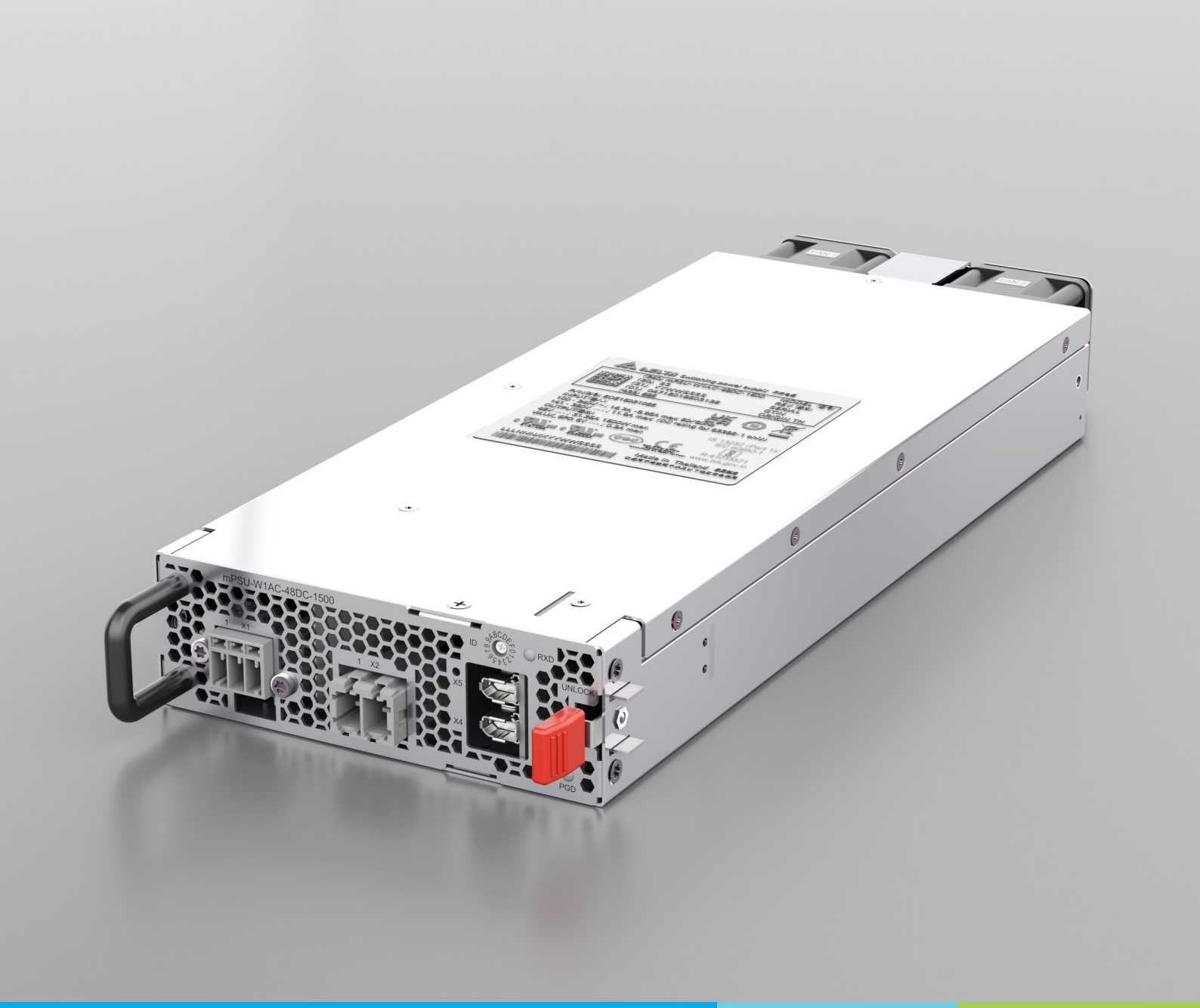

Medical Power Supply Unit

mPSU-W1AC-xxDC-1500W

Application note

NOTE

This product is only for installation by professional electricians within other equipment and must not be operated as a standalone product.

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Table of Contents

1. Features

- regulatory compliance for global healthcare and AV/ICT markets (IEC, ANSI, CSA, UL, CCC, BIS)
- wide-range AC & DC input (external DC fuse needed for DC operation)
- full medical I/O isolation within full nominal input voltage range
- industry-standard housing format: 1U (40.6 mm) x 5” (127 mm) with scaling in depth
- tool-less mounting via slide-in with locking mechanism
- modular mounting in 19” rack (1U), on a flat panel or on a back panel
- pre-assembled fans with front-to-back air-flow direction (fans at the back)
- low input and output noise
- low leakage current by minimized Y-capacitors
- immunity against backvoltage at the output (e.g. when directly connected to batteries)
- protection at all inputs against overvoltage and ESD
- protection of all outputs against overvoltage (except V_AUX), overload, overtemperature and ESD
- no minimum load required
- all electrical interfaces are accessible with finger-safe, reliable and lockable multi-pin connectors at the front
- remote controllable and diagnosable via 0V/5...24V, CANopen, Modbus RTU/ASCII over RS485 and two LED indicators
- adjustable output voltage, e.g. for direct battery charging
- adjustable output current limitation, e.g. for stable ramp-up of high capacitive loads or direct battery charging
- boost mode with 120% of output power and current for 10 seconds
- adjustable overcurrent behavior and shutdown with threshold and blanking time
- serial connectivity of 2 units asymmetric or 4 units symmetric to PE (with derating in isolation)
- autonomous current/voltage sharing via PMI_CAN for thermally balanced parallel/serial connection
- software update capability via CANopen

2. Components of the mPSU

2.1 Overview

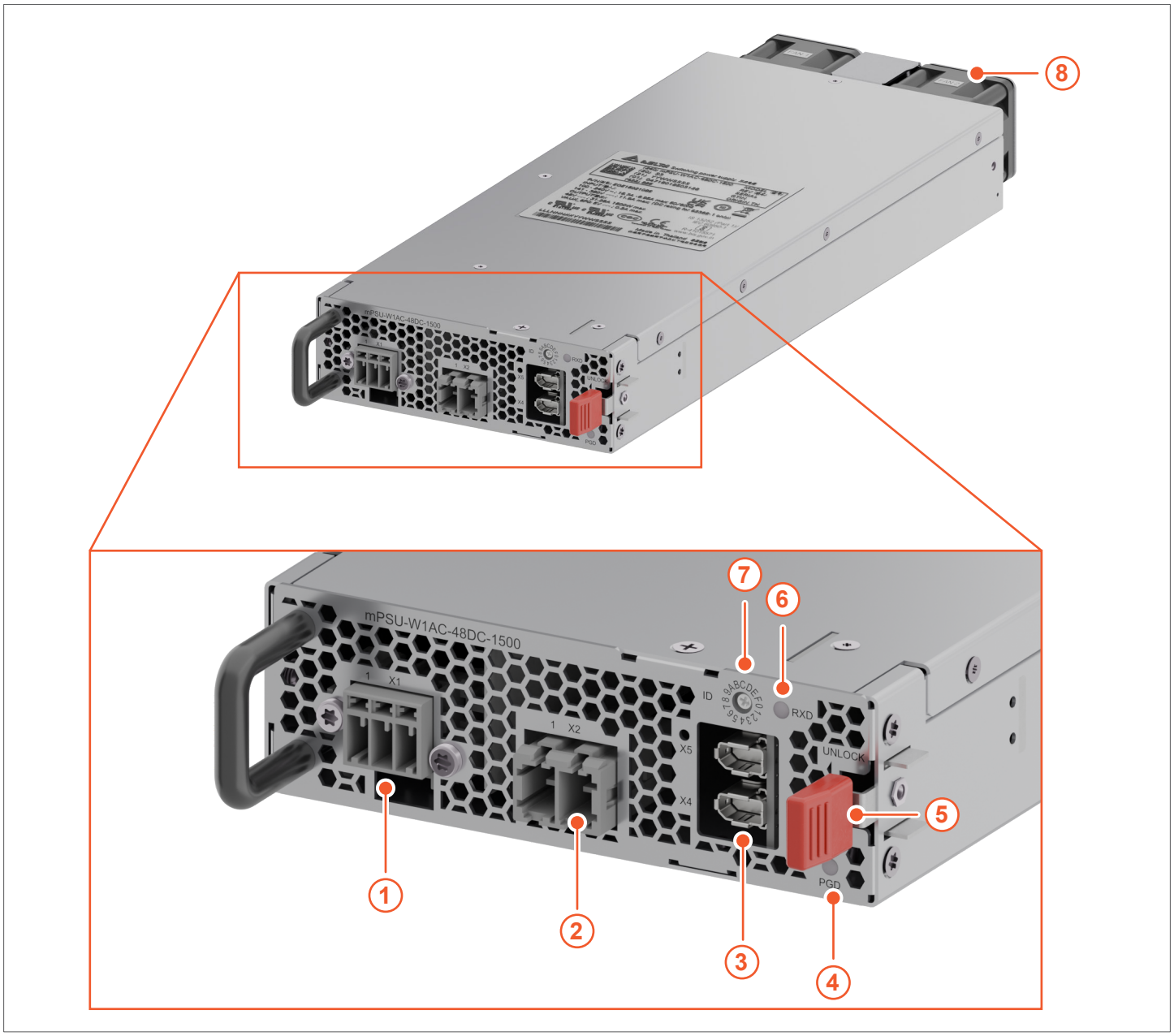


Fig. 1: Components of the mPSU

1 AC/DC input connector (X1)
2 DC output connector (X2)
3 2 x PMI interface (X4 + X5)
4 PGD LED (green); ON when Power Good
5 Unlock lever
6 RXD LED (green); ON when CANopen or Modbus RTU is detected
7 Rotary switch to set the CANopen node ID or Modbus RTU ID
8 Fans (2x)

2.2 AC/DC Input Connector (X1)

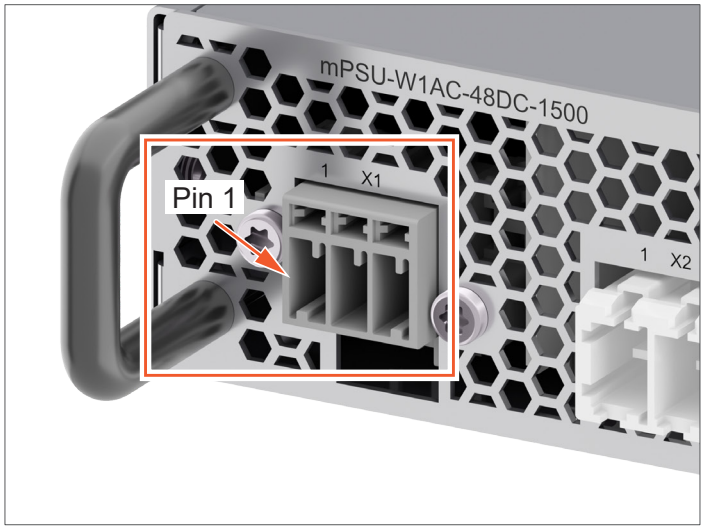
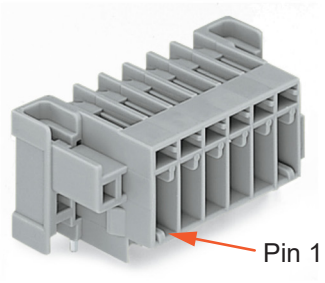


Fig. 2: AC/DC Input connector (X1)

X1 Connector Type

Connector (X1)	mPSU
Connector Type	3-pin, male
Manufacturer	Wago
Manufacturer Part Number	769-663/004-000
Product Image [1]	

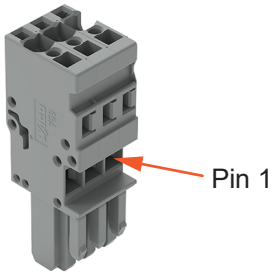
1) The image can show a different pin count.

X1 Pin Assignment

Pin assignment (X1)	
X1.1	PE [1]
X1.2	IN_N / N
X1.3	IN_1 / P

1) PE connector pin is connected to metal housing

X1 Suitable Counter Parts

Connector (X1)	External Counter Part
Connector Type	3-pin, female
Manufacturer	Wago
Manufacturer Part Number	769-103
Wire cross section	
Nominal	4 mm^2 / 12 AWG
Range	0.08 to 4 mm^2 (28 to 12 AWG)
Product Image	

Connector (X1)	External Counter Part
Connector Type	Locking lever
	Locks the female connector to the male connector; placed to pins 2 + 3
Manufacturer	Wago
Manufacturer Part Number	769-431
Product Image	

2.3 Main DC Output Connector (X2)

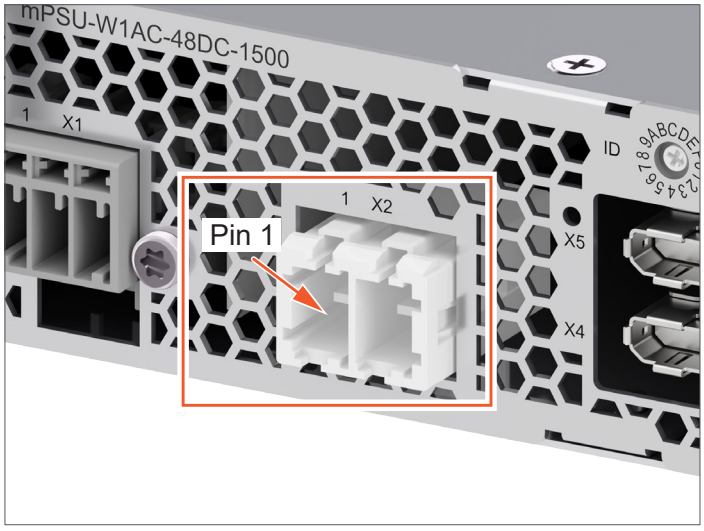


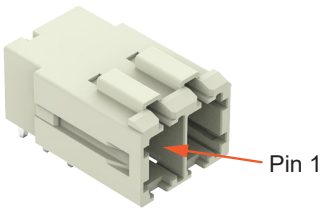
Fig. 3: Main DC Output Connector (X2)

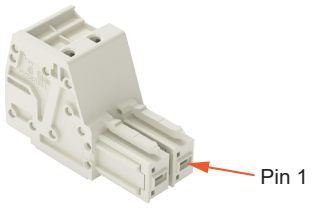
X2 Connector Type

X2 Pin Assignment

Pin Assignment (X2)	
X2.1	OUT_N
X2.2	OUT_P

X2 Suitable Counter Parts

Connector (X2)	mPSU
Connector Type	MCS MAXI 6, 2-pin, male
Manufacturer	Wago
Manufacturer Part Number	831-3622
Product Image [1]	

Connector (X2)	External Counter Part
Connector Type	MCS MAXI 6, 2-pin, female
Manufacturer	Wago
Manufacturer Part Number	831-3102
Wire cross section	
Nominal	4 mm^2 / 12 AWG
Range	0.5 to 10 mm^2 (20 to 8 AWG) (0.5 to 6 mm^2 with wire end sleeve)
Product Image [1]	

2.4 Power Management Interface (X4, X5)

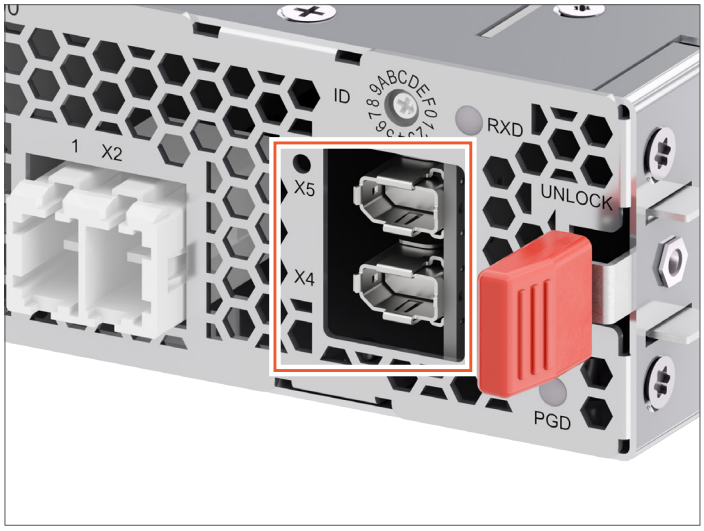
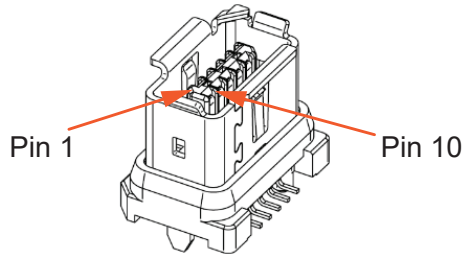


Fig. 4: Power Management Interface (X4, X5)

X4, X5 Connector Type

Connector (X4, X5)	mPSU
Connector Type	male
Manufacturer	Hirose
Manufacturer Part Number	IX80G-B-10P



All the poles at X4 and X5 are connected in parallel with the same signals to realize a „signal-in“ and a „signal-through“ connection. So, they support a daisy-chain wiring in a system with several modules present.

Pin Assignement (X4, X5)		
X4.1	X5.1	CAN_L
X4.2	X5.2	CAN_L
X4.3	X5.3	VAUX_5P0
X4.4	X5.4	PGD_P
X4.5	X5.5	PGD_N
X4.6	X5.6	INH_T_P
X4.7	X5.7	INH_E_P
X4.8	X5.8	PMI_GND
X4.9	X5.9	RS485_AY
X4.10	X5.10	RS485_BZ
X4.SHLD	X5.SHLD	Housing

X4, X5 Suitable Counter Parts

Connector (X4, X5)	External Counter Part
Connector Type	according to IEC 61076-3-124
Manufacturer	Hirose
Manufacturer Part Number	e.g. IX40G-B-10S-CV(7.0)
Wire cross section	4 mm² (12 AWG)
Product Image	

2.5 ID Rotary Switch

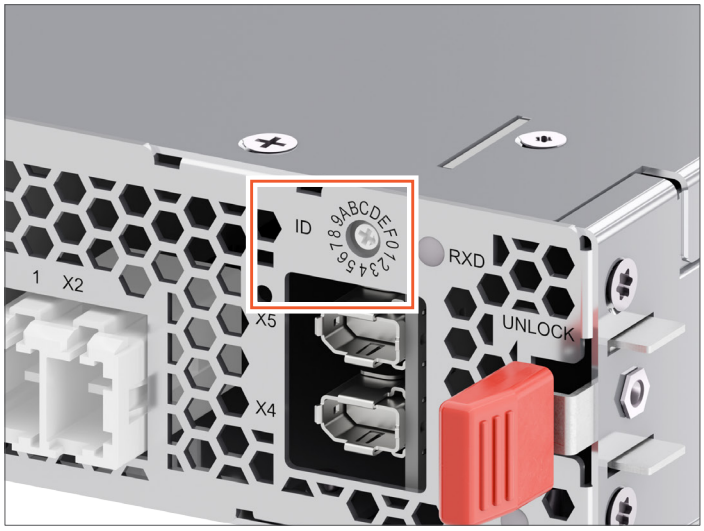


Fig. 5: ID Rotary Switch

The **ID rotary switch** is used set the node ID for CANopen / Modbus RTU.

Number of configurable node IDs: 16 hexadecimal values from **0h** to **Fh**.

Default setting: **1h**.

A newly selected node ID takes effect automatically after 3 seconds at the latest.

2.6 RXD LED

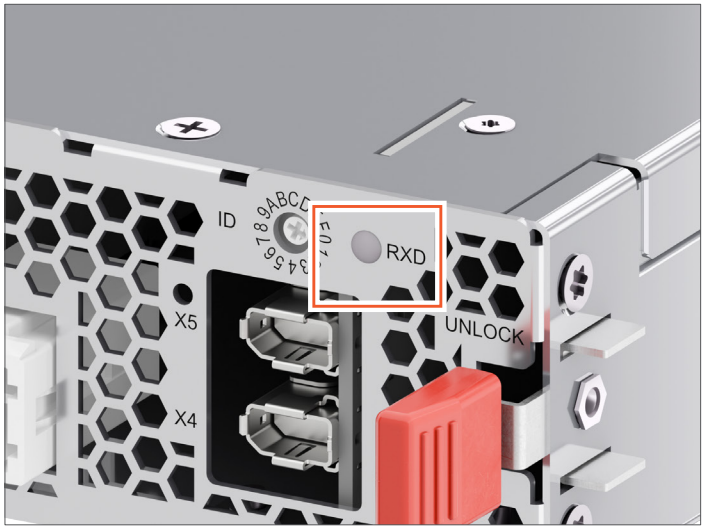


Fig. 6: RXD LED

The **RXD LED** ligths up green when a signal from CANopen or Modbus RTU is detected. The holdup time of 300 to 500 ms to span short pauses in the signal line.

If the mPSU is in *Bootloader mode* according to CANopen CiA 302, the **RXD LED** blinks continously in green (200 msec ON / 200 msec OFF).

2.7 PGD LED

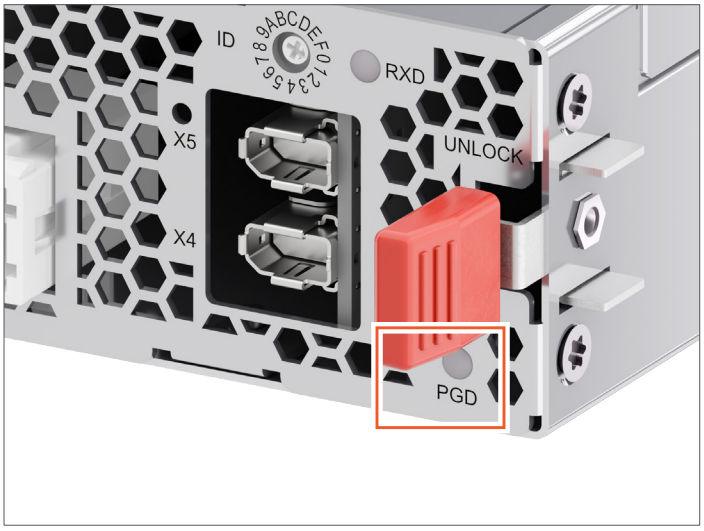


Fig. 7: PGD LED

The **PGD (Power Good) LED** is constantly ON (green) when power is good, and is OFF when power is fail.

2.8 Unlock Lever

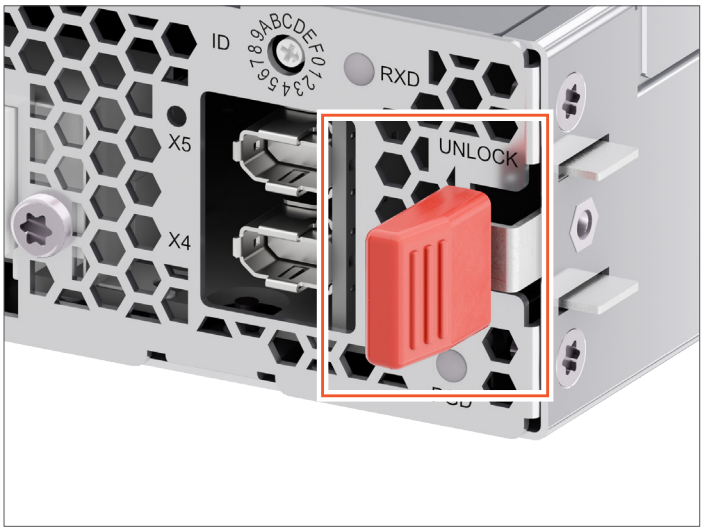


Fig. 8: Unlock Lever

The **unlock lever** releases the mPSU from the rack, allowing the mPSU to be removed.

3. Electrical Functions

3.1 Input Requirements

The AC input voltage and the DC input voltage should be in the defined voltage ranges (see data sheet). Otherwise, the power supply may not work properly or even fail. The maximum investigated branch circuit rating is 25 A. Therefore, a 25-A breaker should be used for medical applications.

3.2 Output Requirements

Main DC Output

Output current and output power of the end product must not exceed the rated/specified values at any value of output voltage. The output current must not exceed the maximum output current.

Auxiliary DC Output

The Auxiliary DC Output supports a maximum current of 200 mA.

3.3 No-load Operation

A no-load operation causes no damage, hazardous condition or reduction in performance.

3.4 Output Over Voltage Protection (OVP)

Main DC Output

The *Output Over Voltage Protection (OVP)* function shuts down the **Main DC Output** when the output voltage reaches the protected voltage.

The OVP shuts down the DC Main output at voltages from >28.8 to ≤32 V.

The settings for the *OVP* function cannot be changed.

Resetting the OVP function for the Main DC Output:

Disconnect the power supply from the supply voltage for a few seconds, then re-connect.

Auxiliary DC Output

The auxiliary supply voltage output permanently withstands a parallel connection with the auxiliary voltage outputs of several other mPSUs and the system load on V_AUX_5P0, also if some other mPSUs are powered off. This is realized by the overcurrent protection of the auxiliary voltage output and a protection against feedback voltage from outside. A current sharing function is not available here.

In case the internal OVP circuit triggers for V_AUX_5P0, the output switches off and is latched in this state. A reset of this state is possible with an input power cycle as well as *INH_E* or *INH_T* or *INH_BUS* cycles.

3.5 Output Over Current Protection (OCP)

Main DC Output

CC limitation is always active. In case of an over temperature, the mPSU goes into hiccup mode.

In case of a failure, the *Output Over Current Protection* (OCP) triggers and switches off the **Main DC output**. A reset of this state is possible with an input power cycle as well as *INH_E* or *INH_T* or *INH_BUS* cycles.

Auxiliary DC Output

The *Output Over Current Protection (OCP)* switches off the **Auxiliary DC Output** and enters hiccup mode when the output current exceeds 1.5 A.

3.6 Main DC Output Inhibit

INH_T is for faster turn on/off time.

INH_E is for better standby efficiency.

The Main DC Output switches off if **one** of the follwoing *Inhibit* events is activated on the **X4/X5** connectors:

- *INH_T* hardware signal is activated (Pin *X4.6* or *X5.6*)
- *INH_E* hardware signal is activated (Pin *X4.7* or *X5.7*)
- *INH_BUS* signal is activated via CANopen (Pins *X4.1*/*X4.2* or *X5.1*/*X5.2*)
- *INH_BUS* signal is activated via Modbus RTU (Pins *X4.9*/*X4.10* or *X5.9*/*X5.10*)

If one of the inhibit signals is activated when the input voltage ramps up, the main DC output will remain off, even if the input voltage reaches its nominal value.

3.7 Output power derating versus ambient temperature

The maximium output power depends on the ambient temperature, see Fig. 9, p. 12.

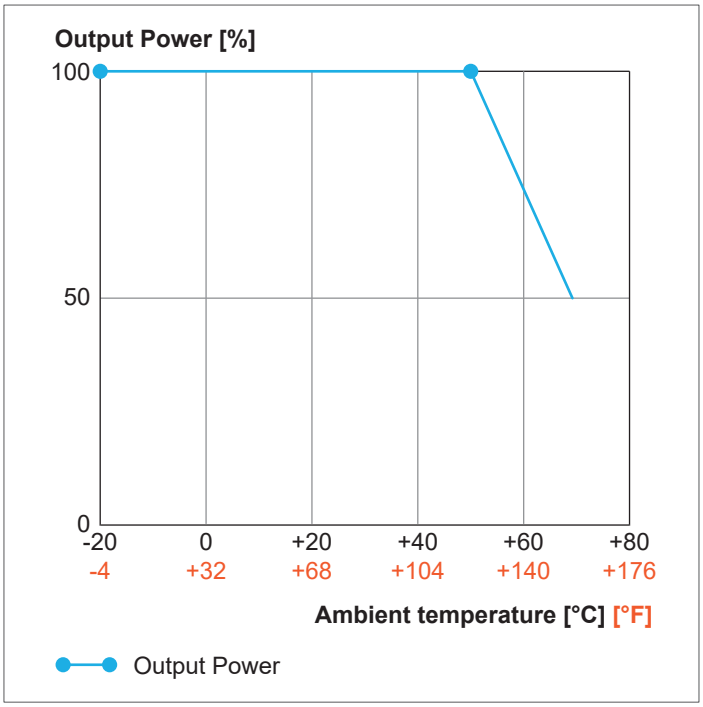


Fig. 9: Output power versus ambient temperature

The mPSU delivers full output power in a temperature range from -20 to 50 °C (-29 to +122 F).

At ambient temperatures above +50 °C (+122 °F), the output power at the Main DC Output is linearly derated from 100% at +50 °C (122 °F) to 50% at +70 °C (+158 °F).

3.8 Over Temperature Protection (OTP)

The *Over Temperature Protection* (*OTP*) function shuts down **Main DC Output** and **Auxiliary DC Output** when the temperature of components inside the mPSU is too high.

A fan fail or blocking of air flow would lead to overheating and thus trigger the OTP function.

Restarting after OTP shutdown

In case of an output power reduction by the OTP function, perform the following steps:

- Turn off the input voltage.
- Eliminate all conditions causing overheating.
- Let the mPSU cool down.
- Turn on the input voltage.

3.9 Power Good

The *Power Good (PGD)* signal is provided on the X4 / X5 connectors:

Pin Assignement (X4, X5)		
X4.4	X5.4	PGD_P
X4.5	X5.5	PGD_N

Tab. 1: Pin assignment of *Power Good* signal

The function uses the circuit as in shown in Fig. 10, p. 12.

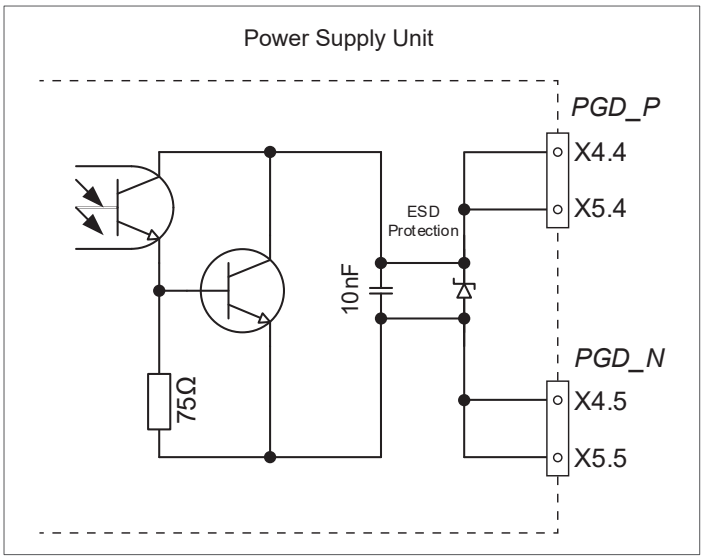


Fig. 10: Power Good (PGD) – Circuit diagram

The power through the PGD path shall be limited by the customer system. The resistor is needed to limit the open-collector current.

As soon as AC input voltage and DC output voltage are present for at least 10 msec, the *Power Good* signal is closed.

The *Power Good* function signal is opened on the following events:

- The power input voltage disappears not later than 15 msec after input voltage disappears.
- The power output voltage leaves the tolerance band of ±8% around the set value for >20 msec.
- An overtemperature warning occurs.
- A shutdown occurs.

3.10 Redundant operation

Up to 4 **mPSU** can be used in redundant operation.

An OR-ing diode is built-in to prevent that the redundant system fails when a single unit fails. Therefore, no external OR-ing diodes are required.

But when more than 2 **mPSU**s are connected in parallel, external fusing is required in the system to protect the power output circuitry against backward over current from other PSUs in case of a first fault condition (output short circuit) of any single **mPSU**.

4. System Interoperability

NOTE: Parallel / serial output combinations of W1AC and W3AC are **NOT** supported. Parallel / serial output combinations **of different variants** are NOT supported and need to be considered and validated for a dedicated application. Parallel / serial output combinations of identical variants are supported.

The connection to the different AC mains or corresponding DC input and the series as well as the parallel connection of the outputs of up to 4S (serial) 4P (parallel) mPSUs are supported with working voltages, given as follows:

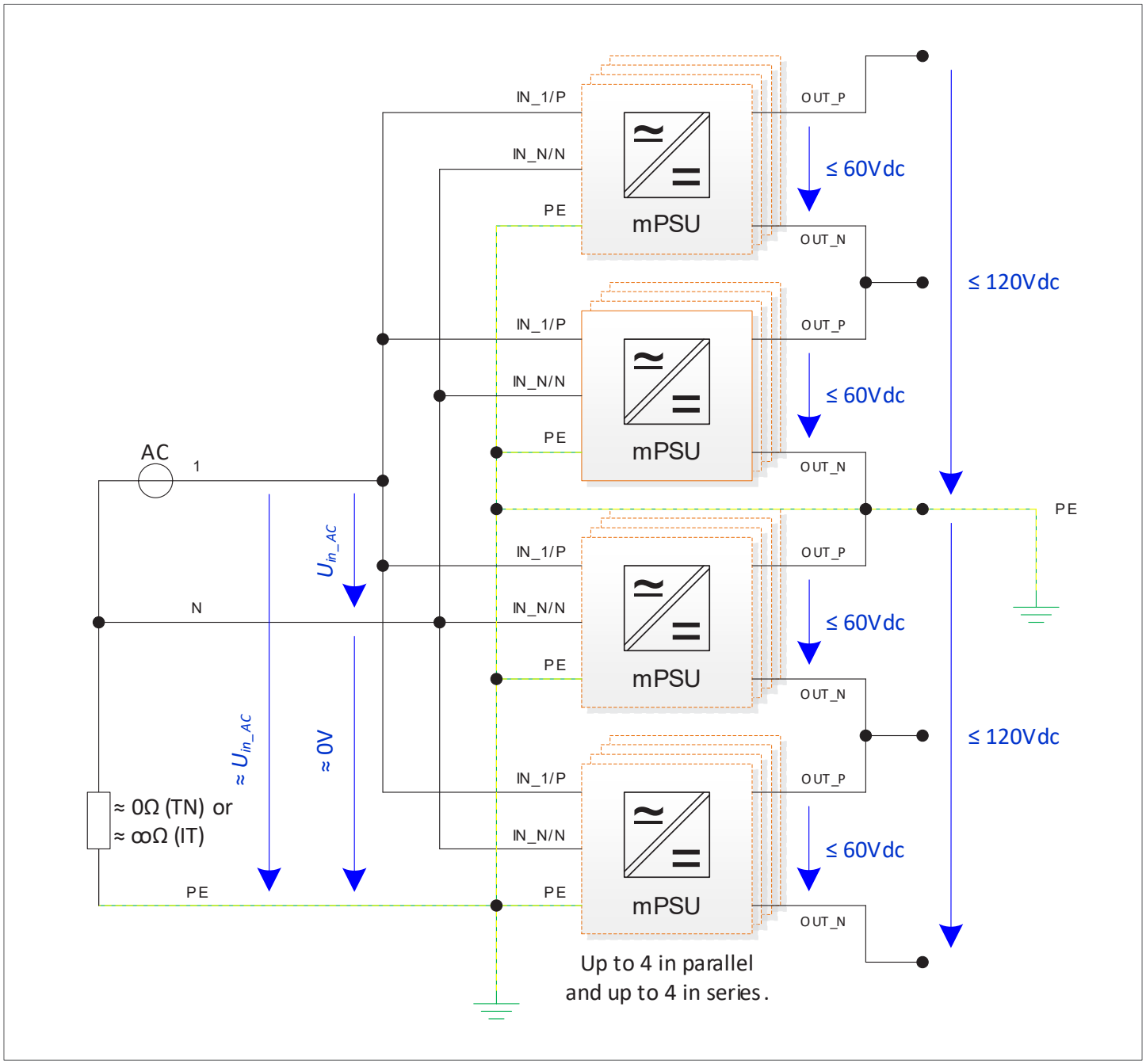


Fig. 11: System interoperability W1AC, 1-phase AC mains

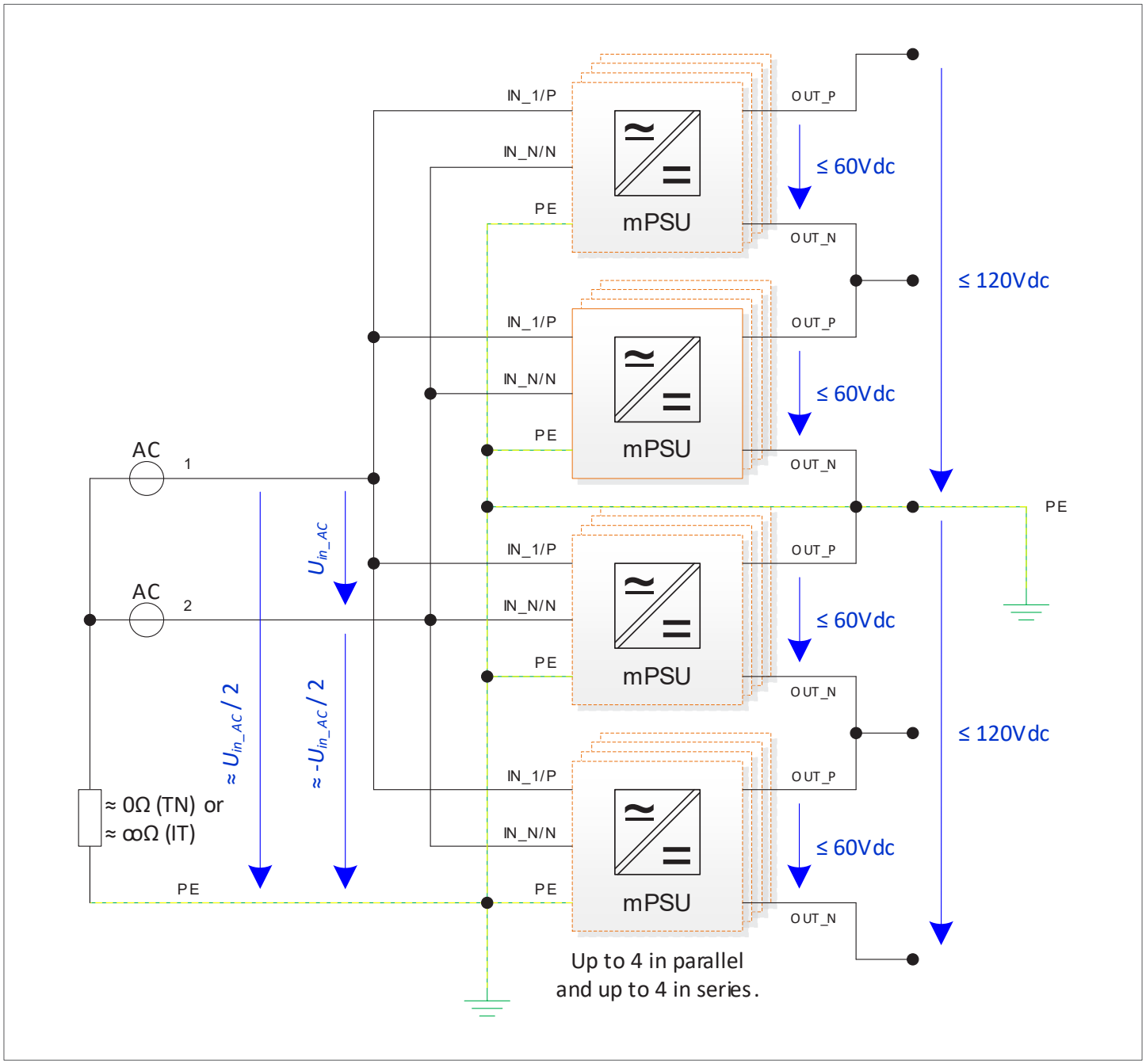


Fig. 12: System interoperability W1AC, 2-phase AC mains

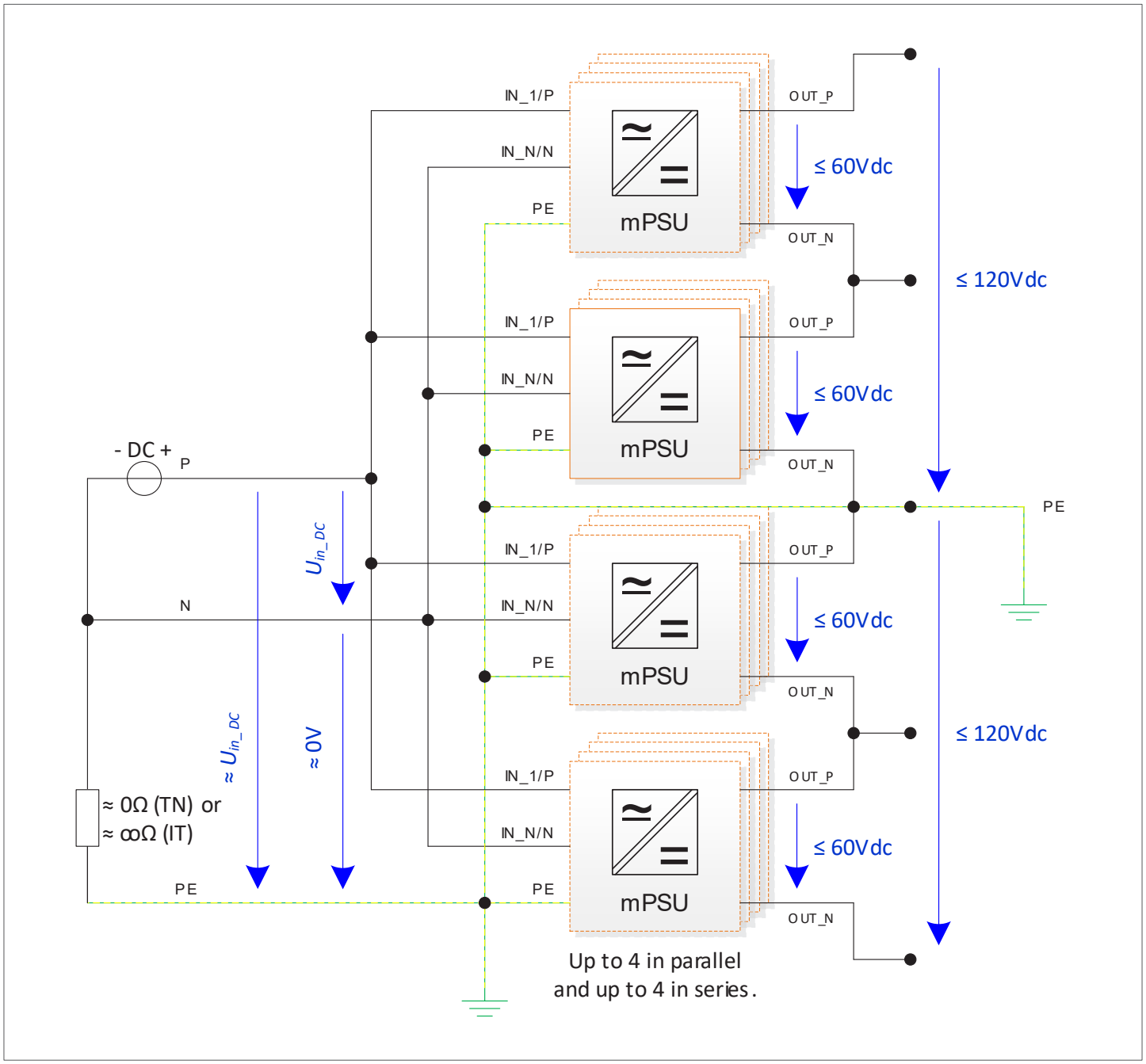


Fig. 13: System interoperability W1AC, DC source

5. Test Setups

5.1 Ripple & Noise

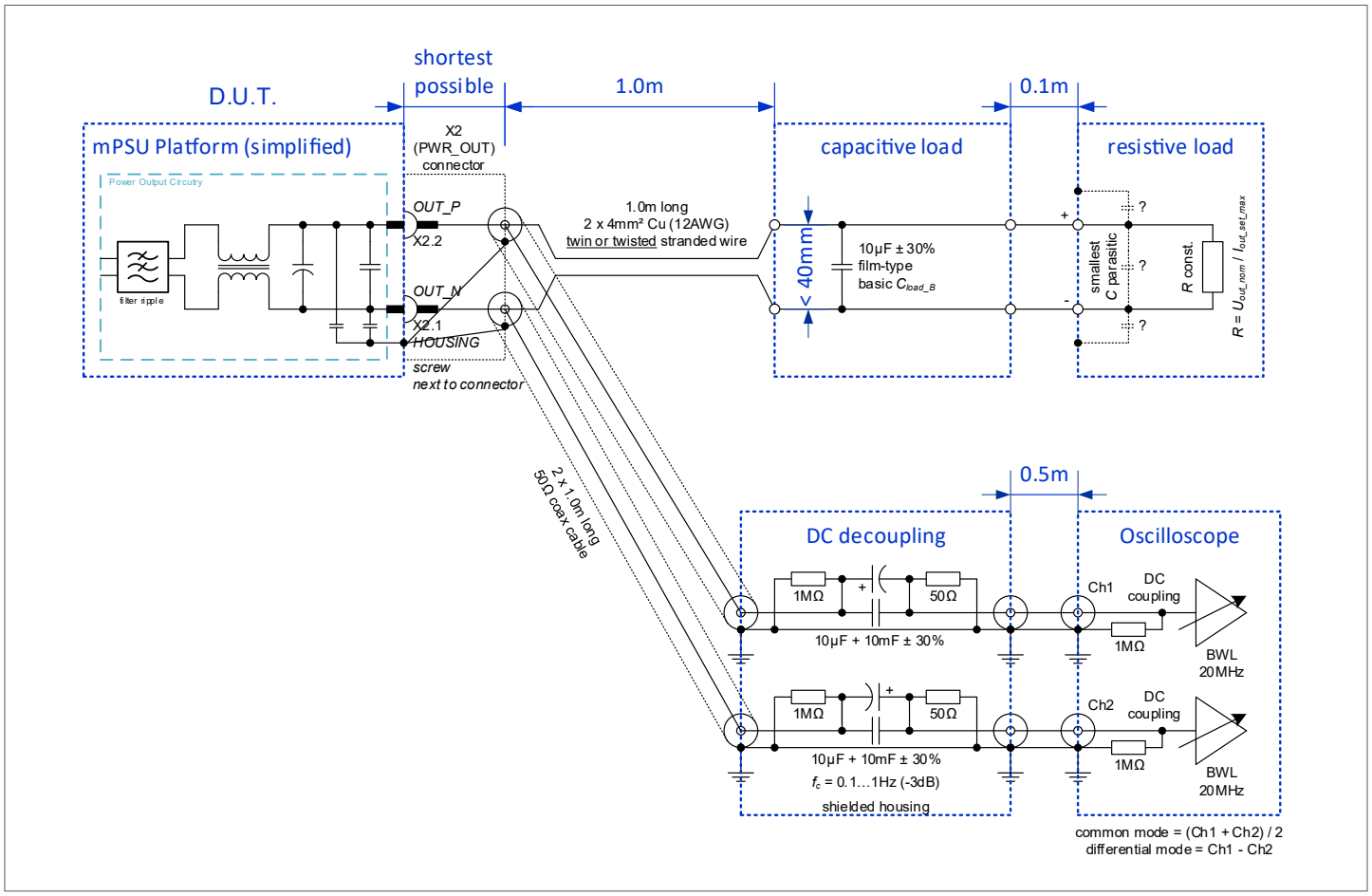


Fig. 14: Test Setup for Ripple & Noise

Herein the “DC-decoupling” network realizes the defined AC coupling into 50 Ohms in front of the oscilloscope, thus the oscilloscope itself is DC- and high-impedance coupled. Via this setup the oscilloscope-internal 50-Ohm termination is protected from damage and additionally the AC coupling high-pass corner frequency is brought down to 0.1 to 1 Hz, which is not given by the oscilloscope-internal AC-coupling.

5.2 Load Step Response

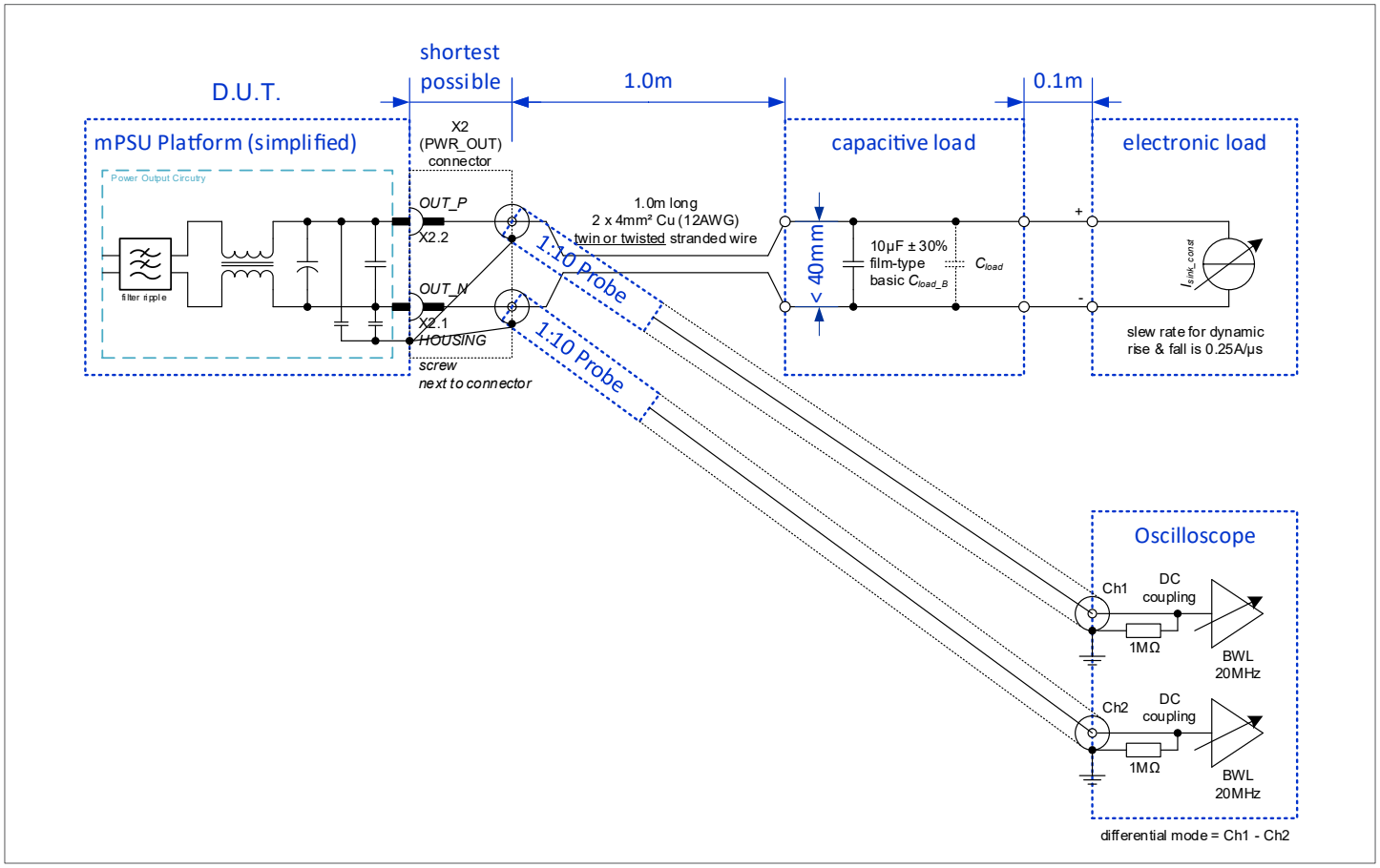


Fig. 15: Test Setup for Load Step Response

6. Installing the mPSU

6.1 General Safety Instructions

WARNING

Risk of electric shock

High voltages during operation.

- ► Always disconnect the **mPSU** from any AC and DC supply voltages, and wait minimum 1 minute before you start working on it.
- ► When connecting the **mPSU** to an AC input voltage, first connect the earth ground wire to the terminal block, then connect N and L.
- ► When disconnecting the **mPSU** from the AC input voltage, first disconnect the wires N and L, then disconnect the earth ground wire from the terminal block.
- ► Take care that no objects can fall into the **mPSU**.
- ► Perform the installation in a dry environment so that no moisture can get into the **mPSU**.

CAUTION

High temperatures

During operation the Power Supply Unit gets very hot.

- ► Let the **mPSU** cool down before you start working on it.

This product is only for installation by professional installers within other equipment and must not be operated as a standalone product.

6.2 General Installation Requirements

The **Power Supply Unit** is a built-in component. For the installation the following relevant standards have to be considered:

Medical:

- IEC 60601-1:2005+AMD1:2012+AMD2:2020
- ANSI/AAMI ES60601-1:2005 & A1:2012 & A2:2021
- CAN/CSA C22.2 No. 60601-1:14/A2-2022

Industrial:

- IEC 62368-1:2018
- UL 62368-1 ed.3
- CSA C22.2 NO. 62368-1:19
- CCC GB4943.1

For creepage distances, clearances, thickness of insulation between primary circuit and PE as well as thickness of insulation between primary and secondary circuits the following standards have to be considered:

- IEC 60601-1:2005+AMD1:2012+AMD2:2020
- IEC 62368-1:2018

The output power shall not exceed the maximum allowed continuous output power. Exception is the boost mode with a maximum current of 120% for maximum of 10 seconds. The value is printed on the unit label of the Power Supply Unit.

6.3 Cooling Requirements

Refer to the data sheet for the maximum continuous rating of the Power Supply Unit under consideration of its environmental temperature.

6.4 Connecting Wires to the mPSU

AC/DC Input connector (X1)

Use flexible cable.

Wire range:	0.08 to 4 mm^2 (28 to 12 AWG)
Cripping length:	8 to 9 mm (0.31 to 0.35 in)

Main DC Output terminal block (X2)

Use flexible cable.

Wire range:	0.5 to 10 mm^2 (20 to 8 AWG) (0.5 to 6 mm^2 with wire end sleeve)
Cripping length:	13 to 15 mm (0.51 to 0.59 in)

6.5 Electromagnetic Compatibility

The **mPSU** has to be installed inside an grounded metal box.

The AC input cable should be twisted and laid as far away as possible from the output cable.

All cables should be routed as close as possible to the grounded metal box.

Add a shielding to the input cable or the output cable (or ideally to both) if they are close to each other.

Ensure the input PE terminal is connected to ground.

6.6 Mounting the mPSU

Installation in a 19” 1U-rack

Push the mPSU into the rack until the locking mechanism snaps into rack.

To unlock the mPSU, push the UNLOCK lever to the left and pull the mPSU out.

Installation on an open metal surface

Use M3 screws with the appropriate length (see Fig. 16, p. 20) through the base mounting holes. This is necessary to ensure a safety distance between the screw and internal components.

Recommended mounting tightening torque is 0.6 Nm (5.3 lb-in).

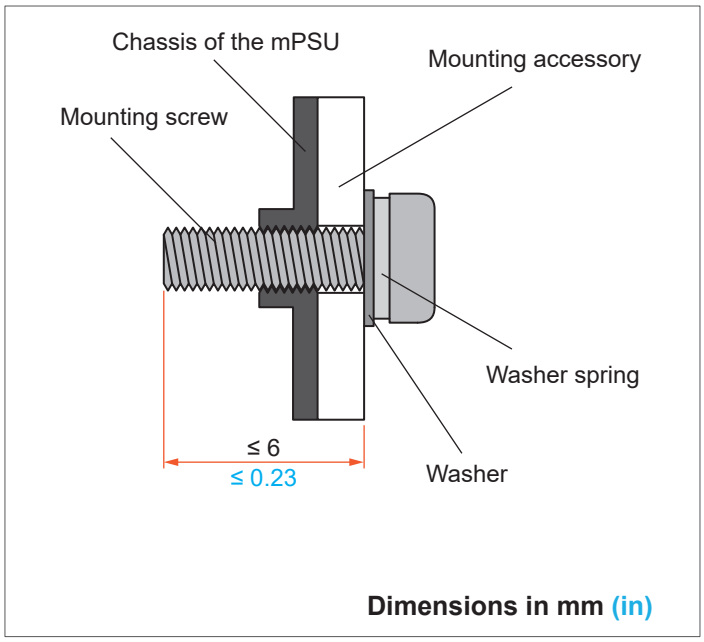


Fig. 16: Mounting the Power Supply Unit

7. Conditions of Regulatory Acceptability

7.1 Power Input

Mandatorily, the system for integration of a mPSU has to provide an external fusing or circuit breaker prior the power input with nominal ratings not higher than 25 A AC or DC. The tripping characteristic for AC or DC shall be not higher than a circuit breaker with C-characteristic ($I_{mt} \leq 10\ I_n$ for t = 0.02 to 2 s). The selectivity of external circuit breakers or fuses shall be considered with the branch circuit breaker in the application system (IEC 60601-1 Subclause 8.9.2.a).

In DC operation of the power input, the impulse voltage at the power input is to be limited to not higher than 2.5 kVp by the system.

An additional abnormal test could be considered to prove continued safety even at a possible fault situation with a short circuit at the power input, which the system fuses then will interrupt.

The defined DC operating voltages from here above shall be applied also with the given tables out of the medical standards, even when they are above 250 V_{DC}.

7.2 Output Voltage Offset

Due to possible series connection of several mPSUs or external voltage sources in the system, permissible external output offset voltages (values are defined in the tables here above) shall be supported and considered as additional internal working voltages at the mPSU internal dimensioning and verification of isolation.

7.3 UL Standards

The external power interface connectors are to be considered with UL1977 Standard.

7.4 Mechanics

Strain-reliefs are not supported by the mPSU itself but, if required, by the system of integration.

8. Dimensions and Mounting Orientation

8.1 Dimensions

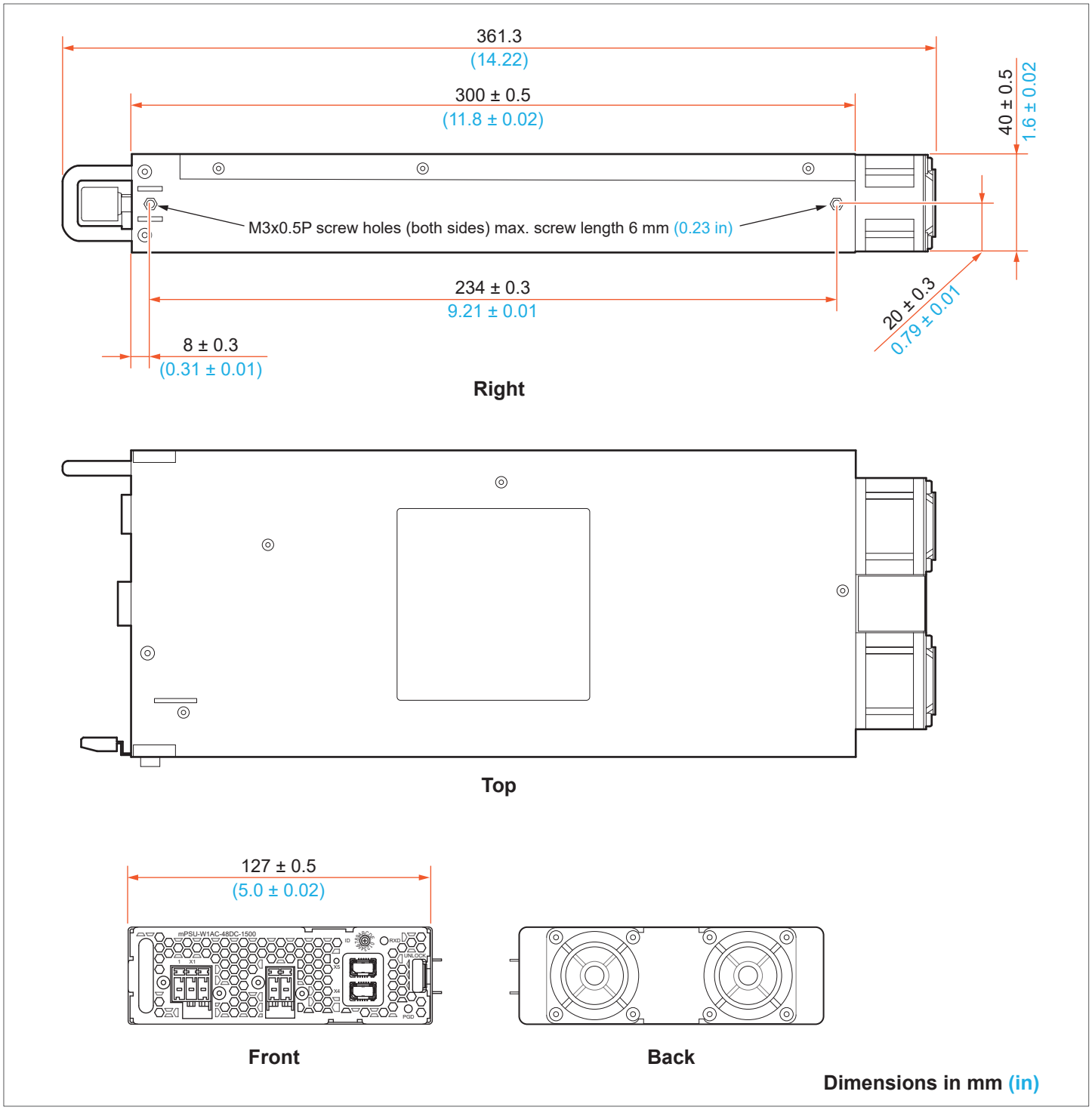


Fig. 17: Dimensions

8.2 Mounting orientations

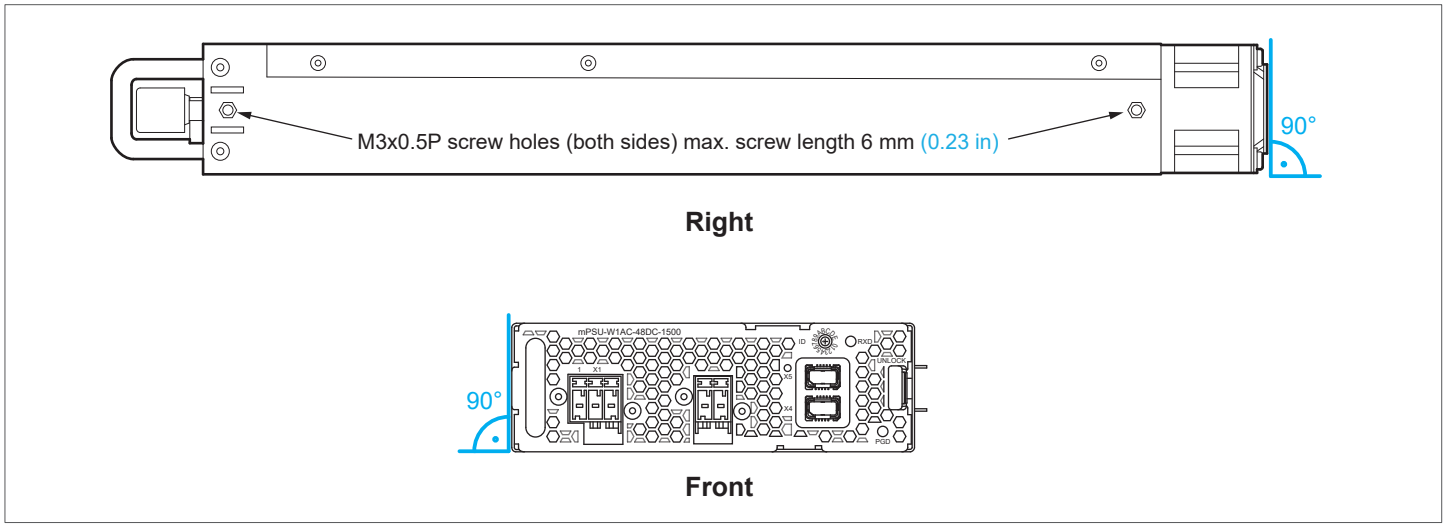


Fig. 18: Mounting orientations

9. Curves

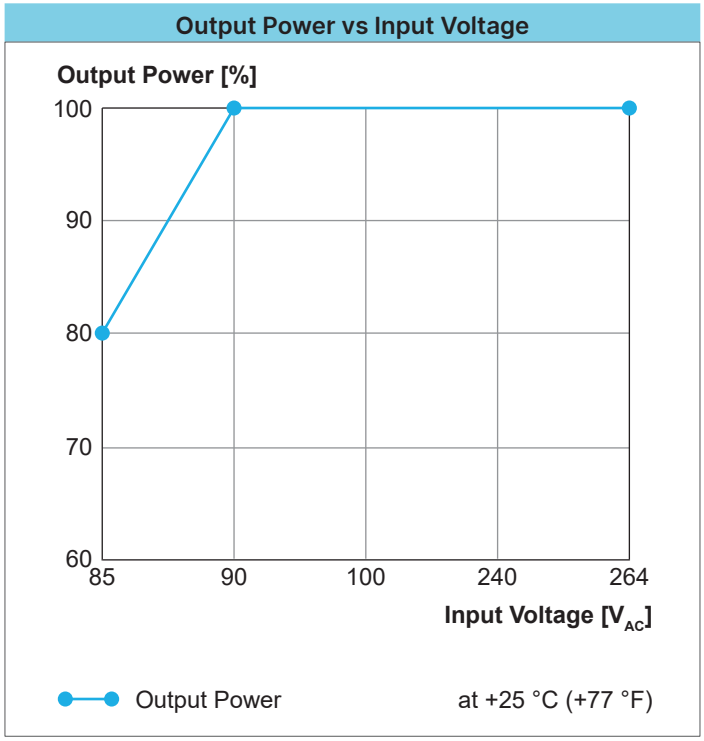


Fig. 19: Output power versus input voltage for W1AC-**xx**DC-1500W

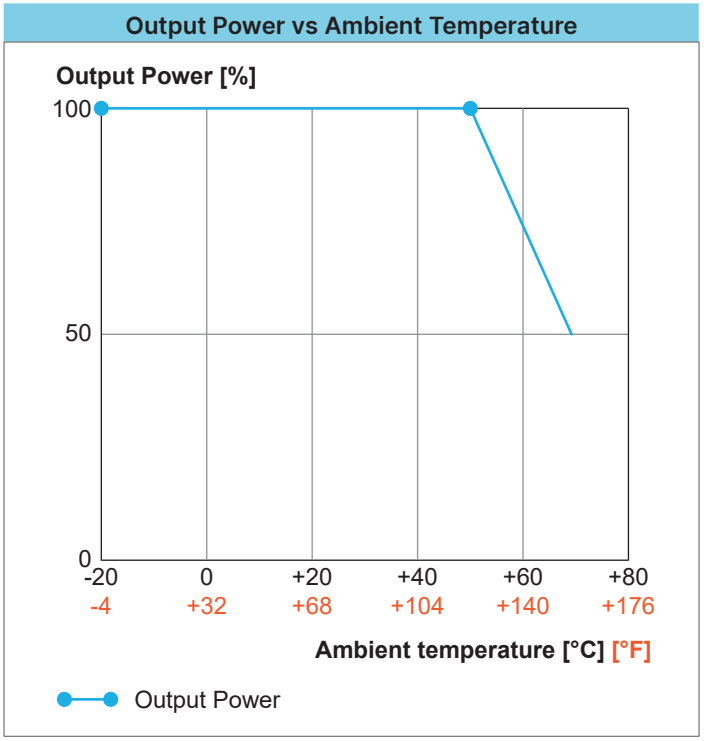


Fig. 20: Output power versus ambient temperature for W1AC-**xx**DC-1500W

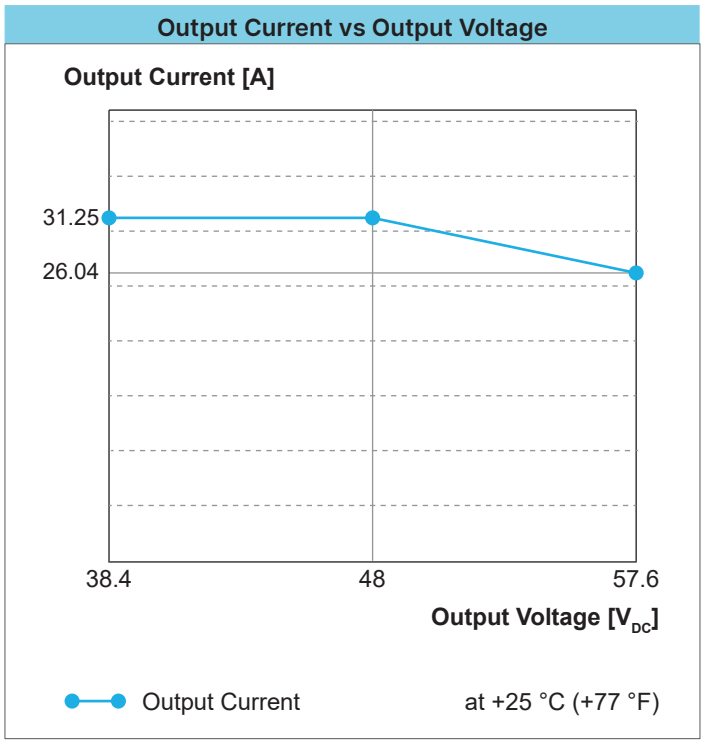


Fig. 21: Output current versus output voltage for W1AC-**48**DC-1500W

9. Curves

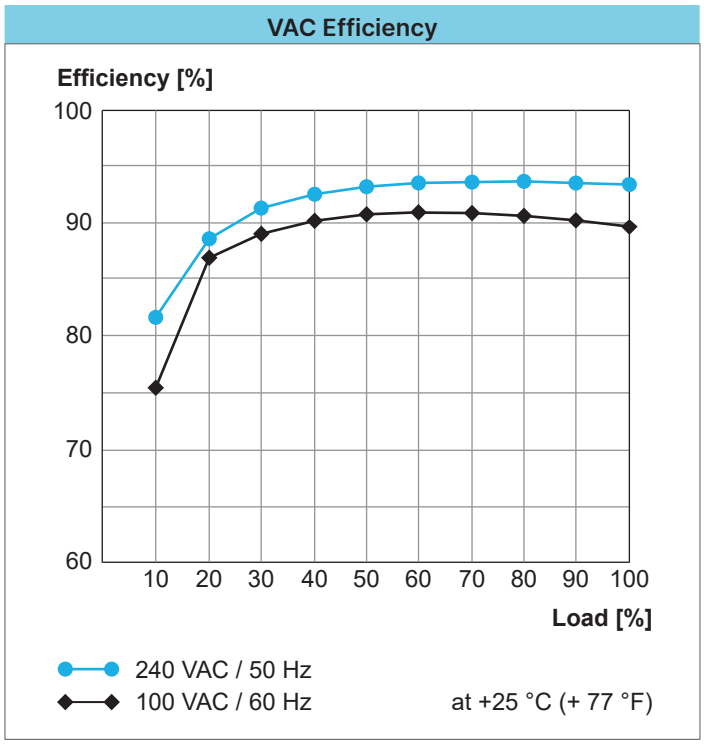


Fig. 22: VAC Efficiency for W1AC-**48**DC-1500W

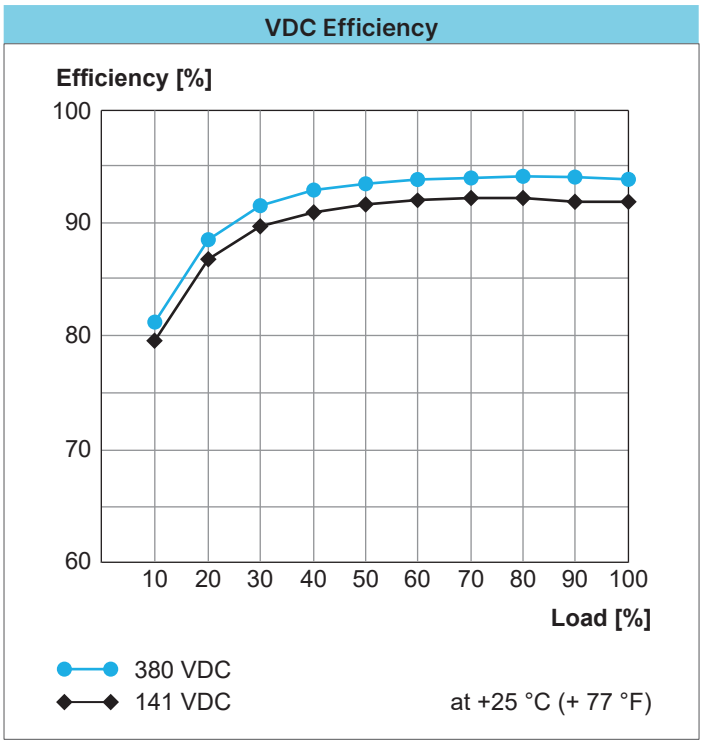


Fig. 23: VDC Efficiency for W1AC-**48**DC-1500W

10. CANopen / Modbus RTU

10.1 Related Documents

Contact Delta to get the documents.

CANopen Protocol Specification Document
Modbus RTU Protocol Specification Document

10.2 Selection of Communication Mode

After turn-on of the mains voltage, the mPSU goes in CANopen communication mode per default. Continuously the mPSU detects if any kind of CAN messages are received within a time window of 1.0 second. If yes, it stays in CANopen communication mode. If not, the mPSU goes in Modbus RTU communication mode until any kind of CAN message is received or a mains off-on-cycle occurs.

During operation of the mPSU, the communication interface towards the system remains available all the time.

10.3 Setting the Bitrate

The mPSU must have the same bitrate as the NMT-Master and the host system.

The longer the cable, the lower the possible bitrate. Please note that the maximum length of the branches depends on the bitrate (see CiA-301).

The bitrate can be configured with the LSS (Layer Setting Service, CiA-305).

Default bitrate: 500 KBit/s

10.4 Setting the Node ID

The node ID is set with the ID rotary switch, see “2.5 ID Rotary Switch”, p. 10.

Default ID is **1h**.

NOTE: Each device in a CAN / RS485 network must have a unique node ID (node address).

10.5 mPSU as Master

CAN

In a CAN bus, the mPSU can only work as slave.

RS485

In a RS845, the mPSU can only work as slave.

10.6 Communication Master Disconnection

During CANopen communication, the master device on the bus typically sends periodic heartbeat signals. In case there is no heartbeat signal at all or the heartbeat signal of the master cannot be detected anymore, the actual operating state and communication is maintained by the mPSU.

During Modbus RTU communication, there is no periodic heartbeat signal. Thus, the actual operating state and communication is maintained by the mPSU in all cases.

10.7 Software Updates

During a software update procedure, the power output interface is deactivated and is not configurable via bus communication.

If the software update procedure via CAN interface is interrupted, the mPSU is able to be available for a following software update cycle.

10.8 Use of Termination Resistors

The mPSU has no integrated termination resistor.

For both CAN and RS485 networks, a 120-Ω termination resistor has to be connected if the mPSU on one end of bus, see Fig. 24.

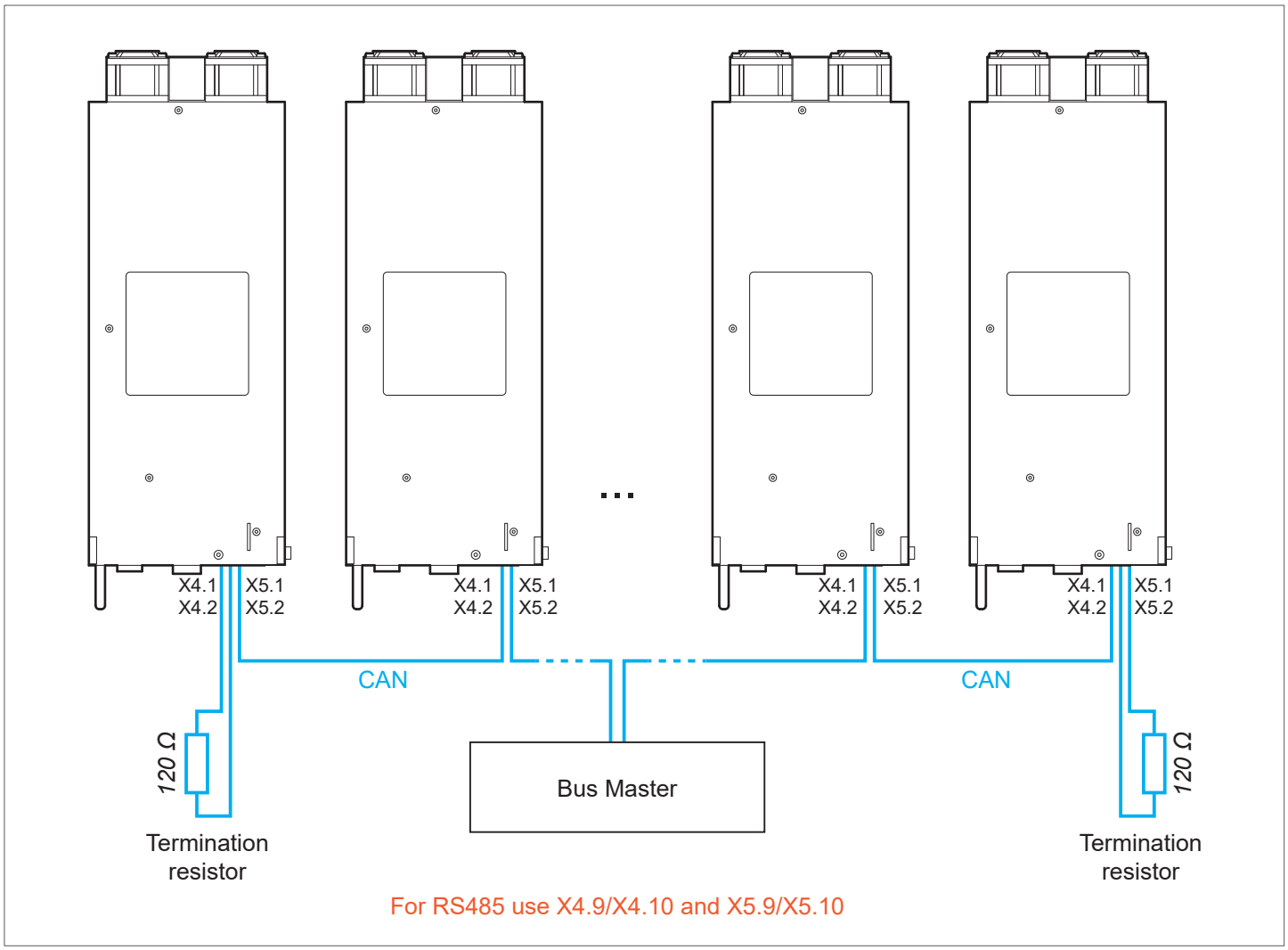


Fig. 24: Use of termination resistors in CAN / RS485 bus

11. Disposal

Do not dispose of electrical appliances as unsorted municipal waste, use separate collection facilities instead . Contact your local authorities available. If electrical appliances are disposed of in landfills or dumps, hazardous substances can leak into the groundwater and get into the food chain, damaging your health and well-being. when replacing old appliances with new once, the retailer is legally obligated to take back your old appliance for disposal at least for free of charge.

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