Hardware specifications of the White Rabbit Switch version 4 (WRS-4)

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Version 1.1
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1. Introduction

The aim of this technical report is to document the hardware specifications of the White Rabbit Switch version v4 (WRS-4) after addressing the WR community feedback provided during the WRS-4 Workshop. The first prototype of the WRS-4 follows this specification.

It is important to note that this report only lists the hardware specifications and features of the WRS-4, the detailed description and justification of each feature are documented in:

- Study on the new hardware features for the WRS-4.
- WRS-4 main board (Hardware_Architecture).
- Table of accepted/rejected feedback to the above documents

While the two documents provide a thorough description of WRS-4 features and architectural decisions, a number of features were (re-)discussed following the feedback from the WRS-4 Workshop. These discussions are documented using ohwr [issues], which are summarized in the Table of accepted/rejected feedback. Links to respective issues are provided for relevant features listed in this document.

The design of the WRS-4 is meant to be backward compatible with the White Rabbit Switch version 3 (WRS-3) and serve as a drop-in replacement for the WRS-3 [issue 25] & [issue 38] while adding new features and functionalities.
2. Hardware features

The hardware features listed in this section focus on the aspects related to the enclosure, interfaces, power supply and fans.

2.1. Enclosure dimensions

- Height: 44.45 mm (1U).
- Wide: 482.6 mm (19").
- Depth: 310 mm.

Figure 1. Enclosure general view.

Figure 2. Main parts of the WRS-4.
2.2. Fans

Main features of the fans module:

- Hot-swappable and self-docking module with a simple bracket (Figure 3).
- 3 or 4 fans per module.
- Configurable airflow direction (mechanical adjustment).
- Adjustable speed controller.
- Broken rotor protection.
- PWM control.
- Tachometer.

For more information on this fans module, see the document Study on the new hardware features for the WRS-4, section 4.2, option 3.2.

NOTE: See [issue 41] for discussion on making the switch fanless. While it is not intended for the default version, the switch will be made as fanless-ready as possible.

Figure 3. Fans module.
2.3. Power supply

Main features of the 1U redundant compact module power supply chosen:

- Redundant and hot-swappable (Figure 4) with standard connectors and size (three or more different manufacturers have been found to have the same width and height dimension for this type of compact module PSU).
- ATX standard compliant connectors.
- PMBus included.
- Compliant with the EN55022, class B conducted and class B radiated emissions requirements and a low “ripple and noise” [Issue 31 and Issue 5].
- Size allowed for the power supply in the enclosure: 215 x 106 x 42 mm (accommodates models from different manufacturers).

The selected power supply unit is the YH5151-1EBR.

For more details on power supply, see the Study on the new hardware features for the WRS-4, section 4.3, option 3.

Figure 4. Redundant and hot-swappable power supply.
2.4. Front Panel

- 5 SMA connectors, the distance between SMA centers is 11 mm.
- WR port number:
  - v4.0 (HW prototype), the configuration will be 24 stacked SFP+ connectors:
    - 3x block connectors 2x4.
  - v4.1 (1 Gb only) will have 18 ports (or 20 if the old GW ok):
    - 2x block connectors 2x4.
    - 1x block connectors 2x1.
  - v4.2 (1 & 10 Gb) will have 20 ports if we can have 1 & 10 Gb on the same port, otherwise 20x1Gb and 4x10Gb:
    - 2x block connectors 2x4.
    - 1x block connectors 2x2.
- The main board will be prepared for 24 ports, since there is compatibility of SFP cages with different number of slots [Issue 40].
- 1 SFP Port (Management).
- 1 x RS-232 port over a RJ45 connector.
- 1 x USB Type C connector [Issue 11 and Issue 37].
- 1 x USB-A connector [Issue 28].
- 1 x RJ45 Ethernet port.
- 1x Reset button [Issue 14].
- 2x Buttons next to the OLED display [Issue 15] and [Issue 52].
- 1x Programmable Red and Green LEDs for status.
- OLED display.

Figure 6. Final front panel layout.

NOTE: The original proposal in "Study on the new hardware features for the WRS-4" of front panel with 18 ports was updated based on the WR community feedback which showed a need to have at least 20 ports [Issue 1].
2.5. Expansion board

The WRS-4 will have an expansion connector that can be used to integrate expansion boards providing new functionalities (e.g. holdover capabilities or high-performance oscillators). The expansion board and connector are characterised as follows:

- Custom expansion board (Figure 7 and 8)
  - Size: 85 x 235 mm
  - Overhead space: 32 mm
  - Pluggable from the rear panel
  - By default, airflow circulation ensured by the main fans via air guide [issue 20], optionally separate airflow circulation can be implemented.
  - It can work as an FMC carrier at the same level as the main board (Figure 7). In this way, the expansion FMC can be inserted without having to open the enclosure (and losing the warranty)

- Expansion connector(Figure 9)
  - Single connector with 300 pins
  - Up to 28+ Gbps support
  - SAMTEC SEAF-SEAM
    - SEAM-50-01-L-06-1-RA-GP-TR - Expansion Board side
    - SEAF-50-01-L-06-1-RA-GP-TR - WRS-4 side

Note: See "WRS-4 Expansion Connector" document and the Issue 42 for information on different options that have been evaluated.

![Figure 7. Expansion board with FMC board.](image-url)
Figure 8. Expansion board and the back panel.

Figure 9: SEAF-SEAM connectors.
3. Main Board

3.1. Architecture and features

Figure 10. WRS-4/24 main board block diagram.
The main board features of the WRS-4 are listed below:

- **Xilinx Zynq Ultrascale+ XCZU17EG-1FFVC1760E.**
  - Quad-core ARM® Cortex™-A53 MPCore™ up to 1.5GHz.
  - Dual-core ARM Cortex-R5 MPCore™ up to 600MHz.
  - 32 GTH 16.3Gb/s and 16 GTY 32.75Gb/s.
  - C1760 footprint compatible with the devices ZU11 and ZU19.

- **On board memory:**
  - SO-DIMM module with a capacity of 4GB (MTA4ATF51264HZ-2G6E1) [Issue 46].
  - File system memory (single footprint)
    - Prototype: 1x SD memory card (8 GB) for booting and file system storage, including on the board a secure digital input/output (SDIO) interface to an SD card connector.
    - Final version: 1x eMMC (4 GB and Industrial range).
  - 2x Dual serial NOR flash Quad-SPI memory (2 x 1Gb) for booting and to implement a recovery system.
  - 1x I2C Serial EEPROM (64K - 8K x 8-bit) for storing serial number, calibration parameters and other critical data.
  - 1x m.2 SATA interface is provided for SATA SSD access using the PS-side GTR transceiver [Issue 39].

- **Clocking resources (under evaluation with a FMC prototype [Issue 4]):**
  - 1x Fixed frequency 50 MHz oscillator for the ARM.
  - 1x 25.000 MHz VCTCXO controlled by a DAC with 16-bit SPI interface, with a compatible footprint for the following oscillators: Connor-Winfield DOT050, Abracom ABLNO, Crystek CVHD-950.
  - 1x 16-bit DAC AD5662 to control the main oscillator.
  - 2x Si549 oscillators for bootstrap and/or Helper.
  - 1x LMX2594 PLL for the GrandMaster input. It will provide to the FPGA the required 62.5MHz clock from an external 10MHz clock source.
  - 1x HMC7044 PLL for the main loop.

- **Internal connectors/buttons/sensors:**
  - 1x JTAG header for Xilinx programming during debugging.
  - Expansion connector (SAMTEC SEAF-50-01-L-06-1-RA-GP-TR connector) [Issue 42]:
    - FMC LPC compatible [Issue 19].
    - 68 pins are user-defined and FMC power pins [Issue 42].
    - High speed interface for data (link aggregation) using 8 GTH ports and 16 GTY ports [Issue 42] and [Issue 21].
  - ATX connectors for the power supply.
  - 2x connector for cooling fans.
  - Buttons:
    - 1x PS_POR connected to ARM reset.
    - 1x PS_SRTS_B.
    - 1x PL system reset.
    - 1x PS general purpose.
    - 1x PROGRAM B button for FPGA.
    - 2x programmable buttons / connectors for additional buttons for OLED.
○ 8x temperature sensors (TMP100).
  ■ 1x near oscillator
  ■ 3x below SFP cages
  ■ 4x in different places of PCB (not affected by component temp)
○ 1x USB-A [Issue 34].
○ Clocking [Issue 9]
  ■ CLK AUX IN: LVCMOS-3.3V standard input.
  ■ CLK AUX Out: LVCMOS-3.3V standard 62.5 MHz output.

● Front panel interfaces:
○ Clocking interfaces (SMA connectors [Issue 17 and Issue 18]):
  ■ PPS-IN: LVCMOS-3.3V and 5V TTL compatible [Issue 7] with Hi-Z or 50 Ohm selectable termination.
  ■ 10 MHz-IN: Sine or digital signal. The same input as the one used in the Low Jitter Daughterboard. Input levels from -10 dBm to +24 dBm into 50 Ohm impedance (Hi-Z no optional).
  ■ PPS-OUT: TTL-5.0V standard PPS output [Issue 7].
  ■ 10MHz-OUT: AC-coupled 10 MHz output [Issue 8].
  ■ AUX (abscale).
○ Management:
  ■ 1 x SFP port (1 Gb ethernet) directly connected to the PS - GTR transceiver.
  ■ 1 x RJ45 port (10/100/1000 Ethernet). The interface with the ARM will be RGMII using the transceiver KSZ9031MNXIC-TR.
  ■ 1 x UART RS-232 port over a RJ45 connector.
  ■ 1 x USB Type C [Issue 11 and Issue 37] connector for an UART interface through the FT2232HL bridge controller [Issue 10].
  ■ 1 x USB-A for firmware updates and for connecting some additional sensors [Issue 28].
○ Buttons:
  ■ Reset [Issue 14].
  ■ 2x Buttons next to LCD to change the content [Issue 15] and [Issue 52].
○ 24x SFP+ ports. The WRS-v4 prototype will have 24 ports, final product TBD (minimum 20 ports) [Issue 1] and [Issue 40].
○ Status and diagnostics
  ■ 1x OLED display [Issue 16].
  ■ 1x Programmable (color-blind friendly [issue 13], if possible) Red and Green LEDs for status.

● Back panel:
○ 1x Location LED on the back of the switch [Issue 12].

NOTE: An initial architecture proposal for the WRS-4 main board was presented in the document WRS-4 main board (Hardware Architecture) and has been updated based on the WR community feedback and its resolution.
3.2. Board Specifications

**PCB Material**

Itera MT40 from Isola (just for layers with high-speed links), in order to support speeds up to 24 GHz [Issue 32].

**Environmental**

**Temperature**
Operating: 0°C to +45°C.
Storage: -25°C to +60°C.

**Humidity**
10% to 90% non-condensing.