Building bare-metal applications in DS-5 using GCC compiler

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1. Overview

This tutorial shows you how to set up your project to use the GCC bare-metal compiler. It then guides you through creating a simple bare-metal Hello World application and finally running it on a debug configuration on a Cortex-A9 Fixed Virtual Platform (FVP) provided with DS-5.

Including set-up for bare-metal debug sessions on Fixed Virtual Platforms

To debug applications for bare-metal targets in Arm DS-5 Development Studio, you can use GCC "Launchpad" compiler toolchain. However, in general we recommend use of Arm Compiler for building bare-metal applications in DS-5.

This tutorial shows you how to set up your project to use the GCC bare-metal compiler. It then guides you through creating a simple bare-metal Hello World application and finally running it on a debug configuration on a Cortex-A9 Fixed Virtual Platform (FVP) provided with DS-5.

Prerequisites

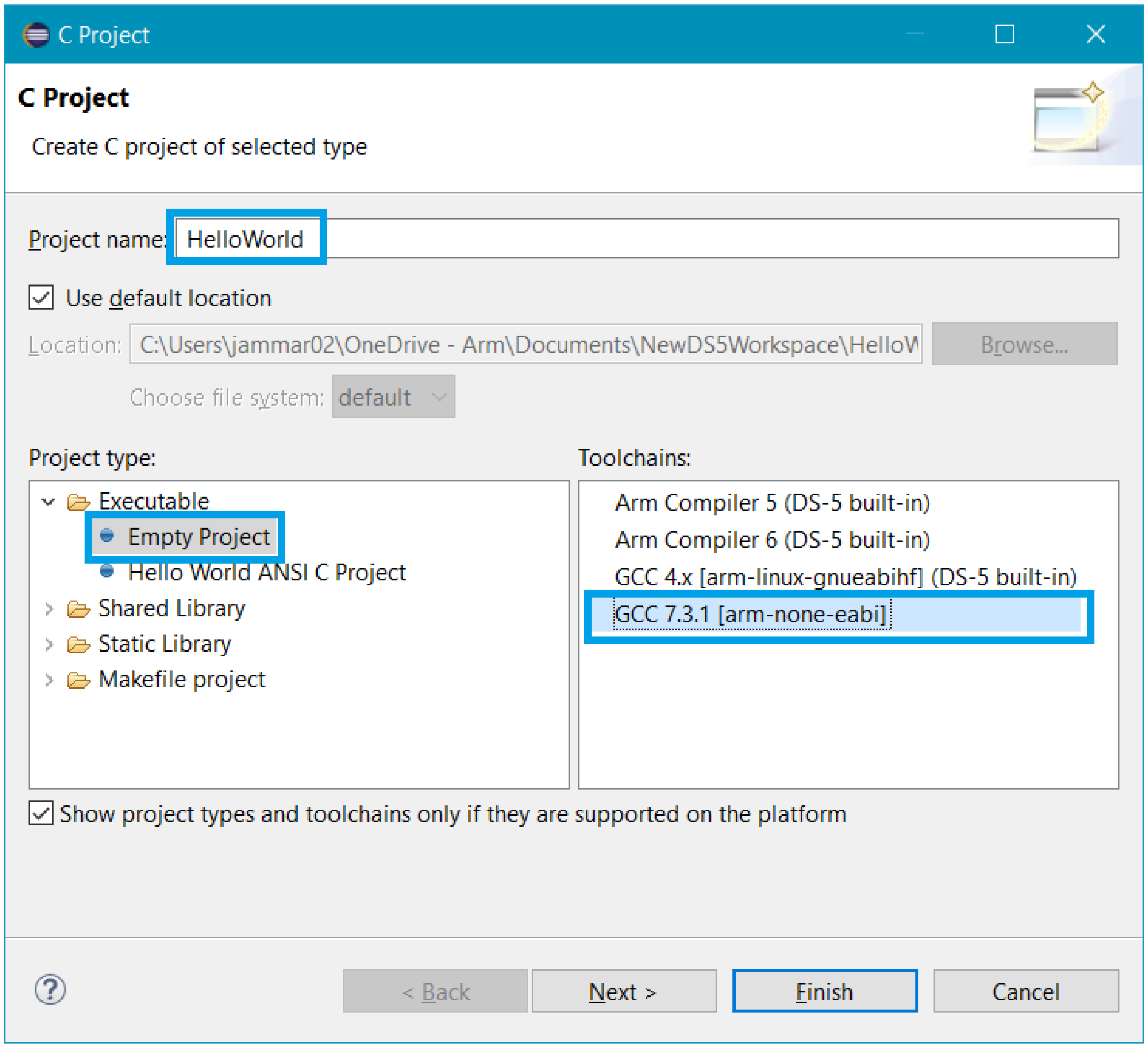
- Download, install, and acquire a license for DS-5. If you haven't, see the Getting Started with Arm DS-5 tutorial for more information.
- Download and install the GCC bare-metal toolchain:
  - If you are compiling for Cortex-A, select a toolchain from linaro.org.
    - For more information regarding the Linaro Toolchain releases, support, and selection, go to https://wiki-archive.linaro.org/WorkingGroups/ToolChain/FAQ.
  - If you are compiling for Cortex-R or Cortex-M, select a toolchain from GNU Arm Embedded Toolchain.
    - For more information regarding the GNU Arm Embedded Toolchain releases, support, and selection, go to GNU Arm Embedded Toolchain.
    - If you need help adding a new toolchain to Arm DS-5, see the tutorial on Adding New Compiler Toolchains to DS-5.

2. Creating a new C project

To create a new C project follow the steps:

1. From the DS-5 main menu, select File > New > C Project to display the C Project dialog.
2. In the C Project dialog:
   a. In the Project name field, enter HelloWorld as the name of your project.
   b. Under Project type, select Executable > Empty Project.

Figure 2-1: C Project dialog options for GCC



C Project

C Project

Create C project of selected type

Project name: HelloWorld

☑ Use default location

Location: C:\Users\jammar02\OneDrive - Arm\Documents\NewDS5Workspace\HelloW

Choose file system: default

Project type:
- Executable
  - Empty Project
  - Hello World ANSI C Project
- Shared Library
- Static Library
- Makefile project

Toolchains:
- Arm Compiler 5 (DS-5 built-in)
- Arm Compiler 6 (DS-5 built-in)
- GCC 4.x [arm-linux-gnueabihf] (DS-5 built-in)
- GCC 7.3.1 [arm-none-eabi]

☑ Show project types and toolchains only if they are supported on the platform

When selecting a Bare-metal toolchain option, the toolchain assumes that the application is executed directly on the hardware instead of on top of a complex operating system such as Linux.

   c. Under Toolchains, select the name of the GCC toolchain you have downloaded.

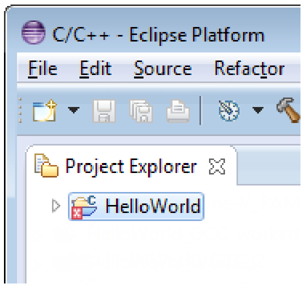
Note

If the toolchain that you downloaded is not listed, you need to add it to the list.

d. Click Finish to create a C project called HelloWorld.

You can view the project in the Project Explorer view.

Figure 2-2: Project Explorer view



You might see a red cross on the project which indicates that the project configuration is incomplete, depending on your version of DS-5. The next sections explain how to set up the rest of the settings for the project.

3. Configuring the settings for the project

You need to be aware that when configuring settings for a project using a compiler not shipped with DS-5 (but supported by DS-5), there might be options and settings that you will have to investigate before applying any changes. For example, you need to know the processor you are compiling your code for and you might also need to investigate the RAM starting address for your target, so you can specify it in the linker script.

For this tutorial, we are going to customize the project to:

- Set up the appropriate commands and flags for the GCC C Compiler, GCC Assembler, and GCC C Linker. This tells the project to use specific switches when compiling the program.
- Configure the project environment to locate and use the GCC compiler executable.
- Modify the GCC linker script to set the RAM starting address.

Setting up the commands and flags for the GCC C Compiler, GCC Assembler, and GCC C Linker

Once you have created your project, you need to specify the commands and flags required to compile it.

Note

This configuration exists on a per-project basis. You must separately reconfigure all projects that you want to use with the new toolchain.

Setting up project commands and flags:

1. Locate your project in the Project Explorer view, right-click it, and select Properties.
2. In the Properties dialog:
   a. Navigate to C/C++ Build > Settings.
   b. Select All configurations in the Configuration list.
   c. Select GCC C Compiler, and confirm that you are using an arm-none-eabi-gcc toolchain, then check if the command is available under Commands. Similarly, confirm the command is available under GCC Assembler, and GCC C Linker.
   d. Select Target and in the CPU (-mcpu) field, enter cortex-a9.
   e. Select GCC C Linker > Libraries, and:
      1. Click the add library button to Add a library, and in the Enter Value dialog, enter `c`.
      2. Click the add library button to Add a library again, and in the Enter Value dialog, enter

```
rdimon
enables semihosting on your target.
```

```
        Semihosting is a mechanism that enables code running on an ARM
target to communicate and use the Input/Output facilities on a host
computer that is running a debugger.


        For more information about semihosting, see What is semihosting?
```

3. Select GCC C Linker > Miscellaneous and in the Other flags field, enter:

```
--specs=nano.specs --specs=rdimon.specs -mcpu=cortex-a9 -T ../gcc.ld
```

The `gcc.ld` is the shared linker script that we will add to the project and modify at a later step.

The commands and flags for the GCC compiler to compile code using the appropriate libraries and processor switches are now set up. Now, you need to set up the project environment variable to point to the GCC compiler executable which is installed separately from DS-5. Leave the project Properties dialog open to configure the project Environment settings.

Check out this blog for some information about GCC command line options for Arm Cortex-A processors: Arm Cortex-A Processors and GCC Command Lines

Set up the project environment to use the GCC compiler executable

To ensure DS-5 can find the GCC compiler executable, add its location to the `PATH` environment variable.

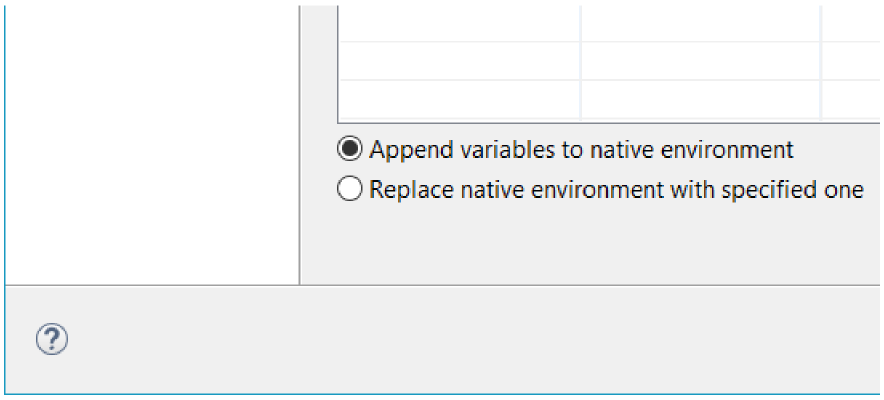
Note

This configuration exists on a per-project basis. You must separately reconfigure all projects that you want to use with the new toolchain.

In the project Properties dialog:

1. Navigate to C/C++ Build > Environment.
2. Ensure the Append variables to native environment option is selected.

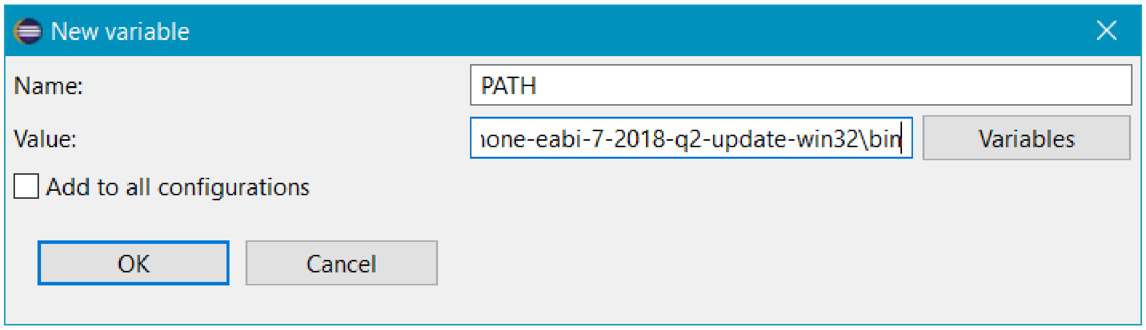
Figure 3-1: Append Variables option.



[✓ Append variables to native environment]
Replace native environment with specified one

3. Click Add.
4. In the New variable dialog:
    a. In the Name field, enter PATH.
    b. In the Value field, enter the path where the GCC compiler is installed. For example: `C:\Program Files (x86)\GNU Tools ARM Embedded\4.7 2013q3\bin`

    Figure 3-2: New PATH variable dialog.

    New variable

    Name: PATH

    Value: ıone-eabi-7-2018-q2-update-win32\bin

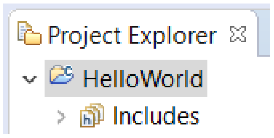
    c. Click OK to save the changes and close the Edit variable dialog.
5. Click OK to save the changes and close the project Properties dialog.

4. Modifying the GCC shared linker script

After setting up the new project with appropriate flags, you now need to copy and modify the GCC shared linker script so that the linker knows what the RAM starting address for the FVP is.

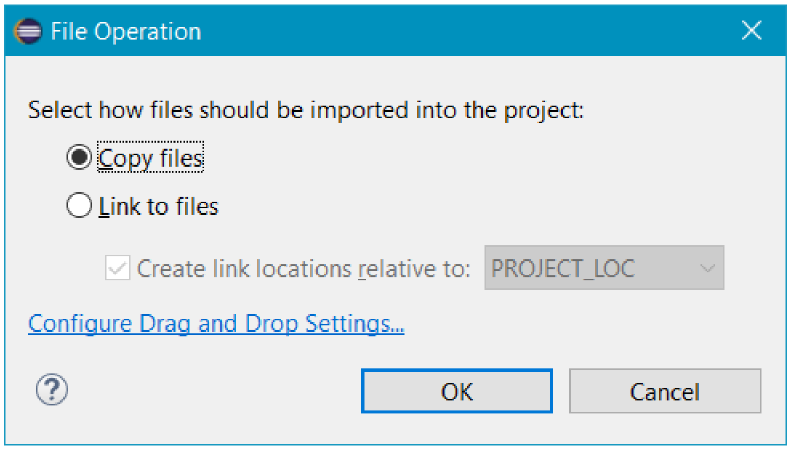
1. Locate the gcc.ld file in: `C:\Program Files (x86)\GNU Tools ARM Embedded\4.7 2013q3\share \gcc-arm-none-eabi\samples\ldscripts`
2. Drag and drop the file from the location on your computer to the project in DS-5.

Figure 4-1: Drag and Drop gcc.ld file.



3. In the File Operation dialog, select Copy files and click OK to copy the file and close the dialog.

Figure 4-2: File Operation dialog.


File Operation

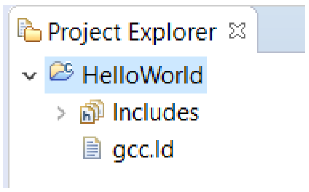
Select how files should be imported into the project:

● Copy files
○ Link to files

✓ Create link locations relative to: PROJECT_LOC

4. Expand the project to view the copied file.

Figure 4-3: gcc.ld file in project.



5. Double-click to open the `gcc.ld` file in the default editor set up in DS-5.
6. Change:

```
MEMORY
{
  FLASH (rx) : ORIGIN = 0x0, LENGTH = 0x20000 /* 128K */
  RAM (rwx) : ORIGIN = 0x10000000, LENGTH = 0x2000 /* 8K */
}
```

To

```
MEMORY
{
  RAM (rwx) : ORIGIN = 0x80000000, LENGTH = 0x2000 /* 8K */
}
```

Where can I locate more information about Versatile Express FVPs and their memory maps?

The Fixed Virtual Platforms FVP Reference Guide contains more information. See VE - model memory map for information specific to VE memory maps.

7. Locate `ENTRY(Reset_Handler)` and change it to `ENTRY(_start)`.
8. Locate all instances of `} > FLASH` and change it to `} > RAM`.
9. Save the file.

After creating the shared linker script, you need to create a target initialization debugger script.

5. Creating the source code and building the project

Now that the project is set up, we can start creating code for it and build the application. After a successful build, we can then create a debug configuration, and run the application on the target.

1. In the Project Explorer view, right-click the HelloWorld project and select New > Source File.
2. In the New Source File dialog, enter the file name hello_world.c.
3. Click Finish to create the source file and open it in the code editing view. The source file is also visible in the Project Explorer view, under the Hello World project.
4. Add the following code to the new source file, and press CTRL+S to save it.

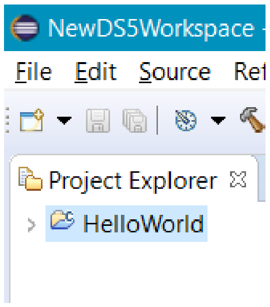
```
#include <stdio.h>
int main(int argc, char** argv)
{
        printf("Hello world\n");
return 0
}
```

5. In the Project Explorer view, right-click on the Hello World project and select Build Project.

You can view the output image `hello_world.axf` in the Debug folder under the HelloWorld project.

The `.axf` file contains both the object code and debug symbols that enable the debugger to perform source-level debugging.

Figure 5-1: Compiled GCC project.

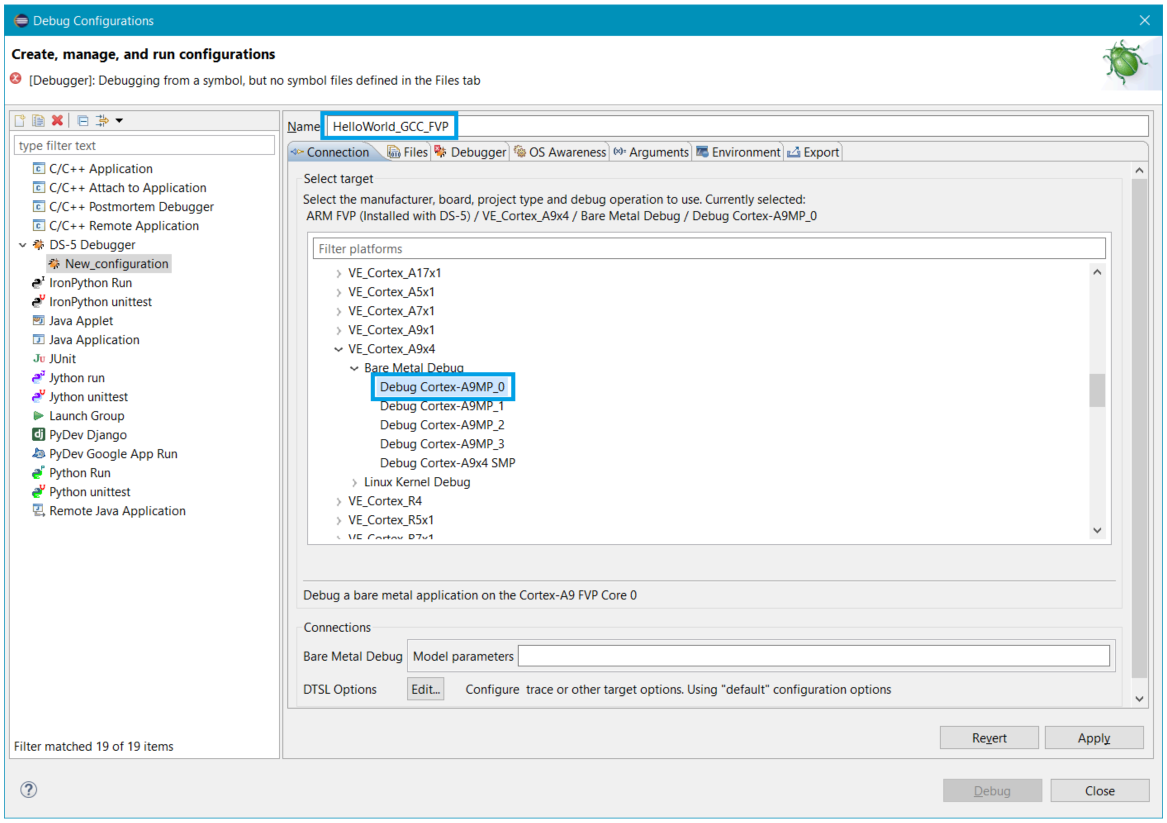


6. Creating a DS-5 debug configuration and connecting to the FVP

To create a DS-5 debug configuration and connecting to the FVP follow the steps:

1. From the DS-5 main menu, select Run > Debug Configurations.
2. In the Debug Configurations dialog:
   a. Select DS-5 Debugger.
   b. Click the New launch configurations button.

Figure 6-1: Debug configurations - New



Create, manage, and run configurations

[Debugger]: Debugging from a symbol, but no symbol files defined in the Files tab

Name: HelloWorld_GCC_FVP

Select target

Select the manufacturer, board, project type and debug operation to use. Currently selected:
ARM FVP (Installed with DS-5) / VE_Cortex_A9x4 / Bare Metal Debug / Debug Cortex-A9MP_0

Debug a bare metal application on the Cortex-A9 FVP Core 0

Connections

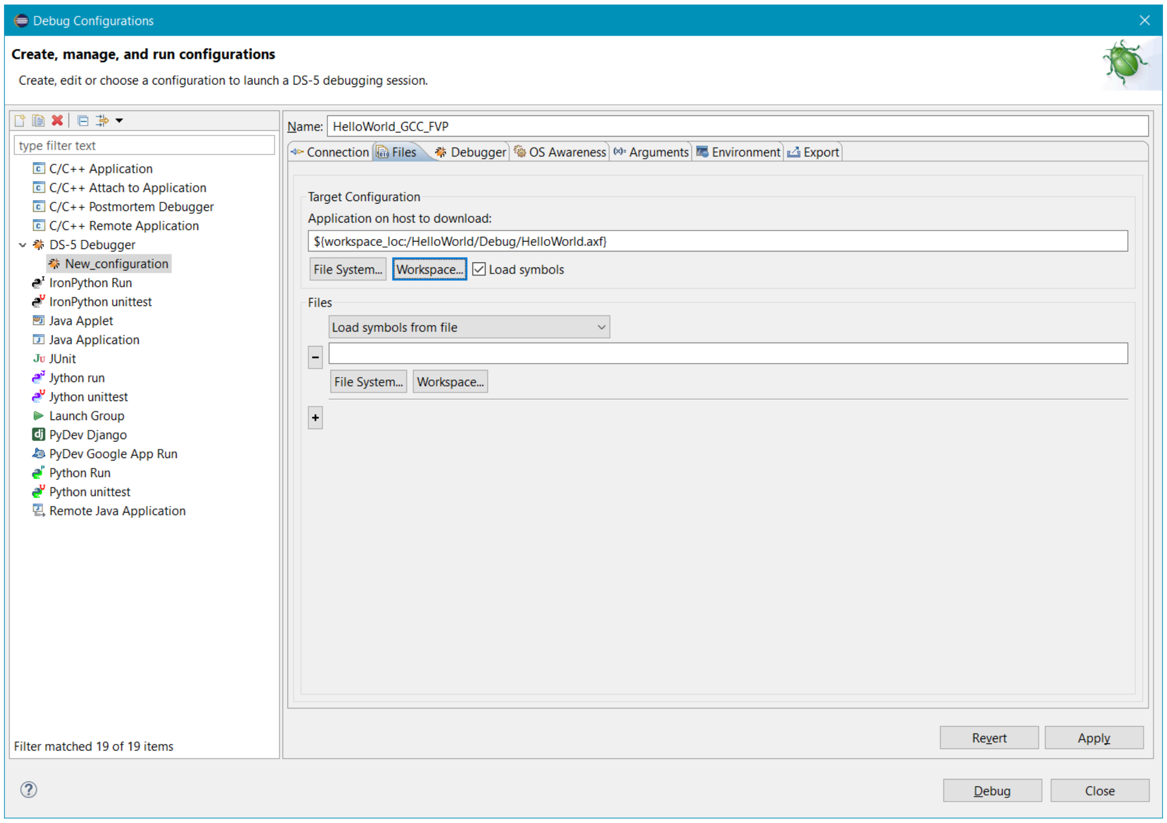
Bare Metal Debug | Model parameters

DTSL Options | Configure trace or other target options. Using "default" configuration options

Filter matched 19 of 19 items

This creates a new DS-5 debug configuration and displays the various tabs required to specify settings for loading your application on the target.

Figure 6-2: Debug configurations - Tabs


Debug Configurations

Create, manage, and run configurations

Create, edit or choose a configuration to launch a DS-5 debugging session.

type filter text
- C/C++ Application
- C/C++ Attach to Application
- C/C++ Postmortem Debugger
- C/C++ Remote Application
- DS-5 Debugger
  - New_configuration
- IronPython Run
- IronPython unittest
- Java Applet
- Java Application
- JUnit
- Jython run
- Jython unittest
- Launch Group
- PyDev Django
- PyDev Google App Run
- Python Run
- Python unittest
- Remote Java Application

Filter matched 19 of 19 items

Name: HelloWorld_GCC_FVP

Connection | Files | Debugger | OS Awareness | Arguments | Environment | Export

Target Configuration
Application on host to download:
${workspace_loc:/HelloWorld/Debug/HelloWorld.axf}
File System... Workspace... ☑ Load symbols

Files
Load symbols from file

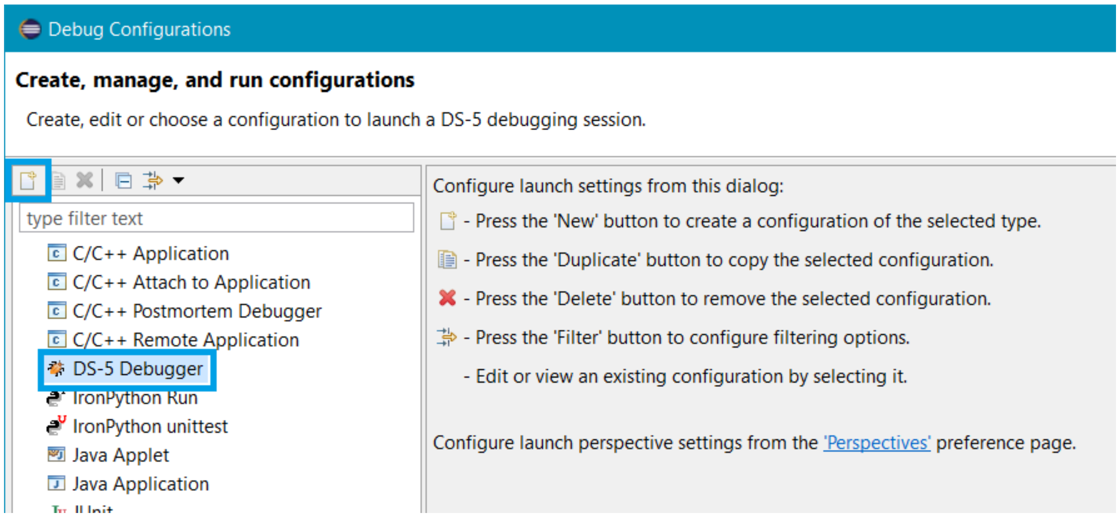
File System... Workspace...

Revert Apply
Debug Close

c. In the Debug Configurations dialog:

1. Give a name to the debug configuration. For example, `HelloWorld_GCC_FVP`.
2. In the Connection tab, select Arm FVP > VE_Cortex_A9x4 > Bare-Metal Debug > Debug Cortex-A9_0.

Figure 6-3: Debug configurations - Debugger tab


Debug Configurations

Create, manage, and run configurations

Create, edit or choose a configuration to launch a DS-5 debugging session.

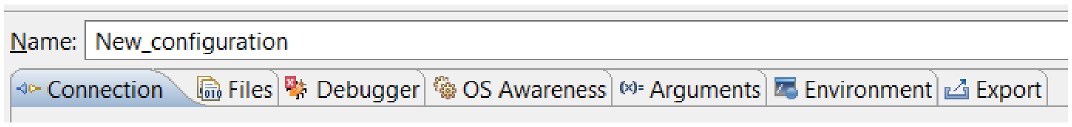
type filter text
- C/C++ Application
- C/C++ Attach to Application
- C/C++ Postmortem Debugger
- C/C++ Remote Application
- DS-5 Debugger
- IronPython Run
- IronPython unittest
- Java Applet
- Java Application
- JUnit

Configure launch settings from this dialog:
- Press the 'New' button to create a configuration of the selected type.
- Press the 'Duplicate' button to copy the selected configuration.
- Press the 'Delete' button to remove the selected configuration.
- Press the 'Filter' button to configure filtering options.
- Edit or view an existing configuration by selecting it.

Configure launch perspective settings from the 'Perspectives' preference page.

3. Select the Files tab, and:
   a. Under Target Configuration in the Application on host to download field, click Workspace.

   Figure 6-4: Debug configurations - Files Tabs

   Name: New_configuration

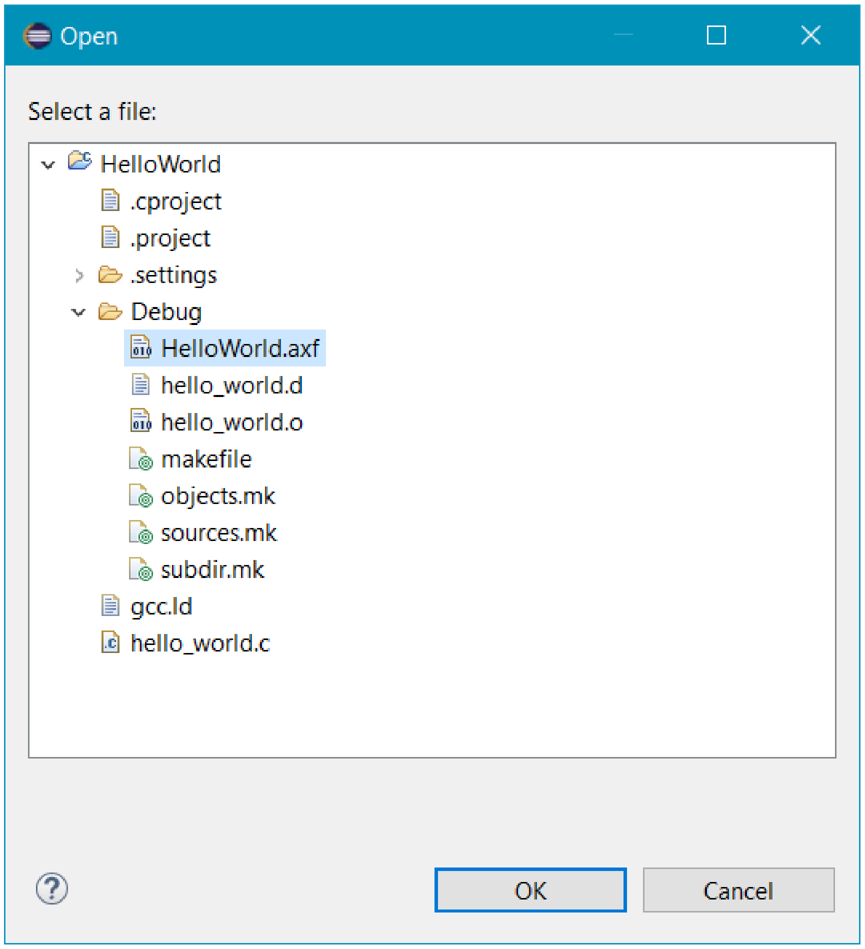
   The Workspace contains the HelloWorld.axf application file you created when you built the Hello World project.

   Note

   Ensure that the Load symbols option is selected.

   b. Select `HelloWorld.axf`.

Figure 6-5: Open Hello World



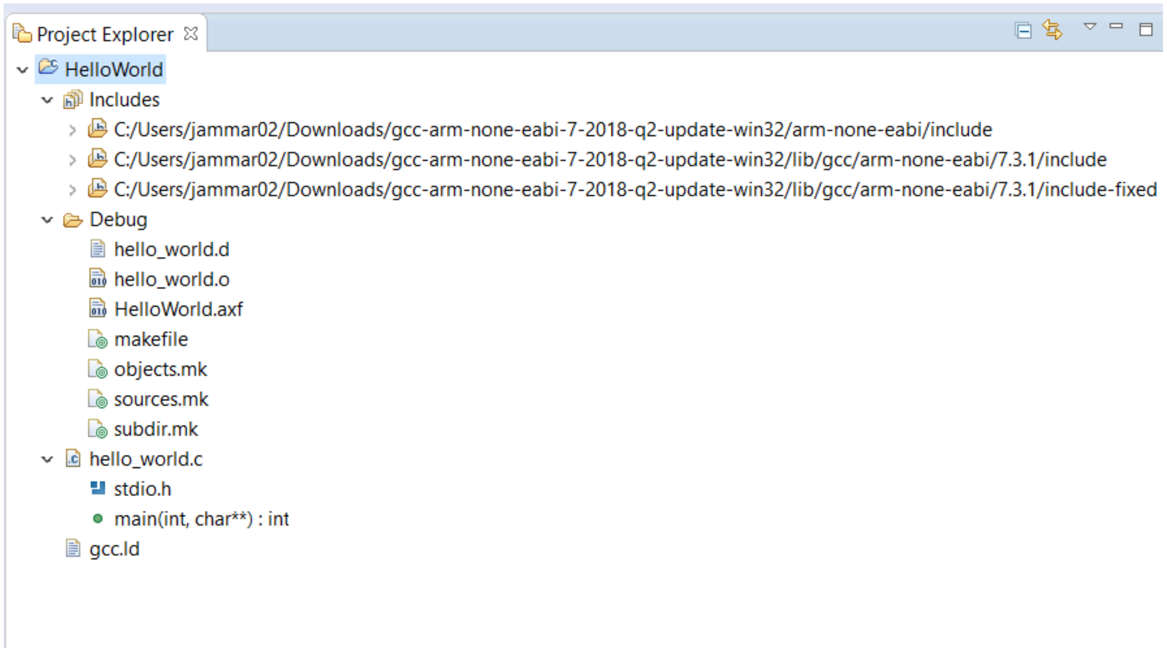
c. Click OK to load the file.

d. Select the Debugger tab, and ensure the Debug from symbol option is selected and set to `main`.

e. Click Debug to load the application on the FVP, and load the debug information into the debugger.

f. In the Confirm Perspective Switch dialog that appears, click Yes. DS-5 connects to the FVP and displays the connection status in the Debug Control view.

Figure 6-6: Debug Control view - Altera GCC configuration



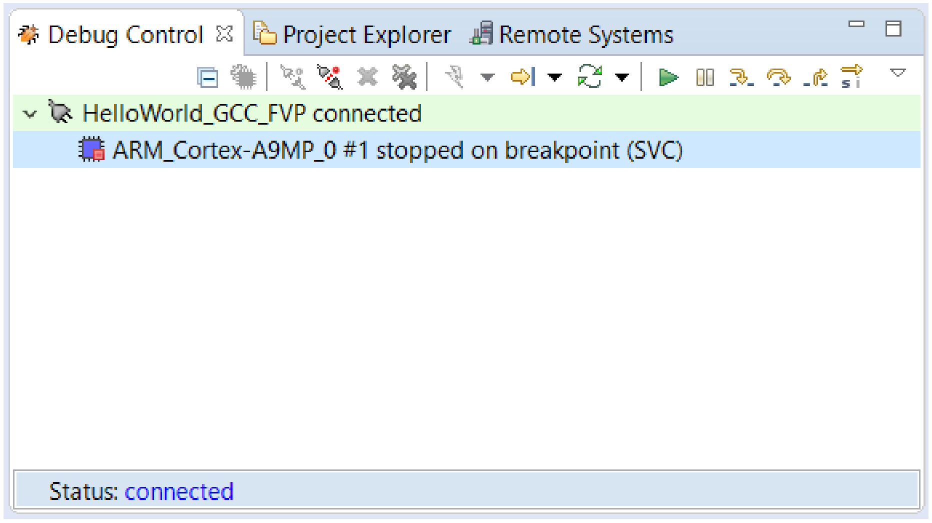
Project Explorer

- HelloWorld
  - Includes
    - C:/Users/jammar02/Downloads/gcc-arm-none-eabi-7-2018-q2-update-win32/arm-none-eabi/include
    - C:/Users/jammar02/Downloads/gcc-arm-none-eabi-7-2018-q2-update-win32/lib/gcc/arm-none-eabi/7.3.1/include
    - C:/Users/jammar02/Downloads/gcc-arm-none-eabi-7-2018-q2-update-win32/lib/gcc/arm-none-eabi/7.3.1/include-fixed
  - Debug
    - hello_world.d
    - hello_world.o
    - HelloWorld.axf
    - makefile
    - objects.mk
    - sources.mk
    - subdir.mk
  - hello_world.c
    - stdio.h
    - main(int, char**) : int
  - gcc.ld

The application is loaded on the target, and has stopped at the `main()` function, ready to run.

g. Click the continue button to continue running the application. You can view the application output in the `Target Console` view.

Figure 6-7: Target Console output



HelloWorld_GCC_FVP connected
ARM_Cortex-A9MP_0 #1 stopped on breakpoint (SVC)

Status: connected