

SCR1 SDK. Altera Arria-V Starter Kit Edition. Quick Start Guide

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Revision History

Version	Date	Description
1.0	2017-08-01	Initial revision
1.1	2019-01-30	Modifications: <ul style="list-style-type: none">• New section: "Windows - USB JTAG Cable drivers installation"• Sections with memory map and IRQ mapping are moved to appendix;• Figure numbering is introduced.
1.2	2019-03-21	OpenOCD section updated for RISC-V debug. JTAG speed requirement added.
1.3	2019-03-29	Fix figures numbers, fix image borders

1. Setup equipment

Arria-V based SCR1 SDK HW platform consist of three mandatory components:

1. Arria V GX FPGA Starter Kit
https://www.altera.com/products/boards_and_kits/dev-kits/altera/kit-arria-v-starter.html
2. CP2104-MINIEK
<http://www.silabs.com/products/development-tools/interface/cp2104-mini-evaluation-kit>
3. ARM-USB-OCD-H
<https://www.olimex.com/Products/ARM/JTAG/ARM-USB-OCD-H/>

Additionally, you may need some wires and cables:

1. Wires: 3 mounting wires
2. Cables:
 - USB A (m) - mini USB B (m)
 - Ethernet cat.5E

1.1. Prerequisites

FPGA board image update is done over the network, so you'll need access to the local network with DHCP capability. Besides of the Arria-V board, you'll need PC, connected to the same network.

IMPORTANT

1. Before the upgrade, please, make sure the board cooling Fan is ON. If not, turn on Fan before power on.
2. To switch on board cooling Fan, move FAN_FORCE DIP switch to ON position at SW. Corresponding DIP is marked by cursor in the figure below



Figure 1. DIP Switch setup

2. SDK HW assembly

2.1. Connecting serial console

In order to get access to the board console, it is required to mount [HSMC Debug Header Breakout Board](#) (included in Arria-V Starter Devkit) and connect [CP2104-MINIEK](#) USB-to-UART converter to the breakout board with external wiring, as described in this section.

2.2. Pins assignment

- Connect CP2104 pin GND to the GND pin on the HSMC Debug board
- Connect CP2104 pin TXD to the 3 pin on the HSMC Debug board
- Connect CP2104 pin RXD to the 4 pin on the HSMC Debug board

- Connect JTAG pin GND to the 38 pin on the HSMC Debug board
- Connect JTAG pin GND to the 36 pin on the HSMC Debug board
- Connect JTAG pin GND to the 34 pin on the HSMC Debug board
- Connect JTAG pin GND to the 32 pin on the HSMC Debug board
- Connect JTAG pin GND to the 30 pin on the HSMC Debug board
- Connect JTAG pin GND to the 28 pin on the HSMC Debug board
- Connect JTAG pin GND to the 26 pin on the HSMC Debug board
- Connect JTAG pin GND to the 24 pin on the HSMC Debug board
- Connect JTAG pin VREF to the 22 pin on the HSMC Debug board
- Connect JTAG pin VREF* to the 21 pin on the HSMC Debug board
- Connect JTAG pin SRSTn to the 35 pin on the HSMC Debug board
- Connect JTAG pin TDO to the 33 pin on the HSMC Debug board
- Connect JTAG pin TCK to the 29 pin on the HSMC Debug board
- Connect JTAG pin TMS to the 27 pin on the HSMC Debug board
- Connect JTAG pin TDI to the 25 pin on the HSMC Debug board
- Connect JTAG pin TRSTn to the 23 pin on the HSMC Debug board

IMPORTANT

For proper JTAG interface functioning JTAG clock (TckFreq) and system clock (SysClkFreq) frequencies must satisfy the following relation: $\text{SysClkFreq} / \text{TckFreq} \geq 12$.

IMPORTANT

You can either connect JTAG port using mounting wires, or apply the existing flat cable from the Olimex kit. For the Olimex kit, some rework will be needed, it also affects couple of unused pins on the header. It is mandatory to cut two wires (19 and 20) in the Olimex cable, as shown below.

The following figures assume the re-worked Olimex cable is used:

1. Wires connection to the CP2104



Figure 2. CP2104 serial interface connection

2. HSMC Debug Board mounting to the Arria-V HMSC header

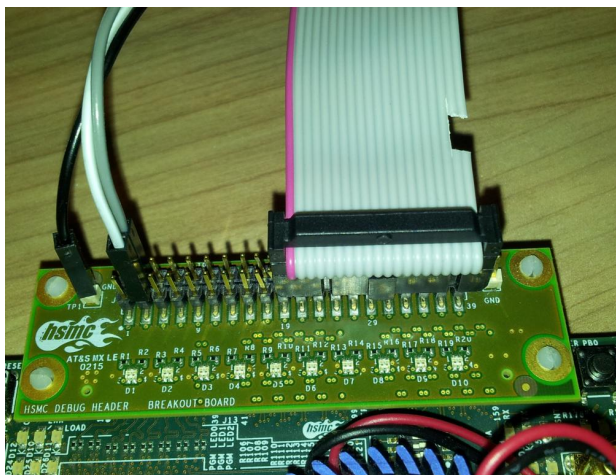


Figure 3. HSMC header connection

3. Resulting setup



Figure 4. Arria V SDK setup

3. Arria-V HW image update

1. Connect board by the ethernet-cable to the network with DHCP-server
2. Power on the board and wait for IP-address to appear at the board LCD-display (IP address may be different):



Figure 5. IP address indication on LCD display

3. Open web browser at PC and open http-connection the IP-address from LCD
4. You will see Board Update Portal page.
5. Press button "Choose File" and set proper file for "Hardware File Name:" (as shown on the Figure), then press the "Upload" button

Upload a New Design to Flash		
Hardware File Name:		Software File Name:
Choose File	tpga_hw.flash	Choose File No file chosen
		Upload

Figure 6. Upload parameters definition

6. Wait for upload completion:

Upload Complete!

Toggle push button **PGM_SEL (S2)** until D25 LED is lighted and then press push button **PGM_CONFIG (S1)** to re-configure the FPGA with the new design.

Figure 7. Upload completion message

7. Power off the board. Flash update is complete.

4. Booting the new FPGA image

IMPORTANT

After FPGA image updated successfully, in order to load the new image, you have to do the following sequence after every power on!

Otherwise (by default), system will boot into standard board update portal image.

1. Press **PGM_SEL (S2)** one time so D25 LED is lighted green.
That selects new image to boot into - otherwise you'll load the default image with Altera board update portal SW.
Corresponding button is marked by cursor in the figure below:



Figure 8. PGM_SEL (S2) button

2. Press **PGM_CONFIG (S1)** once to load the selected image and check **CONFDN (D12)** led is active
Corresponding button is marked by cursor in the figure below:



Figure 9. PGM_CONFIG (S1) button

3. If **CONFDN(D12)** led is not active green and/or **ERR (D10)** led is active red after this step, repeat the flash update sequence, as described in the section “Arria-V HW image update”

5. Resetting the board:

NOTE

Press **PB2** button if you need to reset board to the bootloader.
Corresponding button is in the figure below:

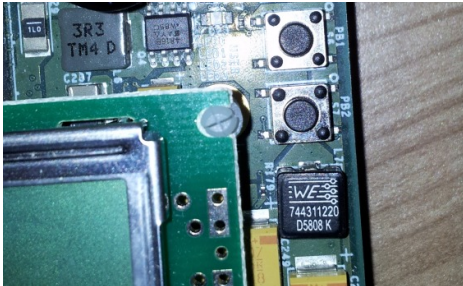


Figure 10. RESET (PB2) button

6. UART connection settings

NOTE

- Bps/Par/Bits - 115200 8N1
- speed - 115200
- bits - 8
- stop bits - 1
- parity - none
- Hardware Flow Control: No

7. Using UART terminal

1. Connect PC to the uart port and open any terminal (minicom is used in the example below)
After reset or FPGA firmware update you will see the bootloader prompt:

```
SCR loader v1.0-scr1_RC
Copyright (C) 2015-2017 Syntacore. All rights reserved.
ISA: RV32IMC [40001104] IMPID: 17101000
BLDID: 17121400
Platform: a5_scr1, cpuclock 30MHz, sysclk 30MHz
Memory map:
00000000-0FFFFFFF      00000000      DDR
F0000000-F001FFFF      00000000      TCM
F0040000-F0040FFF      00000000      MTimer
FF000000-FF0FFFFF      00000000      MMIO
FFFF0000-FFFFFFFF      00000000      On-Chip RAM

1: xmodem load @addr
g: start @addr
d: dump mem
m: modify mem
i: platform info
:
```

1. If you press "i" button you can see additional info about the platform

```
ISA: RV32IMC [40001104] IMPID: 17101000
BLDID: 17121400
Platform: a5_scr1, cpuclock 30MHz, sysclk 30MHz
Memory map:
00000000-0FFFFFFF      00000000      DDR
F0000000-F001FFFF      00000000      TCM
F0040000-F0040FFF      00000000      MTimer
FF000000-FF0FFFFF      00000000      MMIO
FFFF0000-FFFFFFFF      00000000      On-Chip RAM
Platform configuration:
FF010000      irq 0      UART16550
:
```

7.1. Load binary images to the Memory address

TIP | *SCR bootloader supports only .binary files loading using x-modem*

1. Wait for the booloader prompt

```
1: xmodem load @addr
g: start @addr
d: dump mem
m: modify mem
i: platform info
:
```

2. Press button “1”

3. Print required TCM address (in hex) and press “Enter”. “C” character starts to print continuously

```
xload @addr
addr: f0000000
CCCCCCCCCCCCCCC
```

1. Open xmodem upload menu (for minicom terminal you need to press “Ctrl+A” and press “S”). Then select “xmodem”:

```
+--[Upload]--+
| zmodem      |
| ymodem      |
| xmodem      |
| kermi       |
| ascii       |
+-----+
```

1. Press “Enter”. Then select required bin-file for the loading (mark it and press “space” button for minicom).

```
+-----[Select a file for upload]-----+
|Directory: /images/a5/scr1/              |
| [..]                                   |
| dhry21-o3lto.bin                       |
|                                         |
```

1. Press “Enter” button. Image transfer will start.

```
+-----[xmodem upload - Press CTRL-C to quit]-----+
|Sending dhry21-o3lto.bin, 107 blocks: Give your local XMODEM |
|receive command now.                                         |
|Bytes Sent: 13952    BPS:5468                                |
|                                                              |
|Transfer complete                                             |
|                                                              |
| READY: press any key to continue...                         |
+-----+
```

- ```
Xmodem successfully received 13952 bytes
```

## 7.2. Example: Dhrystone run from TCM memory

1. Load **dhry21-o3lto.bin** to the TCM base address (0xf0000000)  
And run test from **0xf0000200** address:

```
1: xmodem load @addr
g: start @addr
d: dump mem
m: modify mem
i: platform info
start @addr
addr: f000200
```

1. After run you will see test results

Dhrystone Benchmark, Version 2.1 (Language: C)

Program compiled without 'register' attribute

Compiler flags: -O3 -funroll-loops -fpeel-loops -fgcse-sm -fgcse-las -flto

HZ 1000000, CPU MHz 30.000

Execution starts, 500 runs through Dhrystone

...

Time: begin= 48999682, end= 49004684, diff= 5002

Microseconds for one run through Dhrystone: 10.004

Dhrystones per Second: 99960

## 7.3. Using OpenOCD

The OpenOCD (Open On-Chip Debugger) is open-source software that interfaces with a hardware debugger's JTAG port. OpenOCD provides debugging and in-system programming for embedded target devices.

### IMPORTANT

When you boot from OpenOCD, you use images in .elf or .bin formats.

### 7.3.1. Installing OpenOCD

Official OpenOCD documentation is available at <http://openocd.org/doc/html/index.html>.

### 7.3.2. Starting the OpenOCD server

1. Setting environment variables:

```
$ export OOCd_ROOT=<Path to the OpenOCD installation directory>
```

2. Server start-up is entered in one line (Ubuntu):



```
$ sudo ${OCD_ROOT}/bin/openocd \
-s ${OCD_ROOT}/share/openocd/scripts \
-f ${OCD_ROOT}/share/openocd/scripts/interface/ftdi/olimex-arm-usb-ocd-h.cfg \
-f ${OCD_ROOT}/share/openocd/scripts/target/syntacore_riscv.cfg
```

or if you build it from sources:

```
$ sudo ${OCD_ROOT}/src/openocd \
-s ${OCD_ROOT}/tcl \
-f ${OCD_ROOT}/tcl/interface/ftdi/olimex-arm-usb-ocd-h.cfg \
-f ${OCD_ROOT}/tcl/target/syntacore_riscv.cfg
```

After execution to the current terminal, you will receive a message about the connection to the RISC-V kernel:

```
Open On-Chip Debugger 0.10.0+dev-01972-g01f0c8951 (2019-03-20-20:10)
Licensed under GNU GPL v2
For bug reports, read
 http://openocd.org/doc/doxygen/bugs.html
sw_reset_halt
Info : Listening on port 6666 for tcl connections
Info : Listening on port 4444 for telnet connections
adapter speed: 2000 kHz
trst_and_srst separate srst_gates_jtag trst_push_pull srst_open_drain
connect_deassert_srst
Info : auto-selecting first available session transport "jtag". To override use
'transport select <transport>'.
riscv.cpu
Info : clock speed 2000 kHz
Info : JTAG tap: riscv.cpu tap/device found: 0xdeb11001 (mfg: 0x000 (<invalid>), part:
0xeb11, ver: 0xd)
Info : riscv.cpu: datacount=2 progbufsize=6
Info : riscv.cpu: Examined RISC-V core; found 1 harts
Info : riscv.cpu: hart 0: XLEN=32, misa=0x40001104
Info : Listening on port 3333 for gdb connections
```

3. Open the second terminal (terminal 2) and enter the command:

```
$ telnet localhost 4444
```

4. OpenOCD is up and ready to go. This terminal is an interactive console OpenOCD.  
The help command lists the available openocd commands

### 7.3.3. Downloading and running an image using OpenOCD

1. The load command is entered in the OpenOCD console (terminal 2):

```
halt ; load_image dhry21-o3lto.bin 0xf0000000 bin ; resume 0xf0000200
```

or

```
halt ; load_image dhry21-o3lto.elf 0x0 elf ; resume 0xf0000200
```

**IMPORTANT**

The boot command assumes the location of the file in the current directory. For a different location, the name of the uploaded file must include a relative path.

2. After entering the command, the progress of the load is displayed
3. After the download is complete, the image will start with log output to the uart terminal:

```
Dhrystone Benchmark, Version 2.1 (Language: C)
```

```
Program compiled without 'register' attribute
```

```
Compiler flags: -O3 -funroll-loops -fpeel-loops -fgcse-sm -fgcse-las -flto
```

```
HZ 1000000, CPU MHz 30.000
```

```
Execution starts, 500 runs through Dhrystone
```

```
...
```

```
Time: begin= 48999682, end= 49004684, diff= 5002
```

```
Microseconds for one run through Dhrystone: 10.004
```

```
Dhrystones per Second: 99960
```

# 8. Building SDK FPGA-project for the Arria V GX SDK

## 8.1. General structure of the SDK project

The composition of the SDK folders is:

- doc - SDK and SCR1 user guides
- fpga
  - a5
    - scr1 - DE10-Lite FPGA project
      - ip - additional RTL IPs + bootloader image
        - uart - Opencores UART 16550 IP
  - arty
  - de10lite
- images
  - a5
    - scr1 - pre-built FPGA image
  - arty
  - de10lite
- scr1 - SCR1 repository, included as sub-module
  - src - SCR1 core RTL sources
- sw
  - fsbl - FPGA-bootloader
  - tests - some benchmark tests

Essential files: FPGA project file - a5\_sdk.qpf (fpga/a5/scr1/a5\_sdk.qpf)

Top module - a5\_sdk (fpga/a5/scr1/a5\_sdk.sv)

## 8.2. Additional requirements for compilation

FPGA build requires "Altera Quartus 13.0.1 Build 232" tool or earlier.

### NOTE

FPGA-project compilation was verified for "Altera Quartus 13.0.1 Build 232" Full version on Linux xUbuntu 16.04 with 8 GB of RAM.

Some build steps may be different for other Quartus versions.

Quartus Full version is required for a non time-limited HW firmware generation.

## 8.3. Building SDK FPGA project

The step-by-step FPGA project build procedure is described below:

### 8.3.1. FPGA firmware generation (sof-format)

- Run Quartus 13.0.1 in GUI-mode
- Select and open fpga-project file (a5\_sdk.qpf)
- Press "Start Compilation" button or select from menu Processing → "Start Compilation"

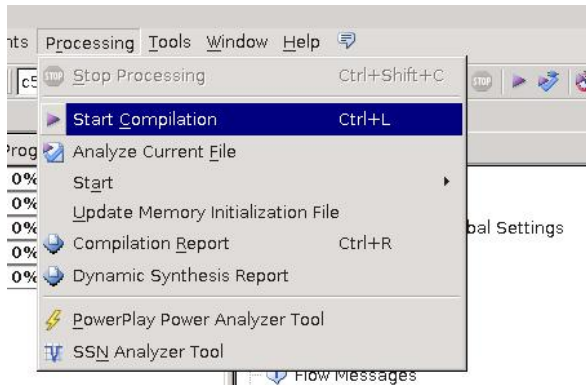


Figure 11. Selection of the "Start Compilation" option

- Wait for the compilation to complete (build time is typically 10-15 minutes)
- New "output" subfolder should appear in the "fpga" folder. It contains **a5\_sdk.sof** file (Arria V GX FPGA image in sof-format).

### 8.3.2. Converting FPGA-image to the board flash memory image (flash-format)

- Open bash console and run  
`<PATH_TO_QUARTUS_ROOT_DIR>/nios2eds/nios2_command_shell.sh`

```
$ <PATH_TO_QUARTUS_ROOT_DIR>/nios2eds/nios2_command_shell.sh

Altera Nios2 Command Shell [GCC 4]

Version 13.0sp1, Build 232

```

- Run sof2flash programm with arguments below

```
sof2flash --input=<PATH_TO_A5_SOF>/a5_sdk.sof --output=./a5_hw.flash
--offset=0x01640000 --pfl --optionbit=0x00018000 --programmingmode=FPP
```

- Wait for the generation to complete

Info: \*\*\*\*\*

Info: Running Quartus II 32-bit Convert\_programming\_file

Info: Version 13.0.1 Build 232 06/12/2013 Service Pack 1 SJ Full Version

Info: Copyright (C) 1991-2013 Altera Corporation. All rights reserved.

Info: Your use of Altera Corporation's design tools, logic functions

Info: and other software and tools, and its AMPP partner logic

Info: functions, and any output files from any of the foregoing

Info: (including device programming or simulation files), and any

Info: associated documentation or information are expressly subject

Info: to the terms and conditions of the Altera Program License

Info: Subscription Agreement, Altera MegaCore Function License

Info: Agreement, or other applicable license agreement, including,

Info: without limitation, that your use is for the sole purpose of

Info: programming logic devices manufactured by Altera and sold by

Info: Altera or its authorized distributors. Please refer to the

Info: applicable agreement for further details.

Info: Processing started: Thu Nov 23 15:49:43 2017

Info: Command: quartus\_cpf -c a5\_hw.cof

Info (210033): Memory Map File a5\_hw.map contains memory usage information for file a5\_hw.pof

Info: Quartus II 32-bit Convert\_programming\_file was successful. 0 errors, 0 warnings

Info: Peak virtual memory: 162 megabytes

Info: Processing ended: Thu Nov 23 15:49:59 2017

Info: Elapsed time: 00:00:16

Info: Total CPU time (on all processors): 00:00:16

Info: \*\*\*\*\*

Info: Running Quartus II 32-bit Convert\_programming\_file

Info: Version 13.0.1 Build 232 06/12/2013 Service Pack 1 SJ Full Version

Info: Copyright (C) 1991-2013 Altera Corporation. All rights reserved.

Info: Your use of Altera Corporation's design tools, logic functions

Info: and other software and tools, and its AMPP partner logic

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Info: Agreement, or other applicable license agreement, including,

Info: without limitation, that your use is for the sole purpose of

Info: programming logic devices manufactured by Altera and sold by

Info: Altera or its authorized distributors. Please refer to the

Info: applicable agreement for further details.

Info: Processing started: Thu Nov 23 15:49:59 2017

Info: Command: quartus\_cpf -c a5\_hw.pof a5\_hw.hexout

Info: Quartus II 32-bit Convert\_programming\_file was successful. 0 errors, 0 warnings

Info: Peak virtual memory: 126 megabytes

Info: Processing ended: Thu Nov 23 15:50:26 2017

Info: Elapsed time: 00:00:27

Info: Total CPU time (on all processors): 00:00:27

Extracting Option bits SREC  
Extracting FPGA Image SREC  
Deleting intermediate files

- Flash memory image (a5\_hw.flash) is generated in the current folder  
Flash update steps described in section 3

### 8.3.3. SDK-specific pins assignment in FPGA-project

Most of the pins assignments of the SDK project "inherit" from the basic design:

[Arria V GX Starter Board Reference Manual](#)

SDK-specific connection pins are used for interfaces UART0 and OpenOCD/JTAG. The purpose of these pins is shown below:

Table 1. SDK-specific pins assignment

| FPGA-pin | Port name   | I/O Standard | Description      |
|----------|-------------|--------------|------------------|
| PIN_AJ10 | uart0_rxd   | 2.5V         | Input UART RXD   |
| PIN_AH10 | uart0_txd   | 2.5V         | Output UART TXD  |
| PIN_AJ6  | jtag_trst_n | 2.5V         | Input JTAG TRSTn |
| PIN_AH6  | jtag_tdi    | 2.5V         | Input JTAG TDI   |
| PIN_AC6  | jtag_tms    | 2.5V         | Input JTAG TMS   |
| PIN_AC7  | jtag_tck    | 2.5V         | Input JTAG TCK   |
| PIN_AM3  | jtag_tdo    | 2.5V         | Inout JTAG TDO   |
| PIN_AD9  | jtag_vcc[0] | 2.5V         | Output JTAG VCC  |
| PIN_AM11 | jtag_vcc[1] | 2.5V         | Output JTAG VCC  |
| PIN_AL12 | jtag_gnd[0] | 2.5V         | Output JTAG GND  |
| PIN_AK12 | jtag_gnd[1] | 2.5V         | Output JTAG GND  |
| PIN_AM13 | jtag_gnd[2] | 2.5V         | Output JTAG GND  |
| PIN_AL13 | jtag_gnd[3] | 2.5V         | Output JTAG GND  |
| PIN_AH12 | jtag_gnd[4] | 2.5V         | Output JTAG GND  |
| PIN_AG12 | jtag_gnd[5] | 2.5V         | Output JTAG GND  |
| PIN_AJ13 | jtag_gnd[6] | 2.5V         | Output JTAG GND  |
| PIN_AH13 | jtag_gnd[7] | 2.5V         | Output JTAG GND  |

## 8.4. SCR1 SDK FPGA-project functional description

### 8.4.1. Common project structure

The SDK project is configured and ready to be built immediately from the repository. The project contains the following main modules:

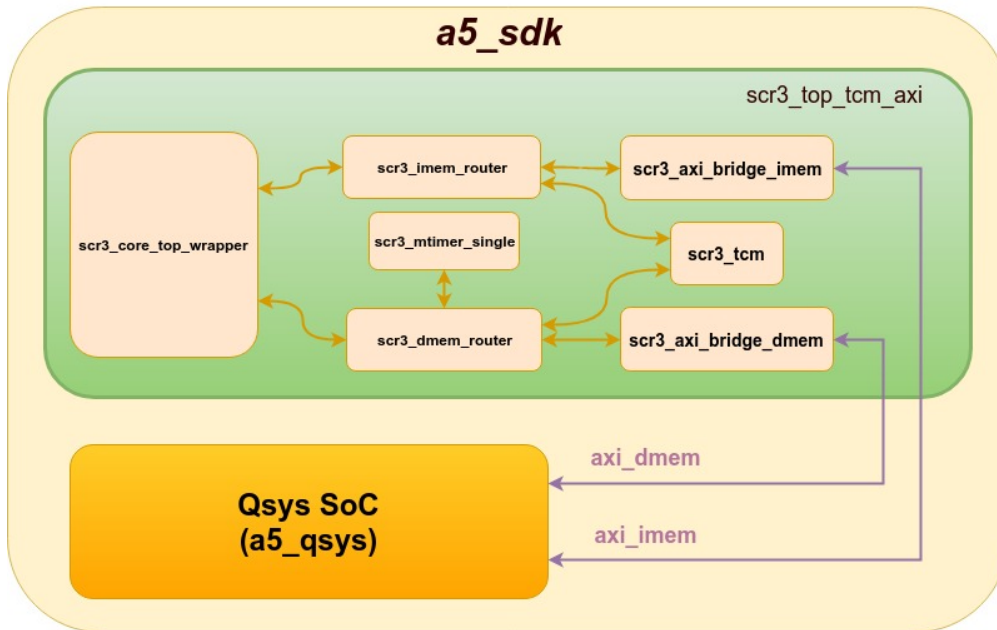


Figure 12. Arria V SDK FPGA project structure

Modules description:

- **SCR1-core** - (supplied as an SystemVerilog RTL, is available from the repository)
- **Two data routers** - (imem\_route/dmem\_router - instruction/data transfers, supplied as an SystemVerilog RTL, is available from the repository)
- **Two AXI bridges** - (axi\_imem/axi\_dmem - instruction/data transfers, supplied as an SystemVerilog RTL, is available from the repository)
- **Timer block** - (external timer block, supplied as an SystemVerilog RTL, is available from the repository)
- **scr1\_tcm** - (Tightly Coupled Memory (TCM), supplied as an SystemVerilog RTL, is available from the repository)
- **UART 16550** - (Opencores UART 16550 IP, supplied as an Verilog RTL, is available from the repository)
- **Qsys SoC block** - (Qsys component, containing the generated IP-components)

### 8.4.2. Qsys SoC module structure

Qsys SoC module consists of:

- BUILD ID
- Onchip RAM

- DDR3 controller
- UART Bridge
- Qsys Default slave

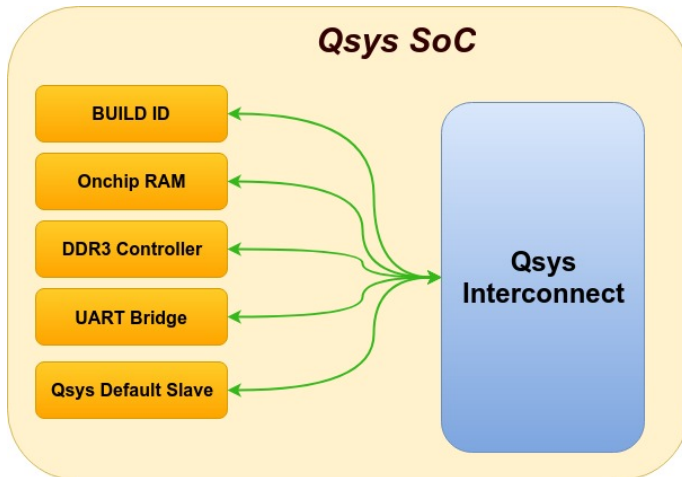


Figure 13. Arria V SDK QSys SOC module structure

### 8.4.3. Description of the blocks used in the SDK project

#### 8.4.3.1. SCR1-core

Syntacore RISC-V core.

The core is supplied as SystemVerilog RTL sources.

A detailed description of the external interfaces of the core and other details are described in the document "SCR1 External Architecture Specification".

#### 8.4.3.2. AXI bridge

The AXI bridge module is used to convert the internal interface of the core to the external interface that is compatible with AXI4 for external memory access. The module is provided in the source code (RTL) and contains an intermediate buffer for the external interface requests.

#### 8.4.3.3. Opencores UART 16550 IP

There is a 16550 compatible (mostly) UART core. The bus interface is WISHBONE SoC bus Rev. B.

Features all the standard options of the 16550 UART: FIFO based operation, interrupt requests and other.

[UART 16550 core project](#)

### 8.4.4. Description of the IP-components of the module Qsys SOC

Detailed description of Altera's common Qsys components used in the project:

- [Embedded Peripheral IP User Guide](#)
- [Qsys System Design Tutorial](#)
- [Qsys Interconnect](#)



#### **8.4.4.1. BUILD ID**

PIO-block contains the project build date parameter, which is available for reading by the processor.

The parameter FPGA\_A5\_BUILD\_ID is defined in the file scr1\_arch\_custom.svh.

Component base address - 0xFF000000.

#### **8.4.4.2. Onchip RAM**

Internal bootload memory with bootloader code resides in the FPGA.

Memory size - 64KB.

Memory base address - 0xFFFF0000.

Memory initialization data is supplied in a5\_sdk.hex (hex format). The code and instructions for building the bootloader are available from the current repository.

Further details:

[http://www.altera.com/literature/hb/qts/qts\\_qii54006.pdf](http://www.altera.com/literature/hb/qts/qts_qii54006.pdf)

#### **8.4.4.3. DDR3 Controller**

The component is used to configure and manage external DDR3 memory using the Hard-IP block for the FPGA family Arria V. The component is configured to work with an external memory of 256MB at DDR3 266(533) MHz.

Component base address - 0x00000000.

Further details:

<http://www.altera.com/support/literature/lit-external-memory-interface.html>

#### **8.4.4.4. UART Bridge**

Altera avalon bridge for the Opencores UART 16550 IP.

Component base address - 0xFF010000.

#### **8.4.4.5. Qsys Default slave**

The slave responder component by "default". The main function is to generate an error status for any transactions in the unused ranges of the addresses of the Qsys SoC.

## 9. Appendix A. SDK Memory Map

Memory map is shown in the table below:

*Table 2. SCR1 Arria V GX SDK memory map*

| Base address | Size   | Block name | Description                     |
|--------------|--------|------------|---------------------------------|
| 0xFFFF0000   | 64 KB  | Onchip RAM | Internal memory                 |
| 0xFF010000   | 32 B   | UART       | UART 16550                      |
| 0x00000000   | 256 MB | DDR3       | External DDR3 memory            |
| 0xF0000000   | 128 KB | TCM        | Internal Tightly-Coupled Memory |
| 0xFF000000   | 16 B   | BLD ID     | Build ID register (Read only)   |
| 0xFFFFFFFF80 | 4 B    | MTVEC      | MTVEC init value                |
| 0xFFFFFFFF00 | 4 B    | RESET      | RESET value                     |

## 10. Appendix B. SDK IRQs

The connection scheme for interrupt lines is given below:

*Table 3. SCR1 core IRQ connection*

| IRQ line for the SCR1 core | IRQ init block                   |
|----------------------------|----------------------------------|
| 0                          | UART (UART 16550)                |
| 1-31                       | Not connected (constant level 0) |

# 11. Appendix C. Software build instructions

This build guide describes how to build software provided as a part of the SCR1 SDK.

## 11.1. SCR bootloader

### 11.1.1. Getting the sources

```
$ git clone git@github.com:syntacore/sc-bl.git
```

### 11.1.2. Building SCR bootloader

Follow the instructions in `sc-bl/README.md` to build bootloader for target plaforms ('`scbl.hex`' for Terasic DE10-Lite, '`scbl.mem`' for Digilent Arty and Nexys4DDR).

## 11.2. Zephyr OS

### 11.2.1. Getting the sources

```
$ git clone git@github.com:syntacore/zephyr.git
```

### 11.2.2. Building Zephyr OS

Follow the instructions in [https://www.zephyrproject.org/doc/getting\\_started/getting\\_started.html](https://www.zephyrproject.org/doc/getting_started/getting_started.html) and `zephyr/README.md` to build Zephyr OS image for target plaform.

## 11.3. SCR1 OpenOCD

### 11.3.1. Getting the latest release

The latest release (`sc-riscv-0.10.0-1972`) can be downloaded from the link:  
<https://github.com/syntacore/openocd/releases>  
or you can build it from sources.

### 11.3.2. Getting the sources

```
$ git clone -b syntacore https://github.com/syntacore/openocd
```

### 11.3.3. Building and using OpenOCD

Please, refer to the Syntacore OpenOCD wiki page for instructions: <https://github.com/syntacore/>

### 11.3.4. Windows - USB JTAG Cable drivers installation

In order to use Olimex and Digilent JTAG cable with the OpenOCD the correct drivers should be installed at the host PC. After cable is connected to the host PC, the properly installed drivers should appear in the device manager as shown in the figure below:

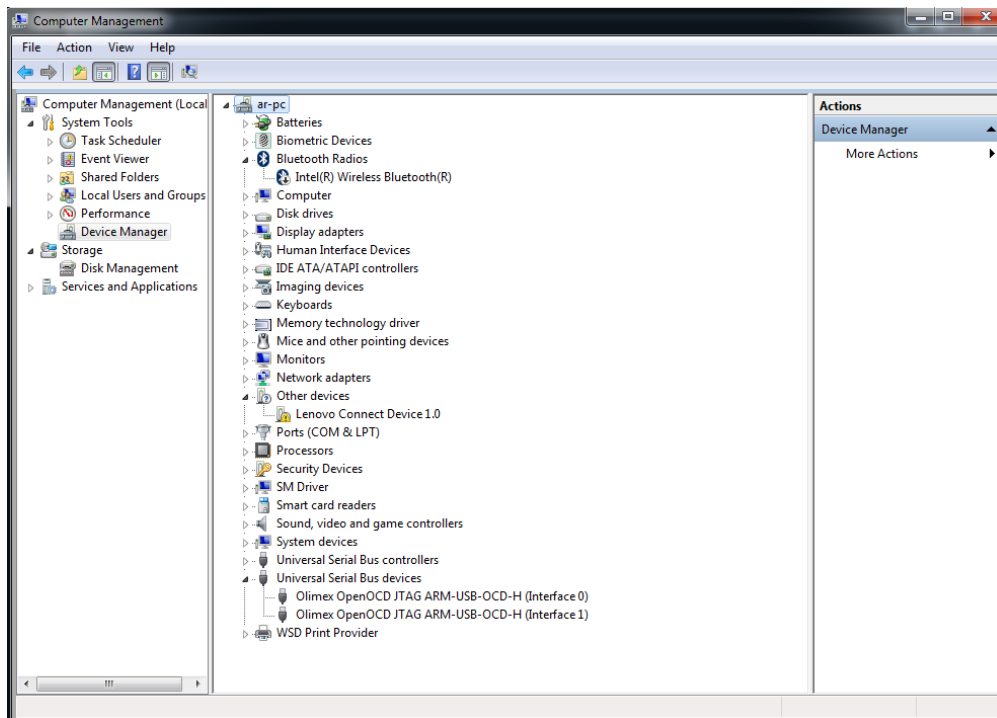


Figure 14. Windows device manager with properly installed USB JTAG Cable drivers

If your system doesn't recognize devices properly (as in the figure below), you may need to install the latest available drivers.

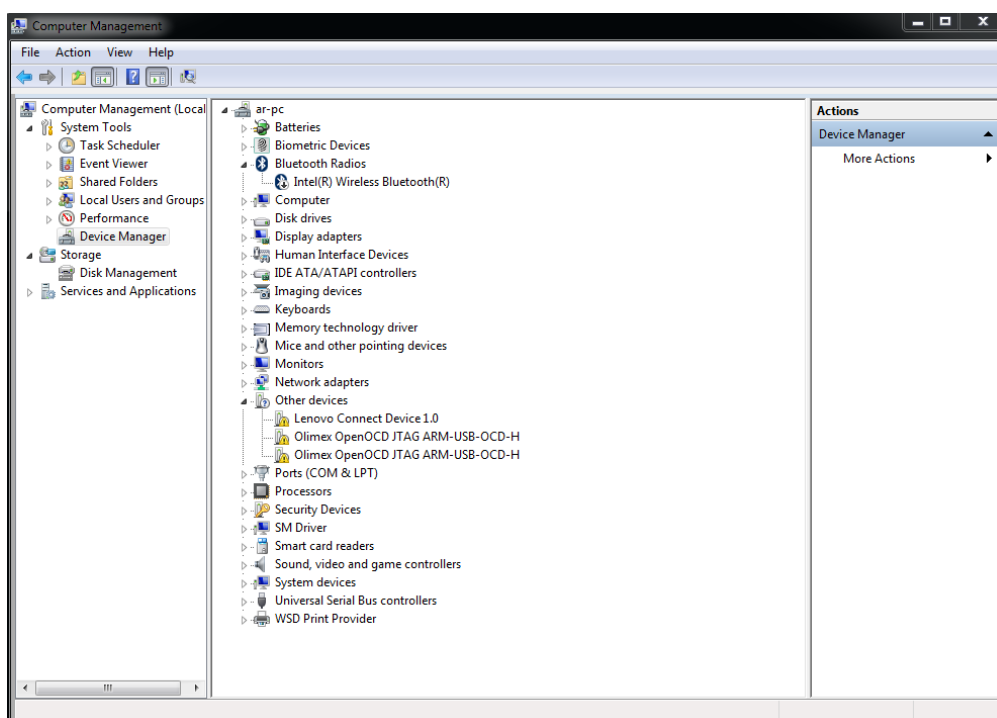


Figure 15. Windows device manager: USB JTAG Cable drivers are not installed

In many cases, generic WinUSB driver by Microsoft, which can be enforced using Zadig application, can solve the problem:

<http://zadig.akeo.ie/>

### IMPORTANT

Be very very careful! You should see and select the exactly proper USB device/channel before pressing 'Zadig' WinUSB replace driver button! Don't press button with no selection or without proper selection!

To apply WinUSB driver to Olimex and Digilent devices, just start application, make sure "Options→ List all devices" menu item is checked:

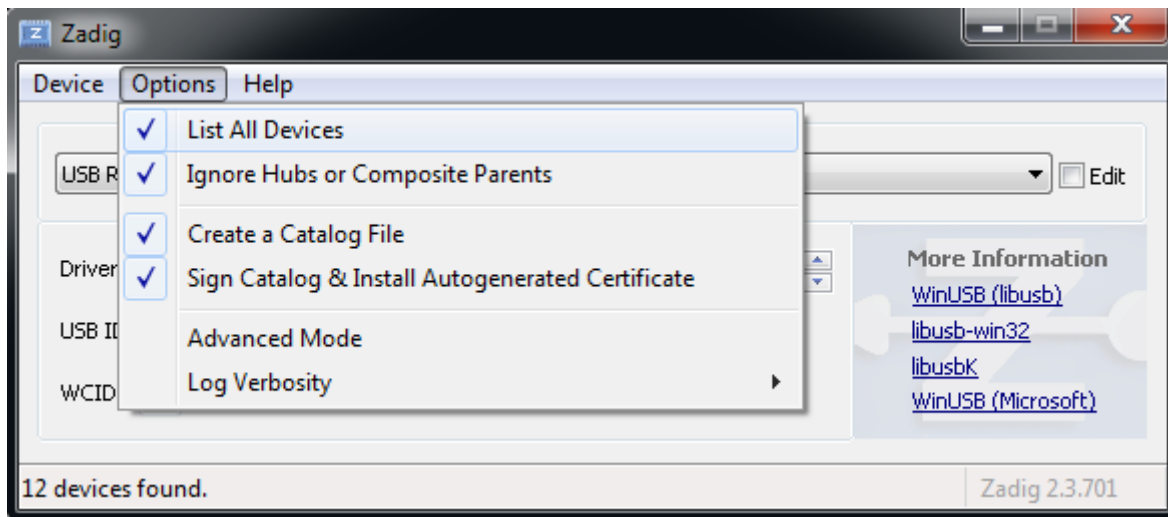


Figure 16. Zadig program: choose to enumerate all devices

Then, choose WinUSB driver for the device, and press Install. This should be done two times, for Olimex both interfaces.

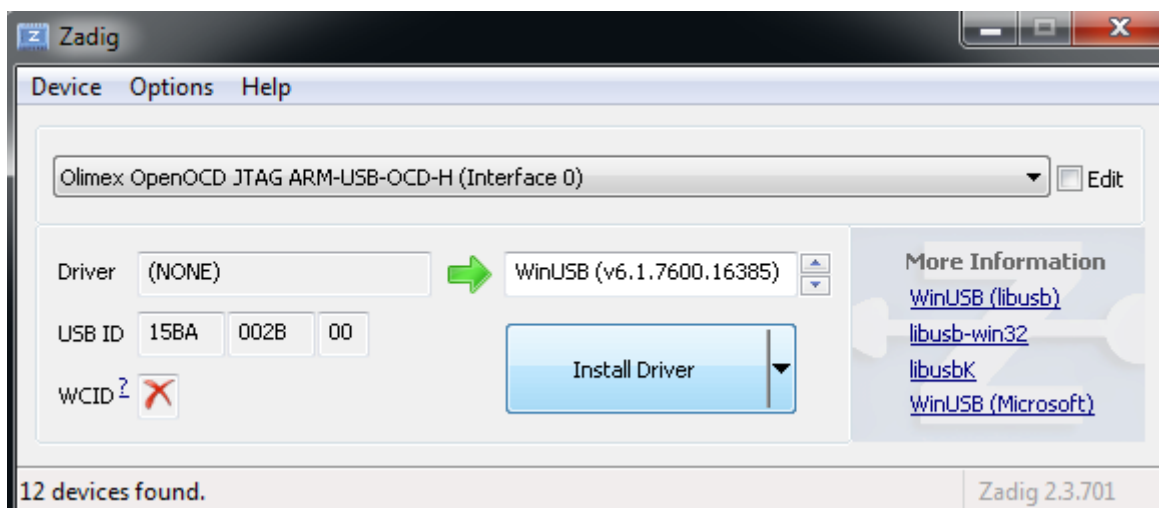


Figure 17. Zadig program: replace previously assigned driver with WinUSB

You can also check this page for the latest information on the Olimex drivers availability for your platform:

<https://www.olimex.com/wiki/ARM-USB-OCD>