ARM® Cortex®-M3 DesignStart™ Eval
Revision: r0p0

FPGA User Guide
ARM® Cortex®-M3 DesignStart™ Eval
FPGA User Guide
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Release Information

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Preface

This preface introduces the ARM® Cortex®-M3 DesignStart™ Eval FPGA User Guide.

It contains the following:

• About this book on page 7.
• Feedback on page 10.
About this book

This book describes how to use the FPGA platform in the ARM Versatile™ Express Cortex®-M Prototyping System to evaluate a design developed using Cortex-M3 DesignStart™ Eval.

Product revision status

The rmnpn identifier indicates the revision status of the product described in this book, for example, r1p2, where:

- rm Identifies the major revision of the product, for example, r1.
- pn Identifies the minor revision or modification status of the product, for example, p2.

Intended audience

This book is written for hardware engineers, software engineers, system integrators, and system designers, who might not have previous experience of ARM products, but want to run a complete example of a working system.

Using this book

This book is organized into the following chapters:

**Chapter 1 Introduction**
This chapter introduces Cortex-M3 DesignStart Eval and gives an overview of the FPGA Evaluation Flow, its directory structure, and limitations.

**Chapter 2 Using the prebuilt FPGA image**
Cortex-M3 DesignStart Eval includes a prebuilt FPGA image file of the Cortex-M3 DesignStart Eval example system. This chapter describes how to set up the MPS2+ platform to load the prebuilt file and run a self-test program.

**Chapter 3 FPGA platform overview**
This section gives an overview of the FPGA components that are used in Cortex-M3 DesignStart Eval.

**Chapter 4 Clocks**
This chapter describes the source and derived clocks for the FPGA design.

**Chapter 5 Serial Communication Controller**
This chapter describes the Serial Communication Controller (SCC) used in the Cortex-M3 DesignStart Eval FPGA image.

**Chapter 6 FPGA build**
This chapter describes the steps that are required to build an FPGA bit file from the supplied source code.

**Chapter 7 Integrating with mbed™ OS**
This chapter describes the support available for integrating the FPGA system with mbed OS.

**Chapter 8 Performance and utilization**
This chapter describes the performance, resources, and utilization for the default system of the FPGA design in Cortex-M3 DesignStart Eval.

**Appendix A Revisions**
This appendix describes the technical changes between released issues of this book.

**Glossary**

The ARM® Glossary is a list of terms used in ARM documentation, together with definitions for those terms. The ARM Glossary does not contain terms that are industry standard unless the ARM meaning differs from the generally accepted meaning.
See the ARM® Glossary for more information.

**Typographic conventions**

*italic*  
Introduces special terminology, denotes cross-references, and citations.

**bold**  
Highlights interface elements, such as menu names. Denotes signal names. Also used for terms in descriptive lists, where appropriate.

**monospace**  
Denotes text that you can enter at the keyboard, such as commands, file and program names, and source code.

**monospace**  
Denotes a permitted abbreviation for a command or option. You can enter the underlined text instead of the full command or option name.

**monospace italic**  
Denotes arguments to monospace text where the argument is to be replaced by a specific value.

**monospace bold**  
Denotes language keywords when used outside example code.

<and>  
Encloses replaceable terms for assembler syntax where they appear in code or code fragments. For example:

```
MRC p15, 0, <Rd>, <CRn>, <CRm>, <Opcode_2>
```

**SMALL CAPITALS**  
Used in body text for a few terms that have specific technical meanings, that are defined in the ARM® Glossary. For example, IMPLEMENTATION DEFINED, IMPLEMENTATION SPECIFIC, UNKNOWN, and UNPREDICTABLE.

**Timing diagrams**

The following figure explains the components used in timing diagrams. Variations, when they occur, have clear labels. You must not assume any timing information that is not explicit in the diagrams.

Shaded bus and signal areas are undefined, so the bus or signal can assume any value within the shaded area at that time. The actual level is unimportant and does not affect normal operation.

**Signals**

The signal conventions are:
Signal level

The level of an asserted signal depends on whether the signal is active-HIGH or active-LOW. Asserted means:

• HIGH for active-HIGH signals.
• LOW for active-LOW signals.

Lowercase n

At the start or end of a signal name denotes an active-LOW signal.

Additional reading

This book contains information that is specific to this product. See the following documents for other relevant information.

ARM publications

• Cortex®-M3 DesignStart™ Eval publications:
• Other ARM publications:
  — Application Note AN531 uSDCARD SPI Adapter for the Cortex-M Prototyping System (MPS2+) (ARM DAI 0531).
  — Application Note AN502 Adapter for Arduino for the Cortex-M Prototyping System (MPS2 and MPS2+) (ARM DAI 0502).
  — ARM® AMBA® 3 AHB-Lite Protocol Specification (v1.0) (ARM IHI 0033).
  — ARM® Architecture Reference Manual ARMv7, for ARMv7-M architecture profile (ARM DDI0403).

Other publications

None.
Feedback

Feedback on this product

If you have any comments or suggestions about this product, contact your supplier and give:

• The product name.
• The product revision or version.
• An explanation with as much information as you can provide. Include symptoms and diagnostic procedures if appropriate.

Feedback on content

If you have comments on content then send an e-mail to errata@arm.com. Give:

• The title ARM Cortex-M3 DesignStart Eval FPGA User Guide.
• The number 100896_0000_00_en.
• If applicable, the page number(s) to which your comments refer.
• A concise explanation of your comments.

ARM also welcomes general suggestions for additions and improvements.

Note

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Chapter 1
Introduction

This chapter introduces Cortex-M3 DesignStart Eval and gives an overview of the FPGA Evaluation Flow, its directory structure, and limitations.

It contains the following sections:

• 1.1 About Cortex®-M3 DesignStart™ Eval on page 1-12.
• 1.2 About the ARM Versatile Express Cortex-M Prototyping System (V2M-MPS2+) on page 1-14.
• 1.3 Using the documentation on page 1-15.
• 1.4 FPGA Evaluation Flow directory structure on page 1-17.
• 1.5 Limitations on page 1-18.
1.1 About Cortex®-M3 DesignStart™ Eval

Cortex-M3 DesignStart Eval provides developers an easy way to develop and simulate SoC designs based on the ARM Cortex-M3 processor. It allows a system designer to design and test on a simulator and then proceed with hardware prototyping using an FPGA.

The Cortex-M3 DesignStart Eval package is aimed at developers who are new to ARM or have limited soft IP system design experience. The package includes the following:

- 1.1.1 RTL on page 1-12.
- 1.1.2 Execution Testbench on page 1-13.

Cortex-M3 DesignStart Eval provides an easy entry into the ARM ecosystem, rather than a complete solution for all Cortex-M processor design scenarios.

The hardware ecosystem in Cortex-M3 DesignStart Eval is built around the CoreLink™ SSE-050 Subsystem and includes the use of the Cortex-M System Design Kit (CMSDK) standard library of Advanced High-performance Bus (AHB) and Advanced Peripheral Bus (APB) components. For more information on the CMSDK, see the ARM® Cortex®-M System Design Kit Technical Reference Manual.

The software ecosystem in Cortex-M3 DesignStart Eval uses the ARM Cortex Microcontroller Software Interface Standard (CMSIS) software standard library.

The use of CMSDK and CMSIS, coupled with a reprogrammable FPGA, allows for a fast turnaround and prototyping of Cortex-M3 processor-based hardware and software.

Cortex-M3 DesignStart Eval does not support the implementation of the Cortex-M3 processor into silicon. Any implementation of the Cortex-M3 processor into silicon requires you to obtain Cortex-M3 DesignStart Pro, or take a full Cortex-M3 processor license from ARM.

A Cortex-M3 DesignStart Pro license offers the following:

- The Cortex-M3 processor.
- The SDK-100 System Design Kit (SDK), which includes:
  - The CoreLink SSE-050 Subsystem.
  - The CMSDK components.
  - A Real Time Clock (RTC).
  - A stand-alone True Random Number Generation (TRNG).

An Embedded Trace Macrocell (ETM) is not included in Cortex-M3 DesignStart Pro, and requires a separate license.

If you are working on ASIC implementation, then ARM recommends that you license Cortex-M3 DesignStart Pro as early as possible.

1.1.1 RTL

The RTL in Cortex-M3 DesignStart Eval includes the components and peripherals that are required to implement a complete example system in an FPGA.

The example system is intended to provide a reference starting point for a typical IoT endpoint application and is a supported ARM mbed™ platform when implemented on the ARM Versatile Express Cortex-M Prototyping System (V2M-MPS2+) platform.

The Cortex-M3 DesignStart Eval RTL provides an example system that includes:

- A Cortex-M3 processor in a fixed configuration (obfuscated but synthesizable).
- A modified CoreLink SSE-050 subsystem supporting a single Cortex-M3 processor with support for debug and trace.
- A memory subsystem supporting Execute In Place (XIP). The MPS2+ platform preloads a code file at powerup.
- Two timers for Operating System use (privileged access only).
• Peripherals for:
  — Application use, including Timers, UART, Watchdog, Real Time Clock (RTC), True Random Number Generator (TRNG).
  — MPS2+ platform, including Color LCD, Audio, and Ethernet.
  — Arduino Shield expansion using the adapter for the Arduino board.
• SPI interface supporting application persistent storage on microSD card.
• Reusable ARM Advanced Microcontroller Bus Architecture (AMBA) SoC interconnect components for system level development.

You must not modify the obfuscated Cortex-M3 processor (cortexm3ds_logic.v).

You are only permitted to redistribute the following files (modified or original), with the original headers unchanged, and any modifications clearly identified:
• fpga_top.v
• m3ds_user_partition.v
• m3ds_peripherals_wrapper.v

1.1.2 Execution Testbench

The Execution Testbench in Cortex-M3 DesignStart Eval is an RTL package that allows system design and simulation with a suitable Verilog simulator.

The Cortex-M3 DesignStart Eval Execution Testbench includes:
• A simulation model of the processor that includes register visibility and instruction execution tracing.
• Memory models that match the FPGA target.
• ARM CoreSight™ debug test engine that is preconfigured for a single fixed debug and trace implementation.
• Integration tests for memories and internal peripherals.

You are expected to modify the test code to support any modifications you make to your design. You must not redistribute any test code or binaries from these deliverables unless it is developed using mbed source code.

You are only permitted to redistribute the following files (modified or original), with the original headers unchanged, and any modifications clearly identified:
• tb_fpga_shield.v
• cmsdk_uart_capture_ard.v

1.1.3 FPGA Evaluation Flow

The Cortex-M3 DesignStart Eval FPGA Evaluation Flow allows developers to build an image file of the simulation system that can be used with the ARM Versatile Express Cortex-M Prototyping System (V2M-MPS2+). The FPGA image can be customized to the user system requirements.

The Cortex-M3 DesignStart Eval FPGA Evaluation Flow requires the purchase of the MPS2+ FPGA platform.

The MPS2+ FPGA platform includes a Motherboard Configuration Controller (MCC) on the baseboard, which provides the following features that are necessary to emulate an ARM mbed compliant system:
• Target application code. The target has no flash memory. The SRAM is instead initialized at powerup by the MCC using information stored on the configuration microSD card.
• DAPLink implementing CMSIS-DAP over USB for debug access.
• UART access is provided by a serial connector (and included serial to USB cable).
• Real Time Clock (RTC) initialization from baseboard processor on powerup.

For more information on how to use the MPS2+ FPGA platform, see the ARM® Versatile™ Express Cortex®-M Prototyping System (V2M-MPS2 and V2M-MPS2+) Technical Reference Manual.

You must not redistribute any FPGA bit files or other representations of the design that are produced from Cortex-M3 DesignStart Eval.
1.2 About the ARM Versatile Express Cortex-M Prototyping System (V2M-MPS2+)

The MPS2+ platform is a small FPGA development board that contains:
• A Motherboard Configuration Controller (MCC).
• An Altera Cyclone V FPGA.
• Various memories and debug connectors.
• A color LCD touch screen.
• Connectors for Ethernet, VGA, Audio, and serial interfaces.
• User switches and LEDs.
• An SPI to microSD card adapter.

You can program the FPGA with the FPGA image built using ARM Cortex-M3 DesignStart Eval.

The MPS2+ platform enables hardware and software developers to rapidly design and test hardware and software components as part of a Cortex-M3 processor ecosystem.

For more information on the MPS2+ platform specification, see the ARM® Versatile™ Express Cortex®-M Prototyping System (V2M-MPS2 and V2M-MPS2+) Technical Reference Manual.

This section contains the following subsection:
• 1.2.1 Decryption Key on page 1-14.

1.2.1 Decryption Key

ARM supplies the MPS2+ platform with a decryption key that is programmed into the FPGA.

The decryption key is required to enable loading of the prebuilt images, which are encrypted.

User images do not require the decryption key.

--- Note ---

A battery supplies power to the key storage area of the FPGA. Any keys stored in the FPGA are lost when battery power is lost. If battery power is lost, you must return the board to ARM for reprogramming of the key.
1.3 Using the documentation

There are several documents provided with Cortex-M3 DesignStart Eval.

Scope of this document

The ARM® Cortex®-M3 DesignStart™ Eval FPGA User Guide describes how to build an FPGA image and evaluate software running on the Versatile Express Cortex-M Prototyping System (V2M-MPS2+) platform.

Other documents

The following table shows the documents that relate to the design flow processes for Cortex-M3 DesignStart Eval:

<table>
<thead>
<tr>
<th>Document name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARM® Cortex®-M3 DesignStart™ Eval RTL and Testbench User Guide</td>
<td>Describes information required for system design and RTL simulation.</td>
</tr>
<tr>
<td>ARM® Cortex®-M3 DesignStart™ Eval RTL and FPGA Quick Start Guide</td>
<td>Describes how to run basic tests using an RTL simulator and an FPGA platform.</td>
</tr>
<tr>
<td>ARM® Cortex®-M3 DesignStart™ Eval Customization Guide</td>
<td>Describes the high-level steps to integrate your own peripherals, and make other modifications to the Cortex-M3 DesignStart Eval system.</td>
</tr>
</tbody>
</table>

For more information about:
- Programming the Cortex-M3 processor, see the ARM® Cortex®-M3 Technical Reference Manual.
- Software development on a Cortex-M3 device, see the ARM® Cortex®-M3 Devices Generic User Guide. This is a generic device user-level reference document.
- The ARM architecture that the Cortex-M3 processor complies with, and the instruction set and exception model it uses, see the ARM® Architecture Reference Manual ARMv7, for ARMv7-M architecture profile.
- The AHB-Lite master interface that the Cortex-M3 processor implements, see the ARM® AMBA® 3 AHB-Lite Protocol Specification (v1.0).
- The Real Time Clock (RTC), see the ARM® PrimeCell™ Real Time Clock (PL031) Technical Reference Manual.
• The MPS2+ platform, see the *ARM® Versatile™ Express Cortex®-M Prototyping System (V2M-MPS2 and V2M-MPS2+) Technical Reference Manual*.
• The True Random Number Generator (TRNG), see the *ARM® TrustZone® TRNG True Random Number Generator Technical Reference Manual*.
1.4 FPGA Evaluation Flow directory structure

The following diagram and table describe the main directories of the Cortex-M3 DesignStart Eval FPGA Evaluation Flow:

```
<install_directory>/
  docs/
  cmsdk/
  m3designstart/
    fpga/
    logical/
    software/
  m3designstart_iot/
  rtc_pl031/
  smm/
  trng/
  boards/
    Recovery/
```

**Figure 1-1 FPGA Evaluation Flow main directories**

<table>
<thead>
<tr>
<th>Directory</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>docs/</td>
<td>Contains documentation for Cortex-M3 DesignStart Eval.</td>
</tr>
<tr>
<td>cmsdk/</td>
<td>Contains the RTL for:</td>
</tr>
<tr>
<td></td>
<td>• ARM Cortex-M System Design Kit (CMSDK) components. Some CMSDK components are used in the example system in Cortex-M3 DesignStart Eval.</td>
</tr>
<tr>
<td>m3designstart/</td>
<td>Contains the following:</td>
</tr>
<tr>
<td></td>
<td>• Scripts for building an FPGA image.</td>
</tr>
<tr>
<td></td>
<td>• Example DesignStart system.</td>
</tr>
<tr>
<td></td>
<td>• Testbench in testbench/execution_tb/.</td>
</tr>
<tr>
<td></td>
<td>• Integration tests in testbench/testcodes/.</td>
</tr>
<tr>
<td></td>
<td>• ARM Cortex Microcontroller Software Interface Standard (CMSIS) support files for the Cortex-M3 DesignStart Eval.</td>
</tr>
<tr>
<td>m3designstart_iot/</td>
<td>Cortex-M3 DesignStart Eval version of ARM CoreLink SSE-050 subsystem.</td>
</tr>
<tr>
<td>rtc_pl031/</td>
<td>Real Time Clock peripheral.</td>
</tr>
<tr>
<td>smm/</td>
<td>Peripherals and support code for the MPS2+ FPGA platform.</td>
</tr>
<tr>
<td>trng/</td>
<td>Stand-alone True Random Number Generator.</td>
</tr>
<tr>
<td>boards/Recovery/</td>
<td>Contains the files required to be loaded onto the microSD card of the MPS2+ platform, in order to program and run the prebuilt FPGA image and software.</td>
</tr>
</tbody>
</table>
1.5 Limitations

This section describes the limitations of the Cortex-M3 DesignStart Eval FPGA Evaluation Flow.

You should not use the processor technology or the supporting deliverables as an indicator of what is received under a full technology license of the ARM Cortex-M3 processor.

This section contains the following subsections:

- 1.5.1 Deliverables on page 1-18.
- 1.5.2 Processor support on page 1-18.

1.5.1 Deliverables

Cortex-M3 DesignStart Eval does not contain the EDA tools used for simulation or compilation. You must obtain the software tools separately.

The following table shows the supported software tools for Cortex-M3 DesignStart Eval:

<table>
<thead>
<tr>
<th>Tool</th>
<th>Supported software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compile test code</td>
<td>The recommended minimum versions are:</td>
</tr>
<tr>
<td></td>
<td>• ARM Keil Microcontroller Development Kit (MDK) version 5.22.</td>
</tr>
<tr>
<td></td>
<td>• ARM Development Studio 5 (DS-5) version 5.06.409.</td>
</tr>
<tr>
<td></td>
<td>• GNU Tools for ARM Embedded Processors (ARM GCC) version 5-2016q2.</td>
</tr>
<tr>
<td>Compile RTL and FPGA build software</td>
<td>The recommended minimum version is:</td>
</tr>
<tr>
<td></td>
<td>• Intel Quartus version 16.1.</td>
</tr>
</tbody>
</table>

**Note**

The Cyclone device on the ARM MPS2+ platform is also supported by the free Lite Edition of Quartus Prime. No Quartus license is required to build the Cortex-M3 DesignStart Eval FPGA Evaluation Flow.

For more information on how to compile and simulate the RTL, see the ARM® Cortex®-M3 DesignStart™ Eval RTL and Testbench User Guide.

1.5.2 Processor support

The FPGA Evaluation Flow supports the Cortex-M3 processor from Cortex-M3 DesignStart Eval.

For more information, see the ARM® Cortex®-M3 DesignStart™ Eval RTL and Testbench User Guide.
Chapter 2
Using the prebuilt FPGA image

Cortex-M3 DesignStart Eval includes a prebuilt FPGA image file of the Cortex-M3 DesignStart Eval example system. This chapter describes how to set up the MPS2+ platform to load the prebuilt file and run a self-test program.

It contains the following sections:

- 2.1 Setting up the MPS2+ FPGA platform on page 2-20.
- 2.2 Running the self-test program on page 2-21.
- 2.3 Connecting to a debugger on page 2-23.
2.1 Setting up the MPS2+ FPGA platform

To set up the MPS2+ platform with the provided prebuilt FPGA image file of the Cortex-M3 DesignStart Eval example system, follow these steps:

1. Connect a USB lead from your computer to the USB-B connector on the MPS2+ platform.
2. Connect the 12V power adapter to the power input connector on the MPS2+ platform. Your computer should recognize the MPS2+ platform as an external USB drive, named V2M_MPS2.
3. Load an Application Note by locating the boards/Recovery directory in the Cortex-M3 DesignStart Eval bundle. Copy the following files to the MPS2+ platform directory, which has a similar directory structure:

   - /MB/HBI0263C/AN511/
     - Copy the complete directory.
   - /MB/HBI0263C/board.txt
     - Copy the following two lines in the board.txt file:
       
       ```
       [MCCS]
       MBBIOS: mbb_v221.ebf ; MB BIOS IMAGE. Supports RTC with time updates via MCC
       APPFILE: AN511\an511_v1.txt ; Cortex-M3 DesignStart
       
       Note
       Ensure that the APPFILE:an511_v1.txt line is uncommented, and that all other APPFILE lines are commented. Only one APPFILE line may be enabled.
       ```
   - /MB/HBI0263C/mbb_v221.ebf
     - Copy the file.
   - /SOFTWARE/iot_test.axf
     - Copy the file.
   - /config.txt
     - Copy the file.

   **Note**
   In this file, RTC = TRUE. This setting is different from other Application Notes. The Real Time Clock (RTC) is enabled because Cortex-M3 DesignStart Eval supports RTC, which is updated at boot-up by the Motherboard Configuration Controller (MCC).

   If you are starting with a blank microSD card in the MPS2+ motherboard card slot, you can copy the entire contents of the boards/Recovery directory (not including the Recovery part of the path) into the root of the microSD card.

4. Power up the MPS2+ platform.

When the platform is first powered up with a new BIOS file mbb_v221.ebf, the BIOS file is copied internally. This is indicated by the rapid flashing of LED[0]. After the new BIOS has been successfully copied, the platform resumes with its standard FPGA loading process, which is indicated by a count sequence on LED[7:0]. After the FPGA is fully loaded, then the color LCD screen displays a self-test splash screen.

If the MPS2+ platform does not boot correctly, then refer to the log.txt in the root directory of the MPS2+ platform, which provides a log of the files loaded at bootup.

For more information on the instructions to set up the platform, see the *ARM® Versatile™ Express Cortex®-M Prototyping System (V2M-MPS2 and V2M-MPS2+) Technical Reference Manual.*
2.2 Running the self-test program

The MPS2+ FPGA platform uses a self-test program to test its main components. This self-test program is specific to the prebuilt image, which is based on the Cortex-M3 DesignStart Eval example system.

If you extend the example system, then you may need to modify the self-test program.

If you need to modify and recompile the self-test image, you are required to install legacy support in Keil® MDK. This provides the low-level interface which is used by the self-test. Source code for the self-test is located at m3designstart/selftest/build_keil/ in the deliverables.

To run a self-test program, follow these steps:
1. Connect an RS232 serial lead to the General UART connector (FPGA), on the MPS2+ platform.
2. Configure the UART according to the following settings:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baud rate</td>
<td>38400</td>
</tr>
<tr>
<td>Data bits</td>
<td>8</td>
</tr>
<tr>
<td>Stop bits</td>
<td>1</td>
</tr>
<tr>
<td>Parity</td>
<td>None</td>
</tr>
<tr>
<td>Flow control</td>
<td>XON/XOFF protocol</td>
</tr>
</tbody>
</table>

3. Select the self-test program that you want to run based on the following options available that are displayed by the UART console window when the MPS2+ platform has booted up:

Versatile Express Cortex-M Prototyping System (V2M-MPS2) Test Suite
Version 1.0.0 Build date: Mar 8 2017
Copyright (C) ARM Ltd 2015. All rights reserved.

V2M-MPS2 revision C

Application Note AN511, FPGA build 1

CPU: Cortex-M3 r2p1

Summary of results
====================================
1 AACI (Audio) : Not Run
2 CLCD (Video) : Not Run
3 TSC (touchscreen) : Not Run
4 LEDs/Switches/Buttons : Not Run
5 SSP (eeprom) : Not Run
6 Ethernet : Not Run
7 Memory : Not Run
8 Timer : Not Run
9 RTC : Not Run

Select the test you wish to run. (X - Exit)

Choice:

Note

To run Test 1, AACI (Audio), you must connect a 3.5mm stereo jack lead from the audio output connector to the audio input connector.

When the test runs, the console window displays the self-test status:

Versatile Express Cortex-M Prototyping System (V2M-MPS2) Test Suite
Version 1.0.0 Build date: Mar 8 2017
Copyright (C) ARM Ltd 2015. All rights reserved.

V2M-MPS2 revision C
Application Note AN511, FPGA build 1

CPU: Cortex-M3 r2p1

Summary of results
====================================
1 AACI (Audio)            : PASS
2 CLCD (Video)            : PASS
3 TSC (touchscreen)       : PASS
4 LEDs/Switches/Buttons   : PASS
5 SSP (eeprom)            : PASS
6 Ethernet                : PASS
7 Memory                   : PASS
8 Timer                    : PASS
9 RTC                      : PASS

Select the test you wish to run. (X - Exit)

Choice:

You can select 'X' to exit the self-test program.
2.3 Connecting to a debugger

The MPS2+ platform supports debug over USB, using CMSIS-DAP. This is a standard interface that is supported by most debug tools.

For details on connecting and configuring specific debug toolchains, see the *ARM® Versatile™ Express Cortex®-M Prototyping System (V2M-MPS2 and V2M-MPS2+) Technical Reference Manual.*
Chapter 3
FPGA platform overview

This section gives an overview of the FPGA components that are used in Cortex-M3 DesignStart Eval.

It contains the following sections:

- 3.1 System overview on page 3-25.
- 3.2 Memory map on page 3-26.
- 3.3 Block RAM instances on page 3-27.
- 3.5 External PSRAM on page 3-29.
- 3.6 Arduino adapter board on page 3-30.
- 3.7 Embedded Trace Macrocell interface on page 3-31.
- 3.8 CMSDK APB subsystem on page 3-32.
- 3.9 AHB GPIO on page 3-33.
- 3.10 Serial Peripheral Interface on page 3-34.
- 3.11 Color LCD parallel interface on page 3-35.
- 3.12 Ethernet on page 3-36.
- 3.13 VGA on page 3-37.
- 3.14 Audio I2S on page 3-38.
- 3.15 Audio configuration on page 3-40.
- 3.16 FPGA system control and I/O on page 3-41.
### 3.1 System overview

The Soft Macro Model (SMM) is an FPGA implementation of an ARM processor or subsystem. The SMM is based on the SSE-050 Subsystem. Extra peripherals that are required by the FPGA are placed on the expansion of APB and AHB ports.

The following figure shows the block diagram of the FPGA design, indicating the Cortex-M3 processor from DesignStart, the CMSDK components (peripherals and interconnect), and the interfaces to the MPS2+ platform peripherals.

---

**Figure 3-1 System overview**

---

This block diagram shows the functional hierarchy of the FPGA design.

---

Note

This block diagram shows the functional hierarchy of the FPGA design.
3.2 Memory map

For more information on the memory map, see the ARM® Cortex®-M3 DesignStart™ Eval RTL and Testbench User Guide.
3.3 Block RAM instances

The Soft Macro Model (SMM) implements 256KB of FPGA internal block RAM as 32-bit AHB SRAM, as an emulation of flash. The boot code must be placed in this location. If your FPGA image file is large, you can transfer execution to the code stored in the ZBT SSRAM1.

The SMM implements four regions of 32KB internal block RAM as individual 32-bit AHB SRAM, intended for use as program RAM.
3.4 External Zero Bus Turnaround SSRAM

This section describes the Zero Bus Turnaround (ZBT) SSRAM in the FPGA platform.

This section contains the following subsections:
- 3.4.1 ZBT SSRAM1 on page 3-28.
- 3.4.2 ZBT SSRAM2 and ZBT SSRAM3 on page 3-28.

3.4.1 ZBT SSRAM1

This section describes the Zero Bus Turnaround (ZBT) SSRAM in the code region, which is an additional area in memory which can be used to store executable code.

This interface consists of two external 32-bit ZBT SSRAMs in parallel, forming a 64-bit ZBT SSRAM. This makes 4MB available (each ZBT SSRAM is 2MB).

This ZBT SSRAM1 is connected through the AHB.

3.4.2 ZBT SSRAM2 and ZBT SSRAM3

ZBT SSRAM2 and ZBT SSRAM3 are two external 32-bit ZBT SSRAMs that are connected to two independent ZBT interfaces.

Each ZBT SSRAM occupies 2MB of memory space. When combined, the ZBT SSRAMs occupy 4MB of memory space. This provides an additional RAM region. The addresses of the two ZBT SSRAMs are interleaved as shown in the following diagram:

```
<table>
<thead>
<tr>
<th>Address</th>
<th>ZBT SSRAM2</th>
<th>ZBT SSRAM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x2040_0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x2040_0004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x207F_FFF8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x207F_FFFC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x2040_0008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x2040_000C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

Figure 3-2  32-bit ZBT SSRAM memory space

The ZBT SSRAM2 and ZBT SSRAM3 are connected through the AHB.
3.5 External PSRAM

An external PSRAM is available in the FPGA platform.

A 16MB 16-bit PSRAM area is available and the memory map allocates the address-range `0x21000000 - 0x21FFFFFF`. This PSRAM space enables large test programs to be used in the SRAM region of the Cortex-M3 memory space.

--- Note ---

The internal bus structure is such that the accesses to the PSRAM and ZBT SSRAM take longer than the accesses to the internal block RAM used for flash memory and SRAM regions. Therefore, any program using the PSRAM for code or data accesses suffers a corresponding performance degradation.
3.6 **Arduino adapter board**

The MPS2+ platform supports Arduino shields by using the ARM adapter for Arduino board. This is an expansion board which plugs into the GPIO connectors on the MPS2+ platform and allows you to connect up to two Arduino shields.

If you want to use the adapter, you can purchase this from ARM.

For more details on how to use the adapter, see the *Application Note AN502 Adapter for Arduino for the Cortex-M Prototyping System (MPS2 and MPS2+).*
3.7 Embedded Trace Macrocell interface

If you want to use the MPS2+ platform to capture Embedded Trace Macrocell (ETM) trace, then you are required to use a suitable debug adapter, such as DSTREAM or ULINKpro. This can be connected using the 20-pin debug connector.

Serial Wire trace (instrumentation trace only) can be captured using a DSTREAM, ULINKpro-D, ULINKplus, or ULINK2 debug adapter.
3.8 CMSDK APB subsystem

The Soft Macro Model (SMM) uses a CMSDK-based APB subsystem for timers, UARTs, watchdog, and APB expansion ports.

For more information on the APB memory map, see the ARM® Cortex®-M3 DesignStart™ Eval RTL and Testbench User Guide.
3.9 AHB GPIO

The *Soft Macro Model* (SMM) uses six instances of the CMSDK GPIO. GPIO0 through GPIO3 map to the expansion ports. GPIO4 and GPIO5 have no external connections.

Where the GPIO expansion is shared with other peripherals, the pin muxing is controlled using the GPIO alternate function registers. Setting the alternate function bit to '1' disables the GPIO connection for the pin and enable the other peripheral connection.

For more information on the CMSDK GPIO registers, see the *ARM® Cortex®-M System Design Kit Technical Reference Manual*. 
3.10 Serial Peripheral Interface

The Soft Macro Model (SMM) implements five PL022 Serial Peripheral Interface (SPI) modules:

- One general-purpose SPI module that connects to the general-purpose SPI connector, J21. An adapter board is available from ARM to mount a microSD card on this connector.
- One color LCD touch screen module control.
- One SPI interface for an ADC on the Arduino shield expansion adapter board.
- Two SPI interfaces for the Arduino shield expansion.

All these SPI interfaces are configured for master mode only.

If you are using the mbed OS, then it is required to connect the microSD card over SPI to provide the file system for the target. For more information on a supported adapter, see the Application Note AN531 uSDCARD SPI Adapter for the Cortex-M Prototyping System (MPS2+).

To purchase the adapter, visit [www.arm.com/mps](http://www.arm.com/mps).
3.11 Color LCD parallel interface

The color LCD module has two interfaces:

- SPI for LCD module that is used for sending image data to the LCD.
- I²C to transfer data input from the touch screen.

These interfaces are connected to a STMicroelectronics STMPE811QTR Port Expander with Advanced Touch Screen Controller on the KEIL MCBSTM32C display board. This display board contains an Ampire AM-240320LG 2.4” Touch Panel. Schematics for this board are listed in the ARM® Versatile™ Express Cortex®-M Prototyping System (V2M-MPS2 and V2M-MPS2+) Technical Reference Manual.

Self-test that is provided with the MPS2+ platform includes example code for both of these interfaces.
3.12 Ethernet

The FPGA design connects SMSC LAN9220 through the AHB to the external memory block.
The Soft Macro Model (SMM) self-test code includes an example code for a simple loopback operation.
The Ethernet interface is supported in mbed.

Related references

2.2 Running the self-test program on page 2-21.
3.13 VGA

The following table shows the memory map for controlling a screen using the VGA interface:

<table>
<thead>
<tr>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x41000000 - 0x4100FFFF</td>
<td>Writes to the current location of the cursor.</td>
</tr>
<tr>
<td>0x41100000 - 0x4110FFFF</td>
<td>512x128 image area at the top right of the screen. 0x41100000 is the top left of the image area and 0x4110FFFF is the bottom right. Pixels are mapped into memory from the base address using an offset address of {YYYYYYYYYYYYYYYY,0b00}, where X and Y are the horizontal and vertical pixel offset respectively.</td>
</tr>
</tbody>
</table>

For the image data, each pixel requires one 32-bit word, therefore, a total of 256KB are needed. The values in the data buffer are packed as 4 bits per channel in the format 0x00000RGB.

The pixel in the top left corner of the display occupies address 0x41100000 with each successive row using an offset of 0x00000400 from the previous row. For example: the Left-Most Pixel (LMP) of the second row is at 0x41100400 and the LMP of the third row is at 0x41100800.
3.14 Audio I²S

A simple FIFO interface generates and receives I²S audio.

The following table describes the memory map for I²S audio registers:

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x40024008</td>
<td>ERROR</td>
<td>Error status register&lt;br&gt;  [31:2] Reserved&lt;br&gt;  [1] Rx overrun. Set this bit to clear.&lt;br&gt;  [0] Tx overrun or underrun. Set this bit to clear.</td>
</tr>
<tr>
<td>0x4002400C</td>
<td>DIVIDE</td>
<td>Divide ratio register (for left or right clock)&lt;br&gt;  [31:10] Reserved&lt;br&gt;  [9:0] LRDIV (Left/Right). The default value is 0x80.&lt;br&gt;  12.288MHz / 48kHz / 2*(L+R) = 128.</td>
</tr>
<tr>
<td>Address</td>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>0x40024010</td>
<td>TXBUF</td>
<td>Transmit Buffer FIFO Data Register. This is a write-only register.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31:16] Left channel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[15:0] Right channel</td>
</tr>
<tr>
<td>0x40024014</td>
<td>RXBUF</td>
<td>Receive Buffer FIFO Data Register. This is a read-only register.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31:16] Left channel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[15:0] Right channel</td>
</tr>
<tr>
<td>0x40024018 - 0x400242FC</td>
<td>RESERVED</td>
<td>-</td>
</tr>
<tr>
<td>0x40024300</td>
<td>ITCR</td>
<td>Integration Test Control Register</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31:1] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[0] ITCR</td>
</tr>
<tr>
<td>0x40024304</td>
<td>ITIP1</td>
<td>Integration Test Input Register 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31:1] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[0] SDIN</td>
</tr>
<tr>
<td>0x40024308</td>
<td>ITOP1</td>
<td>Integration Test Output Register 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31:4] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[3] IRQOUT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[2] LRCK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[1] SCLK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[0] SDOUT</td>
</tr>
</tbody>
</table>
### 3.15 Audio configuration

The FPGA design implements a simple serial interface that is based on I²C. The following table describes the registers for the audio I²C control interface:

| Address    | Name     | Description                                                                 |
|------------|----------|                                                                            |
| 0x40023000 | CONTROL  | Reads from this register return:                                           |
|            |          | 1 Serial Data (SDA) input                                                  |
|            |          | 0 Serial Clock (SCL) output                                                 |
| 0x40023000 | SET[1:0] | Bits written as 0b1 set the appropriate output bit:                        |
|            |          | 1 SDOUTEN_n                                                               |
|            |          | 0 SCL                                                                     |
| 0x40023004 | CLEAR[1:0] | Bits written as 0b1 clear the appropriate output bit:                     |
|            |          | 1 SDOUTEN_n                                                               |
|            |          | 0 SCL                                                                     |
|            |          | Reads from this register return 0b00.                                      |

The serial data is driven LOW when SDOUTEN_n is driven high, otherwise it is configured as an input pin.

The audio I²C control interface drives the Cirrus Logic CS42L52 codec chip on the baseboard.
### 3.16 FPGA system control and I/O

The FPGA design implements an FPGA system control block.

The following table shows the system control and I/O memory map:

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x40028000</td>
<td>LED0</td>
<td>LED connections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31:2] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[1:0] LED</td>
</tr>
<tr>
<td>0x40028004</td>
<td>-</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x40028008</td>
<td>BUTTON</td>
<td>Buttons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31:2] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[1:0] Buttons</td>
</tr>
<tr>
<td>0x4002800C</td>
<td>-</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x40028010</td>
<td>CLK1HZ</td>
<td>1Hz up counter</td>
</tr>
<tr>
<td>0x40028014</td>
<td>CLK100HZ</td>
<td>100Hz up counter</td>
</tr>
<tr>
<td>0x40028018</td>
<td>COUNTER</td>
<td>Cycle Up Counter Increments when the 32-bit prescale counter reaches zero.</td>
</tr>
<tr>
<td>0x4002801C</td>
<td>PRESCALE</td>
<td>Contains the reload value for the prescale counter.</td>
</tr>
<tr>
<td>0x40028020</td>
<td>PSCNTR</td>
<td>32-bit prescale counter – current value of the prescaler counter. The Cycle Up Counter increments when the prescale down counter reaches zero. The prescaler counter is reloaded with PRESCALE after reaching zero.</td>
</tr>
<tr>
<td>0x40028024</td>
<td>-</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x4002804C</td>
<td>MISC</td>
<td>Miscellaneous control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31:7] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[6] CLCD_BL_CTRL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[5] CLCD_RD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[4] CLCD_RS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[3] CLCD_RESET</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[2] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[1] SPI_nSS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[0] CLCD_CS</td>
</tr>
</tbody>
</table>
Chapter 4
Clocks

This chapter describes the source and derived clocks for the FPGA design.

It contains the following sections:

- 4.1 Source clocks on page 4-43.
- 4.2 Derived clocks on page 4-44.
4.1 Source clocks

There are several source clocks for the FPGA design.

The following table shows the source clocks and their respective frequency for the system:

Table 4-1 Source clocks

<table>
<thead>
<tr>
<th>Name</th>
<th>Purpose</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSCCLK[0]</td>
<td>Source clock for system PLL. This generates the system processor clock and ZBT phase shifted clock.</td>
<td>50MHz</td>
</tr>
<tr>
<td>OSCCLK[1]</td>
<td>Source clock for audio PLL. This generates two audio clocks.</td>
<td>24.576MHz</td>
</tr>
<tr>
<td>OSCCLK[2]</td>
<td>Source clock to the peripherals PLL. The output from this PLL is unused.</td>
<td>25MHz</td>
</tr>
<tr>
<td>CFGCLK</td>
<td>Used by the Motherboard Configuration Controller (MCC) to load the Serial Communication Controller (SCC). For more information, see the 5.1 SCC interface overview on page 5-46.</td>
<td>0.5MHz</td>
</tr>
<tr>
<td>CS_TCK</td>
<td>Debugger clock</td>
<td>Determined by the debugger.</td>
</tr>
<tr>
<td>SPICFGCLK</td>
<td>Used by MCC to load the software to the ZBT memories.</td>
<td>7.5MHz</td>
</tr>
</tbody>
</table>
4.2 Derived clocks

There are several derived clocks for the FPGA design.

The following table shows the derived clocks and respective frequencies for the system:

<table>
<thead>
<tr>
<th>Name</th>
<th>Frequency</th>
<th>Division Factor</th>
<th>Multiplication Factor</th>
<th>Derived From</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSCLK</td>
<td>25MHz</td>
<td>2</td>
<td>1</td>
<td>OSCCLK[0]</td>
</tr>
<tr>
<td>DBGCLK</td>
<td>25MHz</td>
<td>2</td>
<td>1</td>
<td>OSCCLK[0]</td>
</tr>
<tr>
<td>SPI LCD</td>
<td>25MHz</td>
<td>2</td>
<td>1</td>
<td>OSCCLK[0]</td>
</tr>
<tr>
<td>SPI CON</td>
<td>25MHz</td>
<td>2</td>
<td>1</td>
<td>OSCCLK[0]</td>
</tr>
<tr>
<td>I2C LCD</td>
<td>25MHz</td>
<td>2</td>
<td>1</td>
<td>OSCCLK[0]</td>
</tr>
<tr>
<td>I2C AUD</td>
<td>25MHz</td>
<td>2</td>
<td>1</td>
<td>OSCCLK[0]</td>
</tr>
<tr>
<td>AUD MCL</td>
<td>12.29MHz</td>
<td>2</td>
<td>1</td>
<td>OSCCLK[1]</td>
</tr>
<tr>
<td>AUD SCL</td>
<td>3.07MHz</td>
<td>8</td>
<td>1</td>
<td>OSCCLK[1]</td>
</tr>
</tbody>
</table>

The system clock is **SYSCLK** in the Table 4-2 Derived clocks on page 4-44.

The clock frequencies are controlled by the configuration file an511_v1.txt located in the following directory:

```text
MPS2+/MB/H810263C/AN511
```

As **OSCCLK[0]** controls the Cortex-M3 DesignStart Eval system clock (**SYSCLK**), it is possible to increase the clock by changing the **OSC0** value. This value can be set from 2MHz to 230MHz, with a 1% accuracy, subject to the constraints of FPGA timing performance.

Note

If the source clocks are changed, you must modify the AN511_SMM_CM3DS.sdc in the `<install_directory>/m3designstart/fpga/AN511_SMM_CM3DS/synthesis/` directory to reflect the new clock frequencies.
Chapter 5
Serial Communication Controller

This chapter describes the Serial Communication Controller (SCC) used in the Cortex-M3 DesignStart Eval FPGA image.

It contains the following sections:
- 5.1 SCC interface overview on page 5-46.
- 5.2 SCC memory map on page 5-47.
5.1 SCC interface overview

The FPGA design implements communication between the microcontroller and the FPGA system through an SCC interface.

The following diagram provides an overview of the SCC interface:

![SCC Interface Diagram](image)

The read addresses and write addresses of the SCC interface do not use bits [1:0].

All address words are word-aligned.
## 5.2 SCC memory map

The following table shows the SCC register memory map:

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00000000</td>
<td>CFG_REG0</td>
<td>[31:0] Reserved</td>
</tr>
<tr>
<td>0x00000004</td>
<td>CFG_REG1</td>
<td>[31:8] Reserved, [7:0] Motherboard Configuration Controller (MCC) LEDs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 Off, 1 On</td>
</tr>
<tr>
<td>0x00000008</td>
<td>CFG_REG2</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x0000000C</td>
<td>CFG_REG3</td>
<td>[31:8] Reserved, [7:0] MCC LEDs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 Off, 1 On</td>
</tr>
<tr>
<td>0x00000010</td>
<td>CFG_REG4</td>
<td>[31:4] Reserved, [3:0] Board revision</td>
</tr>
<tr>
<td>0x00000014</td>
<td>CFG_REG5</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x00000018</td>
<td>CFG_REG6</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x0000001C</td>
<td>CFG_REG7</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x00000020 - 0x0000009C</td>
<td>-</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x000000A0</td>
<td>SYS_CFGDATA_RTN</td>
<td>32-bit serial configuration data. This is a read/write register.</td>
</tr>
<tr>
<td>0x000000A4</td>
<td>SYS_CFGDATA_OUT</td>
<td>32-bit APB configuration data. This is a read/write register.</td>
</tr>
<tr>
<td>0x000000A8</td>
<td>SYS_CFGCTRL</td>
<td>[31] Start (generates interrupt on write to this bit), [30] Read/write access</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[11:0] Device (value of 0/1/2 for supported clocks)</td>
</tr>
<tr>
<td>0x000000AC</td>
<td>SYS_CFGSTAT</td>
<td>[31:2] Reserved, [1] Error, [0] Complete</td>
</tr>
<tr>
<td>0x000000AD – 0x000000FC</td>
<td>-</td>
<td>Reserved</td>
</tr>
<tr>
<td>Address</td>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>0x00000100</td>
<td>SCC_DLL</td>
<td>DLL lock register</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31: 24] Indicate that the DLL lock is masked. These bits are mapped to DLL LOCK MASK[7:0].</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[23:16] Indicate whether the DLLs are locked or unlocked. These bits are mapped to DLL LOCK MASK[7:0].</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[15:1] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[0] Indicates whether all enabled DLLs are locked.</td>
</tr>
<tr>
<td>0x00000104 – 0x00000FF4</td>
<td>-</td>
<td>Reserved</td>
</tr>
<tr>
<td>0x00000FF8</td>
<td>SCC_AID</td>
<td>SCC AID register is a read-only register.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[19:8] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[7:0] Number of SCC configuration registers.</td>
</tr>
<tr>
<td>0x00000FFC</td>
<td>SCC_ID</td>
<td>SCC ID register is a read-only register.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[31: 24] Implementer ID: 0x41 = ARM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[23:20] Application note IP variant number</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[19:16] IP Architecture: 0x4 = AHB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[15:12] Reserved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[11:4] Primary part number: 511 = AN511</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[3:0] Reserved</td>
</tr>
</tbody>
</table>
Chapter 6
FPGA build

This chapter describes the steps that are required to build an FPGA bit file from the supplied source code.

It contains the following sections:

• 6.1 Build flow on page 6-50.
• 6.2 Build requirements on page 6-52.
6.1 Build flow

Cortex-M3 DesignStart Eval includes a prebuilt FPGA image file that is based on an example system. However, if your design is different from the example system, then you are required to build your own FPGA image file.

The build flow involves two stages, which are creating a new user bit file, and loading the bit file onto the MPS2+ platform.

This section contains the following subsections:
- 6.1.1 Creating a user bit file on page 6-50.
- 6.1.2 Loading a new bit file onto the MPS2+ platform on page 6-50.

6.1.1 Creating a user bit file

To create a user bit file, follow these steps:

1. Open the Intel Quartus software.
   a. Select File > Open Project. Navigate to the project file:
      `/m3designstart/fpga/AN511_SMM_CM3DS/synthesis/AN511_SMM_CM3DS.qpf`
   b. Select Processing > Start Compilation to compile the design. This compiles the standard design and creates various report files in the `output_files` folder. After the compilation is completed, an SOF file, titled `AN511_SMM_CM3DS.sof`, is created in the `output_files` folder.

2. Open a terminal window (Linux) or a command prompt (Microsoft Windows).
3. Navigate to the following directory:
   `/m3designstart/fpga/AN511_SMM_CM3DS/synthesis/`
4. Execute the following command:
   `make convert`

This converts the SOF file to an RBF file, titled `an511_01.rbf`, in the current directory.

Note
To allow for a degree of traceability between different user bit files, the final digit can be used as a version number.

The Motherboard Configuration Controller (MCC) for the MPS2+ platform only supports a format of 8:3 characters for the filename, so only one digit is possible as the suffix. To change this digit when generating the RBF file, modify the `REV` variable in the header of the makefile with any text editor. If you provide an RBF file that uses a long file name, the MPS2+ platform will not boot.

6.1.2 Loading a new bit file onto the MPS2+ platform

To load a new user bit file onto the MPS2+ platform, execute the following instructions:

1. Power up the MPS2+ platform, connect a USB cable to your computer and the USB-B port (labeled USB) on the board. The computer recognizes a new USB device called `V2M_MPS2`.
2. Access the MPS2+ platform directory and copy the `an511_XX.rbf` file to the folder `MB\HBI0263C\AN511`.
3. Change which image is being programmed into the FPGA. In the USB device, the `board.txt` file allows you to select which hardware image is programmed into the FPGA. This affects which project to run. The board file is located in the directory `MB\HBI0263C\board.txt`. The image to be loaded is selected with the line starting with `APPFILE:`. A selection of images has been preloaded onto the USB device. All but one has been commented out with a ';' character.
To select an image, remove the comment ‘;’ in front of the appropriate line and ensure that all other
APPFILE: references are preceded by the comment character. In the following example, the board.txt
selects Application Note 511 which is the Cortex-M3 DesignStart Eval.

| BOARD: HBI0263 | TITLE: Motherboard configuration file |
|               | [MCCS] |
|               | MBBIOS: mbb_v217.ebf ; MB BIOS IMAGE |
| processor     | [APPLICATION NOTE] ; Please select the required |
|               | ;APPFILE: AN382/an382_v2.txt ; - Cortex-M0 |
|               | ;APPFILE: AN383/an383_v2.txt ; - Cortex-M0+ |
|               | ;APPFILE: AN384/an384_v2.txt ; - Cortex-M1 |
|               | ;APPFILE: AN385/an385_v2.txt ; - Cortex-M3 |
|               | ;APPFILE: AN386/an386_v2.txt ; - Cortex-M4 |
|               | ;APPFILE: AN399/an399_v2.txt ; - Cortex-M7 |
|               | ;APPFILE: AN400/an400_v2.txt ; - Cortex-M4 with coresight |
|               | ;APPFILE: AN387/an387_v3.txt ; - Cortex-M0 DesignStart |
|               | ;APPFILE: AN511/an511_v1.txt ; - Cortex M3 DesignStart |

4. Specify the bit file to use. Modify the file an511_v1.txt located in the MB\HBI0263C\AN511 folder.
   Use the following line to select which bit file to load:
   F0FILE: an511_v1.rbe ;FPGA0Filename

        Note

ARM supplies an encrypted prebuilt bit file (.rbe) with the MPS2+ platform. If you are rebuilding
the bit file, the file produced is not encrypted (.rbf). Therefore, if you are not using the prebuilt FPGA
image and you are modifying an511_v1.txt, it is necessary to change the file extension from .rbe
to .rbf.

         Note

5. When you have completed steps 3 and 4, save and close both files. Eject the V2M_MPS2 volume using
   Windows Explorer.
6. Press the ON button on the MPS2+ platform. When the bit file completes loading, either the board
   LEDs stop flashing, or a splash screen is displayed on the LCD display. The board is then ready to
   use.

        Note

If the FPGA does not seem to have loaded correctly, then check the log.txt in the root directory of
the MPS2+ platform. This log file contains the details of which files were loaded at boot-up.
6.2 Build requirements

To build the FPGA files, use the Intel Quartus software, version 16.1 onwards.

You can use the Lite Edition of Quartus Prime, which does not require a license.
Chapter 7
Integrating with mbed™ OS

This chapter describes the support available for integrating the FPGA system with mbed OS.

It contains the following section:
• 7.1 Compatibility with mbed™ OS on page 7-54.
7.1 Compatibility with mbed™ OS

The MPS2+ platform is supported as a target in the mbed online compiler.

See https://developer.mbed.org/platforms/ARM-CM3DS/ for more information on:

- Details of the platform.
- Links to the example code.
- mbed Cloud Quick Start application.
Chapter 8
Performance and utilization

This chapter describes the performance, resources, and utilization for the default system of the FPGA design in Cortex-M3 DesignStart Eval.

It contains the following sections:

- 8.1 Performance and clocks on page 8-56.
- 8.2 Utilization of default system on page 8-57.
8.1 Performance and clocks

There are several source and derived clocks in the FPGA board default system.

For details on the clocks used in the default system and their respective frequencies, see Table 4-2 Derived clocks on page 4-44.

ARM recommends that you do not modify the clock frequencies. However, if you require modification of these clock frequencies, see 4.2 Derived clocks on page 4-44.
8.2 Utilization of default system

The FPGA on the MPS2+ platform is an Altera Cyclone V 5CEBA9F31C8.

The following table shows the resources of the FPGA:

<table>
<thead>
<tr>
<th>Resources</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUTs</td>
<td>113 560</td>
</tr>
<tr>
<td>DFFs</td>
<td>454 240</td>
</tr>
<tr>
<td>Memory</td>
<td>3.9Mbit</td>
</tr>
<tr>
<td>DSP</td>
<td>342</td>
</tr>
<tr>
<td>PLLs</td>
<td>7</td>
</tr>
</tbody>
</table>

The following table shows the Cortex-M3 DesignStart Eval code utilization of FPGA resources:

<table>
<thead>
<tr>
<th>Resources</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUTs</td>
<td>20%</td>
</tr>
<tr>
<td>DFFs</td>
<td>6%</td>
</tr>
<tr>
<td>Memory</td>
<td>32%</td>
</tr>
<tr>
<td>DSP</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>PLLs</td>
<td>42%</td>
</tr>
</tbody>
</table>
Appendix A
Revisions

This appendix describes the technical changes between released issues of this book.

It contains the following section:
A.1 Revisions - Cortex®-M3 DesignStart™ Eval

This section describes the technical changes between released issues of this document.

<table>
<thead>
<tr>
<th>Change</th>
<th>Location</th>
<th>Affects</th>
</tr>
</thead>
<tbody>
<tr>
<td>First release</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>