1. Expansion board options

The expansion board is meant to allow adding functionalities to the switch. Examples of considered additional functionalities include:

- stable and/or low-noise oscillator for holdover and/or increased performance
- DDS for frequency synthesis
- additional ports with 10Gbps or 25 Gbps links (or custom speeds)

For the expansion board of the WRS-4, we are considering two different options:

1. The expansion board in a form factor of a standard FMC board, in this case an FMC+ or an FMC HPC connector is mounted on the WRS-4 main board (Figure 1). Remind that FMC+ has backward compatibility with original FMC mezzanines, and in addition the number of Gigabit transceivers increases to 32 with a maximum data rate up to 28 Gbps. The price is about **21 € for FMC HPC** and about **30 € for FMC+ connector**.

2. Designing a custom expansion board which can work as an FMC carrier (in the same level as the main board) (Figure 2). Please see its details on this option below.

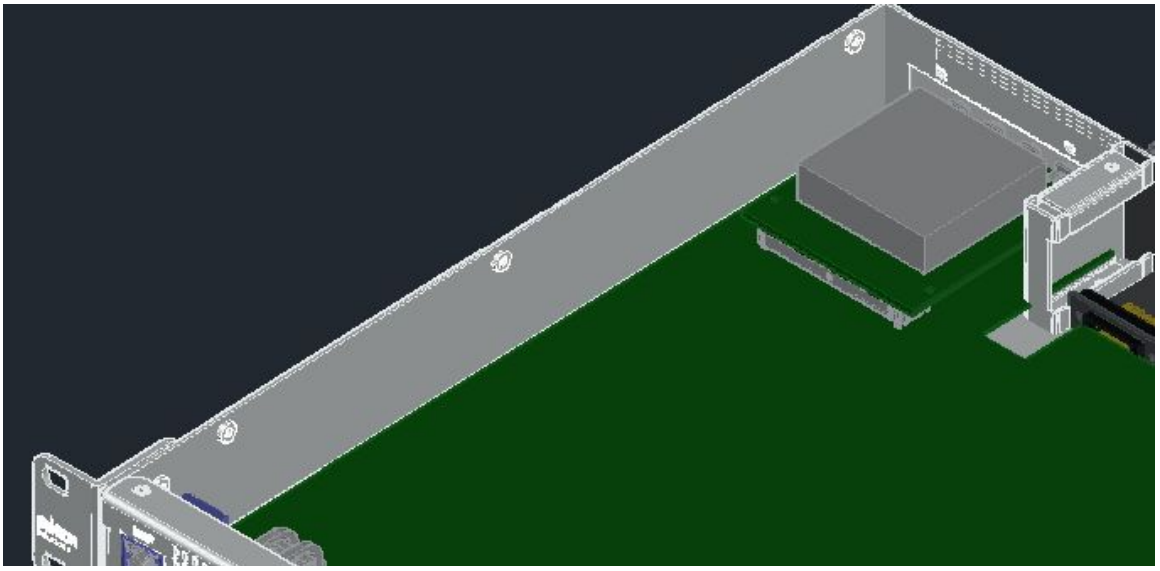

Figure 1: Standard FMC board connected directly to the main board.

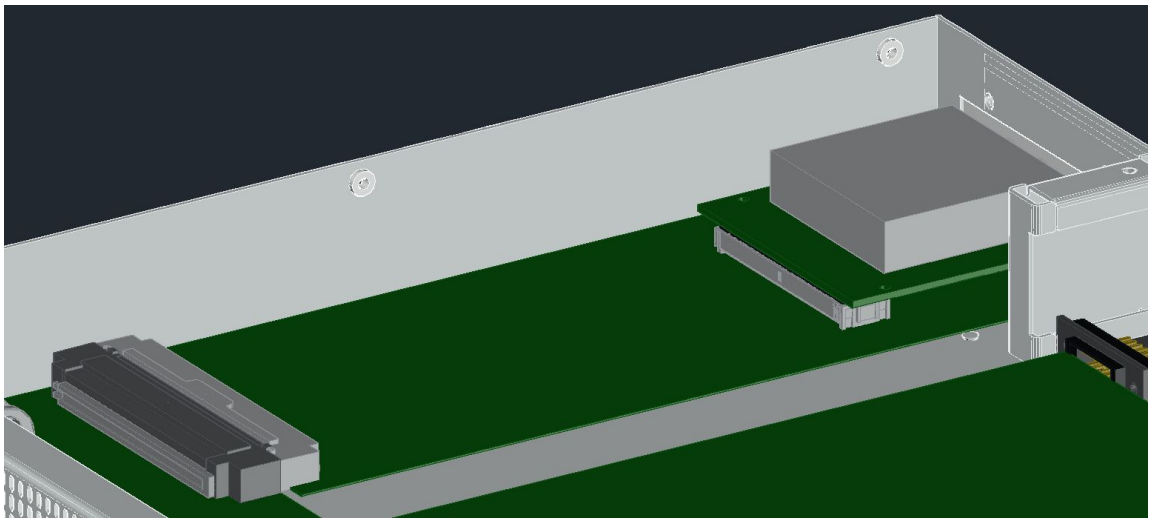

Figure 2: New expansion board working as an FMC carrier, with SEAF-SEAM connectors.

In order to choose the best solution, a pros/cons summary is shown below:

FMC Connector:

- Pros:

1) No need of designing a carrier expansion board, simplifying the architecture of the WRS-4. The WRS-4 will only have the main board, with an FMC connector where the expansion boards will be connected.

2) The WRS-4 cost will be lower than the other solution in which a new expansion board has to be designed with its connectors, components and mechanical guides. However, we should note that connecting a FMC board directly implies that the main board must be larger in order to place the FMC board so it is accessible from the rear panel in case that the FMC board includes some connectors. This could increase the price of the basic WRS-4, when it is not necessary to have any expansion board.

- Cons:

1) The ANSI/VITA 57 FMC standard has tight physical constraints so most of the low-noise low-jitter OCXO oscillators cannot fit in a FMC board respecting the standard.

2) In order to connect the FMC board into the WRS-4, the user has to open the top cover of the chassis to access the FMC socket connector. This implies several consequences since the equipment could be altered when an user has access to the inside of the switch. Therefore the seal of warranty would be broken and in case of any fault the warranty won't cover it

3) FMC HPC and FMC+ connectors provide 10 and 32 high speed connections respectively. However, with the limited space not many SFP cages can be accommodated in the rear panel to take advantage of these high speed connections.

Non-FMC Connector:

- Pros:

1) No need to open the equipment. This carrier expansion board with a non-FMC connector could be slided into the equipment, with the help of mechanical guides, from a rear panel cutout like in the Figure 3. Therefore, without opening the chassis, we can save the warranty and more importantly, protecting the WRS-4 from any fault derived from the access to the inside.

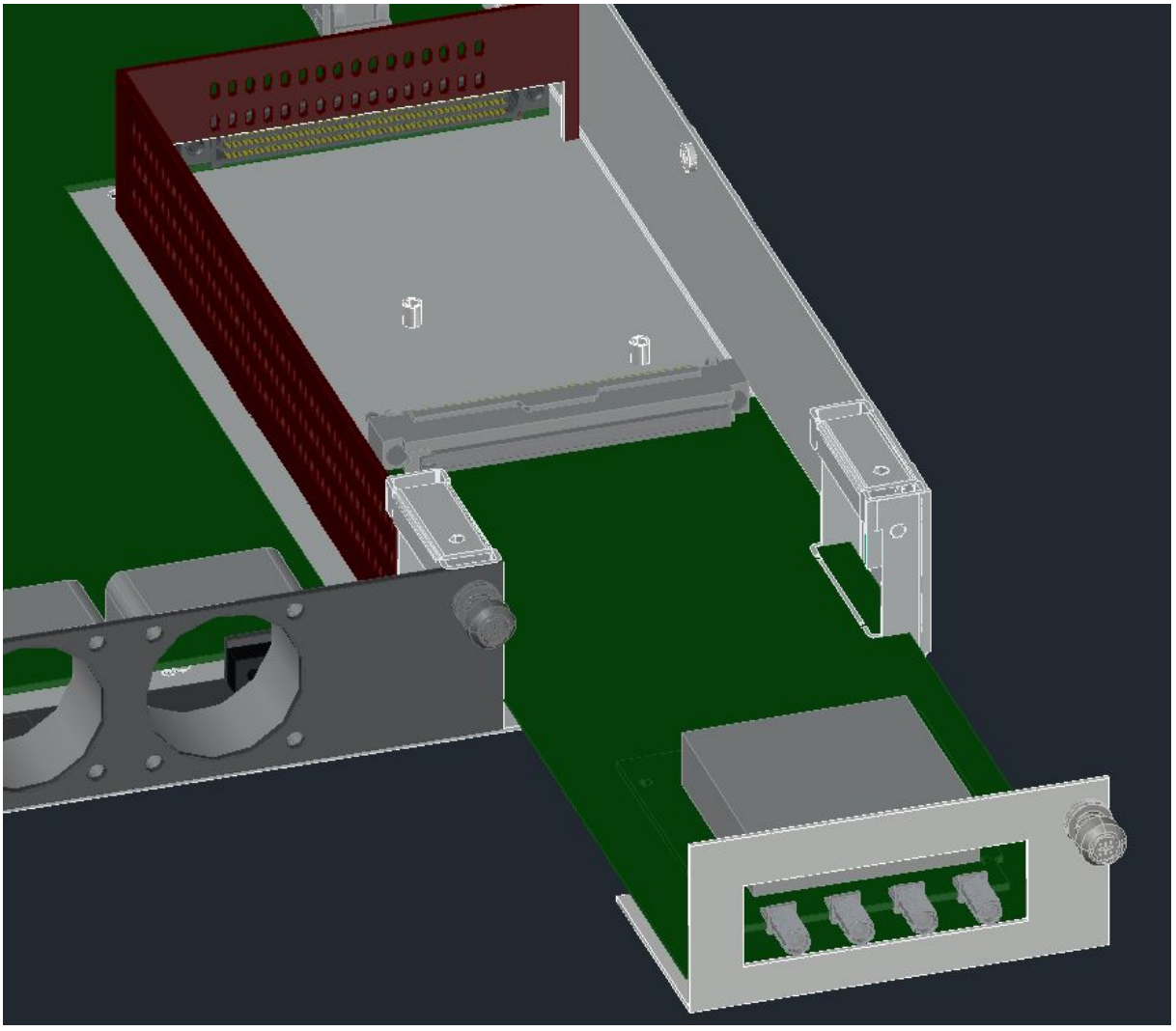

Figure 3: custom pluggable FMC carrier expansion board.

2) The size of this expansion board is larger than an FMC board. Furthermore, there is more height available for oscillators since it is at the same level of the main board (see section 4). The low-noise OCXO oscillators could be mounted directly on the expansion board allowing for a larger oscillator.

3) This custom expansion board is more flexible regarding the physical constraints, and it could be a carrier board for whatever connector we would like to use, allowing the design of carrier boards for FMC boards or any other options (PCIe, XMC...).

4) The expansion board can be used for additional ports (Figure 4 and 5):
    a) Up to 10 SFP+ ports (10/25 Gbps).
    b) Up to 4 QSFP ports (40 Gbps).

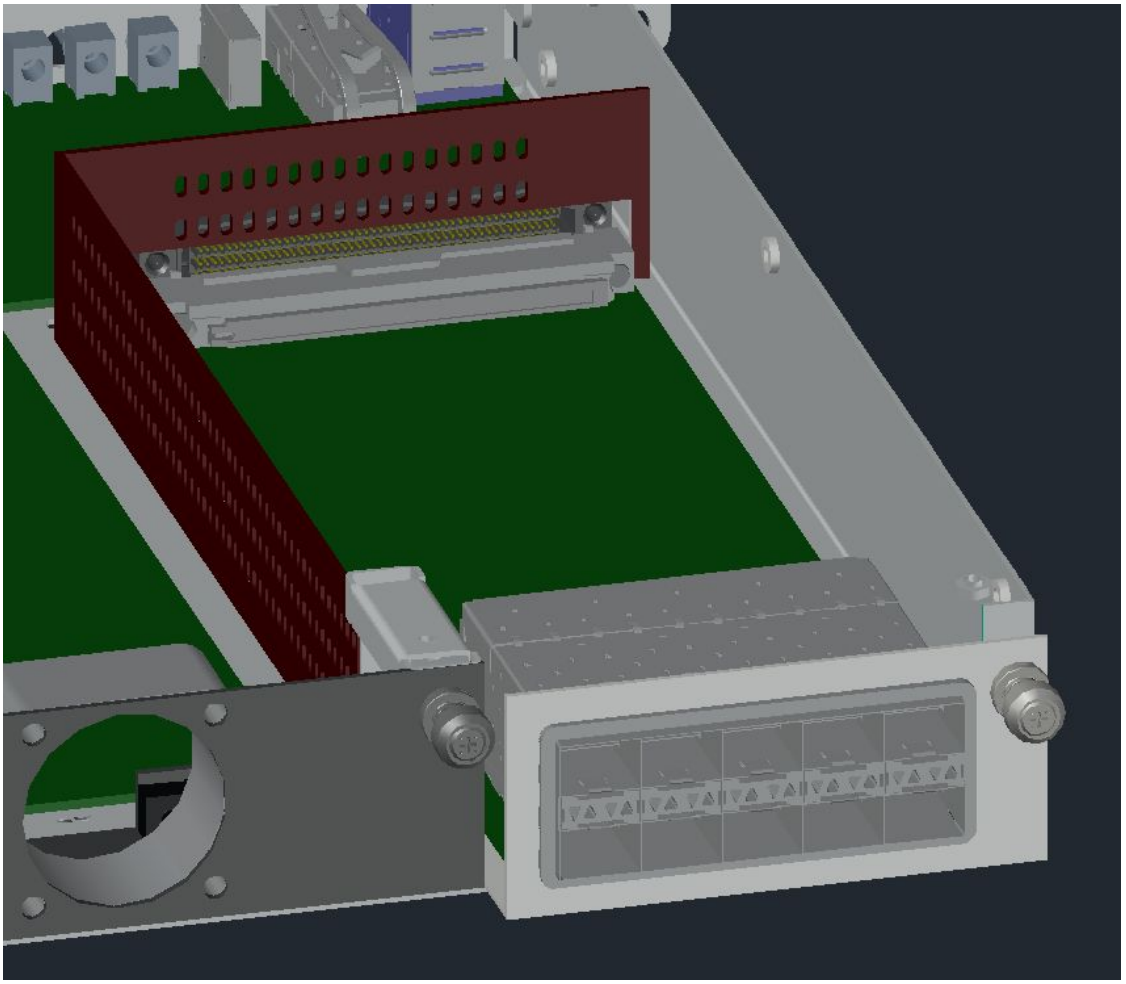

Figure 4: Expansion board with 10 SFP+ ports.

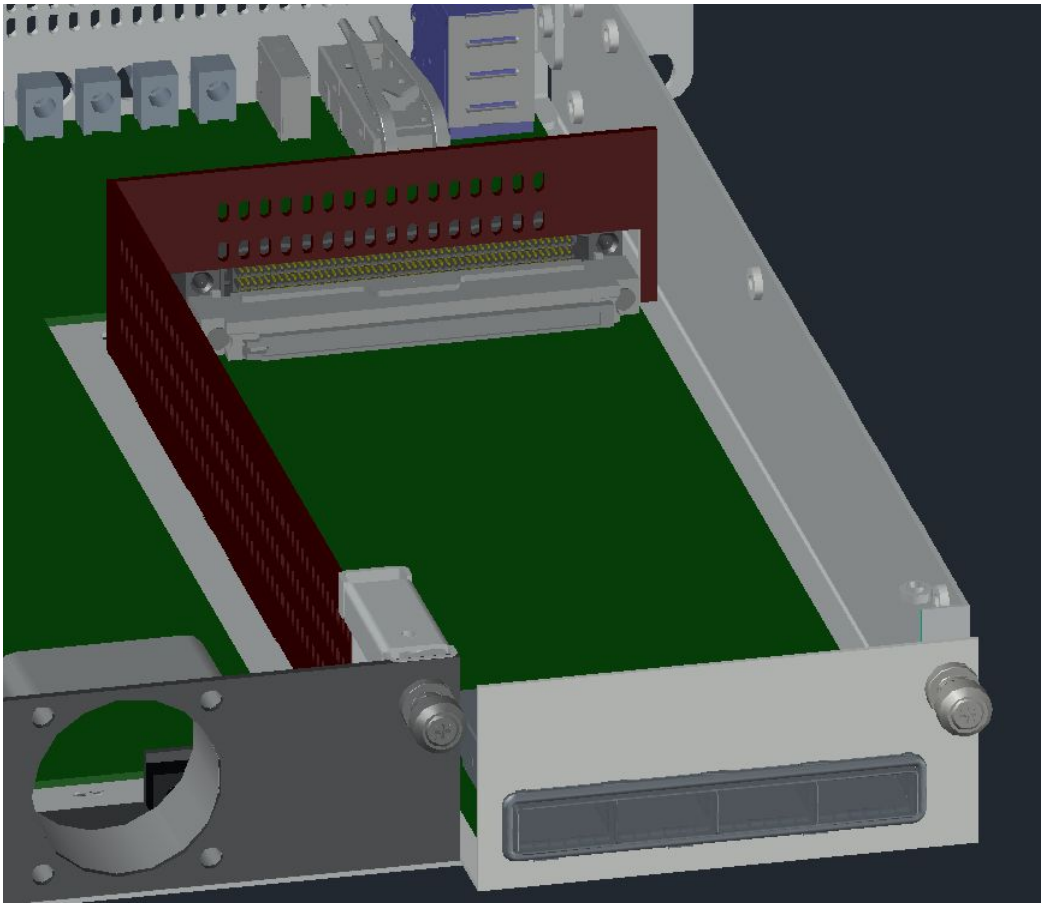

Figure 5: Expansion board with 4 QSFP ports.

- Cons:

1) Need of a custom pinout arrangement in the connector since it is not standard (see sections 2 and 3).

2) The mechanical complexity of the chassis is a little bit higher since the expansion board is pluggable.

3) Cost increase, due to the need of a new expansion board, with a higher mechanical complexity of the chassis.

2. Requirement in number of pins for a custom expansion board.

The number of pins estimated that we need is about 200 - 260:

1) **100 pins at minimum for the Low Pin-count FMC (Low pin-count FMC has 4 rows of 40 pins = 160 pins, out of which):**

- 61 pins are GND
- 2 pins are VADJ
- 68 pins are user-defined
- 1 pin is VREF_A_M2C
- 1 pin is 3p3 VAUX
- 4 pins are 3P3V
- 2 pins are 12POV
- 21 is non-user-defined functional
- So, it needs 89 "functional" pins, 5 different power pins and ground, roughly ~100 pins on the other connector included on the expansion board.

2) **80 high speed pins (25 Gbps) to route 16 GTY and 20 pins to route 4* GTH** (actually, 1 GTH can be included into the FMC LPC):

- ZU17 has 32 GTH ports, we use 24 ports, some of the remaining 8 we use, say we are left with 4 to route to the expansion.

- We need 20 pins for each GTH/GTY Quad (4 ports):
    - 2 pins: MGTREFCLK0P/MGTREFCLK0N
    - 2 pins: MGTREFCLK1P/MGTREFCLK1N
    - 8 pins: MGTYRXP[3:0]/MGTYRXN[3:0]
    - 8 pins: MGTYTXP[3:0]/MGTYTXN[3:0]

One choice can be to include two different connectors: one for basic and functional pins (low-cost, low-speed connector for FMC LPC compatibility) and another for high-speed signals like GTHs/GTYs (high-cost). In this way, mounting the high-speed connector could be an option and the WRS-4 would be less expensive.

3. Price and connectors proposed for a custom expansion board.

As already mentioned, according to the estimated number of pins needed, we can use only one big connector, or divide the signals into two different connectors (one for low-speed signals and power pins, the other for high speed signals).

Another important issue is the available width for the expansion board and its connectors, since the width is determined by the fan tray and the PSU.

According to these characteristics, some part numbers are proposed:

- **ERNI:**

*IMPORTANT: There is no right angle option for all ERmet male connectors… These connectors are thought included in a rackeable system like Compact PCI, where the PCBs are connected to a perpendicular motherboard. So this connector is not suitable for our project.

This solution divides the estimated signals into two connectors:

* ERmet ZDpro type (no price for 100 pos):
  - Header (80 pos, Vertical) + Receptacles (80 pos) => 21€ + 27€ = 48€

* ERmet ZD:
  - Header (135 pos) + Receptable (135 pos) => 20 € (estimation, no price for 135 pos) + 25€ = 45€

So, if we would need around 200-260 pins:
- 100-160 for FMC LPC (ERmet ZD type 135 pos)
- and 100 for GTH/GTYs (ERmet ZD pro 80 pos)

The price will be around 50 € for the main board price, if both connectors are used.

- **SAMTEC SEAF-SEAM:**

This connector has capability for all the required pins, so only one connector would be needed.

* SEAF-50-01-L-06-1-RA-GP-TR (SEAF-RA 300 pos, 6 rows, 50 pins) => 27 €
* SEAM-50-01-L-06-1-RA-GP-TR (SEAM-RA 300 pos, 6 rows, 50 pins) => 24 €

We only need a couple, so for this option **the price will be around 25€,** for the main board price.

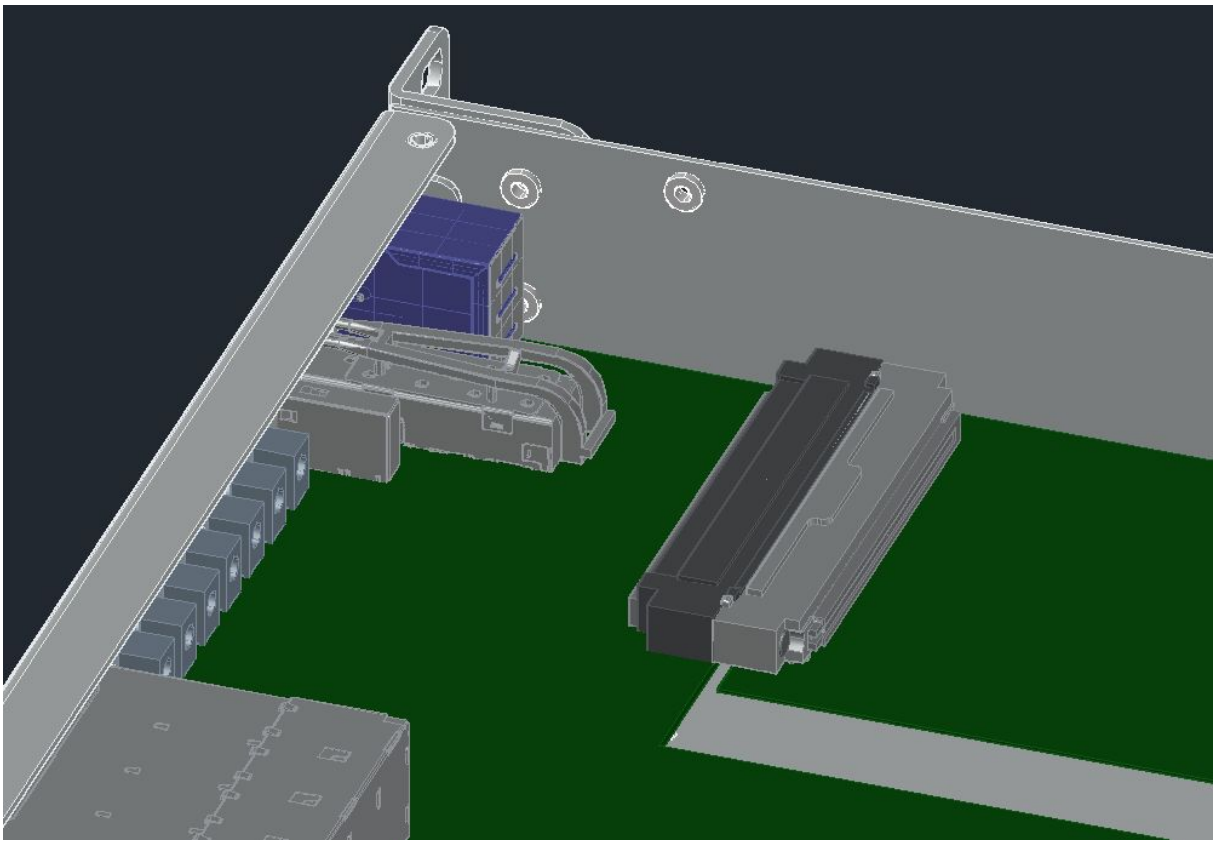

Figure 6: SEAF-SEAM connectors.

- **ExaMAX:**

- Right-Angle Header EBTM-RA (EBTM–6–12–2.0–S–RA–1, 144 positions) => 20 €
- Right-Angle Receptacle EBTF-RA (EBTF–6–12–2.0–S–RA–1, 144 positions) => 29 €

This option has to include two connectors due to the number of pins, so the price will be around **50 €**.

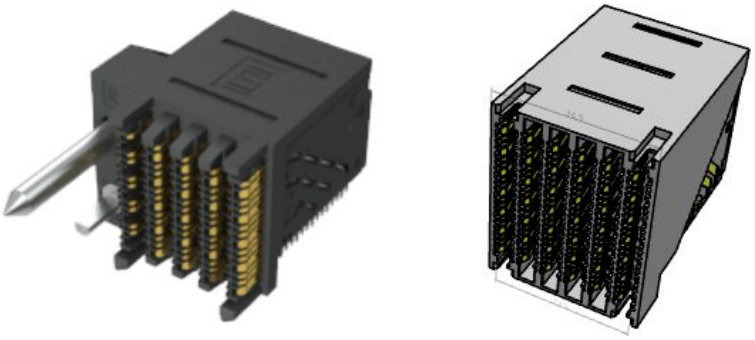

Figure 7: ExaMAX connectors.

Any of the above options could be suitable, but taking into account the final cost, we can choose the Samtec SEAF-SEAM connectors. In any case, before choosing the connectors to include, we should evaluate (buying some units) that these connectors have an easy and soft connection since the board would slide from the rear panel without opening the cover of the chassis.

4. Size of oscillators for both options.

The minimum stack height in FMC boards is 8.5 mm (the most common option is 10 mm). This dimension has to be added to the height of the main board, which would be elevated about 5 mm from the base panel of the chassis. So the upper side of the FMC board will be at about 16.7 mm from the base panel (taking into account 1.6 mm of PCB thickness in the main board and the FMC board).
Therefore, until reach the 1U height of the chassis, a space remaining of about 25 mm is available. In order to include some tolerance between the top of the oscillator and the cover of the equipment, we recommend to choose oscillators smaller than 22 mm height.

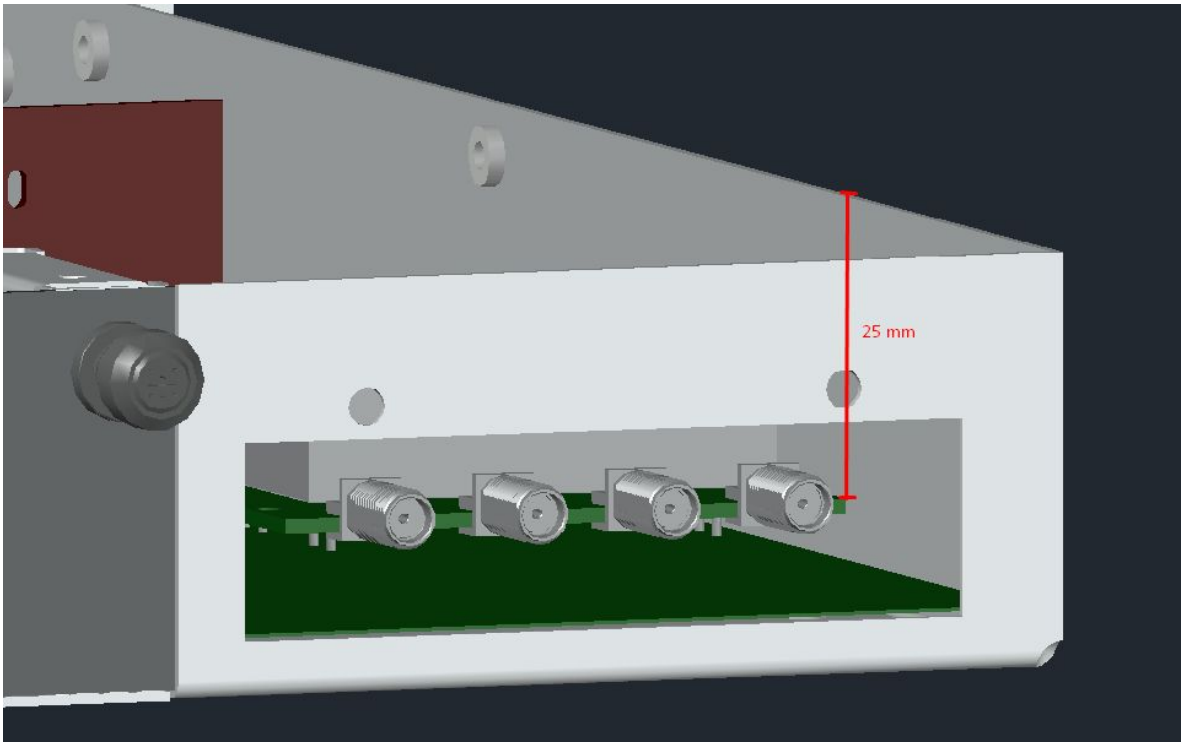

Figure 8: Height available from the top of a FMC board.

If the oscillator was mounted on the carrier expansion board directly, the height available would be 10 mm more, so the oscillator could measure up to 32 mm height. This implies that the slot in the rear panel should be larger enough to slide a big oscillator. The best solution would be to totally open the rear panel and to design a board tray to insert the board, as shown in Figure 9.

NOTE: The heights of the oscillators evaluated for high-end WR applications range from 11mm to 38mm. 25% of the oscillators have the height above 22mm.

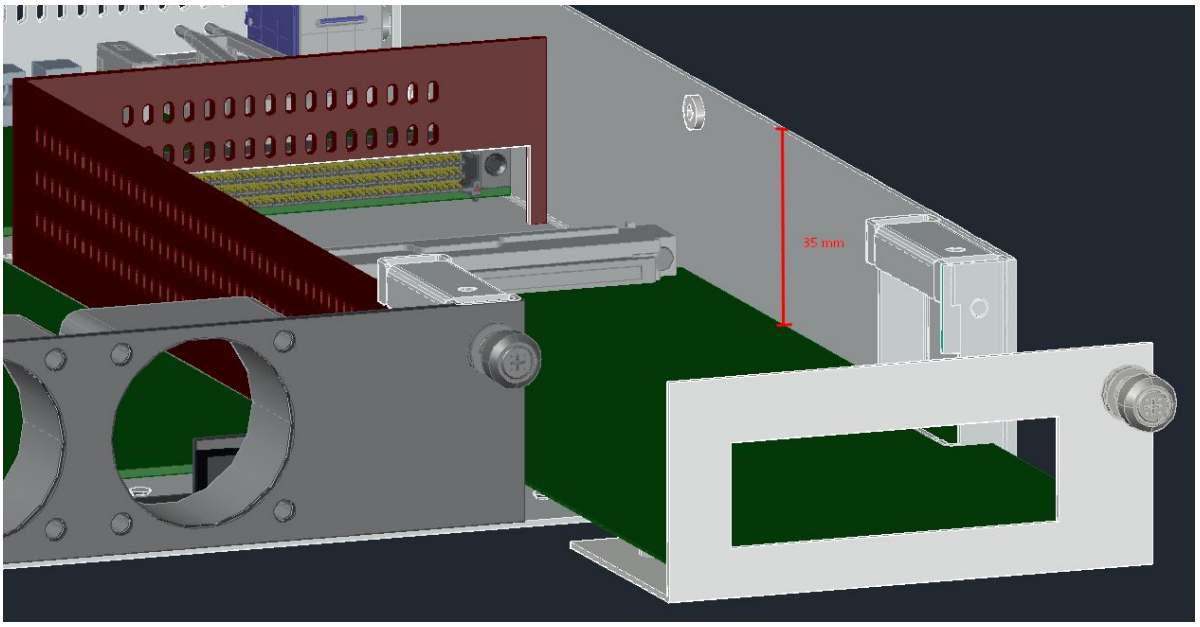

Figure 9: Height available from the expansion board with tray.

5. Conclusions

Using an FMC connector incurs lower costs but imposes many limitations that hinders extensibility of the new WRS-v4. A custom expansion module allows more flexibility and avoids having to open the enclosure to insert the module. The price of the SAMTEC SEAF-SEAM is comparable with the price of the FMC connector (~25 euro vs 20-30 euro). The estimated increase in the cost of the WRS-v4 is mainly in the mechanical components and it is considered reasonable (< 50 euro). Thus, the custom **SAMTEC SEAF-SEAM** connector is recommended for the expansion board.