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EDMS NO.	REV.	VALIDITY
-------	1.0	DRAFT

REFERENCE

Date: 2022-10-06

ENGINEERING SPECIFICATION

DI/OT crate v2

ABSTRACT:

This document defines the specifications for the DI/OT crate v2.0 [1]. The DI/OT crate is a main component of the Distributed I/O Tier hardware kit [2]. Following on development and prototype testing of version 1, this specification lists required modifications and improvements to be implemented comparing to the original DI/OT specification [3].

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DOCUMENT SENT FOR INFORMATION TO:

HISTORY OF CHANGES

REV. NO.	DATE	PAGES	DESCRIPTIONS OF THE CHANGES
0.1	2022-10-06	14	First version of the doc.
1.0	2022-10-20	14	Version 1.0 ready to start design changes

TABLE OF CONTENTS

1. INTRODUCTION

This document defines the specifications for the DI/OT crate v2.0 [1]. The DI/OT crate is a main component of the Distributed I/O Tier hardware kit (Figure 1, [2]). It hosts two redundant power supplies, the DI/OT System Board (SB), up to 8 application-specific Peripheral Boards (PB) and up to 8 application-specific Rear Transition Modules (RTMs).

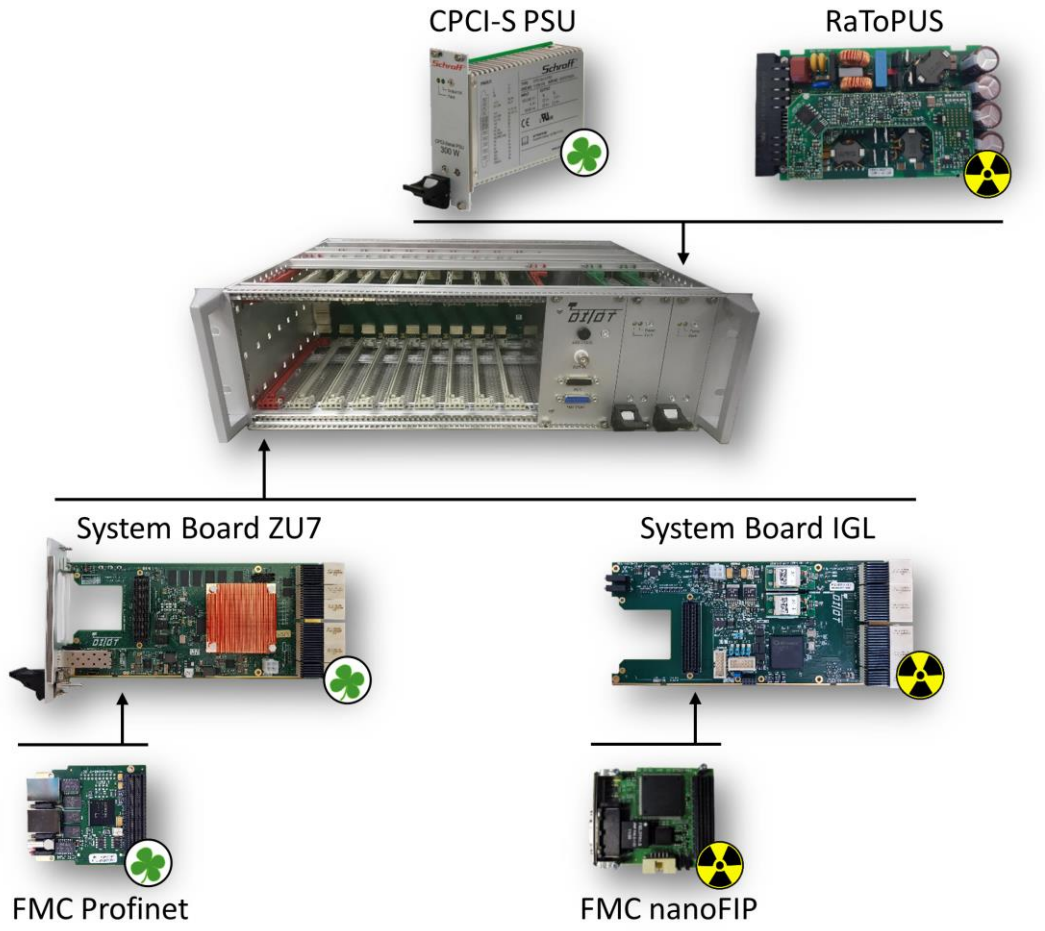

Figure 1: DI/OT modular hardware kit

Following on development and prototype testing of version 1, this specification lists required modifications and improvements to be implemented comparing to the initial DI/OT specification [3]. The main motivation for these modifications are:

- split of RaToPUS (DI/OT rad-tol power supply) into two modules (front: DC/DC stage; back: AC/DC stage);
- past assembly issues and mistakes in cabling and setting dip-switches configuration on two separate power backplanes.
- requirements coming from new applications like CERN power converters control and Quantum Computing community.

2. MODIFICATION OF MECHANICAL DESIGN

Figure 2 presents a conceptual design of DI/OT crate mechanics v2.0. The following modifications shall be applied to the mechanical design with respect to DI/OT crate v1.x:

1. Extended enclosure length to enlarge the space available for RTMs from 100mm to 160mm and Rear Panel PCBs. This way the RaToPUS AC/DC stage can be hosted behind the Power Backplane.
2. Reduced cabling – a 3-board assembly (Main Backplane, Power Backplane, Front Panel) is introduced to distribute power (12V, 5V, GND) and control/diagnostic signals. Appropriate connectors are proposed in a dedicated section for each of these boards.
3. Addition of back panel PSU slots that plug directly into the Power Backplane. This space shall replace 230VAC sockets of version 1.x and be used to host either:
    a. for non-rad-tol DI/OT variant: Back Panel PCB (described in the next section);
    b. for rad-tol DI/OT variant: AC/DC stage of RaToPUS (specified outside the scope of this document).
4. 230VAC relays moved from the Front Panel PCB to the Back Panel PCBs. This way all 230VAC circuits are kept in the back of the crate.
5. Merge two instances of Power Backplane v1.0 into a single PCB (Dual Power Backplane).
6. Dual Power Backplane shall be held in place using a short horizontal rail that does not disturb air flow through front boards (https://ohwr.org/project/diot-crate-hw/issues/36).
7. Power Backplane shall be covered in the front with a Formex insulation sheet, to prevent exposure of 230VAC through-holes to a user.
8. Modified placement of PSUs to ensure 4HP spacing between two modules at a cost of the front panel size reduction (from 14HP to 10HP).
9. Cable connection of PE terminal block on the Power Backplane to the chassis.

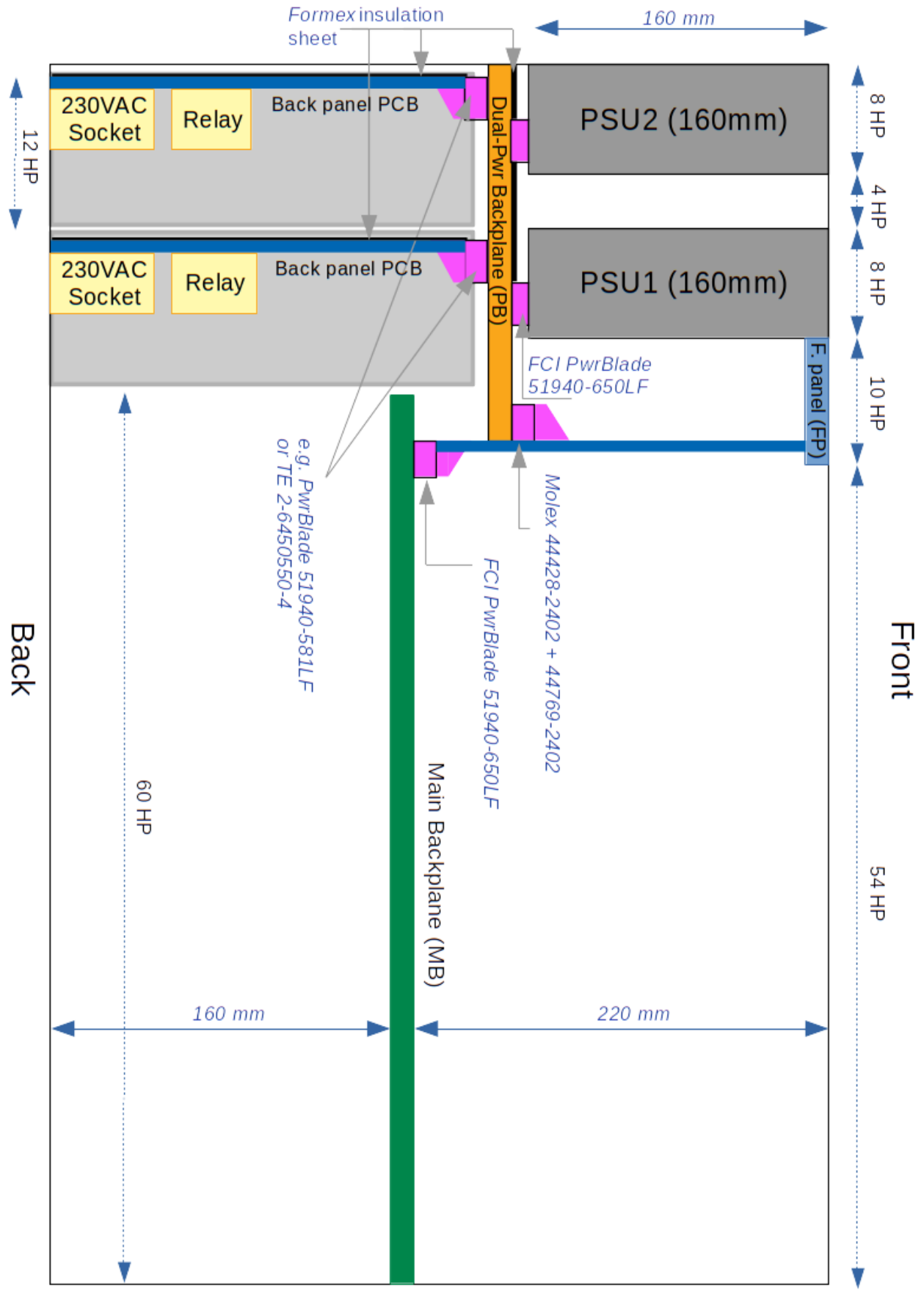

Figure 2: DI/OT crate mechanics v2.0

3. MODIFICATION OF PCBs

With respect to DI/OT crate version 1.0, all PCBs: Main Backplane (MB), Power Backplane (PB), Front Panel (FP) shall be modified. Additionally, a new board is introduced: Back Panel PCB. The sections below list modifications that need to be introduced to all these designs.

3.1 Main Backplane

1. Additional (LVDS15_P/N) differential pair for each Peripheral Slot to communicate with the System Slot. In each Peripheral Slot pins E2, F2 of connector P1 shall be used. In the System Slot, rows 5, 6 of connector P2 shall be used.
2. Additional RTM connector P3, for each Peripheral Slot, providing 56 GPIO pins between a Peripheral Board and an RTM and 2 supplementary voltage levels distributed over row 1 of the P3 connector. For this reason, similarly to the P4 routing, two power planes (Vaux3, Vaux4) shall be created in the P3 space of the backplane and connected to P3 pins according to Table 1.

Pin	A	B	C	D	E	F	G	H	I	J	K	L
3-08	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*
3-07	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*
3-06	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*
3-05	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*
3-04	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*
3-03	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*
3-02	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*	*GND*	*I/O*	*I/O*
3-01	*Vaux3*	*Vaux3*	*GND*	*Vaux3*	*Vaux3*	*GND*	*Vaux4*	*Vaux4*	*GND*	*Vaux4*	*Vaux4*	*GND*

Table 1: Peripheral Slot P3 (RTM) connector pinout

3. Fan Tray, Utility and Aux connectors shall be replaced with a single press-fit Utility connector to interface with the Front Panel PCB. Over that same connector also power (12V, 5V, GND) is provided to the Main Backplane. The connector shall provide a mix of power and signal lines: 9P, 24S (9 power contacts, 24 signal contacts). *FCI PwrBlade 51940-650LF* with pinout is proposed in Table 2.

P1	P2	P3	P4	P5	D1	D2	D3	D4	D5	D6	P6	P7	P8	P9
Vaux1	Vaux2	Vaux3	Vaux4	+5V	RTN_Sense	P12V_Sense	PS_ON_N	PWRFAIL_N	P_PRES0	P_PRES1	GND	GND	+12V	+12V
					C1	**C2**	**C3**	**C4**	**C5**	**C6**				
					GND	M_SCL	GND	P_IO0	GND	P_IO1				
					B1	**B2**	**B3**	**B4**	**B5**	**B6**				
					M_SDA	F_IO0	F_IO1	P_IO2	P_RST	GND				
					A1	**A2**	**A3**	**A4**	**A5**	**A6**				
					GND	F_RST	GND	PWRBTN_N	GND	PRSTN				

Table 2: Main Backplane Utility connector pinout

4. Vaux1-4 power planes can be used to distribute to all Peripheral Boards four, low power voltages referenced to common GND. Alternatively, Vaux2 and Vaux4 can be used as galvanically separated GNDaux planes. In this case Vaux1 is referenced to GNDaux1 (Vaux2) and Vaux3 is referenced to GNDaux3 (Vaux4).
5. Leave rectangular power terminals as an alternative.
6. Ext PSU connector shall be expanded to accommodate two additional auxiliary voltage levels (*Vaux3, Vaux4*).
7. The length of the backplane shall be extended to fit the 3-board assembly (Power Backplane, Front Panel PCB, Main Backplane) in Figure 2. This might require displacement of the current Ext PSU connector in the back of the MB to avoid collision with the new Utility Connector in the front.

3.2 Power Backplane

1. Two instances of the Power Backplane v1 shall be merged into a single PCB.
2. Ensure 4HP spacing between front power supplies.
3. Replace PSU connector *FCI PwrBlade 51940-473* with a non-faston, fully press-fit variant *FCI PwrBlade 51940-650LF*
4. Add 2 connectors to receive AC or DC current from Back Panel PCBs. E.g. *FCI PwrBlade 51940-581LF or TE 2-6450550-4*. See Table 3 for example connector pinout. In that pinout all AC (*L, N, PE*) and DC (*DC_IN, DC_RTN*) power inlets shall be directly wired to appropriate contacts of the *FCI PwrBlade 51930-473*. *DC_IN* and *DC_RTN* are used in case of full DC powering for a DI/OT crate is required (e.g. 24VDC or 48VDC).
5. Each back panel connector shall feed directly one front PSU slot, i.e. input AC/DC current lines from two PSUs cannot be connected together.
6. Place back panel connectors to host 12HP back modules.
7. Route BNC power-cycle request received from the Front Panel to both Back Panel connectors. See Table 3 and Table 4 for reference pinout.
8. Remove DIP switches.
9. Connect *CUR_SHARE* signal between two PSUs through a 0R resistor, mounted by default.
10. Add a weak pull-down on *PS_ON_N* signal to ensure the system is powered even if running without a System Board (https://ohwr.org/project/diot-crate-hw/issues/56).
11. Add a Utility connector to interface with the Front Panel PCB made of 2 vertically aligned *Molex 44769-2402* connectors with pinout proposed in Table 4.
12. If possible, leave rectangular power terminals as an alternative.
13. Add PE rectangular power terminal.
14. The length of the backplane shall be modified to fit the 3-board assembly (Main Backplane, Power Backplane, Front Panel) in Figure 2.

P1	P2	P3	P4	P5	D1	D2
L	N	PE	DC_IN	DC_RTN	--	--
					C1	**C2**
					--	--
					B1	**B2**
					--	--
					A1	**A2**
					BNC_RST+	BNC_RST-

Table 3: Back Panel PCB connector pinout

Lower Molex connector											
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
RTN_Sense	P12V_Sense	PS_ON_N	PWRFAIL_N	P_PRES0	P_PRES1	M_SDA	M_SCL	P_RST	P_IO0	P_IO1	P_IO2
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
BNC_RST+	BNC_RST-	PE	PE	GND	GND	GND	GND	5V	5V	5V	5V
Upper Molex connector											
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
12V	12V	12V	12V	GND	GND	GND	GND	Vaux1	Vaux2	Vaux3	Vaux4
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
12V	12V	12V	12V	GND	GND	GND	GND	Vaux1	Vaux2	Vaux3	Vaux4

Table 4: Power Backplane Utility connector pinout

3.3 Front Panel PCB

1. Replace Fan Tray and Aux D-SUB connectors with a PCB mounted, dual-stacked D-SUB female connectors (e.g. *Amphenol L17H2440121*). Keep pin assignment from v1.x (see also Table 5 and Table 6).
2. Remove 230VAC relays. They are now moved to the Back Panel PCB.
3. Keep ESD socket and BNC reset connectors.
4. ESD plug shall be connected through 1MOhm resistor to the chassis (PE) (https://ohwr.org/project/diot-crate-hw/issues/15).
5. Couple outer of the BNC reset connector to chassis to improve EMC immunity. (https://ohwr.org/project/diot-crate-hw/issues/58).
6. Place Utility connectors to interface with the Main Backplane and Power Backplane. Use mating connectors to the ones used on Power (2x *Molex 44428-2402*) and Main Backplanes (*FCI PwrBlade 51939-667LF*). See Table 4 for Power Backplane Utility connector pinout and Table 2 for Main Backplane Utility connector pinout.
7. Expand PCB length to 220mm to fit the 3-board assembly (Power Backplane, Front Panel PCB, Main Backplane) in Figure 2.

1	2	3	4	5	6	7	8
GND	12V	GND	12V	GND	12V	GND	12V
9	**10**	**11**	**12**	**13**	**14**	**15**	**--**
F_RST	M_SCL	P5V	M_SDA	F_IO0	F_IO1	GND	--

Table 5: Pinout of the front panel Fan Tray D-SUB15

1	2	3	4	5	6	7	8
GND	5V	PWRBTN_N	PRST_N	GND	GND	--	--
9	**10**	**11**	**12**	**13**	**14**	**15**	**--**
--	--	--	--	--	--	--	--

Table 6: Pinout of the front panel Aux D-SUB15

3.4 Back Panel PCB

1. Integrate IEC power entry socket with built-in dual fuse, power switch, locking mechanism, EMC filter – FN 282-2-06 or PCB-mounted equivalent.
2. Integrate 230VAC relay with protection diode (circuit copied from the Front Panel PCB v1.0)
3. Enclose the whole module in a case including Formex insulation sheet to ensure no 230VAC contacts are exposed to the user.
4. Place a Utility connector to interface with the Power Backplane. Use mating connector to the one used on Power Backplane. E.g. *PwrBlade 51939-1064LF* is a male, angled mating connector to *PwrBlade 51940-581LF*. Proposal of pinout in Table 3.
5. Length of the board shall be adjusted to fully occupy the space from the Power Backplane until the back of a crate (~220mm).

4. INCOMPATIBILITIES WITH DI/OT CRATE v1.x

Even if the design of DI/OT crate v2.0 is done to keep as much as possible backwards compatibility with DI/OT crate version 1.x, certain incompatibilities had to be introduced to cater for new requirements. These incompatibilities might trigger a redesign of some application-specific boards already designed by users for v1.x.

Here is the complete list of incompatibilities with respect to DI/OT crate v1.x design:

1. Rear Transition Modules (RTM) space expanded in length from 100mm to 160mm.
2. Aux PSU space expanded in length from 100mm to 160mm (together with the whole RTM space).

5. ANEXES

5.1 DI/OT crate design files

The following design files are base for v2.0 crate modifications:

- Main Backplane: https://edms.cern.ch/item/EDA-04211-V1-1/0
- Power Backplane: https://edms.cern.ch/item/EDA-04212-V1-0/0
- Front Panel: https://edms.cern.ch/item/EDA-04213-V2-0/0

5.2 3-board assembly prototype

As a feasibility study, a prototype of a 3-board assembly (Main Backplane, Power Backplane, Front Panel PCB) was prepared by Karol Motala (SY-EPC). Even if different connectors were used, it still demonstrates a general idea.

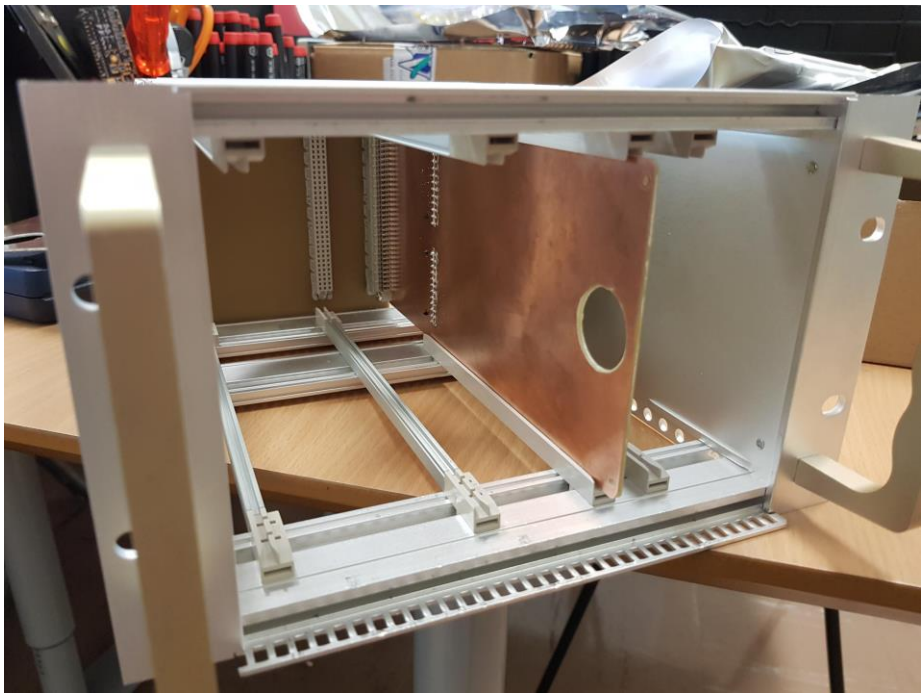

Figure 3: 3-board assembly, left side view

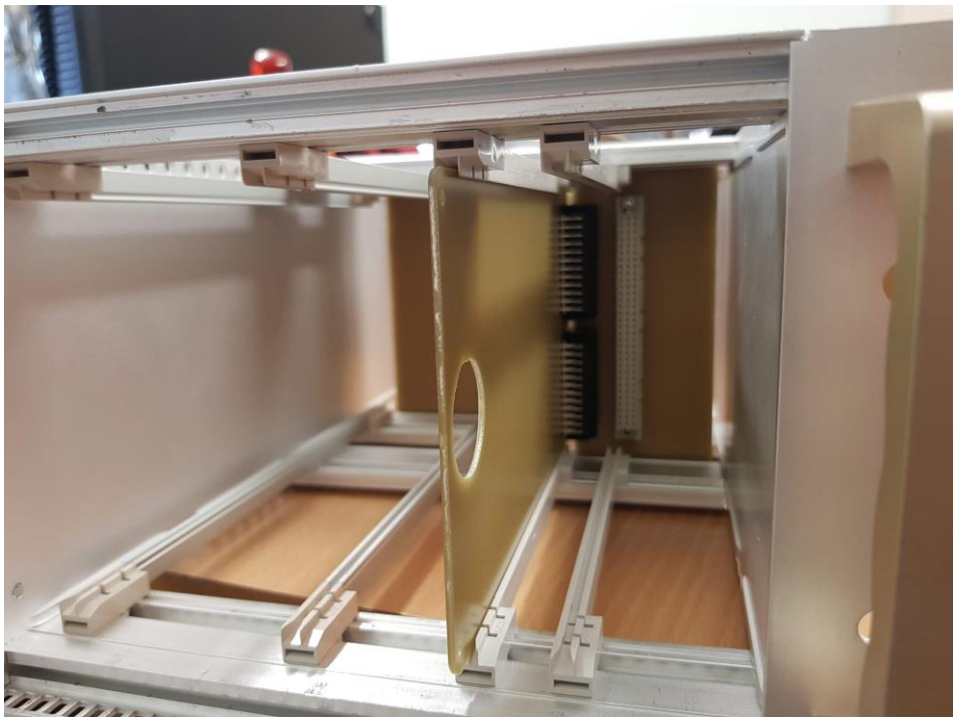

Figure 4: 3-board assembly, right side view

Figure 5: Front Panel PCB mock-up

6. REFERENCES

[1] https://ohwr.org/project/diot-crate-hw/wikis

[2] https://ohwr.org/project/diot/wikis

[3] https://ohwr.org/project/diot/wikis/files#diot-system-specification