Rev. D / April, 2022

SYSTEM DESCRIPTION

The type C enclosure is designed to host up to six PEB power modules and provides IP20 protection from the surroundings. The system also provides power supply to the modules as well as variable-speed air cooling. Finally, the enclosure is equipped with an LCD screen allowing to monitor the status of the modules.

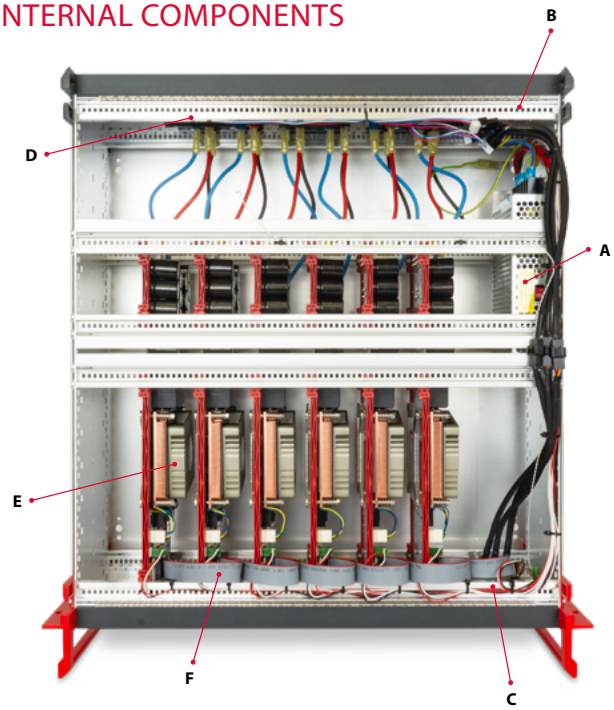
The box is designed for mounting within 19" cabinets.

Imperix also offers other types of module enclosures, as summarized in Table 1.

Name	Enclosure style	Compatible module types	# slots
Type A	Open chassis	PEB8024, PEB8038, PEB4050	8x
Type B	Open chassis	PEH2015, PEH4010	8x
Type C	IP20 enclosure	PEB8024, PEB8038, PEB4050	6x / 8x
Type D	IP20 enclosure	PEN8018	6x / 8x

Table 1. **Available types of module enclosures.**

INTERNAL COMPONENTS



Type C enclosures can host different types of modules, which are commercialized as independent products. One is here shown with 6x PEB8038 half-bridge modules (not included).

The enclosure itself embeds the components listed in Table 1. The corresponding circuit schematics are given in Figure 1 and Figure 2.

	Designation	Manufacturer	Part Number
A	Auxiliary power supply	Delta Electronics	
B	Fuse	Bel Fuse Inc.	
C	LCD control board	Imperix	
D	Cooling fan (3x)	Orion Fans	OD7020-12HHB10A
E	Power module (6x)	Imperix	PEBxxxx
F	Board-to-board cable (6x)		

Table 2. **Main components of the type C enclosure.**

MAIN ELECTRICAL SCHEMATIC

Power modules are directly wired to the rear panel. As such, they can operate entirely independently from each other. In particular, no common DC bus is present.

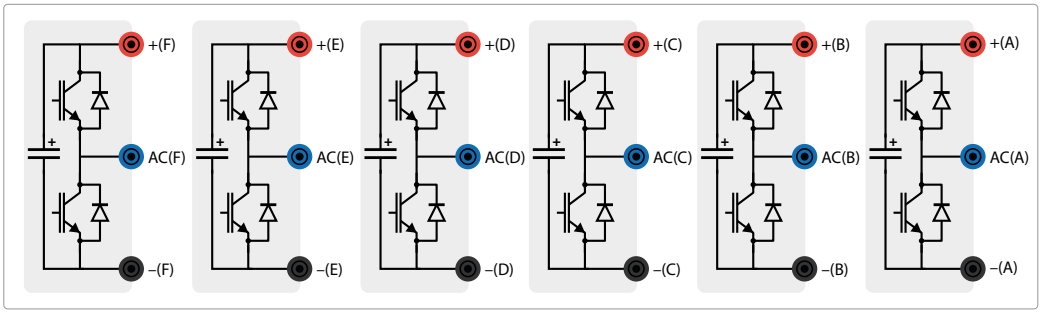
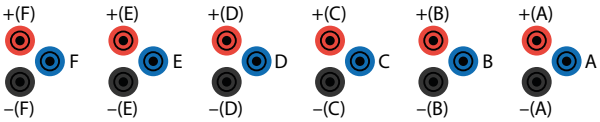


Figure 1. **Electrical schematic of the main power section, corresponding to the individual power modules.**

REAR PANEL CONNECTORS

Pluggable power terminals are available for each possible connection point of the modules. Their designation are indicated below (rear view).



Connector type: 4 mm safety laboratory plugs (banana)

MAIN ELECTRICAL SPECIFICATIONS

Electrical specifications are mostly dependent on the ratings of the power modules, combined with the implemented modulation and control software. As such, specifications may vary significantly from one configuration to another. In any case, the *typical maximum power* is limited by the current and voltage ratings of the rear panel connectors.

Module type	AC voltage	AC current	AC power
PEB8024	3~ 230/400V	24A (rms)	16 kW
PEB8038	3~ 230/400V	32A (rms) terminal limited	22 kW
PEB4050	3~ 110/190V	32A (rms) terminal limited	10 kW
PEN8018	3~ 230/400V	18A (rms)	12 kW

Table 3. **Typical maximum specifications in three-phase configuration, with 20 kHz hard switching conditions.**

Characteristic	Nom.	Max.	Unit
Operating DC voltage	800	1000	V (dc)
Operating AC current	32		A (rms)

Table 4. **Electrical specifications of the rear panel connectors.**

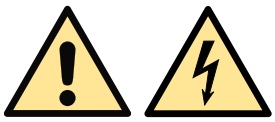
Note: External wiring such as laboratory cables must be arranged in agreement with the expected current ratings. Imperix recommends not to exceed 5A/mm^2. For long connections or when a risk of fire cannot be avoided, <3A/mm^2 should be observed.

ENVIRONMENTAL CONDITIONS

This product is designed for use within an indoor-conditioned environment (IEC 60721-3-3).

Characteristic	Conditions
Operating temperature	15–35°C
Storage temperature	0–60°C
Operating relative humidity	10–75° RH, non condensing
Overvoltage category	OVC II
Mechanical protection	IP20
Altitude	< 2000 m
Air pollution degree	PD 2

Table 5. **Storage and operating conditions.**



Caution, hazardous voltage inside. Risk of electrical shock! Do not open cover unless all DC busses are completely discharged.

When using this product with three-phase mains voltage, suitable circuit breaker(s) or fuse(s) must be used (PSCC < 6kA).

This product is designed for use within electric research laboratories (or similar test facilities) by trained personnel only.
Applicable safety regulations must be observed at all times.

Disregarding this warning or other relevant instructions may lead to severe injury and/or cause serious damage.

SYSTEM PROTECTION

POWER SEMICONDUCTORS

All imperix power modules provide on-board protections against over-current, over-voltage and over-temperature. These mechanisms act by blocking the PWM gating signals. They are hence very fast (few µs), and protect effectively the power semiconductors.

On-board protections are however unable to prevent uncontrolled diode currents in case the DC bus is inadequately conditioned. These protections are therefore insufficient for electrical safety purposes.

SAFETY HAZARDS

For some applications, such as when using this product for interfacing a power converter to the AC mains, fuse(s) or circuit breaker(s) must be present upstream, so that personnel safety is guaranteed at all times, and that risks or fire are mitigated.

On the other hand, circuit breakers or fuses generally act within few (tens) of ms only, making them ineffective for protecting power semiconductors and other sensitive components.

ON-BOARD PROTECTION COORDINATION

A global fault signal is shared across all modules and with the supervisory board (behind the LCD screen). This signal triggers the blocking of all modules in case one of them detects a fault condition.

Once triggered, a fault condition remains active until it is cleared (see *fault clearing* below) or the enclosure is power cycled.

More information on the fault signal sharing is provided in the datasheet of the power modules.

BOOTING AND NORMAL OPERATION

When the enclosure is switched on, the LCD displays a welcome message for 1 second:

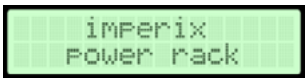


Figure 2. **LCD display message during boot.**

After the boot, the LCD screen displays the following information:

- The temperature inside the enclosure [°C]
- The highest fan speed of the three rear fans [rpm]
- The highest temperature among all modules [°C]
- The highest fan speed among all modules [rpm]

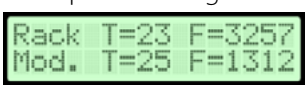


Figure 3. **LCD display showing temperature and fan speed.**

BEHAVIOR UNDER FAULT

As long as there are no faults, the screen is refreshed every second.

In case of fault, all modules are instantly blocked and the system enters in fault mode. Several messages will then repeat continuously until the fault is cleared:

Fault source

A first message indicating the fault source is displayed. The possible sources are:

- "POWER MODULE FAULT", indicating that one of the modules triggered the fault.
- "RACK COOLING ERROR", indicating that the supervisory module triggered a fault due to inoperative enclosure fans or excessive temperature.

Figure 4. **LCD display fault message.**

Figure 5. **LCD display fault source.**

Module status information

Six messages are also displayed one after the other, indicating the individual modules status. In case a fault is present, its probable cause is indicated. Otherwise, module temperature and fan speed are displayed.

Modules are numbered from M0 to M5, counting from left to right (front view). The supervisory module automatically detects how many modules are connected.

Figure 6. **Module status display example with fault.**

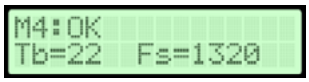


Figure 7. **Module status display example without fault.**

The different types of faults are listed in Table 6.

Displayed code	Corresponding fault source
I.	Over-current (AC midpoint sensor)
V.	Over-voltage (DC bus sensor)
T.F.	Over-temperature of fan failure (not spinning)
P.	Inadequate local power supply voltage
D.	Desaturation detected on one power semiconductor.

Table 6. **Storage and operating conditions.**

Rack status information

The last message displays the highest fan speed and temperature, as during normal operation (Figure 3).

FAULT CLEARING

Faults can be acknowledged and cleared by pressing the small button located under the LCD screen.

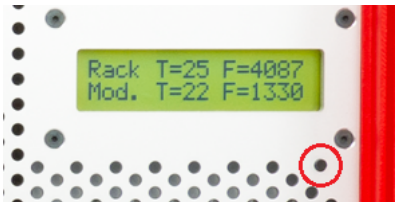


Figure 8. **Fault clearing button located under the LCD screen**

In case the cause of the fault is still present, the fault cannot be cleared. Waiting sufficient time for the fault to clear may be required.

POSSIBLE CUSTOMIZATIONS

Imperix can offer various customizations to the type C enclosures, for instance:

DC bus bars can be used for connecting 2-6 modules together. They exist in variable lengths.

Customized rear panels can be designed upon customer request with a special arrangement of the terminals.

Special power terminals can be implemented, for instance to accommodate larger current ratings.

For all such customizations, please contact our engineering team at sales@imperix.com.

AUXILIARY CIRCUIT SCHEMATIC

The auxiliary circuit is used for powering the gate driver section of the power modules, the LCD screen, as well as the cooling fans (on-board the modules, as well as on the rear side of the enclosure).

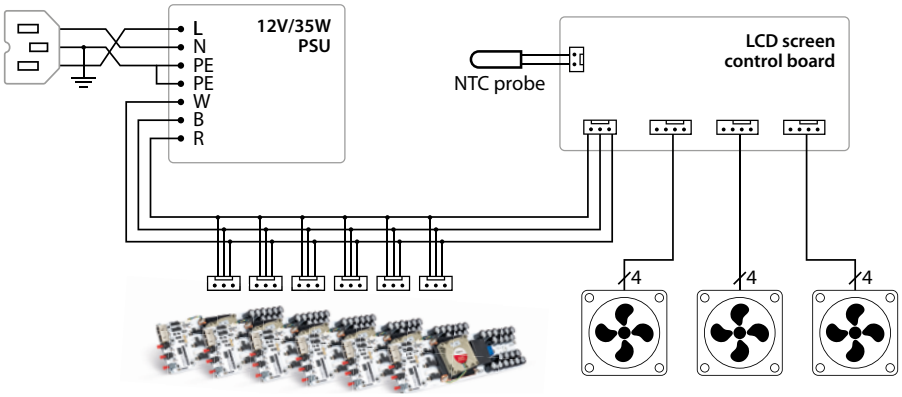


Figure 9. **Electrical schematic of the auxiliary circuit.**

AUXILIARY CIRCUIT SPECIFICATIONS

Characteristic	Test conditions	Specification
Operating AC voltage	50-60 Hz	88-132 V (rms), or 176-264 V(rms), selectable by switch
Operating AC current	110 VAC	< 0.5 A (rms)
CE conformity	230VAC	EMC directive 2014/30/EU Low-voltage directive 2014/35/EU RoHS directive 2011/65/EU + 2015/863 +2017/2102
EMC emissions (conducted and radiated)	CISPR32, FCC part 15	Class B (residential)
EMC immunity (conducted and radiated)	IEC 61000-4-2 to -6	EN61000-6-2 (industrial)

Table 7. **Electrical specifications of the auxiliary circuit.**

PRODUCT SAFETY

FCC Compliance Statement

This device is exempted from compliance with Part 15 of the FCC Rules, pursuant CFR47 §15.103(c) regarding industrial, commercial or medical test equipment.
CAUTION Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Canadian Compliance Statement

This digital apparatus is exempted from compliance with Canadian ICES-003, pursuant article 1.5.1(d). / Cet appareil numérique est exempté de conformité à la norme NMB-003 du Canada, ainsi que stipulé par l'article 1.5.1(d).

APPLICATION EXAMPLES

CONNECTION TO GRID THROUGH AN ISOLATION TRANSFORMER

This straightforward scenario implements an isolation transformer between the power converter and the grid. In this configuration, the EMC filter + LC filters are recommended to be connected as shown. Common-mode currents circulate between the filter and the converter enclosure only. Residual current protective devices (RCD) can be used without trouble.

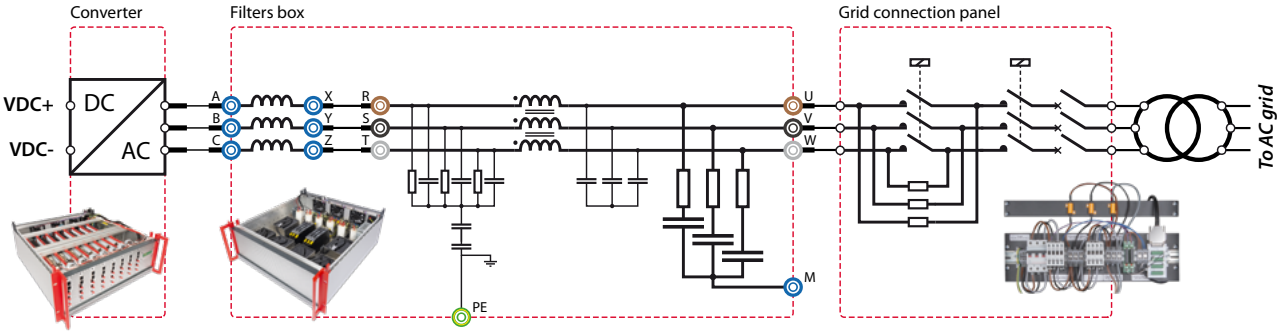


Figure 10. **Filter topology for a connection to the grid with an isolation transformer.**

TRANSFORMER-LESS CONNECTION TO GRID

This scenario provides increased filtering performance, and hence can be implemented in a transformer-less configuration, even if a conventional RCD is used (~20mA). In this case, a direct feedback path is arranged to the converter DC bus, so that common-mode current do not circulate through the grounding. Besides, the EMC filter is connected differently, so that ground currents are reduced to a negligible level.

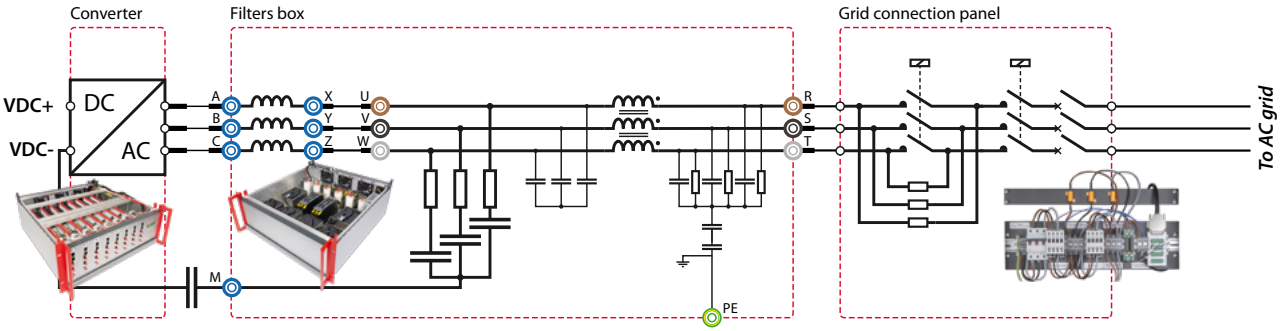


Figure 11. **Filter topology for a transformer-less connection to the grid.**

Other application examples can be browsed at imperix.com/doc

About us

Imperix is a company established in Sion, Switzerland. Its name is derived form the Latin verb *imperare*, which stands for "controlling" and refers to the company's main business: the control of power electronic systems. Imperix commercializes hardware and software solutions for the fast implementation of prototyping and pilot systems in the fields of power electronics, energy storage, smart grids and related systems.

Note