Freedom Studio User Manual

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Table of Contents

Introduction	6
Product Overview	6
Eclipse	6
Setting Up Freedom Studio	7
Download and Install	7
Windows Installation	7
MacOS Installation	9
Linux Installation	9
Contents	10
Tools Setup	10
The Freedom Studio Environment	11
Workspaces	11
Eclipse Perspectives	11
The SiFive Perspective	12
Project Explorer	13
Editor, Outline, Disassembly	14
Terminal	15
Breakpoints	16
Registers	17
Expressions	17
Getting Started	18
The First Run Dialog	19
Flashing Your Arty FPGA Board	20

Before you continue	20
Flash the Arty Board	20
Windows Only	22
Create a Freedom E SDK Software Project	22
IP Projects	26
Creating a new IP Project	26
IP Project from IP Deliverable Wizard	27
Migrating Freedom Studio 2019.05 to Freedom Studio 2019.08	35
Migrating Projects	35
Migrating Debug Launch Configurations	38
Importing Debug Launch Configurations	38
Updating Debug Launch Configurations	39
What's New	41
What's New in Freedom Studio 2019.08	41
Updated Eclipse Platform and OpenJ9	41
Create IP Projects from IP Deliverable Packages	41
Work Easily with Multiple SDKs	41
Cleaner Preference UI	42
Windows MSYS Environment	42
Share BSP with Multiple Projects	43
Share Metal Library with Multiple Projects	44
The SiFive Shell	45
Environment and PATH Exports	46
Notes:	47
Create dev_env.sh for Project	49
File/Folder Path Utils	50

Shorter Package Paths	50
Benchmark Examples Default to Release Configuration	51
Selecting File Resources	51
Launch OpenOCD Externally	52
Use Memory Browser (instead of Memory View)	54
Use Bundled Packages	54
Traditional New Project Wizard Works Again	55
Freedom Studio HOWTO Guides	56
Register List Management	56
A Quick Example	56
Creating Register List Files	57
Commenting the Register List File	57
Specifying Register Names	57
Single Registers	57
Built-in Macros	57
Include File	58
Register Ordering	58
Using Register List Files	58
Where To Specify a Register List File	58
Managing Hardware Breakpoint Resources	61
Option 1: Add a gdb initialization command	62
Option 2: Set a preference or project property	63
Valid settings	64
Setting the Global Preference	64
Setting the Workspace Preference	66
Setting the Project Property	67

Setting the Launch Configuration Attribute	68
Conditional Optimization	69
Known Issues	74
When the debugger first connects I receive a message saying "No source availabl address"	e for 74
Upon starting a debug connection, the Console prints out a lot of text in red color 74	ed font
Troubleshooting	75
Linux USB Permission Issues	75
Correcting Terminal Output	75
Target Board Setup	76
Windows Board Setup	76
Windows JLink USB Driver	76
macOS Board Setup	76
Linux OS Board Setup	77
Required Libraries	77
Let's Check Our Dependencies	78
Enable Access to USB Devices	79
SiFive Copyright Notice	81
Software Licenses	81
SiFive End User License Agreement	81
Eclipse Public License - v 2.0	82
GNU GENERAL PUBLIC LICENSE, V2	87
GNU GENERAL PUBLIC LICENSE, V3	95



Introduction

Freedom Studio is an integrated development environment which can be used to write and debug software targeting SiFive based processors. Freedom Studio is based on the industry standard Eclipse platform and is bundled with a pre-built RISC-V GCC Toolchain, OpenOCD, and the freedom-e-sdk. The freedom-e-sdk is a complete software development kit targeting SiFive bare metal processors.

Product Overview

This section will describe the individual components used in a release.

Eclipse

The major versions of the Eclipse feature plugins are as follows:

- Eclipse 2019.06
- Java 11 JRE with OpenJ9 (<u>https://www.eclipse.org/openj9/</u>)
- Eclipse C/C++ Development Tools
- Git Integration for Eclipse (eGit)
- Terminal View Core
- SiFive RISC-V Cross Compiler

- SiFive OpenOCD Debugging
- SiFive J-LINK Debugging
- SiFive QEMU Debugging
- SiFive freedom-e-sdk Project Template

Setting Up Freedom Studio

Download and Install

Freedom Studio can be downloaded from the SiFive website at the following address:

https://www.sifive.com/boards/#software

Downloads are provided for Windows, MacOS, and Linux.

Windows Installation

Important

Rule #1

It is important that you choose an installation path that does not contain spaces. Freedom Studio will check the installation path when started and will warn you if it detects a path that contains any space characters.

Rule #2

You should enable Windows Long Path support. You should do this before extracting the product archive. The Freedom Studio installation folder may contains paths that are deep enough to exceed the "legacy" MAX_PATH (=260) character limit imposed by Windows. This limit is still enabled by default, but Windows 10 (starting with version 1607) allows for disabling this limit by installing a specific register key/value using the Windows regedit tool:

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\FileSystem LongPathsEnabled REG_DWORD = 0x1

To simplify this process you can download the following registry file and double-click it to install this key automatically:

https://static.dev.sifive.com/dev-tools/FreedomStudio/misc/EnableLongPaths.reg

If you still have problems extracting the archive after enabling Long Path Support contact support@sifive.com

More information on this topic can be found here:

https://docs.microsoft.com/en-us/windows/desktop/fileio/naming-a-file#paths

Important Note

Starting with Freedom Studio 2019.08 the windows package contains much shorter paths (around 199 character). This means the native Windows extraction tools should work fine as long as the total length of the installation root path is less than about 60 characters. If it is longer, then you should use a tool like 7-zip to extract the package.

Now that we have those important notes are out of the way...

You can install multiple versions of Freedom Studio on your system, and use all of them.

We recommend that you keep the installation path as short as possible. We suggest creating a folder at the root of your installation drive called "FreedomStudio" (no spaces). Then inside that folder you can install multiple versions of Freedom Studio into subfolders. Like:

```
c:\FreedomStudio
    |
    +- FreedomStudio-2019.03
    +- FreedomStudio-2019.05
```

The product zip archive extracts to a long folder name (for instance FreedomStudio-4.7.2.2019-03-4-win32.win32.x86_64). We recommend that you shorten the folder name using a naming scheme similar (or identical) to the one shown above.

We recommend using a tool like 7-Zip to handle large zip archives on Windows. Unzip the downloaded zip archive to a directory on your PC by right-clicking on the zip file and selecting "Extract All". After unzipping the bundle, you can open Freedom Studio by double-clicking on FreedomStudio.exe in the installation directory.

For more information setting up SiFive development platforms, please consult the platform's User Guide and Windows Board Setup.

MacOS Installation

Important

It is important that you choose an installation path that does not contain spaces. Freedom Studio will check the installation path when started and will warn you if it detects a path that contains any space characters.

Extract FreedomStudio.tar.gz to the desired folder by double clicking the bundle. Freedom Studio is not a signed macOS application and therefore may present an error when running. Therefore in order to run Freedom Studio on macOS it may be necessary to open Freedom Studio for the first time as described in this URL:

https://support.apple.com/kb/PH25088?locale=en_US

It is also possible to execute this command line to remove the extended attribute marking the .app file for quarantine:

\$ xattr -d com.apple.quarantine FreedomStudio.app

Start Freedom Studio by clicking on FreedomStudio.app found in the FreedomStudio folder which was just extracted.

For setting up SiFive development platforms, please consult the platform's User Guide and macOS Board Setup.

Linux Installation

Important

It is important that you choose an installation path that does not contain spaces. Freedom Studio will check the installation path when started and will warn you if it detects a path that contains any space characters.

Important

Starting with FreedomStudio 2019.08, The Freedom Studio IDE will no longer run on CentOS6 because the upgraded Eclipse platform (2019.06) only supports GTK3, and GTK3 is not available on CentOS6.

Extract FreedomStudio.tar.gz to the desired folder using the following command:

tar -xzf /path/to/FreedomStudio.tar.gz

For setting up SiFive development platforms, please consult the platform's User Guide and Linux OS Board Setup.

Contents

The directory contents are as follows:

FreedomStudio The installation root directory

FreedomStudio(.exe)(.app) The OS specific executable to open

SiFive SiFive files

SiFive/doc The documentation delivered with Freedom Studio.

SiFive/Licenses Open Source Licenses.

SiFive/Misc Directory containing miscellaneous files such as OpenOCD config files, and Linux OpenOCD udev rules

SiFive/openocd Directory containing the bundled OpenOCD

SiFive/toolchain Directory containing the RISC-V GCC toolchain

Build Tools (Windows Only)

Tools which allow eclipse CDT to function in a Windows environment such as make, echo, etc...

jre (Windows and Linux Only)

The Java Run Time Environment (JRE). On macOS the JRE is located under the FreedomStudio.app bundle.

Tools Setup

Freedom Studio will automatically detect its installation path on the first run and configure itself to use the bundled tools described in Section <Contents>>. If, for any reason, Freedom Studio was not able to detect the bundled tools, it will prompt the user to enter the tool

paths directly with the dialog shown in Figure ???. If prompted, be sure to select the "bin" directory which contains the tool binaries. These paths will set the global defaults used by Freedom Studio.

The tool paths can be changed at anytime by clicking the following:

Windows and Linux - *Window - Preferences - Freedom Studio*

MacOS - *Freedom Studio – Preferences – Freedom Studio*

Global RISC-V Toolchain Paths - for SiFive toolchains, select the default toolchain **RISC-V GCC/Newlib** and use the browse button to select the toolchain directory

Global OpenOCD Paths - for SiFive OpenOCD distributions, set the OpenOCD executable to "openocd" and use the browse button to select the OpenOCD directory

The tool path preferences can be set at 3 different scopes: Global, Workspace, and Project. Global scope sets the default for the installation and is the lowest priority. Workspace scope allows you to set the toolchain preferences specific a a given Workspace, and will override the Global setting. Project scope, which can be set by right clicking a project in your workspace and selecting **Properties – Freedom Studio**, allows you to set preferences on a per-project basis. Project scope always takes priority over Global and Workspace.

This flexibility allows the user to easily work with a number of different tools installed on the same system, such as one built from source using Freedom-E-SDK, while still maintaining project portability.

The Freedom Studio Environment

Workspaces

Eclipse uses workspaces to group together a set of related projects. Eclipse workspaces allow for a lot of flexibility in how one organizes their projects. For example, it is possible to have a workspace which contains only a single project. It is also possible to have a workspace which contains multiple related projects such as a library project and an application which depends on that library.

Switching workspaces is accomplished by selecting *File – Switch Workspace*.

When starting Freedom Studio, Eclipse will prompt you to select a workspace. Freedom Studio will remember the locations of previously selected workspaces.

Important

When choosing a workspace location do not chose a location that contains spaces in the path.

Eclipse Perspectives

Eclipse uses perspectives to group windows together which are collectively useful for a given task.

Freedom Studio ships with its own SiFive perspective which can be useful for both programming and debugging. Please see Section ??? for a detailed description of the SiFive Eclipse perspective.

Freedom Studio also ships with the standard Eclipse perspectives: C/C++ , Debug, and Git. From Eclipse, you can change perspectives by clicking **Window – Perspectives – Open Perspective**.

Perspectives are user customizable and persistent to a workspace.

The SiFive Perspective

The SiFive Perspective.



- 1. Project Explorer, Register, and Peripheral Views. These views are described below.
- 2. Build Toolbar Button. Pressing this button will build (compile) the active project.

- 3. Debug Toolbar Button. The down arrow next to the bug lets you pick a specific configuration.
- 4. Debug Control Toolbar Buttons. These buttons are used for debug run, halt, and stepping control.
- 5. Console. These views display useful information when building applications.
- 6. Breakpoint and Debug Views displays useful information when debugging applications.
- 7. Variable, Expression, and Memory Views. These views are described below.
- 8. Editor View is used to edit source code.
- 9. Outline, Disassembly, and Terminal Views are described below.

Project Explorer



The Project Explorer view displays projects in the workspace. Use this view for opening, editing, and creating new project source files. If a project contains files under revision control, Project Explorer will also display information regarding the repositories and branches.

Editor, Outline, Disassembly

The Editor and Outline views are used to write and navigate code. The Editor also provides useful contextual information for your code. Hovering the mouse over statements will reveal pop-ups which expand macros, evaluate variables and structures, provide function definitions, etc... Double-clicking a line number in the editor will set a breakpoint at that line.



The Outline view, shown in Figure ???, gives a "top-level" view of the active file in the editor including functions, types, constants, etc... Clicking on an item in the Outline view will take you to that items location in the source code.

Terminal

The Terminal view, shown in Figure ???, can be used to display a local terminal, a serial terminal, or ssh into a remote machine. The serial terminal allows the user to view serial

output, such as that from a SiFive development board, without leaving the development environment. On Windows platforms this view negates the need for an external serial terminal program. On MacOS and Linux platforms, it is possible to open serial port directly, or open a local terminal and run GNU Screen.

To open a serial terminal, open the Terminal view and select the "Launch Terminal" button which resembles a screen. In the **Choose Terminal** menu, select **Serial Terminal**. It is then possible to select the desired serial settings such as baud rate and encodings.

Settings		
Serial port:	/dev/cu.usbserial-14332401	~
Baud rate:	115200	٥
Data size:	8	٥
Parity:	None	٥
Stop bits:	1	٥
Encoding:	Default (ISO-8859-1)	٥

If the text in the serial terminal is displayed incorrectly, make sure that the correct baud rate is selected. SiFive example projects default to 115200 baud. Changing the encoding to UTF-8 might also help.



Breakpoints

The Breakpoints view allows for creating, enabling, and disabling of breakpoints. You can set a breakpoint's properties by right-clicking on a breakpoint and selecting "Properties". From the properties menu, you can set properties such as breakpoint type (hard, soft), and ignore count.

Registers

Project Ex	1999 Registers 🔀 🚡	Peripheral 🗖 🗖
	法	* 🕒 📬 🖻 🔻
Name	Value	Description
🔻 👬 General I	Re	General Purpose.
1010 0101 xO	0x0	
10101 ×1	0x40400074	
10101 x2	0x80003ff0	
1919 x3	0x800011a0	
1010 0101 ×4	0x0	
1919 ×5	0x40404884	
1010 x6	0x40000	
1919 x7	0x0	
1010 0101 x8	0x0	
1919 x9	0x0	
1010 x10	0x0	
1919 ×11	0x0	
1010 0101 x12	0x1	
1010 x13	0x1	
1010 x14	0x80001080	
1919 x15	0x40400432	
1010 x16	Oxf	12
1919 ×17	0x0	
1919 x18	0x0	
1010 x19	0x0	
1010 x20	0x0	

The Registers view displays the integer and floating point register files. It is possible to write to registers by double-clicking their value field. While stepping through code, the Registers view will highlight registers as they change.

Expressions

The Expression view allows you to view any variable within scope. In addition to variables, it is possible to use this view to see the current value of CSRs on your device. The Expression view, along with other eclipse views which display variables and memory,

allows for changing the value format (for example to hexadecimal). The format can be changed by clicking the down arrow marked with "2" in screenshot:

(x)= Variabl	经 Expres 없	1010 Registe 🔀	Periphe 🛋 N	Nodule 🗖 🗖
1		% _ ⇒t	E 4 X	🗞 📫 🖻 🔽
Expression	Туре		Value	2
(×)= \$mstatus	int64_t		0x1800	
(×)= \$mip	int64_t		0x80	
🐈 Add new expression				
			6	

Getting Started

This section walks step-by-step through creating and debugging a freedom-e-sdk project.

Starting with version Freedom Studio 2019.05, Freedom Studio includes a brand new dedicated Freedom E SDK project wizard.

The First Run Dialog

When you start Freedom Studio with a new workspace you will be presented with the First Run Dialog. This dialog is simply an easy way to get started with common first time tasks.

5	
Velcome to Free	edom Studio! Let's Get Started
Select one of the you choose to go	following actions. You will return here after each action until to the Workbench or create a project.
	I want to import my Core IP Deliverable
	I want to flash an MCS file to my Arty board
	I want to create a new Freedom E SDK Project
	Open the documentation browser
	I'm done here, take me to the Workbench
Note	
This dialog is only after you create y	y shown on new workspaces that contain no projects. It won't be shown our first project. You can, however, always get here from the Help menu
] Don't show met	this dialog again while using this installation (except via the Help menu)

• I want to import my Core IP Deliverable

Choose this option if you have a core IP deliverable that you'd like to start working with. With this option you will select an IP Deliverable package (usually a tar.gz file) and Freedom Studio will create a new IP project from the package. The wizard will optionally offer to flash an included MCS file, and create a new software project from the freedom-e-sdk embedded in the package.

• I want to flash an MCS file to my Arty board

Choose this option if you want to get started by flashing an MCS file to your Arty board. You will also have the choice to jump right into creating a project at the end of the flashing process.

- I want to create a new Freedom E SDK project If you have a HiFive series board or an Arty FPGA board already flashed with core IP and want to jump straight to creating a project, select this option.
- **Open the documentation browser** Choose this option to open the documentation browser. From here you can dig into

all the documentation bundled with Freedom Studio.

• Just take me to the workbench

If you don't want to start with any of the options listed above, choose this option and you'll be taken to your new clean workspace.

Flashing Your Arty FPGA Board

Before you continue

Before continuing with this section please review the <u>Target Board Setup</u> instructions to ensure that everything is properly configured and all host dependencies have been installed.

Flashing the Arty requires both the Olimex probe and the Arty board USB connector be connected to the host PC. Both USB connections are used during the process. Do not simply connect the Arty USB to a power supply when flashing.

Flashing an Arty Board using a JLink connection is not supported at this time.

Flash the Arty Board

First open the Arty Flash Dialog. This dialog can be opened from the main menu by selecting SiFiveTools \rightarrow Flash MCS File to Arty FPGA...



or by clicking the Arty Flash icon on the main toolbar:

			<u>_</u> 8		×
N 3. 9 .	2 i→ ≅, x] & i	■ Flash MCS File to	⇒ <> ▼ <>	•	9
🎋 Debug 🔀	Debugger Console	● _● Breakpoints	i≉ i		

Selecting either of these will open the Arty Flash Dialog. This dialog will look a little different on each host platform:

	5			×
	Flash MCS file to Arty FPGA Arty board is not connected. Olimex probe is not connected.		4	9
3	Flash image file: FPGA size ○ 35T	1) 5	✓ Bro	owse
U	? Flash MC	S File	Cance	1

- 1. First select the MCS file you want to flash. MCS files are available in Core IP deliverables; in downloaded evaluation packages, or directly from Sifive, or may be created in your flow.
- 2. Important: Make sure you select the correct FPGA configuration for your MCS file and Arty board. Freedom Studio will attempt to select the correct setting, but if it cannot be determined heuristically,, no default selection is made and you will have to choose. Choose wisely.
- 3. Check this box if you want to open the New Freedom E SDK Project Wizard when the flashing process is completed.

Once you've made your selections, click the **Flash MCS File** button to start the flashing process. See the notes below regarding Windows hosts.

The flash process can take several minutes to complete. When it is complete Freedom Studio will prompt you to press the PROG button on the Arty board. You must do this in order to load and use the newly flashed MCS file.

Windows Only

On Windows host platforms Freedom Studio can monitor the connection status of the Olimex probe and the Arty Digilent connection. The Arty Flasher will report the status (as shown above) and the **Flash MCS File** button will not be enabled unless both are detected as connected.

Freedom Studio also monitors the driver status for both devices and will install required drivers as parts of the flashing process. You may have to authorize the driver installation if Windows displays a UAC prompt. Flashing will not succeed unless you authorize the driver installation.

Create a Freedom E SDK Software Project

Creating a new Freedom E SDK Project is very simple. There are multiple ways to start:

• If you have just created a new workspace with no existing projects, the Project Explorer view will have a quick start menu, similar to this:



Select "Freedom E SDK Software Project", to open the wizard.

• From the main menu, select **File** → **New** → **Freedom E SDK Software Project**, as shown below:

5 f:	s-runtime-clear - FreedomStudio		1.0.0.0				
File	Edit Navigate Search Project	Run SiFiveTools	Wi	ndow Help	p		
	New	Alt+Shift+N >	C	C Project			i→ ₹
	Open File		C++	C++ Project	ct		
	Open Projects from File System		\$	Freedom E	SDK Software Project	N	
	Recent Files	>	\$	IP Project f	from IP Deliverable	4	·- (maya)
	Close	Ctrl+W		Project			
	Close All	Ctrl+Shift+W	Ċ	Folder			
	Save	Ctrl+S	Ľ	File			root
	Save As			Other		Ctrl+N	abled. Th
6	Save All	Ctrl+Shift+S	Г		You can open the	"Let's	Get Starte
	Revert				rou can open ene		occ starte

• From the SiFiveTools menu, select **New Freedom E SDK Project**, as shown:

File Edit Navigate Search Project Run	SiFiveTools Window Help	
📬 🕶 🔚 🐚 🗞 + 🍕 + 📴 🗙 🖿	Create IP Project from IP Deliverable	🎋 • 🔘 • 💁 • 🗐 • 🛷 •
	Create a Freedom E SDK Software Project	
🏠 Project Expl 🔀 🚻 Registers 🖵 🗖	Freedom DeviceTree Tools	ate a new Freedom E SDK software project
There are no projects in your works are	Freedom Studio Status	

• On the main application toolbar, click the "New Freedom E SDK Project" icon, as shown:

Window Help	
3. ⊙ .R i+ ≅ 死 &	ि 💐 🛛 💠 र 🔾 र 💁 र 🖾 र 🔗 र 🖉 र
	Contra a new Freedom F SDK anthony and inthe
	Create a new Freedom E SDK software project

Selecting any of these will open the Freedom E SDK New Project Wizard. The first page of this wizard is shown below:

	🕏 Create a Freedom E SDK Project — 🗌	×		
(1	Use this Freedom E SDK	V		
F		~		
-	Select Target			
6	Filter Tags: V (no tags selected, hide rtl) Contains:	X		
(Z	freedom-e310-arty v showing 8 of 8			
	The Freedom E310 Arty is a completely open-source	~		
	implementation of RISC-V using the Rocket Chip Generator, designed for use with the <u>Digilent Arty FPGA Evaluation Kit</u> .			
	This target is ideal for getting familiarize with RISC-V ISA			
	instructions set and freedom-metal libraries. It supports:	~		
	Use the BSP from the SDK when building this project			
	Use the Metal Library from the SDK when building this project			
6	Select Example Program			
(3	sifive-welcome	~		
	sifive-welcome	^		
	A simple welcome example which prints SiFive banner and uses board LEDs	~		
(11	Options	5		
	Project name inection-eshorarty-sinve-welcome	-)		
/E	(you can change the project name on the next page)			
()				
	< Back Next > Finish Cancel			

1. New in Freedom Studio 2019.08 is the ability to work with multiple SDK instances. You can select from any SDK instance on your host computer and create software projects from the selected SDK. The drop-down box is automatically populated with any SDK instances found in you workspace projects. Using the '+' button you can also select an SDK instance that is not contained in your workspace.

- 2. When you first open the wizard the target selection box might be empty. You need to select a target from the options in the drop-down. You should select the target that matches your core and target platform of choice.
- 3. Select an example program. Several examples are provided and each one demonstrates different features sets of the core.
- 4. The project name is automatically generated based on your target and example selections. If you do not like the generated name you can change it on the next wizard page.
- 5. Finally, you can choose to automatically create a debug launch configuration for your new project. Select the type of launch as determined by your debugger probe. Choose "OpenOCD" if you are using an Olimex probe, and "JLink" if you are using a JLink probe or a target with a built-in JLink OB device, and "QEMU" if you are using one of the QEMU targets. Selecting certain targets will automatically select the best option for that target.

That's really all there is to creating a new Freedom E SDK project. If you are satisfied with your choices, go ahead and click the **Finish** button. If you would like to change the project name, click the **Next** button and give your project a new name on the next page.

When you click the **Finish** button, Freedom Studio will create your new project and build it. When the build is complete Freedom Studio will reveal the built ELF file in the project explorer and open the main source file, as shown:



If you chose to create a debug launch configuration when creating your project the Debug Launch Configuration Dialog will automatically open after the ELF file is built.

IP Projects

Freedom Studio 2019.08 introduces a new project type called "IP Projects". IP Projects are created by importing an IP Deliverable package. Once imported, you can use Freedom Studio to perform actions on the IP package assets.

Creating a new IP Project

There are two ways to create an IP Project:

- 1. Import an IP Deliverable package. This can be a tar.gz file or an unpacked folder on your host system. You will use the "IP Project from IP Deliverable" wizard to import your package.
- 2. Any clone of the open sourced freedom-e-sdk can be easily converted to an IP project to enable all the Freedom Studio integrations.

IP Project from IP Deliverable Wizard

This wizard is accessible from all the usual spots in Freedom Studio:

- The "Let's Get Started" Dialog (via the Help menu)
- The SiFiveTools menu
- Main Menu -> File -> New -> IP Project from IP Deliverable
- Project Explorer Context Menu
- New Workspace Project Explorer Menu

Before creating a new IP Project you should have an IP Deliverable tarball. If you do not, go to the SiFive Core Designer website and create an awesome SiFive RISC-V core based SOC. When you receive your IP deliverable pack, return here to continue.

Open the Wizard

Open the "IP Project from IP Deliverable" wizard using any of the commands listed above. This wizard has only a single page:

Import an IP Deliverable Package		<u></u>		×
Import an IP deliverable package				
Import an IP Deliverable package as a project in your workspace. If left blank, the project name will be generated from the selected pac	kage name.			
Project Name				_
Import IP Package From				
O Import from an existing IP package folder				
			Brow	se
Copy package assets into the workspace				
Import from an IP package archive				
			Brow	se
Post Import Options				
If your package includes an MCS file then start the Flash Wizard aff	ter importing			
Start the New Project Wizard to create a project using the included	l freedom-e-so	lk		
	Finish		Cance	1
Start the New Project Wizard to create a project using the included	l freedom-e-so Finish	ik	Cance	I

The most common scenario is to create the new project by pointing to the IP tarball, so that is the default option when the wizard is opened. You can also import from an existing folder (perhaps you unpacked the tarball outside of Freedom Studio already). When importing from a folder you have the option of linking to the folder content, or copying the content into the workspace.

A project name will be generated automatically from the name of the IP tarball. You can accept this name, or enter a name manually.

At the bottom of the page are two options:

- 1. Option 1 tells Freedom Studio to start the Arty Flash Wizard to flash the MCS file included in the IP package.
- 2. Option 2 tells Freedom Studio to start the Freedom E SDK Software Project wizard when the import is complete.

If you have an IP tarball, go ahead and select it using the "Browse..." button and create a new IP Project. IP Projects are denoted in the Project Explorer with a small "IP" icon in the upper-right corner of the project icon.



Working with the IP Project

Now that you have a new IP Project, let's do stuff with it. You can:

• **Flash the included MCS file: R**ight-click on the MCS file in the project and selecting "Flash this MCS File"



This will open the Arty Flash wizard with the selected MCS file ready to go.

• **Create a new Freedom E SDK Software Project:** Right-click on the freedom-e-sdk folder and select "Create a new project using this SDK"



• **Build the freedom-devicetree-tools**: right-click on the "freedom-devicetree-tools" folder (found under the freedom-e-sdk folder) and select "Build freedom-devicetree-tools"

Project Expl 🔀 🐰 F	Registers 🗖 🗖	📮 Console 🔀 શ Problems
	□ 🔄 🗸	
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 >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	New Go Into Show in Local Open SiFive Sh File/Folder Pat	Terminal > nell Here h Utils > -devicetree-tools
Makefile	📔 Сору	Ctrl+C

Building these tools requires that several native packages be installed on the host system. On Windows and Mac Freedom Studio will offer to install these packages if they are not detected (they are not included with the Freedom Studio installation). On Linux, manual installation of these package is required. See the <u>freedom-devicetree-tools github project</u> for details on which packages are required.

• **Rebuild your BSP**: If you have edited your BSP DTS file, right-click on the DTS file and select "Run update-targets using this DTS file"



This command requires that the freedom-devicetree-tools are compiled. If they are not, Freedom Studio will ask if you'd like to compile them first, then continue updating the BSP.

• **Create a new BSP from an existing BSP**: Right-click on a DTS file in a BSP folder and select "Create a new BSP from this DTS file"

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 E21-1908-ipdelivery arty_a7_100t-sifive coreip-arty-userg design.bit design.mcs docs freedom-e-sdk bsp design-arty 	רפי ערשיים איין איין איין איין איין איין איין א	Freedom Studio Status You can open the "Let's Get Starts = Welcome to SiFive Freedor
i desig i meta i me	New Open Open With Show in Local Term Open SiFive Shell H File/Folder Path Ut Run update-target Create a new BSP f	F3 F3 hinal Here tils ts using this DTS file
	Copy Paste	Ctrl+C Ctrl+V

You will be prompted to give your new BSP a name.

bsp	<	>	
✓	5 BSP Name		×
🖻 metal-inline.h 💼 metal-platform.l	Give your new BSP a great name		
metal.default.lds	design-arty-copy		
metal.ramrodata			
g openocd.cfg			_
) 🗁 design-rtl		OK Cancel	
update-targets.sh			

The BSP type (Arty or RTL) will be determined by the existing settings.mk file. If for

some reason the settings.mk is not present or does not specify the type, Freedom Studio will prompt you for the type of BSP to create.

When you click OK Freedom Studio will create a new BSP folder (a sibling to the existing folder) and automatically run update-targets on the new BSP to generate the BSP support files.

Migrating Freedom Studio 2019.05 to Freedom Studio 2019.08

Migrating Projects

We have updated the version of Eclipse from Oxygen (2017.06) to 2019.06 (a 2 year leap). Workspaces from Freedom Studio 2019.05 will be upgraded when opened in Freedom Studio 2019.08. This will render the workspace no longer compatible with Freedom Studio 2019.05. A safer migration is to create a new workspace for Freedom Studio 2019.08 and then import the projects from your Freedom Studio 2019.05 workspace using the Import Wizard called "Existing Projects into Workspace" accessed via the Import dialog. If you have a new empty workspace open, then you can open this Dialog from the empty Project Explorer by selecting "Import projects..."



If you already have one or more projects in your workspace then open the Import dialog from the main menu: File \rightarrow Import.
Once opened, expand the "General" category, and select "Existing Projects into Workspace".

5 Import	223		×
Select Create new projects from an archive file or directory.		Z	5
Select an import wizard:			
type filter text			
 ✓ General ↓ Archive File ☆ Existing Projects into Workspace ↓ File System ↓ Preferences ↓ Projects from Folder or Archive > ▷ C/C++ > ⊘ Git > ⊘ Install > ∞ Run/Debug > ⊘ Other 			
< Back Next > Fini	ish	Cance]

Click [Next>], then [Browse...] to select the Freedom Studio 2019.05 workspace directory. The Import wizard will show a list of all projects in the workspace. Check the ones you want to import. (If present, you should uncheck the project called "RemoteSystemTempFiles")

Be sure to check "Copy projects into workspace" so that your original Freedom Studio 2019.05 projects do not get updated.

5 Import					220		×
Import Projects Select a directory to sear	ch for existin	ng Eclipse <mark>j</mark>	projects.	0			
• Select root directory:	C:\workspa	aces\19.05	worksp	ace	~	Brows	e
○ Select archive file:					\sim	Brows	e
Projects:							
freedom-e310-art	y-sifive-weld	come (C:\v	vorkspa	ces\19.05\wo	rkspa	Select	All
RemoteSystems Te	mpFiles (C:\	workspace	es\19.05	\workspace\H	Remo	Deselect	t All
						Refres	h
 Options Search for nested pro 	jects	n l			>		
Close newly imported	orkspace d proiects ur	oon compl	etion				
Hide projects that alr	eady exist in	the works	pace				
Working sets							
Add project to work	ing sets					New	
Working sets:					~	Select	
	< Back	Next	>	Finish	4	Cance	el

Once you've checked that all imported projects are functioning correctly you may then decide to delete the Freedom Studio 2019.05 workspace and projects.

Migrating Debug Launch Configurations

Importing Debug Launch Configurations

If your debug launch configurations are "shared" configuration stored in your project directory then they will be imported when you import your projects as described in the previous section.

If your debug launch configurations are "local" then they will not be imported when you import your projects. You will have to use the "Launch Configurations" import wizard. Open the Import dialog (File \rightarrow Import), select the "Run/Debug" category, select the "Launch Configurations" wizard, then click [Next>] to open the wizard.

5 Import	– D X
Select Import launch configurations from the local file system.	Ľ
Select an import wizard:	
General	
 Existing Projects into Workspace File System Preferences 	
 Projects from Folder or Archive C/C++ Git 	
> > Install > > Run/Debug Breakpoints	
> > Team	
< Back Next > Fin	ish Cancel

Now use the [Browse...] button to select the following location within your Freedom Studio 2019.05 workspace directory:

<2019.05-workspace-dir>/.metadata/.plugins/org.eclipse.debug.core/.launches

The dialog will show the .launches directory in the left hand pane. Check the checkbox. The dialog will now list all "local" debug launch in the right pane. Check those that you want to import. Then click [Finish]

Updating Debug Launch Configurations

Debug launch configurations from Freedom Studio 2019.05 are compatible with Freedom Studio 2019.08 (this may not always be true in future versions of Freedom Studio).

The only significant change for Freedom Studio 2019.08 is that now you can more easily specify the openocd configuration script. In Freedom Studio 2019.05 you had to specify the script in the "Config options" text box using the "-f <path>" construct. Like this:

Executable path:	\${openocd_gdbserver}		Browse	Variables
Actual executable:	C:\FS_Releases\FreedomStudio-	-4.7.2.2019-05-0\SiFive\riscv-openocd\riscv-openocd-0.10	0.0-2019.05.1\bin\o	penocd.exe
	(to change it use the <u>global</u> or <u>we</u>	orkspace preferences pages or the project properties page	:)	
GDB port:	3333	N		
Telnet port:	4444	high states and states		
Tcl port:	6666			
Config options:	-f bsp\openocd.cfg			~
				~

This method still works with Freedom Studio 2019.08. You do not have to do anything. But Freedom Studio 2019.08 has a better method to select and manage openocd configuration scripts. If you want to use the new method, simply delete the "-f <script>" construct and use the new script selector UI to specify the script. The OpenOCD Config Script dropdown box will auto-populate with scripts found in the current project, just select the correct (or only) one. Like this:

Start OpenOCD locally	y	Launch C	penOCD Ex	ternally	Copy O	penOCD Cor	mmand Line
Executable path:	\${openocd_gdbserver}					Browse	Variables
Actual executable:	C:\dev-root\SiFive\riscv-open	ocd-0.10.0	-2019.08.0-	RC3-debug	-log-reg-	failure\bin\c	penocd.exe
	(to change it use the <u>global</u> or	workspace	preferences	s pages or tl	he <u>projec</u>	t properties	page)
GDB port:	3333						
Telnet port:	4444						
Tcl port:	6666						
OpenOCD Config Script	bsp\openocd.cfg	~	Project	Workspac	e Fil	e System	Variables
Actual path	bsp\openocd.cfg C:\workspaces\19.08\workspa		m-e310-arty	-sifive-weld	come\bsp	o\openi Oj	oen in editor
Config options:							~
Config options:							^
Config options:							< >

You'll notice it is also easy to select a script from anyplace else on your host system if you need to.

What's New

What's New in Freedom Studio 2019.08

Updated Eclipse Platform and OpenJ9

Freedom Studio has been updated to the latest <u>Eclipse 2019.06</u> release and Oracle Java has been replaced by <u>Eclipse OpenJ9</u>.

Create IP Projects from IP Deliverable Packages

IP Deliverable packages can now be imported into Freedom Studio as "IP Projects". An IP Project is not a normal software project, but a higher level container project to hold all the assets from an IP Deliverable. Once a package has been imported Freedom Studio makes it simple to flash MCS files, modify, create, and rebuild BSPs, and create multiple software projects using the same BSP and Metal library.

Work Easily with Multiple SDKs

This release of Freedom Studio makes it much easier to work with multiple instances of Freedom E SDKs on your host system. You no longer need to constantly go to the Preferences page and point to the instance you want to work with. The Freedom E SDK Software Project wizard and IP Projects make working with any instance of the SDK simple.

Cleaner Preference UI

The Freedom Studio 2019.08 preference pages have been divided into Global and Workspace categories:

5 Preferences		– D X
type filter text	Global Scope	
 > General > C/C++ > Freedom Studio > Global Scope Environment and PATH Freedom E SDK Path HW Breakpoint Limit Metal and BSP Locations Msys Path OpenOCD Path QEMU Path Register List File SEGGER J-Link Path Target Architecture Toolchain Path > Workspace Scope > Help > Install/Update > Mylyn > Remote Development > Run/Debug 	Freedom Studio specific preferences. Here you preferences. Global Scope preferences apply to this installation of Freedom Studio. You can ow the Workspace Scope or Project Scope (via the	u can set your Global Scope o all workspaces associated with rerride these global preferences in Project Properties dialog).
> leam > Terminal	R	estore Defaults Apply
? 2 4	Арр	ly and Close Cancel

Windows MSYS Environment

The Windows MSYS environment has been greatly expanded to include many new tools and the ability to install additional MSYS packages using the 'pacman' tool. This expands the ability to write sophisticated Makefiles that can be used on all three host platforms.

This enhancement is why the Windows package has grown much larger.

You can also point Freedom Studio to a different MSYS environment (that you have installed and are responsible for managing) via the Global Preferences, Workspace Preferences, or Project Properties.

Share BSP with Multiple Projects

Prior to Freedom Studio 2019.08 each freedom-e-sdk based project had to have its own copy of the BSP. Changes in one copy had to be manually propagated to other copies.

You can now share a BSP with multiple projects. The BSP can be located in your workspace (as a separate project, or as part of a software project), or anywhere on the host file system. You can specify a BSP location via the Global Preferences, Workspace Preferences, or Project Properties.

For example, the Project Properties dialog shown here specifies that the BSP for this project should be pulled from the "my_e31_bsp" project in the Workspace.

Properties for sifive-welcome	— 🗆 🗙
type filter text	Project Metal and BSP Locations 🗢 👻 🗢
 > Resource Builders > C/C++ Build > C/C++ General > Freedom Studio Environment and PATH > Freedom E SDK Path > HW Breakpoint Limit Msys Path OpenOCD Path > Project Metal and BSP Locations O QEMU Path Register List File > SEGGER J-Link Path Target Architecture Toolchain Path > Project References Refactoring History Run/Debug Settings Task Repository 	Specify the Project locations for the metal source and BSP folders. These will be used unless overridden by a tighter scope. Leave blank to not specify in this scope. If not specified in any scope, then the values specified in the Makefile will be used. BSP_DIR Expression §[project_loc:my_e31_bsp] Workspace File System Variables Actual path C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace\my_e31_bsp MeTAL_SOU[CE_PATH Expression §[project_loc:my_metal_lib] Workspace File System Variables Actual path C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace\my_e31_bsp Variables METAL_SOU[CE_PATH Expression §[project_loc:my_metal_lib] Workspace File System Variables Actual path C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace\my_metal_lib Variables Actual path Actual path C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace\my_metal_lib Variables
?	Apply and Close Cancel

Share Metal Library with Multiple Projects

Prior to Freedom Studio 2019.08 each freedom-e-sdk based project had to have its own copy of the metal library. Changes in one copy had to be manually propagated to other copies.

You can now share a metal library with multiple projects. The metal library can be located in your workspace (as a separate project, or as part of a software project), or anywhere on the host file system. You can specify a metal library location via the Global Preferences, Workspace Preferences, or Project Properties.

For example, the Project Properties dialog shown here specifies that the metal library for this project should be pulled from the "my_metal_lib" project in the Workspace.

5 Properties for sifive-welcome	— D X
type filter text	Project Metal and BSP Locations 🗢 👻 🗢
 > Resource Builders > C/C++ Build > C/C++ General > Freedom Studio Environment and PATH Freedom E SDK Path HW Breakpoint Limit Msys Path OpenOCD Path > Project Metal and BSP Locations QEMU Path Register List File SEGGER J-Link Path Target Architecture Toolchain Path > Project Natures > Project References Refactoring History Run/Debug Settings Task Repository 	Specify the Project locations for the metal source and BSP folders. These will be used unless overridden by a tighter scope. Leave blank to not specify in this scope. If not specified in any scope, then the values specified in the Makefile will be used. BSP_DIR Expression \${project_loc:my_e31_bsp} Workspace File System Variables Actual path C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace\my_e31_bsp MetaL_SOUPCE_PATH Expression \${project_loc:my_metal_lib} Workspace File System Variables Actual path C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace\my_e31_bsp Variables Variables Actual path C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace File System Variables Actual path C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace\my_metal_lib Morkspace File System Variables Actual path C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace\my_metal_lib Morkspace Mathematical_lib Mathematical_lib
?	Apply and Close Cancel

The SiFive Shell

You can now open a shell in the Terminal View at any location in a project by right-clicking on the location in the Project Explorer and selecting "Open SiFive Shell Here"



By default Freedom Studio will use bash for the shell on Window and the SHELL variable on Linux and MacOS. If you need to use a different shell you can set the environment variable SIFIVE_SHELL=<path-to-shell-of-choice>. On Windows, you'll want to ensure that your chosen shell is installed in the MSYS environment.

Environment and PATH Exports

When you build a freedom-e-sdk based project several environment variables can be exported and the PATH can be changed to include various tool locations. This is controlled in the new "Environment and PATH" node of the Global Preferences, Workspace Preferences, or Project Properties.

5 Preferences	— 🗆 X
type filter text	 i) Settings on this page will be used (no overrides detected)
type filter text General C/C++ Freedom Studio Global Scope Environment and PAT Freedom E SDK Path HW Breakpoint Limit Metal and BSP Locatio Msys Path OpenOCD Path QEMU Path Register List File SEGGER J-Link Path Target Architecture Toolchain Path Workspace Scope Help Install/Update Java Library Hover Remote Development Run/Debug Team Terminal	 (1) Settings on this page will be used (no overrides detected) (2) * (2) * * Specify the global preferences for exported environment variables. These will be used unless overridden by a tighter scope. See also: workspace preferences and project properties (2) Use settings on this page (overriding settings of more general scopes). General Export Options Export file and folder environment variables as msys-style paths Export file environment variables with fully qualified absolute paths Export RISCV_PATH Include in exported PATH When building, the toolchain and msys paths will always be added to the path. You can add these paths as well: FREEDOM_STUDIO_OPENOCD_PATH FREEDOM_STUDIO_QEMU_PATH FREEDOM_STUDIO_TRACE_DECODER_PATH Checked items will always be added to the path. SiFive Shell Options The msys paths will always be added to the path. Create dev_env.sh in project root folder when opening a shell Include toolchain in exported PATH Show informational message dialog when opening a new SiFive shell
< >	Restore Defaults Apply
? è i	Apply and Close Cancel

Notes:

• Export RISCV_PATH

If checked. RISCV_PATH is exported in to the build environment and into the dev_env.sh script.

• **Create dev_env.sh in project root folder when opening a shell** This option, when enabled, will create a shell script file called dev_env.sh in the project root folder when you open a SiFive Shell. This script defines several environment variables and adds additional entries (if enabled) to the PATH. You can also create this file using the Project Explorer context menu on a Project node.

- Include toolchain in exported PATH If checked, the project toolchain will be added to the PATH in dev_env.sh
- Inherit native PATH [Windows Only] If checked, the native PATH will be added to the MSYS PATH
- Show informational message dialog when opening a new SiFive Shell [Global Preferences Only] If checked, Freedom Studio will display an informational dialog box when opening a new shell. This information summarizes the state of the dev_env.sh feature.

A complete list of exported environment variables can be viewed on the "C/C++ Build/Environment" project property node. For example:

pe filter text	Environment	¢	• <> •
Resource			
Builders			
C/C++ Build	Configuration: debug [Active]	 Manage Cor 	figurations.
Build Variables			
Environment			
Logging	Environment variables to set		Add
Settings	Mainhla		Auu
Tool Chain Editor	Variable	Value	Select
C/C++ General	BSP_DIR	/C/FS_Releases/FreedomStudio-2019-08-D-w	-
Freedom Studio	CWD	C:\FS_Releases\FreedomStudio-2019-08-D-wi	Edit
Environment and PAIH	FREEDOM_STUDIO_GDB	riscv64-unknown-elf-gdb.exe	Delete
Freedom E SDK Path	FREEDOM_STUDIO_INSTALL_PATH	C:\FS_Releases\FreedomStudio-2019-08-D-wi	
Hw Breakpoint Limit	FREEDOM_STUDIO_MSYS_PATH	C:\FS_Releases\FreedomStudio-2019-08-D-wi	Undefin
OnenOCD Bath	FREEDOM_STUDIO_OPENOCD	openocd.exe	
Droject Metal and PSD Locations	FREEDOM_STUDIO_OPENOCD_PATH	C:\FS_Releases\FreedomStudio-2019-08-D-wi	
OEMIL Dath	FREEDOM_STUDIO_PROJECT_NAME	sifive-welcome	
Register List File	FREEDOM_STUDIO_PROJECT_PATH	C:\FS_Releases\FreedomStudio-2019-08-D-wi	
SEGGER I-Link Path	FREEDOM_STUDIO_QEMU	qemu-system-riscv32.exe	
Target Architecture	FREEDOM_STUDIO_QEMU_PATH	C:\FS_Releases\FreedomStudio-2019-08-D-wi	
Toolchain Path	FREEDOM_STUDIO_SDK_PATH	C:\FS_Releases\FreedomStudio-2019-08-D-wi	
Project Natures	FREEDOM_STUDIO_TOOLCHAIN_PATH	C:\FS_Releases\FreedomStudio-2019-08-D-wi	
Project References	FREEDOM_STUDIO_TRACE_DECODER	dqr.exe	
Refactoring History	FREEDOM_STUDIO_TRACE_DECODER_PATH	C:\FS_Releases\FreedomStudio-2019-08-D-wi	
Run/Debug Settings	METAL_SOURCE_PATH	/C/FS_Releases/FreedomStudio-2019-08-D-w	
Task Repository	PATH R	C:\FS_Releases\FreedomStudio-2019-08-D-wi	
	PWD	C:\FS Releases\FreedomStudio-2019-08-D-wi	
	RISCV PATH	C:\FS Releases\FreedomStudio-2019-08-D-wi	
	•		
	Append variables to native environment		
	Replace native environment with specified of the speci	one	
		Restore Defaults	Apply

All of these variables are available to use in your Makefiles and scripts. But be aware that these are exported only when building from within Freedom Studio. If you want to maintain CLI builds then be sure to update your makefiles to specify appropriate defaults for any used variables, or to source the optionally generated dev_env.sh file.

Create dev_env.sh for Project

The context menu for a project node in the Project Explorer has a new menu entry called "Create dev_env.sh in project root". Selecting this menu item will create a new dev_env.sh script file in the project root. An existing dev_env.sh file will be replaced without warning. Do not hand edit this script file. Your changes will be lost.



File/Folder Path Utils

The context menu for project files and folders in the Project Explorer has a new sub-menu called "File/Folder Path Utils". This submenu has some simple, but very useful items.

	<		>
Open Open With Show in Local	Terminal	a	Disassembly Exercise editor that provides an outline.
File/Folder Pat	h Utils	>	Reveal in System Explorer
Copy		Ctrl+C	Copy File/Folder Name
Paste		Ctrl+V	Copy File/Folder Full Windows Path
🗙 Delete		Delete	Copy File/Folder Full Msys Path
	 Copen Open Open With Show in Local Open SiFive Sh File/Folder Pat Copy Paste Delete Mare 	 New Open Open With Show in Local Terminal Open SiFive Shell Here File/Folder Path Utils Copy Paste Delete Mawa 	New > Open Open Open With > Show in Local Terminal > Open SiFive Shell Here > File/Folder Path Utils > Copy Ctrl+C Paste Ctrl+V Delete Delete

• Reveal in System Explorer

Selecting this menu item will open the default file explorer application on you host system and take you to the folder containing the selected resource.

- Copy File/Folder Name Selecting this menu item will copy the file or folder name to the clipboard.
 Copy File /Folder Full Windows Path
- **Copy File/Folder Full Windows Path** [Windows only] Copies the full absolute path of the selected resource to the system clipboard using Windows compatible paths.
- **Copy File/Folder Full Msys Path** [Windows only] Copies the full absolute path of the selected resource to the system clipboard using Msys compatible paths.

• **Copy File/Folder Full Path** [Linux/MacOS] Copies the full absolute path of the selected resource to the system clipboard.

Shorter Package Paths

This change primarily affects Windows users, but is also reflected in Linux and Mac packages. The Freedom Studio distribution archives are built to contain shorter paths. All paths are less than the Windows MAX_PATH limit of 268 characters (the longest is around 199 characters). This means that the native Windows extraction tool can successfully extract the Freedom Studio archive as long as the sum of the path length to the installation location and the deepest path in the archive is less than MAX_PATH.

If you want to install to a location that may exceed MAX_PATH then you must use a third-party extraction tool (like 7-Zip) to extract the archive.

Benchmark Examples Default to Release Configuration

When creating a new freedom-e-sdk project with 'coremark' or 'dhrystone' the project will default to the "release" configuration. All other example programs will default to the 'debug' configuration.

Defaulting to the 'release' configuration for benchmarks helps to ensure that: (1) accurate benchmark results are reported by default (the user does not have to remember to switch to the 'release' configuration); (2) benchmarks will build successfully and fit into the available memory.

Selecting File Resources

Selecting file resources in debug launch configurations is easier. You can now select from Project, Workspace, or File System scopes, and use Eclipse variables to build expressions.

Main 🗱 T	arget DTS 🕸 Debugger 🕟 Startup 😳 Config 🦆 Source 🔳	Common			
larget Device	Tree				
DTS File	bsp\design.dts	Project	Workspace	File System	Variables
Actual path	C:\FS_Releases\FreedomStudio-2019-08-D-win64\workspace\free	edom-e310-a	rty-local-interru	pt\bsp\desi 0	pen in editor

There is a new "Open in Editor" button that will open the selected resource in a Freedom Studio editor window.

Launch OpenOCD Externally

Sometimes you need to launch OpenOCD as an external process. This is most useful when you need to capture an OpenOCD debug log to a file. Freedom Studio now has helper features to make this process simpler. The OpenOCD launch configuration dialog gains two new buttons that make it very easy to launch OpenOCD as an external process (i.e. a process not managed by Freedom Studio).

		innunu cinc
	Browse	Variables
penocd-0.10.0-2019.05.1\bin\openocd.exe		
	penocd-0.10.0-2019.05.1\bin\openocd.exe	penocd-0.10.0-2019.05.1\bin\openocd.exe

The "Copy OpenOCD Command Line" button copies the exact command line that Freedom Studio will use when launching to the system clipboard. You can paste (and edit, if desired) this command line in a shell (cmd prompt or powershell in Windows, or a terminal shell in Linux and MacOS).

The "Launch OpenOCD Externally..." button opens a new dialog box where you can configure the OpenOCD process with a custom debug level and optionally redirect the output to a file.

5	— C) X
Launch OpenC (i) Everything Ic	OCD Externally poks good!	1
Debug log level:	-d3 (debug, info, warnings, and error messages)	~
Redirect Oper	OCD output to a log file	
Also show our	tput in console (not recommended with -d or -d3)	
Debug log file:	openocd-debug.log V	Browse
Command line:		
C:\dev-root\SiF 3333" -c "telnet C:\FS_Releases\ -d3 > openocd	ive\riscv-openocd-0.10.0-2019.05.1\bin\openocd.exe -c "gdb_port _port 4444" -c "tcl_port 6666" -f FreedomStudio-2019-08-D-win64\workspace\freedom-e310-arty-local-interrupt\bsp\openocd.cfg -debug.log 2>&1	
The copied com	mand line can be pasted into a cmd or powershell window	Close

The "Debug log level" combo box lets you select a custom log level for the session. When preparing a debug log to send to support@sifive please use "-d3".

If the "Redirect OpenOCD output to a log file" checkbox is not checked OpenOCD log output only goes to the console. Checking this box will output the log to the specified file.

If you check the "Also show output in the console" checkbox then the out will go to both the console and the log file. It is recommended that you not check this box when using the "-d3" log level.

The "Debug log file" specifies where to create the log file. If a relative path is specified, then the path is relative to the project directory.

You can use the "Copy" button (to the right of the command line box) to copy the command line to the clipboard.

When launched as an external (unmanaged) process it is your responsibility to terminate the OpenOCD process when it is no longer needed. Note that you do not have to terminate the OpenOCD process and restart it between successive debug launches. Freedom Studio will happily use the running process multiple times.

Windows Only: When the "Launch" button is pressed, a new Command Window is opened and the OpenOCD process is started and the "Start OpenOCD locally" checkbox is automatically unchecked. [Linux and MacOS do not show the "Launch" button, but the command line can still be copied and pasted into a terminal shell. Besure to uncheck the "Start OpenOCD locally" checkbox.]

Use Memory Browser (instead of Memory View)

The SiFive Perspective now uses the Memory Browser by default for examining target memory. There are known problems with the Memory View that can cause Eclipse (and thus Freedom Studio) to hang. We do not recommend using the Memory View any longer.

If the Memory Browser is not open, you can open it via the Main Menu | Window | Show View menu:



Use Bundled Packages

Many of the Freedom Studio preference pages now have a "Use Bundled" button that simplifies reverting to the bundled package after having selected an unbundled instance of the package.

ype filter text	Toolchain Path	\Diamond	• 🗢 •
> General ∧ > C/C++ ✓ Freedom Studio	Select the root directory of the globally preferred Newlib riscv64-unknown-elf tool directory must contain a 'bin' directory with an executable compiler. Leave blank t This global setting can be overridden by the workspace preference, or the project p	lchain. o have propert	The choser no prefere y setting.
 Global Scope Environment and I Freedom E SDK Pa HW Breakpoint Lir Metal and BSP Loc Msys Path OpenOCD Path 	Toolchain Path C:\dev-root\SiFive\riscv64-unknown-elf-gcc-8.2.0-2019.05.3		Browse

Traditional New Project Wizard Works Again

The traditional new project wizard path to creating freedom-e-sdk project shipped in a broken state in Freedom Studio 2019.05. It has been repaired and can be used to create new projects again (although there are much easier ways to do this).

Freedom Studio HOWTO Guides

Register List Management

This document provides an overview on how to use and customize the list of registers displayed in the Freedom Studio IDE Registers View. This feature is primarily intended to give you control over what registers are displayed. You may want to use this, for example, when you do not want to see a complete list of all target registers. Or alternately, you may want to specify registers that are not included in the default list of registers.

A Quick Example

Let's assume you have a register list file called 'status-registers.txt'. The content of the file looks like:



Now specify that file as a register list in the debug launch configuration:



When you launch your debug session and open the Register View you will see this list:

🗤 Registers 🕅	🏝 🎫 🗖 📋	<u>†</u> 🕈 🕆 🗖 🗖
Name	Value	Description
✓ ₩ General Registers		General Purpose
1010 mstatus	0x1800	
1010 misa	0x40101105	
1010 mie	0x0	
1010 mtvec	0x0	
1010 mscratch	0x0	
1010 mepc	0x0	
1010 mcause	0x0	
1010 mtval	0x0	
1919 mip	0x80	

Creating Register List Files

The Register List File is a text file that, at its simplest form, lists a single register name on each line. Each listed register will be displayed in the Registers View in the order specified.

Commenting the Register List File

The register list file treats any line that starts with a # (hash) character as a comment line. It is ignored by the parser. The # character can be preceded by whitespace.

Only the first word of a line is treated as a register name. Any additional words are ignored.

Specifying Register Names

Single Registers

Any register can be specified by putting the name of the register as the first word on a line.

Built-in Macros

The following macros can be used to specify multiple related registers without having to list each register individually

Built-in Register List Macros

Macro Name	Description
general_registers	The 32 General Purpose Registers plus PC
machine_registers	The machine status registers
perfmon_registers	Performance Monitor Control and Data Registers

fpu_registers

Floating Point Registers

Include File

You can create several register list files, for example, building your lists of related registers, and then build a master register list by including these files in a composite register list file. To include another register list simply use:

#include <register-list-file>

The **#include** directive can be used multiple times in a single file.

Nested **#include** directives are supported. An **#include** file may **#include** additional files.

Where register-list-file is either an absolute or relative path. Relative paths are relative to the folder containing the current register list file being parsed. Keep this in mind if you are using nested #include directives and your register list files live in different folders.

Register Ordering

Registers are displayed in the Register View in the same order as they are specified in the Register List File.

Using Register List Files

Now that you have created one or more register list files you may want to use them with Freedom Studio. This section explains your options for specifying how to use your register list files.

Where To Specify a Register List File

A register list file can be specified in 4 places. These four locations are prioritized such that a specification in a higher priority location will override any specification in a lower priority location. The four locations are, in descending priority order (highest priority first):

Prioritized Register List Specification Locations

Location	Description
Debug Launch Config	Specify a register list file for each individual launch configuration
Project Property	Specify a register list file for each project
Workspace Preference	Specify a register list file for each workspace
Global Preference	Specify a global register list file, for all Freedom Studio workspaces

Debug Launch Configuration

This is the highest priority option for specifying a register list file. You will find the controls to specify the debug launch register list file on the Config tab of the Debug Launch Configuration Dialog:

] Main 🗱 Ta	rget DTS 🎋 Debugger 🕨 Startup	🞯 Config 🙀 So	ource	Common		
Register List						
Register List	status-registers.txt	~ Pro	ject	Workspace	File System	Variables
Actual path	C:\workspaces\19.08\workspace\fre	edom-e310-arty-s	ifive-we	elcome\status-re	egisters.txt (Open in editor

When you specify a register list file in a debug launch configuration the path displayed in the Actual Path box will always reflect the fully resolved path to the register list file. If you are not specifying a register list file here then the Actual Path may display a path to another register list file if one has been specified using a lower priority specifier.

Project Property

Specifying a register list file as a project property will cause that register list to be used with all launch configuration created for the project, overriding any global or workspace preferences. Each launch can override the project specification by using the launch configuration option to specify a register list file.

You can setup the project register list file specification by opening the Project Properties dialog and navigating to the MCU \rightarrow Register List property page:

Properties for freedom-e310-	arty-sifive-welcome —		×
type filter text	Register List File	⇔ - ⇔	- -
 > Resource > Builders > C/C++ Build > C/C++ General 	Specify the project register list file. The register list file defines the list of registers displayed in If you do not specify a list then a default list from the target will be used. If you want to refine specify a file here that lists the registers that you want to see. This project setting will override workspace and global settings, but can be overridden by the debug launch configuration set	the Registe this list yo both the ting.	er View. u can
 ✓ Freedom Studio Environment and PAT HW Breakpoint Limit Msys Path OpenOCD Path QEMU Path Register List File 	Register List File	Brows	e
< · · · · · · · · · · · · · · · · · · ·	Restore Defaults	Appl	у
	Apply and Close	Cancel	

Workspace Preferences

Specifying a workspace register list file will cause that file to be used for all projects within the workspace unless a project overrides the setting by specifying a register list in the project properties or a debug launch configuration.

You can specify the workspace preference by opening the Freedom Studio Preference Window and navigating to the MCU \rightarrow Workspace Register List page:

type filter text	Register List File	
 General C/C++ Dynamic Languages Freedom Studio Global Scope Worksnace Scope 	Specify the default workspace register list list of registers displayed in the Register V default list from the target will be used. If specify a file here that lists the registers the setting will override the global setting, bu debug launch configuration setting.	t file. The register list file defines the /iew. If you do not specify a list then f you want to refine this list you can hat you want to see. This workspace ut can be overridden by the project o
* Workspace scope		
Environment and I HW Breakpoint Lir Msys Path OpenOCD Path QEMU Path Register List File	Register List File	Browse

Global Preferences

Specifying a global register list file will cause that file to be used for all Freedom Studio workspaces unless a workspace, project, or debug launch overrides the setting.

You can specify the global preference by opening the Freedom Studio Preference Window and navigating to the MCU \rightarrow Global Register List page:

5 Preferences		<u>444</u>		×
type filter text	Register List File	Ŷ	• 🖒	• •
 Freedom Studio Global Scope Environment and I HW Breakpoint Lir Msys Path OpenOCD Path 	Specify the default global register list file. The register list fregisters displayed in the Register View. If you do not specidefault list from the target will be used. If you want to refise specify a file that lists the registers that you want to see. The overridden by the workspace, project, or debug launch setting.	file defi ify a lis ne this his glob i config	nes the t then a list you bal settir uration	list of can ig can
QEMU Path Register List File SDK BSP, METAL, a SEGGER J-Link Pat Target Architectur Toolchain Path	Register List File		Browse	2
< >	Apply and Close		Cancel	×

Managing Hardware Breakpoint Resources

This document summarizes how to manage hardware breakpoint resources on a target system. Different cores have different numbers of hardware breakpoints. It is important for GDB to know how many hardware breakpoints exist on a target. Attempting to use more breakpoints than exist on the target will cause unpredictable debugger problems.

When GDB knows how many hardware breakpoints exist on the target, you can create as many hardware breakpoints as you need, but only the number that exist will be enabled. Freedom Studio will indicate which breakpoints cannot be enabled due to lack of resources. You can then manage the enablement of each breakpoint to ensure that the breakpoint you need is enabled (by disabling breakpoints that you do not need). This screenshot shows how Freedom Studio indicates that too many hardware breakpoints have been enabled.



Too Many Hardware Breakpoints

Freedom Studio cannot automatically determine the number of hardware breakpoints present on the system. We plan to add this ability in a future release.

GDB needs to know the number of hardware breakpoints on the target. There are two ways to do this.

Option 1: Add a gdb initialization command

Add the 'set remote hardware-breakpoint-limit' command to the Initialization Commands section of a launch configuration. You must do this for every new launch configuration.

Debug Configurations	×
Create, manage, and run config	urations
📑 🗎 🗶 📄 🎲 🕶	Name: coreplexip_welcome OpenOCD
GDB OpenOCD Debugging c coreplexip_welcome OpenOCD GDB SEGGER J-Link Debugging	Main SP Debugger Startup O Config S Source Common Initialization Commands Initial Reset. Type: Initial Reset. Type: set remote hardware-breakpoint-limit 2 Enable ARM semihosting Load Symbols and Executable Load symbols Use project binary: coreplexip_welcome.elf Use file: Workspace
< >> Filter matched 4 of 25 items	Revert Apply
0	Debug Close

Note

Setting this setting using Option 1 takes precedence over Option 2 (described below). If you find that your preference setting is not being applied, check to make sure that you do not have this command specified in the Initialization Commands.

Option 2: Set a preference or project property

You can set global and workspace preferences to define the number of hardware breakpoints on your target system. You can also set this in your project properties and in a launch configuration.

Finer-grain settings take priority over courser-grain settings. The priority, from highest to lowest is:

- Debug Launch Configuration
- Project Property
- Workspace Preference
- Global Preference

Each new launch configuration will use the highest priority setting that exists. If no setting exists, then Freedom Studio will use the hard-coded default of '2'.

The launch configuration dialog always describes the setting used and where the setting originates. For instance, the screenshot below shows the setting is 4 and originates from the workspace preference setting. This implies that the project property setting has not been defined (it is blank). Clicking on any of the underlined setting scopes will open the corresponding settings page where you can change the setting if desired.

Hardware Breakpoints	
Hardware Breakpoint Limit	
When unspecified here, will use a value See also the <u>global</u> and <u>workspace</u> pref	erences, and the <u>project</u> properties.

Setting value description

Valid settings

The following table shows the valid setting values.

Valid Setting Values

Value blank	Description Leave the setting blank and it will not be used.
'unlimited', or -1	Tells GDB that you have unlimited hardware breakpoints.
'none', or 0	Tells GDB that you have no hardware breakpoints
<i>x</i> , a positive integer	Tells GDB that you have <i>x</i> hardware breakpoints.

GDB defaults to 'unlimited'. Freedom Studio overrides this default and uses '2'. Using 'unlimited' allows you to set more hardware breakpoints than may exist on the target. GDB will attempt to set all of them. This leads to unpredictable debugger behavior. We do not recommend using 'unlimited', but we won't stop you from doing so.

Setting the Global Preference

We recommend setting the hardware-breakpoint-limit globally when you have a single target system. This ensures that the setting applies in all workspaces, projects, and launch configurations. If you ever need to use a different target that has a different number of hardware breakpoints you can easily override the global setting using any of the higher priority settings.

Set the global preference by opening the Preferences Dialog (Windows \rightarrow Preferences) and navigating to the MCU | Global HW Breakpoint Limit page.

Preferences	— D X
type filter text	HW Breakpoint Limit 🗘 🔻 🗢 💌
 Freedom Studio Global Scope Environment and I HW Breakpoint Lir Msys Path OpenOCD Path QEMU Path Register List File SDK BSP, METAL, a SEGGER J-Link Pat Target Architecture Toolchain Path Workspace Scope Help Install/Update Java Library Hover 	Specify the maximum number of hardware breakpoints that exist on a target system. Value must be one of: blank, 'unlimited' (or -1), 'none' (or 0), or a positive integer. Caution: Using 0 or 'none' means that no hardware breakpoints can or will be used. Using '-1' or 'unlimited' will cause problems if you attempt to set more hardware breakpoints than the core supports. This global setting can be overridden by the workspace, project, debug launch configuration setting, or DTS file value. Hardware Breakpoint Limit Restore Defaults Apply
	Apply and Close Cancel

Setting the Workspace Preference

We recommend using the Workspace Preference when you have multiple target systems and want to create a workspace for each target system. This ensures the setting is correctly applied for the target used in each workspace.

Set the workspace preference by opening the Preferences Dialog (Windows \rightarrow Preferences) and navigating to the MCU | Workspace HW Breakpoint Limit page.

5 Preferences	— D X
type filter text	HW Breakpoint Limit 🗘 🕆 🗸 👻
 Freedom Studio Global Scope Workspace Scope Environment and I HW Breakpoint Lir Msys Path OpenOCD Path QEMU Path Register List File SDK BSP, METAL, a SEGGER J-Link Pat Target Architectum Toolchain Path Help Install/Update Java Library Hover Man pages 	Specify the maximum number of hardware breakpoints that exist on a target system. Value must be one of: blank, 'unlimited' (or -1), 'none' (or 0), or a positive integer. Caution: Using 0 or 'none' means that no hardware breakpoints can or will be used. Using '-1' or 'unlimited' will cause problems if you attempt to set more hardware breakpoints than the core supports. This workspace setting will override the global setting, but can be overridden by the project, debug launch configuration setting, or DTS file value. Hardware Breakpoint Limit Restore Defaults Apply
	Apply and Close Cancel

Setting the Project Property

We recommend using the Project Property setting when you have multiple target system and want to work on all of them within a single Workspace. This ensures the setting is correctly applied for the target used in each project.

Set the project property by opening the Project Properties Dialog (Project \rightarrow Properties) and navigating to the MCU | HW Breakpoint Limit page.

type filter text	HW Breakpoint Limit	
Resource Builders C/C++ Build C/C++ General Freedom Studio Environment and PAT HW Breakpoint Limit Msys Path OpenOCD Path SDK BSP, METAL, and SEGGER J-Link Path Target Architecture Toolchain Path Project References Refactoring History	Specify the maximum number of hardware be system. Value must be one of: blank, 'unlimit positive integer. Caution: Using 0 or 'none' means that no har used. Using '-1' or 'unlimited' will cause prob hardware breakpoints than the core supports This project setting will override both the wo can be overridden by the debug launch conf Hardware Breakpoint Limit	Preakpoints that exist on a target ted' (or -1), 'none' (or 0), or a rdware breakpoints can or will be blems if you attempt to set more s. Prkspace and global settings, but figuration setting or DTS file value Restore Defaults Apply

Setting the Launch Configuration Attribute

We recommend using the launch configuration attribute setting for target connections that you do not use often. This ensures the setting is not applied to oft-used targets (that are better served using a more broadly applied setting from the project, workspace, or global settings).

Set the launch configuration attribute by opening the launch configuration dialog, navigating to the 'Config' tab, where the breakpoint count can be set for this single launch config.

Register List [\${bsp_reglist} ~	Project	Workspace	File System	Variables
Actual path	C:\workspaces\19.08\workspace\freedom-e310-arty-	sifive-welcor	ne\bsp\design.r	eglist	Open in edito
ardware Brea	knoints				
ardware Brea Jardware Brea	kpoints				
lardware Brea Hardware Brea	kpoints akpoint Limit				
lardware Brea Hardware Brea When unspeci See also the <u>q</u>	kpoints akpoint Limit	erties.			
lardware Brea Hardware Brea When unspeci See also the <u>g</u> arget Architer	kpoints akpoint Limit	erties.			
lardware Brea Hardware Brea When unspect See also the g	kpoints akpoint Limit	erties.			

Conditional Optimization

This section describes how to apply compiler optimization conditionally within a source file.

Debugging optimized code can be complicated because the optimizer will change the order of the code and optimize out variables. When single-stepping through the code the source line indication can jump around erratically. You will not be able to examine variable values that have been optimized away.

The normal solution is to turn off optimizations for the entire project when you need to debug something. Sometimes this is not desirable (or even possible). In these cases you can turn off optimization for just the code that needs to be debugged using compile-time #pragma statements.

The comments in the following source example explain how, when, and when not do use the **#pragma** statements.

Example source code.

```
// See LICENSE for license details.
#include <stdint.h>
#include <stdbool.h>
#include <stdatomic.h>
#include "encoding.h"
#include <platform.h>
#ifndef _SIFIVE_COREPLEXIP_ARTY_H
#error 'coreplexip_welcome' demo only supported for Coreplex IP Eval Kits
#endif
void pwm(uint16_t r, uint16_t g, uint16_t b);
uint16 t option0(uint16 t p1, uint16 t p2);
uint16_t option1(uint16_t p1, uint16_t p2);
uint16_t option2(uint16_t p1, uint16_t p2);
static const char sifive_msg[] = "\n\r\
n\r
               SIFIVE, INC.\n\r\
n\r
        5555
                             5555\n\r\
      5555
                              5555\n\r\
     5555
                              5555\n\r\
    5555
              55555555555555555555555555\n\r\
   5555
              555555555555555555555555555\n\r\
```

```
5555
                                  5555\n\r\
  5555
                                   5555\n\r\
 5555
                                    5555\n\r\
55555\n\r\
 55555
               555555555
                                   55555\n\r\
  55555
                 55555
                                 55555\n\r\
                    5
    55555
                              55555\n\r\
      55555
                             55555\n\r\
        55555
                            55555\n\r\
          55555
                         55555\n\r\
            55555
                      55555\n\r\
              55555 55555\n\r\
                55555555\n\r\
                  55555\n\r\
                    5\n\r\
n\r
";
#if __riscv_xlen == 32
  static const char welcome_msg[] = "\n\r\
n^r
Welcome to the E31 Coreplex IP FPGA Evaluation Kit!\n\r\
n';
#else
static const char welcome_msg[] = "\n\r\
n^r
Welcome to the E51 Coreplex IP FPGA Evaluation Kit!\n\r\
n';
#endif
static void _putc(char c) {
 while ((int32_t) UART0_REG(UART_REG_TXFIF0) < 0);</pre>
 UART0_REG(UART_REG_TXFIFO) = c;
}
int _getc(char * c){
  int32_t val = (int32_t) UART0_REG(UART_REG_RXFIF0);
  if (val > 0) {
   *c = val & 0xFF;
   return 1;
  }
  return 0;
}
static void _puts(const char * s) {
 while (*s != '\0'){
   _putc(*s++);
```

```
}
}
* Enable maximum optimization for the main() function. The pragma directive
for
 * optimization act on a function scope. You cannot place these pragmas
around code
 * inside of a function (it will generate a compiler error).
 */
#pragma GCC push_options
#pragma GCC optimize ("3")
int main (void){
  // 115200 Baud Rate at (65 / 2) MHz
  UART0_REG(UART_REG_DIV) = 282;
  UART0_REG(UART_REG_TXCTRL) = UART_TXEN;
  UART0_REG(UART_REG_RXCTRL) = UART_RXEN;
  // Wait a bit because we were changing the GPIOs
  volatile int i=0;
  while(i < 10000){i++;}</pre>
  _puts(sifive_msg);
  _puts(welcome_msg);
 * These pragma, if uncommented, will generate compiler errors because this
 * only works when used outside of functions. Optimization is performed
 * on function blocks, not on individual code lines.
 */
//#pragma GCC push_options
//#pragma GCC optimize ("0")
  uint16_t r=0x3F;
  uint16_t g=0;
  uint16 t b=0;
//#pragma GCC push_options
  PWMO_REG(PWM_CFG) = 0;
                      = (PWM_CFG_ENALWAYS) | (PWM_CFG_ZEROCMP) |
  PWM0 REG(PWM CFG)
(PWM CFG DEGLITCH);
  PWM0 REG(PWM COUNT) = 0;
  // The LEDs are intentionally left somewhat dim.
  PWMO_REG(PWM_CMPO) = OxFE;
```
```
while(1){
    volatile uint64_t * now = (volatile uint64_t*)(CLINT_CTRL_ADDR +
CLINT_MTIME);
    volatile uint64_t then = *now + 400;
    while (*now < then) { }</pre>
    if(r > 0 \&\& b == 0){
      r--;
      g++;
    }
    if(g > 0 \&\& r == 0){
     g--;
      b++;
    }
    if(b > 0 \&\& g == 0){
     r++;
      b--;
    }
    pwm(r,g,b);
    g = option0(r, b);
    b = option1(r, g);
    r = option2(g, b);
 }// While (1)
}
#pragma GCC pop_options
/*
* This function uses the project setting for optimization
 */
void pwm(uint16_t r, uint16_t g, uint16_t b)
{
    PWMO_REG(PWM_CMP1) = 0 \times FF - (r >> 2);
    PWMO_REG(PWM_CMP2) = 0 \times FF - (g >> 2);
    PWMO_REG(PWM_CMP3) = 0 \times FF - (b >> 2);
}
/*
* Enable maximum optimization. The 'result' variable will be optimized out.
*/
#pragma GCC push_options
#pragma GCC optimize ("3")
uint16 t option0(uint16 t p1, uint16 t p2) {
    int result = p1 * p2;
    return result;
```

```
}
#pragma GCC pop_options
/*
* Turn off all optimization. The 'result' variable is not optimized out.
*/
#pragma GCC push options
#pragma GCC optimize ("0")
uint16_t option1(uint16_t p1, uint16_t p2) {
    int result = p1 * p2;
    return result;
}
#pragma GCC pop_options
/*
* Enable maximum optimization. The 'result' variable would normally be
optimized out.
*/
#pragma GCC push_options
#pragma GCC optimize ("3")
uint16_t option2(uint16_t p1, uint16_t p2) {
    /*
    * Use 'volatile' keyword to ensure variable does not get optimized out.
    */
    volatile int result = p1 * p2;
    return result;
}
#pragma GCC pop_options
```

Known Issues

If you come across other issues not reported here, please let us know on our forum: https://forums.sifive.com/.

When the debugger first connects I receive a message saying "No source available for address"

This occurs when instructing the debugger to halt immediately after connecting to the target. It is safe to ignore this message. Stepping/Running the target will work as expected from this point.

Upon starting a debug connection, the Console prints out a lot of text in red colored font

While red font can be scary, it is generally benign debugging output. This happens because OpenOCD output status message through stderr and Freedom Studio renders stderr in red. You can change this color in the Freedom Studio Preference, but be aware that this will affect all consoles that accept and display stderr text.

Troubleshooting

Launch fails with "can't add breakpoint"

This can happen if a "bad" breakpoint exists in the breakpoint view prior to the launch. Freedom Studio will try to install the breakpoint and if it at an address that does not map to the current target, you will get this error. Simply delete this bad breakpoint then relaunch.

Linux USB Permission Issues

By default, some Linux distributions do not give users permissions to access USB devices. The HiFive1 and FPGA getting started guides describe the process to grant your user the correct permissions. For your convenience the *99-openocd.rules* file is included with in the *FreedomStudio/SiFive/Misc* directory.

Correcting Terminal Output

When using the Terminal View in Freedom Studio you may see terminal output from a target UART that does not properly handle "carriage returns". You may see output that looks like :



To resolve this, open a command window and issue the following command:

```
stty -F <tty-device-name> onlcr inlcr
```

You can do this while connected to the terminal in Freedom Studio. You should see immediate results. You may need to adjust other stty settings depending on your environment.

Target Board Setup

Windows Board Setup

This section will describe how to connect SiFive development boards to your Windows computer.

Digilent (on Arty boards) and Olimex devices require specific device drivers to function properly with Freedom Studio. Starting with Freedom Studio 2019.05 these device drivers are automatically installed when needed. There is no need to manually install any device drivers. When a driver is installed you may be prompted by Windows UAC to authorize the installation of the driver.

The device driver for the Digilent USB connection is only installed when you use the Arty Flashing utility within Freedom Studio. If you intended to use Vivado to update your FPGA images then we suggest you use Vivado only to update your FPGA. Vivado and Freedom Studio use two different device drivers for updating the FPGA image.

If you have used Freedom Studio to update or install and FPGA image and then decide to use Vivado, you will need to manually uninstall the device driver installed by Freedom Studio (via the Device Manager) before Vivado will recognize the target again.

Windows JLink USB Driver

Note

If you have installed JLink software independently of Freedom Studio then the USB driver is already installed.

If you are using a HiFive1-revB board (which has a JLink interface built-in), or if you intend to use a JLink Probe you need to ensure that the JLink USB device driver is installed. Freedom Studio, at this time, does not install this driver automatically. The driver installation file is located at:

```
<install-folder>/SiFive/jlink/jlink<version-info>/USBDriver/x64/dpinst_x64.ex
```

Run the installer and accept the default choices.

macOS Board Setup

By default, macOS has the standard FTDI driver installed while OpenOCD expects to communicate over USB using libusb. In order to allow OpenOCD to communicate with the SiFive development boards, it is necessary to unload the FTDI driver from macOS.

The procedure to unload the driver is available through the *SiFiveTools -> Setup OpenOCD FTDI Access* menu entry or by typing it manually at the command prompt:

• Open Applications/Utilities/Terminal

- Paste in the following command: sudo kextunload -p -b com.apple.driver.AppleUSBFTDI
- Paste in the following command: sudo kextutil -b com.apple.driver.AppleUSBFTDI -p AppleUSBEFTDI-6010-1

Note: This is not a permanent solution and after logging out of you computer it is necessary to issue the above commands above.

To avoid having to issue these commands on every log-in, it is possible to add the above commands to your user's *.17ex/.bash_profile*. By doing so, the above commands will be issued automatically every time your user logs in.

To switch back to standard Apple FTDI Access the *SiFiveTools -> Restore Apple FTDI Access* menu entry can be used or again it can be typed manually at the command prompt:

- Open Applications/Utilities/Terminal
- Paste in the following command: sudo kextunload -p -b com.apple.driver.AppleUSBFTDI
- Paste in the following command: sudo kextutil -b com.apple.driver.AppleUSBFTDI

Linux OS Board Setup

Required Libraries

Important Note

Starting with Freedom Studio 2019.08 all dependencies are included or statically linked. This section is only applicable to earlier releases of Freedom Studio.

For Arty board and Olimex support The following libraries need to be installed on the host system:

- libftdi1
- libusb

These can be installed on Ubuntu with the following command:

```
>sudo apt-get install libftdi1-2 libusb-0.1-4 libusb-1.0
```

And on CentOS 7 with the following command:

```
>sudo yum install libftdi libusb
```

And on Fedora 29 with the following command:

>sudo yum install libftdi-1.3-12.fc29.x86_64 libusb-1:0.1.5-13.fc29.x86_64

Let's Check Our Dependencies

The two programs that require these libraries are OpenOCD and xc3sprog. You can check that all dependencies are satisfied using the 1dd utility.

For instance, on Ubuntu:

```
$ cd ~/FreedomStudio/SiFive/xc3sprog/xc3sprog-0.1.2-2019.04.1
$ ldd xc3sprog
    linux-vdso.so.1 => (0x00007ffed35f8000)
    libftdi1.so.2 => not found
    libusb-0.1.so.4 => not found
    libstdc++.so.6 => /usr/lib/x86 64-linux-gnu/libstdc++.so.6
(0x00007f395565f000)
    libgcc s.so.1 => /lib/x86 64-linux-gnu/libgcc s.so.1 (0x00007f3955447000)
    libc.so.6 => /lib/x86 64-linux-gnu/libc.so.6 (0x00007f395507d000)
    libm.so.6 => /lib/x86 64-linux-gnu/libm.so.6 (0x00007f3954d74000)
    /lib64/ld-linux-x86-64.so.2 (0x00007f3955a42000)
$ cd
~/FreedomStudio/SiFive/riscv-openocd/riscv-openocd-0.10.0-2019.05.0-RC1/bin
$ ldd openocd
    linux-vdso.so.1 => (0x00007ffe3cadd000)
    libusb-1.0.so.0 => /lib/x86 64-linux-gnu/libusb-1.0.so.0
(0x00007fe58b0b1000)
    libm.so.6 => /lib/x86 64-linux-gnu/libm.so.6 (0x00007fe58ada8000)
    librt.so.1 => /lib/x86 64-linux-gnu/librt.so.1 (0x00007fe58aba0000)
    libdl.so.2 => /lib/x86 64-linux-gnu/libdl.so.2 (0x00007fe58a99c000)
    libpthread.so.0 => /lib/x86 64-linux-gnu/libpthread.so.0
(0x00007fe58a77f000)
    libc.so.6 => /lib/x86 64-linux-gnu/libc.so.6 (0x00007fe58a3b5000)
    libudev.so.1 => /lib/x86 64-linux-gnu/libudev.so.1 (0x00007fe58b4b2000)
    /lib64/ld-linux-x86-64.so.2 (0x00007fe58b2c9000)
```

While OpenOCD looks good, we can see the we need to install libusb (version 0.1) and libftdi in order to satisfy dependencies for xc3sprog, so let's do that:

```
$ sudo apt-get install libftdi1-2 libusb-0.1-4
 <not showing all the output here>
$ cd ~/FreedomStudio/SiFive/xc3sprog/xc3sprog-0.1.2-2019.04.1
$ ldd xc3sprog
    linux-vdso.so.1 => (0x00007ffc051b5000)
    libftdi1.so.2 => /usr/lib/x86_64-linux-gnu/libftdi1.so.2
(0x00007fbded75d000)
    libusb-0.1.so.4 => /lib/x86_64-linux-gnu/libusb-0.1.so.4
(0x00007fbded554000)
    libstdc++.so.6 => /usr/lib/x86_64-linux-gnu/libstdc++.so.6
(0x00007fbded171000)
    libgcc_s.so.1 => /lib/x86_64-linux-gnu/libgcc_s.so.1 (0x00007fbdecf59000)
    libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007fbdecf59000)
```

```
libusb-1.0.so.0 => /lib/x86_64-linux-gnu/libusb-1.0.so.0
(0x00007fbdec977000)
libm.so.6 => /lib/x86_64-linux-gnu/libm.so.6 (0x00007fbdec66e000)
/lib64/ld-linux-x86-64.so.2 (0x00007fbded96b000)
libudev.so.1 => /lib/x86_64-linux-gnu/libudev.so.1 (0x00007fbdedb54000)
libpthread.so.0 => /lib/x86_64-linux-gnu/libpthread.so.0
(0x00007fbdec451000)
librt.so.1 => /lib/x86_64-linux-gnu/librt.so.1 (0x00007fbdec249000)
```

That looks good! Now both openocd and xc3sprog are ready to go.

Enable Access to USB Devices

By default, most Linux distributions do not give users permissions to access USB devices. One either needs root access or to be given the appropriate permissions.

Below are steps you can follow to access your development kit without sudo permissions (although sudo permissions are required for the initial setup):

Step 1: With your board's debug interface connected, make sure your device shows up with the lsusb command:

```
+
```

\$ lsusb .

With your devices connected, check the output of the lsusb command to see that your devices are visible to the system. Use the table below to determine which entry you should see for your devices.

lsusb identifiers

Device	USB Identifier
Arty USB	Bus XXX Device XXX: ID 0403:6010 Future Technology Devices International, Ltd FT2232C Dual USB-UART/FIFO IC
HiFive2	Bus 001 Device 019: ID 0403:6011 Future Technology Devices International, Ltd FT4232H Quad HS USB-UART/FIFO IC
Olimex	Bus XXX Device XXX: ID 15ba:002a Olimex Ltd. ARM-USB-TINY-H JTAG interface.
HiFive1 RevB	Bus XXX Device XXX: ID 1366:1051 SEGGER

JLink Probe Bus XXX Device XXX: ID 1366:0101 SEGGER J-Link PLUS

Step 2: Set the udev rules to allow the device to be accessed by the plugdev group:

Note

For your convenience a *99-freedomstudio.rules* file is included with Freedom Studio in the *FreedomStudio/SiFive/Misc* directory. You can install this file with this command:

\$ sudo cp 99-freedomstudio.rules /etc/udev/rules.d/

The 99-freedomstudio.rules files installs rules that recognize the following USB devices and adds them to the plugdev group:

- Olimex ARM_USB_TINY_H
- HiFive2
- Arty Digilent USB

Step 3: See if your board shows up as a serial device belonging to the plugdev group. For instance with the Arty Board USB connector connected and an Olimex probe connected you should see something like

But how do you know which serial port belongs to which device? You cannot tell from the output above. In fact, there is no simple way to do it, so we have provided a handy shell script called *listusb.sh* located in the *FreedomStudio/SiFive/Misc* directory.

Running that script yields much enlightenment:

```
$ ./listusb.sh
/dev/ttyUSB1 - Digilent_Digilent_USB_Device_210319A92CC9
/dev/ttyUSB0 - Digilent_Digilent_USB_Device_210319A92CC9
/dev/ttyUSB2 - 15ba_Olimex_OpenOCD_JTAG_ARM-USB-TINY-H_OL150D61
```

Note

If you have other serial devices or multiple boards attached, you may have more devices listed.

The ID (ttyUSB *X*) is assigned dynamically and is dependent on the order in which you connect your devices. Their assignment will change if you disconnect and reconnect in a

different order. (But as long as you do not disconnect a device, its assigned ID will not change.)

Note

If your device present more than a single UART you will always want to select the higher number of the pair. In the example above you would want to use /dev/ttyUSB1

Note

The tty/USB device provided by the Olimex probe cannot be used as a UART. You can ignore this device.

Step 4: Add yourself to the plugdev group. You can use the whoami command to determine your user name.

> sudo usermod -a -G plugdev `whoami`

1. Log out and log back in, then check that you're now a member of the plugdev group:

```
$ groups
... plugdev ...
```

If you are not part of the plugdev group, perform a full reset.

Now you should be able to access the serial (UART) and debug interface without sudo permissions.

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