following actions:

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.

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 send to the debuggee (see *Newline Formats* on page 269).

Semihosting Settings

Opens the Semihosting Settings Dialog (see *Semihosting Settings Dialog* on page 82).

Export

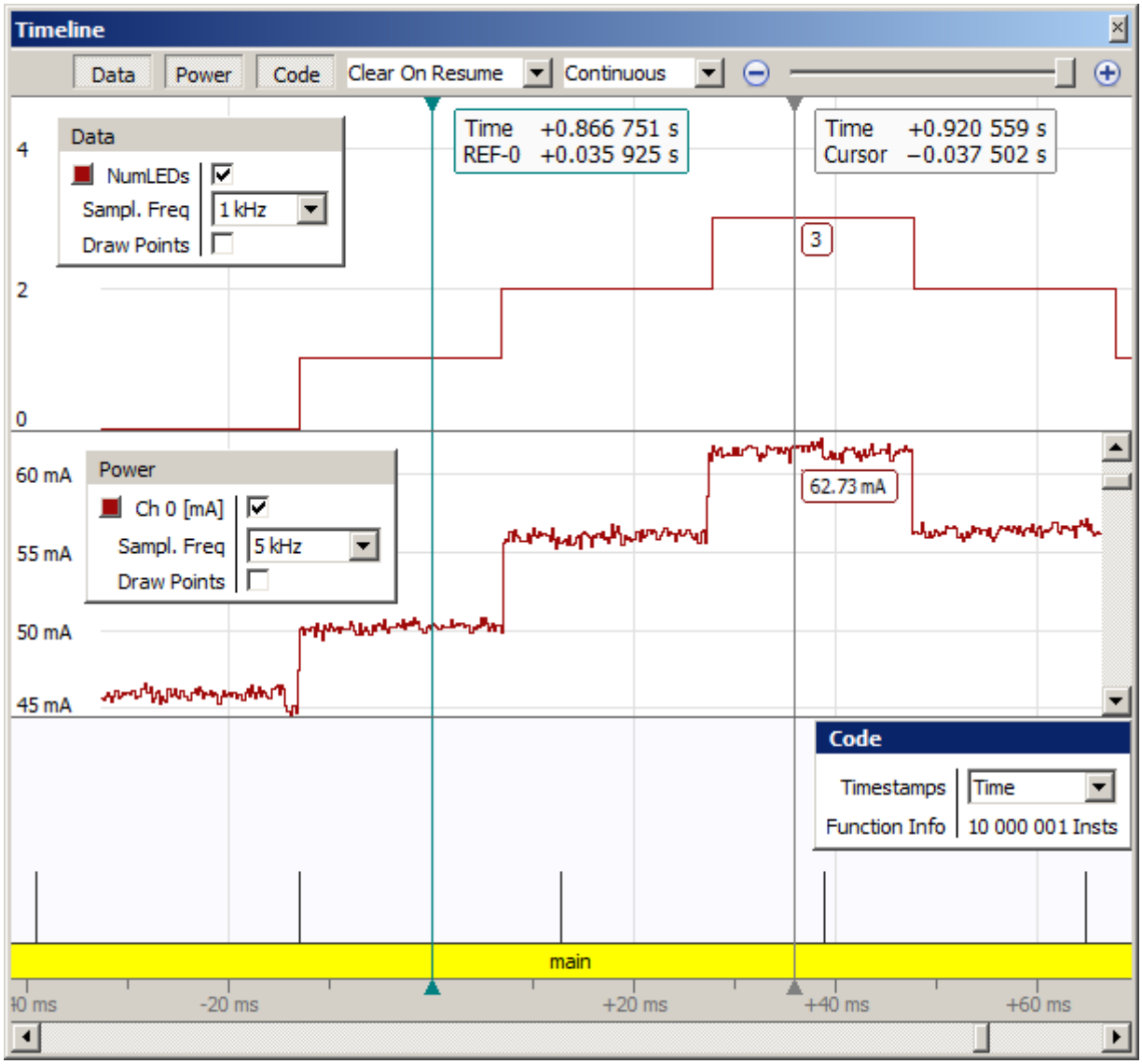
Opens a file dialog that enables users to export the window content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.21.8 Terminal Window Preferences

Section *Terminal Window Settings* on page 89 lists all user preference settings pertaining to the Terminal Window.

4.22 Timeline Window

Ozone's timeline window visualizes the supported trace and data sampling channels in a combined signal plot.



4.22.1 Overview

The timeline provides multiple interactive features that allow users to quickly understand the time course of the displayed data both on a broad and on a narrow time scale.

The timeline is subdivided into 3 data panes:

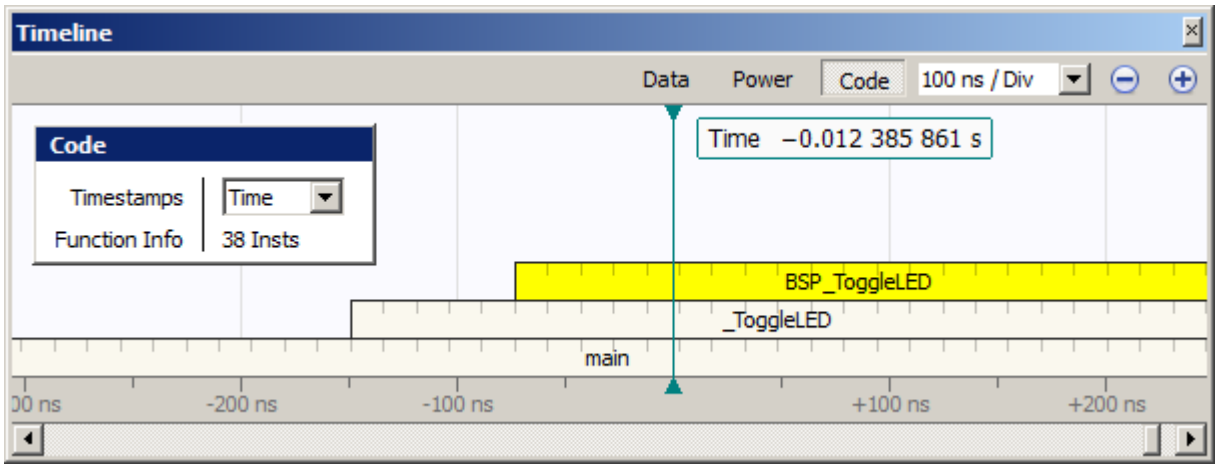
Position	Pane	Description
Top	Data	Displays the graphs of recorded variables and expressions
Middle	Power	Displays the target's power consumption
Bottom	Code	Displays the course of the program's call stack

The visibility of each pane can be toggled via the toolbar or the context menu.

All data panes share a common time axis, or timescale. This enables users to e.g:

- compare the target's power consumption against code execution
- observe selected data state at a particular program execution point

In the title figure, the debuggee switched 3 LED's on and off in short succession. Traced 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 code pane shows multiple call stack transitions (shown as spikes). Zooming into one of the call stack transitions presents the following view:



Timeline plot after zooming in

confirming that each call stack transition corresponds to the toggling of an LED.

Instruction Ticks

The vertical ticks displayed in the figure above mark instruction boundaries. The instruction ticks help to understand relative instruction execution durations, for example the execution time difference of a load/store and an ALU instruction.

4.22.2 Navigating the Window with the Mouse

Navigating the window with the mouse is quite intuitive:

- Moving the mouse will move the Hover Cursor.
- A single left mouse click will position the Sample Cursor.
- Dragging the mouse will pan the selected pane vertically and all panes horizontally.
- Spinning the scroll wheel will perform the action specified in the preferences: pan horizontally, pan vertically, zoom horizontally, zoom vertically, or no action. Horizontal actions are performed on all panes, vertical actions only on the pane under the mouse cursor.
- Spinning the scroll wheel while [ctrl] is pressed will zoom the pane under the mouse cursor horizontally.
- Spinning the scroll wheel while [shift] is pressed will zoom the pane under the mouse cursor vertically.
- Tilting the scroll wheel (or using the horizontal scroll wheel) will pan horizontally.

4.22.3 Hardware Requirements

The timeline window has individual hardware requirements for each of the 3 data panes:

Pane	Hardware Requirements
Data	Same as *Data Sampling Window* on page 114.
Power	Same as *Power Sampling Window* on page 145.
Code	Same as *Instruction Trace Window* on page 128.

In case your target does not satisfy all of the above hardware requirements, you may still want to check out all capabilities of the Timeline Window using SEGGER's Cortex-M trace reference board.

4.22.4 Setup

The timeline window is setup using project settings. Each data pane has an individual configuration requirement, as explained by this section.

Data

The list of traced expressions is setup using the *Data Sampling Window* on page 114. The data sampling rate is configured in any of the ways described in section *Sampling Frequency* on page 145. A data sampling rate of 0 disables data trace.

Power

The power sampling rate is configured in any of the ways described in section *Sampling Frequency* on page 145. A power sampling rate of 0 disables power trace.

Code

In order to obtain a consistent output when debugging multi-threaded applications, either:

- an RTOS-awareness plugin must have been loaded (see *Project.SetOSPlugin* on page 343) or
- information about program code that performs a task switch must have been supplied (see *OS.AddContextSwitchSymbol* on page 366).

For applications that include custom instructions, additionally:

- a disassembly support plugin must have been loaded (see *Project.SetDisassemblyPlugin* on page 343).

4.22.5 Code Pane

This section describes details of the code pane.

Call Frames

Each horizontal bar of the code pane 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.

Exception Frames

An exception handler or interrupt service routine frame is painted with rounded corners and a deeper color saturation level (compare with `SysTick_Handler` in the figure below).

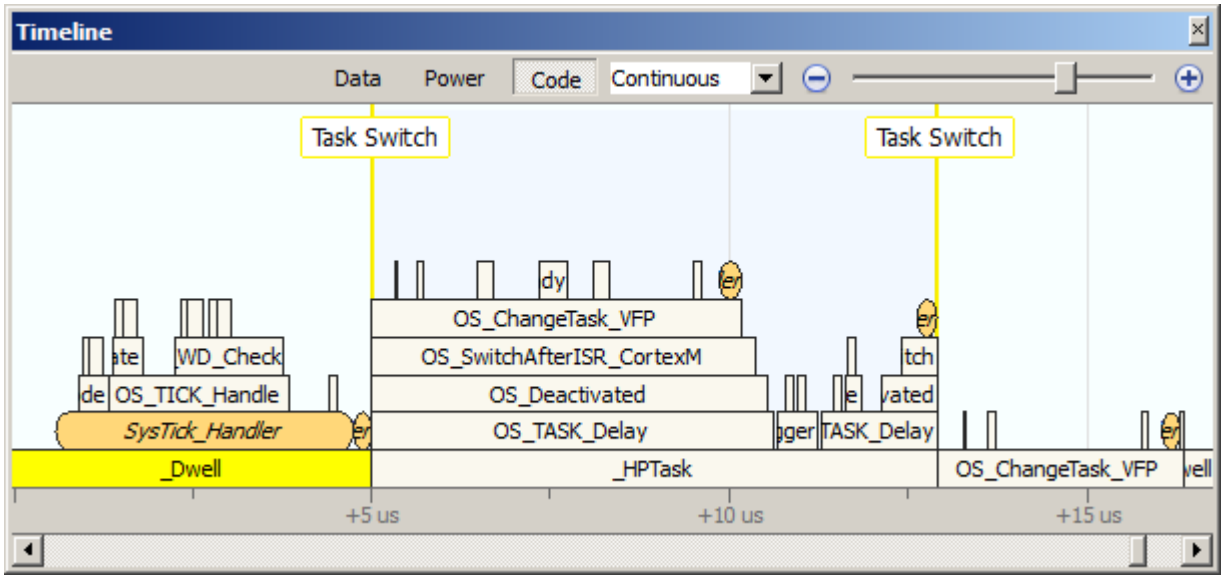
The information whether a function is an interrupt service routine or not is determined by a heuristic from the ELF file. Sometimes this heuristic cannot retrieve the correct results, leading to an unexpected display in the code pane. In such a case the exact location and size of the vector table can be specified by means of the system variables `VAR_VECTORTABLE_ADDR` and `VAR_VECTORTABLE_SIZE`.

Frame Tooltips

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

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 set (see *RTOS Awareness Plugin* on page 237).

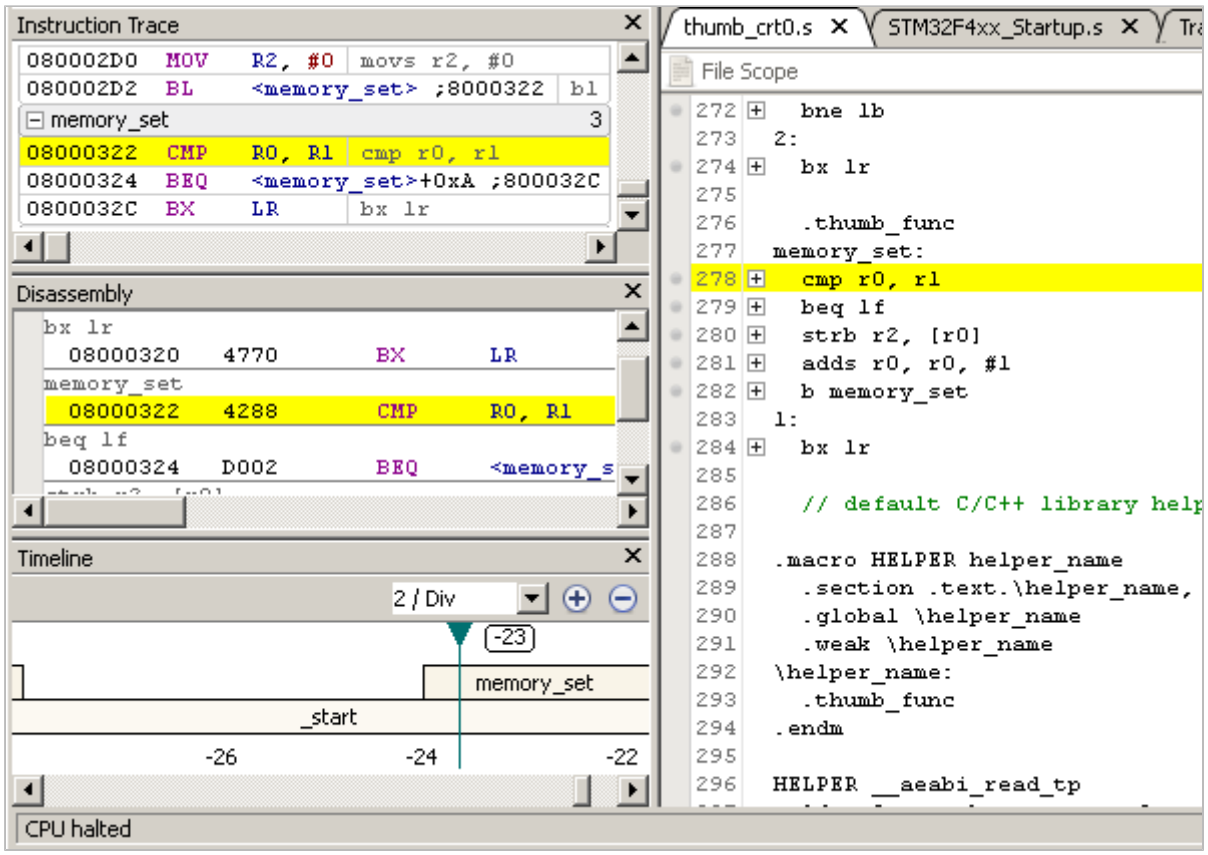


Task context highlighting within the Timeline Window.

4.22.6 Sample Cursor

The sample cursor marks the program execution point that is currently set within the PC aware debug information windows. This enables users to get a complete view of the program execution context for any position of the timeline plot. Conversely, changing the selection within one of the PC-aware debug windows also causes the sample cursor to adjust.

The default color used for execution point highlighting is yellow and can be adjusted via command Edit.Color (see *Edit.Color* on page 309) or via the User Preference Dialog (see *User Preference Dialog* on page 86).



The sample cursor is synchronized with Ozone's execution point aware debug windows.

4.22.6.1 Positioning the Sample Cursor

The sample cursor can be positioned by single click, drag & drop or the keys shown in the table below. In this table, "sample" refers to the data sample or instruction of the pane which has the input focus.

Key	Description
Left/Right	Moves the sample cursor 1/5 grid spacing left or right
Shift + Left/Right	Moves the sample cursor 1 grid spacing left or right
Up/Dn	Moves the sample cursor to the previous/next sample
Page Up	Moves the sample cursor 1 page left
Page Down	Moves the sample cursor 1 page right
Home	Moves the sample cursor to the least recent sample
End	Moves the sample cursor to the most recent sample

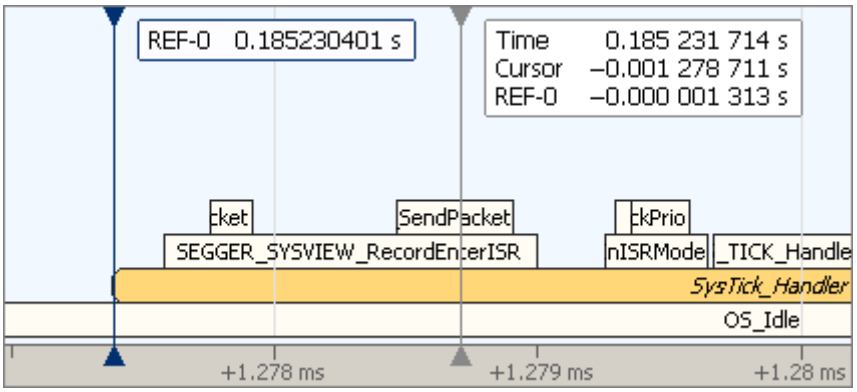
4.22.6.2 Pinning the Sample Cursor

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.

4.22.7 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. The figure below and the title figure give examples for the hover cursor.

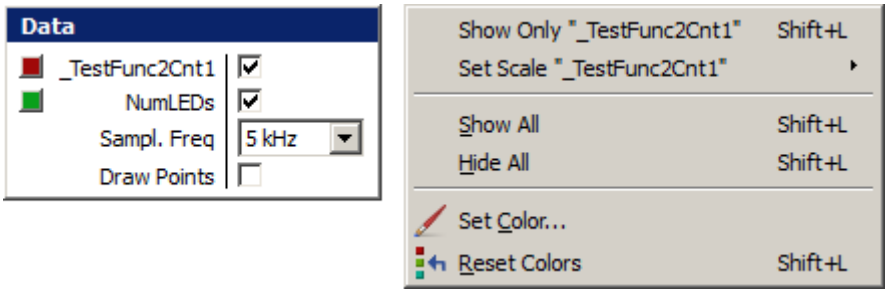
4.22.8 Time Reference Points



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

4.22.9 Graph Legends

Each data pane provides a graph legend with a context menu:

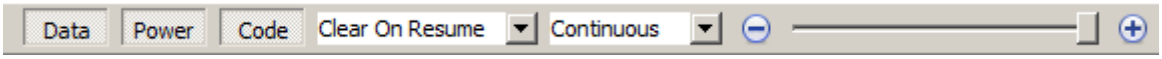


The graph legend enables users to:

- show or hide individual graphs
- assign colors to graphs
- assign a vertical scale factor to graphs

A graph legend can be freely moved within a pane.

4.22.10 Toolbar



The toolbar of the timeline window has the following layout, from left to right:

- 3 buttons to toggle the display of the 3 data panes.
- a drop-down box which sets the debug event upon which timeline data is cleared (see *Clear Event* on page 173).
- a drop-down box sets the time resolution of the timeline to discrete levels.
- a slider which sets the time resolution of the timeline to continuous levels.

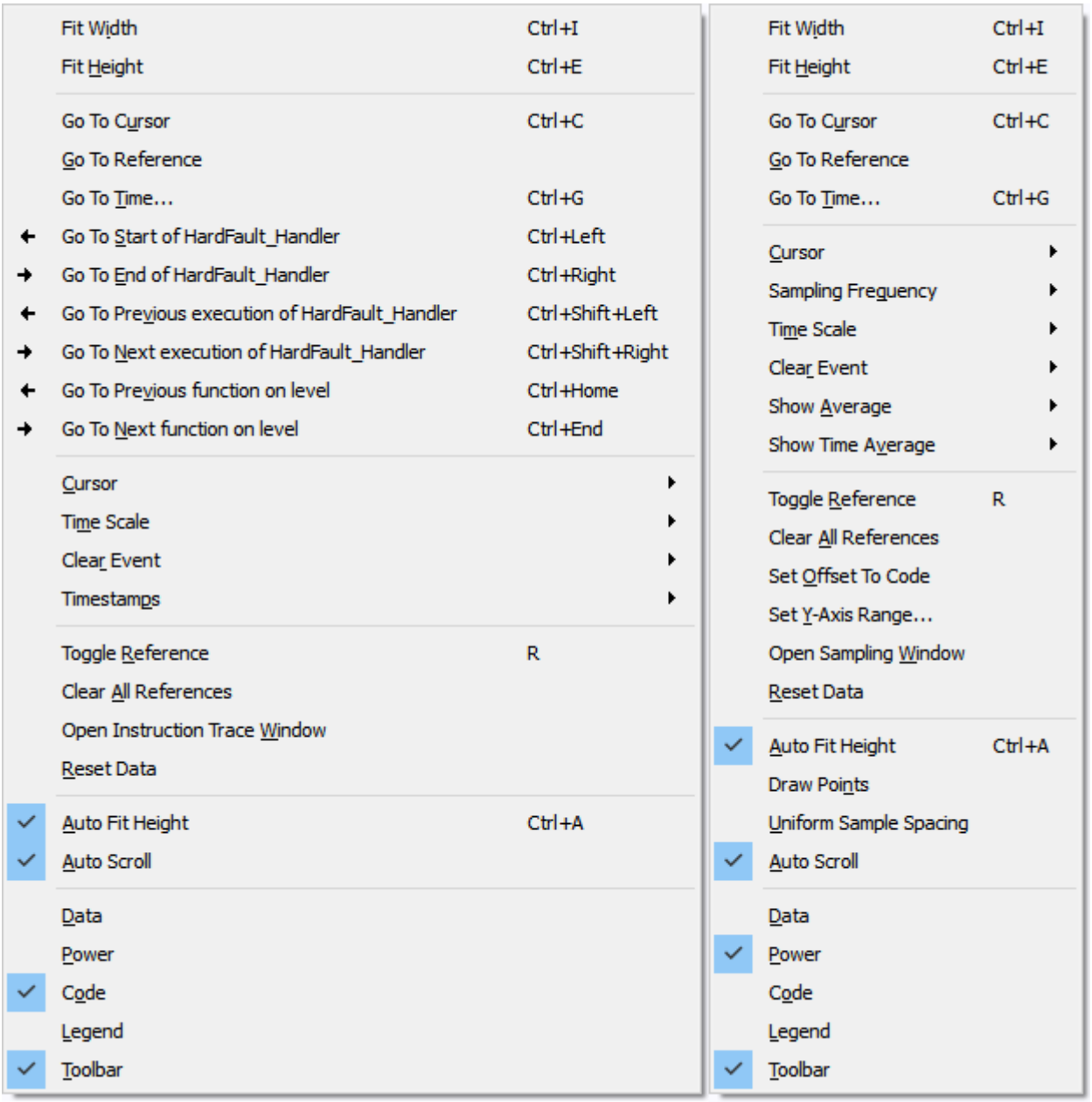
The time resolution drop-down provides two special options:

- continuous: the time resolution is selected via the zoom slider.
- data fit: the time resolution adapts to the data in order to fit all data into view.

If the toolbar is not shown it can be made visible via the context menu.

4.22.11 Context Menu

The panes of the timeline window provide individual context menus. The illustration below depicts the context menu of the code and power panes. The context menu of the data pane is identical to that of the power pane, with the exception of entries *Show Average*, *Show Time Average* and *Show Names at Cursor*.



Context menus of the code pane (left) and power pane (right).

Common Actions

Context menu actions provided by all panes:

Action	Description
Fit Width	Fits the selected data horizontally into view. When there is no selection, fits all data of the focused pane into view
Fit Height	Fits the selected data vertically into view. When there is no selection, fits all visible data of the focused pane into view
Go To Cursor	Scrolls the sample cursor into view
Go To Reference	Scrolls to the time reference nearest to the sample cursor
Go To Time	Shows an input dialog and scrolls to input plot position
Cursor	Pins the sample cursor at a fixed window position
Time Scale	Sets the time resolution of the timeline plot
Toggle Reference	Sets or clears a time reference at the sample cursor position
Clear All References	Removes all time references

Action	Description
Open Data Window	Opens the data sampling window affiliated with the pane
Reset Data	Resets the session's trace and sampling data and thereby all timeline panes.
Auto Fit Height	When checked, the zoom factor of the y-axis auto-adjusts to data in order to provide integer-valued grid labels. When unchecked, the zoom factor of the y-axis remains unchanged.
Data	Toggles the data pane
Power	Toggles the power pane
Code	Toggles the code pane
Legend	Toggles the pane's graph legend
Toolbar	Toggles the toolbar

Sampling Pane Actions

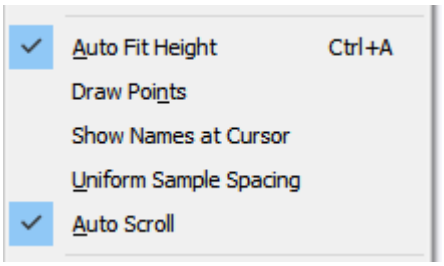
Context menu actions provided by the data and power panes:

Action	Description
Sampling Frequency	Sets the data sampling frequency. Entry "Off" (0) disables data sampling.
Set Offset To Code	Starts operation Set Offset To Code (see *Set Offset To Code* on page 173)
Draw Points	Displays sampling data as a point cloud instead of graphs
Uniform Sample Spacing	When checked, sample timestamps are computed by Ozone based on the sampling frequency. When unchecked, Ozone uses the sample timestamps provided by J-Link.

Data Pane Actions

Context menu actions exclusive to the data pane:

Action	Description
Show Names at Cursor	When checked, displays the expression or variable name together with the value in the boxes close to the hover cursor.



Power Pane Actions

Context menu actions exclusive to the power pane:

Action	Description
Show Average	Selects the sample width of the running-average filter used to compute the filtered power graph. The filtered power graph is displayed along with to the power graph within the power pane. A sample width of 0 disables the display of the filtered power graph.
Show Time Average	Selects the time range used to compute the average power value. The average power value is displayed within the data legend of the power pane. It is taken at the position of the hover cursor or the most recent data sample, when the hover cursor is not visible.

Code Pane Actions

Context menu actions exclusive to the code pane:

Action	Description
Set Breakpoint	Sets/clears a breakpoint on the function of the selected frame
Go To Start/End of	Sets the sample cursor on to the start/end of the selected frame
Go To Next/Previous execution of	Sets the sample cursor on to the next/previous execution of the selected frame
Go To Next/Previous function on level	Sets the sample cursor on to the next/previous function on the selected stack level
Time Stamps	Selects the time unit to use with frame tooltips.

4.22.12 Settings

The timeline window evaluates the following system variables settings:

System Variable	Description
VAR_TRACE_MAX_INST_CNT	Maximum number of instructions that can be acquired from target and displayed within the code pane
VAR_TRACE_CORE_CLOCK	Conversion factor used to convert execution times between CPU cycles and time units
VAR_VECTORTABLE_ADDR	Used for identifying interrupt service routines. Not identifying all ISRs or assuming a function for an ISR that is not, may result in inappropriate display of the contents of the code pane.
VAR_VECTORTABLE_SIZE	Used for identifying interrupt service routines. Not identifying all ISRs or assuming a function for an ISR that is not, may result in inappropriate display of the contents of the code pane.

Section *Timeline Window Settings* on page 90 lists all user preference settings pertaining to the Timeline Window.

4.22.13 Clear Event

The debug event upon which the session's trace and sampling data is cleared can be specified via the toolbar, the context menu or command Edit.Preference. The possible values of user preference PREF_TIMELINE_CLEAR_EVENT are listed in section *Clear Events* on page 271. The clear event takes effect even when the timeline window is not open. In addition, timeline data can also be cleared from the project script using command Timeline.Reset (see *Timeline.Reset* on page 363).

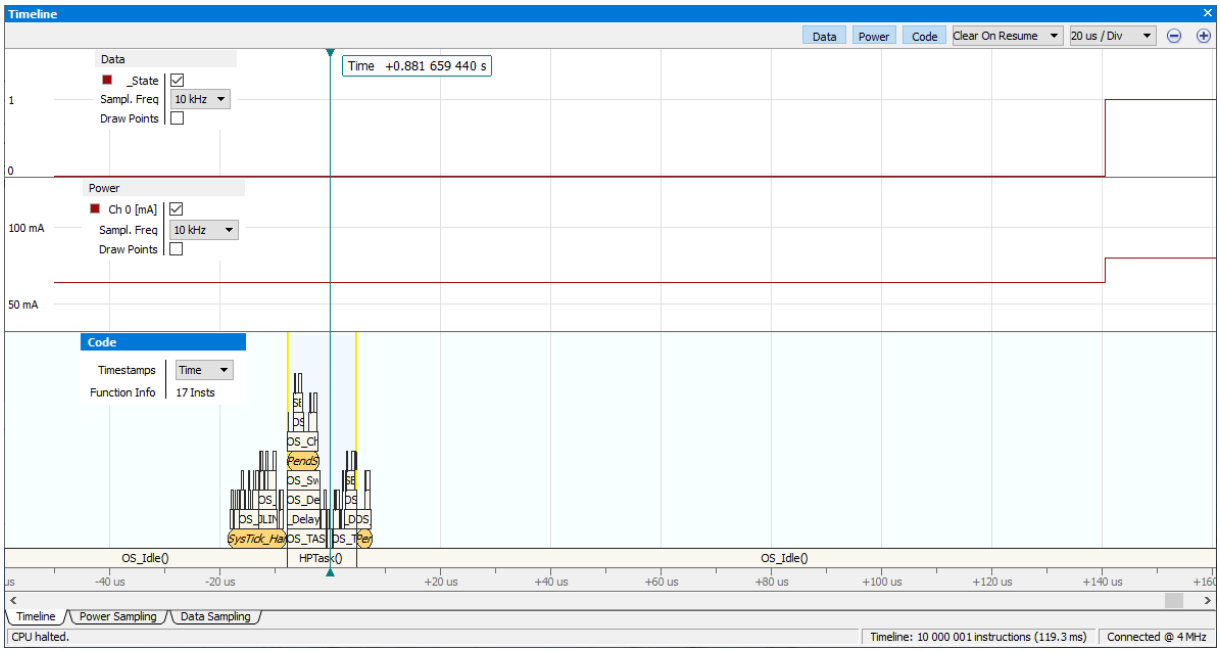
> **Note**
>
> When the timeline is cleared, the data contents of the Instruction Trace Window, Code Profile Window, Data Sampling Window and Power Sampling Window are reset as well.

4.22.14 Set Offset To Code

This feature allows specifying an offset on the time axis to the data and power panes with respect to the code pane. The intention is to change the alignment or fix a potential misalignment in the display of the repsective curves.

Assume the following state: An application toggles a variable and sets an LED according to the new state of the variable. In the data pane we can see the graph going from 0 to 1 and the power graph also indicates an increase in power consumption caused by the LED

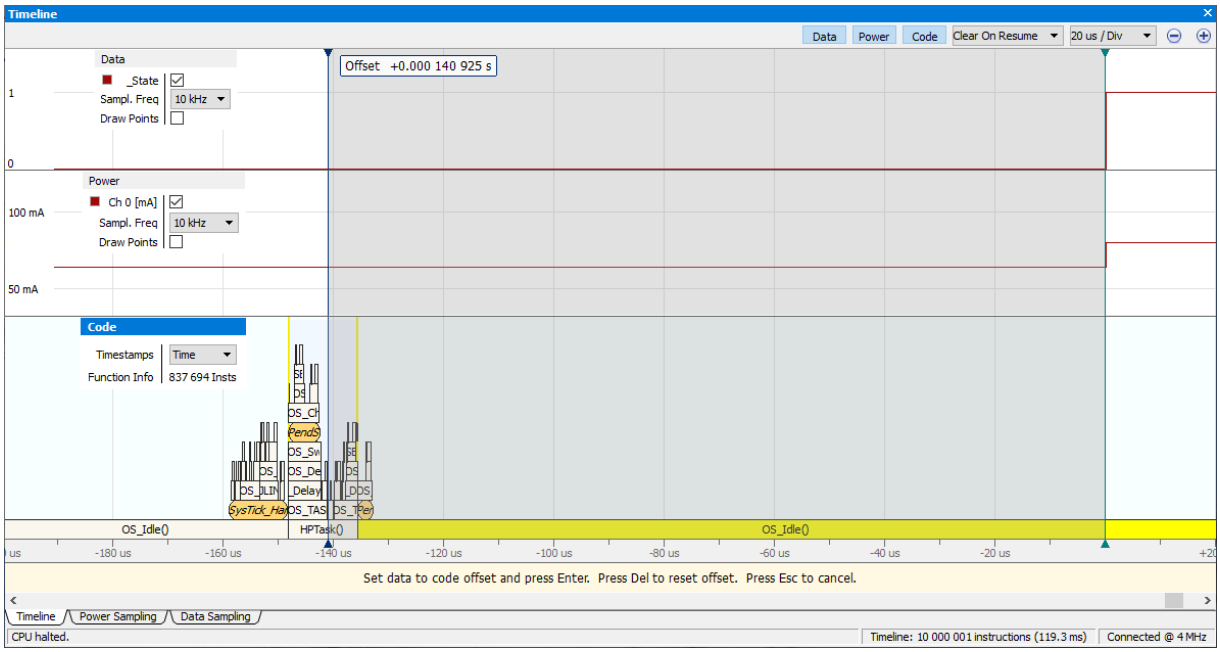
now being active. The code that triggers that action is executed shortly beforehand at the cursor position. This can be seen in the subsequent graphic:



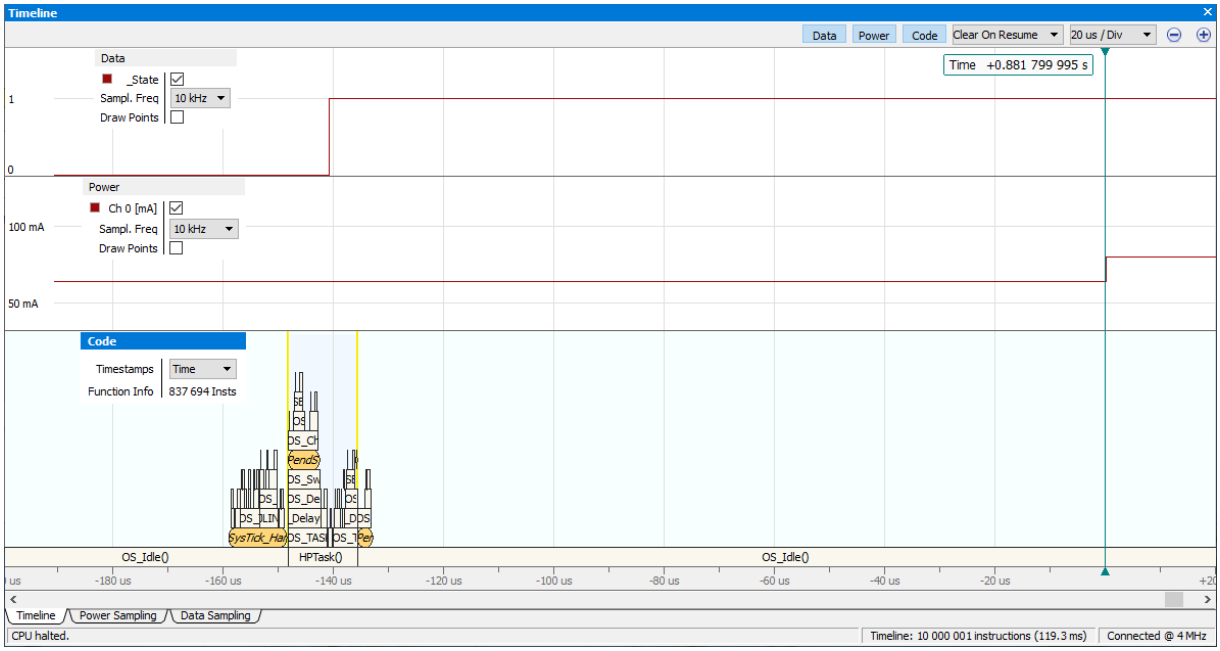
Adding an offset to the data graph's position on the time axis allows aligning the rising edge with the code that changes the variable and toggles the LED.

To do so, first set the cursor onto the rising edge in the power pane by clicking onto that rising edge. Once the cursor is in place, open the context menu of the data pane and select "Set Offset to Code". A 2nd cursor, the offset cursor, will appear and the area between the two cursors will be highlighted. In addition, below the code pane, a text is displayed which shows the available options.

Move the offset cursor to the respective place in the code pane.



Once the offset cursor is in the correct place, press the [Enter] key. Now the offset will be applied to the data pane and the rising edge will be aligned with the respective code. Please note that the offset is applied only to the data graph since the context menu was opened for the data pane. In order to specify an offset for the power graph please follow the same steps but open the context menu for the power pane.



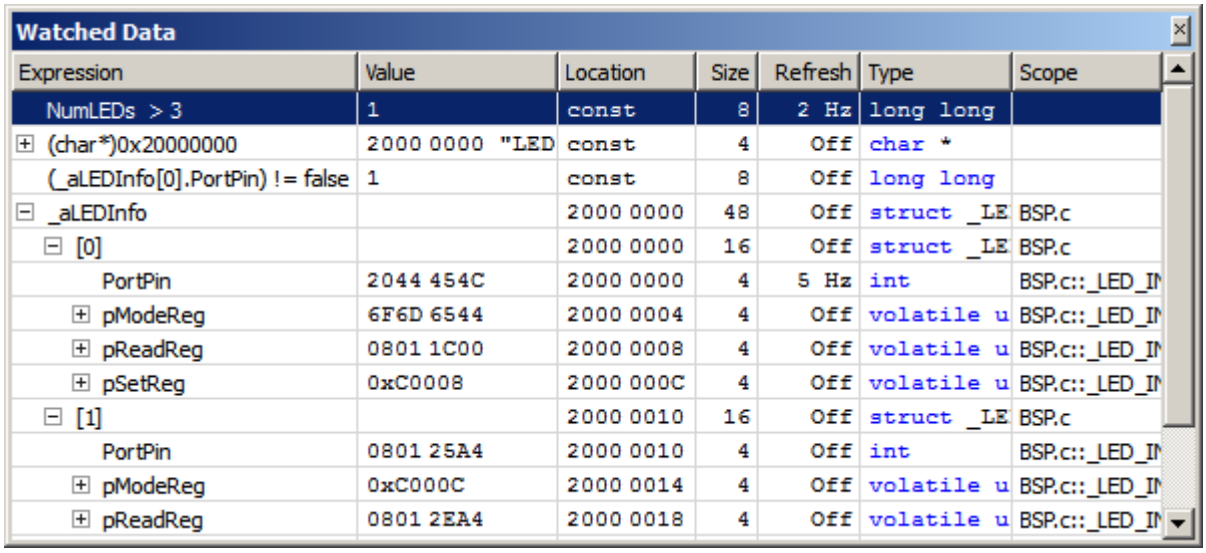
In order to abort the action, please press the [Esc] key.

For removing the offset from a pane, open the pane's context menu, select "Set Offset to Code" and press the [Del] key.

Panning and zooming may be used for setting both the cursor and the offset cursor in order to precisely hit the correct spot in the respective pane.

4.23 Watched Data Window

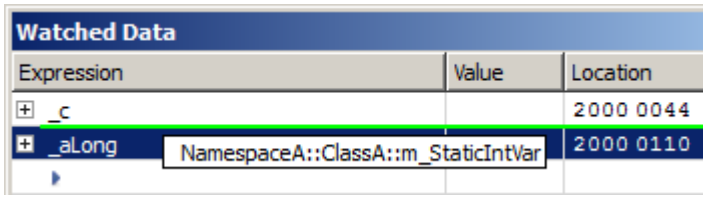
Ozone's Watched Data Window tracks the values of C-style expressions that the user chose for explicit observation (see *Working With Expressions* on page 205).



4.23.1 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 command Window.Add (see *Window.Add* on page 316).
- via context menu entry "Watch..." that opens an input dialog.
- by entering an expression into the last table row, which acts as an input field.
- by dragging a symbol or any other source of text mime data onto the window.



The list of expressions can be reordered in any of the following ways:

- By dragging an expression to a new position
- By using the "up" and "down" buttons of the toolbar. If the toolbar is not shown it can be made visible via the context menu.
- By using hotkeys "Ctrl+Up" and "Ctrl+Dn"

4.23.2 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".

4.23.3 Live Watches

The Watched Data Window supports live updating of expressions while the program is running. Each expression can be assigned an individual update frequency via the windows context menu or via command Edit.RefreshRate (see *Edit.RefreshRate* on page 311).

> **Note**

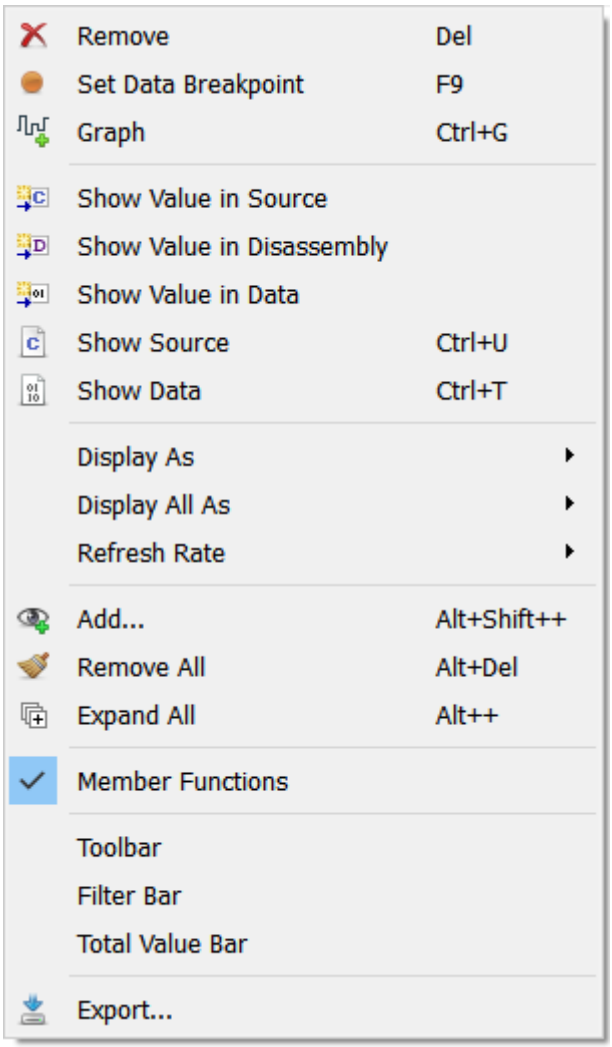
> The live watches feature requires the target to support background memory access.

4.23.4 Quick Watches

Where it suffices to evaluate a symbol expression momentarily, users can resort to the Quick Watch Dialog.

4.23.5 Context Menu

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



Remove

Removes an expression from the window.

Set/Clear/Edit Data Breakpoint

Sets/clears/edits a data breakpoint on the selected expression (see *Data Breakpoints* on page 194).

Graph

Adds the selected expression to the Data Sampling Window.

Show Value in Source

Displays the source code declaration location of the symbol pointed to within the Source Viewer. Only shown for pointer-type variables.

Show Value in Disassembly

Displays the disassembly location of the symbol pointed to within the Disassembly Window. Only shown for pointer-type variables.

Show Value in Data

Displays the memory location of the symbol pointed to within the Memory Window. Only shown for pointer-type variables.

Show Source

Displays the source code declaration location of the selected variable in the Source Viewer (see *Source Viewer* on page 156).

Show Data

Displays the data location of the selected variable in either the Memory Window (see *Memory Window* on page 135) or the Registers Window (see *Registers Window* on page 147).

Display (All) As

Changes the display format of the selected item or of all items (see *Display Format* on page 58).

Refresh Rate

Sets the refresh rate of the selected expression (see *Live Watches* on page 176).

Add

Opens the Watch Dialog (see *Working With Expressions* on page 205).

Remove All

Removes all items from the Watched Data Window.

Expand/Collapse All

Expands or collapses all top-level nodes.

Member Functions

Toggles the display of class member functions. This item is only visible when the debuggee's source language is C++.

Tool Bar

Toggles display of the tool bar.

Filter Bar / Total Value Bar

Toggles the named table header bar.

Export

Opens a file dialog that enables users to export the table content to a CSV file. This action can also be executed from the project script using command Window.Export.

4.23.6 Multiple Instances

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

4.23.7 Table Window

The Watched Data Window shares multiple features with other table-based debug information windows provided by Ozone (see *Table Windows* on page 58).

Chapter 5

Debugging With Ozone

This chapter explains how to debug an embedded application using Ozone’s basic and advanced debug features.

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 35). 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.

```
/*********************************************************************
*
*     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 301)

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

5.1.4 Programmability

Users may reprogram key debug operations within the project file. This aspect of project files is covered in detail in section *Project Script* on page 226.

5.1.5 Project Settings

Any user action that configures the debugger in some way is a valid project setting (see *User Actions* on page 43). Project settings are specified by inserting user action commands into the obligatory script function `OnProjectLoad` (compare with *Project File Example* on page 180). The most relevant project settings include:

- Program File
- Target Device
- Connection Settings
- RTOS Plugin

- Source File Resolution Settings

each of these settings are described in more detail below.

5.1.5.1 Program File

The program to be debugged is specified using command File.Open. This command has a single file path argument which can be an absolute path or a path relative to the project file directory (see *File.Open* on page 301). Section *Supported Program File Types* on page 183 lists the supported program file types.

5.1.5.2 Target Device

Command Project.SetDevice specifies the target device (see *Project.SetDevice* on page 340).

5.1.5.3 Connection Settings

Commands Project.SetHostIF and Project.SetTargetIF specify in which way the debug probe is connected to the Host-PC and to the target device, respectively (see *Project Actions* on page 294).

5.1.5.4 RTOS Plugin

Command Project.SetOSPlugin specifies the file path or name of the plugin that adds RTOS awareness to the debugger (see *Project.SetOSPlugin* on page 343).

See *Available RTOS Plugins* on page 152 for the RTOS awareness scripts shipped with Ozone. A guide on programming RTOS plugins is given in section *RTOS Awareness Plugin* on page 237.

5.1.5.5 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 Sequence* on page 207.

5.1.5.6 Required Project Settings

A valid project file must specify the following settings:

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

5.1.6 Project Load Diagnostics

Each time a project file is opened, Ozone performs an integrity check of the project file and its settings. When issues are detected, the *Project Load Diagnostics Dialog* on page 78 is shown.

5.1.7 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 debug 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 Registers Windows. Furthermore, many advanced debug features such as instruction trace and terminal IO are operational even when the program file does not provide symbol information.

Configuring the ELF Parser

Ozone provides command Elf.SetConfig to configure the ELF parser for optimal handling of special situations and corner cases. This command usually does not need to be employed.

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 command File.Open into the Console Window's command prompt (see *File.Open* on page 301).

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 123), Source Files Window (see *Source Files Window* on page 154), Global Data Window (see *Global Data Window* on page 126) and Code Profile Window (see *Code Profile Window* on page 106).

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 Debug Settings Dialog (see *Debug Settings Dialog* on page 68) and action Target.SetEndianess (see *Target.SetEndianess* on page 362).

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 command Debug.Start (see *Debug.Start* on page 331). This action can be triggered from the Debug Menu or by pressing the hotkey F5.

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).

5.3.1 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 332). 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 connection to the target is established via J-Link/J-Trace.
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 *Initial Program Operation* on page 184).

Flow Chart

Section *Startup Sequence Flow Chart* on page 282 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

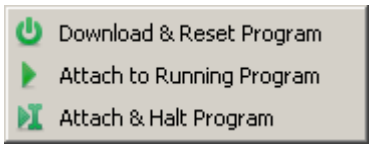
This connection mode attaches the debugger to the debuggee by performing phases 1 and 2 of the default startup sequence (see *Download & Reset Program* on page 184).

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 command Debug.SetConnectMode (see *Debug.SetConnectMode* on page 332), via the System Variable Editor (see *System Variable Editor* on page 83) 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 190):

Reset Mode	Initial Program Operation
Reset & Break at Symbol	Program execution is advanced to a particular symbol.
Reset & Halt	The program is halted at the reset PC.
Reset & Run	The program is resumed.

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`.

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 184).

> **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]`
RISC-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 behavior 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 the SP and PC registers are initialized according to their needs. Ozone's scripting system is discussed in detail in chapter *Scripting Interface* on page 24.

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 behavior per default (see *Project Wizard* on page 35). The register initialization scheme of wizard-generated projects can be specified on the last page of the Project Wizard. The default settings are depicted in the table below. The depicted values apply for both download and hardware reset.

Architecture	Initial PC (ELF)	Initial PC (Non-ELF)	Initial SP
Legacy ARM	`Elf.e_entry`	`<baseaddr>`	
Cortex-A/R	`Elf.e_entry`	`<baseaddr>`	

Architecture	Initial PC (ELF)	Initial PC (Non-ELF)	Initial SP
Cortex-M	Elf.e_entry	[<baseaddr> + 4]	[<baseaddr>]
RISC-V	Elf.e_entry	<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 Startup Completion Point

Startup completion is the moment during program execution when the debuggee has completed memory initialization. This moment is implementation-defined and not necessarily identical to the program's entry point function.

Knowledge about the startup completion point enables Ozone to safely initialize its instruction-level debug information once the entire machine code of the debuggee is accessible to the debugger. For example, a debuggee may decompress parts of the program code into target RAM before branching to the main function. In this situation, the compressed machine code is not accessible to the debugger before startup completion.

Upon startup completion, Ozone:

- calls project script function `OnStartupComplete`.
- updates instruction-level debug information.
- starts debug features that access memory, such as RTT and data sampling.

Startup completion reoccurs each time the startup completion point is reached following program reset.

In certain special situations as described in section *Setting Up The Instruction Cache* on page 209, the debugger may not be able to initialize its instruction-level debug information automatically upon startup completion. In these cases, the instruction cache must be initialized manually using command Debug.ReadIntoInstCache.

5.5.1 Specifying the Startup Completion Point

The startup completion point is maintained as system variable `VAR_STARTUP_COMPLETION_POINT`. This variable can be edited via the System Variable Editor or using command Edit.SysVar (see *System Variable Editor* on page 83 and *Edit.SysVar* on page 309). The default value of this system variable is identical to the system variable `VAR_BREAK_AT_THIS_SYMBOL`, i.e. the program's symbol or address upon which execution shall be stopped during start-up.

Empty Startup Completion Point

When the startup completion point is set to an empty string, startup completion is defined to occur on the first CPU halt.

Startup Completion Point When Attaching

When the program is not reset during target connection, startup completion is defined to occur on the first CPU halt. This is the case when the connection mode is `CM_ATTACH` or `CM_ATTACH_HALT` (see *Connection Modes* on page 267).

5.6 Symbol or PC to Stop Target during Startup

When the reset mode “Reset & Break at Symbol” is used, the startup is to be stopped once execution reaches the respective symbol or address.

Upon reaching that point Ozone calls the project script function `OnDebugStartBreakSymReached`. This script function is to be considered a break point call-back function with a special name that is automatically attached to a break point on that symbol or address.

The user may specify a dedicated break point on the same symbol or address, but in case a call-back is attached to that break point, it will not be called - instead `OnDebugStartBreakSymReached` will be invoked, if it exists.

This project script function can be used for automating jobs with Ozone. In particular, debug actions that change the target state, such as Debug.Continue (see *Debug.Continue* on page 333), should be invoked here and not in the context of `OnStartupComplete`.

5.6.1 Specifying the Symbol or PC to Stop Target during Startup

For that purpose the system variable `VAR_BREAK_AT_THIS_SYMBOL` is maintained which can be edited via the System Variable Editor or using command Edit.SysVar (see *System Variable Editor* on page 83 and *Edit.SysVar* on page 309). The default value of this system variable is identical to system variable `VAR_STARTUP_COMPLETION_POINT`, i.e. the program’s startup completion point.

5.7 Debugging Controls

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

5.7.1 Reset

The program can be reset via command Debug.Reset (see *Debug.Reset* on page 333). The action can be executed from the Debug Menu (see *Debug Menu* on page 47) or by pressing F4.

5.7.1.1 Reset Mode

The reset behavior depends on the value of the reset mode parameter (see *Reset Modes* on page 267). 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 184).

Setting the Reset Mode

The reset mode can be set via command Debug.SetResetMode (see *Debug.SetResetMode* on page 334), via the System Variable Editor (see *System Variable Editor* on page 83) 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.

5.7.2 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 53). The table below considers each situation and describes the resulting behavior.

Action	Source Viewer is Active Code Window	Disassembly Window is Active Code Window
Debug.StepInto	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).
Debug.StepOver	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. Context aware stepping is supported, if enabled.	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. Context aware stepping is supported, if enabled.
Debug.StepOut	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.

5.7.2.1 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 it's assembly code instructions, the debugger will use its instruction stepping mode instead of performing source line steps.

5.7.2.2 Context Aware Stepping

The expected behavior of stepping over a function call is to continue execution until the next source line is reached. In the case of an RTOS-based application a context switch might happen and the next line is reached in the context of another task. In the case of a recursive function call, the next line might be reached in the context of a deeper level in the recursion.

With context-aware stepping enabled, Ozone ensures to continue execution until the next line is reached in the same context, i.e. on the same call frame in which the step over is performed.

Context-aware stepping can be enabled or disabled via the system variable `VAR_CONTEXT_AWARE_STEPPING` (see System Variable Identifiers).

> **Note**
>
> With context-aware stepping the target may halt multiple times, which may impact runtime performance and behavior of the target application.

5.7.3 Resume

The program can be resumed via command Debug.Continue (see *Debug.Continue* on page 333). The action can be executed from the Debug Menu or by pressing the hotkey F5.

5.7.4 Halt

The program can be halted via command Debug.Halt (see *Debug.Halt* on page 333). The action can be executed from the Debug Menu or by pressing the hotkey F6.

5.7.5 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 335). 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.

5.7.6 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 335). The action is accessible from the context menu of the Source Viewer.

5.7.7 Set Next PC

User action Debug.SetNextPC advances program execution to a particular instruction address (see *Debug.SetNextPC* on page 335). 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.

5.8 Breakpoints

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

5.8.1 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.

5.8.1.1 Editing Source Breakpoints

Source breakpoints can be edited within the Source Viewer (see *Source Viewer* on page 156), within the Breakpoints/Tracepoints Window (see *Breakpoints/Tracepoints Window* on page 96) or via commands Break.SetOnSrc, Break.ClearOnSrc, Break.EnableOnSrc, Break.DisableOnSrc and Break.ClearAll (see *Breakpoint Actions* on page 290. Source code locations are specified in a predefined format (see *Source Code Location Descriptor* on page 264).

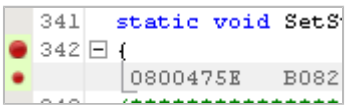
5.8.2 Instruction Breakpoints

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

5.8.2.1 Editing Instruction Breakpoints

Instruction breakpoints can be edited within the Disassembly Window (see *Disassembly Window* on page 117), within the Breakpoints/Tracepoints Window (see *Breakpoints/Tracepoints Window* on page 96) or via commands Break.Set, Break.Clear, Break.Enable, Break.Disable and Break.ClearAll (see *Breakpoint Actions* on page 290).

5.8.3 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.

5.8.4 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 63) or via command Break.Edit (see *Break.Edit* on page 370). Please refer to section *Breakpoint Properties* on page 96 for an overview of all available advanced breakpoint properties.

5.8.5 Permitted Implementation Types

Each breakpoint can be assigned a permitted implementation type (see *Breakpoint Implementation Types* on page 267). The permitted implementation type of a breakpoint can be edited via the Breakpoint Properties Dialog (see *Breakpoint Properties Dialog* on page 63), via the Breakpoints/Tracepoints Window (see *Breakpoints/Tracepoints Window* on page 96) or via command Break.SetType (see *Break.SetType* on page 367).

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 277).

5.8.6 Flash Breakpoints

All J-Link/J-Trace debug probes come with a unique feature that enables 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.

5.8.7 Breakpoint Callback Functions

Each breakpoint can be assigned a script function (see *User Functions* on page 228) 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 63) or programmatically via commands Break.SetCommand (see *Break.SetCommand* on page 375) and Break.SetCmdOnAddr (see *Break.SetCmdOnAddr* on page 376).

> **Note**
>
> Due to hardware limitations, break point callback functions are supported only for source- and instruction break points but not for data break points.

5.8.8 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.

5.9 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.

5.9.1 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 2n many memory addresses.
Symbol	Variable or function parameter whose data location corresponds to the memory address of the data breakpoint.
On	Indicates if the data breakpoint is enabled or disabled.
Access Type	Type of IO access that is monitored by the data breakpoint (see *Access Types* on page 267).
Access Size	Number of bytes that need to be accessed in order to trigger the data breakpoint (see *Memory Access Widths* on page 266. As an example, a data breakpoint with an access size of 4 bytes (word) will only be triggered when a word is written to one of the monitored memory locations. It will not be triggered when, say, a byte is written.
Match Value	Value condition required to trigger the data breakpoint. A data breakpoint will only be triggered when the match value is written to or read from one of the monitored memory addresses.
Value Mask	Indicates which bits of the match value are ignored when monitoring access events. A value mask of `0xFFFFFFFF` disables the value condition.

5.9.2 Editing Data Breakpoints

Data breakpoints can be set, cleared and edited via the Data Breakpoint Dialog (see *Data Breakpoint Dialog* on page 67). This dialog is accessible from the context menus of the Code Windows and the Breakpoints/Tracepoints Window.

Data breakpoints can also be manipulated within script functions. For this, the actions listed in *Breakpoint Actions* on page 290 that end on either "Data" or "Symbol" are provided.

> **Note**
>
> The number 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.

> **Note**
>
> Due to hardware limitations, break point callback functions, as described in section *Breakpoint Callback Functions* on page 193, are not supported for data break points.

5.10 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.

5.10.1 Execution Point

Users may navigate to the current position of program execution, also called the PC line, via commands Show.PC (see *Show.PC* on page 328) and Show.PCLine (see *Show.PCLine* on page 328).

5.10.2 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.

5.10.3 Data Symbols

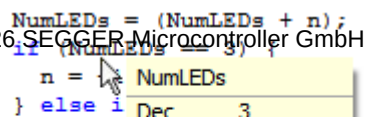
Ozone provides 3 symbol windows that allow users to observe, edit and modify program variables and function parameters. The capabilities of these windows are summarized below.

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 commands Window.Add and Window.Remove (see *Window Actions* on page 297). Observed variables are displayed within the Watched Data Window (see *Watched Data Window* on page 176).

Symbol Data Locations

The data location of a variable or function parameter can be navigated-to by executing the command Show.Data (see *Show.Data* on page 325). This action is available from the context menu of all symbol windows.

5.10.4 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 157).

5.10.5 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 102).

5.10.6 Target Registers

The current state of the target registers can be inspected and edited via Ozone's Registers Window (see *Registers Window* on page 147). The commands:

- Target.GetReg and
- Target.SetReg

are provided to read and write target registers within script functions or at the command prompt (see *Target Actions* on page 296). Command *Register.Addr* on page 357 returns the address of a memory-mapped register.

Target Register Types

Ozone categorizes target registers as described in section *Register Groups* on page 148.

5.10.7 Target Memory

The current state of target memory can be inspected and edited via Ozone's Memory Window (see *Memory Window* on page 135).

The commands:

- 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 296). These actions access memory byte (U8), halfword (U16) and word-wise (U32).

5.10.7.1 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 command Target.SetAccessWidth (see *Target.SetAccessWidth* on page 360).

5.10.8 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 debug controls	All debug controls except "halt" and "disconnect" are deactivated.

Limitation	Description
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.

5.10.8.1 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 176). The Watched Data Window enables users to set refresh rates between 1 and 5 Hz for each watched item individually.

5.10.8.2 Data Trace

In situations where a high-resolution trace of a data symbol is required, users can resort to Ozone's Data Sampling Window (see *Data Sampling Window* on page 114). The Data Sampling Window supports sampling rates of up to 1 MHz. The resulting data graphs can be explored within the Timeline Window.

5.10.8.3 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 enables "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 213. For further information on streaming trace, please consult the *J-Link User Guide* or *SEGGER's website* .

5.10.8.4 Power Trace

The Power Sampling Window tracks the current drawn by the target while executing the debuggee. The acquired power sampling data can be explored within the Timeline Window.

5.11 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 301)
- File.Load: (see *File.Load* on page 300)
- Exec.Download: (see *Exec.Download* on page 364)
- Target.LoadMemory: (see *Target.LoadMemory* on page 362)

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?

5.11.1 Download Behavior Comparison

The table below compares the mentioned actions regarding the named aspects. Only command File.Open triggers the standard download sequence that is also performed during debug session startup (see *Starting the Debug Session* on page 184). The hardware reset is identical to the operation performed by command Exec.Reset (see *Exec.Reset* on page 364). For a description of the initial program operation, refer to section *Initial Program Operation* on page 184.

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

5.11.2 Script Callback Behavior 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		

5.11.3 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.

5.11.4 Downloading Bootloaders

For details on how to configure Ozone for the download and execution of a bootloader prior to the download of the debuggee, refer to section *Incorporating a Bootloader into Ozone's Startup Sequence* on page 259.

5.11.5 Target Download Addresses

An ELF file contains for each program segment a physical address and a virtual address. The physical address is the address where the respective segment content is stored whereas the virtual address is the address where the respective content resides at execution time. The physical address range may also be referred to as load region and the virtual address range as execution region or exec region. When downloading an image into the target, Ozone writes the firmware into the physical address ranges by default, i.e. into the load regions.

If both physical and virtual addresses match the code is executed in-place, i.e. at the very same location where it is stored. If virtual and physical address ranges are not the same, the code is executed from a different location than where it is stored. Thus the segment content needs to be copied from the physical address range into the virtual address range. This may be done e.g. by a bootloader or by some initialization code executing between reset vector and main().

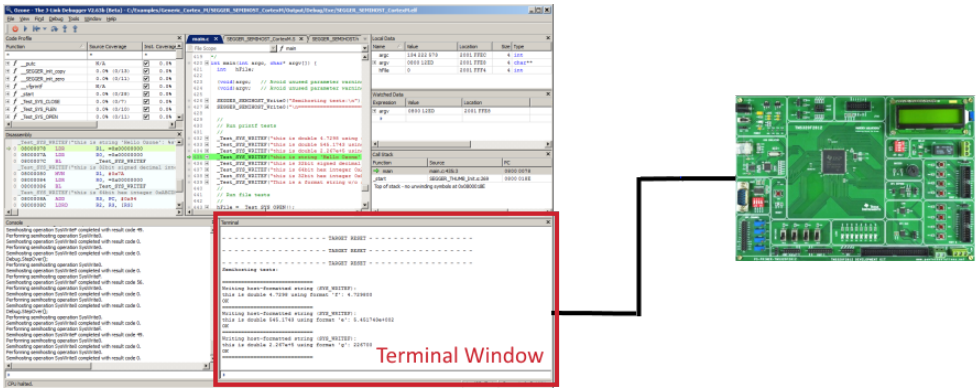
Assuming a device that has a slow mass-storage memory from which code execution is not possible but that is used for storing the firmware. On such a device the firmware needs to be copied from the mass-storage device to a memory that supports code execution. When debugging firmware on such devices it may be desired to download the firmware image directly into the virtual address range, i.e. the address range where the code can be executed. This allows to start debugging immediately since no loader needs to be executed that copies the data from the mass storage device into the executable memory.

Certain build tool chains do create ELF files where the physical addresses are not filled-in but only the virtual addresses are. For such images it is also required to download the firmware image into the virtual address ranges instead of the physical address ranges.

Ozone offers the system variable `VAR_DOWNLOAD_ADDR` which allows to specify wether the firmware is to be downloaded into the physical or the virtual address ranges (see System Variable Identifiers and Destination Address Ranges for Download).

5.12 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 162).



5.12.1 Real-Time Transfer

SEGGER's Real-Time Transfer 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, refer to *SEGGER's website* .

5.12.1.1 RTT Configuration

When a program file is opened, Ozone tries to sense whether the debuggee uses the RTT software library to support Text-IO via RTT. If RTT use is detected, the debugger automatically starts to capture data on the RTT interface. The program file is expected to provide debug symbol *_SEGGER_RTT* for fast and reliable RTT discovery. Command Project.AddRTTSearchRange (see *Project.AddRTTSearchRange* on page 344) is provided to speed up RTT discovery in all other cases, e.g. when debugging release builds. Please refer to *SEGGER's website* for further information on how to set up and use the RTT software library within your debuggee.

5.12.2 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.

5.12.2.1 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 84) or via commands Project.SetTraceSource (see *Project.SetTraceSource* on page 345) and Project.ConfigSWO (see *Project.ConfigSWO* on page 349). The SWO interface can also be enabled by checking the Terminal Window's context menu "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.

5.12.3 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. Semihosting with Ozone is covered by section *Semihosting* on page 200.

5.13 Semihosting

Semihosting is the name of a communication protocol which provides a debuggee access to Host-PC resources. Among the possibilities, semihosting enables a target application running under a debugger to output messages to the debugger's Terminal Window or to obtain text input from the user.

The focus of this section lies on the configuration and usage of semihosting within Ozone. For a technical background on semihosting, including an overview on how the setup the target application for semihosting, the reader is redirected to the ARM information center and SEGGER's wiki homepage.

5.13.1 Supported Architectures

Ozone supports semihosting on the following target architectures:

- Cortex-M
- Cortex-A/R
- Legacy-ARM
- RISC-V

5.13.2 Enabling Semihosting

Ozone automatically enables semihosting on the first CPU halt after debug session start. When not required, semihosting can be explicitly disabled by setting *ModeBP*, *ModeBKPT* and *ModeSVC* to No.

5.13.3 Supported Operations

This section lists the possible operation codes that the debuggee can write to the semihosting operation code register when issuing a semihosting request to Ozone.

Semihosting operations defined by SEGGER:

Name	Code	Description
SysIsConnected	`0x0`	Returns the debugger connection status. When the debugger is connected to the target, it writes a value of 1 to the result register. Otherwise, the result register will be left unmodified. This operation has no arguments.
SysWritef	`0x40`	Outputs a formatted string on the debug terminal. The text formatting is performed by the debugger, i.e. on the host. The argument block for SysWritef (pointed to by `a1`) consists of two entries: the first entry is the target address of the format string. The second entry is a pointer to a variable argument list (`va_list`) which contains the format arguments. The format string and arguments must follow the C library rules for printf.

Semihosting operations defined by ARM:

File operations

Name	Code	Description
SysOpen	`0x1`	Open a file or stream on the host system
SysIsTty	`0x9`	Check whether a file handle is associated with a file or a stream/terminal such as stdout
SysWrite	`0x5`	Write to a file or stream
SysRead	`0x6`	Read from a file at the current cursor position

Name	Code	Description
SysClose	0x2	Closes a file on the host which has been opened by SysOpen
SysFlen	0xC	Get the byte size of a file
SysSeek	0xA	Set the file cursor to a given position in a file
SysTmpNam	0xD	Get a temporary absolute file path to create a temporary file
SysRemove	0xE	Remove a file on the host system
SysRename	0xF	Rename a file on the host system

Terminal I/O operations

Name	Code	Description
SysWriteC	0x3	Write one character to the debug terminal
SysWrite0	0x4	Write a 0-terminated string to the debug terminal
SysReadC	0x7	Read one character from the debug terminal

Time operations

Name	Code	Description
SysClock	0x10	Returns the system clock counter value
SysElapsed	0x30	Returns the clocks since debug session start
SysTickFreq	0x31	Returns the clocks per seconds
SysTime	0x11	Returns the current time

System / Misc operations

Name	Code	Description
SysErrno	0x13	Returns the value of the C library errno variable that is associated with the semihosting implementation
SysGetCmdLine	0x15	Returns the command line parameters for the target application to run with (argc and argv for main())
SysExit	0x18	An application calls this operation to report an exception to the debugger directly. The most common use is to report that execution has completed.

For further information on the legacy operations, including their parameter definitions, refer to the ARM information center.

5.13.4 Input Operations

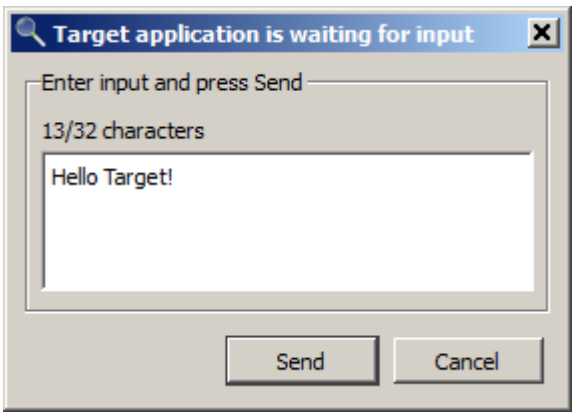
The debuggee may request user input via the following semihosting operations supported by Ozone:

- SysReadC and
- SysRead with IsTtyHandle(R1)==1

Users may serve input requests by:

- entering text into the terminal window's input field and pressing enter or
- by entering text into a popup dialog.

The input mode can be configured via setting `InputViaTerminal=0/1`, as described in sec-



tion *Semihosting Configuration* on page 203.

5.13.5 Unsafe Operations

The following group of semihosting operations are classified to be unsafe:

- SysOpen
- SysRemove
- SysRename

These operations can potentially damage the host system. Each time an unsafe operation is requested by the debuggee, Ozone will ask the user for permission to perform the operation via a popup dialog. Individual permission dialogs can be suppressed. As an example, operation SysRename can be suppressed via setting `AllowRename=0`, as described in section *Semihosting Configuration* on page 203.

5.13.6 Semihosting Configuration

Ozone's semihosting functionality can be configured in two ways:

- using command Project.ConfigSemihosting
- using the Semihosting Settings Dialog

A detailed description of each setting is given by section *Project.ConfigSemihosting* on page 345.

5.13.7 Starting and Stopping Semihosting

Ozone automatically enables semihosting when the debug session is started. No user interaction is required. However, it is recommended to disable semihosting when it is not needed for performance reasons. To disable semihosting, the settings `ModeBP`, `ModeBKPT` and `ModeSVC` must be set to `No`, i.e. their highest allowed value

5.13.8 Generic Semihosting

SEGGER has defined the first instruction of function `SEGGER_SEMIHOST_DebugHalt` to be a universal semihosting trap which is available on all supported target architectures, including RISC-V. In order to catch this trap, Ozone sets a hidden breakpoint on the function whenever it is implemented by the debuggee. In order to perform a semihosting request, the debuggee simply calls this function with the desired operation code as first parameter and the operation argument block pointer as second parameter.

```
/*********************************************************************
*
*     SEGGER_SEMIHOST_DebugHalt()
*
* Function description
*   Generic semihosting request function.
*   The debugger may set a breakpoint on this function, handle the
*   semihosting request, and return to the caller.
*
* Parameters
*   a0: semihosting operation code
*   a1: semihosting operation argument pointer
*
* Return value
*   a0 if debugger is not connected.
*   Semihosting operation result code if debugger is connected.
*/
int __attribute__((noinline)) SEGGER_SEMIHOST_DebugHalt(int a0, int a1) {
  (void)a1; // Avoid unused parameter warning
```



```
  return a0;
}
```


5.14 Working With 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 compliant with certain limitations as described below.

5.14.1 Areas of Application

Expressions are used in the following areas:

- As monitorable entities within the Watched Data Window (see *Watched Data Window* on page 176).
- As monitorable entities within the Quick Watch Dialog (see *Quick Watch Dialog* on page 94).
- As traceable entities within the Data Sampling Window (see *Data Sampling Window* on page 114).
- As specifiers for the data locations of data breakpoints (see *Data Breakpoints* on page 194).
- As specifiers for the trigger conditions of conditional breakpoints (see *Advanced Breakpoint Properties* on page 192).
- At the command prompt or within Project Scripts (see *Elf.GetExprValue* on page 378).
- Within RTOS Awareness Plugins (see *Debug.evaluate* on page 386).
- Within SmartView Plugins (see *Debug.evaluate* on page 386).

5.14.2 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_ACCESS_WIDTH, FREQ_1_MHZ`)
- User-defined constants (see *Script.DefineConst* on page 323)

5.14.3 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 205)

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

5.14.4 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`)
- Members (e.g. `OS_Global`.Time)

<dest>

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

5.15 Locating Missing Source Files

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

5.15.1 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 prefixed to relative file paths specified within the program file.

5.15.2 Missing File Indicators

A missing source file is indicated by a 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 154.

5.15.3 File Path Resolution Sequence

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 or folder on the file system.

The file path resolution sequence can be configured via script commands which enables users to correct the file paths of missing source code files.

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. For a generic overview about file path argument handling, see *File Path Arguments* on page 222.

> **Note**
>
> The root of relative file paths is the project file directory. If the project file directory is not available, the system's current working directory is used instead.

Step 1 - Source File Name Lookup

Step 1 of file path resolution is only applied to plain source file name input (e.g. "main.c"). A lookup of the source file name is performed within the contents of the source files window. If a source file with the given name is found, resolution is complete.

Step 2 - Path Substitution

Step 2 of the file path resolution sequence is applied to source files 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 351). If the file path obtained from path substitution points to a valid file on the file system, resolution is complete.

Step 3 - 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 350). If the alias points to a valid file on the file system, resolution is complete.

Step 4 - Path Expansion

All directory macros and environment variables contained within the file path are expanded (see *Directory Macros* on page 281). If the expanded file path points to a valid file on the file system, resolution is complete.

Step 5 - Source File Root Paths

Step 5 of file path resolution is only applied to unresolved relative file paths. These are appended successively to each source file root path (see *Project.AddRootPath* on page 350). If any of the so-obtained file paths points to a valid file on the file system, resolution is complete.

Step 6 - Application Directories

Step 6 of file path resolution is only applied to unresolved relative file paths. These are appended successively to each of the application directories listed in *Directory Macros* on page 281. If any of the so-obtained file paths points to a valid file on the file system, resolution is complete.

Step 7 - Search Directories

Step 7 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 351). If any of the search directories contains a file with the sought name, resolution is complete.

5.15.4 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.

5.16 Setting Up The Instruction Cache

All instruction-level debug features of Ozone require the debugger to perform an initial analysis of the machine code to be debugged.

In cases where:

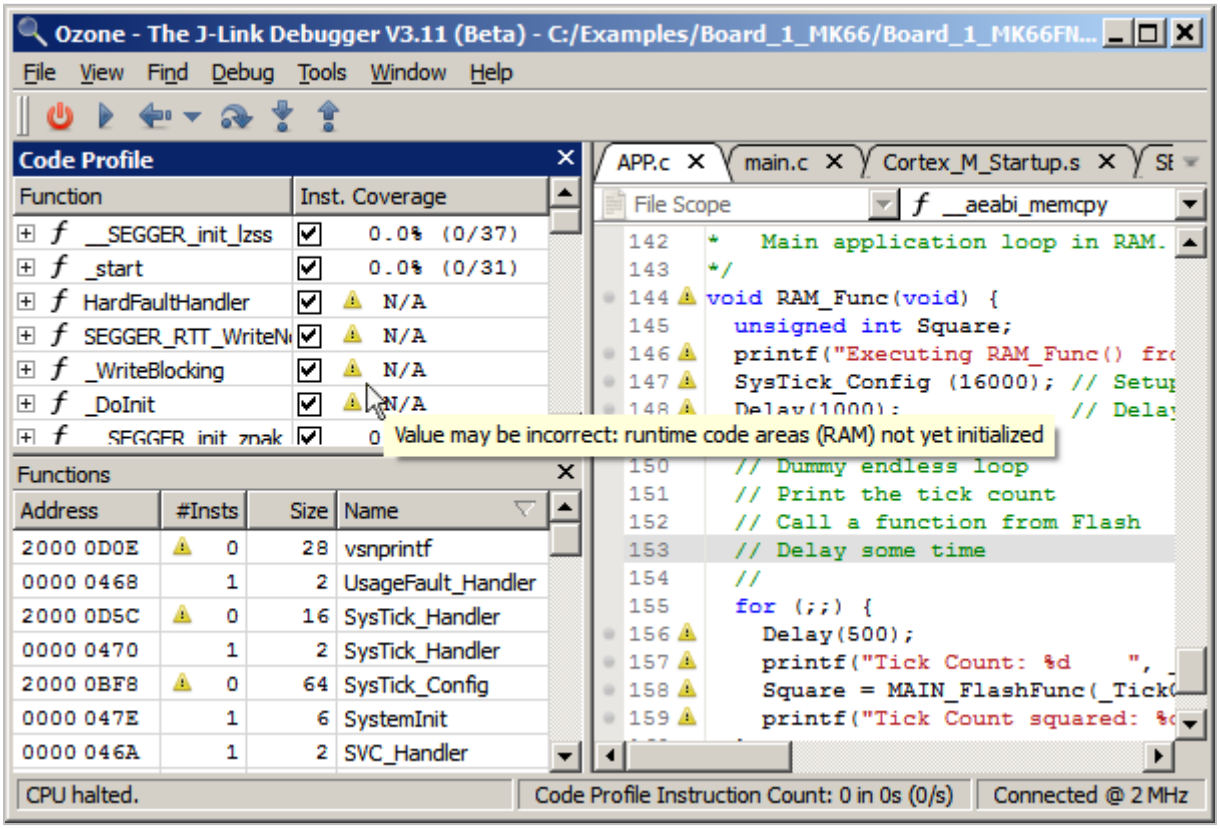
- the debuggee's machine code is fully accessible from the program file,
- the debuggee's machine code is fully accessible from target memory at the Startup Completion Point,

the debugger will perform this analysis automatically and no user interaction is required.

In all other cases, e.g. when:

- a non-ELF program file is specified,
- a secondary program image is in use, such as a bootloader,

parts of the instruction cache may need to be initialized manually. For this purpose, Ozone provides the command Debug.ReadIntoInstCache (see *Debug.ReadIntoInstCache* on page 336). The preferred way to employ this command is to call it from project script function `OnStartupComplete`.



Instruction-level debug information which is unavailable due to an incompletely initialized instruction cache is indicated by a warning sign.

When the instruction cache misses data for a particular code address range, Ozone will display a warning sign next to all affected GUI elements as shown above.

5.17 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* .

5.17.1 Trace Features Overview

Ozone's trace features consist of the following elements:

- Instruction Trace Window (see *Instruction Trace Window* on page 128)
- Timeline Window (see *Timeline Window* on page 165)
- Code Profile Window (see *Code Profile Window* on page 106)
- Execution Counters (see *Code Execution Counters* on page 55)

5.17.2 Target Requirements

Ozone currently supports trace on the following MCU architectures:

- Cortex-M
- Cortex-A

ARM's Cortex MCU architecture principally enables 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 197).

5.17.2.1 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/J-Trace, i.e. accessible via the selected target interface. ETB-Trace otherwise poses no additional requirements on the hardware setup.

5.17.2.2 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.

5.17.3 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.

5.17.4 Trace Settings

- ETB trace does not need to be configured in Ozone.
- ETM trace has multiple configuration settings which can be edited via the Trace Settings Dialog (see *Trace Settings Dialog* on page 84) or via debugger commands as shown below.

Command	Description	Default
Project.SetTraceSource	Selects the trace source to use. See *Trace Sources* on page 269 for the list of valid values.	none
Project.SetTracePortWidth	Specifies the number of trace pins provided by the target. Permitted values are 1, 2 and 4.	4

Command	Description	Default
Project.SetTraceTiming	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. See *Project.SetTraceTiming* on page 348 for further information.	2.0ns
Edit.SysVar(VAR_TRACE_MAX_INST_CNT)	Specifies the maximum number of instructions that Ozone can process and store during a streaming trace session.	10M
Edit.SysVar(VAR_TRACE_TIMESTAMPS_ENABLED)	Specifies weather the target is to output (and J-Link/Ozone is to process) PC timestamps multiplexed into the trace data stream.	1
Edit.SysVar(VAR_TRACE_CORE_CLOCK)	CPU frequency in Hz. Ozone uses this variable to convert instruction timestamps from CPU cycle count to time format (see VAR_TRACE_TIMESTAMPS_ENABLED).	100kHz

Note

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

5.18 Selective Tracing

5.18.1 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.

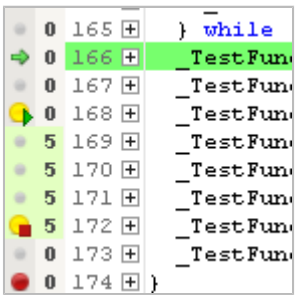
5.18.2 Hardware Requirements

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

Upon target connection, J-Link/J-Trace automatically detects if the target supports selective tracing and enables the debugger to use the feature when available.

5.18.3 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.

5.18.4 Scope

All of the features summarized in *Trace Features Overview* on page 210 are affected by selective tracing.

5.19 Advanced Program Analysis And Optimization Hints

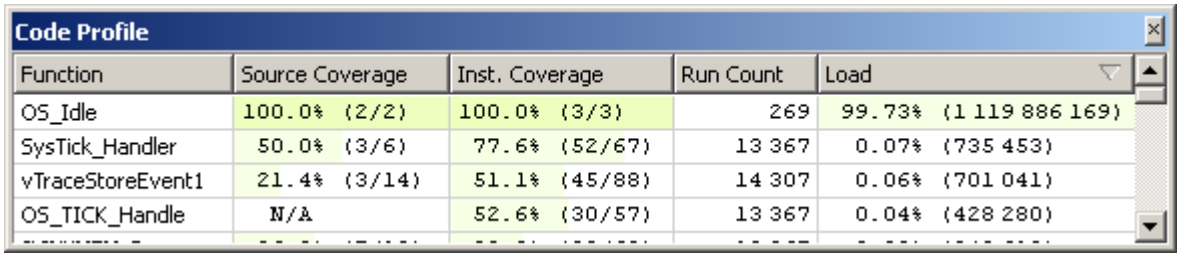
This section describes use-cases of advanced program analysis using the (streaming) instruction trace and code profiling capabilities of Ozone. For code profiling hardware requirements, see *Hardware Requirements* on page 212.

5.19.1 Program Performance Optimization

5.19.1.1 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:

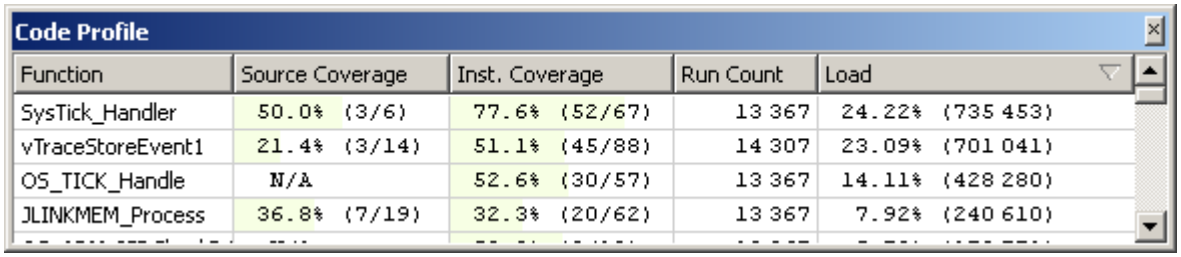


Filtering Functions

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

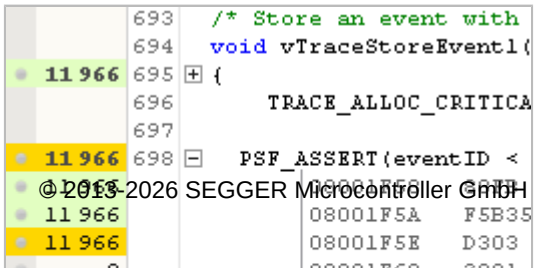
A compiler may furthermore emit code alignment instructions (NOP’s) that are likewise not relevant for code optimization. NOP Instructions can be filtered from the code profile statistic by clicking on context menu entry “Exclude NOP Instructions” or via command Coverage.ExcludeNOPs (see *Coverage.ExcludeNOPs* on page 356).



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 spend 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.

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.

5.20 Debug Snapshots

The debug session and affiliated system state can be saved to / restored from a session file called debug snapshot. This includes:

- RAM
- Flash
- CPU registers
- Selected Peripherals
- Timeline
- Code Profile (Execution Counters)
- Data Graphs
- Power Graphs
- Terminal Log
- Console Log

Snapshots are saved and loaded using the Snapshot Dialog (see *Snapshot Dialog* on page 79). After loading a snapshot, all debug windows show the same information they did at the time the snapshot has been created. Snapshots can be loaded and observed in target-offline mode. This means that no hardware is required to load a snapshot, not even a J-Link or J-Trace. Snapshots are compressed using SEGGER's emCompress software library.

5.20.1 Use Cases

Typical use cases of snapshots are:

- Snapshots allow customers to break away from a debug session with the ability to resume the session at a later point in time.
- Snapshots allow easier reproduction and analysis of bugs, possibly by multiple parties on different Host-PCs.
- Snapshots enhance Ozone's teaching and demonstration capabilities in training sessions and conferences.

5.20.2 Supported Architectures

Snapshots are currently supported on the following target architectures:

- Cortex-M

5.20.3 Default System Restore

When a snapshot is loaded, target CPU registers and memory regions are restored in the order they appear within the snapshot. This order is identical to the order that was displayed by the Snapshot Dialog at the time the snapshot was saved. The default system state saved to snapshots consists of:

- all basic CPU registers, including FP registers.
- all FLASH and RAM regions of the target as defined by J-Link's MCU database.
- all ELF program data sections with the allocatable flag (A) set.

5.20.4 Advanced System Restore

In order to restore advanced system state such as (clocked) peripherals from a snapshot, it is generally necessary for users to program the exact sequence of restore operations. For this reason, any system or peripheral register stored within a snapshot is not automatically written to the target when a snapshot is loaded. Instead, users must program the specific way in which special-purpose registers are saved to and restored from snapshots as explained in section *Snapshot Programming* on page 255.

5.20.5 The Scope of Snapshots

Snapshot store binary debug session data which cannot be easily or efficiently stored in a user-readable format. Snapshots do not replace any of Ozone's existing configuration facilities. In particular, snapshots do not store nor replace:

- Project settings such as Project.SetDevice or Target.PowerOn.
- User file settings such as breakpoints and open documents.
- User preferences and GUI settings.

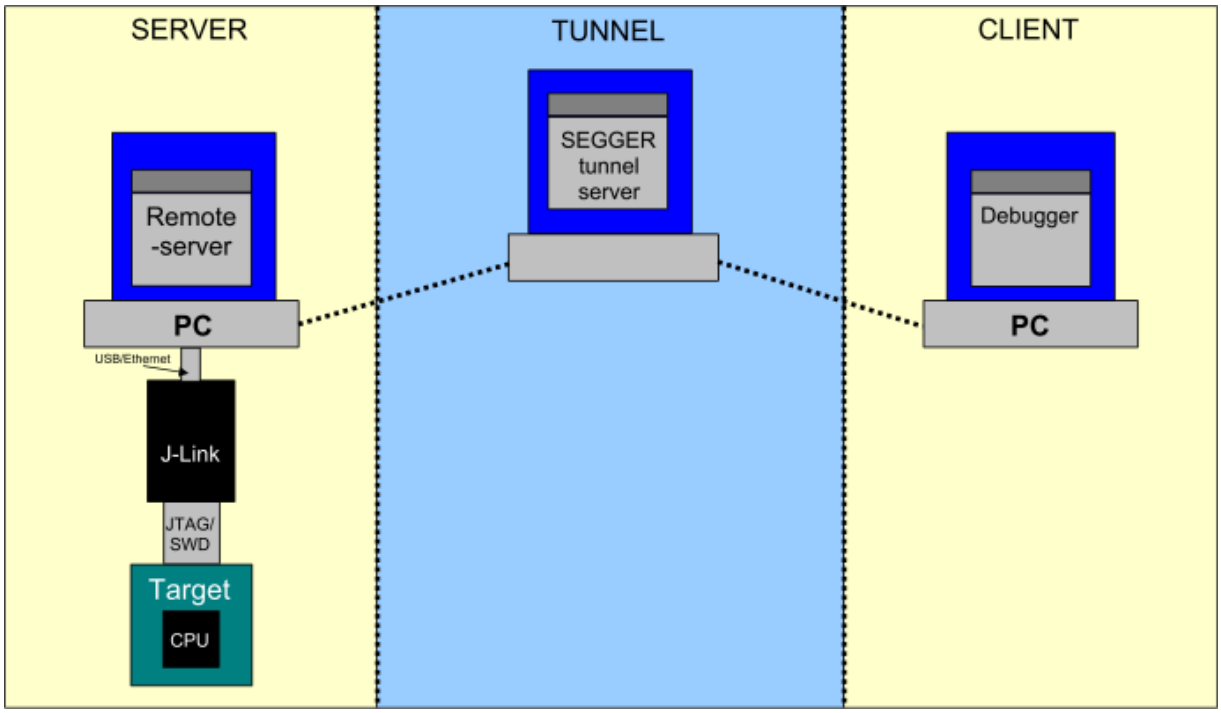
5.21 Remote Debugging

Ozone can connect to a remote J-Link/J-Trace debug probe to debug on a remote target. When debugging remotely, the J-Link/J-Trace debug probe is connected to a remote PC via the Ethernet host interface.

5.21.1 Remote Debugging Over LAN

When the remote PC is on the same LAN as the PC hosting Ozone (host PC), it suffices to start a J-Link Remote Server on the remote PC and supply the IP address of the remote server within Ozone's Host Interface Dialog (instead of the IP of the J-Link / J-Trace debug probe). The Host Interface Dialog is accessible via Ozone menu path Tools->Debug Settings->Host Interface. Note that J-Link Remote Server V6.53b and later also supports encrypted connections.

5.21.2 Remote Debugging Over The Internet



When the remote PC is not on the same LAN as the host-PC, an intermediary tunnel server at SEGGER can be used to be mediate a connection for remote debugging. Both Ozone and the J-Link Remote Server then connect to this tunnel server instead of connecting to each other directly.

For remote debugging via the J-Link Tunnel Server, the IP address field of Ozone's host interface dialog expects a tunnel server credential of the form:

```
tunnel:<Probe>[:<Password>[:<Server>]]
```

where:

Argument	Description
Probe	Either the serial number or nickname of the J-Link / J-Trace to connect to.
Password	Password that was used when the J-Link / J-Trace debug probe was registered with the Remote Server.
Server	Address or hostname of the tunnel server. For use when a tunnel server other than the SEGGER default tunnel server (jlink.segger.com, port 19020) is used.

The short credential variant `tunnel:<Probe>` can be used when the connection is to be established to the default J-Link Tunnel Server and is not password-protected. When debugging via the tunnel server, make sure that port 19020 is not blocked by a firewall.

Examples

Input	Description
tunnel:932000:Pass123:jlink.segger.com	J-Link was registered by S/N, with a password, at jlink.segger.com
tunnel:MyJLink::jlink2.segger.com	J-Link was registered by Name, without a password, at jlink2.segger.com
tunnel:600100000:MyPassword123	J-Link was registered by S/N, with a password, at the default tunnel server.

5.22 Debugging via GDB Server

Ozone provides a GDB client that can connect to a GDB server which is attached to the target to be debugged. Both in the new project wizard as well as in the J-Link settings dialog the GDB server is available as an option to connect to the debug probe, alongside “USB” and “IP”.

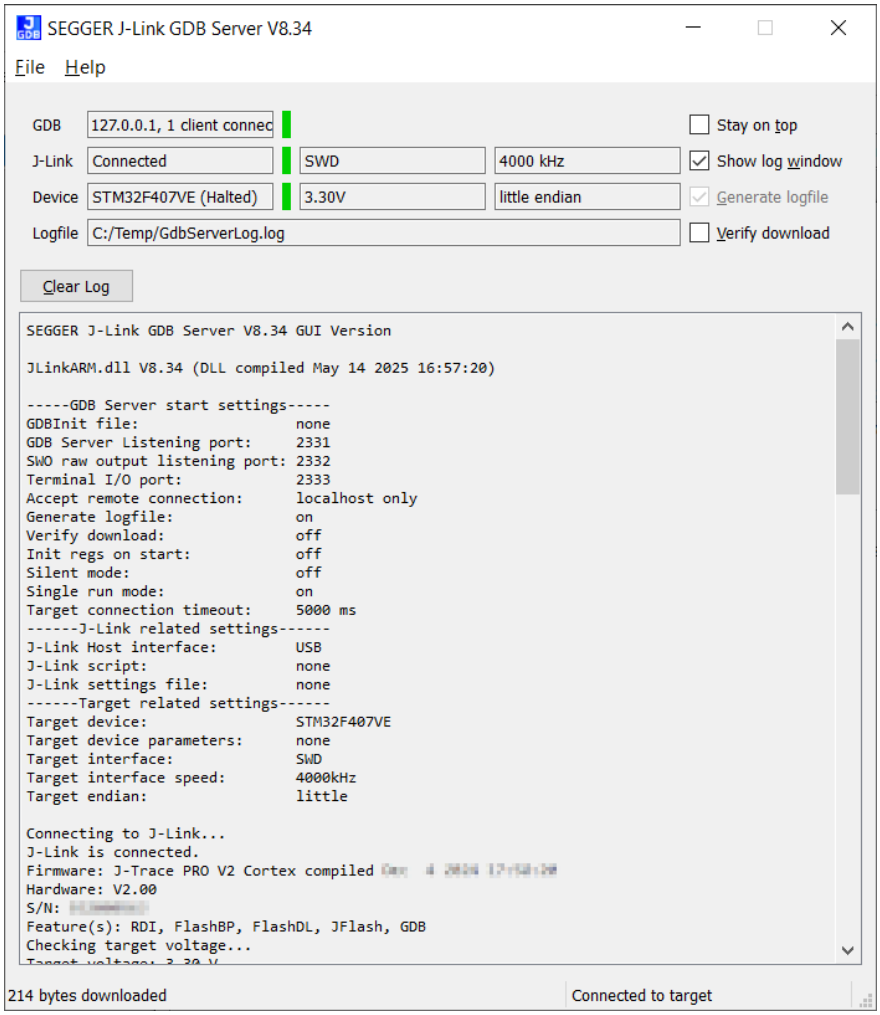
The GDB server is specified by means of its IP-address and port number. If the GDB server runs on the same host as Ozone, setting the IP-address to `localhost` will be sufficient. In that case the default port-number 2331 will be used. Of course, `127.0.0.1:2331` can also be used.

By adding the command `Project.SetHostIF (“GDB_Server”, “localhost:2331”);` to the function `OnProjectLoad`, the setting will be made permanent.

5.22.1 Automatically starting GDB Server

It is possible to automatically start the GDB server on the local machine when the debug session is started. For doing so, the command starting the GDB server must be added to the Ozone project script function `BeforeTargetConnect`. Here is an example command line starting the J-Link GDB server to debug a target application on the SEGGER trace reference board:

```
Process.Exec(“C:/Program Files/SEGGER/JLink/JLinkGDBServer.exe”, “-select USB -device STM32F407VE -endian little -if SWD -speed 4000 -noir -LocalhostOnly -port 2331 -singlerun”, 0);
```



This command line tells the J-Link GDB Server how to connect to the J-Link or J-Trace via USB and provides target details such as device name and endianess as well as connection details such as the target interface and the interface speed. For further information on the command line parameters used in this example please refer to the documentation of the J-Link GDB server.

In this example the GDB server is started such that it automatically closes once the GDB client closes the connection. This will have the effect that the GDB server closes automatically once the debug session is ended. If the GDB server does not automatically close, it needs to be closed manually. Otherwise, with the start of the next debug session, a new instance of the GDB server may be started, which is likely to collide with the existing instance.

5.22.2 3rd Party Debug Probe Support

By making use of a GDB server, Ozone can also connect to 3rd party debug probes. Depending on the functionality provided by the GDB server some features Ozone offers may not be supported, thus limiting the end-user experience.

5.22.3 GDB Remote Protocol Log

Ozone communicates with the GDB server using the GDB remote protocol. This communication can be logged into a file. The command `Project.SetJLinkLogFile` will enable that logging. Due to performance reasons, huge commands and responses will not be written to the file - they are replaced by short placeholder messages.

Commands sent by Ozone to the GDB server are prepended with a >, responses sent by the GDB server to Ozone are prepended with a <. Hex-encoded messages are visible in clear text as well, they are prepended with >> or <<, respectively.

5.22.4 GDB server types

Some GDB servers add extensions to the GDB remote protocol, thus granting access to functionality otherwise not reachable. Even though the GDB remote protocol specifies how to handle such extensions in case the extension is not supported, not all GDB servers adhere to the spec srictly. To avoid overwhelming GDB servers with such extensions the user can specify which GDB server type is being used. This is controlled via the system variable VAR_GDB_SERVER_TYPE (see *GDB Server Type* on page 272) which is accessible in the System Variable Editor.

The system variable is evaluated during the early phase of the debug session, where the connection to the GDB server is established and the mutual capabilities are negotiated. Changing the system variable during an active debug session may not have an immediate effect. The change may become effective only after a new debug session is started.

5.23 Messages And Notifications

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

5.23.1 Message Format

The format of Ozone application messages is <type>(<code>): <message>, where <type> is either *error* or *warning* and <code> is a unique message number.

5.23.2 Message Codes

Section *Errors and Warnings* on page 283 lists all user-visible error and warning messages by their code and provides an overview of the cause and possible solution to each exception.

5.23.3 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

5.23.4 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.

5.23.5 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 279).

5.23.6 Other Logfiles

Messages output to the Console Window or Terminal Window can additionally be logged to a separate logfile (see *Project.SetConsoleLogFile* on page 353 and *Project.SetTerminal-LogFile* on page 353).

In case of connecting to a GDB server the command *Project.SetJLinkLogFile* on page 352 will have the effect that the communication between GDB client and GDB server is written to a log file.

5.24 File Path Arguments

This section explains the rules pertaining to file path input.

Ozone obtains user file path input via multiple channels, such as:

- export dialogs
- command arguments
- console prompt

Regardless of the input channel, a file path argument is processed in the following globally consistent way:

- A file path may be specified either as an absolute or as a relative path. In the latter case, the path is relative to the project file directory. If the project file directory does not exist, the path is relative to the system's current working directory.
- File path arguments may include Ozone directory macros, environment variables and cd-up (..) macros (see *Directory Macros* on page 281 and *Environment Variables* on page 281).
- User preference `PREF_AUTO_CREATE_DIR_PATHS` governs if the output directory path will be automatically created when it does not exist.
- The letter casing of file paths is only relevant on macOS and Linux.
- A file path must end with a file name and a file extension. The file extension can be omitted when explicitly indicated within this user guide.
- Every time Ozone encounters an invalid file path argument that does not point to a file or directory, the debugger tries to resolve the file path as described in *File Path Resolution Sequence* on page 207. When the path could be successfully resolved, it replaces the user input.

5.25 Other Debugging Activities

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

5.25.1 Finding Text Occurrences

Text patterns within source code documents may be located using the **Find In Files Dialog** (see *Find In Files Dialog* on page 71). This dialog supports regular expressions and standard text search options.

Text patterns within the content of the Instruction Trace Window may be located using the **Find In Trace Dialog** (see *Find In Trace Dialog* on page 73). This dialog supports regular expressions and standard text search options.

When a text pattern is to be found within the active document, users may furthermore resort to the convenient **Quick Find Widget** (see *Quick Find Widget* on page 92). The quick find widget can be used alternatively to locate a particular function, global variable or source code file of the debuggee.

The Find In Trace Dialog is provided to locate text patterns within Instruction Trace Window content.

5.25.2 Saving And Loading Memory

Ozone enables 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 command Target.SaveMemory (see *Target.SaveMemory* on page 361) or via the *Save Memory Dialog* (see *Memory Dialog* on page 137).

File-To-Memory

File contents can be downloaded to target memory via command Target.LoadMemory (see *Target.LoadMemory* on page 362) or via the *Load Memory Dialog* (see *Memory Dialog* on page 137).

5.25.3 Relocating Symbols

To allow the debugging of runtime-relocated programs such as bootloaders, Ozone provides command Project.RelocateSymbols (see *Project.RelocateSymbols* on page 352). 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. Symbol relocation must be specified before the program file is opened.

5.25.4 Closing the Debug Session

The debug session can be closed via command Debug.Stop (see *Debug.Stop* on page 331). The action can be executed from the Debug Menu or by pressing the hotkey Shift-F5.

5.25.5 Interworking with External Applications

Ozone can spawn processes and execute external applications. The exit code of the application can be used in Ozone for further processing and textual poutput created by the application on standard output channels (such as `stdout` and `stderr`) is captured and displayed in Ozone's console window. The preferences dialog allows specifying the colors for such messages in the console window.

A timeout duration can be specified. If the application does not terminate within that time limit, the application is killed by Ozone.

Applications can be launched in 2 ways:

- **Waiting for termination**: The application is started and Ozone waits until the application terminates. Ozone supports starting only a single process at a time this way. Another application can be started only after the previous application terminated.
- **Fire-and-forget**: The application is started without Ozone waiting for its termination. The exit code of the application is not available in Ozone and textual outputis neither captured nor displayed in the console window. Multiple applications can be started this way at the same time.

For this feature the command Process.Exec (see *Process.Exec* on page 339) is used. When launching the application, the following information must be provided:

- The **application's name** as it is used to start the application from the OS shell's command line. The path information may be included.
- The **argument list** as it would be specified when starting the application from the OS shell. The argument list must be provided in a single string containing all arguments separated by whitespaces.
- The **Timeout**. This is the expected execution time in milliseconds after which the process will be killed in case the application did not termiante beforehand.

Quotes in the file name and/or arguments need to be escaped with a preceeding backslash, i.e. '\"' must be used.

Chapter 6

Scripting Interface

This chapter describes Ozone’s scripting interface. The scripting interface enables users to:

- reprogram key debug operations
- incorporate a bootloader into Ozone’s startup sequence
- extend Ozone’s target application insight via RTOS awareness plugins
- support custom instructions

among other applications.

6.1 Project Script

Ozone project scripts (*.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.

It is also possible to use functions inside the project script as macros for complex command sequences. For details please refer to *User Functions* on page 228.

6.1.1 Script Language

Ozone project scripts are written in a simplified C language that supports most C language constructs such as functions and control structures.

Types

The following types and type definitions can be used within project scripts:

```
int           __int64       U64           I64
short         __int32       U32           I32
char          __int16       U16           I16
void          __int8        U8            I8
```

as well as pointers to – and arrays of – the types listed above.

Type Modifiers

The following type modifiers can be used within project scripts:

- `signed`
- `unsigned`
- `static`
- `const`

Operators

Ozone project scripts support all binary and unary C operators with the exception of the unary increment and decrement operators.

Syntax Constraints

The following syntax constraints apply to project scripts:

- variables must be declared before they can be initialized.
- local variable declarations have to be placed on top of the function body before all other code.
- quotes in strings need to be escaped with a preceeding backslash.

> **Note**
>
> Escaped quotes are supported only by a selection of commands. In case a command supports escaped quotes there is a note in the respective command's documentation.

6.1.2 Script Structure

On a top level, there are 3 structural elements within a project script:

Global Variable Declarations

```
static unsigned int _PC;
```


Constant Value Definitions

```
__constant unsigned int PC_OFFSET = 4;
```

Function Definitions

```
void AfterTargetReset(void) {
  Target.WriteU32(0x40004002, 0xFF);
}
```

All other script code must be contained within script functions. In addition, global constants can be defined using command Script.DefineConst (see *Script.DefineConst* on page 323).

6.1.3 Script Functions Overview

Project file script functions belong to three different categories: event handler functions, process replacement functions and user functions. Each script function may contain 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.

6.1.4 Event Handler Functions

Ozone defines a set of event handler functions that the debugger executes upon entry of specific debug events. The Table below lists the event handler functions and their associated events. The event handler function `OnProjectLoad` must be present in a project file. All other functions are optional.

Event Handler Function	Description
`void OnProjectLoad();`	Executed when the project file is opened.
`void AfterProjectLoad();`	Executed after the project file is opened.
`void OnStartupComplete();`	Executed when the Startup Completion Point was reached.
`void OnDebugStartBreakSymbolReached();`	Executed when the symbol to be stopped at during startup was reached.
`void BeforeTargetReset();`	Executed before the target is reset.
`void AfterTargetReset();`	Executed after the target was reset.
`void BeforeTargetDownload();`	Executed before the program file is downloaded.
`void AfterTargetDownload();`	Executed after the program file was downloaded.
`void BeforeTargetConnect();`	Executed before a connection to the target is established.
`void AfterTargetConnect();`	Executed after a connection to the target was established.
`void BeforeTargetDisconnect();`	Executed before the debugger disconnects from the target.
`void AfterTargetDisconnect();`	Executed after the debugger disconnected from the target.
`void AfterTargetHalt();`	Executed after the target processor was halted.
`void BeforeTargetResume();`	Executed before the target processor is resumed.
`void OnSnapshotLoad();`	Executed when a debug snapshot is loaded.
`void OnSnapshotSave();`	Executed when a debug snapshot is saved.
`void OnError(char* sErrorMsg);`	Executed when an error occurred.

6.1.5 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.

User functions can also be called via the command Script.Exec (to be entered into the Command Prompt in the Console Window), or via the Custom Toolbar. Thus user functions may serve as macros for complex sequences of steps: The sequence needs to be implemented into a user function so it can be executed each time the respective button in the Custom Toolbar is clicked.

User functions may also be linked to a break point, so they are invoked each time the breakpoint is taken. This can be used for automation purposes but also for smarter triggering, by evaluating complex conditions inside the function and resuming execution of the target in case they are not met. Details on that topic can be found in the section *Breakpoint Callback Functions* on page 193.

6.1.6 Debugger API Functions

In the context of project script files, any user action that has a text command is referred to as an API function or API command (see *Action Tables* on page 43). API functions can be called from project script files to execute specific functions of the debugger and to exchange data with the debugger. In short, API functions resemble the debugger's programming interface (or API).

6.1.7 Process Replacement Functions

Ozone defines 4 script functions that can be implemented within the project file to replace the default implementations of certain debug operations. The behavior that is expected from process replacement functions is described in this section.

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

6.1.7.1 DebugStart

When 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.

Startup Sequence

The table below lists the different phases of Ozone's default debug session startup sequence (see *Download & Reset Program* on page 184). 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 connection to the target is established via J-Link/J-Trace.	`TargetConnect`
Phase 2: Breakpoints	Pending (data) breakpoints that were set in offline mode are applied.	

Startup Phase	Description	Process Replacement Function
Phase 3: Reset	A hardware reset of the target is performed.	TargetReset
Phase 4: Download	The debuggee is downloaded to target memory.	TargetDownload
Phase 5: Finish	The initial program operation is performed (see *Initial Program Operation* on page 184).	

Flow Chart

Appendix *Startup Sequence Flow Chart* on page 282 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 227).

Breakpoint Phase

Phase 2 (Breakpoints) of the default startup sequence is always executed implicitly after the connection to the target was established.

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.

```
void DebugStart (void) {
  Exec.Connect();
  Exec.Reset();
  Exec.Download("C:/examples/keil/stm32f103/blinky.axf");
}
```

6.1.7.2 TargetConnect

When 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.

6.1.7.3 TargetDownload

When 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.

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
  Exec.Download();

  // 2. Download the additional program image
  Target.LoadMemory("C:/AdditionalProgramData.hex", 0x20000400);
}
```

Using command "Exec.Download" to perform the download guarantees that there will be no script function recursion (see *Download Behavior Comparison* on page 198).

6.1.7.4 TargetReset

When script function `TargetReset` is defined within the project file, the debugger's default target hardware reset operation is replaced with the operation defined by the script function.

J-Link Reset Routine

Ozone's default hardware reset routine is based on the J-Link/J-Trace firmware routine "`JLINKARM_Reset`". Please refer to the *J-Link User Guide* for details on this routine and its target-dependent behavior.

Writing a Reset Routine for RAM Debug

A typical example where the J-Link/J-Trace 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);
}
```

6.1.8 Executing Script Functions

Ozone provides the command Script.Exec (see *Script.Exec* on page 322) that enables users to execute individual project script functions from the Command Prompt (see *Command Prompt* on page 111).

6.2 Disassembly Plugin

A disassembly plugin adds support for custom instructions to Ozone. It enables users to debug and analyze a program containing custom instructions without limitations.

In particular, a disassembly plugin:

- enables the disassembly of custom instructions within the Disassembly Window (see *Disassembly Window* on page 117).
- enables all features of Ozone that rely on numerical instruction information to process custom instructions and output accurate results.

An example for the latter case is the Call Graph Window. This debug window requires knowledge about the branch destination PC for all branch-type instructions in order to build function call graphs.

6.2.1 Script Language

Disassembly plugins are written in JavaScript. All of JavaScript's basic language constructs are supported. The following restrictions apply:

- All script code must be contained within functions.
- Exception handling (`throw`, `try`, `catch`) is not supported.

6.2.2 Loading the Plugin

Command Project.SetDisassemblyPlugin loads a disassembly plugin. When this command is added to project script function `OnProjectLoad`, the plugin will be loaded each time the project is opened (see *Project.SetDisassemblyPlugin* on page 343).

Users may alternatively execute action *Set Script* of the disassembly window context menu in order to load a disassembly plugin. When executed, this action will also edit the project file accordingly.

6.2.3 Script Functions Overview

A disassembly plugin consists of 3 predefined functions:

Function	Description	Executed When
`init`	performs initialization tasks	plugin load
`printInstAsm`	Returns the disassembly text of a custom (or overridden) instruction	on-demand
`getInstInfo`	Returns numeric information about a custom (or overridden) instruction, such as the PC branched to	program file load

The implementation of each function is optional.

Next to the predefined script functions, users are free to add their own functions to disassembly plugins in order to structure the code.

6.2.4 Debugger API

Ozone defines a set of commands that can be called from disassembly plugins to communicate and exchange data with the debugger. These commands are implemented as methods of Ozone's JavaScript API classes:

Class	Description
Debug	Provides methods that query information from the debugger.
TargetInterface	Provides methods that read or write target memory and registers.

The following API commands are of particular importance for the development of disassembly plugins:

Command	Description	Typical Application
`Debug.enableOverrideInst`	Overrides a known instruction	called from function `init`
`Debug.getSymbol`	Returns the name of a symbol	Obtain the label of a branch instruction
`TargetInterface.peekBytes`	Reads target memory data	Obtain the word at the access location of a load/store instruction

An example-based description of the API classes can be found in section *Writing the Disassembly Plugin* on page 233. A formal description is given by section *JavaScript Classes* on page 383.

6.2.5 Writing the Disassembly Plugin

This section provides an example implementation which adds support for a custom instruction on a RI5CY RISC-V MCU core.

6.2.5.1 init

A disassembly plugin implementation typically starts with script function `init`. This function is called when the disassembly plugin is loaded. The main purpose of function `init` is to provide a place where instruction overrides using command `Debug.enableOverrideInst` can be defined. An instruction override enables users to alter the disassembly and numerical information of a known instruction.

```
/*********************************************************************
*
*     init
*
* Function Description
*   Called by Ozone when the script was loaded
*   (i.e. when command “Project.SetDisassemblyPlugin” was executed).
*
*   Typical usage: executes one or multiple “Debug.enableOverrideInst”
*   commands which define the instructions whose default disassembly
*   is to be overridden by this plugin.
*
* Return Value
*   0 on success, -1 on error
*/
function init() {

  var aInst = new Array();
  var aMask = new Array();
  //
  // This plugin overrides instruction “ADDI sp, sp, -16” (0x1141):
  //
  aInst[0] = 0x41;
  aInst[1] = 0x11;
  aMask[0] = 0xFF; // all encoding bits are relevant
  aMask[1] = 0xFF; // all encoding bits are relevant

  Debug.enableOverrideInst(aInst, aMask);

  return 0;
}
```


This example implementation of `init` overrides the instruction with integer encoding `0x1141`.

6.2.5.2 printInstAsm

Next, we implement function `printInstAsm` in order to:

- provide the disassembly of custom instruction “P.BEQIMM”
- provide the disassembly of overridden instruction `0x1141`

```
/*************************************************************************
*
*     printInstAsm
*
* Function Description
*   Prints the assembly code of an instruction.
*
* Function Parameters
*   Addr: instruction address (type: U64).
*   aInst: instruction bytes (type: byte array).
*   Flags: basic info about the instruction required for analysis.
*
* Return Value
*   assembly code string of format: <mnemonic>\t<operands>\t;<comment>.
*   undefined if the input instruction is not supported by this plugin.
*/
function printInstAsm(Addr, aInst, Flags) {
  if (aInst.length == 4) {
    //
    // convert byte array “aInst” to integer “Encoding”
    //
    var Encoding = (aInst[3]<<24) | (aInst[2]<<16) | (aInst[1]<<8) | aInst[0];
    if ((Encoding & 0x707F) == 0x2063) { // opcode == “P.BEQIMM” ?
      //
      // “P.BEQIMM” is a PC-relative conditional branch
      //
      // Operation:
      //   If (Rs1 == Imm5) branch to Addr + (Imm12 << 1).
      //
      var sInst = "P.BEQIMM\t" + regName(Rs1) + ", " + Imm5 + ", " + Imm12;
      var sSymbol = Debug.getSymbol(Addr + (Imm12 << 1));
      return sInst + “\t; ” + sSymbol;
    }
  } else if (aInst.length == 2) {
    var Encoding = (aInst[1] << 8) | aInst[0];
    if (Encoding == 0x1141) { // “ADDI sp, sp, -16” ?
      return “ADDI\tsp, sp, -0x10”;
    }
  }
  return undefined;
}
```

The above example of function `printInstAsm` executes a single debugger API command with `Debug.getSymbol`. This command returns the name of the symbol at or preceding the input address. The symbol name is appended as comment to the returned assembly code text. Function `regName` is a user-defined script function which returns the name of a RISC-V register. The extraction of fields Imm5 and Imm12 from the encoding has been omitted from this example to improve readability.

6.2.5.3 getInstInfo

We also want the disassembly plugin to provide numerical information about custom instruction “P.BEQIMM” to Ozone, such as the branch destination PC. This will allow Ozone to assemble and display correct information in areas that are based on numerical instruction information, such as the Call Graph Window.

The plugin delivers numerical instruction information to Ozone via script function `getInstInfo`.

```
/*****************************************************************
*
*     getInstInfo
*
* Function Description
*   Returns numerical information about an instruction.
*
*   Used by Ozone to generate timeline stacks and call-graphs,
*   among other applications.
*
* Function Parameters
*   Addr: instruction address (type: U64)
*   aInst: instruction data bytes (type: byte array)
*   Flags: basic info about the instruction required for analysis.
*
* Return Value
*   undefined if the input instruction is not supported by this plugin.
*   otherwise a javascript object corresponding to C structure INST_INFO:
*
* struct INST_INFO {
*   U32 Mode; // instruction execution mode (for ex. THUMB or ARM)
*   U32 Size; // instruction byte size
*   U64 AccessAddr; // access address (load/store location, branch dest.)
*   int StackAdjust; // Difference of SP before and after inst. execution
*   U32 Flags; // binary instruction information
* }
*/
function getInstInfo(Addr, aInst, Flags) {
  if (aInst.length == 4) {
    //
    // convert byte array “aInst” to integer “Encoding”
    //
    var Encoding = (aInst[3]<<24) | (aInst[2]<<16) | (aInst[1]<<8) | aInst[0];
    if ((Encoding & 0x707F) == 0x2063) { // opcode == “P.BEQIMM” ?

      var InstInfo;
      InstInfo = new Object();
      InstInfo.Size = 4;
      InstInfo.Mode = 0;
      InstInfo.StackAdjust = 0;
      InstInfo.AccessAddr = Addr + Imm12;
      InstInfo.Flags = 0x0888; // IsBranch | IsConditional | IsFixedAddress
      return InstInfo;

    } // if opcode == “P.BEQIMM”
  } // if aInst.length == 4

  return undefined;
}
```

as demonstrated in the example above, numerical instruction information is returned as a JavaScript object containing a predefined set of members. The member names are fixed

and must match the example. The 32 bit unsigned *Flags* member of the object has the following bit field layout:

InstInfo.Flags

Field	Pos	Len	Description
IsValid	0	1	InstInfo.Flags is not initialized when this field is 0
IsCtrlTransfer	1	1	Instruction possibly alters the PC
IsSoftIRQ	2	1	Instruction is a software interrupt request
IsBranch	3	1	Instruction is a simple branch (B, JMP, …)
IsCall	4	1	Instruction is a function call (Branch with Link, BL, CALL, …)
IsReturn	5	1	Dedicated return instruction or return-style branch (e.g. POP PC)
IsMemAccess	6	1	Instruction reads from or writes to memory
IsFixedAddress	7	1	Branch or access address is fixed (absolute or PC-relative)
IsBP	8	1	Instruction is a SW breakpoint
IsSemiHosting	9	1	Instruction could be a semihosting instruction
IsNOP	10	1	Instruction is a NOP
IsConditional	11	1	Instruction is conditionally executed
Condition	12	4	Condition if conditionally executed

The field *Condition* is currently unused.

This concludes the plugin example. We have seen that from a top-level perspective, a disassembly plugin consists of 3 predefined functions.

6.2.6 The Flags Parameter

The 32 bit unsigned Flags parameter of script functions `printInstAsm` and `getInstInfo` provides basic instruction information required for disassembly and analysis. The interpretation of this parameter depends on the target architecture, as explained below.

6.2.6.1 Flags on ARM

Value	Meaning
0	Address is contained within a (code-inline) data segment
1	Address is contained within an AArch32 thumb code segment
2	Address is contained within an AArch32 ARM code segment
3	Address is contained within an AArch64 code segment

6.2.6.2 Flags on RISC-V

The Flags parameter currently has no meaning on RISC-V.

6.3 RTOS Awareness Plugin

By implementing an RTOS-awareness plugin, users are able to add a task list and other RTOS-specific debug information to the RTOS Window (see *RTOS Window* on page 151). An RTOS plugin may furthermore enable Ozone to show the execution context of any suspended or interrupted task within the Registers, Call Stack and Local Data windows.

6.3.1 Script Language

RTOS awareness plugins are written in JavaScript. All of JavaScript's basic language constructs are supported. The following restrictions apply:

- All script code must be contained within functions.
- Exception handling (throw, try, catch) is not supported.

6.3.2 Loading the Plugin

Command Project.SetOSPlugin loads an RTOS plugin. When this command is added to project script function `OnProjectLoad`, the plugin will be loaded each time the project is opened (see *Project.SetOSPlugin* on page 343).

When an RTOS plugin is loaded, the entry for the RTOS Window will become active in the the debuggers View Menu (see *View Menu* on page 46).

6.3.3 Script Functions Overview

Ozone defines the prototypes of 6 script functions that serve specific purposes and that are executed upon entry of specific events.

Function	Description	Executed When
`init`	initializes the RTOS Window	program file load
`update`	updates the RTOS Window	program execution halt
`getregs`	returns the register set of a task	task context activation
`getname`	returns the name of a task	program execution halt
`getOSName`	returns the name of the RTOS	program file load
`gettls`	returns the base address of a task's thread local storage	program execution halt
`getContextSwitchAddrs`	returns information about all RTOS kernel functions that perform a task switch	program file load

The implementation of function *update* is obligatory while all other functions may be omitted from a plugin implementation.

Next to the predefined script functions, users are free to add their own functions to RTOS scripts in order to structure the code.

6.3.4 Debugger API

Ozone defines a set of functions that can be called from RTOS scripts to communicate and exchange data with the debugger. These functions are implemented as methods of Ozone's JavaScript API classes:

Class	Description
Debug	Provides methods that query information from the debugger.
Threads	Provides methods that control and edit the RTOS Window.
TargetInterface	Provides methods that read or write target memory and registers.

An example-based description of the API classes can be found in section *Writing the RTOS Plugin* on page 238. A formal description is given by section *JavaScript Classes* on page 383.

6.3.5 Writing the RTOS Plugin

The examples presented in this section assume that the debuggee defines a recursive task control block structure similar to the following type definition:

```
TCB {
  U32*  pStack;     // memory address of the task stack
  U32*  pTLS;       // base address of the task's thread local storage
  TCB*  pNext       // memory address of the next TCB
  …
};
```

6.3.5.1 init

An RTOS plugin implementation typically starts with script function `init` – this function is expected to set up all RTOS informational views of the RTOS Window so that RTOS information can be quickly updated once the debug session is running.

```
/*********************************************************************
*
*     init
*
* Function description
*   Initializes all RTOS informational views of the RTOS Window.
*
*********************************************************************
*
function init()
{
  // Init the task table
  Threads.newqueue("Tasks");
  Threads.setColumns("Name", "Priority", "Status", "Timeout");
  Threads.setSortByNumber("Priority");
  Threads.setColor("Status", "Ready", "Executing", "Waiting");

  / Init the timers table
  Threads.newqueue("Timers");
  Threads.setColumns("Name", "Priority", "Interval");
  Threads.setSortByNumber("Priority");
  Threads.setSortByNumber("Interval");
}
```

`Threads.newqueue` appends a new table to the RTOS Window and activates it. When the table already exists, it is simply activated.

> **Note**
>
> The RTOS task list is required to be added as the first table of the RTOS window.

`Threads.setColumns` sets the columns of the active table. Note that all methods of the `Threads` class that do not specify a table name act upon the active table. For conveniance, Ozone implicitly adds table "Task List" to the RTOS window when method `Threads.setColumns` is called before any table was added.

`Threads.setSortByNumber` specifies that a particular column of the active table should be sorted numerically rather than alphabetically.

`Threads.setColor` configures the task list highlighting scheme. The tasks with states "Ready", "Executing" and "Waiting" will be highlighted in light green, green and light red, respectively.

6.3.5.2 update

An implementation of `update` is expected to perform an all-table update of the RTOS Window.

```
/*****************************************************************
*
*     update
*
* Function description
*   Updates all RTOS informational views of the RTOS Window.
*
*****************************************************************
*/
function update()
{
  var aRegs = [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16];

  // clear all tables
  Threads.clear();

  // fill the task table
  if (Threads.shown("Tasks")) {
    Threads.newqueue("Tasks");
    Threads.add("Task1", "0", "Executing", "1000", 0x20003000);
    Threads.add("Task2", "1", "Waiting", "2000", aRegs);
  }

  // fill the timers table
  if (Threads.shown("Timers")) {
    Threads.newqueue("Timers");
    Threads.add("Timer1", "1000", "2000");
  }
}
```

`Threads.clear` removes all rows from all tables of the RTOS Window. Table columns remain unchanged.

`Threads.shown` tests if a RTOS Window table is currently visible. The methods main use is to allow a faster update of the RTOS Window.

`Threads.newqueue` activates the table named "Tasks" so that the following call to `Threads.add` will append a data row to this table.

The last parameter of method `Threads.add` is either:

- an integer value that identifies the task, usually the address of the task control block.
- an unsigned integer array containing the register values of the task. The array must be sorted according to the logical indexes of the registers as defined by the ELF-DWARF ABI.

The first option should be preferred since it defers the readout of the task registers until the task is activated within the RTOS Window (see method `getregs`).

The special task identifier value *undefined* indicates to the debugger that the task registers are the current CPU registers. In this case, the debugger does not need to execute method `getregs`.

6.3.5.3 getregs

An implementation of `getregs` is expected to return the (saved) register set of a task.

```
/*****************************************************************
*
*     getregs
*
* Function description
*   Returns the register set of a task.
*   For ARM cores, this function is expected to return the values
*   of registers R0 to R15 and PSR.
*
* Parameters
*   hTask: integer number identifying the task.
*   Identical to the last parameter supplied to method Threads.add.
*   For convenience, this should be the address of the TCB.
*
* Return Values
*   An array of unsigned integers containing the task's register values.
*   The array must be sorted according to the logical indexes of the regs.
*   The logical register indexing scheme is defined by the ELF-DWARF ABI.
*
*****************************************************************
*/
function getregs(hTask)
{
  var i;
  var tcb;
  var aRegs = new Array(16);

  // get the task's TCB data structure
  tcb = Debug.evaluate("*(TCB*)" + hTask);

  if (tcb == undefined) {
    return [];
  }
  // copy the registers stored on the task stack to the output array
  for (i = 0; i < 16; i++) {
    aRegs[i] = TargetInterface.peekWord(tcb.pStack + i * 4);
  }
  return aRegs;
}
```

The method `Debug.evaluate` instructs Ozone to evaluate a C-style symbol expression and return the result as a JavaScript object (see *Working With Expressions* on page 205).

In the example above, an expression including a type cast and a pointer dereference is employed to return a JavaScript object that mirrors the TCB type defined by the debuggee. The member tree of the returned JavaScript object is fully initialized with the exception that pointer members cannot be dereferenced.

The return value of `Debug.evaluate` can be compared to value undefined in order to test if the evaluation succeeded.

Method `TargetInterface.peekWord` instructs the debugger to read and return a word from target memory. In the example above, `peekWord` is used to read a register value of the task stack.

6.3.5.4 getname

Function `getname` is expected to return the name of a task.

```
/*****************************************************************
*
*     getname
*
* Function description
*   Returns the name of a task.
*
* Parameters
*   hTask: see the description of method getregs.
*
*****************************************************************
*/
function getname(hTask)
{
  var tcb;
  tcb = Debug.evaluate("*(TCB*)" + hTask);
  return tcb.sName;
}
```

6.3.5.5 getOSName

Function `getOSName` is expected to return the name of the RTOS. The name will be used within Ozone's view menu, among other applications.

```
function getOSName() {
  return "embOS";
}
```

6.3.5.6 gettls

Function `gettls` is expected to return the base address of the memory block containing the task's thread local storage.

```
/*****************************************************************
*
*     gettls
*
* Function description
*   Returns a pointer to the thread local storage of a task.
*
* Parameters
*   hTask: see the description of method getregs.
*
*****************************************************************
*/
function gettls(hTask)
{
  var tcb;
  tcb = Debug.evaluate("*(TCB*)" + hTask);
  return tcb.pTLS;
}
```


6.3.5.7 getContextSwitchAddrs

Function `getContextSwitchAddrs` is expected to return the base addresses of all functions and instructions that complete a task switch when executed.

```
/*****************************************************************
*
*     getContextSwitchAddrs
*
* Function description
*   Returns the base addresses of all functions and instructions
*   that complete a task switch when executed.
*
*****************************************************************
*/
function getContextSwitchAddrs()
{
  var aAddrs = new Array(1);
  var Addr;

  Addr = Debug.evaluate("&vTaskSwitchContext");

  if (Addr != undefined) {
    aAddrs[0] = Addr;
    return aAddrs;
  } else {
    return [];
  }
}
```

6.3.5.8 Iterating the Task List

The next example demonstrates an advanced implementation of method `update` which employs `Debug.evaluate` to iteratively update the task list.

```
/*****************************************************************
*
*     update
*
* Function description
*   Updates the RTOS Window
*
*****************************************************************
*/
function update()
{
  var pTCB;
  var tcb;
  var count;

  pTCB = Debug.evaluate("OS_Global.pCurrentTask");
  count = 0;

  while ((pTCB != undefined) && (pTCB != 0) && (count < MAX_TASK_COUNT))
  {
    tcb = Debug.evaluate("*(TCB*)" + pTCB);
    Threads.add(tcb.name, tcb.priority, tcb.status, tcb.timeout, pTCB);
    count++;
    pTCB = tcb.pNext;
  }
}
```


6.3.5.9 Computing The Stack Usage

A common task when implementing an RTOS plugin is to compute the (maximum) stack usage of a particular task. Often times, this information is not provided by the RTOS and must be computed via a data analysis of the task stack. To serve this purpose, Ozone provides the methods `TargetInterface.findByte` and `TargetInterface.findNotByte`. Both methods search through a target memory block for the first byte matching, respectively not matching, a comparison value. An example implementation is given below.

```
/*********************************************************************
*
*     getMaxStackUsage
*
* Function description
*   Returns the maximum stack usage of a task.
*
* Parameters
*   hTask: address of the task control block.
*
*********************************************************************
*/
function getMaxStackUsage(hTask)
{
  var tcb;
  var index;

  tcb = Debug.evaluate("*(TCB*)" + hTask);

  if (tcb.stackSize > STACK_CHECK_LIMIT) {
    return undefined; // skip analysis if stack is too big
  }
  index = TargetInterface.findNotByte(tcb.pStack, tcb.stackSize, FILL_VAL);
  return tcb.stackSize - index;
}
```

where `STACK_CHECK_LIMIT` limits stack analysis to a preset byte length and `FILL_VAL` is the byte value used to initialize the task stack when the stack is allocated.

6.3.5.10 Convenience Methods

The methods `Threads.setColumns2` and `Threads.add2` are convenience functions that take as first parameter the name of the table to be altered. Both methods implicitly execute `Threads.newqueue` with the table name parameter as a first step. Next, both methods perform exactly the same operations as their `Threads.setColumns` and `Threads.add` counterparts. There is one exception in that `Threads.add2` misses the trailing parameter of `Threads.add`, i.e. it cannot be used to specify the register set of a task.

6.3.6 Compatibility with Embedded Studio

The JavaScript API of Ozone is a subset of the API employed by Embedded Studio. All methods necessary to program an RTOS plugin have been adopted. It is, therefore, possible to write an RTOS plugin once and use it within both software products. Function `getContextSwitchAddrs` is required for proper displaying task switches in the TimeLine window. It is not required for displaying the contens in the RTOS Window (see *RTOS Window* on page 151).

6.4 SmartView Plugin

By implementing a SmartView plugin, users are able to display complex information from the target software in a comprehensive, human readable form.

6.4.1 Script Language

SmartView plugins are written in JavaScript. All of JavaScript's basic language constructs are supported. The following restrictions apply:

- All script code must be contained within functions.
- Exception handling (`throw`, `try`, `catch`) is not supported.

6.4.2 Loading the Plugin

Command Project.SetSmartViewPlugin loads a SmartView plugin. When this command is added to project script function `OnProjectLoad`, the plugin will be loaded each time the project is opened (see *Project.SetSmartViewPlugin* on page 344).

When a SmartView plugin is loaded, the entry for the SmartView Window will become active in the debuggers View Menu (see *View Menu* on page 46).

6.4.3 Script Functions Overview

Ozone defines the prototypes of 6 script functions that need be implemented in the JavaScript script in order for the SmartView window to function properly.

Function	Description
`init`	Applies initial settings and states in the context of the JavaScript script. Is executed once the script is loaded.
`getName`	Returns the name of the middleware or building block this script supplies support for. The result is a string depicting the name of the plugin.
`getPages`	Returns the names of the pages this script is capable to display. The result consists of a list of strings, each of those strings depicting the name of a page.
`getColHeaders(PageName)`	Returns the names of the columns for a given page. `PageName` specifies the name of the page, as delivered by the function `getPages`. The result consists of a list of strings, each of those strings depicting the name of a column. For each column a string must be given, this string may be empty in order to have a column with no headline.
`getFirstRow(PageName)`	Returns the values of the 1st row for a given page. `PageName` specifies the name of the page, as delivered by the function `getPages`. The result consists of a list of strings, each of those strings depicting the content of a cell. For an empty cell an empty string must be provided inside the list.
`getNextRow(PageName)`	Returns the values of the next row for a given page. `PageName` specifies the name of the page, as delivered by the function `getPages`. The result consists of a list of strings, each of those strings depicting the content of a cell. For an empty cell an empty string must be provided inside the list.

Function	Description
onTargetChanged	Is called each time the target status has changed, e.g. after a single step was performed or a breakpoint was taken.

The implementation of all functions is mandatory.

In addition to those pre-defined functions users are free to implement their own functions in order to structure the code.

6.4.4 Debugger API

Ozone defines a set of functions that can be called from SmartView scripts to communicate and exchange data with the debugger. These functions are implemented as methods of Ozone's JavaScript API classes:

Class	Description
Debug	Provides methods that query information from the debugger.
TargetInterface	Provides methods that read or write target memory and registers.

The following API commands are of particular importance for the development of SmartView plugins:

Command	Description	Typical Application
Debug.evaluate	Evaluates a C-language expression	Obtain the value or address of a symbol
Debug.getSymbol	Returns the name of a symbol	Obtain the name of the symbol at an address
TargetInterface.peekWord	Returns a word from target memory	Evaluating memory contents Rescuing memory contents that need be changed for later restauration
TargetInterface.pokeWord	Writes a word to target memory	Changing memory contents
TargetInterface.getRegister	Returns the content of a register	Evaluating register contents Rescuing register contents that need be changed for later restauration
TargetInterface.setRegister	Sets the value of a register	Changing register contents, e.g. for the purpose of selecting the bank of banked registers
TargetInterface.message	Prints a text into the console window	Debugging the script

An example-based description of the API classes can be found in section *Writing the SmartView Plugin* on page 245. A formal description is given by section *JavaScript Classes* on page 383.

6.4.5 Writing the SmartView Plugin

The example presented here displays the elements of a polygon. The polygon consists of a linked list of points, a point consisting of its position specified by x- and y-coordinates:

```
typedef struct {
  int xPos;
```



```
  int yPos;
} tPoint; // a point, consisting of its coordinates

typedef struct PolyElement {
  tPoint Position;
  struct PolyElement* pNext;
} tPolyElement; // an element of a polygon, used to form a linked list of points

tPolyElement* pPoly; // the root element of the polygon


/*********************************************************************
*
* main()
*
* Function description
* Application entry point.
*/
int main(void) {
  tPolyElement Points[5];

  Points[0].Position.xPos = 42;
  Points[0].Position.yPos = 23;
  Points[0].pNext = NULL;

  Points[1].Position.xPos = 42;
  Points[1].Position.yPos = 42;
  Points[1].pNext = NULL;

  Points[2].Position.xPos = 23;
  Points[2].Position.yPos = 42;
  Points[2].pNext = NULL;

  Points[3].Position.xPos = 23;
  Points[3].Position.yPos = 23;
  Points[3].pNext = NULL;

  Points[4].Position.xPos = 42;
  Points[4].Position.yPos = 23;
  Points[4].pNext = NULL;

  pPoly = &Points[0];

  Points[0].pNext = &Points[1];
  Points[1].pNext = &Points[2];
  Points[2].pNext = &Points[3];
  Points[3].pNext = &Points[4];

  do {
  } while (1);
}
```

In the subsequent sections a SmartView script is described which steps through the linked list, seizes the x- and y-coordinates for each point and displays that in a table. For each point the table has one row, each depicting the position in the list, the x- and the y-coordinate.

6.4.5.1 init

This function is invoked by Ozone when the script is loaded. It is supposed to do the basic initialization of the script.

The interface contains a `getFirstRow(PageName)` / `getNextRow(PageName)` part. This implies that the current row for each page needs be stored somewhere inside the script. Besides that, the script stores the elements of the polygon internally after read-out from the target. All that information needs be initialized.


```
var _Points = []; // the list of points read from the target

/*********************************************************************
*
* init()
*
* Functions description:
* This function does the basic initialization of the script.
*/
function init() {
  _Points = [];
  for (var PageIdx = 0; PageIdx < _NumPages; PageIdx++) {
  _CurrentRowOnPage[PageIdx] = 0;
  }
}
```

6.4.5.2 getName

This function delivers the name of the script. The result is a string containing the script name. Ozone adds that name to each page name displayed in the drop-down field allowing the selection of the page to be displayed.

```
/*********************************************************************
*
* getName()
*
* Functions description:
* Returns the name of the middleware or building block this script supplies
* support for.
*/
function getName() {
  return “Poly”;
}
```

6.4.5.3 getPages

This function is expected to deliver the names of all the pages the plugin provides. The page names are delivered as a list of strings, each string depicting the name of one page.

Please note that the name of the script (which is displayed in the Ozone drop-down list) is not supposed to be part of the name. A hierarchy of pages may be specified. In that case the hierarchy levels need be separated by a slash (“/”). Even though in the current implementation all pages are presented to the user in a flat list in the drop-down-box this may be changed into a tree browser in a future release.

```
/*********************************************************************
*
* getPages()
*
* Functions description:
* Returns the names of the pages this script is capable to display.
*/
function getPages() {
  var PageNames = [“Polygon”,
                   “Script Info”];
  return PageNames;
}
```


6.4.5.4 getColHeaders (PageName)

This function receives the name of the page as a string and delivers a list of strings which describe the name of each column, starting on the left-most column (as seen in the default table layout; the customer may change the order of columns but doing so does not need to be handled inside the script).

In case a column shall not bear a title, an empty string must be provided.

When displaying the respective page, Ozone provides one column for each member of the string list. In other words, this function specifies the width of the table.

```
/*****************************************************************
*
* getColHeaders()
*
* Functions description:
* Returns the names of the colums for a given page.
*/
function getColHeaders(PageName) {
  var Result;
  var PageIdx;

  PageIdx = _GetPageIdx (PageName)
  switch (PageIdx) {
    case 0:
      Result = _GetPagePolygonColHeader();
      break;
    case 1:
      Result = _GetPageScriptInfoColHeader();
      break;
    default:
      Result = null;
      break;
  }
  return Result;
}
```

In this sample implementation there is a dedicated function delivering the column titles for one page:

```
/*****************************************************************
*
* _GetPageScriptInfoColHeader()
*
* Functions description:
* Delivers the column headers of the respective page.
*/
function _GetPageScriptInfoColHeader () {
  var Result;

  Result = [“Script Info”];
  return Result;
}

/*****************************************************************
*
* _GetPagePolygonColHeader()
*
* Functions description:
* Delivers the column headers of the respective page.
*/
```



```
function _GetPagePolygonColHeader () {
  var Result;

  Result = ["", "x-Position", "y-Position"];
  return Result;
}
```

As can be seen, the functions just return a fixed list of constant strings.

6.4.5.5 getFirstRow (PageName) / getNextRow (PageName)

This pair of functions delivers the 1st row of the table and any subsequent row, respectively. The name of the page is specified as a string. The result is a list of strings, each string being the content of a cell, starting on the left-most column. Ozone expects those functions to return a list with exactly one entry for each cell in a row, i.e. the list must be of the same length as the list provided by `getColHeaders`.

In case the respective row is empty (e.g. because the required data is not yet available in the target), `null` is to be returned.

When updating a page, Ozone invokes `getFirstRow` once and `getNextRow` repeatedly, until any of the functions returns `null`. By doing so the whole table content is transferred from the script into Ozone.

```
/*****************************************************************
*
* getFirstRow()
*
* Functions description:
* Returns the values of the 1st row for a given page.
*/
function getFirstRow(PageName) {
  var Result;
  var PageIdx;

  PageIdx = _GetPageIdx(PageName);
  if (PageIdx != null) {
    _CurrentRowOnPage[PageIdx] = 0;
    Result = _getCurrentRow(PageName);
  } else {
    Result = null;
  }
  return Result;
}

/*****************************************************************
*
* getNextRow()
*
* Functions description:
* Returns the values of the next row for a given page.
*/
function getNextRow(PageName) {
  var Result;
  var PageIdx;

  PageIdx = _GetPageIdx(PageName);
  if (PageIdx != null) {
    _CurrentRowOnPage[PageIdx] += 1;
    Result = _getCurrentRow(PageName);
  } else {
    Result = null;
```



```
  }
  return Result;
}
```

In this sample implementation the script keeps track of the row to be returned to Ozone with the next call. For this purpose there is `_CurrentRowOnPage`, which is an array accommodating that information for each page.

```
var _CurrentRowOnPage = [];
```

We have seen that array already in the function init where it is initialized. `GetFirstRow` sets the row counter for the respective page to 0 before calling `getCurrentRow` which is shared between `getFirstRow` and `getNextRow`. `GetNextRow` does the same as `GetFirstRow` but instead of resetting the row counter it is incremented.

`_getCurrentRow` finally splits into the functions which deliver the actual row content.

```
/*****************************************************************
*
* _getCurrentRow()
*
* Functions description:
* Returns the values of the currently selected row for
* a given page.
*/
function _getCurrentRow(PageName) {
  var Result;
  var PageIdx;

  PageIdx = _GetPageIdx (PageName)
  switch (PageIdx) {
    case 0:
      Result = _GetPagePolygonRow(_CurrentRowOnPage[PageIdx]);
      break;
    case 1:
      Result = _GetPageScriptInfoRow(_CurrentRowOnPage[PageIdx]);
      break;
    default:
      Result = null;
      break;
  }
  return Result;
}
```

The implementation for the script info page is pretty straight forward. For each row number a constant list containing exactly 1 string is returned (the script info page has 1 column).

```
/*****************************************************************
*
* _GetPageScriptInfoRow()
*
* Functions description:
* Returns a row for the respective page.
*/
function _GetPageScriptInfoRow(RowIdx) {
  var Result;

  switch (RowIdx) {
    case 0:
      Result = [“LinkedList demo plug-in V1.0.0”];
      break;
```



```
    case 1:
      Result = [“Last modified: 2022-08-10”];
      break;
    case 2:
      Result = [“Copyright (c) 2022 SEGGER Microcontroller GmbH”];
      break;
    default:
      Result = null;
      break;
  }
  return Result;
}
```

For the Polygon page the implementation is a bit more complicated:

```
/*********************************************************************
*
* _GetPagePolygonRow()
*
* Functions description:
* Returns a row for the respective page.
*/
function _GetPagePolygonRow(RowIdx) {
  var Result;
  var NumPoints;

  NumPoints = _Points.length;
  if (RowIdx < NumPoints) {
    var xPos;
    var yPos;

    Result = [];
    xPos = _Points[RowIdx][“xPos”];
    yPos = _Points[RowIdx][“yPos”];
    Result.push (RowIdx.toString());
    Result.push (xPos.toString());
    Result.push (yPos.toString());
  } else {
    Result = null;
  }
  return Result;
}
```

The information is read from the array `_Points`. This contains a record per linked list item, each record consisting of the members `xPos` and `yPos`. Those members are converted into a string and added to a string list, which, in the end, contains the line number (which actually is the row index parameter), the `xPos` member, and finally the `yPos` member.

In case the array `_Points` is empty or contains less members than required for creating the row contents for the given row, `null` is returned.

In this sample implementation, internal addressing of the pages takes place via a numerical value, not via the name. `_GetPageIdx` does that translation. The actual work is done inside `_getCurrentRow` which is shared between `getFirstRow` and `getNextRow`.

```
/*********************************************************************
*
* _GetPageIdx()
*
* Functions description:
* Returns the Index of a given page.
*/
```



```
function _GetPageIdx(PageName) {
  var Result;
  var Pages;

  Pages = getPages();
  Result = null;
  for (var Idx = 0; Idx < Pages.length; Idx++) {
    if (Pages[Idx] == PageName) {
      Result = Idx;
      break;
    }
  }
  return Result;
}
```

6.4.5.6 onTargetChanged

In the previous section it is depicted how the content of the list `_Points` is transferred to Ozone. `OnTargetChanged` is invoked by Ozone each time the target status may have changed, e.g. after starting a debug session, reaching a break point or performing a single step. In this sample application this event is used to read the data from the target.

```
/*********************************************************************
*
* onTargetChanged()
*
* Functions description:
* Handles the event of target state having changed.
*/
function onTargetChanged() {
  init();
  _GetPolygonInfoFromTarget();
}
```

The main work is done in `_GetPolygonInfoFromTarget`. This function steps through the linked list, extracts the desired data and writes that into the list `_Points`.

```
/*********************************************************************
*
* _GetPolygonInfoFromTarget()
*
* Functions description:
* Reads the linked list of points forming the polygon
* from the target
*/
function _GetPolygonInfoFromTarget () {
  var Expression;
  var RootPtr;

  _Points = [];
  Expression = "pPoly";
  RootPtr = Debug.evaluate(Expression);
  if (RootPtr != 0) {
    var CurrentItem;
    var NextElemAddr;

    CurrentItem = {};
    Expression = "*pPoly";
    do {
      var CurrentXPos;
      var CurrentYPos;
```



```
      var CurrentPoint;

      CurrentItem = Debug.evaluate(Expression);
      if (typeof CurrentItem != “undefined”) {
        CurrentPosition = CurrentItem[“Position”];
        CurrentXPos = CurrentPosition[“xPos”];
        CurrentYPos = CurrentPosition[“yPos”];
        CurrentPoint = {};
        CurrentPoint[“xPos”] = CurrentXPos;
        CurrentPoint[“yPos”] = CurrentYPos;
        _Points.push(CurrentPoint);
        NextElemAddr = CurrentItem[“pNext”];
        Expression = “*(tPolyElement*)” + NextElemAddr.toString();
      } else {
        NextElemAddr = 0;
      }
    } while (NextElemAddr != 0);
  }
}
```

The root element of the polygon is `pPoly`. This is a pointer and the script first reads the value of that pointer from the target by calling `Debug.evaluate`. This API function evaluates the expression which is passed as a parameter, and the expression `pPoly` evaluates to the address pointed-to by that pointer. In case the address is 0 nothing more is to be done, the function terminates. Otherwise the structure found at the address is loaded into `CurrentItem`. Again, this is done by means of `Debug.evaluate`. Finally, the struct member Position is extracted from `CurrentItem`, and in a subsequent step, the struct members `xPos` and `yPos` are copied into `CurrentPoint` which is added to `_Points`.

At the end, the next pointer `pNext` is evaluated in order to process the next element in the very same way. In case `pNext` is 0 the function terminates.

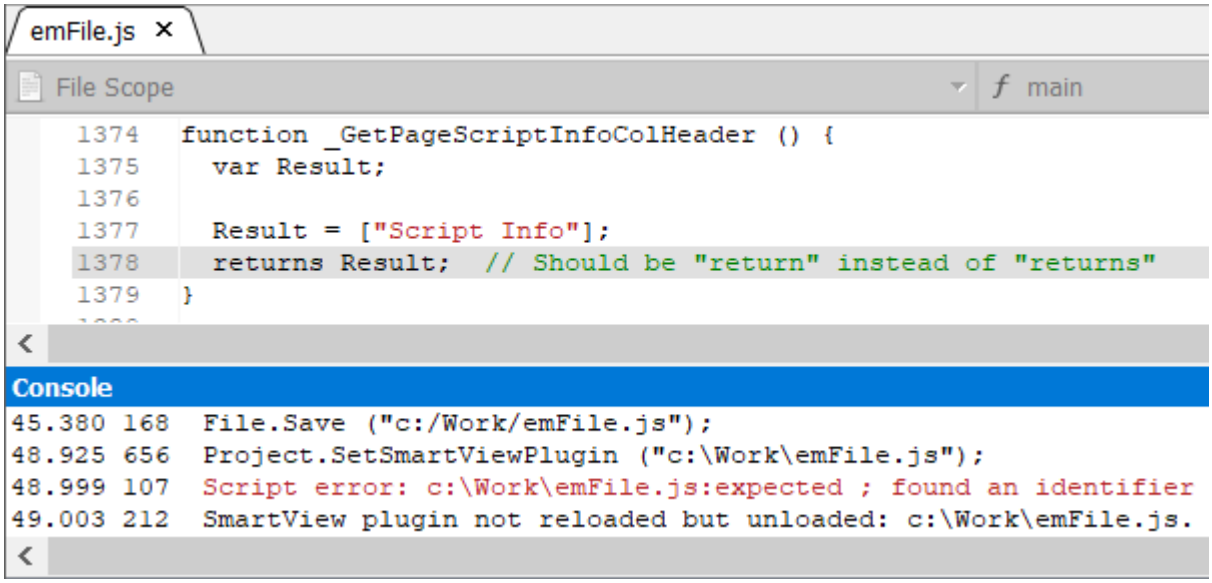
So extracting the information from the target is pretty straight forward and takes place in the same way as it would be done in the target software.

6.4.5.7 General Remarks

The script presented in the sections above adheres to some coding rules (e.g. any non-exposed, global symbol is prefixed with an underscore, any local symbol starts with a capital letter, 2 spaces are used for indentation). Those coding rules are not mandatory.

Please keep in mind that this is a sample application, intended to giving users an entry point for creating their own scripts. Different ways of achieving the same result are possible.

After editing the JavaScript source and saving the new content to disk, the plugin needs to be reloaded. This can be done via the context menu (*Context Menu* on page 177). In case the JavaScript interpreter identifies an error a respective message will be displayed in the console window.



Error in script and message in console window

Ann erroneous JavaScript cannot be reloaded, it will be unloaded instead. In that case the reload functionality is not available anymore in the context menu. After fixing the bug the script needs to be loaded manually, e.g. via the command Project.SetSmartViewPlugin or by reloading the project (in case the plugin is loaded in the project file).

In the example depicted above, the contents are displayed in a vertical table, i.e. there are 3 columns and as many rows as there are points forming the polygon. It is possible to change the script such that the same information is displayed in a horizontal table, i.e. 3 rows and as many columns as there are points. It is up to the user to select the most appropriate layout for the respective use-case.

All target data required by this script is read each time `onTargetChanged` is invoked. For bigger scripts providing many pages, this may not be advantageous since the accumulated, potentially slow target accesses, may lead to a significant delay when reading big amounts of data from the target. Typically, a single page requires only a small fraction of that data, so it might be desirable to read the data from the target only when `getFirstRow` is invoked. This allows to limit the target interaction to those elements being required for that very page. Since pages may be updated also upon other events (e.g. changing the window layout), adding caching functionality can further reduce the number of target interactions. In such an implementation `onTargetChanged` would be a good place for invalidating the caches. Such an implementation can be found in the emFile script which is provided with Ozone.

It is not required to have a script info page, however it is advisable to implement one. When it comes to documentation of the debug process and the tools used, the information displayed here might provide valuable details such as the version of the plug-in script.

6.5 Snapshot Programming

As introduced in section *Debug Snapshots* on page 215, Ozone debug snapshots allow to save the debug session to disk and restore it at a later point in time.

In order to restore advanced system state such as (clocked) peripherals from a debug snapshot, it is generally necessary for users to program the exact sequence of restore operations. To support this, Ozone defines two project script functions:

- `OnSnapshotSave` and
- `OnSnapshotLoad`

which are executed when a snapshot is saved or loaded, respectively.

When script function `OnSnapshotLoad` is not implemented, a snapshot's system state is restored in a default way: memory regions and CPU registers are written to the target in the order of appearance within the snapshot.

6.5.1 Snapshot Commands

For the programming of script functions `OnSnapshotSave` and `OnSnapshotLoad`, Ozone provides the command group "Snapshot". Commands of this group can be employed to access and restore snapshot file data as summarized below.

Command	Description
Snapshot.SaveReg(const char* sReg)	Saves a register (group) to a snapshot
Snapshot.SaveU32(U64 Addr, U32 Value)	Saves a memory value to a snapshot
Snapshot.ReadReg(const char* sReg)	Reads a register from a snapshot
Snapshot.ReadU32(U64 Addr)	Reads a memory value from a snapshot
Snapshot.LoadReg(const char* sReg)	Reads a register (group) from a snapshot and writes it to target
Snapshot.LoadU32(U64 Addr)	Reads a memory value from a snapshot and writes it to target

In addition, Ozone provides the following general commands to support snapshots:

Command	Description
Register.Addr(const char* sReg)	Returns the address of a memory mapped register
Target.WriteU32(U64 Addr, U32 Value)	Writes a 32 bit value to target memory
Target.ReadU32(U64 Addr)	Reads a 32 bit value from target memory
Target.SetReg(const char* sReg, U64 Value)	Writes a CPU or system register
Target.GetReg(const char* sReg)	Reads a CPU or system register

6.5.2 OnSnapshotSave

The following script example saves the system state of an embOS blinky debuggee on a SEGGER Cortex-M trace reference board to a snapshot.

```
/*********************************************************************
*
*       OnSnapshotSave
*
* Function description
*   Optional event handler, called upon saving a snapshot.
*
* Additional information
*   This function is usually used to save values of the target
```



```
*   state which can either not be trivially read,
*   or need to be restored in a specific way or order.
*   Typically use: memory mapped registers,
*   such as PLL and GPIO configuration.
*
*********************************************************************
*/
void OnSnapshotSave (void) {

  // Save Vector table offset register
  Snapshot.SaveReg("CPU.Peripherals.SCB.VTOR");

  // Save DWT unit status & control register (used by SystemView)
  Snapshot.SaveReg("CPU.Peripherals.DWT.DWT_CTRL");

  // Save System timer configuration (used by embOS)
  Snapshot.SaveReg("CPU.Peripherals.SYSTICK");

  // Save Cortex-M IRQ priorties 12-15
  Snapshot.SaveReg("CPU.Peripherals.SCB.SHPR3");

  // Save FPU and coprocessor state
  Snapshot.SaveReg("CPU.Peripherals.SCB.CPACR");

  // Save system clock configuration
  Snapshot.SaveReg("Peripherals.RCC.CR");
  Snapshot.SaveReg("Peripherals.RCC.CFGR");
  Snapshot.SaveReg("Peripherals.RCC.PLLCFGR");

  // Save LED port state
  Snapshot.SaveReg("Peripherals.RCC.AHB1RSTR");
  Snapshot.SaveReg("Peripherals.RCC.AHB1ENR");
  Snapshot.SaveReg("Peripherals.GPIO.GPIOA.MODER");
  Snapshot.SaveReg("Peripherals.GPIO.GPIOA.ODR");
}
```

6.5.3 OnSnapshotLoad

The following example is an excerpt from an `OnSnapshotLoad` implementation which restores the system state saved in the preceding section.

```
/*********************************************************************
*
*       OnSnapshotLoad
*
* Function description
*   Optional event handler, called upon loading a snapshot.
*
* Additional information
*   This function is used to restore the target state in cases
*   where values cannot simply be written to the target.
*   Typical use: GPIO clock needs to be enabled, before
*   GPIO is configured.
*
*********************************************************************
*/
void OnSnapshotLoad (void) {

  SNAPSHOT_Restore_SysClock();
  SNAPSHOT_Restore_OS();
  ...
}
```

```
/*********************************************************************
*
```



```
*       SNAPSHOT_Restore_SysClock
*
* Function description
*   Restores a HSE clock configuration from a snapshot
*
*********************************************************************
*/
void SNAPSHOT_Restore_SysClock(void) {

  unsigned int  HSE_STARTUP_TIMEOUT;
  unsigned int  RCC_CR_HSEON;
  unsigned int  RCC_CR_HSERDY;
  unsigned int  RCC_CR_PLLON;
  unsigned int  RCC_CR_PLLRDY;
  unsigned int  RCC_CFGR_SW;
  unsigned int  RCC_CFGR_SW_PLL;
  unsigned int  RCC_CFGR_SWS;
  unsigned int  RCC_CFGR_SWS_HSE;
  unsigned int  RCC_CFGR_SWS_PLL;
  unsigned int  HSEStatus;
  unsigned int  Locked;
  unsigned int  StartUpCounter;
  unsigned int  Value;

  HSE_STARTUP_TIMEOUT  =  500;
  RCC_CR_HSEON         =  0x00010000;
  RCC_CR_HSERDY        =  0x00020000;
  RCC_CR_PLLON         =  0x01000000;
  RCC_CR_PLLRDY        =  0x02000000;
  RCC_CFGR_SWS         =  0x0000000C;
  RCC_CFGR_SW_PLL      =  0x00000002;
  RCC_CFGR_SW          =  0x00000003;
  RCC_CFGR_SWS_HSE     =  0x00000004;
  RCC_CFGR_SWS_PLL     =  0x00000008;
  HSEStatus            =  0;
  StartUpCounter       =  0;
  Locked               =  0;
  //
  // Reset RCC clock configuration
  //
  SetRegBits     ("Peripherals.RCC.CR",      0x00000001); // Set HSION bit
  Target.SetReg  ("Peripherals.RCC.CFGR",    0x00000000); // Reset CFGR register
  ClearRegBits   ("Peripherals.RCC.CR",      0x01090000); // HSEON, CSSON, PLLON
  Target.SetReg  ("Peripherals.RCC.PLLCFGR", 0x24003010); // Reset PLLCFGR
  ClearRegBits   ("Peripherals.RCC.CR",      0x00040000); // Reset HSEBYP bit

  if ((Snapshot.ReadReg("Peripherals.RCC.CR") & 0x10000) == 0) { // HSEON clear ?
    return 0; // snapshot session ran on reset clock (HSI)
  }
  // Disable all interrupts
  Target.SetReg("Peripherals.RCC.CIR", 0x24003010);

  // Enable the HSE
  SetRegBits("Peripherals.RCC.CR", RCC_CR_HSEON);

  // Wait till the HSE is ready
  do {
     HSEStatus = (Target.GetReg("Peripherals.RCC.CR") & RCC_CR_HSERDY);
     StartUpCounter = StartUpCounter + 1;
  } while((HSEStatus == 0) && (StartUpCounter != HSE_STARTUP_TIMEOUT));

  // Early out when timeout was reached
  if ((Target.GetReg("Peripherals.RCC.CR") & RCC_CR_HSERDY) == 0) {return -1;}

  // Restore peripheral clock enable
  Snapshot.LoadReg("Peripherals.RCC.APB1ENR");

  // Restore regulator voltage output mode
```



```
  Snapshot.LoadReg("Peripherals.PWR.CR");

  // Restore the clock dividers
  Value = Snapshot.ReadReg("Peripherals.RCC.CFGR") & 0xF0;
  SetRegBits("Peripherals.RCC.CFGR", Value);

  // Restore the PLL parameters
  Snapshot.LoadReg("Peripherals.RCC.PLLCFGR");

  // Enable the PLL
  SetRegBits("Peripherals.RCC.CR", RCC_CR_PLLON);

  // Wait till the PLL is ready
  while((Target.GetReg("Peripherals.RCC.CR") & RCC_CR_PLLRDY) == 0) {}

  // Restore Flash prefetch, Instruction cache, Data cache and wait state
  Snapshot.LoadReg("Peripherals.FLASH.ACR");

  // Select the PLL as system clock source
  ClearRegBits ("Peripherals.RCC.CFGR", RCC_CFGR_SW);
  SetRegBits   ("Peripherals.RCC.CFGR", RCC_CFGR_SW_PLL);

  // Wait till the PLL is used as system clock source */
  StartUpCounter = 0;
  do {
    Value = Target.GetReg("Peripherals.RCC.CFGR") & RCC_CFGR_SWS;
    Locked = (Value & RCC_CFGR_SWS) == RCC_CFGR_SWS_PLL;
    StartUpCounter = StartUpCounter + 1;
  } while ((Locked == 0) && (StartUpCounter != HSE_STARTUP_TIMEOUT));
}
```

```
/*********************************************************************
*
*       SNAPSHOT_Restore_OS
*
* Function description
*   Restores a RTOS system state from a snapshot
*
*********************************************************************
*/
void SNAPSHOT_Restore_OS() {

  unsigned int  NOCYCCNT_BIT;
  unsigned int  RegVal;

  NOCYCCNT_BIT = (1 << 25);
  RegVal = 0;

  // Restore reload register
  Snapshot.LoadReg("CPU.Peripherals.SYSTICK.SYST_RVR");

  // Restore Priority for Systick Interrupt
  Snapshot.LoadReg("CPU.Peripherals.SCB.SHPR3");

  // Restore the SysTick Counter Value
  Snapshot.LoadReg("CPU.Peripherals.SYSTICK.SYST_CVR");

  // Restore SysTick IRQ and SysTick Timer
  Snapshot.LoadReg("CPU.Peripherals.SYSTICK.SYST_CSR");

  // Restore the cycle counter for SystemView functions
  RegVal = Snapshot.ReadReg("CPU.Peripherals.DWT.DWT_CTRL");
  if ((RegVal & NOCYCCNT_BIT) == 0) { // Cycle counter supported?
    Target.SetReg("CPU.Peripherals.DWT.DWT_CTRL", RegVal);
  }
}
```


6.6 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 application to be debugged instead of the bootloader. This ensures that the debug windows that show static program information are initialized to show the applications's information and not the bootloader's, 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");
}
```

The script function `TargetDownload` instructs Ozone to download the bootloader instead of the application image when the debug session is started. Note that the 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 Behavior Comparison* on page 198).

AfterTargetDownload

```
/*********************************************************************
*
*     AfterTargetDownload
*
* Function description
```



```
*   Initializes PC and SP for either bootloader or debuggee execution
*
*********************************************************************
*/
void AfterTargetDownload (void)
{
  U64 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));
}
```

The 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. The information, whether the bootloader or the application is executing, is provided by the user function `TargetIsHaltedAtBootloaderEnd`, whose way of working is described in the subsequent section describing the function `AfterTargetHalt`.

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 set a break point at the end of the bootloader. Once the bootloader hits this breakpoint, Ozone senses that the target has halted and executes the script function `AfterTargetHalt`. Here, the user function `TargetIsHaltedAtBootloaderEnd` checks if the end of the bootloader is reached by comparing the current value of the PC register with the address that marks the end of the boot loader. If the check succeeds, the download of the image of the application to be debugged is performed. A key aspect here is that the command "File.Load" is used to perform the download of the application image. This way, the target is not hardware-reset prior to the download (which would possibly revert changes performed by the bootloader) and the script function `AfterTargetDownload` is executed after the download. For an overview of the behavioral differences of Ozone's downloading user actions, refer to section *Download Behavior Comparison* on page 198.

> **Note**

Implementing the user function `TargetIsHaltedAtBootloaderEnd` is the user's responsibility. The function name is used as an example here, the user may chose a different name according to his liking.

Note

Further information on this topic can be found on the SEGGER Wiki page *Debug Bootloader and Application in same Ozone project* .

6.7 Automation Socket Interface

The automation interface allows complete control of Ozone via a TCP socket connected to the console window. It allows complete control of the application, either manually using a terminal or fully automated via another application.

Getting started

When Ozone is started, a TCP socket is opened at localhost on the port 19200. Simply connect to it using a raw TCP connection. As soon as a connection has been established, a welcome message is shown and Ozone is ready to be used.

As this connection is an interface to the console window, all commands from the console window may also be used here. See *Console Window* on page 111 for more information. Commands are expected to have a linebreak at the end.

> **Note**
>
> Currently only one connection is supported at a time.

Configuration

The used port may be configured by adding the specific argument when executing Ozone, as described in *Command Line Arguments* on page 279.

Chapter 7

Appendix

The Appendix provides quick references and formal listings about different types of user information, including Ozone API commands, system variables and application error messages.

7.1 Value Descriptors

This section describes how certain objects such as fonts and source code locations are specified textually, for use as command and script function arguments.

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 System Register Descriptor

A System register descriptor (SRD) is a string that identifies a system register (see *Register Groups* on page 148). The format of the SRD depends on the target architecture as shown below.

7.1.5.1 ARM AArch32

An AArch32 system register descriptor has the following format:

```
"<CpNum> , <CRn> , <CRm> , <Opc1> , <Opc2>"
```

Values enclosed by “<>” denote numbers. These numbers are the fields of the system register access instruction (MRC, MCR, MRRC, MCCR,…) that is used to read the system register.

7.1.5.2 ARM AArch64

An AArch64 system register descriptor has the following format:

```
"<Op0> , <CRn> , <CRm> , <Op1> , <Op2>"
```

Values enclosed by “<>” denote numbers. These numbers are the fields of the system register access instruction (MRS, MSR, AT, IC,…) that is used to read the system register.

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 341.

Constant	Description
USB	The debug probe is connected to the host-PC via USB.
IP	The 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.SetTargetIF* on page 341).

Constant	Description
JTAG	The debug probe is connected to the target via JTAG.
cJTAG	The debug probe is connected to the target via cJTAG.
SWD	The 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.SetDisplayFormat* on page 315).

Constant	Description
`DISPLAY_FORMAT_DEFAULT`	Display values in the format that is best suited.
`DISPLAY_FORMAT_BINARY`	Display integer values in binary notation.
`DISPLAY_FORMAT_DECIMAL`	Display integer values in decimal notation.
`DISPLAY_FORMAT_HEX`	Display integer values in hexadecimal notation.
`DISPLAY_FORMAT_CHAR`	Display 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 360).

Constant	Description
`AW_ANY`	Automatic access.

Constant	Description
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 370).

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 332).

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 334).

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 VAR_BREAK_AT_THIS_SYMBOL.
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 367).

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.

Constant	Description
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 277).

7.2.10 Disassembler Option Flags

The tables below list all options provided to control behavioral aspects of the disassembler. (see *Project.ConfigDisassembly* on page 353).

> **Note**
>
> Architecture-specific flags cannot be placed in script code which gets executed before obligatory project command Project.SetDevice.

Generic:

Constant	Description
DASM_FLAG_SHOW_COMMENTS	Show assembly code comments, e.g to indicate memory access addresses
DASM_FLAG_PREFER_ABI_NAMES	Use ABI names (a0) instead of numeric names (x10)
DASM_FLAG_PREFER_PSEUDO_INST	Prefer pseudo instruction disassembly over normal mode

Arm:

Constant	Description
DASM_ARM_FLAG_USE_ADR	ADR syntax is preferred over “ADD [PC..” syntax
DASM_ARM_FLAG_SHOW_ZERO_SHIFT	Do not omit the shift amount for instructions with bit-shift, when the shift amount is 0.
DASM_ARM_FLAG_SYSREGS_USE_OPC	Prefer system register opcode over decoded name

RISC-V:

Constant	Description
DASM_RISCV_FLAG_PREFER_FORMAT_C	Indicates if the C. prefix should be displayed for compressed instructions
DASM_RISCV_FLAG_HUAWEI_EXTENSION	Indicates that the Huawei instruction set extension is present
DASM_RISCV_FLAG_ANDESTAR_EXTENSION	Indicates that the AndeStar V5 instruction set extensions (Performance, CoDense) are present
DASM_RISCV_FLAG_P_EXTENSION	Indicates that the provisional P instruction set extension is present
DASM_RISCV_FLAG_ZFINX_EXTENSION	Indicates that Zfinx standard instruction set extension is present. Must be set as well in case Zdinx is present.

Constant	Description
DASM_RISCV_FLAG_ZCMT_EXTENSION	Indicates that Zcmt standard instruction set extension is present.
DASM_RISCV_FLAG_ZCMP_EXTENSION	Indicates that Zcmp standard instruction set extension is present.
DASM_RISCV_FLAG_ZCB_EXTENSION	Indicates that Zcb standard instruction set extension is present.

7.2.11 Trace Sources

The Table below lists permitted values for the trace source parameter (see *Project.SetTraceSource* on page 345).

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 Ozone team plans to remove this constraint in the near future.

7.2.12 Tracepoint Operation Types

The table below lists permitted values for the tracepoint operation parameters required by tracepoint manipulating actions (see *Trace Actions* on page 297).

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.

7.2.13 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.

7.2.14 Trace Timestamp Formats

The table below lists supported units for trace timestamps.

Constant	Description
TIMESTAMP_FORMAT_OFF	Timestamps are not displayed.

Constant	Description
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.

7.2.15 Code Profile Export Options

The table below lists binary options that can be specified with action Export.CodeProfile.

Constant	Description
EXPORT_FILE_PATHS	Export full file paths instead of file names.
EXPORT_AS_CSV	Export in CSV format. When not set (the default), a text report is generated.
EXPORT_CSV_FUNCS	Use CSV format 1: code profile listing by function (default).
EXPORT_CSV_LINES	Use CSV format 2: code profile listing by source line.
EXPORT_CSV_INSTS	Use CSV format 3: code profile listing by instruction.

When all CSV export format flags are clear (the default), EXPORT_CSV_FUNCS is assumed.

7.2.16 Disassembly Export Options

The table below lists binary options that can be specified with action Export.Disassembly.

Constant	Description
REMOVE_TRAILING_NOPS	Do not export trailing NOP instructions. This flag cannot be used in conjunction with flag EXPORT_AS_CSV.
EXPORT_AS_CSV	Export disassembly in CSV format. Disassembly is exported in assembly code format per default, i.e. when this flag is not set. Export as assembly code is however only available on Cortex-M.

7.2.17 Session Save Flags

The following flags identify session information that can be disabled within User Files (see *User Files* on page 181).

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 Registers Window's display configuration.

7.2.18 Snapshot Save Flags

The following flags identify session information that can be omitted from debug snapshots see *Debug.SaveSnapshot* on page 337.

Flag	Description
DISABLE_SAVE_TARGET_MEM	Do not save selected target memory regions.
DISABLE_SAVE_TARGET_REGS	Do not save selected target registers.
DISABLE_SAVE_TRACE	Do not save trace and code profile data.
DISABLE_SAVE_POWER_TRACE	Do not save power trace data.
DISABLE_SAVE_HSS	Do not save symbol trace data.
DISABLE_SAVE_CONSOLE	Do not save the console log.
DISABLE_SAVE_TERMINAL	Do not save the terminal log.

7.2.19 ELF Config Flags

ELF parser configuration flags that can be used with command Elf.SetConfig (see *Elf.SetConfig* on page 378).

Flag	Description
ELF_BIT_OFFSET_CORRECTION	When set, the ELF parser auto-corrects erroneous bitfield debug information (DW_AT_bit_offset).

7.2.20 Clear Events

Valid values of user preference PREF_TIMELINE_CLEAR_EVENT (see *User Preference Identifiers* on page 273). PREF_TIMELINE_CLEAR_EVENT selects the debug event upon which timeline data is cleared (see *Clear Event* on page 173).

Value	Description
CLEAR_ON_RESET	Trace and sampling data is cleared when the program is reset.
CLEAR_ON_RESUME	Trace and sampling data is cleared when the program is resumed.
CLEAR_NEVER	Trace and sampling data is never cleared.

7.2.21 Destination Address Ranges for Download

Valid values of system variable VAR_DOWNLOAD_ADDR (see *System Variable Identifiers* on page 277). VAR_DOWNLOAD_ADDR selects the memory addresses into which the program segments are downloaded.

Value	Description
DL_PMA	Download program segments into physical memory addresses
DL_VMA	Download program segments into virtual memory addresses

7.2.22 Unwinding Information Source

Valid values of system variable VAR_CALLSTACK_UNWIND_INFO_SRC (see *System Variable Identifiers* on page 277). VAR_CALLSTACK_UNWIND_INFO_SRC specifies whether the unwinding information is to be taken from the ELF file or obtained by instruction analysis.

Value	Description
UNWINDING_SRC_AUTO	Unwinding information source is selected automatically: In case unwinding information may not be present for all parts in the ELF file and the Ozone supports obtaining unwinding

Value	Description
	information by instruction analysis for the respective CPU architecture, the unwinding information is obtained by instruction analysis, otherwise it is read from the ELF file.
UNWINDING_SRC_DWARF	Unwinding information is read from the ELF file.
UNWINDING_SRC_INST_ANALYSIS	Unwinding information is obtained by instruction analysis.

7.2.23 GDB Server Type

Valid values of system variable VAR_GDB_SERVER_TYPE (see *Debugging via GDB Server* on page 219).

Value	Description
GDB_SERVER_TYPE_AUTO	The GDB server is attempted to be detected atomatically.
GDB_SERVER_TYPE_JLINK	A J-Link GDB server is connected.
GDB_SERVER_TYPE_STLINK	An ST-Link GDB server is connected.
GDB_SERVER_TYPE_OPENOCD	An OpenOCD GDB server is connected.
GDB_SERVER_TYPE_OTHER	Another GDB server is connected.

7.2.24 Font Identifiers

The following constants identify application fonts (see *Edit.Font* on page 310).

Constant	Description
FONT_APP	Default application font.
FONT_APP_MONO	Default mono-space application font.
FONT_ASM_CODE	assembly code text font.
FONT_CONSOLE	Console Window text font.
FONT_EXEC_CNT_ASM	Font used for Disassembly Window execution counters.
FONT_EXEC_CNT_SRC	Font used for Source-Viewer execution counters.
FONT_ITEM_NAME	Symbol name text font.
FONT_ITEM_VALUE	Symbol value text font.
FONT_LINE_NUMBERS	Line number text font.
FONT_SRC_CODE	Source code text font.
FONT_TABLE_HEADER	Table header text font.

7.2.25 Color Identifiers

The following constants identify application colors (see *Edit.Color* on page 309).

Constant	Description
COLOR_ASM_BACKG	Disassembly Window background color.
COLOR_ASM_LABEL_BACKG	Disassembly Window – label background color.
COLOR_CALL_SITE_ACTIVE	Function call site highlight (active window).
COLOR_CALL_SITE_INACTIVE	Function call site highlight (inactive window).
COLOR_CHANGE_LEVEL_1_BG	Change Level 1 background color.
COLOR_CHANGE_LEVEL_2_BG	Change Level 2 background color.

Constant	Description
COLOR_CHANGE_LEVEL_3_BG	Change Level 3 background color.
COLOR_CHANGE_LEVEL_1_FG	Change Level 1 foreground color.
COLOR_CHANGE_LEVEL_2_FG	Change Level 2 foreground color.
COLOR_CHANGE_LEVEL_3_FG	Change Level 3 foreground color.
COLOR_EXEC_PROFILE_GOOD_INST	Code profile highlighting − good instruction.
COLOR_EXEC_PROFILE_GOOD_INST	Code profile highlighting − bad instruction.
COLOR_LOGGING_SCRIPT	Console Window script message color.
COLOR_LOGGING_INFO	Console Window command feedback message color.
COLOR_LOGGING_WARNING	Console Window warning message color.
COLOR_LOGGING_ERROR	Console Window error message color.
COLOR_LOGGING_JLINK	Console Window J-Link message color.
COLOR_LOGGING_APP	Console Window external application output color.
COLOR_LOGGING_APP_ERROR	Console Window external application error output color.
COLOR_PC_ACTIVE	PC Line highlight (active window).
COLOR_PC_INACTIVE	PC Line highlight (inactive window).
COLOR_PC_BACKTRACE	Selected trace PC highlighting color.
COLOR_PROGRESS_BAR_PROGRESS	Progress bar progress background color.
COLOR_PROGRESS_BAR_REMAINING	Progress bar remaining background color.
COLOR_SELECTION_HIGHLIGHT	Selection highlight background color.
COLOR_SELECTION_HIGH-LIGHT_TEXT	Selection highlight text color.
COLOR_SELECTION_SRC_VIEWER	Cursor line background color.
COLOR_SYNTAX_REGISTER	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_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_TABLE_GRID_LINES	Table grid color.
COLOR_MATCH_HIGHLIGHT	Text match highlight color.

Color identifiers

7.2.26 User Preference Identifiers

The following constants identify Ozone user preferences (see *Edit.Preference* on page 308).

Name	Description
PREF_AUTO_CREATE_DIR_PATHS	Specifies if automatic creation of output directory paths is allowed.

Name	Description
PREF_BIN_BLOCK_SEPARATOR	Specifies the block separator character for binary numbers (0:none, 1:half-space, 2:space, 3:comma, 4:colon 5:underscore).
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 LAYOUT_CURR_FRAME_ON_TOP (0) and LAYOUT_CURR_FRAME_ON_BOTTOM (1).
PREF_CALLSTACK_DEPTH_LIMIT	Selects the maximum number of frames the call stack can hold.
PREF_CALLSTACK_SHOW_PARAM_NAMES	Specifies if function parameter names should be shown within the call stack window.
PREF_CALLSTACK_SHOW_PARAM_VALUES	Specifies if function parameter values should be shown within the call stack window.
PREF_CALLSTACK_SHOW_PARAM_TYPES	Specifies if function parameter types should be shown within the call stack window.
PREF_DEC_BLOCK_SEPARATOR	Specifies the block separator character for decimal numbers (0:none, 1:half-space, 2:space, 3:comma, 4:colon, 5:underscore)
PREF_DIALOG_SHOW_DNSA	Indicates if a check box should be added to popup dialogs that enables users to prevent the dialog from popping up.
PREF_DATA_SAMPLING_DATA_LIMIT	Specifies the data limit of the Data Sampling Window in KB.
PREF_DASM_REG_NAME_FORMAT	Specifies the register name format of disassembly text: 0=ABI, 1=Numerical.
PREF_DOC_TAB_CYCLE_WIDGET_ENABLED	Ctrl+Tab opens an overlay widget to cycle document tabs within the Source Viewer.
PREF_EXEC_PROFILE_RESPECTS_FILTERS	Specifies if source/instruction execution profiles take code coverage filters into account (see *Execution Profile Color-Codes* on page 56 and *Adding and Removing Profile Filters* on page 108).
PREF_FILTER_BARS_DISABLED	Specifies whether table filter bars are globally disabled.
PREF_HEX_BLOCK_SEPARATOR	Specifies the block separator character for hexadecimal numbers (0:none, 1:half-space, 2:space, 3:comma, 4:colon, 5:underscore)
PREF_HIDE_MEMBER_FUNCS	Specifies if C++ class member functions should be hidden
PREF_HIDE_MAPPING_SYMBOL_LABELS	Specifies if mapping symbol labels should be hidden from disassembly.
PREF_INDENT_INLINE_ASSEMBLY	Specifies whether the Source Viewer aligns inline 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.

Name	Description
PREF_MAX_SYMBOL_MEMBERS	Specifies the maximum number of members to be displayed for expanded symbol items.
PREF_MAX_POWER_SAMPLES	Specifies the data limit of the Power Sampling Window in number of samples.
PREF_PREFIX_FUNC_CLASS_NAMES	Specifies if the class name should be prefixed to C++ member functions.
PREF_PLUGIN_FUNC_EXEC_TIME_LIMIT	Time limit for (JavaScript) plugin function execution in milliseconds. At value of 0 (default) denotes no limit.
PREF_RESET_DIALOG_DNSA	Resets all dialog options "do not show again".
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_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_SHOW_ASM_SOURCE	Specifies whether the Disassembly Window augments assembly code with source code.
PREF_SHOW_ASM_LABELS	Specifies whether the Disassembly Window augments assembly code with symbol labels.
PREF_SHOW_EXP_INDICATORS	Specifies whether the Source Viewer displays source line expansion indicators.
PREF_SHOW_BP_BAR_SRC	Specifies whether the Source Viewer displays its breakpoint bar.
PREF_SHOW_BP_BAR_ASM	Specifies whether the Disassembly Window displays its breakpoint bar.
PREF_SHOW_EXEC_COUNTERS_SRC	Specifies if execution counters are displayed within the Source Viewer
PREF_SHOW_EXEC_COUNTERS_ASM	Specifies if execution counters are displayed within the Disassembly Window.
PREF_SHOW_PROGBAR_WHILE_RUNNING	Specifies if a moving progress indicator is displayed within the status bar while the program is running.
PREF_SHOW_PROJECT_WARNINGS_DIALOG	Specifies if a warnings dialog is to pop up when project settings are erroneous.
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_SHOW_TOOLTIPS	Specifies whether tooltips are enabled.

Name	Description
PREF_SHOW_TIMESTAMPS_CONSOLE	Specifies whether the console window shows message timestamps.
PREF_SHOW_ENCODINGS_ASM	Toggles the display of instruction encodings within the Disassembly Window.
PREF_SHOW_ENCODINGS_ITRACE	Toggles the display of instruction encodings within the Instruction Trace Window.
PREF_SHOW_ENCODINGS_SRC	Toggles the display of instruction encodings within the Source Viewer.
PREF_SHOW_FUNC_TYPE_SIGNATURES	Specifies if type signatures are to be appended to function names.
PREF_SHOW_PSEUDO_INSTS	Specifies if instructions should be disassembled using pseudo syntax if possible.
PREF_START_WITH_MOST_RECENT_PROJ	Specifies if the most recent project is automatically opened on application start.
PREF_SESSION_SAVE_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 (see *Session Save Flags* on page 270).
PREF_TAB_SPACING	Source Viewer tabulator spacing.
PREF_TOTAL_VALUE_BARS_DISABLED	Specifies whether total value rows within table windows are globally disabled.
PREF_TERMINAL_EOL_FORMAT	Specifies the line break characters that the Terminal Window appends to user input before the input is send to the debuggee (see *Newline Formats* on page 269).
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_TERMINAL_DATA_LIMIT	Specifies the data limit of the Terminal Window in KB.
PREF_TIMESTAMP_FORMAT	Specifies the timestamp display format for the Instruction Trace Window. For the list of supported values, refer to *Trace Timestamp Formats* on page 269.
PREF_TIMELINE_CURSOR_LABELS	Selects the cursor labels to be displayed within the Timeline Window.
PREF_TIMELINE_WHEEL_MODE	Selects the mouse wheel action to be used for the Timeline Window: 0=Scroll, 1=Zoom, 2=None.
PREF_TIMELINE_TIME_ORIGIN	Selects the time origin of the Timeline Window: 0=CPU Halt, 1=Program Start.
PREF_TIMELINE_AUTO_SCROLL	Selects the auto-scrolling behavior(0: do not auto scroll, 1: auto scroll while program is running).

Name	Description
PREF_TIMELINE_CLEAR_EVENT	Debug event upon which trace and sampling data is cleared (Clear On Reset=0,Clear On Resume=1,Clear Never=2).
PREF_CP_HIGHLIGHT_SRC	Specifies if source code lines, as shown within the code profile window, are syntax-highlighted.
PREF_CP_HIGHLIGHT_ASM	Specifies if assembly code lines, as shown within the code profile window, are syntax-highlighted.
PREF_CP_SHOW_ENCODINGS	Specifies if instruction encodings are shown within the code profile window.
PREF_CP_SHOW_LINE_NUMBERS	Specifies if source line numbers are shown within the code profile window.
PREF_CP_SHOW_BP	Specifies if breakpoints are shown within the code profile window.
PREF_TRACE_SYNC_WITH_CODE	Sync instruction trace and code window selections (see *Backtrace Highlighting* on page 129).

User Preferences

7.2.27 System Variable Identifiers

The following constants identify Ozone system variables (see *Edit.SysVar* on page 309).

Name	Description
VAR_ACCESS_WIDTH	Memory access width (see *Memory Access Widths* on page 266 for permitted values).
VAR_ALLOW_BMA_EMULATION	This system variable is deprecated. Please remove statements changing this variable from your Ozone project file(s)
VAR_BREAK_AT_THIS_SYMBOL	Specifies the symbol or PC where program execution should be stopped when reset mode "Reset & Break at Symbol" is used.
VAR_BREAKPOINT_TYPE	Specifies the default breakpoint implementation type to use when setting breakpoints.
VAR_CALLSTACK_UNWIND_INFO_SRC	Specifies whether the call stack unwinding information shall be obtained from the DWARF information inside the ELF file or from instruction analysis. By default, automatic selection of the unwinding information source is enabled. See *Unwinding Information Source* on page 271 for permitted values.
VAR_CONTEXT_AWARE_STEPPING	Specifies whether to halt in the same function context (call frame) or anywhere on step over.
VAR_DOWNLOAD_ADDR	Specifies the download address for program segments. Possible value are DL_PMA (0) for physical memory address and DL_VMA (1) for virtual memory address (see *Destination Address Ranges for Download* on page 271).
VAR_GDB_SERVER_TYPE	Specifies the type of GDB server. Possible values are GDB_SERVER_TYPE_AUTO (0), GDB_SERVER_TYPE_OTHER (1), GDB_SERVER_TYPE_JLINK (2), GDB_SERVER_TYPE_STLINK (3) and GDB_SERVER_TYPE_OPENOCD (4), see *GDB Server Type* on page 272

Name	Description
VAR_HSS_SPEED	Data sampling frequency in Hz.
VAR_MEM_ZONE_RUNNING	Selects the default memory zone to be accessed when the program is running.
VAR_POWER_SAMPLING_SPEED	Power sampling frequency in Hz.
VAR_RESET_MODE	Specifies the program reset mode (see *Reset Modes* on page 267).
VAR_STARTUP_COMPLETION_POINT	Specifies the symbol or PC of the startup completion point (see *Startup Completion Point* on page 188).
VAR_TARGET_POWER_ON	Specifies whether J-Link / J-Trace 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_TRACE_MAX_INST_CNT	Specifies the maximum number of instructions that Ozone can process and store during a streaming trace session.
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_CORE_CLOCK	CPU frequency in Hz. Ozone uses this variable to convert instruction timestamps from CPU cycle count to time format.
VAR_VECTORTABLE_ADDR	Specifies the base address of the vector table, thus overriding the result of the heuristic used to detect the base address. If set to "Automatic", the result of the heurisitic is used.
VAR_VECTORTABLE_SIZE	Specifies the base size of the vector table, thus overriding the result of the heuristic used to detect the size. If set to "Automatic", the result of the heurisitic is used.
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.

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.

> **Note**
>
> Arguments containing white spaces must be quoted.

7.3.1 Project Generation

Command line arguments that generate (or update) a project.

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 IP 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/J-Trace to connect to.
-ip <IP>	Sets the host interface to IP and specifies the IP address of the J-Link/J-Trace 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 *Project.SetJTAGConfig* on page 342).

A project is generated when the file path given under '-project' does not exist. Otherwise, an existing project is updated with the command line arguments. The device, target interface and host interface settings must be present if the project is created.

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.

Argument	Description
-loginterval <bytes>	The byte interval at which the log file is updated. When 0, the log file is updated immediately.
-debug	Opens a debug console window along with Ozone.

7.3.3 Configuration

Command line arguments that adjust functional settings.

Argument	Description
-port <number>	Sets the used port for the *Automation Socket Interface* on page 262

7.4 Directory Macros

The following macros can be used as placeholders for directory paths wherever file path input is required:

$(DocDir)	The document directory. Expands to "${InstallDir}/doc".
$(PluginDir)	The plugin directory. Expands to "${InstallDir}/plugins".
$(ConfigDir)	The configuration directory. Expands to "${InstallDir}/config".
$(LibraryDir)	The library directory. Expands to "${InstallDir}/lib".
$(ProjectDir)	The directory containing the project file.
$(InstallDir)	The installation directory.
$(AppDir)	The directory containing the program file.
$(ExecutableDir)	The directory containing the Ozone executable.
$(AppBundleDir)	The application bundle directory (macOS).
$(Date)	The current date in the format YYMMDD.
$(DateYYYY)	The current year as four digit number.
$(DateYY)	The current year as two digit number.
$(DateMM)	The current month as number with a leading zero (01 to 12).
$(DateDD)	The current day as number with a leading zero (01 to 31).
$(Time)	The current time in the format HHMMSS.
$(TimeHH)	The hour of the current time with a leading zero (00 to 23).
$(TimeMM)	The minute of the current time with a leading zero (00 to 59).
$(TimeSS)	The second of the current time with a leading zero (00 to 59).

The date and time macros may be used for composing directory names and/or file names, e.g. when exporting window contents in an automated environment.

7.4.1 Environment Variables

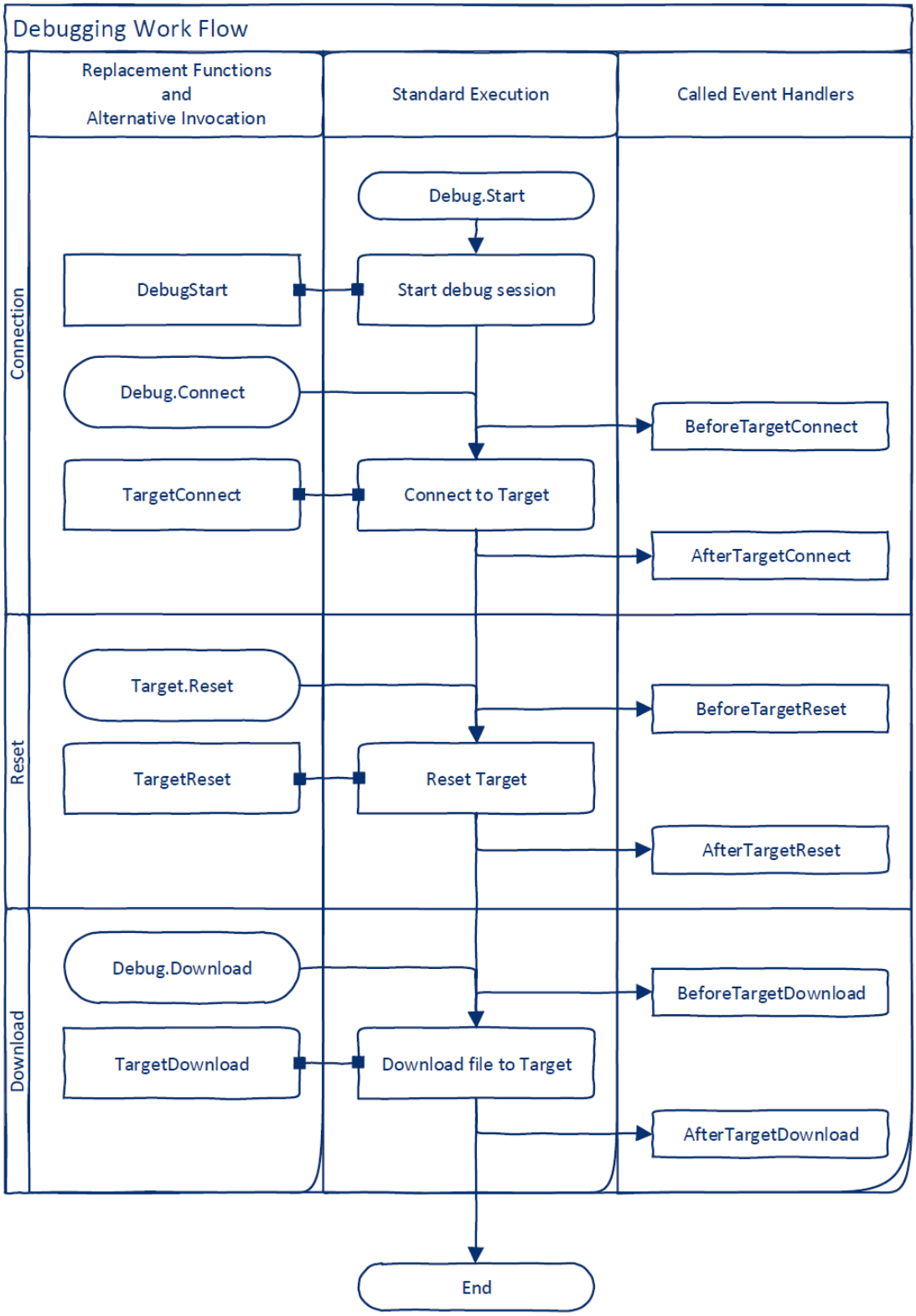
System environment variables can be used as placeholders for directory paths wherever file path input is required. The following environment variable formats are understood:

Format	Operating System(s)
%<varname>%	windows
$<varname>	unix
$(<varname>)	all plattforms

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

7.5 Startup Sequence Flow Chart

The figure below illustrates the different phases of the "Debug & Download Program" startup sequence and how it inter-operates with script functions (see *Download & Reset Program* on page 184). 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.

7.6 Errors and Warnings

The following table 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 390 when the problem persists.

Work on the application message tables is currently ongoing.

Code	Description	Possible Causes	Solution Proposals
0	File not tagged with ELF magic number	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
1	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
2	The ELF parser attempted to load an ELF file having an unspecified class (`ELF_CLASS_NONE`)	Incorrect toolchain settings or build target	Check toolchain settings
3	The ELF parser attempted to load an ELF file having an unspecified data encoding (`ELF_DATA_NONE`)	Incorrect toolchain settings or build target	Check toolchain settings
4	The ELF parser attempted to load an ELF file whose header version number is not `EV_CURRENT`	Incorrect toolchain settings or build target	Check toolchain settings
5	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
6	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 *Support* on page 390)
7	The ELF parser attempted to load an ELF file but could not open the file for reading	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
8	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

Code	Description	Possible Causes	Solution Proposals
9	Not enough free RAM to load the ELF file.	The ELF file contains more debug symbols than fit into Host PC RAM	Insufficient target RAM
10	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
11	The ELF parser attempted to initialize its DWARF parser subcomponent, which failed	1. Corrupted ELF program file	Check toolchain settings
12	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	Check toolchain settings
13	The ELF parser attempted to load an ELF file whose data endianess does not match the target settings	1. Project setting 'Target.SetEndianess' not present or set incorrectly 2. Incorrect toolchain settings pertaining to the byte order of the output file	1. Project setting 'Target.SetEndianess' not present or set incorrectly 2. Incorrect toolchain settings pertaining to the byte order of the output
14	The ELF parser attempted to load an ELF file whose instruction endianess does not match the target settings	1. Project setting 'Target.SetEndianess' not present or set incorrectly 2. Incorrect toolchain settings pertaining to the byte order of the output file	1. Project setting 'Target.SetEndianess' not present or set incorrectly 2. Incorrect toolchain settings pertaining to the byte order of the output
78	RTT could not be activated.	Hardware setup does not support background memory access.	1. verify that the target application uses SEGGER's RTT library. 2. verify that the hardware setup supports background memory access.
84	High speed sampling could not be started.	Hardware setup does not support background memory access.	Check the sampling frequency and verify that the hardware setup supports background memory access.
86	The project script contains a syntax or semantical error	The project file was created with a newer version of Ozone and contains identifiers not supported by the current installation	Check project file for valid syntax. Remove commands and identifiers from the project file that are not supported by the current installation.
90	The file path to the CMSIS-SVD file containing the register set description for the selected target is not valid	1. Incorrect input to command 'Project.AddSvdFile' 2. Command 'Project.AddSvdFile not specified and a default file path is not available. 3. Incorrect use of command Project.Ad-	Add command Project.AddSvdFile to project script function OnProjectLoad

Code	Description	Possible Causes	Solution Proposals
		dSvdFile (must be placed in project script function 'OnProjectLoad')	
103	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)
104	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 \ref{Support})
105	The ELF parser encountered an empty data section	Incorrect toolchain settings	Check toolchain settings
106	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)
107	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)
108	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)
109	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)
110	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
111	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 \ref{Support})
112	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)
113	ELF data section \em{debug_loc} has an unexpected byte size	1. Unsupported debug symbol format or extension. 2. Software bug in	Change the debug information output format (e.g. from DWARF-5 to DWARF-4)

Code	Description	Possible Causes	Solution Proposals
		the employed toolchain or in Ozone’s ELF parser	
114	ELF data section \em{debug_line} 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)
115	ELF data section \em{debug_frame} 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)
116	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 \ref{Support})
117	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 \ref{Support})
118	ELF data section \em{debug_frame} 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)
119	ELF data section \em{debug_frame} 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)
120	The ELF parser encountered an inconsistency within call frame information data	Software bug in the employed toolchain	Contact SEGGER support (see \ref{Support})
121	ELF data section \em{debug_frame} 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)
122	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)
123	ELF data section \em{debug_frame} 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)
124	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)
125	The program macro information decoder encoun-	1. Unsupported debug symbol format or exten-	Change the debug information output format

Code	Description	Possible Causes	Solution Proposals
	tered an internal error state	sion. 2. Software bug in the employed toolchain or in Ozone's ELF parser	(e.g. from DWARF-5 to DWARF-4)
129	The ELF parser reports that a debugging information entry at a specific section offset could not be parsed/generated	1. Unsupported debug symbol format or extension. 2. Program file contains corrupted DWARF debug information	Change the debug information output format (e.g. from DWARF-5 to DWARF-4)
130	The DWARF parser encountered an error parsing the debug info for a type unit	-1. Unsupported debug symbol format or extension. 2. Program file contains corrupted DWARF debug information	Change the debug information output format (e.g. from DWARF-5 to DWARF-4)
131	The DWARF parser encountered an error parsing the debug info for a compile unit	1. Unsupported debug symbol format or extension. 2. Program file contains corrupted DWARF debug information	Change the debug information output format (e.g. from DWARF-5 to DWARF-4)
132	The DWARF parser encountered an error parsing the source file info of a compile unit	1. Unsupported debug symbol format or extension. 2. Program file contains corrupted DWARF debug information	Change the debug information output format (e.g. from DWARF-5 to DWARF-4)
133	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 \ref{Support})
134	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	Update J-Link software drivers (e.g. by using the J-Link DLL Updater tool)
135	Power sampling could not be started	1. Power output to the target is not enabled (see *System Variable Identifiers* on page 277). 2. The hardware setup does not support power sampling	1. Enable power output (see \ref{Power Sampling Window}). 2. Update J-Link software drivers (e.g. by using the J-Link DLL Updater tool)
137	The debuggee uses embOS-specific functionality, but an RTOS-awareness plugin was not loaded	Missing use of command Project.SetOSPlugin	Add command 'Project.SetOSPlugin(embOSPlugin)' to the project file
138	The debuggee uses FreeRTOS-specific functionality, but an RTOS-awareness plugin was not loaded	Missing use of command Project.SetOSPlugin	Add command 'Project.SetOSPlugin(FreeRTOSPlugin_<port>) to the project file
178	All physical addresses in program segments are 0x0	Linker information may be incorrect or build tool chain does not fill-in physical addresses	Add command 'Edit.SysVar(VAR_DOWNLOAD_ADDR, DL_VMA)' to the project file

Code	Description	Possible Causes	Solution Proposals
179	All virtual addresses in program segments are `0x0`	Linker information may be incorrect or build tool chain does not fill-in virtual addresses	command 'Edit.SysVar(VAR_DOWNLOAD_ADDR, DL_PMA)' to the project file or remove command 'Edit.SysVar(VAR_DOWNLOAD_ADDR, DL_VMA)' from the project file
183	Illegal command found in script function `OnStartupComplete`	Illegal command added to script function `OnStartupComplete`	Remove the respective command. Check if it should be moved to `OnDebugStartBreakSymReached`
184	The debuggee uses FreeRTOS-specific functionality, but an RTOS-awareness plugin was not loaded	Missing use of command Project.SetOSPlugin	Create an RTOS-awareness script and add command 'Project.SetOSPlugin(<plugin>) to the project file

7.7 Minidumps

When Ozone crashes due to an unexpected condition, a compact crash report (minidump) is stored to the file system.

Users are kindly asked to include the minidump within bug reports, as it greatly simplifies the task of locating the bug for the Ozone team.

Minidumps are stored to the following directory:

Operating System	Directory
Windows	%LOCALAPPDATA%/SEGGER/Ozone
Linux	$HOME/.local/share/data/SEGGER/Ozone
macOS	$HOME/Library/Application Support/SEGGER/Ozone

The full path of the minidump is indicated by a popup dialog that will be shown when the crash occurs. Additionally, the file path will be printed to the standard error output channel (stderr). The file extension of Ozone minidumps is “dmp”.

7.8 Action Tables

The following tables provide a quick reference on user actions provided by Ozone (see *User Actions* on page 43).

7.8.1 Breakpoint Actions

Actions that modify the debugger's breakpoint state.

Action	Description
Break.Clear	Clears an instruction breakpoint.
Break.ClearOnSrc	Clears a source breakpoint.
Break.ClearOnData	Clears a data breakpoint.
Break.ClearOnSymbol	Clears a data breakpoint on a symbol.
Break.ClearAllOnData	Clears all data breakpoints.
Break.ClearAll	Clears all code breakpoints.
Break.Disable	Disables an instruction breakpoint.
Break.DisableOnSrc	Disables a source breakpoint.
Break.DisableOnData	Disables a data breakpoint.
Break.DisableOnSymbol	Disables a data breakpoint on a symbol.
Break.Enable	Enables an instruction breakpoint.
Break.EnableOnSrc	Enables a source breakpoint.
Break.EnableOnData	Enables a data breakpoint.
Break.EnableOnSymbol	Enables a data breakpoint on a symbol.
Break.Edit	Edits a breakpoints advanced properties.
Break.EditOnData	Edits a data breakpoint.
Break.EditOnSymbol	Edits a data breakpoint on a symbol.
Break.OnChange	Sets a data breakpoint on a symbol.
Break.Set	Sets an instruction breakpoint.
Break.SetEx	Sets an instruction breakpoint.
Break.SetOnSrc	Sets a source breakpoint.
Break.SetOnSrcEx	Sets a source breakpoint.
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.SetOnSymbol	Sets a data breakpoint on a symbol.
Break.SetVectorCatch	Edits the vector catch state.

7.8.2 Code Profile Actions

Code profile related actions.

Action	Description
Coverage.Exclude	Filters program entities from the code coverage statistic.
Coverage.Include	Re-adds program entities to the code coverage statistic.
Coverage.ExcludeNOPs	Filters trailing NOPs from the code coverage statistic.

Action	Description
Profile.Exclude	Filters program entities from the code profile statistic.
Profile.Include	Re-adds program entities to the code profile statistic.
Profile.Reset	Clears code profile data and resets all execution counters.

7.8.3 Debug Actions

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

Action	Description
Debug.Connect	Connects the debugger to the target.
Debug.Continue	Resumes program execution.
Debug.Disconnect	Disconnects the debugger from the target.
Debug.Download	Downloads the program file to the target.
Debug.Halt	Halts program execution.
Debug.IsHalted	Queries the program state.
Debug.Reset	Reset the program.
Debug.ReadIntoInstCache	Reads a code block into the instruction cache.
Debug.RunTo	Advances program execution to a particular location.
Debug.SetConnectMode	Sets the connection mode.
Debug.Start	Starts the debug session.
Debug.Stop	Stops the debug session.
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.SetResetMode	Sets the reset mode.
Debug.SaveSnapshot	Saves a debug snapshot.
Debug.LoadSnapshot	Loads a debug snapshot.

7.8.4 Edit Actions

Actions that edit behavioral and appearance settings of the debugger.

Action	Description
Edit.Color	Edits an application color.
Edit.DisplayFormat	Edits an item's integer value display format.
Edit.Font	Edits an application font.
Edit.MemZone	Edits the memory zone of a watched expression.
Edit.Preference	Edits a user preference.
Edit.RefreshRate	Edits the refresh rate of a window or watched expression.
Edit.SysVar	Edits a system variable.

7.8.5 ELF Actions

Actions for retrieving ELF program file information.

Action	Description
Elf.GetBaseAddr	Returns the program file's download address.
Elf.GetFileClass	Returns the ELF file class of the program file.
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.GetEndianess	Returns the program file's byte order.
Elf.SetConfig	Configures the ELF parser.
Elf.PrintSectionInfo	Prints ELF file section information.

7.8.6 Export Actions

Actions that export debug session data to CSV or text files.

Action	Description
Export.CodeProfile	Exports code profile data.
Export.DataGraphs	Exports all data graphs to a CSV file.
Export.Disassembly	Exports program disassembly.
Export.PowerGraphs	Exports all power graphs to a CSV file.
Export.Trace	Exports instruction trace data to a CSV file.

7.8.7 File Actions

Actions that perform file system and related operations.

Action	Description
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.CloseAllUnedited	Closes all unedited documents.
File.Exit	Closes the application.
File.Find	Searches for a text pattern.
File.Load	Loads a file.
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.OpenProjectInEditor	Opens the project file within the source viewer.
File.Reload	Reloads a file from disk.
File.SaveProjectAs	Saves the project file under a new file path to disk.
File.Save	Saves an open document to disk.
File.SaveAs	Saves an open document under a new file path to disk.
File.SaveCopyAs	Saves a copy of an open document to disk.

Action	Description
File.SaveAll	Saves all modified files.
File.SelectInExplorer	Selects a source file within the file explorer.

7.8.8 Find Actions

Actions that locate program entities.

Action	Description
Find.Function	Locates a program function.
Find.GlobalData	Locates a global symbol.
Find.SourceFile	Locates a source file.
Find.Text	Opens the Quick Find Widget.
Find.TextInFiles	Opens the Find In Files Dialog.
Find.TextInTrace	Opens the Find In Trace Dialog.

7.8.9 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.UserGuide	Displays the user guide and reference manual.
Help.ReleaseNotes	Displays the release notes.
Help.LicenseManager	Opens the license manager.

7.8.10 J-Link Actions

Actions that perform J-Link operations.

Action	Description
Exec.AddCommandOnOpen	Schedules a J-Link command to be executed immediately before or after opening J-Link connection (i.e. `JLink_Open()` is called).
Exec.Connect	Connects the debugger to the target.
Exec.Command	Executes a J-Link/J-Trace command.
Exec.Download	Downloads a program or a data file to target memory.
Exec.Reset	Performs a hardware reset of the target.

7.8.11 OS Actions

Actions that perform RTOS related operations.

Action	Description
OS.AddContextSwitchSymbol	Identifies a code symbol that executes a task switch.

7.8.12 Process Actions

Actions that control interaction with external processes.

Action	Description
Process.Exec	Spawns a process and executes an external application.

7.8.13 Project Actions

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

Action	Description
Project.AddSvdFile	Adds a register set description file.
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.ConfigSWO	Configures the Serial Wire Output (SWO) interface.
Project.ConfigSemihosting	Configures the Semihosting interface.
Project.ConfigDisassembly	Edits disassembler options.
Project.DisableSessionSave	Disables saving of individual session information.
Project.RelocateSymbols	Relocates one or multiple symbols.
Project.SetDevice	Specifies the target device.
Project.SetFlashLoader	Specifies the flash loader(s) to be used for one or more flash banks.
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.SetRTT	Enables or disables Real Time Transfer (RTT).
Project.SetSWO	Enables or disables Serial Wire Output (SWO) capture.
Project.SetCorePlugin	Specifies the file path of the target support plugin.
Project.SetDisassemblyPlugin	Specifies the disassembly support plugin to be used.
Project.SetSmartViewPlugin	Specifies the SmartView plugin to be used.
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/J-Trace logging output. In case of debugging via a GDB server the communication between GDB client and GDB server is written into that file.
Project.SetConsoleLogFile	Sets the text file that receives console window output.

Action	Description
Project.SetTerminalLogFile	Sets the text file that receives terminal window output.

7.8.14 Register Actions

Actions that inform about target register properties.

Action	Description
Register.Addr	Returns the memory location of a target register.

7.8.15 Script Actions

Actions that perform script operations.

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

7.8.16 Show Actions

Actions that navigate to particular objects displayed on the graphical user interface.

Action	Description
Show.CallGraph	Displays the call graph of a function.
Show.Data	Displays the data location of a program variable.
Show.Definition	Displays the source code definition location of a symbol.
Show.Declaration	Displays the source code declaration location of a symbol.
Show.Disassembly	Displays the assembly code of an object.
Show.InstTrace	Displays a position in the instruction execution history.
Show.Line	Displays a text line in the active document.
Show.Memory	Displays a memory location.
Show.MemoryMap	Displays a symbol within the memory map of the target.
Show.NextResult	Displays the next search result item.
Show.PC	Displays the PC instruction in the Disassembly Window.
Show.PCLine	Displays the PC line in the Source Viewer.
Show.PrevResult	Displays the previous search result item.
Show.Source	Displays the source code location of an object.
Show.ValueData	Displays the symbol pointed to within the memory window.
Show.ValueDisassembly	Displays the symbol pointed to within the disassembly window.
Show.ValueSource	Displays the symbol pointed to within the source viewer.

7.8.17 Snapshot Actions

Actions to program snapshot operations.

Action	Description
Snapshot.LoadReg	Reads a register from a snapshot and writes it to target.

Action	Description
Snapshot.LoadU32	Reads a memory value from a snapshot and writes it to target.
Snapshot.ReadReg	Reads a register from a snapshot.
Snapshot.ReadU32	Reads a memory value from a snapshot.
Snapshot.SaveReg	Saves a register to a snapshot.
Snapshot.SaveU32	Saves a memory value to a snapshot.

7.8.18 Target Actions

Actions that perform target memory and register IO.

Action	Description
Target.AddMemorySegment	Adds a memory segment to the memory map.
Target.EraseChip	Erases the target's FLASH memory (to `0xFF`).
Target.FillMemory	Fills a block of target memory with a particular value.
Target.FillMemoryEx	Fills a block of target memory with a particular value and a particular word width.
Target.GetReg	Reads a target register.
Target.LoadMemory	Downloads the contents of a data file to target memory.
Target.LoadMemoryMap	Loads a memory map from a memory map file.
Target.PowerOn	Toggles target power supply by J-Link/J-Trace.
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.SaveMemory	Saves a block of target memory to a binary data file.
Target.SetAccessWidth	Specifies the memory access width.
Target.SetEndianess	Configures the debugger for a particular data endianess.
Target.SetReg	Writes 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.

7.8.19 Timeline Actions

Actions related to the Timeline Window.

Action	Description
Timeline.Reset	Resets trace and sampling data.

7.8.20 Tools Actions

Actions that open tool dialogs.

Action	Description
Tools.DebugSettings	Opens the Debug Settings Dialog.
Tools.Preferences	Opens the User Preference Dialog.

Action	Description
Tools.SemihostingSettings	Opens the Semihosting Settings Dialog.
Tools.SysVars	Opens the System Variable Editor.
Tools.TraceSettings	Opens the Trace Settings Dialog.

7.8.21 Toolbar Actions

Actions that modify the state of toolbars.

Action	Description
Toolbar.Show	Displays a toolbar.
Toolbar.Close	Hides a toolbar.
Toolbar.AddCustomButton	Adds a button to the Custom Toolbar.
Toolbar.RemoveCustomButton	Removes a button from the Custom Toolbar.
Toolbar.EnableCustomButton	Enables a button in the Custom Toolbar.
Toolbar.DisableCustomButton	Disables a button in the Custom Toolbar.
Toolbar.PressButton	Performs the same action as when clicking on a button in a toolbar.

7.8.22 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.Reset	Resets instruction trace data.

7.8.23 Utility Actions

Script function utility actions.

Action	Description
Util.Error	Shows an error message box and stops the debug session.
Util.Log	Prints a message to the console window.
Util.LogHex	Prints a formated message to the console window.
Util.Sleep	Pauses the current operation for a given amount of time.

7.8.24 Window Actions

Actions that edit the state of debug information windows.

Action	Description
Window.Add	Adds a symbol to a window.
Window.Close	Closes a window.
Window.CloseAll	Closes all windows.
Window.Clear	Clears a window.
Window.CollapseAll	Collapses all items of a window.
Window.ExpandAll	Expands all items of a window.
Window.Export	Exports the window content to file.
Window.Insert	Inserts a symbol into a window.
Window.Remove	Removes a symbol from a window.
Window.Show	Shows a window.
Window.SetDisplayFormat	Sets a window's integer value display format.
Window.ShowFullScreen	Toggles main window full screen mode.
Window.WaitForUpdateComplete	Waits until all debug windows have completed updating following a change of the program execution point.

7.8.25 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
Watch.Quick	Shows an expression within the Quick Watch Dialog

7.9 User Actions

7.9.1 File Actions

7.9.1.1 File.Close

Closes a document (see *Source Viewer* on page 156).

Prototype

```
int File.Close(const char* sFilePathOrName);
```

Argument	Meaning
sFilePathOr-Name	File path (or name) of a source file (see *File Path Arguments* on page 222).

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Window → Close Document (Ctrl+F4)

7.9.1.2 File.CloseAll

Closes all open documents (see *File Menu* on page 45).

Prototype

```
int File.CloseAll();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Window → Close All Documents (Ctrl+Alt+F4)

7.9.1.3 File.CloseAllButThis

Closes all but the active document (see *Source Viewer* on page 156).

Prototype

```
int File.CloseAllButThis();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Document Tab → Context Menu → Close All But This (Ctrl+Shift+F4)

7.9.1.4 File.CloseAllUnedited

Closes all unedited documents (see *Source Viewer* on page 156).

Prototype

```
int File.CloseAllUnedited();
```

Return Value

-1: error
 0: success

GUI Access

Document Tab → Context Menu → Close All Unedited Documents

7.9.1.5 File.Exit

Closes the application (see *File Menu* on page 45).

Prototype

```
int File.Exit();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → File → Exit (Alt+F4)

7.9.1.6 File.Find

Searches a text pattern in source code documents (see *Find In Files Dialog* on page 71).

Prototype

```
int File.Find(const char* sFindWhat);
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → Find → Find In Files (Ctrl+Shift+F)

7.9.1.7 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 Behavior Comparison* on page 198). 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 into script functions (see *Avoiding Script Function Recursions* on page 198).

Prototype

```
int File.Load(const char* sFilePath, U64 Address);
```

Argument	Meaning
sFilePath	Path to a program or data file (see *File Path Arguments* on page 222).
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

7.9.1.8 File.NewProject

Creates a new project (see *File Menu* on page 45).

Prototype

```
int File.NewProject();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → File → New → New Project (Ctrl+N)

7.9.1.9 File.NewProjectWizard

Opens the Project Wizard (see *Project Wizard* on page 35).

Prototype

```
int File.NewProjectWizard();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → File → New → New Project Wizard (Ctrl+Alt+N)

7.9.1.10 File.Open

Opens a file (see *File Menu* on page 45). 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 into script functions (see *Avoiding Script Function Recursions* on page 198).

Prototype

```
int File.Open(const char* sFilePathOrName);
```

Argument	Meaning
sFilePathOr-Name	File path (or name) of a project-, source- or program-file (see *File Path Arguments* on page 222).

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → File → Open (Ctrl+O)

7.9.1.11 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

7.9.1.12 File.OpenProjectInEditor

Opens the project file within the source viewer.

Prototype

```
int File.OpenProjectInEditor();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → File → Edit Project File

7.9.1.13 File.Reload

Reloads a document from disk. Note that unsaved document changes will be lost when this command is executed.

Prototype

```
int File.Reload(const char* sFilePathOrName);
```

Argument	Meaning
sFilePath	File path or name of a document currently open within the Source Viewer (see *File Path Arguments* on page 222).

Return Value

-1: error
 0: success

GUI Access

Document Tab -> Reload from disk

7.9.1.14 File.SaveAll

Saves all modified files.

Prototype

```
int File.SaveAll();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → File → Save all

7.9.1.15 File.SaveProjectAs

Saves the project file under a new file path to disk.

Prototype

```
int File.SaveProjectAs(const char* sFilePath);
```

Argument	Meaning
sFilePath	New project file path (see *File Path Arguments* on page 222).

Return Value

-1: error
 0: success

GUI Access

Main Menu → File → Save Project as (Ctrl+Shift+S)

7.9.1.16 File.Save

Saves an open document to disk.

Prototype

```
int File.Save(const char* sFilePathOrName);
```

Argument	Meaning
sFilePathOr-Name	File path (or name) of a document which is opened within the Source Viewer. When empty, the file path of the active document is used (see *File Path Arguments* on page 222).

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → File → Save (Ctrl+S)

7.9.1.17 File.SaveAs

Saves an open document under a new file path to disk.

Prototype

```
int File.SaveAs(const char* sFilePathOrName, const char* sFilePathNew);
```

Argument	Meaning
sFilePathOr-Name	File path (or name) of a document which is opened within the Source Viewer. When empty, the file path of the active document is used (see *File Path Arguments* on page 222).
sFilePathNew	File path to save to.

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → File → Save As…

7.9.1.18 File.SaveCopyAs

Saves a copy of an open document to disk.

Prototype

```
int File.SaveCopyAs(const char* sFilePathOrName, const char* sFilePathOut);
```

Argument	Meaning
sFilePathOr-Name	File path (or name) of a document which is opened within the Source Viewer. When empty, the file path of the active document is used (see *File Path Arguments* on page 222).
sFilePathOut	File path to save to.

Return Value

-1: error
 0: success

GUI Access

Main Menu → File → Save Copy As…

7.9.1.19 File.SelectInExplorer

Selects a source file or a directory within the file explorer of the operating system.

Prototype

```
int File.SelectInExplorer(const char* sLocation);
```

Argument	Meaning
sLocation	File path (or name) of a source file or directory path (see *File Path Arguments* on page 222).

Return Value

-1: error
 0: success

GUI Access

Source Viewer → File Tab → Select In Explorer (Ctrl+F2)

7.9.2 Find Actions

7.9.2.1 Find.Text

Shows the Quick Find Widget to locate a text pattern within the active document (see *Quick Find Widget* on page 92).

Prototype

```
int Find.Text();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → Find → Find (Ctrl+F)

7.9.2.2 Find.TextInFiles

Opens the Find In Files Dialog (see *Find In Files Dialog* on page 71).

Prototype

```
int Find.TextInFiles();
```

Return Value

-1: error

0: success

GUI Access

Main Menu → Find → Find In Files (Ctrl+Shift+F)

7.9.2.3 Find.TextInTrace

Opens the Find In Trace Dialog (see *Find In Trace Dialog* on page 73).

Prototype

```
int Find.TextInTrace();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → Find → Find In Trace (Ctrl+Shift+T)

7.9.2.4 Find.Function

Shows the Quick Find Widget to locate a program function (see *Quick Find Widget* on page 92).

Prototype

```
int Find.Function();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → Find → Find Function (Ctrl+M)

7.9.2.5 Find.GlobalData

Shows the Quick Find Widget to locate a global variable (see *Quick Find Widget* on page 92).

Prototype

```
int Find.GlobalData();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → Find → Find Global Data (Ctrl+J)

7.9.2.6 Find.SourceFile

Shows the Quick Find Widget to open a source file (see *Quick Find Widget* on page 92).

Prototype

```
int Find.SourceFile();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Find → Find Source File (Ctrl+K)

7.9.3 Tools Actions

7.9.3.1 Tools.DebugSettings

Opens the Debug Settings Dialog (see *Debug Settings Dialog* on page 68).

Prototype

```
int Tools.DebugSettings();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Tools → Debug Settings (Ctrl+Alt+D)

7.9.3.2 Tools.TraceSettings

Opens the Trace Settings Dialog (see *Trace Settings Dialog* on page 84).

Prototype

```
int Tools.TraceSettings();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Tools → Trace Settings (Ctrl+Alt+T)

7.9.3.3 Tools.Preferences

Displays the User Preference Dialog (see *User Preference Dialog* on page 86).

Prototype

```
int Tools.Preferences();
```

Return Value

```
-1: error
 0: success
```


GUI Access

Main Menu → Tools → Preferences (Ctrl+Alt+P)

7.9.3.4 Tools.SysVars

Displays the System Variable Editor (see *System Variable Editor* on page 83).

Prototype

```
int Tools.SysVars();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Tools → System Variables (Ctrl+Alt+V)

7.9.3.5 Tools.SemihostingSettings

Opens the Semihosting Settings Dialog (see *Semihosting Settings Dialog* on page 82).

Prototype

```
int Tools.SemihostingSettings();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Tools → Semihosting Settings (Ctrl+Alt+H)

7.9.4 Edit Actions

7.9.4.1 Edit.Preference

Edits a user preference.

Prototype

```
int Edit.Preference(int ID, int Value);
```

Argument	Meaning
ID	User preference identifier (see *User Preference Identifiers* on page 273).
Value	User preference value. Certain user preferences are specified in a predefined format (see *Value Descriptors* on page 264).

Additional Information

User preferences can be alternatively edited using the User Preference Dialog (see *User Preference Dialog* on page 86).

Return Value

-1: error
 0: success

GUI Access

None.

7.9.4.2 Edit.SysVar

Edits a system variable (see *System Variable Identifiers* on page 277).

Prototype

```
int Edit.SysVar(int ID, int Value);
```

Argument	Meaning
ID	System variable identifier (see *System Variable Identifiers* on page 277).
Value	System variable value. Certain system variable values are specified in a predefined format (see *Value Descriptors* on page 264).

Return Value

-1: error
 0: success

GUI Access

Main Menu → Tools → System Variables (Ctrl+Alt+V)

7.9.4.3 Edit.Find

Searches a text pattern in the active document (see *Source Viewer* on page 156). 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

Main Menu → Find → Find (Ctrl+F)

7.9.4.4 Edit.Color

Edits an application color (see *Color Identifiers* on page 272).

Prototype

```
int Edit.Color(int ID, int Value);
```

Argument	Meaning
ID	Color identifier (see *Color Identifiers* on page 272).

Argument	Meaning
Value	Color descriptor (see *Color Descriptor* on page 264).

Return Value

-1: error
 0: success

GUI Access

Main Menu → Edit → Preferences → Appearance

7.9.4.5 Edit.Font

Edits an application font (see *Font Identifiers* on page 272).

Prototype

```
int Edit.Font(int ID, const char* sFont);
```

Argument	Meaning
ID	Font identifier (see *Font Identifiers* on page 272).
sFont	Font descriptor (see *Font Descriptor* on page 264).

Return Value

-1: error
 0: success

GUI Access

Main Menu → Edit → Preferences → Appearance

7.9.4.6 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. Registers can be specified using the plain name (such as “MODER”) or register window path name (such as “Peripherals.GPIO.GPIOA.MODER”).
Format	Value Display Formats (see *Value Display Formats* on page 266).

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Display As

7.9.4.7 Edit.RefreshRate

Sets the refresh rate of a debug window or watched expression (see *Live Watches* on page 197).

Prototype

```
int Edit.RefreshRate (const char* sDest, int Frequency);
```

Argument	Meaning
sDest	Debug window name (e.g. "Registers 1") or C-Language expression (see *Working With Expressions* on page 205).
Frequency	Update frequency in Hz (see *Frequency Descriptor* on page 264).

Return Value

-1: error
 0: success

GUI Access

Watched Data Window → Context Menu → Refresh Rate

7.9.4.8 Edit.MemZone

Assigns a memory zone to a watched expression (see *Live Watches* on page 197). 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 *Working With Expressions* on page 205).
sMemZone	Memory zone name

Return Value

-1: error
 0: success

GUI Access

Watched Data Window → Context Menu → Memory Zone

7.9.5 Export Actions

7.9.5.1 Export.CodeProfile

Exports the current code profile dataset.

Prototype

```
int Export.CodeProfile (const char* sFilePath, int Options, const char* sItem-
sToExport);
```


Argument	Meaning
sFilePath	Destination text file (see *File Path Arguments* on page 222). An empty string prompts the export to be performed to a temporary file. The temporary file is opened within the Source Viewer and can be saved to disk later on.
Options	bitwise-OR combination of export option flags (see *Code Profile Export Options* on page 270). Use value 0 to specify default options.
sItemsToExport	A comma-separated list containing the names of the functions to export. The list may also contain source file (module) names, in which case all functions contained within the module are selected for export. An empty list (the default) selects all program functions for export.

Additional Information

Command Window.WaitForUpdateComplete can be employed to ensure that the Code Profile Window has processed all available sampling data before the export is performed.

Return Value

-1: error
 0: success

GUI Access

Code Profile Window → Context Menu → Export…

7.9.5.2 Export.Disassembly

Exports program disassembly (see *Disassembly Export Dialog* on page 69).

Prototype

```
int Export.Disassembly(const char* sFilePath, const char* sFuncOrArange, U32 Flags);
```

Argument	Meaning
sFilePath	Output file path (see *File Path Arguments* on page 222). An empty string prompts the export to be performed to a temporary file. The temporary file is opened within the Source Viewer and can be saved to disk later on.
sFuncOrArange	A function name or an address range string of the format "<StartAddr>-<EndAddr>". When set, only the specified function or address range is exported. An empty string selects the whole program. This option requires the output format to be "CSV".
Flags	Bitwise-OR combination of export options (see *Disassembly Export Options* on page 270). This argument defaults to 0.

Return Value

-1: error
 0: success

GUI Access

Disassembly Window → Context Menu → Export…

7.9.5.3 Export.DataGraphs

Exports all data graphs to a CSV file (see *Data Sampling Window* on page 114).

Prototype

```
int Export.DataGraphs(const char* sFilePath);
```

Argument	Meaning
sFilePath	Output file path (see *File Path Arguments* on page 222). An empty string prompts the export to be performed to a temporary file. The temporary file is opened within the Source Viewer and can be saved to disk later on.

Additional Information

Command Window.WaitForUpdateComplete can be employed to ensure that the Data Sampling Window has processed all available sampling data before the export is performed.

Return Value

-1: error
 0: success

GUI Access

Data Sampling Window → Context Menu → Export…

7.9.5.4 Export.PowerGraphs

Exports power sampling data to a CSV file (see *Power Sampling Window* on page 145).

Prototype

```
int Export.PowerGraphs(const char* sFilePath);
```

Argument	Meaning
sFilePath	Output file path (see *File Path Arguments* on page 222). An empty string prompts the export to be performed to a temporary file. The temporary file is opened within the Source Viewer and can be saved to disk later on.

Additional Information

Command Window.WaitForUpdateComplete can be employed to ensure that the Power Sampling Window has processed all available sampling data before the export is performed.

Return Value

-1: error
 0: success

GUI Access

Power Sampling Window → Context Menu → Export…

7.9.5.5 Export.Trace

Exports the contents of the Instruction Trace Window to a CSV file.

Prototype

```
int Export.Trace(const char* sFilePath, U64 InstCnt);
```


Argument	Meaning
sFilePath	Output file path (see *File Path Arguments* on page 222). An empty string prompts the export to be performed to a temporary file. The temporary file is opened within the Source Viewer and can be saved to disk later on.
MaxInstCnt	Maximum number of instructions to export. When not specified (0), this value defaults to the number of instructions currently loaded by the Instruction Trace Window. This value is limited by system variable `VAR_TRACE_MAX_INST_CNT`.

Additional Information

Command Window.WaitForUpdateComplete can be employed to ensure that the Instruction Trace Window has loaded and processed all available instructions before the export is performed.

Return Value

-1: error
 0: success

GUI Access

Instruction Trace Window → Context Menu → Export…

7.9.6 Window Actions

7.9.6.1 Window.Show

Shows a window (see *Window Layout* on page 139).

Prototype

```
int Window.Show(const char* sWindow);
```

Argument	Meaning
sWindow	Name of the window (e.g. "Source Files"). See *View Menu* on page 46.

Return Value

-1: error
 0: success

GUI Access

Main Menu → View → Window Name (Shift+Alt+Letter)

7.9.6.2 Window.Close

Closes a window (see *Window Layout* on page 139).

Prototype

```
int Window.Close(const char* sWindow);
```


Argument	Meaning
sWindow	Name of the window (e.g. "Source Files"). See *View Menu* on page 46.

Return Value

-1: error
 0: success

GUI Access

Main Menu → Window → Close Window (Alt+X)

7.9.6.3 Window.CloseAll

Closes all windows (see *Window Layout* on page 139).

Prototype

```
int Window.CloseAll();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → Window → Close All Window (Alt+Shift+X)

7.9.6.4 Window.SetDisplayFormat

Set's a window's value display format (see *Display Format* on page 58).

Prototype

```
int Window.SetDisplayFormat(const char* sWindow, int Format);
```

Argument	Meaning
sWindow	Name of the window (e.g. "Source Files"). See *View Menu* on page 46.
Format	Value display format (see *Value Display Formats* on page 266).

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Display All As (Alt+Number)

7.9.6.5 Window.ShowFullScreen

Activates or deactivates main window full screen mode.

Prototype

```
int Window.ShowFullScreen(int On);
```


Return Value

-1: error
 0: success

GUI Access

Main Menu → View → Enter/Exit Full Screen (Alt+Shift+Return)

7.9.6.6 Window.Add

Adds a symbol to a debug window (see *Debug Information Windows* on page 95).

Prototype

```
int Window.Add(const char* sWindow, const char* sSymbol);
```

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Add (Alt+Plus)

7.9.6.7 Window.Insert

Inserts a symbol into a table window (see *Debug Information Windows* on page 95).

Prototype

```
int Window.Insert(const char* sWindow, const char* sSymbol, int TableRow);
```

Argument	Meaning
sWindow	Window name, as displayed within the window title.
sSymbol	Function name, variable or expression.
TableRow	insertion position.

Return Value

-1: error
 0: success

GUI Access

None

7.9.6.8 Window.Insert

Inserts a symbol into a debug window (see *Debug Information Windows* on page 95).

Prototype

```
int Window.Insert (const char* sWindow, const char* sSymbol, int Row);
```

Argument	Meaning
sWindow	Name of the window (e.g. "Source Files"). See *View Menu* on page 46.

Argument	Meaning
sSymbol	Name of the symbol to insert.
Row	Insert symbol at this position. When empty, append the symbol.

Return Value

-1: error
 0: success

GUI Access

None

7.9.6.9 Window.Remove

Removes a symbol from a debug window (see *Debug Information Windows* on page 95).

Prototype

```
int Window.Remove(const char* sWindow, const char* sSymbol);
```

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Remove (Del)

7.9.6.10 Window.Clear

Clears a window.

Prototype

```
int Edit.TerminalSettings();
```

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Clear (Alt+Del)

7.9.6.11 Window.ExpandAll

Expands all expandable window items.

Prototype

```
int Window.ExpandAll();
```

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Expand All (Alt+Plus)

7.9.6.12 Window.Export

Exports the contents of a debug window to file.

Prototype

```
int Window.Export(const char* sWindow, const char* sFilePath);
```

Argument	Meaning
sWindow	Window name, as displayed within the window title.
sFilePath	Output file path (see *File Path Arguments* on page 222).

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Export

7.9.6.13 Window.CollapseAll

Collapses all collapsible window items.

Prototype

```
int Window.CollapseAll();
```

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Collapse All (Alt+Minus)

7.9.6.14 Window.WaitForUpdateComplete

Waits until all debug information windows have finished updating following a change of the program execution point.

Prototype

```
int Window.WaitForUpdateComplete(U32 MaxTimeMillis);
```

Argument	Meaning
MaxTimeMillis	Maximum time to wait in milliseconds.

Return Value

-1: error
 0: success

GUI Access

None

7.9.7 Toolbar Actions

7.9.7.1 Toolbar.Show

Displays a toolbar (see *Showing and Hiding Toolbars* on page 50).

Prototype

```
int Toolbar.Show(const char* sToolbar);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → View → Toolbars → Toolbar Name

7.9.7.2 Toolbar.Close

Hides a toolbar (see *Showing and Hiding Toolbars* on page 50).

Prototype

```
int Toolbar.Show(const char* sToolbar);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → View → Toolbars → Toolbar Name

7.9.7.3 Toolbar.AddCustomButton

Adds a button to the Custom Toolbar. The parameters specify the text to be displayed on the button and the function call that is to be executed each time the button is pressed.

Upon creation of the button it is not checked, whether the respective function call works or not. This becomes visible only after the button is pressed.

Each invocation of this function creates a new button. If a button with the same text already exists, the result will be two buttons with the same text. It is not possible to alter the command or text of a button after it was created.

Prototype

```
int Toolbar.AddCustomButton(const char* sButtonName, const char* sCommand);
```

Return Value

```
-1: error
 0: success
```


GUI Access

None

7.9.7.4 Toolbar.RemoveCustomButton

Removes a button from the Custom Toolbar. The parameter specifies the button to be removed, numbering starts at 1.

Prototype

```
int Toolbar.RemoveCustomButton(int Number);
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.7.5 Toolbar.EnableCustomButton

Enables a button in the Custom Toolbar. The parameter specifies the button to be enabled, numbering starts at 1.

Upon creation a button is always enabled. It may be disabled using the command Toolbar.DisableCustomButton.

Prototype

```
int Toolbar.EnableCustomButton(int Number);
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.7.6 Toolbar.DisableCustomButton

Disables a button in the Custom Toolbar. The parameter specifies the button to be disabled, numbering starts at 1.

Upon creation a button is always enabled. It may be disabled using this command. Once it is disabled, it may be re-enabled using Toolbar.EnableCustomButton.

Prototype

```
int Toolbar.DisableCustomButton(int Number);
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.7.7 Toolbar.PressButton

Performs the same action as if clicking onto a button in a toolbar with the mouse. The parameters specify the name of the toolbar and the number of the button to be pressed, numbering starts at 1.

Pressing a disabled button does not have any effect.

Prototype

```
int Toolbar.PressButton(const char* sToolbar, int Number);
```

Return Value

-1: error
 0: success

GUI Access

Click on the respective button

7.9.8 Utility Actions

7.9.8.1 Util.Error

Shows an error message box and optionally stops the debug session.

Prototype

```
int Util.Error(const char* sError, int StopDebug);
```

Argument	Meaning
sError	Error message
StopDebug	1: Ask the user if the debug session is to be stopped. 2: Stop the debug session. Otherwise, simply show the error message. Optional.

Return Value

-1: error
 0: success

GUI Access

None

7.9.8.2 Util.Log

Prints a message to the Console Window (see *Console Window* on page 111).

Prototype

```
int Util.Log(const char* sMessage);
```

Return Value

-1: error
 0: success

GUI Access

None

> **Note**
>
> This command supports escaped quotes.

7.9.8.3 Util.LogHex

Appends an integer value to a text message and prints the result to the Console Window (see *Console Window* on page 111).

Prototype

```
int Util.LogHex(const char* sMessage, unsigned int IntValue);
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

> **Note**
>
> This command supports escaped quotes.

7.9.8.4 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

7.9.9 Script Actions

7.9.9.1 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 integer type.

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

7.9.9.2 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 *Working With Expressions* on page 205). The symbol expression cannot contain local variables.

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.10 Show Actions

7.9.10.1 Show.Memory

Displays a memory location within the Memory Window (see *Memory Window* on page 135).

Prototype

```
int Show.Memory(U64 Address);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Memory Window → Context Menu → Go To (Ctrl+G)

7.9.10.2 Show.MemoryMap

Displays a symbol within the Memory Usage Window (see *Memory Usage Window* on page 139).

Prototype

```
int Show.MemoryMap(const char* sSymbol);
```


Return Value

-1: error
 0: success

GUI Access

Source Viewer → Context Menu → Show in Memory Map (Ctrl+B)

7.9.10.3 Show.Source

Displays the source code location of a variable, function or machine instruction within the Source Viewer (see *Source Viewer* on page 156).

Prototype

```
int Show.Source(const char* sLocation);
```

Argument	Meaning
sLocation	Variable name: displays the source code declaration of a variable. Function name: displays the source code implementation of a function. Memory address: displays the source line affiliated with an instruction. Source location: displays a particular source location (see *Source Code Location Descriptor* on page 264).

Return Value

-1: error
 0: success

GUI Access

Symbol Windows → Context Menu → Show Source (Ctrl+U)

7.9.10.4 Show.ValueSource

Displays the symbol pointed to within the Source Viewer.

Prototype

```
int Show.ValueSource(const char* sExpression);
```

Argument	Meaning
sExpression	Variable name: name of a function or data pointer. Memory address: memory location of a function or data pointer. Register name: register location of a function or data pointer.

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Show Value in Source

7.9.10.5 Show.ValueDisassembly

Displays the symbol pointed to within the Disassembly Window.

Prototype

```
int Show.ValueDisassembly(const char* sExpression);
```

Argument	Meaning
sExpression	Variable name: name of a function or data pointer. Memory address: memory location of a function or data pointer. Register name: register location of a function or data pointer.

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Show Value in Disassembly

7.9.10.6 Show.ValueData

Displays the symbol pointed to within the Memory Window.

Prototype

```
int Show.ValueData(const char* sExpression);
```

Argument	Meaning
sExpression	Variable name: name of a function or data pointer. Memory address: memory location of a function or data pointer. Register name: register location of a function or data pointer.

Return Value

-1: error
 0: success

GUI Access

Window → Context Menu → Show Value in Data

7.9.10.7 Show.Data

Displays the data location of a global or local program variable within the Registers Window (see *Registers Window* on page 147) or the Memory Window (see *Memory Window* on page 135).

Prototype

```
int Show.Data(const char* sVariable);
```

Return Value

-1: error
 0: success

GUI Access

Symbol Windows → Context Menu → Show Data (Ctrl+T)

7.9.10.8 Show.Disassembly

Displays the assembly code of a function or source code statement within the Disassembly Window (see *Disassembly Window* on page 117).

Prototype

```
int Show.Disassembly(const char* sLocation);
```

Argument	Meaning
sLocation	Function name: displays the disassembly of a function. Memory address: displays the disassembly at a memory location. Source location: displays the disassembly of a source statement (see *Source Code Location Descriptor* on page 264).

Return Value

-1: error
 0: success

GUI Access

Symbol Windows → Context Menu → Show Disassembly (Ctrl+D)

7.9.10.9 Show.Definition

Displays the source code definition location of a symbol within the Source Viewer (see *Source Viewer* on page 156).

Prototype

```
int Show.Definition(const char* sSymbol);
```

Return Value

-1: error
 0: success

GUI Access

Source Viewer → Context Menu → Show Definition (F12)

7.9.10.10 Show.Declaration

Displays the source code declaration location of a symbol within the Source Viewer (see *Source Viewer* on page 156).

Prototype

```
int Show.Declaration(const char* sSymbol);
```

Return Value

-1: error
 0: success

GUI Access

Source Viewer → Context Menu → Show Declaration (Shift+F12)

7.9.10.11 Show.CallGraph

Displays the call graph of a function.

Prototype

```
int Show.CallGraph (const char* sFuncName);
```

Return Value

```
-1: error
 0: success
```

GUI Access

→ Source Viewer → Context Menu → Show Call Graph (Ctrl+H)

7.9.10.12 Show.InstTrace

Displays a position in the history (stack) of executed machine instructions.

Prototype

```
int Show.InstTrace (int StackPos);
```

Argument	Meaning
StackPos	Position 1 = most recently executed machine instruction.

Return Value

```
-1: error
 0: success
```

GUI Access

Instruction Trace Window → Context Menu → Go To

7.9.10.13 Show.Line

Displays a text line in the active document.

Prototype

```
int Show.Line(unsigned int Line);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Source Viewer → Context Menu → Go To Line (Ctrl+L)

7.9.10.14 Show.PC

Displays the program's execution point within the Disassembly Window (see *Disassembly Window* on page 117).

Prototype

```
int Show.PC();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Disassembly Window → Context Menu → Go To PC (Ctrl+P)

7.9.10.15 Show.PCLine

Displays the program's execution point within the Source Viewer (see *Source Viewer* on page 156).

Prototype

```
int Show.PCLine();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Source Viewer → Context Menu → Go To PC (Ctrl+P)

7.9.10.16 Show.NextResult

Displays the next search result.

Prototype

```
int Show.NextResult();
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.10.17 Show.PrevResult

Displays the previous search result.

Prototype

```
int Show.PrevResult();
```


Return Value

-1: error
 0: success

GUI Access

None.

7.9.11 Snapshot Actions

7.9.11.1 Snapshot.SaveReg

Saves a register or register group to a snapshot (see *Register Groups* on page 148).

Prototype

```
int Snapshot.SaveReg(const char* sReg);
```

Argument	Meaning
sReg	Plain register (group) name (such as "MODER") or register window path name (such as "Peripherals.GPIO.GPIOA.MODER"). The latter variant is obligatory when the input is a vendor-specific peripheral register (group).

Return Value

-1: error
 0: success

GUI Access

None

7.9.11.2 Snapshot.SaveU32

Saves a 32 bit integer value to a snapshot.

Prototype

```
int Snapshot.SaveU32(U64 Addr, U32 Value);
```

Argument	Meaning
Addr	Address of the integer value to store. The integer is written to this target memory location when the snapshot is loaded.
Value	32-bit integer value. The value is converted to target endianess before download.

Return Value

-1: error
 0: success

GUI Access

None

7.9.11.3 Snapshot.ReadReg

Reads a register value from a snapshot (see *Register Groups* on page 148).

Prototype

```
int Snapshot.ReadReg(const char* sReg);
```

Argument	Meaning
sReg	Plain register name (such as "MODER") or register window path name (such as "Peripherals.GPIO.GPIOA.MODER"). The latter variant is obligatory when the input is a vendor-specific peripheral register. When a register group was stored to the snapshot, each group register can be accessed individually.

Return Value

-1 when register (or containing group) is not stored in snapshot, otherwise register value.

GUI Access

None

7.9.11.4 Snapshot.ReadU32

Reads a 32 bit value from a snapshot.

Prototype

```
int Snapshot.ReadU32(U64 Addr);
```

Argument	Meaning
Addr	Target memory address.

Return Value

-1 when the snapshot does not contain integer data for the given address, otherwise data.

GUI Access

None

7.9.11.5 Snapshot.LoadReg

Reads a register (group) from a snapshot and writes it to target (see *Register Groups* on page 148).

Prototype

```
int Snapshot.LoadReg(const char* sReg);
```

Argument	Meaning
sReg	Plain register (group) name (such as "MODER") or register window path name (such as "Peripherals.GPIO.GPIOA.MODER"). The latter variant is obligatory when the input is a vendor-specific peripheral register (group). When a register group was stored to the snapshot, each group register can be accessed individually. When a register group is loaded to the target, registers are written piece-wise.

Return Value

-1: error, i.e. register (or containing group) not stored in snapshot
 0: success

GUI Access

None

7.9.11.6 Snapshot.LoadU32

Reads a 32 bit value from a snapshot and writes it to target.

Prototype

```
int Snapshot.LoadU32(U64 Addr);
```

Argument	Meaning
Addr	Target memory address.

Return Value

-1: error, i.e. snapshot does not contain integer data at the given address or value could not be downloaded.
 0: success

GUI Access

None

7.9.12 Debug Actions

7.9.12.1 Debug.Start

Starts the debug session (see *Starting the Debug Session* on page 184). The startup routine can be reprogrammed (see *TargetConnect* on page 229).

Prototype

```
int Debug.Start();
```

Return Value

-1: error
 0: success

GUI Access

Main Menu → Debug → Start Debugging (F5)

7.9.12.2 Debug.Stop

Closes the debug session (see *Closing the Debug Session* on page 223).

Prototype

```
int Debug.Stop();
```


Return Value

-1: error
 0: success

GUI Access

Main Menu → Debug → Stop Debugging (Shift+F5)

7.9.12.3 Debug.Disconnect

Disconnects the debugger from the target.

Prototype

```
int Debug.Disconnect();
```

Return Value

-1: error
 0: success

GUI Access

None

7.9.12.4 Debug.Connect

Establishes a 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

7.9.12.5 Debug.SetConnectMode

Sets the connection mode (see *Connection Mode* on page 184).

Prototype

```
int Debug.SetConnectMode(int Mode);
```

Argument	Meaning
Mode	Connection mode (see *Connection Modes* on page 267).

Return Value

-1: error
 0: success

GUI Access

None

7.9.12.6 Debug.Continue

Resumes program execution (see *Resume* on page 191).

Prototype

```
int Debug.Continue();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Debug → Continue (F5)

7.9.12.7 Debug.Halt

Halts program execution (see *Halt* on page 191).

Prototype

```
int Debug.Halt();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Debug → Halt (Ctrl+F5)

7.9.12.8 Debug.Reset

Resets the target and the debuggee (see *Reset* on page 190). The reset operation can be customized via the scripting interface (see `TargetReset`).

Prototype

```
int Debug.Reset();
```

Argument	Meaning
Mode	Reset mode (see *Reset Modes* on page 267).

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Debug → Reset (F4)

7.9.12.9 Debug.SetResetMode

Sets the reset mode. The reset mode determines how the program is reset (see *Reset Mode* on page 190).

Prototype

```
int Debug.SetResetMode(int Mode);
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.12.10 Debug.StepInto

Steps into the current subroutine (see *Step* on page 190).

Prototype

```
int Debug.StepInto();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Debug → Step Into (F11)

7.9.12.11 Debug.StepOver

Steps over the current subroutine (see *Step* on page 190).

Prototype

```
int Debug.StepOver();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Debug → Step Over (F12)

7.9.12.12 Debug.StepOut

Steps out of the current subroutine. (see *Step* on page 190).

Prototype

```
int Debug.StepOut();
```

Return Value

```
-1: error
```


0: success

GUI Access

Main Menu → Debug → StepOut (Shift+F11)

7.9.12.13 Debug.SetNextPC

Sets the execution point to a particular machine instruction (see *Execution Point* on page 195).

Prototype

```
int Debug.SetNextPC(U64 Address);
```

Return Value

-1: error
 0: success

GUI Access

Disassembly Window → Context Menu → Set Next PC (Shift+F10)

7.9.12.14 Debug.SetNextStatement

Sets the execution point to a particular source code line (see *Execution Point* on page 195).

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 *Source Code Location Descriptor* on page 264).

Return Value

-1: error
 0: success

GUI Access

Source Viewer → Context Menu → Set Next Statement (Shift+F10)

7.9.12.15 Debug.RunTo

Advances the program execution point to a particular source code line, function or instruction address (see *Execution Point* on page 195).

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.

Argument	Meaning
	Source location: advances program execution to a particular source code line (see *Source Code Location Descriptor* on page 264).

Return Value

-1: error
 0: success

GUI Access

Code Window → Context Menu → Run To Cursor (Ctrl+F10)

7.9.12.16 Debug.Download

Downloads the debuggee to the target (see *Program Files* on page 183). The download operation can be reprogrammed (see `TargetDownload`).

Prototype

```
int Debug.Download();
```

Return Value

-1: error
 0: success

GUI Access

None

7.9.12.17 Debug.ReadIntoInstCache

Reads a machine code block into Ozone's instruction cache (see *Setting Up The Instruction Cache* on page 209). The preferred way to employ this command is to call it from project script function `OnStartupComplete`.

Prototype

```
int Debug.ReadIntoInstCache(U64 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

7.9.12.18 Debug.IsHalted

Queries the program state.

Prototype

```
int Debug.IsHalted();
```

Return Value

0: Program is running
1: Program is halted

GUI Access

None

7.9.12.19 Debug.LoadSnapshot

Loads a debug snapshot (see *Snapshot Dialog* on page 79).

Prototype

```
int Debug.LoadSnapshot(const char* sFilePath);
```

Argument	Meaning
sFilePath	Snapshot file path (*.jsnap, see *File Path Arguments* on page 222).

Return Value

-1: error
0: success

GUI Access

Debug → Load Snapshot

7.9.12.20 Debug.SaveSnapshot

Saves a debug snapshot (see *Snapshot Dialog* on page 79).

Prototype

```
int Debug.SaveSnapshot(const char* sFilePath, unsigned int Flags);
```

Argument	Meaning
sFilePath	Snapshot file path (*.jsnap, see *File Path Arguments* on page 222).
Flags	Bitwise-OR combination of individual debug snapshot settings (see *Snapshot Save Flags* on page 270. This argument defaults to 0.

Return Value

-1: error
0: success

GUI Access

Debug → Save Snapshot

7.9.13 Help Actions

7.9.13.1 Help.About

Shows the About Dialog.

Prototype

```
int Help.About();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Help → About

7.9.13.2 Help.UserGuide

Opens the user guide within the default PDF viewer.

Prototype

```
int Help.UserGuide();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Help → User Guide (F1)

7.9.13.3 Help.ReleaseNotes

Opens the release notes within the web browser.

Prototype

```
int Help.ReleaseNotes();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Help → Release Notes

7.9.13.4 Help.LicenseManager

Opens the license manager.

Prototype

```
int Help.LicenseManager();
```

Return Value

```
-1: error
 0: success
```


GUI Access

Main Menu → Help → License Manager

7.9.13.5 Help.Commands

Prints the command help to the Console Window (see *Command Help* on page 112)

Prototype

```
int Help.Commands();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Help → Commands (Shift+F1)

7.9.14 Process Actions

7.9.14.1 Process.Exec

Spawns a process and executes an external application.

The exit code of the application is conveyed in the return value of this command.

Text output of the application to `stdout` and `stderr` is captured and displayed in the console window in dedicated colors. The colors can be changed, see Message Colors.

A timeout in milliseconds is specified. If the application does not terminate before the timeout is reached, the application will be killed. In that case the command will return the value -1.

Setting the timeout to 0 will launch the application in a fire-and-forget way; in that case the command will return 0 and output on `stdout` and `stderr` will neither be captured nor be displayed in the console window.

Only a single external application can be executed at the same time. The next application cannot be started before the previous application has terminated. This limit does not apply to applications started in the fire-and-forget way.

Quotes in the command line and/or argument list need to be escaped by a preceeding backslash (i.e. '\"').

Prototype

```
int Process.Exec(const char* sCmd, const char* sArgs, int Timeout);
```

Argument	Meaning
sCmd	The command line for launching the process to be spawned.
sArgs	The argument list to be passed to the process, formatted in a single string.
Timeout	The timeout in milliseconds.

Return Value

```
    -1: error: Timeout occurred or process could not be spawned.
otherwise: the exit code of the Process
```


Note

An application returning the exit code -1 cannot be distinguished from an application that could not be started or that was killed due to the timeout since in all those cases the command returns the value -1.

Note

This command supports escaped quotes.

7.9.15 Project Actions

7.9.15.1 Project.SetDevice

Specifies the target device (see *Debug Settings Dialog* on page 68).

Prototype

```
int Project.SetDevice(const char* sDeviceName);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Tools → Debug Settings (Ctrl+Alt+D)

7.9.15.2 Project.SetFlashLoader

Specifies the flash loader configuration, i.e. the flash loader(s) to be used for one or multiple flash bank(s).

The configuration string consists of a list of tupels, each tupel specifying the base address of a flash bank and the name of the flash loader to be used for that flash bank, both separated by an equal sign character (“=”). Multiple tupels are separated by a semicolon (“;”). Specifying one tupel is mandatory, specifying more than one tupel is optional.

“<BankAddress> = <LoaderName>[; <BankAddress2> = <LoaderName2>]..[; <BankAddress_n> = <LoaderName_n>]”

For flash banks which are not listed in the configuration string, J-Link will use the respective bank’s default flash loader.

This function shall be invoked only from within `OnProjectLoad()` in the Ozone project script.

Prototype

```
int Project.SetFlashLoader(const char* sConfig);
```

Argument	Meaning
sConfig	The flash loader configuration string

Return Value

```
-1: error
```


0: success

GUI Access

None

7.9.15.3 Project.SetHostIF

Specifies the host interface (see *Host Interfaces* on page 266).

Prototype

```
int Project.SetHostIF(const char* sHostIF, const char* sHostID);
```

Argument	Meaning
sHostIF	Host interface (see *Host Interfaces* on page 266).
sHostID	Host identifier (USB serial number or IP address).

Return Value

-1: error
 0: success

GUI Access

Main Menu → Tools → Debug Settings (Ctrl+Alt+D)

7.9.15.4 Project.SetTargetIF

Specifies the target interface (see *Target Interfaces* on page 266).

Prototype

```
int Project.SetTargetIF(const char* sTargetIF);
```

Argument	Meaning
sTargetIF	Target interface (see *Target Interfaces* on page 266).

Return Value

-1: error
 0: success

GUI Access

Main Menu → Tools → Debug Settings (Ctrl+Alt+D)

7.9.15.5 Project.SetTIFSpeed

Specifies the target interface speed (see *Debug Settings Dialog* on page 68).

Prototype

```
int Project.SetTIFSpeed(const char* sFrequency);
```

Argument	Meaning
sFrequency	Frequency Descriptor (see *Frequency Descriptor* on page 264).

Return Value

-1: error
 0: success

GUI Access

Main Menu → Tools → Debug Settings (Ctrl+Alt+D)

7.9.15.6 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 → Tools → Debug Settings (Ctrl+Alt+D)

7.9.15.7 Project.SetBPType

Sets the permitted breakpoint implementation type, i.e. restricts breakpoints to be implemented in the way specified by the command argument.

Prototype

```
int Project.SetBPType(int Type);
```

Argument	Meaning
Type	Breakpoint Implementation Types (see *Breakpoint Implementation Types* on page 267).

Return Value

-1: error
 0: success

GUI Access

Main Menu → Tools → System Variables (Ctrl+Alt+V)

7.9.15.8 Project.SetCorePlugin

Sets the file path of the plugin that provides target support (see *Target Support Plugins* on page 28. Applying this setting causes the debugger's automatic plugin selection to be overridden.

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 on all platforms. For further details, see *File Path Arguments* on page 222.

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.15.9 Project.SetDisassemblyPlugin

Sets the file path of the plugin that provides disassembly support for custom instructions (see *Disassembly Plugin* on page 232.

Prototype

```
int Project.SetDisassemblyPlugin(const char* sFilePath);
```

Argument	Meaning
sFilePath	File path to a JavaScript plugin file. The file path may be specified case-insensitively on all platforms. For further details, see *File Path Arguments* on page 222.

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.15.10 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. The valid plugin file extension is .js on all platforms. The file path may be specified case-insensitively on all platforms. The file extension may be omitted. For further details, see *File Path Arguments* on page 222.

The provided plugins may be found in the section *Available RTOS Plugins* on page 152.

7.9.15.11 Project.SetSmartViewPlugin

Specifies the file path or name of a SmartView plugin to the debugger.

Prototype

```
int Project.SetSmartViewPlugin(const char* sFilePath);
```

Argument	Meaning
sFilePath	Plugin file path or name.

Additional Description

Multiple SmartView scripts may be loaded at the same time. In that case Project.SetSmartViewPlugin needs be invoked once for each script.

A programming guide for SmartView plugins is provided by section *SmartView Awareness Plugin* on page .

7.9.15.12 Project.SetRTT

Enables or disables the Real-Time Transfer interface (see *Real-Time Transfer* on page 200).

Prototype

```
int Project.SetRTT(int OnOff);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Terminal Window → Context Menu → Capture RTT

7.9.15.13 Project.AddRTTSearchRange

Specifies a memory range to be considered during RTT initialization, specifically RTT control block discovery (see *Real-Time Transfer* on page 200).

The RTT control block is a data structure located at the address of global program variable *_SEGGER_RTT*. When the program file provides a debug symbol for variable _SEGGER_RTT, no discovery is neccessary. RTT discovery refers to the process of searching target RAM for a byte pattern specific to the control block in order to locate it. To speed up this process, command Project.AddRTTSearchRange is provided.

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

7.9.15.14 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 *Trace Sources* on page 269).

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Tools → Trace Settings (Ctrl+Alt+T)

7.9.15.15 Project.ConfigSemihosting

Configures the Semihosting interface (see *Semihosting* on page 201).

> **Note**
>
> Ozone automatically enables semihosting on the first CPU halt after debug session start. When not required, semihosting can be explicitly disabled by setting ModeBP, ModeBKPT and ModeSVC to No.

Prototype

```
int Project.ConfigSemihosting(const char* sConfig);
```

Argument	Meaning
sConfig	Settings string of the format `setting1=value1;setting2=value2,…` The available settings are listed below. The default value of each setting is highlighted.

AllowOpenRead

Sets the permission for semihosting operation SysOpen when file flag `READ` is set.

Value	Description
0 (Ask)	A popup dialog is shown which asks the user if the operation should be performed.
1 (Yes)	The operation is always allowed
2 (No)	The operation is never allowed

AllowOpenWrite

Sets the permission for semihosting operation SysOpen when file flag `WRITE` is set.

Value	Description
0 (Ask)	A popup dialog is shown which asks the user if the operation should be performed.
1 (Yes)	The operation is always allowed
2 (No)	The operation is never allowed

AllowRename

Sets the permission for semihosting operation SysRename.

Value	Description
0 (Ask)	A popup dialog is shown which asks the user if the operation should be performed.
1 (Yes)	The operation is always allowed
2 (No)	The operation is never allowed

AllowRemove

Sets the permission for semihosting operation SysRemove.

Value	Description
0 (Ask)	A popup dialog is shown which asks the user if the operation should be performed.
1 (Yes)	The operation is always allowed
2 (No)	The operation is never allowed

ModeSVC

Enables or disables semihosting via the SVC instruction.

Value	Description
0 (Yes, ask on non-semihosting SVC)	Semihosting via SVC enabled. A vector catch will be set on the SVC exception at debug session start. A popup dialog will be shown each time the program stops on the vector catch, but not due to a semihosting request (i.e. when a non-semihosting software interrupt was triggered).
1 (Yes)	Semihosting via SVC enabled. A vector catch will be set on the SVC exception at debug session start.
2 (No)	Semihosting via SVC disabled. No vector catch will be set for semihosting on debug session start.

ModeBKPT

Enables or disables semihosting via the BKPT instruction (ARM) / EBREAK instruction (RISC-V).

Value	Description
0 (Yes)	Semihosting via BKPT/EBREAK enabled.
1 (No and continue)	Semihosting via BKPT/EBREAK disabled. When the debuggee halts on a BKPT/EBREAK semihosting trap instruction, it is automatically resumed by Ozone.
2 (No and halt)	Semihosting via BKPT/EBREAK disabled. The debuggee halts on BKPT/EBREAK semihosting trap instructions.

ModeBP

Enables or disables semihosting via the generic trap instruction.

Value	Description
0 (Yes)	Semihosting on breakpoint enabled. Ozone will set a hidden breakpoint on address `BPAddress` on debug session start in order to serve semihosting requests.
1 (No)	Semihosting on breakpoint disabled. No hidden breakpoint is set on debug session start.

InputViaTerminal

Sets the user input mode.

Value	Description
0 (No)	User input is obtained via a popup dialog that is shown each time Ozone receives a semihosting input request from the debuggee.
1 (Yes)	User input is obtained via the terminal prompt, which gets highlighted and focused each time Ozone receives a semihosting input request from the debuggee.

ExitMode

Specifies Ozone's reaction on a `SYS_EXIT` semihosting operation.

Value	Description
0 (No)	The debug session is ended. Debug.Stop() is executed.
1 (Yes)	The target is haltet. Debug.Halt() is executed.

Vector

When semihosting is in its default configuration state and enabled, Ozone will set a vector catch on the SVC instruction at address `0x8` in order to catch semihosting requests. This default behavior can reduce the run-time performance of clients which make extensive use of software interrupts. In order to alleviate this problem, Ozone provides semihosting configuration setting `Vector`.

Setting `Vector` instructs Ozone to set a hidden breakpoint on arbitrary address `Vector` within the SVC handler instead of setting a vector catch on SVC. The breakpointed instruction then acts as the semihosting SVC trap instead of the vector catch. This way, developers get the chance to evaluate the SWI opcode within the SVC handler on the target side. The handler code is expected to execute the trap instruction only when the SWI opcode matches a semihosting SWI opcode. When this option is employed, developers have to make sure that the semihosting opcode and argument pointer registers R0, R1 and R2 are not modified within SVC handler code up to the point where the trap instruction is executed.

SVCNumberThumb

Edits the SWI number definition of the 16-bit thumb SVC semihosting trap instruction. The default value for this setting is `0xAB`. The valid range for this value is 0-`0xFF`. As an example, when SVC semihosting requests are to be performed via instruction SVC `#0x10`, then this setting should be set to value `0x10`.

SVCNumberARM

Edits the SWI number definition of the 32-bit ARM SVC semihosting trap instruction. The default value for this setting is `0x123456`. The valid range for this value is 0-`0xFFFFFF`. As an example, when SVC semihosting requests are to be performed via instruction SVC `#0x1234`, then this setting should be set to value `0x1234`.

BKPTNumber

Edits the software breakpoint number definition of the BKPT semihosting trap instruction. The default value for this setting is `0xAB`. The valid range for this value is 0-`0xFF`. As an example, when SVC semihosting requests are to be performed via instruction BKPT `#0x10`, then this setting should be set to value `0x10`.

BPAddress

Edits the address of the generic semihosting trap instruction. The default value for this setting is the base address of function `SEGGER_SEMIHOST_DebugHalt`. The valid value range for this setting is the address range of function `SEGGER_SEMIHOST_DebugHalt`. Depending on setting `ModeBP`, Ozone will or will not set a hidden breakpoint on the configured address in order to catch generic semihosting requests by the debuggee.

TargetCmdLine

Sets the command line text that Ozone is to transmit to the debuggee when it receives semihosting request SysGetCmdLine. This is the only setting that can not be edited via the settings dialog.

Return Value

-1: error
 0: success

GUI Access

None

7.9.15.16 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 345).

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 → Tools → Trace Settings (Ctrl+Alt+T)

7.9.15.17 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 345).

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 → Tools → Trace Settings (Ctrl+Alt+T)

7.9.15.18 Project.ConfigSWO

Configures the Serial Wire Output (SWO) interface (see *SWO* on page 200). This setting is only relevant when the selected trace source is SWO (see *Project.SetTraceSource* on page 345).

Prototype

```
int Project.ConfigSWO(const char* sSWOFreq, char* sCPUFreq);
```

Argument	Meaning
sSWOFreq	Specifies the data transmission speed on the SWO interface (see *Frequency Descriptor* on page 264).
sCPUFreq	Specifies the target's processor frequency (see *Frequency Descriptor* on page 264).

Return Value

```
-1: error
 0: success
```

GUI Access

Main Menu → Tools → Trace Settings (Ctrl+Alt+T)

7.9.15.19 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 → Tools → System Variables (Ctrl+Alt+V)

7.9.15.20 Project.AddSvdFile

Adds a register set description file to be loaded by the Registers Window (see *SVD Files* on page 147).

Prototype

```
int Project.AddSvdFile(const char* sFilePath);
```

Argument	Meaning
sFilePath	Path to a CMSIS-SVD file. Both .svd and .xml file extensions are supported. For further details, see *File Path Arguments* on page 222.

Return Value

-1: error
0: success

GUI Access

None

7.9.15.21 Project.AddFileAlias

Adds a file path alias (see *File Path Resolution Sequence* on page 207).

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)

7.9.15.22 Project.AddRootPath

Adds a source file root path. The root path helps the debugger resolve relative file path arguments (see *File Path Resolution Sequence* on page 207). 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

7.9.15.23 Project.AddPathSubstitute

Replaces a substring within unresolved source file path arguments (see *File Path Resolution Sequence* on page 207).

Prototype

```
int Project.AddPathSubstitute(const char* sSubStr, const char* sAlias);
```

Argument	Meaning
sSubStr	Substring (directory name) within original file paths.
sAlias	Replacement for the given substring.

Return Value

-1: error
 0: success

GUI Access

None

7.9.15.24 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 Sequence* on page 207).

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

7.9.15.25 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 on overview on J-Link script files.

Prototype

```
int Project.SetJLinkScript(const char* sFilePath);
```

Argument	Meaning
sFilePath	Path to a J-Link script file (see *File Path Arguments* on page 222).

Return Value

-1: error
 0: success

GUI Access

None

7.9.15.26 Project.SetJLinkLogFile

Specifies the text file that receives J-Link logging output or, in case of a GDB server being connected, the communication between GDB server and Ozone's GDB client.

Prototype

```
int Project.SetJLinkLogFile(const char* sFilePath);
```

Argument	Meaning
sFilePath	Path to a text file (see *File Path Arguments* on page 222).

Return Value

-1: error
 0: success

GUI Access

None

7.9.15.27 Project.RelocateSymbols

Relocates one or multiple symbols. The command must be executed before the ELF program file is opened. It is currently not supported to execute the command at program run-time. Furthermore, relocating symbols outside of their containing ELF data section address range is currently not supported. When an ELF data section lies completely within a relocated address range, it is relocated together with all containing 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.

Argument	Meaning
Offset	The offset that is added to the base addresses of all specified symbols.

Return Value

-1: error
 0: success

GUI Access

None

7.9.15.28 Project.SetConsoleLogFile

Sets the text file to which Console Window messages are logged.

Prototype

```
int Project.SetConsoleLogFile(const char* sFilePath);
```

Argument	Meaning
sFilePath	Log file path (see *File Path Arguments* on page 222).

Return Value

-1: error
 0: success

GUI Access

None

7.9.15.29 Project.SetTerminalLogFile

Sets the text file to which Terminal Window messages are logged.

Prototype

```
int Project.SetTerminalLogFile(const char* sFilePath);
```

Argument	Meaning
sFilePath	Log file path (see *File Path Arguments* on page 222).

Return Value

-1: error
 0: success

GUI Access

None

7.9.15.30 Project.ConfigDisassembly

Configures the disassembler.

Prototype

```
int Project.ConfigDisassembly(unsigned int Flags);
```

Argument	Meaning
Flags	Bitwise-OR combination of individual flags. Each flag specifies a disassembler option. Refer to *Disassembler Option Flags* on page 268 for the list of supported options.

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.15.31 Project.DisableSessionSave

Selects 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 *Session Save Flags* on page 270 for the list of supported flags.

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.15.32 Project.SetSWO

Enables or disables the Serial Wire Output (SWO) capture (see *SWO* on page 200).

Prototype

```
int Project.SetSWO(int OnOff);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Terminal Window → Context Menu → Capture SWO

7.9.16 Code Profile Actions

7.9.16.1 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…

7.9.16.2 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…

7.9.16.3 Profile.Reset

Clears code profile data and resets all execution counters.

Prototype

```
int Profile.Reset ();
```

Return Value

-1: error
 0: success

GUI Access

Code Profile Window → Context Menu → Reset Execution Counters

7.9.16.4 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…

7.9.16.5 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…

7.9.16.6 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 Trailing NOPs…

7.9.17 Register Actions

7.9.17.1 Register.Addr

Returns the memory location of a target register.

Prototype

```
int Register.Addr(const char* sReg);
```

Argument	Meaning
sReg	Plain register name (such as "MODER") or register window path name (such as "Peripherals.GPIO.GPIOA.MODER"). The latter variant is obligatory when the input is a vendor-specific peripheral register.

Return Value

Target memory address or -1 on invalid input (e.g. when not a memory-mapped register).

GUI Access

None

7.9.18 Target Actions

7.9.18.1 Target.EraseChip

Erases all of the target's FLASH memory by writing all data bytes to `0xFF`.

Prototype

```
int Target.EraseChip();
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.18.2 Target.SetReg

Writes a target register (see *Register Groups* on page 148).

Prototype

```
int Target.SetReg(const char* sReg, unsigned int Value);
```


Argument	Meaning
sReg	Plain register name (such as "MODER") or register window path name (such as "Peripherals.GPIO.GPIOA.MODER"). The latter variant is obligatory when the input is a vendor-specific peripheral register. System registers can also be specified using an architecture-specific notation, as described in *System Register Descriptor* on page 265.
Value	Register value to write.

Return Value

-1: error
 0: success

GUI Access

Register Window → Register

7.9.18.3 Target.GetReg

Reads a target register (see *Register Groups* on page 148).

Prototype

```
U32 Target.GetReg(const char* sReg);
```

Argument	Meaning
sReg	Plain register name (such as "MODER") or register window path name (such as "Peripherals.GPIO.GPIOA.MODER"). The latter variant is obligatory when the input is a vendor-specific peripheral register. System registers can also be specified using an architecture-specific notation, as described in *System Register Descriptor* on page 265.

Return Value

-1: error
register value: success

GUI Access

Register Window → Register

7.9.18.4 Target.WriteU32

Writes a word to target memory (see *Target Memory* on page 196).

Prototype

```
int Target.WriteU32(U64 Address, U32 Value);
```

Return Value

-1: error
 0: success

GUI Access

Memory Window

7.9.18.5 Target.WriteU16

Writes a half word to target memory (see *Target Memory* on page 196).

Prototype

```
int Target.WriteU16(U64 Address, U16 Value);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Memory Window

7.9.18.6 Target.WriteU8

Writes a byte to target memory (see *Target Memory* on page 196).

Prototype

```
int Target.WriteU8(U64 Address, U8 Value);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Memory Window

7.9.18.7 Target.ReadU32

Reads a word from target memory (see *Target Memory* on page 196).

Prototype

```
U32 Target.ReadU32(U64 Address);
```

Return Value

-1:	error
Memory value:	success

GUI Access

Memory Window

7.9.18.8 Target.ReadU16

Reads a half word from target memory (see *Target Memory* on page 196).

Prototype

```
U16 Target.ReadU16(U64 Address);
```

Return Value

-1:	error
Memory value:	success

GUI Access

Memory Window

7.9.18.9 Target.ReadU8

Reads a byte from target memory (see *Target Memory* on page 196).

Prototype

```
U32 Target.ReadU8(U64 Address);
```

Return Value

-1:	error
Memory value:	success

GUI Access

Memory Window

7.9.18.10 Target.SetAccessWidth

Specifies the default access width to be used when accessing target memory (see *Target.SetAccessWidth* on page 360).

Prototype

```
int Target.SetAccessWidth(U32 AccessWidth);
```

Argument	Meaning
AccessWidth	Memory access width (See *Memory Access Widths* on page 266).

Return Value

-1: error
 0: success

GUI Access

Main Menu → Tools → System Variables (Ctrl+Alt+V)

7.9.18.11 Target.FillMemory

Fills a block of target memory with a particular value (see *Target.FillMemory* on page 360).

Prototype

```
int Target.FillMemory(U64 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+I)

7.9.18.12 Target.FillMemoryEx

Fills a block of target memory with a particular value (see *Target.FillMemoryEx* on page 361) and a particular word width.

The value can be seen as a pattern which is used to fill the memory and the word width specifies the period of the pattern. Supported values for width are 1, 2, 3, 4 and 8 bytes, so the memory area can be filled byte-wise, half-word-wise, word-wise and double-word-wise. In addition, frame buffers containing information organized in 3 bytes, can directly be filled, as well.

Prototype

```
int Target.FillMemoryEx(U64 Address, U32 Size, U8 Width, U64 FillValue);
```

Argument	Meaning
Address	Start address of the memory block to fill.
Size	Size of the memory block to fill (in bytes).
Width	The word width.
FillValue	Value to fill the memory block with.

Return Value

-1: error
 0: success

GUI Access

Memory Window → Context Menu → Fill (Ctrl+I)

7.9.18.13 Target.SaveMemory

Saves a block of target memory to a binary data file (see *Target.SaveMemory* on page 361).

Prototype

```
int Target.SaveMemory(const char* sFilePath, U64 Address, U32 Size);
```

Argument	Meaning
sFilePath	Output binary data file (*.bin, see *File Path Arguments* on page 222).
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

7.9.18.14 Target.LoadMemory

Downloads the contents of a binary data file to target memory (see *Download Behavior Comparison* on page 198).

Prototype

```
int Target.LoadMemory(const char* sFilePath, U64 Address);
```

Argument	Meaning
sFilePath	Input binary data file (*.bin, see *File Path Arguments* on page 222).
Address	Download address.

Return Value

-1: error
 0: success

GUI Access

Memory Window → Context Menu → Load

7.9.18.15 Target.SetEndianess

Sets the data endianness mode of the target.

Prototype

```
int Target.SetEndianess(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 → Tools → Debug Settings → Target Device (Ctrl+Alt+D)

7.9.18.16 Target.LoadMemoryMap

Loads a memory map from an Embedded Studio memory map file. The loaded memory map is applied to the Memory Usage Window (see *Supplying Memory Segment Information* on page 140).

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. For further details, see see *File Path Arguments* on page 222.

Return Value

-1: error

0: success

GUI Access

Memory Usage Window → Context Menu → Edit Regions

7.9.18.17 Target.AddMemorySegment

Adds a segment to the memory map displayed by the Memory Usage Window (see *Supplying Memory Segment Information* on page 140).

Prototype

```
int Target.AddMemorySegment(const char* sName, U64 Addr, U32 Size);
```

Argument	Meaning
sName	Segment name.
Addr	Segment base address.
Size	Segment byte size.

Return Value

-1: error
0: success

GUI Access

Memory Usage Window → Context Menu → Edit Regions

7.9.18.18 Target.PowerOn

Enables or disables target power supply via the debug probe.

Prototype

```
int Target.PowerOn(int On);
```

Argument	Meaning
On	When 1, the target is powered via the debug probe. When 0, target power via J-Link/J-Trace is switched off.

Return Value

-1: error
0: success

GUI Access

Main Menu → Edit → System Variables (Ctrl+Alt+V)

7.9.19 Timeline Actions

7.9.19.1 Timeline.Reset

Resets all panes of the timeline window, i.e. the session’s trace and sampling data (see *Timeline Window* on page 165).

Prototype

```
int Timeline.Reset();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Timeline Window

7.9.20 J-Link Actions

7.9.20.1 Exec.Connect

Establishes a connection to the target (see `DebugStart`).

Prototype

```
int Exec.Connect();
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.20.2 Exec.Reset

Performs a hardware reset of the target (see `DebugStart`).

Prototype

```
int Exec.Reset();
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.20.3 Exec.Download

Downloads the contents of a program file to target memory (see *Download Behavior Comparison* on page 198 and *Supported Program File Types* on page 183).

Prototype

```
int Exec.Download(const char* sFilePath);
```

Argument	Meaning
sFilePath	Path to a program or data file (see *File Path Arguments* on page 222).

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.20.4 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 on overview on the available commands).

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.20.5 Exec.AddCommandOnOpen

Schedules a J-Link command to be executed immediately before or after opening the J-Link connection (i.e. `JLink_Open()` is invoked). This function shall be invoked only from within `OnProjectLoad()` in the Ozone project script.

Prototype

```
int Exec.AddCommandOnOpen(const char* sCommand, int BeforeNotAfterOpen);
```

Argument	Meaning
sCommand	J-Link command to execute (refer to the *J-Link User Guide* for on overview on the available commands).
BeforeNo-tAfterOpen	Indicates wether the command is to be executed immediately before (1) or after (0) opening a J-Link connection.

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.21 OS Actions

7.9.21.1 OS.AddContextSwitchSymbol

Specifies a function or program instruction that performs a task switch when executed. This command can be used to enable a consistent output within the Timeline Window even when no RTOS Awareness Plugin was loaded (see *Timeline Window* on page 165).

Prototype

```
int OS.AddContextSwitchSymbol(const char* sSymbol);
```

Argument	Meaning
sSymbol	Function name, assembly label or instruction address.

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.22 Breakpoint Actions

7.9.22.1 Break.Set

Sets an instruction breakpoint (see *Instruction Breakpoints* on page 192).

Prototype

```
int Break.Set(U64 Address);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Breakpoint Window → Context Menu → Set / Clear (Ctrl+Alt+B)

7.9.22.2 Break.SetEx

Sets an instruction breakpoint of a particular implementation type (see *Instruction Breakpoints* on page 192).

Prototype

```
int Break.SetEx(U64 Address, int Type);
```

Argument	Meaning
Address	Instruction address.
Type	Breakpoint Implementation Types (see *Breakpoint Implementation Types* on page 267).

Return Value

```
-1: error
 0: success
```


GUI Access

None

7.9.22.3 Break.SetOnSrc

Sets a source breakpoint (see *Source Breakpoints* on page 192).

Prototype

```
int Break.SetOnSrc(const char* sLocation);
```

Argument	Meaning
sLocation	Name of a program function (e.g. "`Reset_Handler`") or source location (e.g. "main.c:100", see *Source Code Location Descriptor* on page 264).

Return Value

```
-1: error
 0: success
```

GUI Access

Breakpoint Window → Context Menu → Set / Clear (Ctrl+Alt+B)

7.9.22.4 Break.SetOnSrcEx

Sets a source breakpoint of a particular implementation type (see *Source Breakpoints* on page 192).

Prototype

```
int Break.SetOnSrc(const char* sLocation, int Type);
```

Argument	Meaning
sLocation	Name of a program function (e.g. "`Reset_Handler`") or source location (e.g. "main.c:100", see *Source Code Location Descriptor* on page 264).
Type	Breakpoint Implementation Types (see *Breakpoint Implementation Types* on page 267).

Return Value

```
-1: error
 0: success
```

GUI Access

Breakpoint Window → Context Menu → Set / Clear (Ctrl+Alt+B)

7.9.22.5 Break.SetType

Sets a breakpoint's permitted implementation type (see *Breakpoint Implementation Types* on page 267).

Prototype

```
int Break.SetType(const char* sLocation, int Type);
```


Argument	Meaning
sLocation	The breakpoint's source location (e.g. "main.c:100", see *Source Code Location Descriptor* on page 264) or instruction address.
Type	Breakpoint Implementation Types (see *Breakpoint Implementation Types* on page 267).

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Edit (F8)

7.9.22.6 Break.Clear

Clears an instruction breakpoint (see *Instruction Breakpoints* on page 192).

Prototype

```
int Break.Clear(U64 Address);
```

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Set / Clear (Ctrl+Alt+B)

7.9.22.7 Break.ClearOnSrc

Clears a source breakpoint (see *Source Breakpoints* on page 192).

Prototype

```
int Break.ClearOnSrc(const char* sLocation);
```

Parameter Description

Refer to *Break.SetOnSrc* on page 367.

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Set / Clear (Ctrl+Alt+B)

7.9.22.8 Break.Enable

Enables an instruction breakpoint (see *Instruction Breakpoints* on page 192).

Prototype

```
int Break.Enable(U64 Address);
```


Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Enable (Ctrl+F9)

7.9.22.9 Break.Disable

Disables an instruction breakpoint (see *Instruction Breakpoints* on page 192).

Prototype

```
int Break.Disable(U64 Address);
```

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Disable (Ctrl+F9)

7.9.22.10 Break.EnableOnSrc

Enables a source breakpoint (see *Source Breakpoints* on page 192).

Prototype

```
int Break.EnableOnSrc(const char* sLocation);
```

Parameter Description

Refer to *Break.SetOnSrc* on page 367.

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Enable (Ctrl+F9)

7.9.22.11 Break.DisableOnSrc

Disables a source breakpoint (see *Source Breakpoints* on page 192).

Prototype

```
int Break.DisableOnSrc(const char* sLocation);
```

Parameter Description

Refer to *Break.SetOnSrc* on page 367.

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Disable (Ctrl+F9)

7.9.22.12 Break.Edit

Edits a breakpoint's advanced properties.

Prototype

```
int Break.Edit(const char* sLocation, const char* sCondition, int DoTrig-
gerOnChange, int SkipCount, const char* sTaskFilter, const char* sConsoleMsg,
const char* sMsgBoxMsg);
```

Argument	Meaning
sLocation	The breakpoint's source location (e.g. "main.c:100", see *Source Code Location Descriptor* on page 264) or instruction address.
sCondition	Symbol expression that must evaluate to non-zero for the breakpoint to be triggered (see *Working With Expressions* on page 205).
DoTriggerOn-Change	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)

7.9.22.13 Break.SetOnData

Sets a data breakpoint (see *Data Breakpoints* on page 194).

Prototype

```
int Break.SetOnData(U64 Address, U64 AddressMask, U8 AccessType, U8 Ac-
cessSize, 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.

Argument	Meaning
AccessType	Type of access that is monitored by the data breakpoint (see *Connection Modes* on page 267).
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 (Ctrl+Alt+D)

7.9.22.14 Break.ClearOnData

Clears a data breakpoint (see *Data Breakpoints* on page 194).

Prototype

```
int Break.ClearOnData(U64 Address, U64 AddressMask, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnData* on page 370.

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Clear (Ctrl+Alt+D)

7.9.22.15 Break.ClearAll

Clears all breakpoints (see *Data Breakpoints* on page 194).

Prototype

```
int Break.ClearAll();
```

Return Value

-1: error
 0: success

GUI Access

Breakpoint Toolbar → Clear All Breakpoints

7.9.22.16 Break.ClearAllOnData

Clears all data breakpoints (see *Data Breakpoints* on page 194).

Prototype

```
int Break.ClearAllOnData();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Breakpoint Toolbar → Clear All Data Breakpoints

7.9.22.17 Break.EnableOnData

Enables a data breakpoint (see *Data Breakpoints* on page 194).

Prototype

```
int Break.EnableOnData(U64 Address, U64 AddressMask, U8 AccessType, U8 Ac-
cessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnData* on page 370.

Return Value

```
-1: error
 0: success
```

GUI Access

Breakpoint Window → Context Menu → Enable (Ctrl+F9)

7.9.22.18 Break.DisableOnData

Disables a data breakpoint (see *Data Breakpoints* on page 194).

Prototype

```
int Break.DisableOnData(U64 Address, U64 AddressMask, U8 AccessType, U8 Ac-
cessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnData* on page 370.

Return Value

```
-1: error
 0: success
```

GUI Access

Breakpoint Window → Context Menu → Disable (Ctrl+F9)

7.9.22.19 Break.EditOnData

Edits a data breakpoint (see *Data Breakpoints* on page 194).

Prototype

```
int Break.EditOnData(U64 Address, U64 AddressMask, U8 AccessType, U8 AccessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnData* on page 370.

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Edit (F8)

7.9.22.20 Break.SetOnSymbol

Sets a data breakpoint on a symbol (see *Data Breakpoints* on page 194).

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 *Access Types* on page 267).
AccessSize	Memory access size required to trigger the data breakpoint (see *Memory Access Widths* on page 266).
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 (Ctrl+Alt+D)

7.9.22.21 Break.OnChange

Sets a data breakpoint on a symbol that triggers when the symbol value changes (see *Data Breakpoints* on page 194).

Prototype

```
int Break.OnChange(const char* sSymbolName);
```

Argument	Meaning
sSymbolName	Name of the symbol that is monitored by the data breakpoint.

Return Value

-1: error
 0: success

GUI Access

Source Viewer → Context Menu → Break On Change

7.9.22.22 Break.ClearOnSymbol

Clears a data breakpoint on a symbol (see *Data Breakpoints* on page 194).

Prototype

```
int Break.ClearOnSymbol(const char* sSymbolName, U8 AccessType, U8 Ac-
cessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnSymbol* on page 373.

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Clear (Ctrl+Alt+D)

7.9.22.23 Break.EnableOnSymbol

Enables a data breakpoint on a symbol (see *Data Breakpoints* on page 194).

Prototype

```
int Break.EnableOnSymbol(const char* sSymbolName, U8 AccessType, U8 Ac-
cessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnSymbol* on page 373.

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Enable (Ctrl+F9)

7.9.22.24 Break.DisableOnSymbol

Disables a data breakpoint on a symbol (see *Data Breakpoints* on page 194).

Prototype

```
int Break.DisableOnSymbol(const char* sSymbolName, U8 AccessType, U8 Ac-
cessSize, U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnSymbol* on page 373.

Return Value

```
-1: error
 0: success
```

GUI Access

Breakpoint Window → Context Menu → Disable (Ctrl+F9)

7.9.22.25 Break.EditOnSymbol

Edits a data breakpoint on a symbol (see *Data Breakpoints* on page 194).

Prototype

```
int Break.EditOnSymbol (const char* sSymbolName, U8 AccessType, U8 AccessSize,
U32 MatchValue, U32 ValueMask);
```

Parameter Description

Refer to *Break.SetOnSymbol* on page 373.

Return Value

```
-1: error
 0: success
```

GUI Access

Breakpoint Window → Context Menu → Edit (F8)

7.9.22.26 Break.SetCommand

Assigns a script function to a breakpoint that is executed when the breakpoint is hit.

> **Note**
>
> Due to hardware limitations, break point callback functions are not supported for data break points.

Prototype

```
int Break.SetCommand (const char* sLocation, const char* sFuncName);
```

Argument	Meaning
sLocation	The breakpoint's source location (e.g. "main.c:100", see *Source Code Location Descriptor* on page 264) or 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)

7.9.22.27 Break.SetCmdOnAddr

Assigns a script function to a breakpoint that is executed when the breakpoint is hit.

> **Note**
>
> Due to hardware limitations, break point callback functions are not supported for data break points.

Prototype

```
int Break.SetCmdOnAddr (U64 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)

7.9.22.28 Break.SetVectorCatch

Edits the vector catch state.

Prototype

```
int Break.SetVectorCatch(U32 IndexMask);
```

Argument	Meaning
IndexMask	A bitmask where bit <n> corresponds to the vector catch at table row <n> of the *Breakpoints/Tracepoints Window* on page 96. Vector catch <n> is activated by setting bit <n>. A bitmask of 0 clears all vector catches.

Return Value

-1: error
 0: success

GUI Access

Breakpoints/Tracepoints Window → Context Menu → Vector Catches

7.9.23 ELF Actions

7.9.23.1 Elf.GetBaseAddr

Returns the program file's download address. This is the lowest memory address written to during program download.

ARM specific:

The address returned by Elf.GetBaseAddr may or may not correspond to the base address of the program's vector table. The addresses in particular do not coincide when a code section is linked before the vector table, such as a bootloader.

Prototype

```
int Elf.GetBaseAddr();
```

Return Value

-1:	error
Base address:	success

GUI Access

None

7.9.23.2 Elf.GetFileClass

Returns the ELF file class of the program file. The ELF file class may be 32-bit or 64-bit.

Prototype

```
int Elf.GetFileClass();
```

Return Value

0:	none / invalid
1:	32-bit architecture
2:	64-bit architecture

GUI Access

None

7.9.23.3 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

7.9.23.4 Elf.GetEntryFuncPC

Returns the base address 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

7.9.23.5 Elf.GetExprValue

Evaluates a symbol expression.

Prototype

```
int Elf.GetExprValue(const char* sExpression);
```

Return Value

-1:	error
Expression value:	success

GUI Access

Watched Data Window → Context Menu → Add (Alt+Shift+Plus)

7.9.23.6 Elf.GetEndianess

Returns the program file's data encoding scheme.

Prototype

```
int Elf.GetEndianess(const char* sExpression);
```

Return Value

-1: indeterminable
0: Little Endian
1: Big Endian

GUI Access

None

7.9.23.7 Elf.SetConfig

Configures the ELF parser.

Prototype

```
int Elf.SetConfig(U32 ConfigFlags);
```

Argument	Meaning
ConfigFlags	Bitwise-or combination of ELF parser configuration flags (see *ELF Config Flags* on page 271).

Return Value

0: OK
-1: Error

GUI Access

None

7.9.23.8 Elf.PrintSectionInfo

Prints ELF file section information to the Console Window.

Prototype

```
int Elf.PrintSectionInfo(int SortCol);
```

Argument	Meaning
SortCol	0: sort output by name, 1: sort output by address

Return Value

0: OK
-1: Error

GUI Access

None

7.9.24 Trace Actions

Actions performing trace related operations.

7.9.24.1 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 *Tracepoint Operation Types* on page 269).
sLocation	Location of the tracepoint as displayed within the Breakpoints/Tracepoints Window (see *Breakpoints/Tracepoints Window* on page 96)).

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Set Tracepoint (Ctrl+Alt+E)

7.9.24.2 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 *Breakpoints/Tracepoints Window* on page 96)).

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Clear (Ctrl+Alt+E)

7.9.24.3 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 *Breakpoints/Tracepoints Window* on page 96)).

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Enable (Ctrl+F9)

7.9.24.4 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 *Breakpoints/Tracepoints Window* on page 96)).

Return Value

-1: error
 0: success

GUI Access

Breakpoint Window → Context Menu → Disable (Ctrl+F9)

7.9.24.5 Trace.ClearAllPoints

Clears all tracepoints.

Prototype

```
int Trace.ClearAllPoints();
```

Return Value

```
-1: error
 0: success
```

GUI Access

Breakpoint Toolbar → Clear All Tracepoints

7.9.24.6 Trace.Reset

Resets Ozone's trace data buffer and the contents of the Instruction Trace Window.

Prototype

```
int Trace.Reset();
```

Return Value

```
-1: error
 0: success
```

GUI Access

None

7.9.25 Watch Actions

7.9.25.1 Watch.Add

Adds an expression to the Watched Data Window (see *Watched Data Window* on page 176).

Prototype

```
int Watch.Add(const char* sExpression);
```

Return Value

```
-1: error
 0: success
```

GUI Access

Watched Data Window → Context Menu → Add (Alt+Shift+Plus)

7.9.25.2 Watch.Insert

Inserts an expression into the Watched Data Window (see *Watched Data Window* on page 176).

Prototype

```
int Watch.Insert(const char* sExpression, int Row);
```


Argument	Meaning
sExpression	Ozone symbol expression. See *Working With Expressions* on page 205.
Row	Insert expression at this table row. When empty, append the expression.

Return Value

-1: error
 0: success

GUI Access

None

7.9.25.3 Watch.Remove

Removes an expression from the Watched Data Window (see *Watched Data Window* on page 176).

Prototype

```
int Watch.Remove(const char* sExpression);
```

Return Value

-1: error
 0: success

GUI Access

Watched Data Window → Context Menu → Remove (Del)

7.9.25.4 Watch.Quick

Shows an expression within the Quick Watch Dialog (see *Quick Watch Dialog* on page 94).

Prototype

```
int Watch.Quick(const char* sExpression);
```

Argument	Meaning
sExpression	Ozone symbol expression. See *Working With Expressions* on page 205.

Return Value

-1: error
 0: success

GUI Access

Shift+F9

7.10 JavaScript Classes

This section provides a quick reference on Ozones build-in JavaScript classes that are provided for the development of JavaScript plugins.

7.10.1 Threads Class

The `Threads` class supports the implementation of RTOS-awareness plugins by providing methods that control and edit the RTOS Window (see *RTOS Window* on page 151). Methods of the `Threads` class that do not specify a table name parameter target the "active" table of the RTOS Window. The active table is usually the table that has been added last. The active table can be switched via methods `Threads.newqueue`, `Threads.setColumns2` and `Threads.add2`.

7.10.1.1 Threads.add

Appends a data row to the active table of the RTOS Window.

Prototype

```
void Threads.add (s1,…,sN,x);
```

Argument	Meaning
s1,…,sN	Text to be inserted into columns 0 to n
x	a generic parameter described below

Additional Description

The last parameter is either:

- an integer value that identifies the task, usually the address of the task's control block.
- an unsigned integer array containing the register values of the task. The array must be sorted according to the logical register indexes as defined by the ELF-DWARF ABI.

The first option should be preferred since it defers the readout of the task registers until the task is activated within the RTOS Window (see method *getregs* on page 240).

The special task identifier value *undefined* indicates to the debugger that the task registers are the current CPU registers. In this case, the debugger does not need to execute method `getregs`.

7.10.1.2 Threads.add2

Appends a data row to a specific table of the RTOS Window.

Prototype

```
void Threads.add2 (sTable,s1,…,sN);
```

Argument	Meaning
sTable	Table name
s1,…,sN	Text to be inserted into columns 0 to n

Additional Description

When the specified table does not exist, it is added implicitly. The specified table becomes the active table of the RTOS Window.

7.10.1.3 Threads.clear

Removes all rows from all tables of the RTOS Window. Table columns remain unchanged.

Prototype

```
void Threads.clear (void);
```

7.10.1.4 Threads.newqueue

Appends a table to the RTOS Window.

Prototype

```
void Threads.newqueue (sTable);
```

Argument	Meaning
sTable	Table name

Additional Description

The specified table becomes the active table of the RTOS Window. The task list is required to be added as the first table of the RTOS Window.

7.10.1.5 Threads.shown

Indicates if a RTOS Window table is currently visible.

Prototype

```
int Threads.shown (sTable);
```

Argument	Meaning
sTable	Table name

0: table is not shown
1: table is shown

7.10.1.6 Threads.setColumns

Sets the column titles of the active table of the RTOS Window.

Prototype

```
void Threads.setColumns (s1,…,sN);
```

Argument	Meaning
s1,…,sN	Column titles

Additional Description

When no table has been added to the RTOS Window before this method is executed, a default table will be added. The default table can be accessed via the table name “Default”.

7.10.1.7 Threads.setColumns2

Sets the column titles of a RTOS Window table.

Prototype

```
void Threads.setColumns2 (sTable, s1,…,sN);
```

Argument	Meaning
sTable	Table name
s1,…,sN	Column titles

Additional Description

When the RTOS Window does not contain a table of the given name, a new table is added to the window and its columns are set.

The specified table becomes the active table of the RTOS Window.

7.10.1.8 Threads.setColor

Assigns a task list highlighting scheme to the RTOS Window.

Prototype

```
void Threads.setColor (sTitle, sReady, sExecuting, sWaiting);
```

Argument	Meaning
sTitle	Title of the table column that displays the task status
sReady	Display text for task status "ready"
sExecuting	Display text for task status "executing"
sWaiting	Display text for task status "waiting"

Additional Description

- the task whose status text matches "sExecuting" will be highlighted in green.
- all tasks whose status text match "sReady" will be highlighted in light green.
- all tasks whose status text match "sWaiting" will be highlighted in light red.

7.10.1.9 Threads.setSortByNumber

Specifies that a particular table column should be sorted numerically rather than alphabetically.

Prototype

```
void Threads.setSortByNumber (sColTitle);
```

Argument	Meaning
sColTitle	Column title

Additional Description

The method acts upon the active table of the RTOS Window.

7.10.2 Debug Class

The `Debug` class provides methods that expose debugger functionality to JavaScript plugins.

7.10.2.1 Debug.enableOverrideInst

Allows a disassembly plugin to override the disassembly of a known instruction. This command must be executed from script function `init`.

Prototype

```
int Debug.enableOverrideInst (aInst, aMask);
```

Argument	Type	Meaning
aInst	byte array	Instruction data bytes
aMask	byte array	Instruction bits significant for matching. This argument must have the same byte size as argument *Encoding*. The argu-

Argument	Type	Meaning
		ment effectively enables users to override multiple instructions at once. This is commonly desirable when overriding all instructions of a particular type.

Return Value

Success: 0
Failed: -1

7.10.2.2 Debug.evaluate

Evaluates a C-style symbol expression.

Prototype

```
object Debug.evaluate (sExpression);
```

Argument	Meaning
sExpression	Ozone expression (see *Working With Expressions* on page 205)

Return Value

Success: JavaScript object corresponding to the evaluated expression
Failed: value undefined

Additional Description

When the input expression evaluates to a complex-type symbol, a JavaScript object is returned that exactly mirrors this symbol. The member tree of the returned object is fully initialized but pointer members cannot be dereferenced.

Example

```
var Global = Debug.evaluate("*(OS_GLOBAL_STRUCT*)0x20002000");
var Count = Global.Counters.Cnt;
```

7.10.2.3 Debug.getSymbol

Returns the name of the symbol at or preceding the input address. Ozone only considers symbols of variable, constant, function and assembly label type for the return value.

Prototype

```
string Debug.getSymbol (U64 Address);
```

Return Value

Success: 0
Failed: -1

7.10.3 TargetInterface Class

The `TargetInterface` class provides methods that access target memory and registers.

7.10.3.1 TargetInterface.findByte

Searches a memory block for a particular byte value.

Prototype

```
int TargetInterface.findByte (Addr,Size,Value);
```

Argument	Meaning
Addr	Base address of the memory block to search
Size	Size of the memory block to search
Value	Byte value to search

Return Value

≥0: byte offset of the matching byte
-1: no match found

7.10.3.2 TargetInterface.findNotByte

Searches a memory block for the first byte not matching a particular value.

Prototype

```
int TargetInterface.findNotByte (Addr,Size,Value);
```

Argument	Meaning
Addr	Base address of the memory block to search
Size	Size of the memory block to search
Value	Match value

Return Value

≥0: byte offset of the first byte not matching “Value”
-1: not found, i.e. all bytes match “Value”

7.10.3.3 TargetInterface.peekBytes

Returns target memory data.

Prototype

```
Array TargetInterface.peekBytes (Addr,Size);
```

Argument	Meaning
Addr	Base address to read from
Size	Number of bytes to read

Return Value

Success: memory data (as byte array)
Failed: value undefined

Additional Description

This method returns the target memory content residing at the specified address. The amount of data is specified by the paramter Size and is an upper limit. In case the specified address range is at least partially not readable the memory content is returned only up to but not including the first non-readable address. This implies that a shorter byte array than requested may be returned.

7.10.3.4 TargetInterface.peekWord

Returns a word from target memory.

Prototype

```
unsigned int TargetInterface.peekWord (Addr);
```

Argument	Meaning
Addr	Memory address

Return Value

Success: data word
Failed: value undefined

7.10.3.5 TargetInterface.pokeWord

Writes a word to target memory.

Prototype

```
unsigned void TargetInterface.pokeWord (Addr, Value);
```

Argument	Meaning
Addr	Memory address
Value	Value to be written

7.10.3.6 TargetInterface.getRegister

Returns the content of a register.

Prototype

```
unsigned int TargetInterface.getRegister (Reg);
```

Argument	Meaning
Reg	Register name

Return Value

Success: register content
Failed: value undefined

7.10.3.7 TargetInterface.setRegister

Sets the value of a register.

Prototype

```
unsigned void TargetInterface.setRegister (Reg, Value);
```

Argument	Meaning
Reg	Register name
Value	New register value

7.10.3.8 TargetInterface.message

Logs a message to the Console Window (see *Console Window* on page 111).

Prototype

```
void TargetInterface.message (Text);
```

Argument	Meaning
Text	Text to be written to the console window

Chapter 8

Support

How to Report Bugs

Users are kindly asked to include as much as possible of the following information in Ozone bug reports (in order of importance):

- Ozone version number
- A detailed description of the problem
- A minidump in the case of a crash (see *Minidumps* on page 289)
- A visual studio core dump file (.dmp) in case of a crash or freeze on Windows or a GDB core dump file (.core) in case of a crash or freeze on Linux
- An Ozone application log of the faulting session (for this, start Ozone with arguments "-logfile <filepath>" and "–loginterval 0")
- Information about the target hardware (processor, board, etc.)
- The debug probe model employed (e.g. J-Trace PRO Cortex-M V2)
- The operating system and OS version of the Host PC

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.

HSS

High Speed Sampling. A feature of J-Link/J-Trace which enables high speed data readout of individual target memory locations.

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; an operating system employed within an embedded system.

SVD

System View Description, a standard by Keil for describing the register layout of an MCU.

System Register

A special-purpose CPU register that controls or monitors advanced core functions, usually memory-mapped and accessible via dedicated machine instructions.

Peripheral Register

A memory-mapped special function register (SFR) provided by a peripheral hardware unit of the MCU/SoC.

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.

