Getting Started

Mpression Sulfur Type-A Development Kit

Revision 1.0

2024/04/10

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Contents

1. Read This First

1.1 Important Information

READ FIRST:
- *READ* this Getting Started before using this product.
- *KEEP* the Getting Started handy for future reference.
- *Do not attempt* to use the product until you fully understand its mechanism.

Purpose of the Product:
- This product is an equipment to support the development and evaluation of a system that uses the Agilex™ 5 SoC FPGA. It provides support for system development in both software and hardware.

  Be sure to use this product correctly for this purpose.

For Users of This Product:
- This product can only be used by operators who have carefully read and understand this manual and "Reference Manual". Use of this product requires a basic knowledge of FPGAs, logic circuits, electric circuits, and microcomputers.

Precautions to be taken when using This Product:
- This product is to be used for development of a program, and the evaluation stage. You cannot install this Board in your product and cannot use this Board for mass-production. When mass-producing a program you have finished developing, be sure to decide at your own responsibility whether it can be put to practical use by performing integration test, evaluation, or some other experiment.
- In no event shall Macnica Inc. be liable for any consequence arising from the use of this product.
- Macnica Inc. shall make effort to provide a workaround or fix for failures of this product, with or without charge. This does not mean, however, that Macnica Inc. guarantees to provide a workaround or fix under all circumstances.
- Macnica Inc. cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this Getting Started and on the product are therefore not all-inclusive. Use this product correctly and safely at your own responsibility.
- Even if a device installed on this product has a failure, it cannot be replaced.
- Not all types of USB peripheral devices and SD cards are guaranteed to operate with this product.
- Not all types of apparatus are guaranteed to connect with the LAN interface of this product.
- Remodeling or damages caused by the customer is not guaranteed.
- This product is a lead-free mounting product.
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Warranty:

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Macnica Inc. cannot exchange products in cases where breakdown is caused for the following reasons:

(1) Misuse, abuse of the product or use under abnormal conditions

(2) Remodeling or repair

(3) A fire, earthquake, fall or other accidents

Figures:

- Some figures in this Getting Started may differ from your system as purchased.

1.2 Developer Information

The Developer of this product is:

Macnica Inc.

1-6-3 Shin-Yokohama, Kouhoku-ku, Yokohama, 222-8561 JAPAN

1.3 Inquires

In case you have any inquiries about the use this product, please contact your local Macnica company or make inquiries through the contact form in the following web site:

http://www.m-pression.com/contact

2. For Ensuring Safe Use

Be sure to follow the instructions given in this Manual which are intended to prevent harm to the user and others as well as material damage.

2.1 Legend

⚠ Danger	Indicates an imminent hazardous situation which if not avoided will result in death or serious injury.
⚠ Warning	Indicates a potentially hazardous situation which if not avoided could result in death or serious injury.
⚠ Caution	Indicates a potentially hazardous situation which if not avoided may result in minor or moderate injury or in property damage.

2.2 Cautions

⚠ Danger	Make sure to use the AC adapter (included in the package) that meets the specification described in this manual. Using an AC adapter not meeting the specifications described in this Manual may cause the kit to emit heat, explode, or ignite.
⚠ Warning	Do not apply strong impacts or blows to the kit. Doing so may cause the kit to emit heat, explode, or ignite, or the equipment in the kit to fail or malfunction. This may also cause fire.
	Do not put the main unit or the AC adapter in cooking appliances such as microwave ovens, or high-pressure containers. Doing so might cause the main unit or AC adapter to emit heat, explode, ignite, or emit smoke, or its parts to break or warp.
	Do not wrap the main unit that is in use with cloth or other materials that are likely to allow heat to build up inside the wrapping. This will cause heat to build up inside the wrapping which may cause the main unit to ignite or malfunction.
	When disposing of the main unit, do not dispose of it along with general household waste. Throwing the main unit into fire may cause it to explode. Dispose of the main unit following the laws, regulations, and ordinances governing waste disposal.
	Do not pull the power supply cable with excessive force or place heavy items on it. Do not damage, break, bundle, or tamper with the power supply cable. Damaged parts of the power supply cable might cause a short circuit resulting in fire or accidents involving electrical shock.
	Do not plug or unplug the power plug with wet or moist hands. This might cause injuries or equipment malfunctions or failures due to electrical shock.

⚠️	**Warning** (Continued from previous page)	Plug the power plug securely into the outlet. If the power plug is not securely plugged into the outlet, it may cause accidents involving electrical shock or fire due to heat emitted.
		Do not connect many electrical cords to a single socket or connect an AC adapter to an outlet that is not rated for the specified voltage. Doing so may cause the equipment to malfunction or fail, or lead to accidents involving electrical shock or fire due to heat emitted.
		Periodically remove any dust accumulated on the power plug and around the outlet (socket). Do not use a power plug with dust accumulated on it because doing so will lead to insulation failure due to moisture which may lead to fire. Remove any dust on the power plug and around the outlet with dried cloth.
		Do not place any containers such as cups or vases filled with water or other liquid on this Board. If this Board is exposed to water or other liquids it may cause the Board to malfunction or lead to accidents involving electrical shock. If you spilled water or other liquid on this Board, immediately stop using the Board, turn off the power, and unplug the power plug. If you have any requests for repairs or technical consultation, please contact the local Macnica company or Mpression inquiry URL.
		Keep this board and accessories out of reach of children. Failure to do so may lead to injuries.
⚠️	**Caution**	Do not place the kit on unstable places such as shaky stands or tilted locations. Doing so may cause injuries or cause this Board to malfunction if the Board should fall.
		Do not attempt to use or leave the kit in places subject to strong direct sunlight or other places subject to high temperatures such as in cars in hot weather. Doing so might cause the kit to emit heat, break, ignite, run out of control, warp, or malfunction. Also, some parts of the equipment might emit heat causing burn injuries.
		Do not use the kit in places subject to extremely high or low temperatures or severe temperature changes. Doing so may cause the kit to fail or to malfunction. Always be sure to use the kit within a temperature range of 5°C to 35°C and a humidity range of 0% to 85%.
		Unplug the power supply cable when carrying out maintenance of devices in which the main unit is embedded. Failure to do so may lead to accidents involving electrical shock.
		Do not place this Board in locations where excessive force is applied to the Board. Doing so may cause the PC board to warp, leading to breakage of the PC board, missing parts or malfunctioning parts.
		When using the kit together with expansion boards or other peripheral devices, be sure to carefully read each of their manuals and to use them correctly. Developer does not guarantee the operation of specific expansion boards or peripheral devices when used in conjunction with this Board unless they are specifically mentioned in this Manual or their successful operation with this Board has been confirmed in separate documents.

Caution (Continued from previous page)	Be sure to turn off the power switch when moving this Board to connect to other devices. Failure to do so may cause this Board to fail or lead to accidents involving electrical shock.
	Do not clean this Board by using a rag containing chemicals such as benzine or thinner. Failure to do so will likely to cause this Board to deteriorate. When using a chemical cloth be sure to comply with any directions or warnings.
	Do not immediately turn on the power if you find that water or moisture had condensed onto the main unit after removing the board from the package. Condensation might occur on this Board when taking it out of the box, if the board is cool yet the room temperature is warm. Do not apply power to the Board while water or moisture has condensed on it because the moisture may cause the Board to break or may shorten the service life of the parts. When you first take this Board out of the box be sure to leave it at room temperature for a while before using it. If condensation or moisture has occurred on this Board, first wait for the moisture to fully evaporate before installing or connecting the Board to other devices.
	Do not disassemble, dismantle, modify, alter, or recycle parts unless they are clearly described as customizable in this Manual. Although this kit is customizable, if parts not specified in this Manual as customizable are modified in any way, then the overall product operation cannot be guaranteed. Please contact the local Macnica company or Mpression inquiry URL beforehand if you wish to customize or modify any parts that are not described in this Manual as customizable.

3. Preparations

3.1 About This Manual

This document describes how to use prebuilt image files to run the Agilex™ 5 SoC FPGA on the Sulfur Type-A Development Kit (hereinafter, this is called "Sulfur Type-A"). The instructions include configuration operations for the FPGA fabric and operations to boot the Arm processor built into the Hard Processor System (HPS) and boot Linux.

This document describes the following:
- Basic specifications of Sulfur Type-A
- Writing SD boot disk for Sulfur Type-A
- Programming FPGA Configuration file (.sof)
- Booting Arm Processors and Running Linux

* Addendum: Sulfur is the name of the development kit that combines a System-on-Module (SoM) with an Agilex™ 5 SoC FPGA and a carrier board with various interfaces. In the descriptions in this document, the terms SoM and carrier board are used differently to refer to target parts.

3.2 Preparations

A. Preparing the Reference Design

The reference design to be provided contains the following:
- FPGA Configuration File (.sof)
- SD boot disk Image (.img)
    The SD boot disk includes:
    - U-Boot & Arm Trusted Firmware (uboot.itb)
    - Linux Kernel (Image)
    - Device Tree Blob (socfpga_agilex5_sulfur.dtb)
    - Root File System
- Golden Hardware Reference Design (GHRD)
- substrate information
    The following items are included in the substrate information.
    - Schematic
    - Bill of Materials
    - Layout

Download the design described above from the following URL:
https://www.rocketboards.org/foswiki/Documentation/MpressionSulfurDevelopmentKitForIntelAgilexR5FPGAESeries

B. Preparing Tools

Prepare the following tools before executing this design:
- Intel® Quartus® Prime Pro Edition Programmer and Tools Version 24.1

- Terminal software like Tera Term (for UART input/output)
- Win32DiskImager (to create SD card boot disk)
  http://sourceforge.net/projects/win32diskimager

Also prepare the following tools for design changes and development work. (This manual does not explain how to use it.)

- Intel® Quartus® Prime Pro Edition Design Software Version 24.1
- Arm* Development Studio for Intel® SoC FPGA
- MCUXpresso Integrated Development Environment (IDE) (for NXP MCU software work)

4. Setup

4.1 Board Specification

This section describes the layout of components on this Board and their specifications.
The following shows the layout of components on this Board.
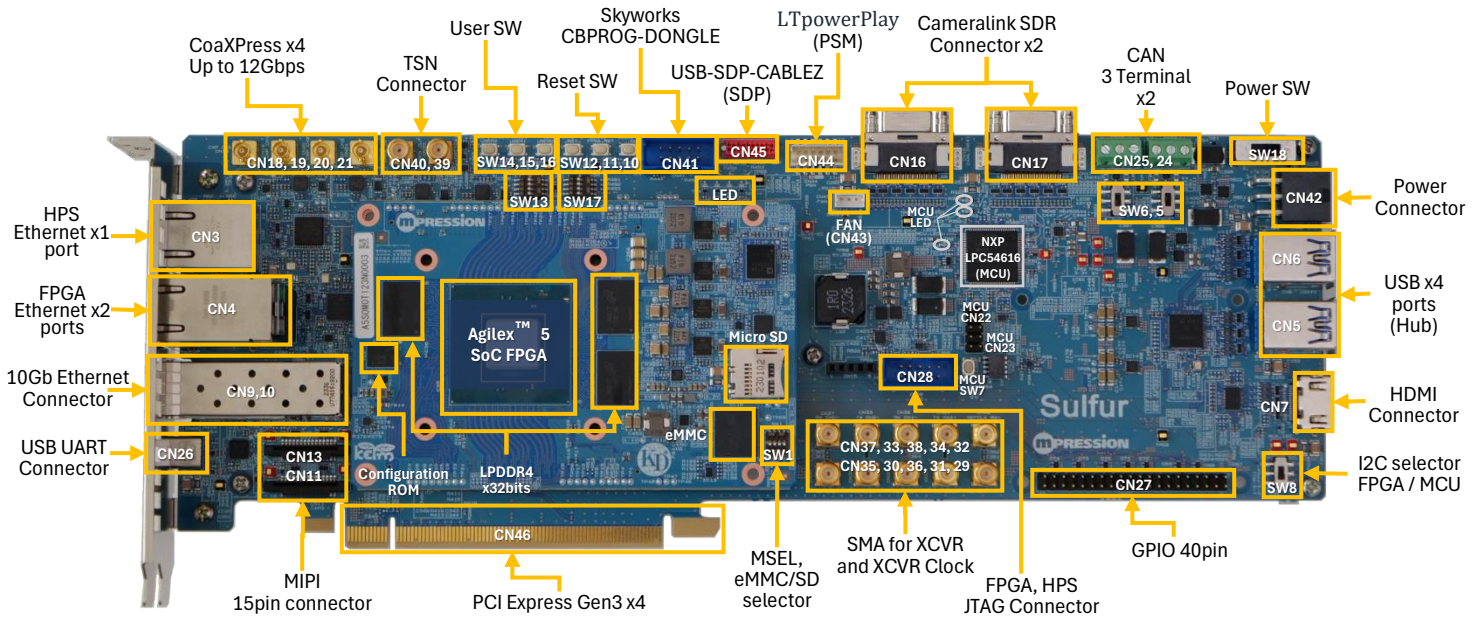
Figure 1 Layout (Top view)
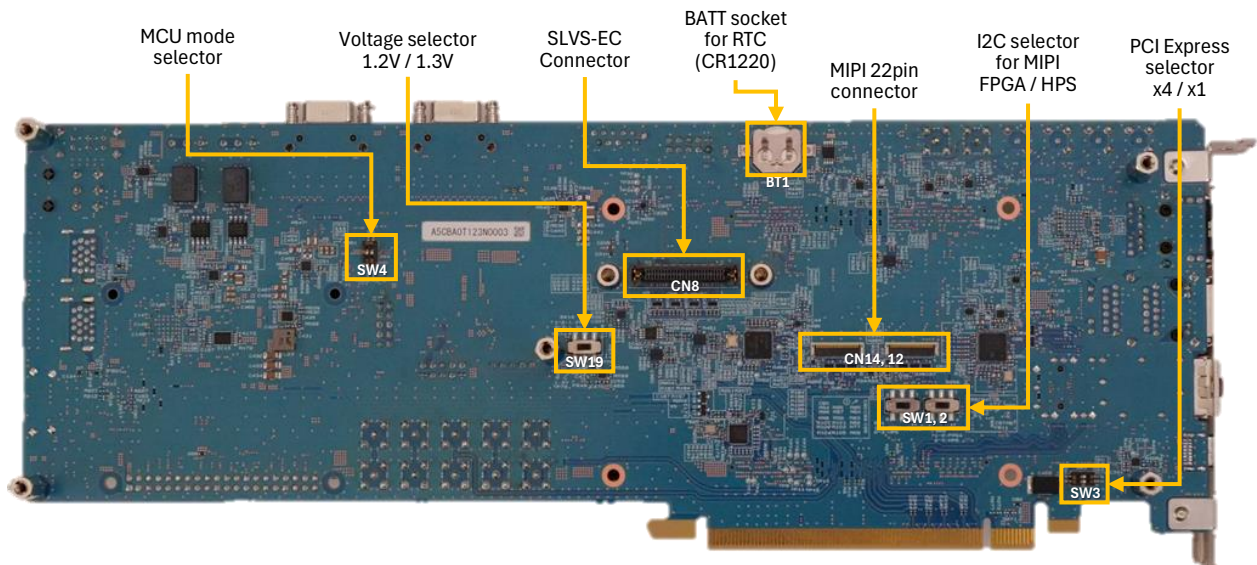
Figure 2 Layout (Bottom view)

Table 1 Main Components of this Board

Reference	Name	Description
SoM		
-	SoM	Agilex™ 5 FPGA E-Series A5ED065BB32AE5SR0
CN1, CN2	Connector for connecting SoM	400 pin 0.635 mm pitch 4 rows BtoB connector Carrier board side: ADM6-100 -1.5 -L-4-2-A (Samtec) SoM side: ADF6-100 -3.5 -L-4-2-A (Samtec)
CN28	JTAG connector	10 pin 2.54 mm pitch FPGA Download Cable II can be connected to debug and configure Agilex™ 5 E-Series SoC FPGA
Gigabit Ethernet		
CN3	LAN Connector (HPS)	RJ45 Connector with built-in pulse transformer
CN4	LAN Connector (FPGA)	2-port RJ45 connector with built-in pulse transformer
10GbE		
CN9, CN10	10GbE ports	SFP+ 20 pin connector, SFP+ cage
USB 3.1/2.0		
CN5, CN6	USB 3.1 connector	2 Type-A Super Speed 2-port connectors
HDMI		
CN7	HDMI connector	Type-A connector
SLVS-EC		
CN8	Connector for SLVS-EC connection	50 pin 0.8 mm pitch 2 rows BtoB connector ERM8-025-05.0-L-DV-L-K (Samtec)
MIPI		
CN11, CN13	MIPI 2 lane port	15 pin 1 mm pitch FFC connector
CN12, CN14	MIPI 4 lane port	22 pin 0.5 mm pitch FFC connector
PCIe		
CN46	PCIe card edge	4 connections (x 16 physical)
Camera Link		
CN16, CN17	Camera Link Connector	26 pin SDR Connector
CoaXPress		
CN18, CN19, CN20, CN21	CoaXPress Connector	Micro BNC
IC19, IC22, IC25, IC28	Transmitter/Receiver	EQCO125X40 (Microchip)
CAN		
CN24, CN25	CAN connector	3-terminal block connector
SW5, SW6	CAN termination switch	Slide switch controls termination ON/OFF
CN23	SWD connector for MCU	1.27 mm pitch 10 pin header, ARM SWD connection
SW4	MCU mode setting switch	Used to specify MCU boot mode
CN22	Pin header for MCU signals	2.54 mm pitch 10 pin header, some MCU ports connected
LED1, LED2, LED3	MCU status LED	MCU operation check LED
UART		
CN26	Connector for UART	USB Type-C
40 pin header		

Reference	Name	Description
CN27	Pin header	2.54 mm pitch 40 pin header, IO pins (28) all connected to HVIO
Switch, LED		
SW10	Push switch for reset	For reconfiguration
SW11	Push switch for reset	FPGA user reset
SW12	Push switch for reset	HPS reset
SW13	User dip switch	3 out of 4 elements can be used, all connected to HVIO
SW14, SW15, SW16	Push switch for user	All connected to HVIO
LED4, LED5, LED6, LED7	User LEDs	All connected to HVIO
SMA		
CN29, CN32	GTS clock input connector	Connects to the transceiver reference clock input
CN30, CN33	GTS transmit channel 0	Connect to transceiver transmit channel
CN35, CN37	GTS receive channel 0	Connect to transceiver receive channel
CN31, CN34	GTS transmit channel 1	Connect to transceiver transmit channel
CN36, CN38	GTS receive channel 1	Connect to the transceiver receive channel
CN39, CN40	TSN sync signal output/input	Connected to PPS output and PPS input of HPS
Clock		
CN41	Connector for CBPROG	Connect CBPROG-DONGLE (Skyworks) and program Si5340B using dedicated software Clock Builder Pro
SW17	X7 switch for setting change	Switching the X7 output frequency
Power input		
CN42	Power input connector	ATX6 pin, +12 V input
SW18	Power switch	Turn +12 V supply to the carrier board ON/OFF
CN43	FAN connector	+12 V output

4.2 Setting Up the Board

4.2.1   External Connection

Set up the board before starting this board. The setup procedure is as follows:

1) Check that the power switch (SW18) is OFF.
2) Connect the AC adapter to the power input connector (CN42).
3) Connect the USB cable to the UART connector (CN26) and your PC.
   =>For the serial console.
4) Connect Intel ® FPGA Download Cable II to the JTAG connector (CN28).
   =>In addition to FPGA configuration applications, it can be used for HPS debugger connections.
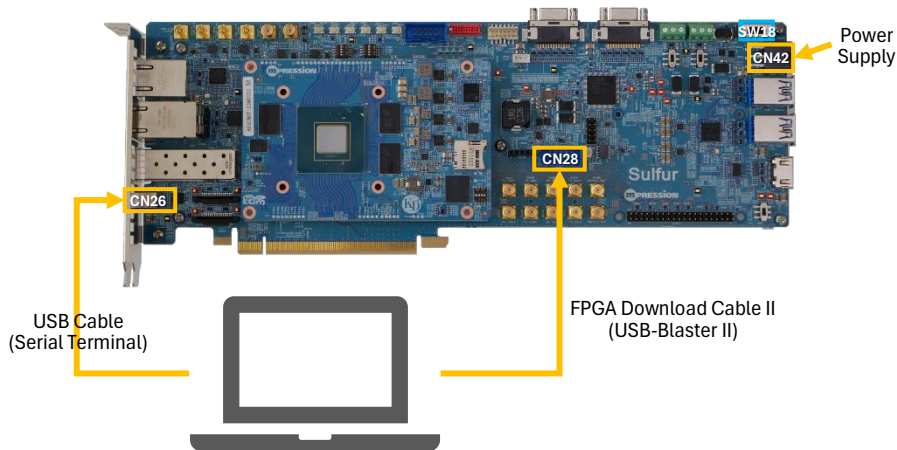

Figure 3 Board Setup

4.2.2   DIPSW/Slide Switch Settings (Carrier Board)

Check the DIPSW and Slide Switch settings on the carrier board.
For the items listed in underlined bold in Table 1 DIPSW/Slide Switches on the Carrier Board, adjust the switch to the underlined bold setting.

Table 1 DIPSW/Slide Switches on the Carrier Board

Reference	Signal name	Settings
SW18	-	Power switch ● 1-2: ON ● 2-3: OFF
SW1, SW2	MIPI1_I2C, MIPI2_I2C	I2C Master Device Selection for MIPI (Setting SW1 for CAMs 1 and 3 and SW2 for CAMs 2 and 4) ● 1-2: FPGA ● 2-3: HPS

Reference	Signal name	Settings
SW3	PCIE_PRSNT	Select the number of lanes supported by PCI-Express. Set the x1 mode in SW3 [1] and the x4 mode in SW3 [2]. ● ON: Enable ● OFF: Disable
SW4	[1] MCU_ISP0, [2] MCU_GPIO0_17	Select the MCU mode. SW4 [1] enables/disables ISP (In-System Programming) mode. ● ON: ISP disabled (boot from internal Flash) ● OFF: ISP enabled (debug/Flash write) SW4 [2] is the MCU user switch (available as the MCU GPIO input) ● ON: Low ● OFF: High
SW5, SW6	CAN0_RES, CAN1_RES	Enable/disable selection of the terminal resistor of the CAN bus. Settings for CAN#0 in SW5 and CAN#1 in SW6 (basically, Enable fixed) ● 1-2: Disable ● 2-3: Enable
SW8	MUX_I2C	Master Device Selection for I2C ● 1-2: MCU ● 2-3: FPGA
SW13	[1:3] FPGA_USER_SW0,1,2 [4] Signal Unassigned	FPGA User Switch (can be used to implement FPGA logic) ● ON: High ● OFF: Low
SW17	[1] SLVS-EC_OSC_FS, [2] HDMI_OSC_FS (NC), [3] SFP_OSC_FS (NC), [4] signal unconnected	Input selection to the FS (Frequency Select) terminal of the crystal oscillator. ([1:3] supports SLVS-EC, HDMI, and SFP settings, respectively) ● ON: Low(FS=0) ● OFF: High(FS=1)
SW19	HSIO_2A_VCCIO	IO voltage selection for FPGA HSIO2A bank. For CameraLink and MIPI I/F (basically fixed at 1.2 V) ● 1 When using -2: 1.2 V MIPI ● 2 When using -3: 1.3 V Cameralink (LVDS)

※ Items grayed out in Table 1 should only be considered when evaluating the relevant interface.

4.2.3   DIPSW Settings (SoM)

Check the DIPSW settings on the SoM.

For the items listed in underlined bold in Table 2 DIPSW on SoM, adjust the switch to the underlined bold setting.

See also the image of SW1 to which the expected setting is applied (Figure 1 SW1 Configuration for SoM.

Table 2 DIPSW on SoM

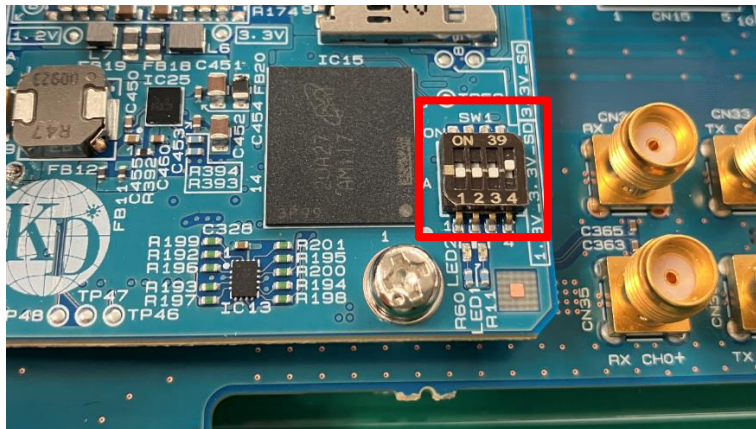| Reference	Signal name	Settings
SW1 [3:1]	MSEL[2:0]	FPGA configuration mode selection ● OFF-OFF-OFF: JTAG mode ● ON-ON-OFF: AS(Fast) mode ● ON-OFF-OFF: AS(Normal) mode
SW1 [4]	SDMMC_SEL	Flash Device Selection for HPS ● ON: SD Card ● OFF: eMMC

Figure 1 SW1 Configuration for SoM

4.3 Creating an SD Boot Disk for Sulfur Type-A

For prebuilt SD card images for Sulfur Type-A, the compressed file format
sdiimage_agilex5_sulfur_*.7z is available from [RocketBoards.org](#).
Unzip the above file to generate sdiimage_agilex5_sulfur_*.img.

This image contains the following files required to run Linux on Sulfur Type-A.
- FIT image file containing U-Boot and Arm Trusted Firmware (ATF bl31)
- Linux Kernel
- Device Tree Blob
- Root File System

Install and use the [Win32 Disk Imager](#) to create an SD Boot Disk in a Windows environment.
Start Win32DiskImager.exe and follow the steps below.
1) Connect the SD card to the PC.
2) Start the Win32 Disk Imager.
3) From the Device pull-down menu, select a drive that recognizes the SD card.
4) Select an unzipped prebuilt SD card image (.img) in the Image File.
5) Click Write.

Figure 2 Writing an SD Card Image

ⓘ **Notes:**

If a partition other than FAT exists on the SD card to be written, format the SD card before writing. Take special care when reusing a card that has already been written Linux image.

The formatting tools available for Windows are also available on the SD Association site.

📄 **Refer to:** [SD Memory Card Formatter for Windows/Mac | SD Association (sdcard.org)](#)

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5. Executing the Design

5.1 Powering on the Board

Load the SD card with the pre-built SD card image (see Section 4.3) into the MicroSD slot.
Then turn the power switch (SW18) ON.

5.2 Setting Up the USB-to-Serial Interface

This board has a USB-to-Serial interface using FTDI FT232R. This board uses CN26 as a USB serial console. In advance, install terminal software such as Tera Term and PuTTY and the device driver for the USB console on the console PC terminal.

5.2.1   Installing the Device Driver for USB-to-Serial

Download the latest Virtual COM Port (VCP) Driver file for your console PC and install the Device Driver for USB-to-Serial from the FTDI URL below.
VCP Drivers - FTDI (ftdichip.com)

5.2.2   Setting up Terminal Software

The following describes how to configure Terminal Software.
- Baud Rate: 115200
- Parity: none
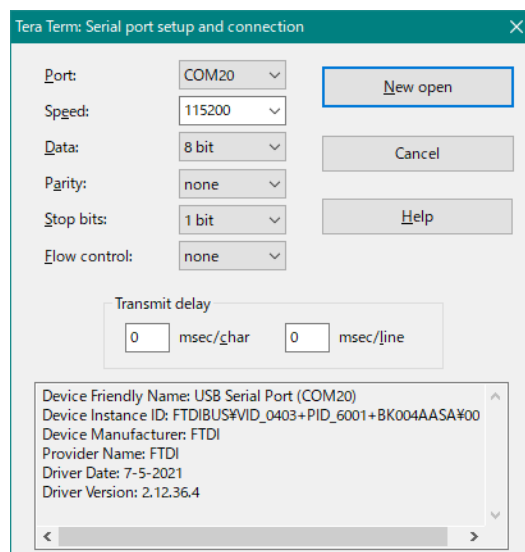- Stop: 1 bit
- Flow Control: none

Figure 3 Terminal Software Configuration Screen (Example: Tera Term)

5.3 Perform Configuration and Boot

5.3.1   Agilex™ 5 Boot Flow

Assumptions include the Agilex™ 5 SoC FPGA boot flow. The Agilex™ 5 SoC FPGA includes a management block called Secure Device Manager (SDM), which manages the entire SoC FPGA device.

When booting the device, the SDM must read a bitstream that contains both the FPGA fabric configuration data and the processor's 1st Stage Bootloader (FSBL).

After FSBL boot, the processor spontaneously reads programs from the SD card and runs.

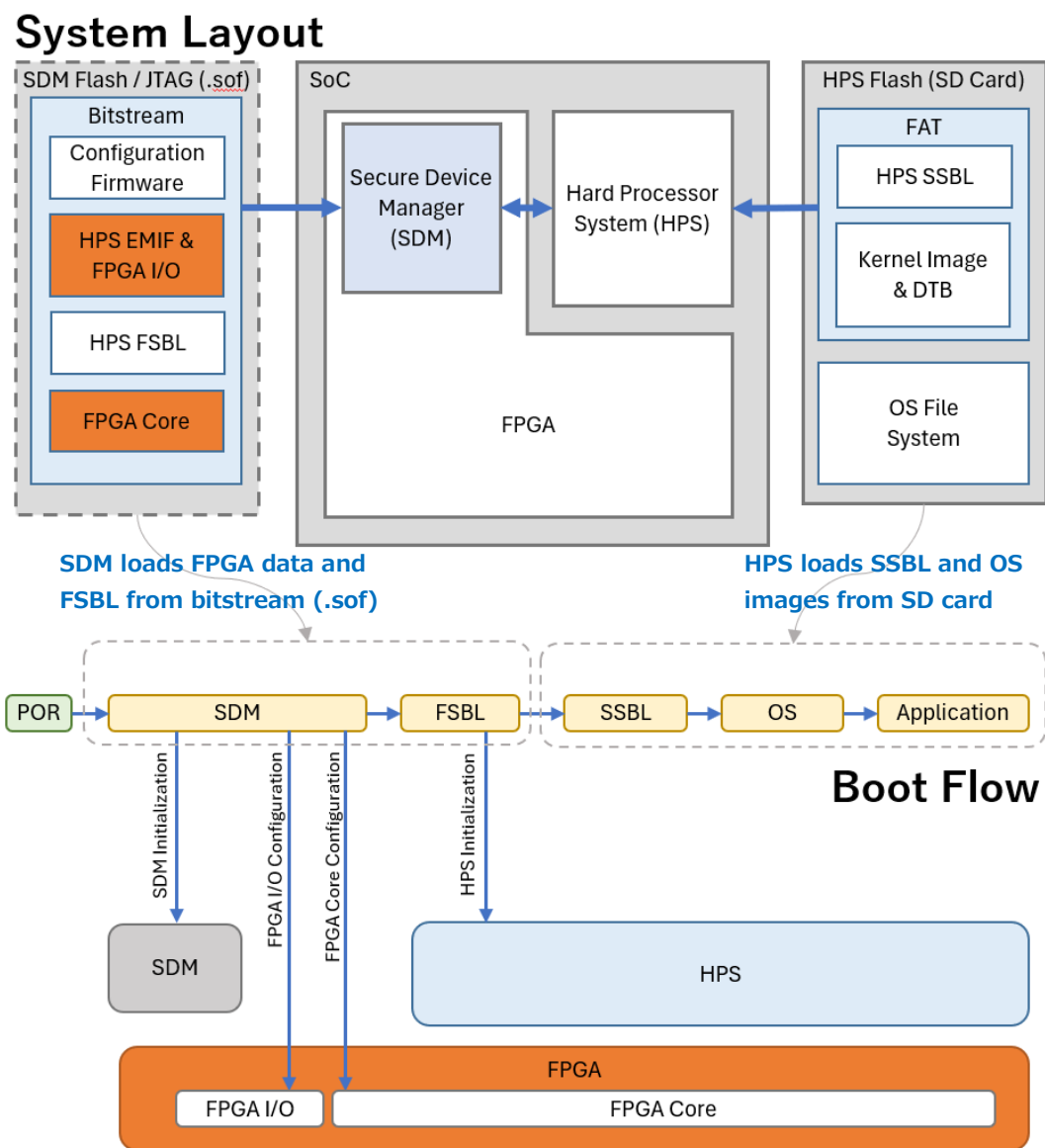See Hard Processor System Booting User Guide: Agilex™ 5 SoCs for more information.

Figure 4 System Layout and Boot Flow for Agilex™ 5

5.3.2 Writing .sof Files

Start the Quartus Programmer and write a .sof file. For the prebuilt .sof file, download sulfur_ghrd_top_hps_*.sof from RocketBoards.org.
*Also check that SW1 [3:1] of SoM is set to OFF-OFF-OFF: JTAG mode.
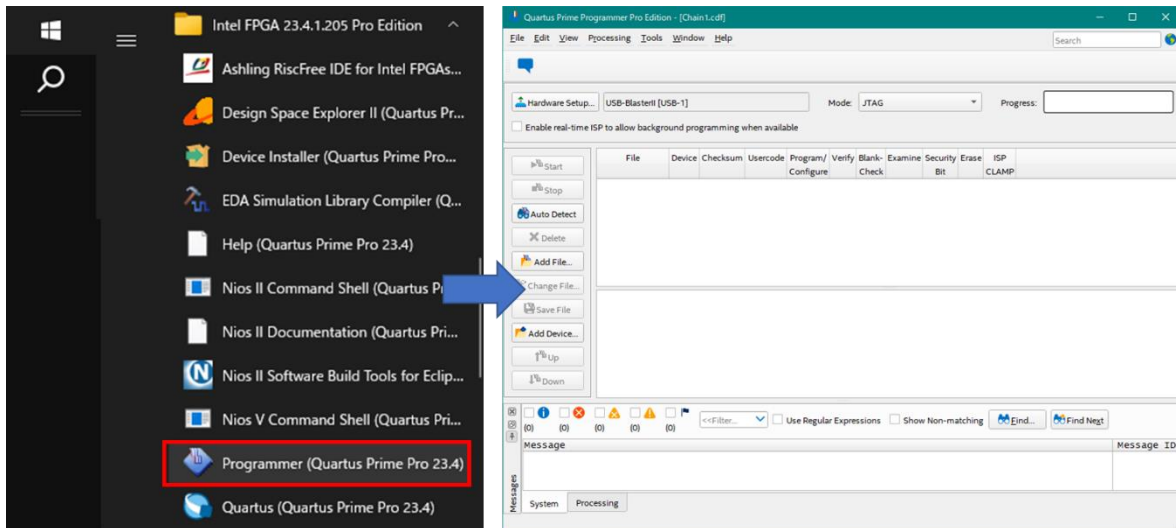
6) Start the Quartus Programmer.

Figure 5 Starting the Quartus Programmer

7) Press the Hardware Setup button to specify the JTAG hardware and clock frequency to connect to. Then click the Auto Detect button.
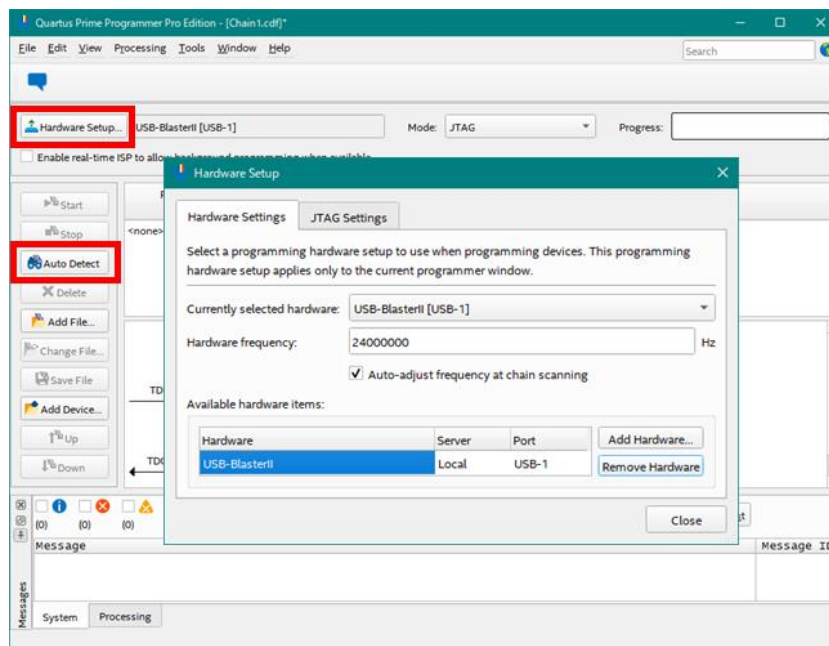

Figure 6 Hardware Setup and Auto Detect

8) With the auto-detected device selected, click the Change File button to select the .sof file to write to. Then check Program/Configure.
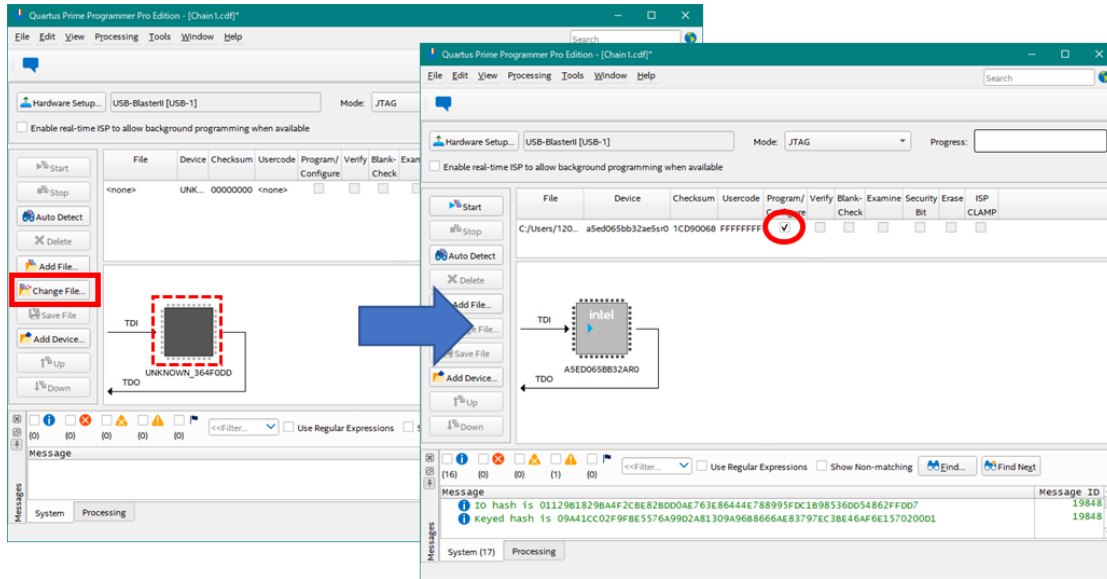

Figure 7 Specifying the .sof File and Program/Configure

9) Click the Start button. If writing is successful, the display will look like the one on the right.
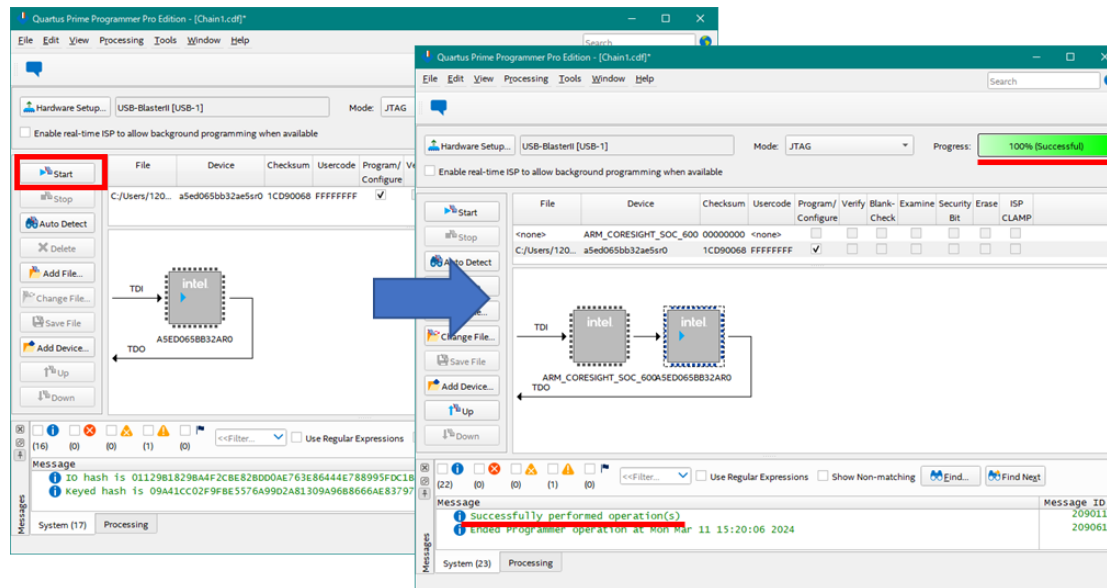

Figure 8 Writing start to completion

The processor will boot as soon as the .sof file has been written.

5.3.3 Check the Serial Terminal and Linux Boot

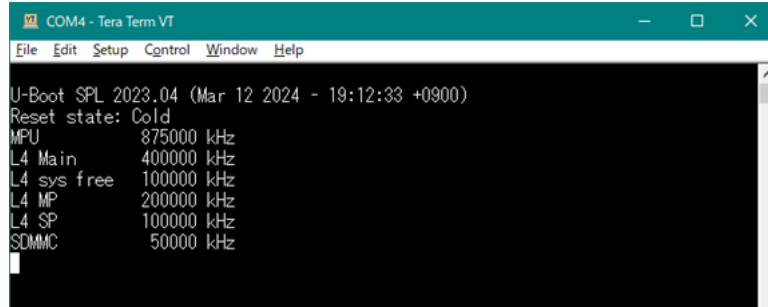Check the operation of the processor using the boot log displayed in the serial terminal.

Figure 9 Terminal Immediately After HPS Boot

When you are finished booting Linux, you will see a login prompt as in Figure 10 Terminal at the end of Linux startup
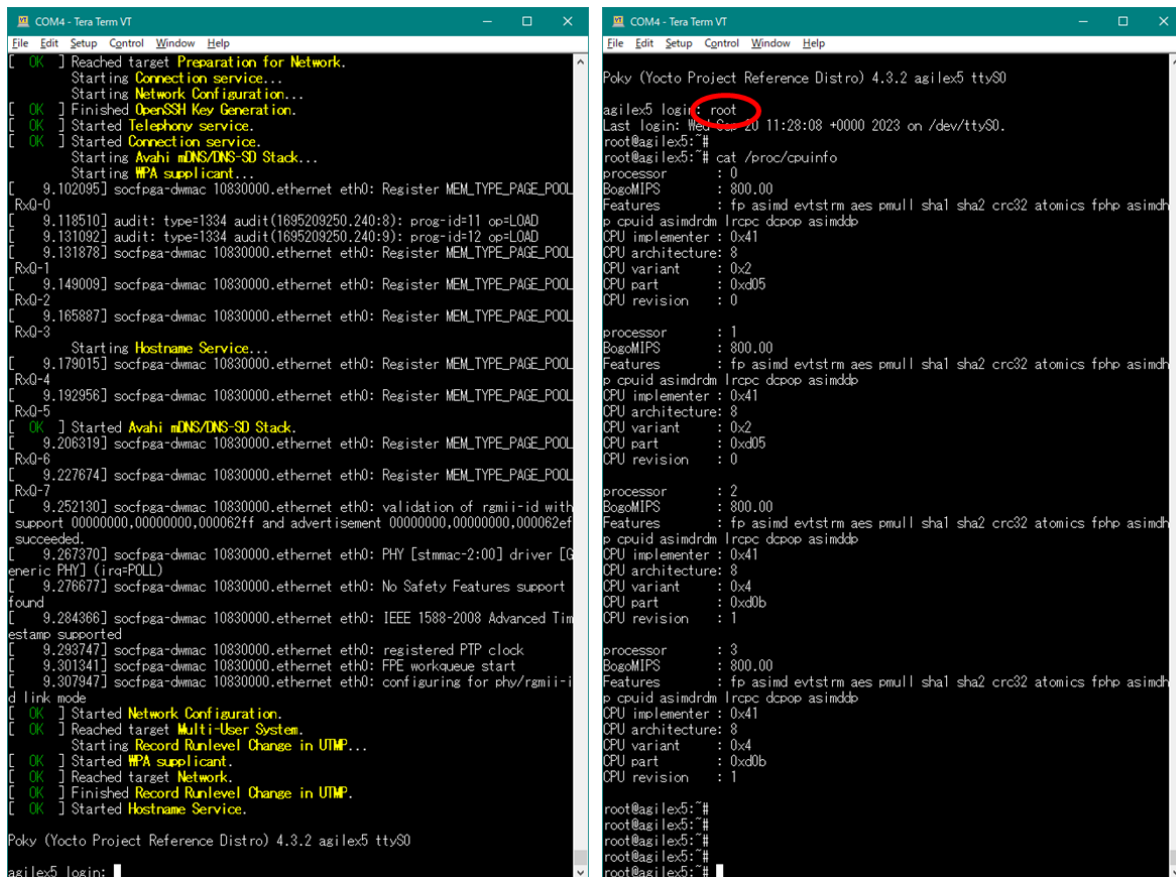Username: root, allows you to log in to Linux without a password.

Figure 10 Terminal at the end of Linux startup

That's all for running the reference design.

6. Reference Information

- Mpression Sulfur Type-A Development Kit by Macnica
  Macnica Sulfur ~ Development Kit for Agilex™ 5 FPGA E-Series ~ | Documentation | RocketBoards.org

- Mpression – Solutions by Macnica Group
  Home | Mpression (m-pression.com)

- Agilex™ 5 FPGA and SoC FPGA - Documentation:
  https://www.intel.com/content/www/us/en/products/details/fpga/agilex/5/docs.html
  - ✓ Agilex™ 5 FPGAs and SoCs Device Overview (intel.com)
  - ✓ Agilex™ 5 FPGAs and SoCs Device Data Sheet (intel.com)
  - ✓ Agilex™ 5 Hard Processor System Technical Reference Manual... (intel.com)
  - ✓ Device Configuration User Guide: Agilex™ 5 FPGAs and SoCs (intel.com)
  - ✓ Hard Processor System Booting User Guide: Agilex™ 5 SoCs (intel.com)

- SoC FPGAs Linux Community Portal:
  RocketBoards.org

7. Document Revision History

Date	Revision	Changes
10 April, 2024	1.0	• Document created
		•
		•