

PS1000-A9-24.40-IO

Power Supply

Technical Information



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1 Introduction

The information given in this document is correct to the best of our knowledge and experience at the time of publication. If not expressly agreed otherwise, this information does not represent a warranty in the legal sense of the word. As the state of our knowledge and experience is constantly changing, the information in this data sheet is subject to revision. We therefore kindly ask you to always use the latest issue of this document (available under www.pepperl-fuchs.com).

No part of this document may be reproduced or utilized in any form without our prior permission in writing.

Packaging and packaging aids can and should always be recycled. The product itself may not be disposed of as domestic refuse.

2 Terminology and Abbreviations

PE and \oplus symbol	PE is the abbreviation for Protective Earth and has the same meaning as the symbol \oplus .
Earth, Ground	This document uses the term earth which is the same as the U.S. term ground .
T.b.d.	To be defined, value or description will follow later.
AC 230V	A figure displayed with the AC or DC before the value represents a nominal voltage with standard tolerances (usually $\pm 15\%$) included. E.g.: DC 12V describes a 12V battery disregarding whether it is full (13.7V) or flat (10V)
230Vac	A figure with the unit (Vac) at the end is a momentary figure without any additional tolerances included.
50Hz vs. 60Hz	As long as not otherwise stated, AC 230V parameters are valid at 50Hz mains frequency.
may	A key word indicating flexibility of choice with no implied preference.
shall	A key word indicating a mandatory requirement.
should	A key word indicating flexibility of choice with a strongly preferred implementation.

3 Intended Use

This device is designed for installation in an enclosure and is intended for professional/commercial use, such as in industrial control, process control, monitoring and measurement equipment or the like.

Do not use this device in equipment where malfunction may cause severe personal injury or threaten human life.

If this device is used in a manner outside of its specification, the protection provided by the device may be impaired.

Do not connect the IO Link port to any other equipment except industrial control equipment.

Function

The device is used to supply field devices with 24 V DC and 40 A.

The device has a large power reserve of 150 % for up to 5 s to support the starting of heavy loads such as DC motors or capacitive loads.

The device is equipped with an IO-Link interface V1.1 to configure and parameterize the device and access data.

Communication status, device status and overload are indicated by LEDs.

The device has a relay contact output for remote monitoring.

The device is mounted on a 35 mm DIN mounting rail according to EN 60715.

Reference Conditions

All parameters are specified at 24V, 40A, 3x400Vac, 25°C ambient and after a 5 minutes run-in time unless otherwise noted.

4 Installation Instructions



Warning!

Risk of electrical shock, fire, personal injury or death.

- Do not use the power supply without proper grounding (Protective Earth). Use the terminal on the input block for earth connection and not one of the screws on the housing.
- Turn power off before working on the device. Protect against inadvertent re-powering.
- Make sure that the wiring is correct by following all local and national codes.
- Do not modify or repair the unit.
- Do not open the unit as high voltages are present inside.
- Use caution to prevent any foreign objects from entering the housing.
- Do not use in wet locations or in areas where moisture or condensation can be expected.
- Do not touch during power-on, and immediately after power-off. Hot surfaces may cause burns.



Warning!

Explosion hazards

- Substitution of components may impair suitability for this environment.
- Do not disconnect the unit or operate the voltage adjustment or S/P jumper unless power has been switched off or the area is known to be non-hazardous.
- A suitable enclosure must be provided for the final power system which has a minimum protection of IP54 and fulfills the requirements of the EN 60079-15:2010.



Note

Observe the safety information in the instruction manual and in chapter 23.

This device may only be installed and put into operation by qualified personnel.

This device does not contain serviceable parts. The tripping of an internal fuse is caused by an internal defect.

If damage or malfunction should occur during installation or operation, immediately turn power off and send unit to the factory for inspection.

Mount the unit on a DIN-rail so that the output and input terminals are located on the bottom of the unit. For other mounting orientations see de-rating requirements in this document. See chapter 25.13.

This device is designed for convection cooling and does not require an external fan. Do not obstruct airflow and do not cover ventilation grid (e.g. cable conduits) by more than 15%!

Keep the following installation clearances: 40mm on top, 20mm on the bottom, 5mm on the left and right sides are recommended when the device is loaded permanently with more than 50% of the rated power. Increase this clearance to 15mm in case the adjacent device is a heat source (e.g. another power supply).

5 AC Input

AC input	nom.	3AC 380-480V	suitable for TN, TT and IT mains networks, grounding of one phase is allowed except in UL 508 applications
AC input range	min.	3x 323-576Vac	continuous operation
Allowed voltage L to earth	max.	576Vac	acc. IEC 60664-1
Input frequency	nom.	50–60Hz	±6%
Turn-on voltage	typ.	3x 305Vac	steady-state value, load independent, see Figure 5.1
Shut-down voltage	typ.	3x 275Vac	steady-state value, load independent, see Figure 5.1

		3AC 400V	3AC 480V	
Input current	typ.	1.65A	1.35A	at 24V, 40A, symmetrical phase voltages, see Figure 5.3
Power factor ¹	typ.	0.88	0.90	at 24V, 40A, see Figure 5.4
Start-up delay	typ.	500ms	600ms	see Figure 5.2
Rise time	typ.	35ms	35ms	at 24V, 40A, resistive load, 0mF see Figure 5.2
	typ.	40ms	40ms	at 24V, 40A, resistive load, 40mF see Figure 5.2
Turn-on overshoot	max.	500mV	500mV	see Figure 5.2

¹ The power factor is the ratio of the true (or real) power to the apparent power in an AC circuit.

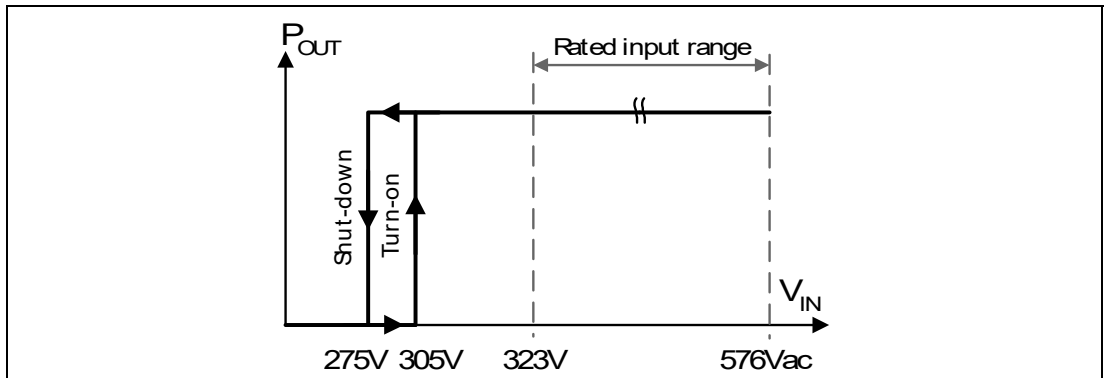


Figure 5.1 Input voltage range

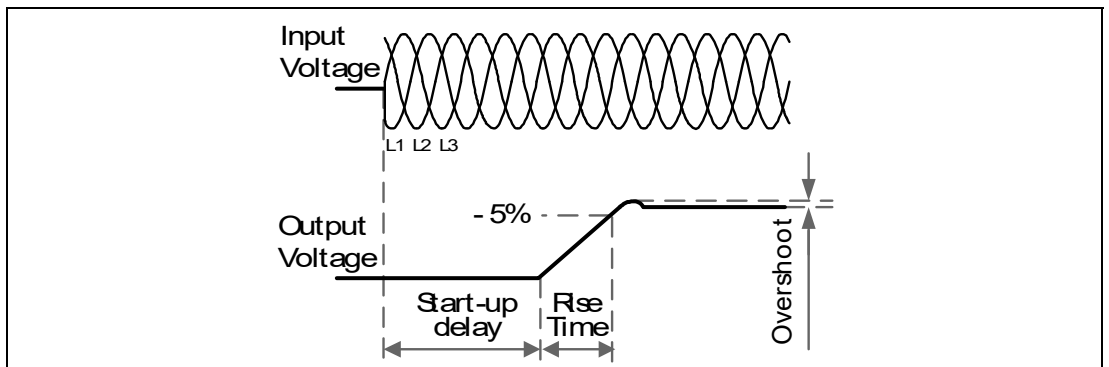


Figure 5.2 Turn-on behavior, definitions

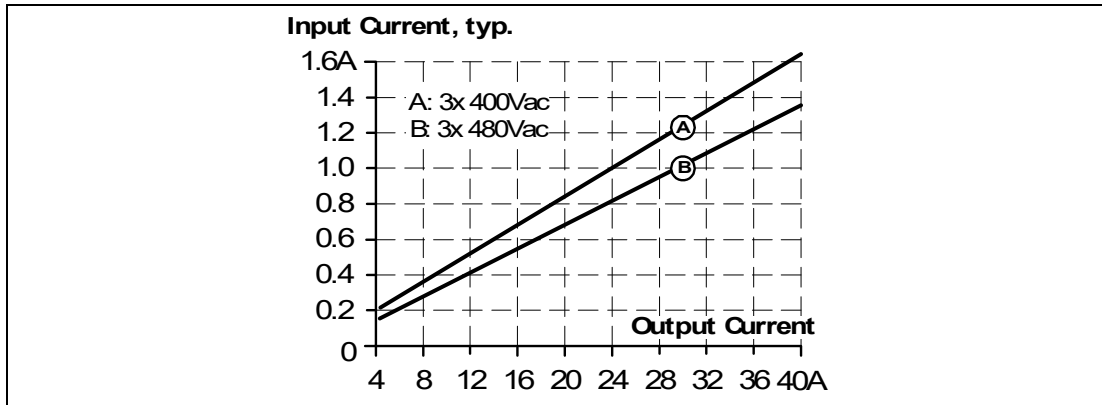


Figure 5.3 Input current vs. output current at 24V

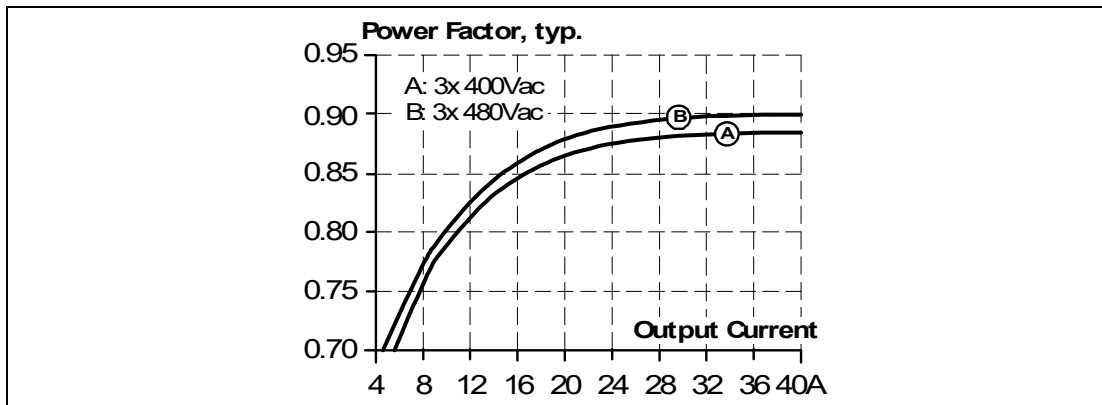


Figure 5.4 Power factor vs. output current at 24V

6 Input Inrush Current

The power supply is equipped with an active inrush current limitation circuit, which limits the input inrush current after turn-on to a negligible low value. The input current is usually smaller than the steady state input current.

		3AC 400V	3AC 480V	
Inrush current ¹	max.	6A _{peak}	6A _{peak}	over entire temperature range
	typ.	4.5A _{peak}	4.5A _{peak}	over entire temperature range
Inrush energy	max.	1.5A ² s	1.5A ² s	over entire temperature range
Inrush delay	typ.	500ms	600ms	

¹ The charging current into EMI suppression capacitors is disregarded in the first microseconds after switch-on.

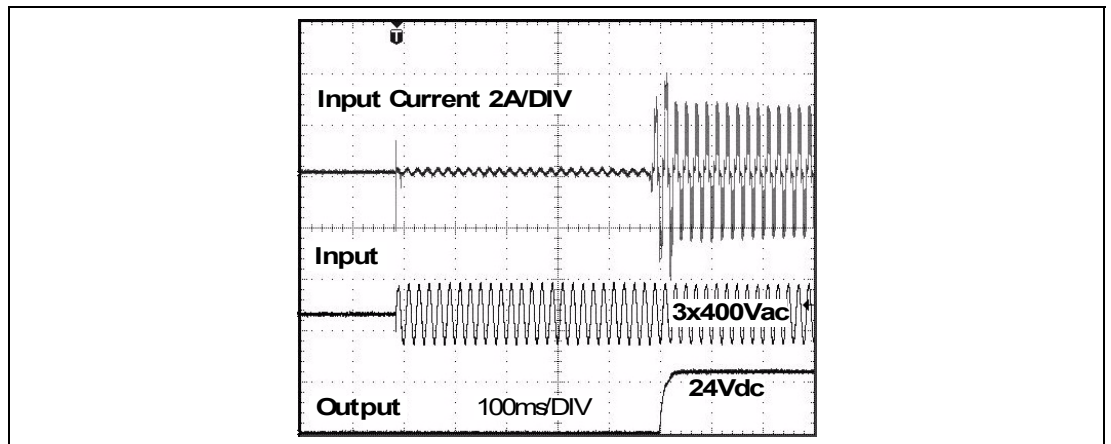


Figure 6.1 Typical turn-on behavior at nominal load and 25°C ambient

7 DC Input

Do not operate this power supply with DC-input voltage.

8 Output

Output voltage	nom.	24V	
Adjustment range	min.	24-28.5V	guaranteed
Factory setting	typ.	24.1V	±0.2%, at full load, cold unit
Line regulation	max.	10mV	3x 323-576Vac
Load regulation	max.	50mV	static value, 0A → 40A, see Figure 8.1
Ripple and noise voltage	max.	100mVpp	20Hz to 20MHz, 50Ohm
Output current	nom.	40A	continuously available at 24V, see Figure 8.1
	nom.	33.7A	continuously available at 28.5V, see Figure 8.1 and Figure 8.2
	nom.	60A	short term (5s) available BonusPower ^{®1} , at 24V, see Figure 8.1 and Figure 8.3
	nom.	50.5A	short term (5s) available BonusPower ^{®*1} , at 28.5V, see Figure 8.1 and Figure 8.3
	typ.	110A	up to 25ms, output voltage stays above 20V, see Figure 8.3 This peak current is available once every second. See chapter 26.2 for more peak current measurements.
Output power	nom.	960W	continuously available at 24-28V
	nom.	1440W ¹	short term available BonusPower ^{®1} at 24-28.5V
BonusPower [®] time	typ.	5s	duration until the output voltage dips, see Figure 8.2
BonusPower [®] recovery time	typ.	10s	overload free time to reset power manager, see Figure 8.4
Overload behavior		cont. current	see Figure 8.1
Short-circuit current ²	min.	40A	continuous, load impedance 25mOhm, see Figure 8.1
	max.	44A	continuous, load impedance 25mOhm, see Figure 8.1
	min.	60A	short-term (5s), load impedance 25mOhm, see Figure 8.1
	max.	68A	short-term (5s), load impedance 25mOhm, see Figure 8.1
	typ.	46A	continuous, load impedance <10mOhm
	max.	51A	continuous, load impedance <10mOhm
Output capacitance	typ.	10 200μF	included in the power supply

¹ **BonusPower**[®], short term power capability (up to typ. 5s)

The power supply is designed to support loads with a higher short-term power requirement without damage or shutdown. The short-term duration is hardware controlled by an output power manager. This **BonusPower**[®] is repeatedly available. Detailed information can be found in chapter 25.1. If the power supply is loaded with the **BonusPower**[®] longer than shown in the bonus-time diagram (see Figure 8.2), the max. output power is automatically reduced to 960W.

² Discharge current of output capacitors is not included.

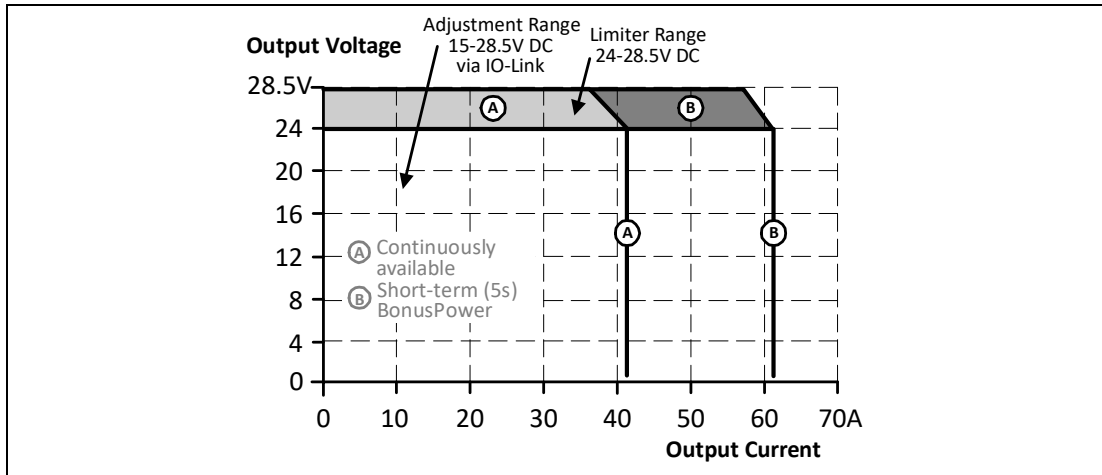


Figure 8.1 Output voltage vs. output current, typ.

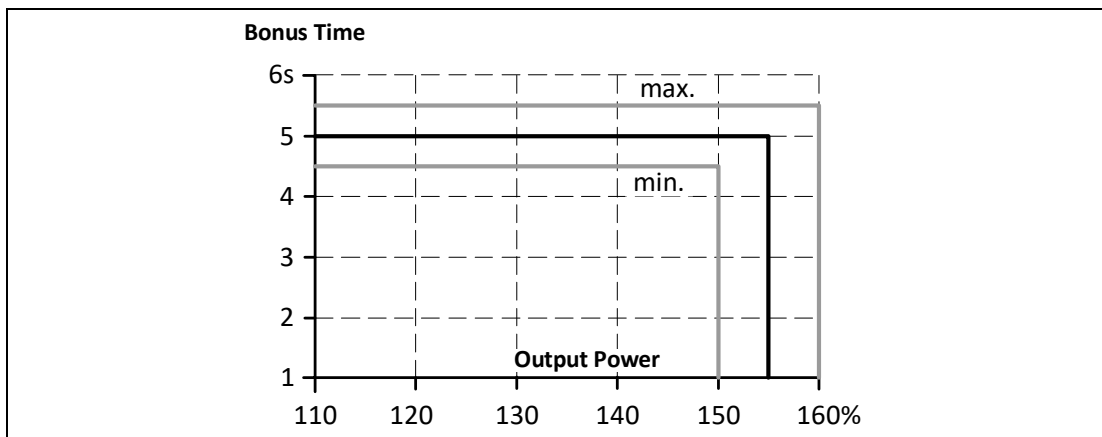


Figure 8.2 Bonus time vs. output power

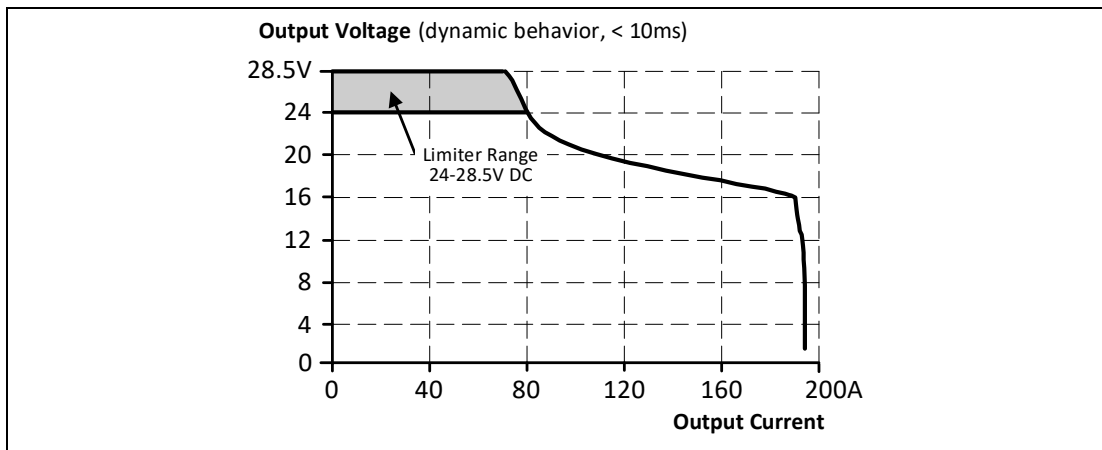


Figure 8.3 Dynamic overcurrent capability, typ.

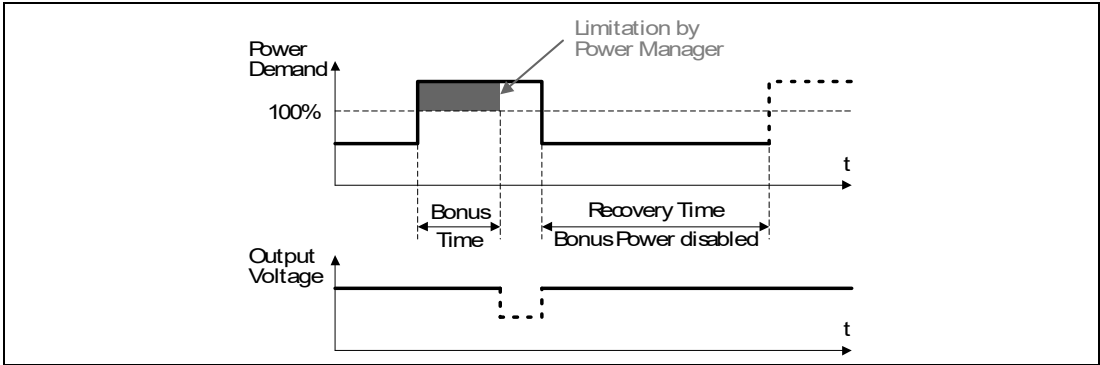


Figure 8.4 **BonusPower**® recovery time

The **BonusPower**® is available as soon as power comes on and after the end of an output short circuit or output overload.

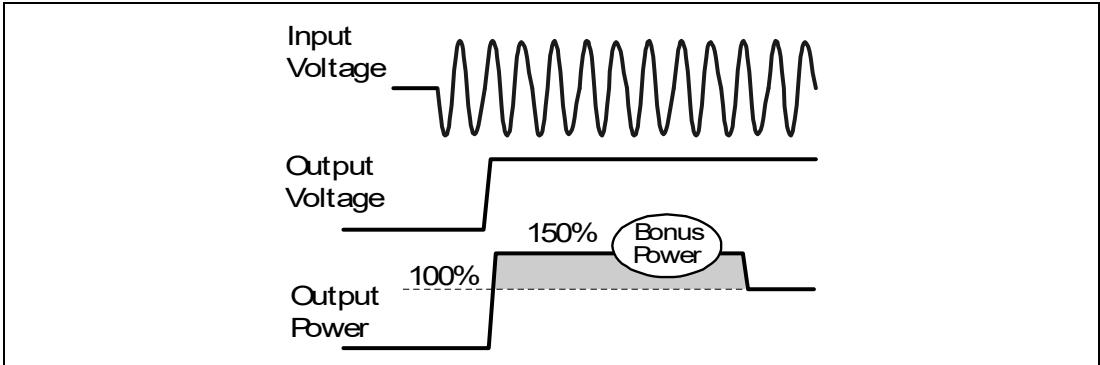


Figure 8.5 **BonusPower**® after input turn-on

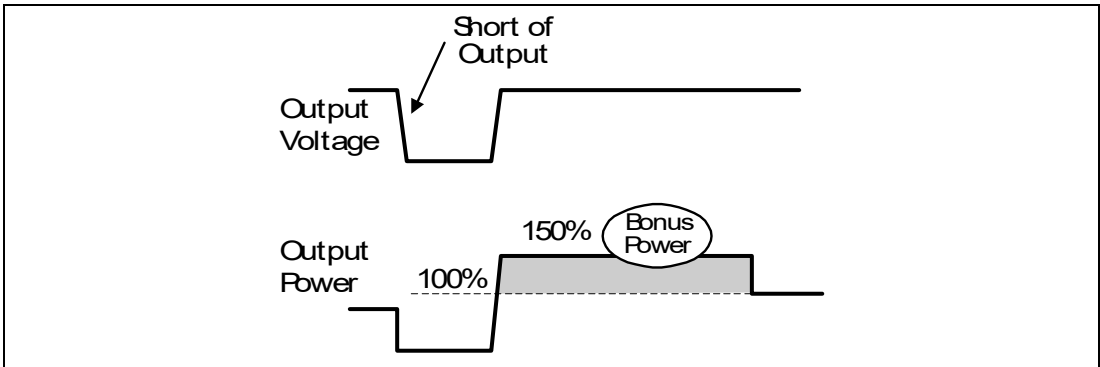


Figure 8.6 **BonusPower**® after output short

9 Hold-Up Time

		3AC 400V ¹	3AC 480V ¹	
Hold-up Time	typ.	50ms	50ms	at 24V, 20A, see Figure 9.1
	min.	40ms	40ms	at 24V, 20A, see Figure 9.1
	typ.	25ms	25ms	at 24V, 40A, see Figure 9.1
	min.	20ms	20ms	at 24V, 40A, see Figure 9.1

¹ Curves and figures for operation on only 2 legs of a 3-phase system can be found in chapter 25.4.

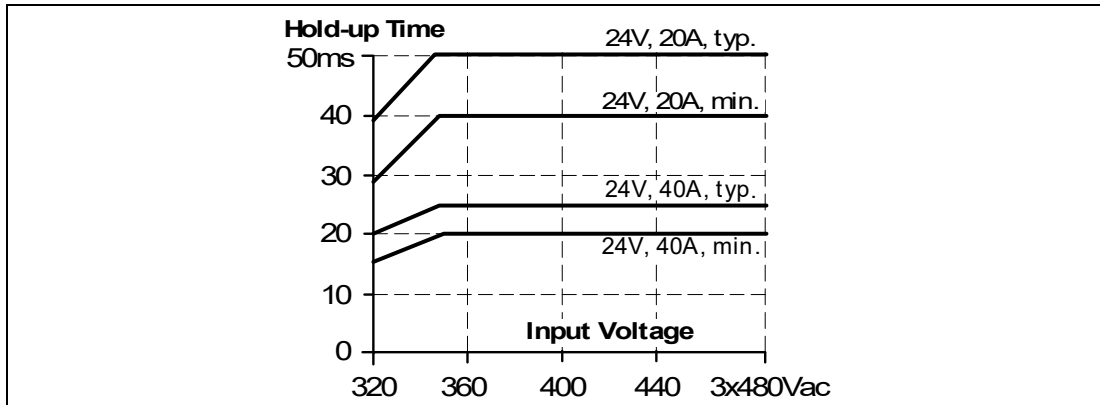


Figure 9.1 Hold-up time vs. input voltage

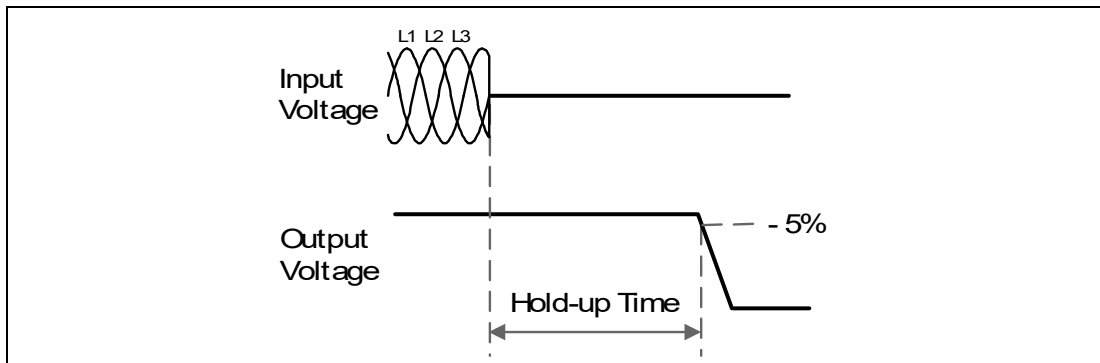


Figure 9.2 Shut-down behavior, definitions

10 IO-Link Interface

This power supply is equipped with an IO-Link interface compliant to IO-Link protocol V1.1 (M12 male, A-coded) on the device front side and can be connected to any IO-Link masters compliant to V1.1 of IO-Link protocol. The Pin Assignment is shown in Figure 10.1.

It is possible to operate the power supply without IO-Link communication. Due to a built-in EEPROM, the power supply can also be operated with values which have previously been updated via IO-Link also in case of no IO-Link master is connected or in case of defective IO-Link connection.

Via IO-Link the power supply can communicate current status, in-/output values and it is also possible to configure the output voltage (see chapter 12) as well as to remotely shut-down the power supply (described in chapter 11).

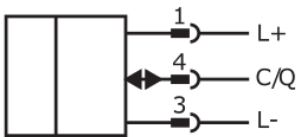
Connection Diagram	Description
	Plug, M12, 3-pin 1: L+ 3: L- 4: C/Q

Figure 10.1 IO-Link Interface Pin Assignment

In order to operate the IO-Link interface it is required to install/upload the IODD-File (IO-Link Device Description) into the connected IO-Link master in the first step. The most recent IODD File can be found on the Pepperl+Fuchs website (www.pepperl-fuchs.com) in the download section of the product detail page of the device. The device can be accessed via IO-Link also, if the power supply is not connected to AC-mains and switched off.

Communication Characteristics	
IO-Link revision	V1.1 (specification V1.1.2)
IO-Link backward compatibility	n/a
Data transmission rate	COM3 (230.4 kbit/s)
Min. cycle time	2.0 ms
Process data input	6 byte
Process data output	n/a
SIO mode support	no
Compatible master port type	Class A, Class B

The power supply provides three types of data via IO-Link.

1. The first dataset is called process data and refers to data that is periodically sent to the IO-Link master. The length is 2Byte and the data is updated and communicated every 2ms. All other data in the power supply itself is generated every 50ms and stored in the IO-Link registers. The higher cycle frequency enables operation with IO-Link masters and attached PLCs without configuration.
2. The second set of data is called parameter values. The parameter values can be accessed to read out additional data (e.g. current output voltage, temperatures etc.), but in addition some of these values can also be written by the user to configure the power supply (e.g. output voltage and remote on/off).
3. Events are the third set of data. This information is triggered by certain situations and will result in an event notification to the IO-Link master. Typical events are notification in case of ideal (e.g. DC-OK) and non-ideal situations (e.g. ambient temperature too hot, high input voltage etc.).

All data types used in the device are listed and described in the IO-Link parameter datasheet (DOCT-7234). The document can be found on the Pepperl+Fuchs website (www.pepperl-fuchs.com) in the download section of the product detail page of the device.

For additional information on remote shut-down as well as output voltage adjustment, please refer to chapter 11 and 12.

Parallel-Use with automated load regulation:

It is possible to operate multiple paralleled power supplies (as described in chapter 25.7 and/or 25.8) with and without a load sharing mode. To activate load sharing, please place jumper into the parallel slot. Then turn limiter to the maximum voltage required in the application (e.g. 25.1Vdc) and then enter a slightly higher value in IO-Link (e.g. 25.1Vdc+1Vdc = 26.1Vdc). The load sharing mode is then activated and the acyclic data set **actual output voltage** will return the actual self-adjusted output voltage value. The self adjusting load regulation will regulate up 1000mV automatically.

11 Remote Control of Shut-Down

To use this feature it is essential not to power the IO-Link master from the power supply, which is subject to remote shut-down itself. Please assure an independent power supply for the IO-Link master according to the specification of the master and do use the IO-Link power supply only for powering the load lines.

This feature allows a switch-off of the output of the power supply with a logic **1** in the acyclic parameter data set **Shutdown**, described in the IO-Link parameter datasheet (DOCT-7234). The shut-down occurs immediately while the turn-on is delayed up to 350ms. In a shut-down condition, the output voltage is <2V and the output power is <0.5W.

There are two typical use cases for remote shut-down of the device:

A. Energy Saving

Input		380Vac	480Vac	
Power losses	typ.	1.5W	1.5W	with activated shut-down
	typ.	9.5W	9.8W	at 24V, 0A (no load)

Using remote shut-down will therefore result in a saving of 8.3W; Assuming a 8h downtime every workday, this feature can generate a saving of $8h \times 5 \times 4 \times 8.3W = 1.33kWh$ per month and per power supply.

B. Maintenance

In case of maintenance situation, where loads have to be disconnected but sensor voltages have to stay available, the remote shut-down function can be used. Please note, that the communication protocol is IO-Link V1.1 and not IO-Link Safety; for safety relevant shut-downs, it is prohibited to use this function.

12 Remote Control of Output Voltage

The standard pre-set value of the output voltage is 24.1V, but the power supply can be set to any output voltage between 15V to 28.5Vdc via IO-Link using the acyclic parameter data set **Output voltage setpoint** as mentioned in the IO-Link parameter datasheet (DOCT-7234).

It is recommended to operate above 24V, since the usage from 15Vdc to 24Vdc is not specified in this datasheet, but theoretically possible. The power supply is equipped with a hardware protection mechanism in order to prevent unauthorized adjustment of its output voltage.



Adjusting the output voltage of the power supply

1. Establish a stable IO-Link communication with the power supply (it is recommended to connect the power supply to AC-mains)
2. In the software environment, please navigate to the section **acyclic data - parameters**.
3. Enter the desired value to the data field **Output voltage setpoint** and submit the new value to the power supply.
 - If hardware protection is required:

Please connect the power supply to AC-mains and switch it on.

Navigate to **acyclic data - parameters** and read the data field **Actual output voltage**.

If the actual output voltage value is lower, than the programmed output voltage, please adjust the limiter on the front of the product by a few right turns (if actual output voltage too low) or by a few left turns (if the actual output voltage is too high).

After this, please refresh the data field **Actual output voltage** and compare with the programmed output voltage. Please repeat this procedure until the actual output voltage is exactly the value of the set output voltage.
 - If hardware protection is not required:

Please move the limiter on the front of the power supply to the very right position with a few turns. The hardware limitation will allow the maximum of 28.5V output voltage. No hardware protection is in place. It is now possible to adjust voltages up to 28.5V via IO-Link and all connected loads have to be capable of 28.5V.

↳ The power supply is now operating with the adjusted output voltage.
4. To verify the adjusted output voltage, please navigate to **acyclic data - parameters** and read the data field **Actual output voltage**. This value should now be the same as the adjusted output voltage. If not, please continue with step 3).

↳ This data is stored in the EEPROM of the power supply, so that the power supply keeps the adjusted output voltage also in case of no IO-Link communication or if the power supply is disconnected from AC-mains.

13 Efficiency and Power Losses

Efficiencies for 3-Phase operation:

		3AC 400V	3AC 480V	
Efficiency	typ.	95.3%	95.2%	at 24V, 40A
Average efficiency ¹⁾	typ.	94.7%	94.6%	25% at 10A, 25% at 20A, 25% at 30A, 25% at 40A
Power losses	typ.	1.5W	1.5W	with activated shut-down
	typ.	9.5W	9.8W	at 24V, 20A (no load)
	typ.	24.1W	25.0W	at 24V, 20A (half load)
	typ.	47.3W	48.4W	at 24V, 40A (full load)

¹⁾ The average efficiency is an assumption for a typical application where the power supply is loaded with 25% of the nominal load for 25% of the time, 50% of the nominal load for another 25% of the time, 75% of the nominal load for another 25% of the time and with 100% of the nominal load for the rest of the time.

Efficiencies when using only 2 legs of a 3-phase system:

		2AC 400V	2AC 480V	
Efficiency	typ.	94.4% ¹⁾	94.7% ¹⁾	at 24V, 40A
Power losses	typ.	56.9W ¹⁾	53.7W ¹⁾	at 24V, 40A (full load)

¹⁾ Curves can be found in chapter 25.4.

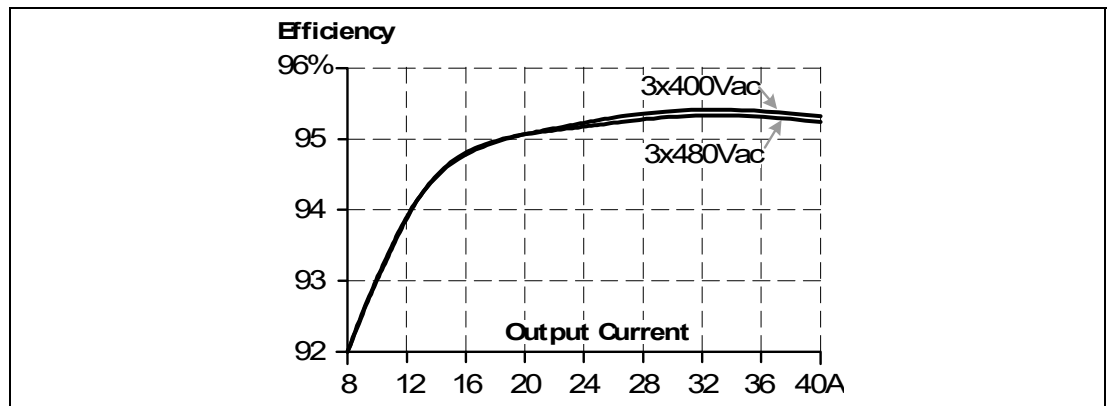


Figure 13.1 Efficiency vs. output current at 24V, typ.

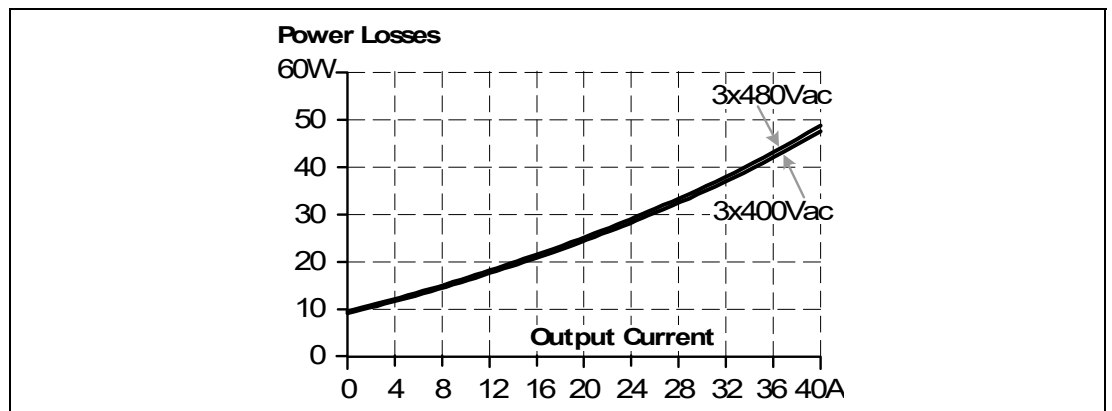


Figure 13.2 Losses vs. output current at 24V, typ.

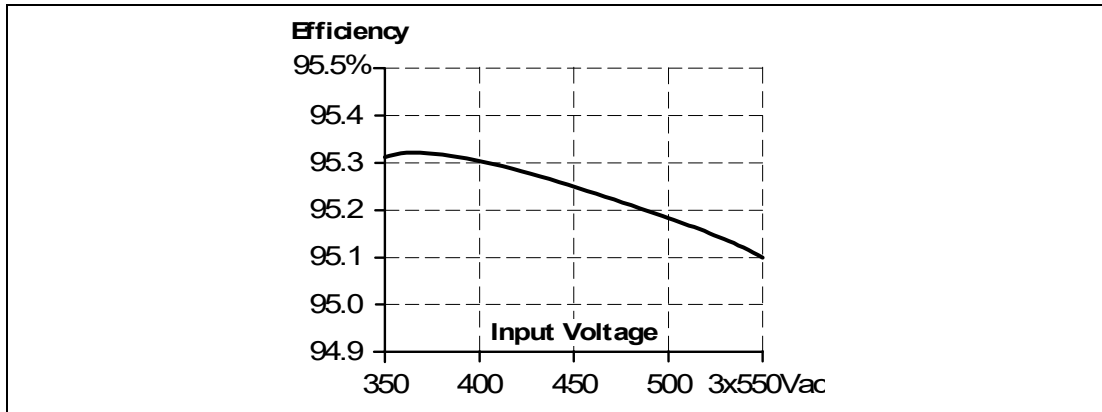


Figure 13.3 Efficiency vs. input voltage at 24V, 40A, typ.

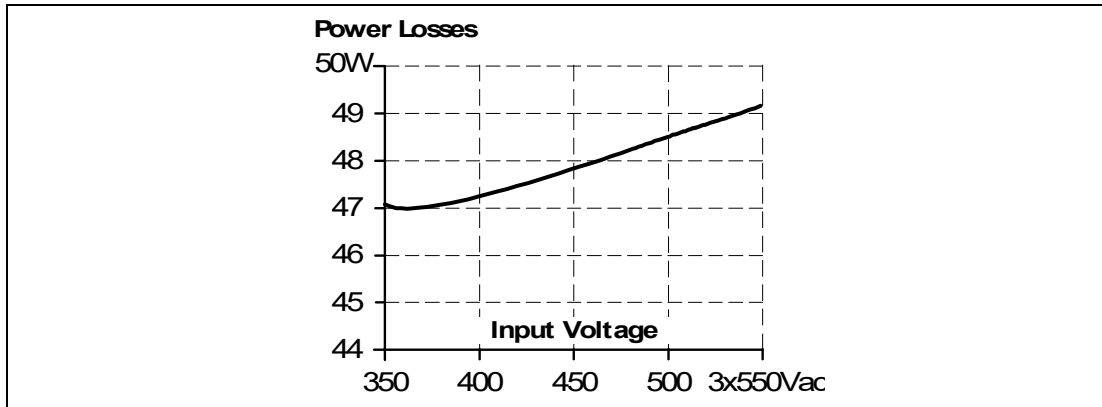


Figure 13.4 Losses vs. input voltage at 24V, 40A, typ.

14 Lifetime Expectancy and MTBF

	3AC 400V	3AC 480V	
Calculated lifetime expectancy ¹	69 000h	66 000h	at 24V, 40A and 40°C
	86 000h	81 000h	at 24V, 32A and 40°C
	114 000h	112 000h	at 24V, 20A and 40°C
	196 000h ¹	186 000h ¹	at 24V, 40A and 25°C
	244 000h ¹	230 000h ¹	at 24V, 32A and 25°C
	322 000h ¹	316 000h ¹	at 24V, 20A and 25°C

¹ The **calculated lifetime expectancy** shown in the table indicates the minimum operating hours (service life) and is determined by the lifetime expectancy of the built-in electrolytic capacitors. Lifetime expectancy is specified in operational hours and is calculated according to the capacitor's manufacturer specification. The manufacturer of the electrolytic capacitors only guarantees a maximum life of up to 15 years (131 400h). Any number exceeding this value is a calculated theoretical lifetime which can be used to compare devices.

	3AC 400V	3AC 480V	
MTBF ¹ SN 29500, IEC 61709	375 000h	369 000h	at 24V, 40A and 40°C
	685 000h	678 000h	at 24V, 40A and 25°C
MTBF ¹ MIL HDBK 217F	158 000h	157 000h	at 24V, 40A and 40°C; Ground Benign GB40
	211 000h	210 000h	at 24V, 40A and 25°C; Ground Benign GB25

¹ **MTBF** stands for **Mean Time Between Failure**, which is calculated according to statistical device failures, and indicates reliability of a device. It is the statistical representation of the likelihood of a unit to fail and does not necessarily represent the life of a product. The MTBF figure is a statistical representation of the likelihood of a device to fail. A MTBF figure of e.g. 1 000 000h means that statistically one unit will fail every 100 hours if 10 000 units are installed in the field. However, it can not be determined if the failed unit has been running for 50 000h or only for 100h.

15 Functional Diagram

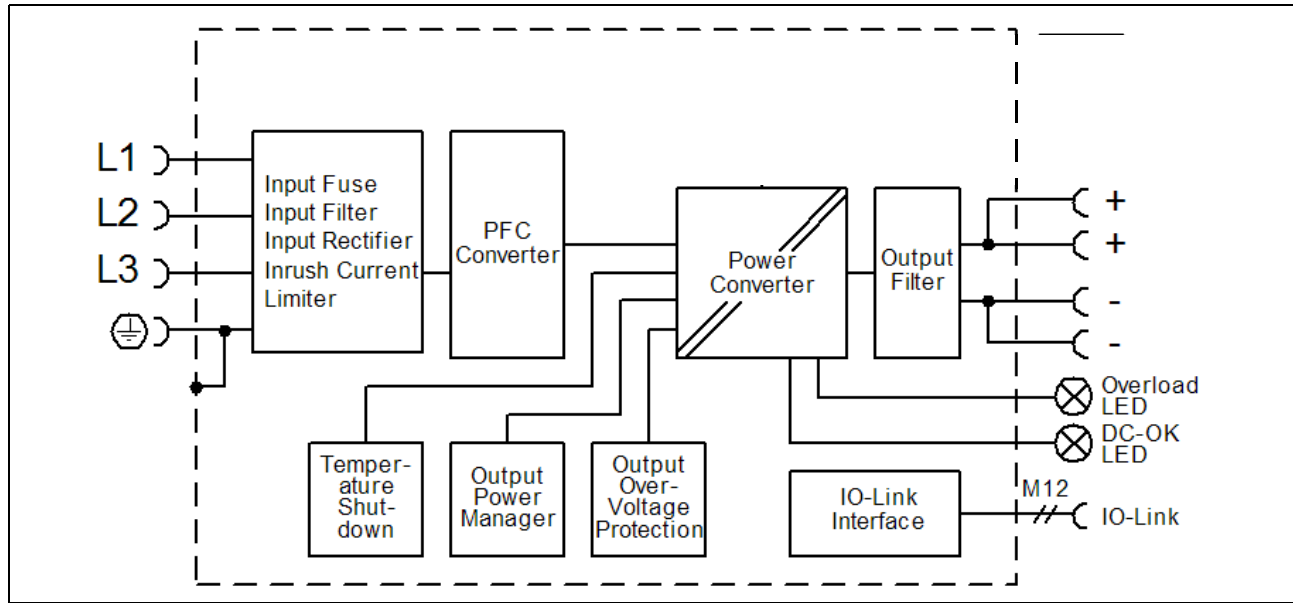


Figure 15.1 Functional diagram

16 Terminals and Wiring

The terminals are IP20 finger safe constructed and suitable for field- and factory wiring.

	Input	Output	IO-Link
Type	screw termination	screw termination	A-coded M12 male
Solid wire	0.5-6mm ²	0.5-16mm ²	–
Stranded wire	0.5-4mm ²	0.5-10mm ²	–
American Wire Gauge	AWG 20-10	AWG 22-8	–
Max. wire diameter	2.8mm (including ferrules)	5.2mm (including ferrules)	–
Wire stripping length	7mm / 0.28inch	12mm / 0.5inch	–
Screwdriver	3.5mm slotted or cross-head No 2	3.5mm or 5mm slotted or cross-head No 2	Screw-nut might require wrench
Recommended tightening torque	1Nm, 9lb.in	2.3Nm, 20.5lb.in	0.6Nm, 5.3lb.in



Connecting Terminals

- Use appropriate copper cables that are designed for minimum operating temperatures of:
 - 60°C for ambient up to 45°C and
 - 75°C for ambient up to 60°C minimum
 - 90°C for ambient up to 70°C minimum.
- Follow national installation codes and installation regulations!
- Ensure that all strands of a stranded wire enter the terminal connection!
- Unused terminal compartments should be securely tightened.
- Ferrules are allowed.

Daisy chaining:

Daisy chaining (jumping from one power supply output to the next) is allowed as long as the average output current through one terminal pin does not exceed 54A. If the current is higher, use a separate distribution terminal block as shown in Figure 16.2.

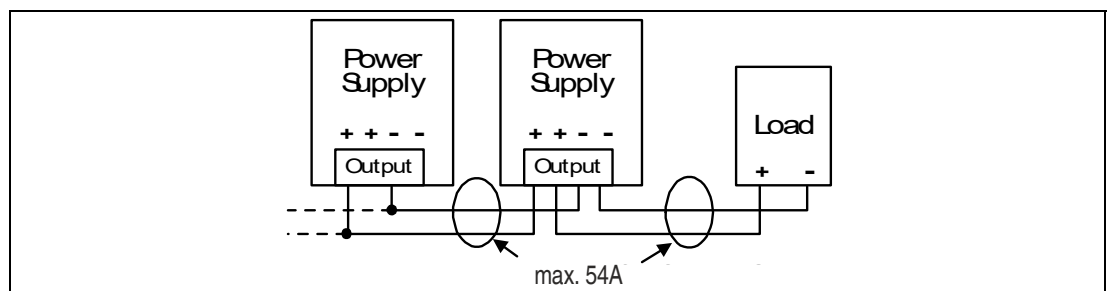


Figure 16.1 Daisy chaining of outputs

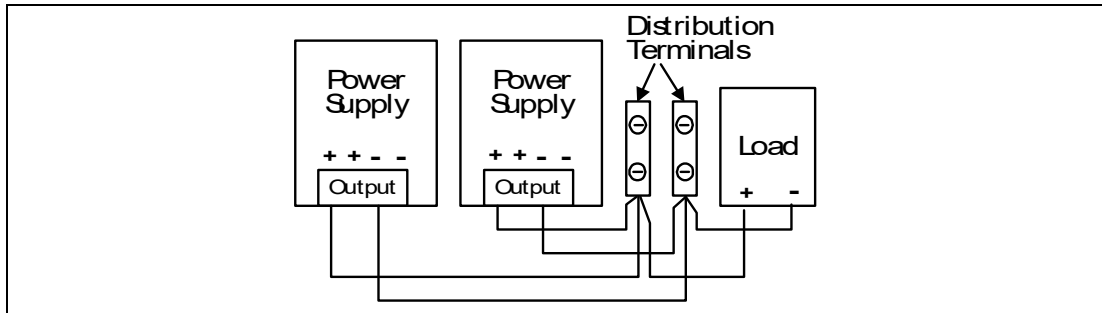
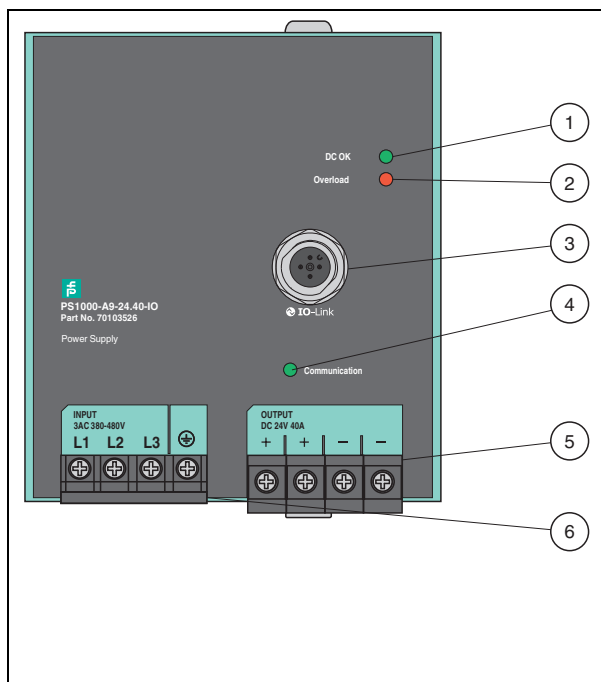


Figure 16.2 Using distribution terminals

17 Front Side and User Elements



- 1 DC-OK LED (green)**
On, when the output voltage is >90% of the adjusted output voltage.
- 2 Overload LED (red)**
 - On, when the voltage on the output terminals is <90% of the adjusted output voltage, or in case of a short circuit in the output.
 - Flashing, when the shut-down has been activated or the unit has switched off due to over-temperature.
 - Input voltage is required
- 3 IO-Link connector**
M12 A-coded male
- 4 IO-Link Communication LED (green/red)**
 - Green flashing, when communication is active
 - Green on, when IO-Link powered.
 - Green off, when IO-Link not powered.
 - Red on, when IO-Link event is triggered
 - Red off, when no event or DC-OK
- 5 Output Terminals**
Screw terminals, two pins per pole
(+) Positive output
(-) Negative (return) output
- 6 Input Terminals**
Screw terminals
L1, L2, L3 Line input
⊕ PE (Protective Earth) input

Figure 17.1 Front side

Indicators, LEDs

	Overload LED	DC-OK LED	IO-Link LED
Normal mode	OFF	ON	–
During BonusPower [®]	OFF	ON	–
Overload ($V_{out} < 90\%$)	ON	OFF	–
Output short circuit	ON	OFF	–
Temperature Shut-down	flashing	OFF	–
Active Shut-down input	flashing	OFF	–
No input power	OFF	OFF	–
No IO-Link power	–	–	Green OFF
No IO-Link connection	–	–	Green ON
IO-Link connection active	–	–	Green flashing
IO-Link event	–	–	Red ON

18 EMC

The power supply is suitable for applications in industrial environment as well as in residential, commercial and light industry environment without any restrictions. A detailed EMC report is available on request.

All results assume a three phase operation of the power supply.

EMC Immunity	According generic standards: EN 61000-6-1 and EN 61000-6-2			
Electrostatic discharge	EN 61000-4-2	contact discharge air discharge	8kV 15kV	Criterion A Criterion A
Electromagnetic RF field	EN 61000-4-3	80MHz-2.7GHz	10V/m	Criterion A
Fast transients (Burst)	EN 61000-4-4	input lines output lines DC-OK signal (coupling clamp)	4kV 2kV 2kV	Criterion A Criterion A Criterion A
Surge voltage on input	EN 61000-4-5	L1 → L2, L2 → L3, L1 → L3 L1 / L2 / L3 → PE	2kV 4kV	Criterion A Criterion A
Surge voltage on output	EN 61000-4-5	+ → - + / - → PE	1kV 1kV	Criterion A Criterion A
Surge voltage on DC-OK	EN 61000-4-5	DC-OK signal → PE	1kV	Criterion A
Conducted disturbance	EN 61000-4-6	0.15-80MHz	10V	Criterion A
Mains voltage dips (Dips on three phases)	EN 61000-4-11	0% of 380Vac (0Vac) 0% of 480Vac (0Vac)	0Vac, 20ms 0Vac, 20ms	Criterion A, Criterion A
Mains voltage dips (Dips on two phases)	EN 61000-4-11	40% of 380Vac (152Vac) 40% of 480Vac (192Vac) 70% of 380Vac (266Vac) 70% of 480Vac (336Vac)	200ms 200ms 500ms 500ms	Criterion A Criterion A Criterion A Criterion A
Voltage interruptions	EN 61000-4-11	0Vac	5000ms	Criterion C
Voltage sags	SEMI F47 0706	dips on two phases according to section 7.2. of the SEMI F47 standard 80% of 380Vac (304Vac) 70% of 380Vac (266Vac) 50% of 380Vac (160Vac)	1000ms 500ms 200ms	Criterion A Criterion A Criterion A
Powerful transients	VDE 0160	over entire load range	1550V, 1.3ms	Criterion A

Criterion A The device shows normal operation behavior within the defined limits.

Criterion C Temporary loss of function is possible. Power supply may shut-down and restarts by itself. No damage or hazards for the power supply will occur.

EMC Emission	According generic standards: EN 61000-6-3 and EN 61000-6-4	
Conducted emission input lines	EN 55011, EN 55022, FCC Part 15, CISPR 11, CISPR 22	Class B
Conducted emission output lines	IEC/CISPR 16-1-2, IEC/CISPR 16-2-1	5dB higher than average limits for DC power port according EN 61000-6-3 ¹
Radiated emission	EN 55011, EN 55022	Class A
Harmonic input current	EN 61000-3-2	fulfilled for class A equipment
Voltage fluctuations, flicker	EN 61000-3-3	fulfilled ²

This device complies with FCC Part 15 rules.

Operation is subjected to following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

¹ Restrictions apply for applications in residential, commercial and light-industrial environments, where local DC power networks according to EN 61000-6-3 are involved. No restrictions for all kinds of industrial applications.

² Tested with constant current loads, non pulsing

Switching Frequencies

The power supply has three converters with three different switching frequencies included. One is nearly constant. The others are variable.

Switching frequency 1	105kHz	Resonant converter, nearly constant
Switching frequency 2	1kHz to 150kHz	Boost converter, load dependent
Switching frequency 3	40kHz to 300kHz	PFC converter, input voltage and load dependent

19 Environment

Operational temperature ¹	-25°C to +70°C (-13°F to 158°F)	reduce output power according to Figure 19.1
Storage temperature	-40 to +85°C (-40°F to 185°F)	for storage and transportation
Output de-rating	20W/°C	55-70°C (140°F to 158°F)
Humidity ²	5 to 95% r.H.	IEC 60068-2-30
Vibration sinusoidal	2-17.8Hz: ±1.6mm; 17.8-500Hz: 1g 2 hours / axis	IEC 60068-2-6
Shock	15g 6ms, 10g 11ms 3 bumps / direction, 18 bumps in total	IEC 60068-2-27
Altitude	0 to 2000m (0 to 6 560ft) 2000 to 6000m (6 560 to 20 000ft)	without any restrictions reduce output power or ambient temperature, see Figure 19.2 IEC 62103, EN 50178, overvoltage category II
Altitude de-rating	60W/1000m or 5°C/1000m	> 2000m (6500ft), see Figure 19.2
Over-voltage category	III II	IEC 62103, EN 50178, altitudes up to 2000m altitudes from 2000m to 6000m
Degree of pollution	2	IEC 62103, EN 50178, not conductive
LABS compatibility	The unit does not release any silicone or other LABS-critical substances and is suitable for use in paint shops.	

¹ Operational temperature is the same as the ambient or surrounding temperature and is defined as the air temperature 2cm below the unit. Curves and figures for operation on only 2 legs of a 3-phase system can be found in chapter 25.4.

² Do not energize while condensation is present.

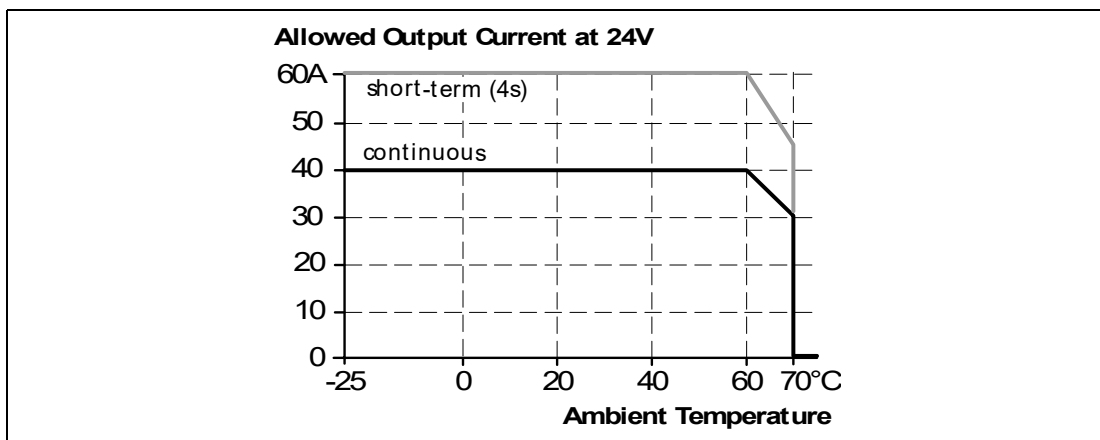


Figure 19.1 Output current vs. ambient temp.

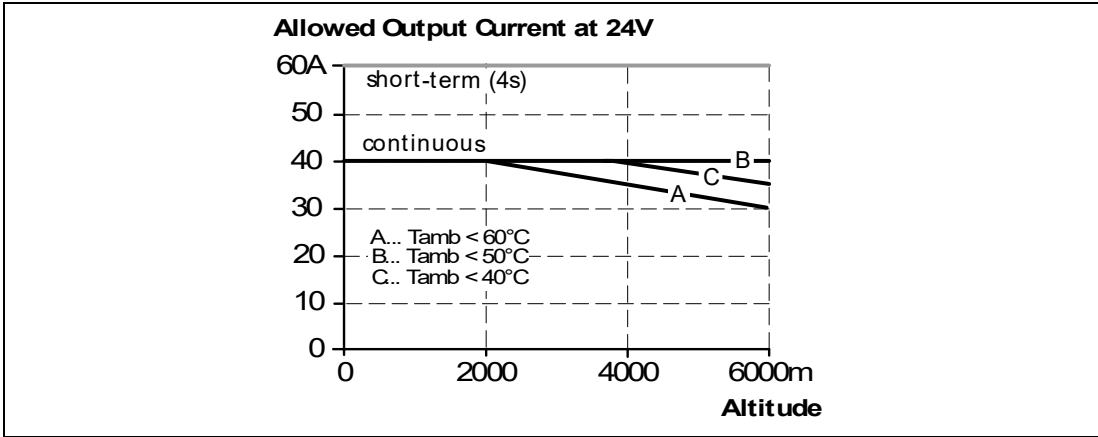


Figure 19.2 Output current vs. altitude

20 Protection Features

Output protection	Electronically protected against overload, no-load and short-circuits ¹	
Output over-voltage protection	typ. 30Vdc max. 32Vdc	In case of an internal power supply defect, a redundant circuit limits the maximum output voltage. The output shuts down and automatically attempts to restart.
Degree of protection	IP 20	EN/IEC 60529 Caution: For use in a controlled environment according to CSA 22.2 No 107.1-01.
Penetration protection	> 5mm	e.g. screws, small parts
Over-temperature protection	yes	Output shut-down with automatic restart
Input transient protection	MOV (Metal Oxide Varistor)	
Internal input fuse	included	not user replaceable

¹ In case of a protection event, audible noise may occur.

21 Safety Features

The supply voltage for the IO-Link must be powered from a PELV or SELV source or an **Isolated Secondary Circuit** in order to maintain a SELV or PELV output. Do not connect the IO Link port to any other equipment except industrial control equipment.

Input / output separation ¹	SELV	IEC/EN 60950-1
	PELV	IEC/EN 60204-1, EN 50178, IEC 62103, IEC 60364-4-41
	double or reinforced insulation	
Class of protection	I	PE (Protective Earth) connection required
Isolation resistance	> 5M Ω	input to output, 500Vdc
PE resistance	< 0.1 Ω	
Touch current (leakage current)	typ. 0.35mA / 0.64mA	3x400Vac, 50Hz, TN-,TT-mains / IT-mains
	typ. 0.45mA / 0.91mA	3x480Vac, 60Hz, TN-,TT-mains / IT-mains
	max. 0.45mA / 0.78mA	3x440Vac, 50Hz, TN-,TT-mains / IT-mains
	max. 0.60mA / 1.20mA	3x528Vac, 60Hz, TN-,TT-mains / IT-mains

¹ double or reinforced insulation

22 Dielectric Strength

The output voltage is floating and has no ohmic connection to the ground.

Type and factory tests are conducted by the manufacturer. Field tests may be conducted in the field using the appropriate test equipment which applies the voltage with a slow ramp (2s up and 2s down). Connect all phase terminals together as well as all output poles before conducting the test. When testing, set the cut-off current settings to the value in the table below.

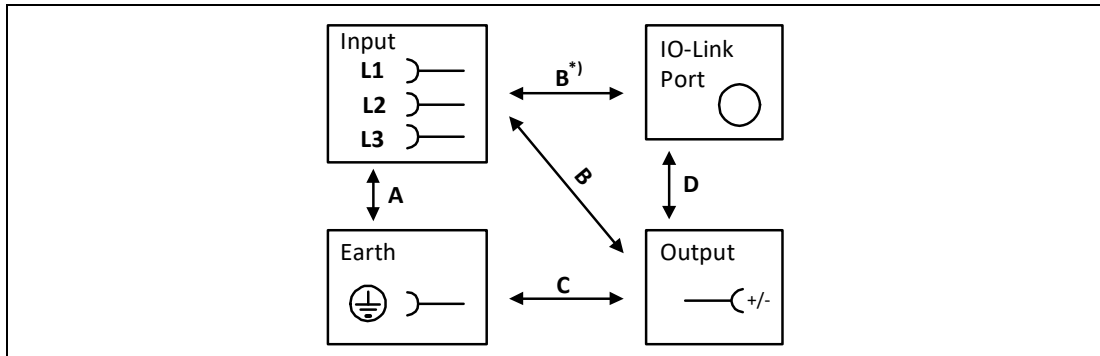


Figure 22.1 Dielectric strength

B*) When testing input to DC-OK ensure that the max. voltage between DC-OK and the output is not exceeded (column D). We recommend connecting DC-OK pins and the output pins together when performing the test.

		A	B	C	D
Type test	60s	2 500Vac	3 000Vac	500Vac	500Vac
Factory test	5s	2 500Vac	2 500Vac	500Vac	500Vac
Field test	5s	2 000Vac	2 000Vac	500Vac	500Vac
Cut-off current settings		> 10mA	> 10mA	> 40mA	> 1mA

To fulfill the PELV requirements according to EN 60204-1 § 6.4.1, we recommend that either the +pole, the –pole or any other part of the output circuit shall be connected to the protective earth system. This helps to avoid situations in which a load starts unexpectedly or can not be switched off when unnoticed earth faults occur.

23 Approvals

EU Declaration of Conformity



The CE mark indicates conformance with the European

- ATEX directive
 - EMC directive
 - Low-voltage directive (LVD)
 - RoHS directive
-

24 Physical Dimensions and Weight

Width	110mm, 4.33 inch
Height	124mm, 4.88 inch
Depth	143.5mm, 5.65 inch The DIN mounting rail height must be added to the unit depth to calculate the total required installation depth.
Weight	1500g/3.3lb
DIN mounting rail	Use 35mm DIN mounting rails according to EN 60715 or EN 50022 with a height of 7.5 or 15mm.
Housing material	Body: Aluminium alloy Cover: zinc-plated steel
Installation instructions	See chapter 4.

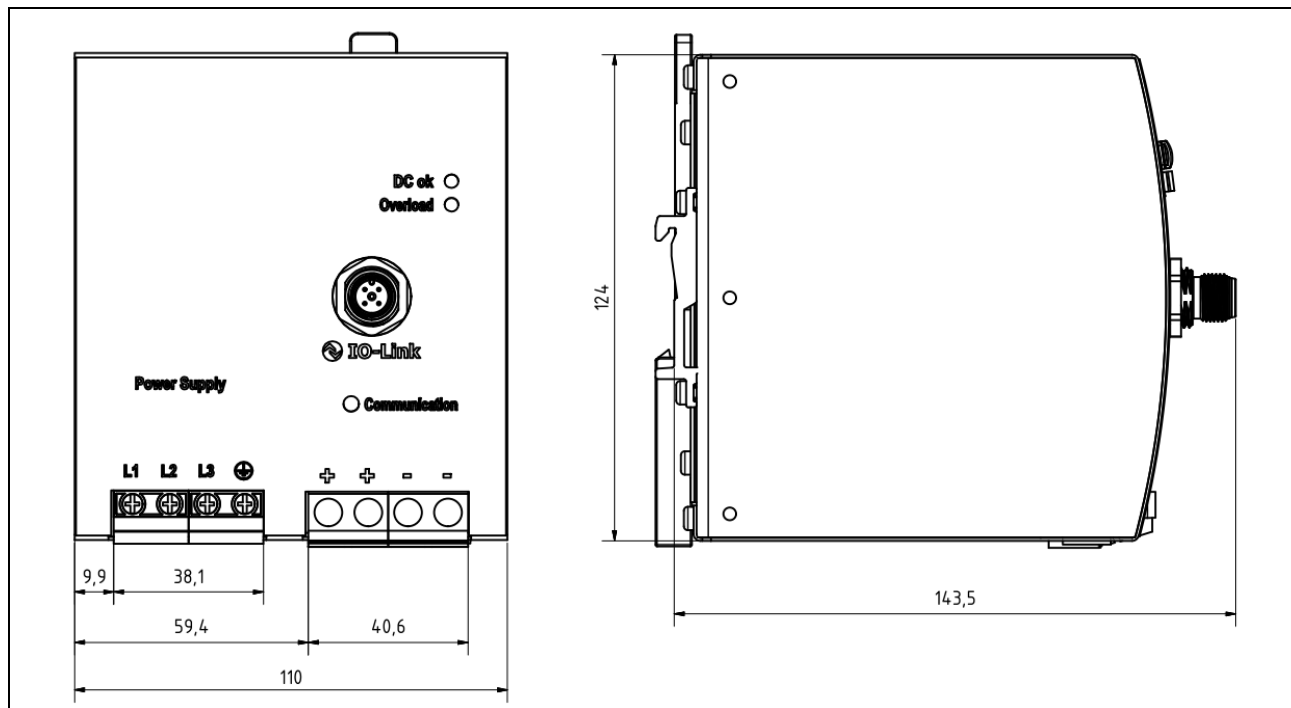


Figure 24.1 Device dimensions, all dimensions in mm

25 Application Notes

25.1 Repetitive Pulse Loading

Typically, a load current is not constant and varies over time. This power supply is designed to support loads with a higher short-term power demand (=BonusPower®). The short-term duration is hardware controlled by an output power manager and is available on a repeated basis. If the BonusPower® load lasts longer than the hardware controller allows it, the output voltage will dip and the next BonusPower® is available after the BonusPower® recovery time (see chapter 8) has elapsed.

To avoid this, the following rules must be met:

- The power demand of the pulse must be below 150% of the nominal output power.
- The duration of the pulse power must be shorter than the allowed BonusPower® time (see chapter 8)
- The average (R.M.S.) output current must be below the specified continuous output current. If the R.M.S. current is higher, the unit will respond with a thermal shut-down after a period of time. Use the maximum duty cycle curve (Figure 25.2) to check if the average output current is below the nominal current.
- The duty cycle must be below 0.75.

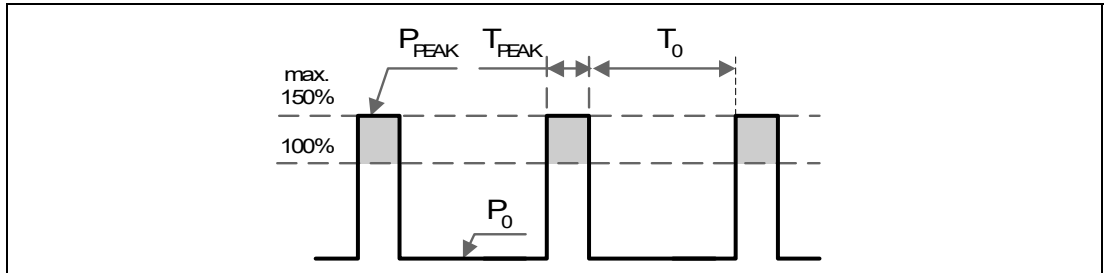


Figure 25.1 Repetitive pulse loads, definitions

P₀	Base load (W)
P_{PEAK}	Pulse load (above 100%)
T₀	Duration between pulses (s)
T_{PEAK}	Pulse duration (s)

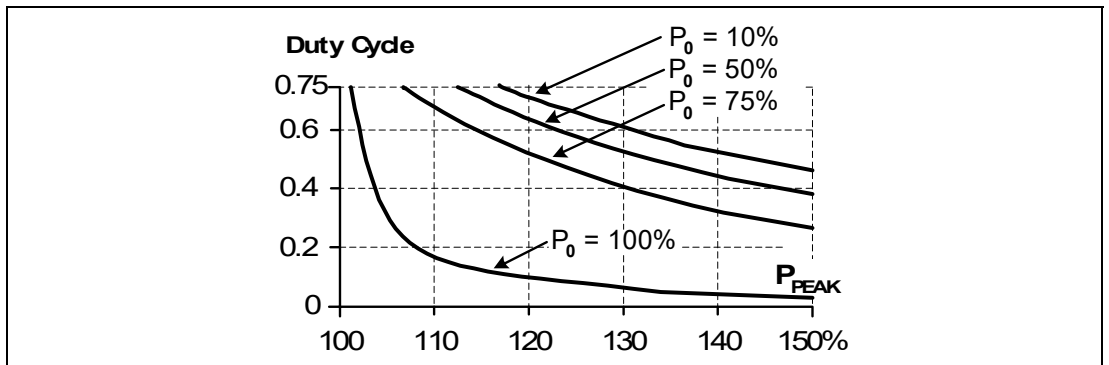


Figure 25.2 Max. duty cycle curve

$$\text{DutyCycle} = \frac{T_{\text{peak}}}{T_{\text{peak}} + T_0}$$

$$T_0 = \frac{T_{\text{peak}} - (\text{DutyCycle} \times T_{\text{peak}})}{\text{DutyCycle}}$$

Example:

A load is powered continuously with 480W (= 50% of the rated output load). From time to time a peak power of 1440W (= 150% of the rated output load) is needed for 1 second.

The question is: How often can this pulse be supplied without overloading the power supply?

- Make a vertical line at $P_{PEAK} = 150\%$ and a horizontal line where the vertical line crosses the $P_0 = 50\%$ curve. Read the max. duty cycle from the duty cycle-axis (= 0.37)
- Calculate the required pause (base load) length T_0 :

$$T_0 = \frac{T_{peak} - (DutyCycle \times T_{peak})}{DutyCycle} = \frac{1s - (0.37 \times 1s)}{0.37} = \underline{\underline{1.7s}}$$

- Result: The required pause length = **1.7s**
- Max. repetition rate = pulse + pause length = **2.7s**

More examples for pulse load compatibility:

P_{PEAK}	P_0	T_{PEAK}	T_0
1440W	960W	1s	>25s
1440W	0W	1s	>1.3s
1200W	480W	1s	> 0.75s

P_{PEAK}	P_0	T_{PEAK}	T_0
1440W	480W	0.1s	>0.16s
1440W	480W	1s	>1.6s
1440W	480W	3s	>4.9s

25.2 Peak Current Capability

The device can deliver peak currents (up to several milliseconds) which are higher than the specified short term currents. This helps to start current demanding loads. Solenoids, contactors and pneumatic modules often have a steady state coil and a pick-up coil. The inrush current demand of the pick-up coil is several times higher than the steady-state current and usually exceeds the nominal output current (including the **BonusPower®**). The same situation applies when starting a capacitive load.

The peak current capability also ensures the safe operation of subsequent circuit breakers of load circuits. The load branches are often individually protected with circuit breakers or fuses. In case of a short or an overload in one branch circuit, the fuse or circuit breaker need a certain amount of over-current to open in a timely manner. This avoids voltage loss in adjacent circuits.

The extra current (peak current) is supplied by the power converter and the built-in large sized output capacitors of the power supply. The capacitors get discharged during such an event, which causes a voltage dip on the output. The following two examples show typical voltage dips:

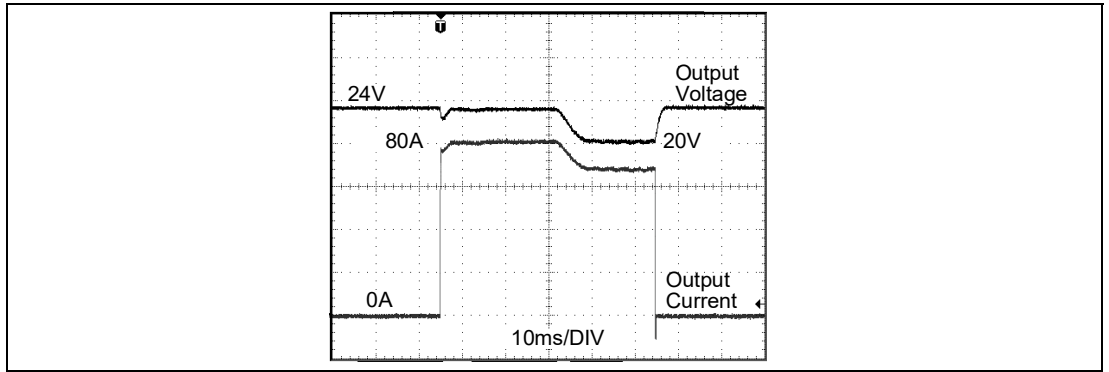


Figure 25.3 Peak load with 2x the nominal current for 50ms, typ.
80A Peak load (resistive) for 50ms
Output voltage dips from 24V to 20V.

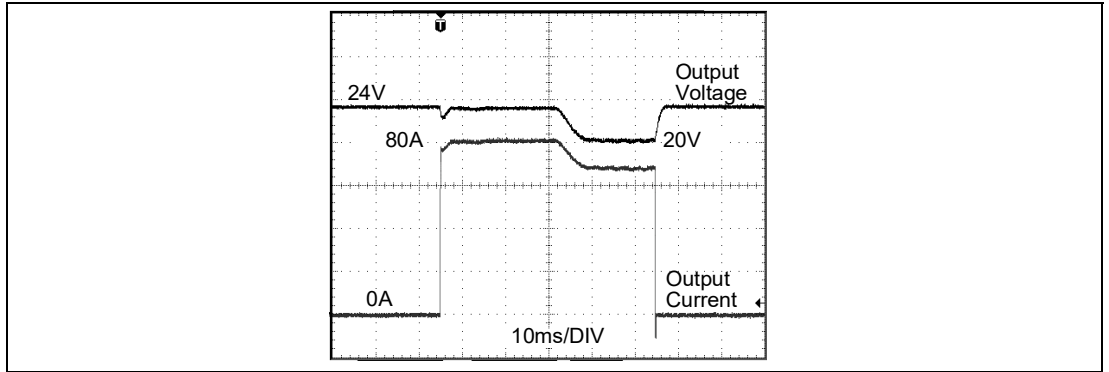


Figure 25.4 Peak load with 5x the nominal current for 5ms, typ.
200A Peak load (resistive) for 5ms
Output voltage dips from 24V to 12V.



Note

The DC-OK relay triggers when the voltage dips more than 10% for longer than 1ms.

Peak current voltage dips	typ.	from 24V to 20V	at 80A for 50ms, resistive load
	typ.	from 24V to 12V	at 200A for 2ms, resistive load
	typ.	from 24V to 12V	at 200A for 5ms, resistive load

25.3 External Input Protection

The unit is tested and approved for branch circuits up to 30A (U.S.A.) and 32A (IEC). An external protection is only required if the supplying branch has an ampacity greater than this. Check also local codes and local requirements. In some countries local regulations might apply.

If an external fuse is necessary or utilized, minimum requirements need to be considered to avoid nuisance tripping of the circuit breaker. A minimum value of 6A B- or C-Characteristic breaker should be chosen.

25.4 Using only 2 Legs of a 3-Phase System

No external protection devices are required to protect against a phase-loss failure.

This power supply can also be permanently operated on two legs of a 3-phase system. However, it is not recommended for this power class since the supplying 3-phase network can become unbalanced.

The output power must be reduced according to the curves below when operation on only two legs of a 3-phase system. A long-term exceeding of these limits will result in a thermal shut-down of the unit.

A use below 340Vac with more than 30A output current can also result in a thermal shut-down.

During power-on, some start-up attempts can occur until a permanent output power is available.

EMC performance, hold-up time, losses and output ripple differ from a three phase operation. Therefore, check suitability of your individual application.

Such use is not included in the UL approval. Additional tests might be necessary when the complete system has to be approved according to UL 508 or UL60950-1.

The screw of the terminal which remains unused must be securely tightened.

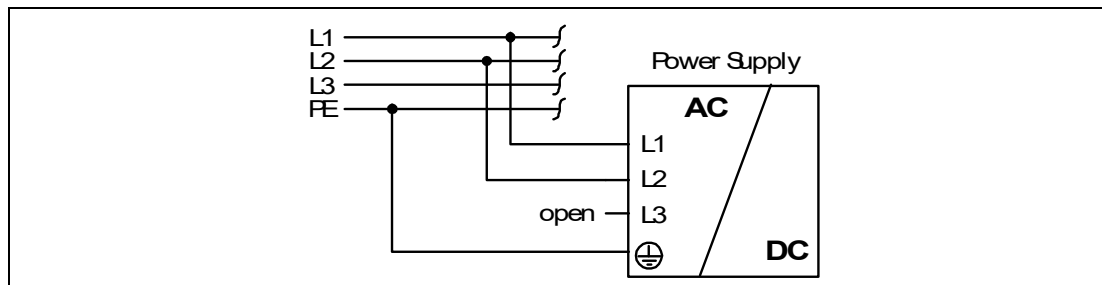


Figure 25.5 Two legs of a 3-phase system

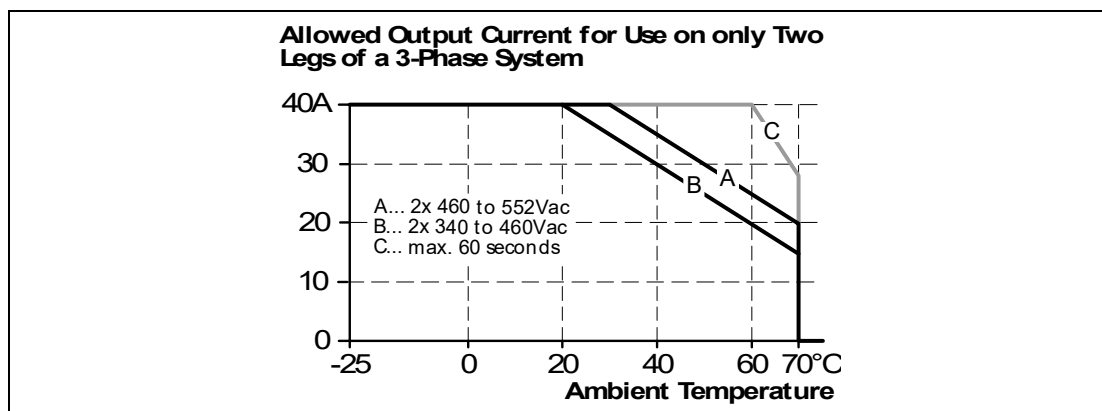


Figure 25.6 Output current vs. ambient temperature

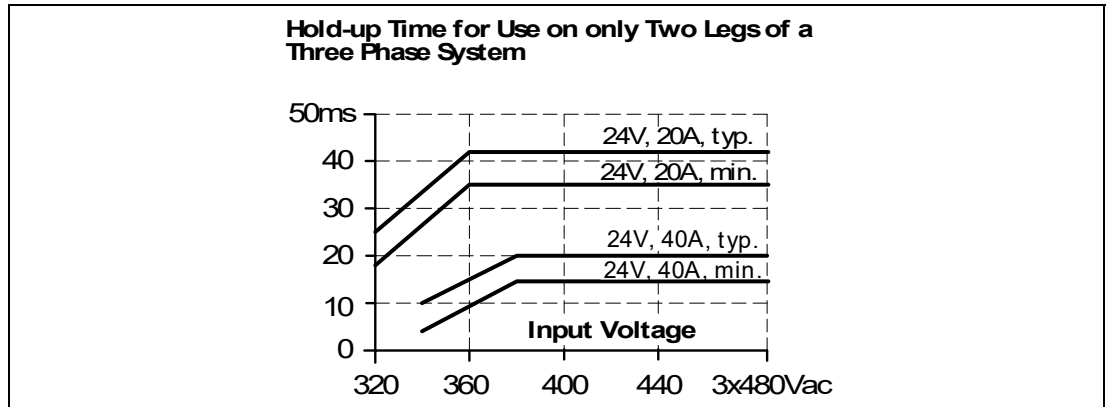


Figure 25.7 Hold-up time vs. input voltage

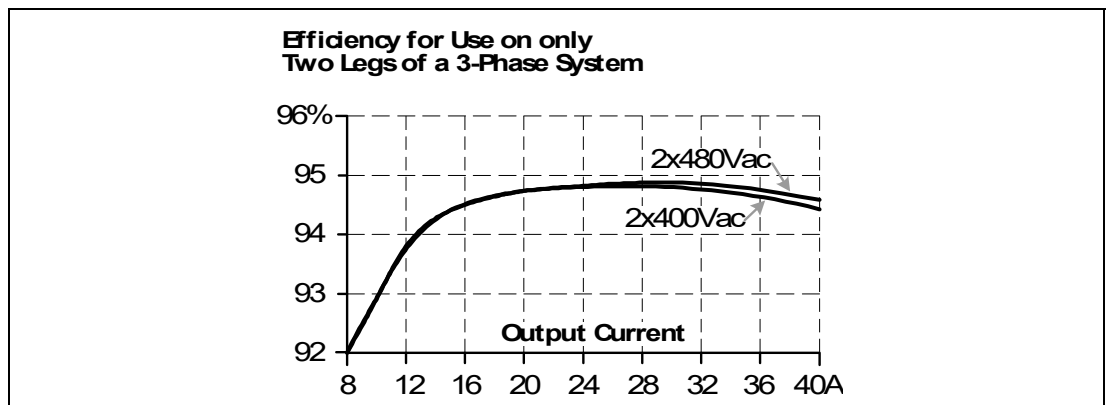


Figure 25.8 Efficiency vs. output current at 24V

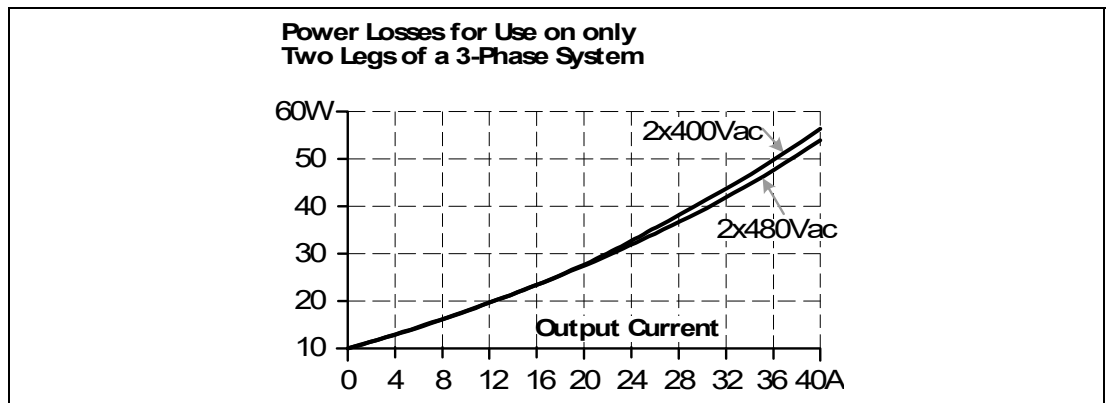


Figure 25.9 Losses vs. output current at 24V

25.5 Charging of Batteries

The power supply can be used to charge lead-acid or maintenance free batteries.
(Two 12V batteries in series)



Charging Batteries

1. Set output voltage (measured at no load and at the battery end of the cable) very precisely to the end-of-charge voltage.
2. Use a 50A or 63A circuit breaker (or blocking diode) between the power supply and the battery.
3. Ensure that the output current of the power supply is below the allowed charging current of the battery.
4. Use only matched batteries when putting 12V types in series.
5. The return current to the power supply (battery discharge current) is typ. 35mA when the power supply is switched off (except in case a blocking diode is utilized).

End-of-charge voltage	27.8V	27.5V	27.15V	26.8V
Battery temperature	10°C	20°C	30°C	40°C

25.6 Output Circuit Breakers

Standard miniature circuit breakers (MCB's or UL1077 circuit breakers) are commonly used for AC-supply systems and may also be used on DC branches.

MCB's are designed to protect wires and circuits. If the ampere value and the characteristics of the MCB are adapted to the wire size that is used, the wiring is considered as thermally safe regardless of whether the MCB opens or not.

To avoid voltage dips and under-voltage situations in adjacent 24V branches which are supplied by the same source, a fast (magnetic) tripping of the MCB is desired.

A quick shutdown within 10ms is necessary corresponding roughly to the ride-through time of PLC's. This requires power supplies with high current reserves and large output capacitors. Furthermore, the impedance of the faulty branch must be sufficiently small in order for the current to actually flow. The best current reserve in the power supply does not help if Ohm's law does not permit current flow. The following table has typical test results showing which B- and C-Characteristic MCBs magnetically trip depending on the wire cross section and wire length.

Maximal wire length ¹ for a fast (magnetic) tripping:

	0.75mm ²	1.0mm ²	1.5mm ²	2.5mm ²
C-2A	28m	38m	54m	78m
C-3A	26m	35m	50m	74m
C-4A	19m	26m	38m	58m
C-6A	12m	16m	24m	32m
C-8A	9m	12m	17m	25m
C-10A	7m	10m	15m	21m
C-13A	4m	5m	7m	11m
B-6A	19m	26m	35m	59m
B-10A	11m	17m	26m	37m
B-13A	10m	13m	21m	32m
B-16A	8m	11m	14m	24m
B-20A	4m	6m	8m	14m

¹ Don't forget to consider twice the distance to the load (or cable length) when calculating the total wire length (+ and - wire).

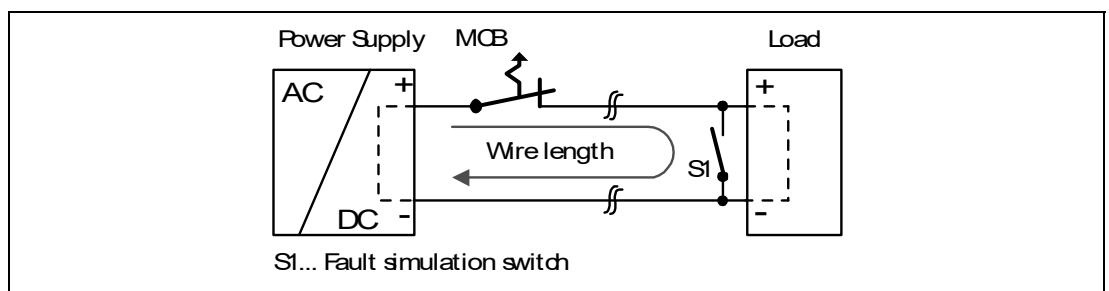


Figure 25.10 Test circuit

25.7 Parallel Use to Increase Output Power

Power supplies from the same series can be paralleled to increase the output power. The output voltage shall be adjusted to the same value ($\pm 100\text{mV}$) in **Single use** mode or without a placed jumper mode with the same load conditions on all units, or the units can be left with the factory settings. For load sharing option in **parallel use**, please refer to chapter 10 on the IO-Link Interface.

If more than three units are connected in parallel, a fuse or circuit breaker with a rating of 50A or 63A is required on each output. Alternatively, a diode or redundancy module can also be utilized.

Restrictions

- Keep an installation clearance of 15mm (left / right) between two power supplies and avoid installing the power supplies on top of each other.
- Do not use power supplies in parallel in mounting orientations other than the standard mounting orientation (terminals on the bottom of the unit) or in any other condition where a derating of the output current is required (e.g. altitude, above 60°C, ...).

Pay attention that leakage current, EMI, inrush current will increase when using multiple devices.

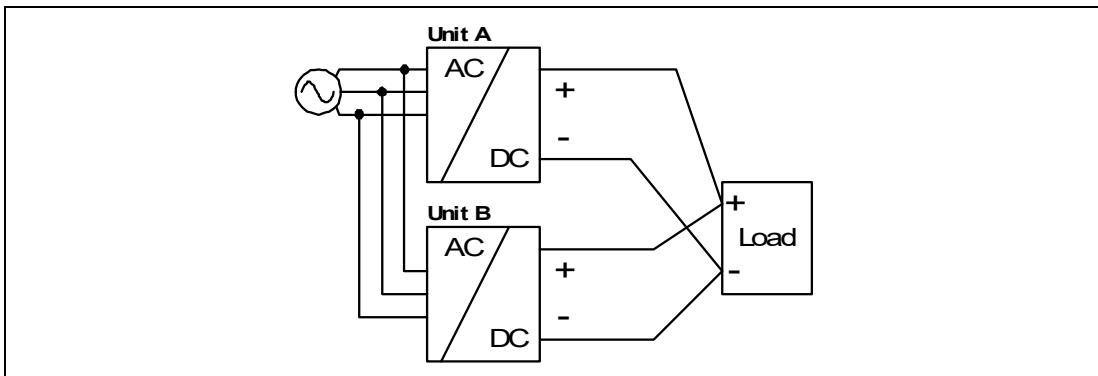


Figure 25.11 Parallel use to increase output power

25.8 Parallel Use for Redundancy

Power supplies can be paralleled for redundancy to gain higher system availability. Redundant systems require a certain amount of extra power to support the load in case one power supply unit fails. The simplest way is to put two power supplies in parallel. This is called a 1+1 redundancy. In case one power supply unit fails, the other one is automatically able to support the load current without any interruption. Redundant systems for a higher power demand are usually built in a N+1 method. E.g. five power supplies, each rated for 40A are paralleled to build a 160A redundant system. For N+1 redundancy the same restrictions apply as for increasing the output power, see also chapter 25.7.



Note

This simple way to build a redundant system does not cover failures such as an internal short circuit in the secondary side of the power supply. In such a case, the defective unit becomes a load for the other power supplies and the output voltage can not be maintained any more. This can be avoided by utilizing redundancy modules, which have decoupling devices (diodes or mosfets) included.

Recommendations for building redundant power systems:

- Use separate input fuses for each power supply. A separate source for each supply when possible increases the reliability of the redundant system.
- Set the power supply into **Parallel Use** mode, please refer to chapter 10.
- Monitor the individual power supply units. Therefore, use the DC-OK IO-Link event of the power supply.
- It is desirable to set the output voltages of all units to the same value ($\pm 100\text{mV}$) or leave it at the factory setting.

25.9 Series Operation

Devices of the same type can be connected in series for higher output voltages. It is possible to connect as many units in series as needed, providing the sum of the output voltage does not exceed 150Vdc. Voltages with a potential above 60Vdc are not SELV any more and can be dangerous. Such voltages must be installed with a protection against touching.

Earthing of the output is required when the sum of the output voltage is above 60Vdc.

Avoid return voltage (e.g. from a decelerating motor or battery) which is applied to the output terminals.

Restrictions

- Keep an installation clearance of 15mm (left / right) between two power supplies and avoid installing the power supplies on top of each other.
- Do not use power supplies in series in mounting orientations other than the standard mounting orientation (terminals on the bottom of the unit).

Pay attention that leakage current, EMI, inrush current, harmonics will increase when using multiple power supplies.

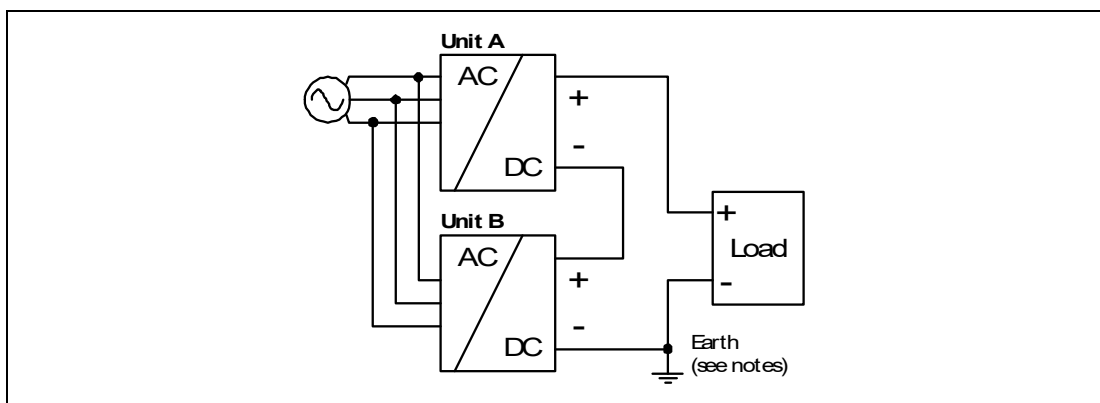


Figure 25.12 Series operation

25.10 Inductive and Capacitive Loads

The unit is designed to supply any kind of loads, including capacitive and inductive loads.

25.11 Back-Feeding Loads

Loads such as decelerating motors and inductors can feed voltage back to the power supply. This feature is also called return voltage immunity or resistance against Back- E.M.F. (Electro Magnetic Force).

This power supply is resistant and does not show malfunctioning when a load feeds back voltage to the power supply. It does not matter whether the power supply is on or off.

The maximum allowed feed-back-voltage is 35Vdc. The absorbing energy can be calculated according to the built-in large sized output capacitor which is specified in chapter 8. Feed-back-voltages can be detected and accessed via the IO-Link interface, as described in chapter 10.

25.12 Use in a Tightly Sealed Enclosure

When the power supply is installed in a tightly sealed enclosure, the temperature inside the enclosure will be higher than outside. In such situations, the inside temperature defines the ambient temperature for the power supply.

The following measurement results can be used as a reference to estimate the temperature rise inside the enclosure.

The power supply is placed in the middle of the box, no other heat producing items are inside the box.

Enclosure size	254x180x165mm Rittal Type IP66 Box PK 9522 100, plastic
Input voltage	230Vac
Load	24V, 32A; (=80%) load is placed outside the box
Temperature inside the box	57.5°C (in the middle of the right side of the power supply with a distance of 2cm)
Temperature outside the box	23.6°C
Temperature rise	33.9K

25.13 Mounting Orientations

Mounting orientations other than all terminals on the bottom require a reduction in continuous output power or a limitation in the maximum allowed ambient temperature.

The amount of reduction influences the lifetime expectancy of the power supply.

Therefore, two different derating curves for continuous operation can be found below:

Curve A1 Recommended output current.

Curve A2 Max allowed output current (results in approximately half the lifetime expectancy of A1).

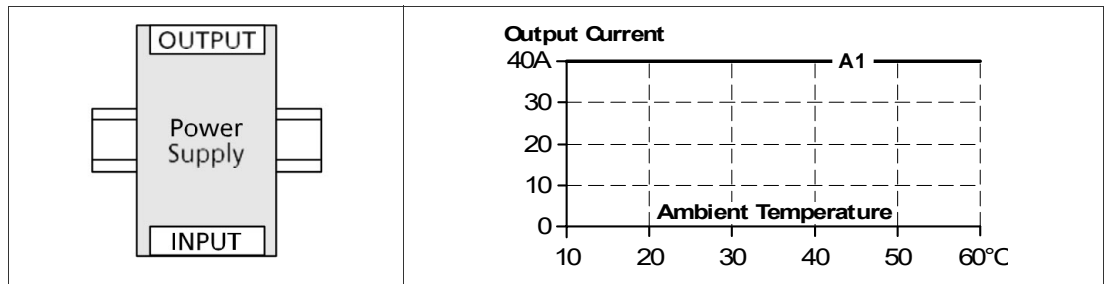


Figure 25.13 Mounting orientation A (standard orientation)

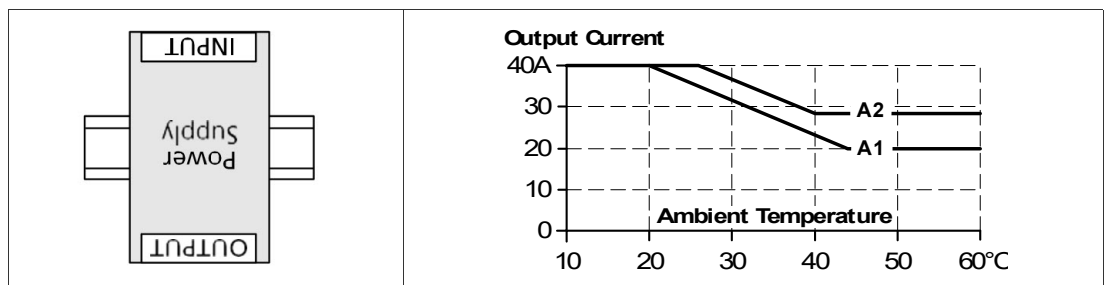


Figure 25.14 Mounting orientation B (upside down)

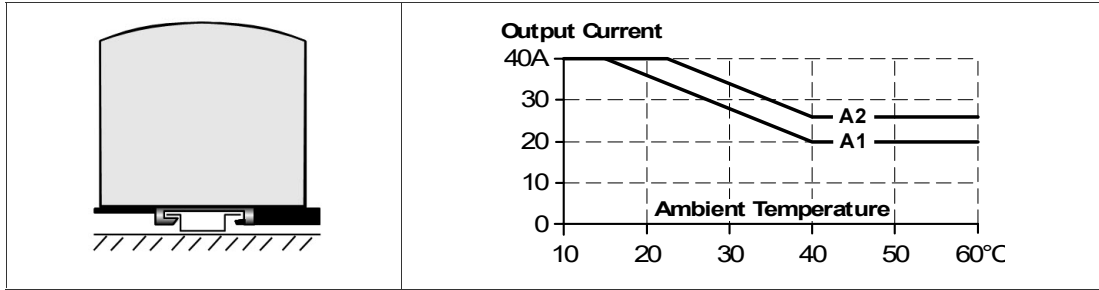


Figure 25.15 Mounting orientation C (table-top mounting)

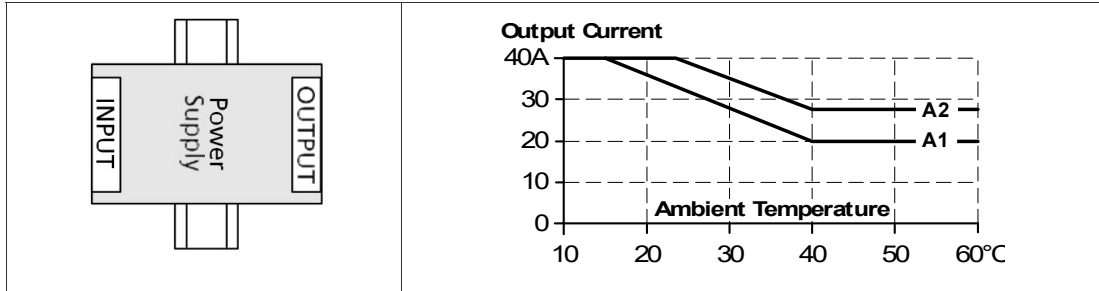


Figure 25.16 Mounting orientation D (horizontal cw)

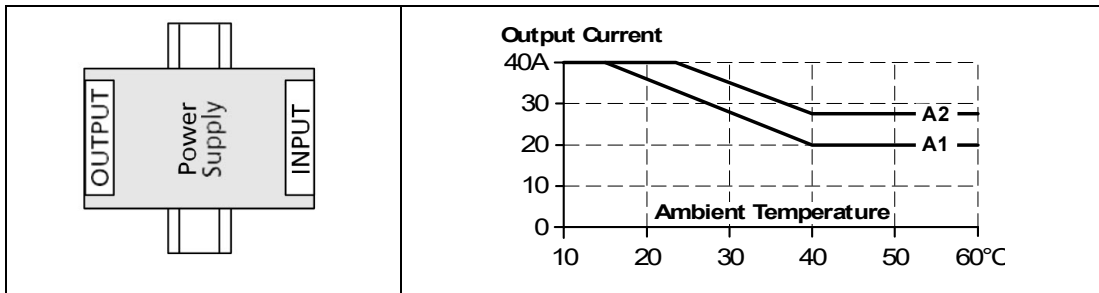


Figure 25.17 Mounting orientation E (horizontal ccw)

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